

Bernese GNSS Software Version 5.2

Tutorial

Processing Example Introductory Course Terminal Session

Rolf Dach, Pierre Fridez

February 2021



Astronomical Institute, University of Bern

Contents

1	Intro	oduction to the Example Campaign	1
	1.1	Stations in the Example Campaign	1
	1.2	Directory Structure	3
		1.2.1 The DATAPOOL Directory Structure	4
		1.2.2 The Campaign–Directory Structure	6
		1.2.3 Input Files for the Processing Examples	7
		1.2.4 The SAVEDISK Directory Structure	10
2	Terr	ninal Session: Monday	13
	2.1	Start the Menu	13
	2.2	Select Current Session	13
	2.3	Campaign Setup	14
	2.4	Menu Variables	14
	2.5	Generate A Priori Coordinates	16
	2.6	Session Goals	18
3	Terr	ninal Session: Pole and Orbit Preparation	19
	3.1	Prepare Pole Information	19
	3.2	Generate Orbit Files	21
	3.3	Session Goals	28
4	Terr	ninal Session: Tuesday	29
	4.1	Importing the Observations	29
	4.2	Data Preprocessing (I)	33
		4.2.1 Receiver Clock Synchronization	33
		4.2.2 Form Baselines	37
		4.2.3 Preprocessing of the Phase Baseline Files	40
	4.3	Daily Goals	43
5	Terr	ninal Session: Wednesday	45
	5.1	Data Preprocessing (II)	45
	5.2	Produce a First Network Solution	54
	5.3	Ambiguity Resolution	58
		5.3.1 Ambiguity Resolution: Quasi–Ionosphere–Free (QIF)	58
		5.3.2 Ambiguity Resolution: Short Baselines	67
		5.3.3 Ambiguity Resolution: Bernese Processing Engine (BPE)	70
		5.3.4 Ambiguity Resolution: Summary	74
	5.4	Daily Goals	76
6	Terr	ninal Session: Thursday	79
	6.1	Final Network Solution	79
	6.2	Check the Coordinates of the Fiducial Sites	84
	6.3	Check the Daily Repeatability	91

	6.4	_	ute the Reduced Solution of the Sessions	93
	6.5		ty Estimation	97
		6.5.1	Preparation for ITRF2014/IGS14 Velocity Estimation	97
		6.5.2	Velocity Estimation Based on NEQ Files	98
	6.6	Daily	Goals	105
7	Add		Examples	107
	7.1	Advan	aced Aspects in Using ITRF2014/IGS14	108
		7.1.1	Using ITRF2014/IGS14 Frames for Reprocessing	108
		7.1.2	Ignoring Stations with PSD Corrections for Datum Definition $\ . \ .$	109
		7.1.3	Recovering a Linear Velocity Field for a Certain Interval	110
	7.2	Prepa	ring Combined GPS and GLONASS IGS–Orbits	114
		7.2.1	Prepare Pole Information	114
		7.2.2	Merging Precise Orbit Files	115
		7.2.3	Generating Standard Orbit Files	116
	7.3	Kinem	natic Positioning	120
		7.3.1	Estimating Kinematic Positions in a Double–Difference Solution	120
		7.3.2	Extracting the Program Output from a Kinematic Positioning	124
		7.3.3	Further suggestions	125
	7.4	Zero I	Difference Processing for Clock Estimation	126
		7.4.1	Preprocessing	126
		7.4.2	Residual Screening	130
		7.4.3	Generate Clock Solutions	137
		7.4.4	Further Suggestions	145
	7.5	Using	RINEX 3 Data	146
		7.5.1	Basic Principles	146
		7.5.2	RINEX 3 Handling in RNXSMT	147
		7.5.3	RINEX 3 Handling in the Example BPEs	148
	7.6	Proces	ssing Galileo Observations	149
		7.6.1	Galileo Satellite-Related Metadata	149
		7.6.2	Preparing the Orbit and Clock Products	149
		7.6.3	Observation Selection	151
		7.6.4	Processing the Example Including Galileo	152
		7.6.5	Adapting the Example BPEs	155
	7.7	Simula	ation of Global Navigation Satellite Systems (GNSS) Observations .	157
		7.7.1	Simulation of GNSS Observations	157
		7.7.2	Zero Difference Solution from Simulated GNSS Observations	160
		7.7.3	Double–Difference Solution from Simulated GNSS Observations	164
		7.7.4	Final Remarks	168

1 Introduction to the Example Campaign

1.1 Stations in the Example Campaign

Data from thirteen European stations of the International GNSS Service (IGS) network and from the EUREF Permanent Network (EPN) were selected for the example campaign. They are listed in Table 1.1. The locations of these stations are given in Figure 1.1. Three of the stations support only Global Positioning System (GPS) whereas all other sites provide data from both GPS and its Russian counterpart Глобальная навигационная спутниковая система: Global Navigation Satellite System (GLONASS).

The observations for these stations are available for four days. Two days in year 2010 (day of year 207 and 208) and two in 2011 (days 205 and 206)¹. In the terminal sessions you will analyze the data in order to obtain a velocity field based on final products from Center for Orbit Determination in Europe (CODE). For eight of these stations, coordinates and velocities are given in the IGS14 reference frame, an IGS-specific realization of the ITRF2014 (see $D/STAT_LOG/IGS14.snx$).

Between these days in 2010 and 2011 the receivers at LAMA, TLSE, and WTZR and the full equipment at WTZZ was changed. The receiver type, the antenna type, and the antenna height are provided in Table 1.1. Notice, that for three antennas (at GANP, WTZR, and ZIM2) values from an individual calibration are available from

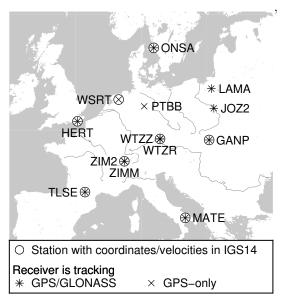


Figure 1.1: Stations used in example campaign

the EPN processing. For all other antennas only type–specific calibration results from the IGS processing (\${X}/GEN/I14.ATX) are available. More details are provided in Table 1.2. Only in one case where no calibration of the antenna/radome combination was available (ONSA) the calibration values of the antenna without radome were used instead. With the exception of ONSA even system–specific calibrations for GPS and GLONASS measurements are available.

The distances between occupied locations in the network are between 200 and 1000 km. Two locations (Zimmerwald and Kötzting) are occupied by receiver/antenna pairs defining

¹A fifth day (day 213 of year 2017) is available to demonstrate the usage of RINEX 3 data and the processing of Galileo observations, see Sections 7.5 and 7.6, respectively. These data are only relevant if you want to follow the examples in these two sections.

as well a	as the antenna height.	
~ .		Receiver type Antenna
Station name	Location	Antenna type Radome height
GANP 11515M001	Ganovce, Slovakia	TRIMBLE NETR8 TRM55971.00 NONE $0.3830\mathrm{m}$
HERT 13212M010	Hailsham, United Kingdom	LEICA GRX1200GGPRO LEIAT504GG NONE 0.0000 m
J0Z2 12204M002	Jozefoslaw, Poland	LEICA GRX1200GGPRO LEIAT504GG NONE 0.0000 m
LAMA 12209M001	Olsztyn, Poland	2010: LEICA GRX1200GGPR0 LEIAT504GG LEIS 0.0600 m 2011: LEICA GRX1200+GNSS LEIAT504GG LEIS 0.0600 m
MATE 12734M008	Matera, Italy	LEICA GRX1200GGPR0 LEIAT504GG NONE $0.1010\mathrm{m}$
ONSA 10402M004	Onsala, Sweden	JPS E_GGD AOAD/M_B OSOD 0.9950 m
PTBB 14234M001	Braunschweig, Germany	ASHTECH Z-XII3T ASH700936E SNOW $0.0562\mathrm{m}$
TLSE 10003M009	Toulouse, France	2010: TRIMBLE NETR5 TRM59800.00 NONE 1.0530 m 2011: TRIMBLE NETR9 TRM59800.00 NONE 1.0530 m
WSRT 13506M005	Westerbork, The Netherlands	AOA SNR-12 ACT AOAD/M_T DUTD 0.3888 m
WTZR 14201M010	Kötzting, Germany	2010: LEICA GRX1200GGPR0 LEIAR25.R3 LEIT 0.0710 m 2011: LEICA GRX1200+GNSS LEIAR25.R3 LEIT 0.0710 m
WTZZ 14201M014	Kötzting, Germany	2010: TPS E_GGD TPSCR3_GGD CONE 0.2150 m 2011: JAVAD TRE_G3TH DELTA LEIAR25.R3 LEIT 0.0450 m
ZIM2 14001M008	Zimmerwald, Switzerland	TRIMBLE NETR5 TRM59800.00 NONE $0.0000\mathrm{m}$
ZIMM 14001M004	Zimmerwald, Switzerland	TRIMBLE NETRS TRM29659.00 NONE $0.0000\mathrm{m}$

 Table 1.1: List of stations used for the example campaign including receiver and antenna type as well as the antenna height.

		Type of c	alibration	used at
Antenna type		for GPS	for GLONASS	stations
AOAD/M_B	OSOD	ADOPTED from NONE	ADOPTED from GPS	ONSA
AOAD/M_T	DUTD	ROBOT		WSRT
ASH700936E	SNOW	ROBOT		PTBB
LEIAR25.R3	LEIT	ROBOT	ROBOT	WTZR,
				WTZZ(2011)
LEIAT504GG	NONE	ROBOT	ROBOT	JOZ2, HERT,
				MATE
LEIAT504GG	LEIS	ROBOT	ROBOT	LAMA
TPSCR3_GGD	CONE	ROBOT	ROBOT	WTZZ(2010)
TRM29659.00	NONE	ROBOT		ZIMM
TRM55971.00	NONE	ROBOT	ROBOT	GANP
TRM59800.00	NONE	ROBOT	ROBOT	TLSE, ZIM2

 Table 1.2: List of antenna/radome combinations used in the example campaign together with the available antenna calibration values in IGS14 model.

separate stations each: in Zimmerwald, the distance between ZIMM and ZIM2 is only 19 m. In Kötzting, WTZR and WTZZ are separated by less than 2 m — these are short GPS/GLONASS baselines.

The receivers used at the stations MATE, ONSA, PTBB, and WSRT are connected to H-Maser clocks. The receiver type ASHTECH Z-XII3T used at PTBB was specifically developed for time and frequency applications. In 2011 both receivers in Kötzting (WTZR and WTZZ) were connected to the same H–Maser (EFOS 18).

1.2 Directory Structure

The data belonging to this example campaign is included in the distribution of the *Bernese GNSS Software*. Therefore, you may also use this document to generate solutions from the example dataset to train yourself in the use of the *Bernese GNSS Software* outside the environment of the *Bernese Introductory Course*.

There are three areas relevant for the data processing (in the environment of the *Bernese Introductory Course* they are all located in the *\${HOME}/GPSDATA* directory):

- **\${D}:** The DATAPOOL area is intended as an interface where all external files can be deposited after their download. It can be used by several processing campaigns.
- \${P}: The CAMPAIGN52 directory contains all processing campaigns for the Version 5.2 of the Bernese GNSS Software. In the Bernese Introductory Course environment all groups use \${P}/INTRO² in their \${HOME} directory.
- \${S}: The SAVEDISK area serves as a product database where the result files from different processes/projects can be collected and archived. Before you start processing, only reference files (*.*_REF) obtained with the example BPE from the distribution are available here.

 $^{^2 \}rm The second campaign <math display="inline">P/EXM_GAL$ is only related to Section 7.6 where the analysis of Galileo measurements is explained.

1.2.1 The DATAPOOL Directory Structure (\${D})

Motivation for the DATAPOOL area

The idea of the DATAPOOL area is to store local copies of external files on your filesystem. This offers several advantages compared to downloading the data each time when the processing is started:

- The files are downloaded only once, even if they are used for several campaigns.
- The data download can be organized with a set of scripts running independently from the Bernese GNSS Software environment, scheduled by the expected availability of the external files to download.
- The processing itself becomes independent from the availability of external data sources.

Structure and content of the DATAPOOL area

The DATAPOOL area contains several subdirectories taking into account the different sources of files and their formats:

RINEX :

The data of GNSS stations is provided in Receiver INdependent EXchange format (RINEX) files. The directory contains observation (Hatanaka–compressed) and navigation (GPS and GLONASS) files. These RINEX files are "originary" files that are not changed during the processing.

The RINEX files can be downloaded from international data centers. Project–specific files are copied into this area. If you mix the station lists from different projects, take care about the uniqueness of the four–character IDs of all stations in the RINEX file names.

HOURLY :

The same as the **RINEX** directory but dedicated to hourly RINEX data used for near real-time applications. Note: not all stations in this example provide hourly RINEX files.

RINEX3 :

The same as the **RINEX** directory but the data are given in the RINEX 3 format. These files support the description on how to use RINEX 3 data, see Section 7.5.

LEO :

This directory is intended to host files which are necessary for Low Earth Orbiter (LEO) data processing. RINEX files are stored in the subdirectory **RINEX** (of the LEO directory). The corresponding attitude files are placed in the subdirectory **ATTIT**.

These files are needed to run the example BPE on LEO orbit determination (LEOPOD. PCF). They are not used in the example during the *Bernese Introductory Course*.

SLR NP :

The Satellite Laser Ranging (SLR) data is provided in the quicklook normal point format. The directory contains the normal point files downloaded from the International Laser Ranging Service (ILRS) data centers.

These files are needed to run the example BPE on orbit validation using SLR observations (SLRVAL.PCF). They are not used in the example during the *Bernese Introductory Course*.

STAT_LOG :

This directory contains the station information files (e.g., from ftp://igs.org/pub/ station/log). This information may be complemented by the originary information on the reference frame (e.g., the IGb08.snx or IGS14.snx from ftp://igs.org/pub/ station/coord).

Apart from the coordinates and velocities of selected IGS sites, it also contains the history of the used equipment as it has been assumed for the reference frame generation. A comparison with the igs.snx file constructed at the IGS Central Bureau (IGSCB) from the site information files may be useful for a verification of the history records.

COD/COM/IGS :

Orbits, Earth orientation parameters (EOP), and satellite clock corrections are basic external information for a GNSS analysis. The source of the files may be the FTP server from CODE (ftp://ftp.aiub.unibe.ch/CODE or http://www.aiub. unibe.ch/download/CODE/), or the Crustal Dynamics Data Information System FTP server (e.g., for downloading GPS-related IGS products ftp://cddis.gsfc. nasa.gov/gnss/products and in ftp://cddis.gsfc.nasa.gov/glonass/products for GLONASS-related IGS products). The files are named by the GPS week and the day of the week (apart from files containing information for the entire week, e.g., EOP, or the processing summaries).

The IGS provides GPS and GLONASS orbits only in separate files (IGS/IGL-series from the final product line) stemming from independent combination procedures with different contributing analysis centers. Nevertheless, they are consistent enough to merge both files together as the first step of the processing as described in Section 7.2. CODE contributes fully combined multi-GNSS solutions to the IGS final (and rapid as well as ultra-rapid) product line.

When you are going to process Galileo data (see Section 7.6) you will need related orbit, EOP, and satellite clock corrections for these satellites as well. They are not included in the legacy IGS products. For that reason you need products from the Multi-GNSS Extension (MGEX) project of the IGS. CODE's MGEX products are available with the label COM at ftp://ftp.aiub.unibe.ch/CODE_MGEX/CODE or ftp://cddis.gsfc.nasa.gov/gnss/products/mgex.

BSW52 :

In this directory we have placed files containing external input information in Bernese-specific formats. The files are neutral with respect to the data you are going to process. Typical examples are ionosphere maps or differential code biases (DCB) files. These files can be downloaded from http://www.aiub.unibe.ch/download/CODE/ or http://www.aiub.unibe.ch/download/BSWUSER52/ areas.

REF52 :

Here we propose to collect files in Bernese format which are useful for several campaigns (e.g., reference frame files: IGB08_R.CRD, IGB08_R.VEL or IGS14_R.CRD, IGS14_R.VEL). Typical examples are station coordinate, velocity, and information files (e.g., EXAMPLE.CRD, EXAMPLE.VEL, EXAMPLE.STA, ..., EPN.CRD). All stations of a project are contained in one file but the processing of the project's data may be performed in different campaigns.

MSC :

This directory contains example files for the automated processing with the BPE.

VMF1 :

The grids for the Vienna Mapping Function (VMF1) are located in a separate directory. The files can be downloaded from http://vmf.geo.tuwien.ac.at/trop_ products/GRID/2.5x2/VMF1/VMF1_OP. They are not used for the examples but it is an indication that for other types of files additional directories may be created.

All files and meta-information related to the 13 stations selected for the example campaign are already in this DATAPOOL-area (\${D}) after installing the *Bernese GNSS Software*. GNSS orbit information is available from CODE (legacy and MGEX) and IGS (directories \${D}/COD, \${D}/COM or \${D}/IGS, respectively).

1.2.2 The Campaign–Directory Structure

Putting data from the DATAPOOL into the campaign

When running an automated processing using the BPE there is a script at the beginning of the process which copies the data from the DATAPOOL—area into the campaign. If you are going to process data manually you first have to copy the necessary files into the campaign and decompress them if necessary using standard utilities (uncompress, gunzip³, or CRZ2RNX for RINEX—files).

Content of the campaign area to process the example

All files needed to process the data according to this tutorial are already copied into the campaign area. If you want to follow the example outside the *Bernese Introductory Course* environment you have to put the following files at the correct places in the campaign directory structure.

\${P}/INTRO/ATM/	COD10207.ION	COD10208.ION	COD11205.ION	COD11206.ION	
<pre>\${P}/INTRO/BPE/</pre>					
<pre>\${P}/INTRO/GRD/</pre>	VMF10207.GRD	VMF10208.GRD	VMF11205.GRD	VMF11206.GRD	
<pre>\${P}/INTRO/OBS/</pre>					
\${P}/INTRO/ORB/	COD15941.PRE COD15947.IEP	COD15942.PRE	COD16460.PRE COD16467.IEP	COD16461.PRE	
	IGS15941, PRE	IGS15942.PRE	IGS16460, PRE	IGS16461.PRE	
	IGL15941.PRE	IGL15942.PRE	IGL16460, PRE	IGL16461.PRE	
	IGS15947.IEP		IGS16467.IEP		
	P1C11007.DCB		P1C11107.DCB		
	P1P21007.DCB		P1P21107.DCB		
<pre>\${P}/INTRO/ORX/</pre>					
φ [] / INT O / OUT /	COD15941.CLK	COD15942.CLK	COD16460 CLK	COD16461.CLK	
\${P}/INTRO/OUT/		000100121020	000101001001	00010101000	
	IGS15941.CLK	IGS15942.CLK	IGS16460.CLK	IGS16461.CLK	
\${P}/INTRO/RAW/	GANP2070.100	GANP2080.100	GANP2050.110	GANP2060.110	
	HERT2070.100	HERT2080.100	HERT2050.110	HERT2060.110	
	J0Z22070.100	J0Z22080.100	J0Z22050.110	J0Z22060.110	
	LAMA2070.100	LAMA2080.100	LAMA2050.110	LAMA2060.110	

³These tools are also available for WINDOWS-platforms, see www.gzip.org. Note, that gunzip can also be used to uncompress UNIX-compressed files with the extension .Z.

	MATE2070.100	MATE2080.100	MATE2050.110	MATE2060.110
	ONSA2070.100	ONSA2080.100	ONSA2050.110	ONSA2060.110
	PTBB2070.100	PTBB2080.100	PTBB2050.110	PTBB2060.110
	TLSE2070.100	TLSE2080.100	TLSE2050.110	TLSE2060.110
	WSRT2070.100	WSRT2080.100	WSRT2050.110	WSRT2060.110
	WTZR2070.100	WTZR2080.100	WTZR2050.110	WTZR2060.110
	WTZZ2070.100	WTZZ2080.100	WTZZ2050.110	WTZZ2060.110
	ZIM22070.100	ZIM22080.100	ZIM22050.110	ZIM22060.110
	ZIMM2070.100	ZIMM2080.100	ZIMM2050.110	ZIMM2060.110
\${P}/INTRO/SOL/				
\${P}/INTRO/STA/	EXAMPLE.CRD	EXAMPLE.VEL	EXAMPLE.STA	EXAMPLE.ABB
	EXAMPLE.BLQ	EXAMPLE.ATL	EXAMPLE.CLU	EXAMPLE.PLD
	IGB08_R.CRD	IGB08_R.VEL	IGB08.FIX	IGB08.SIG
	IGS14_R.CRD	IGS14_R.VEL	IGS14.PSD	
	IGS14.FIX	IGS14.SIG		
	SESSIONS.SES			

The directory P/INTRO/GEN/ contains copies of the files from the X/GEN directory, which are used by the processing programs. The files $PCV_Bxx.I08$ and $PCV_Bxx.I14$, respectively, are user-specific and the "xx" chars represent your terminal account number. If you want to view these files, please use those in your campaign and not the ones in the X/GEN directory to prevent potential interferences with your colleagues.

\${P}/INTRO/GEN/	CONST.	DATUM.	GPSUTC.	POLOFF.
	RECEIVER.			
	SATELLIT.108	PCV.108	PCV_Bxx.I08	IO8.ATX
	SATELLIT.I14	PCV.I14	PCV_Bxx.I14	I14.ATX
	SAT_2010.CRX	SAT_2011.CRX		
	IAU2000R06.NUT	IERS2010XY.SUB	OT_FES2004.TID	TIDE2000.TPO
	EGM2014_SMALL.	s1_s2_def_ce.dat		
	SINEX.	SINEX.PPP	SINEX.RNX2SNX	
	IONEX.	IONEX.PPP		

1.2.3 Input Files for the Processing Examples

Atmosphere files ATM

The input files in this directory are global ionosphere models in the Bernese format obtained from the IGS processing at CODE. They will be used to support the phase ambiguity resolution with the QIF strategy and to enable the higher order ionosphere (HOI) corrections.

General files GEN

These general input files contain information that is neither user- nor campaign-specific. They are accessed by all users, and changes in these files will affect processing for everyone. Consequently, these files are located in the $\{X\}/GEN$ directory. Table 1.3 shows the list of general files necessary for the processing example. It also shows which files need to be updated from time to time by downloading them from the anonymous ftp-server of AIUB (http://www.aiub.unibe.ch/download/BSWUSER52/GEN).

Since GPS week 1934 (29 January 2017) the IGS is using the IGS14 reference frame together with the related antenna model (I14.ATX). They are available in the related SATELLIT.I14 and PCV.I14 files. The predecessor antenna model is related to the IGb08 reference frame and is provided in the SATELLIT.I08 and PCV.I08 files. Please check the consistent usage of these files.

Filename	Content	Modification	Update from
CONST.	All constants used in the Bernese GNSS Software	No	BSW aftp
DATUM.	Definition of geodetic datum	Introducing new reference ellipsoid	BSW aftp
GPSUTC.	Leap seconds	When a new leap second is announced by the IERS	BSW aftp
POLOFF.	Pole offset coefficients	Introducing new values from IERS annual report (until 1997)	
RECEIVER.	Receiver information	Introducing new receiver type	BSW aftp
SATELLIT.I14 or SATELLIT.I08	Satellite information file	New launched satellites	BSW aftp
PCV.I14 or PCV.I08	Phase center eccentricities and variations	Introducing new antenna corrections or new antenna/radome combinations	BSW aftp or update with ATX2PCV
SAT_\$Y+0.CRX	Satellite problems	Satellite maneuvers, bad data,	BSW aftp
IAU2000R06.NUT	Nutation model coefficients	No	
IERS2010XY.SUB	Subdaily pole model coefficients	No	
OT_FES2004.TID	Ocean tides coefficients	No	
TIDE2000.TPO	Solid Earth tides coefficients	No	
EGM2008_SMALL.	Earth potential coefficients (reduced version, sufficient for GNSS and LEO orbit determination)	No	
s1_s2_def_ce.	S1/S2 atmospheric tidal	No	
dat	loading coefficients		
SINEX. SINEX.TRO SINEX.PPP SINEX.RNX2SNX	SINEX header information for the PPP example for RNX2SNX example	Adapt SINEX header for your institution	
IONEX.	IONEX header information	Adapt IONEX header for your institution	
IONEX.PPP	for the PPP example		

Table 1.3: List of general files to be used in the Bernese programs for the processing example.

Each Bernese processing program has its own panel for general files. Make sure that you use the correct files listed in Table $1.3\,.$

$Grid\ files\ {\tt GRD}$

In this directory the grid files *****.**GRD** are collected. To apply, e.g., the VMF1 troposphere model (a priori information from European Centre for Medium-Range Weather Forecasts (ECMWF) and Vienna mapping function) you need a grid with the necessary coefficients.

Orbit files ORB

The precise orbits in the files *****.**PRE** are usually the final products from CODE analysis center containing GPS and GLONASS orbits from a rigorous multi–GNSS analysis. Alternatively also the combined final products from the IGS can be used. They do not contain orbits for the GLONASS satellites. The combined GLONASS satellite orbits from the IGS are available in IGL–files. Both precise orbit files need to be merged for a multi–GNSS analysis.The corresponding EOP are given in weekly files with the extension *****.**IEP** (take care on full consistency with the orbit product).

Furthermore, the directory contains monthly means for the DCB.

Clock RINEX files OUT

The clock RINEX files are located in the OUT-directory. They are consistent with the GNSS orbits and EOP products in the ORB-directory. They contain station and satellite clock corrections with at least 5 minutes sampling — there are also files from the IGS or some of the analysis center (AC)s providing satellite clock corrections with a sampling of 30 seconds.

RINEX files RAW

The raw data are given in RINEX format. The observations *. YO (Y is the menu time variable for the two-digit year of the current session) are used for all examples.

Station files $\ensuremath{\texttt{STA}}$

The coordinates and velocities of the stations given in the IGS realization of the reference frame ITRF2014 are available in the files $IGS14_R.CRD$ and $IGS14_R.VEL$. Since the ITRF2014 solution, in addition to the linear station velocities (see VEL) for some stations also corrections for Post Seismic Deformation (PSD) need to apply that are provided in the file IGS14.PSD. The IGS core stations are listed in IGS14.FIX. This file will be used to define the geodetic datum when estimating station coordinates. The files for the previously used IGS realization of the ITRF2008 are available as well: IGB08_R.CRD, IGB08_R.VEL and IGB08.FIX (Note that the PSD corrections are not yet in use). You can browse all these files with a text editor or with the menu ("Menu>Campaign>Edit station files").

For all stations that have unknown coordinates in the IGS14 reference frame a Precise Point Positioning (PPP) using the example BPE (PPP_BAS.PCF) for day 207 of year 2010 has been executed. For our EXAMPLE-project a resulting coordinate file EXAMPLE.CRD has been generated. It contains all IGS core sites (copied from file IGS14_R.CRD) and the PPP results for the remaining stations. The epoch of the coordinates is January 01, 2010. The corresponding velocity file EXAMPLE.VEL contains the velocities for the core sites (copied from file IGS14_R.VEL) completed by the NNR-NUVEL1A velocities for the other stations. The assignment of stations to tectonic plates is given in the file EXAMPLE.PLD.

To make sure that you process the data in the *Bernese GNSS Software* with correct station information (station name, receiver type, antenna type, antenna height, etc.) the file **EXAMPLE.STA** is used to verify the RINEX header information. The reason to use this file has to be seen in the context that some antenna heights or receiver/antenna types in the RINEX files may not be correct or may be measured to a different antenna reference point. Similarly, the marker (station) names in the RINEX files may differ from the names we want to use in the processing. The antenna types have to correspond to those in the file X/GEN/PCV.I14 in order that the correct phase center offsets and variations are used. The receiver types have to be defined in the X/GEN/RECEIVER. file to correctly apply the DCB corrections.

For each station name unique four– and two–character abbreviations to construct the names for the Bernese observation files need to be defined in the file EXAMPLE.ABB. It was automatically generated by the PPP–example BPE. If you want to process big networks, the baselines need to be divided into clusters to speed up the processing. For that purpose each station has to be assigned to a region by a cluster number in the file EXAMPLE. CLU.

The last files to be mentioned in this directory are EXAMPLE.BLQ and EXAMPLE.ATL. They respectively provide the coefficients for the ocean and atmospheric tidal loading of the stations. They should at least be applied in the final run of GPSEST.

1.2.4 The SAVEDISK Directory Structure (\${S})

Motivation for the SAVEDISK area

When processing GNSS data, a lot of files from various processing steps will populate your campaign directories. The main result files from the data analysis should be collected in the SAVEDISK area. This area is intended as long-term archive for your result files.

Because the result files are stored in the SAVEDISK area, you can easily clean up your campaign area without loosing important files. Please keep in mind that the computing performance decreases if you have several thousands of files in a directory.

Structure and content of the SAVEDISK area

We propose to build subdirectories in the SAVEDISK area for each of your projects. If these projects collect data over several years, yearly subdirectories are recommended. It is also practical to use further subdirectories like ATM, ORB, OUT, SOL, STA to distribute the files and to get shorter listings if you are looking for a file.

The SAVEDISK area contains after its installation a directory structure according to the description above. Each example BPE is assumed as a project. Therefore, you will find on the top level of the SAVEDISK the directories PPP, RNX2SNX, CLKDET, LEOPOD, and SLRVAL (related to the different example BPEs). There may even be specific directories for different series of solutions in various projects (e.g., PPP_GAL, RNX2SNX_GAL where also Galileo measurements have been included; see Section 7.6 on how to generate these solutions).

In each of these directories you will find several files ending with _REF. They are generated by running the example BPEs on the system at Astronomical Institute of the University of Bern (AIUB). Even if the objectives of this tutorial and of the RNX2SNX example BPE are in both cases to process data from a regional network, the results will not be identical since there are some differences in the processing strategies and selected options.

2 Terminal Session: Monday

Today's terminal session is to:

- 1. become familiar with the UNIX environment, the menu of the Bernese GNSS Software, and the example campaign,
- 2. verify the campaign setup done for you (see sections 2.2 and 2.3, and also the handout for the terminal sessions),
- 3. generate the a priori coordinates for all 4 days using COOVEL (see Section 2.5), and
- 4. start to prepare pole and orbit information according to chapter 3.

2.1 Start the Menu

Start the menu program using the command G^1 .

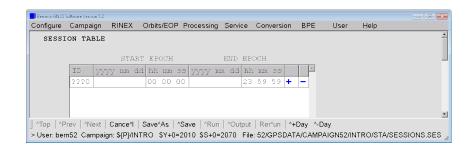
Navigate through the submenus to become familiar with the structure of the menu. Read the general help (available at "Menu> $\underline{H}elp>\underline{G}eneral$ ") to get an overview on the usage of the menu program of the *Bernese GNSS Software*.

For the terminal session in the *Bernese Introductory Course*, the campaign setup has already been done for each user. Please check that the campaign name in the statusbar of the Bernese Menu is set correctly to your campaign (i.e., Campaign $\{P\}/INTRO$) and that the current session is set to the first session (i.e., Y+0=2010, S+0=2070). If this is not the case, please contact the staff in the terminal room.

2.2 Select Current Session

Select "Menu><u>C</u>ampaign>Edit session <u>table</u>" to check the session table. It is recommended to use the wildcard string ???0 for the "List of sessions" in panel "SESSION TABLE". The panel below shows the session definition for a typical permanent campaign with 24-hours sessions. The setup of the session table is a very important task when you prepare a campaign. Please read the corresponding online help carefully.

 $^{^{1}}$ At the exercise terminals the Bernese environment is loaded automatically during login. At home you have to source the file ${X}/EXE/LOADGPS.setvar$ on UNIX-platforms either manually or during login.



Save the session table (press the <code>^Save</code> button) and open the "Date Selection Dialog" in the "Menu>Configure>Set session/compute date" in order to define the current session:

Date Selection Dialog	? 💌
Year Month Day (YYYY MM DD)	2010 7 26
Modified Julian Date	55403
GPS Week, Day of Week (WWWW D)	1594 1
Year, Day of Year (YYYY DDD)	2010 207
+1 -1 Toda	Compute
Session Char	0
Session Table	SESSIONS SES
Job ID	
Help Set Ca	oK OK

2.3 Campaign Setup

Usually, a new campaign must be added to the campaign list ("Menu>Campaign>Edit list of campaigns") first and select it as the active campaign ("Menu>Campaign>Select active campaign"), before the directory structure can be created ("Menu>Campaign>Create <u>n</u>ew campaign"). In the *Bernese Introductory Course* environment this should already have been done for your campaign, but please verify that.

In the *Bernese Introductory Course* environment the selected campaign should be P/INTRO. In order to become familiar with the campaign structure, you can inspect your campaign directory and inspect the contents using the command line (using *cd* for changing directories and *ls* to create directory listings) or using a filemanager (e.g., midnight commander *mc*).

2.4 Menu Variables

When processing GNSS data, it is often necessary to repeat a program run several times with only slightly different option settings. A typical example would be the processing of several sessions of data. The names of observation files change from session to session because the session number is typically a part of the filename. It would be very cumbersome to repeat all the runs selecting the correct files manually every time. For the BPE an automation is mandatory. For such cases the Bernese menu system provides a powerful tool: the so-called menu variables. The menu variables are defined in the user-specific menu input file \${U}/PAN/MENU_VAR.INP that is accessible through "Menu

>Configure>Menu variables". Three kinds of menu variables are available: predefined variables (also called menu time variables), user-defined variables, and system environment variables.

The use of system environment variables is necessary to generate the complete path to the files used in the *Bernese GNSS Software*. The campaign data are located in the directory P/INTRO=HOME/GPSDATA/CAMPAIGN52/INTRO. The user-dependent files can be found at U=HOME/GPSUSER52 — note that HOME may have been already translated into the name of your home-directory. The temporary user files are saved in T=/scratch/local/bern52 (change bern52 to your user name). Finally, the campaign-independent files reside in X=/home/bswadmin/BERN52/GPS.

Bernese GNSS Software									- • •
Configure Cam	paign <u>R</u> INEX	Orbits/EOP	processing	<u>S</u> ervice	Conversion	BPE	∐ser	Help	
MENU VAR	ABLES - ME	NU_VAR 1: \	ariables	5					÷
DEFERTN	D VARTABLE	-							
		-							
	lated in th								
	le Curr	ent value		riptio					
\$Y		10	Two	digit j	year of th	ne curr	ent se	ssion	
\$M		07	Mont	h of tl	ne current	: sessi	on		
\$D		26	Day	of mon	th of the	currer	nt sess	ion	
\$J			Job	ID					
USER-DEF:	NED VARIAB	LES				ENVIRO	MENT V	ARIABLE	is
(tran	slated in t	he menu)			(tra	anslate	ed in m	ain pro	gram)
Varia	ble (w/o \$) Value		~		Va	ariable		g 📕
				+ -		X		+ -	
						P		+ -	
						U		+ -	
						-			
						T		+ -	
						US	SER	+ -	
									<u> </u>
] ^Top ^Prev	^Next │ Cance^I	Save^As ^S	ave ^Run	^Output	Rer^un ^+	Day ^-Da	ау		
> User: bern52 (ampaign: \${P}/l	NTRO \$Y+0=2	010 \$S+0=2	2070 File	: /home/bern5	2/GPSUS	SER52/PA	N/MENU_\	/AR.INP

The predefined variables provide a set of time strings assigned to the current session. From the second panel of the menu variables you get an overview on the available variables and their usage:

Minus ranç	EDEFINED VARIA 19 -1 🗮	Plus range	1 -	
Without rang (n=0,1,9)		ith ranges	Format	Description
\$+n		\$+-	DDD	Day of Year (DOY)
\$S+n	\$S-n	\$S+-	DDDS	
\$Y+n	\$Y-n	\$Y+-	YYYY	Year
\$W+n	\$W-n	\$W+-	WWWWW	GPS Week
\$M+n	\$M-n	\$M+-	YYMM	Year, Month
\$JD+n	\$JD-n	\$JD+-	DDDDD	Modified Julian Date
\$WD+n	\$WD-n	\$WD+-	WWWWD	GPS Week and Day
\$YD+n	\$YD-n	\$YD+-	YYDDD	Year and DOY
\$YSS+n	\$YSS-n	\$YSS+-	YYDDDS	Year, DOY, Sess. Char.
SYMD STR+n	SYMD STR-n	SYMD STR+-	YYYY MM DD	Year, Month, Day

Be aware that the variable **\$S+1** refers to the next *session*. Because we are using a session table for daily processing it also corresponds to the next day.

These variables are automatically translated by the menu upon saving the panel or running the program. We recommend to make use of them in the input panels (e.g. for filename specification).

2.5 Generate A Priori Coordinates

As stated before the a priori coordinates generated from the PPP processing example BPE refer to the epoch January 01, 2010. The first step is to extrapolate the coordinates to the epoch that is currently processed. Starting with ITRF2014 also Post Seismic Deformation (PSD) corrections have to be applied when the epoch of the coordinate sets are changed. They are provided in the input field "PSD corrections (ITRF14)". Of course this feature is also included in the IGS14 frame – the IGS-specific realization of the ITRF2014. Note that for earlier reference frames (e.g., ITRF2008) this input field has to be empty.

This is the task of the program COOVEL. Open the program input panel in "Menu>Service >Coordinate tools>Extrapolate coordinates":

Bernese GNSS Software Version 5.2	
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help	
EXTRAPOLATE COORDINATES - COOVEL 1: Filenames	
GENERAL FILES	
Show all general files	
INPUT FILES	
Input coordinate file EXAMPLE CRD	
Input velocity file EXAMPLE VEL	
PSD correction (ITRF14) IGS14 PSD	
REFERENCE EPOCH yyyy mm dd hh mm ss SYMD_STR+0 00 00 00	
RESULT FILE	
Output coordinate file APR\$YD+0 CRD	
Stations without PSD corrections FIX	
GENERAL OUTPUT FILES	
Program output I use COOVEL.Lnn or COOVE	U OUT
Error messages	MSG
TITLE EXAMPLE: Session \$YSS+0: Coordinate propagation	
ATop ^Prev *Next Cance*I Save*As *Save *Run *Output Rer*un *+Day *-Day	
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/COOVEL.INP	1.

"Reference epoch: date"	\$YMD_STR+0	ightarrow 2010 07 26
"Output coordinate file"	APR\$YD+0	ightarrow APR10207
"Title line"	Session \$YSS+0:	ightarrow Session 102070:

Start the program with the <code>^Run</code>-button. The program generates an output file COOVEL. L?? in the directory P/INTRO/OUT. This file may be browsed using the <code>^Output</code>-button or with "Menu>Service>Browse program output". It should look like

```
Bernese GNSS Software, Version 5.2
    Program : COOVEL
Purpose : Extrapolate coordinates
       -----
Campaign : ${P}/INTRO
Default session: 2070 year 2010
          : 03-Sep-2019 14:42:30
 Date
 User name
                  : bern52
 _____
 EXAMPLE: Session 102070: Coordinate propagation
 INPUT AND OUTPUT FILENAMES
               Geodetic datum : ${X}/GEN/DATUM.

Input coordinate file : ${P}/INTRO/STA/EXAMPLE.CRD

Input velocity file : ${P}/INTRO/STA/EXAMPLE.VEL

Output coordinate file : ${P}/INTRO/STA/APR10207.CRD

PSD corrections (ITRF14) : ${P}/INTRO/STA/IGS14.PSD

Stations without PSD corrections
 Stations without PSD corrections:
Program output : ${P}/INTRO/OUT/COOVEL.LOO
Error message : ${U}/WORK/ERROR.MSG
Session table : ${D}/INTRO/OTT/COOVEL.CO
                                      : ${P}/INTRO/STA/SESSIONS.SES
 Session table

        REFERENCE EPOCH:
        2010-01-01 00:00:00

        INTERPOLATION FACTOR:
        -0.5639972621492129

>>> CPU/Real time for pgm "COOVEL": 0:00:00.073 / 0:00:00.072
>>> Program finished successfully
```

The header area of the program output is standardized for all programs of the *Bernese GNSS Software*, Version 5.2. Furthermore each program has a title line that should characterize the program run. It is printed to the program output and to most of the result files. Many program output files furthermore provide a list of input and output files that have been used or generated.

The last two lines of the above example appear also in each program output of the *Bernese* GNSS Software, Version 5.2. It reports the processing time and the status successful or with error.

The result of the COOVEL run is an a priori coordinate file (\${P}/INTRO/STA/APR10207. CRD) containing the positions of the sites to be processed for the epoch of the current session (the lines for the other stations are ignored in the processing):

EXAM	PLE: S	Session 1020	70: Coordinate p	ropagation		
LOCA	L GEOI	DETIC DATUM:	IGS14	EPOCH: 2010-	07-26 00:00:00	
NUM	STATI	ION NAME	X (M)	Y (M)	Z (M)	FLAG
75	GANP	11515M001	3929181.42149	1455236.82074	4793653.95013	I
92	HERT	13212M010	4033460.84965	23537.88977	4924318.31452	I
107	JOZ2	12204M002	3664880.48096	1409190.68062	5009618.53020	Р
122	LAMA	12209M001	3524522.83273	1329693.71243	5129846.40652	Р
136	MATE	12734M008	4641949.45305	1393045.52644	4133287.54704	I
176	ONSA	10402M004	3370658.46071	711877.21784	5349787.00718	I
192	PTBB	14234M001	3844059.87505	709661.40917	5023129.60833	Р
236	TLSE	10003M009	4627851.75737	119640.11911	4372993.61061	I
262	WSRT	13506M005	3828735.78447	443305.04516	5064884.77803	I
263	WTZR	14201M010	4075580.45375	931853.89112	4801568.17900	I
264	WTZZ	14201M014	4075579.33655	931853.20686	4801569.08922	Р
276	ZIM2	14001M008	4331299.79586	567537.42125	4633133.77671	I
278	ZIMM	14001M004	4331296.98727	567555.97754	4633133.99975	I

Have a look at the LOCAL GEODETIC DATUM: in the resulting coordinate file. It is set to IGS14 in this case. If you go back to your input file (e.g., pressing the Rer^un button) you may open the dialog to select the "Input coordinate file" by pressing on the button next to the input field. Select now the file EXAMPLE.CRD and press the button Browse in order to open a window where the selected file is displayed.

-	Software Version 5.2		Orbits/EOP	Processing	Service	Conversion	RPF	User	Help	0	
		1000-0000000000	TES - COO				DIL	0001			
	RAL FILES				_						
Sho	ow all ge	eneral 1	tiles		7						
INPU	F FILES										
Inj	put coord	dinate d	Eile		EX	AMPLE CRD					
In	put velo	city fil	Le		EX	AMPLE VEL					
PSI	D correct	tion (I	TRF14)		IG	S14 PSD					
CRDINP	RENCE EPO)CH				y mm dd	0.00	n mm s:			
				1 .		ID_STR+0	00	0 00 0	0		
Look in:	ATA/CAI	MPAIGN52	/INTRO/STA/	• E 6							
.											
EXAN	IPLE.CRD					\$YD+0 CRI					
						FIX					
File nam	e: EXAMPL	E.CRD			Open						
				100		L.Lnn		or	Ī	COOVEL	ou
File type	EXAMPL	E.CRD		Ľ.	Cancel	program c	utput	or	E	RROR	MS
				Brows	se		100				
11111	- TEXAP	PLE: Se	ssion șis:	5+U: COO	rainate	propagat.	ion			-	
						Rer^un A+					
User: bei	rn52 Campa	ign: \${P}/IN	ITRO \$Y+0=2	010 \$S+0=	2070 File	e: /home/bern5	2/GPSUS	ER52/PA	N/COOVE	L.INP	

Here you can see the LOCAL GEODETIC DATUM: is set to IGS14_0. This difference is the indicator whether the PSD corrections have been applied or not. Coordinate files that indicate that the PSD corrections have not been applied cannot be used for processing GNSS data. At the same time it is protecting you to apply the corrections twice. For that reason the execution of the program COOVEL for applying the PSD corrections is also essential even if none of the stations in your processing (as in our example) is effected by these corrections.

You can repeat all steps for the other three sessions in the example campaign by changing the current session using the *`+Day* or *`-Day* to change a limited number of days (not sessions) or via "Menu>Configure>Set session/compute date". You can then use the Rer[^]un button to restart the program. No options need to be changed because of the consequent use of the menu time variables was made. Even if you are going to process only the first day (207, year 2010) of the example dataset during the terminal sessions, you will need prepared coordinate files for all four days later on Thursday. That's why, this step should be executed for all four days: 207 and 208 of year 2010 as well as 205 and 206 of year 2011.

2.6 Session Goals

At the end of this session, you should have created the following files:

1. a priori coordinates in your campaign's STA directory: for four sessions APR10207. CRD, APR10208. CRD, APR11205. CRD, and APR11206. CRD Until the end of today's terminal session you should start with preparing the pole and orbit information, see Chapter 3.

3 Terminal Session: Pole and Orbit Preparation (Monday/Tuesday)

The terminal session on pole and orbit preparation is to:

- 1. generate the pole information file in the Bernese format (POLUPD)
- 2. generate tabular orbit files from CODE precise files (PRETAB)
- 3. generate the Bernese standard orbit files (ORBGEN)

You should start with these tasks during Monday's terminal sessions and finish the processing during the terminal session on Tuesday.

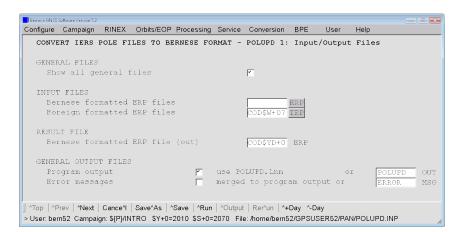
Introductory Remark

We recommend to use the final or reprocessed products from CODE because they contain consistent orbits for GPS and GLONASS. They also include all active GNSS satellites (even if they are unhealthy or during GPS satellite repositioning events) with the highest possible accuracy thanks to three–day long–arc technology. Due to this choice you will get the best possible consistency between the external products and the software.

You may alternatively use the products from IGS. Separate product files for GPS and GLONASS orbits exist from independent combination procedures that first need to be merged for a multi–GNSS processing. For most of the applications, merging the precise orbit files is sufficient — a tutorial on the procedure is given in Section 7.2 of this book. On the other hand, the consistency of the orbits can not be as good as that of CODE (or other analysis center) following the strategy of the rigorous combined processing of GPS and GLONASS measurements for orbit determination.

3.1 Prepare Pole Information

Together with the precise orbit files (PRE), a consistent set of Earth orientation parameters (EOP) is provided in the ORB directory. Whereas the orbits are given in daily files the EOP are available in weekly files for the final product series from the CODE analysis center. We have to convert the information from the International Earth Rotation and Reference Systems Service (IERS)/IGS standard format (file extension within the *Bernese GNSS Software* is IEP) into the internal Bernese EOP format (file extension within the *Bernese GNSS Software* is ERP). This is the task of the program POLUPD ("Menu>Orbits/EOP>Handle EOP files>Convert IERS to Bernese Format") which is also able to update the EOP records of an existing file.





Bernese GNSS	Software Version 5.	2								- • ×
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
POLUE	D 2: Opt	cions								
HEADE	R INFORM	ATION								
Tit	le [EXAMPLE:	Session	\$YSS+0:	Import	IERS Pole	info	into E	Bernese	
Nut	ation m	odel		IAU:	2000R06	NUT				
ទារ	daily p	ole mode	1	IER	32010XY	SUB				
BULLE	TIN B AS	5 INPUT								
Use	elor5	day val	ues	1	•					
OPTIC	NS									
Use	e ERP ra	tes		Y						
A1:	low doub.	le epoch	3	Г						
Ind	lude nu	tation o	ffsets							
Use	e time w	indow		Y						
] ^Top ^F	rev ^Next	Cance [^] l	Save^As ^	Save ^Run	^Output	Rer^un ^+	Day ^-D	Day		
> User: ber	n52 Campa	iign: \${P}/IN	TRO \$Y+0=	2010 \$S+0=	2070 File	: /home/bern5	2/GPSU	SER52/P/	AN/POLUPI	D.INP

E Bernese GNSS :	Software Version 5.2									
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
POLUP	D 3: Tim	e Windo	w							
TIME	WINDOW									
0	. Defin	ied by	Year and	Session :	identif	ier				
	Year	\$ Y	+0 S	ession	\$S+0					
0	Defir	ned by	Start and	End time	es					
		YY.	yy mm dd	hh m	m ss		уууу	mm dd	hh mm ss	
	Start	: \$YI	MD_STR+0	00 0	0 00	End	\$YMD_	STR+0	23 59 59	
] ^Top ^P	rev ^Next	Cance [^] l	Save^As ^	Save ^Run	^Output	Rer^un *+	Day ^-Da	ау		
> User: ber	n52 Campai	gn: \${P}/IN	NTRO \$Y+0=	2010 \$S+0=	2070 File	e: /home/bern5	2/GPSUS	SER52/PA	N/POLUPD.INP	1.

The last panel for the program POLUPD is an example for the specification of time windows in the *Bernese GNSS Software*, Version 5.2. Time windows can be defined by sessions (a single session or a range of sessions). Alternatively, a time window may be specified by a start and an end epoch. By entering either a start or an end epoch you may define only the beginning or the end of the time interval. We refer to the online help for more details.

The messages

```
### PG POLUPD: NUTATION MODEL NAME NOT EQUAL DEFAULT
DEFAULT NUTATION MODEL NAME : IAU2000R06
NUTATION MODEL NAME IN FILE : IAU2000
#### PG POLUPD: SUBDAILY POLE MODEL NAME NOT EQUAL DEFAULT
DEFAULT SUBDAILY POLE MODEL NAME : IERS2010
SUBDAILY POLE MODEL NAME IN FILE : IERS2000
```

just inform that you have selected the most recent nutation and subdaily pole model whereas the operational solution at CODE was computed using an older model at that time.

If you do not want to accept this inconsistency you may alternatively use the results from a reprocessing effort (e.g., http://www.aiub.unibe.ch/download/REPRO_2015/CODE/).

3.2 Generate Orbit Files

In this processing example we use only two programs of the orbit part of the *Bernese* GNSS Software. The first program is called PRETAB and may be accessed using "Menu \geq Orbits/EOP>Create tabular orbits". The main task of PRETAB is to create tabular orbit files (TAB; i.e., to transform the precise orbits from the terrestrial into the celestial reference frame) and to generate a satellite clock file (CLK). The clock file will be needed, e.g., in program CODSPP (see Section 4.2.1, to be discussed in the Tuesday's lectures on preprocessing).

Bernese GNSS Software Version 5.2						
Configure Campaign RINEX Orbits/EOP	Processing Service	Conversion	BPE	User	Help	
CREATE TABULAR ORBITS - PRETA	B 1: Filenames					
GENERAL FILES Show all general files	M					
INPUT FILES						
Precise ephemeris	COD\$WD+0 PRE					
Pole file	COD\$YD+0 ERP	15	22.62.5			
Ocean loading corr Atmospheric loading corr	EXAMPLE BLQ EXAMPLE ATL		CMC) CMC)			
RESULT FILES						
Tabular file(s)	COD\$YD+0 TAB	(blank:	same r	name as	input file	(s))
Satellite clock file	COD\$YD+0 CLK					
GENERAL OUTPUT FILES						
Program output	🚩 use PRETA	B.Lnn		or	PRETA	B OUT
Error messages	merged to	program (output	or	ERROR	MSG
] ^Top ^Prev *Next Cance^I Save^As *	Save ^Run ^Output	Rer^un 1+	Day ^-D	ay		
> User: bern52 Campaign: \${P}/INTRO \$Y+0=	2010 \$S+0=2070 File	e: /home/bern5	2/GPSUS	SER52/PA	N/PRETAB.INP	

You have to apply the same subdaily pole and nutation models as you have used before when you have generated the Bernese formatted pole file (COD\$YD+0.ERP).

Bernese GNSS Software Version 5.2		- 0 💌
Configure Campaign RINEX Orbits/EOP	Processing Service Conversion BPE User Help	
PRETAB 1.1: General Files		
GENERAL INPUT FILES General constants	CONST.	
Subdaily pole model	IERS2010XY SUB	
Nutation model	IAU2000R06 NUT	
Satellite problems	SAT_\$Y+0 CRX	
MENU SETTINGS		
Selected campaign	\${P}/INTRO	
Selected session	year 2010 session 2070	
Session table	\${P}/INTRO/STA/SESSIONS.SES	
I ATop APrev ANext CanceAL SaveAs A	Save ARun Output Rer^un A+Day -Day	
	2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/PRETAB.INF	, ,
1.5 .(.)		16
Bernese GNSS Software Version 5.2		
-	Processing Service Conversion BPE User Help	_ • •
-	Processing Service Conversion BPE User Help	
Configure Campaign RINEX Orbits/EOP PRETAB 2: General Options		
Configure Campaign RINEX Orbits/EOP PRETAB 2: General Options	Processing Service Conversion BPE User Help 53+0: Tabular Orbit/Clock Information	
Configure Campaign RINEX Orbits/EOP PRETAB 2: General Options TITLE EXAMPLE: Session SYS		
Configure Campaign RINEX Orbits/EOP PRETAB 2: General Options TITLE EXAMPLE: Session SYS GENERAL OFTIONS	38+0: Tabular Orbit/Clock Information	
Configure Campaign RINEX Orbits/EOP PRETAB 2: General Options TITLE EXAMPLE: Session \$YS GENERAL OFTIONS Reference system	3+0: Tabular Orbit/Clock Information	
Configure Campaign RINEX Orbits/EOP PRETAB 2: General Options TITLE EXAMPLE: Session SYS GENERAL OFTIONS	3+0: Tabular Orbit/Clock Information J2000 • OTL: 🗹	
Configure Campaign RINEX Orbits/EOP PRETAB 2: General Options TITLE EXAMPLE: Session \$YS GENERAL OFTIONS Reference system	3+0: Tabular Orbit/Clock Information	
Configure Campaign RINEX Orbits/EOP PRETAB 2: General Options TITLE EXAMPLE: Session \$YS GENERAL OFTIONS Reference system	3+0: Tabular Orbit/Clock Information J2000 • OTL: 🗹	
Configure Campaign RINEX Orbits/EOP PRETAB 2: General Options TITLE EXAMPLE: Session SYS GENERAL OFTIONS Reference system Apply CMC correction	53+0: Tabular Orbit/Clock Information J2000 Y OTL: P ATL: P	
Configure Campaign RINEX Orbits/EOP PRETAB 2: General Options TITLE EXAMPLE: Session SYS GENERAL OFTIONS Reference system Apply CMC correction SATELLITE OPTIONS	3+0: Tabular Orbit/Clock Information J2000 V OTL: P ATL: P	
Configure Campaign RINEX Orbits/EOP PRETAB 2: General Options TITLE EXAMPLE: Session SYS GENERAL OFTIONS Reference system Apply CMC correction SATELLITE OPTIONS Remove bad satellites Use accuracy codes from SPE Exclude sat. with accuracy	3240: Tabular Orbit/Clock Information J2000 S OTL: P ATL: P 3-file P code 0 P	
Configure Campaign RINEX Orbits/EOP PRETAB 2: General Options TITLE EXAMPLE: Session \$YS GENERAL OFTIONS Reference system Apply CMC correction SATELLITE OPTIONS Remove had satellites Use accuracy codes from SPS	3240: Tabular Orbit/Clock Information J2000 S OTL: P ATL: P 3-file P code 0 P	
Configure Campaign RINEX Orbits/EOP PRETAB 2: General Options TITLE EXAMPLE: Session SYS GENERAL OFTIONS Reference system Apply CMC correction SATELLITE OPTIONS Remove bad satellites Use accuracy codes from SPE Exclude sat. with accuracy	3240: Tabular Orbit/Clock Information J2000 S OTL: P ATL: P 3-file P code 0 P	
Configure Campaign RINEX Orbits/EOP PRETAB 2: General Options TITLE EXAMPLE: Session SYS GENERAL OFTIONS Reference system Apply CMC correction SATELLITE OPTIONS Remove bad satellites Use accuracy codes from SPE Exclude sat. with accuracy Exclude sat. with acc. code	3240: Tabular Orbit/Clock Information J2000 S OTL: P ATL: P 3-file P code 0 P	

If you process precise orbits from CODE it is generally not necessary to remove bad satellites. It might become necessary for orbit products from other sources (e.g., from the IGS). Because CODE introduces the correct accuracy code for all its satellites the above settings do not harm the import of satellite orbits from CODE.

Bernese GNSS	Software Version 5.2									- • •
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
OPTIC	B 3: Opt:	LOCKS					1			
	erval fo. ynomial (omials			12	hours			
						Rer^un ^+				
> User: ber	n52 Campaig	gn: \${P}/IN	TRO SY+0=:	2010 \$S+0=	2070 File	: /home/bern5	2/GPSUS	ER52/PAI	N/PRETAB.INP	li.

Panel "PRETAB 3: Options for Clocks" contains the options for extracting the satellite clock information. The clock values in the precise orbit file are sampled to 15 min. We interpolate with a "Polynomial degree" of 2 with an "Interval for polynomials" of 12 hours. This is good enough for the receiver clock synchronization in CODSPP.

A message like this is expected:

```
### PG PRETAB: SATELLITE CLOCK VALUES MISSING
SATELLITE : 101
FILE NUMBER: 1
FILE NAME : ${P}/INTRO/ORB/COD15941.PRE
```

```
### PG PRETAB: SATELLITE CLOCK VALUES MISSING
    SATELLITE : 102
    FILE NUMBER: 1
    FILE NAME : ${P}/INTRO/ORB/COD15941.PRE
...
```

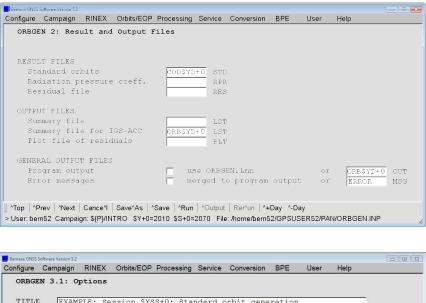
It indicates that the precise orbit files do not contain clock corrections for GLONASS satellites (GLONASS satellite are indicated with satellite number between 100 and 199 within the *Bernese GNSS Software*). Consequently the synchronization of the receiver clocks in CODSPP will only be done based on the GPS satellite clocks.

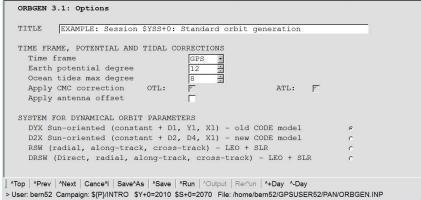
The second program of the orbit part used here is called ORBGEN ("Menu><u>Orbits/EOP</u>>Create/update <u>standard orbits</u>"). It prepares the so-called standard orbits using the satellite positions in the tabular orbit files as pseudo-observations for a least-squares adjustment.

Bernese GNSS Software Version 5.2	
Configure Campaign RINEX Orbits/EOP Processing Si	ervice Conversion BPE User Help
CREATE/UPDATE STANDARD ORBITS - ORBGEN	1: Input Files
GENERAL FILES Show all general files	۲.
INPUT FILES	
 Start with tabular orbits 	COD\$YD+0 TAB
 Start with precise orbits 	PRE
 Update standard orbit 	
Orbital elements, file 1	ELE
Orbital elements, file 2 Pole file	COD\$YD+0 ERP
Ocean loading corrections	EXAMPLE BLO (for CMC)
Atmospheric loading corrections	EXAMPLE ATL (for CMC)
interpreter reading corrections	
] ^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^	Output Rer^un ^+Day ^-Day
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=207	70 File: /home/bern52/GPSUSER52/PAN/ORBGEN.INP

Make sure that the ERP file, the nutation, and the subdaily pole model are the same you have used in PRETAB. It is mandatory to consistently use this triplet of files together with the generated standard orbits for all processing programs (otherwise a warning message is issued).

onfigure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
ORBGE	EN 1.1: G	eneral	Files							
	RAL INPUT	1								
	neral con			CONST.						
	cellite p			SAT_\$1	2.2.2.8	CRX				
	cellite i				IT.I14					
	anetary e	-		DE405		EPH				
	daily po		el	IERS20		SUB				
	cation mo			IAU200		NUT				
	eff. of E	-			SMALL.					
1000	lid Earth		file	TIDE20		TPO				
	ean tides			OT_FES		TID				
GPS	S-UTC sec	onds		GPSUTO	2.					
MENU	SETTINGS									
Se	lected ca	mpaign		\${P}/I	NTRO					
Se	lected se	ession		year	2010	sessio	n 207	0		
Sea	ssion tab	le		\${P}/I	NTRO/S	TA/SESSIO	NS.SES			
TEMPO	RARY FIL	ES								
Sci	ratch fil	es		ORBGEN	I\$J	SCR		ORB	GEN\$J	SC2
Sci	ratch fil	es		ORBGEN	1\$J	SCR		ORB	GEN\$J	SC2
^Top ^F	rev ^Next	Cance ⁴	Save^As ^	Save ^Run	^Output	Rer^un 14	Day ^-Da	ay		





With the beginning of GPS week 1826 (January 4, 2015), the CODE analysis center introduced a new Empirical CODE Orbit Model (new ECOM). Therefore, when using orbits from CODE after January 4, 2015 (or from the CODE's most recent reprocessing effort) you have to choose the new model when importing the orbit files in ORBGEN. This is done by changing the option SYSTEM FOR DYNAMICAL ORBIT PARAMETERS from "System DYX" to "System D2X" in panel 3.1.

