Bernese GPS Software
Version 5.0

Tutorial
Processing Example
Introductory Course
Terminal Session

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1. Introduction to the Example Campaign

Data from eight European stations of the IGS Network are selected for the example campaign. They are listed in Table 1.1 together with the receiver and antenna type and the antenna height. The locations of these stations are given in Figure 1.1.

Three of these stations (MATE, ONSA, and VILL) are IGS core sites. This is a set of about 95 IGS stations representing the realization of the reference frame (IGS 00: IGS realization of the ITRF 2000).

Furthermore, two stations (FFMJ and ZIMJ) are equipped with GNSS receivers tracking GPS and GLONASS satellites. The receiver antennas of only two sites (ONSA and PTBB) are equipped with radomes (type OSOD resp. SNOW).

The receivers used at the stations BRUS and PTBB are connected to H-Maser clocks. The receiver type ASHTECH Z-XII3T was developed for time and frequency applications.

The distances between neighboring stations are between 300 and 1200 km. Two GPS receivers in Zimmerwald are included into the example (ZIMM and ZIMJ, distance 14 m).

The observations for these stations are available for four days. Two days in year 2002 (day of year 143 and 144) and two in 2003 (days 138 and 139). In these terminal sessions you will analyze the data in order to obtain a velocity field based on IGS final products.

The data belonging to this example campaign are included in the distribution. Therefore, you may also use this document to repeat the generation of the solution at home to exercise the use of the Bernese GPS Software.
### Table 1.1: List of stations used for the example campaign including receiver and antenna type as well as the antenna height.

<table>
<thead>
<tr>
<th>Station name</th>
<th>Location</th>
<th>Receiver type</th>
<th>Antenna type</th>
<th>Radome</th>
<th>Antenna height</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRUS 13101M004</td>
<td>Brussels, Belgium</td>
<td>ASHTECH Z-XII3T</td>
<td>ASH7019455M</td>
<td>NONE</td>
<td>3.9702 m</td>
</tr>
<tr>
<td>FFMJ 14279M001</td>
<td>Frankfurt (Main), Germany</td>
<td>JPS LEGACY</td>
<td>JPSREGANT_SD_E</td>
<td>NONE</td>
<td>0.0000 m</td>
</tr>
<tr>
<td>MATE 12734M008</td>
<td>Matera, Italy</td>
<td>TRIMBLE 4000SSI</td>
<td>TRM29659.00</td>
<td>NONE</td>
<td>0.1010 m</td>
</tr>
<tr>
<td>ONSA 10402M004</td>
<td>Onsala, Sweden</td>
<td>ASHTECH Z-XII3</td>
<td>AOAD/M_B</td>
<td>OSOD</td>
<td>0.9950 m</td>
</tr>
<tr>
<td>PTBB 14234M001</td>
<td>Braunschweig, Germany</td>
<td>ASHTECH Z-XII3T</td>
<td>ASH700936E</td>
<td>SNOW</td>
<td>0.0562 m</td>
</tr>
<tr>
<td>VILL 13406M001</td>
<td>Villafranca, Spain</td>
<td>ASHTECH Z-XII3</td>
<td>AOAD/M_T</td>
<td>NONE</td>
<td>0.0437 m</td>
</tr>
<tr>
<td>ZIMJ 14001M006</td>
<td>Zimmerwald, Switzerland</td>
<td>JPS LEGACY</td>
<td>JPSREGANT_SD_E</td>
<td>NONE</td>
<td>0.0770 m</td>
</tr>
<tr>
<td>ZIMM 14001M004</td>
<td>Zimmerwald, Switzerland</td>
<td>TRIMBLE 4000SSI</td>
<td>TRM29659.00</td>
<td>NONE</td>
<td>0.0000 m</td>
</tr>
</tbody>
</table>
2. Terminal Session: Monday

Today’s terminal session is to

1. become familiar with the UNIX environment, the menu of the Bernese GPS 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 2.6), and
4. import the observations from the RINEX into the Bernese format for all four days of the example using RXOBV3 (section 2.7).

2.1 Start the Menu

Start the menu program using the command \texttt{G1}.

Navigate through the submenus to become familiar with the structure of the menu. Read the general help (available at “Menu>Help>General”) to get an overview on the usage of the menu program of the Bernese GPS Software.

For the terminal session in the Bernese introduction 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 (refer to the separate handout) and that the current session is set to the first session (i.e. $Y+0=2002, S+0=1430$). If this is not the case, please ask for help.

2.2 Select Current Session

Select “Menu>Campaign>Edit session table” to check the session table. It is recommended to use the wildcard string ???0 for the “SESSION identifier” 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.

\footnote{At the exercise terminals the Bernese environment is loaded automatically during the login. At home you have to source the file \$\{X\}/EXE/LOADGPS.setvar on UNIX–platforms either manually or during the login.}
2. Terminal Session: Monday

Save the session table (press the "Save" button) and open the “Date Selection Dialogue” in order to define the current session:

2.3 Campaign Setup

Usually, a new campaign must first be added to the campaign list (“Menu>Campaign>Edit list of campaigns”) and set as active campaign (“Menu>Campaign>Select active campaign”), before the directory structure can be created (“Menu>Campaign>Create new campaign”. This is already done for your campaign, but you should verify that this is correctly done. In order to become familiar with the campaign structure, you can now visit your campaign directory and inspect the contents using the command line (using cd and ls for changing directories and creating directory listings, respectively.

You will find the following directories and input data for the processing of the example campaign (note that ${P}/INTRO is used in this document in place of your individual campaign name):
The directory `$(P)/INTRO/GEN/` contains copies of files from the `$(X)/GEN/` directory, which are actually used by all users. If you want to view these files please use those in your campaign and not in the `$(X)/GEN/` directory to prevent interferences with your colleagues. The processing summary files in the directory `$(P)/INTRO/TXT/` are just for your information.

In addition you find reference files (`.REF`) to compare the solutions obtained with the example BPEs provided in the distribution (PPP.PCF, RNX2SNX.PCF, CLKDET.PCF). The first set (PPP*) contains the results from the Precise Point Positioning (PPP.PCF). In this course, we assume that this BPE was already successfully executed such that you can start with good a priori coordinates and velocities (files `IGS_00.CRD` and `IGS_00.VEL` in the STA–directory) and with a complete list of station abbreviations (file `EXAMPLE.ABB`):

<table>
<thead>
<tr>
<th>Directory</th>
<th>Files</th>
</tr>
</thead>
<tbody>
<tr>
<td>$(P)/INTRO/ATM/</td>
<td>CDD11674.ION CDD11675.ION CDD12190.ION CDD12191.ION</td>
</tr>
<tr>
<td>$(P)/INTRO/GEN/</td>
<td>DATUM.IONEX.PPP PHAS_IGS.REL RECEIVER. SAT_2002.CRX SAT_2003.CRX SATELLIT. SATELLIT.I01 SATELLIT.I05</td>
</tr>
<tr>
<td>$(P)/INTRO/OBS/</td>
<td>BULLET_A.ERP CODEE0205.DCB CODE0205.DCB IGS11674.PRE IGS11677.IEP IGS12190.PRE IGS12191.PRE IGS11677.IEP IGS12190.PRE IGS12191.PRE</td>
</tr>
<tr>
<td>$(P)/INTRO/ORB/</td>
<td>CODE0205.DCB CODEE0305.DCB IGS11674.PRE IGS11675.PRE IGS12190.PRE IGS12191.PRE</td>
</tr>
<tr>
<td>$(P)/INTRO/ORX/</td>
<td>BRUS1430.020 BRUS1440.020 BRUS1380.030 BRUS1390.030</td>
</tr>
<tr>
<td>$(P)/INTRO/OUT/</td>
<td>IGS11674.CLK IGS11675.CLK IGS12190.CLK IGS12191.CLK</td>
</tr>
<tr>
<td>$(P)/INTRO/RAW/</td>
<td>IGS11674.CRD IGS_00.R.CRD</td>
</tr>
<tr>
<td>$(P)/INTRO/STA/</td>
<td>IGS_00.R.CRD SESSIONS.SES</td>
</tr>
<tr>
<td>$(P)/INTRO/SOL/</td>
<td>EXAMPLE.BLQ EXAMPLE.PLD EXAMPLE.STA</td>
</tr>
<tr>
<td>$(P)/INTRO/TXT/</td>
<td>CDD11677.SUM CODD12197.SUM</td>
</tr>
</tbody>
</table>

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In the terminal session we will more or less follow the example BPE `RNX2SNX.PCF` to compute station coordinates and troposphere parameters for a regional GNSS network. As we will practice the topics of the theoretical morning lessons in these terminal sessions, we will not strictly follow all steps of this example BPE. The reference solutions from this example are:

Another example provided in the distribution concerns the estimation of receiver and satellite clock corrections starting from the broadcast navigation messages (`CLKDET.PCF`). You may use the terminal session on Thursday or Friday to follow this example. The reference result files are:
2.4 Input Files for the Processing Examples

### 2.4.1 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 resolve the phase ambiguities using the QIF–strategy (QIF: Quasi–Ionosphere–Free).

### 2.4.2 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 this files will affect processing for everyone. Consequently, these files are located in the `{X}/GEN` directory. Table 2.1 shows the list of general files necessary for the processing example. It also shows which files need updating from time to time by downloading them from the anonymous ftp-server of AIUB (http://www.aiub.unibe.ch/download/BSWUSER50/GEN).

Each Bernese processing program has its own panel for general files. Make sure that you use the correct files listed in Table 2.1.

Copies of these files are available in your campaign’s GEN–directory. In order to prevent accidental change of the ”live” files in `{X}/GEN, we recommend that you only inspect/browse the files in your campaign area.

### 2.4.3 Orbit files ORB

The precise orbits in the files *.PRE are the combined final products from the IGS. They do not contain orbits for the GLONASS satellites. The corresponding Earth orientation parameters are given in weekly files with the extension *.IEP.
2. Terminal Session: Monday

Table 2.1: List of general files to be used in the Bernese programs for the processing example.

<table>
<thead>
<tr>
<th>Filename</th>
<th>Content</th>
<th>Modification</th>
<th>Download</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONST.</td>
<td>All constants used in the <em>Bernese GPS Software</em></td>
<td>No</td>
<td>BSW aftp</td>
</tr>
<tr>
<td>DATUM.</td>
<td>Definition of geodetic datum</td>
<td>Introducing new reference ellipsoid</td>
<td>BSW aftp</td>
</tr>
<tr>
<td>RECEIVER.</td>
<td>Receiver information</td>
<td>Introducing new receiver type</td>
<td>BSW aftp</td>
</tr>
<tr>
<td>PHAS.COD.01</td>
<td>Phase center eccentricities and variations including radome codes</td>
<td>Introducing new elevation-dependent corrections</td>
<td>BSW aftp</td>
</tr>
<tr>
<td>SATELLIT.01</td>
<td>Satellite information file</td>
<td>New launched satellites</td>
<td>BSW aftp</td>
</tr>
<tr>
<td>SATSY+0.CRX</td>
<td>Satellite problems</td>
<td>Satellite maneuvers, bad data, ...</td>
<td>BSW aftp</td>
</tr>
<tr>
<td>GPSUTC.</td>
<td>Leap seconds</td>
<td>When a new leap second is announced by the IERS</td>
<td>BSW aftp</td>
</tr>
<tr>
<td>IAU2000.NUT</td>
<td>Nutation model coefficients</td>
<td>No</td>
<td>—</td>
</tr>
<tr>
<td>IERS2000.SUB</td>
<td>Subdaily pole model coefficients</td>
<td>No</td>
<td>—</td>
</tr>
<tr>
<td>POLOFF.</td>
<td>Pole offset coefficients</td>
<td>Introducing new values from IERS annual report (until 1997)</td>
<td>—</td>
</tr>
<tr>
<td>JGM3.</td>
<td>Earth potential coefficients</td>
<td>No</td>
<td>—</td>
</tr>
<tr>
<td>OT.CSRC.R.D</td>
<td>Ocean tides coefficients</td>
<td>No</td>
<td>—</td>
</tr>
<tr>
<td>SINEX.</td>
<td>SINEX header information</td>
<td>Adapt SINEX header for your institution</td>
<td>—</td>
</tr>
<tr>
<td>SINEX.TRO</td>
<td>…for the PPP example</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>SINEX.PPP</td>
<td>…for the double-diff. example</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>SINEX.RNX2SNX</td>
<td>…for the PPP example</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>IONEX.</td>
<td>IONEX header information</td>
<td>Adapt IONEX header for your institution</td>
<td>—</td>
</tr>
<tr>
<td>IONEX.PPP</td>
<td>…for the PPP example</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

Furthermore, the directory contains monthly means for the differential code biases (DCBs).

2.4.4 RINEX files ORX, OUT

The raw data are given in RINEX format. The observations $*$.$SYO ($SY$ is the menu time variable for the two-digit year of the current session) are used for all examples. The navigation messages $*$.$SYN$ are only used for the clock determination example.

The clock RINEX files are located in the OUT-directory. They are consistent with the IGS orbit and ERP products in the ORB-directory. They contain station and satellite clock corrections with 5 min. sampling.

