



# Bernese GPS Software Version 5.0

Tutorial

Processing Example  
Introductory Course  
Terminal Session

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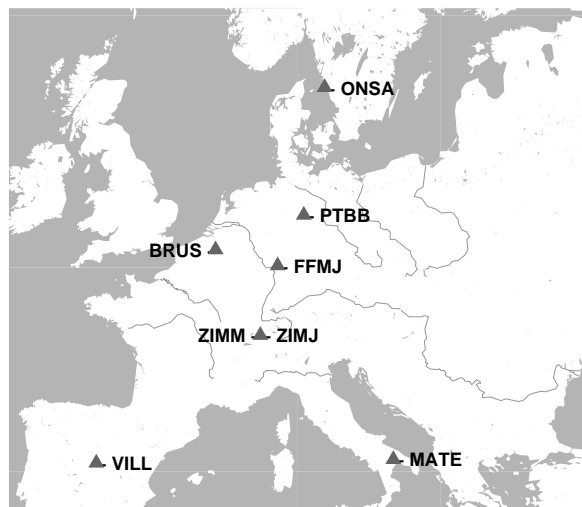
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# 1. Introduction to the Example Campaign

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).



**Figure 1.1:** Stations used in example campaign

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.

| Station name   | Location                  | Receiver type   | Antenna type   | Radome | Antenna height |
|----------------|---------------------------|-----------------|----------------|--------|----------------|
| BRUS 13101M004 | Brussels, Belgium         | ASHTECH Z-XII3T | ASH701945B_M   | NONE   | 3.9702 m       |
| FFMJ 14279M001 | Frankfurt (Main), Germany | JPS LEGACY      | JPSREGANT_SD_E | NONE   | 0.0000 m       |
| MATE 12734M008 | Matera, Italy             | TRIMBLE 4000SSI | TRM29659.00    | NONE   | 0.1010 m       |
| ONSA 10402M004 | Onsala, Sweden            | ASHTECH Z-XII3  | AOAD/M_B       | OSOD   | 0.9950 m       |
| PTBB 14234M001 | Braunschweig, Germany     | ASHTECH Z-XII3T | ASH700936E     | SNOW   | 0.0562 m       |
| VILL 13406M001 | Villafranca, Spain        | ASHTECH Z-XII3  | AOAD/M_T       | NONE   | 0.0437 m       |
| ZIMJ 14001M006 | Zimmerwald, Switzerland   | JPS LEGACY      | JPSREGANT_SD_E | NONE   | 0.0770 m       |
| ZIMM 14001M004 | Zimmerwald, Switzerland   | TRIMBLE 4000SSI | TRM29659.00    | NONE   | 0.0000 m       |

## 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 `G`<sup>1</sup>.

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

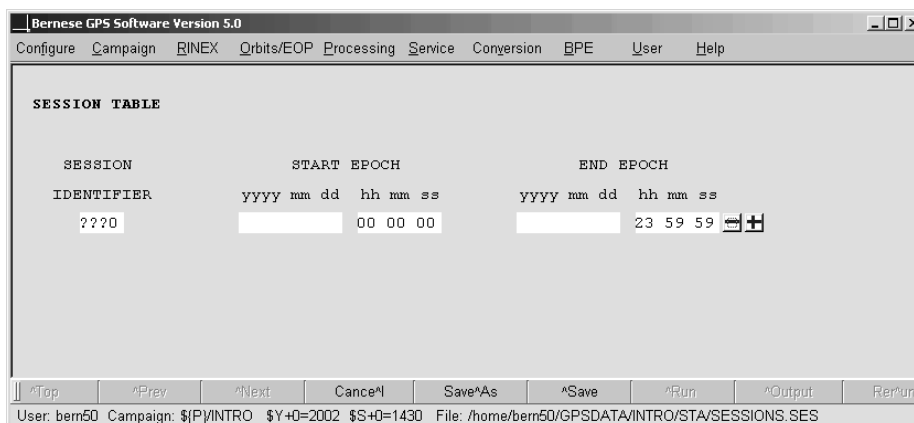
Select "Menu>Campaign>Edit session table" to check the session table. It is recommended to use the wildcard string `????` for the "SESSion identifier" in panel "SESSION TABLE". The panel below shows the session definition for a typical permanent campaign with 24-hours sessions. The setup of the session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

---

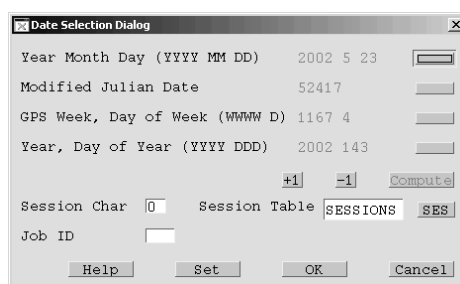
<sup>1</sup>At the exercise terminals the Bernese environment is loaded automatically during the login. At home you have to source the file `/${X}/EXE/LOADGPS.setvar` on UNIX-platforms either manually or during the login.

## 2. Terminal Session: Monday

---



Save the session table (press the `^Save` button) and open the "Date Selection Dialogue" the "`Menu>Configure>Set session/compute date`" 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):

|                     |  |  |  |  |
|---------------------|--|--|--|--|
| $\${P}$ /INTRO/ATM/ | COD11674.ION   | COD11675.ION   | COD12190.ION   | COD12191.ION   |
| $\${P}$ /INTRO/GEN/ | DATUM.<br>IONEX.PPP<br>PHAS_IGS.REL<br>RECEIVER.<br>SAT_2002.CRX<br>SAT_2003.CRX<br>SATELLIT.<br>SINEX.PPP<br>SINEX.RNX2SNX  | PHAS_COD.I01   | PHAS_COD.I05   |  |
| $\${P}$ /INTRO/OBS/ |  |  |  |  |
| $\${P}$ /INTRO/ORB/ | BULLET_A.ERP<br>CODE0205.DCB<br>IGS11674.PRE<br>IGS11677.IEP<br>P1C10205.DCB<br>P1P20205.DCB   | IGS11675.PRE   | CODE0305.DCB<br>IGS12190.PRE<br>IGS12197.IEP<br>P1C10305.DCB<br>P1P20305.DCB   | IGS12191.PRE   |
| $\${P}$ /INTRO/ORX/ | BRUS1430.020<br>FFMJ1430.020<br>MATE1430.020<br>ONSA1430.020<br>PTBB1430.020<br>VILL1430.020<br>ZIMJ1430.020<br>ZIMM1430.020<br>BRDC1430.02N<br>IFAG1430.02N<br>MATE1430.02N<br>VILL1430.02N<br>ZIMJ1430.02N | BRUS1440.020<br>FFMJ1440.020<br>MATE1440.020<br>ONSA1440.020<br>PTBB1440.020<br>VILL1440.020<br>ZIMJ1440.020<br>ZIMM1440.020<br>BRDC1440.02N<br>IFAG1440.02N<br>MATE1440.02N<br>VILL1440.02N<br>ZIMJ1440.02N | BRUS1380.030<br>FFMJ1380.030<br>MATE1380.030<br>ONSA1380.030<br>PTBB1380.030<br>VILL1380.030<br>ZIMJ1380.030<br>ZIMM1380.030<br>BRDC1380.03N<br>IFAG1380.03N<br>MATE1380.03N<br>VILL1380.03N<br>ZIMJ1380.03N | BRUS1390.030<br>FFMJ1390.030<br>MATE1390.030<br>ONSA1390.030<br>PTBB1390.030<br>VILL1390.030<br>ZIMJ1390.030<br>ZIMM1390.030<br>BRDC1390.03N<br>IFAG1390.03N<br>MATE1390.03N<br>VILL1390.03N<br>ZIMJ1390.03N |
| $\${P}$ /INTRO/OUT/ | IGS11674.CLK   | IGS11675.CLK   | IGS12190.CLK   | IGS12191.CLK   |
| $\${P}$ /INTRO/RAW/ |  |  |  |  |
| $\${P}$ /INTRO/SOL/ |  |  |  |  |
| $\${P}$ /INTRO/STA/ | EXAMPLE.BLQ<br>EXAMPLE.PLD<br>EXAMPLE.STA<br>IGS_00_R.CRD<br>SESSIONS.SES  | IGS_00_R.VEL   | IGS_00.FIX   |  |
| $\${P}$ /INTRO/TXT/ | COD11677.SUM<br>IGS11677.SUM   |  | COD12197.SUM<br>IGS12197.SUM   |  |

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):

## 2. Terminal Session: Monday

---

```

${P}/INTRO/ATM/  RIM021430.INX_REF  RIM021440.INX_REF  RIM031380.INX_REF  RIM031390.INX_REF
${P}/INTRO/GEN/
${P}/INTRO/OBS/
${P}/INTRO/ORB/
${P}/INTRO/ORX/
${P}/INTRO/OUT/  PPP021430.PRC_REF  PPP021440.PRC_REF  PPP031380.PRC_REF  PPP031390.PRC_REF
                  PPP021430.CLK_REF  PPP021440.CLK_REF  PPP031380.CLK_REF  PPP031390.CLK_REF
                  PPP021430.OUT_REF  PPP021440.OUT_REF  PPP031380.OUT_REF  PPP031390.OUT_REF
${P}/INTRO/RAW/
${P}/INTRO/SOL/
${P}/INTRO/STA/  EXAMPLE.ABB_REF
                  IGS_00.CRD_REF      IGS_00.VEL_REF
                  PPP021430.CRD_REF  PPP021440.CRD_REF  PPP031380.CRD_REF  PPP031390.CRD_REF
                  REF021430.CRD_REF  REF021440.CRD_REF  REF031380.CRD_REF  REF031390.CRD_REF
${P}/INTRO/TXT/

```

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:

```

${P}/INTRO/ATM/  F1_021430.TRP_REF  F1_021440.TRP_REF  F1_031380.TRP_REF  F1_031390.TRP_REF
${P}/INTRO/GEN/
${P}/INTRO/OBS/
${P}/INTRO/ORB/
${P}/INTRO/ORX/
${P}/INTRO/OUT/  R2S021430.PRC_REF  R2S021440.PRC_REF  R2S031380.PRC_REF  R2S031390.PRC_REF
                  F1_021430.OUT_REF  F1_021440.OUT_REF  F1_031380.OUT_REF  F1_031390.OUT_REF
${P}/INTRO/RAW/
${P}/INTRO/SOL/  F1_021430.SNX_REF  F1_021440.SNX_REF  F1_031380.SNX_REF  F1_031390.SNX_REF
${P}/INTRO/STA/  F1_021430.CRD_REF  F1_021440.CRD_REF  F1_031380.CRD_REF  F1_031390.CRD_REF
${P}/INTRO/TXT/

```

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:

```

${P}/INTRO/ATM/
${P}/INTRO/GEN/
${P}/INTRO/OBS/
${P}/INTRO/ORB/  TT_021430.CLK_REF  TT_021440.CLK_REF  TT_031380.CLK_REF  TT_031390.CLK_REF
${P}/INTRO/ORX/
${P}/INTRO/OUT/  CLK021430.PRC_REF  CLK021440.PRC_REF  CLK031380.PRC_REF  CLK031390.PRC_REF
                  TT_021430.CLK_REF  TT_021440.CLK_REF  TT_031380.CLK_REF  TT_031390.CLK_REF
                  TTG021430.OUT_REF  TTG021440.OUT_REF  TTG031380.OUT_REF  TTG031390.OUT_REF
${P}/INTRO/RAW/
${P}/INTRO/SOL/
${P}/INTRO/STA/
${P}/INTRO/TXT/

```

## 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.

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

| Filename  | Content   | Modification   | Download |
|---|---|--|----------|
| CONST.  | All constants used in the <i>Bernese GPS Software</i>                                   | No   | BSW aftp |
| DATUM.  | Definition of geodetic datum  | Introducing new reference ellipsoid                            | BSW aftp |
| RECEIVER.   | Receiver information  | Introducing new receiver type                                  | BSW aftp |
| PHAS_COD.I01                                      | Phase center eccentricities and variations including radome codes                       | Introducing new elevation-dependent corrections<br>New antenna | BSW aftp |
| SATELLIT.I01                                      | Satellite information file  | New launched satellites  | BSW aftp |
| SAT_\$Y+0.CRX                                     | Satellite problems  | Satellite maneuvers, bad data, ...                             | BSW aftp |
| GPSUTC.   | Leap seconds  | When a new leap second is announced by the IERS                | BSW aftp |
| IAU2000.NUT                                       | Nutation model coefficients   | No   | —        |
| IERS2000.SUB                                      | Subdaily pole model coefficients  | No   | —        |
| POLOFF.   | Pole offset coefficients  | Introducing new values from IERS annual report (until 1997)    | —        |
| JGM3.   | Earth potential coefficients  | No   | —        |
| OT_CSRC.TID                                       | Ocean tides coefficients  | No   | —        |
| SINEX.<br>SINEX.TRO<br>SINEX.PPP<br>SINEX.RNX2SNX | SINEX header information<br>... for the PPP example<br>... for the double-diff. example | Adapt SINEX header for your institution                        | —        |
| IONEX.<br>IONEX.PPP                               | IONEX header information<br>... for the PPP example                                     | Adapt IONEX header for your institution                        | —        |

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 `*.$Y0` (`$Y` is the menu time variable for the two-digit year of the current session) are used for all examples. The navigation messages `*.$YN` 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 `IGS_00.CRD`. It was generated using the PPP example for day 143 of year 2002. It contains all IGS core sites (copied from file `IGS_00_R.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 `IGS_00.VEL` contains the velocities for the core sites (copied from file `IGS_00.R.VEL`) completed by the NNR-NUVEL1A velocities for the other stations. The assignment of stations to tectonic plates is given in the file `EXAMPLE.PLD`. The file `IGS_00.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>Campaign>Edit station files").