	Software Version 5.2									- • •
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
ORBGI	IN 3.2: 0	ptions								
PRIN	RESIDUA	LS		NO	•					
	NICAL INT. Noer of i			4						
Po.	PION OF M Lynomial ngth of i	degree		10 = 01 00 0	0	(hh mm ss)				
Po. Lei Ade	ATIONAL E lynomial ngth of i litional e extende	degree nterval sets		12 📰 06 00 0 0 📑	0	(hh mm ss)				
						: Rer^un ^+ e: /home/bern5			N/ORBGEN	I.INP

ernese GNSS Software Version 5.2							
n <u>f</u> igure <u>C</u> ampaign <u>R</u> INEX	Orbits/EOP Processing	<u>Service</u> Con <u>v</u> e	rsion <u>B</u>	PE L	Jser	Help	
ORBGEN 4: Parameter	Selection						
DYNAMICAL ORBIT PARA	METERS						
Apart from six osc	ulating elements	, estimate th	ne foll	owing	param	eters:	
D0 (direct)	P	Periodic D1					2
		Periodic D2					2
VO (m bieg)	F	Periodic D4					7
YO (y-bias) XO	<u>त्</u>	Periodic Y1 Periodic X1					ব
AU	r.	Ferrourc XI	CEIMS	(005,	5111)		I. I
R (radial)	Г	Periodic R1	terms	(cos,	sin)		Г
S (along-track)	Ē	Periodic S1					Ē
W (out-of-plane)	Г	Periodic W1	terms	(cos,	sin)		Г
STOCHASTIC PULSES IN		TIONS		-			
Satellite selectio				Z	4LL	*	
	5						
List of satellites				1			
Parameter spacing Fop ^Prev ^Next Cance^I				/ ^-Day	.2 00 R52/PAN		h mm ss) I.INP
Parameter spacing Top ^Prev ^Next Cance'l ser: bern52 Campaign: \${P}/IN med 60555dtware Venon52	TRO \$Y+0=2010 \$S+0	=2070 File: /home	/bern52/G	/ ^-Day PSUSER	852/PAN	V/ORBGEN	
Parameter spacing Fop ^Prev ^Next Cance'l Iser: bern52 Campaign: \${P}/IN mere GNSSaffware Venan 52 nfigure Campaign RINEX	TRO \$Y+0=2010 \$S+0 Orbits/EOP Processing	=2070 File: /home	/bern52/G	/ ^-Day PSUSER			I.INP
Parameter spacing Top ^Prev ^Next Cance'l ser: bern52 Campaign: \${P}/IN med 60555dtware Venon52	TRO \$Y+0=2010 \$S+0 Orbits/EOP Processing	=2070 File: /home	/bern52/G	/ ^-Day PSUSER	852/PAN	V/ORBGEN	I.INP
Parameter spacing Top ^Prev ^Next Cance'l Iser: bern52 Campaign: \${P}/IN more OD25 Software Yanon 52 nfigure Campaign RINEX ORBGEN 5: Orbital Ar	TRO \$Y+0=2010 \$S+0 Orbits/EOP Processing C Definition	=2070 File: /home	/bern52/G	/ ^-Day PSUSER	852/PAN	V/ORBGEN	I.INP
Parameter spacing Top ^Prev ^Next Cance'l ser: bern52 Campaign: \$(P)/IN max GHS52dWare Venen52 ffgure Campaign RINEX ORBGEN 5: Orbital Ar ORBITAL ARC DEFINITI	TRO \$Y+0=2010 \$S+0 Orbits/EOP Processing to Definition	=2070 File: /home	rsion Bl	/ ^-Day PSUSER	852/PAN	V/ORBGEN	I.INP
Parameter spacing Top ^Prev ^Next Cance'l Iser: bern52 Campaign: \${P}/IN mose GNS5 Software Varian 52 nfigure Campaign RINEX ORBGEN 5: Orbital Ar	TRO \$Y+0=2010 \$S+0 Orbits/EOP Processing to Definition	=2070 File: /home	/bern52/G	/ ^-Day PSUSER	852/PAN	V/ORBGEN	I.INP
Parameter spacing Top ^Prev ^Next Cance'l ser: bern52 Campaign: \$(P)/IN max GHS52dWare Venen52 ffgure Campaign RINEX ORBGEN 5: Orbital Ar ORBITAL ARC DEFINITI	TRO \$Y+0=2010 \$S+0 Orbits/EOP Processing to Definition ON whin the time win	=2070 File: /home	rsion Bl	/ ^-Day PSUSER	852/PAN	V/ORBGEN	I.INP
Parameter spacing Top 'Prev 'Next Cance' Iser: bern52 Campaign: \$(P)/IN more 6035 Software Vencen52 nfigure Campaign RINEX ORBGEN 5: Orbital Ar ORBITAL ARC DEFINITI Number of arcs wit Time window to be	TRO \$Y+0=2010 \$S+0 Orbits/EOP Processing to Definition ON whin the time win	=2070 File:/home 3 Service Conve dow tandard orbit	rsion Bl	/ ^-Day PSUSER	852/PAN	V/ORBGEN	I.INP
Parameter spacing Top 'Prev 'Next Cance' Jser: bern52 Campaign: \$(P)/IN mmue602520MwaeYmcm52 nfigure Campaign RINEX ORBGEN 5: Orbital Ar ORBITAL ARC DEFINITI Number of arcs wit Time window to be	TRO \$Y+0=2010 \$S+0 Orbits/EOP Processing C Definition ON thin the time win covered by the s Year and Session	=2070 File:/home g Service Conve dow tandard orbit identifier	rsion Bl	/ ^-Day PSUSER	852/PAN	V/ORBGEN	I.INP
Parameter spacing Top 'Prev 'Next Cance' Jser: bern52 Campaign: \$(P)(N mode BUSIoNexe Voicen52 nfigure Campaign RINEX ORBETAL ARC DEFINITI Number of arcs wit Time window to be c Defined by Year SYY(C	TRO \$Y+0=2010 \$S+0 Orbits/EOP Processing C Definition ON thin the time win covered by the s Year and Session Session	=2070 File:/home 3 Service Conve dow tandard orbit identifier 58+0	rsion Bl	/ ^-Day PSUSER	852/PAN	V/ORBGEN	I.INP
Parameter spacing Top 'Prev 'Next Cance' Jser: bern52 Campaign: \$(P)(IN enext 0005500wer Venon52 onfigure Campaign RINEX ORBGEN 5: Orbital Ar ORBETAL ARC DEFINITI Number of arcs wit Time window to be c Defined by Year SY+C c Defined by	TRO \$Y+0=2010 \$S+0 Orbits/EOP Processing TO Definition ON thin the time win covered by the s Year and Session Start and End tim	=2070 File:/home g Service Conve dow tandard orbit identifier [SS+0]	rsion Bl	/ ^-Day BPSUSER	Jser	VORBGEN Help	LINP
Parameter spacing Top 'Prev 'Next Cance' Iser: bern52 Campaign: \$(P)(N mmue 0NS5atter Vmen52 nfigure Campaign RINEX ORBGEN 5: Orbital Ar ORBITAL ARC DEFINITI Number of arcs wit Time window to be c Defined by Year SY+C C Defined by Year	TRO \$Y+0=2010 \$S+0 Orbits/EOP Processing to Definition ON thin the time win covered by the s Year and Session Start and End tim ry mm dd hh	=2070 File:/home g Service Conve dow tandard orbit identifier [53+0] wes mm ss	v/bern52/G	PE L	Jser dd	NORBGEN Help	LINP
Parameter spacing Top Prev *Next Cance'l Iser: bern52 Campaign: \$(P)(N more GMS5afbare Vman52 Affgure Campaign RINEX ORBGEN 5: Orbital Ar ORBITAL ARC DEFINITI Number of arcs wit Time window to be c Defined by Year SY+C C Defined by Yaar	TRO \$Y+0=2010 \$S+0 Orbits/EOP Processing to Definition ON thin the time win covered by the s Year and Session Start and End tim ry mm dd hh	=2070 File:/home g Service Conve dow tandard orbit identifier [SS+0]	v/bern52/G	/ ^-Day BPSUSER	Jser dd	NORBGEN Help	LINP
Parameter spacing Fop Prev *Next Cance'l Iser: bern52 Campaign: \$(P)(N more GNSSoftware Vensen52 nfigure Campaign RINEX ORBGEN 5: Orbital Ar ORBITAL ARC DEFINITI Number of arcs wit Time window to be c Defined by Year 5Y+C C Defined by Start 5Y1	TRO \$Y+0=2010 \$S+0 Orbits/EOP Processing to Definition ON thin the time win covered by the s Year and Session Start and End tim ry mm dd hh dD_STR+0 00	2070 File:/home	nd S	Y *-Day PEUSER PE U	Jser dd	NORBGEN Help	LINP
Parameter spacing op ^Prev ^Next Cance'l ser: bem52 Campaign: \$(P)/IN max 005540bere Veners 52 ffgure Campaign RINEX ORBGEN 5: Orbital Ar ORBITAL ARC DEFINITI Number of arcs wit Time window to be c Defined by Year 5Y+0 c Defined by Yaar 5Y+0	TRO \$Y+0=2010 \$S+0 Orbits/EOP Processing to Definition ON thin the time win covered by the s Year and Session Start and End tim ry mm dd hh dD_STR+0 00	2070 File:/home	nd S	Y *-Day PEUSER PE U	Jser dd	NORBGEN Help	LINP

The program produces an output file $\tt ORB10207.OUT$ (or corresponding to the other sessions) which should look like

		\${X}/GEN/CONST.
		\${X}/GEN/GPSUTC.
Planetary ephemeris file		
Coeff. of Earth potential		
Solid Earth tides file	:	\${X}/GEN/TIDE2000.TPD
Ocean tides file		\${X}/GEN/OT_FES2004.TID
Satellite problems		\${X}/GEN/SAT_2010.CRX
Satellite information	:	\${X}/GEN/SATELLIT.I14
Nutation model	:	\${X}/GEN/IAU2000R06.NUT
Subdaily pole model	:	\${X}/GEN/IERS2010XY.SUB
Pole file	:	\${P}/INTRO/ORB/COD10207.ERP
Ocean loading corrections	:	<pre>\${P}/INTRO/STA/EXAMPLE.BLQ</pre>
Atmospheric loading corrections	:	<pre>\${P}/INTRO/STA/EXAMPLE.ATL</pre>
Orbital elements, file 1	:	
Orbital elements, file 2	:	
Standard orbits	:	\${P}/INTRO/ORB/COD10207.STD
Radiation pressure coeff.	:	
Summary file	:	
Summary file for IGS-ACC	:	<pre>\${P}/INTRO/OUT/ORB10207.LST</pre>
Residual plot file	:	
Residual file	:	
Program output	:	\${P}/INTRO/OUT/ORB10207.OUT
Error message	:	\${U}/WORK/ERROR.MSG
Scratch file	:	\${U}/WORK/ORBGEN.SCR
Scratch file	:	\${U}/WORK/ORBGEN.SC2
Session table	:	<pre>\${P}/INTRO/STA/SESSIONS.SES</pre>

RMS H	ERRORS	AND MAX. RE	SIDUALS	ARC NUMB	ER: 1			ITERATI	ON:
			•				MAX. R		
5AT 	#POS	RMS (M)	TOTAL	RADIAL			RADIAL	ALONG	
1	96	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.00
2	96	0.001	0.001	0.001		0.001	0.002	0.002	0.00
3	96	0.001	0.001	0.001	0.001	0.001	0.003	0.003	0.00
4	96	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.00
5	96	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.00
6	96	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.00
7	96	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.00
8	96	0.001	0.001	0.001	0.001	0.001	0.003	0.003	0.00
9	96	0.001	0.001	0.001	0.001	0.001	0.002	0.004	0.00
10	96	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.00
11	96	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.00
12	96	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.00
13	96	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.00
28	96	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.00
29	96	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.00
30	96	0.001	0.001	0.001	0.001	0.001	0.003	0.003	0.00
31	96	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.00
32	96	0.001	0.001	0.001	0.001	0.001	0.003	0.003	0.00
L01	96	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.00
102	96	0.001	0.001	0.001	0.001	0.001	0.003	0.003	0.00
103	96	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.00
104	96	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.00
L05	96	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.00
107	96	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.00
121	96	0.001	0.001	0.001		0.001	0.002	0.003	0.00
122	96	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.00
123	96	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.00
24	96	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.00

The most important information in the output file are the RMS errors for each satellite. These should be 1 mm (for older orbits it may also achieve 3...5 mm) if precise orbits from CODE were used together with the consistent EOP information (the actual RMS errors depend on the quality of the precise orbits, on the pole file used for the transformation between IERS Terrestrial Reference Frame (ITRF) and International Celestial Reference Frame (ICRF) in PRETAB, and on the orbit model used in ORBGEN).

Comparing the RMS error from the third and the fourth iteration you will see that three iterations should already be enough to produce precise standard orbits for GNSS satellites.

The file \${P}/INTRO/OUT/ORB10207.LST summarizes the orbit fit RMS values in one table:

EXAMPLE: Session 102070: Standa	0	12-JAN-18 12:59	
TIME FROM DAY : 1 GPS WEEK: 159 TO DAY : 2 GPS WEEK: 159			
ORBIT REPEATABILITY FROM A 1-DA	AY FIT THROUGH DAILY ORBIT	SOLUTIONS (MM)	
# ECLIPSING SATELLITES: 5 E ,			
	E. E. E		
DOY 1 2 3 4 5 6	12 13 14 15 16	32 101 102 103 104 105 107	· ·
207 1 1 1 1 1 1		1 1 1 1 1 1 1	
	···· 1 1 1 1 1	1 1 1 1 1 1 1	
	••••	•••• ••••••••••••••••••••••••••••••••••	

The output shows that 5 satellites are in eclipse (indicated above the satellite number by E for Earth or M for Moon).

A similar file may be generated using the orbit products from IGS (including the EOP information) following the procedure described in Section 7.2. As you can notice the RMS errors are slightly higher. It does not mean that the orbits from CODE are better than the IGS orbits. The orbit model in ORBGEN is only more consistent with the orbit model used at CODE:

	FROM	1 DA	Y : 1	GPS	S WEE	EK:	1594	orbit	gen	erat	ion			12	2 - JAN - 18	31	3:32	2		
	10 	DA 	Y : 2	GP:	5 WEB	SK:	1594													
											ILY	ORBIT	SOLUT	IONS	(MM)					
# ECI	LIPSI	NG	SATEL	LITI	ES:	5	E /	0 М (0	EM)										
ECL									Ε.	Ε.	Ε.									
DOY	1	2	3	4	5	6		12	13	14	15	16	• • •	32						
207	2	2	4	1	2	3		3	3	3	2	3		2						
ALL	2	2	4	1	2	3		3	3	3	2	3		2						

(Note the missing GLONASS satellites in the IGS orbit product.)

In the example for day 208 of year 2010 a satellite 75 appears. The GPS–satellite 25 had a repositioning event at 2010-07-27 16:08:03 (see $\{X\}/GEN/SAT_2010.CRX$). The satellite is introduced in the processing with two independent arcs: one before (number 25) and one after (number 75) the event (you may verify this by the number of epochs available for each of these two satellite arcs).

3.3 Session Goals

At the end of this session, you should have created the following files:

- 1. Bernese pole file in the campaign's ORB directory: COD10207. ERP,
- 2. Bernese standard orbit file in the ORB directory: COD10207. STD,
- 3. Bernese satellite clock file in the ORB directory: COD10207. CLK.

4 Terminal Session: Tuesday

Today's terminal session is to:

- 1. import the observations from the RINEX format into the Bernese format using RXOBV3 (section 4.1).
- 2. preprocess the Bernese observation files:
 - receiver clock synchronization (CODSPP, section 4.2.1)
 - baseline generation (SNGDIF, section 4.2.2)
 - preprocess baselines (MAUPRP, section 4.2.3)

4.1 Importing the Observations

The campaign has been set up and all necessary files are available. The first part of processing consists of the transfer of the observations from RINEX to Bernese (binary) format. To get an overview of the data availability you may generate a pseudographic from the RINEX observation files using the program RNXGRA in "Menu>RINEX>RINEX <u>u</u>tilities>Create observation <u>statistics</u>" — this step is not mandatory but it may be useful to get an impression of the tracking performance of the stations before you start the analysis.

Importing the RINEX observation files is the task of the program RXOBV3 in "Menu>RINEX >Import RINEX to Bernese format>Observation files" (we do not use the RINEX navigation files for this processing example).

Bernese GNSS Software Version 5.2 Configure Campaign RINEX Orbits/EOI		ing Canies	Conversion	BDE	User	Help	- • •
TRANSFER RINEX OBSERVATION F		<u> </u>					
GENERAL FILES							
Show all general files			F				
INPUT FILES							
 original RINEX obse 	rvation	files	2222\$8	+0 100			
c smoothed RINEX obse	rvation	files	2222\$8				
Station information file			EXAMPL	E STA			
RESULT FILES							
Measurement types to save							
c Code 🏲 Phase	Y			C 1	Range		
Update coordinates		CRD	П (њ1	ank if n	ot use	d)	
-1	1	0.111]				
GENERAL OUTPUT FILES							
Program output		use RXOF	3V3.Lnn		or	RXO\$YD+	TUO
Error messages		merged t	to program	output	or	ERROR	MSG
^Top ^Prev ^Next Cance^I Save^As	^Save ^	Run ^Outpu	t Rer^un ^	+Day ^-Day			
> User: bern52 Campaign: \${P}/INTRO \$Y+0	=2010 \$S	+0=2070 Fil	le: /home/bern	52/GPSUSE	R52/PAN	RXOBV3.INP	

All RINEX observation files fitting the pattern P/INTRO/RAW/????2070.100 are selected automatically by the current entry in the input field "original RINEX observation files". You can verify this by pressing the button just right from this input field (labeled with the

file extension 100). In the file selection dialog you will find the list of currently selected files. The RINEX files of the year 2011 are shown if a current session from the year 2011 is selected. In that case the label of the button changes to 110.

The next panel specifies the general input files. For the tutorial session during the course the phase center offset file has to be changed to a user-specific file (replace the "xx" chars with your user number, e.g.: PCV_Bxx.I14 to PCVB01.I14). Be aware that the file PCV_Bxx.I14 is not part of the distribution. If you are running the tutorial campaign on your own machine you have to use either the PCV.I14 or create a copy of the original file.

Bernese GNSS Software Version 5.2			
Configure Campaign RINEX Orbits/EOP	Processing Service Conversion	BPE User	Help
RXOBV3 1.1: General Files			
GENERAL INPUT FILES			
General constants	CONST.		
Satellite information	SATELLIT.I14		
Satellite problems	SAT_\$Y+0 CRX		
Phase center offsets	PCV_Bxx.I14		
GPS-UTC seconds	GPSUTC.		
Abbreviation table	EXAMPLE ABB		
Frequency information	ERQ		
MENU SETTINGS			
Selected campaign	\${P}/INTRO		
Selected session	1 0010	2070	
Session table	\${P}/INTRO/STA/SESSION	S.SES	
TEMPORARY FILES			
Scratch files	RXOBV3\$J SCR RXOR	BV3\$J SC1	RXOBV3\$J SC2
∣ ∥ ^Top ^Prev ^Next Cance^I Save^As ^3			
Interp Prev Next Cancer SaverAs Sources being Campaign: \${P}/INTRO \$Y+0=2			
> User, bernoz, Campaigh: \${P}/INTRO_\$Y+0=2	1010 \$5+0-2070 File: /nome/bern	DZIGPOUSER5Z/PA	IN/RAOBV3.INP

There are three further panels defining the input options for RXOBV3. They allow to select the data to be imported and to specify a few parameters for the Bernese observation header files.

Bernese GNSS Software Version 5.2		- • •
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BF	PE <u>U</u> ser	Help
RXOBV3 2: Input Options 1		
TITLE EXAMPLE: Session \$YSS+0: tutorial lecture		
SATELLITE SYSTEM SELECTION		
Satellite system to be considered	GPS/GLO	•
STATION NAMES		
Gather station names from	FILE NAME	E
Action if station not in abbreviation list	ERROR	•
SESSION IDENTIFIER		
Session ID used for Bernese observation files	\$\$+0 (1	blank: AUTO)
DATA SAMPLING		
Sampling interval	30 💌 Sr	econds
Sampling offset to full minute	0 - 3	econds
↑Top ^Prev ^Next Cance ⁴ Save ⁴ As ^Save ^Run ^Output Rer ⁴ un ^+Day vuser: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/G		rxobv3.inp

We select $\mathsf{GPS}/\mathsf{GLO}$ for the option "Satellite system to be considered" to exclude observations from GNSS where no orbits are available.

E Bernese GNSS S	oftware Version 5.2									- 0 ×
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
RXOBV	3 3: Obse	ervatio	n Window							
OBSER	VATION W	INDOW								
c	Take	all ob:	servation	s						
	Defir Year		Year and •0 Se		dentif \$s+0	ier				
c	Defir Start	222	Start and Y mm dd MD_STR+0	hh m	m ss	End		mm dd STR+0	hh mm 23 59	
						Rer^un ^+			N/RXOBV3.INP	. <i>li</i>

Bernese GNSS Software Version 5.2	
Configure Campaign RINEX Orbits/EOP Processing Service Conversion	BPE User Help
RXOBV3 4: Input Options 2	
SIGNAL STRENGTH REQUIREMENTS	
Minimum signal strength	1 .
Accept signal strength = 0	
Accept cycle slip flags from RINEX	Г
MINIMUM OBSERVATION NUMBER	
Minimum number of epochs requested per file	30 epochs
OPTIONS CONCERNING ANTENNAS	
Consider radome code of the antennas	Ч
Correct position of radome code	T
Check phase center file for antenna type	else ERROR .
EVENT FLAG HANDLING	
What to do in case of event flags	SKIP
FREQUENCY CHECK FOR SLR	
Check frequency information file for frequency	WARNING
^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output Rer^un ^+Da	ay ^-Day
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/	GPSUSER52/PAN/RXOBV3.INP

The next two panels are only displayed, if you specified a station information file in "RXOBV3 1: Filenames". They allow you to configure the RINEX header information verification:

Bernese GNSS Software Versio	15.2								- 0 ×
Configure Campaig	n <u>R</u> INEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
RXOBV3 5.1:	Check C	ontent of	RINEX He	ader 1					
ACTIONS IN	CASE OF	INCONSIST	ENCIES						
Station r	ame		ERROR	•	Try	also t	filename		Y
Receiver/	antenna	type	ERROR	-					
Receiver/	antenna	number	ERROR	*					
Antenna p	osition		ERROR	•					
Marker ty	pe		WARNII	IG ·					
_	: Writ Skip	check is d e warning file and e error m	and cont continue	with :		ng			
∬ ^Top │ ^Prev │ ^Ne > User: bern52 Cam	xt Cance^I	Save^As /	'Save ^Run	^Output	Rer^un ^+	-Day ^-I		N/RXOBV3.IN	IP ,

			Orbits/EOP			Conversion	BPE	User	Help		
ADDIT	IONAL VE	RIFICAT	TION								
Ve	cify stat	ion nar	me/number	using			2	M	ARKER DOMES	*	
Ve	cify stat	ion nar	ne using :	RINEX fil	ename		۲				
HANDI	JING OF K	NOWN IN	CONSISTE	NCIES							
Ac	cepted st	ation :	informati	on					CRX		

Start the program with the **^Run**-button.

A warning message may appear to inform you that the observations for the GLONASS satellite R09 (satellite system R for GLONASS in RINEX whereas satellite numbers between 100 and 199 are in use within the *Bernese GNSS Software*) are removed because of an entry in the "Satellite problems" file provided in panel "RXOBV3 1.1: General Files".

###	SR	SAVMEA:	PROBLEM FOR SATELLITE	::	109
			INDICATED IN SATCRUX	:	\${X}/GEN/SAT_2010.CRX
			PROBLEM	:	BAD PHASE+CODE
			REQUESTED ACTION	:	OBS. REMOVED
			TIME WINDOW	:	2008-05-14 00:00:00 2010-09-30 23:59:59
			IN RINEX FILE	:	\${P}/INTRO/RAW/GANP2070.100

Messages from SR R2RDOH: TOO MANY COMMENT LINES may appear for some RINEX files but they are not critical.

The program produces an output file RX010207.0UT in the directory P/INTRO/OUT (resp. corresponding filenames for the other sessions). This file may be browsed using the ^Output button or with "Menu>Service>Browse program output". After echoing the input options, the file provides an overview of the station information records in the RINEX observation file header and the values that are used for the processing in the *Bernese GNSS Software*. In addition some observation statistics are available. In the last section you may check the completeness of the Bernese observation files by the available number of epochs:

								#sat	011
11 m	Rinex file name	Bernese	code	header	file	name	#еро		
am	MINCA IIIC Mamo			observ.			"cpo	 ur b	010
				header			#epo	GPS	GI.O
				observ.			" opo	 41.5	420
1	\${P}/INTRO/RAW/GANP2070.100	\${P}/IN	TRO/OB	S/GANP20	70.CZ	Н	2880	 30	20
		\${P}/IN	TRO/OB	S/GANP20	70.CZ	0			
		\${P}/IN	TRO/OB	S/GANP20	70.PZ	Н	2880	 30	20
		\${P}/IN	TRO/OB	S/GANP20	70.PZ	0			
2	\${P}/INTRO/RAW/HERT2070.100	\${P}/IN	TRO/OB	S/HERT20	70.CZ	H	2880	 31	20
		\${P}/IN	TRO/OB	S/HERT20	70.CZ	0			
		\${P}/IN	TRO/OB	S/HERT20	70.PZ	H	2880	 31	20
		\${P}/IN	TRO/OB	S/HERT20	70.PZ	0			
3	\${P}/INTRO/RAW/JOZ22070.100	\${P}/IN	TRO/OB	S/JOZ220	70.CZ	Н	2880	 30	20
		\${P}/IN	TRO/OB	S/JOZ220	70.CZ	0			
		\${P}/IN	TRO/OB	S/JOZ220	70.PZ	Н	2880	 30	20
		\${P}/IN	TRO/OB	S/JOZ220	70.PZ	0			

11	\${P}/INTRO/RAW/WTZZ2070.100	\${P}/INTRO/OBS/WTZZ2070.CZH	2880	 32	20
		\${P}/INTRO/OBS/WTZZ2070.CZO			
		\${P}/INTRO/OBS/WTZZ2070.PZH	2880	 32	20
		\${P}/INTRO/OBS/WTZZ2070.PZO			
12	\${P}/INTRO/RAW/ZIM22070.100	\${P}/INTRO/OBS/ZIM22070.CZH	2879	 32	20
		<pre>\${P}/INTRO/OBS/ZIM22070.CZO</pre>			
		<pre>\${P}/INTRO/OBS/ZIM22070.PZH</pre>	2879	 32	20
		\${P}/INTRO/OBS/ZIM22070.PZO			
13	<pre>\${P}/INTRO/RAW/ZIMM2070.100</pre>	\${P}/INTRO/OBS/ZIMM2070.CZH	2879	 31	0
		\${P}/INTRO/OBS/ZIMM2070.CZO			
		\${P}/INTRO/OBS/ZIMM2070.PZH	2879	 31	0
		\${P}/INTRO/OBS/ZIMM2070.PZO			
>>> (PU/Real time for pgm "RXOBV3":	0:00:14.767 / 0:00:14.791			
>>> F	rogram finished successfully				

If epochs or satellites are missing for some RINEX files you may check this with the RINEX observation graphic from program RNXGRA ("Menu>RINEX>RINEX utilities>Create observation statistics"). In July 2010 32 GPS and 20 GLONASS satellites were active, where one of the GPS satellites (PRN 01) was unhealthy. For that reason many of the stations did track only 31 out of 32 GPS satellites.

4.2 Data Preprocessing (I)

4.2.1 Receiver Clock Synchronization

Now we are ready to invoke the processing part of the *Bernese GNSS Software*. We have to run three programs for this example. The first program is called CODSPP ("Menu ><u>Processing>Code-based clock synchronization</u>"). Its main task is to compute the receiver clock corrections.

Bernese GNSS Software Version 5.2					- 0 ×
Configure Campaign RINEX Orbits/EC	P Processing Service	Conversion BPE	User	Help	
CODE-BASED CLOCK SYNCHRONIZ	ATION - CODSPP 1:	Filenames			
GENERAL FILES Show all general files	7				
INFUT ORBITS C Broadcast orbits C Standard orbits	COD\$YD+0 STD	Satellite c.	locks		COD\$YD+0 CLK
INFUT FILES Code observation files Estimated tropo values Maps of VMFl coeff. Pole file	2222\$\$+0 TRP GRD COD\$YD+0 ERP	A priori co Site eccent: Kin. input Code bias in Station sign	cicities coordina aput fil	tes es	APR\$YD+0 CRD ECC KIN P1C1\$M+0 DCB SOS
LEO files	Γ				
^Top ^Prev ^Next Cance^I Save^As > User: bern52 Campaign: \${P}/INTRO_\$Y+I				N/CODS	PP.INP

Bernese GNSS So	ftware Version 5.2										• ×
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help		
CODSPE	2 1.3: 0	utput F	iles								
RESULI	F FILES										
Coor	rdinate	results				CRD					
Kine	ematic c	oordina	ites	<u> </u>		KIN					
Res	idual fi	le		i i		RES					
Sate	ellite c	lock re	sults	i i		CLK					
Clo	sk RINEX	result	s	Í		CLK					
GNS:	3 receiv	er LC I	CB values	,		DCB					
OUTPUI	F FILES										
Out	out summ	ary (XY	Z coord.)			SMC					
Out	put summ	ary (El	l.coord.)	İ		SME					
GENERA	AL OUTPU'	T FILES									
Pro	gram out	put		Г	use C	CODSPP.Lnn			or	COD\$YD+0	OUT
Erre	or messa	ges			merge	ed to prog	ram ou	itput or		ERROR	MSG
^Top ^Pr	ev ^Next	Cance ⁴	Save^As ^	Save ARun	^Output	Rer^un ^+	Day ^-D	Day			
User: bern	52 Campaid	an: \${P}/IN	TRO \$Y+0=	2010 \$S+0=	2070 File	e: /home/bern5	2/GPSU	SER52/PA		SPP.INP	

	Software Version 5.2 Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	- 0 -×-
	PP 2: Inpu		ons							
TITL	E EXAM	PLE: Se	ssion \$YS	S+0: Clo	ck sync	hronizati	on			
Fr	METERS equency ock polyn	omial d	lemree			L3 E	• •	one	offset per	r enach
Sar	ve clock timate co	estimat	es			BOTH NO	· ·	•		. opcom
ATMOS	SPHERE MOI	DELS								
Tr	oposphere					GMF		•		
Ioi	nosphere					Γ		_		
						Rer^un ^+ : /home/bern5		-	AN/CODSPP.	INP /

We already have geocentric coordinates of good quality available for the sites from the PPP example BPE. Therefore, the option "Estimate coordinates" may be set to NO. The most important option for this CODSPP run is "Save clock estimates". It has to be set to BOTH.

Bernese GNSS Software Version 5.2							- • •
Configure Campaign RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help
CODSPP 3: Input Opti	ons						
OBSERVATION SELECTIO	N						
Minimum elevation				3 🖬 de	egrees		
Sampling rate				1 -			
Interpolation of c	locks all	owed ove:	r	0 :	seconds	(0:no	interpolation)
Observation window							
Use mark flags fro	m observa	tion fil	98				
PRINT OPTIONS							
Residuals							
Elevations							
	C	Saura Lannua			D A D		
^Top ^Prev ^Next Cance^l							
> User: bern52 Campaign: \${P}/IN	TRO 31+0=2	010 35+0=	2070 File	e. /nome/bern5	2/685036	IK9Z/PAP	WCODSPP.INP

Bernese GNSS Software Version 5.2									
Configure Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
CODSPP 4: Scre	ening	Options							
ITERATIONS									
Max. number	of ite	rations	10						
OUTLIER DETECT	ION								
Outlier dete	ction		Y						
Max. residua	l allo	wed	30.	0	meters				
Confidence i	nterva	.1	5.0		(in units	of one	e sigma	1)	
Min. degree	of fre	edom	1	121					
Max. RMS of	kin. s	olution	5.0)	meters				
Mark outlier	s in c	bs. files	NO NO	-	[
] ^Top ^Prev ^Next									
> User: bern52 Campaig	n: \${P}/IN	TRO \$Y+0=:	2010 \$S+0=:	2070 File	e: /home/bern5:	2/GPSUSI	ER52/PAN	V/CODSPP.INP	

The warning messages issued by the program CODSPP remind that only GPS satellite clock corrections have been extracted from the precise orbit files. Consequently, the receiver clocks are synchronized with respect to the GPS system time.

CODSPP produces the following output:

```
STATION: GANP 11515M001 FILE: ${P}/INTRO/OBS/GANP2070.CZO
                                                                                                                                            RECEIVER UNIT:
                                                                                                                                                                                     999999
                                                                                                                                                                                    . . . . . . . .
DAY OF YEAR : 207
OBSERVATIONS :
REQUESTED WINDOW :
                                                                               FROM
                                                       FROM TO
2010-07-26 00:00: 0.00 2010-07-26 23:59:30.00
                                                                                                                                                 TO
                                                                                                                                                  - -
MEASUREMENT INTERVAL: 30 SEC
SAMPLING RATE : 1
PROCESSED FREQUENCY : L3
                                                     1
ELEVATION LIMIT : 3 DEG
                                                                TROPOSPHERE IONOSPHERE
GMF
 ATMOSPHERE MODELS :
STATISTICS FOR GPS SATELLITES:
 SATELLITE NUMBER
                                                                    3
                                                                                                                                                             10
                                                                                                                                                                         11 ... TOTAL
                                                       2
                                                                                 4
                                                                                               5
                                                                                                           6
                                                                                                                        7
                                                                                                                                    8
                                                                                                                                                  9
                                                                                                    838 914
838 914

        DBSERVATIONS IN FILE:
        1015
        910
        1019
        1029

        USED DBSERVATIONS :
        1015
        910
        1019
        1029

        BAD DBSERVATIONS (%):
        0.0
        0.0
        0.0
        0.0

        RMS ERROR (M)
        :
        0.9
        1.1
        0.9
        1.0

                                                                                                                            841 832 971 857 ... 27074
841 832 971 857 ... 27074
                                                                                                                                                                       857 ... 27074
                                                                                                                                         0.0
                                                                                                      0.0
                                                                                                                    0.0
                                                                                                                                0.0
                                                                                                                                                          0.0
                                                                                                                                                                       0.0 ... 0.0
                                                                                                      1.0
                                                                                                                  1.0
                                                                                                                               1.0
                                                                                                                                                          1.2
                                                                                                                                                                       0.9 ...
                                                                                                                                                                                             1.0
STATISTICS FOR GLONASS SATELLITES:
SATELLITE NUMBER
                                                   101
                                                                 102
                                                                             103
                                                                                          104
                                                                                                       105
                                                                                                                    107
                                                                                                                                108
                                                                                                                                              110
                                                                                                                                                          111
                                                                                                                                                                       113 ... TOTAL
                                           •

        SATELLITE NUMBER
        :
        101
        102
        103

        OBSERVATIONS IN FILE:
        905
        932
        935

        USED OBSERVATIONS :
        0
        0
        0

        BAD OBSERVATIONS (%):
        0.0
        0.0
        0.0

        RMS ERROR (M)
        :
        0.0
        0.0
        0.0

                                                                                         929 1149 1097
                                                                                                                               905
                                                                                                                                          1005
                                                                                                                                                          991
                                                                                                                                                                   903 ... 19977
                                                                                                      0

        0
        0
        0
        0
        0
        ...

        0.0
        0.0
        0.0
        0.0
        0.0
        ...

        0.0
        0.0
        0.0
        0.0
        0.0
        ...

                                                                                                                                                                         0 ...
                                                                                            0
                                                                                                                                                                                               0
                                                                                        0.0 0.0
0.0 0.0
                                                                                                                                                                                             0.0
                                                                                                                                                                                           0.0
 RESULTS:

        OBSERVATIONS IN FILE:
        47051

        USED OBSERVATIONS :
        27074

        BAD OBSERVATIONS :
        0.000 %

        RMS OF UNIT WEIGHT :
        1.07 M

 NUMBER OF ITERATIONS:
                                                                 2
 . . .
```

You see in this statistic that the GLONASS measurements have not been used (because of the missing GLONASS satellite clock corrections).

 STATION COORDINATE	:S :				
LOCAL GEODETIC DA	TUM: IGS14				
GANP 11515M001 (MARKER)	Y Z HEIGHT LATITUDE	3929181.42 1455236.82 4793653.95 746.01 49 2 4.971	3929181.42 1455236.82 4793653.95 746.01 49 2 4.971	NEW - A PRIORI 0.00 0.00 0.00 0.00 0.00 0.00 0.000 0.000	0.00 0.00 0.00 0.00 0.00
CLOCK PARAMETERS:					
OFFSET FOR REFERE	INCE EPOCH:	-0.00	0000021 SEC		
GPS/GLONASS SYSTE	M DIFFERENCE:	OFFSET : RMS ERROR :			
CLOCK OFFSETS STO	RED IN CODE+PH	ASE OBSERVATION	FILES		

```
*************
SUMMARY OF BAD OBSERVATIONS
MAXIMUM RESIDUAL DIFFERENCE ALLOWED : 30.00 M
CONFIDENCE INTERVAL OF F*SIGMA WITH F:
                                                    5.00
NUMBER OF BAD OBSERVATION PIECES : 3
                                                                          TO
                               TYP SAT
NUMB FIL STATION
                                                 FROM
                                                                                        #EPO
                       -----

        1
        8
        TLSE
        10003M009
        OUT
        1
        10-07-26
        15:10:00
        10-07-26
        15:28:30

        2
        8
        TLSE
        10003M009
        OUT
        1
        10-07-26
        15:32:30
        10-07-26
        15:33:00

                                                                                            38
                                                                                            2
   3 12 ZIM2 14001M008
                               OUT 26 10-07-26 20:08:30 10-07-26 20:08:30
                                                                                             1
               ******
GLONASS/GPS TIME OFFSETS
 TIME OFFSET (NS) RMS ERROR (NS)
FILE STATION NAME
GANP11515150001NORESULTSAVAILABLEHERT13212M010NORESULTSAVAILABLEJOZ212204M002NORESULTSAVAILABLELAMA12209M001NORESULTSAVAILABLEMATE12734M008NORESULTSAVAILABLEONSA10402M004NORESULTSAVAILABLETLSE10003M009NORESULTSAVAILABLEWSRT13506M005NORESULTSAVAILABLEWTZZ14201M010NORESULTSAVAILABLEWTZZ14201M014NORESULTSAVAILABLEZIM214001M008NORESULTSAVAILABLEZIMM14001M004NORESULTSAVAILABLE
  1
  2
  3
  4
  5
  6
  7
  8
  9
 10
 11
 12
 13
                                          0.000
 0 TOTAL
                                                      0.000
```

The most important message in the output file is CLOCK OFFSETS STORED IN CODE+PHASE OBSERVATION FILES. This indicates that the receiver clock corrections

computed by CODSPP are stored in code and phase observation files. After this step we will no longer use the code observations in this example.

The a posteriori RMS error (for each zero difference file processed) should be checked in the CODSPP output file. A value of about 20–30 m is normal if Selective Availability (SA) — artificial degradation of the satellite clock accuracy — is on (before May 2000). Without SA a value of about 3 m is expected if P–code measurements are available (this is the case for the time interval of the processing example). However, much worse code measurements would still be sufficiently accurate to compute the receiver clock corrections with the necessary accuracy of $1 \,\mu$ s.

In the section GLONASS/GPS TIME OFFSETS you may only find the inter–system bias (ISB) for each of the receivers as they have been estimated by CODSPP if both, GPS and GLONASS satellite clock corrections were introduced.

You may use the extraction program CODXTR ("Menu>Processing>Program output extraction>Codebased clock synchronization") to generate a short summary from the CODSPP program output:

```
File Input files
1 ${P}/INTRO/OUT/COD10207.OUT
13 FILES, MAX. RMS: 2.12 M FOR STATION: PTBB 14234M001
MAX. BAD: 5.26 % FOR STATION: WSRT 13506M005
>>> CPU/Real time for pgm "CODXTR": 0:00:00.008 / 0:00:00.007
>>> Program finished successfully
```

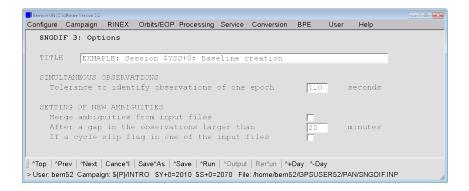
4.2.2 Form Baselines

The second preprocessing program is called SNGDIF and may be activated in "Menu \geq Processing>Create baseline files". SNGDIF creates the single differences and stores them into files. We use the strategy OBS-MAX for PHASE observation files.

Bernese GNSS S	oftware Version 5.2									
onfigure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	1 BPE	User	Help	
CREAT	E SINGLE	DIFFER	ENCE/BASE	LINE FIL	ES - S	NGDIF 1:	Input	File Se	lection	
	AL FILES w all ge	neral f	iles			Y				
GENER	AL OPTIO	NS								
Mea	surement	type				PHASE	-			
Pro	cessing	strateg	ſΥ			OBS-MAX	-			
Sta	tions mu	st cont	ain obser	v. from		GPS	•			
AUTOM	ATED BASI	ELINE C	REATION							
Zer	o-differ	ence ob	servation	n files		2???\$S+O	PZH	21	???\$S+0 CZH	
Ref	erence s	tation	for STAR	strategy			PZH		CZH	
MANUA	L BASELII	NE CREA	TION							
Fir	st zero	-differ	ence inpu	ut file			PZH		CZH	
Sec	ond zero	-differ	ence inpu	it file			PZH		CZH	
Sin	gle-diff	erence	output f:	le			PSH		CS.	H
Top ^Pi	rev ^Next	Cance^l	Save^As ^	Save ^Run	^Outpu	t Rer^un	^+Day ^-	Day		
Jser: berr	n52 Campaig	gn: \${P}/IN	TRO \$Y+0=	2010 \$S+0=	2070 Fil	e: /home/ber	n52/GPS	USER52/PA	AN/SNGDIF.INP	

To enter GPS in option "Stations must contain observ. from a GNSS" requires that each station included in the baseline creation provides at least GPS measurements. This option can be used to exclude those datasets containing only GLONASS observations.

📕 Bernese GNSS :	Software Version 5.	2								- • •
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
SNGDI	F 2: Fi	Lenames								
	FILES			_						
	ation co			AI	PR\$YD+0	CRD				
	e eccen					ECC				
Pre	edefined	baselin	nes			BSL				
Clu	ister de	finition	n			CLU				
Lis			baselines			BSL				
Clu	ster/ba:	seline a	assignment	-	0	CLB (C	2 digits	will	be appended)
GENER	AL OUTPU	JT FILES	3							
Pro	ogram ou	tput		🚩 use	SNGDI	F.Lnn		or	SNGDIE	OUT
Erı	or messa	ages		mer mer	ged to	program	output	or	ERROR	MSG
] ^Top ^P	rev ^Next	Cance ⁴	Save^As ^	Save / ^Run	^Output	Rer^un ^	+Day ^-Day	ý		
> User: ber	n52 Campa	ign: \${P}/IN	ITRO \$Y+0=	2010 \$S+0=	2070 File	e: /home/berr	152/GPSUSI	ER52/PA	N/SNGDIF.INP	



Bernese GNSS Software Version 5.2			- 0
Configure Campaign RINEX Orbits/EOP Processing Service Conversion	n BPE l	Jser Help	
SNGDIF 3.1: Options for Strategy OBS-MAX			
SPEED UP BASELINE SELECTION ALGORITHM			
Minimum number of observations requested	600	(scaled, se	e help)
Maximum distance for fast observation count	0 *		
Maximum baseline length considered	9000 🚆	kilometers	
ALLOW REDUNDANT BASELINES Add redundant baselines	Γ		
ADD BONUS DEPENDING ON BASELINE LENGTH			
Maximum bonus for number of observations	10	percent	
Direct L1/L2: Baseline length from 0 to	20	kilometers	
Wide-/Narrowlane: Baseline length from 0 to	200	kilometers	
Other: Baseline length from O to	0 .	kilometers	
^ * * * * * * * * * * * * * * * * * * *	`+Day ^-Day		
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern	152/GPSUSEF	R52/PAN/SNGDIF.II	VP //

The output of SNGDIF simply echoes the zero difference files used and the single difference files created. The first table confirms that all stations provide at least data from GPS. For that reason all stations are included in the baseline creation.

NUM	HEADER	FILE NAM	IES		STATI	ON NAME	#SAT	SYS	REMARK
1	\${P}/IN	TRO/OBS/	GANP2070.	PZH	GANP	11515M001	50	GR	included
2	\${P}/IN	TRO/OBS/	HERT2070.	PZH	HERT	13212M010	51	GR	included
3	\${P}/IN	TRO/OBS/	JOZ22070.	PZH	JOZ2	12204M002	50	GR	included
4	\${P}/IN	TRO/OBS/	LAMA2070.	PZH	LAMA	12209M001	50	GR	included
5	\${P}/IN	TRO/OBS/	MATE2070.	PZH	MATE	12734M008	51	GR	included
6	\${P}/IN	TRO/OBS/	ONSA2070.	PZH	ONSA	10402M004	50	GR	included
7	\${P}/IN	TRO/OBS/	PTBB2070.	PZH	PTBB	14234M001	32	G	included
8	\${P}/IN	TRO/OBS/	TLSE2070.	PZH	TLSE	10003M009	52	GR	included
9	\${P}/IN	TRO/OBS/	WSRT2070.	PZH	WSRT	13506M005	31	G	included
10	\${P}/IN	TRO/OBS/	WTZR2070.	PZH	WTZR	14201M010	51	GR	included
11	\${P}/IN	TRO/OBS/	WTZZ2070.	PZH	WTZZ	14201M014	52	GR	included
12	\${P}/IN	TRO/OBS/	ZIM22070.	PZH	ZIM2	14001M008	52	GR	included
13	\${P}/IN	TRO/OBS/	ZIMM2070.	PZH	ZIMM	14001M004	31	G	included

The creation of the following 12 baseline files from 13 zero difference observation files is reported:

SNGDIF: INPUT AND OUTPUT OBSERVA	TION FILE NAMES				
0-DIF. HEADER FILE NAMES (INPUT)	0-DIF. OBS. FILE NAMES (INPUT)	NUM			
**********	******	***			
\${P}/INTRO/OBS/GANP2070.PZH	\${P}/INTRO/OBS/GANP2070.PZO	1			
\${P}/INTRO/OBS/JOZ22070.PZH	<pre>\${P}/INTRO/OBS/JOZ22070.PZO</pre>	2			
\${P}/INTRO/OBS/HERT2070.PZH	\${P}/INTRO/OBS/HERT2070.PZO	3			
\${P}/INTRO/OBS/ZIM22070.PZH	<pre>\${P}/INTRO/OBS/ZIM22070.PZO</pre>	4			
\${P}/INTRO/OBS/JOZ22070.PZH	<pre>\${P}/INTRO/OBS/JOZ22070.PZO</pre>	5			
\${P}/INTRO/OBS/LAMA2070.PZH	<pre>\${P}/INTRO/OBS/LAMA2070.PZO</pre>	6			
\${P}/INTRO/OBS/JOZ22070.PZH	<pre>\${P}/INTRO/OBS/JOZ22070.PZO</pre>	7			
\${P}/INTRO/OBS/ONSA2070.PZH	\${P}/INTRO/OBS/ONSA2070.PZO	8			
\${P}/INTRO/OBS/ZIM22070.PZH	<pre>\${P}/INTRO/OBS/ZIM22070.PZO</pre>	23			
\${P}/INTRO/OBS/ZIMM2070.PZH	\${P}/INTRO/OBS/ZIMM2070.PZO	24			
1-DIF. HEADER FILE NAMES (OUT)	1-DIF. OBS. FILE NAMES (OUT)	NR1	NR2	STAT.	
*********	******	***	***	****	
\${P}/INTRO/OBS/GAJO2070.PSH	\${P}/INTRO/OBS/GAJO2070.PSO	1	2	OK	
\${P}/INTRO/OBS/HEZI2070.PSH	<pre>\${P}/INTRO/OBS/HEZI2070.PSO</pre>	3		OK	
\${P}/INTRO/OBS/JOLA2070.PSH	<pre>\${P}/INTRO/OBS/JOLA2070.PSO</pre>	5	6	OK	
\${P}/INTRO/OBS/JOON2070.PSH	\${P}/INTRO/OBS/JOON2070.PSO	7	8	OK	
\${P}/INTRO/OBS/ZIZM2070.PSH	<pre>\${P}/INTRO/OBS/ZIZM2070.PS0</pre>	23	24	OK	

If the strategy OBS-MAX was selected all possible pairs of zero difference files are listed with the corresponding criterion value. The baselines belonging to the created network configuration are labeled with OK .

1	GANP	11515M001	-	HERT	13212M010	#SAT:	50	CRIT.:	20892		
2	GANP	11515M001	-	JOZ2	12204M002	#SAT:	50	CRIT.:	23424	OK	
3	GANP	11515M001	-	LAMA	12209M001	#SAT:	50	CRIT.:	22806		
4	GANP	11515M001	-	MATE	12734M008	#SAT:	50	CRIT.:	20725		
21	HERT	13212M010	-	WTZZ	14201M014	#SAT:	51	CRIT.:	22697		
22	HERT	13212M010	-	ZIM2	14001M008	#SAT:	51	CRIT.:	23219	OK	
23	HERT	13212M010	-	ZIMM	14001M004	#SAT:	31	CRIT.:	13051		
24	JOZ2	12204M002	-	LAMA	12209M001	#SAT:	50	CRIT.:	24807	OK	
25	JOZ2	12204M002	-	MATE	12734M008	#SAT:	50	CRIT.:	20969		
26	JOZ2	12204M002	-	ONSA	10402M004	#SAT:	50	CRIT.:	23855	OK	
27	JOZ2	12204M002	-	PTBB	14234M001	#SAT:	30	CRIT.:	11243		
28	JOZ2	12204M002	-	TLSE	10003M009	#SAT:	50	CRIT.:	21991		
29	JOZ2	12204M002	-	WSRT	13506M005	#SAT:	30	CRIT.:	14464	OK	
30	JOZ2	12204M002	-	WTZR	14201M010	#SAT:	50	CRIT.:	24390	OK	
31	JOZ2	12204M002	-	WTZZ	14201M014	#SAT:	50	CRIT.:	24182		

4.2.3 Preprocessing of the Phase Baseline Files

The main task of the program MAUPRP is the cycle–slip detection and correction. It is started using "Menu>Processing>Phase preprocessing".

Bernese GNSS Software Version 5.2	- • •
Configure Campaign RINEX Orbits/EOP Processing Service	e Conversion BPE User Help
PHASE PREPROCESSING - MAUPRP 1: Input Files	s
GENERAL FILES	
Show all general files	
INPUT FILES	
 Zero-difference observation files 	????\$S+0 PZH
 Single-difference observation files 	????\$S+0 PSH
A priori coordinates	APR\$YD+0 CRD
Site eccentricities	ECC
Kinematic input coordinates	KIN
GNSS standard orbits	COD\$YD+0 STD
Pole file	COD\$YD+0 ERP
Satellite clocks	CLK
Estimated troposphere values	TRP
Meteo data files	MET
Maps of VMF1 coefficients	GRD
Ionosphere models	ION
Process LEOs	
I ∥ ^Top ^Prev *Next Cance^I Save*As *Save *Run *Outpu	ut Rer^un ^+Day ^-Day
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 F	ile: /home/bern52/GPSUSER52/PAN/MAUPRP.INP

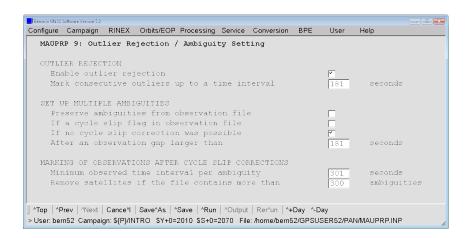
In the next input panel "MAUPRP 2: Output Files" you only need to specify the "Program output", e.g., to MPR\$YD+0.

MAUPRP 3: General Options				
TITLE EXAMPLE: Session \$YSS+0: Phase clea	ning			
GENERAL SETTINGS				
Screening mode, frequency to check	AUTO	•		
Max. baseline length to use BOTH mode	20	km		
Interpolation of clocks allowed over	0	seconds	(0:no in	nterp)
Save screened observation files	- -			
TROPOSPHERE MODELING				
ZPD model and mapping function	GMF		•	
SAVING COORDINATES				
Define the fixed station			_	
Define the fixed Station	(blan	k: automa	tic sele	ction)
op ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output			tic sele	ction)
	Rer^un ^+Day	-Day		
öp ^Prev ^Next Cance^l Save^As ^Save ^Run ^Output	Rer^un ^+Day	-Day		
op ^Prev ^Next Cance^l Save^As ^Save ^Run ^Output ser: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File:.	Rer^un ^+Day	-Day		INP
op ^Prev ^Next Cance^l Save^As ^Save ^Run ^Output ser: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: mese6NS55oftware Venion 52	Rer^un │ ^+Day ⁄home/bern52/GPS	-Day SUSER52/PA	N/MAUPRP.	
op ^Prev ^Next Cance^l Save^As ^Save ^Run ^Output ser: bern52 Campaign: \${P}/INTRO SY+0=2010 SS+0=2070 File. mere 6NS Software Version 52 nfigure Campaign RINEX Orbits/EOP Processing Service (Rer^un │ ^+Day ⁄home/bern52/GPS	-Day SUSER52/PA		INP
op ^Prev ^Next Cance^l Save^As ^Save ^Run ^Output ser: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: mese6NS55oftware Venion 52	Rer^un │ ^+Day ⁄home/bern52/GPS	-Day SUSER52/PA	N/MAUPRP.	INP
op ^Prev ^Next Cance^l Save^As ^Save ^Run ^Output ser: bern52 Campaign: \${P}/INTRO SY+0=2010 SS+0=2070 File. mere 6NS Software Version 52 nfigure Campaign RINEX Orbits/EOP Processing Service (Rer ^a un ^a +Day fnome/bern52/GPC Conversion BPE	-Day SUSER52/PA	N/MAUPRP.	INP
op ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output ser: bern52 Campaign: \${P}/INTRO SY+0=2010 SS+0=2070 File: new GNSS Software Venion 52 figure Campaign RINEX Orbits/EOP Processing Service G MAUPRP 4: Marking of Observations	Rer ^a un ^a +Day fnome/bern52/GPC Conversion BPE	-Day SUSER52/PA	N/MAUPRP.	INP
op ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output ser: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: mere 6KSSoftware Verson 52 nfigure Campaign RINEX Orbits/EOP Processing Service (MAUPRP 4: Marking of Observations MARKING OF OBSERVATIONS BEFORE CYCLE SLIP DET	Ren ^a un A+Day fhome/bern52/GPS Conversion BPE	-Day IUSER52/PA	N/MAUPRP.	INP
op 'Prev 'Next Cance'l Save'As 'Save 'Run 'Output ser: bern52 Campaign: \${P}/INTRO SY+0=2010 SS+0=2070 File: mse 0H/SS0Nwe Verson 52 nfigure Campaign RINEX Orbits/EOP Processing Service (MAUPRP 4: Marking of Observations MARKING OF OBSERVATIONS BEFORE CYCLE SLIP DET Mark if marking flags in observation file	Rer ^a un A+Day home/bern52/GPS Conversion BPE ECTION	-Day IUSER52/PA	Help	INP
<pre>'Prev 'Next Cance'l Save'As 'Save 'Run 'Output' ser: bern52 Campaign: \${P}/INTRO SY+0=2010 SS+0=2070 File: mrve GNSS Software Version 52 figure Campaign RINEX Orbits/EOP Processing Service Of MAUPRP 4: Marking of Observations MARKING OF OBSERVATIONS BEFORE CYCLE SLIP DET Mark if marking flags in observation file Mark observations below an elevation of Minimum time interval accepted for continued Minimum time interval accepted for continued</pre>	Rer'un *+Day / fhome/bern52/GPS Conversion BPE ECTION 5 deg 0 deg us observati	-Day SUSER52/PA User rees for	NMAUPRP. Help stations LEOs 301	INP
op 'Prev 'Next Cance'l Save'As 'Save 'Run 'Output ser: bern52 Campaign: \${PyINTRO SY+0=2010 SS+0=2070 File: new GNSS Software Venuen 52 nfgure Campaign RINEX Orbits/EOP Processing Service G MAUPRP 4: Marking of Observations MARKING OF OBSERVATIONS BEFORE CYCLE SLIP DET Mark if marking flags in observation file Mark observations below an elevation of	Rer'un *+Day / fhome/bern52/GPS Conversion BPE ECTION 5 deg 0 deg us observati	-Day SUSER52/PA User rees for	NMAUPRP.	NP

Bernese GNSS Softw											- 0 ×	
Configure Ca	ampaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help			
MAUPRP	5: Non-	-Parame	tric Scre	ening								
GENERAL OPTIONS												
Exten	nt of p	rogram	output				SUMMA	RY •				
Maxim	uum tim	e inter	val for p	oolynomia	l fit		2	minute	s			
SCREENI	NG ON I	DIFFERE	NT DIFFER	ENCE LEV	ELS							
	Origi	nal ob	servation	s from fi	le	for	ZD-fi]	les: ze	ro	diff.		
	Po	lynomi	al degree		1 1		SD-fil	les: si	ngle	diff.		
	Di	sconti	nuity lev	el 🗍	0.4	meters						
r	Diffe	rences	between	satellite	28	for	ZD-fil	les: si	ngle	diff.		
	Po	lynomi	al degree		1 .		SD-fil	les: do	uble	diff.		
	Di	sconti	nuity lev	el 🖡	0.01	meters						
						t Rer^un ^+						
> User: bern52	2 Campaig	gn: \${P}/IN	TRO \$Y+0=	2010 \$S+0=	2070 Fil	e: /home/bern5	2/GPSUS	SER52/PA	N/MAU	PRP.INP	1.	

Bernese GNSS Software Version 5.2									- 0 -			
Configure Campaign RIN	NEX Orbits/EOP F	Processing	Service	Conversion	BPE	User	Help					
MAUPRP 6: Epoch-Difference Solution												
EPOCH-DIFFERENCE	SOLUTION			for	ZD-fil	.es: do	uble c	liff.				
Frequency for	the solution		L3	•	SD-fil	les: ti	riple 🤇	diff.				
Kinematic coor	dinate estimat	tion	i T	_								
Maximum observ	ed-computed va	alue	0.5	meter	s (0.0	: no c	heck)					
RMS limit for	epoch solution	n	1.0	meter	s (0.0	no c	heck)					
M A priori	coordinate/ba	seline v	ector :	sigmas								
X-coordir	nate		0.1	mete	ers							
Y-coordir	nate		0.1	mete	ers							
Z-coordir	nate		0.1	mete	ers							
∬ ^Top ^Prev ^Next Car	nce^l Save^As ^S	ave ^Run	^Output	Rer^un / +	Day ^-Da	ay						
> User: bern52 Campaign: \$	{P}/INTRO \$Y+0=20	010 \$S+0=2	2070 File	: /home/bern5:	2/GPSUS	ER52/PA	N/MAUP	RP.INP	li			

Benese BNSSoftware Version S2 Configure Campaign RINEX Orbits/EOP Processing Service Conversion BF	PE User	Help
	C User	neip
MAUPRP 8: Cycle Slip Detection/Correction		
CYCLE SLIP DETECTION		
Extent of program output	SUMMARY	•
Do not accept cycle slip corrections		_
Minimum size of accepted cycle slip correction	10	cycles
Test only observations with cycle slip flag		
L5 is clean except for observations with flags		
NO CYCLE SLIP HYPOTHESIS		
Sigma for L1 observations	0.0020	meters
Sigma for L2 observations	0.0020	meters
Maximum ionospheric change from epoch to epoch	p.0020	meters
for single frequency mode (or short bsl.)	30	% of Ll cycles
for combined mode (or long bsl.)	400	% of L1 cycles
use the combined mode value for bsl longer than	2000	km
	,	
CYCLE SLIP CORRECTIONS		
Search width to find L1 cycle slip correction	5 🛋 int	egers
Search width to find L5 cycle slip correction	2 🛋 int	egers
ATan ADway ANast Canaad Sayadda ASaya ADwa AOutaut Daafur Ay Day	A Deu	
↑ Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output Rer^un ^+Day		
> User: bern52_Campaign: \${P}/INTRO_\$Y+0=2010_\$S+0=2070_File: /home/bern52/G	PSUSER52/PA	N/MAUPRP.INP



The output of the program MAUPRP is discussed in detail in the lecture session. The software manual contains a detailed description, too.

You can find here the results of the adjustment of the input parameters for the maximum accepted change of the ionosphere from one epoch to the next, which is computed according to the baseline length (AUTO in option "Screening mode, frequency to check", panel "MAUPRP 3: General Options").

The most important item to check is the epoch difference solution:

EPOCH DIFFERENCE SOLUTION		
FREQUENCY OF EPOCH DIFF. SOLU.:	3	
#OBS. USED FOR EPOCH DIFF. SOLU:	42814	
RMS OF EPOCH DIFF. SOLUTION (M):	0.012	
COORDINATES NEW-A PRIORI X (M):	0.185 +-	0.021
Y (M):	0.032 +-	0.021
Z (M):	0.290 +-	0.014

The epoch difference solution is used as the reference for the data screening. For a successful phase preprocessing the RMS OF EPOCH DIFF. SOLUTION has to be below 2 cm. The estimates for the coordinates in the epoch difference solution are expected to be smaller than about 0.5 m.

It should be pointed out that it is not necessary to run the program MAUPRP more than once for each baseline. However, it is mandatory to run MAUPRP again if you (for whatever reason) have to re-create the baselines with program SNGDIF.

You might get some warning messages regarding too large O - C (i.e., observed minus computed) values on certain baselines for certain epochs. The corresponding observations get flagged, and will not disturb the processing.

You can use the extraction program MPRXTR ("Menu>Processing>Program output extraction>Phase preprocessing") to generate a short summary of the MAUPRP output. The file you have specified in "MAUPRP station summary file" looks like this:

	SUMMARY OF THE MAUPRP OUTPUT FILE														
SESS	FIL	OK?	ST1	ST2	L(KM)	#OBS.	RMS	DX	DY	DZ	#SL	#DL	#MA	MAXL3	MIN. SLIP
2070	1	ок ОК	GANP	JOZ2	344	42814	12	185	32	290	12	369	72	49	12
2070	2	OK	HERT	ZIM2	685	41498	13	-317	11	-329	6	591	95	47	11
2070	3	OK	J0Z2	LAMA	201	43720	11	-12	-4	71	39	826	101	49	11
2070	4	OK	JOZ2	ONSA	830	41462	11	-416	-151	-456	7	609	113	34	11
2070	5	OK	JOZ2	WSRT	981	22358	11	-198	-21	-229	8	413	47	33	11
2070	6	OK	JOZ2	WTZR	663	41785	13	-231	-76	-377	11	641	81	48	11
2070	7	OK	MATE	ZIM2	1014	38157	13	471	42	455	64	876	117	49	11
2070	8	OK	PTBB	ZIM2	640	20063	12	43	-8	-10	82	242	36	50	13
2070	9	OK	TLSE	ZIM2	597	41698	13	8	38	126	6	609	89	47	11
2070	10	OK	WTZR	WTZZ	0	43787	12	- 9	-13	-4	96	461	65	0	0
2070	11	OK	WTZR	ZIM2	476	42211	14	147	11	91	6	974	89	43	13
2070	12	OK	ZIM2	ZIMM	0	23786	13	-16	4	-32	25	88	35	0	0
Tot:	12				536	43787	14	471	42	455	96	974	117	50	0

Note that in the bottom line the maximum values for each column are reported to show the "worst case".

4.3 Daily Goals

At the end of today's session, you should have created the following files:

- Bernese formatted zero difference observation files in your campaign's OBS directory: GANP2070. CZH, GANP2070. PZH, GANP2070. CZO, GANP2070. PZO, ... (for all stations).
- 2. Single difference files (baseline files) in the OBS directory: GAJ02070. PSH, GAJ02070. PSO, HEZI2070. PSH, HEZI2070. PSO,... for all baselines,
- 3. you should also have verified the outputs of these programs: ORBGEN, CODSPP, SNGDIF, and MAUPRP

5 Terminal Session: Wednesday

Today's terminal session is to: 1. perform a residual screening (GPSEST, RESRMS, SATMRK),

- 2. generate a first estimation for coordinates and troposphere parameters (GPSEST),
- 3. resolve the double difference ambiguities (GPSEST).

5.1 Data Preprocessing (II)

The main parameter estimation based on a least–squares adjustment is the task of program GPSEST. It is a good idea to start GPSEST first in the session mode and to produce a L_3 solution (ionosphere–free linear combination) with real–valued ambiguities. We do not expect any final results from this run but we want to check the quality of data and save the residuals after the least–squares adjustment. The program is available via "Menu>Processing >Parameter estimation". We use the following options:

Bernese GNSS Software Version 5.2			· ·	005			- 0 🗙
Configure Campaign RINEX	Orbits/EOP Processi	ing Service	Conversion	BPE	User	Help	
PARAMETER ESTIMATION	- GPSEST 1.1:	Input Fil	es 1				
GENERAL FILES AND PR							
Space geodetic tec	-	GNSS	-				
Differencing level		DOUBLE	· ·				
LEO data processin							
Show all general f	files	7					
OBSERVATION FILES							
Phase observations		2222\$8	+O PSH	2.2	??\$S+0	PZH	
Code observations			CSH			CZH	
Range observations	3		CZH				
MAIN INPUT FILES							
Station coordinate	s	APR\$YD	+0 CRD				
Satellite standard	l orbits	COD\$YD	+0 STD				
Earth rotation par	ameters	COD\$YD	+O ERP				
Satellite clock co	prrections		CLK				
Differential code	biases		DCB				
Gridded VMF1 coeff	icients		GRD				
Ionosphere models			ION				
CORRECTIONS FOR LOAD	ING EFFECTS AND	CENTER C	F MASS				
Ocean tidal loadin	ıg	EXAMPL	EBLQ				
Atmospheric tidal	loading	EXAMPL	EATL				
│ ∬ ^Top │ ^Prev │ *Next │ Cance*I │	Save^As ^Save ^F	Run ^Output	Rer^un / *+	Day ^-Da	ау		
> User: bern52_Campaign: \${P}/IN	TRO \$Y+0=2010 \$S-	+0=2070 File	: /home/bern5	2/GPSUS	ER52/PA	N/GPSES	T.INP

No files are input in the second input panel.