2.4.5 Station files STA

The a priori coordinates of the stations in the IGS realization of the reference frame ITRF2000 are available in the file IGS00.CRD. It was generated using the PPP example for day 143 of year 2002. It contains all IGS core sites (copied from file IGS00R.CRD — the IGS realization of the reference frame ITRF2000) and the PPP results for the remaining
stations. The epoch of the coordinates is January 01, 2000. The corresponding velocity file \texttt{IGS00.VEL} contains the velocities for the core sites (copied from file \texttt{IGS00.R.VEL}) completed by the NNR-NUVEL1A velocities for the other stations. The assignment of stations to tectonic plates is given in the file \texttt{EXAMPLE.PLD}. The file \texttt{IGS00.FIX} contains the list of all IGS core sites. It will be useful to define the geodetic datum when estimating station coordinates. You can browse all these files with a text editor or with the menu ("Menu>\texttt{Campaign}>\texttt{Edit station files}").

To make sure that you process the data in the \textit{Bernese GPS Software} with correct station information (station name, receiver type, antenna type, antenna height, etc.) the file \texttt{EXAMPLE.STA} is used to verify the RINEX header information. The reason to use this file has to be seen in the fact 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 \texttt{PHASCOD.IO1} in order that the correct phase center offsets and variations are used. The receiver types have to be defined in the \texttt{RECEIVER} file to correctly apply the DCB corrections.

The last file to be mentioned in this list is \texttt{EXAMPLE.BLQ}. It provides the coefficients for the ocean tidal loading of the stations to be processed. It has to be applied at least in the final run of GPSEST.

### 2.5 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 file name. It would be very cumbersome to repeat all the runs selecting the correct files manually every time. For the BPE an automatization is mandatory. For such cases the Bernese menu system provides a powerful tool — so-called menu variables. The menu variables are defined in the user–specific menu input file $\{\text{U}\}/\text{PAN}/\text{MENU\_VAR.INP}$ that is accessible through "Menu>\texttt{Configure}>Menu \texttt{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 \textit{Bernese GPS Software}. The campaign data are located in the directory $\{\text{P}\}/\text{INTRO}=/\text{aiub\_u\_camp}/\text{INTRO}$. The user–dependent files can be found at $\{\text{U}\}=/u/\text{aiub}/\text{bern50}/\text{GPSUSER}$ — note, that you will find instead of bern50 your user name in the path. The temporary user files are saved in $\{\text{T}\}=/\text{scratch/bern50}$. Finally, the campaign–independent files reside in $\{\text{X}\}=/\text{aiub\_sw}/\text{BERN50}/\text{GPS}$. 

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2. Terminal Session: Monday

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

Be aware that the variable $S+1$ refers to the next session. Because we are using a session table for a 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).

2.6 Generate A priori Coordinates

As stated before the a priori coordinates generated from the PPP example BPE refer to the epoch January 01, 2000. The first step is to extrapolate the coordinates to the epoch that is currently processed. The program COOVEL is used for this purpose. Open the program input panel in "Menu>Service>Coordinate tools>Extrapolate coordinates":

```
"REFERENCE EPOCH"  $YMD,STR+0  →  2002 05 23
"Output coordinate file"  APR$YD+0  →  APR02143
"TITLE"  Session $YSS+0:  →  Session 021430:
```

Start the program with the "Run"-button. The program generates an output file COOVEL.L* in the directory ${{P}/INTRO/OUT}. This file may be browsed using the "Output"-button or with "Menu>Service>Browse program output". It should look like...
The header area of the program output is standardized for all programs of the *Bernese GPS Software*, Version 5.0. 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 result of the run of **COOVEL** is an a priori coordinate file (\$\{P\}/INTRO/STA/APR02143.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):

<table>
<thead>
<tr>
<th>Num</th>
<th>Station Name</th>
<th>X (M)</th>
<th>Y (M)</th>
<th>Z (M)</th>
<th>Flag</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>BRUS 13101M004</td>
<td>4027893.7773</td>
<td>307045.7760</td>
<td>4919475.0809</td>
<td>PPP</td>
</tr>
<tr>
<td>15</td>
<td>FFMJ 14273M001</td>
<td>4053455.9006</td>
<td>617729.6193</td>
<td>4869395.6681</td>
<td>PPP</td>
</tr>
<tr>
<td>36</td>
<td>MATE 12734M008</td>
<td>4641949.6104</td>
<td>1393045.3794</td>
<td>4133287.4177</td>
<td>IGS00</td>
</tr>
<tr>
<td>42</td>
<td>ONSA 10402M004</td>
<td>3370658.5806</td>
<td>711877.1009</td>
<td>5349786.9189</td>
<td>IGS00</td>
</tr>
<tr>
<td>47</td>
<td>PTBB 14234M001</td>
<td>3840509.9795</td>
<td>709661.2696</td>
<td>5023129.5003</td>
<td>PPP</td>
</tr>
<tr>
<td>56</td>
<td>VILL 13406M001</td>
<td>4849833.7343</td>
<td>-335049.0774</td>
<td>4116014.9013</td>
<td>IGS00</td>
</tr>
<tr>
<td>63</td>
<td>ZIMJ 14001M006</td>
<td>4331293.9550</td>
<td>567542.0890</td>
<td>463313.6788</td>
<td>PPP</td>
</tr>
<tr>
<td>64</td>
<td>ZIMM 14001M004</td>
<td>4331297.0935</td>
<td>567555.8333</td>
<td>4633133.8919</td>
<td>PPP</td>
</tr>
</tbody>
</table>

Repeat this step for the other three sessions of the example by changing the current session using "Menu>Configure>Set session/compute date". You can then use the Rer"un button to restart the program. No options need to be changed since consequent use of the menu time variables was made.
2.7 Importing the Observations

The campaign has now 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 utilities>Create observation statistics" — 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). You need to run this program for all 4 sessions of the example.

All RINEX observation files fitting $\{P\}/INTRO/RAW/????1430.02O 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 02O). In the file selection dialogue you will see the list of currently selected files. The RINEX files of the year 2003 are shown if a current session from the year 2003 is selected. In that case the label of the button changes to 03O.
The next panel specifies the general input files. 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:

We select GPS for the option “Satellite system to be considered” because the IGS orbits provide only the positions of the GPS satellites.
Two more panels provide options to verify the RINEX header information:

Start the program with the "Run"-button.
2. Terminal Session: Monday

A warning message will appear to inform you that the observations to the GLONASS satellites (satellite system R) are removed from the two stations equipped with GNSS receivers.

---

### PG RXOBV3: OBSERVATION DATA FROM OTHER SATELLITE SYSTEM REJECTED
RINEX FILE NAME: $(P)/INTRO/RAW/FFMJ1430.02O
SR R2RDOR: SATELLITES SKIPPED! SYSTEM: "R"

### PG RXOBV3: OBSERVATION DATA FROM OTHER SATELLITE SYSTEM REJECTED
RINEX FILE NAME: $(P)/INTRO/RAW/ZIMJ1430.02O

---

The program produces an output file RX002143.OUT 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 GPS Software. In addition some observation statistics are available. In the following section you may check the completeness of the Bernese observation files by the available number of epochs:

---

**TABLE OF INPUT AND OUTPUT FILE NAMES:**

<table>
<thead>
<tr>
<th>Run</th>
<th>Rinex file name</th>
<th>Bernese code header file name</th>
<th>Bernese code observ. file name</th>
<th>Bernese phase header file name</th>
<th>Bernese phase observ. file name</th>
<th>#epo</th>
<th>...</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$(P)/INTRO/RAW/BRUS1430.02O</td>
<td>$(P)/INTRO/OBS/BRUS1430.CZH</td>
<td>$(P)/INTRO/OBS/BRUS1430.CZO</td>
<td>$(P)/INTRO/OBS/BRUS1430.PZH</td>
<td>$(P)/INTRO/OBS/BRUS1430.PZO</td>
<td>2778</td>
<td>...</td>
</tr>
<tr>
<td>2</td>
<td>$(P)/INTRO/RAW/FFMJ1430.02O</td>
<td>$(P)/INTRO/OBS/FFMJ1430.CZH</td>
<td>$(P)/INTRO/OBS/FFMJ1430.CZO</td>
<td>$(P)/INTRO/OBS/FFMJ1430.PZH</td>
<td>$(P)/INTRO/OBS/FFMJ1430.PZO</td>
<td>2799</td>
<td>...</td>
</tr>
<tr>
<td>3</td>
<td>$(P)/INTRO/RAW/MATE1430.02O</td>
<td>$(P)/INTRO/OBS/MATE1430.CZH</td>
<td>$(P)/INTRO/OBS/MATE1430.CZO</td>
<td>$(P)/INTRO/OBS/MATE1430.PZH</td>
<td>$(P)/INTRO/OBS/MATE1430.PZO</td>
<td>2880</td>
<td>...</td>
</tr>
</tbody>
</table>

---

If epochs are missing for some RINEX files you may check this with the RINEX observation graphic from the program RNXGRA.
2.8 Daily Goals

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

1. a priori coordinates in your campaign’s STA directory: file APR02143.CRD, APR02144.CRD, ... (for all 4 days)

2. Bernese formatted zero difference observation files in your campaign’s OBS directory: BRUS1430.CZH, BRUS1430.PZH, BRUS1430.CZO, BRUS1430.PZO, ... (for all stations).

These files must be generated for all four days.
2. Terminal Session: Monday
3. Terminal Session: Tuesday

Today’s terminal session is to

1. generate the pole information file in Bernese format (POLUPD)
2. generate tabular orbit files from IGS precise files (PRETAB)
3. generate Bernese standard orbit files (ORBGEN)
4. preprocess the Bernese observation files:
   - receiver clock synchronization (CODSPP)
   - baseline generation (SNGDIF)
   - preprocess baselines (MAUPRP)

for all four days of the processing example. You can run all programs for one day, and then rerun them for the next day.

3.1 Prepare Pole Information

Together with the precise orbit files (PRE), a consistent set of Earth orientation information is provided in the ORB–directory. Whereas the orbits are given in daily files the EOPs are available in weekly files for the IGS final product series. We have to convert the information from the IERS/IGS standard format (file extension within the Bernese GPS Software is IEP) into the internal Bernese EOP format (file extension within the Bernese GPS 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 to an existing file.
3. Terminal Session: Tuesday
3.2 Generate Orbit Files

The last panel for the program POLUPD is an example for the specification of time windows in the *Bernese GPS Software*, Version 5.0. 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 the user 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 NOT SPECIFIED IN INPUT ERP FILE
USING NUTATION MODEL NAME : IAU2000