To make sure that you process the data in the *Bernese GPS Software* with correct station information (station name, receiver type, antenna type, antenna height, etc.) the file `EXAMPLE.STA` is used to verify the RINEX header information. The reason to use this file has to be seen in the 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 `PHAS_COD.I01` in order that the correct phase center offsets and variations are used. The receiver types have to be defined in the `RECEIVER.` file to correctly apply the DCB corrections.

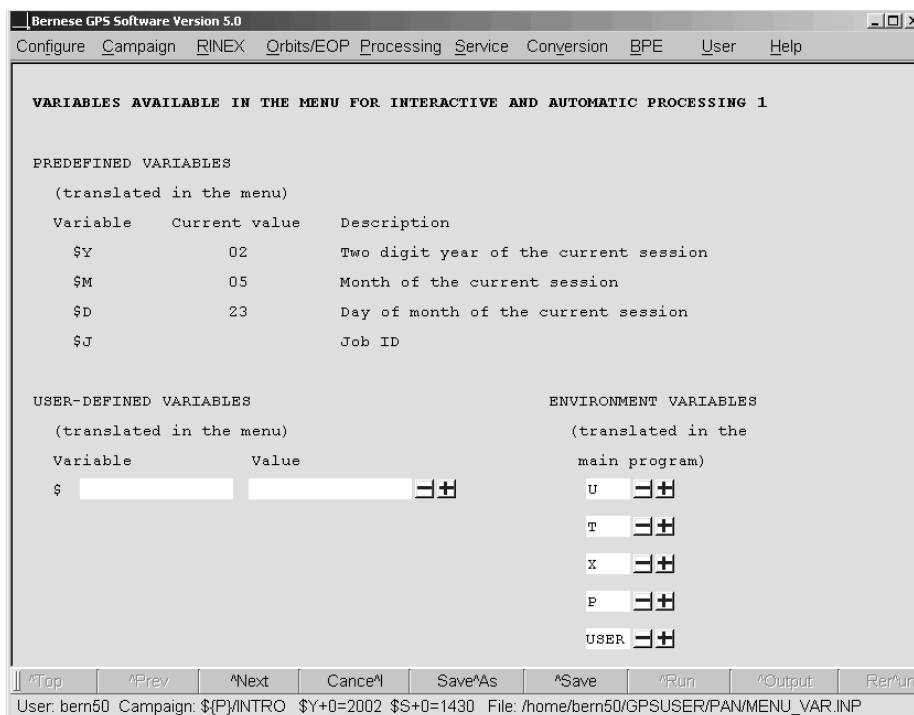
The last file to be mentioned in this list is `EXAMPLE.BLQ`. It provides the coefficients for the ocean tidal loading of the stations to be processed. It has to be applied at least in the final run of `GPSEST`.

## 2.5 Menu Variables

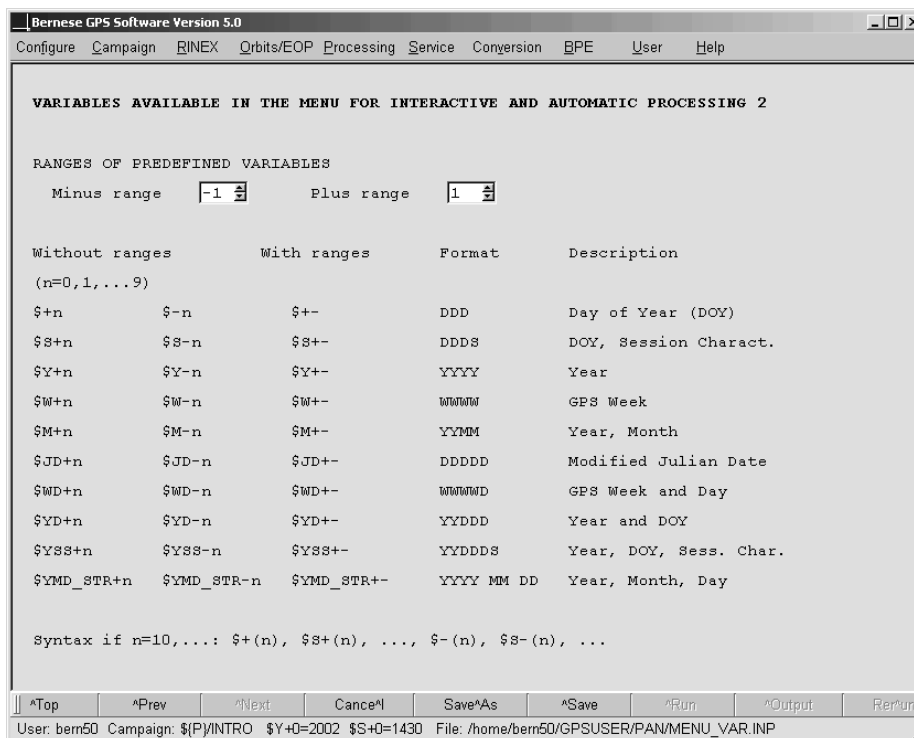
When processing GNSS data, it is often necessary to repeat a program run several times with only slightly different option settings. A typical example would be the processing of several sessions of data. The names of observation files change from session to session because the session number is typically 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 `#{U}/PAN/MENU_VAR.INP` that is accessible through "Menu>Configure>Menu variables". Three kinds of menu-variables are available: predefined variables (also called menu time variables), user-defined variables, and system environment variables.

The use of system environment variables is necessary to generate the complete path to the files used in the *Bernese GPS Software*. The campaign data are located in the directory `#{P}/INTRO=/aiub_u_camp/INTRO`. The user-dependent files can be found at `#{U}=/u/aiub/bern50/GPSUSER` — note, that you will find instead of `bern50` your user name in the path. The temporary user files are saved in `#{T}=/scratch/bern50`. Finally, the campaign-independent files reside in `#{X}=/aiub_sw/BERN50/GPS`.

## 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:



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

## 2. Terminal Session: Monday

---

```
=====
Program : coovel                               Bernese GPS Software Version 5.0
Purpose : Propagation of coordinates with a given velocity field
Campaign: ${P}/INTRO                           Default session: 1430 year 2002
Date    : 26-Aug-2011 13:35                    User name      : bern50
=====

EXAMPLE: Session 021430: Coordinate propagation
-----

INPUT AND OUTPUT FILENAMES
-----

Session table           : ${P}/INTRO/STA/SESSIONS.SES
Input coordinate file   : ${P}/INTRO/STA/IGS_00.CRD
Output coordinate file  : ${P}/INTRO/STA/APRO2143.CRD
Input velocity file     : ${P}/INTRO/STA/IGS_00.VEL
Program output          : ${P}/INTRO/OUT/COOVEL.LOO
Error message           : ${U}/WORK/ERROR.MSG
-----
...

```

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 ( $\${P}/INTRO/STA/APRO2143.CRD$ ) 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):

| IGS00 COORDINATES BASED ON IGS01P37_RS54.SNX |                |              |                           |              | 29-JUN-03 |
|--|----------------|--------------|---------------------------|--------------|-----------|
| LOCAL GEODETIC DATUM: IGS00                  |                |              | EPOCH: 2002-05-23 0:00:00 |              |           |
| NUM  | STATION NAME   | X (M)        | Y (M)                     | Z (M)        | FLAG      |
| 6  | BRUS 13101M004 | 4027893.7773 | 307045.7760               | 4919475.0809 | PPP       |
| 15   | FFMJ 14279M001 | 4053455.9006 | 617729.6193               | 4869395.6681 | PPP       |
| 36   | MATE 12734M008 | 4641949.6104 | 1393045.3794              | 4133287.4177 | IGS00     |
| 42   | ONSA 10402M004 | 3370658.5806 | 711877.1009               | 5349786.9189 | IGS00     |
| 47   | PTBB 14234M001 | 3844059.9795 | 709661.2696               | 5023129.5003 | PPP       |
| 56   | VILL 13406M001 | 4849833.7343 | -335049.0774              | 4116014.9013 | IGS00     |
| 63   | ZIMJ 14001M006 | 4331293.9550 | 567542.0890               | 4633135.6788 | PPP       |
| 64   | ZIMM 14001M004 | 4331297.0935 | 567555.8333               | 4633133.8919 | PPP       |

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 **Rerun** 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.

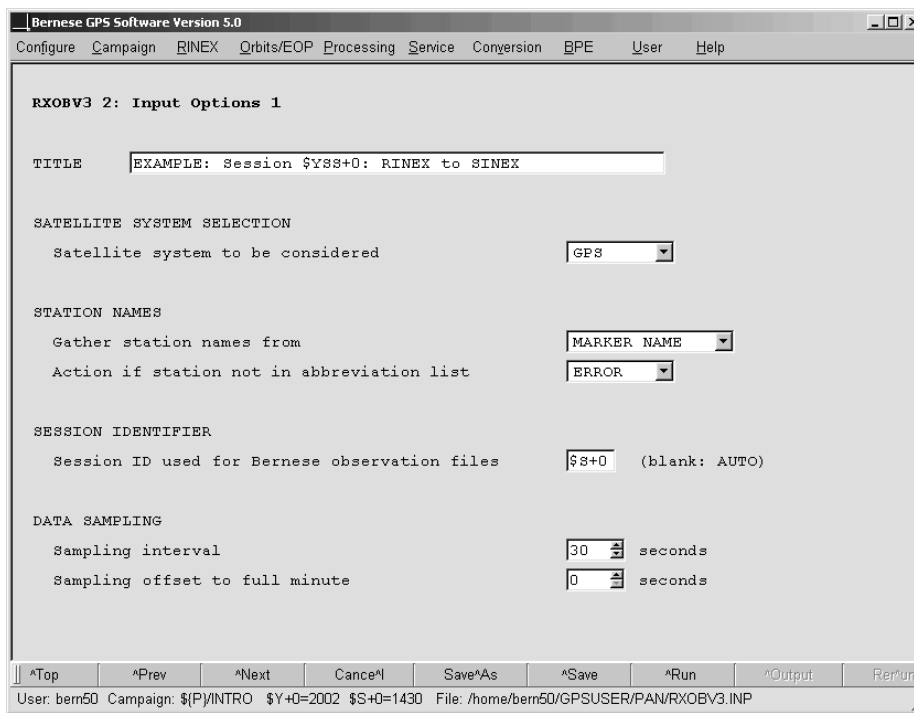
Importing the RINEX observation files is the task of the program RXOBV3 in "Menu>RINEX >Import RINEX to Bernese format>Observation files" (we do not use the RINEX navigation files for this processing example). You need to run this program for all 4 sessions of the example.

All RINEX observation files fitting  $\${P}/INTRO/RAW/????1430.020$  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 020). 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 030.