Bernese GNSS Software Version 5.2							- • •
Configure Campaign RINEX Orbits/EOF	Processing	Service	Conversion	BPE	User	Help	
GPSEST 2.1: Output Files 1							
GENERAL OUTPUT FILES							
Program output	use use	e GPSES	T.Lnn		or	EDT\$YD+C	OUT
Error message	mei mei	ged to	program o	putput	or	ERROR	MSG
NORMAL EQUATION SYSTEM			NÕO				
STATION- AND SATELLITE-RELAT	ED RESULT	S					
Station coordinates			CRD				
Satellite orbital elements			ELE				
Earth rotation parameters			ERP				
Earth rotation parameters	(IERS)		IEP				
ATMOSPHERE-SPECIFIC RESULTS							
Troposphere estimates			TRP				
Troposphere estimates (SIN	IEX)		TRO				
Ionosphere models			ION				
Ionosphere models (IONEX)			INX				
			1				
∬ ^Top ^Prev ^Next Cance^I Save^As							
> User: bern52 Campaign: \${P}/INTRO \$Y+0	=2010 \$S+0=	2070 File	e: /home/bern5	2/GPSUS	ER52/PAN	I/GPSEST.INP	li.

Benese 6N35 Software Version 52 Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE Us	er Help
GPSEST 2.2: Output Files 2	
ADDITIONAL RESULT FILES	
Differential code biases DCB	
Inter-system biases ISB	
Phase center variations (gridded)	
Phase center variations (spherical) PHH	
EPOCH-SPECIFIC RESULTS	
GNSS clock corrections CLK	
Clock RINEX	
Kinematic coordinates	
AUXILIARY FILES	
Observation residuals EDT\$YD+0 RES	
Covariance matrix COV	
Covariance matrix wrt coordinates COV	
^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output Rer^un ^+Day ^-Day Concert Save^As ^Save ^Run ^Output Rer^un ^+Day ^-Day	
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER5	Z/PAN/GPSEST.INP

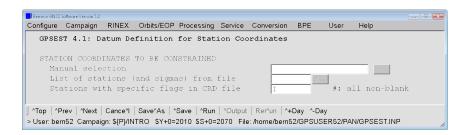
This run is intended to screen the post–fit residuals for outliers. Later on, for the ambiguity resolution, all observations are needed without down–sampling the data. To run the program GPSEST for the network with 13 stations and the observations to more than 50 satellites without reducing the data sampling rate takes easily 10 minutes or more. For that reason we are forced to sample the data, e.g., down to 3 minutes — we will see in the next step how to solve this discrepancy.

_	Software Version 5.2									
Configure	Campaign	RINEX	Orbits/EOF	Processing	Service	Conversion	BPE	User	Help	
GPSES	ST 3.1: G	General	Options	1						
TITLE	EXAM	IPLE: Se	ession \$Y	5S+0: Sav	e resio	duals				
0.000										
	VATION S		NIV NI		_					
	cellite s					LL	<u> </u>			
			combinati	on	L		-			
	evation o mpling in		angie		5		grees conds			
			ultaneity		-		conas lliseco	anda		
	ecial dat		-		1 N		TTTSecc	JIIGS		
-	servatior				IN		<u> </u>			
0.0.	Servation	i windo.	•		1					
OBSEF	NATION M	ODELING	AND PAR	AMETER ES	TIMATI	ON				
Αĸ	oriori si	lqma of	unit wei	qht	0	.001 me	ters			
Ele	evation-c	depender	nt weight	ing	C	osz •				
Typ	be of com		residuals	-	N	ORMALIZED	•			
Cor	relatior	n strate	egy		В	ASELINE	-			
							_			
LEO-S	SPECIFIC	SELECT	ON AND M	ODELING O	PTIONS					
Ele	evation o	utoff a	angle		0	de	grees			
Ele	evation-c	depende	nt weight	ing	N	one 👻				
					1	1				
						Rer^un 14	-	-		
> User: I_b	ern52 Camp	aign: \${P}	'INTRO \$Y+	0=2010 \$S+0)=2070 F	ile: gpfs/home	fs/aiub/l_l	pern52/G	PSUSER/PA	N/GPSEST.INP

Bernese GNSS	Software Version 5.2									- • •
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
GPSES	ST 3.2: G	eneral	Options 2	2						
A PRI	ORI TROP	OSPHERE	MODELING	;						
ZPI) model a	nd mapp	ing funct	ion	DRY MENI	GMF DES-PAVLIS		GNSS SLR		
HANDI	JING OF A	MBIGUIT	IES							
So. Coi Sat In	ve resolv troduce w	uities S quart ed ambi idelane	for er-cycle	3	NONI ALL IF	INDICATED	r F			
SPECI	AL PROCE	SSING C	PTIONS							
St	op progra	m after	NEQ savi	ing						
Ac	ivate ex	tended	program o	output						
						Rer^un ^+l : /home/bern5			N/GPSEST.I	NP 🥻

We want to put loose constraints on the station coordinates that are available from the IGS realization of ITRF2014 reference frame (flag I like IGS14 in the coordinate file).

📕 Bernese GNSS So	oftware Version	5.2								
Configure	Campaig	n RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
GPSES	T 4: Da	atum Defi	inition fo	or Static	n Coord	dinates				
DATUM	DEFIN	ITION TYP	PE							
С	Fr∈	e networ	k solutio	n						
c	Coc	ordinates	constrai	ned		WITH FLAG	÷ •	1		
c	Coc	ordinates	fixed			MANUAL	¥	İ		
A PRI	ORI SI	GMAS								
Nor	th	0.01	mete	rs						
Eas	t	0.01	mete	rs						
Up		0.01	mete	rs						
^Top ^Pr	rev ^Ne	kt Cance^l	Save^As ^	Save ARun	^Output	Rer^un ^+	Day ^-Da	iy		
> User: bern	152 Camp	paign: \${P}/IN	NTRO \$Y+0=	2010 \$S+0=	2070 Fil	e: /home/bern5	2/GPSUS	ER52/PA	N/GPSEST.	INP



No parameters (not even ambiguity parameters) can be pre–eliminated if residuals should be written into the residual output file:

Bernese GNSS Software Version 5.2			- 0 ×
Configure Campaign RINEX Orbits/EOP Processing Ser	rvice Conversion	BPE User Help	
GPSEST 5.1: Setup of Parameters and Pre-	Elimination 1		
STATION-RELATED PARAMETERS	Setup	Pre-Elimination	
Station coordinates		NO	-
Ambiguities		NO	*
ATMOSPHERIC PARAMETERS			
	-		
Site-specific troposphere parameters	P	NO	-
Global ionosphere parameters		NO	×
GLOBAL PARAMETERS			
Orbital parameters	Г	NO	-
Earth orientation parameters		NO	
Geocenter coordinates		NO	~
EPOCH PARAMETERS			
Receiver clock offsets		EVERY EPOCH	*
Satellite clock offsets		EVERY EPOCH	Ψ.
Kinematic coordinates		EVERY EPOCH	÷
Stochastic ionosphere parameters		EVERY EPOCH	Ψ.
^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^C) utput Rer^un ^+C	Day ^-Day	
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070			

Bernese GNSS Software Version 5.2	- ·			- • •
Configure Campaign RINEX Orbits/EOP Processing Service	Conversion	BPE Us	ser Help	
GPSEST 5.2: Setup of Parameters and Pre-Eli	mination 2			
BIAS PARAMETERS	Setup	Pr	e-Elimir	nation
Differential code biases		NO		*
GLONASS receiver clock biases		NO		*
GNSS-specific translation parameters		NO		Y
ANTENNA PHASE CENTER PARAMETERS	_			
Satellite phase center offsets		NO		*
Satellite phase center variations		NO		*
Receiver phase center offsets		NO		*
Receiver phase center variations		NO		Y
PARAMETER SCALING FACTORS				
Scaling related to loading effects	_	NO		
Higher-order ionosphere scaling		NO		<u> </u>
nigher-order tonosphere scaring	I	INO		
SLR-RELATED PARAMETERS				
Range biases		NO		T.
	·	1		
TIME OFFSET FOR PARAMETER INTERVALS			(hhh mm ss)
		1		
] ^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Outpu	t Rer^un ^+	Day ^-Day		
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 Fi	le: /home/bern5	2/GPSUSER5	52/PAN/GPS	EST.INP
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 Fi	le: /home/bern5	2/GPSUSER5	52/PAN/GPS	EST.INP //

emese GNSS Software Version 5.2 Infigure Campaign RINEX Orbits/EOP P	rocessing Service Conversio	on BPE	User	Help	
GPSEST 6.1.1: Site-Specific Tro	oposphere Parameters	1			
ZENITH PATH DELAY PARAMETERS					
Mapping function	WET GMF ·				
Parameter spacing	04 00 00 (hh	mm ss)			
HORIZONTAL GRADIENT PARAMETERS					
Gradient estimation model	NONE				
Parameter spacing	24 00 00 (hh	mm ss)			
A PRIORI SIGMAS	Absolute		Relat	tive	
Zenith path delay	mete	ers		mete	ers
Horizontal gradients	mete	ers		mete	ers
EXTRACTION OF PARAMETERS FOR TH	ROPOSPHERE SINEX FILE				
Offset (hhh mm	ss) Time res	olution		(hh	mm ss)
Jser: bern52 Campaign: \${P}/INTRO \$Y+0=20	10 \$S+0=2070 File: /home/be	rn52/GPSU	SER52/PAN	N/GPSEST.INP	
Jser: bern52 Campaign: \${P}/INTRO \$Y+0=20 emese 6NSS Software Version 5.2	10 \$S+0=2070 File: /home/be	rn52/GPSU	SER52/PAP	WGPSESTINP	- 0
emere GNSS Software Version 5.2	10 \$S+0=2070 File: /home/be rocessing Service Conversio		User	Help	_ 0
emere GNSS Software Version 5.2	rocessing Service Conversic	on BPE			
ensee 6NSS Software Venion 5.2 Infigure Campaign RINEX Orbits/EOP P	rocessing Service Conversic oposphere Parameters	on BPE			0
enese 0005 Software Vergen 52 nfigure Campaign RINEX Orbits/EOP P GPSEST 6.1.2: Site-Specific Tro STATIONS TO BE EXCLUDED FROM TH Station selection	rocessing Service Conversic oposphere Parameters	on BPE			
mmse 0055100wmWmson52 nfigure Campaign RINEX Orbits/EOP P GPSEST 6.1.2: Site-Specific Tre STATIONS TO BE EXCLUDED FROM TI Station selection Station list from file	rocessing Service Conversio oposphere Parameters ROPOSPHERE ESTINATION	on BPE			
enese 0005 Software Vergen 52 nfigure Campaign RINEX Orbits/EOP P GPSEST 6.1.2: Site-Specific Tro STATIONS TO BE EXCLUDED FROM TH Station selection	rocessing Service Conversic oposphere Parameters ROFOSPHERE ESTIMATION NONE	on BPE			
mmse 0055100wmWmson52 nfigure Campaign RINEX Orbits/EOP P GPSEST 6.1.2: Site-Specific Tre STATIONS TO BE EXCLUDED FROM TI Station selection Station list from file	rocessing Service Conversion oposphere Parameters ROPOSPHERE ESTIMATION NONE	on BPE			
and GNSS10Hwar Varian52 nfigure Campaign RINEX Orbits/EOP P GPSEST 6.1.2: Site-Specific Tra STATIONS TO BE EXCLUDED FROM TI Station selection Station list from file Manual selection STATIONS WITH SPECIAL A FRIORI Station selection	rocessing Service Conversion oposphere Parameters ROPOSPHERE ESTIMATION NONE	on BPE			
energe 005500/www.vecen52 infigure Campaign RINEX Orbits/EOP P GPSEST 6.1.2: Site-Specific Tro STATIONS TO BE EXCLUDED FROM TH Station selection Station list from file Manual selection STATIONS WITH SPECIAL A FRIORI Station selection Station list from file	rocessing Service Conversion oposphere Parameters ROPOSPHERE ESTIMATION NONE	on BPE			-
and GNSS10Hwar Varian52 nfigure Campaign RINEX Orbits/EOP P GPSEST 6.1.2: Site-Specific Tra STATIONS TO BE EXCLUDED FROM TI Station selection Station list from file Manual selection STATIONS WITH SPECIAL A FRIORI Station selection	rocessing Service Conversion oposphere Parameters ROPOSEHERE ESTIMATION NONE	on BPE			. 0
energe 0055500were Venera 52 infigure Campaign RINEX Orbits/EOP P GPSEST 6.1.2: Site-Specific Tre STATIONS TO BE EXCLUDED FROM TH Station selection Station list from file Manual selection STATIONS WITH SPECIAL A FRIORI Station selection Station list from file	rocessing Service Conversion oposphere Parameters ROPOSEHERE ESTIMATION NONE	on BPE		Help	. 0
ance 605510/Ware Veron 52 nfigure Campaign RINEX Orbits/EOP P GPSEST 6.1.2: Site-Specific Trr STATIONS TO BE EXCLUDED FROM TH Station selection Station list from file Manual selection Station selection Station selection Station list from file Manual selection	rocessing Service Conversion oposphere Parameters ROPOSEHERE ESTIMATION NONE	on BPE 2	User	Help	
ance 005300Ware Varian52 nfigure Campaign RINEX Orbits/EOP P GPSEST 6.1.2: Site-Specific Tra STATIONS TO BE EXCLUDED FROM TI Station selection Station list from file Manual selection Station selection Station list from file Manual selection Station list from file Manual selection SPECIAL A PRIORI SIGMAS	rocessing Service Conversion oposphere Parameters NOFOSEHERE ESTINATION NONE SIGMAS	n BPE	User	Help	
more 00051000000 Variants2 nfigure Campaign RINEX Orbits/EOP P GPSEST 6.1.2: Site-Specific Transform STATIONS TO BE EXCLUDED FROM TH Station selection Station list from file Manual selection STATIONS WITH SPECIAL A FRIORI Station selection Station list from file Manual selection SPECIAL A PRIORI SIGMAS Zenith path delay Horizontal gradients	rocessing Service Conversion opposphere Parameters ROPOSEHERE ESTIMATION NONE		User	Help /emeters	
more MUSIONWARY WARANG2 Infigure Campaign RINEX Orbits/EOP P GPSEST 6.1.2: Site-Specific Tra STATIONS TO BE EXCLUDED FROM TH Station selection Station list from file Manual selection Station selection Station list from file Manual selection SPECIAL A PRIORI SIGMAS Zenith path delay	rocessing Service Conversion oposphere Parameters ROPOSPHERE ESTIMATION NONE	n BPE 2 7 	User	/e meters	

A 4 hour resolution in time for the troposphere parameters is sufficient for this purpose:

The program output of GPSEST summarizes all important input options, input data, and reports the estimated results. An important information in the output file is the a posteriori RMS error:

```
A POSTERIORI SIGMA OF UNIT WEIGHT (PART 1):

A POSTERIORI SIGMA OF UNIT WEIGHT : 0.0013 M (SIGMA OF ONE-WAY L1 PHASE OBSERVABLE AT ...

DEGREE OF FREEDOM (DOF) : 72462

CHI**2/DOF : 1.66

...
```

An a posteriori RMS error of about $1.0...1.5 \,\mathrm{mm}$ is expected if elevation–dependent weighting is used. A significant higher RMS error indicates that either your data stems from low–quality receivers, that the data was collected under extremely bad conditions, or that the preprocessing step (MAUPRP and CODSPP) was not successfully performed.

Below you find the section reporting on coordinate estimation. You should check the improvement for the a priori coordinates. If all stations get approximately the same improvement in the order of decimeters, very likely the datum definition failed. Check that you have really selected datum stations.

			A PRIORI VALUE			
	GANP 11515M001	X	3929181.4215	3929181.4183	-0.0032	0.0042
		Y	1455236.8207	1455236.8270	0.0062	0.0041
		Z	4793653.9501	4793653.9485	-0.0016	0.0042
		HEIGHT		746.0131		0.0044
		LATITUDE	49 2 4.971296	49 2 4.971282	-0.0004	0.0040
		LONGITUDE	20 19 22.574398	20 19 22.574740	0.0069	0.0041
107	JOZ2 12204M002		3664880.4810	3664880.4813	0.0004	0.0042
		Y	1409190.6806	1409190.6835	0.0029	0.0041
		Z	5009618.5302	5009618.5337	0.0035	0.0041
		HEIGHT	152.5315	152.5351	0.0036	0.0043
			52 5 52.211587			0.0040
		LONGITUDE	21 1 56.470161	21 1 56.470295	0.0025	0.0040
92	HERT 13212M010	Х	4033460.8497	4033460.8497	0.0000	0.0042
		Y	23537.8898	23537.8977	0.0080	0.0041
		Z	4924318.3145	4924318.3219	0.0074	0.0042
		HEIGHT	83.3341	83.3399	0.0058	0.0044
		LATITUDE	50 52 2.929075	50 52 2.929224	0.0046	0.0040
		LONGITUDE	0 20 3.676778	0 20 3.677186	0.0079	0.0040
276	ZIM2 14001M008	X	4331299.7959			0.0041
		Y	567537.4213 4633133.7767	567537.4272 4633133.7769	0.0059	0.0040
		Z	4633133.7767	4633133.7769	0.0002	0.0041
		HEIGHT	956.4292	956.4237	-0.0055	0.0042
			46 52 37.540239			0.0040
		LONGITUDE	7 27 54.115566	7 27 54.115899	0.0070	0.0040

If the residuals have been stored in the binary residual file (specified in "GPSEST 2.2: Output Files 2") it is possible to have a look to the residuals (program REDISP, "Menu>Service>Residual files>Display residual file").

To screen the residuals automatically use the program RESRMS in "Menu>Service>Residual files >Create residual statistics".

Bernese GNSS Software Version 5.2		_ 0 🔀
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE	User	Help
CREATE RESIDUAL STATISTICS - RESRMS 1: Input/Output Files		
GENERAL FILES Show all general files 🛛 🏲		
INFUT FILES Residual files EDT\$YD+0 RES		
OUTPUT FILES Summary file Residual histogram Edit information file Station observation sigma file SOS		
GENERAL OUTPUT FILES Program output	or or	RMS\$YD+0 OUT ERROR MSG
^Top ^Prev ^Next Cance^l Save^As ^Save ^Run ^Output Rer^un ^+Day ^-D > User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSU3		N/RESRMS.INP

The sampling interval you have previously introduced in option "Sampling interval" in program GPSEST has to be repeated here. RESRMS makes the assumption that the observations between two outliers in the sampled residual file are also bad.

Bernese GNSS Software Version 5.2	
Configure Campaign RINEX Orbits/EOP Processing Service Conversion B	PE User Help
RESRMS 2: Options	
TITLE EXAMPLE: Session \$YSS+0: Residual statistics	
GENERAL OPTIONS	
Frequency to check	
Sampling rate of residual files	30 seconds
DETECT LARGE RESIDUALS	mit
	.004 meters
	.004 meters
	3000 meters
	3000
DETECT BAD DATA	
Minimum continuously observed time interval	51 seconds
Detect ambiguities with few observations	
Minimum number of observations per ambiguity 3	
Sampling rate for counting the observations	seconds
 ATan ADami Abbath Constable ACame ADam AOatant Desture As Des	4 D
↑ Top ^Prev ^Next Cance [®] I Save [®] As ^Save ^Run ^Output Rer [®] un ^+Day	

Bernese GNSS Software Version 5.2				
Configure Campaign RIN	EX Orbits/EOP Processing	Service Conversion	BPE User	Help
RESRMS 3: Residua	al Statistics and Sig	ma Factors		*
OPTIONS FOR RESIL	UAL HISTOGRAM			
Size of histogr	am	50		
Bin width for h	nistogram	0.1 mil	limeters	
STATION OBSERVATI				
*	ement noise from 	MEDIAN	y of resi	duals
Default sigma f	actor	1.00		
Non signa fag	tor Noise larger that	n (m)		
1.41		+ -		
	0.005			
1.73	0.010	+ -		
2.00	0.015	+ -		
				•
	ce^l Save^As ^Save ^Run			
> User: bern52 Campaign: \${	P}/INTRO \$Y+0=2010 \$S+0=	2070 File: /home/bern5	2/GPSUSER52/PA	N/RESRMS.INP

The program output of ${\sf RESRMS}$ (${\rm RESRMS}$ (${\rm RESRMS}$ (${\rm RESRMS}$) provides a nice overview on the data quality.

FIL	E INFORMATION A	ND STATISTIC:						
Num	Station 1	Station 2	Total RMS m	ed.Resi Sigma	numObs	nSat	nDel	
							·	
1	GANP 11515M00	01 JOZ2 12204M002	1.4	0.7	1.2	7611	50	16
	HERT 13212M0:	10 ZIM2 14001M008	1.4	0.8	1.1	7372	51	11
	10011010			010		1012	01	
3	JOZ2 12204M00	02 LAMA 12209M001	1.3	0.7	1.1	7741	50	17
4	JOZ2 12204M00	02 ONSA 10402M004	1.3	0.7	1.0	7368	50	20
	JOZ2 12204M00	02 WSRT 13506M005	1.3	0.8	1.2	4192	30	12
	JUZZ 122041100	52 WBR1 1550011005	1.5	0.0	1.2	4152	50	12
6	JOZ2 12204M00	02 WTZR 14201M010	1.6	0.8	1.2	7460	50	18
7	MATE 12734M00	08 ZIM2 14001M008	1.6	0.8	1.2	6788	51	22

8	PTBB	14234M001	ZIM2	14001M008	1.4	0.8	1.2	3819	32	15
9	TLSE	10003M009	ZIM2	14001M008	1.6	0.8	1.3	7443	52	19
10	WTZR	14201M010	WTZZ	14201M014	1.6	0.7	1.0	7817	51	51
11	WTZR	14201M010	ZIM2	14001M008	1.7	1.0	1.4	7563	51	28
				4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4		0.5		45.40		
12	ZIM2	14001M008	ZIMM	14001M004	0.9	0.5	0.8	4540	31	1
NUMBER	ROFI	EDIT REQUESTS	3: 2	230						

In addition, files containing a summary table ($\{P\}/INTRO/OUT/RMS10207.SUM$) and a histogram ($\{P\}/INTRO/OUT/RMS10207.LST$) of the residuals are available. The most important result file for the data screening is the "Edit information file" ($\{P\}/INTRO/OUT/RMS10207.EDT$), which may be used by the program SATMRK to mark outliers in the observation files ("Menu>Service>Bernese observation files>Mark/delete observations"):

📕 Bernese 6NSS Software Version 5.2
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help
MARK/DELETE OBSERVATIONS - SATMRK 1: Filenames
GENERAL FILES
Show all general files 🛛 🚩
OPTIONS
Desired task EDIT FILE -
Re-initialize ambiguities ALL 🗹 for ALL GNSS 💆
OBSERVATION FILES
Observation type GNSS
Zero diff. code CZH phase PZH both
Single diff. code CSH phase ????\$\$+0 PSH both
Range CZH
GENERAL OUTPUT FILES
Program output Y use SATMRK.Lnn or <u>SATMRK</u> OUT Error messages merged to program output or <u>ERROR</u> MSG
LIFET messages merged to program output of ERROR MSG
TITLE EXAMPLE: Session \$YSS+0: Mark bad observations
ATTEM SESSION VISA-0. Mark bad Observations
, ^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output Rer^un ^+Day _^Day
> User: bern52 Campaign: \${P}/INTRO_\$Y+0=2010_\$S+0=2070_File: /home/bern52/GPSUSER52/PAN/SATMRK.INP
📕 Bernese GNSS Software Version 5.2
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help
SATMRK 2: Manual and File Selection
FILE SELECTION
Edit information file RMS\$YD+0 EDT
hard to a meri
MANUAL SELECTION
Type of change MARK
Frequency L1&L2
Satellite(s) ALL (ALL: all satellites)
From epoch (blank: first observation number)
to epoch (blank: last observation number)
or
@ Observation window
yyyy mm dd hh mm ss yyyy mm dd hh mm ss
Start Cymp gapio Do oo a Trd Cymp gapio Do so so

The program output from SATMRK reports the number of marked observations per base-line:

> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/SATMRK.INP

... SUMMARY OF ACTION IN THE OBS. FILE(S): \${P}/INTRO/OUT/RMS10207.EDT Mea- Observations

^Top | ^Prev | ^Next | Cance^I | Save^As | ^Save | ^Run | ^Output | Rer^un | ^+Day ^-Day

1	Num	Stat:	ion name 1	Stati	on name 2	tyj	pe	mark	unmark	delete	••
	1	GANP	11515M001	JOZ2	12204M002	Р	:	420	0	0	••
•••	2	HERT	13212M010	ZIM2	14001M008	Р	:	300	0	0	
••	3	JOZ2	12204M002	LAMA	12209M001	Р	:	422	0	0	
••	4	JOZ2	12204M002	ONSA	10402M004	Р	:	530	0	0	
••	5	JOZ2	12204M002	WSRT	13506M005	Р	:	370	0	0	
••	6	JOZ2	12204M002	WTZR	14201M010	Р	:	526	0	0	
••	7	MATE	12734M008	ZIM2	14001M008	Р	:	688	0	0	
••		PTBB	14234M001	ZIM2	14001M008	Р	:	326	0	0	
••		TLSE	10003M009	ZIM2	14001M008	Р	:	512	0	0	
•••	10	WTZR	14201M010	WTZZ	14201M014	Р	:	1096	0	0	
••	11	WTZR	14201M010	ZIM2	14001M008	Р	:	874	0	0	
••	12	ZIM2	14001M008	ZIMM	14001M004	Р	:	22	0	0	
· · - ·		Total									• • •
• •		rota.						0000	0	0	
											•

5.2 Produce a First Network Solution

After screening the observations for outliers we can generate an ionosphere–free (L_3) solution with unresolved ambiguities. A detailed discussion on the Troposphere/Ionosphere modeling will be given in a dedicated lecture tomorrow. The input options are very similar to the previous preprocessing step. There are only a few differences shown in the following panels:

Bernese GNSS Software Version 5.2						- 0
Configure Campaign RINEX Orbits/EOP Processi	ng Service	Conversion	BPE	User	Help	
PARAMETER ESTIMATION - GPSEST 1.1:	Input Fil	les 1				
GENERAL FILES AND PROCESSING MODE						
Space geodetic technique	GNSS	•				
Differencing level	DOUBLE					
LEO data processing		_				
Show all general files	F					
OBSERVATION FILES			_			
Phase observations Code observations	2222\$5	+0 PSH	23	??\$S+0		
Range observations		CSH			CZH	
kange opservations		CZH				
MAIN INPUT FILES						
Station coordinates	APR\$YE	+0 CRD				
Satellite standard orbits	COD\$YE	+0 STD				
Earth rotation parameters	COD\$YE	+0 ERP				
Satellite clock corrections		CLK				
Differential code biases		DCB				
Gridded VMF1 coefficients		GRD				
Ionosphere models	COD\$YE	0+0 ION				
CORRECTIONS FOR LOADING EFFECTS AND	CENTER (OF MASS				
Ocean tidal loading	EXAMPI	E BLQ				
Atmospheric tidal loading	EXAMPI					
^Top ^Prev ^Next Cance^I Save^As ^Save ^R	un ^Output	Rer^un +	Day ^-D	ay		
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+	+0=2070 File	e: /home/bern5	2/GPSU	SER52/PA	N/GPSES	T.INP

The file in the input field "lonosphere models" enables the HOI–corrections. We store the coordinates and troposphere parameters into files to be re–introduced later:

Bernese GNSS Software Version 5.2							- 0 💌
Configure Campaign RINEX O	rbits/EOP Processing	Service	Conversion	BPE	User	Help	
GPSEST 2.1: Output Fil	es 1						
GENERAL OUTPUT FILES							
Program output	_ us	e GPSES	T.Lnn		or	FLT\$YD+0	OUT
Error message	me	rged to	program d	output	or	ERROR	MSG
NORMAL EQUATION SYSTEM			NQO				
STATION- AND SATELLITE	-RELATED RESUL	rs					
Station coordinates		FLT\$	YD+0 CRD				
Satellite orbital el	ements		ELE				
Earth rotation param	eters		ERP				
Earth rotation param	eters (IERS)		IEP				
ATMOSPHERE-SPECIFIC RE							
Troposphere estimate		FLT\$	YD+0 TRP				
Troposphere estimate	s (SINEX)		TRO				
Ionosphere models			ION				
Ionosphere models (I	UNEA)		INX				
∬ ^Top │ ^Prev │ ^Next │ Cance^l │ Si > User: bern52 Campaign: \${P}/INTR				•		I/GPSEST.INP	//

In the subsequent panel you should remove the output filename for the "Residuals" because we do not need the residuals from this run.

The next two panels with the general options for GPSEST remain untouched:

PSEST 3.1: General Options 1	
TITLE EXAMPLE: Session \$YSS+0: Firs	
,	st network solution (float)
DESERVATION SELECTION	
Satellite system	ALL
Frequency/linear combination	L3 V
Elevation cutoff angle	5 degrees
Sampling interval	180 seconds
Tolerance for simultaneity	100 milliseconds
Special data selection	NO
Observation window	Г
DESERVATION MODELING AND PARAMETER EST	IMATION
A priori sigma of unit weight	0.001 meters
Elevation-dependent weighting	COSZ -
Type of computed residuals	NORMALIZED
Correlation strategy	BASELINE
LEO-SPECIFIC SELECTION AND MODELING OF	
Elevation cutoff angle	0 degrees
Elevation-dependent weighting	NONE
p ^Prev ^Next Cance^I Save^As ^Save ^Run	
er:I_bern52 Campaign:\${P}/INTRO \$Y+0=2010 \$S+0:	=2070 File: gpfs/homefs/aiub/l_bern52/GPSUSER/PAN/GPSES
ese GNSS Software Version 5.2	
igure Campaign RINEX Orbits/EOP Processing	Service Conversion BPE User Help
GPSEST 3.2: General Options 2	
A PRIORI TROPOSPHERE MODELING	
ZPD model and mapping function	DRY GMF . for GNSS
	MENDES-PAVLIS 🖌 for SLR
INDUTIO OF INDICUTEERS	
HANDLING OF AMBIGUITIES Resolution strategy	NONE
Solve ambiguities for	ALL
	IF INDICATED
	TT THOTOGIDD
Consider GPS quarter-cycle biases	
Consider GPS quarter-cycle biases Save resolved ambiguities	
Consider GPS quarter-cycle biases Save resolved ambiguities Introduce widelane integers Introduce L1 and L2 integers	
Consider GPS quarter-cycle biases Save resolved ambiguities Introduce widelane integers Introduce L1 and L2 integers SPECIAL PROCESSING OPTIONS	
Consider GPS quarter-cycle biases Save resolved ambiguities Introduce widelane integers	
Consider GPS quarter-cycle biases Save resolved ambiguities Introduce widelane integers Introduce L1 and L2 integers SPECIAL PROCESSING OPTIONS Stop program after NEQ saving	

To heavily constrain the coordinates of the IGS core sites is not the best way to realize the geodetic datum for a solution. The program ADDNEQ2 offers more sophisticated options (e.g., minimum constraint solution). Today we will follow this simple approach:

Bernese GNSS So	oftware Version 5.2									
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
GPSES	r 4: Dat	um Defi	nition fo	r Statio	n Coord	linates				
			_							
DATUM	DEFINIT	TON TAF	Έ							
С	Free	networ	k solutio	n						
c	Coor	dinates	constrai	ned		WITH FLAG		1		
c	Coor	dinates	fixed			MANUAL		i		
						1		1		
A PRIC	DRI SIGM	IAS								
Nor	th	0.003	1 mete	rs						
Eas	t	0.003	1 mete	rs						
Up		0.00	1 mete	rs						
		,								
^Top ^Pr	ev ^Next	Cance ⁴	Save^As ^	Save ARun	^Output	Rer^un ^+I	Day ^-Da	ay		
> User: bern	52 Campa	ian: \${P}/IN	TRO \$Y+0=	2010 \$S+0=	2070 File	e: /home/bern5	2/GPSUS	ER52/PA	N/GPSEST	INP

Since we do not store residual files in this run, ambiguity parameters may be pre–eliminated from the normal equation before the parameters are estimated:

📕 Bernese GNSS S	oftware Version 5.2										- 0 -
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help		
GPSES	т 5.1: s	etup of	Paramete	ers and P	re-Elin	mination 1					
	ON-RELATI					Setup		Pre-E	liminat	ion	
	tion coo		S				NO				•
Amb	iguities						EVE	RY SES	SION		•
ATMOS	PHERIC PA	ARAMETE	RS								
Sit	e-specif	ic trop	osphere p	barameter	s	7	NO				•
Glo	bal iono	sphere	parameter	3			NO				*
GLOBA	L PARAME'	TERS									
	ital par						NO				~
			parameter	:3			NO				¥
Geo	center c	oordina	tes				NO				*
EPOCH	PARAMETI	ERS									
Rec	eiver cl	ock off	sets				EVE	RY EPC	CH		¥
Sat	ellite c	lock of	fsets				EVE	RY EPC	CH		÷
Kin	ematic c	oordina	tes				EVE	RY EPC	CH		~
Sto	chastic	ionosph	ere para	neters			EVE	CRY EPC	CH		Y
^ ^Top ^P	rev ^Next	Cance ^{*I}	Save^As ^	Save ^Run	^Output	Rer^un *+	Day ^-Da	ау			
> User: berr	n52 Campaig	gn: \${P}/IN	TRO \$Y+0=	2010 \$S+O=	2070 File	: /home/bern5	2/GPSUS	SER52/PA	N/GPSES	T.INP	

The estimation of troposphere parameters is mandatory for a campaign of this type. We increase the number of estimated parameters (e.g., to 24 instead of 6 parameters per station and session). In addition, it is recommended to set up troposphere gradient parameters.

In order to avoid a format overflow in the "Troposphere estimates" output file that may happen if a troposphere parameter is estimated based on very few observations concentrated at one end of the interval of parameter validity, a small relative sigma (e.g., 5 meter) may help.

📕 Bernese GNSS	Software Version 5.2									- • •
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
GPSE	ST 6.1.1:	Site-S	pecific T	roposphe	re Para	meters 1				
ZENI	TH PATH D	ELAY PA	RAMETERS							
Maj	pping fun	ction		[WET GME	•				
Pa	rameter s	pacing		F	01 00 0	0 (hh mm	. ss)			
Gr	ZONTAL GR adient es rameter s	timatio			CHENHER 24 00 0		. 38)			
A PR	IORI SIGM	AS		7	bsolut	e		Rela	ntive	
Ze	nith path	delay		Г				5		meters
Ho	rizontal	gradier	nts	İ		meters		5		meters
	ACTION OF	PARAME				JEX FILE 'ime resol'	ution		_	(hh mm ss)
] ^Top ^Prev ^Next Cance'l Save'As ^Save ^Run ^Output Rer^un ^+Day ^-Day > User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/GPSEST.INP									

In the first part of the output generated by program GPSEST, the selected options are echoed. The result part starts with some statistics on the parameters and the observations:

```
. . .
13. RESULTS (PART 1)
 - - -
NUMBER OF PARAMETERS (PART 1):
                               #PARAMETERS #PRE-ELIMINATED #SET-UP ...
PARAMETER TYPE
             39

        STATION COORDINATES
        39
        0
        39

        AMBIGUITIES
        1369
        1369
        (BEFORE INV)
        1481

        SITE-SPECIFIC TROPOSPHERE PARAMETERS
        377
        0
        377

                                                                            . . .
                                                                           · · · ·
· · ·
                      S 1785 1369 1897 ...
TOTAL NUMBER OF PARAMETERS
                                              -----
NUMBER OF OBSERVATIONS (PART 1):
 TYPE
          FREQUENCY FILE/PAR #OBSERVATIONS
    ------
                          ALL 73602
PHASE
            1.3
                       TOTAL NUMBER OF OBSERVATIONS
                                 73602
```

Then the a posteriori RMS error and the results of the initial least–squares adjustment are given

Below you find the output of the results for coordinates and troposphere parameters:

 STAT 	ION COORDINATES:		\${P}/INTRO	/STA/FLT10207.CRE)	
NUM	STATION NAME	PARAMETER	A PRIORI VALUE	NEW VALUE		RMS ERROR
75	GANP 11515M001	X Y Z	3929181.4215 1455236.8207 4793653.9501		0.0008	
		HEIGHT LATITUDE	746.0149 49 2 4.971296	746.0136 49 2 4.971309	-0.0013 0.0004	0.0009
•••		LONGITUDE	20 19 22.574398	20 19 22.574460	0.0013	0.0007
107	J0Z2 12204M002	X Y Z	3664880.4810 1409190.6806 5009618.5302	1409190.6787		0.0007 0.0006 0.0007
		HEIGHT	152.5315	152.5318		0.0008
		LATITUDE LONGITUDE	52 5 52.211587 21 1 56.470161		0.0035	0.0005
 92	HERT 13212M010	X Y	4033460.8497 23537.8898		0.0002	

	Z	4924318.3145	4924318.3167	0.0022	0.0007
	HEIGHT	83.3341	83.3359	0.0018	0.0009
	LATITUDE	50 52 2.929075	50 52 2.929114	0.0012	0.0005
•••	LONGITUDE	0 20 3.676778	0 20 3.676679	-0.0019	0.0007

SITE-SPECIFIC TROPOSPHERE PARAMETERS: \${P}/INTRO/ATM/FLT10207.TRP	
REFERENCE ELEVATION ANGLE OF GRADIENT TERMS : 45.0 DEGREES	
MINIMUM ELEVATION ANGLE : 5.0 DEGREES	
MAPPING FACTOR AT MINIMUM ELEVATION ANGLE : 11.4	
CORRECTIONS (M) RMS ERRORS (M)	
REQU. STATION NAME NORTH EAST ZENITH NORTH EAST ZENITH	
1 GANP 11515M001 -0.00024 -0.00019 0.12103 0.00011 0.00013 0.00226	
2 GANP 11515M001 -0.00021 -0.00015 0.11639 0.00011 0.00012 0.00167	
3 GANP 11515M001 -0.00018 -0.00010 0.11814 0.00010 0.00011 0.00156	
4 GANP 11515M001 -0.00015 -0.00006 0.12171 0.00009 0.00010 0.00160	
5 GANP 11515M001 -0.00012 -0.00001 0.12203 0.00009 0.00010 0.00129	
24 GANP 11515M001 0.00044 0.00085 0.13680 0.00011 0.00012 0.00181	
25 GANP 11515M001 0.00047 0.00090 0.12869 0.00012 0.00013 0.00224	
26 HERT 13212M010 -0.00142 -0.00190 0.19943 0.00013 0.00015 0.00299	
27 HERT 13212M010 -0.00135 -0.00181 0.19841 0.00012 0.00014 0.00153	
28 HERT 13212M010 -0.00127 -0.00172 0.18943 0.00011 0.00014 0.00187	
29 HERT 13212M010 -0.00120 -0.00163 0.19009 0.00011 0.00013 0.00178	
30 HERT 13212M010 -0.00113 -0.00154 0.19263 0.00010 0.00012 0.00149	

Because outliers have been removed in the previous step, the obtained a posteriori RMS error should decrease (at least not increase). If this is not the case, it is likely that the observations and the heavily constrained a priori coordinates are inconsistent.

5.3 Ambiguity Resolution

To resolve the ambiguities, we process the baselines separately one by one using the Quasi– Ionosphere–Free (QIF) strategy. This baseline processing mode is necessary because of the tremendous number of parameters. The attempt to resolve the ambiguities in a session solution might require too much CPU and memory to be feasible (several iterations with inversions of the full normal equation (NEQ) are necessary).

5.3.1 Ambiguity Resolution: Quasi-Ionosphere-Free (QIF)

The complete list of baseline observation files of a session (e.g., session 2070 of year 2010) can be generated by listing all phase single–difference header files in the campaign's observation directory of your campaign:

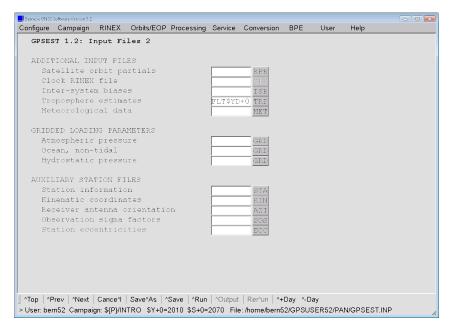
```
bern52@carina:~ > ls ${P}/INTRO/OBS/???2070.PSH
${P}/INTRO/OBS/GAJ02070.PSH
${P}/INTRO/OBS/JOLA2070.PSH
${P}/INTRO/OBS/JOLA2070.PSH
${P}/INTRO/OBS/JOW2070.PSH
${P}/INTRO/OBS/JOW2070.PSH
${P}/INTRO/OBS/JOW2070.PSH
${P}/INTRO/OBS/JOW22070.PSH
${P}/INTRO/OBS/JOW22070.PSH
${P}/INTRO/OBS/MAZI2070.PSH
${P}/INTRO/OBS/MAZI2070.PSH
${P}/INTRO/OBS/MAZI2070.PSH
${P}/INTRO/OBS/TZI2070.PSH
${P}/INTRO/PS/PX
```

```
${P}/INTRO/OBS/WTWZ2070.PSH
${P}/INTRO/OBS/WTZI2070.PSH
${P}/INTRO/OBS/ZIZM2070.PSH
```

The first baseline for this session is from GANP to JOZ2 with the observation filename GAJ02070. Using the menu time variables this name is specified as GAJ0\$S+0. The following options are used for the ambiguity resolution step:

Bernese GNSS Software Version 5.2 Configure Campaign RINEX Orbits/EOP Processir	- Service Conversion	BPE User I	- • •
	-	BPE User I	Help
PARAMETER ESTIMATION - GPSEST 1.1:	Input Files 1		
GENERAL FILES AND PROCESSING MODE			
Space geodetic technique	GNSS -		
Differencing level	DOUBLE -		
LEO data processing			
Show all general files	Y		
OBSERVATION FILES			
Phase observations	GAJOSS+0 PSH	2222\$S+0 E	17.17
Code observations	CSH		ZH
Range observations	CZH	<u> </u>	
	Contraction of the second seco		
MAIN INPUT FILES			
Station coordinates	FLT\$YD+0 CRD		
Satellite standard orbits	COD\$YD+0 STD		
Earth rotation parameters	COD\$YD+0 ERP		
Satellite clock corrections	CLK		
Differential code biases	DCB		
Gridded VMF1 coefficients	GRD		
Ionosphere models	COD\$YD+0 ION		
CORRECTIONS FOR LOADING EFFECTS AND			
Ocean tidal loading	EXAMPLE BLQ		
Atmospheric tidal loading	EXAMPLE ATL		
 ^Top ^Prev ^Next Cance^I Save^As ^Save ^R	un ^Output Rer^un ^+	Day ^-Day	
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+			
- Oser, benioz, Ganipaigh, \${F}/INTRO, \$1+0-2010, \$0+	0-2070 The Monteberna	2/01/0002/FAN/	GFSEST.INF //

Only one baseline file is selected. Coordinates and troposphere estimates are introduced from the previous first network solution (Section 5.2).



Specify a baseline specific output to prevent overwriting in subsequent runs: GAJO\$+0Q. The Q at the end shall indicate that it is the output from the QIF-strategy.

Bernese GNSS Software Version 5.2							- 0 ×
Configure Campaign RINEX Orbits/EOP P	Processing	Service	Conversion	BPE	User	Help	
GPSEST 2.1: Output Files 1							
GENERAL OUTPUT FILES							
Program output	🔲 use	GPSES	T.Lnn		or	GAJO\$+0Q	OUT
Error message	∏ mer	ged to	program d	output	or	ERROR	MSG
NORMAL EQUATION SYSTEM			NQO				
STATION- AND SATELLITE-RELATED	RESULT:	s					
Station coordinates			CRD				
Satellite orbital elements			ELE				
Earth rotation parameters			ERP				
Earth rotation parameters (I	ERS)		IEP				
ATMOSPHERE-SPECIFIC RESULTS							
Troposphere estimates			TRP				
Troposphere estimates (SINEX	()	Í	TRO				
Ionosphere models			ION				
Ionosphere models (IONEX)			INX				
		,					
^Top ^Prev ^Next Cance^I Save^As ^Sa	ave ^Run	^Output	Rer^un ^+	Day ^-Da	Y		
> User: bern52 Campaign: \${P}/INTRO \$Y+0=20				•	-	VGPSEST.INP	li.

Because the QIF–ambiguity resolution strategy is very sensitive to the formal errors of the ambiguity parameters we have to include all measurements with the full sampling of $30 \, \text{s}$ into the processing.

Bernese GNSS Software Version 5.2	- •
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help	
GPSEST 3.1: General Options 1	
TITLE EXAMPLE: Baseline GAJO\$S+0: QIF ambiguity resolution	
OBSERVATION SELECTION	
Satellite system ALL	
Frequency/linear combination	
Elevation cutoff angle 10 degrees	
Sampling interval 30 seconds	
Tolerance for simultaneity 100 milliseconds	
Special data selection NO	
Observation window	
OBSERVATION MODELING AND PARAMETER ESTIMATION	
A priori sigma of unit weight 0.001 meters	
Elevation-dependent weighting	
Type of computed residuals NORMALIZED	
Correlation strategy BASELINE	
based in the second sec	
LEO-SPECIFIC SELECTION AND MODELING OPTIONS	
Elevation cutoff angle 0 degrees	
Elevation-dependent weighting NONE	
] ^Top ^Prev ^Next Cance*I Save*As *Save *Run *Output Rer*un *+Day *-Day	
>User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/GPSEST.	INP //

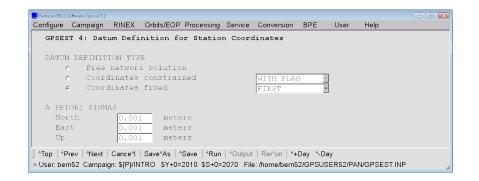
The selection of a "ZPD model and mapping function (GNSS)" is disabled because a troposphere file has been introduced in panel "GPSEST 1.2: Input Files 2". The program uses the troposphere model from this input file and allows no other selection for consistency reasons.

In the subsequent panel the "Resolution strategy" is chosen. Please, do not forget to store the resolved integer ambiguities in your observation file (mark checkbox at "Save resolved ambiguities").

📕 Bernese GNSS	Software Version 5.2									- 0 -
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
GPSES	ST 3.2: G	eneral	Options 2	2						
A PRI	ORI TROP	OSPHERE	MODELING	;						
ZPI) model a	nd mapp	oing funct	tion		GMF DES-PAVLIS		GNSS SLR		
HANDI	JING OF A	MBIGUIT	IES							
Res	solution	strateg	īΣ		QIF		•			
Sol	lve ambig	uities	for		ALL		-			
Cor	nsider GP	S quart	er-cycle	biases	IF :	INDICATED	•			
Sat	ve resolv	ed ambi	iguities		~		_			
Int	croduce w	idelane	e integers	3						
Int	roduce L	1 and I	.2 integer	8						
SPECI	AL PROCE	SSING C	PTIONS							
Sto	op progra	m aftei	: NEQ sav:	ing						
Act	civate ex	tended	program (output						
 ^Top ^F	rev Allevt	CanceA	Save^As ^	Save ARun		Rer^un /+I	ີງav_^-Dav	,		
						e: /home/bern5			N/GPSEST.IN	> //

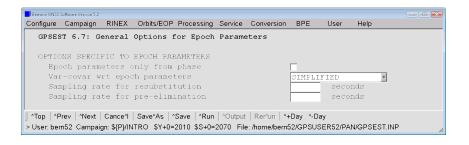
In case of ambiguity resolution including GLONASS, only one ambiguity per iteration can be resolved. The program will adjust the setting automatically issuing a warning message.

						Conversion		User	Help	
PSEST	3.2.4:	Quasi-	Ionospher	e-Free A	mbiguit	y Resolut	ion Sti	rategy		
PTIONS	S AND CI	RITERIA	FOR TEST	ING						
Maxir	mal num	per of	ambiguiti	es fixed	l per it	eration s	step	1	181	
Sear	ch widt!	n for p	airs of I	.1 and L2	ambiqu	ities		0.	50 WL	cycles
		na of r	esolvable	NL ambi	quities	3		0.	03 NL	cycles
Maxir	mal sici									
	-			resolvab	le NL a	ambiquitie	es	0.	10 NL	cvcles
	-			resolvab	le NL s	ambiguitie	es	0.	10 NL	cycles
	-									



Bernese GNSS Software Version 5.2					- 0 💌
Configure Campaign RINEX Orbits/EOP Processing Service	Conversion	BPE L	Jser	Help	
GPSEST 5.1: Setup of Parameters and Pre-Eli	mination 1.				
STATION-RELATED PARAMETERS	Setup	D	ro-Fl	imination	
Station coordinates	n e e alb	NO	1 - 11 -		-
Ambiguities		NO			•
ATMOSPHERIC PARAMETERS					
Site-specific troposphere parameters		NO			~
Global ionosphere parameters		NO			Y
GLOBAL PARAMETERS					
Orbital parameters		NO			~
Earth orientation parameters		NO			v
Geocenter coordinates		NO			r
EPOCH PARAMETERS					
Receiver clock offsets		EVERY	EPOC	Ή	*
Satellite clock offsets		EVERY	EPOC	CΗ	*
Kinematic coordinates		EVERY	EPOC	Ή	¥
Stochastic ionosphere parameters	M	EVERY	EPOC	CΗ	•
∬ ^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output					
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 F	ile: /home/bern52	2/GPSUSER	852/PAN	V/GPSEST.INP	//

An additional panel with options specific to epoch–parameters is displayed now because the "Parameter Setup: stochastic ionosphere parameters" are pre-eliminated EV-ERY_EPOCH.



Bemese GNSS Software Version 5.2	- • •
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE Us	ser Help
GPSEST 6.10: Stochastic Ionosphere Parameters	
STOCHASTIC IONOSPHERE PARAMETERS	
Elimination of reference ionosphere parameters	
Elevation-dependent parameter constraining	
Absolute a priori sigma on single difference level 0.	.25 meters
Relative a priori sigma of ionospheric random walk	m/min**1/2
^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output Rer^un ^+Day ^-Day	
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER5	2/PAN/GPSEST.INP

After reporting input options and input data for the current run of GPSEST, the results are presented in two parts. The first part refers to the solution where the ambiguities are estimated as real values whereas the second part reports the results after resolving the ambiguity parameters to integer values. The real-valued estimates for the ambiguities may be found below the STATION COORDINATES section of the program output: ... 13. RESULTS (PART 1) _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ . NUMBER OF PARAMETERS (PART 1): #PARAMETERS #PRE-ELIMINATED #SET-UP ... PARAMETER TYPE _____
 3
 0
 3
 ...

 196
 0
 242
 ...

 40364
 40364
 (EPOCH-WISE)
 45454
 ...
 STATION COORDINATES AMBIGUITIES STOCHASTIC IONOSPHERE PARAMETERS _____ OF PARAMETERS 40563 40364 45699 ... TOTAL NUMBER OF PARAMETERS ----NUMBER OF OBSERVATIONS (PART 1): -----TYPE FREQUENCY FILE/PAR #OBSERVATIONS _____ ALL 37484 ALL 37484 PHASE L1 PHASE L2 -----TOTAL NUMBER OF OBSERVATIONS 74968 . . .

```
A POSTERIORI SIGMA OF UNIT WEIGHT (PART 1):

A POSTERIORI SIGMA OF UNIT WEIGHT : 0.0011 M (SIGMA OF ONE-WAY L1 PHASE OBSERVABLE AT ...

DEGREE OF FREEDOM (DOF) : 34405

CHI**2/DOF : 1.18

...
```

 STAT	ION COORDINATES:		\${P}/INTRO)/STA/FLT10207.CRI)	
NUM	STATION NAME	PARAMETER	A PRIORI VALUE	NEW VALUE	NEW- A PRIORI	RMS ERROR
107	J0Z2 12204M002	X Y	3664880.4789 1409190.6787	3664880.4791 1409190.6784	0.0003	0.0002
		Z HEIGHT	5009618.5326 152.5318	5009618.5331 152.5323	0.0005	0.0002
		LATITUDE LONGITUDE	52 5 52.211702 21 1 56.470106	52 5 52.211710 21 1 56.470086	0.0002	0.0001 0.0002

• • •												
AMBIG	UITIES	5:										
		-										
							REFE	RENCE				
AMBI	FILE	SAT.	EPOCH	FRQ	WLF	CLU	AMBI	CLU	AMBIGUITY	RMS	TOTAL AMBIGU.	DL/L
1	1	3	2199	1	1	3	-	-	1.07	21.81	1747244.07	
2	1	11	1	1	1	4	-	-	2.12	21.81	-120949.88	
3	1	11	2613	1	1	6	-	-	-3.84	21.81	-120952.84	
4	1	14	1	1	1	7	-	-	1.74	21.81	-484082.26	
5	1	14	1478	1	1	8	-	-	-0.67	21.81	-484244.67	
6	1	14	2569	1	1	9	-	-	1.17	21.81	-484299.83	
7	1	17	1	1	1	10	-	-	3.38	21.81	-1280029.62	
8	1	17	1111	1	1	11	-	-	-1.90	21.81	-1280192.90	
9	1	19	1	1	1	13	-	-	2.64	21.81	1400087.64	
10	1	19	897	1	1	14	-	-	0.38	21.82	1400165.38	
11	1	19	2337	1	1	15	-	-	-2.80	21.81	1400190.20	
12	1	20	1	1	1	16	-	-	2.31	21.81	757891.31	

If GLONASS data are processed, single–difference (instead of double–difference) ambiguities are resolved and no — REFERENCE — as in case of GPS–only appears.

In the next part of the output the result of the QIF ambiguity resolution algorithm is given:

AMBIGUITY RESOLUTION: STRATEGY : QUASI-IONOSPHERE-FREE AMBIGUITY RESOLUTION (QIF) AMBIGUITY RESOLUTION ITERATION: 1 BEST INT. CORRECTIONS FILE AM1 CL1 #AM1 AM2 CL2 #AM2 L1 L2 L1 L2 CORRECTIONS IN CYCLES L5 L3 RMS(L3) SA1 SA2 1 89 106 1 94 112 1 -4 -3 -0.03 -0.04 0.009 0.002 0.003 27 9 _____ AMBIGUITY RESOLUTION ITERATION: 2 _____ BEST INT. CORRECT. I.2 L1 L2 CORRECTIONS IN CYCLES FILE AM1 CL1 #AM1 AM2 CL2 #AM2 L1 L2 L1 L2 L5 L3 RMS(L3) SA1 SA2 1 18 22 1 82 97 1 0 1 0.09 0.11 -0.022 0.009 0.003 24 6 AMBIGUITY RESOLUTION ITERATION: 3 BEST INT. CORRECTIONS IN CY FILE AM1 CL1 #AM1 AM2 CL2 #AM2 L1 L2 L1 L2 L5 CORRECTIONS IN CYCLES L3 RMS(L3) SA1 SA2 1 1 3 1 82 97 2 -1 -1 -0.02 -0.03 0.006 -0.002 0.003 3 6 _____ AMBIGUITY RESOLUTION ITERATION: 4 BEST INT. CORRECTIONS IN C FILE AM1 CL1 #AM1 AM2 CL2 #AM2 L1 L2 L1 L2 L5 CORRECTIONS IN CYCLES L5 L3 RMS(L3) SA1 SA2 -----1 16 20 1 82 97 3 -4 -2 -0.08 -0.10 0.021 -0.005 0.003 22 6 _____ AMBIGUITY RESOLUTION ITERATION: 5 _____ CORRECTIONS IN CYCLES BEST INT. L1 L2 L5 FILE AM1 CL1 #AM1 AM2 CL2 #AM2 L1 L2 L3 RMS(L3) SA1 SA2 1 11 15 1 82 97 4 -5 -3 0.13 0.18 -0.043 -0.021 0.003 19 6 AMBIGUITY RESOLUTION ITERATION: 54 -----BEST INT. CORRECTIONS IN CYCLES FILE AM1 CL1 #AM1 AM2 CL2 #AM2 L1 L2 L1 L2 L5 L3 RMS(L3) SA1 SA2 -2 -3 0.22 0.31 -0.086 -0.079 1 70 82 3 71 83 1 0.009 111 111 _____ AMBIGUITY RESOLUTION ITERATION: 55 BEST INT. CORRECTIONS IN CYCLES FILE AM1 CL1 #AM1 AM2 CL2 #AM2 L1 L2 L1 L2 L5 I L3 RMS(L3) SA1 SA2 1 25 29 1 66 77 3 6 5 -0.05 -0.06 0.014 0.001 0.009 105 101

The individual iteration steps are first described (we specified that only one ambiguity may be resolved within each iteration step — see panel "GPSEST 3.2.4: Quasi-Ionosphere-Free Ambiguity Resolution Strategy"). The following information is listed for each resolved double-difference ambiguity:

FILE file number (1 in our case; we process one baseline only),

- AM1 first ambiguity number (single-difference level),
- CL1 corresponding ambiguity cluster,
- #AM1 number of ambiguities belonging to the same cluster,

AM2, CL2, #AM2

similar information for the second ambiguity.

BEST INT. L1, L2

are the integer corrections to the a priori values (a priori values are computed using the a priori coordinates and may be rather inaccurate).

CORRECTIONS IN CYCLES

for carriers L1 and L2 gives the information about the fractional parts of the L_1 and L_2 ambiguities. The CORRECTIONS IN CYCLES L5 and L3 are of greater interest. The value L5 represents the ionosphere-induced bias expressed in L_5 cycles. These values may not be greater than the maximum value specified in panel "GPSEST 3.2.4: Quasi-lonosphere-Free Ambiguity Resolution Strategy" (option "Search width for pairs of L1 and L2 ambiguities"). RMS(L3) is the criterion according to which the ambiguities are sorted. Ambiguities with L_3 RMS errors larger than the value specified in the program input panel (in our example 0.03) will not be resolved.

SA1, SA2

first and second satellite number related to the ambiguities. Note that in AM-BIGUITY RESOLUTION ITERATION: 65 and 66 there are examples for resolving pairs of ambiguities from the same satellite (path-to-path ambiguity resolution) — GLONASS satellites 114, and 119.

•••							REFE	RENCE				
AMBI	FILE	SAT.	EPOCH	FRQ	WLF	CLU			AMBIGUITY	RMS	TOTAL AMBIGU.	DL/L
1	1	3	2199	1	1	3	-	-	- 1		1747242.	0.00000
2	1	11	1	1	1	4	-	-	1		-120951.	0.00000
3	1	11	2613	1	1	6	-	-	0		-120949.	0.00000
4	1	14	1	1	1	7	-	-	5		-484079.	0.00000
5	1	14	1478	1	1	8	-	-	3		-484241.	0.00000
6	1	14	2569	1	1	9	-	-	5		-484296.	0.00000
7	1	17	1	1	1	10	-	-	5		-1280028.	0.00000
8	1	17	1111	1	1	11	-	-	-1.83	22.57	-1280192.83	
9	1	19	1	1	1	13	-	-	7		1400092.	0.00000
10	1	19	897	1	1	14	-	-	0.47	22.57	1400165.47	
11	1	19	2337	1	1	15	-	-	- 5		1400188.	0.00000
12	1	20	1	1	1	16	-	-	1		757890.	0.00000
13	1	20	2770	1	1	17	-	-	6		757842.	0.00000
14	1	22	1	1	1	18	-	-	1.30	22.59	-893533.70	
15	1	22	1248	1	1	19	-	-	6		-893514.	0.00000
16	1	22	2254	1	1	20	-	-	-4		-893533.	0.00000
17	1	24	1	1	1	21	-	-	5		427188.	0.00000
18	1	24	2196	1	1	22	-	-	0		427032.	0.00000
19	1	28	1	1	1	23	-	-	1.75	22.60	-394055.25	
20	1	28	782	1	1	24	-	-	-4		-394018.	0.00000

The following table summarizes the results of the ambiguity resolution: The ambiguities for which an RMS is specified could not be resolved (these ambiguities will be treated as real values by all subsequent program runs). In case of GLONASS, only ambiguities with the same channel number are resolved in Version 5.2 of *Bernese GNSS Software*.

Ambiguity resolution has an influence on other parameters. Therefore, the results of the ambiguity–fixed solution are given in Part 2 of the output:

14. RESULTS (PART 2) NUMBER OF PARAMETERS (PART 2): PARAMETER TYPE **#PARAMETERS #PRE - ELIMINATED** #SET-UP ... STATION COORDINATES 3 0 3 242 AMBIGUITIES 66 0 40364 STOCHASTIC IONOSPHERE PARAMETERS 40364 (EPOCH-WISE) 45454 40433 TOTAL NUMBER OF PARAMETERS 40364 45699 ... ----- ... NUMBER OF OBSERVATIONS (PART 2): TYPE FREQUENCY FILE/PAR #OBSERVATIONS . . . PHASE L1 ALL 37484 PHASE L2 ALL 37484 TOTAL NUMBER OF OBSERVATIONS 74968 . . .

```
A POSTERIORI SIGMA OF UNIT WEIGHT (PART 2):

A POSTERIORI SIGMA OF UNIT WEIGHT : 0.0011 M (SIGMA OF ONE-WAY L1 PHASE OBSERVABLE AT ...

DEGREE OF FREEDOM (DOF) : 34535

CHI**2/DOF : 1.27

...
```

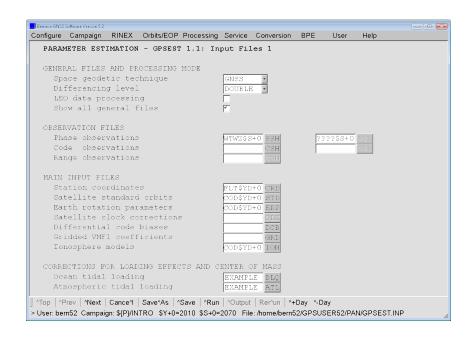
 STAT	ION COORDINATES:			\${P}/INTR	D/STA/	FLT10207.CR)	
NUM	STATION NAME	PARAMETER	A PR	IORI VALUE	NE	W VALUE	NEW- A PRIORI	RMS ERROR
107	JOZ2 12204M002	Х	366	4880.4789	366	4880.4789	0.0000	0.0001
		Y	140	9190.6787	140	9190.6780	-0.0007	0.0001
		Z	500	9618.5326	500	9618.5333	0.0007	0.0002
		HEIGHT		152.5318		152.5322	0.0004	0.0002
		LATITUDE	52	5 52.211702	52	5 52.211720	0.0006	0.0001
		LONGITUDE	21	1 56.470106	21	1 56.470073	-0.0006	0.0001

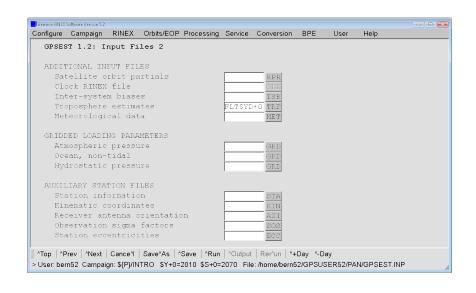
You may see from the output that from a total of 196 ambiguities 130 ambiguities could be resolved (compare part 1 AMBIGUITIES with part 2 AMBIGUITIES). Note that these numbers include reference ambiguities for each GNSS, GLONASS frequency number and frequency.