### PG POLUPD: SUBDAILY POLE MODEL NOT SPECIFIED IN INPUT ERP FILE
USING SUBDAILY POLE MODEL NAME : IERS2000
```

just inform you that the subdaily pole and nutation model from the input panel is written to the output file because no Bernese formatted ERP file was used as input.

3.2 Generate Orbit Files

In this processing example we use only two programs of the orbit part of the *Bernese GPS Software*. The first program is called PRETAB and may be accessed using "Menu>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 in program CODSPP (see Section 3.3.1) if no broadcast orbits are used.
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 and an “Interval for polynomials” of 12 hours. This is good enough for the receiver clock synchronization in CODSPP.

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

Make sure that the EOP file, the nutation, and the subdaily pole model are the same you have used in PRETAB. It is mandatory to use this triplet of files together with the generated standard orbits for all processing programs.
3. Terminal Session: Tuesday

The "ORBGEN 1.1: General Files" is used to check the consistency between input files and options. To generate standard orbits from IGS or CODE products use orbit model B. If the JPL planetary ephemeris (DE200.EPH) is unavailable you may leave the corresponding input field "Planetary ephemeris file" in the panel "ORBGEN 1.1: General Files" empty and set the "ORB MODEL IDENTIFIER" to ?.
### 3.2 Generate Orbit Files

**ORBOEWE 3.2: Options**

- **PRINT RESIDUALS**: NO
- **NUMERICAL INTEGRATION**
  - Number of iterations: 3
- **EQUATION OF MOTION**
  - Polynomial degree: 10
  - Length of interval: 1.0 hours
- **VARIATIONAL EQUATIONS**
  - Polynomial degree: 12
  - Length of interval: 6.0 hours

**ORBOEWE 4: Parameter Selection**

**DYNAMICAL ORBIT PARAMETERS**
- DO (direct)
- YO (y-bias)
- XO

**ORBOEWE 5: Orbital Arc Definition**

**ORBITAL ARC DEFINITION**
- Number of arcs within the time window: 1
- Time window to be covered by the standard orbits:
  - Defined by year and session number:
    - Year: 77-79
    - Session: 77-79
  - Defined by start and end time:
    - Start: yyyy mm dd hh mm ss
    - End: yyyy mm dd hh mm ss
The program produces an output file `ORB02143.OUT` (or corresponding to the other sessions) which should look like

... INPUT AND OUTPUT FILENAMES ...

<table>
<thead>
<tr>
<th>Session table:</th>
<th>${P}/INTRO/STA/SESSIONS.SES</th>
</tr>
</thead>
<tbody>
<tr>
<td>General constants:</td>
<td>${X}/GEN/CONST.</td>
</tr>
<tr>
<td>Pole file:</td>
<td>${P}/INTRO/ORB/IGS02143.ERP</td>
</tr>
<tr>
<td>Subdaily pole model:</td>
<td>${X}/GEN/TEERE2000_SUB</td>
</tr>
<tr>
<td>Nutation model:</td>
<td>${X}/GEN/IAU2000.NUT</td>
</tr>
<tr>
<td>Coeff. of Earth potential:</td>
<td>${X}/GEN/JGM3.</td>
</tr>
<tr>
<td>Satellite problems:</td>
<td>${X}/GEN/SAT_2002.CRX</td>
</tr>
<tr>
<td>Satellite information:</td>
<td>${X}/GEN/SATELLIT.I01</td>
</tr>
<tr>
<td>Planetary ephemeris file:</td>
<td>${X}/GEN/DE200.EPH</td>
</tr>
<tr>
<td>Ocean tides file:</td>
<td>${X}/GEN/OT_CSRC.TID</td>
</tr>
<tr>
<td>Orbital elements, file 1:</td>
<td>---</td>
</tr>
<tr>
<td>Orbital elements, file 2:</td>
<td>---</td>
</tr>
<tr>
<td>Standard orbits:</td>
<td>${P}/INTRO/ORB/IGS02143.STD</td>
</tr>
<tr>
<td>Radiation pressure coeff.:</td>
<td>---</td>
</tr>
<tr>
<td>Residual file:</td>
<td>---</td>
</tr>
<tr>
<td>Summary file:</td>
<td>${P}/INTRO/OUT/ORB02143.LST</td>
</tr>
<tr>
<td>Scratch file:</td>
<td>${U}/WORK/ORBGEN.SCR</td>
</tr>
<tr>
<td>Scratch file:</td>
<td>${U}/WORK/ORBGEN.SC2</td>
</tr>
<tr>
<td>Program output:</td>
<td>${P}/INTRO/OUT/ORB02143.OUT</td>
</tr>
<tr>
<td>Error message:</td>
<td>${U}/WORK/ERROR.MSG</td>
</tr>
</tbody>
</table>

RMS ERRORS AND MAX. RESIDUALS ARC NUMBER: 1 ITERATION: 2

<table>
<thead>
<tr>
<th>SAT</th>
<th>#POS</th>
<th>RMS (M)</th>
<th>QUADRATIC MEAN OF O-C (M)</th>
<th>MAX. RESIDUALS (M)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>TOTAL</td>
<td>RADIAL ALONG OUT</td>
<td>RADIAL ALONG OUT</td>
</tr>
<tr>
<td>1</td>
<td>96</td>
<td>0.01</td>
<td>0.01 0.01 0.01 0.01</td>
<td>0.02 0.02 0.03</td>
</tr>
<tr>
<td>2</td>
<td>96</td>
<td>0.01</td>
<td>0.01 0.01 0.01 0.01</td>
<td>0.04 0.02 0.01</td>
</tr>
<tr>
<td>3</td>
<td>96</td>
<td>0.01</td>
<td>0.01 0.02 0.01 0.00</td>
<td>0.03 0.03 0.02</td>
</tr>
<tr>
<td>4</td>
<td>96</td>
<td>0.01</td>
<td>0.01 0.01 0.01 0.01</td>
<td>0.02 0.02 0.02</td>
</tr>
</tbody>
</table>

The most important information in the output file are the RMS errors for each satellite. These should not be larger than about 1...2 cm if precise orbits 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 ITRF and ICRF in PRETAB, and on the orbit model used in ORBGEN).\(^1\)

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

The file ${P}/INTRO/OUT/ORB02143.LST summarizing the orbit fit rms values may be compared with the corresponding section in the solution reference file ${P}/INTRO/OUT/R2S021430.PRC.REF.

\(^1\)You may check this statement by using the BULLET1.ERP file instead of the IGS02143.ERP. This is only for a test — please, do not use the resulting standard orbit for any further processing!
3.3 Data Preprocessing (I)

3.3.1 Receiver Clock Synchronization

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

![CODSPP Interface](image1.png)

![CODSPP Interface](image2.png)
We have already 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.
CODSPP produces the following output:

```
...
STATION: BRUS 13101M004  FILE: $(P)/INTRO/OBS/BRUS1430.CZO  RECEIVER UNIT:  0

RESULTS:
--------
OBSERVATIONS IN FILE:  21844
BAD OBSERVATIONS :  0.15 %
RMS OF UNIT WEIGHT :  0.98 M
NUMBER OF ITERATIONS:  2
...
STATION COORDINATES:
---------------------
LOCAL GEODETIC DATUM:  IGS00

BRUS 13101M004 (MARKER)  A PRIORI  NEW  NEW+ A PRIORI  RMS ERROR
X  4027893.78  4027893.78  0.00  0.00
Y  307045.78  307045.78  0.00  0.00
Z  4919475.08  4919475.08  0.00  0.00

HEIGHT  149.66  149.66  0.00  0.00
LATITUDE  50 47 52.143  50 47 52.143  0 0 0.000  0.0000
LONGITUDE  4 21 33.186  4 21 33.186  0 0 0.000  0.0000

CLOCK PARAMETERS:
-------------------
OFFSET FOR REFERENCE EPDCH:  0.000000632  SEC
CLOCK OFFSETS STORED IN CODE+PHASE OBSERVATION FILES
...
```
The most important message in the output file is **CLOCK OFFSETS STORED IN CODE+PHASE OBSERVATION FILES.** Indicates that the receiver clock corrections $\delta_k$ 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 $\delta_k$ with the necessary accuracy of 1 $\mu$s.

If you get warning messages concerning irregularities, then it is probable that you did not exclude GLONASS in the observation import step. In the GNSS case (GLONASS and GPS) the time offset between the two satellite systems is estimated. The parameter is set up if at least one GNSS observation was found. Because no orbit for GLONASS is available in the standard orbit file, the GLONASS observations are skipped, and therefore no observations for this parameter are available. Because we only process GPS data in this terminal session, you can ignore these warning messages.

You may use the extraction program CODXTR ("Menu>Processing>Program output extraction>Code-based clock synchronization") to generate a short summary from the CODSPP program output. This summary is included in the solution reference file ($\{P\}/INTRO/OUT/R2S021430.PRCREF).

### 3.3.2 Form Baselines

The second processing program is called SNGDIF and may be activated in "Menu>Processing >Baseline file creation". SNGDIF creates the single differences and stores them into files. We use the strategy OBS-MAX for PHASE observation files.
3.3 Data Preprocessing (I)

CREATE SINGLE-DIFFERENCE OBSERV. FILES - SNOFFID 1: Observation File Selection

GENERAL FILES
- Show all general files

GENERAL OPTIONS
- Measurement type: PHASE
- Processing strategy: OBS-MAX

AUTOMATED BASELINE CREATION
- Zero-difference observation files: 1234567890
- Reference station for STAR strategy: PHH

MANUAL BASELINE CREATION
- First zero-difference input file: PPH
- Second zero-difference input file: PPH
- Single-difference output file: PHH

SNOFFID 2: Filenames

INPUT FILES
- Station coordinates
- Site eccentricities
- Predefined baselines
- Cluster definition

RESULT FILES
- Listing of formed baselines
- Cluster/baseline assignment: CM (2 digits will be appended)

GENERAL OUTPUT FILES
- Program output: use SNOFFID.Lnn or SNOFFID.OUT
- Error messages: merged to program output or SNOFFID.ERR
The output of SNGDIF simply echoes the zero difference files used and the single difference files created. If the strategy OBS-MAX is used the following lines are included:

All possible pairs of zero difference files are listed with the corresponding criterion value. The optimal baselines actually created are labeled with “OK”.

If you introduced GLONASS data you may end up with different baselines than given here, but this will not affect the results.
3.3.3 Preprocessing of the Phase Baseline Files

The main task of the program MAUPRP is the cycle-slip screening. It is started using “Menu > Processing > Phase preprocessing”.

![Image of MAUPRP interface]

![Image of MAUPRP interface with options selected]
3. Terminal Session: Tuesday

MAIFPRP 4: Marking of Observations

MARKING OF OBSERVATIONS BEFORE CYCLE SLIP DETECTION

- Mark if marking flags in observation file
- Mark observations below an elevation of 5 degrees
- Maximum time interval accepted for continuous observations: 301 seconds
- Maximum gap accepted within continuous observations: 64 seconds

General options
- Maximum time interval for polynomial fit: 5 minutes

MAIFPRP 5: Non-Parametric Screening

GENERAL OPTIONS
- Maximum time interval for polynomial fit: 5 minutes

SCREENING ON DIFFERENT DIFFERENCE LEVELS
- Original observations from file for ZF-files: zero diff.
- Differences between satellites for ZF-files: single diff.
- Polynomial degree: 2
- Discontinuity level: 0.4 meters

MAIFPRP 6: Epoch-Difference Solution

EPOCH-DIFFERENCE SOLUTION
- Frequency for the solution: L1
- Kinematic coordinate estimation
- Maximum observed-computed value: 0.5 meters (0.0: no check)
- RMS limit for epoch solution: 1.0 meters (0.0: no check)
- A priori coordinate/baseline vector sigma:
  - X-coordinate: 0.1 meters
  - Y-coordinate: 0.1 meters
  - Z-coordinate: 0.1 meters
3.3 Data Preprocessing (I)

**MAUPP 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: [ ]
- Is clean except for observations with flags: [ ]

**NO CYCLE SLIP HYPOTHESIS**
- Sigmas for LL observations: 0.0020 meters
- Sigmas for L2 observations: 0.0020 meters
- Maximum ionospheric change from epoch to epoch: 400 km of LL cycles

**CYCLE SLIP CORRECTIONS**
- Search width to find LL cycle slip correction: 3 integers
- Search width to find L2 cycle slip correction: 3 integers

**MAUPP 9: Outlier Rejection / Ambiguity Setting**

**OUTLIER REJECTION**
- Enable outlier rejection: [ ]
- Mark consecutive outliers up to a time interval: 181 seconds

**SET UP MULTIPLE AMBIGUITIES**
- Preserve ambiguities from observation file: [ ]
- If a cycle slip flag in observation file: [ ]
- If no cycle slip correction was possible: [ ]
- After an observation gap larger than: 181 seconds

**MARKING OF OBSERVATIONS AFTER CYCLE SLIP CORRECTIONS**
- Minimum observed time interval per ambiguity: 301 seconds
- Remove satellites if the file contains more than: 300 ambiguities
3. Terminal Session: Tuesday

The output of the program **MAUPRP** is discussed in detail in the lecture session. The software manual contains a detailed description, too. The most important item to check is the epoch difference solution:

```
---
STATION 1: BRUS 13101M004 YEAR: 2002 SESSION: 1430
STATION 2: ONSA 10402M004 DAY: 143 FILE: 0
BASELINE LENGTH (M): 883750.408
OBSERVAT. FILE NAME: ${(P)/INTRO/OBS/BRON1430.PSH}
---
EPOCH DIFFERENCE SOLUTION
---
FREQUENCY OF EPOCH DIFF. SOLU.: 3
#OBS. USED FOR EPOCH DIFF. SOLU: 17643
RMS OF EPOCH DIFF. SOLUTION (M): 0.011
COORDINATES NEW-A PRIORI X (M): 0.145 ± 0.026
Y (M): 0.061 ± 0.032
Z (M): 0.285 ± 0.020
---
```

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 values on certain baselines for certain epochs. The corresponding observations get flagged, and will not disturb processing.

You can use the extraction program **MPRXTR** (“Menu>Processing>Program output extraction>Phase preprocessing”) to generate a short summary of the **MAUPRP** output:

```
SUMMARY OF THE MAUPRP OUTPUT FILE

<table>
<thead>
<tr>
<th>SESS</th>
<th>FIL</th>
<th>OK?</th>
<th>ST1</th>
<th>ST2</th>
<th>L(KM)</th>
<th>#OBS.</th>
<th>RMS</th>
<th>DX</th>
<th>DY</th>
<th>DZ</th>
<th>#SL</th>
<th>#DL</th>
<th>#MA</th>
<th>MAXL3</th>
<th>MIN. SLIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1430</td>
<td>1</td>
<td>OK</td>
<td>BRUS</td>
<td>ONSA</td>
<td>884</td>
<td>17643</td>
<td>0.011</td>
<td>0.145</td>
<td>0.061</td>
<td>0.285</td>
<td>131</td>
<td>235</td>
<td>41</td>
<td>0.050</td>
<td>11</td>
</tr>
<tr>
<td>1430</td>
<td>2</td>
<td>OK</td>
<td>FFMJ</td>
<td>MATE</td>
<td>1220</td>
<td>18002</td>
<td>0.012</td>
<td>0.161</td>
<td>0.030</td>
<td>0.286</td>
<td>36</td>
<td>430</td>
<td>58</td>
<td>0.049</td>
<td>558</td>
</tr>
<tr>
<td>1430</td>
<td>3</td>
<td>OK</td>
<td>FFMJ</td>
<td>ONSA</td>
<td>840</td>
<td>20430</td>
<td>0.011</td>
<td>0.205</td>
<td>0.021</td>
<td>0.068</td>
<td>101</td>
<td>141</td>
<td>44</td>
<td>0.050</td>
<td>11</td>
</tr>
<tr>
<td>1430</td>
<td>4</td>
<td>OK</td>
<td>FFMJ</td>
<td>ZIMJ</td>
<td>368</td>
<td>11610</td>
<td>0.011</td>
<td>0.020</td>
<td>0.032</td>
<td>0.071</td>
<td>76</td>
<td>224</td>
<td>24</td>
<td>0.049</td>
<td>11</td>
</tr>
<tr>
<td>1430</td>
<td>5</td>
<td>OK</td>
<td>FFMJ</td>
<td>ZIMM</td>
<td>368</td>
<td>19563</td>
<td>0.011</td>
<td>0.015</td>
<td>0.015</td>
<td>0.089</td>
<td>46</td>
<td>199</td>
<td>39</td>
<td>0.042</td>
<td>46188</td>
</tr>
<tr>
<td>1430</td>
<td>6</td>
<td>OK</td>
<td>PTBB</td>
<td>ZIMM</td>
<td>640</td>
<td>17032</td>
<td>0.013</td>
<td>0.018</td>
<td>0.047</td>
<td>0.128</td>
<td>45</td>
<td>97</td>
<td>21</td>
<td>0.049</td>
<td>46188</td>
</tr>
<tr>
<td>1430</td>
<td>7</td>
<td>OK</td>
<td>VILL</td>
<td>ZIMM</td>
<td>1162</td>
<td>17990</td>
<td>0.012</td>
<td>0.175</td>
<td>0.080</td>
<td>0.199</td>
<td>54</td>
<td>219</td>
<td>30</td>
<td>0.050</td>
<td>17</td>
</tr>
<tr>
<td>Tot:</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>783</td>
<td>17467</td>
<td>0.012</td>
<td>70</td>
<td>220</td>
<td>37</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```
This summary file is included in the solution reference file ($\{P\}/INTRO/OUT/R2S021430.PRC_REF — the results may be slightly different since the input options were not exactly identical).