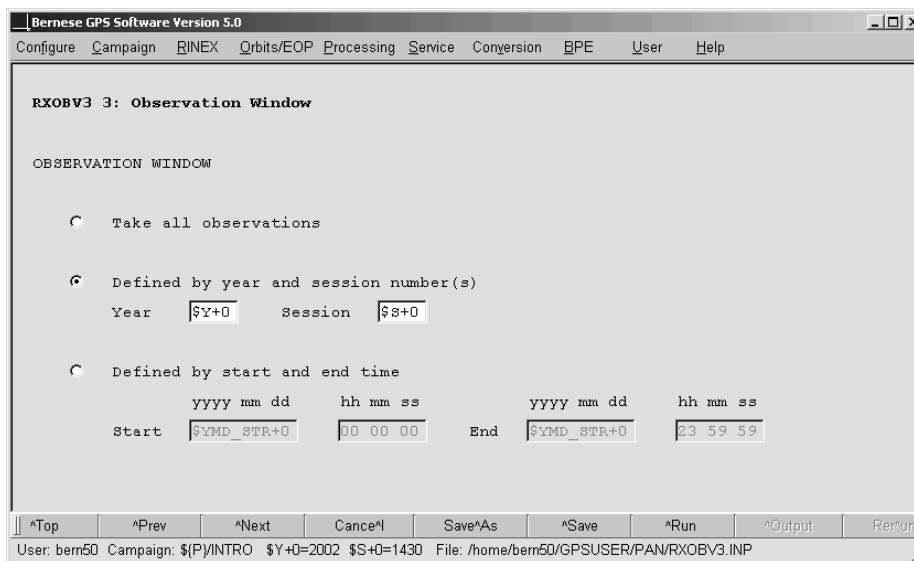
## 2. Terminal Session: Monday

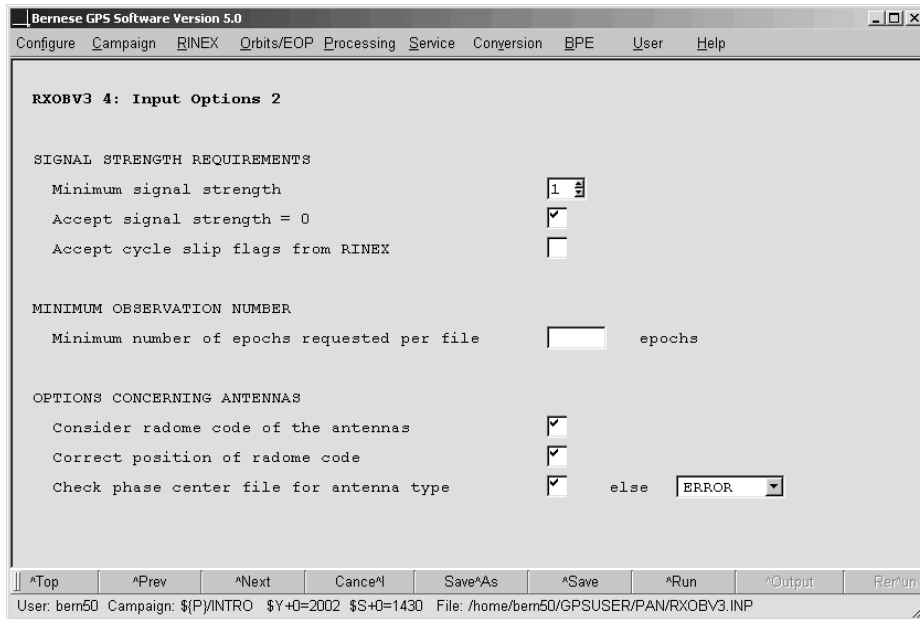
---

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:

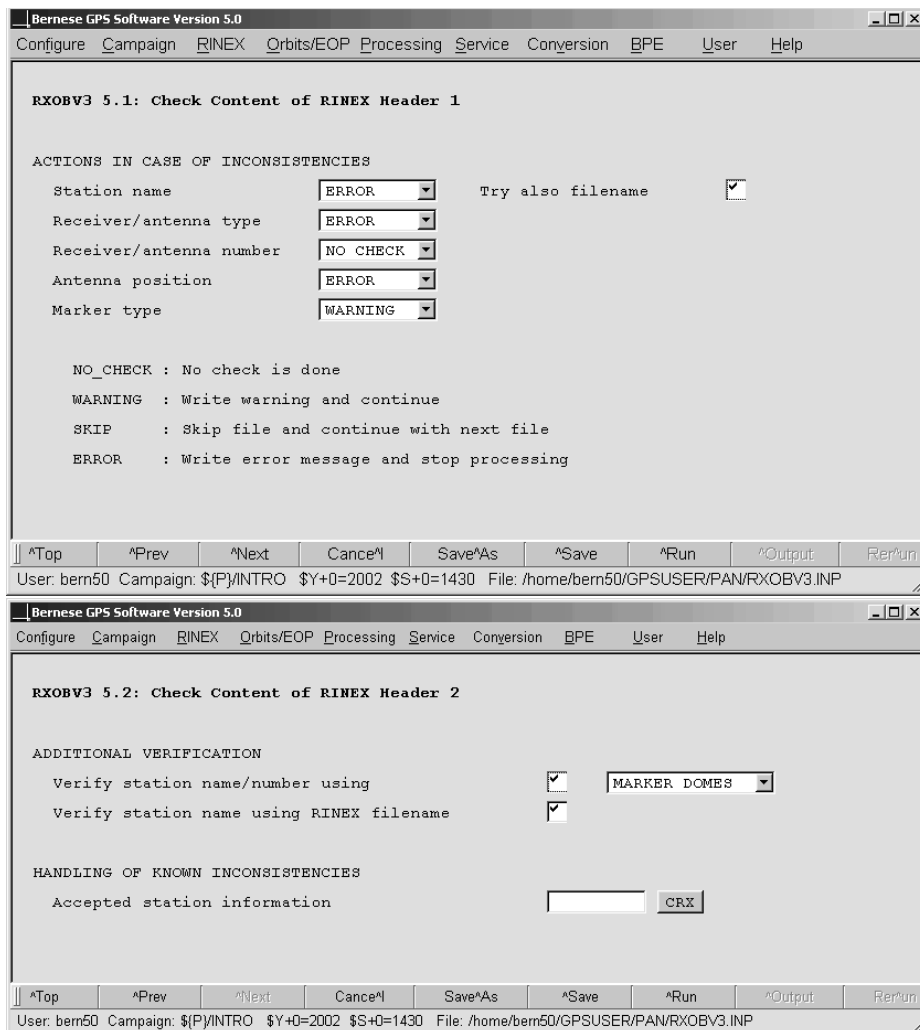


We select GPS for the option “Satellite system to be considered” because the IGS orbits provide only the positions of the GPS satellites.





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/FFMJ1430.020

SR R2RDOR: SATELLITES SKIPPED! SYSTEM: "R"

### PG RXOBV3: OBSERVATION DATA FROM OTHER SATELLITE SYSTEM REJECTED
              RINEX FILE NAME: ${P}/INTRO/RAW/ZIMJ1430.020
```

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:
-----
```

| Num | Rinex file name                           | Bernese code header file name             | #epo | ... |
|-----|---|---|------|-----|
|     |   | Bernese code observ. file name            |      |     |
|     |   | Bernese phase header file name            | #epo | ... |
|     |   | Bernese phase observ. file name           |      |     |
| 1   | <code>\${P}/INTRO/RAW/BRUS1430.020</code> | <code>\${P}/INTRO/OBS/BRUS1430.CZH</code> | 2778 | ... |
|     |   | <code>\${P}/INTRO/OBS/BRUS1430.CZO</code> |      |     |
|     |   | <code>\${P}/INTRO/OBS/BRUS1430.PZH</code> | 2778 | ... |
|     |   | <code>\${P}/INTRO/OBS/BRUS1430.PZO</code> |      |     |
| 2   | <code>\${P}/INTRO/RAW/FFMJ1430.020</code> | <code>\${P}/INTRO/OBS/FFMJ1430.CZH</code> | 2799 | ... |
|     |   | <code>\${P}/INTRO/OBS/FFMJ1430.CZO</code> |      |     |
|     |   | <code>\${P}/INTRO/OBS/FFMJ1430.PZH</code> | 2799 | ... |
|     |   | <code>\${P}/INTRO/OBS/FFMJ1430.PZO</code> |      |     |
| 3   | <code>\${P}/INTRO/RAW/MATE1430.020</code> | <code>\${P}/INTRO/OBS/MATE1430.CZH</code> | 2880 | ... |
|     |   | <code>\${P}/INTRO/OBS/MATE1430.CZO</code> |      |     |
|     |   | <code>\${P}/INTRO/OBS/MATE1430.PZH</code> | 2880 | ... |
|     |   | <code>\${P}/INTRO/OBS/MATE1430.PZO</code> |      |     |

```
...
```

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 APRO2143.CRD, APRO2144.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.*



## 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>**Q**rbits/EOP>Handle EOP files>Convert IERS to **B**ernese format") which is also able to update the EOP records to an existing file.

### 3. Terminal Session: Tuesday

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Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help

---

**EXTRACT BERNESE POLE FILE FROM IERS FILE - POLUPD 1: Input/Output Files**

GENERAL FILES

Show all general files

INPUT FILES

Bernese formatted ERP files  **ERP**

Foreign formatted ERP files  **IEP**

RESULT FILE

Resulting Bernese formatted ERP file  **ERP**

GENERAL OUTPUT FILES

Program output  use POLUPD.Lnn or  **OUT**

Error messages  merged to program output or  **MSG**

---

**^Top ^Prev ^Next Cancel Save\*As ^Save ^Run ^Output Rerun**

User: bern50 Campaign: \${P}/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/POLUPD.INP

---

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---

**POLUPD 1.1: General Files**

GENERAL INPUT FILES

Pole offset coefficients  **---**

GPS-UTC seconds  **---**

MENU SETTINGS

Selected campaign

Selected session year 2002 session 1430

Session table

---

**^Top ^Prev ^Next Cancel Save\*As ^Save ^Run ^Output Rerun**

User: bern50 Campaign: \${P}/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/POLUPD.INP

---

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---

**POLUPD 2: Options**

HEADER INFORMATION

Title

Nutation model  **NUT**

Subdaily pole model  **SUB**

BULLETIN B AS INPUT

Use 1 or 5 day values

USE ERP RATES

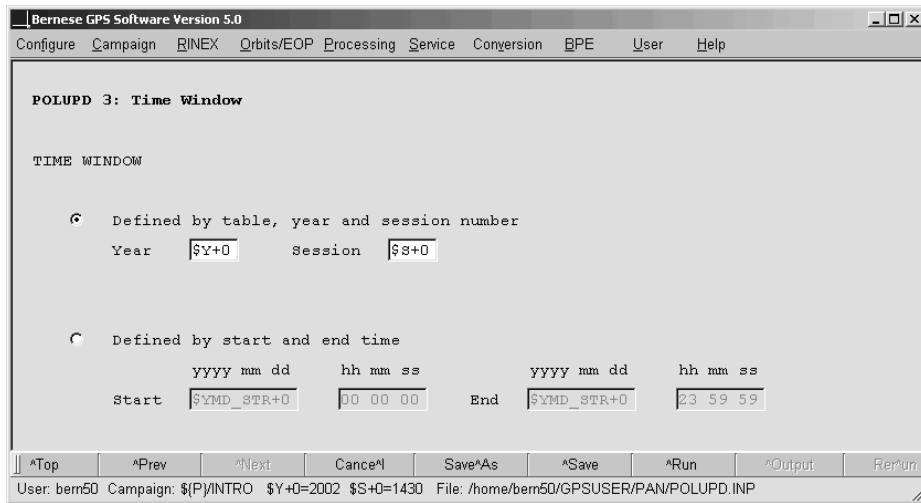
INCLUDE NUTATION OFFSETS

USE TIME WINDOW

---

**^Top ^Prev ^Next Cancel Save\*As ^Save ^Run ^Output Rerun**

User: bern50 Campaign: \${P}/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/POLUPD.INP