5.3.2 Ambiguity Resolution: Short Baselines

There are two very short baselines in the network where a direct ambiguity resolution for the L_1 and L_2 signal is possible applying the sigma–strategy.

The ultra–short baseline in Kötzting is between WTZR and WTZZ (WTWZ2070.PSH). The GPSEST input panels should look like follows:





The program output name is again related to the name of the baseline but contains an identifier 1 at the end to distinguish the files from the output files of the QIF-strategy:

- Bernese GNSS Software Version 5.2	- 0 -
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User H	Help
GPSEST 2.1: Output Files 1	
GENERAL OUTPUT FILES	
Program output 📄 use GPSEST.Lnn or	WTWZ\$+01 OUT
Error message 🛛 🦳 merged to program output or	ERROR MSG
NORMAL EQUATION SYSTEM NQO	
· · · · · · · · · · · · · · · · · · ·	
STATION- AND SATELLITE-RELATED RESULTS Station coordinates	
Satellite orbital elements ELE	
Earth rotation parameters ERP	
Earth rotation parameters (IERS)	
ATMOSPHERE-SPECIFIC RESULTS	
Troposphere estimates TRP	
Troposphere estimates (SINEX) TRO Ionosphere models ION	
Ionosphere models (IONEX) INX	
│ │ ^Top │ *Prev │ *Next │ Cance*l │ Save*As │ *Save │ *Run │ ^Output │ Rer*un │ *+Day _*-Day	
> User: bern52 Campaign: \${P}/INTRO_\$Y+0=2010_\$S+0=2070_File: /home/bern52/GPSUSER52/PAN/C	GPSEST.INP
Emrese GNSS Software Version 5.2	- • •
	Help
GPSEST 3.1: General Options 1	
TITLE EXAMPLE: Baseline WTWZ\$S+0: L1&L2 ambiguity resolution	
philippine wiwsyster and gainy resolution	
OBSERVATION SELECTION	
Satellite system ALL • Frequency/linear combination L16L2 •	
Elevation cutoff angle 10 degrees	
Sampling interval 30 seconds	
Tolerance for simultaneity 100 milliseconds Special data selection NO •	
Observation window	
OBSERVATION MODELING AND FARAMETER ESTIMATION A priori sigma of unit weight 0.001 meters	
Elevation-dependent weighting COSZ	
Type of computed residuals NORMALIZED - Correlation strategy BASELINE -	
Correlation strategy BASELINE	
LEO-SPECIFIC SELECTION AND MODELING OPTIONS	
Elevation cutoff angle 0 degrees Elevation-dependent weighting NONE	
∬ ^Top ^Prev ^Next Cance^1 Save^As ^Save ^Run ^Output Rer^un ^+Day ^-Day > User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/C	
- Con benez Campaign. or protice of the 2010 Contro-2010 File, nonichbernoz/OPSUSER52/PAIW	
Pernese GNSSSoftware Version 5.2	
	Help
GPSEST 3.2: General Options 2	
A DETORT MEADACHTERE MADELING	
A PRIORI TROPOSPHERE MODELING ZPD model and mapping function DRY GMF F for GNSS	
MENDES-PAVLIS · for SLR	
HANDLING OF AMBIGUITIES Resolution strategy SIGMA	
Solve ambiguities for ALL	
Consider GPS quarter-cycle biases IF INDICATED	
Save resolved ambiguities 🚩 Introduce widelane integers	
Introduce L1 and L2 integers 🔽	
SPECIAL PROCESSING OPTIONS	
Stop program after NEQ saving	
Activate extended program output	
│ │ ^Top │ ^Prev │ *Next │ Cance*l │ Save^As │ *Save │ ^Run │ ^Output │ Rer^un │ ^+Day _ *-Day	
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/C	GPSEST.INP

emese 6NSS Software Version 5.2 onfigure Campaign RINEX Orbits/EOP Processing Serv	ice Conversion	BPE	User	Help		
GPSEST 3.2.3: Sigma-Dependent Ambiguity R			0.501	Therp		
		51				
OPTIONS AND CRITERIA FOR TESTING						
Maximal number of ambiguities fixed per		tep	1		181	
Ambiguity resolvable if exactly one int			3		sigma	
Maximal sigma of resolvable ambiguities			<u> </u>	07	cycle	
Minimal sigma used for testing			μ.	05	cycle	33
OPTIONS FOR GLONASS AMBIGUITY RESOLUTION						
Resolution between different frequency	channels		SF	ME R	CVR GF	OUP -
			1			_
Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Ou		•	•			
Jser: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070	File: /home/bern5	2/GPSUS	ER52/PA	N/GPS	ESTINP	
emese GNSS Software Version 5.2		BPE	User	Help		
	ing Conversion					
onfigure Campaign RINEX Orbits/EOP Processing Serv			Usei	neip		
			USEI	nep		
onfigure Campaign RINEX Orbits/EOP Processing Serv	limination 1				nation	
nfigure Campaign RINEX Orbits/EOP Processing Sev GPSEST 5.1: Setup of Parameters and Pre-E						
nfigure Campaign RINEX Orbits/EOP Processing Serv GPSEST 5.1: Setup of Parameters and Pre-E STATION-RELATED PARAMETERS	limination 1					
nfigure Campaign RINEX Orbits/EOP Processing Serv GPSEST 5.1: Setup of Parameters and Pre-E STATION-RELATED PARAMETERS Station coordinates	limination 1	NO				•
nfigure Campaign RINEX Orbits/EOP Processing Serv GPSEST 5.1: Setup of Parameters and Pre-E STATION-RELATED PARAMETERS Station coordinates Ambiguities ATMOSPHERIC PARAMETERS	limination 1	NO				
nfigure Campaign RINEX Orbits/EOP Processing Serv GPSEST 5.1: Setup of Parameters and Pre-E STATION-RELATED PARAMETERS Station coordinates Ambiguities ATMOSPHERIC PARAMETERS Site-specific troposphere parameters	limination 1	NO NO				-
nfigure Campaign RINEX Orbits/EOP Processing Serv GPSEST 5.1: Setup of Parameters and Pre-E STATION-RELATED PARAMETERS Station coordinates Ambiguities ATMOSPHERIC PARAMETERS	limination 1	NO				
nfigure Campaign RINEX Orbits/EOP Processing Serv GPSEST 5.1: Setup of Parameters and Pre-E STATION-RELATED PARAMETERS Station coordinates Ambiguities ATMOSPHERIC PARAMETERS Site-specific troposphere parameters Global ionosphere parameters	limination 1	NO NO				1
nfigure Campaign RINEX Orbits/EOP Processing Serv GPSEST 5.1: Setup of Parameters and Pre-E STATION-RELATED PARAMETERS Station coordinates Ambiguities ATMOSPHERIC PARAMETERS Site-apecific troposphere parameters Global ionosphere parameters GLOBAL PARAMETERS	limination 1	NO NO NO				
nfigure Campaign RINEX Orbits/EOP Processing Serv GPSEST 5.1: Setup of Parameters and Pre-E STATION-RELATED PARAMETERS Station coordinates Ambiguities ATMOSPHERIC PARAMETERS Site-specific troposphere parameters Global ionosphere parameters	limination 1	NO NO				
nfigure Campaign RINEX Orbits/EOP Processing Serv GPSEST 5.1: Setup of Parameters and Pre-E STATION-RELATED PARAMETERS Station coordinates Ambiguities ATMOSPHERIC PARAMETERS Site-specific troposphere parameters Global ionosphere parameters GLOBAL PARAMETERS Orbital parameters	limination 1	NO NO NO				
nfigure Campaign RINEX Orbits/EOP Processing Serv GPSEST 5.1: Setup of Parameters and Pre-E STATION-RELATED PARAMETERS Station coordinates Ambiguities ATMOSPHERIC PARAMETERS Site-specific troposphere parameters Global ionosphere parameters GLOBAL PARAMETERS Orbital parameters Earth orientation parameters Geocenter coordinates	limination 1	NO NO NO NO				
nfigure Campaign RINEX Orbits/EOP Processing Serv GPSEST 5.1: Setup of Parameters and Pre-E STATION-RELATED PARAMETERS Station coordinates Ambiguities ATMOSPHERIC PARAMETERS Site-specific troposphere parameters Global ionosphere parameters GLOBAL PARAMETERS Orbital parameters Earth orientation parameters Geocenter coordinates EPOCH PARAMETERS	limination 1	N0 N0 N0 N0 N0 N0	Pre-E	limir		
nfigure Campaign RINEX Orbits/EOP Processing Serv GPSEST 5.1: Setup of Parameters and Pre-E STATION-RELATED PARAMETERS Station coordinates Ambiguities ATMOSPHERIC PARAMETERS Site-specific troposphere parameters Global ionosphere parameters GloBAL PARAMETERS Orbital parameters Earth orientation parameters Geocenter coordinates EPOCH FARAMETERS Receiver clock offsets	limination 1	NO NO NO NO NO EVE	Pre-E RY EPO	Limir		
nfigure Campaign RINEX Orbits/EOP Processing Serv GPSEST 5.1: Setup of Parameters and Pre-E STATION-RELATED PARAMETERS Station coordinates Ambiguities ATMOSPHERIC PARAMETERS Site-specific troposphere parameters Global ionosphere parameters GLOBAL PARAMETERS Orbital parameters Earth orientation parameters Geocenter coordinates EPOCH FARAMETERS Receiver clock offsets Satellite clock offsets	limination 1	NO NO NO NO NO EVE EVE	Pre-E RY EPO RY EPO	CH		
nfigure Campaign RINEX Orbits/EOP Processing Serv GPSEST 5.1: Setup of Parameters and Pre-E STATION-RELATED PARAMETERS Station coordinates Ambiguities ATMOSPHERIC PARAMETERS Site-specific troposphere parameters Global ionosphere parameters GloBAL PARAMETERS Orbital parameters Earth orientation parameters Geocenter coordinates EPOCH FARAMETERS Receiver clock offsets	limination 1	NO NO NO NO NO EVE EVE EVE	Pre-E RY EPO	CH CH CH		

The structure of the program output is the same as it has extensively been described in the previous section for the QIF ambiguity resolution strategy. It starts with PART 1 for the solution before the ambiguity resolution. Here are the corresponding parameter statistics:

 13. RESUL	TS (PART 1)					
	PARAMETERS (PART					
PARAMETER	ТҮРЕ		#PARAMETERS	#PRE-ELIMINATED	#SET-UP	· · · ·
STATION C AMBIGUITI	CORDINATES ES		3 206	0	3 232	
TOTAL NUM	BER OF PARAMETERS		209		235	• • •
NUMBER OF	OBSERVATIONS (PA)	RT 1):				
TYPE	FREQUENCY		#OBSERVAT	IONS		
	L1 L2	ALL ALL	38232 38232			
TOTAL NUM	BER OF OBSERVATIO	IS	76464			· · · · · · ·

```
A POSTERIORI SIGMA OF UNIT WEIGHT (PART 1):

A POSTERIORI SIGMA OF UNIT WEIGHT : 0.0012 M (SIGMA OF ONE-WAY L1 PHASE OBSERVABLE AT ...

DEGREE OF FREEDOM (DOF) : 76255

CHI**2/DOF : 1.53
```

After the ambiguity resolution the same statistics is provided in PART 2:

14. RESULTS (PART 2)				
NUMBER OF PARAMETERS (PART 2):				
PARAMETER TYPE		#PARAMETERS	#PRE-ELIMINATED	#SET-UP
STATION COORDINATES		-	0	3
AMBIGUITIES		40	0	232
TOTAL NUMBER OF PARAMETERS		43	0	235
A POSTERIORI SIGMA OF UNIT WEIGH	T (PART 2):			
A POSTERIORI SIGMA OF UNIT WEIGH	т: 0.00	13 M (SIGMA	OF ONE-WAY L1 PHASE	OBSERVABLE AT
DEGREE OF FREEDOM (DOF)	: 764	21		
CHI**2/DOF	: 1.	82		

From the number of ambiguity parameters it can be computed that 166 out of 206 ambiguities from both GPS and GLONASS have been resolved to their integer numbers. Please remind, that at least 4 ambiguity parameters must remain as real values because of one reference ambiguity per GNSS and frequency are needed. Because the two receivers belong to different groups regarding "GLONASS amb. resol. between different frequencies" only the ambiguities between the same frequency numbers have been resolved. In addition, depending on the receiver type, not all ambiguities for GPS are allowed to be resolved too, to prevent problems with the quarter-cycle bias between the L2P and L2C signal (see option "Consider GPS quarter-cycle biases" in panel "GPSEST 3.2: General Options 2" and the lecture on ambiguity resolution).

5.3.3 Ambiguity Resolution: BPE

Admittedly, it is cumbersome to process the baselines "manually" one after the other — you have twelve baselines per session for this small example campaign. On Thursday you will have a lecture on automation of the data processing using the BPE.

In the example BPE RNX2SNX.PCF a sequence for the ambiguity resolution is included. For this tutorial lecture a small part of this BPE is extracted into a separate TUTORIAL.PCF BPE. The process control file (PCF) is located in the directory U/PCF. If you are

not in the *Bernese Introductory Course* environment, you have to use the RNX2SNX.PCF instead of the TUTORIAL.PCF and skip the unneeded scripts (a brief description is given in the panel description of the RUNBPE) program.

The PCF consists of three parts: the first part defines the scripts and the option directories where the program's input files are taken from. In addition the waiting conditions are defined to keep the correct order for the execution of the scripts. In the second part, special execution modes are defined, e.g., that the scripts GNSQIF_P with PID 132 and GNSL12_P with PID 142 may run in parallel for each individual baseline. The preparatory scripts GNSQIFAP and GNSL12AP define the list of baselines to be processed. The third part defines the so called BPE- or PCF-variables that can be used within the scripts or in the input fields of the menu. A detailed introduction to the BPE will be the topic of a lecture on Thursday.

The TUTORIAL.PCF is responsible for the following tasks:

011 TUT_COP :

Copies the files from the previous processing steps of the tutorial to the filenames used in the RNX2SNX.PCF example BPE. It uses the PCF- and time variables for that purpose:

copy file from ../STA/APR\${yyddd}.CRD to ../STA/APR\${yyssss}.CRD copy file from ../STA/FLT\${yyddd}.CRD to ../STA/FLT\${yyssss}.CRD copy file from ../ATM/FLT\${yyddd}.TRP to ../ATM/FLT\${yyssss}.TRP copy file from ../ORB/COD\${yyddd}.STD to ../ORB/COD\${yyssss}.STD copy file from ../ORB/COD\${yyddd}.ERP to ../ORB/COD\${yyssss}.ERP

where $\{yyddd\}$ stands for the two-digit year and the day of year. The new filename contains $\{yyssss\}$ the two-digit year together with the session (in our case day of year plus the zero-character 0).

If you are not in the *Bernese Introductory Course* environment, you have to copy these files manually to run the ambiguity resolution sequence of RNX2SNX.PCF.

101 SATMRK :

All previously resolved ambiguities are re–initialized to start for all files from unresolved ambiguities (otherwise the interpretation of the statistic of resolved ambiguities may become difficult).

131 GNSQIFAP and 132 GNSQIF_P :

Applies the QIF ambiguity resolution strategy to all baselines of the example in a baseline–by–baseline mode, where several baselines may be processed at the same time in parallel.

141 GNSL12AP and 142 GNSL12_P :

Applies the SIGMA ambiguity resolution strategy directly to the original observations on the L_1 and L_2 frequency for both short baselines in the example network: Kötzting (WTZR and WTZZ) and Zimmerwald (ZIM2 and ZIMM). These scripts also run in a baseline–by–baseline mode, allowing for a parallel processing.

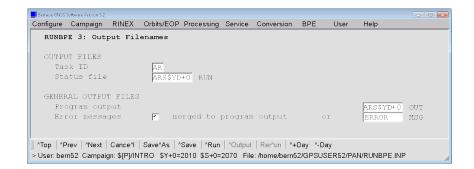
```
# TUTORTAL PCF
#
# Purpose: Run the ambiguity resolution for one session in the
             <<Terminal Session>> of the
#
             Bernese Software Introductory Course
# _____
#
         : R. Dach
: 23-Jan-2012
# Author
# Created
                                Last modified: 23-Jan-2012
# Changes
         :
#
#
PID SCRIPT OPT_DIR CAMPAIGN CPU P WAIT FOR....
#
# Copy input files
011 TUT_COP R2S_GEN ANY 1
# Resolve phase ambiguities
101 SATMRK R2S GEN
                        ANY
                               1 011
131 GNSQIFAP R2S_QIF
                              1 101
1 131
1 132
1 141
                        ANY
132 GNSQIF_P R2S_QIF
                        ANY
### GNSL12AP R2S_L12
142 GNSL12_P R2S_L12
#
                        ANY
                        ANY
# End of BPE
999 DUMMY NO_OPT
                       ANY
                              1 142
PID USER
           PASSWORD PARAM1 PARAM2 PARAM3 PARAM4 PARAM5 PARAM6
# Resolve phase ambiguities
# -----
131
                     $131
132
                    PARALLEL $131
141
                    $141
                    PARALLEL $141
142
#
VARIABLE DESCRIPTION
                                        DEFAULT
V_A A priori information
V_B Orbit/ERP, DCB, CLK information
                                        APR
                                        COD
V_C Preliminary (ambiguity-float) results
V_CRDINF Project related station filenames
                                        FLT
                                        EXAMPLE
V_GNSSAR GNSS to be used for ambiguity resolution ALL
V_BL_QIF Maximum baseline length for QIF AR 2000
<code>V_BL_L12</code> Maximum baseline length for <code>L1&L2</code> AR
                                        20
V_PCV
      Absolute/relative PCV model
                                        T14
V_SATINF Satellite information file
                                        SATELLIT
V_PCVINF PCV information file
                                        PCV_Bxx
V_SATCRX Satellite problem file
                                        SAT_$Y+0
V_RECINF Receiver characterization file
V_BLQINF BLQ FILE NAME, CMC CORRECTIONS
V_ATLINF ATL FILE NAME, CMC CORRECTIONS
                                        RECEIVER.
                                        EXAMPLE
                                        EXAMPLE
V_HOIFIL Ionosphere model
                                        COD$YD+0
# DO NOT USE V_D, V_J, V_M, V_Y VARIABLES!
# (they are used already by the menu)
#
```

In the *Bernese Introductory Course* environment the TUTORIAL.PCF BPE can be started for one session (e.g., day 207 of year 2010) using "Menu><u>BPE>Start BPE processing</u>":

Bernese GNSS Software Version 5.2						- 0
Configure Campaign RINEX Orbits/EOP Proce	essing Service	Conversion	BPE	User	Help	
START BPE PROCESSING - RUNBPE 1:	Client Envi:	ronment/S	ession	Select.	ion	
CLIENT FILES/ENVIRONMENT						
Client script	\${BPE}/RU	JBPE.pm			-	
Client's environment file	\${X}/EXE/1	OADGPS.s	etvar		_	
MENU SETTINGS						
Campaign	\${P}/INTRC	L. C. C. C. C. C. C. C. C. C. C. C. C. C.				
Session table	\${P}/INTRC	/STA/SESS	SIONS.SE	S		
SESSION PROCESSING OPTIONS						
Start processing		Year	2010	Ses	ssion	2070
Number of sessions to be proce:			1	Moc	dulo	1
Cont. with next sess. if not me	ore errors t	han	0			
Run sessions in parallel						
Stop BPE with an error after				1	seconds	
			(blank	= unl	imited)	
	Len Len i i					
] ^Top ^Prev ^Next Cance^I Save^As ^Save						
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010	\$S+0=2070 File	/home/bern5	2/GPSUSE	R52/PAN	I/RUNBPE.	INP //

📕 Bernese GNSS S	oftware Version 5.2									- 0
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
RUNBP	E 2: Pro	cess Co	ntrol Opt	ions						
CPU C	ONTROL									
CPU	control	file			UNIX	CPU				
Che	ck for f	ree CPU	every		10	seconds				
BPE T	ASK SELE	CTION								
	cess con		le		TUTORI	AL PCF		_		
	rt with	-								
Ski	p script	s								
OURDU	T OPTION:	-1								
			nt commun			_				
^ ^					nmont	-				
DO	not remo	ve temp	orary use	enviro	nment.	1				
∬ ^Top ^P	rev ^Next	Cance [^] l	Save^As ^	Save ARun	^Output	Rer^un ^+	Day ^-Day	1		
> User: berr	n52 Campai	gn: \${P}/IN	TRO \$Y+0=	2010 \$S+0=	2070 File	e: /home/bern5	2/GPSUSE	ER52/PA	N/RUNBPE.	INP //

If you follow the tutorial outside from the environment of the *Bernese Introductory Course* you can select RNX2SNX in option "Process control file" and skip all scripts apart from PID 401 SATMRK and the range from PID 431 GNSQIFAP to PID 442 GNSL12_P (option "Skip scripts").



Variable	Value	Description		*
V_A	APR	A priori information	+	-
V_B	COD	Orbit/ERP, DCB, CLK information	+	-
V_C	FLT	Preliminary (ambiguity-float) results	+	-
V_CRDINF	EXAMPLE	Project related station filenames	+	-
V_GNSSAR	ALL	GNSS to be used for ambiguity resoluti	+	-
V_BL_QIF	2000	Maximum baseline length for QIF AR	+	-
V_BL_L12	20	Maximum baseline length for L1&L2 AR	+	-
V_PCV	I14	Absolute/relative PCV model	+	-
V_SATINF	SATELLIT	Satellite information file	+	-
V_PCVINF	PCV_Bxx	PCV information file	+	-
V_SATCRX	SAT_\$Y+0	Satellite problem file	+	-
V_BLQINF	EXAMPLE	BLQ FILE NAME, CMC CORRECTIONS	+	-
V_ATLINF	EXAMPLE	ATL FILE NAME, CMC CORRECTIONS	+	-
V HOIFIL	COD\$YD+0	Ionosphere model	+	-

Run the BPE for the current session. If the BPE stops with an error you can inspect the files ARyyddd0_...PRT and ARyyddd0_...LOG belonging to your current session. They are located in the BPE directory of your campaign. These files notice for instance if an input file is missing. This might be the case if you did not follow the naming convention proposed in the tutorial. In that case you have to copy the file from your naming to the expected one.

5.3.4 Ambiguity Resolution: Summary

For each observation file a corresponding program output file is generated. Using the program GPSXTR ("Menu>Processing>Program output extraction>Parameter estimation/stacking") you can generate a summary of the ambiguity resolution for all baselines of the session:

Bernese GNSS Software Version 5.2					- • •
Configure Campaign RINEX Orbits/EOP	Processing Service Conversion	n BPE	User	Help	
EXTRACT GPSEST/ADDNEQ2 PROGRA	M OUTPUT - GPSXTR 1: E	xtraction	s		
GENERAL FILES					
Show all general files	<u> ~</u>				
INPUT FILENAMES					
c	GPSEST.L??	(GPSEST.)	Lxx/AD	DNEQ2.Lxx)	
e	*\$S+0_0_OUT	(GPSEST/)	ADDNEQ	2 output)	
GENERAL OUTPUT FILES					
Program output	🚩 use GPSXTR.Lnn		or	GPSXTI	TUO S
Error messages	merged to program	n output	or	ERROR	MSG
∬ ^Top │ ^Prev │ ^Next │ Cance*l │ Save*As │ ^	Save ^Run ^Output Rer^un	^+Day ^-Day	(
> User: bern52 Campaign: \${P}/INTRO \$Y+0=	2010 \$S+0=2070 File: /home/be	rn52/GPSUSE	ER52/PA	V/GPSXTR.INP	1.

All program output files related to the QIF ambiguity resolution method have been specified with program output filenames fitting in the shape P/INTRO/OUT/??? s+0_Q.OUT and can, therefore, easily be selected in the input field "GPSEST/ADDNEQ output files".

Bernese GNSS Software Version 5.2		×
Configure Campaign RINEX Orbits/EOP Processing S	ervice Conversion BPE User Help	
GPSXTR 2: Output Files		
TITLE EXAMPLE: Session \$YSS+0: QIE	ambiguity resolution summary	
OUTPUT FILES Output summary	SIM	
Coordinate summary	SIM	
Kinematic summary	SIM	
GIM summary	SUM	
Clock summary	SUM Baseline BSL	
Clock Allan deviation	SUM	
Ambiguity resolution QIF\$YD+0	SUM GNSS EACH&ALL . ID QIF .	
Ambiguity fractionals	SUM	
Campaign summary	SUM	
Weekly summary	SUM	
Pole output	SUM Pole parameter sets ALL 🔽	
^Top ^Prev ^Next Cance^I Save^As ^Save ^Run	Output Rer^un ^+Day ^-Day	
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=20	0 File: /home/bern52/GPSUSER52/PAN/GPSXTR.INP	/

The program issues a warning message because only for a global network the evaluation of the ambiguity resolution statistics allow to assess the orbit quality:

SR EXTAMB: ORBIT ACCURACY NOT ESTIMATED

This summary $({P}/INTRO/OUT/QIF10207.SUM)$ reports among others how many ambiguities are resolved for each baseline¹:

File	Sta1	Sta2	Length (km)					Res	Sys	
GAJ02070	GANP	JOZ2	344.407	102	1.1	24	1.1	76.5	G	 #AR_QIF
GAJ02070	GANP	JOZ2	344.407	90	1.1	38	1.1	57.8	R	 #AR_QIF
GAJ02070	GANP	JOZ2	344.407	192	1.1	62	1.1	67.7	GR	 #AR_QIF
HEZI2070	HERT	ZIM2	685.151	120	1.1	46	1.1	61.7	G	 #AR_QIF
HEZI2070	HERT	ZIM2	685.151	98	1.1	64	1.1	34.7	R	 #AR_QIF
HEZI2070			685.151	218	1.1	110	1.1	49.5		 #AR_QIF
JOLA2070	JOZ2	LAMA	201.183	118	1.0	36	1.0	69.5	G	 #AR_QIF
JOLA2070			201.183	96	1.0	38		60.4		 #AR_QIF
JOLA2070			201.183	214	1.0	74		65.4		 #AR_QIF
J00N2070	JOZ2	ONSA	829.775	136	1.0	58	1.1	57.4	G	 #AR_QIF
J00N2070	JOZ2	ONSA	829.775	104	1.0	68	1.1	34.6	R	 #AR_QIF
J00N2070	JOZ2		829.775		1.0	126	1.1	47.5	GR	 #AR_QIF
JOWS2070	JOZ2	WSRT	981.243	106	1.1	32	1.1	69.8	G	 #AR_QIF
JOWT2070			663.182		1.4	28		73.1		 #AR_QIF
JOWT2070	JOZ2	WTZR	663.182		1.4	50	1.5	49.0	R	 #AR_QIF
JOWT2070	JOZ2	WTZR	663.182	202	1.4	78	1.5	61.4	GR	 #AR_QIF
MAZI2070	MATE	ZIM2	1013.811	122	1.2	54	1.3	55.7	G	 #AR_QIF
MAZI2070	MATE	ZIM2	1013.811	94	1.2	60	1.3	36.2	R	 #AR_QIF
MAZI2070	MATE	ZIM2	1013.811	216	1.2	114	1.3	47.2	GR	 #AR_QIF
PTZI2070			640.077	114	1.3	26	1.4	77.2	G	 #AR_QIF
TLZI2070			596.848	120	1.3	20		83.3		 #AR_QIF
TLZI2070			596.848	90	1.3	58		35.6		 #AR_QIF
TLZI2070			596.848		1.3	78	1.3	62.9	GR	 #AR_QIF
WTZI2070			475.909	116	1.5	44	1.5	62.1	G	 #AR_QIF
WTZI2070					1.5	56	1.5	39.1	R	 #AR_QIF
WTZI2070	WTZR	ZIM2	475.909	208	1.5	100	1.5	51.9	GR	 #AR_QIF
Tot: 10			643.159							#AR_QIF
Tot: 8			601.283		1.2					#AR_QIF
Tot: 10			643.159	1920	1.2	800	1.3	58.3	GR	 #AR_QIF

¹You may check the impact of introducing the ionosphere model (COD\$YD+0 in "lonosphere models" of panel "GPSEST 1.1: Input Files 1") by cleaning this input field. Repeat the ambiguity resolution (without saving the resolved ambiguities into the observation file: unmark option "Save resolved ambiguities" in panel "GPSEST 3.2: General Options 2") and compare the a posteriori RMS and the number of resolved ambiguities.

An analogue statistics can be produced for the short baseline ambiguity resolution. Exchange the entry for the input file selection ("GPSEST/ADDNEQ output files") to catch all files of the shape P/INTRO/OUT/??? S+0_1.0UT. It is recommended to change also the name of the resulting summary ("Ambiguity res. summary") and the identification string in the summary (e.g., L12 for "Ambiguity resolution: $#AR_ID$ ") in panel "GPSXTR 2: Output Files".

File	Sta1	Sta2	Length		ore	Aft		Res	Sys		
			(km)	#Amb	(mm)	#Amb	(mm)	(%)		• • •	
WTWZ2070) WTZR	WTZZ	0.002	108	1.2	16	1.3	85.2	G		#AR_L12
WTWZ2070	WTZR	WTZZ	0.002	94	1.2	20	1.3	78.7	R		#AR_L12
WTWZ2070	WTZR	WTZZ	0.002	202	1.2	36	1.3	82.2	GR		#AR_L12
ZIZM2070	ZIM2	ZIMM	0.019	108	1.1	2	1.1	98.1	G		#AR_L12
Tot: 2	2		0.010	216	1.2	18	1.2	91.7	G		#AR_L12
Tot:	L		0.002	94	1.2	20	1.3	78.7	R		#AR_L12
Tot: 2	2		0.010	310	1.2	38	1.2	87.7	GR		#AR_L12

The solutions from the BPE are identical to the two manually processed solutions. You can compare the following two files in P/INTRO/OUT for each strategy (e.g., with tkdiff):

	Filenames from						
	Manual processing	processed by the BPE					
Strategy: QIF:	GAJO207Q.OUT	GAJO2070_Q.OUT					
Strategy: direct L_1/L_2 :	WTWZ2071.OUT	WTWZ2070_1.OUT					

If you compare the number of ambiguity parameters in the GPSEST program output with the number of ambiguities in the GPSXTR summary files, the number of reference ambiguities that need to be kept unresolved are considered.

5.4 Daily Goals

At the end of today's session, you should have:
1. used GPSEST for residual screening, created files: EDT10207. OUT,
EDT10207. RES in your campaign's OUT directory,
2. screened the residual files from the above run using RESRMS : created files
RMS10207. SUM, RMS10207. LST, RMS10207. EDT, and RMS10207. OUT,
3. used SATMRK to mark the identified outliers,
<i>4. used GPSEST for a first coordinate and troposphere estimation, created files:</i>
FLT10207. CRD and FLT10207. TRP,
5. used GPSEST for QIF ambiguity resolution, created files: GAJ0207Q. OUT,
6. used GPSEST for direct SIGMA ambiguity resolution, created files:
WTWZ2071. OUT,
7. apply the ambiguity resolution to all baselines running a BPE,
8. used GPSXTR to create a summary of the ambiguity resolution, created file:
QIF10207. SUM

Proposal for Further Activities

Even if it is not needed for the processing progress of the regional network you may use some time in this terminal session to have a look into the examples for "Epoch Parameter Processing" (sections 7.3 for *Kinematic Positioning* and 7.4 for *Zero Difference Processing for Clock Estimation*). This section also provides some instructions on other topics, e.g., the usage of RINEX 3 observation files in Section 7.5.

Note that some panels assume the availability of the final solution for regional network processing (FIN\$YD+0) that will be generated in the terminal session of tomorrow only. You may replace these files by the results from the first network solution before the ambiguity resolution (FLT\$YD+0) for this exercise.

6 Terminal Session: Thursday

Finish the work of yesterday by resolving the ambiguities for all baselines (day 207 year 2010).

Today's terminal session is to:

- 1. compute a final network solution of the day (GPSEST),
- 2. check the coordinates of the fiducial sites (ADDNEQ2, HELMR1),
- 3. check the daily repeatability (COMPAR),
- 4. recompute final solution and generate reduced size normal equation files (ADDNEQ2),
- 5. compute velocities (ADDNEQ2),

```
for the current session. Compare the final coordinate results of the daily solutions (which are already processed and available).
```

6.1 Final Network Solution

The resolved ambiguities may be introduced from the Bernese observation files into the final network solution. To start the program GPSEST in session mode you have to select all single difference files of the corresponding session. In panel "GPSEST 1.1: Input Files 1":

Bemese GNSS Software Version 5.2			
Configure Campaign RINEX Orbits/EOP Processing	g Service Conversion	BPE User	Help
PARAMETER ESTIMATION - GPSEST 1.1: I	nput Files 1		
GENERAL FILES AND PROCESSING MODE Space geodetic technique	GNSS .		
Differencing level	DOUBLE ·		
LEO data processing			
Show all general files	M		
OBSERVATION FILES			
Phase observations	????\$S+0 PSH	????\$S+O	
Code observations	CSH		CZH
Range observations	CZH		
MAIN INPUT FILES			
Station coordinates	APR\$YD+0 CRD		
Satellite standard orbits	COD\$YD+0 STD		
Earth rotation parameters	COD\$YD+0 ERP		
Satellite clock corrections	CLK		
Differential code biases Gridded VMF1 coefficients	DCB		
Ionosphere models	VMF\$YD+0 GRD		
ronosphere moders	COD\$YD+0 ION		
CORRECTIONS FOR LOADING EFFECTS AND	CENTER OF MASS		
Ocean tidal loading	EXAMPLE BLQ		
Atmospheric tidal loading	EXAMPLE ATL		
∬ ^Top ^Prev ^Next Cance^I Save^As ^Save ^Ru			
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0	=2070 File: /home/bern5	2/GPSUSER52/PA	N/GPSEST.INP

If the grid files for the coefficients of the VMF1 are available (downloaded from http: //vmf.geo.tuwien.ac.at/trop_products/GRID/2.5x2/VMF1/VMF1_OP and the five grid files of the day are concatenated), we can introduce them into panel "GPSEST 1.1: Input Files 1".

We do not introduce "Troposphere estimates" anymore from the previous solutions.

Bernese GNSS Software Version 5.2					- 0 ×
Configure Campaign RINEX Orbits/EOP Processing	J Service Conv	ersion BPE	User	Help	
GPSEST 1.2: Input Files 2					
ADDITIONAL INPUT FILES					
Satellite orbit partials	R	PR			
Clock RINEX file	C				
Inter-system biases	I:	BB			
Troposphere estimates	T	RP			
Meteorological data	M	ΕT			
GRIDDED LOADING PARAMETERS					
Atmospheric pressure	G	RD			
Ocean, non-tidal	G	RD			
Hydrostatic pressure	G	RD			
AUXILIARY STATION FILES					
Station information		ΡΑ			
Kinematic coordinates		IN			
Receiver antenna orientation		ZI			
Observation sigma factors		DS			
Station eccentricities	E	C.			
∣ ∥ ^Top ^Prev ^Next Cance^I Save^As ^Save ^Ru	• Cutout Rer	un A+Day /	^-Dav		
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0				NGRSESTING	
- oser. bernoz oumpaign. of photocol of to-zoro ooro	2070 The mon	choenioz/or e	JOOLNULIA		1.

In panel "GPSEST 2.1: Output Files 1" we request the normal equation file as the only output file.

Bernese GNSS Software Version 5.2		- • •
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE U	lser	Help
GPSEST 2.1: Output Files 1		
GENERAL OUTPUT FILES		
Program output 📄 use GPSEST.Lnn	or	FIX\$YD+0 OUT
Error message 🛛 🦷 merged to program output	or	ERROR MSG
NORMAL EQUATION SYSTEM		
STATION- AND SATELLITE-RELATED RESULTS		
Station coordinates CRD		
Satellite orbital elements ELE		
Earth rotation parameters ERP		
Earth rotation parameters (IERS)		
ATMOSPHERE-SPECIFIC RESULTS		
Troposphere estimates TRP		
Troposphere estimates (SINEX) TRO		
Ionosphere models		
Ionosphere models (IONEX) INX		
] ^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output Rer^un ^+Day _^-Day		
> User: bern52_Campaign: \${P}/INTRO_\$Y+0=2010_\$S+0=2070_File: /home/bern52/GPSUSER	52/PAN	I/GPSEST.INP

For the final run of **GPSEST** we consider the correlations between the observations correctly:

Bernese GNSS Software Version 5.2	
Configure Campaign RINEX Orbits/EOP Processing Service	vice Conversion BPE User Help
GPSEST 3.1: General Options 1	
-	
TITLE EXAMPLE: Session \$YSS+0: Final r	network solution (fixed)
OBSERVATION SELECTION	
Satellite system	ALL
Frequency/linear combination	L3 ·
Elevation cutoff angle	5 degrees
Sampling interval	180 seconds
Tolerance for simultaneity	100 milliseconds
Special data selection	NO
Observation window	
OBSERVATION MODELING AND PARAMETER ESTIMA	ATION
A priori sigma of unit weight	0.001 meters
Elevation-dependent weighting	COSZ .
Type of computed residuals	NORMALIZED
Correlation strategy	CORRECT
correlation buildedgy	CONNECT
LEO-SPECIFIC SELECTION AND MODELING OPTIC	NS
Elevation cutoff angle	0 degrees
Elevation-dependent weighting	NONE
Elorabion appendente worghoing	INCINE D
^^ ^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^O	utput Rer^un ^+Day ^-Day
	0 File: gpfs/homefs/aiub/l_bern52/GPSUSER/PAN/GPSEST.INP
- 0301.1_001102_0411pagn. v() p1411(0_01+0-2010_00+0-207	

If the VMF1 grid files are available we can switch now from DRY_GMF to DRY_VMF to use the VMF1 instead of the Global Mapping Function (GMF). In the *Bernese Introductory Course* environment these files are available. Remember that you need to specify the grid files with the coefficients in the input field "Gridded VMF1 coefficients" in panel "GPSEST 1.1: Input Files 1".

Ambiguities which have been resolved in the previous runs of program GPSEST are introduced as known.

📕 Bernese GNSS Si	oftware Version 5.2									- • •
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
GPSES	I 3.2: G	eneral	Options 2	!						
A PRI	DRI TROP	OSPHERE	MODELING	;						
ZPD	model a	nd mapp	ing funct	ion		VMF DES-PAVLIS		GNSS SLR		
Res Sol Con Sav Int	e resolv roduce w	strateg uities S quart ed ambi idelane	y for er-cycle	3	NONE ALL 0	2				
SPECI.	AL PROCE	SSING C	PTIONS							
Sto	p progra	m after	NEQ sav:	ing	~					
Act	ivate ex	tended	program (output	Y					
						Rer^un ^+I			N/GPSEST.INF	, <i>h</i>

The checkbox in option "Stop program after NEQ saving" reduces the task of GPSEST to setting up the NEQ but not solving it. In particular in case of bigger networks this may save a lot of computing time because the solution for the session will be computed later on by ADDNEQ2 anyhow.

Since this is the final run of **GPSEST**, it is worthwhile to add some additional information about the observation files into the program output. This is useful if you archive the program output of this run together with the observation files and the resulting normal equation files.

mese GNSS Software Version 5.2			
nfigure Campaign RINEX Orbits/EOP Processing Service Conversion BPE	User	Help	
GPSEST 3.2.1.1: Extended Program Output Options			
INFORMATION RELATED TO OBSERVATIONS			
List of observations given in files	_		
List of observations used for processing			
Satellite elevations	E I		
Histogram of observations by elevation angle bins	- -		
Histogram of observations by nadir angle bins	2		
Phase-connected time intervals	7		
INFORMATION RELATED TO ESTIMATED PARAMETERS			
List of all parameters			
Unresolved ambiguities after each iteration step			
Suppression of output concerning troposphere parameter			
Suppression of output concerning coordinate parameter			
Suppression of output concerning ambiguity parameter			
Suppression of output concerning epoch parameters			
		N/GPSEST.II	۱P
ser: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSL		N/GPSEST.IN	
ser: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSL		N/GPSEST.II	1P
ser: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSL	JSER52/PAI		
ser: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSL mere 6105 Suftware Version 52 figure Campaign RINEX Orbits/EOP Processing Service Conversion BPE GPSEST 3.2.1.2: Extended Program Output Options	JSER52/PAI		
ser: bern52 Campaign: S{P}/INTRO SY+0=2010 SS+0=2070 File: /home/bern52/GPSL more GM25 Software Version 52 nfigure Campaign RINEX Orbits/EOP Processing Service Conversion BPE GPSEST 3.2.1.2: Extended Program Output Options OTHER INFORMATION	JSER52/PAI		
ser:bem52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File:/home/bem52/GPSU mmse0H2550HomeVenon52 figure Campaign RINEX Orbits/EOP Processing Service Conversion BPE GPSEST 3.2.1.2: Extended Program Output Options OTHER INFORMATION Resolved ambiguities from observation files	JSER52/PAI		
ser:bem52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File:/home/bem52/GPSU mmsr0H252Mmsr0ms12 figure Campaign RINEX Orbits/EOP Processing Service Conversion BPE GPSEST 3.2.1.2: Extended Program Output Options OTHER INFORMATION Resolved ambiguities from observation files Constants, antenna offsets, ionosphere coefficients	JSER52/PAI		
ser: bern52 Campaign: S{P}/INTRO SY+0=2010 SS+0=2070 File: /home/bern52/GPSU Infgure Campaign RINEX Orbits/EOP Processing Service Conversion BPE GPSEST 3.2.1.2: Extended Program Output Options OTHER INFORMATION Resolved ambiguities from observation files Constants, antenna offsets, ionosphere coefficients Station eccentricities, receiver information	JSER52/PAI		
<pre>ser.bem52 Campaign \${P}/INTRO \$Y+0=2010 \$S+0=2070 File:/home/bem52/GPSU mode0H350/www.Wmon52 nfigure Campaign RINEX Orbits/EOP Processing Service Conversion BPE GPSEST 3.2.1.2: Extended Program Output Options OTHER INFORMATION Resolved ambiguities from observation files Constants, antenna offsets, ionosphere coefficients Station eccentricities, receiver information Receiver synchronization errors</pre>	JSER52/PAI		
ser:bem52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File:/home/bem52/GPSU figure Campaign RINEX Orbits/EOP Processing Service Conversion BPE GPSEST 3.2.1.2: Extended Program Output Options OTHER INFORMATION Resolved ambiguities from observation files Constants, antenna offsets, ionosphere coefficients Station eccentricities, receiver information Receiver synchronization errors RMS of ellipsoidal coordinates and differences	JSER52/PAI		
se: bem52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bem52/GPSU Infigure Campaign RINEX Orbits/EOP Processing Service Conversion BPE GPSEST 3.2.1.2: Extended Program Output Options OTHER INFORMATION Resolved ambiguities from observation files Constants, antenna offsets, ionosphere coefficients Station eccentricities, receiver information Receiver synchronization errors RMS of ellipsoidal coordinates and differences Slope distances and their RMS	JSER52/PAI		
ser:bem52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File:/home/bem52/GPSU figure Campaign RINEX Orbits/EOP Processing Service Conversion BPE GPSEST 3.2.1.2: Extended Program Output Options OTHER INFORMATION Resolved ambiguities from observation files Constants, antenna offsets, ionosphere coefficients Station eccentricities, receiver information Receiver synchronization errors RMS of ellipsoidal coordinates and differences	JSER52/PAI		
se: bem52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bem52/GPSU Infigure Campaign RINEX Orbits/EOP Processing Service Conversion BPE GPSEST 3.2.1.2: Extended Program Output Options OTHER INFORMATION Resolved ambiguities from observation files Constants, antenna offsets, ionosphere coefficients Station eccentricities, receiver information Receiver synchronization errors RMS of ellipsoidal coordinates and differences Slope distances and their RMS	JSER52/PAI		
ser.bem52 Campaign \${P}/INTRO \$Y+0=2010 \$S+0=2070 File:/home/bem52/GPSU figure Campaign RINEX Orbits/EOP Processing Service Conversion BPE GPSEST 3.2.1.2: Extended Program Output Options OTHER INFORMATION Resolved ambiguities from observation files Constants, antenna offsets, ionosphere coefficients Station eccentricities, receiver information Receiver synchronization errors RMS of ellipsoidal coordinates and differences Slope distances and their RMS Statistics on the parameter dimensions	JSER52/PAI		
GPSEST 3.2.1.2: Extended Program Output Options OTHER INFORMATION Resolved ambiguities from observation files Constants, antenna offsets, ionosphere coefficients Station eccentricities, receiver information Receiver synchronization errors PMS of ellipsoidal coordinates and differences Slope distances and their RMS Statistics on the parameter dimensions HELMERT TRANSFORMATION OF RESULTING STATION COORDINATES Activate Helmert transformation Coordinate system for transformation	User User		
ser:bem52 Campaign: S{PJ/INTRO SY+0=2010 SS+0=2070 File:/home/bem52/GPSU	User User	Help	

We do not fix any stations on their a priori position, i.e., the coordinates of all stations will be estimated. This retains the flexibility for later changes in the realization of the reference frame (station constraints) with program ADDNEQ2. Because no solution in GPSEST is computed you can select here all types of datum definition apart from "Coordinates fixed" (the normal equations are always stored without any constraints):

> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/GPSEST.INP

Bernese GNSS	Software Version 5.2									- 0 -
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
GPSEST 4: Datum Definition for Station Coordinates										
DATUN	I DEFINIT	ION TYP	Έ							
(Free	networ	k solutio	n						
(Coord	dinates	constrai	ned		ALL	•			
(Coord	dinates	fixed			MANUAL	×			
A PRI	ORI SIGM	AS								
Not	th	0.001	L mete	rs						
Eas	st	0.001	mete	rз						
Up		0.001	L mete	rs						
^Top ^P	rev ^Next	Cance [^] l	Save^As ^	Save ^Run	^Output	Rer^un ^+	Day ^-Da	ıy		
> User: ber	n52 Campai	gn: \${P}/IN	TRO \$Y+0=	2010 \$S+0=	2070 File	e: /home/bern5	2/GPSUS	ER52/PA	N/GPSEST.INF	>

	Software Version 5. Campaign		Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
GPSES	ST 5.1: S	Setup of	Paramete	rs and P	re-Elin	uination 1				
STATI	ION-RELA	'ED PARA	METERS			Setup		Pre-B	limination	
Sta	ation co	ordinate	8				NO			•
Amb	oiguitie:	3					AS	SOON A	AS POSSIBLE	•
ATMOS	SPHERIC I	PARAMETE	RS							
Sit	te-speci	fic trop	osphere p	arameter	3	M	NO			*
Glo	obal ion	osphere	parameter	S		Γ	NO			Y
GLOBA	AL PARAMI	TERS								
Orł	oital pa:	rameters					NO			*
Ear	rth orie:	ntation	parameter	s			NO			*
Geo	ocenter (coordina	ites				NO			*
EPOCH	I PARAME:	rers								
Red	ceiver c.	lock off	sets			Г	EVI	SRY EPC	CH	Ŧ
Sat	tellite	clock of	fsets			Г	EVI	SRY EPC	CH	*
Kir	nematic (coordina	ites				EVI	SRY EPC	CH	-
Sto	ochastic	ionospł	ere param	eters		Г	EVI	SRY EPC	CH	-
Top ^F	Prev / ^Next	Cance ⁴	Save^As ^:	Save ^Run	^Output	Rer^un A+	Day ^-D	ay		

The unresolved ambiguities are pre–eliminated. In addition we may setup additional parameters of interest.

The selection of the mapping function has to be consistent with the selection of the troposphere model in "ZPD model and mapping function (GNSS)" in panel "GPSEST 3.2: General Options 2".

Bernese GNSS Software Version 5.2							- 0 💌			
Configure Campaign RINEX	Orbits/EOP Processing	Service C	Conversion	BPE	User	Help				
GPSEST 6.1.1: Site-S	pecific Troposphe	re Param	eters 1							
ZENITH PATH DELAY PARAMETERS										
Mapping function	-	WET VMF	•							
Parameter spacing	Ĩ	01 00 00	(hh mm	SS)						
HORIZONTAL GRADIENT	PARAMETERS									
Gradient estimatio	n model	CHENHER	•							
Parameter spacing	Ē	24 00 00	(hh mm	ss)						
A PRIORI SIGMAS	1	Absolute			Relat	ive				
Zenith path delay	[meters		5		meters			
Horizontal gradien	ts		meters		5		meters			
EXTRACTION OF PARAME	TERS FOR TROPOSPH	ERE SINE:	X FILE							
Offset	(hhh mm ss)	Ti	me resolu	ution			(hh mm ss)			
Arop APrev ANext CanceAl SaveAs Ase Arun AOutput RerAun A-Day										
> User: bern52 Campaign: \${P}/IN	TRO \$Y+0=2010 \$S+0=	2070 File: /	home/bern52	2/GPSUSE	R52/PAN	I/GPSES	ST.INP			

The output of the **GPSEST** contains only the input parameter and ends with the parameter statistics:

13. RESULTS (PART 1)					
NUMBER OF PARAMETERS (PART 1):					
PARAMETER TYPE	#PARAMETERS	#PRE - E1	LIMINATED	#SET - UP	
STATION COORDINATES AMBIGUITIES SITE-SPECIFIC TROPOSPHERE PARAMETERS	39 673 377	0 673 0	(BEFORE INV)	39 785 377	
TOTAL NUMBER OF PARAMETERS	1089	673		1201	

NUMBER OI	F OBSERVATIONS (PA	RT 1):		
TYPE	FREQUENCY	FILE/PAR	#OBSERVATIONS	
PHASE	L3	ALL	73602	
TOTAL NUM	BER OF OBSERVATION	S	73602	
SOLUTION :	SKIPPED			
	al time for pgm "G m finished success		682 / 0:00:47.752	

After running GPSEST in session mode the normal equation file <code>FIX10207.NQO</code> should be available in the directory P/INTRO/SOL

In the environment of the Bernese Introductory Course these files are provided in the archive $\{S\}/RNX2SNX/2010/SOL/$ and $\{S\}/RNX2SNX/2011/SOL/$ respectively. Copy the files of the additional three days into your campaign. Following files should be now available in the directory $\{P\}/INTRO/SOL$

FIX10207.NQ0, FIX10208.NQ0, and FIX11205.NQ0, FIX11206.NQ0.

6.2 Check the Coordinates of the Fiducial Sites

To check the consistency of our network solution with respect to the coordinates available in the IGS14 reference frame we generate a minimum constraint solution for the network using program ADDNEQ2 ("Menu>Processing>Combine normal equation systems") with the following options:

Bernese GNSS S	Software Version 5.2									
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
COMBI	NE NORMAL	L EQUAT	ION SYSTE	MS - ADD	NEQ2 1	1: Input	Files	1		
GENER	AL FILES									
Sho	w all ge	neral i	files	7						
NORMA	L EQUATIO	ON SYSI	EMS							
Nor	mal equa	tions		FIX	K\$YD+0	NQ0				
Var	ciance re	scaling	g factors		j	WGT				
MAIN	INPUT FI	LES								
Sta	ation coo	rdinate	es	API	R\$YD+0	CRD				
Sta	ation vel	ocities	3		1	VEL				
Sta	ation inf	ormatio	on	EX	AMPLE	STA				
∬ ^Top ^P	rev ^Next	Cance [^] l	Save^As ^	Save ^Run	^Output	Rer^un	+Day ^-D	Day		
> User: ber	n52 Campaig	gn: \${P}/IN	ITRO \$Y+0=	2010 \$S+0=	2070 File	e: /home/bern	52/GPSU	SER52/PA	AN/ADDNEQ	2.INP

No further input files in the next panel are needed.

Bernese GNSS Software Version 5.2								- 0 ×
Configure Campaign RIN	IEX Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
ADDNEQ2 2.1: Outp	out Files 1							
GENERAL OUTPUT FI								
Program output		use AD				or	FIN\$YD+	-
Error messages	Γ	merged	to pr	ogram outp	out	or	ERROR	MSG
MAIN RESULT FILES								
Normal equation	າຮ		FINS	YD+0 NQ0				
SINEX with N	EQ			SNX				
STATION- AND SATE	LLITE-RELATE	D RESULT	3					
Station coordin	nates		FINS	YD+0 CRD				
Station velocit	ties			VEL				
Satellite orbit	tal elements			ELE				
Earth rotation	parameters			ERP				
Earth rotation	parameters	(IERS)		IEP				
ATMOSPHERE-SPECIE	IC RESULTS							
Troposphere est	timates		FINS	YD+0 TRP				
Troposphere est	timates (SINE	(X)		TRO				
Ionosphere mode	els			ION				
Ionosphere mode	els (IONEX)			INX				
 ^Top ^Prev ^Next Can > User: bern52 Campaign: \${						·		D

A troposphere SINEX file may be generated in this solution by adding an output filename to the "Troposphere estimates (SINEX)" input field in panel "ADDNEQ2 2.1: Output Files 1".

Errese GNSS Software Version 5.2	
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help	
ADDNEQ2 3.1: Options 1	
TITLE EXAMPLE: Session \$YSS+0: Final coordinate/troposphere results	
GENERAL OPTIONS	
Maximum number of parameters in combined NEQ 1000 A priori sigma of unit weight 0.0010 meters Compute and compare individual solutions NO Reference epoch for station coordinates (yyyy mm dd Stop program after NEQ saving)
ADD PARAMETERS TO THE SYSTEM	
Set up station velocities	
Set up Geocenter coordinates	
^Top ^Prev ^Next Cance'l Save'As ^Save ^Run ^Output Rer'un ^+Day ^-Day > User: bern52 Campaign: \${P}INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/ADDNEQ2.IN	IP //

Bernese GNSS Software Version 5.2				- 0 ×
Configure Campaign RINEX Orbits/EOP Processing Service Conversion	BPE	User	Help	
ADDNEQ2 3.2: Options 2				
REMOVE STATION PARAMETERS FROM THE SYSTEM				
If receiver changes	NEVER			•
If antenna changes	NEVER			*
INPUT FILE OPTIONS				
Truncate NEQ station names after position 14	NO		•	
Keep input NEQs in alphabetical order				
OUTFUT OFTIONS				
Extended output wrt estimated parameters	7			
Notify station inconsistencies between NEQs				
Notify changes due to station information file	<u>۲</u>			
Print detailed list of parameter manipulations				
] ^Top ^Prev ^Next Cance ^a l Save ^a As ^Save ^Run ^Output Rer ^a un ^				
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern	52/GPSUS	ER52/PA	N/ADDNEQ2	.INP //

In the following three panels, all parameter types supported by ADDNEQ2 are listed. You may specify whether a parameter shall be pre-eliminated or not. An empty entry means that the parameter is not expected in the input NEQ files.

Please note that an automated preselection is not possible for technical reasons. If a parameter with an empty input field is detected in the input NEQ files, the program will stop with an error. In the opposite case, a warning message is issued.

Bernese GNSS Software Version 5.2		- 0
	Jser Help	
	osei Heib	
ADDNEQ2 4.1: Parameter Pre-Elimination		
	except:	ions for
STATION-RELATED PARAMETERS	files	station
Station coordinates NO -		Г
ATMOSPHERIC PARAMETERS		
Troposphere zenith path delays NO •		
Troposphere gradients NO .	Í	
Global ionosphere parameters		
GLOBAL PARAMETERS		
Orbital elements		
Stochastic pulses	Í	
Polar motion parameters		
Length of day parameters		
Universal time parameters		
Nutation parameters		
Geocenter coordinates		
	,	
^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output Rer^un ^+Day ^-Day		
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSEF	R52/PAN/ADDNEQ	2.INP

For the validation of the datum stations we choose the "Minimum constraint solution". Because it is a regional network, we only apply the no-translation condition. The other conditions are sufficiently defined by the satellite orbits.

Bernese GNSS Software Version 5.2	- 0 💌
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help	>
ADDNEQ2 5: Datum Definition for Station Coordinates	
DATUM DEFINITION TYPE	
c Free network solution	
c Minimum constraint solution FROM FILE -	
C Coordinates constrained MANUAL	
c Coordinates fixed MANUAL	
MINIMUM CONSTRAINT CONDITIONS	
Translation YES •	
Rotation NO -	
Scale NO .	
A PRIORI SIGMAS	
North 0.001 meters	
East 0.001 meters	
Up 0.001 meters	
 *Top *Prev *Next Cance*I Save*As *Save *Run *Output Rer*un *+Day *-Day	
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/ADE	NEQ2.INP
Bernese GNSS Software Version 5.2	
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help	>
ADDNEQ2 5.1: Datum Definition for Station Coordinates	
STATIONS CONSIDERED FOR MINIMUM CONSTRAINT CONDITIONS Manual selection	
List of stations from file IGS14 FIX	
Stations with specific flags in CRD file #: all no	on-blank
Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output Rer^un ^+Day ^-Day	
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/ADE	NEQ2.INP

The following panel allows to change the parameter spacing. We do not need this feature at the moment and leave, therefore, all input fields empty.

Emese GNSS Software Version 5-2	_ 0 💌
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help	
ADDNEQ2 8: Interval Length of Parameters	
NEW PARAMETER SPACING hhh mm ss Troposphere zenith path delays Troposphere gradients Time-dependent inter-system biases Earth rotation parameters Nutation parameters	
REFERENCE EFOCH FOR PARAMETER INTERVALS	S
^Top ^Prev ^Next Cance ⁺ I Save ⁺ As ^Save ^Run ^Output Rer ⁴ un ^+Day ^-Day Vuser; bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/ADDN	EQ2.INP

The relative constraints applied to the vertical troposphere and gradient parameters are so loose that they do not affect the solution. As in GPSEST, they simply prevent a format overflow in the output troposphere file in case of very weakly observed parameters due to gaps in the observation scenario.