3.4 Daily Goals

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

1. Bernese pole file in the campaign’s ORB directory: IGS02143.ERP,
2. Bernese standard orbit file in the ORB directory: IGS02143.STD,
3. Bernese satellite clock files in the ORB directory: IGS02143.CLK,
4. Single difference files (baseline files) in the OBS directory: BRON1430.PSH, BRON1430.PSO, FFMA1430.PSH, FFMA1430.PSO,... for all baselines,
5. you should also have verified the outputs of these programs: ORBGEN, COBSPP, SNGDIF, and MAUPRP

Files should be generated for all four days. Simply adapt the session definition for the other days and rerun the programs.
3. Terminal Session: Tuesday
4. 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),
ideally for all four days of the processing example, but at least one session for each year, e.g.: 2002, 143 and 2003, 138. You can run through these steps session by session.

4.1 Data Preprocessing (II)

The 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 an ambiguity−free $L_3$ solution. 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:
We do not sample the observations in this run. This is important if we want to check all observations (we want to use all observations without sampling for the ambiguity resolution). Consequently the program run might be time consuming (about 3 min. CPU time on ubecx).
We want to give loose constraints to the station coordinates that are available from the IGS realization of ITRF 2000 reference frame (flag I like IGS00 in the coordinate file).
No parameters (not even ambiguity parameters) may be pre-eliminated if residuals should be written into the residual output file:

4. Terminal Session: Wednesday
A 4 hour resolution in time for the troposphere parameters is sufficient for this purpose:
The program output of program GPSEST repeats all important input options, summarizes the input data, and reports the estimated results. An important information in the output file is the a posteriori RMS error:

\[ \text{A POSTERIORI SIGMA OF UNIT WEIGHT (PART 1):} \]
\[ \text{A POSTERIORI SIGMA OF UNIT WEIGHT : 0.0011 M (SIGMA OF ONE-WAY L1 PHASE OBSERVABLE AT ZENITH)} \]

An a posteriori RMS error of about 1.0...1.5 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 pre–processing step (MAUPRP and CODSPP) was not successfully performed.

If the residuals have been stored in the binary residual files (“GPSEST 2.1: Output Files 1”) it is possible to have a look on 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 >Generate residual statistics".
The program output of RESRMS ($\{P\}/INTRO/OUT/RMS021430.OUT) provides a nice overview on the data quality. In addition, files containing a summary table ($\{P\}/INTRO/OUT/RMS02143.SUM — also included in the reference solution file $\{P\}/INTRO/OUT/R2S02143.PRC,REF) — and a histogram ($\{P\}/INTRO/OUT/RMS02143.LST) of the residuals are available. The most important result file for the data screening is the “Edit information file” ($\{P\}/INTRO/OUT/RMS02143.EDT) which may be used by the program SATMRK to mark outliers (“Menu>Service>Bernese observation files>Mark/delete observations”):
4.2 Make a First Network Solution

After screening the observations for outliers we generate an ionosphere–free \( (L_3) \) solution with unresolved ambiguities. The input options are very similar to the previous processing step. There are only a few differences shown in the following:

We store the coordinates and troposphere parameters into files to be re–introduced later:
4. Terminal Session: Wednesday

To speed up the processing we increase the sampling rate:

![Image of GPS software interface](image1)

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). This will be the topic of the lecture session tomorrow. Today we will follow this simple approach:

![Image of GPS software interface](image2)
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:

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 parameter and the observations:

<table>
<thead>
<tr>
<th>PARAMETER TYPE</th>
<th>#PARAMETERS</th>
<th>#PRE-ELIMINATED</th>
<th>#SET-UP</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATION COORDINATES</td>
<td>24</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td>AMBIGUITIES</td>
<td>419</td>
<td>419 (BEFORE INV)</td>
<td>451</td>
</tr>
<tr>
<td>SITE-SPECIFIC TROPOSPHERE PARAMETERS</td>
<td>56</td>
<td>0</td>
<td>56</td>
</tr>
<tr>
<td>TOTAL NUMBER OF PARAMETERS</td>
<td>499</td>
<td>419</td>
<td>531</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TYPE</th>
<th>FREQUENCY</th>
<th>FILE</th>
<th>#OBSERVATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHASE</td>
<td>L3</td>
<td>ALL</td>
<td>20415</td>
</tr>
<tr>
<td>TOTAL NUMBER OF OBSERVATIONS</td>
<td>20415</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4. Terminal Session: Wednesday

Then the a posteriori rms error and the results of the initial least-squares adjustment are given

<table>
<thead>
<tr>
<th>A POSTERIORI SIGMA OF UNIT WEIGHT (PART 1):</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>A POSTERIORI SIGMA OF UNIT WEIGHT : 0.0011 M (SIGMA OF ONE-WAY L1 PHASE OBSERVABLE AT ZENITH)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>DEGREE OF FREEDOM (DOF) : 19929</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>CHI**2/DOF : 1.22</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>STATION COORDINATES: $(P)/*INTRO/STA/FLT02143.CRD</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>NUM</th>
<th>STATION NAME</th>
<th>PARAMETER</th>
<th>A PRIORI VALUE</th>
<th>NEW VALUE</th>
<th>NEW- A PRIORI RMS ERROR</th>
</tr>
</thead>
</table>

| 6   | BRUS 13101NO04 | X         | 4027893.7773   | 4027893.7796 | 0.0023 | 0.0016 |
|     |               | Y         | 307045.7760    | 307045.7747  | -0.0013 | 0.0014 |
|     |               | Z         | 4919475.0809   | 4919475.0796 | -0.0013 | 0.0017 |
|     |               | HEIGHT    | 149.6632       | 149.6636     | 0.0004  | 0.0022 |
|     |               | LATITUDE  | 50 47 52.1433365 | 50 47 52.143365  | -0.0025 | 0.0009 |
|     |               | LONGITUDE| 4 21 33.1866467 | 4 21 33.186391  | -0.0015 | 0.0014 |

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. To check this in detail will be a topic of the terminal session tomorrow.

4.3 Ambiguity Resolution (QIF)

To resolve the ambiguities, we process the baselines separately one by one using the QIF (quasi- ionosphere-free) 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. The theoretical background for the ambiguity resolution will be the topic of the lecture session on Thursday morning. Nevertheless you may start the processing “cookbook”-like already today if you have time.

The complete list of baseline observation files of a session (e.g., session 1430 of year 2002) can be generated by listing all phase single-difference header files in the campaign’s observation directory of your campaign:

```bash
> ls $(P)/INTRO/UBS/????1430.PSH
$(P)/INTRO/UBS/BRON1430.PSH
$(P)/INTRO/UBS/FFMA1430.PSH
$(P)/INTRO/UBS/FFON1430.PSH
$(P)/INTRO/UBS/FFZI1430.PSH
$(P)/INTRO/UBS/FFZM1430.PSH
$(P)/INTRO/UBS/PTZM1430.PSH
$(P)/INTRO/UBS/VIZM1430.PSH
```
The first baseline for this session is from BRUS to ONSA with the observation filename BRON1430. Using the menu time variables this name is specified as BRON$S+0$. The following options were used for the ambiguity resolution step:

Only one baseline file is input and coordinates and troposphere estimates are introduced from the previous step. Specify a baseline specific output to prevent overwriting in subsequent runs.
4. Terminal Session: Wednesday

**OPSEST 3.1: General Options 1**

**TITLE** EXAMPLE: Baseline BROW+F1; GIP ambiguity resolution

**OBSERVATION SELECTION**
- Satellites system: GPS
- Frequency: L1/L2
- Elevation cutoff angle: 0 degrees
- Sampling interval: 30 seconds
- Tolerance for simultaneity: 100 milliseconds
- Special data selection: NO
- Observation window

**OBSERVATION MODELING AND PARAMETER ESTIMATION**
- A priori sigmas: 0.001 meters
- Elevation-dependent weighting: COS2
- Type of computed residuals: NORMALIZED
- Correlation strategy: BASELINE
- Polarization effect: only if later than 18000
  - total: only if later than 18000

---

**OPSEST 3.2: General Options 2**

**A PRIORI TROPOSPHERE MODELING**
- ZVD model and mapping function: DRY NIEUW

**MANAGEMENT OF AMBIGUITIES**
- Resolution strategy: GIP
- Save resolved ambiguities: ON
- Introduce widebaseline integers: ON
- Introduce L1 and L2 integers: ON

**SPECIAL PROCESSING OPTIONS**
- Maximum tolerated C-C term: X
- Var-cover wrt epoch parameters: SIMPLIFIED

**EXTENDED PRINTING OPTIONS**
- Selection of printing options: NO
4.3 Ambiguity Resolution (QIF)

GPSEST 3.2.3: Quasi-Ionosphere-Free (QIF) Ambiguity Resolution Strategy

OPTIONS AND CRITERIA FOR TESTING
Maximal number of ambiguities fixed per iteration step 10
Search width for pairs of L1 and L2 ambiguities 0.10 NL cycles
Maximal sigma of resolvable NL ambiguities 0.03 NL cycles
Maximal fractional part of resolvable NL ambiguities 0.10 NL cycles

GPSEST 4: Datum Definition for Station Coordinates

DATUM DEFINITION TYPE
- Free network solution
- Coordinates constrained
- Coordinates fixed

A PRIORI SIGMA
North 0.01 meters
East 0.01 meters
Up 0.01 meters

GPSEST 5.1: Setup of Parameters and Pre-Elimination

STATION-RELATED PARAMETERS
Station coordinates NO
Ambiguities NO
Receiver antenna offsets NO
Receiver antenna ECV patterns NO

ATMOSPHERIC PARAMETERS
Site-specific troposphere parameters NO
Global ionosphere parameters NO

EPOCH PARAMETERS
Kinematic coordinates EVERY EPOCH
Receiver clock offsets EVERY EPOCH
GNSS clock offsets EVERY EPOCH
Stochastic ionosphere parameters EVERY EPOCH
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):

<table>
<thead>
<tr>
<th>PARAMETER TYPE</th>
<th>#PARAMETERS</th>
<th>#PRE-ELIMINATED</th>
<th>#SET-UP</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATION COORDINATES</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>AMBIGUITIES</td>
<td>120</td>
<td>0</td>
<td>138</td>
</tr>
<tr>
<td>STOCHASTIC IONOSPHERE PARAMETERS</td>
<td>20560</td>
<td>20560 (EPOCH-WISE)</td>
<td>20560</td>
</tr>
<tr>
<td>TOTAL NUMBER OF PARAMETERS</td>
<td>20683</td>
<td>20560</td>
<td>20701</td>
</tr>
</tbody>
</table>

NUMBER OF OBSERVATIONS (PART 1):

<table>
<thead>
<tr>
<th>TYPE</th>
<th>FREQUENCY</th>
<th>FILE</th>
<th>#OBSERVATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHASE</td>
<td>L1</td>
<td>ALL</td>
<td>17787</td>
</tr>
<tr>
<td>PHASE</td>
<td>L2</td>
<td>ALL</td>
<td>17787</td>
</tr>
<tr>
<td>TOTAL NUMBER OF OBSERVATIONS</td>
<td>35574</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```
In the next part of the output the result of the QIF ambiguity resolution algorithm is given:

### AMBIGUITIES:

| AMBI FILE SAT. EPOCH FRQ WLF CLU AMBI CLU AMBIGUITY RMS TOTAL AMBIGU. DL/L |
|-----------------|---------------|-----|----------------|----------------|-----------------|---------------|----------------|
| 1 1 18 1 1 1 1 121 25 | -0.69 | 0.71 | 3181809.31 |
| 2 1 18 803 1 1 2 121 25 | 1.56 | 0.27 | 5312279.56 |
| 3 1 18 1140 1 1 3 122 47 | 9.09 | 0.37 | 21539287.09 |
| 4 1 18 2541 1 1 4 122 47 | 8.43 | 0.29 | 7052711.43 |
| ... |
| 121 1 30 1 1 1 25 | --- REFERENCE --- | 4265892. |
| 122 1 13 1688 1 1 47 | --- REFERENCE --- | 4765818. |
| ... |