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

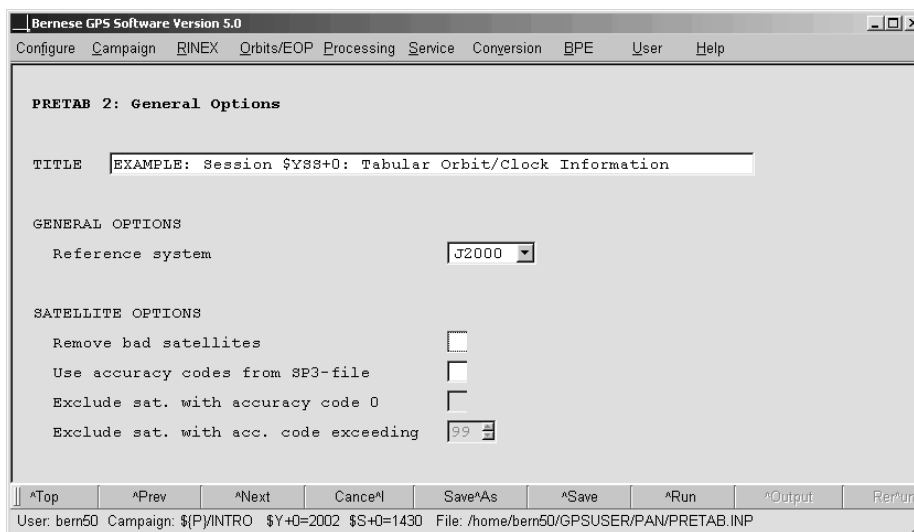
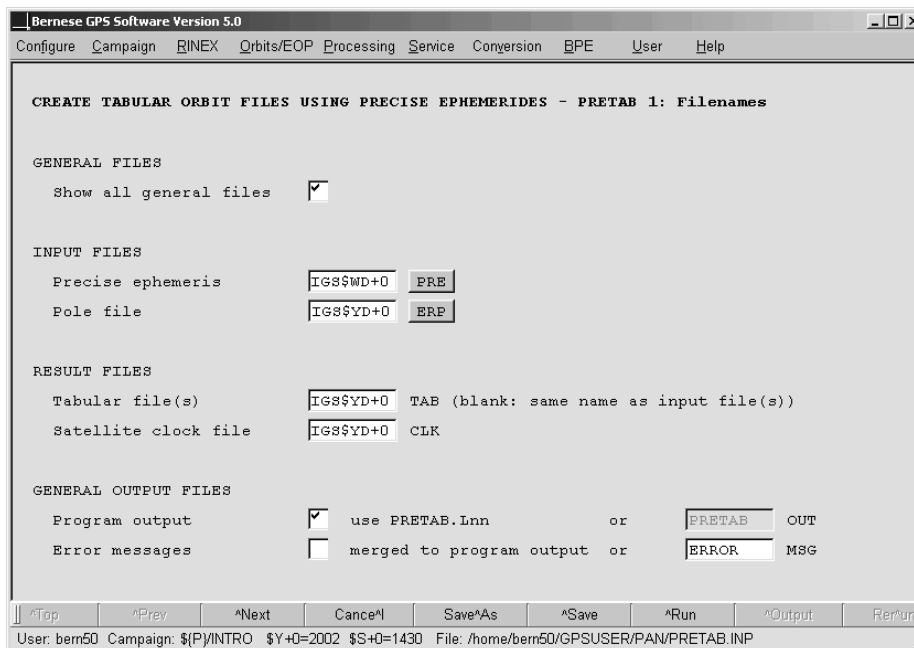
```

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

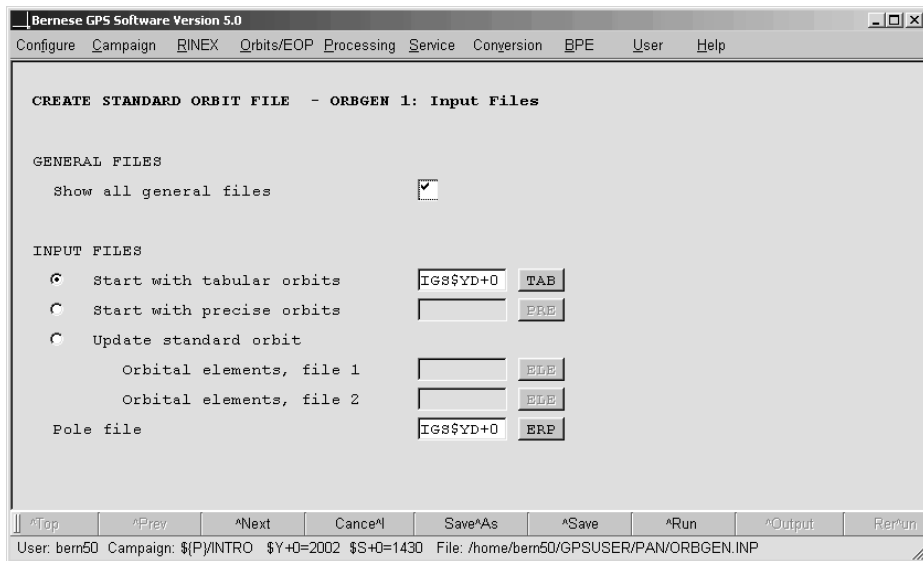
In this processing example we use only two programs of the orbit part of the *Bernese GPS Software*. The first program is called PRETAB and may be accessed using "Menu>Orbits/EOP >Create tabular orbits". The main task of PRETAB is to create tabular orbit files (TAB) (i.e., to transform the precise orbits from the terrestrial into the celestial reference frame) and to generate a satellite clock file (CLK). The clock file will be needed in program CODSP (see Section 3.3.1) if no broadcast orbits are used.

### 3. Terminal Session: Tuesday

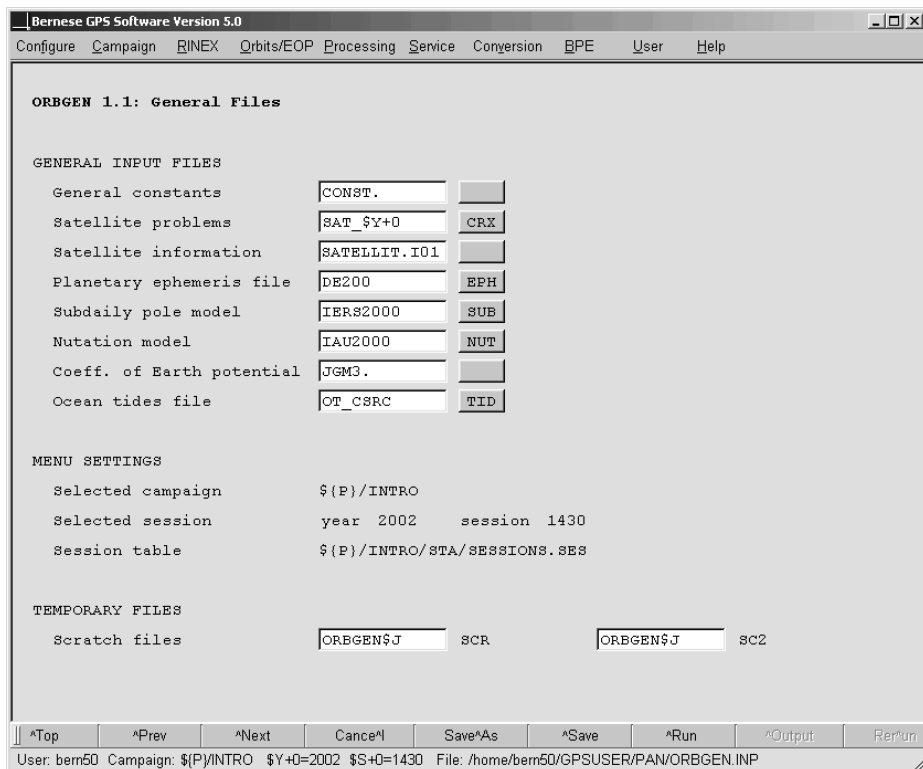


Panel “PRETAB 3: Options for Clocks” contains the options for extracting the satellite clock information. The clock values in the precise orbit file are sampled to 15 min. We interpolate with a “Polynomial degree” of 2 with an “Interval for polynomials” of 12 hours. This is good enough for the receiver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

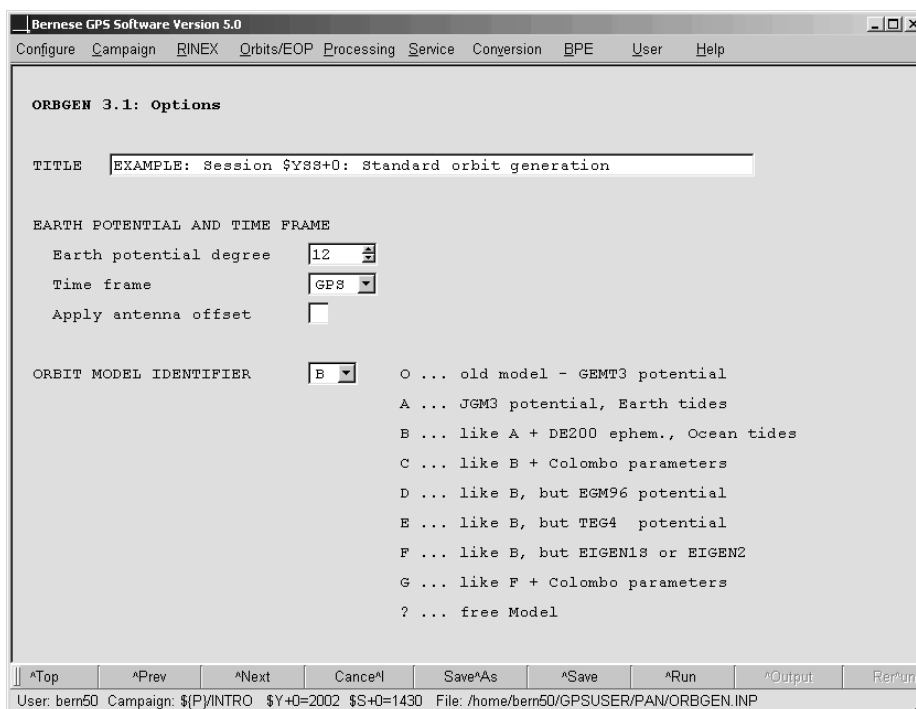
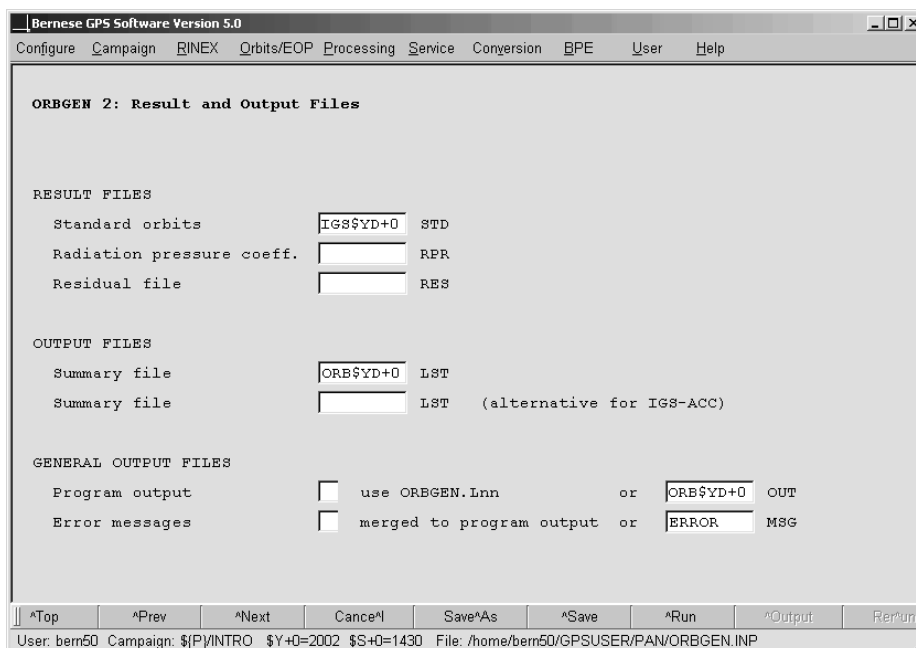
The second program of the orbit part used here is called ORBGEN (“Menu>Orbits/EOP>Create standard orbits”). It prepares the so-called standard orbits using the satellite positions in the tabular orbit files as pseudo-observations for a least-squares adjustment.



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 "ORBIT MODEL IDENTIFIER" 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 "ORBIT MODEL IDENTIFIER" to ?.

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---

**ORBGEN 3.2: Options**

PRINT RESIDUALS

NUMERICAL INTEGRATION  
Number of iterations

EQUATION OF MOTION  
Polynomial degree   
Length of interval  hours

VARIATIONAL EQUATIONS  
Polynomial degree   
Length of interval  hours

|| ^Top ^Prev ^Next Cancel Save\*As \*Save \*Run \*Output Rerun  
User: bern50 Campaign: \$(P)INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/ORBGEN.INP

---

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---

**ORBGEN 4: Parameter Selection**

DYNAMICAL ORBIT PARAMETERS

Apart from six osculating elements estimate the following parameters

|             |                                     |                             |                                     |
|-------------|-------------------------------------|-----------------------------|-------------------------------------|
| D0 (direct) | <input checked="" type="checkbox"/> | Periodic D terms (cos, sin) | <input checked="" type="checkbox"/> |
| Y0 (y-bias) | <input checked="" type="checkbox"/> | Periodic Y terms (cos, sin) | <input checked="" type="checkbox"/> |
| X0          | <input checked="" type="checkbox"/> | Periodic X terms (cos, sin) | <input checked="" type="checkbox"/> |

|| ^Top ^Prev ^Next Cancel Save\*As \*Save \*Run \*Output Rerun  
User: bern50 Campaign: \$(P)INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/ORBGEN.INP

---

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---

**ORBGEN 5: Orbital Arc Definition**

ORBITAL ARC DEFINITION

Number of arcs within the time window

Time window to be covered by the standard orbits

Defined by year and session number  
Year  Session

Defined by start and end time

|       | yyyy mm dd                               | hh mm ss                              |     | yyyy mm dd                               | hh mm ss                              |
|-------|--|---------------------------------------|-----|--|---------------------------------------|
| Start | <input type="text" value="\$YMD_STR+0"/> | <input type="text" value="00 00 00"/> | End | <input type="text" value="\$YMD_STR+0"/> | <input type="text" value="23 59 59"/> |

|| ^Top ^Prev ^Next Cancel Save\*As \*Save \*Run \*Output Rerun  
User: bern50 Campaign: \$(P)INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/ORBGEN.INP

### 3. Terminal Session: Tuesday

The program produces an output file `ORB02143.OUT` (or corresponding to the other sessions) which should look like

```

...
INPUT AND OUTPUT FILENAMES
-----

Session table           : ${P}/INTRO/STA/SESSIONS.SES
General constants      : ${X}/GEN/CONST.
Pole file               : ${P}/INTRO/ORB/IGS02143.ERP
Subdaily pole model    : ${X}/GEN/IERS2000.SUB
Nutation model         : ${X}/GEN/IAU2000.NUT
Coeff. of Earth potential : ${X}/GEN/JGM3.
Satellite problems     : ${X}/GEN/SAT_2002.CRX
Satellite information  : ${X}/GEN/SATELLIT.IO1
Planetary ephemeris file : ${X}/GEN/DE200.EPH
Ocean tides file       : ${X}/GEN/OT_CSRC.TID
Orbital elements, file 1 : ---
Orbital elements, file 2 : ---
Standard orbits        : ${P}/INTRO/ORB/IGS02143.STD
Radiation pressure coeff. : ---
Residual file          : ---
Summary file           : ${P}/INTRO/OUT/ORB02143.LST
Summary file for IGS-ACC : ---
Scratch file           : ${U}/WORK/ORBGEN.SCR
Scratch file           : ${U}/WORK/ORBGEN.SC2
Program output         : ${P}/INTRO/OUT/ORB02143.OUT
Error message          : ${U}/WORK/ERROR.MSG
-----

...
...