📕 Bernese GNSS S	oftware Version 5.2									- 0 ×
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
ADDNE	Q2 9: Opt	cions f	or Atmosp	heric Pa:	rameter	s				
ABSOL	UTE CONS!	PRAININ	G							
Tro	posphere	zenith	path del	ays		meters				
Tro	posphere	gradie	nts	Ī		meters				
Glo	bal iono:	sphere	parameter	s [TECU				
Tro Tro	posphere posphere	zenith gradie	G AND VAL . path del nts parameter	ays		OF CONSTR meters meters TECU		01 00 24 00		(hh mm ss) (hh mm ss) (hh mm ss)
EXTRA	CTION OF	PARAME	TERS FOR	TROPOSPHI	ERE SIN	IEX FILE				
Off	set 🗌		(hhh	mm ss)	Tim	e resolut:	ion			(hh mm ss)
						Rer^un ^+[•	N/ADD1	VEQ2.INP

The ADDNEQ2 program output starts with some information about the parameters contained in the input NQO file(s). The input options for the program run follow. An important part is the statistics for the current ADDNEQ2 solution:

SUMMARY OF RESULTS					
Number of parameters:					
Parameter type	Adjusted	explicitly /	implicitly	Deleted	
Station coordinates / velocities		39	0		
Site-specific troposphere parameters	377	377		0	• • •
Previously pre-eliminated parameters	656		656		• • •
Total number	1072		656	0	• • •

Statistics:		
Total number of authentic observations	73602	
Total number of pseudo-observations	341	
-		
Total number of explicit parameters	416	
Total number of implicit parameters	656	
····· ··· ···· ··· ··· ··· ··· ··· ···		
Total number of observations	73943	
Total number of adjusted parameters	1072	
	72871	
Degree of freedom (DOF)	12011	
	0.00115	
A posteriori RMS of unit weight	0.00115 m	
Chi**2/DOF	1.32	
Total number of observation files	12	
Total number of stations	13	
Total number of satellites	0	

Below this part the program output reports the results of the parameter estimation in a standardized format for all parameter types:

ol Station name	Тур	Correction	Estimated value		A priori value	•••	
1 GANP 11515M001	X	-0.00246	3929181.41903	0.00050	3929181.42149		
1 GANP 11515M001	Y	-0.00001	1455236.82073	0.00024 0.00059	1455236.82074		# C
1 GANP 11515M001	Z	-0.00240	4793653.94773	0.00059	4793653.95013		# C
1 HERT 13212M010	Х	-0.0001 -0.00240 -0.00135 -0.00158 0.00045 -0.00418 -0.00372 -0.00019 -0.00759	4033460.84830	0.00058	4033460.84965		#0
1 HERT 13212M010	Y	-0.00158	23537.88819	0.00020	23537.88977		#(
1 HERT 13212M010	Z	0.00045	4924318.31497	0.00062	4924318.31452		#(
1 JOZ2 12204M002	Х	-0.00418	3664880.47678	0.00051	3664880.48096		#(
1 JOZ2 12204M002	Y	-0.00372	1409190.67690	0.00051 0.00025 0.00063 0.00055	1409190.68062		#(
1 JOZ2 12204M002	Z	-0.00019	5009618.53001	0.00063	5009618.53020		#(
1 LAMA 12209M001	х	-0.00759	3524522.82514	0.00055	3524522.83273		
••							
ite-specific tropos							
tation name	Тур				A priori value		
	 N	-0.00035			0.00000		
ANP 11515M001			-0.00035 0.00011	0.00007			
NP 11515M001	E	0.00011	0.00011	0.00009			
NP 11515M001		0.13553		0.00135	2.11411		
NP 11515M001	0	0.13073	2.24507	0.00101	2.11433		
NP 11515M001	U	0.13286	2.24742 2.25379		2.11456		
NP 11515M001	U	0.13901	2.25379	0.00097	2.11478		
ANP 11515M001	U U U	0.13493	2.24993 2.25041 2.24604	0.00085	2.11500	• • •	
NP 11515M001	U	0.13519	2.25041	0.00098	2.11522		
NP 11515M001	U	0.13060		0.00095	2.11544		
ANP 11515M001	U	0.13367	2.24951	0.00082	2.11584		
ANP 11515M001	UU	0.13178	2.24801	0.00089	2.11623		
	U	0.13341	2.25003	0.00085	2.11662		
ANP 11515M001	U	0.13276	2.24977	0.00083	2.11701		
ANP 11515M001	U U	0.13687	2.25427	0.00083	2.11740		#
ANP 11515M001		0.14007	2.25786	0.00077	2.11779		#
ANP 11515M001	U	0.14164	2.25973	0.00086	2.11809		#
ANP 11515M001	U	0.13776	2.25614	0.00104	2.11838		#
NP 11515M001	U	0.13772	2.25639	0.00096	2.11867		#
NP 11515M001	U	0.13297	2.25194	0.00101	2.11897		#
NP 11515M001	U	0.13823	2.25749	0.00091	2.11926		#
NP 11515M001	U	0.13867	2.25822	0.00088	2.11955		
ANP 11515M001	U	0.13921	2.25881	0.00088	2.11960		#
ANP 11515M001	U	0.13899	2.25864	0.00101	2.11965		#
ANP 11515M001	U	0.13434	2.25403	0.00102	2.11970		
ANP 11515M001	U	0.14064	2.26039	0.00094	2.11975		
ANP 11515M001	U	0.14075	2.26055	0.00107	2.11980		
ANP 11515M001	N	0.00019	0.00019	0.00007	0.00000		
ANP 11515M001	E	0.00080	0.00080	0.00009	0.00000		
ANP 11515M001	Ŭ	0.13904	2.25888	0.00140	2.11985		
	N	-0.00105	-0.00105	0.00007	0.00000		
FRT 13212M010							
ERT 13212M010 ERT 13212M010	E	-0.00216	-0.00216	0.00010	0.00000		

The coordinate solution for the session (P/INTRO/STA/FIN10207.CRD) may be compared with the a priori coordinates for the IGS core sites. The program HELMR1 ("Menu ><u>S</u>ervice><u>C</u>oordinate tools><u>H</u>elmert transformation") is used for this purpose:

	rocessing Service Conversion BPE User Help	
HELMERT TRANSFORMATION - HELMR1	L 1: Input/Output Files	
GENERAL FILES		
Show all general files	7	
INPUT FILES	Transmitter and the second sec	
First coordinate file Velocities for first file	EXAMPLE CRD EXAMPLE VEL (blank: no veloc. applied)	
PSD correction (ITRF14)	EXAMPLE VEL (blank: no veloc. applied) IGS14 PSD stations with PSD USE	
Second coordinate file	FINSYD+0 CRD	
File with list of stations	IGS14 FIX other stations MARK	
RESULT FILES Coordinates	CRD	
File with list of stations	FIX	
GENERAL OUTPUT FILES		
Program output	use HELMR1.Lnn or HLM\$YD+0 OUT	
Error messages	merged to program output or ERROR MSG	
Top ^Prev ^Next Cance^I Save^As ^Sav		
User: bern52 Campaign: \${P}/INTRO \$Y+0=201	10 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/HELMR1.INP	
Bernese GNSS Software Version 5.2		- 0
	P Processing Service Conversion BPE User Help	
HELMR1 2: Options for Helmer	rt fransformation	
TITLE EXAMPLE: Session SY	(SS+0: Check fiducial coordinates	
ITTURE [EVANLER: Session 51		
	too.o. chech Haddial Cooraliacoo	
STATION SELECTION		
STATION SELECTION Automatic station		
	selection (all stations or selection from file)	
 Automatic station 	selection (all stations or selection from file)	
 Automatic station Manual station sel HELMERT TRANSFORMATION 	selection (all stations or selection from file) .ection	
 Automatic station Manual station sel HELMERT TRANSFORMATION System of transformation, 	selection (all stations or selection from file) .ection LOCAL (N,E,U) or GEOCENTRIC (X,Y,Z) <u>NEU</u>	
 Automatic station Manual station sel HELMERT TRANSFORMATION 	selection (all stations or selection from file) .ection LOCAL (N,E,U) or GEOCENTRIC (X,Y,Z) NEU	
 Automatic station Manual station sel HELMERT TRANSFORMATION System of transformation, Unit of residuals (meter of 	selection (all stations or selection from file) .ection LOCAL (N,E,U) or GEOCENTRIC (X,Y,Z) or millimeter)	
 Automatic station Manual station sel HELMERT TRANSFORMATION System of transformation, 	selection (all stations or selection from file) .ection LOCAL (N,E,U) or GEOCENTRIC (X,Y,Z) or millimeter) shift 1 7 rot 1	
 Automatic station Manual station sel HELMERT TRANSFORMATION System of transformation, Unit of residuals (meter of 	selection (all stations or selection from file) ection LOCAL (N,E,U) or GEOCENTRIC (X,Y,Z) or millimeter) shift 1 P rot 1 shift 2 P rot 2	×
 Automatic station Manual station sel HELMERT TRANSFORMATION System of transformation, Unit of residuals (meter of 	selection (all stations or selection from file) LOCAL (N,E,U) or GEOCENTRIC (X,Y,Z) NEU or millimeter) MM shift 1 F rot 1 shift 2 F rot 2 shift 3 F rot 3	
 Automatic station Manual station sel HELMERT TRANSFORMATION System of transformation, Unit of residuals (meter of 	selection (all stations or selection from file) ection LOCAL (N,E,U) or GEOCENTRIC (X,Y,Z) NEU or millimeter) shift 1 P rot 1 shift 2 P rot 2	
 Automatic station Manual station sel HELMERT TRANSFORMATION System of transformation, Unit of residuals (meter of 	selection (all stations or selection from file) LOCAL (N,E,U) or GEOCENTRIC (X,Y,Z) NEU or millimeter) MM shift 1 F rot 1 shift 2 F rot 2 shift 3 F rot 3	
 Automatic station Manual station sel HELMERT TRANSFORMATION System of transformation, Unit of residuals (meter of Parameters to be computed 	selection (all stations or selection from file) LOCAL (N,E,U) or GEOCENTRIC (X,Y,Z) NEU or millimeter) MM shift 1 F rot 1 shift 2 F rot 2 shift 3 F rot 3	X
 Automatic station Manual station sel HELMERT TRANSFORMATION System of transformation, Unit of residuals (meter of Parameters to be computed 'Top 'Prev 'Next Cance' Save'As	selection (all stations or selection from file) LOCAL (N,E,U) or GEOCENTRIC (X,Y,Z) MEU or millimeter) MM shift 1 F rot 1 shift 2 F rot 2 shift 3 F rot 3 F scale	
 Automatic station Manual station sel HELMERT TRANSFORMATION System of transformation, Unit of residuals (meter of Parameters to be computed 'Top 'Prev 'Next Cance' Save'As	selection (all stations or selection from file) LOCAL (N,E,U) or GEOCENTRIC (X,Y,Z) NEU or millimeter) MM shift 1 P rot 1 shift 2 P rot 2 shift 3 P rot 3 scale NUM NOUTUR Rer'un A+Day A-Day	×
 Automatic station Manual station sel HELMERT TRANSFORMATION System of transformation, Unit of residuals (meter of Parameters to be computed *Top *Prev *Next Cance" Save*As User: berm52 Campaign: \${P}/INTRO \$Y+0 	selection (all stations or selection from file) LOCAL (N,E,U) or GEOCENTRIC (X,Y,Z) NEU or millimeter) MM shift 1 P rot 1 shift 2 P rot 2 shift 3 P rot 3 scale NUM NOUTUR Rer'un A+Day A-Day	
 Automatic station Manual station sel HELMERT TRANSFORMATION System of transformation, Unit of residuals (meter of Parameters to be computed *Top *Prev *Next Cance" Save*As User: bern52 Campaign: \${P}/INTRO \$Y+0 Emmed \$N\$25050000 \$\$ 	selection (all stations or selection from file) LOCAL (N,E,U) or GEOCENTRIC (X,Y,2) NEU or millimeter) MM shift 1 rot 1 shift 2 rot 2 shift 3 rot 3 scale ^Save ^Run ^Output Rer'un ^+Day ^-Day >=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/HELMR1.INP	
 Automatic station Manual station sel HELMERT TRANSFORMATION System of transformation, Unit of residuals (meter of Parameters to be computed *Top *Prev *Next Cance" Save*As User: bern52 Campaign: \${P}/INTRO \$Y+0 Emmed \$N\$25050000 \$\$ 	selection (all stations or selection from file) LOCAL (N,E,U) or GEOCENTRIC (X,Y,2) NEU or millimeter) MM shift 1 rot 1 shift 2 rot 2 shift 3 rot 3 scale ^Save ^Run ^Output Rer'un ^+Day ^-Day >=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/HELMR1.INP	
 Automatic station Manual station sel HELMERT TRANSFORMATION System of transformation, Unit of residuals (meter of Parameters to be computed *Top *Prev *Next Cance*I Save*As User: bem52 Campaign: \${PyINTRO \$Y+0 Emmor \$NISSoftware Varian \$2 	selection (all stations or selection from file) LOCAL (N,E,U) or GEOCENTRIC (X,Y,2) NEU or millimeter) MM shift 1 rot 1 shift 2 rot 2 shift 3 rot 3 scale ^Save ^Run ^Output Rer'un ^+Day ^-Day >=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/HELMR1.INP	
 Automatic station Manual station sel HELMERT TRANSFORMATION System of transformation, Unit of residuals (meter of Parameters to be computed *Top *Prev *Next Cance'l Save'As User: bern52 Campaign: \${P}/INTRO \$Y+0 Hence GND\$Software Varian \$2 configure Campaign RINEX Orbits/EOF HELMR1 3: Outlier Rejection 	selection (all stations or selection from file) LOCAL (N,E,U) or GEOCENTRIC (X,Y,2) NEU or millimeter) MM shift 1 rot 1 shift 2 rot 2 shift 3 rot 3 scale ^Save ^Run ^Output Rer'un ^+Day ^-Day >=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/HELMR1.INP	
 Automatic station Manual station sel HELMERT TRANSFORMATION System of transformation, Unit of residuals (meter of Parameters to be computed *Top *Prev *Next Cance* Save*As User: bem52 Campaign: \${P}/INTRO \$Y+0 Isomore 603550/bere Verson 52 configure Campaign RINEX Orbits/EOF HELMRI 3: Outlier Rejection OUTLIER REJECTION 	selection (all stations or selection from file) LOCAL (N,E,U) or GEOCENTRIC (X,Y,2) NEU or millimeter) MM shift 1 rot 1 shift 2 rot 2 shift 3 rot 3 scale ^Save ^Run ^Output Rer'un ^+Day ^-Day >=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/HELMR1.INP	
 Automatic station Manual station sel HELMERT TRANSFORMATION System of transformation, Unit of residuals (meter of Parameters to be computed *Top 'Prev 'Next Cance' Save'As User: bern52 Campaign: \${P}/INTRO \$Y+0 Estimate \$105306see Vector \$2 configure Campaign RINEX Orbits/EOF HELMR1 3: Outlier Rejection OUTLIER REJECTION Enable outlier rejection 	Selection (all stations or selection from file) LOCAL (N,E,U) or GEOCENTRIC (X,Y,Z) NEU or millimeter) MM shift 1 P rot 1 shift 2 P rot 2 shift 3 P rot 3 Scale ^Save ^Run ^Output Rer/un ^+Day ^-Day D=2010 \$S+0=2070 File:/home/bern52/GPSUSER52/PAN/HELMR1.INP P Processing Service Conversion BPE User Help	
 Automatic station Manual station sel HELMERT TRANSFORMATION System of transformation, Unit of residuals (meter of Parameters to be computed *Top *Prev *Next Cance'l Save*As User: bern52 Campaign: S{P}/INTRO SY+0 Liemer 60550bere Versen52 Configure Campaign RINEX Orbits/EOF HELMR1 3: Outlier Rejection OUTLIER REJECTION Enable outlier rejection Outlier criteria nort 	selection (all stations or selection from file) LOCAL (N,E,U) or GEOCENTRIC (X,Y,2) NEU or millimeter) NM shift 1 P rot 1 shift 2 P rot 2 shift 3 P rot 3 scale NAUN / NOUTPUT Rer'un ^+Day ^-Day >=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/HELMR1.INP P Processing Service Conversion BPE User Help th component 10 millimeters	
 Automatic station Manual station sel HELMERT TRANSFORMATION System of transformation, Unit of residuals (meter of Parameters to be computed *Top *Prev *Next Cance'l Save*As User: bem52 Campaign: \$(P)/INTRO \$Y+0 Benee 6NS1504wer Vacion \$2 configure Campaign RINEX Orbits/EOF HELMR1 3: Outlier Rejection OUTLIER REJECTION Enable outlier rejection Outlier criteria nort east 	selection (all stations or selection from file) .ection LOCAL (N, E, U) or GEOCENTRIC (X, Y, Z) or millimeter) shift 1 shift 2 rot 1 shift 3 cale 'Save ^Run ^Output Rer'un ^+Day ^.Day >=2010 \$\$+0=2070 File: /home/bern52/GPSUSER52/PAN/HELMR1.INP P Processing Service Conversion BPE User Help ch component 10 millimeters	
 Automatic station Manual station set HELMERT TRANSFORMATION System of transformation, Unit of residuals (meter of Parameters to be computed *Top 'Prev 'Next Cance'l Save'As User: bem52 Campaign: \${P}/INTRO \$Y+0 Emoce \$ND\$ Software Varian \$2 configure Campaign RINEX Orbits/EOF HELMR1 3: Outlier Rejection OUTLIER REJECTION Enable outlier rejection Outlier criteria nort east up 	selection (all stations or selection from file) LOCAL (N,E,U) or GEOCENTRIC (X,Y,Z) NEU or millimeter) MM shift 1 7 rot 1 shift 2 7 rot 2 shift 3 7 rot 3 5 scale 7 rot 3 7 *Save ^Run ^Output Rer'un ^+Day ^-Day D=2010 \$S+0=2070 File:/home/bern52/GPSUSER52/PAN/HELMR1.INP P Processing Service Conversion BPE User Help P Processing Service Conversion BPE User Help th component 10 millimeters component 10 millimeters millimeters	
 Automatic station Manual station sel HELMERT TRANSFORMATION System of transformation, Unit of residuals (meter of Parameters to be computed *Top *Prev *Next Cance'l Save*As User: bem52 Campaign: \$(P)/INTRO \$Y+0 Benee 6NS1504wer Vacion \$2 configure Campaign RINEX Orbits/EOF HELMR1 3: Outlier Rejection OUTLIER REJECTION Enable outlier rejection Outlier criteria nort east 	selection (all stations or selection from file) .ection LOCAL (N, E, U) or GEOCENTRIC (X, Y, Z) or millimeter) shift 1 shift 2 rot 1 shift 3 cale 'Save ^Run ^Output Rer'un ^+Day ^.Day >=2010 \$\$+0=2070 File: /home/bern52/GPSUSER52/PAN/HELMR1.INP P Processing Service Conversion BPE User Help ch component 10 millimeters	-
 Automatic station Manual station set HELMERT TRANSFORMATION System of transformation, Unit of residuals (meter of Parameters to be computed *Top 'Prev 'Next Cance'l Save'As User: bem52 Campaign: \${P}/INTRO \$Y+0 Emoce \$ND\$ Software Varian \$2 configure Campaign RINEX Orbits/EOF HELMR1 3: Outlier Rejection OUTLIER REJECTION Enable outlier rejection Outlier criteria nort east up 	selection (all stations or selection from file) LOCAL (N,E,U) or GEOCENTRIC (X,Y,Z) NEU or millimeter) MM shift 1 7 rot 1 shift 2 7 rot 2 shift 3 7 rot 3 5 scale 7 rot 3 7 *Save ^Run ^Output Rer'un ^+Day ^-Day D=2010 \$S+0=2070 File:/home/bern52/GPSUSER52/PAN/HELMR1.INP P Processing Service Conversion BPE User Help P Processing Service Conversion BPE User Help th component 10 millimeters component 10 millimeters millimeters	-
 Automatic station Manual station sel HELMERT TRANSFORMATION System of transformation, Unit of residuals (meter of Parameters to be computed *Top 'Prev 'Next Cance' Save*As User: bem52 Campaign: \${P}/INTRO \$Y+0 Ennex 6053 Software Venion 52 configure Campaign RINEX Orbits/EOF HELMR1 3: Outlier Rejection OUTLIER REJECTION Enable outlier rejection Outlier criteria nort east up List of rejected stations 	selection (all stations or selection from file) LOCAL (N,E,U) or GEOCENTRIC (X,Y,Z) NEU or millimeter) MM shift 1 7 rot 1 shift 2 7 rot 2 shift 3 7 rot 3 5 scale 7 rot 3 7 *Save ^Run ^Output Rer'un ^+Day ^-Day D=2010 \$S+0=2070 File:/home/bern52/GPSUSER52/PAN/HELMR1.INP P Processing Service Conversion BPE User Help P Processing Service Conversion BPE User Help th component 10 millimeters component 10 millimeters millimeters	

For our example we get the following output. The M-flag for some stations indicates that they are not used to compute the transformation parameters. For these sites, only the residuals are printed to the program output.

_____ Bernese GNSS Software, Version 5.2 -----Program : HELMR1 Purpose : Helmert Transformation -----Campaign : \${P}/INTRO Default session: 2070 year 2010 Date : 28-Aug-2017 15:43:08 User name : bern52 _____ EXAMPLE: Session 102070: Check fiducial coordinates FILE 1: EXAMPLE.CRD: IGS14: coordinate list FILE 2: FIN10207.CRD: EXAMPLE: Session 102070: Final coordinate/troposphere res LOCAL GEODETIC DATUM: IGS14 RESIDUALS IN LOCAL SYSTEM (NORTH, EAST, UP) | NUM | NAME | FLG | RESIDUALS IN MILLIMETERS | | _____
 75
 GANP 11515M001
 I
 I
 W

 92
 HERT 13212M010
 I
 W
 I

 107
 JOZ2 12204M002
 P
 A
 I
 3.40 | | 0.71 | | 3.26 | M | 7.27 | M | -1.72 | | -0.24 -0.40 1.34 2.98 1.30 1.02 -1.50 -3.44 | P A | | I W | 122 | LAMA 12209M001 -4.14 3.61 136 | MATE 12734M008

 136
 MATE
 12734M008
 I
 I
 W
 3.61

 176
 ONSA
 10402M004
 I
 I
 W
 -0.75

 192
 PTBB
 14234M001
 P
 A
 -3.95

 236
 TLSE
 10003M009
 I
 W
 2.83

 262
 WSRT
 13506M005
 I
 W
 -0.72

 263
 WTZR
 14201M010
 I
 W
 0.52

 264
 WTZZ
 14201M014
 P
 A
 -2.77

 276
 ZIM2
 14001M008
 I
 W
 -4.38

 278
 ZIMM
 14001M004
 I
 W
 0.64

 -0.15 -0.64 | -3.95 3.14 7.02 | M -3.44 -0.06 0.56 | -0.05 1.41 -1.24 | | 3.46 1.50 | M | -1.23 -1.83 | | 1.49 0.82 | | ------

 | RMS / COMPONENT |
 |
 2.35
 1.60
 1.63 |

 | MEAN
 |
 0.00
 -0.00
 -0.00 |

 | MIN
 |
 -4.38
 -3.44
 -1.83 |

 | MAX
 |
 |
 3.61
 1.49
 3.40 |

 1 T NUMBER OF PARAMETERS : NUMBER OF COORDINATES : 3 27 RMS OF TRANSFORMATION : 1.89 MM BARYCENTER COULT LATITUDE : LONGITUDE : : BARYCENTER COORDINATES: 48 45 56.82 9 29 24.71 -37.545 KM PARAMETERS: TRANSLATION IN N : TRANSLATION IN E : TRANSLATION IN U : 0.02 +- 0.63 MM 0.03 +- 0.63 MM +- 0.63 0.00 MM NUMBER OF ITERATIONS : 1 NO OUTLIER DETECTED >>> CPU/Real time for pgm "HELMR1": 0:00:00.076 / 0:00:00.075 >>> Program finished successfully

We can conclude that no problems concerning the stations used for the datum definition were detected.

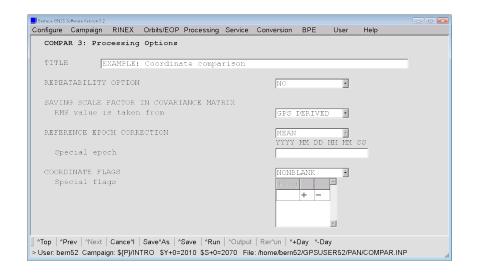
If there were problems, the ADDNEQ2 run needs to be repeated with the problematic station either removed from the file \${P}/INTRO/STA/IGS14.FIX or with manual selection of the stations used for the datum definition in panel "ADDNEQ2 5.1: Datum Definition for Station Coordinates".

In order to check the repeatability of the coordinate solutions for all 4 days, repeat the above steps for the remaining three days.

6.3 Check the Daily Repeatability

If the minimum constraint solutions of the four sessions are available, the repeatability of the coordinate solutions may be checked using the program COMPAR ("Menu>Service >Coordinate tools>Coordinate comparison").

Bernese GNSS Software Version 5.2					- 0 🗙
Configure Campaign RINEX	Orbits/EOP Processing	Service Convers	ion BPE	User	Help
COORDINATE COMPARISO	ON - COMPAR 1: Inp	ut Files			
GENERAL FILES					
Show all general :	files	۲			
INPUT FILES					
Coordinates		FIN???	?? CRD		
Covariances			COV		
same name as	coordinate file(s)				
A priori coordina	tes		CRD		
A priori velociti	es		VEL	(to un	ify the epochs)
Baseline definiti	ons		BSL		
Plot skeleton			SKL		
] ^Top ^Prev *Next Cance*I				•	
> User: bern52 Campaign: \${P}/IN	NTRO \$Y+0=2010 \$S+0=	2070 File: /home/b	ern52/GPSUS	ER52/PAN	/COMPAR.INP



The program computes the arithmetic mean for all station coordinates. The difference of each individual coordinate set to this mean value and the overall RMS are reported in the following section of the program output:

	0		P		0	p	-		
NUM	STAT	ON	#FIL	С	RMS	1	2	3	4
75	GANP	11515M001							
						-10.03			
				U	2.76	1.58	2.51	-0.36	-3.73
92	HERT	13212M010							
						-8.75			
				U	3.39	-2.48	-0.29	-2.11	4.88
107	1070	12204M002	4	M	0 1 1	6 01	7 1 2	7 96	6 70
107	1022	122041002				-10.51			
						2.98			
				0	1.10	2.50	1.00	-0.40	-1.00
122	τΔΜΔ	12209M001	4	N	8 4 2	-7 37	-7 19	6 66	7 91
122	DAIIA	1220011001				-10.50			
						3.42			
				č	0.00	0.12	1.20		0110
136	MATE	12734M008	4	N	11.57	-10.24	-9.76	10.86	9.15
						-11.97			
						-0.11			
176	ONSA	10402M004	4	Ν	8.22	-7.14	-7.08	6.50	7.72
						-8.76			
						-2.34			
192	PTBB	14234M001	4	Ν	8.91	-6.90	-8.50	7.82	7.58
		14234M001		Е	11.57	-9.92	-10.12	9.75	10.29
						-1.66			
236	TLSE	10003M009	4	Ν	9.13	-8.60	-7.18	7.67	8.11
						-10.17			
				U	2.14	-0.50	-2.65	0.69	2.46
262	WSRT	13506M005							
						-8.35			
				U	2.26	2.45	-0.43	-2.89	0.87
0.00		1 1001 2001			0.00	7	7		7
263	WTZR	14201M010							
						-10.20			
				U	2.42	0.47	2.96	-0.56	-2.88
004	11777	14001 1014		NT	0 20	7 04	7 17	C 07	7 4 4
264	WIZZ	14201M014	4	N	8.32	-7.24	-1.11	6.97	1.44
						-11.43			
				U	1.59	-1.97	1.18	1.40	-0.60
276	7110	14001M008	4	N	0 33	-8 01	-8 14	7 69	8 47
210	2112	140010008				-9.93			
				II	0.86	-9.93	-0.04	0 34	0.86
				0	0.00	-1.10	-0.04	0.54	0.00
278	7 T M M	14001M004	4	N	9 46	-8.26	-8 11	8 4 1	7 96
210	21111	1100111004				-9.63			
						0.70			
				0	0.00	0.10	0.11	0.00	0.01

While interpreting this output, keep in mind that the first two columns and the last two columns refer to different epochs (see warning message). The difference between these epochs is about one year. Obviously, station velocities need to be estimated (this will be done in the next step described in Section 6.5).

Bernese GNSS Software Version 5.2	- 0 🐱
Configure Campaign RINEX Orbits/EOP Processing Service	rice Conversion BPE User Help
COORDINATE COMPARISON - COMPAR 1: Input B	iles
GENERAL FILES	
Show all general files	¥
INPUT FILES	
Coordinates	FIN????? CRD
Covariances	COV
same name as coordinate file(s)	
A priori coordinates	CRD
A priori velocities	EXAMPLE VEL (to unify the epochs)
Baseline definitions	BSL
Plot skeleton	SKL
^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Or	itput Rer^un ^+Day ^-Day
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070	File: /home/bern52/GPSUSER52/PAN/COMPAR.INP

If reliable velocities for all stations are available they can be introduced:

You may check the influence on the repeatability on your own. Please be reminded, that for the ITRF2014 (IGS14) reference frame the linear station velocities are not sufficient. You may see the effect of the PSD corrections in the repeatablity. This is not the case for this example because none of the stations is affected by an earthquake and, therefore, no PSD corrections have to be considered.

This output may be used for quality assessment. Stations with a problem in one or more sessions can be identified and excluded from the final ADDNEQ2 solution by adding them to section TYPE 003: STATION PROBLEMS in the station information file (\${P}/INTRO/STA/EXAMPLE.STA). All parameters of these stations will be pre-eliminated before the normal equations are stacked and, therefore, also before the solution is computed.

6.4 Compute the Reduced Solution of the Sessions

If one or more stations have to be excluded from the session solution or if the datum definition of the solution is still not acceptable, the final solution of the session has to be re-computed by repeating the ADDNEQ2 in Section 6.2. Finally, the result files for the final solution of the session are:

\${P}/INTRO/SOL/FIN\$YD+0.NQ0,
\${P}/INTRO/STA/FIN\$YD+0.CRD, and
\${P}/INTRO/ATM/FIN\$YD+0.TRP.

It is preferable for the velocity estimation to have smaller normal equation files containing only the coordinate parameters for each session. In addition, we generate a coordinate Solution INdependent EXchange format (SINEX) file (in NEQ representation) as the final solution of the day, so the troposphere parameters have to be pre-eliminated before the solution is computed. We introduce the station coordinates (\${P}/INTRO/STA/FIN\$YD+ 0.CRD) obtained with the minimum constraint solution in the previous run of ADDNEQ2 and constrain the solution to these coordinates.

To generate these reduced NQO files and the SINEX file, the execution of ADDNEQ2 has to be repeated with the following changes in the input options:

Bernese GNSS Software Version 5.2	
Configure Campaign RINEX Orbits/EOP Proce	essing Service Conversion BPE User Help
COMBINE NORMAL EQUATION SYSTEMS -	ADDNEQ2 1.1: Input Files 1
GENERAL FILES	
Show all general files	Y
NORMAL EQUATION SYSTEMS	
Normal equations	FINSYD+0 NQO
Variance rescaling factors	WGT
MAIN INPUT FILES	
Station coordinates	FIN\$YD+0 CRD
Station velocities	VEL
Station information	EXAMPLE STA
] ^Top ^Prev ^Next Cance^I Save^As ^Save	^Run ^Output Rer^un ^+Day ^-Day
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$	\$S+0=2070 File: /home/bern52/GPSUSER52/PAN/ADDNEQ2.INP

Please note that the output SINEX file includes a skeleton from ${X}/GEN/SINEX$. RNX2SNX. We propose to derive individual SINEX skeletons for different tasks that you can include a specific description how the product has been generated. The skeleton is provided in the input field "SINEX general input file" in panel "ADDNEQ2 1.3: General Files".

nfigure Campaign RINEX Orbits/EOP Proc ADDNEQ2 1.3: General Files	essing Service Conversion	BPE User	Help	
GENERAL INPUT FILES				
General constants	CONST.			
Geodetic datum	DATUM.			
Phase center variations	PCV Bxx.I14			
Receiver information	RECEIVER.			
Satellite information	SATELLIT.I14			
Satellite problems	SAT \$Y+0 CRX			
Subdaily pole model	IERS2010XY SUB			
Nutation model	IAU2000R06 NUT			
SINEX header file	SINEX.			
IONEX control file	IONEX.			
MENU SETTINGS				
Selected campaign	\${P}/INTRO			
Selected session	Year 2010 Sess	ion 2070		
Session table	\${P}/INTRO/STA/SESS	IONS.SES		
TEMPORARY FILES				
Scratch file	ADDNEQ2\$J SCR			
ser: bern52 Campaign: \${P}/INTRO \$Y+0=2010	\$S+0=2070 File: /home/bern52	GPSUSER52/PA	N/ADDNEQ2.INP	,
mese GNSS Software Version 5.2				
mese BNSS Software Version 5.2 Ifigure Campaign RINEX Orbits/EOP Proce		IGPSUSER52/PA	N/ADDNEQ2.INP Help	
mese BNSS Software Version 5.2 Ifigure Campaign RINEX Orbits/EOP Proce				
moreONSSONWARYFONDS2 figure Campaign RINEX Orbits/EOP Proc. ADDNEQ2 2.1: Output Files 1 GENERAL OUTPUT FILES				
mere ONIS Software Venion 52 figure Campaign RINEX Orbits/EOP Proce ADDNEQ2 2.1: Output Files 1 GENERAL OUTPUT FILES Program output us	essing Service Conversion	BPE User	Help	<u> </u>
mere ONIS Software Venion 52 figure Campaign RINEX Orbits/EOP Proce ADDNEQ2 2.1: Output Files 1 GENERAL OUTPUT FILES Program output us	essing Service Conversion	BPE User	Help RED\$YD+C	<u> </u>
mex 6N35 Software Version 52 figure Campaign RINEX Orbits/EOP Proce ADDNEQ2 2.1: Output Files 1 GENERAL OUTPUT FILES Program output ux Error messages me	essing Service Conversion se ADDNEQ2.Lnn erged to program outpu	BPE User	Help RED\$YD+C	
mere GNUS Software Version 52 figure Campaign RINEX Orbits/EOP Proce ADDNEQ2 2.1: Output Files 1 GENERAL OUTPUT FILES Program output us Error messages mo MAIN RESULT FILES	essing Service Conversion	BPE User	Help RED\$YD+C	<u> </u>
Marc ONS Software Verson 52 Ifigure Campaign RINEX Orbits/EOP Proce ADDNEQ2 2.1: Output Files 1 GENERAL OUTPUT FILES Program output us Error messages mo MAIN RESULT FILES Normal equations	essing Service Conversion se ADDNEQ2.Lnn erged to program outpu <u>RED\$YD+0</u> NQ0 <u>RED\$YD+0</u> SNX	BPE User	Help RED\$YD+C	<u> </u>
MER GNUS Software Venion 52 Infigure Campaign RINEX Orbits/EOP Proce ADDNEQ2 2.1: Output Files 1 GENERAL OUTPUT FILES Program output us Error messages me MAIN RESULT FILES Normal equations SINEX with NEQ T	essing Service Conversion se ADDNEQ2.Lnn erged to program outpu <u>RED\$YD+0</u> NQ0 <u>RED\$YD+0</u> SNX	BPE User	Help RED\$YD+C	<u> </u>
mere GNUS Subware Version 52 figure Campaign RINEX Orbits/EOP Proce ADDNEQ2 2.1: Output Files 1 GENERAL OUTPUT FILES Program output un Error messages me MAIN RESULT FILES Normal equations SINEX with NEQ S STATION- AND SATELLITE-RELATED RE	essing Service Conversion se ADDNEQ2.Lnn erged to program outpu <u>REDSYD+0</u> NQ0 <u>REDSYD+0</u> SNX 2SULTS	BPE User	Help RED\$YD+C	<u> </u>
Mark ONUS Software Venon 52 Ifigure Campaign RINEX Orbits/EOP Proc. ADDNEQ2 2.1: Output Files 1 GENERAL OUTPUT FILES Program output us Error messages me MAIN RESULT FILES Normal equations SINEX with NEQ S STATION- AND SATELLITE-RELATED RE Station coordinates	essing Service Conversion se ADDNEQ2.Lnn erged to program outpu RED\$YD+0 NQ0 RED\$YD+0 SNX SSULTS	BPE User	Help RED\$YD+C	<u> </u>
More ONES Software Venion 52 Ifigure Campaign RINEX Orbits/EOP Proc. ADDNEQ2 2.1: Output Files 1 GENERAL OUTPUT FILES Program output us Error messages me MAIN RESULT FILES Normal equations SINEX with NEQ S STATION- AND SATELLITE-RELATED RE Station coordinates Station velocities	essing Service Conversion ce ADDNEQ2.Lnn erged to program outpu <u>FEDSYD+0</u> NQ0 <u>REDSYD+0</u> SNX ESULTS CRD VEL	BPE User	Help RED\$YD+C	<u> </u>
MAIN RESULT FILES Normal equations STATION - AND SATELLITE-RELATED RE Station velocities Station velocities Station velocities Statilite orbital elements	essing Service Conversion se ADDNEQ2.Lnn erged to program outpu <u>RED\$YD+0</u> NQ0 <u>RED\$YD+0</u> SNX SSULTS CRD VEL ELE ELE ERP	BPE User	Help RED\$YD+C	<u> </u>
MAIN RESULT FILES Normal equations STATION- AND SATELLITE-RELATED RE Station coordinates Station velocities Satellite orbital elements Earth rotation parameters Earth rotation parameters (IER: ATMOSPHERE-SPECIFIC RESULTS	essing Service Conversion se ADDNEQ2.Lnn erged to program outpu <u>RED\$YD+0</u> NQ0 <u>RED\$YD+0</u> SNX SSULTS CRD VEL ELE ELE ERP	BPE User	Help RED\$YD+C	<u> </u>
MAIN RESULT FILES Normal equations SINEX with NEQ S STATION- AND SATELLITE-RELATED RE Station coordinates Station velocities Satellite orbital elements Earth rotation parameters Earth rotation parameter	essing Service Conversion se ADDNEQ2.Lnn erged to program outpu <u>RED\$YD+0</u> NQ0 <u>RED\$YD+0</u> SNX SSULTS CRD VEL ELE ELE ERP 3) TRP	BPE User	Help RED\$YD+C	<u> </u>
Main GNUSSONWAY Version 52 Ifigure Campaign RINEX Orbits/EOP Proc. ADDNEQ2 2.1: Output Files 1 GENERAL OUTPUT FILES Program output us Error messages me MAIN RESULT FILES Normal equations SINEX with NEQ STATION- AND SATELLITE-RELATED RE Station coordinates Station velocities Statellite orbital elements Earth rotation parameters Earth rotation parameters (IER: ATMOSPHERE-SPECIFIC RESULTS Troposphere estimates Troposphere estimates (SINEX)	essing Service Conversion se ADDNEQ2.Lnn erged to program outpu REDSYD+0 NQ0 REDSYD+0 SNX ESULTS CRD VEL ELE ERF S) TRP TRO	BPE User	Help RED\$YD+C	<u> </u>
MAIN RESULT FILES Normal equations SINEX with NEQ TATION AND AND AND AND AND AND AND AND AND AN	essing Service Conversion se ADDNEQ2.Lnn erged to program outpu <u>RED\$YD+0</u> NQ0 <u>RED\$YD+0</u> SNX ESULTS CRD VEL ELE ELE ERP 3) TRP TRO ION	BPE User	Help RED\$YD+C	<u> </u>
Main GNUSSONWAY Version 52 Ifigure Campaign RINEX Orbits/EOP Proc. ADDNEQ2 2.1: Output Files 1 GENERAL OUTPUT FILES Program output us Error messages me MAIN RESULT FILES Normal equations SINEX with NEQ STATION- AND SATELLITE-RELATED RE Station coordinates Station velocities Statellite orbital elements Earth rotation parameters Earth rotation parameters (IER: ATMOSPHERE-SPECIFIC RESULTS Troposphere estimates Troposphere estimates (SINEX)	essing Service Conversion se ADDNEQ2.Lnn erged to program outpu REDSYD+0 NQ0 REDSYD+0 SNX ESULTS CRD VEL ELE ERF S) TRP TRO	BPE User	Help RED\$YD+C	<u> </u>
MAIN RESULT FILES Normal equations SINEX with NEQ STATION- AND SATELLITE-RELATED RE Station coordinates Station velocities Satellite orbital elements Earth rotation parameters (IER: ATMOSPHERE-SPECIFIC RESULTS Troposphere estimates (SINEX) Ionosphere models	essing Service Conversion se ADDNEQ2.Lnn erged to program outpu REDSYD+0 NQ0 REDSYD+0 SNX SSULTS CRD VEL ELE ELE ERP S) TRP TRO ION INX	BPE User or ut or	Help RED\$YD+C	<u> </u>

Bernese GNSS Software Version 5.2		- 0 ×
Configure Campaign RINEX Orbits/EOP Processing Service Conve	version BPE User Help	
ADDNEQ2 3.1: Options 1		
TITLE EXAMPLE: Session \$YSS+0: Generate NQO wi	with coordinates only	
GENERAL OPTIONS		
Maximum number of parameters in combined NEQ	1000	
A priori sigma of unit weight	0.0010 meters	
Compute and compare individual solutions	NO	
Reference epoch for station coordinates	(yyyy mm dd	1)
Stop program after NEQ saving		
ADD PARAMETERS TO THE SYSTEM		
Set up station velocities		
Set up Geocenter coordinates		
∬ ^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output Rer∿		
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home	ne/bern52/GPSUSER52/PAN/ADDNEQ2.IN	VP ,

Because you are storing a SINEX file in NEQ representation (see option "Content of SINEX") no regularization is necessary.

Bernese GNSS Software Version 5.2	
Configure Campaign RINEX Orbits/EOP Processing Service Conv	ersion BPE User Help
ADDNEQ2 3.2: Options 2	
REMOVE STATION PARAMETERS FROM THE SYSTEM	
If receiver changes	NEVER
If antenna changes	NEVER
INPUT FILE OPTIONS	
Truncate NEQ station names after position 14	NO
Keep input NEQs in alphabetical order	
OUTPUT OPTIONS	
Extended output wrt estimated parameters	Y
Notify station inconsistencies between NEQs	
Notify changes due to station information file	
Print detailed list of parameter manipulations	
] *Top *Prev *Next Cance*I Save*As *Save *Run *Output Rer*	'un ^+Day ^-Day
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /hom	e/bern52/GPSUSER52/PAN/ADDNEQ2.INP

The troposphere parameters are pre-eliminated:

Bernese GNSS Software Version 5.2						_ 0 💌
Configure Campaign RINEX Orbits/EOP Processing	g Service	Conversion	BPE I	Jser	Help	
ADDNEQ2 4.1: Parameter Pre-Eliminati	on					
					excepti	ons for
STATION-RELATED PARAMETERS					files	station
Station coordinates	NO		•			
ATMOSPHERIC PARAMETERS						
Troposphere zenith path delays	BEFORE	STACKING	•			
Troposphere gradients	BEFORE	STACKING	•			
Global ionosphere parameters			•			
GLOBAL PARAMETERS						
Orbital elements			-			
Stochastic pulses			*			
Polar motion parameters			•			
Length of day parameters			-			
Universal time parameters			•			
Nutation parameters			•			
Geocenter coordinates			•			
^Top ^Prev ^Next Cance^I Save^As ^Save ^Ru	n ^Output	Rer^un ^+	Day ^-Day			
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0	=2070 File	e: /home/bern5	2/GPSUSEF	R52/PA	V/ADDNEQ	2.INP

To keep the a priori and estimated sets of coordinates in the resulting SINEX file consistent, we introduce the coordinate solution of the session in "Station coordinates" in "ADDNEQ2 1.1: Input Files 1" and constrain all coordinate parameters to these values.

Bernese GNSS Software Version 5.2							- 0 ×
Configure Campaign RINEX	Orbits/EOP Processing	Service	Conversion	BPE	User	Help	
ADDNEQ2 5: Datum De	finition for Stati	on Coor	dinates				
DATUM DEFINITION TY							
 Free network 	ck solution						
 Minimum cor 	nstraint solution	FI	ROM FILE	Ψ.			
 Coordinates 	s constrained	A	LL	*			
c Coordinates	s fixed	M	ANUAL	Ψ.			
MINIMUM CONSTRAINT	CONDITIONS						
Translation YE	IS 🔽						
Rotation NO							
Scale NO							
A PRIORI SIGMAS							
North 0.	001 meters						
East 0.	001 meters						
Up O.	001 meters						
^Top ^Prev ^Next Cance^I		1.00.0000		D A D-			
> User: bern52 Campaign: \${P}/I	NIRO \$Y+0=2010 \$S+0=	2070 File	e: /home/bern5	2/GPSUS	ER52/PA	N/ADDNEQ2.IN	IP //

The normal equation file (\${P}/INTRO/SOL/RED10207.NQ0) contains only the station coordinate parameters. The following section of the program output documents the preelimination of the troposphere parameters:

SUMMARY OF RESULTS					
Number of parameters:					
Parameter type	Adjusted	explicitly /	implicitly	(pre-elimi	
Station coordinates / velocities Site-specific troposphere parameters	39 377	39 0	0 377	(before st	· · · · · · ·
Previously pre-eliminated parameters	656		656		
Total number	1072	39	1033		· · · · · · ·
•••					

Statistics:		
Statistics:		
Total number of authentic observations	73602	
Total number of pseudo-observations	377	
Total number of explicit parameters	39	
Total number of implicit parameters	1033	
Total number of observations	73979	
Total number of adjusted parameters	1072	
Degree of freedom (DOF)	72907	
A posteriori RMS of unit weight	0.00115 m	
Chi**2/DOF	1.32	
	1.02	
Total number of observation files	12	
Total number of stations	13	
Total number of satellites	0	

You can also see that the number of explicit parameters in the NQO file was dramatically reduced (from 416 to 39). This is an advantage for the combination of a big number of normal equation files for the estimation of station velocities.

6.5 Velocity Estimation

6.5.1 Preparation for ITRF2014/IGS14 Velocity Estimation

This section can be skipped if no ITRF2014/IGS14 reference frame is used as geodetic datum.

Because of the PSD corrections, the linear station velocity may not represent the actual station velocity and one has to prepare the station coordinate and velocity files before they can be used for the datum definition in the program ADDNEQ2. We have to compute the station coordinates at the reference epoch using the program COOVEL ("Menu>Service >Coordinate tools>Extrapolate coordinates"):

		ersion 5.2	RINEX	Orbits/E	OP Pro	cessina	Service	Conve	rsion E	PE	User	Help		
				ATES -										
GENEI														
She	ow al	l gen	neral	files			۲							
INPU	r fil	ES												
In	put d	coord	inate	file			Εž	AMPLE	CRD					
In	put v	reloc:	ity fi	le			EX	AMPLE	VEL					
PSI	D COI	rect	ion (I	TRF14)			IC	GS14	PSD					
REFEI	RENCE	EPOC	CH					yy mm 10 01		120	h mm s 0 00 0			
RESUI	T FI	LE												
Out	tput	coord	linate	file			EX	M wPSD	CRD					
Sta	atior	s wi	chout	PSD cor	rectio	ons	F		FIX					
GENEI	RAL C	UTPUT	FILE:	5										
Pro	ogram	u out	out		۲	use	e COOV	EL.Lnn			or		COOVEL	00
Er	ror n	lessa	ges		Γ	mei	ged to	o prog	ram ou	tput	or		ERROR	MS
TITLE	s	EXAMI	LE: S	ession	\$YSS+(): Coo	rdinat	e prop	agatio	n			_	
AT- AD	10011	Movt	Cancel	Save A	ASave	ARun	^Outpu	it Rer^u	n ^+Da	v ^-Da	av			

In our example none of the stations that shall be used for the datum definition is related to the PSD corrections. So, you can continue here. If you have another station selection where the PSD corrections become relevant we refer to Section 7.1 for further instructions.

6.5.2 Velocity Estimation Based on NEQ Files

The velocity estimation in program ADDNEQ2 is easy. Introduce the normal equation files containing only the station coordinate parameters. Copy the prepared files for the three additional days (208 year 2010, 205 and 206 year 2011) from \${S}/RNX2SNX/2010/SOL/RED10*NQO and \${S}/RNX2SNX/2011/SOL/RED11*NQO into \${P}/INTRO/SOL/ directory. The normal equation files have to cover a reasonable time interval to reliably estimate velocities (in this case one year):

Bernese GNSS Software Version 5.2					
Configure Campaign RINEX Orbits/EOP Proce	essing Service Conversion	n BPE User	Help		
COMBINE NORMAL EQUATION SYSTEMS -	ADDNEQ2 1.1: Inpu	Files 1			
GENERAL FILES Show all general files	Ч				
NORMAL EQUATION SYSTEMS Normal equations Variance rescaling factors	RED????? NQ0 WGT				
MAIN INPUT FILES Station coordinates Station velocities Station information	EXM_wPSD CRD EXAMPLE VEL EXAMPLE STA				
∬ ^Top ^Prev ^Next Cance⁴I Save^As ^Save > User: bern52 Campaign: \${P}/INTRO \$Y+0=2010		All and a second s	N/ADDNEQ	2.INP	h
Bernese GNSS Software Version 5.2					- • ×
Configure Campaign RINEX Orbits/EOP	Processing Service Co	nversion BPE	User	Help	
ADDNEQ2 2.1: Output Files 1					
GENERAL OUTPUT FILES					_
Program output	use ADDNEQ2.Lnr		or	FINAL	OUT
Error messages	merged to progr	am output	or	ERROR	MSG
MAIN RESULT FILES					
Normal equations		NQO			
SINEX with NEQ -		 SNX			
STATION- AND SATELLITE-RELATE					
Station coordinates Station velocities	FINAL	CRD			
Station velocities Satellite orbital elements	FINAL	VEL			
Earth rotation parameters		ELE			
Earth rotation parameters (TERSI	IEP			
Laton resultin parameters (12100 /	1.51			
ATMOSPHERE-SPECIFIC RESULTS					
Troposphere estimates		TRP			
Troposphere estimates (SINE	X)	TRO			
Ionosphere models		ION			
Ionosphere models (IONEX)		INX			
^Top ^Prev ^Next Cance^I Save^As ^3	Save ^Run ^Output F	er^un ^+Day ^-D	ay		
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2	2010 \$S+0=2070 File: /h	ome/bern52/GPSU	SER52/PA	N/ADDNEQ2.INI	P

Station velocities are set up by marking the corresponding checkbox:

Bernese GNSS So	oftware Version 5.2									- 8 8
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
ADDNEQ	Q2 3.1:	Options	1							
TITLE	EXAM	IPLE: Es	timate fi	nal solu	tion -	coordinat	es and	veloc	cities	
Max: A p: Comj Refe	GENERAL OPTIONS Maximum number of parameters in combined NEQ A priori sigma of unit weight Compute and compare individual solutions HLM TRA Reference epoch for station coordinates Stop program after NEQ saving									
			E SYSTEM							
	up stat					٦				
Set	up Geoc	center o	cordinate	83		Г				
						Rer^un ^+ : /home/berns			AN/ADDNEQ	2.INP

Furthermore, we check the repeatability of the daily solutions after the velocity estimation. The coordinates in the resulting file will refer to the epoch $2010\,01\,01$.

The input NEQ files only contain coordinates:

Bernese GNSS Software Version 5:2 Configure Campaign RINEX Orbits/EOP Processin	1 Service	Conversion	BPE	User	Help	- 0 ×
ADDNEQ2 4.1: Parameter Pre-Eliminati		Conversion	012		Theip	
					excepti	ons for
STATION-RELATED PARAMETERS					files	
Station coordinates	NO			*		
ATMOSPHERIC PARAMETERS						
Troposphere zenith path delays				•		
Troposphere gradients				•		
Global ionosphere parameters				-		
GLOBAL PARAMETERS						
Orbital elements				•		
Stochastic pulses				•		
Polar motion parameters				-		
Length of day parameters				*		
Universal time parameters				*		
Nutation parameters				•		
Geocenter coordinates				•		
 ^Top ^Prev ^Next Cance^l Save^As ^Save ^Ru	n ^Outpu	t Rer^un ^ +	-Day ^-Day	4		
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0					AN/ADDNEQ2	2.INP

The realization of the geodetic datum is done separately for positions and velocities in the following panels:

📕 Bernese GNSS Softwa	are Version 5.2									- • •
Configure Ca	mpaign	RINEX	Orbits/EO	Processing	Service	Conversion	BPE	User	Help	
ADDNEQ2	5: Da	tum Def	inition	for Stati	on Coor	dinates				
DATUM DI	DATUM DEFINITION TYPE									
0	 Free network solution 									
e	 Minimum constraint solution FROM FILE 									
0	c Coordinates constrained MANUAL									
c	c Coordinates fixed MANUAL									
MINIMUM	MINIMUM CONSTRAINT CONDITIONS									
Trans	lation	YE	s •							
Rotat	ion	NO	*							
Scale		NO	•							
A PRIOR	I SIGM	AS								
North		0.	001	meters						
East		0.1	001	meters						
Up		0.	001	meters						
^Top ^Prev	^Next	Cance [^] l	Save^As	^Save ARun	^Output	Rer^un ^+	Day ^-D	ay		
> User: bern52									N/ADDNE	Q2.INP

Bernese GNSS Software Version 5.2							
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help							
ADDNEQ2 5.1: Datum Definition for Station Coordinates							
STATIONS CONSIDERED FOR MINIMUM CONSTRAINT CONDITIONS							
Manual selection							
List of stations from file IGS14 FIX							
Stations with specific flags in CRD file #: all non-blank							
Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output Rer'un ^+Day ^-Day							
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/ADDNEQ2.INP							

Eemese 6NSS Subbrare Version 5.2
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help
ADDNEQ2 6: Datum Definition for Station Velocities
DATUM DEFINITION TYPE
c Free network solution
Minimum constraint solution FROM FILE
 Velocities constrained MANUAL
c Velocities fixed MANUAL
MINIMUM CONSTRAINT CONDITIONS
Translation YES
Rotation NO •
Scale NO -
A PRIORI SIGMAS
North 0.0001 meters/year
East 0.0001 meters/year
Up 0.0001 meters/year
 ^Top ^Prev ^Next Cance⁴l Save^As ^Save ^Run ^Output Rer⁴un ^+Day _^-Day
> User: bern52 Campaign: \${P}/INTRO_\$Y+0=2010 \$S+0=2070_File: /home/bern52/GPSUSER52/PAN/ADDNEQ2.INP
Bernese GNSS Software Version 5.2
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help
ADDNEQ2 6.1: Datum Definition for Station Velocities
STATIONS CONSIDERED FOR MINIMUM CONSTRAINT CONDITIONS
Manual selection List of stations from file IGS14 FIX
Stations with specific flags in VEL file #: all non-blank
^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output Rer^un ^+Day ^-Day
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/ADDNEQ2.INP

The following panel provides options to detect bad daily solutions based on the repeatability:

Bernese GNSS Sof	tware Version 5.2									- • •
Configure (Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
ADDNEQ	92 7: Con	npariso	n of Indi	vidual S	olution	s				
NOTIFI	CATION C	F POSS	IBLE OUTL	IERS						
Maxi	Maximum tolerated residual							mil	limeters	
						East	15	mil	limeters	
						Up	30	mil	limeters	
Мажі	.mum tole	erated	root-mear	n-square	error	North	10	mil	limeters	
						East	10	mil	limeters	
						Up	20	mil	limeters	
Mini	Minimum number of solutions for each station									
						Rer^un ^+	•	-		1115
> User: bernt	52 Campaig	in: s{P}/iN	TRU 51+0=:	2010 \$\$+0=	2070 File	: /home/bern5	ZIGPSUS	EK52/PA	IN/ADDNEQ2	.ine //

After the velocity estimation the repeatability of the coordinate solutions from the individual normal equations look like:

a								
Statist	Statistics of individual solutions:							
				#Obser	vations		#Parameter	r 9
File	RMS (m)	DOF	Chi**2/DOF			explicit	/ implicit /	
					, pbcuuo		, impiicit ,	
1	0.00115	72874	1.32	73940	6	39	1033	0
2	0.00121	72878	1.46	73861	6	39	950	0
3	0.00123	75378	1.50	76336	6	39	925	0
4	0.00122	75405	1.48	76421	6	39	983	0

10 N 10 E 10 U 02 N 02 E 02 U 01 N 01 E 01 U	0.40 0.53 1.24 0.12 0.41 3.10 0.24 0.40 0.51 0.48 0.14	0.08 -0.48 -0.91 0.06 0.41 -0.60	-0.10 0.45 0.91 -0.05 -0.39 0.63	0.11 -0.20 -3.65	-0.13 0.17 3.71			
10 N 10 E 10 U 02 N 02 E 02 U 01 N 01 E 01 U	0.12 0.41 3.10 0.24 0.40 0.51	0.08 -0.48 -0.91 0.06 0.41 -0.60	-0.10 0.45 0.91 -0.05 -0.39 0.63	0.11 -0.20 -3.65	-0.13 0.17 3.71			
10 N 10 E 10 U 02 N 02 E 02 U 01 N 01 E 01 U	0.12 0.41 3.10 0.24 0.40 0.51	0.08 -0.48 -0.91 0.06 0.41 -0.60	-0.10 0.45 0.91 -0.05 -0.39 0.63	0.11 -0.20 -3.65	-0.13 0.17 3.71			
02 N 02 E 02 U 01 N 01 E 01 U	0.24 0.40 0.51	0.06 0.41 -0.60	-0.05 -0.39 0.63					
02 N 02 E 02 U 01 N 01 E 01 U	0.24 0.40 0.51	0.06 0.41 -0.60	-0.05 -0.39 0.63					
01 N 01 E 01 U				0.28 0.28 0.11	-0.30 -0.28 -0.11			
01 N 01 E 01 U				0.28 0.11	-0.28 -0.11			
01 N 01 E 01 U				0.11	-0.11			
	0.48 0.14	-0.14						
	0.14		0.16	-0.57	0.58			
	4 4 0	-0.16	0.16	0.05	-0.04			
08 N	0.74	-0.25	0.25	0.87	-0.87			
08 E	0.22	0.15	-0.15	-0.23	0.22			
04 N	0.45	-0.09	0.13	-0.53	0.55			
04 E	0.37	0.25	-0.24	-0.37	0.39			
01 N	0.62	0.73	-0.76	0.17	-0.16			
01 E	0.20	0.09	-0.09	-0.22	0.23			
09 N	0.63	-0.77	0.72	-0.21	0.19			
09 E	0.27	-0.22	0.18	-0.28	0.26			
05 N	0.35	0.04	-0.02	0.46	-0.39			
05 E	0.32	0.30	-0.29	-0.24	0.28			
10 N	0.16	-0.18	0.17	-0.09	0.10			
10 E	0.31	-0.23	0.22	-0.32	0.30			
14 N	0.18	-0.08	0.08	-0.19	0.21			
14 E	0.33	-0.01	0.01	-0.40	0.40			
08 N	0.29	0.03	-0.02	-0.36	0.36			
08 E 08 U	0.10 0.48	0.11	-0.09 0.35	-0.07 -0.50	0.06 0.40			
04 N 04 E 04 U	0.23	-0.12	0.11	0.25	-0.27			
	04 N 04 E 04 U 01 N 01 E 01 U 09 N 09 E 09 U 05 N 05 U 10 N 10 U 14 N 14 U	04 N 0.45 04 E 0.37 04 U 1.39 01 N 0.62 01 E 0.20 01 U 0.75 09 N 0.63 09 E 0.27 09 U 1.36 05 N 0.35 05 E 0.32 05 U 2.15 10 N 0.16 10 E 0.31 10 U 1.17 14 N 0.18 14 U 1.31	04 N 0.45 -0.09 04 E 0.37 0.25 04 U 1.39 0.98 01 N 0.62 0.73 01 E 0.20 0.09 01 U 0.75 -0.87 09 N 0.63 -0.77 09 E 0.27 -0.22 09 U 1.36 1.31 05 N 0.35 0.04 05 E 0.32 0.30 05 U 2.15 1.65 10 E 0.31 -0.23 10 U 1.17 -1.09 14 N 0.18 -0.08 14 U 1.31 -1.42	04 N 0.45 -0.09 0.13 04 E 0.37 0.25 -0.24 04 U 1.39 0.98 -0.96 01 N 0.62 0.73 -0.76 01 E 0.20 0.09 -0.09 01 U 0.75 -0.87 0.85 09 N 0.63 -0.77 0.72 09 E 0.27 -0.22 0.18 09 U 1.36 1.31 -1.25 05 N 0.35 0.04 -0.02 05 U 2.15 1.65 -1.59 10 N 0.16 -0.18 0.17 10 E 0.31 -0.23 0.22 10 U 1.17 -1.09 1.03 14 N 0.18 -0.08 0.08 14 U 1.31	04 N 0.45 -0.09 0.13 -0.53 04 E 0.37 0.25 -0.24 -0.37 04 U 1.39 0.98 -0.96 1.40 01 N 0.62 0.73 -0.76 0.17 01 E 0.20 0.09 -0.96 1.40 01 E 0.20 0.09 -0.22 0.18 -0.22 01 U 0.75 -0.87 0.85 -0.35 09 N 0.63 -0.77 0.72 -0.21 09 E 0.27 -0.22 0.18 -0.28 09 U 1.36 1.31 -1.25 -1.08 05 N 0.35 0.04 -0.02 0.46 05 U 2.15 1.65 -1.59 -2.20 10 N 0.16 -0.18 0.17 -0.09 <	08 N 0.74 -0.25 0.25 0.87 -0.87 08 E 0.22 0.15 -0.15 -0.23 0.22 08 U 1.42 0.12 -0.17 1.80 -1.67 04 N 0.45 -0.09 0.13 -0.53 0.55 04 E 0.37 0.25 -0.24 -0.37 0.39 04 U 1.39 0.98 -0.96 1.40 -1.40 01 N 0.62 0.73 -0.76 0.17 -0.16 01 E 0.20 0.09 -0.22 0.22 0.23 01 U 0.75 -0.87 0.85 -0.35 0.29 03 D 0.63 -0.77 0.72 -0.21 0.19 09 U 1.36 1.31 -1.25 -1.08 1.07 05 N 0.3	04 N 0.45 -0.09 0.13 -0.53 0.55 04 E 0.37 0.25 -0.24 -0.37 0.39 04 U 1.39 0.98 -0.96 1.40 -1.40 01 N 0.62 0.73 -0.76 0.17 -0.16 01 E 0.20 0.09 -0.22 0.23 01 U 0.75 -0.87 0.85 -0.35 0.29 09 N 0.63 -0.77 0.72 -0.21 0.19 09 E 0.27 -0.22 0.18 -0.28 0.26 09 U 1.36 1.31 -1.25 -1.08 1.07 05 N 0.35 0.04 -0.02 0.46 -0.39 05 U 2.15 1.65 -1.59 -2.20 1.95 10 N 0.16 -0.18 0.17 -0.99 0.10 10 U 1.17 <th>04 N 0.45 -0.09 0.13 -0.53 0.55 04 E 0.37 0.25 -0.24 -0.37 0.39 04 U 1.39 0.98 -0.96 1.40 -1.40 01 N 0.62 0.73 -0.76 0.17 -0.16 01 E 0.20 0.09 -0.22 0.23 01 U 0.75 -0.87 0.85 -0.35 0.29 09 N 0.63 -0.77 0.72 -0.21 0.19 09 E 0.27 -0.22 0.18 -0.28 0.26 09 U 1.36 1.31 -1.25 -1.08 1.07 05 N 0.35 0.04 -0.02 0.46 -0.39 05 U 2.15 1.65 -1.59 -2.20 1.95 10 N 0.16 -0.18 0.17 -0.92 0.30 10 U 1.17</th>	04 N 0.45 -0.09 0.13 -0.53 0.55 04 E 0.37 0.25 -0.24 -0.37 0.39 04 U 1.39 0.98 -0.96 1.40 -1.40 01 N 0.62 0.73 -0.76 0.17 -0.16 01 E 0.20 0.09 -0.22 0.23 01 U 0.75 -0.87 0.85 -0.35 0.29 09 N 0.63 -0.77 0.72 -0.21 0.19 09 E 0.27 -0.22 0.18 -0.28 0.26 09 U 1.36 1.31 -1.25 -1.08 1.07 05 N 0.35 0.04 -0.02 0.46 -0.39 05 U 2.15 1.65 -1.59 -2.20 1.95 10 N 0.16 -0.18 0.17 -0.92 0.30 10 U 1.17

Below this table, bad daily solutions according to the settings in panel "ADDNEQ2 7: Comparison of Individual Solutions" are summarized (if there are any). In this example we have no additional section and, therefore, no outliers.

If you compare the velocities obtained for the two sites in Kötzting (WTZR and WTZZ) and Zimmerwald (ZIM2 and ZIMM) you will find small differences:

Reference epoch: 2	010-01-01	00:00:00			
Station name	Тур	A priori value	Estimated value	Correction	RMS error
 VTZR 14201M010	VX	-0.01629	-0.01820	-0.00191	0.00050
VIZR 14201M010	VA VY	0.01714		-0.00191	0.00021
	VI VZ	0.00986	0.01648	-0.00088	0.00021
	12	0.00980	0.00751	-0.00235	0.00035
	VU	-0.00043	-0.00352	-0.00309	0.00071
	VN	0.01557		-0.00002	0.00022
	VE	0.02034	0.02012	-0.00022	0.00018
VTZZ 14201M014	VX	-0.01629	-0.01531	0.00098	0.00054
	VY	0.01714	0.02011	0.00297	0.00023
	٧Z	0.00986	0.01007	0.00021	0.00059
	VU	-0.00043	0.00078		
	VN	0.01557		-0.00109	
	VE	0.02034	0.02301	0.00267	0.00020
 ZIM2 14001M008	VX	-0.01393	-0.01354	0.00039	0.00050
14001M008	VX VY	0.01809	0.01860	0.00051	0.00019
	VZ	0.01169	0.01202	0.00033	0.00013
	12	0.01105	0.01202	0.00033	0.00032
	VU	0.00070	0.00125	0.00055	0.00069
	VN	0.01636	0.01625	-0.00011	0.00022
	VE	0.01975	0.02020	0.00045	0.00018
ZIMM 14001M004	VX	-0.01393	-0.01499	-0.00106	0.00084
	VY	0.01809	0.01755	-0.00054	0.00028
	٧Z	0.01169	0.01067	-0.00102	0.00081
	VU	0.00070	-0.00081	-0.00151	0.00113
	VN VE	0.01636 0.01975	0.01648 0.01935	0.00013 -0.00040	0.00034

You can constrain the velocity estimates for the pairs of receivers at one location in the station information file. Copy the original station information file \${P}/INTRO/STA/EXAMPLE. STA and add the following lines to part TYPE 004: STATION COORDINATES AND VE-LOCITIES (ADDNEQ) of this copy.

TYPE 004: STATION COO	ORDINATES AND VELOC	CITIES (ADDNEQ)				
		REL. CONSTR.	POSITION	RELATIV	'E CONSTR.	VELOCITY
STATION NAME 1	STATION NAME 2	EAST	UP	NORTH	EAST	UP
*****	*****	**.****	**.****	**.****	**.****	**.****
WTZR 14201M010	WTZZ 14201M014			0.00001	0.00001	0.00001
ZIM2 14001M008	ZIMM 14001M004			0.00001	0.00001	0.00001

(Pay attention to the number of blank lines before the next section starts.)

When introducing this information, the program ADDNEQ2 will issue the following message:

```
### SR AOPTNET: You are going to use relative constraints for station
coordinates/velocities from station info file.
Please keep in mind that you will NOT constrain the
estimated results but only the improvements of the
apriori values.
```

If only the improvements (column Correction) for the velocities are constrained, you must make sure that also the a priori values (column A priori value) for the velocities are identical to obtain (column Estimated value) the same velocities for a group of stations. You can verify this in the input velocity file \${P}/INTRO/STA/EXAMPLE.VEL:

263	WTZR 14201M010	-0.01629	0.01714	0.00986	IG14 EURA
264	WTZZ 14201M014	-0.01629	0.01714	0.00986	NNR EURA
276	ZIM2 14001M008	-0.01393	0.01809	0.01169	IG14 EURA
278	ZIMM 14001M004	-0.01393	0.01809	0.01169	IG14 EURA

If this is not the case, you should unify the a priori values.