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

### AMBIGUITY RESOLUTION:

| BEST INT. CORRECTIONS IN CYCLES |
|-----------------|---------------|-----|----------------|----------------|-----------------|---------------|----------------|
| FILE AM1 CL1 #AM1 AM2 CL2 #AM2 L1 L2 L1 L2 L5 L3 RMS(L3) |
|-----------------|---------------|-----|----------------|----------------|-----------------|---------------|----------------|
| 1 9 9 1 121 25 | -1 | -1 | 0.66 0.85 -0.189 -0.006 0.004 |
| 1 26 29 1 121 25 | 1 | 2 | 1 | 0.08 | 0.10 | -0.019 | 0.010 0.004 |
| 1 33 38 1 122 47 | 1 | 6 | 9 | 0.74 0.96 -0.219 -0.036 0.004 |
| 1 6 6 1 18 18 1 | 3 | 5 | 0.11 | 0.15 | -0.034 | -0.007 | 0.004 |
| 1 34 39 1 38 43 | 1 | -5 | -5 | -0.01 | -0.01 | 0.001 | -0.007 | 0.004 |
| 1 31 35 1 57 65 | 1 | -1 | -3 | 1.09 | 1.39 | -0.305 | 0.010 0.004 |
| 1 54 62 1 122 47 | 1 | 10 | 12 | -0.14 | -0.18 | 0.037 | -0.006 0.005 |
| 1 25 28 1 122 47 | 2 | 33 | 44 | 0.11 | 0.14 | -0.028 | 0.014 0.005 |
| 1 59 67 1 60 69 | 1 | -11 | -13 | 0.15 | 0.19 | -0.042 | 0.000 0.005 |
| ... |
4. Terminal Session: Wednesday

First the individual iteration steps are described (we specified that up to ten ambiguities may be resolved within each iteration step — see panel “GPSEST 3.2.3: Quasi-Ionosphere-Free (QIF) 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 L1 and L2 ambiguities. The CORRECTIONS IN CYCLES L5 and L3 are of greater interest. The value L5 represents the ionosphere–induced bias expressed in L5 cycles. These values may not be greater than the maximum value specified in panel “GPSEST 3.2.3: QIF Ambiguity Resolution Strategy” (option “Search width of pairs of L1 and L2 ambiguities”). RMS(L3) is the criterion according to which the ambiguities are sorted. Ambiguities with L3 RMS errors larger than the value specified in the program input panel (in our example 0.03) will not be resolved.

The results of the ambiguity resolution are summarized in the following table:

<table>
<thead>
<tr>
<th>AMBI</th>
<th>FILE</th>
<th>SAT.</th>
<th>EPOCH</th>
<th>FRQ</th>
<th>WLF</th>
<th>CLU</th>
<th>AMBI</th>
<th>CLU</th>
<th>AMBIGUITY</th>
<th>RMS</th>
<th>TOTAL AMBIGU.</th>
<th>DL/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>18</td>
<td>1</td>
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<td>1</td>
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<td>121</td>
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<td>3181808.93</td>
<td></td>
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<tr>
<td>2</td>
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<td>18</td>
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<td>1</td>
<td>1</td>
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<td>121</td>
<td>25</td>
<td>3</td>
<td></td>
<td>5312281.00</td>
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</tr>
<tr>
<td>3</td>
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<td>18</td>
<td>1140</td>
<td>1</td>
<td>1</td>
<td>3</td>
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<td>47</td>
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<td></td>
<td>21539289.00</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1</td>
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<td>2541</td>
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<td>1</td>
<td>4</td>
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<td>47</td>
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<td></td>
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<td>1</td>
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<td>121</td>
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<td>2162194.00</td>
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</tr>
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<td>13</td>
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<td>21</td>
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<td>1</td>
<td>1</td>
<td>13</td>
<td>52</td>
<td>60</td>
<td>1</td>
<td></td>
<td>24351827.00</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>1</td>
<td>21</td>
<td>2712</td>
<td>1</td>
<td>1</td>
<td>14</td>
<td>47</td>
<td>55</td>
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<td></td>
<td>6301871.00</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>29</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>15</td>
<td>121</td>
<td>25</td>
<td>-1</td>
<td></td>
<td>2714436.00</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>1</td>
<td>29</td>
<td>1191</td>
<td>1</td>
<td>1</td>
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<td>122</td>
<td>47</td>
<td>17.32</td>
<td>2.15</td>
<td>6067500.32</td>
<td></td>
</tr>
<tr>
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<td>68</td>
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<td></td>
<td>7875520.00</td>
<td></td>
</tr>
</tbody>
</table>

The ambiguities for which a RMS is specified could not be resolved (these ambiguities will be treated as real values by all subsequent program runs).
Ambiguity resolution has an influence on other parameters. Therefore, the results of the ambiguity-fixed solution are given in Part 2 of the output:

You may see from the output that from a total of 120 ambiguities 96 ambiguities could be resolved (compare part 1 AMBIGUITIES with part 2 AMBIGUITIES).
4. Terminal Session: Wednesday

Admittedly, it is cumbersome to process the baselines “manually” one after the other – you have seven baselines per session for this small example campaign. When we switch the input options from one baseline to the next one we have to change the filename for the baseline in three panels of GPSEST. To avoid this, you may benefit from the semi-automated processing capability of the Bernese GPS Software, Version 5.0: First we define a user variable ("Menu >Configure>Menu variables") containing the name of the baseline we want to process (in that case the second one from the list: FFMJ to MATE with the filename FFMA1430):

Now we use the variable $(BSLIN)$ in the three input panels of GPSEST in place of the single difference input filenames:
Now, we can easily switch from one baseline to the next by changing the definition of the variable \$(BSLIN)\$ in the menu variables panel, only. The fields in the input files are updated automatically.

Ambiguity resolution is a typical application for the Bernese Processing Engine (BPE) even if you are going to process the data manually. We have prepared a Perl script that runs
4. Terminal Session: Wednesday

GPSEST based on the current settings in the input panels for all baseline observation files in your campaign. The script checks the main settings for the QIF ambiguity resolution. It is required that you have used menu time variables for the filenames in panel “GPSEST 1.1: Input Files 1”. The script is started without any parameters by typing $U/$SCRIPT/qif_all.com. This script is only available for this course, it is not part of the official distribution of the Bernese GPS Software.

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

In this summary ($P$/INTRO/OUT/QIF02143.SUM) you may easily see how many ambiguities are resolved for each baseline:

<table>
<thead>
<tr>
<th>File</th>
<th>Length (km)</th>
<th>#Amb</th>
<th>RMS0 (mm)</th>
<th>Max/RMS L5 Amb (L5 Cycles)</th>
<th>Max/RMS L3 Amb (L3 Cycles)</th>
<th>#Amb</th>
<th>RMS0 #Amb</th>
<th>Max/RMS L3 Amb %</th>
<th>#Amb Res</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRON1430</td>
<td>883.8</td>
<td>120</td>
<td>1.3</td>
<td>0.495</td>
<td>0.093</td>
<td>24</td>
<td>1.3</td>
<td>80.0</td>
<td></td>
</tr>
<tr>
<td>FFMA1430</td>
<td>1220.4</td>
<td>152</td>
<td>1.5</td>
<td>0.444</td>
<td>0.093</td>
<td>66</td>
<td>1.5</td>
<td>56.6</td>
<td></td>
</tr>
<tr>
<td>FFON1430</td>
<td>840.1</td>
<td>134</td>
<td>1.4</td>
<td>0.479</td>
<td>0.097</td>
<td>30</td>
<td>1.4</td>
<td>77.6</td>
<td></td>
</tr>
<tr>
<td>FFZI1430</td>
<td>368.1</td>
<td>88</td>
<td>1.2</td>
<td>0.396</td>
<td>0.092</td>
<td>34</td>
<td>1.2</td>
<td>61.4</td>
<td></td>
</tr>
<tr>
<td>FFZM1430</td>
<td>368.1</td>
<td>128</td>
<td>1.1</td>
<td>0.384</td>
<td>0.082</td>
<td>30</td>
<td>1.2</td>
<td>76.6</td>
<td></td>
</tr>
<tr>
<td>PTZM1430</td>
<td>640.1</td>
<td>96</td>
<td>1.3</td>
<td>0.488</td>
<td>0.085</td>
<td>14</td>
<td>1.4</td>
<td>85.4</td>
<td></td>
</tr>
<tr>
<td>VIZM1430</td>
<td>1162.3</td>
<td>100</td>
<td>1.3</td>
<td>0.487</td>
<td>0.094</td>
<td>22</td>
<td>1.4</td>
<td>78.0</td>
<td></td>
</tr>
<tr>
<td>Tot:</td>
<td>7</td>
<td>783.3</td>
<td>818</td>
<td>1.3</td>
<td>0.495</td>
<td>0.097</td>
<td>0.022</td>
<td>220</td>
<td>73.1</td>
</tr>
</tbody>
</table>

This table is a part of the solution reference file ($P$/INTRO/OUT/R2S02143.PRC), too.

Additional lines may appear below this table looking like:

```
Estimated Orbit Accuracy: 29.7+- 5.4 mm  
Basic Noise of L3 Amb : 2.2+- 0.2 mm / 0.020 L3 Cycles 
```

The orbit accuracy may be estimated when compiling the summary for the ambiguity resolution containing the RMS for the L3 ambiguity estimates from baselines of a global network. In some cases GPSXTR adds these lines also for regional networks. In that case the Estimated Orbit Accuracy is not really interpretable. If no orbit accuracy was estimated a message is issued:

```
### SR EXTAMB: ORBIT ACCURACY NOT ESTIMATED  
```

1You may check the impact of introducing the ionosphere model (COD$WD+0 in “Ionosphere 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.
4. Terminal Session: Wednesday

4.4 Daily Goals

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

1. used GPSEST for residual screening, created files: EDT02143.OUT, EDT02143.RES in your campaign’s OUT directory,
2. screened the residual files from the above run using RESRMS: created files RMS02143.SUM, RMS02143.LST, RMS02143.EDT, and RMS02143.OUT,
3. used SATMRK to mark the identified outliers,
4. used GPSEST for a first coordinate and troposphere estimation, created files: FLT02143.CRD and FLT02143.TRP,
5. used GPSEST for QIF ambiguity resolution, created files: BRON1430.OUT, FFMA1430.OUT, etc. for all baselines,
6. used GPSXTR to create a summary of the ambiguity resolution, created file: QIF02143.SUM

ideally, files for all sessions should be screened (generation of FLTyyddd files).
5. Terminal Session: Thursday

Finish the work of yesterday by resolving the ambiguities for all baselines of all four days. To save time you may do this for one day of each year (e.g. day 143 year 2002, and day 138 year 2003.

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. (optional) compute velocities (ADDNEQ2),

for all four days of the processing example. Compare the final coordinate results of the daily solutions.

5.1 Final Network Solution

After the loop over all baselines is completed and the ambiguities are resolved you will use the program GPSEST in session mode. In panel “GPSEST 1.1: Input Files 1” you may now select all single difference files of the corresponding session:
In panel “GPSEST 2.1: Output Files 1” we request the normal equation file as only output file
For the final run of GPSEST we consider the correlations between the observations correctly:

Ambiguities which have been resolved in the previous runs of program GPSEST using the QIF strategy are introduced as known:
5. Terminal Session: Thursday

Since this is the final run of GPSEST it is worthwhile to add some more 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.

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. However, to get already a reasonable solution (also for the station coordinates) from GPSEST we put loose constraints on the coordinates (the normal equations are stored without any constraints):
The unresolved ambiguities are pre-eliminated:

The estimation of troposphere parameters is mandatory for a campaign of this type. We increase the number of estimated parameters (e.g., 24 instead of 6 parameters per station and session). In addition, it is recommended to set up troposphere gradient parameters:
The output of a 1-session run of program **GPSEST** should look like this:

```plaintext

13. RESULTS (PART 1)

NUMBER OF PARAMETERS (PART 1):

<table>
<thead>
<tr>
<th>PARAMETER TYPE</th>
<th>#PARAMETERS</th>
<th>#PRE-ELIMINATED</th>
<th>#SET-UP</th>
<th>...</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATION COORDINATES</td>
<td>24</td>
<td>0</td>
<td>24</td>
<td>...</td>
</tr>
<tr>
<td>AMBIGUITIES</td>
<td>120</td>
<td>120 (BEFORE INV)</td>
<td>152</td>
<td>...</td>
</tr>
<tr>
<td>SITE-SPECIFIC TROPOSPHERE PARAMETERS</td>
<td>232</td>
<td>0</td>
<td>232</td>
<td>...</td>
</tr>
<tr>
<td>TOTAL NUMBER OF PARAMETERS</td>
<td>376</td>
<td>120</td>
<td>408</td>
<td>...</td>
</tr>
</tbody>
</table>

NUMBER OF OBSERVATIONS (PART 1):

<table>
<thead>
<tr>
<th>TYPE</th>
<th>FREQUENCY</th>
<th>FILE</th>
<th>#OBSERVATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHASE</td>
<td>L3</td>
<td>ALL</td>
<td>20415</td>
</tr>
<tr>
<td>TOTAL NUMBER OF OBSERVATIONS</td>
<td>20415</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 ZENITH)

DEGREE OF FREEDOM (DOF) : 20059

CHI**2/DOF : 1.30

After four runs of **GPSEST** in session mode the following normal equation files should be available in the directory `$P/intro/sol`:

- FIX02143.NQ0
- FIX02144.NQ0
- FIX03138.NQ0
- FIX03139.NQ0
```
5.2 Check the Coordinates of the Fiducial Sites