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

SAT  #POS  RMS (M)      QUADRATIC MEAN OF O-C (M)      MAX. RESIDUALS (M)
-----
TOTAL  RADIAL  ALONG  OUT      RADIAL  ALONG  OUT
-----
  1   96   0.01      0.01   0.01   0.01   0.01      0.02   0.02   0.03
  2   96   0.01      0.01   0.01   0.01   0.01      0.04   0.02   0.01
  3   96   0.01      0.01   0.02   0.01   0.00      0.03   0.03   0.02
  4   96   0.01      0.01   0.01   0.01   0.01      0.02   0.02   0.02
...

```

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).<sup>1</sup>

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`.

<sup>1</sup>You may check this statement by using the `BULLET.A.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.

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Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help

**SINGLE POINT POSITIONING USING CODE MEASUREMENTS - CODSPP 1: Filenames**

GENERAL FILES

Show all general files

INPUT ORBITS

Broadcast orbits  BRD

Standard orbits IGS\$YD+0 STD Satellite clocks IGS\$YD+0 CLR

INPUT FILES

Code observation files ????\$S+0 CZH A priori coordinates APR\$YD+0 CRD

Estimated tropo.values  TRP Site eccentricities  ECC

Pole file IGS\$YD+0 BRP Kin. input coordinates  KIN

Station sigma factors  SOS Code bias input files P1C1\$M+0 DCB

LEO files

|| ^Top ^Prev ^Next Cancel Save^As ^Save ^Run ^Output Rerun

User: bern50 Campaign: \$(P)INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/CODSPP.INP

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Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help

**CODSPP 1.3: Output Files**

RESULT FILES

Coordinate results  CRD

Kinematic coordinates  KIN

Residual file  RES

Satellite clock results  CLK

Clock RINEX results  CLK

GNSS receiver LC DCB values  DCB

OUTPUT FILES

Output summary (XYZ coord.)  SMC

Output Summary (Ell.coord.)  SME

GENERAL OUTPUT FILES

Program output  use CODSPP.Lnn or COD\$YD+0 OUT

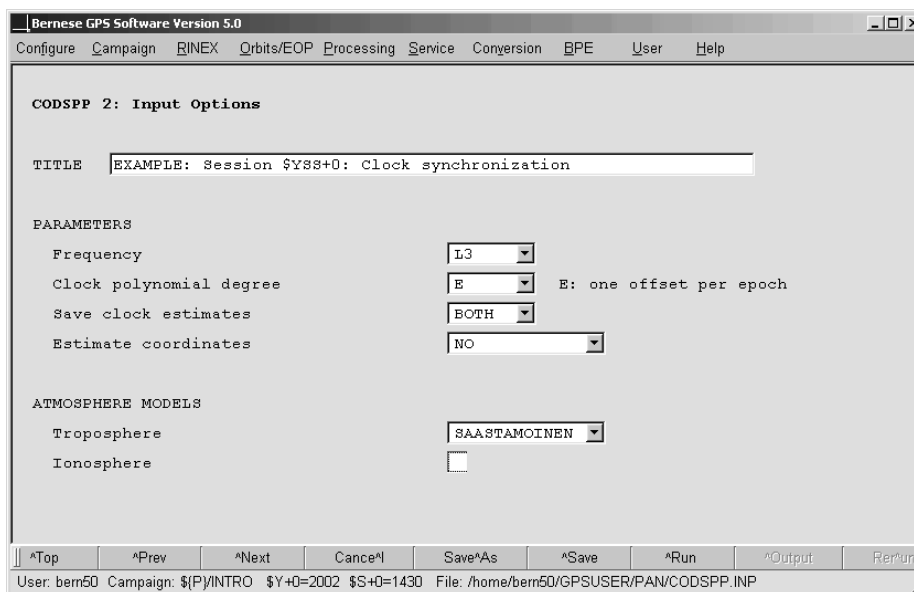
Error messages  merged to program output or ERROR MSG

|| ^Top ^Prev ^Next Cancel Save^As ^Save ^Run ^Output Rerun

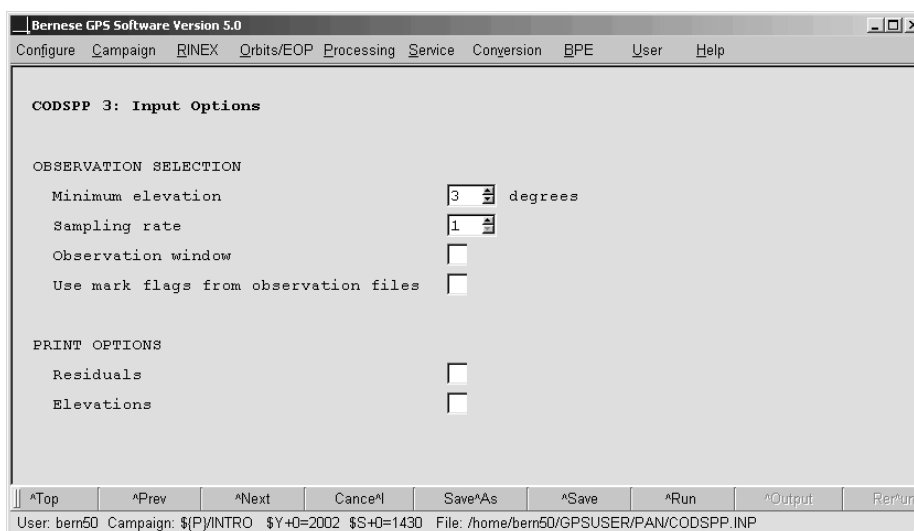
User: bern50 Campaign: \$(P)INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/CODSPP.INP

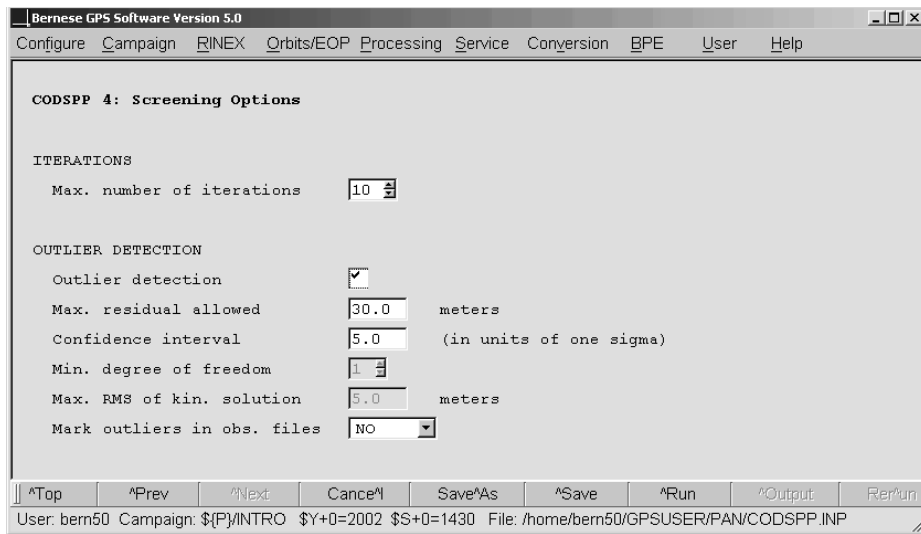
### 3. Terminal Session: Tuesday

---



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

          A PRIORI          NEW          NEW- A PRIORI  RMS ERROR
BRUS 13101M004   X          4027893.78   4027893.78         0.00         0.00
(MARKER)         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 EPOCH:           0.000000632  SEC

CLOCK OFFSETS STORED IN CODE+PHASE OBSERVATION FILES
...

```

```

...
*****
SUMMARY OF BAD OBSERVATIONS
*****

MAXIMUM RESIDUAL DIFFERENCE ALLOWED :    30.00 M
CONFIDENCE INTERVAL OF F*SIGMA WITH F:    5.00

NUMBER OF BAD OBSERVATION PIECES      :        2

NUMB FIL  STATION          TYP SAT      FROM              TO              #EPO
-----
   1   2  FFMJ 14279M001    OUT   7  02-05-23 15:47:30  02-05-23 15:47:30    1
   2   4  ONSA 10402M004    OUT   6  02-05-23 17:34:00  02-05-23 17:34:00    1
-----

```

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.PRC\_REF).

### 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.

Bernese GPS Software Version 5.0

Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help

**CREATE SINGLE-DIFFERENCE OBSERV. FILES - SNGDIF 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 ???S+0 PZH ???S+0 CZH

Reference station for STAR strategy PZH CZH

MANUAL BASELINE CREATION

First zero-difference input file PZH CZH

Second zero-difference input file PZH CZH

Single-difference output file PSH CSH

^Top ^Prev ^Next Cancel Save\*As \*Save \*Run ^Output Rerun

User: bern50 Campaign: \$(P)INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/SNGDIF.INP

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**SNGDIF 2: Filenames**

INPUT FILES

Station coordinates APR\$YD+0 CRD

Site eccentricities ECC

Predefined baselines BSL

Cluster definition CLU

RESULT FILES

Listing of formed baselines BSL

Cluster/baseline assignment CLB (2 digits will be appended)

GENERAL OUTPUT FILES

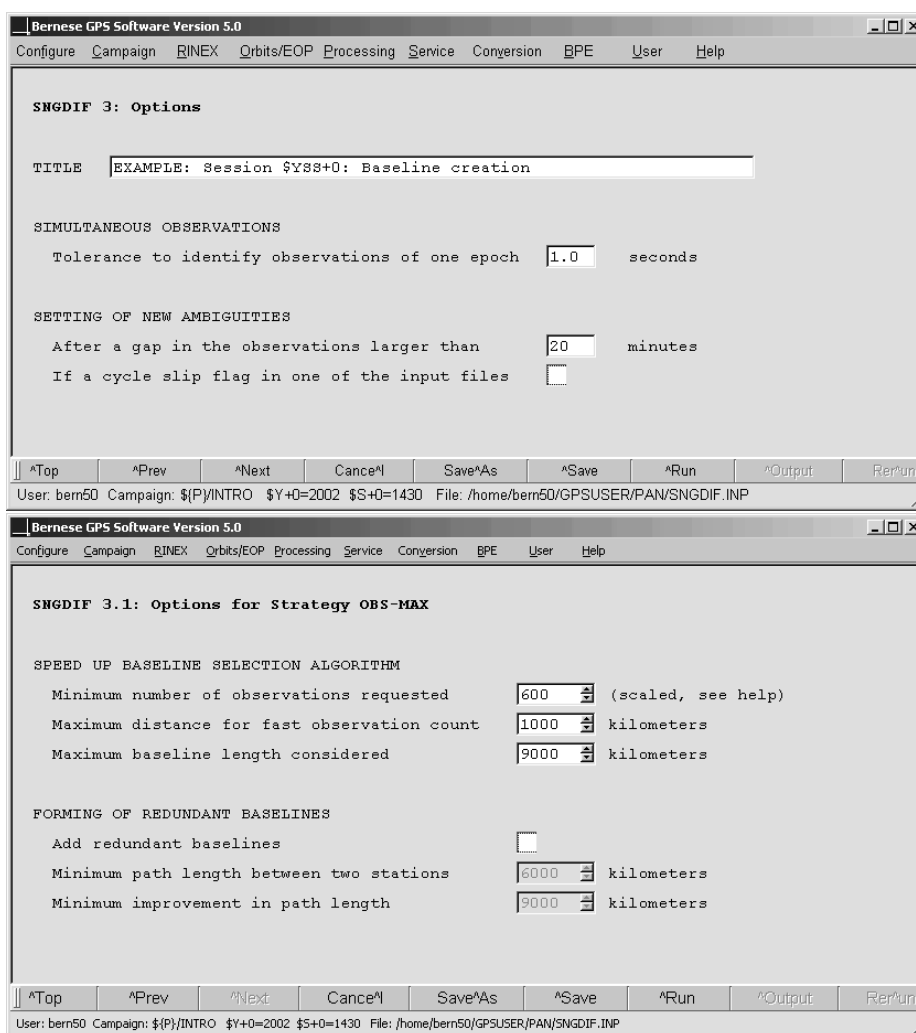
Program output  use SNGDIF.Lnn or SNGDIF OUT