The relative constraining of the velocity estimates is confirmed in the section of the input parameters (below the a priori coordinates and velocities) of the ADDNEQ2–program output:

relative constraints for velocities
N (m/year) E (m/year) U (m/year)
0.00001 0.00001 0.00001
0.00001 0.00001 0.00001

Introducing this modified station information file instead of the original one you will get the following estimates for the station velocities in Kötzting and Zimmerwald:

```
. . .
Station coordinates and velocities:
Reference epoch: 2010-01-01 00:00:00
Station name
                       Typ A priori value Estimated value
                                                                     Correction
                                                                                     RMS error
                                                                                     _ _ _ _ _ _ _ _ _ _ _ _
                                                                                                 . . .
. . .
WTZR 14201M010
                        VX
                                     -0.01629
                                                        -0.01699
                                                                       -0.00070
                                                                                       0.00039
                        VY
                                      0.01714
                                                         0.01806
                                                                       0.00092
                                                                                        0.00016
                        ٧Z
                                      0.00986
                                                         0.00857
                                                                       -0.00129
                                                                                       0.00042
                                                                                       0.00055 ...
                        VU
                                     -0.00043
                                                        -0.00172
                                                                       -0.00129
                                                                       -0.00048
                        VN
                                      0.01557
                                                         0.01509
                                                                                        0.00017
                                                                                                 · · · ·
                                      0.02034
                                                         0.02139
                                                                        0.00105
                        VE
                                                                                        0.00014
WTZZ 14201M014
                        VX
                                     -0.01629
                                                        -0.01699
                                                                       -0.00070
                                                                                        0.00039
                        VY
                                      0.01714
                                                         0.01807
                                                                        0.00093
                                                                                        0.00016
                        ٧Z
                                      0.00986
                                                         0.00857
                                                                       -0.00129
                                                                                        0.00042
                        VU
                                      -0.00043
                                                        -0.00172
                                                                       -0.00128
                                                                                        0.00055
                                                                                                 . . .
                        VN
                                      0.01557
                                                         0.01509
                                                                       -0.00049
                                                                                        0.00017
                                                                                                 . . .
                        VE
                                      0.02034
                                                         0.02140
                                                                        0.00106
                                                                                        0.00014
                                                                                                  . . .
```

• • •						
ZIM2 14001M008	VX	-0.01393	-0.01414	-0.00021	0.00040	
	VY	0.01809	0.01804	-0.00005	0.00015	
	VZ	0.01169	0.01146	-0.00023	0.00041	
	VU	0.00070	0.00037	-0.00032	0.00055	
	VN	0.01636	0.01635	-0.00000	0.00017	
	VE	0.01975	0.01972	-0.00002	0.00014	
ZIMM 14001M004	VX	-0.01393	-0.01414	-0.00021	0.00040	
	VY	0.01809	0.01804	-0.00005	0.00015	
	VZ	0.01169	0.01146	-0.00023	0.00041	
	VU	0.00070	0.00037	-0.00032	0.00055	
	VN	0.01636	0.01635	-0.00000	0.00017	
	VE	0.01975	0.01972	-0.00002	0.00014	

The final results are contained in the files ${P}/{\rm INTRO}/{\rm STA}/{\rm FINAL.CRD}$

EXAMPLE: Estimate final solution - coordinates and velocities 28-AUG-17 16:03							
LOCAL GEODETIC DATUM: IGS14 EPOCH: 2010-01-01 00:00:00							
NUM	STAT	ION NAME	X (M)	Y (M)	Z (M)	FLAG	
75	GANP	11515M001	3929181.43126	1455236.81309	4793653.94428	W	
92	HERT	13212M010	4033460.85505	23537.87958	4924318.30931	W	
107	JOZ2	12204M002	3664880.49055	1409190.66849	5009618.52923	A	
122	LAMA	12209M001	3524522.83658	1329693.70182	5129846.40041	A	
136	MATE	12734M008	4641949.46826	1393045.51501	4133287.53776	W	
176	ONSA	10402M004	3370658.46734	711877.20881	5349787.00033	W	
192	PTBB	14234M001	3844059.87805	709661.39520	5023129.60030	A	
236	TLSE	10003M009	4627851.76301	119640.11214	4372993.60102	W	
262	WSRT	13506M005	3828735.79223	443305.03608	5064884.77220	W	
263	WTZR	14201M010	4075580.46481	931853.87929	4801568.17525	W	
264	WTZZ	14201M014	4075579.34558	931853.19399	4801569.08708	A	
276	ZIM2	14001M008	4331299.80234	567537.41214	4633133.77514	W	
278	ZIMM	14001M004	4331296.99495	567555.96571	4633133.99187	W	

and \${P}/INTRO/STA/FINAL.VEL

EXAM	PLE: Estimate final	solution - coordi	nates and veloc	ities 2	8 - AUG - 17	16:03
LOCA	L GEODETIC DATUM: I	GS14				
NUM	STATION NAME	VX (M/Y)	VY (M/Y)	VZ (M/Y)	FLAG	PLATE
75	GANP 11515M001	-0.02030	0.01400	0.00629	W	EURA
92	HERT 13212M010	-0.01036	0.01632	0.01150	W	EURA
107	J0Z2 12204M002	-0.02293	0.01468	0.00251	A	EURA
122	LAMA 12209M001	-0.02128	0.01414	0.00466	A	EURA
136	MATE 12734M008	-0.01977	0.01941	0.01507	W	EURA
176	ONSA 10402M004	-0.01249	0.01575	0.01282	W	EURA
192	PTBB 14234M001	-0.01518	0.01748	0.01026	A	EURA
236	TLSE 10003M009	-0.00937	0.01952	0.01347	W	EURA
262	WSRT 13506M005	-0.01652	0.01538	0.00835	W	EURA
263	WTZR 14201M010	-0.01699	0.01806	0.00857	W	EURA
264	WTZZ 14201M014	-0.01699	0.01807	0.00857	A	EURA
276	ZIM2 14001M008	-0.01414	0.01804	0.01145	W	EURA
278	ZIMM 14001M004	-0.01414	0.01804	0.01145	W	EURA

6.6 Daily Goals

At the end of today's session, you should have:

- 1. used GPSEST to compute a final solution of the day, created files: FIX10207. OUT, FIX10207. NQ0 (for all sessions),
- 2. checked the coordinates of the fiducial sites using ADDNEQ2 and HELMR1, created files: FIN10207. CRD, FIN10207. TRP, FIN10207. OUT, and HLM10207. OUT,
- 3. used COMPAR to check the daily repeatabilities, created file: COMPAR. OUT,
- 4. used ADDNEQ2 to create a final session solution, and reduced size NEQs, created files: RED10207. NQ0 and RED10207. SNX,
- 5. if possible, used ADDNEQ2 for velocity estimation, created files: FINAL. CRD and FINAL. VEL.

7 Additional Examples

In the previous terminal sessions you have estimated coordinates, velocities, and troposphere parameters. This is the standard application of the *Bernese GNSS Software* for most users.

If you have finished this work or if you want to follow more examples at home, this section of the document provides some suggestions to practice:

- advanced usage of ITRF2014/IGS14 (see Section 7.1 on page 108),
- generation of a combined GPS/GLONASS orbit from IGS (see Section 7.2 on page 114),
- kinematic positioning for a station (see Section 7.3 on page 120),
- zero difference processing to estimate clocks (see Section 7.4 on page 126),
- inclusion of RINEX 3 data in the processing (see Section 7.5 on page 146),
- enabling the processing of Galileo data (see Section 7.6 on page 149), and
- simulation of GNSS observations (see Section 7.7 on page 157).

Extended Example Dataset

In particular for Sections 7.5 and 7.6 the example dataset has been extended. The same set of stations that have been introduced in Section 1.1 are provided also for day 213 in year 2017 (01 August 2017). For all stations RINEX 2 data are available in the datapool (\${D}/RINEX). In the (\${D}/RINEX3 directory observations are also given in RINEX 3 format (long filenames) for 7 of them. Six out of these stations provide also Galileo measurements.

An additional campaign (\${P}/EXM_GAL) in the *Bernese Introductory Course* is defined where these RINEX observation files are copied and extracted into the RAW directory. Please note that RINEX 3 file there have the conventional short filename to guarantee the compatibility with the filenaming convention of the Bernese processing programs.

This campaign is prepared to analyze this day. In particular, the orbit product files from CODE are copied into the ORB directory. Apart from the COD (GPS and GLONASS) also the COM products (CODE's five-system solution for IGS MGEX) are available.

7.1 Advanced Aspects in Using ITRF2014/IGS14

The velocity of a station in the ITRF2014/IGS14 is only derived by the sum of the linear velocities and the (non-linear) PSD corrections. On the other hand, for the datum definition of a velocity field the same parametrization for all stations and coordinate components is needed, which means, only linear station velocity parameters may be taken into account.

There is of course the option to first subtract the PSD corrections from the coordinates so that only linear velocities remain which can be aligned to the linear velocities from the ITRF2014/IGS14 solution SINEX file. It should be noted that this freezes the empirical PSD corrections that have been computed based on the IGS repro2 campaign. Consequently also GNSS modeling effects from the repro2 solution may be transferred into the new coordinate series, even when computed with a different (better) GNSS observation modeling. In addition the linear velocity field must first be adjusted to the PSD corrections before it can be integrated in the interval of your GNSS solution.

In this section we are discussing potential alternative approaches.

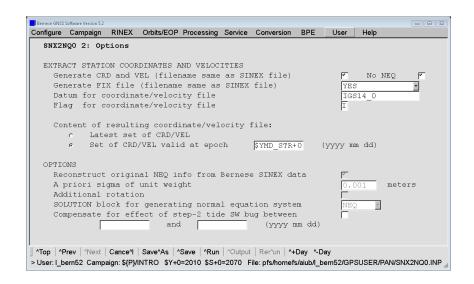
7.1.1 Using ITRF2014/IGS14 Frames for Reprocessing

For reprocessing, the station coordinates for a specific epoch are necessary. This can be done as simply as demonstrated in Section 2.5 of this tutorial.

Nevertheless, it is recommended in case of a reprocessing to not use the IGS14_R.CRD, IGS14_R.VEL, and IGS14.FIX files as they are provided. It is preferable to extract the coordinates and velocities valid for the specific epoch of the session in the reprocessing from the IGS14 SINEX solution file by running the program SNX2NQ0 ("Menu>Conversion >SINEX to normal equations").

Bernese GNSS Software Version 5.2		
Configure Campaign RINEX Orbits/EOP I	Processing Service Conversion BPE User	Help
TRANSFER SINEX FILES TO NORMAI	. EQUATION FILES - SNX2NQO 1: Filename	5
GENERAL FILES Show all general files	<u>ج</u> ا	
INPUT FILES SINEX files	IGS14 SNX	
GENERAL OUTPUT FILES		
Program output	🔽 use SNX2NQO.Lnn or	SNX2NQ0 OUT
Error messages	merged to program output or	ERROR MSG
TITLE Extract CRD-file fr	com IGS14 at epoch \$YMD_STR+0	
- · · · · · · · · · · · · · · · · · · ·	ave ^Run ^Output Rer^un ^+Day ^-Day 2010 \$S+0=2070 File: pfs/homefs/aiub/l_bern52/GPSt	JSER/PAN/SNX2NQ0.INP "

In order to follow the example, you have to copy the IGS14.SNX from ${D}/STAT_LOG/IGS14.snx$ to ${P}/INTRO/SOL/IGS14.SNX$ (note that your operating system might be case sensitive).



Note that only the CRD and VEL information must be extracted but no NEQs are needed.

The following three files should now be available: \${P}/INTRO/STA/IGS14.CRD, \${P}/INTRO/STA/IGS14.VEL, and \${P}/INTRO/STA/IGS14.FIX.

The datum identifier in the coordinate files should be $IGS14_0$ in order to apply the PSD corrections when executing the program COOVEL. Because the files only contain those stations where coordinates and velocities are given in the IGS14 solution for the given epoch, the remaining stations for your project need to be added using the program program CRDMERGE ("Menu>Service>Coordinate tools>Merge coordinate/velocity files").

7.1.2 Ignoring Stations with PSD Corrections for Datum Definition

You may simply follow the approach from previous ITRF solutions by limiting yourself to those stations for the datum definition where no PSD corrections are given in the IGS14 solution. As long as this limited number of stations is sufficient for your application you can follow this simple approach as it was demonstrated in Section 6.5 of this tutorial.

In order to get a list of stations where no PSD corrections are applied the pogram COOVEL offers an option "Stations without PSD corrections".

Bernese GNSS Software	Version 5.2										• 83
Configure Cam		RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help		
EXTRAPOL	ATE CO	ORDINA	TES - COO	OVEL 1: F	ilename	s					
GENERAL											
Show a	ll ger	neral f	Eiles		٦						
INPUT FI	LES										
Input	coordi	inate f	Eile		IG	S14_R CRD					
Input						514_R VEL					
PSD co	rrecti	ion (II	RF14)		IG	314 PSD					
REFERENCI	E EPOC	Ή				ry mm dd 1 07 26	1200.00	n mm s:			
RESULT F	ILE										
Output						MY CRI					
Statio:	ns wit	hout H	SD correc	ctions	114	nPSD FIX	č.				
GENERAL (OUTPUI	FILES									
Program				🚩 use				or	-	OOVEL	OUT
Error	messag	jes		☐ mer	ged to	program c	utput	or	E	RROR	MSG
TITLE	EXAMP	LE: Se	ssion SYS	S+0. Coo	rdinate	propagat:	ion			-	
	1					. tractordare.					
∬ ^Top ^Prev	^Next	Cance [^] l	Save^As ^	Save ^Run	^Output	Rer^un ^+ [Day ^-Day	y			
> User: bern52 (Campaig	n: \${P}/IN	TRO \$Y+0=	2010 \$S+0=	2070 File	e: /home/bern5:	2/GPSUSE	ER52/PA	V/COOVE	L.INP	1.

You may enter the last epoch of interest (e.g., day 206 of year 2011, the last day of the example dataset). The resulting file $P/INTRO/STA/I14_nPSD.FIX$ contains a list of stations where no PSD corrections were given. This file can be used as the list of available set of stations that may be used for the datum definition in program ADDNEQ2:

Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
ADDNE	Q2 5.1:	Datum I	efinition	for Sta	tion Co	ordinates				
			FOR MINIM	UM CONST	RAINT C	ONDITIONS				
	ual sele									
			from file			I14_1	NPSD FI			
Sta	tions wi	th spea	cific flag	gs in CRD	file			#: a	ll non-blank	
^Top ^P	nov Ablest	Cancoll	SavolAs A	Save APun	AQuitout	Rer^un A+				
TOP P	rev next	Cancer	SaverAs	Save "Run	Output	Renun I ···+	⊔ay ∼⊔a	у		
									JSER/PAN/ADDNE	

Use the analogue setting for the datum definition for the station velocities in panel "ADDNEQ2 6.1: Datum Definition for Station Velocities".

7.1.3 Recovering a Linear Velocity Field for a Certain Interval

If you cannot continue in the simple way as in this example by simply ignoring all stations with PSD corrections for the datum definition, a dedicated BPE named \${U}/PCF/ITRF. PCF (description in \${U}/PCF/ITRF.README) is provided with the software. It may be started with "Menu>BPE>Start BPE processing". In the second panel "RUNBPE 2: Process Control Options" the ITRF.PCF is specified for "Process control file". The most interesting is the last panel:

Variable	Value	Description		*
V_REFDIR	REF52	Directory with basic Bernese files	+	-
V_REFSNX	IGS14.SNX	External name of the ITRF SINEX file	+	-
V_REFPSD	IGS14.PSD	Name of the ITRF PSD correction file	+	-
V_REFNAM	myIGS14	Internal name of the CRD/VEL/FIX files	+	-
V_REFDAT	IGS14	Datum string in the CRD/VEL files	+	-
V_REFFLG	IG14	Flag in the resulting CRD/VEL files	+	-
V_REFEPO	2010 01 01	Epoch of coordinates in reference CRD	+	-
V_EPO1	2010 07 01	First epoch for evaluation (yyyy mm dd)	+	-
V_EPO2	2011 07 31	Last epoch for evaluation (yyyy mm dd)	+	-
V_NINT	30	Interval in days to extract CRD	+	-
V_PCV	I14	Absolute/relative PCV model	+	-
V_SATINF	SATELLIT	Satellite information file	+	-
V_RECINF	RECEIVER.	Receiver characterization file	+	-
V_RESULT	ITRF2014	Directory name for the archiving resul	+	-
V_UPD	Y	Update reference files with ITRF resul	+	-
V_SAV	Y	Save results?	+	-
V_DEL	Y	Delete results?	+	-

The BPE copies the files IGS14.SNX (given in V_REFSNX) and IGS14.PSD (given in V_REFPSD) from ${D}/{REF52}$ into the campaign. It extracts the coordinates and velocities into Bernese formatted files where the datum identifier IGS14 (see variable V_REFDAT) is used. Starting from the epoch 2010 07 01 (see V_EPO1) this extraction is repeated every 30 days (see V_NINT) until epoch 2011 07 31 (see V_EPO2) is exceeded. The start and end date should cover the data interval that shall be used for the velocity estimation (in our case from day 207 in year 2010 to day 206 in year 2011).

In this way, 10 coordinate files are extracted. The coordinates are fitted by a linear model in script COMPAR2 (PID 212) expecting that the fit during the interval is better than the thresholds given in the last panel of the related program input file:

Bernese GNSS Software Version 5.2		1000 - 1000 - 1000 - 1000 - 1000 - 1000 - 1000 - 1000 - 1000 - 1000 - 1000 - 1000 - 1000 - 1000 - 1000 - 1000 -								
Configure Campaign RINEX Orbits/EOP Processing Service C	onversion	BPE	User	Help						
COMPAR2 4: Comparison of Individual Solutions	COMPAR2 4: Comparison of Individual Solutions									
NOTIFICATION OF POSSIBLE OUTLIERS										
Maximum tolerated residual	North	0.1	mil	limeters						
	East	0.1	mil	limeters						
	Up	0.1	mil	limeters						
Maximum tolerated root-mean-square error	North	0.1		limeters						
	East	0.1		limeters						
	Up	0.1	mil	limeters						
Minimum number of solutions for each station	ı I	3	2							
LIST OF ACCEPTED MEAN COORDINATES/VELOCITIES		(REFN	IAM) I	FIX						
∬ ^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output F > User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: o				/ITRF_GEN/C	OMPAR2.INP					

(The panel is obtained via "Menu>BPE>Edit PCF program input files" after selecting PID 121: COMPAR2.)

For most of the stations the residuals in the program output file P/INTRO/OUT/myIGS14.0UT (where myIGS14 is again related to the variable V_REFNAM) are zero. Deviations from zero may have two reasons:

• the PSD corrections are close to a linear model with station AREQ as an example where the earthquake from 2001 has only a marginal deviation from a linear station velocity

AREQ 42202M005	N	0.03	0.07	0.03	0.01	-0.01	-0.03	-0.03	-0.04
			-0.03	-0.03	-0.02	-0.01	0.02	0.03	0.05
AREQ 42202M005	Е	0.05	0.08	0.05	0.01	-0.02	-0.03	-0.05	-0.05
			-0.05	-0.04	-0.03	-0.01	0.00	0.04	0.09
AREQ 42202M005	U	0.01	-0.02	-0.01	-0.00	0.01	0.01	0.01	0.01
			0.01	0.01	0.00	0.00	-0.00	-0.01	-0.02

• the IGS14.SNX contains discontinuities like in the example for station WUHN at day 082 of year 2011

WUHN 21	L602M001	N	0.11	0.12	0.08	0.04	-0.00	-0.05	-0.09	-0.13
				-0.17	-0.21	0.16	0.12	0.08	0.04	0.00
WUHN 21	L602M001	E	1.09	1.13	0.73	0.35	-0.04	-0.44	-0.82	-1.21
				-1.61	-1.99	1.56	1.17	0.77	0.39	0.01
WUHN 21	L602M001	U	4.19	-4.34	-2.84	-1.33	0.17	1.67	3.17	4.67
				6.18	7.68	-6.01	-4.51	-3.01	-1.50	-0.00

(Note that discontinuities can be managed according to the description in Section 10.3.5 of the *Bernese GNSS Software* user manual. The station information file may be added in panel "COMPAR2 1: Input Files", PID 121.)

At the end of the procedure three files are obtained that contain only those stations for which the thresholds defined above were not exceeded: $myIGS14_R.CRD$, $myIGS14_R.VEL$, and myIGS14.FIX (where myIGS14 is defined by the variable V_REFNAM). These files may either be copied to ${D}/REF52$ (take care not to overwrite files from other projects) and may be used for variable V_REFINF in other example BPEs.

For the interactive use they should be merged with the stations from you project using the program CRDMERGE:

Bernese GNSS Software Version 5.2			
Configure Campaign RINEX Orbits/EOP Proces	sing Service Conversion	BPE User	Help
MERGE COORDINATE/VELOCITY FILES -	CRDMERGE 1: Input/Ou	tput Files	
GENERAL FILES Show all general files			
Show all general lifes P			
INPUT FILES			
 Coordinates master file 	myIGS14 R CRD Me	rge files	EXAMPLE CRD
c Velocities master file	VEL Me	rge files	VEL
RESULT FILES			
Coordinates	myEXAM CRD		
Velocities	VEL		
Station selection file	FIX		
GENERAL OUTPUT FILES			
Program output	use CRDMERGE.Lnn	or	CRDMERGE OUT
Error messages	merged to program o	utput or	ERROR MSG
^Top ^Prev ^Next Cance^I Save^As ^Save		Contraction of the second second second second second second second second second second second second second s	
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$	S+0=2070 File: /home/bern52	2/GPSUSER52/PAN	V/CRDMERGE.INP

If is of course essential that all coordinate files $(myIGS14_R.CRD \text{ and } EXAMPLE.CRD)$ refer to the same epoch.

Activating the option "Synchronize stations with same DOMES number" is in particular helpful in cases of antenna sharing stations, where not all of the receiver/antenna combinations are included in the reference frame file myIGS14_R.CRD.

Bernese GNSS Software Version 5.2	- 8 %
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help	
CRDMERGE 2: Options	
TITLE Merge a priori into reference frame coordinates (session \$YD+0)	
MERGE OPTIONS	
New local geodetic datum	
New coordinate epoch (YYYY MM DD)	
New coordinate time (HH MM SS)	
Adopt master information for antenna-sharing stations 🛛 🏲	
Flag priority ascending	
(default: RCUTPMAWNI)	
Replace flags Old flag New flag Only in merge files P PPP + A PPP + W PPP + I IG14 +	Г
FLAGS TO BE CONSIDERED FOR CREATION OF STATION SELECTION FILE	
Flag list I	
(default: I)	
Top ^Prev ^Next Cance^1 Save^As ^Save ^Run ^Output Ren^un ^+Day ^-Day User: _bern52 Campaign: \${P/INTRO \$Y+0=2010 \$S+0=2070 File: /homefs/aiub/_bern52/GPSUSER/PAN/CRD	MERGE.INP

Note that this option requires the IGS-related station naming convention with the 4-character ID and the domes number. Repeat the program to merge also the velocity files.

7.2 Preparing Combined GPS and GLONASS IGS–Orbits

In this section the differences to the standard procedure using CODE products containing GPS and GLONASS orbits with respect to IGS products are demonstrated. The IGS uses independent combination procedures for GPS and GLONASS orbits resulting in two sets of precise orbit files. That's why the orbits for the two GNSS first need to be merged.

In contrast, CODE (and other AC) uses a rigorous combined multi–GNSS processing scheme, hence producing a single precise orbit file.

7.2.1 Prepare Pole Information

For the IGS precise orbit files (PRE) the consistent EOP need to be available in the ORB directory (which is the case in the *Bernese Introductory Course* environment). As for the use of CODE products in Section 3.1, the EOP information has to be converted from the IERS/IGS standard format (file extension within the *Bernese GNSS Software* is IEP) to the internal Bernese EOP format (file extension within the *Bernese GNSS Software* is ERP). This is the task of the program POLUPD ("Menu>Qrbits/EOP>Handle EOP files>Convert IERS to Bernese Format"). Simply specify IGS-related filenames — other settings are analogous to Section 3.1.

Bernese GNSS Software Version 5.2			. • ×
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE	User	Help	
CONVERT IERS POLE FILES TO BERNESE FORMAT - POLUPD 1: Input/	Output	Files	
GENERAL FILES			
Show all general files			
INPUT FILES			
Bernese formatted ERP files ERP			
Foreign formatted ERP files IGS\$W+07 IEP			
BESULT FILE			
Bernese formatted ERP file (out) IGS\$YD+0 ERP			
GENERAL OUTPUT FILES			
Program output 🔽 use FOLUPD.Lnn	or	POLUPD	OUT
Error messages 👘 merged to program outp	ut or	ERROR	MSG
		,	
] ^Top ^Prev ^Next Cance'l Save'As ^Save ^Run ^Output Rer'un ^+Day ^-Da	Ý		
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUS	ER52/PAN	I/POLUPD.INP	1.

The messages

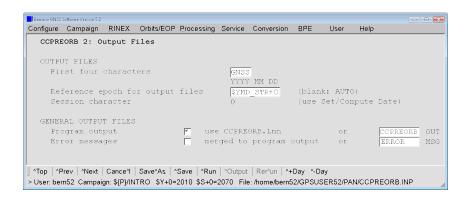
```
### PG POLUPD: NUTATION MODEL NOT SPECIFIED IN INPUT ERP FILE
USING NUTATION MODEL NAME : IAU2000R06
#### PG POLUPD: SUBDAILY POLE MODEL NOT SPECIFIED IN INPUT ERP FILE
USING SUBDAILY POLE MODEL NAME : IERS2010
```

just inform you that the nutation and subdaily pole models from the files in the input panel are written to the output file because no Bernese formatted ERP file was used as input. This is different to importing the EOP from CODE products because here the information on the nutation and sub daily pole model is also available in the international format (with the extension IEP).

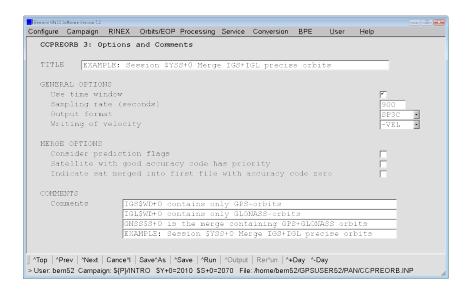
7.2.2 Merging Precise Orbit Files

Before we can prepare the orbits from the IGS for a combined GPS+GLONASS processing we need to merge the two separate files IGS15941.PRE and IGL15941.PRE. This is the task of the program CCPREORB ("Menu>Orbits/EOP>Concatenate/merge precise orbit files"):

📃 Bernese GNSS	Software Version 5.3									- 0
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
CONC	ATENATE/N	MERGE PH	RECISE ORE	IT FILES	- CCPH	REORB 1: 1	nput	Files		
	RAL FILES ow all g		files	7						
	• Merg Firs		se orbit	files		SWD+0 SWD+0 PRE SWD+0				
						: Rer^un ^+ e: /home/bern			AN/CCPREC	DRB.INP



The resulting filename consists of the solution identifier ("First four characters") and the session of the first epoch (if "Reference epoch for output files" is empty). The reference epoch may also be specified by the user as the above example shows. Using the input options from above panel we expect the result file named as P/INTO/ORB/GNSS2070. PRE.



In the next panel you may specify the time window for which the satellite positions shall be included in the resulting precise orbit file.

7.2.3 Generating Standard Orbit Files

The subsequent steps to create the so–called standard orbit files from precise orbit files are again analogue to the standard procedure using CODE products as detailed in Section 3.2.

The first step is the conversion into tabular orbit files (TAB) using the program PRETAB ("Menu>Orbits/EOP>Create tabular orbits"). The merged GPS/GLONASS precise orbit file is chosen as input and IGS-related output files are recommended.

	Software Version 5.2									-	
Configure	<u>C</u> ampaign	RINEX	Orbits/EOP	Processing	<u>S</u> ervice	Conversion	BPE	∐ser	Help		
CREAT	'E TABULA	R ORBIT	S - PRETA	AB 1: Fil	enames						
GENER	AL FILES										
Sho	ow all ge:	neral f	iles	Y							
INPUT	FILES										
	ecise eph	emeris		GNSS\$S+	0 PRE						
	le file			IGS\$YD+	0 ERP						
	ean loadi:	-		EXAMPLE			CMC)				
Atn	aospheric	loadir	lg corr	EXAMPLE	ATL	(for	CMC)				
RESUL	T FILES										
Tak	bular fil	e(s)		IGS\$YD+	0 TAB	(blank:	same	name as	input	file(s))
Sat	cellite c	lock fi	le	IGS\$YD+	0 CLK						
GENER	AL OUTPU'	r FILES									
Pro	ogram out;	put		🚩 use	PRETA	B.Lnn		or		PRETAB	OUT
Err	for messa	ges		mer	ged to	program (outpu	t or		ERROR	MSG
] ^Top ^P	rev ^Next	Cance [^] l	Save^As ^	Save ^Run	^Output	Rer^un ^+	Day ^-	Day			
> User: ber	n52 Campaig	gn: \${P}/IN	TRO \$Y+0=:	2010 \$S+0=	2070 File	: /home/bern5	2/GPSI	JSER52/PAI	V/PRETA	AB.INP	1.

Bernese GNSS	Software Version 5	.2								- 0 ×
Configure	Campaigr	n RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
PRETA	AB 2: Ge	neral Op	ptions							
TITLE	E EXA	MPLE: Se	ession \$YS	S+0: Tab	ilar O:	rbit/Clock	Infor	mation		
GENEF	RAL OPTI	ONS								
Ref	ference	system				J2000	•			
App	ply CMC	correct	ion		PTL:	2	_			
				Į	TL:	M				
SATEI	LLITE OF	TIONS								
Rer	move bac	a satell	ites			2				
Use	e accurs	cy code	s from SP3	8-file		Y				
Exc	clude sa	t. with	accuracy	code O		7				
Exc	clude sa	t. with	acc. code	e exceedi	ng	99				
ATon AE		Cancel	Savo^As ^	Save ARun		t Rer^un ^+ I	nav ∿-⊓	31/		
						e: /home/bern5		•		ND
- User, ber	moz camp	aigii. atryii	VIII.0 - 91+0-	2010 \$0+0-	2070 FI	e. mome/perito	201000	JEN92/FR	INFINE TAB.	INF

It is important to enable the option "Exclude sat. with accuracy code 0" if you process orbits that are not provided by CODE (label "COD").

The precise GLONASS orbit files from the IGS contain the GLONASS broadcast clock information (instead of no clock corrections for GLONASS as in the CODE product files). This leads to two differences with respect to the use of the standard products from CODE:

- The messages on missing GLONASS satellites clocks are not displayed (at least not for all GLONASS satellites).
- Because the Bernese GNSS satellite clock files contain also clock corrections for the GLONASS satellites, the program CODSPP may compute the inter–system bias between IGSF–time scale (GPS satellite clocks in the IGS final product files) and GLONASS broadcast time system.

Both differences have no impact on the obtained results.

For some days a message like this may appear:

### PG PRETAB:	SATELLITE CLOCK VALUES MISSING
	SATELLITE : 1
	FILE NUMBER: 1
	FILE NAME : \${P}/INTRO/ORB/GNSS2080.PRE

It reports that for a specific satellite no clock information is provided in the IGS files. As long as this message lists only a limited number of satellites, the synchronization of the receiver clocks in CODSPP is still possible with the remaining satellites. It is therefore not critical.

To generate the standard orbits (extension STD) from the tabular orbits the program ORBGEN ("Menu>Qrbits/EOP>Create/update standard orbits") has to be used. Introduce the IGS-related tabular orbit file together with the consistent ERP file (as well as the consistent nutation, and the subdaily pole model in panel "ORBGEN 1.1: General Files"):

Bernese GNSS Software Version 5.2	
Configure Campaign RINEX Orbits/EOP Processing Ser	ice Conversion BPE User Help
CREATE/UPDATE STANDARD ORBITS - ORBGEN 1	Input Files
GENERAL FILES	
Show all general files	<u>۲</u>
INPUT FILES	
 Start with tabular orbits 	IGS\$YD+0 TAB
c Start with precise orbits	PRD
 Update standard orbit 	
Orbital elements, file 1	ELE
Orbital elements, file 2	ELE
Pole file	IGS\$YD+0 ERF
Ocean loading corrections	EXAMPLE BLQ (for CMC)
Atmospheric loading corrections	EXAMPLE ATL (for CMC)
] ^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^O	itput Rer^un ^+Day ^-Day
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070	File: /home/bern52/GPSUSER52/PAN/ORBGEN.INP

The name of the resulting orbit file should also be related to IGS:

Bernese GNSS Software Version 5.2					- 0 🔀
Configure Campaign RINEX Orbits/EOP	Processing Service	Conversion	<u>B</u> PE <u>U</u> s	er <u>H</u> e	lp
ORBGEN 2: Result and Output F	iles				
RESULT FILES					
Standard orbits	IGS\$YD+0 ST	5			
Radiation pressure coeff.	RP	2			
Residual file	RE	3			
OUTPUT FILES					
Summary file	LS	P			
Summary file for IGS-ACC	IGS\$YD+0 LS	P			
Plot file of residuals	PL'	ſ			
GENERAL OUTPUT FILES					
Program output	use ORBG	EN.Lnn		or	IGS\$YD+0 OUT
Error messages	🔲 merged t	o program (output	or	ERROR MSG
^Top ^Prev ^Next Cance^I Save^As ^					
> User: bern52 Campaign: \${P}/INTRO \$Y+0=:	2010 \$S+0=2070 Fil	e: /home/bern52	/GPSUSER5:	2/PAN/OR	BGEN.INP

The other options can be used as given in Section 3.2. The resulting program output is expected to look like

RMS	ERRORS	AND MAX.	RESIDUALS	ARC NUMBI	ER: 1			ITERATI	ON:
			QUADR	ATIC MEAN	OF O-C	(M)	MAX. F	ESIDUAL	S (M)
TAZ	#POS	RMS (M)	•	RADIAL	ALONG	OUT	RADIAL		OUT
1	96	0.002	0.002	0.001	0.001	0.003	0.004	0.004	0.00
2	96	0.002	0.002	0.002	0.001	0.002	0.003	0.004	0.00
3	96	0.004	0.004	0.004	0.003	0.004	0.009	0.006	0.00
4	96	0.001	0.001	0.001	0.001	0.001	0.003	0.003	0.00
5	96	0.002	0.002	0.002	0.001	0.002	0.004	0.005	0.01
6	96	0.003	0.003	0.003	0.003	0.004	0.008	0.006	0.00
7	96	0.002	0.002	0.002	0.002	0.002	0.005	0.005	0.00
8	96	0.002	0.002	0.001	0.001	0.002	0.003	0.003	0.00
9	96	0.002	0.002	0.002	0.001	0.003	0.003	0.003	0.00
10	96	0.002	0.002	0.002	0.002	0.003	0.005	0.005	0.00
11	96	0.002	0.002	0.001	0.001	0.002	0.004	0.003	0.00
12	96	0.003	0.003	0.003	0.002	0.003	0.007	0.005	0.00
13	96	0.003	0.003	0.003	0.002	0.003	0.013	0.007	0.00
14	96	0.003	0.003	0.004	0.003	0.002	0.011	0.006	0.00
15	96	0.002	0.002	0.002	0.002	0.002	0.008	0.004	0.00
16	96	0.004	0.003	0.004	0.003	0.004	0.007	0.008	0.00
17	96	0.002	0.002	0.002	0.002	0.002	0.006	0.005	0.00
18	96	0.003	0.002	0.003	0.002	0.003	0.006	0.004	0.00
19	96	0.002	0.002	0.002	0.002	0.003	0.005	0.004	0.00
20	96	0.002	0.002	0.002	0.001	0.003	0.004	0.004	0.00
21	96	0.002	0.002	0.001	0.001	0.003	0.003	0.002	0.00
22	96	0.003	0.003	0.003	0.002	0.003	0.005	0.005	0.00
23	96	0.003	0.003	0.003	0.002	0.003	0.011	0.006	0.0

24	96	0.001	0.001	0.001	0.001	0.002	0.003	0.002	0.005
25	96	0.002	0.002	0.001	0.001	0.003	0.003	0.003	0.007
26	96	0.004	0.004	0.005	0.003	0.003	0.011	0.006	0.005
27	96	0.002	0.002	0.002	0.001	0.003	0.003	0.003	0.006
28	96	0.002	0.002	0.002	0.002	0.002	0.004	0.005	0.007
29	96	0.003	0.003	0.003	0.003	0.003	0.005	0.006	0.007
30	96	0.002	0.002	0.002	0.002	0.002	0.006	0.005	0.005
31	96	0.002	0.002	0.002	0.002	0.003	0.005	0.005	0.009
32	96	0.002	0.002	0.002	0.001	0.003	0.005	0.003	0.006
101	96	0.002	0.002	0.002	0.002	0.002	0.006	0.004	0.007
102	96	0.002	0.002	0.002	0.002	0.002	0.006	0.005	0.005
103	96	0.002	0.002	0.002	0.002	0.002	0.005	0.006	0.006
104	96	0.002	0.001	0.002	0.001	0.002	0.005	0.003	0.004
105	96	0.001	0.001	0.001	0.001	0.002	0.003	0.007	0.004
107	96	0.002	0.002	0.001	0.001	0.002	0.003	0.007	0.005
108	96	0.002	0.002	0.002	0.001	0.002	0.004	0.003	0.004
110	96	0.002	0.002	0.001	0.001	0.003	0.007	0.003	0.005
111	96	0.001	0.001	0.001	0.001	0.002	0.003	0.010	0.006
113	96	0.002	0.002	0.002	0.001	0.002	0.004	0.005	0.005
114	96	0.002	0.002	0.002	0.002	0.002	0.005	0.012	0.004
115	96	0.002	0.002	0.002	0.001	0.002	0.004	0.008	0.005
117	96	0.002	0.002	0.003	0.002	0.002	0.010	0.009	0.003
118	96	0.002	0.002	0.002	0.001	0.002	0.004	0.006	0.006
119	96	0.003	0.002	0.002	0.002	0.003	0.005	0.006	0.006
120	96	0.002	0.002	0.002	0.001	0.003	0.004	0.004	0.006
121	96	0.002	0.002	0.002	0.002	0.003	0.006	0.004	0.014
122	96	0.002	0.002	0.002	0.002	0.002	0.004	0.006	0.004
	96	0.002	0.001	0.001	0.001	0.002	0.003	0.004	0.004
123		0.002	0.002	0.001	0.002	0.001	0.003	0.017	0.003

The RMS error for the orbit fit for precise IGS orbits should be below 5 mm (for older orbits it may also achieve $10 \dots 15 \text{ mm}$).

The file P/INTRO/OUT/IGS10207.LST contains the same results as displayed on page 27 but contains also the GLONASS satellite orbits:

EXAMPLE: Session 102 TIME FROM DAY : 1 GF	PS WEEK: 1594	it generation	28-AUG-17 13:32	
		THROUGH DAILY ORBIT	SOLUTIONS (MM)	
ECL				 :
			$\begin{array}{cccccccccccccccccccccccccccccccccccc$	
ALL 2 2 4 1			2 2 2 2 1 1	 2

If you want to use these orbit files in the processing programs, you simply have to replace the CODE–related by the IGS–related filenames for the standard orbit and EOP files.

7.3 Kinematic Positioning

7.3.1 Estimating Kinematic Positions in a Double–Difference Solution

The example campaign contains no really roving stations. You can, however, define one of them to be kinematic (e.g., station GANP). Introduce the coordinates from the final solution (\${P}/INTRO/STA/FIN10207.CRD) for all other sites.

Bernese GNSS Software Version 5.2			- • •
Configure Campaign RINEX Orbits/EOP Processin	g Service Conversion	BPE User	Help
PARAMETER ESTIMATION - GPSEST 1.1: I	nput Files 1		
GENERAL FILES AND PROCESSING MODE			
Space geodetic technique	GNSS ·		
Differencing level	DOUBLE ·		
LEO data processing			
Show all general files	~		
OBSERVATION FILES			
Phase observations	2222\$S+0 PSH	????\$S+O	PZE
Code observations	CSH		CZH
Range observations	CZH		
MAIN INPUT FILES			
Station coordinates			
Satellite standard orbits	FIN\$YD+0 CRD		
	COD\$YD+U ERP		
	CLA		
tomosphere moders	COD21D+0 TOV		
CORRECTIONS FOR LOADING REFERENCE AND	CENTER OF MASS		
Nemospherio craar rotaing	Inverting VIII		
^ ^ ^ Top ^ Prev ^ Next Cance^I Save^As ^Save ^Ru	In Output Rer^un 1+	⊦Day ^-Day	
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0			AN/GPSEST.INP
Earth rotation parameters Satellite clock corrections Differential code biases Gridded VMF1 coefficients Ionosphere models CORRECTIONS FOR LOADING EFFECTS AND Ocean tidal loading Atmospheric tidal loading	EXAMPLE BLQ EXAMPLE ATL In ^Output Rer^un ^4		AN/GPSEST.INP

Remove the name of the resulting "Normal equations" file in panel "GPSEST 2.1: Output Files 1" if there is any entry in this input field. Store the kinematic coordinates in an output file ("Kinematic coordinates" in panel "GPSEST 2.2: Output Files 2").

Bernese GNSS Software Version 5.2								- • •
Configure Campaign RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
GPSEST 2.1: Output F	iles 1							
GENERAL OUTPUT FILES	3							
Program output		🗌 use	GPSES	T.Lnn		or	KIN\$YD+0	OUT I
Error message		🗌 mer	ged to	program d	output	or	ERROR	MSG
NORMAL EQUATION SYST	'EM			NQO				
STATION- AND SATELLI	TE-RELATE	D RESULT	S					
Station coordinate	28			CRD				
Satellite orbital	elements			ELE				
Earth rotation par	cameters			ERP				
Earth rotation par	ameters (IERS)		IEP				
ATMOSPHERE-SPECIFIC								
Troposphere estima				TRP				
Troposphere estima	ates (SINE	(X)		TRO				
Ionosphere models	(ION				
Ionosphere models	(TONEX)			INX				
AT			Lacutaria		D 4 D-			
^Top ^Prev ^Next Cance ¹								
> User: bern52_Campaign: \${P}/IN	11KU SY+U=:	2010 \$\$+0=	2070 File	e: /nome/bern5	ZIGPSUS	EK52/PAP	WGPSESTINP	1.

Bernese GNSS Software Version 5.	2								- 0 -
Configure Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
GPSEST 2.2:	Output B	Files 2							
ADDITIONAL R	ESULT FI	LES							
Differenti	al code	biases			Π	рсв			
Inter-syst	em biase	es		i i	I	SB			
Phase cent	er varia	ations (g:	ridded)	i i	I	PHG			
Phase cent	er varia	ations (s	pherical)		I	HH			
EPOCH-SPECIF	IC RESUI	LTS							
GNSS clock	correct	tions			C	LK			
Clock RINE	X				C	LK			
Kinematic	coordina	ates		K	EN\$YD+0 P	IN			
AUXILIARY FI	LES								
Observatio	n residu	lals			F	ES			
Covariance	matrix				C	OV			
Covariance	matrix	wrt coord	dinates		C	VOV			
^Top ^Prev ^Next	Cance ⁴	Save^As /	Save ^Run	^Output	Rer^un ^	+Day ^-[Day		
> User: bern52_Campa	aign: \${P}/IN	NTRO \$Y+0=	2010 \$S+0=	2070 File	e: /home/bern	52/GPSU	ISER52/PA	N/GPSEST.I	NP

Because the number of parameters for the kinematic positioning may become very large, we select only a short data interval of one hour for this kinematic position-ing:

Bernese GNSS Software Version 5.2	
Configure Campaign RINEX Orbits/EOP Processing Ser	vice Conversion BPE User Help
GPSEST 3.1: General Options 1	
TITLE EXAMPLE: Session \$YSS+0: Kinema	tic network solution (fixed)
OBSERVATION SELECTION	
Satellite system	ALL
Frequency/linear combination	L3 ·
Elevation cutoff angle	5 degrees
Sampling interval	300 seconds
Tolerance for simultaneity	100 milliseconds
Special data selection	NO
Observation window	
OBSERVATION MODELING AND PARAMETER ESTIM	ATION
A priori sigma of unit weight	0.001 meters
Elevation-dependent weighting	COSZ -
Type of computed residuals	NORMALIZED
Correlation strategy	CORRECT
LEO-SPECIFIC SELECTION AND MODELING OPTI	DNS
Elevation cutoff angle	0 degrees
Elevation-dependent weighting	NONE
^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^C	
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070	File: /home/bern52/GPSUSER52/PAN/GPSEST.INP

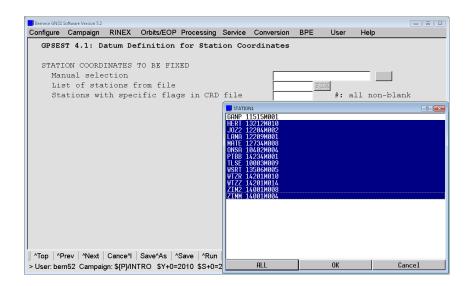
📃 Bernese GNSS Soft	ware Version 5.2									
Configure C	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
GPSEST	3.1.1:	Observ	ation Win	dow						
OBSERV.	ATION W	INDOW								
c	Defin Year	ied by <mark>\$Y</mark>	Year and : FO Se		dentif <u>\$s+0</u>	ier				
٩	Defin Start	YY:	Start and /y mm dd MD_STR+0	hh m		End		mm dd STR+0	hh mm s 02 59 5	_
			Save^As ^; ITRO \$Y+0=2						N/GPSEST.INP	1

The option "Enable extended program output" may be disabled now:

Bernese GNSS Software Version 5.2					- • •
Configure Campaign RINEX Orbits/EOP Processing	Service Conversion	BPE	User	Help	
GPSEST 3.2: General Options 2					
A PRIORI TROPOSPHERE MODELING					
ZPD model and mapping function	DRY VMF MENDES-PAVLIS		GNSS SLR		
HANDLING OF AMBIGUITIES					
Resolution strategy	NONE	•			
Solve ambiguities for	ALL	~			
Consider GPS quarter-cycle biases	0	*			
Save resolved ambiguities					
Introduce widelane integers					
Introduce L1 and L2 integers	Y				
SPECIAL PROCESSING OPTIONS					
Stop program after NEQ saving	Г				
Activate extended program output					
^Top ^Prev ^Next Cance^I Save^As ^Save ^Run	^Output Rer^un *+	Day ^-Day	1		
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=	2070 File: /home/bern5	2/GPSUSI	ER52/PA	N/GPSEST.INP	1.

Fix all station coordinates apart from GANP in the panels "GPSEST 4: Datum Definition for Station Coordinates" (choose MANUAL in panel "GPSEST 4: Datum Definition for Station Coordinates" and select all stations except GANP in panel "GPSEST 4.2").

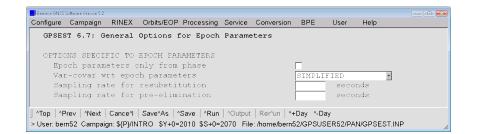
Bernese GNSS	Software Version 5.2								- 0
Configure	Campaign	RINEX	Orbits/EOP F	Processing Se	ervice Conversi	on BPE	User	Help	
GPSES	T 4: Dat	um Defi	nition for	Station (Coordinates				
DATUM	DEFINIT	ION TYP	Б						
(Free	networl	solution						
(Coord	dinates	constrain	ed	ALL	÷]		
c	Coord	dinates	fixed		MANUAL	-]		
A PRI	ORI SIGM	AS							
Not	th	0.001	meter	3					
Eas	st	0.001	meter	3					
Up		0.001	meter	S					
^Top ^P	rev ^Next	Cance [^] l	Save*As *Sa	ave ^Run ^	Output Rer^un	^+Day ^-Da	ay		
> User: ber	n52 Campai	gn: \${P}/IN	TRO \$Y+0=20)10 \$S+0=207	0 File: /home/be	ern52/GPSUS	ER52/PA	AN/GPSEST.INF	> <i>//</i>



Bennese 6NSS Software Version 5.2 Configure Campaign RINEX Orbits/EOP Processing Service	Conversion	BPE	User	Help	- • •
GPSEST 5.1: Setup of Parameters and Pre-Eli	mination 1				
STATION-RELATED PARAMETERS	Setup		Pre-E	limination	L
Station coordinates		NO			-
Ambiguities		NO			•
ATMOSPHERIC PARAMETERS					
Site-specific troposphere parameters	Y	NO			•
Global ionosphere parameters		NO			~
GLOBAL PARAMETERS					
Orbital parameters	Г	NO			*
Earth orientation parameters		NO			-
Geocenter coordinates		NO			Ψ.
EPOCH PARAMETERS					
Receiver clock offsets	Г	EVE	RY EPO	CH	*
Satellite clock offsets	Г	EVE	RY EPO	CH	*
Kinematic coordinates	7	NO			-
Stochastic ionosphere parameters	Г	EVE	RY EPO	CH	*
					_
∫ ^Top ^Prev ^Next Cance [↑] I Save [↑] As ^Save ^Run ^Outpu > User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 Fi					

Enable the kinematic coordinates option without any pre-elimination in a first run:

An additional panel for options related to epoch parameters is displayed where you can accept the default values:



Let us assume only horizontal movements for this site:

Bernese GNSS Software Version 5.2								- 0 ×
Configure Campaign R	RINEX Orbits	EOP Processin	g Service	Conversion	BPE	User	Help	
GPSEST 6.9: Kind	ematic Coc	rdinates						
STATIONS TO BE	TREATED AS	KINEMATIC						
Station selec	tion			MAN	UAL	•		
Station list	from file					FIX		
Manual select	ion			GAN	P 1151	L5M001		
A PRIORI SIGMAS Reference fra Sigma for hor	me	mponents		NEU 100		meters		
Sigma for ver	tical comp	onent		0.0	001	meters		
Sigma for all	component	s		i i i		meters		
ADDITIONAL OPTIC Minimum numbe		vations per	epoch	6				
<pre>_ ^Top ^Prev ^Next Ca > User: bern52 Campaign:</pre>							N/GPSEST.INF	5 //

7.3.2 Extracting the Program Output from a Kinematic Positioning

As expected you will get only small estimates for the kinematic coordinates since GANP was not moving:

KINDM		20.	φ (p) / τυ π	0 (CTA (VIN10007 VIN	
KINEM	ATIC COORDINATE	19:	\${P}/1N1F	O/STA/KIN10207.KIN	
			_		
EPO:	EPOCHS SINCE	2010-07-26	02:00:00 (SAMPLING	300 SEC)	
				CTION AND RMS IN MET	
EPO	EPOCH(MJD)	#OBS STA	LATITUDE	LONGITUDE	HEIGHT
	GANP 11515M00	01	49 2 4.971302	20 19 22.574439	746.0115
1	55403.083333	15 GANP	-0.0048 +- 0.004	-0.0035 +- 0.004	0.0000 +- 0.000
2	55403.086806	14 GANP	0.0049 +- 0.004	-0.0045 +- 0.004	0.0000 +- 0.000
3	55403.090278	14 GANP	0.0019 +- 0.004	-0.0003 +- 0.004	-0.0000 +- 0.000
4	55403.093750	14 GANP	0.0007 +- 0.004	0.0015 +- 0.004	-0.0000 +- 0.000
5	55403.097222	13 GANP	-0.0024 +- 0.004	0.0016 +- 0.004	0.0000 +- 0.000
6	55403.100694	13 GANP	-0.0045 +- 0.004	0.0034 +- 0.004	0.0000 +- 0.000
7	55403.104167	13 GANP	-0.0031 +- 0.004	0.0026 +- 0.004	0.0000 +- 0.000
8	55403.107639	13 GANP	0.0012 +- 0.005	0.0041 + - 0.004	-0.0000 +- 0.000
9	55403.111111	14 GANP	-0.0062 +- 0.005	0.0022 +- 0.004	0.0000 +- 0.000
10	55403.114583	14 GANP	-0.0028 + - 0.005	0.0034 + - 0.005	$0.0000 + - 0.000 \dots$
11	55403.118056	14 GANP	-0.0009 +- 0.005	0.0023 +- 0.005	0.0000 +- 0.000
12	55403.121528	13 GANP	-0.0049 + -0.005	-0.0014 + - 0.005	-0.0000 +- 0.000
12	001001121020	10 000	0.000	0.000	0.0000

With the program GPSXTR ("Menu>Processing>Program output extraction>Parameter estimation/stacking") a comprehensive summary of the estimates for the kinematic solution can be extracted:

Bernese GNSS Software Version 5.2						- 0 -
Configure Campaign RINEX Ort	oits/EOP Processing Service	Conversion	BPE	User	Help	
EXTRACT GPSEST/ADDNEQ2	PROGRAM OUTPUT - GPS)	TR 1: Ext	ractio	ns		
GENERAL FILES						
Show all general file	:S 🚩					
INPUT FILENAMES						
C	GPSEST.L??				DNEQ2.Lxx)	
¢	KIN\$YD+0 OUT		3PSEST/	(ADDNEQ	2 output)	
GENERAL OUTPUT FILES						
Program output	🚩 use GPSXT	R.Lnn		or	GPSXT	R OUT
Error messages	🦳 merged to	program d	utput	or	ERROR	MSG
∬ ^Top │ ^Prev │ ^Next │ Cance^I │ Sav	ve^As ^Save ^Run ^Output	Rer^un *+	Day ^-Da	iy		
> User: bern52 Campaign: \${P}/INTRC	\$Y+0=2010 \$S+0=2070 File	: /home/bern5	2/GPSUS	ER52/PA	V/GPSXTR.INP	//

Bernese GNSS Software Version 5.2	
Configure Campaign RINEX Orbits/EOP Processing	Service Conversion BPE User Help
GPSXTR 2: Output Files	
TITLE EXAMPLE: Session \$YSS+0: K	inematic network solution
OUTPUT FILES Output summary Coordinate summary	SUM
Kinematic summary KIN\$YD+	
GIM summary	SUM
Clock summary	SUM Baseline BSL
Clock Allan deviation	SUM
Ambiguity resolution	SUM GNSS ALL - ID -
Ambiguity fractionals	SUM
Campaign summary	SUM
Weekly summary	SUM
Pole output	SUM Pole parameter sets ALL -
^Top ^Prev ^Next Cance'l Save'As ^Save ^Run	^Output Rer^un ^+Day ^-Day
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=	2070 File: /home/bern52/GPSUSER52/PAN/GPSXTR.INP

*XEPO	12	0	12	
*INI	0.0000	0.0000	0.0000	
*EST	0.0000	0.0000	0.0000	
*DIFXYZ	0.0000	0.0000	0.0000	
*DIFNEU	-0.0017	0.0009	0.0000	
ЕРОСН	 DN	DE	DU	
1	-0.0048	-0.0035	0.0000	
2	0.0049	-0.0045	0.0000	
3	0.0049	-0.0003	-0.0000	
4	0.0013	0.0015	-0.0000	
5	-0.0024	0.0016	0.0000	
6	-0.0024	0.0010	0.0000	
7	-0.0040	0.0026	0.0000	
8	0.0012	0.0020	-0.0000	
9	-0.0062	0.0022	0.0000	
10	-0.0028	0.0034	0.0000	
10	-0.0020	0.0023	0.0000	
12	-0.0049	-0.0014	-0.0000	
12	-0.0045	-0.0014	-0.0000	
* A V G	-0.0017	0.0009	0.0000	
*SIG	0.0036	0.0028	0.0000	
*RMS	0.0033	0.0028	0.0000	
*RMSTC	0.0011			
STATION: G	4NP			
PARAMS :	96 12	0 509 (AM	MB, CRD, CLK, TO	חדו
OBSERV :	0 1592	1592	1D, 010D, 0EK, 10	51/

The resulting summary file looks like:

The different components of the summary are described in the online help.

7.3.3 Further suggestions

- Introduce the result file with kinematic coordinates as an input file for another run of GPSEST. If the estimates become zero it is a confirmation that the file was correctly considered as the a priori kinematic positions for the station GANP.
- Use the pre-elimination EVERY_EPOCH for the "Kinematic coordinates" (they are back-substituted by the program in order to get a solution also for those parameters). Compare the results with the first solution.
- Switch the "Var-covar wrt epoch parameters" in panel "GPSEST 6.7: General Options for Epoch Parameters" from SIMPLIFIED to CORRECT. Compare the results again with the first solution.
- Compute kinematic coordinates for the full day using the epoch–wise pre–elimination and back–substitution algorithm. To save computing power we recommend to sample the data to 300 s.
- Repeat the kinematic solution considering only one of the two GNSS at the time (choose either GPS or GLONASS in option "Satellite system" of panel "GPSEST 3.1: General Options 1").

7.4 Zero Difference Processing for Clock Estimation

For the clock estimation we have to use code and phase data together. The data is analyzed at zero difference level.

7.4.1 Preprocessing

There are two ways for preprocessing zero difference observations in the *Bernese GNSS* Software, Version 5.2 available:

- *Precise satellite clocks are available* for all satellites with the same sampling as the RINEX observations to be processed (typically 30 s):
 - 1. RNXSMT to screen and smooth code measurements based on a consistency check between the code and phase observations
 - 2. RXOBV3 to import the screened smoothed code together with the original phase data into Bernese observation file format
 - 3. CODSPP to synchronize receiver clocks with respect to the GNSS system time
 - 4. MAUPRP to screen the phase measurements
 - 5. GPSEST, RESRMS, SATMRK to screen residuals from a zero difference network solution
- Precise satellite clocks are not available:
 - 1. RNXSMT to screen phase and code measurements based on a consistency check; smooth the code observations
 - 2. RXOBV3 to import the screened phase and smoothed code data into Bernese observation file format
 - 3. CODSPP to synchronize receiver clocks with respect to the GNSS system time
 - 4. GPSEST, RESRMS, SATMRK to screen residuals from a zero difference network solution iteratively with a decreasing threshold

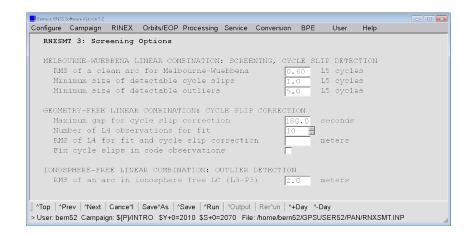
In this text book we follow the second approach.

The preprocessing of zero difference data starts with program RNXSMT, available from "Menu>RINEX>RINEX utilities>Clean/smooth observation files". In the first panel select all RINEX files of the active session:

Bernese GNSS Software Version 5.2	- • •
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User	Help
CLEAN/SMOOTH OBSERVATION FILES - RNXSMT 1: Filenames	
GENERAL FILES	
Show all general files 🚩	
INPUT FILES	
Original RINEX observation files 2???\$S+0 100	
GENERAL OUTPUT FILES	
Program output 📄 use RNXSMT.Lnn or	SMT\$YD+0 OUT
Error messages merged to program output or	ERROR MSG
DIRECT ESTIMATION OF DIFFERENTIAL CODE BIAS VALUES	NO
^Top ^Prev *Next Cance¹ Save^As ^Save ^Run ^Output Rer¹un ^+Day .^Day > User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN	I/RNXSMT.INP

The default input options perform well in most cases:

Bernese GNSS Software Version 5.2	
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User He	lp
RNXSMT 2.1: Options	
TITLE EXAMPLE: Session \$YSS+0: Preprocess RINEX files	
OBSERVATION ARC DEFINITION	
Maximum number of records in a RINEX file 3000	
Sampling interval for RINEX data 30.0 seconds	
Use observation window	
Skip observations with S1 and S2=0.000	
Use C2 if P2 unavailable	
Maximum gap in data to start a new arc 180.0 seconds	
Minimum number of observations per arc 10	
EVENT FLAG HANDLING	
What to do in case of event flags SKIP -	
DETECT CLOCK EVENTS	
Minimum size of a clock event 50.0 nanoseconds	-
Tolerance for ms-jump detection 0.001 millisecond	15
Maximum number of events with unknown size 50 🚆	
^ ^ ^ Top ^ Prev ^ Next Cance^I Save^As ^ Save ^ Run ^ Output Rer^un ^ + Day ^ - Day	
> User: I_bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: gpfs/homefs/aiub/I_bern52/GPSUS	SER/PAN/RNXSMT.INP



In the last panel you decide whether or not to "Preprocess phase observations" by checking or unchecking the box:

Bernese: GNSS Software Version 5	2								- • •
Configure Campaigr	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
RNXSMT 4: Ou	tput Opt	ions							
OUTPUT OPTIC	NS								
Preprocess	phase d	bservatio	ns		Y				
Use smooth	ed inste	ad of rav	r code		Y				
Output det	ail				SUI	M <u>-</u>			
SPECIAL OPTI	ON								
Verify GLC	NASS fre	equency nu	umber		Γ				
] ^Top ^Prev ^Nex	Cance ⁴	Save^As ^	Save ^Run	^Output	Rer^un / ^+	Day ^-Da	ıу		
> User: bern52 Camp	aign: \${P}/IN	TRO \$Y+0=	2010 \$S+0=	2070 File	: /home/bern5	2/GPSUS	ER52/PA	AN/RNXSMT	.INP //

The resulting smoothed RINEX files look like usual RINEX files but the line

indicates that the numbers in the file result from $\mathsf{RNXSMT}.$ The $\mathsf{S/N}$ indicators have the following meaning:

- "1" considered by RNXSMT as bad data
- "5" data have only been copied from the original file by RNXSMT
- "9" considered by RNXSMT as good data

The cycle slip flags in a smoothed RINEX file indicate the epochs/satellites where new ambiguities are needed according to the evaluation of RNXSMT.

In order to import the smoothed RINEX observation files into the Bernese format you have to select them in the first input panel of program RXOBV3 (note that you will overwrite your zero difference observation files from the previous processing example by doing this):

Bernese GNSS Software Version 5.2	- 0 🔀
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help	
TRANSFER RINEX OBSERVATION FILES TO BERNESE FORMAT - RXOBV3 1: Filenames	
GENERAL FILES	
Show all general files 🔽	
INPUT FILES	
c original RINEX observation files 2222\$\$+0 100	
c smoothed RINEX observation files ????\$S+0 SMT	
Station information file EXAMPLE STA	
BAATEDS DIA	
RESULT FILES	
Measurement types to save	
c Code 🗹 Phase 🏹 🕜 Range	
Update coordinates CRD (blank if not used)	
GENERAL OUTPUT FILES	
Program output 🔽 use RXOBV3.Lnn or RXS\$YD4	TUO 01
Error messages	MSG
/ ^Top ^Prev ^Next Cance'l Save'As ^Save ^Run ^Output Rer^un ^+Day ^-Day	
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/RXOBV3.INF	2
	11

If you have preprocessed the phase measurements already in RNXSMT you can resample the observations already in RXOBV3: set the "Sampling interval" in panel "RXOBV3 2: Input Options 1", e.g., to 300 seconds.