To check the consistency of our data with the coordinates of the IGS core sites we generate a minimum constraint solution for the network using program ADDNEQ2 ("Menu>Processing >Normal equation stacking") with the following options:

```
5.2 Check the Coordinates of the Fiducial Sites

To check the consistency of our data with the coordinates of the IGS core sites we generate a minimum constraint solution for the network using program ADDNEQ2 ("Menu>Processing >Normal equation stacking") with the following options:

```

---

**ADDNEQ2 1: Input Files**

- **GENERAL FILES**
  - Show all general files: selected

- **INPUT FILENAMES**
  - Normal equations: PIVVD+0
  - Variance rescaling factors:
  - Station coordinates: IGS_NO
  - Station velocities: IGS_NO
  - Station information: EXAMPLE
  - Troposphere estimates: TRP
  - Ionosphere master file: ION
  - Differential code biases: BDC
  - Earth rotation parameters: ERL
  - Geocenter coordinates: SGC

---

**ADDNEQ2 2: Output Files**

- **GENERAL OUTPUT FILES**
  - Program output: selected
  - Error messages: selected

- **RESULT FILES**
  - Normal equations: PIVVD+0
  - Station coordinates: IGS_NO
  - Station velocities: IGS_NO
  - Troposphere estimates: TRP
  - Ionosphere master file: ION
  - Differential code biases: BDC
  - Earth rotation parameters: ERL
  - Geocenter coordinates: SGC
5. Terminal Session: Thursday

### ADDREQ2 3.1: Options 1

**GENERAL OPTIONS**
- Maximum number of parameters in combined REQ: [1000]
- A priori sigmas of unit weight: [0.0010] meters
- Compute and compare individual solutions: [Y] (yyy mm dd)

**PARAMETER-RELATED OPTIONS**
- Parameter pre-elimination: [Y]
- Change parameter spacing: [Y]
- Set up station velocities: [Y]
- Set up geocenter coordinates: [Y]

### ADDREQ2 3.2: Options 2

**DISPLAY OPTIONS REGARDING**
- Atmospheric parameters: [Y]
- Orbital parameters: [Y]
- Earth orientation parameters: [Y]
- Additional parameters: [Y]

**OUTPUT OPTIONS**
- Provide extended output w/ estimated parameters: [Y]
- Notify station inconsistencies between REQs: [Y]
- Notify changes due to station information file: [Y]
- Print detailed list of all parameter manipulations: [Y]

### ADDREQ2 3.3: Options 3

**SINQX OPTIONS**
- Regularize a priori constraint matrix: [N]
- Sort stations according to BOMBS code: [Y]
- Include ADDREQ1-style statistics block: [Y]

**VAR-COVAR FILE OPTIONS**
- Representation of coordinates and velocities: [CRD/VEL]

**ADDITIONAL OPTIONS**
- Truncate all REQ station names after position 14: [N]
- Compensate for effect of step-2 tide SW bug between: [N] (yyy mm dd)
5.2 Check the Coordinates of the Fiducial Sites

- **Datum Definition for Station Coordinates**
  - **Datum Definition Type**
    - Free network solution
    - Minimum constraint solution from file
    - Coordinates constrained manual
    - Coordinates fixed manual
  - **Minimum Constraint Conditions**
    - Translation YES
    - Rotation NO
    - Scale NO
  - **A PRIORI SIGMA**
    - North 0.001 meters
    - East 0.001 meters
    - Up 0.001 meters

- **Options for Atmospheric Parameters**
  - **A PRIORI SIGMA**
    - Troposphere zenith delays absolute meters
    - Troposphere gradients relative meters
    - Global ionosphere parameters TECU
  - **Maximum Time Interval Between Parameters for Relative Constraining**
    - Troposphere zenith delays 600 sec
    - Troposphere gradients sec
    - Global ionosphere parameters sec
  - **Extraction of Parameters for Troposphere Sine File**
    - Offset 00:36:00 (hh mm ss)
    - Time resolution 01:00:00 (hh mm ss)
The ADDNEQ2 program output starts with some information about the parameters contained in the input NQ0-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:**

<table>
<thead>
<tr>
<th>Parameter type</th>
<th>Adjusted</th>
<th>explicitly / implicitly (pre-eliminated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station coordinates / velocities</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Site-specific troposphere parameters</td>
<td>223</td>
<td>223</td>
</tr>
<tr>
<td>Previously pre-eliminated parameters</td>
<td>109</td>
<td>109</td>
</tr>
<tr>
<td>Total number</td>
<td>356</td>
<td>247</td>
</tr>
</tbody>
</table>

**Statistics:**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of explicit parameters</td>
<td>247</td>
</tr>
<tr>
<td>Total number of implicit parameters</td>
<td>109</td>
</tr>
<tr>
<td>Total number of adjusted parameters</td>
<td>356</td>
</tr>
<tr>
<td>Total number of observations</td>
<td>20415</td>
</tr>
<tr>
<td>Degree of freedom (DOF)</td>
<td>20059</td>
</tr>
<tr>
<td>A posteriori RMS of unit weight</td>
<td>0.00114 m</td>
</tr>
<tr>
<td>Chi**2/DOF</td>
<td>1.30</td>
</tr>
</tbody>
</table>

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

---

### Station coordinates and velocities:

<table>
<thead>
<tr>
<th>Sol</th>
<th>Station name</th>
<th>Typ</th>
<th>Correction</th>
<th>Estimated value</th>
<th>RMS error</th>
<th>A priori value</th>
<th>Unit</th>
<th>...</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BRUS 13101M004</td>
<td>X</td>
<td>0.0136</td>
<td>4027893.7909</td>
<td>0.0011</td>
<td>4027893.7773</td>
<td>meters</td>
<td>...</td>
</tr>
<tr>
<td>1</td>
<td>BRUS 13101M004</td>
<td>Y</td>
<td>0.0056</td>
<td>307045.7816</td>
<td>0.0004</td>
<td>307045.7761</td>
<td>meters</td>
<td>...</td>
</tr>
<tr>
<td>1</td>
<td>BRUS 13101M004</td>
<td>Z</td>
<td>0.0059</td>
<td>4919475.0869</td>
<td>0.0013</td>
<td>4919475.0809</td>
<td>meters</td>
<td>...</td>
</tr>
<tr>
<td>1</td>
<td>FFMJ 14279M001</td>
<td>X</td>
<td>0.0141</td>
<td>4053455.9147</td>
<td>0.0009</td>
<td>4053455.9006</td>
<td>meters</td>
<td>...</td>
</tr>
</tbody>
</table>

### Site-specific troposphere parameters:

<table>
<thead>
<tr>
<th>Station name</th>
<th>Typ</th>
<th>Correction</th>
<th>Estimated value</th>
<th>RMS error</th>
<th>A priori value</th>
<th>Unit</th>
<th>...</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRUS 13101M004</td>
<td>N</td>
<td>-0.0001</td>
<td>-0.0001</td>
<td>0.0001</td>
<td>0.0000</td>
<td>meters</td>
<td>...</td>
</tr>
<tr>
<td>BRUS 13101M004</td>
<td>E</td>
<td>0.0006</td>
<td>0.0006</td>
<td>0.0001</td>
<td>0.0000</td>
<td>meters</td>
<td>...</td>
</tr>
<tr>
<td>BRUS 13101M004</td>
<td>U</td>
<td>0.1278</td>
<td>2.3945</td>
<td>0.0024</td>
<td>2.2667</td>
<td>meters</td>
<td>...</td>
</tr>
</tbody>
</table>
5.2 Check the Coordinates of the Fiducial Sites

The coordinate solution for the session ($\{P\}/INTRO/STA/FINO2143.CRD) may be compared with the a priori coordinates for the IGS core sites. The program HELMR1 ("Menu>Service >Coordinate tools>Helmert transformation") may be used for this purpose:

![HELMERT TRANSFORMATION - HELMR1: Input/Output Files]

![HELMERT 2: Options for Helmert Transformation]
5. Terminal Session: Thursday

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. Only the residuals for those sites are printed to the program output.

<table>
<thead>
<tr>
<th>NUM</th>
<th>NAME</th>
<th>FLG</th>
<th>RESIDUALS IN MILLIMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>North</td>
</tr>
<tr>
<td>6</td>
<td>BRUS 13101M004</td>
<td>P A</td>
<td>6.2 -3.6 -14.1 M</td>
</tr>
<tr>
<td>15</td>
<td>FFMJ 14279M001</td>
<td>P A</td>
<td>7.5 4.0 -12.0 M</td>
</tr>
<tr>
<td>36</td>
<td>MATE 12734M008</td>
<td>I W</td>
<td>0.2 2.0 -6.1</td>
</tr>
<tr>
<td>42</td>
<td>ONSA 10402M004</td>
<td>I W</td>
<td>0.5 -0.0 -6.2</td>
</tr>
<tr>
<td>47</td>
<td>PTBB 14234M001</td>
<td>P A</td>
<td>4.8 1.0 -22.9 M</td>
</tr>
<tr>
<td>56</td>
<td>VILL 13406M001</td>
<td>I W</td>
<td>-0.7 -1.9 12.3</td>
</tr>
<tr>
<td>63</td>
<td>ZIMJ 14001M006</td>
<td>P A</td>
<td>7.0 2.3 -20.7 M</td>
</tr>
<tr>
<td>64</td>
<td>ZIMM 14001M004</td>
<td>P A</td>
<td>6.0 3.0 -12.2 M</td>
</tr>
<tr>
<td></td>
<td>RMS / COMPONENT</td>
<td></td>
<td>0.7 1.9 10.7</td>
</tr>
</tbody>
</table>

...
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 ${P}/INTRO/STA/IGS00.FIX$ or with manual selection of the stations used for the datum definition in panel “ADDNEQ2 5.1: Datum Definition for Station Coordinates”.

### 5.3 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").
The program computes the arithmetic mean for all station coordinates. The difference of each individual coordinate set to this mean value is reported in the following section of the program output:

<table>
<thead>
<tr>
<th>NUM</th>
<th>STATION</th>
<th>FIL C</th>
<th>RMS</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>BRUS</td>
<td>13101M004</td>
<td>4 N</td>
<td>11.5</td>
<td>-10.5</td>
<td>-9.4</td>
<td>8.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>E</td>
<td>10.7</td>
<td>-9.9</td>
<td>-8.6</td>
<td>9.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>U</td>
<td>3.3</td>
<td>2.3</td>
<td>2.3</td>
<td>0.1</td>
</tr>
<tr>
<td>15</td>
<td>FFMJ</td>
<td>14279M001</td>
<td>4 N</td>
<td>6.9</td>
<td>-6.2</td>
<td>-5.7</td>
<td>6.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>E</td>
<td>10.2</td>
<td>-8.8</td>
<td>-8.8</td>
<td>8.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>U</td>
<td>2.3</td>
<td>0.8</td>
<td>-2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>36</td>
<td>MATE</td>
<td>12734M008</td>
<td>4 N</td>
<td>10.6</td>
<td>-8.1</td>
<td>-10.2</td>
<td>9.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>E</td>
<td>13.3</td>
<td>-12.2</td>
<td>-10.8</td>
<td>10.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>U</td>
<td>2.5</td>
<td>3.6</td>
<td>-1.4</td>
<td>-1.9</td>
</tr>
<tr>
<td>42</td>
<td>ONSA</td>
<td>10402M004</td>
<td>4 N</td>
<td>7.3</td>
<td>-6.2</td>
<td>-6.4</td>
<td>6.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>E</td>
<td>10.2</td>
<td>-9.2</td>
<td>-8.5</td>
<td>8.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>U</td>
<td>2.3</td>
<td>-2.5</td>
<td>1.6</td>
<td>2.2</td>
</tr>
<tr>
<td>47</td>
<td>PTBB</td>
<td>14234M001</td>
<td>4 N</td>
<td>8.9</td>
<td>-7.4</td>
<td>-8.0</td>
<td>6.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>E</td>
<td>11.4</td>
<td>-10.2</td>
<td>-9.5</td>
<td>9.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>U</td>
<td>2.6</td>
<td>1.9</td>
<td>2.5</td>
<td>-1.5</td>
</tr>
<tr>
<td>56</td>
<td>VILL</td>
<td>13406M001</td>
<td>4 N</td>
<td>9.2</td>
<td>-8.3</td>
<td>-7.6</td>
<td>7.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>E</td>
<td>11.7</td>
<td>-9.3</td>
<td>-10.9</td>
<td>11.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>U</td>
<td>1.1</td>
<td>-0.8</td>
<td>0.5</td>
<td>-0.9</td>
</tr>
<tr>
<td>63</td>
<td>ZIMJ</td>
<td>14001M006</td>
<td>4 N</td>
<td>9.4</td>
<td>-7.7</td>
<td>-8.5</td>
<td>8.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>U</td>
<td>1.6</td>
<td>2.0</td>
<td>-0.7</td>
<td>0.5</td>
</tr>
<tr>
<td>64</td>
<td>ZIMM</td>
<td>14001M004</td>
<td>4 N</td>
<td>9.2</td>
<td>-7.4</td>
<td>-8.4</td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>E</td>
<td>11.5</td>
<td>-10.0</td>
<td>-9.9</td>
<td>9.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>U</td>
<td>1.9</td>
<td>0.7</td>
<td>-2.7</td>
<td>1.8</td>
</tr>
</tbody>
</table>

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 considered (this will be done in the next step, Section 5.5).
5.4 Compute the Final Solution of the Session

This output may be used to identify problematic daily solutions for individual sessions. They may be excluded from the final ADDNEQ2 solution by listing them in section TYPE 3: STATION PROBLEMS in the station information file ($\{P\}/INTRO/STA/EXAMPLE.STA). All parameters of this station will be pre-eliminated before the normal equations are stacked and, therefore, also before the solution is computed.