Error messages  merged to program output or ERROR MSG

^Top ^Prev ^Next Cancel Save\*As \*Save \*Run ^Output Rerun

User: bern50 Campaign: \$(P)INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/SNGDIF.INP

### 3. Terminal Session: Tuesday



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:

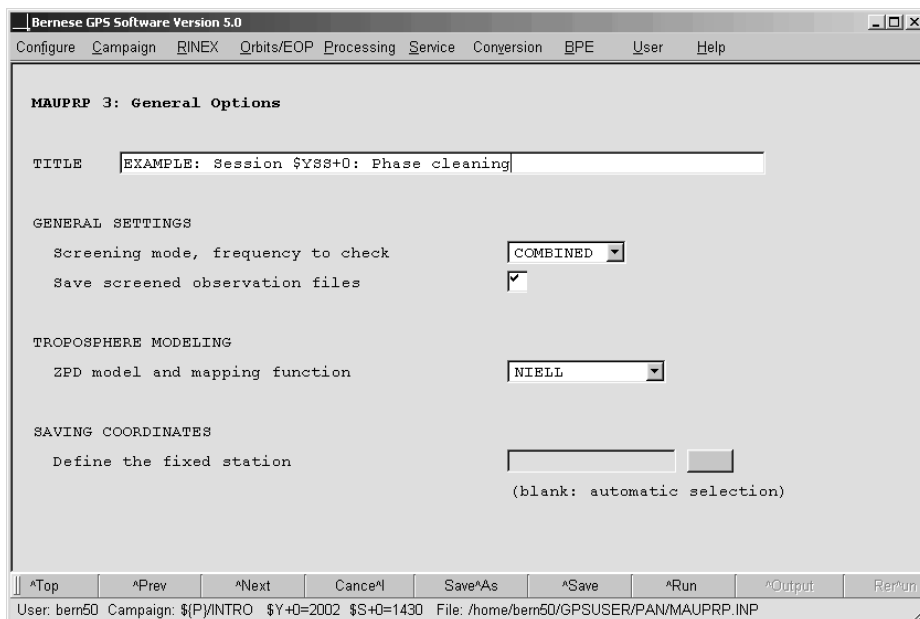
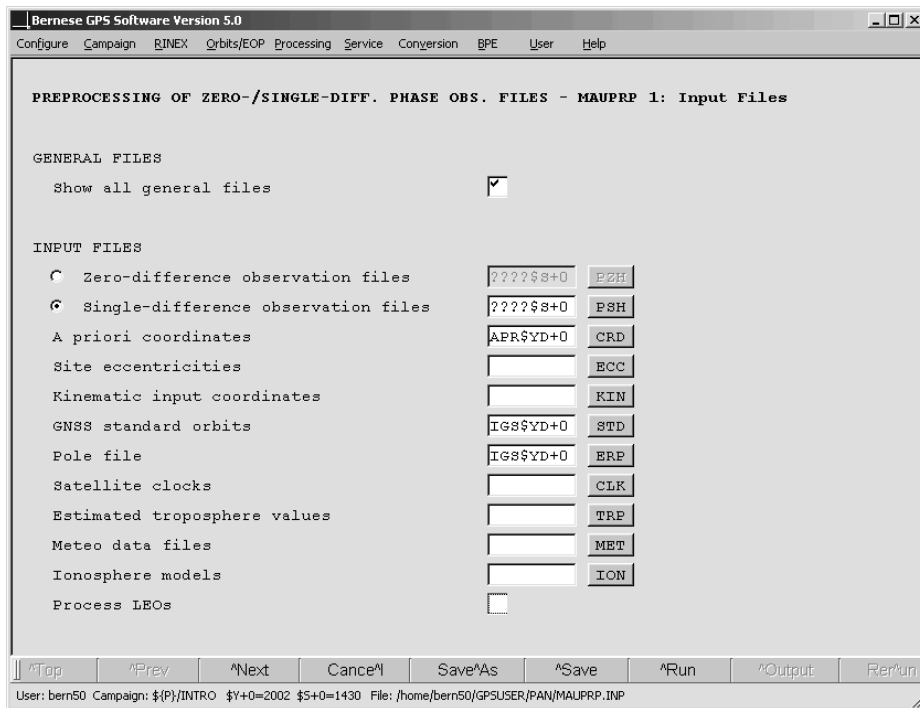
|    |                |                  |                 |
|----|----------------|------------------|-----------------|
| 1  | BRUS 13101M004 | - FFMJ 14279M001 | CRIT.: 11280    |
| 2  | BRUS 13101M004 | - MATE 12734M008 | CRIT.: 9694     |
| 3  | BRUS 13101M004 | - ONSA 10402M004 | CRIT.: 11370 OK |
| 4  | BRUS 13101M004 | - PTBB 14234M001 | CRIT.: 10221    |
| 5  | BRUS 13101M004 | - VILL 13406M001 | CRIT.: 10378    |
| 6  | BRUS 13101M004 | - ZIMJ 14001M006 | CRIT.: 6976     |
| 7  | BRUS 13101M004 | - ZIMM 14001M004 | CRIT.: 11242    |
| 8  | FFMJ 14279M001 | - MATE 12734M008 | CRIT.: 10826 OK |
| 9  | FFMJ 14279M001 | - ONSA 10402M004 | CRIT.: 12603 OK |
| 10 | FFMJ 14279M001 | - PTBB 14234M001 | CRIT.: 10252    |
| 11 | FFMJ 14279M001 | - VILL 13406M001 | CRIT.: 10576    |
| 12 | FFMJ 14279M001 | - ZIMJ 14001M006 | CRIT.: 7076 OK  |
| 13 | FFMJ 14279M001 | - ZIMM 14001M004 | CRIT.: 11705 OK |
| 14 | MATE 12734M008 | - ONSA 10402M004 | CRIT.: 10491    |
|    | ...            |                  |                 |

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".



### 3. Terminal Session: Tuesday

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**MAUPRP 4: Marking of Observations**

MARKING OF OBSERVATIONS BEFORE CYCLE SLIP DETECTION

Mark if marking flags in observation file

Mark observations below an elevation of  degrees for stations

degrees for LBOs

Minimum time interval accepted for continuous observations  seconds

Maximum gap accepted within continuous observations  seconds

^Top ^Prev ^Next Cancel SaveAs ^Save ^Run ^Output ReRun

User: bern50 Campaign: \$(P)/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/MAUPRP.INP

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**MAUPRP 5: Non-Parametric Screening**

GENERAL OPTIONS

Extent of program output

Maximum time interval for polynomial fit  minutes

SCREENING ON DIFFERENT DIFFERENCE LEVELS

Original observations from file for ZD-files: zero diff.  
 Polynomial degree  SD-files: single diff.  
 Discontinuity level  meters

Differences between satellites for ZD-files: single diff.  
 Polynomial degree  SD-files: double diff.  
 Discontinuity level  meters

^Top ^Prev ^Next Cancel SaveAs ^Save ^Run ^Output ReRun

User: bern50 Campaign: \$(P)/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/MAUPRP.INP

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**MAUPRP 6: Epoch-Difference Solution**

EPOCH-DIFFERENCE SOLUTION for ZD-files: double diff.

Frequency for the solution  SD-files: triple diff.

Kinematic coordinate estimation

Maximum observed-computed value  meters (0.0: no check)

RMS limit for epoch solution  meters (0.0: no check)

A priori coordinate/baseline vector sigmas

X-coordinate  meters

Y-coordinate  meters

Z-coordinate  meters

^Top ^Prev ^Next Cancel SaveAs ^Save ^Run ^Output ReRun

User: bern50 Campaign: \$(P)/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/MAUPRP.INP

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**MAUPRP 8: Cycle Slip Detection/Correction**

CYCLE SLIP DETECTION

Extent of program output

Do not accept cycle slip corrections

Minimum size of accepted cycle slip correction  cycles

Test only observations with cycle slip flag

L5 is clean except for observations with flags

NO CYCLE SLIP HYPOTHESIS

Sigma for L1 observations  meters

Sigma for L2 observations  meters

Maximum ionospheric change from epoch to epoch  % of L1 cycles

CYCLE SLIP CORRECTIONS

Search width to find L1 cycle slip correction  integers

Search width to find L5 cycle slip correction  integers

User: bern50 Campaign: \$(P)/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/MAUPRP.INP

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

OUTLIER REJECTION

Enable outlier rejection

Mark consecutive outliers up to a time interval  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  seconds

MARKING OF OBSERVATIONS AFTER CYCLE SLIP CORRECTIONS

Minimum observed time interval per ambiguity  seconds

Remove satellites if the file contains more than  ambiguities

User: bern50 Campaign: \$(P)/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/MAUPRP.INP