Bernese GNSS Software Version 5.2	- • •
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BF	PE User Help
RXOBV3 2: Input Options 1	
TITLE EXAMPLE: Session \$YSS+0: tutorial lecture	
SATELLITE SYSTEM SELECTION	
Satellite system to be considered	GPS/GLO
STATION NAMES	
Gather station names from	FILE NAME
Action if station not in abbreviation list	ERROR
SESSION IDENTIFIER	
Session ID used for Bernese observation files	\$S+0 (blank: AUTO)
	, · ·
DATA SAMPLING	
Sampling interval	300 🗧 seconds
Sampling offset to full minute	0 seconds
	,
 ATan ADmay ANast Canada Canada ACana ADma ACatast Darbar ALDma	
] ^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output Rer^un ^+Day	•
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/Gil	PSUSER52/PAN/RXOBV3.INP

Furthermore, you have to consider the "SIGNAL STRENGTH REQUIREMENTS" for smoothed RINEX files (see above):

Bernese GNSS Software Version 5.2	- • •
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help	
RXOBV3 4: Input Options 2	
SIGNAL STRENGTH REQUIREMENTS	
Minimum signal strength	
Accept signal strength = 0	
Accept cycle slip flags from RINEX 🔽	
MINIMUM OBSERVATION NUMBER	
Minimum number of epochs requested per file 10 epochs	
OPTIONS CONCERNING ANTENNAS	
Consider radome code of the antennas	
Correct position of radome code	
Check phase center file for antenna type 🛛 🔽 else 🖪	R 💌
EVENT FLAG HANDLING	
What to do in case of event flags SKIP •	
/ *Top *Prev *Next Cance*I Save*As *Save *Run *Output Rer*un *+Day *-Day	
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/RXOBV3	.INP //

After importing the data into the Bernese format you have to repeat the receiver clock synchronization with program CODSPP. The options are identical to the settings in Section 4.2.1. The only difference is the option "Mark outliers in obs. files" in the last input panel: depending on your preprocessing chain it is recommended to select:

- BOTH if you have screened phase and code data in RNXSMT, because it is assumed that the corresponding phase measurement is also bad if a problematic code data record has passed RNXSMT.
- CODE if you have used RNXSMT to only screen and smooth code observations so far. From problems in the code data cannot be deduced the quality of the corresponding phase measurements.

Bernese GNSS	Software Version 5.2									- 0 -
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
CODSF	P 4: Scr	eening	Options							
ITERA	TIONS									
Mas	. number	of it:	erations	10						
OUTLI	ER DETEC'	TION								
Out	lier det	ection		M						
Max	. residu	al allo	owed	30.	. 0	meters				
Cor	fidence	interva	al .	5.0)	(in units	of one	e sigma	a)	
	1. degree			1						
	. RMS of			5.0		meters				
Maı	k outlie	rs in (bbs. files	BO:	rh 🛓					
] ^Top ^P	rev ^Next	Cance [^] l	Save^As ^	Save ^Run	^Output	: Rer^un ^+	Day ^-Da	у		
> User: ber	n52 Campaig	gn: \${P}/IN	ITRO \$Y+0=	2010 \$S+O=	2070 File	e: /home/bern5	2/GPSUS	ER52/PA	N/CODSPP.IN	P //

If you have not yet cleaned the phase observations in RNXSMT (approach with precise high-rate clocks available), you have to run MAUPRP now ("Menu>Processing>Phase preprocessing"). For this purpose, you need precise satellite clock corrections for all satellites and with the full sampling of 30 seconds (or even higher). Select "Zero-difference observation files" instead of "Single-difference observation files" and introduce a consistent set of "GNSS standard orbits", "Pole file", and "Satellite clocks" in panel "MAUPRP 1: Input Files". An additional panel "MAUPRP 7: Clock Events" will be displayed (see online help for further details). It is recommended to disable the cycle slip corrections by checking the box for option "Do not accept cycle slip corrections" in panel "MAUPRP 8: Cycle Slip Detection/Correction". All other settings can remain as described in Section 4.2.3: You may skip this step if you have preprocessed the phase data already in RNXSMT.

7.4.2 Residual Screening

Now you are ready to run GPSEST ("Menu>Processing>Parameter estimation") in the zero difference mode to store residuals for screening. You also have to include a DCB file when processing code observations.

	Software Version 5.2 Campaign		Orbite/EOR	Processing	Saniaa	Conversion	BPE	User	Help	- • •
							DFL	USEI	helb	
PARAN	HETER EST	IMATION	- GPSESI	2 1.1: In	put Fil	.es 1				
	AL FILES			MODE						
· ·	ace geode		-		GNSS	<u> </u>				
	fferencin	-			ZERO	×				
) data pr									
Sho	ow all ge	neral t	iles		<u>۲</u>					
	VATION F									
	WATION F. Bse obser					and a second			mound	
	ise obser de obser					PSH		??\$S+0 ??\$S+0		
	ide opsei ide opsei				<u> </u>	CSH	12.3	1195+0	CZH	
nai	iye obser	vacions			1	U ZEL				
MAIN	INPUT FT	LES								
Sta	ation coo	rdinate	s		APRSYD	+0 CRD				
Sat	cellite s	tandard	orbits			+0 STD				
Ear	th rotat	ion par	ameters		COD\$YD					
Sat	cellite c	lock co	rrections	3	COD\$YD	+0 CLK				
Di:	fferentia	l code	biases		P1C1\$M	+O DCB				
Gr:	idded VMF	1 coeff	icients		i i i i i i i i i i i i i i i i i i i	GRD				
Ior	nosphere :	models			COD\$YD	+0 ION				
	CTIONS F			CTS AND C						
	ean tidal					E BLQ				
Atı	nospheric	tidal	loading		EXAMPI	E ATL				
		0	o	0	1.0.1.1					
						Rer^un ^+				07.WD
> User: ber	n52 Campaig	gn: \${P}/IN	IRO \$Y+0=	2010 \$S+0=	2070 File	e: /home/bern5	2/GPSUS	SER52/PA	N/GPSE	IST.INP

In the subsequent two panels, the output files for residuals and clock estimates are specified:

Bernese GNSS Software Version 5.2		_ 0 💌
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE	User	Help
GPSEST 2.1: Output Files 1		
GENERAL OUTPUT FILES		
Program output 🦳 use GPSEST.Lnn	or	CLK\$YD+0 OUT
Error message 🛛 🦳 merged to program output	or	ERROR MSG
NORMAL EQUATION SYSTEM NOO		
STATION- AND SATELLITE-RELATED RESULTS		
Station coordinates CRD		
Satellite orbital elements ELE		
Earth rotation parameters ERP		
Earth rotation parameters (IERS)		
ATMOSPHERE-SPECIFIC RESULTS		
Troposphere estimates TRP		
Troposphere estimates (SINEX) TRO		
Ionosphere models ION		
Ionosphere models (IONEX) INX		
^Top ^Prev ^Next Cance'l Save'As ^Save ^Run ^Output Rer'un ^+Day ^-D	ау	
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUS	SER52/PAN	N/GPSEST.INP

Bernese GNSS Software Version 5.2						- 0 ×
Configure Campaign RINEX Orb	its/EOP Processing	Service Conversion	on BPE	User	Help	
GPSEST 2.2: Output File	s 2					
ADDITIONAL RESULT FILES						
Differential code bia	ses		DCB			
Inter-system biases			ISB			
Phase center variatio	ns (gridded)		PHG			
Phase center variatio	ns (spherical)		PHH			
EPOCH-SPECIFIC RESULTS						
GNSS clock correction	S	CLK\$YD+0	CLK			
Clock RINEX		Í	CLK			
Kinematic coordinates			KIN			
AUXILIARY FILES						
Observation residuals		CLK\$YD+0	RES			
Covariance matrix		Í	COV			
Covariance matrix wrt	coordinates		COV			
∣ ∬ ^Top │ ^Prev │ ^Next │ Cance^I │ Sav	e^As ^Save ^Run	^Output Rer^un	^+Day ^-[Day		
> User: bern52_Campaign: \${P}/INTRO	\$Y+0=2010 \$S+0=2	2070 File: /home/be	rn52/GPSU	SER52/PA	N/GPSEST.IN	Р.

Take care to specify "Correlation strategy" with CORRECT and to store NORMALIZED residuals

Bernese GNSS Software Version 5.2	- 0 -
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help	
GPSEST 3.1: General Options 1	
TITLE EXAMPLE: Sess \$YSS+0: Code+phase solution for residual screening	
OBSERVATION SELECTION	
Satellite system ALL	
Frequency/linear combination L3	
Elevation cutoff angle 5 degrees	
Sampling interval 300 seconds	
Tolerance for simultaneity 100 milliseconds	
Special data selection NO	
Observation window	
OBSERVATION MODELING AND PARAMETER ESTIMATION	
A priori sigma of unit weight 0.001 meters	
Elevation-dependent weighting COSZ	
Type of computed residuals NORMALIZED	
Correlation strategy CORRECT -	
LEO-SPECIFIC SELECTION AND MODELING OPTIONS	
Elevation cutoff angle 0 degrees	
Elevation-dependent weighting NONE -	
ATen ABerry Aberta Connell Courtain ACourt ABerry ADer ADer ADer	
^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output Rer^un ^+Day ^-Day	
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/GPSEST.INP	1.

-	Software Version 5.2 Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPF	User	Help	- • •
			Options 2		ocritice		012		Tielp	
			NODELING		DRY MENI	GMF DES-PAVLIS		GNSS SLR		
Res Sol Cor Sav Int	ve resolv produce w	strate uities S quart ed amb: ridelane	JY for ter-cycle	3	NONH ALL IF	INDICATED				
Sto		m after	PTIONS C NEQ savi program c	-						
						Rer^un ^+I : /home/bern5			N/GPSEST.INF	> //

The options in the following panel are only relevant to zero difference processing. They define, e.g., the source clocks used as a priori for satellites and receivers if more than one potential source is available:

Bernese GNSS Software Version 5.2	- • • ×
Configure Campaign RINEX Orbits/EOP Processing Service Conversion	n BPE User Help
GPSEST 3.3: General Options 3	
OPTIONS CONCERNING INTRODUCED CLOCK CORRECTIONS	
Primary source for satellite clocks	BERNESE FILE
Receiver clock missing in clock RINEX file	CLK FROM OBS FILE -
Satellite clock missing in clock RINEX file	SAT CLK IS ZERO
Satellite clock missing in Bernese clock file	SAT CLK IS ZERO 🔹
Clock interpolation allowed over	seconds
OPTIONS FOR ZERO DIFFERENCE PROCESSING	
Maximum tolerated O-C term	meters
Apply periodic relativistic J2 correction	
Correction for polarization effect	ALWAYS • total effect
	ALWAYS 🥑 geometric part
^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output Rer^un	^+Day ^-Day
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/ber	n52/GPSUSER52/PAN/GPSEST.INP

The datum definition shall be consider according to the information in the a priori coordinate file given in panel "GPSEST 1.1: Input Files 1":

Bernese GNSS Software Version 5.2									
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help									
GPSEST 4: Datum Definition for Station Coordinates									
DATUM DEFINITION TYPE									
c Free network solution									
c Coordinates constrained WITH FLAG									
c Coordinates fixed WITH FLAG									
A PRIORI SIGMAS									
North 0.01 meters									
East 0.01 meters									
Up 0.01 meters									
^ ^ ^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output Rer^un ^+Day ^-Day									
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/GPSEST.IN	P								
Emerce GNSS Software Version 5:2 Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help	- • ×								
GPSEST 4.1: Datum Definition for Station Coordinates									
STATION COORDINATES TO BE CONSTRAINED									
Manual selection									
List of stations (and sigmas) from file									
Stations with specific flags in CRD file I #: all non-bla	ink								
^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output Rer^un ^+Day ^-Day	_								
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/GPSEST.IN	, //,								

Clock parameters are setup and pre–eliminated $\mathsf{EVERY_EPOCH}:$

Bernese GNSS Software Version 5.2							- 0 -
Configure Campaign RINEX Orbits	/EOP Processing	Service	Conversion	BPE	User	Help	
GPSEST 5.1: Setup of Para	meters and P	re-Elin	mination 1				
_							
STATION-RELATED PARAMETER	.S		Setup		Pre-E	limination	1
Station coordinates				NO			•
Ambiguities				NO			•
ATMOSPHERIC PARAMETERS							
Site-specific troposphe		3	Y	NO			•
Global ionosphere param	leters			NO			*
GLOBAL PARAMETERS							
			_	110			
Orbital parameters			-	NO			×
Earth orientation param Geocenter coordinates	leters			NO			<u>×</u>
Geodenter coordinates				NO			*
EPOCH PARAMETERS							
Receiver clock offsets			×	EVE	RY EPC	CH	-
Satellite clock offsets	;		F	EVE	RY EPC	CH	-
Kinematic coordinates			Ē	NO			*
Stochastic ionosphere p	arameters		Г	EVE	RY EPC	CH	*
							_
^Top ^Prev ^Next Cance^I Save^	As ^Save ^Run	^Output	Rer^un ^+	Day ^-Da	у		
> User: bern52 Campaign: \${P}/INTRO \$	SY+0=2010 \$S+0=	2070 File	e: /home/bern5	2/GPSUS	ER52/PA	N/GPSEST.IN	P //

For the residual screening, a reduced set of troposphere parameters can be estimated:

📕 Bernese GNSS S	oftware Version 5.2										•
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help		
GPSES	т 6.1.1:	Site-S	pecific T	roposphe	re Para	meters 1					
	H PATH D		RAMETERS	_							
-	ping fun				WET GMF						
Par	ameter s	pacing		þ	04 00 0	0 (hh mm	. ss)				
HORIZ	ontal grj	ADIENT	PARAMETER	.s							
	dient es				NONE	-					
Par	ameter s	pacing		4	24 00 0	0 (hh mm	SS)				
A PRI	ORI SIGM	AS		2	Absolut	e		Rela	tive		
	ith path			[meters		5.00		meters	
Hor	izontal	gradier	its	[meters		5.00		meters	
EXTRA	CTION OF	PARAME	TERS FOR	TROPOSPH	ERE SIN	EX FILE					
Off	set 🗌		(hhh m	m ss)	T	'ime resolu	ution			(hh mm :	38)
	,							,			
, ∥ ^Top ^P	rev ^Next	Cance [^] l	Save^As ^	Save ^Run	^Output	Rer^un ^+E	Day ^-Da	iy			
						: /home/bern52			N/GPSE	ST.INP	//
									N/GPSE	ST.INP	

The following panel asks for the options regarding the clock estimation. If you include GLONASS you need to choose "Rclk.off: Parameter setup" different from NONE. See online help for additional information.

Bernese GNSS Software Version 5.2	- 0 - X-
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help	
GPSEST 6.8.1: Clock Estimation 1	
DATUM DEFINITION FOR CLOCK ESTIMATION Type of datum definition ZERO-MEAN CONDITION	
REFERENCE STATIONS	
Selection of reference stations ALL	
Manual station selection	
Station list from file	
REFERENCE SATELLITES	
Selection of reference satellites NONE	
Manual satellite selection	
Satellite list from file	
ADDITIONAL OPTIONS	
Minimum number of obs per station clock 7 📓 Minimum number of obs per satellite clock 5 🚆	
Minimum number of obs per satellite clock 🛛 5 🚆	
GLONASS CLOCK ESTIMATION	
GLONASS receiver clock biases NON-GPS SATELLITES -	
Receiver clocks for each satellite system	
] ^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output Rer^un ^+Day _^-Day	
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/GPSEST.II	NP //

The program output file should report the clock parameters:

	LTS (PART 1)						
	PARAMETERS (PART						
PARAMETER	ТҮРЕ			#PRE - E	LIMINATED	#SET - UP	
STATION C	OORDINATES		39	0		39	
	CLOCK BIASES / TIM	E DIACEC				200	
AMBIGUITI		E DIASES	1375	0		1442	
	IFIC TROPOSPHERE F	ARAMETERS	91	0		91	
	E STATION CLOCKS						
	E SATELLITE CLOCKS		5842	5842	(EPOCH-WISE) (EPOCH-WISE)	6059	
TOTAL NUM	BER OF PARAMETERS		11286			11575	
NUMBER OF	OBSERVATIONS (PAF	T 1):					
ТҮРЕ	FREQUENCY		# OBSERVA				
	L3						•••
	L3		5439				
TOTAL NUM	BER OF OBSERVATION	S	10877	7			
	ORI SIGMA OF UNIT):				
	ORI SIGMA OF UNIT		.0015 M (SIGMA	OF ONE-W	AY L1 PHASE OB	SERVABLE AT	
DEGREE OF CHI**2/DO	FREEDOM (DOF)	:					

The residuals are stored in the file P/INTRO/OUT/CLK02143.RES. Use program RESRMS ("Menu>Service>Residual files>Create residual statistics") to screen for outliers bigger than 2 cm for code and phase data (remember that code residuals are scaled to phase residuals — 2 cm in the input field correspond to a 2 m threshold for code residuals):

nese GNSS Software Version 5.2 Ifigure Campaign RINEX Orbits/EOP Processing Service Conversio	on BPE	User	Help	
CREATE RESIDUAL STATISTICS - RESRMS 1: Input/Output		0.501	Ticip	
CREATE RESIDERE STRITSTICS RESIMS 1. INPRC/ORCPUT				
GENERAL FILES				
Show all general files 🛛 🔽				
INPUT FILES				
Residual files CLK\$YD+0 RES				
OUTPUT FILES				
Summary file CLK\$YD+0 SU	м			
Residual histogram CLK\$YD+0 LS				
Edit information file CLKSYD+0 ED				
Station observation sigma file SO:	S			
GENERAL OUTPUT FILES				
Program output 📃 use RESRMS.Lnn		or	RES\$1	
Error messages 📃 merged to program (output	or	ERRO	R MS
			N/RESRMS.	INP
ser: bern52_Campaign: \${P}/INTRO_\$Y+0=2010_\$S+0=2070_File: /home/be			N/RESRMS.	
ser: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/be	ern52/GPSU	ISER52/PA		INP
ser: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$\$+0=2070 File: /home/be nexe015550fbrare Version 52 Ifigure Campaign RINEX Orbits/EOP Processing Service Conversio	ern52/GPSU		N/RESRMS. Help	
ser: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$\$+0=2070 File: /home/be nexe015550fbrare Version 52 Ifigure Campaign RINEX Orbits/EOP Processing Service Conversio	ern52/GPSU	ISER52/PA		
ser: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/be new 6N3550Hwae Venion 52 figure Campaign RINEX Orbits/EOP Processing Service Conversio RESRMS 2: Options	on BPE	User	Help	
ser: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$\$+0=2070 File: /home/be me: 6N355dtwer Venon52 figure Campaign RINEX Orbits/EOP Processing Service Conversio RESRMS 2: Options TITLE EXAMPLE: Sess\$YSS+0: Residual statistic f	on BPE	User	Help	
ser:bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$\$+0=2070 File:/home/be mexe0055266exeeVenen52 figure Campaign RINEX Orbits/EOP Processing Service Conversio RESRMS 2: Options TITLE EXAMPLE: Sess\$YSS+0: Residual statistic f GENERAL OPTIONS	on BPE	User	Help	
ser:bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$\$+0=2070 File:/home/be mex60555dwareVenon52 figure Campaign RINEX Orbits/EOP Processing Service Conversio RESRMS 2: Options TITLE EXAMPLE: Sese\$Y35+0: Residual statistic f GENERAL OPTIONS Frequency to check	on BPE	User	Help	
ser:bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$\$+0=2070 File:/home/be mexe0055266exeeVenen52 figure Campaign RINEX Orbits/EOP Processing Service Conversio RESRMS 2: Options TITLE EXAMPLE: Sess\$YSS+0: Residual statistic f GENERAL OPTIONS	on BPE	User	Help	
ser:bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$\$+0=2070 File:/home/be mex6055540wae.Venon52 figure Campaign RINEX Orbits/EOP Processing Service Conversio RESRMS 2: Options TITLE EXAMPLE: Sese\$Y35+0: Residual statistic f GENERAL OPTIONS Frequency to check	on BPE	User User	Help	
ser:bem52 Campaign: \${P}/INTRO \$Y+0=2010 \$\$+0=2070 File:/home/be mereONSigner Campaign RINEX Orbits/EOP Processing Service Conversion RESRMS 2: Options TITLE EXAMPLE: Sess\$YSS+0: Residual statistic f GENERAL OPTIONS Frequency to check Sampling rate of residual files	on BPE	User User	Help	
ser:bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File:/home/be mex6ND516MwarkVenon52 figure Campaign RINEX Orbits/EOP Processing Service Conversion RESRMS 2: Options TITLE EXAMPLE: Sess\$Y3S+0: Residual statistic f GENERAL OFTIONS Frequency to check Sampling rate of residual files DETECT LARGE RESIDUALS Phase measurements	n BPE	User User phase s sec	Help screening conds	
ser:bem52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File:/home/be mex6055100waeKenon52 figure Campaign RINEX Orbits/EOP Processing Service Conversion RESRMS 2: Options TITLE EXAMPLE: Sess\$Y3S+0: Residual statistic for GENERAL OPTIONS Frequency to check Sampling rate of residual files DETECT LARGE RESIDUALS Phase measurements	m52/GPSU m BPE [L3] [300 11mi1 [0.02]	User User phase s sec 0 met 0 met	Help screening conds	
ser: bem52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/be mex 0055 500wee Venen52 Ifgure Campaign RINEX Orbits/EOP Processing Service Conversion RESRMS 2: Options TITLE EXAMPLE: Sess\$YS3+0: Residual statistic for GENERAL OFTIONS Frequency to check Sampling rate of residual files DETECT LARGE RESIDUALS Phase measurements P Code measurements P Range measurements F	m52/GPSU m BPE [L3] [300 11mi1 [0.02]	User User phase s sec 0 met 0 met	Help screening conds ers ers	
ser:bem52 Campaign: \$(P)/INTRO \$Y+0=2010 \$S+0=2070 File:/home/be mex60551dWave Venon52 figure Campaign RINEX Orbits/EOP Processing Service Conversion RESRMS 2: Options TITLE EXAMPLE: Sess\$Y3S+0: Residual statistic for GENERAL OPTIONS Frequency to check Sampling rate of residual files DETECT LARGE RESIDUALS Phase measurements P Range measurements P Range measurements DETECT EAD DATA	m52/GPSU m BPE [L3] [300 11mi1 [0.02]	User User phase s sec 0 met 0 met	Help screening onds ers ers ers	
ser:bem52 Campaign: \${P}/INTRO \$Y+0=2010 \$\$+0=2070 File:/home/be merefMS2dWareVenon52 figure Campaign RINEX Orbits/EOP Processing Service Conversion RESRMS 2: Options TITLE EXAMPLE: Sess\$YSS+0: Residual statistic f GENERAL OFTIONS Frequency to check Sampling rate of residual files DETECT LARGE RESIDUALS Phase measurements P Range measurements P Range measurements DETECT BAD DATA Minimum continuously observed time interval	m52/GPSU m BPE [L3] [300 11mi1 [0.02]	User User phase s sec 0 met 0 met	Help screening conds ers ers	
ser: bem52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/be mere 0055 Software Versen 52 Ifigure Campaign RINEX Orbits/EOP Processing Service Conversion RESRMS 2: Options TITLE EXAMPLE: Sess\$YS3+0: Residual statistic f GENERAL OPTIONS Frequency to check Sampling rate of residual files DETECT LARGE RESIDUALS Phase measurements P Code measurements P Code measurements P Code measurements P Code measurements P DETECT BAD DATA Minimum continuously observed time interval Detect ambiguities with few observations	m52/GPSU m BPE or code L3 300 limi 0.02 0.02 F	User User phase s sec 0 met 0 met	Help screening onds ers ers ers	
RESRMS 2: Options TITLE EXAMPLE: Sess\$YSS+0: Residual statistic f GENERAL OFTIONS Frequency to check Sampling rate of residual files DETECT LARGE RESIDUALS Phase measurements P Code measurements P Range measurements D DETECT BAD DATA Minimum continuously observed time interval	m52/GPSU m BPE [L3] [300 11mi1 [0.02]	User User phase s sec 0 met 0 met sec	Help screening onds ers ers ers	

The statistics in the program output file clearly indicates some stations with problematic obervations:

> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/RESRMS.INP

^Top | ^Prev | ^Next | Cance^I | Save^As | ^Save | ^Run | ^Output | Rer^un | ^+Day ^-Day

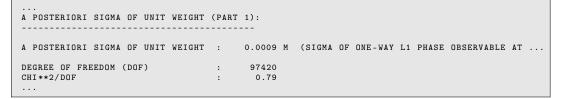
FILE	INFORMATION AND	STATISTIC	:							
Num	Station 1	Tota	1 RMS	med.Resi	Sigma	numObs	nSat	nDel	ObsTyp	
1	GANP 11515M001		1.3	0.7	1.1	4682	50	1	PHASE	
2	HERT 13212M010		2.0	0.7	1.0	4716	51	3	PHASE	••
3	JOZ2 12204M002		2.0	0.8	1.1	4805	50	2	PHASE	••
4	LAMA 12209M001		1.3	0.6	0.9	4786	50	1	PHASE	••
5	MATE 12734M008		3.6	0.8	1.2	4324	51	9	PHASE	••
6	ONSA 10402M004		2.4	0.7	1.0	4624	50	1	PHASE	
7	PTBB 14234M001		1.7	0.9	1.3	2155	32	1	PHASE	
14	GANP 11515M001		0.4	0.1	0.3	4683	50	0	CODE	
15	HERT 13212M010		0.3	0.1	0.2	4718	51	0	CODE	
16	JOZ2 12204M002		0.3	0.1	0.2	4806	50	0	CODE	
17	LAMA 12209M001		0.2	0.1	0.2	4788	50	0	CODE	
18	MATE 12734M008		0.3	0.1	0.2	4325	51	0	CODE	
19	ONSA 10402M004		0.3	0.1	0.2	4624	50	0	CODE	
20	PTBB 14234M001		0.5	0.2	0.3	2155	32	0	CODE	

Mark the corresponding code and phase zero difference observations using program SATMRK ("Menu>Service>Bernese observation files>Mark/delete observations":

Bernice ONISSUMvare Venion 5.2 Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help
MARK/DELETE OBSERVATIONS - SATMRK 1: Filenames
GENERAL FILES Show all general files 🔽 OPTIONS
Desired task EDIT FILE . Re-initialize ambiguities ALL for ALL GNSS .
CBSERVATION FILES Observation type GNSS Zero diff. code 2???\$S+0 CEH phase 2???\$S+0 PEH both Single diff. code CSH phase ESH both Range CSE
GENERAL OUTFUT FILES Program output Broor messages merged to program output or ERROR MSG
TITLE EXAMPLE: Session \$Y33+0: Mark outliers for code+phase screening
∬ ^Top ^Prev ^Next Cance^t Save^As ^Save ^Run ^Output Rer^un ^+Day ^-Day > User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GP\$USER52/PAN/SATMRK.INP
Bennese RNSS Software Version 5.2 Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help
SATMRK 2: Manual and File Selection
FILE SELECTION Edit information file CLKSYD+0 EDT
MANUAL SELECTION Type of change MARK Z Frequency L1&L2 Z
Satellite(s) (ALL: all satellites) From epoch (blank: first observation number) to epoch (blank: last observation number) or
01 C Observation window
yyyy mm dd hh mm ss yyyy mm dd hh mm ss Start Start End Start
 ^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output Rer^un ^+Day _^Day > User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/SATMRK.INP

If you inspect the program output you will notice that only 354 observations have been removed from all observation files.

Repeat the GPSEST-run and store again the residuals.

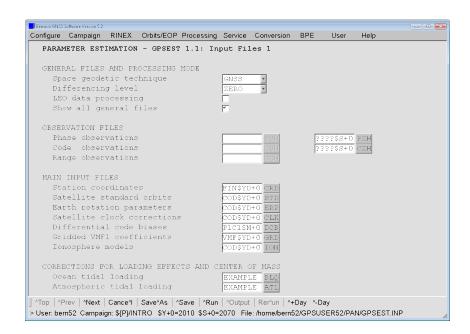


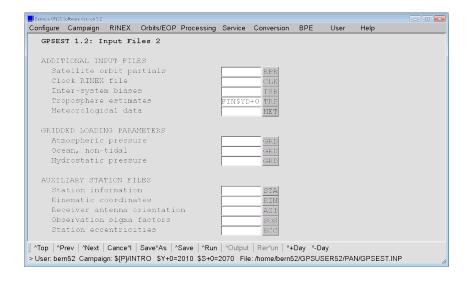
In the second iteration we screen for residuals bigger than $6\,{\rm mm}$ in ${\sf RESRMS}$ and mark these observations with ${\sf SATMRK},$ too.

If you have done the screening of phase observations in MAUPRP instead of RNXSMT you can skip the first iteration and you only need to run once through the residual screening procedure (sequence of GPSEST, RESRMS, SATMRK) using the final threshold for the residuals of $6 \,\mathrm{mm}$.

7.4.3 Generate Clock Solutions

Repeat the run of GPSEST with the clean observation files to get the definitive clock estimates. You may introduce the estimated coordinates and troposphere parameters¹ from the final double-difference solution for the session (e.g., FIN\$YD+0). You also have to include a DCB file when processing code observations.





¹If you introduce a troposphere result file based on VMF1, you also need to introduce the same "Gridded VMF1 coefficients" in panel "GPSEST 1.1: Input Files 1" as you have used to generate the "Troposphere estimates". Store also the coordinate results that correspond to the clock estimates.

Bernese GNSS Software Version 5.2		- • •
Configure Campaign RINEX Orbits/EOP Processing Service Conv	ersion BPE Use	er Help
GPSEST 2.1: Output Files 1		
GENERAL OUTPUT FILES		
Program output 📃 use GPSEST.Lnr	1	or CLK\$YD+0 OUT
Error message 📃 merged to prog	gram output	or ERROR MSG
NORMAL EQUATION SYSTEM	NQO	
STATION- AND SATELLITE-RELATED RESULTS Station coordinates Satellite orbital elements Earth rotation paramèters Earth rotation parameters (IERS)	CRD ELE ERP IEP	
ATMOSPHERE-SPECIFIC RESULTS		
Troposphere estimates	TRP	
Troposphere estimates (SINEX)	TRO	
Ionosphere models	ION	
Ionosphere models (IONEX)	INX	
∬ ^Top ^Prev ^Next Cance ⁴ I Save ⁴ As ^Save ^Run ^Output Rer' > User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /hom		2/PAN/GPSEST.INP //

In the final run the clock results for satellites and receivers shall be stored in a "Clock RINEX" result file in panel "GPSEST 2.2: Output Files 2".

📕 Bernese GNSS So										- 0 ×
Configure	Campaign	RINEX	Orbits/EOF	P Processing	Service	Conversio	n BPE	User	Help	
GPSEST	2.2: 0	utput F	iles 2							
	IONAL REA				_					
	ferentia						DCB			
	er-syste						ISB			
			ations (g				PHG			
Phas	se cente	r varia	ations (s	pherical)			PHH			
	SPECIFIC				_					
	S clock	correct	ions		-		CLK			
	sk RINEX				C:	LK\$YD+0				
Kine	ematic c	oordina	ites				KIN			
	ARY FIL	20								
	ervation		1							
			lais		<u> </u>	LK\$YD+0	RES			
	ariance :						COV			
Cova	ariance :	matrix	wrt coor	dinates			COV			
^Top ^Pr	ev ^Next	Cance [^] l	Save^As	^Save / ^Run	^Output	Rer^un	^+Day ^-I	Day		
> User: bern	52 Campaig	gn: \${P}/IN	ITRO SY+0	=2010 \$S+0=	2070 Fil	e: /home/ber	n52/GPSL	JSER52/PA	N/GPSES	T.INP

The input field for "ZPD model and mapping function (GNSS)" in panel "GPSEST 3.2: General Options 2" is inactive because a file with "Troposphere estimates" is introduced. The same troposphere model is used in this program run.

The datum definition shall be reconsidered when introducing a solution for the coordinates:

	Software Version 5.2	DIVEN	0.13 (500	- ·						- • •
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
GPSES	T 4: Dat	um Defi	nition fo	or Statio	n Coord	dinates				
DATUN	I DEFINIT	ION TYP	È							
(. Free	networ	k solutio	n						
(Coord	dinates	constrai	ned		WITH FLAG	÷ v	[
C	Coord	dinates	fixed			WITH FLAG	; •			
A PRI	ORI SIGM	AS								
Noi	th	0.01	mete	rs						
Eas	t	0.01	mete	rs						
Up		0.01	mete	rs						
I ATon AP	rev ^Nevt	Cance ^A	Save^As /	Save ARun	_^Output	Rer^un / *+	Dav ^-Da	w		
								•	AN/GPSEST.INP	
		5 .(;)								111
(
	Software Version 5.2		0.13 (500	<u> </u>	. ·	- ·				
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
GPSES	T 4.1: D	atum De	finition	for Stat	ion Cod	ordinates				
STATI	ON COORD	TNATES	TO BE ET?	(FD						
	ual sele									
			From file				ΞI	X		
Sta	tions wi	th spec	ific fla	as in CRE	file	#		_	all non-blan	.k
J						1				
] ^Top ^P	rev ^Next	Cance ⁴	Save^As /	Save ^Run	^Output	Rer^un +	Day ^-Da	iy.		
> User: ber	n52 Campai	gn: \${P}/IN	ITRO \$Y+0=	2010 \$S+0=	2070 File	e: /home/bern5	2/GPSUS	ER52/P	AN/GPSEST.INP	1

The sampling of troposphere parameters for those stations where you cannot introduce a complete set of estimates in the file from "Troposphere estimates" given in panel "GPSEST 1.2: Input Files 2" shall be identical with those in the input file:

mese 6NSS Software Version 5.2 nfigure Campaign RINEX Orbits	S/EOP Processing Service	e Conversion	BPE	User	Help	
GPSEST 6.1.1: Site-Speci:	fic Troposphere Pa	rameters 1				
ZENITH PATH DELAY PARAME	PERS					
Mapping function	WET VI	IF ×				
Parameter spacing	01 00	00 (hh mm	uss)			
HORIZONTAL GRADIENT PARA	1ETERS					
Gradient estimation mo	del CHENHI	ER 🔽				
Parameter spacing	24 00	00 (hh mm	ss)			
A PRIORI SIGMAS	Absolu	ite		Rela	tive	
Zenith path delay		meters		5.00		meters
Horizontal gradients		meters		5.00		meters
EXTRACTION OF PARAMETERS	FOR TROPOSPHERE S	INEX FILE				
Offset (1	hh mm ss)	Time resol	ution			(hh mm ss
op ^Prev ^Next Cance^I Save	As ASave ARun AOuto	ut Rer'un "+				
"op ^Prev ^Next Cance^I Save ser: bern52_Campaign: \${P}/INTRO					N/GPSE	ST.INP
					N/GPSE	ST.INP
					N/GPSE	ST.INP
ser: bern52 Campaign: \${P}/INTRO	\$Y+0=2010 \$S+0=2070 F	ile: /home/bern5/	2/GPSUS	ER52/PA		
ser: bern52 Campaign: \${P}/INTRO		ile: /home/bern5/			N/GPSE Help	ST.INP
ser: bern52 Campaign: \${P}/INTRO	\$Y+0=2010 \$S+0=2070 F	ile: /home/bern52 e Conversion	2/GPSUS	ER52/PA		
ser:bern52 Campaign:\${P}/INTRO mear 6H25Suthware Kenon 52 ffigure Campaign RINEX Orbit: GPSEST 6.1.2: Site-Speci:	\$Y+0=2010 \$S+0=2070 F S/EOP Processing Service fic Troposphere Pa:	ile:/home/bern52 e Conversion rameters 2	2/GPSUS	ER52/PA		
ser:bern52 Campaign:\${P}/INTRO mee 00350MwareYenon52 nfigure Campaign RINEX Orbit GPSEST 6.1.2: Site-Speci: STATIONS TO BE EXCLUDED :	\$Y+0=2010 \$S+0=2070 F S/EOP Processing Service fic Troposphere Pa:	ile:/home/bern52	2/GPSUS	ER52/PA		
ser:bern52 Campaign: \${P}/INTRO more ChiSSoftware Vacan52 nfigure Campaign RINEX Orbits GPSEST 6.1.2: Site-Speci: STATIONS TO BE EXCLUDED : Station selection	\$Y+0=2010 \$S+0=2070 F S/EOP Processing Service fic Troposphere Pa:	Conversion Conversion rameters 2 ETIMATION	2/GPSUS	ER52/PA		
ser:bern52 Campaign:\${P}/INTRO mos CHISSUMmar Venue52 figure Campaign RINEX Orbit GPSEST 6.1.2: Site-Speci: STATIONS TO BE EXCLUDED : Station selection Station list from file	\$Y+0=2010 \$S+0=2070 F S/EOP Processing Service fic Troposphere Pa:	ile:/home/bern52	2/GPSUS	ER52/PA		
ser:bern52 Campaign: \${P}/INTRO more ChiSSoftware Vacan52 nfigure Campaign RINEX Orbits GPSEST 6.1.2: Site-Speci: STATIONS TO BE EXCLUDED : Station selection	\$Y+0=2010 \$S+0=2070 F S/EOP Processing Service fic Troposphere Pa:	Conversion Conversion rameters 2 ETIMATION	2/GPSUS	ER52/PA		
ser:bern52 Campaign:\${P}/INTRO more ONDSOMware Venuen52 Afigure Campaign RINEX Orbits GPSEST 6.1.2: Site-Speci: STATIONS TO BE EXCLUDED : Station selection Station list from file Manual selection STATIONS WITH SPECIAL A :	SY+0=2010 \$S+0=2070 F SECP Processing Service FIG Troposphere Par FROM TROPOSPHERE E WITH TRO PRIORI SIGMAS	e Conversion rameters 2 STINATION DPO	2/GPSUS	ER52/PA		
ser:bern52 Campaign: \${P}/INTRO mms: 6NSSubwar:Vnom52 figure Campaign RINEX Orbit: GPSEST 6.1.2: Site-Speci: STATIONS TO BE EXCLUDED : Station selection Station list from file Manual selection STATIONS WITH SPECIAL A : Station selection	SY+0=2010 \$S+0=2070 F S/EOP Processing Service fic Troposphere Pa: FROM TROPOSPHERE E: WITH TRO	Conversion Conversion rameters 2 ETIMATION	2/GPSUS	ER52/PA		
ser:bern52 Campaign:\${P}/INTRO mess GNISSubware Vencen52 Infigure Campaign RINEX Orbits GPSEST 6.1.2: Site-Speci: STATIONS TO BE EXCLUDED : Station selection Station list from file Manual selection STATIONS WITH SPECIAL A : Station selection Station list from file	SY+0=2010 \$S+0=2070 F SECP Processing Service FIG Troposphere Par FROM TROPOSPHERE E WITH TRO PRIORI SIGMAS	e Conversion rameters 2 STINATION DPO	2/GPSUS	ER52/PA		
ser:bern52 Campaign:\${P}/INTRO	SY+0=2010 \$S+0=2070 F SECP Processing Service FIG Troposphere Par FROM TROPOSPHERE E WITH TRO PRIORI SIGMAS	e Conversion rameters 2 STINATION DPO	2/GPSUS	ER52/PA		
ser:bern52 Campaign:\${P}/INTRO mess GNISSubware Vencen52 Infigure Campaign RINEX Orbits GPSEST 6.1.2: Site-Speci: STATIONS TO BE EXCLUDED : Station selection Station list from file Manual selection STATIONS WITH SPECIAL A : Station selection Station list from file	SY+0=2010 \$S+0=2070 F SECP Processing Service FIG Troposphere Par FROM TROPOSPHERE E WITH TRO PRIORI SIGMAS	e Conversion rameters 2 STIMATION JPD 9	2/GPSUS	ER52/PA	Help	
ser:bern52 Campaign: \${P}/INTRO more 000550fware Venuen52 ffigure Campaign RINEX Orbity GPSEST 6.1.2: Site-Speci: STATIONS TO BE EXCLUDED : Station selection Station list from file Manual selection Station selection Station selection Station list from file Manual selection Station list from file Manual selection SPECIAL A PRIORI SIGMAS Zenith path delay	SY+0=2010 \$S+0=2070 F	e Conversion rameters 2 STIMATION JPD 9	2/GPSUS	User	Help	
ser:bern52 Campaign: \${P}/INTRO	SY+0=2010 \$S+0=2070 F	e Conversion rameters 2 STIMATION DEO 2 EXX	2/GPSUS	User	Help ve m	

If you have selected a "Clock RINEX" result file in panel "GPSEST 2.2: Output Files 2" you are asked for the header information. Please replace the placeholders by the information for your institution and give a description for your results.

Bernese GNSS Software Version 5.2							- 0 ×
Configure Campaign RINEX	Orbits/EOP Processing	Service	Conversion	BPE	User	Help	
GPSEST 6.8.2: Clock HEADER ENTRIES FOR C Run by AC designator AC name Time system DCBs applied		UTE	/aiub/CODD	F /	_	_	×
Comment lines:	,		, u100, 000,		_		
EXAMPLE: \$YD	+0, CODE+PHASE CL	UCK EST	IMATION			+ -	×
^Top ^Prev ^Next Cance ⁴	Save^As ^Save ^Run	^Output	Rer^un ^+	Day ^-Da	y		
> User: bern52_Campaign: \${P}/IN	TRO \$Y+0=2010 \$S+0=	2070 File	: /home/bern5	2/GPSUS	ER52/PAN	GPSEST.INP	li.

 NUMBER OF	PARAMETERS (PART	1):						
PARAMETER						IMINATED	#SET-UP	
RECEIVER C	LOCK BIASES / TI	ME BIASES	200				200	
AMBIGUITIE				0			1442	
	STATION CLOCKS					(EPOCH-WISE)		
EPOCH WISE	SATELLITE CLOCK	.S				(EPOCH-WISE)		
	ER OF PARAMETERS		1110:	1	9581		11445	
								• • •
NUMBER OF	OBSERVATIONS (PA	RT 1):						
TYPE	FREQUENCY	FILE/PAR	# 03	BSERVATIO	NS			
PHASE	L3	ALL		54188				
CODE								
TOTAL NUMB	ER OF OBSERVATIO	NS		108578				
TOTAL NUMB	ER OF OBSERVATIO	NS		108578				
		NS 		108578				•••
	ER OF OBSERVATIO	NS 		108578				
		NS 		108578				
A POSTERIO		NS WEIGHT (PART	1):	108578			·	··· ···
A POSTERIO	RI SIGMA OF UNIT	NS WEIGHT (PART WEIGHT : :	1): 0.0008 M (; 97477	108578			·	· · · · ·
A POSTERIO	RI SIGMA OF UNIT RI SIGMA OF UNIT FREEDOM (DOF)	NS WEIGHT (PART WEIGHT : :	1): 0.0008 M (3	108578			·	

The estimated inter–frequency biases caused by different hardware delays in the receiver for each GLONASS satellite due to the individual frequency are reported in the following section in the program output:

1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN	TION NAME P 11515M001 P 11515M001	$\begin{array}{c} 0.00000\\ 0.0000\\ 0.0000\\ 0.0000\\ 0.0000\\ 0.0000\\ 0.0000\\ 0.0000\\ 0.0000\\ 0.0000\\ 0.$	RMS (NSEC) -0.244906 -0.251354 -0.236973 -0.229242 -0.243824 -0.241614 -0.226128 -0.250173 -0.248057 -0.249851	0.000000 -0.244906 -0.251354 -0.236973 -0.229242 -0.243824 -0.241614 -0.226128 -0.250173 -0.248057 -0.249851	0.134 0.144 0.153 0.150 0.128 0.118 0.131 0.129 0.129	SAT GPS SAT 101 SAT 102 SAT 103 SAT 104 SAT 104 SAT 105 SAT 107 SAT 108 SAT 110 SAT 111
1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN	P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001	0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000	$\begin{array}{c} -0.244906\\ -0.251354\\ -0.236973\\ -0.229242\\ -0.243824\\ -0.241614\\ -0.226128\\ -0.250173\\ -0.248057\end{array}$	-0.244906 -0.251354 -0.236973 -0.229242 -0.243824 -0.241614 -0.226128 -0.250173 -0.248057	0.134 0.144 0.153 0.150 0.128 0.118 0.131 0.129 0.129	SAT 101 SAT 102 SAT 103 SAT 104 SAT 105 SAT 105 SAT 107 SAT 108 SAT 110
1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN	P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001	$\begin{array}{c} 0.00000\\ 0.0000\\ 0.0000\\ 0.0000\\ 0.0000\\ 0.0000\\ 0.0000\\ 0.00$	-0.251354 -0.236973 -0.229242 -0.243824 -0.241614 -0.226128 -0.250173 -0.248057	-0.251354 -0.236973 -0.229242 -0.243824 -0.241614 -0.226128 -0.250173 -0.248057	0.144 0.153 0.150 0.128 0.118 0.131 0.129 0.129	SAT 102 SAT 103 SAT 104 SAT 105 SAT 105 SAT 107 SAT 108 SAT 110
1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN	P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001	0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000	-0.236973 -0.229242 -0.243824 -0.241614 -0.226128 -0.250173 -0.248057	-0.236973 -0.229242 -0.243824 -0.241614 -0.226128 -0.250173 -0.248057	0.153 0.150 0.128 0.118 0.131 0.129 0.129	SAT 103 SAT 104 SAT 105 SAT 107 SAT 108 SAT 110
1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN	P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001	0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000	-0.229242 -0.243824 -0.241614 -0.226128 -0.250173 -0.248057	-0.229242 -0.243824 -0.241614 -0.226128 -0.250173 -0.248057	0.150 0.128 0.118 0.131 0.129 0.129	SAT 104 SAT 105 SAT 107 SAT 108 SAT 110
1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN	P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001	0.00000 0.00000 0.00000 0.00000 0.00000 0.000000	-0.243824 -0.241614 -0.226128 -0.250173 -0.248057	-0.243824 -0.241614 -0.226128 -0.250173 -0.248057	0.128 0.118 0.131 0.129 0.129	SAT 105 SAT 107 SAT 108 SAT 110
1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN	P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001	0.000000 0.000000 0.000000 0.000000 0.000000	-0.241614 -0.226128 -0.250173 -0.248057	-0.241614 -0.226128 -0.250173 -0.248057	0.118 0.131 0.129 0.129	SAT 107 SAT 108 SAT 110
1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN	P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001	0.000000 0.000000 0.000000 0.000000	-0.226128 -0.250173 -0.248057	-0.226128 -0.250173 -0.248057	0.131 0.129 0.129	SAT 108 SAT 110
1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN	P 11515M001 P 11515M001 P 11515M001 P 11515M001 P 11515M001	0.000000 0.000000 0.000000	-0.250173 -0.248057	-0.250173 -0.248057	0.129 0.129	SAT 110
1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN	P 11515M001 P 11515M001 P 11515M001 P 11515M001	0.000000	-0.248057	-0.248057	0.129	
1 GAN 1 GAN 1 GAN 1 GAN 1 GAN 1 GAN	P 11515M001 P 11515M001	0.000000				SAT 111
1 GAN 1 GAN 1 GAN 1 GAN 1 GAN	P 11515M001		-0.249851	-0 249851		
1 GAN 1 GAN 1 GAN				-0.249001	0.131	SAT 113
1 GAN 1 GAN		0.00000	-0.250245	-0.250245	0.130	SAT 114
1 GAN	P 11515M001	0.000000	-0.245288	-0.245288	0.128	SAT 115
	P 11515M001	0.000000	-0.243093	-0.243093	0.132	SAT 117
1 (14)	P 11515M001	0.000000	-0.249622	-0.249622	0.131	SAT 118
1 GAN	P 11515M001	0.000000	-0.244722	-0.244722	0.131	SAT 119
1 GAN	P 11515M001	0.000000	-0.243063	-0.243063	0.125	SAT 120
1 GAN	P 11515M001	0.000000	-0.242501	-0.242501	0.113	SAT 121
1 GAN	P 11515M001	0.000000	-0.250258	-0.250258	0.127	SAT 122
1 GAN	P 11515M001	0.000000	-0.242287	-0.242287	0.149	SAT 123
1 GAN	P 11515M001	0.000000	-0.242737	-0.242737	0.140	SAT 124
2 HER	T 13212M010	0.000000		0.00000		SAT GPS
2 HER	T 13212M010	0.000000	0.065866	0.065866	0.131	SAT 101

The report of the clock estimates looks like:

SPOCH	WISE	STATION CLOCKS:		\${P}/INTRO,	/OUT/CLK10207.C	LK		
				STATION CLOCK	VALUES (USEC)			
ГҮРЕ	STAT	EPOCH(MJD)	A PRIORI	CORRECTION	TOTAL	RMS(NSEC)	#0BS	STA
0.2		FF 402 000000	0 001220	0 000000	0.001201	0 000	24 D	# 0AN
23 23	1				-0.021321		34 R	
23	2 3	55403.000000 55403.000000	-0.002644	-0.000817	-0.003462 0.001424	0.003	29 R 35 R	
	3 4				-0.000340		35 R 35 R	
			-0.000525				35 R 30 R	
23	5		-0.028072	0.001137	-0.026935 -31.022376	0.003		
23	6		-31.022254				30 R	
	7	55403.000000	0.528750		0.529076	0.005	11 R	
23	8	55403.000000	-0.035458	-0.000356	-0.035814 0.138509	0.003	28 R	
23	9		0.138215		0.138509		20 R	
23	10		-0.008899			0.003	33 R	
23	11		-219.055034		-219.054822		18 R	
23	12		-0.031458		-0.031623		30 R	
23	13		0.028115		0.027940		18 R	
23	1						34 R	
	2				-0.001959			
23	3	55403.003472	0.001511	-0.000144	0.001367	0.003	34 R	# JOZ
	WISE	SATELLITE CLOCKS	:	\${P}/INTRO/	/ORB/CLK10207.C	LK		
	WISE	SATELLITE CLOCKS	-		/ORB/CLK10207.C	LK		
РОСН			- S.	ATELLITE CLOCK	VALUES (USEC)			
	WISE SAT		- S.	ATELLITE CLOCK		LK RMS(NSEC)	#0BS	
POCH	SAT	EPOCH(MJD)	- A PRIORI	ATELLITE CLOCK CORRECTION	VALUES (USEC) TOTAL	RMS(NSEC)		
РОСН YPE 	SAT 3	EPOCH(MJD) 55403.000000	- A PRIORI 586.451514	ATELLITE CLOCK CORRECTION -0.000519	VALUES (USEC) TOTAL 586.450995	RMS(NSEC)	15	
24 24 24	SAT 3 6	EPOCH(MJD) 55403.000000 55403.000000	- A PRIORI 586.451514 559.025665	ATELLITE CLOCK CORRECTION -0.000519 0.001482	VALUES (USEC) TOTAL 586.450995 559.027147	RMS(NSEC) 0.013 4.082	15 1 *	
POCH YPE 24 24 24 24	SAT 3 6 9	EPOCH(MJD) 55403.000000 55403.000000 55403.000000	- A PRIORI 586.451514 559.025665 20.468252	ATELLITE CLOCK CORRECTION -0.000519 0.001482	VALUES (USEC) TOTAL 586.450995 559.027147	RMS(NSEC) 0.013 4.082	15 1 * 1 *	
POCH 24 24 24 24 24	SAT 3 6 9 11	EPOCH (MJD) 55403.000000 55403.000000 55403.000000 55403.000000	- A PRIORI 586.451514 559.025665 20.468252 -78.075202	ATELLITE CLOCK CORRECTION -0.000519 0.001482 0.007644 0.00795	VALUES (USEC) TOTAL 586.450995 559.027147 20.475896 -78.074407	RMS(NSEC) 0.013 4.082 7.717 0.002	15 1 * 1 * 26	
POCH 24 24 24 24 24 24 24	SAT 3 6 9 11 14	EPOCH(MJD) 55403.000000 55403.000000 55403.000000 55403.000000 55403.000000	- S. A PRIORI 586.451514 559.025665 20.468252 -78.075202 71.688147	ATELLITE CLOCK CORRECTION -0.000519 0.001482 0.00764 0.000795 0.000893	VALUES (USEC) TOTAL 586.450995 559.027147 20.475896 -78.074407 71.689041	RMS(NSEC) 0.013 4.082 7.717 0.002 0.003	15 1 * 1 * 26 26	
POCH YPE 24 24 24 24 24 24 24 24 24 24	SAT 3 6 9 11 14 17	EPOCH (MJD) 55403.000000 55403.000000 55403.000000 55403.000000 55403.000000 55403.000000	- S. A PRIORI 586.451514 559.025665 20.468252 -78.075202 71.688147 163.652097	ATELLITE CLOCK CORRECTION -0.000519 0.001482 0.00764 0.000795 0.000893	VALUES (USEC) TOTAL 586.450995 559.027147 20.475896 -78.074407 71.689041	RMS(NSEC) 0.013 4.082 7.717 0.002 0.003	15 1 * 1 * 26 26 22	
24 24 24 24 24 24 24 24 24 24 24	SAT 3 6 9 11 14 17 19	EPOCH (MJD) 55403.000000 55403.000000 55403.000000 55403.000000 55403.000000 55403.000000	- S. A PRIORI 586.451514 559.025665 20.468252 -78.075202 71.688147 163.652097 -52.512921	ATELLITE CLOCK CORRECTION -0.000519 0.001482 0.007644 0.000795 0.000893 0.000782 0.000782	VALUES (USEC) TOTAL 556.450995 559.027147 20.475896 -78.074407 71.689041 163.652879 -52.512332	RMS(NSEC) 0.013 4.082 7.717 0.002 0.003 0.010 0.003	15 1 * 26 26 22 26	
24 24 24 24 24 24 24 24 24 24 24 24 24	SAT 3 6 9 11 14 17 19 20	EPOCH (MJD) 55403.000000 55403.000000 55403.000000 55403.000000 55403.000000 55403.000000 55403.000000	- S. A PRIORI 586.451514 559.025665 20.468252 -78.075202 71.688147 163.652097 -52.512921 52.929104	ATELLITE CLOCK CORRECTION -0.000519 0.001482 0.007644 0.000795 0.000893 0.000782 0.000589 0.000155	VALUES (USEC) TOTAL 586.450995 559.027147 20.475896 -78.074407 71.689041 163.652879 -52.512332 52.929259	RMS(NSEC) 0.013 4.082 7.717 0.002 0.003 0.010 0.003 0.004	15 1 * 26 26 22 26 26 26	
POCH YPE 24 24 24 24 24 24 24 24 24 24 24 24 24	SAT 3 6 9 11 14 17 19 20 22	EPOCH (MJD) 55403.000000 55403.000000 55403.000000 55403.000000 55403.000000 55403.000000 55403.000000 55403.000000	- S. A PRIORI 586.451514 559.025665 20.468252 -78.075202 71.688147 163.652097 -52.512921 52.929104 166.687820	ATELLITE CLOCK CORRECTION -0.000519 0.001482 0.007644 0.000795 0.000893 0.000782 0.000589 0.000155	VALUES (USEC) TOTAL 586.450995 559.027147 20.475896 -78.074407 71.689041 163.652879 -52.512332 52.929259	RMS(NSEC) 0.013 4.082 7.717 0.002 0.003 0.010 0.003 0.004	15 1 * 26 26 22 26 26 26 26 12	
POCH TYPE 24 24 24 24 24 24 24 24 24 24 24 24 24	SAT 3 6 9 11 14 17 19 20 22 24	EPOCH (MJD) 55403.000000 55403.000000 55403.000000 55403.000000 55403.000000 55403.000000 55403.000000 55403.000000 55403.000000	- S. A PRIORI 586.451514 559.025665 20.468252 -78.075202 71.688147 163.652097 -52.512921 52.929104 166.687820 307.451136	ATELLITE CLOCK CORRECTION -0.000519 0.001482 0.007644 0.000795 0.000893 0.000782 0.000589 0.000155 0.002045 0.000259	VALUES (USEC) TOTAL 586.450995 559.027147 20.475896 -78.074407 71.689041 163.652879 -52.512332 52.929259 166.689865 307.451395	RMS(NSEC) 0.013 4.082 7.717 0.002 0.003 0.010 0.003 0.004 0.014 0.007	15 1 * 26 26 22 26 26 26 12 25	
POCH YPE 24 24 24 24 24 24 24 24 24 24 24 24 24	SAT 3 6 9 11 14 17 19 20 22	EPOCH (MJD) 55403.000000 55403.000000 55403.000000 55403.000000 55403.000000 55403.000000 55403.000000 55403.000000 55403.000000	- S. A PRIORI 586.451514 559.025665 20.468252 -78.075202 71.688147 163.652097 -52.512921 52.929104 166.687820	ATELLITE CLOCK CORRECTION -0.000519 0.001482 0.007644 0.000795 0.000893 0.000782 0.000589 0.000155 0.002045 0.000259 0.000221	VALUES (USEC) TOTAL 586.450995 559.027147 20.475896 -78.074407 71.689041 163.652879 -52.512332 52.929259 166.689865 307.451395 -9.425414	RMS(NSEC) 0.013 4.082 7.717 0.002 0.003 0.010 0.003 0.004 0.014 0.007 0.007	15 1 * 26 26 22 26 26 26 26 12	

24	104	55403.000000	0.000000	-79.261456	-79.261456	7.795	1 *
24	105	55403.000000	0.00000	-153.329680	-153.329680	0.004	18
24	107	55403.000000	0.00000	-292.762903	-292.762903	0.011	18
24	113	55403.000000	0.00000	-276.613710	-276.613710	0.023	9
24	114	55403.000000	0.00000	-168.479768	-168.479768	0.010	15
24	115	55403.000000	0.00000	23.463583	23.463583	0.028	6
24	120	55403.000000	0.00000	-73.657604	-73.657604	0.004	18
24	121	55403.000000	0.00000	-200.315946	-200.315946	0.003	18
24	122	55403.000000	0.00000	-10.570479	-10.570479	0.006	18
24	3	55403.003472	586.452934	-0.001054	586.451879	0.015	13
24	6	55403.003472	559.021364	0.001878	559.023242	4.987	1 *
24	9	55403.003472	20.469100	-0.000804	20.468296	5.760	1 *
24	11	55403.003472	-78.075981	0.000704	-78.075277	0.002	26

The "*"–character indicates satellites where the satellite clock correction has been computed from a limited number of stations.

Because this section can become very long, it can also be skipped in the GPSEST program output by checking the box "Printing: Suppression of output concerning epoch parameters" in panel "GPSEST 3.2.1.1: Extended Program Output Options" (enabled only if the checkbox "Enable extended program output" in panel "GPSEST 3.2: General Options 2" is checked).

Differences of clocks and Allan deviations for differences of clocks can be extracted from the GPSEST program output by the program GPSXTR ("Menu>Processing>Program output extraction >Parameter estimation/stacking"). The pair of clocks (receiver or satellites) are defined by a baseline file (extension BSL).

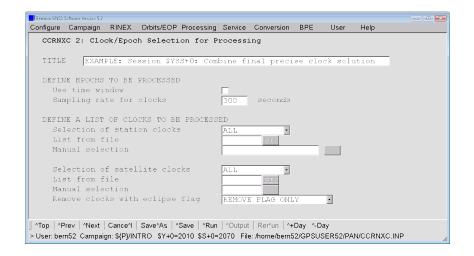
📕 Bernese GNSS	Software Version 5.2									- 0 💌
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
GPSX1	R 2: Out	put Fil	Les							
TITLE	EX EX	AMPLE:	Session S	YSS+0: E	xtract	clock dif	feren	nces		
OUTPU	JT FILES									
Out	tput summ	ary			SUM					
Cod	ordinate	summar	Y		SUM					
Kii	nematic s	ummary			SUM					
GIN	i summary				SUM					
C10	ock summa	rу		DIF\$YD+	0 SUM	Baseli	ne 🛛	CLKDIF	BSL	
C10	ock Allan	devia	tion	ADV\$YD+	0 SUM					
Amb	biguity r	esolut.	ion		SUM	GNSS	ALL	~	ID	w.
Amb	biguity f	ractio	nals		SUM					
Car	upaign su	mmary			SUM					
Wee	ekly summ	ary			SUM					
Po:	le output				SUM	Pole pa	arame	ter sets	ALL	¥.
Top A	nov ANIost	Cancoll	Save^As ^	Savo APun	AOutput	Portun A	Day A	Dav		
										IND
 Oser: ber 	noz Campai	yn. ə{₽}/ir	NTRO \$Y+0=	2010 33+0=	2070 FIR	e. /nome/bern:	2/6P5	USER52/PA	AN/GPSXTR	.INP //

The baseline file might, e.g., be generated via the "Menu>Campaign>Edit station files>Baseline definition file":

Bernese GNSS Software Ve	rsion 5.2								- 0 ×
Configure Camp	aign RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
CREATE/UP:	DATE BASEL	INE DEFIN:	TION FIL	E - ED	ITBSL				-
Filename									
Station	n name 1	Station r	name 2	×					
WTZR 14	201M010	WSRT 1350	6M005 -						_
WTZR 14	201M010	PTBB 1423	4M001 -						
WTZR 14	201M010	ONSA 1040	2M004 -						
			1						<u>×</u>
] ^Top ^Prev ^									
> User: bern52_C;	ampaign: \${P}/	INTRO \$Y+0=	2010 \$S+0=	2070 Fil	e: /home/bern{	52/GPSUS	SER52/PA	N/EDITBSL	.INP

The clock solution is finalized by selecting the reference clock using program CCRNXC ("Menu>Service>Clock tools>Combine/manipulate clock RINEX files"):

Bernese GNSS Software Version 5.2	
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE Use	er Help
COMBINE/MANIPULATE CLOCK RINEX FILES - CCRNXC 1: Filenames	
GENERAL FILES Show all general files P	
INPUT FILES	
Clock RINEX files CLK\$YD+0 CLK Replace station coordinates FIN\$YD+0 CRD	
RESULT FILES Combined clock RINEX file FIN\$YD+0 Bernese satellite clock file FIN\$YD+0 Sigma file with linear fit RMS SIG	
GENERAL OUTPUT FILES	
Program output 🔲 use CCRNXC.Lnn or	REF\$YD+0 OUT
Error messages 🔽 merged to program output or	ERROR M3G
ATOP ^Prev ^Next Cance^1 Save^As ^Save ^Run ^Output Ren'un ^+Day ^-Day Suser; bern52 Campaign: \$(P)(INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER5/)	2/PAN/CCRNXC.INP



Bernese GNSS Software Version 5.2		
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE	User	Help
CCRNXC 3: Options for Clock RINEX File Combination		
CLOCK RINEX FILE OFFSET ESTIMATION		
Use all station clocks	2	
Use all satellite clocks	7	
Use only reference clocks		
A priori sigma of unit weight	0.02	nanoseconds
Maximum residuum allowed	5	nanoseconds
OPTIONS FOR CLOCK COMBINATION		
Strategy for computation of mean value	INPUT	FILES .
Maximum deviation from mean	5	nanoseconds
Minimum number of valid clocks for mean	1	for stations
	1	for satellites
Compute sigma in resulting clock RINEX file from	INPUT	FILES .
	-	
^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output Rer^un ^+Day ^-		
>User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSU	JSER52/PA	N/CCRNXC.INP

7 Additional Examples

Bernese GNSS Software Version 5.2		- • •
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE	User	Help
CCRNXC 4: Select Program Functions, Program Output		
REFERENCE CLOCK SELECTION		
 Select a new reference clock for the output file Retain the reference clock from an input file 		CLK
ENABLE OTHER PROGRAM FUNCTIONS	_	
Enable clock jump detection Enable extrapolation		
PROGRAM OUTFUT OPTIONS		
Detailed report on input clock RINEX files		
Detailed report on clock combination		
Detailed report on reference clock selection		
Detailed report on clock jump detection		
Detailed report on clock extrapolation		
Statistic about the resulting clocks	۲ 	
Sort order for clock statistics	SIGMA	•
ATop ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output Rer^un ^+Day ^-	Day	
> User: bern52_Campaign: \${P}/INTRO_\$Y+0=2010_\$S+0=2070_File: /home/bern52/GPSU	USER52/PAN	V/CCRNXC.INP

Remark BNSS	Software Version 5.2									
	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
CCRNI	KC 5: Sel	ect a N	ew Refere	nce Cloc}	c for O	utput Fil	e			
Se. Mai	RENCE CLO lection o nual sele t list fr	f poten ction f	tial refe or	stations satellite	98		ALL :	STATIO	15	
Po	IMENT OF : lynomial ximum all	degree	for align	ment	nent		1	-	seconds	
						Rer^un ^+[: /home/bern53			N/CCRNXC	.INP

Bernese GNSS Software Version 5.2				- • •
Configure Campaign RINEX Orbits/EOP Processing Service Conversion	BPE	User	Help	
CCRNXC 6: Options for Clock Jump Detection				
CLOCK JUMP DETECTION				
Confidence interval 5		sigmas		
Minimum RMS for jump detection		nanose	ond/300	seconds
CLOCK JUMP OR OUTLIER				
Maximum time interval for outlier detection 5		epochs		
Remove outliers from output for stations				
Remove outliers from output for satellites 🔽				
CLOCK JUMP VERIFICATION				
Enable the clock jump verification				
Polynomial degree for jump size estimation 10				
^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output Rer^un ^+Da	ay ^-D	lay		
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/	GPSU	SER52/PA	N/CCRNXC	.INP //

		• 1	•	C 1 1 1	1.1
The table at the end of the	program output	provides an	OVERVIEW	of the clock	quality.
The table at the end of the	program output	provides an	0,01,10,0	or one crock	quanty.