5.4 Compute the Final Solution of the Session

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. Repeat the execution of ADDNEQ2 corresponding to Section 5.2. 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.

A troposphere SINEX file may be generated in the final solution by adding an output filename to the “Troposphere SINEX” input field in panel “ADDNEQ2 2: Output Files”.

It is preferable for the velocity estimation to have smaller normal equation files containing only the coordinate parameters for each session. In addition, in order to generate a coordinate SINEX file as the final solution of the day, the troposphere parameters have to be pre-eliminated before the solution is computed. To avoid singularities when writing the SINEX file all station coordinates have to be constrained. 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.
5. Terminal Session: Thursday

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:

### ADDNEQ2: Input Files

**GENERAL FILES**
- Show all general files

**INPUT FILENAMES**
- Normal equations
- Variance recalculating factors
- Station coordinates
- Station velocities
- Station information
- Troposphere estimates
- Ionosphere master file
- Differential code biases
- Earth rotation parameters
- Geocenter coordinates

### ADDNEQ2: Output Files

**GENERAL OUTPUT FILES**
- Program output
- Error messages

**RESULT FILES**
- Normal equations
- SINEX with COV
- Station coordinates
- Station velocities
- Troposphere estimates
- Troposphere SINEX
- Ionosphere models
- IONEX
- Code biases
5.4 Compute the Final Solution of the Session

ADDRESS 3.1: Optimize 1

**TITLE**
Example: Session TVE98+G: Generate NRO with coordinates only

**GENERAL OPTIONS**
- Maximum number of parameters in combined NBO: 1000
- A priori sigma of unit weight: 0.0010 meters
- Compute and compare individual solutions: NO
- Reference epoch for station coordinates: yyyy mm dd

**PARAMETER-RELATED OPTIONS**
- Parameter pre-elimination: ✔
- Change parameter spacing: □
- Set up station velocities: □
- Set up geocenter coordinates: □

ADDRESS 5: Datum Definition for Station Coordinates

**DATUM DEFINITION TYPE**
- Free network solution: ✔
- Minimum constraint solution: FROM FILE
- Coordinates constrained: ALL
- Coordinates fixed: MANUAL

**MINIMUM CONSTRAINT CONDITIONS**
- Translation: NO
- Rotation: NO
- Scale: NO

**A PRIORI SIGMAS**
- North: 0.001 meters
- East: 0.001 meters
- Up: 0.001 meters
The normal equation file (\(\text{nP}/\text{INTRO/SOL/RED02143.NQ0}\)) contains only the station coordinate parameters. The following section of the program output documents the pre-elimination of the troposphere parameters:

![Program output table]

You can also see that the number of parameters in the NQ0–file was dramatically reduced. This is an advantage for the combination of a big number of normal equation files for the estimation of station velocities.
5.5 Velocity Estimation

The velocity estimation in program ADDNEQ2 is easy. Introduce the normal equation files containing only the station coordinate parameters. The normal equation files have to cover a reasonable time interval to reliably estimate velocities (in this case one year):
5. Terminal Session: Thursday

Station velocities are set up by marking the checkbox:

Furthermore we check the repeatability of the daily solutions after the velocity estimation. The coordinates in the resulting file will refer to the epoch 2000 01 01.
5.5 Velocity Estimation

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

![Image of the panel](image1.png)

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

![Image of the panel](image2.png)
5. Terminal Session: Thursday

ADDRESSQ 5.1: Datum Definition for Station Coordinates

STATIONS CONSIDERED FOR MINIMUM CONSTRAINT CONDITIONS
Manual selection
List of stations from file
Stations with specific flags in OBS file

ADDRESSQ 6: Datum Definition for Station Velocities

DATUM DEFINITION TYPE
- Free network solution
- Minimum constraint solution from file
- Velocities constrained
- Velocities fixed

MINIMUM CONSTRAINT CONDITIONS
Translation
Rotation
Scale

A PRIORI S0010
North 0.0001 meters/year
East 0.0001 meters/year
Up 0.0001 meters/year

ADDRESSQ 6.1: Datum Definition for Station Velocities

STATIONS CONSIDERED FOR MINIMUM CONSTRAINT CONDITIONS
Manual selection
List of stations from file
Stations with specific flags in VEL file
After the velocity estimation the repeatability of the coordinates solutions from the individual normal equations looks like:

Below this table all bad daily solutions according to the settings in panel “ADDNEQ2 4: Comparison of Individual Solutions” are summarized. If bad daily solution are detected. In that case we have no additional section and, therefore, no outliers.
If you compare the velocities obtained for the two GPS receivers in Zimmerwald (ZIMJ and ZIMM) you will find small differences:

<table>
<thead>
<tr>
<th>Station name</th>
<th>Typ</th>
<th>A priori value</th>
<th>Estimated value</th>
<th>Correction</th>
<th>RMS error</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZIMJ 14001M006</td>
<td>VX</td>
<td>-0.0129</td>
<td>-0.0154</td>
<td>-0.0025</td>
<td>0.0011</td>
</tr>
<tr>
<td>ZIMJ 14001M006</td>
<td>VY</td>
<td>0.0182</td>
<td>0.0176</td>
<td>-0.0006</td>
<td>0.0004</td>
</tr>
<tr>
<td>ZIMJ 14001M006</td>
<td>VZ</td>
<td>0.0098</td>
<td>0.0104</td>
<td>0.0006</td>
<td>0.0011</td>
</tr>
<tr>
<td>ZIMJ 14001M006</td>
<td>VU</td>
<td>0.0000</td>
<td>-0.0013</td>
<td>-0.0013</td>
<td>0.0015</td>
</tr>
<tr>
<td>ZIMJ 14001M006</td>
<td>VN</td>
<td>0.0143</td>
<td>0.0165</td>
<td>0.0022</td>
<td>0.0004</td>
</tr>
<tr>
<td>ZIMJ 14001M006</td>
<td>VE</td>
<td>0.0197</td>
<td>0.0194</td>
<td>-0.0003</td>
<td>0.0003</td>
</tr>
<tr>
<td>ZIMM 14001M004</td>
<td>VX</td>
<td>-0.0129</td>
<td>-0.0129</td>
<td>-0.0000</td>
<td>0.0010</td>
</tr>
<tr>
<td>ZIMM 14001M004</td>
<td>VY</td>
<td>0.0182</td>
<td>0.0186</td>
<td>0.0004</td>
<td>0.0004</td>
</tr>
<tr>
<td>ZIMM 14001M004</td>
<td>VZ</td>
<td>0.0098</td>
<td>0.0124</td>
<td>0.0026</td>
<td>0.0011</td>
</tr>
<tr>
<td>ZIMM 14001M004</td>
<td>VU</td>
<td>0.0000</td>
<td>0.0020</td>
<td>0.0019</td>
<td>0.0014</td>
</tr>
<tr>
<td>ZIMM 14001M004</td>
<td>VN</td>
<td>0.0143</td>
<td>0.0161</td>
<td>0.0018</td>
<td>0.0004</td>
</tr>
<tr>
<td>ZIMM 14001M004</td>
<td>VE</td>
<td>0.0197</td>
<td>0.0202</td>
<td>0.0004</td>
<td>0.0003</td>
</tr>
</tbody>
</table>

You may constrain the velocity estimates for a pair of sites in the station information file. Copy the original station information file $\{P\}/INTRO/STA/EXAMPLE.STA and add the following line to this copy:

```
TYPE 004: STATION COORDINATES AND VELOCITIES (ADDNEQ)
```

```
<table>
<thead>
<tr>
<th>STATION NAME 1</th>
<th>STATION NAME 2</th>
<th>RELATIVE CONSTR. POSITION</th>
<th>RELATIVE CONSTR. VELOCITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZIMM 14001M004</td>
<td>ZIMJ 14001M006</td>
<td>0.00001</td>
<td>0.00001</td>
</tr>
</tbody>
</table>
```

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

Introducing this modified station information file instead of the original one you will get the following estimates for the station velocities in Zimmerwald:
### 5.5 Velocity Estimation

Station coordinates and velocities:

Reference epoch: 2000-01-01 00:00:00

<table>
<thead>
<tr>
<th>Station name</th>
<th>Typ</th>
<th>A priori value</th>
<th>Estimated value</th>
<th>Correction</th>
<th>RMS error</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZIMJ 14001M006</td>
<td>VX</td>
<td>-0.0129</td>
<td>-0.0141</td>
<td>-0.0012</td>
<td>0.0009</td>
</tr>
<tr>
<td></td>
<td>VY</td>
<td>0.0182</td>
<td>0.0182</td>
<td>-0.0000</td>
<td>0.0003</td>
</tr>
<tr>
<td></td>
<td>VZ</td>
<td>0.0098</td>
<td>0.0115</td>
<td>0.0017</td>
<td>0.0009</td>
</tr>
<tr>
<td></td>
<td>VU</td>
<td>0.0000</td>
<td>0.0004</td>
<td>0.0004</td>
<td>0.0012</td>
</tr>
<tr>
<td></td>
<td>VN</td>
<td>0.0143</td>
<td>0.0163</td>
<td>0.0020</td>
<td>0.0004</td>
</tr>
<tr>
<td></td>
<td>VE</td>
<td>0.0197</td>
<td>0.0198</td>
<td>0.0001</td>
<td>0.0003</td>
</tr>
<tr>
<td>ZIMM 14001M004</td>
<td>VX</td>
<td>-0.0129</td>
<td>-0.0141</td>
<td>-0.0012</td>
<td>0.0009</td>
</tr>
<tr>
<td></td>
<td>VY</td>
<td>0.0182</td>
<td>0.0182</td>
<td>-0.0000</td>
<td>0.0003</td>
</tr>
<tr>
<td></td>
<td>VZ</td>
<td>0.0098</td>
<td>0.0115</td>
<td>0.0017</td>
<td>0.0009</td>
</tr>
<tr>
<td></td>
<td>VU</td>
<td>0.0000</td>
<td>0.0004</td>
<td>0.0004</td>
<td>0.0012</td>
</tr>
<tr>
<td></td>
<td>VN</td>
<td>0.0143</td>
<td>0.0163</td>
<td>0.0020</td>
<td>0.0004</td>
</tr>
<tr>
<td></td>
<td>VE</td>
<td>0.0197</td>
<td>0.0198</td>
<td>0.0001</td>
<td>0.0003</td>
</tr>
</tbody>
</table>

The final results are contained in the files `P/INTRO/STA/FINAL.CRD` and `P/INTRO/STA/FINAL.VEL`.

```
EXAMPLE: Estimate final solution - coordinates and velocities  29-AUG-11 14:39
```

```
LOCAL GEODETIC DATUM: IGS00  EPOCH: 2000-01-01 0:00:00

<table>
<thead>
<tr>
<th>NUM</th>
<th>STATION NAME</th>
<th>X (M)</th>
<th>Y (M)</th>
<th>Z (M)</th>
<th>FLAG</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>BRUS 13101M004</td>
<td>4027893.8381</td>
<td>307045.7406</td>
<td>4919475.0651</td>
<td>A</td>
</tr>
<tr>
<td>15</td>
<td>FFMJ 14279M001</td>
<td>4063465.9398</td>
<td>617729.5776</td>
<td>4868936.6488</td>
<td>A</td>
</tr>
<tr>
<td>36</td>
<td>MATE 12734M008</td>
<td>4641949.6613</td>
<td>1393045.3341</td>
<td>4133287.3894</td>
<td>W</td>
</tr>
<tr>
<td>42</td>
<td>DNSA 10402M004</td>
<td>3370658.6188</td>
<td>711877.0653</td>
<td>5349786.9057</td>
<td>W</td>
</tr>
<tr>
<td>47</td>
<td>PTBB 14234M001</td>
<td>3844060.0434</td>
<td>709661.2312</td>
<td>5023129.4994</td>
<td>A</td>
</tr>
<tr>
<td>56</td>
<td>VILL 13406M001</td>
<td>4849833.7467</td>
<td>-335049.1277</td>
<td>4116014.8662</td>
<td>W</td>
</tr>
<tr>
<td>63</td>
<td>ZIMJ 14001M006</td>
<td>4331294.0069</td>
<td>567542.0459</td>
<td>4653313.6597</td>
<td>A</td>
</tr>
<tr>
<td>64</td>
<td>ZIMM 14001M004</td>
<td>4331297.1400</td>
<td>567555.7887</td>
<td>4633133.8682</td>
<td>A</td>
</tr>
</tbody>
</table>
```

```
EXAMPLE: Estimate final solution - coordinates and velocities  29-AUG-11 14:58
```

```
LOCAL GEODETIC DATUM: IGS00

<table>
<thead>
<tr>
<th>NUM</th>
<th>STATION NAME</th>
<th>VX (M/Y)</th>
<th>VY (M/Y)</th>
<th>VZ (M/Y)</th>
<th>FLAG</th>
<th>PLATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>BRUS 13101M004</td>
<td>-0.0199</td>
<td>0.0174</td>
<td>0.0093</td>
<td>A</td>
<td>EURA</td>
</tr>
<tr>
<td>15</td>
<td>FFMJ 14279M001</td>
<td>-0.0109</td>
<td>0.0165</td>
<td>0.0092</td>
<td>A</td>
<td>EURA</td>
</tr>
<tr>
<td>36</td>
<td>MATE 12734M008</td>
<td>-0.0199</td>
<td>0.0185</td>
<td>0.0126</td>
<td>W</td>
<td>EURA</td>
</tr>
<tr>
<td>42</td>
<td>DNSA 10402M004</td>
<td>-0.0136</td>
<td>0.0154</td>
<td>0.0079</td>
<td>W</td>
<td>EURA</td>
</tr>
<tr>
<td>47</td>
<td>PTBB 14234M001</td>
<td>-0.0185</td>
<td>0.0169</td>
<td>0.0060</td>
<td>A</td>
<td>EURA</td>
</tr>
<tr>
<td>56</td>
<td>VILL 13406M001</td>
<td>-0.0089</td>
<td>0.0210</td>
<td>0.0123</td>
<td>W</td>
<td>EURA</td>
</tr>
<tr>
<td>63</td>
<td>ZIMJ 14001M006</td>
<td>-0.0141</td>
<td>0.0182</td>
<td>0.0115</td>
<td>A</td>
<td>EURA</td>
</tr>
<tr>
<td>64</td>
<td>ZIMM 14001M004</td>
<td>-0.0141</td>
<td>0.0182</td>
<td>0.0115</td>
<td>A</td>
<td>EURA</td>
</tr>
</tbody>
</table>
```
5. Terminal Session: Thursday