	CLOCK SELECTION					
				-		
loctod -	eference statio	. n .	WT7P 1400	1 MO10		
	elerence statio	511:	WIZR 1420	JIMOIO		
•						
ATISTICS	ON THE CLOCKS	IN THE	OUTPUT FI	LE		
				rms of		
		out	001	n = 0	n = 1	n = 2
TZR 14201	M010 M005	288	288	1.472	0.000	0.000
SRT 13506	M005	288	288	4.520	0.030	0.030
	M008	288	288	29.164	0.054	0.052
188 14234	M001	288	288	0.397	0.058	0.043
ISA 10402	M004	284	284	0.397 5.626 2.928 3.062	0.081	0.076
MA 12209	M001	288	288	2.928	2.933	2.932
122 12204	M002 M010	288	288	3.062	3.067	3.069
MM 14001	MOOA	200	200	3.316	3.322	3.328
LMM 14001 LSE 10003	M004	200	288 288	4.277 5.174	4.091	3.033
LSE 10003 [M2 14001	MOOS	200	200	5.1/4	4.892	4.734
	M008 M001	201	287 288	5.297 6.752	5.021	4.712
	M014	200	200	0.752	0.009	0.029
22 14201 1						
2		113	59 113	21.055 53.429		
.8		113		42 222	0.159	0.122
9		93		42.222 40.762	0 163	0 136
0			83	14.263	0.176	0.130
7		105		3,172	0.187	0.139
1		87	87	3.172 89.783	0.196	0.194
19		103	103	91.484	0.196	0.135
5			83	91.484 32.984	0.208	0.064
3			98	32.857	0.221	0.115
13		86	86	10.754	0.224	0.171
.2		86	86	10.754 38.001	0.230	0.155
.5		102	102	104.651	0.230	0.203
4				111.497		
16		108	108	87.317	0.243	0.240
1				71.214	0.268	0.165
2		113 110	110	71.214 14.917	0.272	0.244
1		102	102	45.128	0.292	0.254
5		111	111	65.889 248.950	0.357	0.310
6		93		248.950	0.371	0.341
2			98	44.930 22.467	0.371	0.271
.3			103	22.467	0.371	0.341
4		99	99	4.500	0.407	0.380
32		87	87	300.001 19.774	0.425	0.257
5						
.9		100	100	20.046	0.592	0.318

7.4.4 Further Suggestions

- Switch the "Var-covar wrt epoch parameters" in panel "GPSEST 6.7: General Options for Epoch Parameters" from SIMPLIFIED to CORRECT.
- Compute a PPP for one of the stations in the zero difference network solution. Compare the coordinates and clocks from the PPP with the results from the network solution. Exchange the orbits, EOP, and satellite clock corrections from your solution by products from other sources (e.g., CODE or IGS).
- Use the PPP approach to screen the residuals of the Bernese zero difference observation files. This has to be done station by station. Make sure that you use a consistent set of orbits, EOP, and satellite clocks (e.g., IGS final products or CODE final solution).

7.5 Using RINEX 3 Data

The campaign ${P}/EXM_GAL$ in the *Bernese Introductory Course* environment contains some RINEX 3 files in order to follow the example in this section.

7.5.1 Basic Principles

To accommodate for the various GNSS, RINEX 3 format was adapted for additional observation types. However, Version 5.2 of the *Bernese GNSS Software* is still limited to dual-frequency processing, so we need to select two frequencies for the processing. For each frequency, then, different observation types may be selected according to the availability and a priority list given in a file (e.g, ${X}/GEN/OBS.SEL$):

```
GNSS observation selection for Bernese GNSS Software Version 5.2
                                                                            21-Aug-2012
Format version: 1.00
Receiver type
                        S/S O/F RINEX observation codes and their priority
                             ***
                                  *** *** *** ***
                        ***
DEFAULT
                        G
                             L1
                                   L1P L1W L1C
                                                     L1X
                        G
                             L2
                                  L2P L2W L2C L2D L2X
                        G
                             C1
                                   C1P C1W C1C
                                                    C1X
                                   C2P C2W C2C C2D C2X
                        G
                             C2
                             L1
                                  L1P
                                            L1C
                        R
                                                    L1X
                        R
                             L2
                                   L2P
                                            L2C
                                                    L2X
                        R
                             C1
                                   C1P
                                            C1C
                                                    C1X
                        R
                             C2
                                   C2P
                                            C2C
                                                    C2X
STMULA
                        G
                             I.1
                                   T. 1 W
                        G
                             L2
                                   L2W
                        G
                             C1
                                   C1W
                        G
                             C2
                                   C2W
                        R
                             L1
                                   L1W
                        R
                             L2
                                   L2W
                        R
                             C1
                                   T. 1 W
                        R
                             C2
                                   L2W
```

Make sure that the observation types from your RINEX 3 observation files are contained in this priority list. If an observation type is not listed it is not considered by the program RNXSMT.

This selection is performed by the program RNXSMT where the priority list is specified in option "Receiver-specific observation type priority" (panel "RNXSMT 1.1: General Files"). The resulting smoothed RINEX file (extension SMT) contains a special section in its comment lines reporting the original observation types according to the RINEX 3 convention:

###	PG	RNXS	4T: 1	RINEX	(FII	LE CHANGED	COMMENT
GEOS:	1	G 1	C1C	C2W	L1C	L2W	COMMENT
GEOS:	2	G 2	C1C	C2W	L1C	L2W	COMMENT
GEOS:	3	G 3	C1C	C2W	L1C	L2W	COMMENT
GEOS:	4	G 4	C1C	C2W	L1C	L2W	COMMENT
GEOS:	5	G 5	C1C	C2W	L1C	L2W	COMMENT
GEOS:	51	R121	C1P	C2P	L1P	L2P	COMMENT
GEOS:	52	R122	C1P	C2P	L1P	L2P	COMMENT
GEOS:	53	R123	C1P	C2P	L1P	L2P	COMMENT
GEOS:	54	R124	C1P	C2P	L1P	L2P	COMMENT

When importing these files into the binary Bernese observation file format using the program RXOBV3, this information is kept in the header section. This information will be used in future versions of *Bernese GNSS Software* to manage the observation type identification.

This mechanism requires to start with program RNXSMT whenever RINEX 3 files should be imported into *Bernese GNSS Software*, Version 5.2.

7.5.2 RINEX 3 Handling in RNXSMT

In the first panel of RMXSMT the "Original RINEX observation files" are selected. Observation files in RINEX 2 and RINEX 3 format can be processed together in one program run. For that reason the potential long names of RINEX 3 files need to be converted to the conventional names of the RINEX 2 format.

Bernese GNSS Software Version 5.2		
Configure Campaign RINEX Orbits/EOP Processing Service Conversion	BPE User	Help
CLEAN/SMOOTH OBSERVATION FILES - RNXSMT 1: Filenames		
GENERAL FILES Show all general files		
INPUT FILES Original RINEX observation files ????\$\$+0 170	l	
GENERAL OUTPUT FILES		
Program output 🦵 use RNXSMT.Lnn	or	SMT\$YD+0 OUT
Error messages 🔽 merged to program of	utput or	ERROR MSG
DIRECT ESTIMATION OF DIFFERENTIAL CODE BIAS VALUES		NO
^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output Rer^un ^+D		
> User: I_bern52 Campaign: \${P}/EXM_GAL \$Y+0=2017 \$S+0=2130 File: s/homefs	s/aiub/I_bern52/G	PSUSER/PAN/RNXSMT.INP

In order to import RINEX 3 formatted files, a priority list need to be specified in "Receiver-specific observation type priority":

Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help		
RNXSN	4T 1.1: G	eneral	Files								
GENEI	RAL INPUT	FILES									
Gei	neral con	stants		CONS	ST.	_					
Sa	tellite i	nforma	ion	SATE	LLIT.I	14					
Sa	tellite p	roblem	3	SAT	\$Y+0	CRX					
Obs	- servation	types	priority	OBS.	SEL		Print	select:	ion	Г	
MENU	SETTINGS										
Se.	lected ca	mpaign		\${P}/IN	TRO						
Se.	lected se	ssion		year 2	2015	session	300	0			
Se	ssion tab	le		\${P}/IN	TRO/STA	/SESSIONS	S.SES				
^Top ^F	Prev /Next	Cance [^] l	Save^As ^	Save ARun	^Output	Rer^un 1+	-Day ^-D	lay			
llear l b	am52 Camp	aion ¢(D)	INTRO \$Y+0	=2015 \$5+0	=3000 E	ile: anfe/home	fe (aiub/l	bern52/CE	SUISER!	DAN/PNY	SMT INE

In the last panel of RNXSMT you can select whether phase and/or code measurements shall be preprocessed. If both checkboxes are deactivated the original observations from the input RINEX files are simply copied into the smoothed RINEX files.

Bernese GNSS	Software Version 5.2									- 9 %
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
RNXSM	IT 4: Out	put Opt	ions							
OUTPL	T OPTION	3								
Pre	process ;	phase d	bservatio	ons		Г				
Use	e smoothe	d inste	ad of rav	r code						
Out	put deta	il				SU	м 🔹			
	AL OPTIO									
Vei	ify GLON	ASS fre	equency nu	umber						
I										
] ^Top ^F	rev ^Next	Cance [^] l	Save^As ^	Save ^Run	^Output	Rer^un 1+	Day ^-Da	ay		
> User: I_b	ern52 Campa	aign: \${P}/	EXM_GAL \$	Y+0=2017 \$	S+0=2130) File: s/home	fs/aiub/l_	bern52/GI	PSUSER/P/	N/RNXSMT.INP

7.5.3 RINEX 3 Handling in the Example BPEs

Since the release from 2016-Jan-08 of Version 5.2, the BPE examples distributed with the Bernese GNSS Software contain four variables related to the selection of RINEX files to be processed:

- V_OBSSEL to select the stations to be processed (see more information in the README-files of the BPEs),
- V_RNXDIR location of the observation files in RINEX 2 format,
- V RX3DIR location of the observation files in RINEX 3 format, and
- V_OBSINF name of the "Receiver-specific observation type priority" file to be used in the program RNXSMT if RINEX3 formatted observation files are used.

In the default setup the third section of the process control files considers only RINEX 2 formatted observation files:

To accept also observation files in RINEX 3 format for processing, the corresponding directory need to be specified in V $\mbox{\sf RX3DIR}$:

VARIABLE	DESCRIPTION	DEFAULT
8******	40**************	30*******
V_RNXDIR	Directory with the RINEX2 files	RINEX
V_RX3DIR	Directory with the RINEX3 files	RINEX3
V_OBSINF	RINEX 3 observation typ selection	OBS.SEL

The user script RNX_COP copies the observation files with the following priority from the datapool into the campaign area:

- 1. RINEX 3 files with long names; generated by the receiver
- 2. RINEX 3 files with long names; generated from a stream
- 3. RINEX 3 files with long names; source unknown
- 4. RINEX 3 files with short names; source unknown
- 5. RINEX 2 files with short names $% \left({{{\rm{A}}_{{\rm{B}}}} \right)$

As soon as a RINEX 3 observation file is found, the variable designed for the "Receiver-specific observation type priority" becomes relevant. Make sure that for your own BPEs the program RNXSMT is the first program that accesses the RINEX observation files.

7.6 Processing Galileo Observations

Orbit and observation files containing Galileo are provided for one day (doy 213 of year 2017) in the campaign P/EXM_GAL in the *Bernese Introductory Course* environment.

7.6.1 Galileo Satellite-Related Metadata

Since 29 January 2017, the IGS is using the antenna corrections related to the IGS realization of the ITRF2014. The igs14.atx published by the IGS contains also corrections for the Galileo satellite antennas. Galileo meta data are contained in the satellite information file ($\{X\}/GEN/SATELLIT.I14$) as well as the antenna phase center correction file ($\{X\}/GEN/PCV.I14$) published at http://www.aiub.unibe.ch/download/BSWUSER52/GEN or distributed with the software.

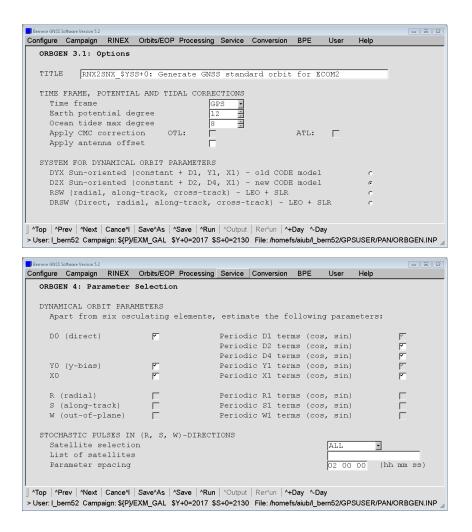
These antenna corrections have been estimated under the assumption that the Galileo L_1/L_5 ground antenna phase center corrections are identical with GPS L_1/L_2 . This assumption has been taken because dedicated Galileo calibrations are not yet available for most antennas. The processing of Galileo observations follows the same scheme and is, therefore, consistent.

7.6.2 Preparing the Orbit and Clock Products

The orbit products that shall be used need also to contain Galileo orbits and satellite clock corrections (in particular for a PPP processing). Since this information is not contained in the IGS legacy products, it is necessary to introduce products from the MGEX project of the IGS. In this context for instance CODE provides a dedicated multi-GNSS solution (the solution label COM is used for this purpose). The products can be downloaded from http://www.aiub.unibe.ch/download/CODE_MGEX/CODE and should be made available in the datapool area D/COM for the use with the BPE.

The orbit files have to be prepared as described in Section 3. Apart from the different filenaming (COM instead of COD) it should be considered that the EOP files are given in daily instead of weekly files. Consequently, you need to specify COMWD+0 instead of CODW+07 to the field "Foreign formatted ERP files" in panel "POLUPD 1: Input/Output Files".

Since the beginning of the year 2014, the MGEX-related products generated by CODE are based on the updated Empirical CODE Orbit Model (ECOM) containing the twiceper-revolution term in the *D*-component (pointing from the satellite to the Sun). In order to correctly integrate these orbits with the program ORBGEN of Version 5.2 of *Bernese GNSS Software* you should consider the remarks in the section on *Orbit Modeling at CODE Analysis Center and Compatibility with Version 5.2* on page 119 of the user manual. It means in particular that the orbit model in the program ORBGEN should be adjusted as follows:



Even if orbits from more than GPS, GLONASS, and Galileo (as supported by Version 5.2 of *Bernese GNSS Software*) are contained in the orbit products, ORBGEN selects only those where records in the satellite information file are available.

If you plan to do a PPP processing you may directly extract the satellite clock corrections from the clock RINEX file using the program RNXCLK ("Menu>RINEX>RINEX utilities>Extract satellite clock"):

Bernese GNSS Software Version 5.2							- 8 %
Configure Campaign RIN	EX Orbits/EOP	Processing Servi	e Conversion	BPE	User	Help	
EXTRACT SATELLITE	CLOCK FROM (CLOCK RINEX H	ILES - RNXC	LK 1:	Filename	s	
GENERAL FILES							
Show all genera	l files	2					
INPUT FILES							
Clock RINEX fil	.es	CON	I\$WD+0 CLK				
GENERAL OUTPUT FI	LES						
Program output	Ч	use RNXCLK	Lnn		or	RNXCLK	OUT
Error messages		merged to p	orogram outp	out	or	ERROR	MSG
TITLE EXAMPLE:	Extract sate	ellite clock:	5				
ATop ^Prev ^Next Canc					•		
> User: I_bern52 Campaign: \$	\${P}/EXM_GAL \$Y	+0=2017 \$S+0=2	130 File: s/home	efs/aiub/l_	bern52/GPS	SUSER/PAN/R	XCLK.INP

The result file will have the same name as the input file but will be located in the ORB directory of the campaign.

7.6.3 Observation Selection

Galileo measurements should only be provided in RINEX 3 format. Basically the instructions from Section 7.5 apply. It is only necessary to extend the observation type priority file by the Galileo-related measurement types. An example ($\{X\}/GEN/OBS_GAL.SEL$) is provided together with the *Bernese GNSS Software*:

Receiver type *********		0/F ***				their pri *** *** *	***	
DEFAULT	G	L1	L1P L1W	L1C	L1X			
	G	L2	L2P L2W	L2C L	2D L2X			
	G	C1	C1P C1W	C1C	C1X			
	G	C2	C2P C2W	1 C2C C	2D C2X			
	R	L1	L1P	L1C	L1X			
	R	L2	L2P	L2C	L2X			
	R	C1	C1P	C1C	C1X			
	R	C2	C2P	C2C	C2X			
	Е	L1	L1C	L1X				
	Е	L2	L5Q L51	L5X				
	Е	C1	C1C	C1X				
	Е	C2	C5Q C51	CEX				

This file needs to be specified in the option "Receiver-specific observation type priority" for the program RNXSMT:

Bernese GNSS Software Version 5.2								
Configure Campaign RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
RNXSMT 1.1: General	Files							
GENERAL INPUT FILE: General constant Satellite inform Satellite proble: Observation type	s ation ns	SAT	ST. SLLIT.I _\$Y+0 _GAL.SE	CRX	Print	select	ion	-
MENU SETTINGS Selected campaig Selected session Session table	a		2017	session STA/SESSIO				
∬ ^Top │ ^Prev │ ^Next │ Cance⁄ > User: I_bern52 Campaign: \${F						•	PSUSER	R/PAN/RNXSMT.INP //

All the other settings may be taken as shown in Section 7.5.2.

The SMT files have now to be imported into the the Bernese internal observation file format using the program RXOBV3:

Bernese GNSS	Software Version 5.2										• 8
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help		
TRANS	FER RINE	X OBSER	VATION FI	LES TO B	ERNESE	FORMAT -	rxobv3	1: Fi	lenames		
CENER	AL FILES										
	ow all ge		ilee			F					
0110	/w arr ge	merar i	1165			r					
INPUI	FILES										
¢	• origi	inal RI	NEX observ	ation f.	iles	????\$S	+0 170				
¢	s smoot	thed RI	NEX observ	ation f.	iles	2222\$8	+0 SMT				
Sta	tion inf	ormatic	n file			EXAMPL	E STA				
RESUI	T FILES										
Mea	surement	types	to save								
6	Code	e 🚩	Phase	7			с	Range			
Upo	late coor	dinates			CRD	(bl	ank if	not us	ed)		
	AL OUTPU			_	DVOD						
	gram out	-			∋e RXOB			or			DUT
Eri	or messa	.ges		n me	erged t	o program	output	: or	ERRO	R M	ISG
^Top ^P	rev ^Next	Cance [^] l	Save^As ^S	ave ^Run	^Output	Rer^un 4	-Day ^-Da	ay			
> User: I b	ern52 Camp	aign: \${P}/	EXM_GAL \$Y	+0=2017 \$	S+0=2130	File: /home	fs/aiub/l be	ern52/GP	SUSER/PAN	VRXOBV	3.INP

Since the observation type priority file acts as a filter, only observations for the systems listed in this file have been passed the program RNXSMT. For that reason the SMT-files contain only observations from the selected satellite systems. No further filtering is needed when importing the observations into the Bernese observation file format. Therefore, ALL satellite systems can selected in option "Satellite system to be considered":

Bemese GNSS Software Version 5.2	
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BF	PE User Help
RXOBV3 2: Input Options 1	
TITLE EXAMPLE: Session \$YSS+0: tutorial lecture	
SATELLITE SYSTEM SELECTION	
Satellite system to be considered	ALL
STATION NAMES	
Gather station names from Action if station not in abbreviation list	FILE NAME
SESSION IDENTIFIER	
Session ID used for Bernese observation files	(hlanh, NIMO)
Session in used for bernese observation files	\$S+0 (blank: AUTO)
DATA SAMPLING	
Sampling interval	30 🗧 seconds
Sampling offset to full minute	0 seconds
Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output Rer^un ^+Day	y ^-Day
> User: I_bern52 Campaign: \${P}/EXM_GAL \$Y+0=2017 \$S+0=2130 File: /homefs/aiu	ub/I_bern52/GPSUSER/PAN/RXOBV3.INP

Please take care on the settings in the section "SIGNAL STRENGTH REQUIREMENTS" in panel "RXOBV3 4: Input Options 2" (see Section 7.4.1).

7.6.4 Processing the Example Including Galileo

At this point you can continue the processing for a regional network as described in this tutorial from Section 4.2 (page 33) onwards in order to generate a double difference network solution including Galileo. You need only to take care that you use the COM instead of COD orbit products and the the selection of the GNSS to be processed does not exclude Galileo (ALL for "Satellite system").

Forcing the Usage of Galileo Data in a Double-Difference Solution

In order to optimize the baseline creation for the usage of Galileo data the following procedure can be established. It is in particular useful if orbits for these satellites shall be estimated and/or the network of the Galileo tracking stations is so sparse that these measurements are not sufficiently available.

Step 1: Create first a set of baselines from those stations that provide Galileo measuren	nonte
Create Hist a set of basefines from those stations that provide Gameo measurem Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help	nenus.
CREATE SINGLE-DIFFERENCE/BASELINE FILES - SNGDIF 1: Input File Selection	
Show all general files	
GENERAL OPTIONS Measurement type PHASE PHASE Processing strategy OBS-MAX Stations must contain observ. from	
AUTOMATED BASELINE CREATION Zero-difference observation files ????\$S+0 PZH ????\$S+0 00000 Reference station for STAR strategy 02000	
MANUAL BASELINE CREATION First zero-difference input file EXE EXE Second zero-difference input file EXE EXE EXE Single-difference output file FSH CSH	
∫ ^Top ^Prev ^Next Cance⁴ Save^As ^Save ^Run ^Output Rer⁴un ^+Day _^Day > User: Lem52 Campaign: \${P}/EXM_GAL \$Y+0=2017 \$S+0=2130 File: fs/homefs/aiub/_bem52/GPSUSER/PAN/SNGDIF.INP	

Store the resulting baselines in a file:

Bernese GNSS S	oftware Version 5.2										
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help		
SNGDI	F 2: Fil	enames									
INPUT	FILES										
Sta	tion coo	rdinate	8	AI	PR\$YD+0	CRD					
	e eccent		-			ECC					
	defined					BSL					
Clu	ster def	inition				CLU					
RESUL	T FILES										
Lis	ting of	formed	baselines	5 G2	AL\$YD+0	BSL					
Clu	ster/bas	eline a	ssignment	-	C	LB (2	digits	will	be append	led)	
GENER	AL OUTPU	T FILES									
Pro	gram out	put		🚩 use	SNGDI	F.Lnn		or	SNG	DIF	OUT
Err	or messa	ges		∏ mer	ged to	program d	output	or	ERR	OR	MSG
^Top ^P	rev ^Next	Cance^I	Save^As ^	Save / ^Run	/Output	Rer^un 1+	Day ^-Day	y			
> User: I_be	ern52 Camp	aign: \${P}/l	EXM_GAL \$	Y+0=2017 \$	S+0=2130	File: fs/home	efs/aiub/l_b	pern52/G	PSUSER/PAN	V/SNGDIF	INP
	uner oamp	~.g			0.0 2100						//

Step 2: Complete the network with the remaining stations:

Bernese GNSS Software Version 5.2	
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help	
CREATE SINGLE-DIFFERENCE/BASELINE FILES - SNGDIF 1: Input File Selection	
GENERAL FILES	
Show all general files 🚩	
GENERAL OPTIONS	
Measurement type PHASE	
Processing strategy OBS-MAX	
Stations must contain observ. from GPS	
AUTOMATED BASELINE CREATION	
Zero-difference observation files ????\$S+0 PZH ????\$S+0 CZE	
Reference station for STAR strategy	
MANUAL BASELINE CREATION	
First zero-difference input file	
Second zero-difference input file	
Single-difference output file PSH CSH	
^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output Rer^un ^+Day ^-Day	
> User: I_bern52 Campaign: \${P}/EXM_GAL \$Y+0=2017 \$S+0=2130 File: fs/homefs/aiub/I_bern52/GPSUSER/PAN/SN	IGDIF.INP

Bernese GNSS S	oftware Version 5.2									
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
SNGDI	F 2: Fil	enames								
INPUT	FILES									
Sta	tion cod	ordinate	85	AI	PR\$YD+0	CRD				
Sit	e eccent	ricitie	es	i i		ECC				
Pre	defined	baselir	nes	GZ	AL\$YD+0	BSL				
Clu	ster def	initior	ı	Ē		CLU				
RESUL	T FILES									
Lis	ting of	formed	baselines	;		BSL				
Clu	ster/bas	seline a	assignment		C	:LB (2	digits	will	be appended	1)
GENER	AL OUTPU	T FILES								
Pro	gram out	put		Y use	SNGDI	F.Lnn		or	SNGDI	f out
Err	or messa	iges		└ mer	ged to	program (output	or	ERROR	MSG
ATon AD	AN AN AN	CanceA	Saua^Ac ^	Sava ARun		Rer^un ^+	Dav A Dav			
									PSUSER/PAN/S	
<pre>> User: I_be</pre>	anoz camp	aiyii. ə{P}/	EAW_GAL \$	170-2017 \$	3-0-2130	File. Is/nom	ers/aiub/i_f	Jem 52/G	FOUSER/PAN/S	NGDIF.INP

Using Galileo in a Zero-Difference Solution

Within the receivers an ISB between the Galileo and GPS pseudorange signals is expected as it is the case between GPS and GLONASS. Because all Galileo satellites are using the same frequencies only one bias parameter per station needs to be added. In order to setup this bias parameter the option "Differential code biases" needs to be enabled:

Bernese GNSS Software Version 5.2					- 9 %
Configure Campaign RINEX Orbits/EOP Processing Service	Conversion	BPE	User	Help	
GPSEST 5.2: Setup of Parameters and Pre-Elin	mination 2				
BIAS PARAMETERS	Setup	1	Pre-El	imination	
Differential code biases	4	NO			-
GLONASS receiver clock biases	2	NO			*
GNSS-specific translation parameters		NO			Ŧ
ANTENNA PHASE CENTER PARAMETERS	_				
Satellite phase center offsets		NO			Ψ.
Satellite phase center variations		NO			Ψ.
Receiver phase center offsets		NO			Y
Receiver phase center variations		NO			Ψ.
PARAMETER SCALING FACTORS					
Scaling related to loading effects	_	170			
Higher-order ionosphere scaling		NO			<u>×</u>
Argher-order tonosphere scaring		NO			<u> </u>
SLR-RELATED PARAMETERS					
Range biases	Г	NO			7
					_
TIME OFFSET FOR PARAMETER INTERVALS				(hhh mm	ss)
^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output	: Rer^un ^+	Day ^-Day			
> User: I_bern52 Campaign: \${P}/EXM_GAL \$Y+0=2017 \$S+0=2130	D File: s/home	fs/aiub/l_be	rn52/GP	SUSER/PAN/G	PSEST.INP

As the "Type of differential code biases" LC for the receivers needs to be selected if the ionosphere-free linear combination L_3 is processed:

Bernese GNSS Software Version 5.2					
Configure Campaign RINEX Orbits/EOP Processing Service Conver	sion BPE User Help				
GPSEST 6.11: Differential Code Biases					
PARAMETER SETUP					
Type of differential code biases	LC ·				
Estimate differential code biases for satellite	s 🔽				
Estimate differential code biases for receivers					
DATUM DEFINITION AND CONSTRAINING					
Reference satellite(s)	SUM -				
A priori sigma for reference satellite biases	0.01 nanoseconds				
A priori sigma for receiver biases nanoseconds					
 ^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output Rer^u	^+Day ^-Day				
> User: I_bern52 Campaign: \${P}/EXM_GAL \$Y+0=2017 \$S+0=2130 File: s					

Unfortunately, this bias parameter cannot be combined with bias parameters from the type P1-C1 or P1-C1_MULTIPLIER. The related biases for GPS need to be introduced as a priori values in "Observable-specifc biases" in panel "GPSEST 1.1: Input Files 1" and cannot be reestimated at the same time. If P1-C1_MULTIPLIER is selected, GPSEST automatically switches to LC if GPS and Galileo observations are processed together.

In case of the geometry-free linear combination L_4 the P1 - P2 bias needs to be specified. Here the necessary Galileo-related bias is set up automatically.

Apart from these modifications, the analysis of the zero-difference network as described in Section 7.4 is possible including Galileo observations.

7.6.5 Adapting the Example BPEs

The PPP (PPP_BAS.PCF and PPP_DEMO.PCF) as well as the double-difference network (RNX2SNX.PCF) processing example BPEs can be switched for processing Galileo observations by changing a few BPE server variables:

• Allow the import of Galileo observations from the RINEX observation files by changing

VARIABLE	DESCRIPT	ION			DEFAULT
8******	40*****	******	*****	*****	30******
V_SATSYS	Select t	he GNSS	(GPS,	GPS/GLO)	GPS/GLO

 to

VARIABLE	DESCRIPTION	DEFAULT
8******	40***************	30******
V_SATSYS	Select the GNSS (GPS, GPS/GLO)	ALL
• • •		

The value of this variable is introduced into the option "Satellite system to be considered" in program RXOBV3 in order to select the GNSS for importing the measurements into the Bernese formatted binary files.

• Another set of changes in the BPE variables is related to the usage of RINEX 3 measurements, which is disabled in the default version:

According to Section 7.5 they are enabled by:

• Finally, the orbit products that shall be used need also to contain Galileo orbits and satellite clock corrections by choosing COM instead of COD products by changing

	DESCRIPTION 40************************************	DEFAULT 30******
 V_B 	Orbit/ERP, DCB, CLK information	COD

 to

It is obvious that the products need to be available in the datapool (\${D}/COM).

• It might be useful to deposit the results from the Galileo processing in a separate folder in the savedisk archive. You may adapt the BPE variable V_RESULT accordingly:

For zero-difference processing, the ISB between the three involved GNSS in the receivers need to be taken into account. In Section 7.4 this is demonstrated between GPS and GLONASS by enabling the "GLONASS receiver clock biases" in panel "GPSEST 5.2: Setup of Parameters and Pre-Elimination 2". To add the ISB for Galileo as well, one additional bias parameter is needed per receiver (because, as GPS, Galileo uses the same frequency for all satellites). This additional bias is enabled automatically by the user script TIMEST_P in conjunction with the program GPSEST. The program switches the "Type of differential code biases" from P1-C1_MULTIPLIER to LC as soon as Galileo data are available. This mechanism allows the PPP example BPEs to use Galileo data. In the case of the zero-difference network processing example (CLKDET.PCF) this would require a reorganization of the bias-handling. For that reason this example BPE does not support the analysis of Galileo data at the current status.

7.7 Simulation of GNSS Observations

The Bernese GNSS Software provides the simulation tool GPSSIM ("Menu>Service>Generate simulated observation data"). It generates synthetic GNSS (i.e., GPS and GLONASS) observations for terrestrial static or kinematic stations as well as for LEO. Code and phase zero difference observation files can be created based on an observation scenario defined by

- GNSS satellite geometry given by a standard orbit and
- a set of receivers with positions from a coordinate file, kinematic positions, or a LEO standard orbit file.

7.7.1 Simulation of GNSS Observations

It is important that you remove all previously existing observation files for this session from the OBS directory of your campaign before your start to simulate observations. Otherwise you run into the danger of mixing your current set of simulated observations with other measurements:

bern52@carina:~ > rm \${P}/INTRO/OBS/????2070.CZ? bern52@carina:~ > rm \${P}/INTRO/OBS/????2070.PZ?

Please keep in mind that the observation files from your previous work in this campaign are lost due to this command. If you still need them, please copy them away.

The input files for the generation of synthetic GNSS observations with program GPSSIM ("Menu>Service>Generate simulated observation data") are defined in the first input panel:

Bernese GNSS Software Version 5.2 Configure Campaign RINEX Orbits	s/EOP Processing Serv	rice Conversion BPE User H	elp
	5		leip
GENERATE SIMULATED OBSER	VATION DATA - GPS	SIM 1: Filenames	
GENERAL FILES			
Show all general files	M		
INPUT FILES			
GNSS Standard orbit	COD\$YD+0 STD	Satellite clocks	CLK
Pole file	COD\$YD+0 ERP	Receiver clocks	CLK
Coordinate file	FIN\$YD+0 CRD	Code bias input file	DCB
Kin.inp. coordinates	KIN	Antenna orientations	AZI
Est.troposphere val. Meteo data files	TRP	Ionosphere models	ION
Meteo data files Maps of VMF1 coeff.	MET VMF\$YD+0 GRD	Ocean loading corr. Atmospheric load. cor.	EXAMPLE BLQ EXAMPLE ATL
Maps of Whri Coeff.	WHESTD+0 GRD	Atmospheric road. cor.	EXAMPLE ATL
Vienna grid files:		Atmospheric press.load	GRD
Ocean non-tidal load	GRD	Hydrostatic press.load	GRD
	,		
LEO-files			
GENERAL OUTPUT FILES			
Program output	use GPSSIM.		YD+0 OUT
Error messages	🔲 merged to p	program output or ERRC	R MSG
TITLE EXAMPLE: Session	n \$YSS+0: Simluat	e observations	
parate be. 000010	or armitude		
	. Lie Lie Lie		
^Top ^Prev ^Next Cance^I Save			
User: bern52 Campaign: \${P}/INTRO	SY+U=2010 \$S+0=2070	File: /home/bern52/GPSUSER52/PAN/G	PSSIM.INP

Select EXAMPLE.ABB in option "Abbreviation table" in the next panel "GPSSIM 1.1: General Files".

In the second panel, the interval for data simulation is defined and the list of stations selected from all sites in the input "Coordinate file":

Bernese GNSS Software Version 5.2	- Saniaa Canvarian	BPE User	Help
Configure Campaign RINEX Orbits/EOP Processin	-	BPE User	нер
GPSSIM 2: Stations and Observation W	indow		
STATIONS			
Station selection SELEC	'ED		
OBSERVATION WINDOW			
 Defined by year and session 	identifier		
Year <u>\$Y+0</u> Session			
	SIMSTA		823
 Defined by start and end time 	VESL 66009M001		
yyyy mm dd hh	VNDP 40420M007		
Start SYMD STR+0 00	WES2 40440S020 WHIT 40136M001		
	WILL 40134M001		
	WIND 31101M001 WSRT 13506M005		
\$S+0 Session for observ	WTZR 14201M010		
10.0	WTZZ 14201M014 WUHN 21602M001		
	YAR1 50107M004		
	YAR2 50107M004 YARR 50107M006		
	YEBE 13420M001		
	YELL 40127M003		
	YIBL 25001M001 ZAMB 34601M001		
	ZECK 12351M001		
	ZIM2 14001M008 ZIMJ 14001M006		
	ZĪMM 14001M004		×
^Top ^Prev ^Next Cance^I Save^As ^Save ^Ru	ALL	0K	Cancel
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0	=2070 File: /home/berns	52/GPSUSER52/PAN/	GPSSIM.INP

The meta data for each station is specified in this panel:

GPSSIM 3.1: Simulation Options OBSERVATION FILE TYPES								
Observation sim	ulation for	: Code 🏴	Ph	ase	· 10	easurement type		
DESERVATION HEADE	R FILE INFO	RMATION						
Campaign	INTRO							
	,							
Station name	Receiver	Antenna type		# Rec	# Ant	Operator	^	
GANP 11515M001		SIMULA	NONE					
HERT 13212M010		SIMULA	NONE					
JOZ2 12204M002		SIMULA	NONE					
LAMA 12209M001		SIMULA	NONE					
MATE 12734M008		SIMULA	NONE					
ONSA 10402M004		SIMULA	NONE					
PTBB 14234M001		SIMULA	NONE					
TLSE 10003M009		SIMULA	NONE					
WSRT 13506M005		SIMULA	NONE					
WTZR 14201M010		SIMULA	NONE					
WTZZ 14201M014		SIMULA	NONE					
ZIM2 14001M008		SIMULA	NONE					
ZIMM 14001M004		SIMULA	NONE					
	-						-0	

The "Receiver" for each station must start with SIMULA to indicate that this is a simulated station. In the input field you may only extend this string by a user input. Note that the receiver and antenna types you are defining here must be registered in the "Receiver information" and "Phase center eccentricities" files given in panel "GPSSIM 1.1: General Files".

Please check the completeness for each involved GNSS which is not defined by the receiver type connected to the antenna but by the list of satellites in the "GNSS Standard orbit". If you would use the real antenna names for the stations as they are given in Tab. 1.1 GPSSIM would fail and issue a message like

```
*** SR SEARCH_OFF: No offset values found for
satellite system R of
Antenna: ASH700936E SNOW
Number: 0
```

which indicates deficiencies that need to be fixed manually or with the support of the program ATX2PCV ("Menu>Conversion>ANTEX to Bernese format"). In that case you need to define some antenna phase center corrections for this antenna type for GLONASS. If there is no need for any other antenna naming convention it is proposed to use the antenna name SIMULA with radome type NONE what seems to be sufficient for most of the simulation purposes.

In the subsequent panels some basic characteristics, assumptions on the ionospheric conditions, and the noise level are introduced. Even cycle slips may be simulated.

Emese GNSS Software Version 5.2	- • •
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE Us	ser Help
GPSSIM 3.2: Simulation Options	
OBSERVATION SELECTION	
Time between subsequent epochs 300 seco	onds
Minimum elevation 3 📑 degr	ees
Maximum clock interpolation interval 0 seco	onds
Periodic relativistic J2-correction	
Maximum number of observed satellites 30 🚆	
TROPOSPHERE MODELING	
ZPD model and mapping function VME	•
∬ ^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output Rer^un ^+Day _^-Day	
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER	52/PAN/GPSSIM.INP

Bernere GNSS	Software Version 5.2									- • •
_		RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
GPSSI	м 3.3: s	imulati	on Option	s						
IONOS	PHERE MO	DELING								
Nic	nt time	electro	n number				0		(10**16)	
Day	r time el	ectron	number				0		(10**16)	
STOCH	ASTIC IO	NOSPHEP	E MODELIN	G						
Var	iance of	irreg.	change d	f ionosp	here co	ntent				
ir	n 1 min.	at 200	km from t	he refer	ence s:	te	0	_	(10**16)	
Ref	ference s	tation								
] ^Top ^P	rev ^Next	Cance^I	Save^As ^	Save ^Run	^Output	Rer^un ^+	Day ^-Da	ý		
> User: ber	n52 Campai	gn: \${P}/IN	TRO \$Y+0=:	2010 \$S+0=	2070 File	: /home/bern5	2/GPSUSI	ER52/PA	AN/GPSSIM.INP	li

Bernese GNSS St Configure		RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	- • •
GPSSI	4 3.4: S	imulati	on Optior	.s						
STATI:	STICAL I	NFORMAT	ION		for	stations		for	LEOs	
Ар	riori si	gma coc	le Ll							meters
Ар	riori si	gma coc	le L2							meters
A p	riori si	gma pha	se Ll							meters
A p	riori si	gma pha	se L2		Í					meters
		-	ndom numb t sigmas	er	(b1 111 ~	ank: no n	oise)			
SIMULA	ATION OF	CYCLE	SLIPS							
Int	roduce c	ycle sl	.ips per t	ile	0					
Max	imum siz	- e of sl	.ip		100)	cycles			
Sam	e dycle	slips i	n L1 and	L2	Γ					
∬ ^Top ^Pr > User: bern						Rer^un ^+				

The observations are generated without noise to check the consistency with the processing program in the subsequent sections.

7.7.2 Zero Difference Solution from Simulated GNSS Observations

The simulated observations can directly be introduced in program GPSEST for an analysis on zero difference level (if you have not simulated cycle slips). Please pay attention to the consistency of all input files:

Bernese GNSS Software Version 5.2				
Configure Campaign RINEX Orbits/EOP Proc	essing Service Conve	rsion BPE	User	Help
PARAMETER ESTIMATION - GPSEST 1.	-			
GENERAL FILES AND PROCESSING MOD				
Space geodetic technique	GNSS ·			
Differencing level	ZERO ·			
LEO data processing				
Show all general files	Y			
OBSERVATION FILES				
Phase observations	PS	-	22\$5+0	PZH
Code observations	Ca		22\$8+0	
Range observations	CZ			
	· -	_		
MAIN INPUT FILES				
Station coordinates	FIN\$YD+0 CB	D		
Satellite standard orbits	COD\$YD+0 ST	D		
Earth rotation parameters	COD\$YD+0 ER	P		
Satellite clock corrections	CL	K		
Differential code biases	DC	в		
Gridded VMF1 coefficients	VMF\$YD+0 GP	D		
Ionosphere models	IC	N		
		_		
CORRECTIONS FOR LOADING EFFECTS	AND CENTER OF MAS	s		
Ocean tidal loading	EXAMPLE BL	Q		
Atmospheric tidal loading	EXAMPLE AT	L		
 ^Top ^Prev ^Next Cance⁴I Save^As ^Save	ARun COutput Rer	in ≜^+Day_^-Da	av	
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010				JGPSESTINP
· oser. bernoz oumpaight of mininter of the zero	6616 2675 The Monte	/bemoz/01/000	ALL COLUMN	

Bernese GNSS Software Version 5.2						_ 0 💌
Configure Campaign RINEX Orbits/EOP Processing	Service	Conversion	BPE	User	Help	
GPSEST 1.2: Input Files 2						
ADDITIONAL INPUT FILES						
Satellite orbit partials		RPR				
Clock RINEX file		CLK				
Inter-system biases		ISB				
Troposphere estimates		TRP				
Meteorological data		MET				
GRIDDED LOADING PARAMETERS Atmospheric pressure Ocean, non-tidal Hydrostatic pressure		GRD GRD GRD				
AUXILIARY STATION FILES						
Station information		STA				
Kinematic coordinates		KIN				
Receiver antenna orientation		AZI				
Observation sigma factors		SOS				
Station eccentricities		ECC				
∬ ^Top ^Prev ^Next Cance^l Save^As ^Save ^Ru > User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0					N/GPSES	T.INP

Result files can be specified to compare the results with the inputs for GPSSIM. A residual file might also be useful.

The processing models also have to be consistent with the simulation or to contain well defined differences which are the subject of your investigation:

Ernese GNSS Suffware Version 5.2	
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help	
GPSEST 3.1: General Options 1	
TITLE EXAMPLE: Sess \$YSS+0: Code+phase solution from simulation	
OBSERVATION SELECTION	
Satellite system ALL	
Frequency/linear combination L3	
Elevation cutoff angle 3 degrees	
Sampling interval seconds	
Tolerance for simultaneity 100 milliseconds	
Special data selection NO	
Observation window	
OBSERVATION MODELING AND PARAMETER ESTIMATION	
A priori sigma of unit weight 0.001 meters	
Elevation-dependent weighting COSZ •	
Type of computed residuals NORMALIZED	
Correlation strategy CORRECT	
LEO-SPECIFIC SELECTION AND MODELING OPTIONS	
Elevation cutoff angle 0 degrees	
Elevation-dependent weighting NONE	
∬ ^Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output Rer^un ^+DayDay	
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/GPSEST.INP	

_	Software Version 5.2									- • •
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
GPSES	T 3.2: G	eneral	Options 2							
A PRI	ORI TROP	OSPHERE	MODELING							
ZPI) model a	nd mapp.	oing funct	ion	VMF MENI	DES-PAVLIS		GNSS SLR		
HANDI	ING OF A	MBIGUIT	IES							
Res	olution	strateq	ŦΥ		NONH	E	~			
Sol	ve ambig	uities	for		ALL		~			
			er-cycle	biases	IF :	INDICATED	v			
	re resolv									
			e integers							
int	roduce L	i and i	52 integer	`S	I					
SPECI	AL PROCE	SSING C	PTIONS							
Sto	p progra	m after	: NEQ savi	ng						
Act	ivate ex	tended	program o	output						
						Rer^un ^+[e: /home/bern53			N/GPSEST.INP	li.

No constraints for datum definition are needed because these are noise–free simulated data:

Bernese GNSS	Software Version 5.2									
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
GPSES	T 4: Dat	um Defi	nition fo	r Statio	n Coord	linates				
DATUM	I DEFINIT	ION TYP	ΡE							
(Free Free	networ	k solutio	n						
(coor	dinates	constrai	ned		WITH FLAG	÷ [*		
(Coor	dinates	fixed			WITH FLAG	÷	*		
A PRI	ORI SIGM	IAS								
Nor	th	0.01	mete	rs						
Eas	st	0.01	mete	rs						
Up		0.01	mete	rs						
^Top ^P	rev ^Next	Cance [^] I	Save^As ^	Save / ^Run	^Output	Rer^un ^+	Day ^-D	lay		
> User: ber	n52 Campa	ign: \${P}/IN	ITRO \$Y+0=	2010 \$S+0=	2070 File	e: /home/bern5	2/GPSU	SER52/PA	N/GPSEST	LINP /

Only the receiver and satellite clocks are estimated:

Evence 6NSSSoftware Version 5:2 Configure Campaign RINEX Orbits/EOP Processing Service	Conversion	BPE User Help
		•
GPSEST 5.1: Setup of Parameters and Pre-El:	imination 1	
STATION-RELATED PARAMETERS	Setup	Pre-Elimination
Station coordinates		NO
Ambiguities		NO
ATMOSPHERIC PARAMETERS		
Site-specific troposphere parameters		NO
Global ionosphere parameters		NO
GLOBAL PARAMETERS Orbital parameters Earth orientation parameters Geocenter coordinates		NO Z
EPOCH PARAMETERS Receiver clock offsets	F	EVERY EPOCH
Satellite clock offsets	- -	EVERI EPOCH
Kinematic coordinates		NO
Stochastic ionosphere parameters	-	EVERY EPOCH
	'	avant aroon
^ Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Outp	ut Rer^un A+I	-Day ^-Day
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 F		

Emise 6NISS Software Version 5.2 Configure Campaian RINEX Orbits/EOP Processing Serv	ice Conversion BPE User Help
GPSEST 6.8.1: Clock Estimation 1	
DATUM DEFINITION FOR CLOCK ESTIMATION	
Type of datum definition	ZERO-MEAN CONDITION
REFERENCE STATIONS	
Selection of reference stations	ALL
Manual station selection	
Station list from file	EIX
REFERENCE SATELLITES	
Selection of reference satellites	NONE
Manual satellite selection	
Satellite list from file	FILM
ADDITIONAL OPTIONS	
Minimum number of obs per station clock	
Minimum number of obs per satellite clo	ck 5
GLONASS CLOCK ESTIMATION	
GLONASS receiver clock biases	NON-GPS SATELLITES
Receiver clocks for each satellite syst	em
^ ^Top _^Prev _^Next _Cance^I _ Save^As _^Save _^Run _^Ou	tput Rer^un ^+Day ^-Day
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070	File: /home/bern52/GPSUSER52/PAN/GPSEST.INP

The resulting program output file looks like the usual output from **GPSEST** but with perfect observations without any noise:

	TS (PART 1)						
	PARAMETERS (PART	1):					
PARAMETER	TYPE		#PARAMETERS	S #PRE-E	LIMINATED	#SET-UP	
							• • •
STATION CO	OORDINATES		39	0		39	
	CLOCK BIASES / TIM	ME BIASES	260	0		260	•••
AMBIGUITIE			1529			1529	•••
	E STATION CLOCKS E SATELLITE CLOCKS		3744	3744	(EPOCH-WISE) (EPOCH-WISE)	3744	• • •
EFUCII WISE	C SAILLEITE CLOCK	2	0302	0302	(EFUCH-WISE)	0302	•••
	BER OF PARAMETERS			10046		11874	
NUMBER OF	OBSERVATIONS (PAR						•••
NUMBER OF	OBSERVATIONS (PAF	FILE/PAR					
NUMBER OF TYPE	OBSERVATIONS (PAF	FILE/PAR	#OBSER	VATIONS			
NUMBER OF TYPE PHASE	DESERVATIONS (PAF FREQUENCY L3	FILE/PAR	#OBSER' 68'	VATIONS 			
NUMBER OF	OBSERVATIONS (PAF	FILE/PAR	#OBSER	VATIONS 			
NUMBER OF TYPE PHASE CODE	DESERVATIONS (PAF FREQUENCY L3	FILE/PAR ALL ALL	# OBSER' 	VATIONS 024 024			
NUMBER OF TYPE PHASE CODE	DESERVATIONS (PAF FREQUENCY L3 L3	FILE/PAR ALL ALL	# 0BSER 	VATIONS 024 024			••••
NUMBER OF TYPE PHASE CODE TOTAL NUME	OBSERVATIONS (PAF FREQUENCY L3 L3 BER OF OBSERVATION	FILE/PAR ALL ALL IS	#OBSER 68 68	VATIONS 024 024			····
NUMBER OF TYPE PHASE CODE TOTAL NUME	DESERVATIONS (PAF FREQUENCY L3 L3	FILE/PAR ALL ALL IS WEIGHT (PART	#OBSER 680 680 1360	VATIONS 024 024			••••
NUMBER OF TYPE PHASE CODE TOTAL NUME	OBSERVATIONS (PAF FREQUENCY L3 L3 BER OF OBSERVATION ORI SIGMA OF UNIT	FILE/PAR ALL ALL IS WEIGHT (PART	# OBSER 68 68 136 1):	/ATIONS 024 024 024 048		3SERVABLE AT	····
NUMBER OF TYPE PHASE CODE TOTAL NUME A POSTERIO	DESERVATIONS (PAF FREQUENCY L3 L3 BER OF OBSERVATION DRI SIGMA OF UNIT	FILE/PAR ALL ALL IS WEIGHT (PART WEIGHT :	#OBSER 68 68 136 1): 0.0000 M (SIGM	/ATIONS 024 024 024 048		3SERVABLE AT	····
NUMBER OF TYPE PHASE CODE TOTAL NUME A POSTERIO	OBSERVATIONS (PAP FREQUENCY L3 L3 BER OF OBSERVATION ORI SIGMA OF UNIT ORI SIGMA OF UNIT FREEDOM (DOF)	FILE/PAR ALL ALL IS WEIGHT (PART WEIGHT : :	#OBSER 68 68 136 1): 0.0000 M (SIGM	/ATIONS 024 024 024 048		3SERVABLE AT	····

STATION COORDINATES:		(NOT SAVED)		
NUM STATION NAME	PARAMETER	A PRIORI VALUE	NEW VALUE	NEW- A PRIORI	RMS ERROR
					·
75 GANP 11515M001	Х	3929181.4190	3929181.4190	0.0000	0.0000
	Y	1455236.8207	1455236.8207	0.0000	0.0000
	Z	4793653.9477	4793653.9477	0.0000	0.0000
	HEIGHT	746.0115	746.0115	0.0000	0.0000
	LATITUDE	49 2 4.971302	49 2 4.971302	0.0000	0.0000
	LONGITUDE	20 19 22.574439	20 19 22.574439	0.0000	0.0000

No improvements for the station coordinates and other parameters are expected:

The inter-system and inter-frequency biases have been assumed to be zero during the simulation (what is equivalent to any other constant number):

•••						
DECETVED	CLOCKS / TIME BI	ACEC.				
RECEIVER	CLUCKS / TIME BI	ASES:				
REQUEST	STATION NAME	OFFSET (USEC)	RMS (NSEC)			
1	GANP 11515M001	0.00000		0.00000		SAT GPS
1	GANP 11515M001	0.00000	0.000000	0.000000	0.000	SAT 101
1	GANP 11515M001	0.00000	-0.000000	-0.00000	0.000	SAT 102
1	GANP 11515M001	0.00000	-0.000000	-0.00000	0.000	SAT 103
1	GANP 11515M001	0.00000	-0.000000	-0.00000	0.000	SAT 104
1	GANP 11515M001	0.00000	-0.000000	-0.00000	0.000	SAT 105
1	GANP 11515M001	0.00000	0.00000	0.00000	0.000	SAT 107
1	GANP 11515M001	0.00000	0.00000	0.00000	0.000	SAT 108
1	GANP 11515M001	0.00000	0.00000	0.00000	0.000	SAT 110
1	GANP 11515M001	0.00000	0.00000	0.00000	0.000	SAT 111
1	GANP 11515M001	0.00000	0.00000	0.00000	0.000	SAT 113
1	GANP 11515M001	0.00000	0.00000	0.00000	0.000	SAT 114
1	GANP 11515M001	0.00000	0.00000	0.00000	0.000	SAT 115
1	GANP 11515M001	0.00000	-0.000000	-0.00000	0.000	SAT 117
1	GANP 11515M001	0.00000	-0.000000	-0.00000	0.000	SAT 118
1	GANP 11515M001	0.00000	-0.00000	-0.00000	0.000	SAT 119
1	GANP 11515M001	0.00000	-0.00000	-0.00000	0.000	SAT 120
1	GANP 11515M001	0.000000	-0.00000	-0.00000	0.000	SAT 121
1	GANP 11515M001	0.00000	-0.000000	-0.000000	0.000	SAT 122
1	GANP 11515M001	0.00000	0.000000	0.000000	0.000	SAT 123

The same holds for the epoch–wise clocks.

The residuals in the optional residual output file of such a dataset is well below the $1\,\mu{\rm m}$ level.

7.7.3 Double–Difference Solution from Simulated GNSS Observations

As in the beginning of the simulation, you should make sure that no other baseline observation files for the current session exist in the OBS-directory of your campaign to prevent any interferences and mixtures of simulated measurements with other ones.

bern52@carina: > rm \${P}/INTRO/OBS/????2070.PS?

The simulated measurements can also be processed in the double-difference mode. In that case you have to start with forming baselines using the program SNGDIF ("Menu>Processing >Create baseline files") in nearly the same shape as in Section 4.2.2 for real observations:

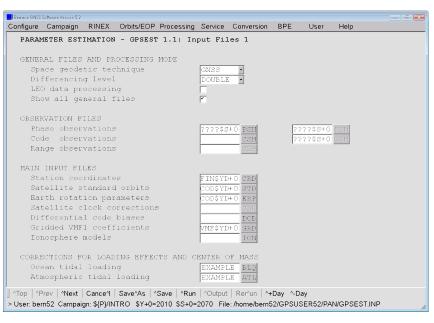
Bernese GNSS Software Version 5.2	- • •
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help	
CREATE SINGLE-DIFFERENCE/BASELINE FILES - SNGDIF 1: Input File Selection	
GENERAL FILES	
Show all general files 🚩	
GENERAL OPTIONS	
Measurement type • •	
Processing strategy OBS-MAX	
Stations must contain observ. from GPS -	
AUTOMATED BASELINE CREATION	
Zero-difference observation files ????\$S+0 PZH ????\$S+0 CZH	1
Reference station for STAR strategy	
MANUAL BASELINE CREATION	
First zero-difference input file PZH	1
Second zero-difference input file	
Single-difference output file PSH CS	H
] ^Top ^Prev *Next Cance*I Save*As *Save *Run *Output Rer*un *+Day *-Day	
> User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUSER52/PAN/SNGDIF.INP	li

Bernese GNSS Software Version	5.2								
Configure Campaig	n RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
SNGDIF 2: F:	lenames								
INPUT FILES									
Station c	oordinat	es	FI	N\$YD+0	CRD				
Site ecce	ntriciti	es	i i i		ECC				
Predefine	d baseli	nes	Í		BSL				
Cluster d	efinitio	n			CLU				
RESULT FILE:	3								
Listing o	f formed	baselines	3		BSL				
Cluster/b	aseline .	assignment		C	'LB (2	digits	will	be appended	1)
GENERAL OUT:	PUT FILE:	S							
Program o	atput		🔽 use	SNGDI	F.Lnn		or	SNGDI	F OUT
Error mes	sages		mer	ged to	program	output	or	ERROR	MSG
^Top ^Prev ^Nex	t Cance^l	Save^As ^	Save ^Run	^Output	Rer^un *	-Day ^-Day	у		
> User: bern52 Camp	aign: \${P}/lf	NTRO \$Y+0=	2010 \$S+0=	2070 File	: /home/bern	52/GPSUS	ER52/PA	N/SNGDIF.INP	li.

The main difference is that you should also keep all ambiguities from the zero difference in the baseline observation files, what is managed by checking the box for option "Merge ambiguities from input files":

Bernese GNSS	Software Version 5.2									
Configure	Campaign	RINEX	Orbits/EOP	Processing	Service	Conversion	BPE	User	Help	
SNGD	IF 3: Opt	ions								
TITL	e Exma	PLE: Se	ssion \$YS	S+0: Bas	eline d	reation				
	LTANEOUS lerance t		ATIONS tify obser	rvations	of one	epoch	1.0		seconds	
Me Af	ter a gap	puities	UITIES from inpu e observat lag in one	tions lar	-		► 20		minutes	
		·				Rer^un ^+			AN/SNGDIF.INF	, ,

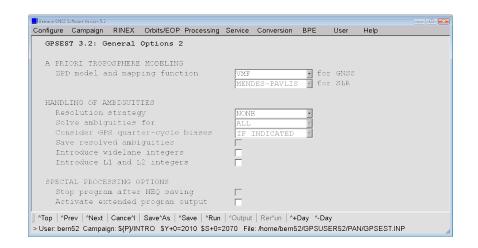
The resulting baseline files from simulated observations can now be analyzed with program GPSEST:



Bernese GNSS Software Version 5.2		- • •
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE	User	Help
GPSEST 2.1: Output Files 1		
GENERAL OUTPUT FILES		
Program output 🦳 use GPSEST.Lnn	or	SM2\$YD+0 OUT
Error message 👘 merged to program output	or	ERROR MSG
NORMAL EQUATION SYSTEM NQ0		
STATION- AND SATELLITE-RELATED RESULTS		
Station coordinates CRD		
Satellite orbital elements ELE		
Earth rotation parameters ERP		
Earth rotation parameters (IERS)		
ATMOSPHERE-SPECIFIC RESULTS		
Troposphere estimates TRP		
Troposphere estimates (SINEX) TRO		
Ionosphere models ION		
Ionosphere models (IONEX) INX		
] ^Top ^Prev ^Next Cance^l Save^As ^Save ^Run ^Output Rer^un ^+Day ^-Da > User: bern52 Campaign: \${P}/INTRO \$Y+0=2010 \$S+0=2070 File: /home/bern52/GPSUS		N/GPSEST.INP

The models are selected to be fully consistent with the simulation:

-	Software Version 5.2 Campaign	RINEX	Orbits/EOP	Processing	Service	Conversio	n BPE	User	Help	- • ×
	ST 3.1: G									
TITL	e by an		68001.0		1 1 1	11.55 1				
1111.	≏ je⊼am	rut: Se	ss \$YSS+C	: Fnase (aoupre-	altr.sol	ution r	rom sin	nulation	
	RVATION SI)N							
	tellite s					LL	•			
	equency/1			⊃n	L		-			
	evation c		angle		3		legrees econds			
	mpling in lerance f		iltencitu		1		econas uillisecu	onde		
	ecial dat.		-		1 N	00	1111580	onas		
· ·	servation					·				
					,					
OBSEI	RVATION M	ODELINC	AND PARA	AMETER ES	TIMATI	DN				
	priori si				0	.001 m	leters			
	evation-d	^		ing	-	osz				
	pe of com					EAL	-			
Co	rrelation	strate	эдХ		C	ORRECT				
LEO-:	SPECIFIC :	SELECTI	ON AND MO	DELING O	PTIONS					
E1	evation c	utoff a	angle		0	d	legrees			
El	evation-d	epender	nt weight.	ing	N	one 🔹				
		C	C		1.00.0000	- Denterra	A.D., A.D.			
	Prev ^Next								NODOFOT	IN ID
Oser: be	rn52 Campaig	yn: s{₽}/IÞ	11KO 21+0=	2010 \$5+0=	2070 Fili	e. mome/ber	192/GPSU8	SEKSZIPA	INGPSEST	JINP



No other parameters than station coordinates and ambiguities are estimated:

📕 Bernese GNSS Si	oftware Version 5.2								- 0 ×
Configure	Campaign	RINEX	Orbits/EOP Processing	Service	Conversion	BPE	User	Help	
GPSES	r 4: Dat	um Defi	nition for Statio	on Coor	dinates				
DATUM	DEFINIT	JON TYP	E						
•	Free	networ	k solution						
C	Coor	dinates	constrained		WITH FLAG	; ;	I		
c	Coor	dinates	fixed		WITH FLAG	; -	Ì		
A PRI	ORI SIGM	IAS							
Nor	th	0.01	meters						
Eas	t	0.01	meters						
Up		0.01	meters						
J	1		a se los los	1	1				
			Save^As Save Aru						
> User: berr	152 Campai	ign: \${P}/IN	TRO \$Y+0=2010 \$S+0	=2070 Fil	e: /home/bern5	2/GPSUS	ER52/PA	N/GPSEST.IN	۱P ,

figure Campaign RINEX Orbits/EOP Processing Servi	ce Conversion	BPE User	Help	
GPSEST 5.1: Setup of Parameters and Pre-E	limination 1			
STATION-RELATED PARAMETERS	Setup	Pre-	Eliminatio	n
Station coordinates		NO		-
Ambiguities		NO		•
ATMOSPHERIC PARAMETERS				
Site-specific troposphere parameters		NO		*
Global ionosphere parameters		NO		-
GLOBAL PARAMETERS				
Orbital parameters		NO		~
Earth orientation parameters		NO		~
Geocenter coordinates		NO		Ψ.
EPOCH PARAMETERS				
Receiver clock offsets	Y	EVERY EI	POCH	~
Satellite clock offsets	Y	EVERY EI	POCH	~
Kinematic coordinates		NO		*
Stochastic ionosphere parameters		EVERY EI	POCH	Y
op ^Prev ^Next Cance^I Save^As ^Save ^Run ^Out	tout Rer^un ^+D	Dav ^-Dav		

The results are analogue to the zero difference case previously described:

A POSTERIORI SIGMA OF UNIT WEIGHT (PART 1): A POSTERIORI SIGMA OF UNIT WEIGHT : 0.0000 M (SIGMA OF ONE-WAY L1 PHASE OBSERVABLE ... DEGREE OF FREEDOM (DOF) : 56179 CHI**2/DOF : 0.00 ...

The ambiguities are set up in a way that the correct resolution for all ambiguities is zero in any case. This is an easy way to verify ambiguity resolution strategies.

7.7.4 Final Remarks

There are many opportunities to use this simulation tool. It depends on your needs and the concrete target of the simulation study to define the experiment. As it was just demonstrated the full consistency between the processing and the simulation programs is guaranteed by the *Bernese GNSS Software*.

The big advantage of a simulation is that the correct solution is known a priori. On the other hand, you have to keep in mind that the simulated data can only contain effects included in the simulation model. If a receiver for instance introduces a significant variation of the inter–system bias between GPS and GLONASS data — an effect that is not considered in the simulation model — the influence of such an effect on the results cannot be evaluated by the simulation.