5.6 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: FIX02143.OUT, FIX02143.NQ0 (for all sessions),
(2) checked the coordinates of the fiducial sites using ADDNEQ2 and HELMR1, created files: FIN02143.CRD, FIN02143.TRP, FIN02143.OUT, and HELMR1.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 NQ0s, created file: RED02143.NQ0 and RED02143.SNX,
(5) if possible, used ADDNEQ2 for velocity estimation, created files: FINAL.CRD and FINAL.VEL.
6. Terminal Session: Friday

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

If you have finished this work you may compute some special solutions today according to your interest. This document provides some suggestions to practice:

- kinematic positioning for a station,
- zero–difference processing to estimate clocks, or
- use of the Bernese Processing Engine.

6.1 Kinematic Positioning

The example campaign contains no really roving stations. You can, however, define one of them to be kinematic (e.g., station FFMJ). Introduce the coordinates from the final solution ($\{P\}/INTRO/STA/FIN02143.CRD) for all other sites.
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”).
6.1 Kinematic Positioning

Because the number of parameters for the kinematic positioning may become very large we select only a short data interval for this kinematic positioning:
Fix all station coordinates apart from FFMJ in the panels “Datum Definitions for Stations” (choose MANUAL in panel “GPSEST 4” and select all stations except FFMJ in panel “GPSEST 4.2”).

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

Let us assume only horizontal movements for this site:
6.1 Kinematic Positioning

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

<table>
<thead>
<tr>
<th>KINEMATIC COORDINATES:</th>
<th>$(P)/INTRO/STA/KIN02143.KIN</th>
</tr>
</thead>
</table>

EPO: EPOCHS SINCE 2002-05-23 02:00:00 (SAMPLING 300 SEC)

<table>
<thead>
<tr>
<th>EPO</th>
<th>EPOCH(MJD)</th>
<th>#OBS</th>
<th>STA</th>
<th>LATITUDE</th>
<th>LONGITUDE</th>
<th>HEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>FFMJ 14279M001</td>
<td>50 5</td>
<td>26.079481</td>
<td>8 39</td>
<td>53.878622</td>
<td>178.1970</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>52417.083333</td>
<td>21</td>
<td>FFMJ</td>
<td>-0.0297 ++ 0.011</td>
<td>-0.0171 ++ 0.007</td>
<td>-0.0001 ++ 0.001</td>
</tr>
<tr>
<td>2</td>
<td>52417.086806</td>
<td>21</td>
<td>FFMJ</td>
<td>-0.0148 ++ 0.009</td>
<td>-0.0048 ++ 0.006</td>
<td>-0.0000 ++ 0.001</td>
</tr>
<tr>
<td>3</td>
<td>52417.090278</td>
<td>22</td>
<td>FFMJ</td>
<td>-0.0041 ++ 0.009</td>
<td>-0.0059 ++ 0.006</td>
<td>0.0002 ++ 0.001</td>
</tr>
<tr>
<td>4</td>
<td>52417.093750</td>
<td>23</td>
<td>FFMJ</td>
<td>-0.0020 ++ 0.010</td>
<td>-0.0055 ++ 0.007</td>
<td>-0.0001 ++ 0.001</td>
</tr>
<tr>
<td>5</td>
<td>52417.097222</td>
<td>23</td>
<td>FFMJ</td>
<td>-0.0048 ++ 0.012</td>
<td>-0.0014 ++ 0.009</td>
<td>-0.0000 ++ 0.001</td>
</tr>
</tbody>
</table>

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 FFMJ.
- 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 3.2: General Options 2” 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.
- You may also run the pre-processing programs CODSPP and MAUPRP for “kinematic stations”.

In addition you may use the *Bernese GPS Software* with zero-difference observations to obtain kinematic positions. Smoothed code, phase-only, or combined code and phase solutions are possible. Consult the following section on clock estimation for the preprocessing of zero-difference data. Compare the results you generate with the different observation types to get an impression on the accuracy that can be obtained.
6.2 Clock Estimation

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

The preprocessing for zero–difference data starts with program RNXSMT, available in "Menu > RINEX > RINEX utilities > Clean/smooth observation files". In the first panel select all RINEX files of a session. The default input options perform well in most cases:

![Image 1](image1.png)

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):
6.2 Clock Estimation

Because we want to compute clock values in GPSEST with only a sampling of 5 minutes, you can resample the observations already in RXOBV3: set the “Sampling interval” in panel “RXOBV3 2: Input Options 1” to 300 seconds.

Furthermore you have to consider the “SIGNAL STRENGTH REQUIREMENTS” for smoothed RINEX files (see online help):

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 Sec-
6. Terminal Session: Friday

tion 3.3.1. The only difference is that we select CODE for the option “Mark outliers in obs. files” in the last input panel. In this way very bad code observations are excluded from the parameter estimation in program GPSEST.

Now you are ready to run GPSEST in the zero-difference mode. Introduce the estimated coordinates and troposphere parameters from the final solution you have computed for the session. You should also include a DCB file while processing code observations.
### 6.2 Clock Estimation

#### GPEDIT 3.1: General Options 1

<table>
<thead>
<tr>
<th>TITLE</th>
<th>EXAMPLE: Session SYSS+0: Save residuals for clock estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td>TITLES</td>
<td>Satellite system: GPS&lt;br&gt;Frequency: 13&lt;br&gt;Elevation cutoff angle: 5 degrees&lt;br&gt;Sampling interval: 300 seconds&lt;br&gt;Tolerance for simultaneity: 100 milliseconds&lt;br&gt;Special data selection: NO&lt;br&gt;Observation window:</td>
</tr>
<tr>
<td>OBTAINED MODELING AND PARAMETER ESTIMATION</td>
<td>A priori signs: 0.001 meters&lt;br&gt;Elevation-dependent weighting: COSE&lt;br&gt;Type of computed residuals: NORMALIZED&lt;br&gt;Correlation strategy: CORRECT&lt;br&gt;Polarization effect geom.: only if later than</td>
</tr>
</tbody>
</table>
6. Terminal Session: Friday
6.2 Clock Estimation

The residuals are stored in the file \( \{P\}/\text{INTRO/OUT/CLK02143.RES} \). Use program RESRMS 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):

![Bernese GPS Software Version 5.0](image)

![Bernese GPS Software Version 5.0](image)
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Mark the corresponding observations using program SATMRK and repeat the GPSEST-run. In the second iteration we screen for residuals bigger than 6 mm in RESRMS and mark these observations with SATMRK, too. Repeat the run of GPSEST a third time to get the definitive clock estimates. Specify a “Clock RINEX” file (e.g., CLK$YD+0) in the panel “GPSEST 2.1: Output Files 1”.

The clock solution is finalized by selecting the reference clock using program CCRNXC (“Menu >RINEX>RINEX_Utilities>Combine/manipulate clock data”):
6.2 Clock Estimation

### CLOCK RINEX FILE OFFSET ESTIMATION

- Use all station clocks
- Use all satellite clocks
- 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: COMBINATION
- Maximum deviation from mean: 5 nanoseconds
- Minimum number of valid clocks for mean:
  - 1 for stations
  - 2 for satellites
- Compute sigmas in resulting clock RINEX file from:

### REFERENCE CLOCK SELECTION

- Select a new reference clock for the output file
- Retain the reference clock from an input file

### ENABLE OTHER PROGRAM FUNCTIONS

- Enable clock jump detection
- Enable extrapolation

### PROGRAM OUTPUT 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
- Statictics about the resulting clocks
- Sort order for clock statistics: SIGMA
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**CURREC 5: Select a New Reference Clock for Output Files**

**REFERENCE CLOCK SELECTION**
- Selection of potential reference clocks: ALL STATIONS
- Manual selection for stations
- satellites
- Get list from file for stations: files
- satellites: files

**ALIGNMENT OF NEW REFERENCE CLOCK**
- Polynomial degree for alignment: 1
- Maximum allowed RMS error for alignment: nanoseconds

**CURREC 6: Options for Clock Jump Detection**

**CLOCK JUMP DETECTION**
- Confidence interval: 5 ± signs
- Minimum RMS for jump detection: 1 nanosecond/360 seconds

**CLOCK JUMP OR OUTLIER**
- Maximum time interval for outlier detection: 5 ± epochs
- Remove outliers from output for stations
- satellites

**CLOCK JUMP VERIFICATION**
- Enable the clock jump verification
- Polynomial degree for jump size estimation: 10 ±
The table at the end of the program output provides an overview of the clock quality:

```
...  
REFERENCE CLOCK SELECTION FOR OUTPUT FILE  
-----------------------------------------  
Selected reference station: MATE 12734M008  
...  
STATISTICS ON THE CLOCKS IN THE OUTPUT FILE  
-------------------------------------------  
# per file rms of poly. fit (ns)  
Clock name out 001 n = 0 n = 1 n = 2  
MATE 12734M008 288 288 57.544 0.000 0.000  
GNSA 10402M004 288 288 36.042 0.100 0.093  
PTBB 14234M001 288 288 1.223 0.138 0.072  
BRUS 13101M004 278 278 2.488 1.396 1.355  
VILL 13406M001 288 288 24.142 23.310 18.686  
FFMJ 14279M001 281 281 0.3E+06 0.3E+06 0.3E+06  
ZIMJ 14001M006 169 169 0.3E+06 0.3E+06 0.3E+06  
ZIMM 14001M004 288 288 0.3E+06 0.3E+06 0.3E+06  
G20 80 80 19.862 0.159 0.160  
G14 106 106 19.862 0.159 0.160  
...  
```  

Further suggestions:

- 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., final IGS products or final CODE solution).

- Switch the “Var-covar wrt epoch parameters” in panel “GPSEST 3.2: General Options 2” from SIMPLIFIED to CORRECT.

- Make a PPP for one of the stations included in the network and compare the obtained clock corrections with the estimates from the network solution generated before. You may either use the IGS clocks (extract the satellite clocks from the clock RINEX files in the OUT-directory of your campaign using the program CCRNXC) or the satellite clock estimates from your network solution (specify a “Bernese satellite clock file” in the “RESULT FILES” section of the panel “CCRNXC 1: Filenames”).

### 6.3 Bernese Processing Engine

It is possible to run one of the example BPEs provided with the distribution. They are installed in your user environment and the data are available, too. In detail these are:

1. **PPP.PCF** — Precise Point Positioning
2. **RNX2SNX.PCF** — Generate a SINEX file starting with GNSS RINEX observation files
3. **CLKDET.PCF** — Estimate station and satellite clocks
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The reference files for the solution are also available in your campaign directories.

Be aware that some of the files you have generated in the previous terminal sessions may be overwritten.

Even if it is simple to run a BPE: please, do not run all BPEs for all sessions. First it is rather boring to look at the screen with a BPE running and, secondly, we like to avoid to overload the CPUs. Running one example for one session with the BPE should be enough to get the BPE output files.

Select first the session for which you want to run the BPE (e.g., day 143 of year 2002). To start the BPE use "Menu>BPE>Start BPE process":

---

BPE 1: Client Environment/Session Selection

CLIENT FILES/ENVIRONMENT
- Client script: $(BPE)/RUNBPE.pn
- Client's environment file: $(B1)/EE/LOADBPE_setenv

MENU SETTINGS
- Campaign: $(P)/INTRO
- Session table: $(P)/INTRO/STA/SESSIONS.SES

SESSION PROCESSING OPTIONS
- Start processing
- Year: 2002
- Session: 143
- Number of sessions to be processed: 1
- Run sessions in parallel:
- Continue with next session in case of error:

---

BPE 2: Process Control Options

CPU CONTROL
- CPU control file: USER CPU
- Check for free CPU every: 10 seconds

BPE TASK SELECTION
- Process control file: PPP CPU
- Start with script:
- Skip scripts:

OUTPUT OPTIONS
- Report server/client communication:
- Do not remove temporary user environment:

---
In addition, we suggest becoming familiar with the structure and the functionality of the BPE in this terminal session, e.g.,

- by reading the header information of the PCF files,
- by viewing the user scripts of the example BPE that can be used as modules for your own BPE at home, or
- by studying the BPE output files.
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