### 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
*****
```

| SESS  | FIL | OK? | ST1  | ST2  | L(KM) | #OBS. | RMS                     | DX          | DY    | DZ    | #SL | #DL | #MA | MAXL3 | MIN. | SLIP  |
|-------|-----|-----|------|------|-------|-------|-------------------------|-------------|-------|-------|-----|-----|-----|-------|------|-------|
| 1430  | 1   | OK  | BRUS | ONSA | 884   | 17643 | 0.011                   | 0.145       | 0.061 | 0.285 | 131 | 235 | 41  | 0.050 |      | 11    |
| 1430  | 2   | OK  | FFMJ | MATE | 1220  | 18002 | 0.012-0.161             | 0.030-0.286 |       |       | 36  | 430 | 58  | 0.049 |      | 558   |
| 1430  | 3   | OK  | FFMJ | ONSA | 840   | 20430 | 0.011-0.205             | 0.021-0.068 |       |       | 101 | 141 | 44  | 0.050 |      | 11    |
| 1430  | 4   | OK  | FFMJ | ZIMJ | 368   | 11610 | 0.011-0.020             | 0.032-0.071 |       |       | 76  | 224 | 24  | 0.049 |      | 11    |
| 1430  | 5   | OK  | FFMJ | ZIMM | 368   | 19563 | 0.011-0.015-0.015-0.089 |             |       |       | 46  | 199 | 39  | 0.042 |      | 46188 |
| 1430  | 6   | OK  | PTBB | ZIMM | 640   | 17032 | 0.013-0.018-0.047-0.128 |             |       |       | 45  | 97  | 21  | 0.049 |      | 46188 |
| 1430  | 7   | OK  | VILL | ZIMM | 1162  | 17990 | 0.012                   | 0.175       | 0.080 | 0.199 | 54  | 219 | 30  | 0.050 |      | 17    |
| ----- |     |     |      |      |       |       |                         |             |       |       |     |     |     |       |      |       |
| Tot:  | 7   |     |      |      |       | 783   | 17467                   | 0.012       |       |       |     | 70  | 220 | 37    |      |       |

This summary file is included in the solution reference file ( $\${P}\}/\text{INTRO}/\text{OUT}/\text{R2S021430.PRC\_REF}$  — 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, CODSPP, SNGDIF, and MAUPRP*

*Files should be generated for all four days. Simply adapt the session definition for the other days and rerun the programs.*



## 4. Terminal Session: Wednesday

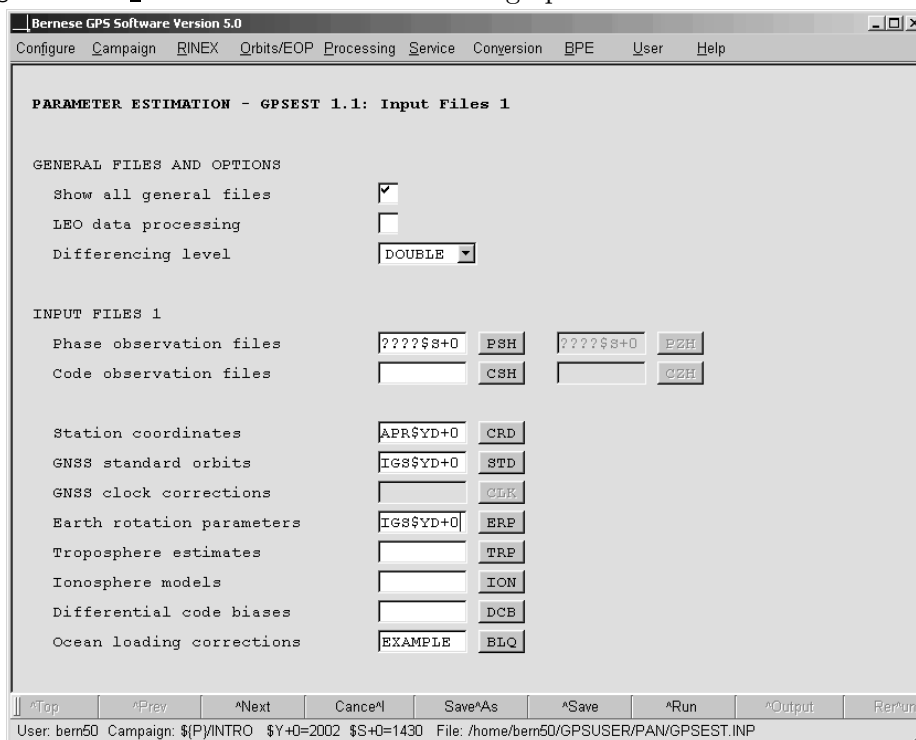
*Today's terminal session is to*

- (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),*

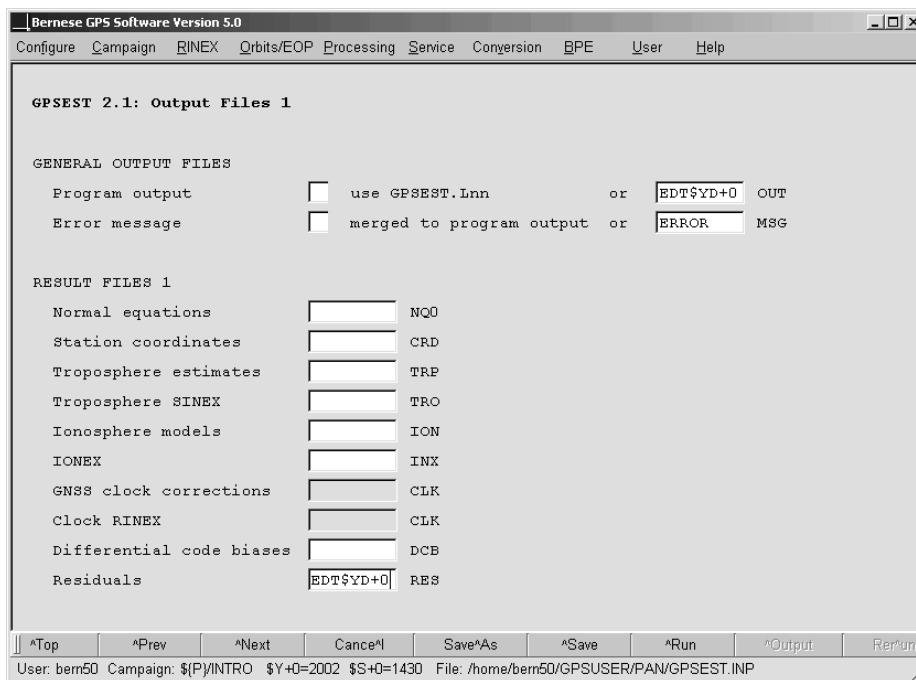
*ideally for all four days of the processing example, but at least one session for each year, e.g.: 2002, 143 and 2003, 138. You can run through these steps session by session.*

### 4.1 Data Preprocessing (II)

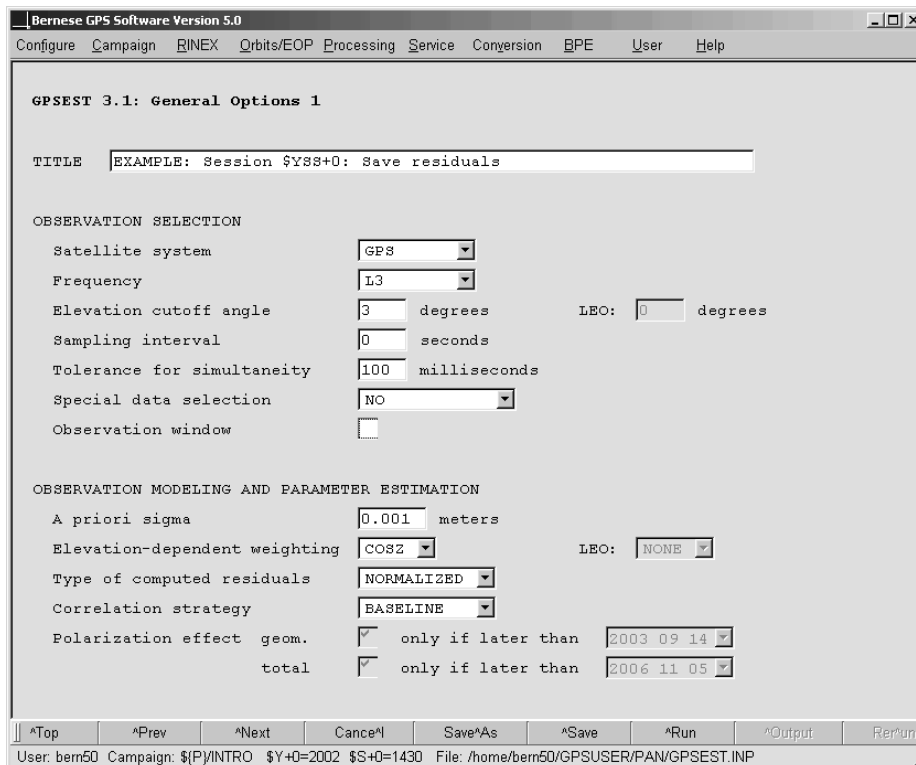
The least-squares adjustment is the task of program GPSEST. It is a good idea to start GPSEST first in the session mode and to produce an ambiguity-free  $L_3$  solution. We do not expect any final results from this run but we want to check the quality of data and save the residuals after the least-squares adjustment. The program is available via "Menu >Processing>Parameter estimation". We use the following options:

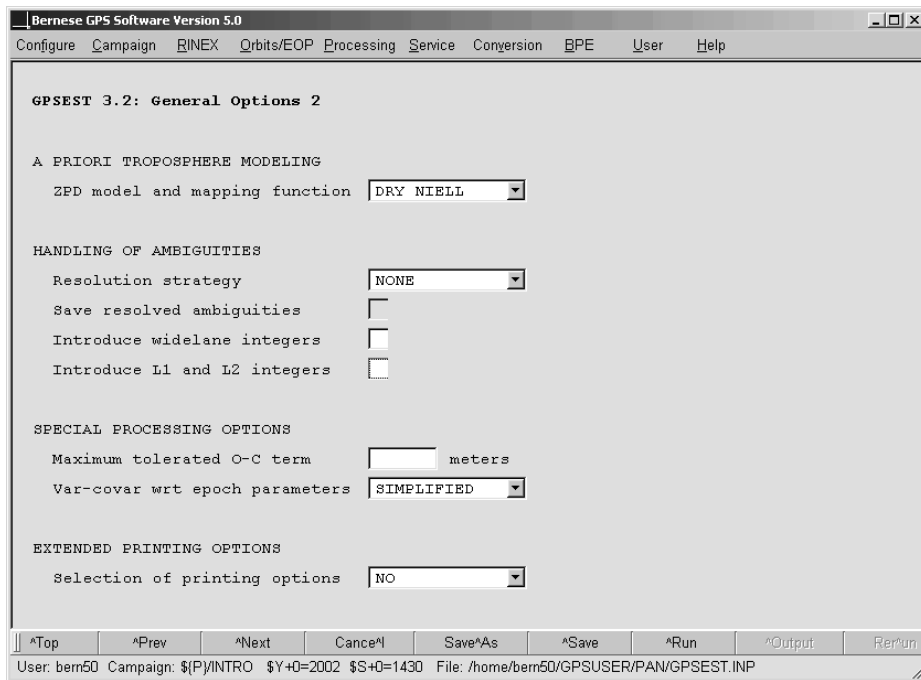


#### 4. Terminal Session: Wednesday

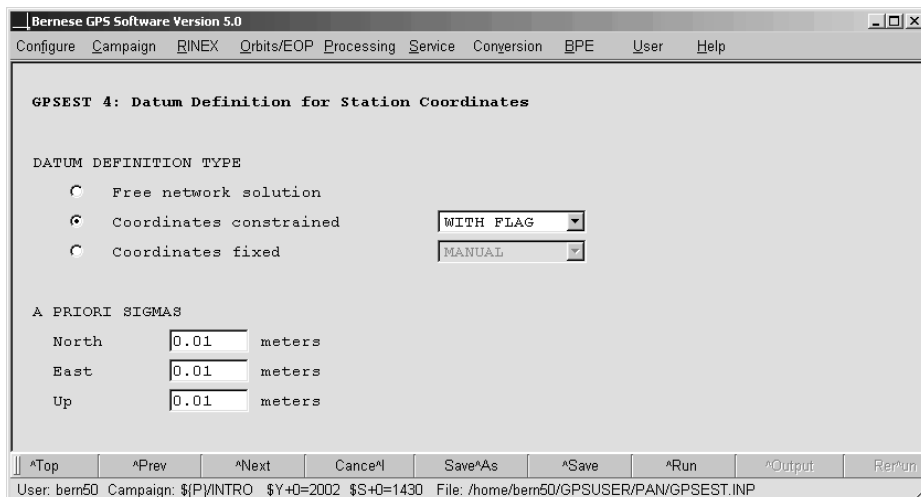


We do not sample the observations in this run. This is important if we want to check *all* observations (we want to use all observations without sampling for the ambiguity resolution). Consequently the program run might be time consuming (about 3 min. CPU time on ubecx).



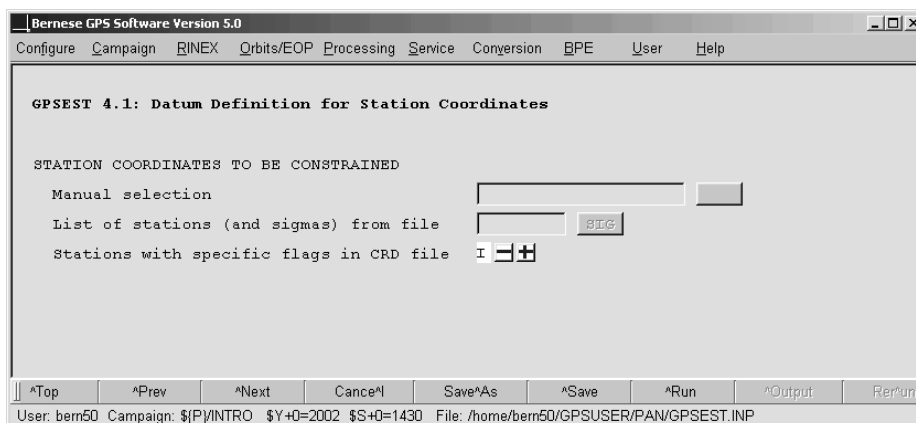


We want to give loose constraints to the station coordinates that are available from the IGS realization of ITRF 2000 reference frame (flag 1 like IGS00 in the coordinate file).

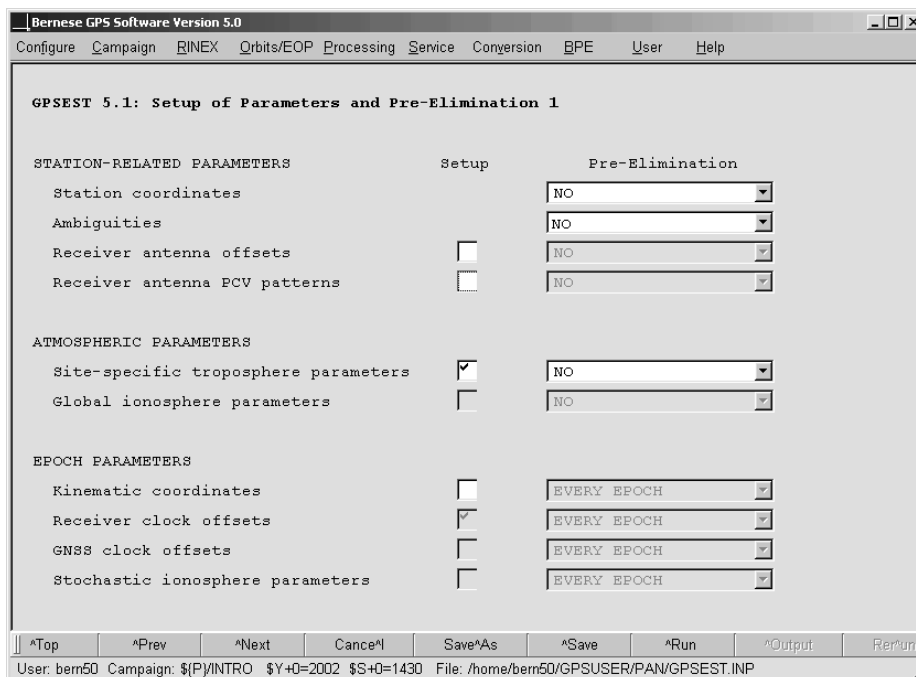


#### 4. Terminal Session: Wednesday

---



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



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**GPSEST 5.2: Setup of Parameters and Pre-Elimination 2**

| SATELLITE-RELATED PARAMETERS    | Setup                    | Pre-Elimination |
|---------------------------------|--------------------------|-----------------|
| GNSS or LEO orbit determination | <input type="checkbox"/> | NO              |
| GNSS antenna offsets            | <input type="checkbox"/> | NO              |
| GNSS antenna PCV patterns       | <input type="checkbox"/> | NO              |

ADDITIONAL PARAMETERS

|                              |                          |    |
|------------------------------|--------------------------|----|
| Differential code biases     | <input type="checkbox"/> | NO |
| Earth orientation parameters | <input type="checkbox"/> | NO |
| Geocenter coordinates        | <input type="checkbox"/> | NO |

TIME OFFSET FOR PARAMETER INTERVALS  (hh mm ss)

User: bern50 Campaign: \${P}/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/GPSEST.INP

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

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**GPSEST 6.3.1: Site-Specific Troposphere Parameters 1**

ZENITH PATH DELAY PARAMETERS

Mapping function

Parameter spacing  (hh mm ss)

HORIZONTAL GRADIENT PARAMETERS

Gradient estimation model

Parameter spacing  (hh mm ss)

A PRIORI SIGMAS

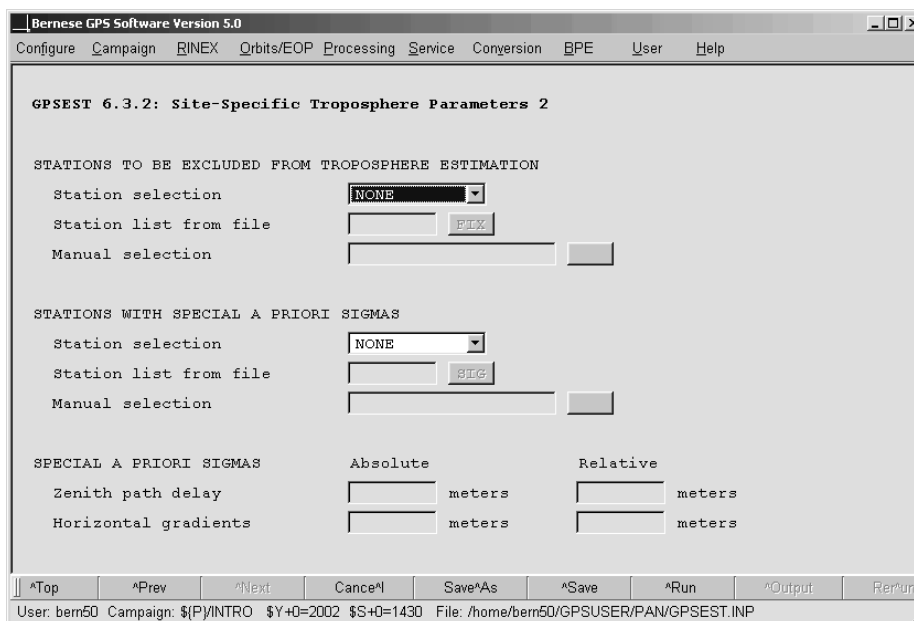
|                      | Absolute                    | Relative                    |
|----------------------|-----------------------------|-----------------------------|
| Zenith path delay    | <input type="text"/> meters | <input type="text"/> meters |
| Horizontal gradients | <input type="text"/> meters | <input type="text"/> meters |

EXTRACTION OF PARAMETERS FOR TROPOSPHERE SINEX FILE

Offset  (hh mm ss) Time resolution  (hh mm ss)

User: bern50 Campaign: \${P}/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/GPSEST.INP

#### 4. Terminal Session: Wednesday



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:

```
...
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)
...
```

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 CODSP) 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".

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**GENERATE RESIDUAL STATISTICS - RESRMS 1: Input/Output Files**

**GENERAL FILES**

Show all general files

**INPUT FILES**

Residual files EDT\$YD+0 RES

**OUTPUT FILES**

Summary file RMS\$YD+0 SUM

Residual histogram RMS\$YD+0 LST

Edit information file RMS\$YD+0 EDT

Station observation sigma file SOS

**GENERAL OUTPUT FILES**

Program output  use RESRMS.Lnn or RMS\$YD+0 OUT

Error messages  merged to program output or ERROR MSG

|| ^Top ^Prev ^Next Cancel Save\*As ^Save ^Run ^Output Rerun

User: bern50 Campaign: \$(P)/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/RESRMS.INP

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**RESRMS 2: Options**

TITLE EXAMPLE: Session \$Y88+0: Residual statistics

**GENERAL OPTIONS**

Frequency to check L3

Sampling rate of residual files 30 seconds

**DETECT LARGE RESIDUALS** limit

Phase measurements  0.004 meters

Code measurements  0.004 meters

Range measurements  0.3000 meters

**DETECT BAD DATA**

Minimum continuously observed time interval 361 seconds

Detect ambiguities with few observations

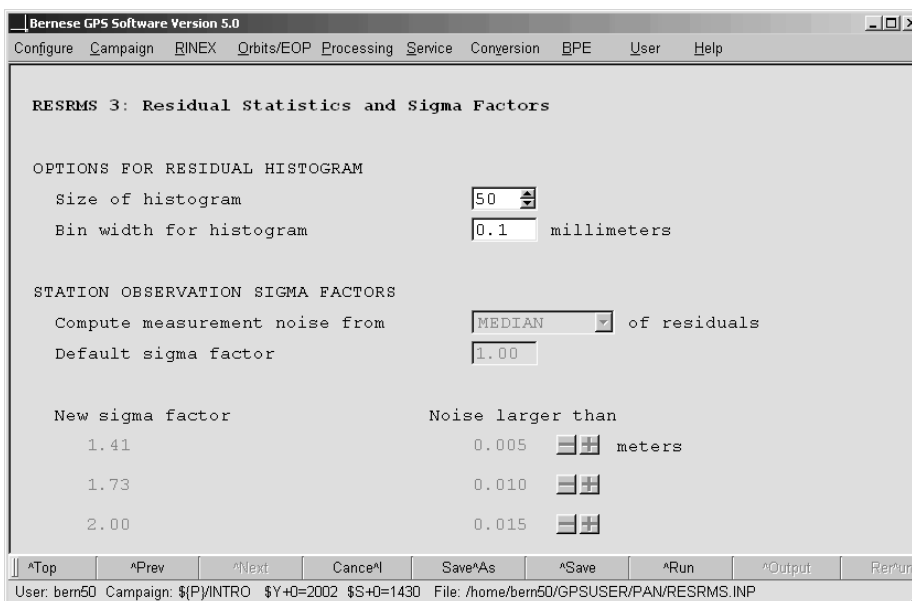
Minimum number of observations per ambiguity 3

Sampling rate for counting the observations seconds

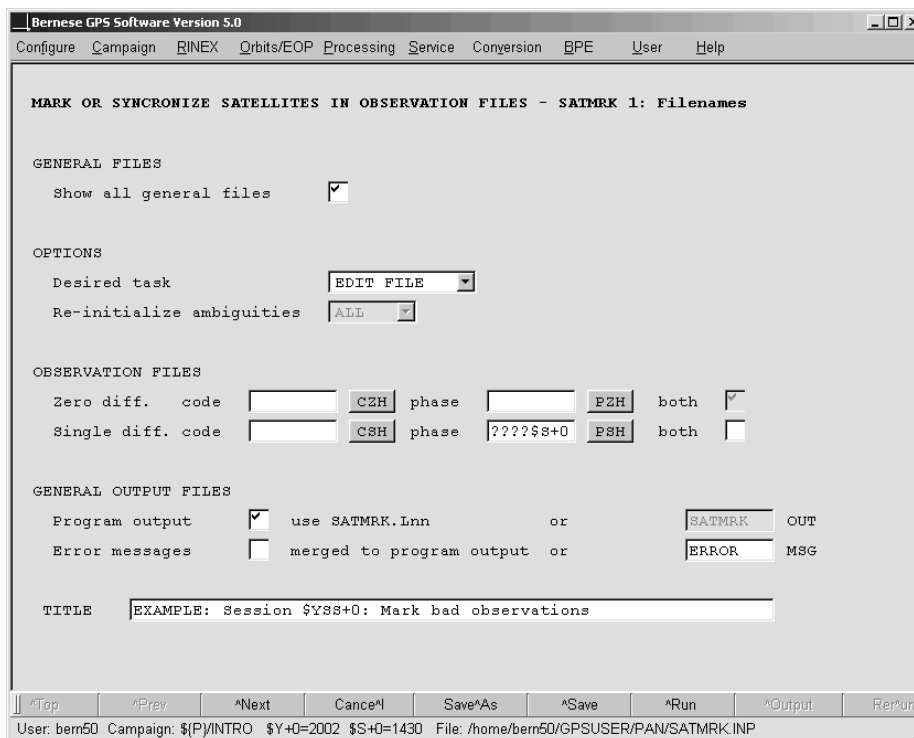
|| ^Top ^Prev ^Next Cancel Save\*As ^Save ^Run ^Output Rerun

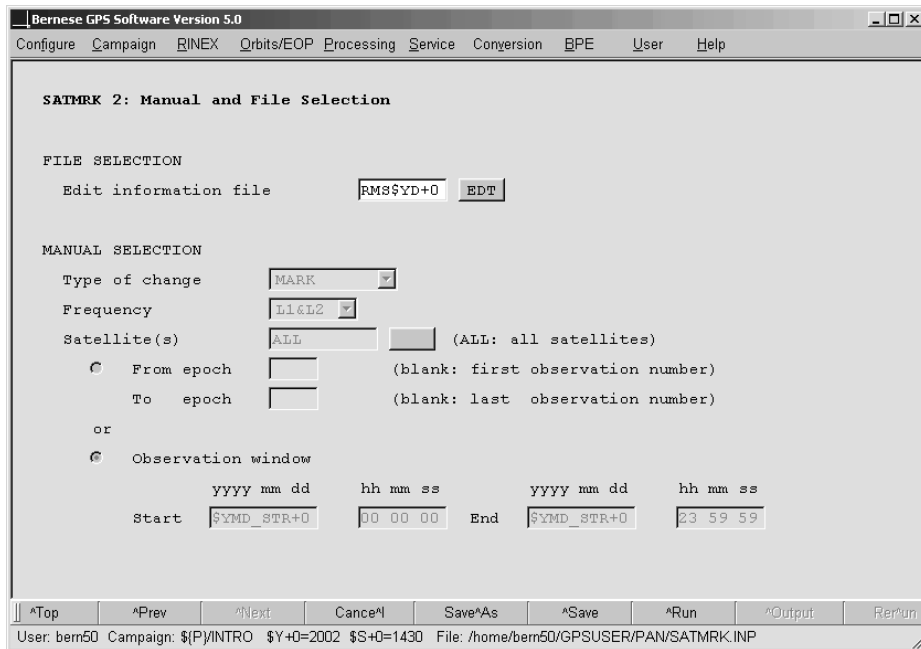
User: bern50 Campaign: \$(P)/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/RESRMS.INP

#### 4. Terminal Session: Wednesday



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”):

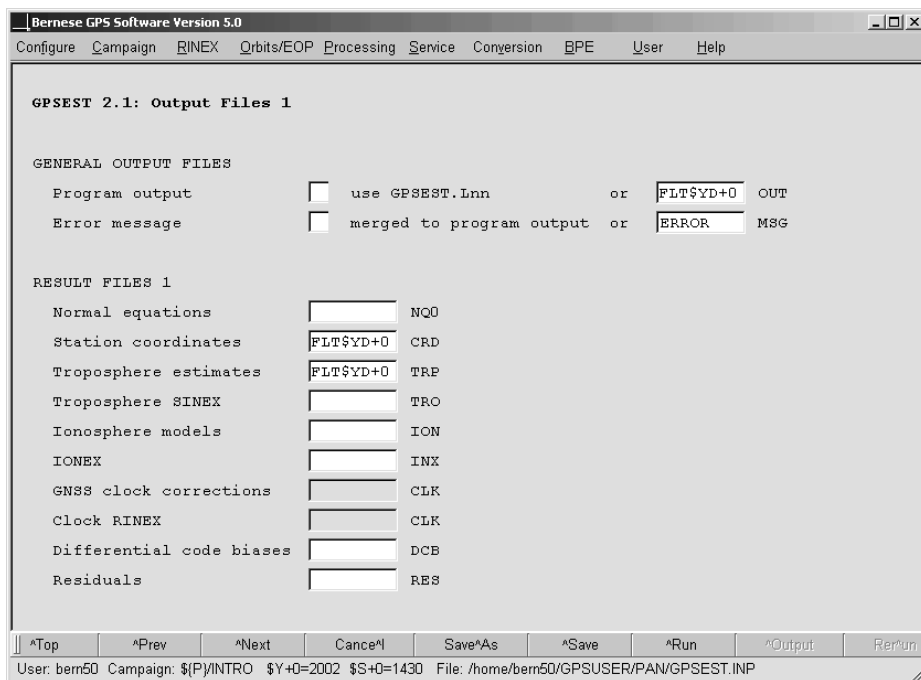




## 4.2 Make a First Network Solution

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:

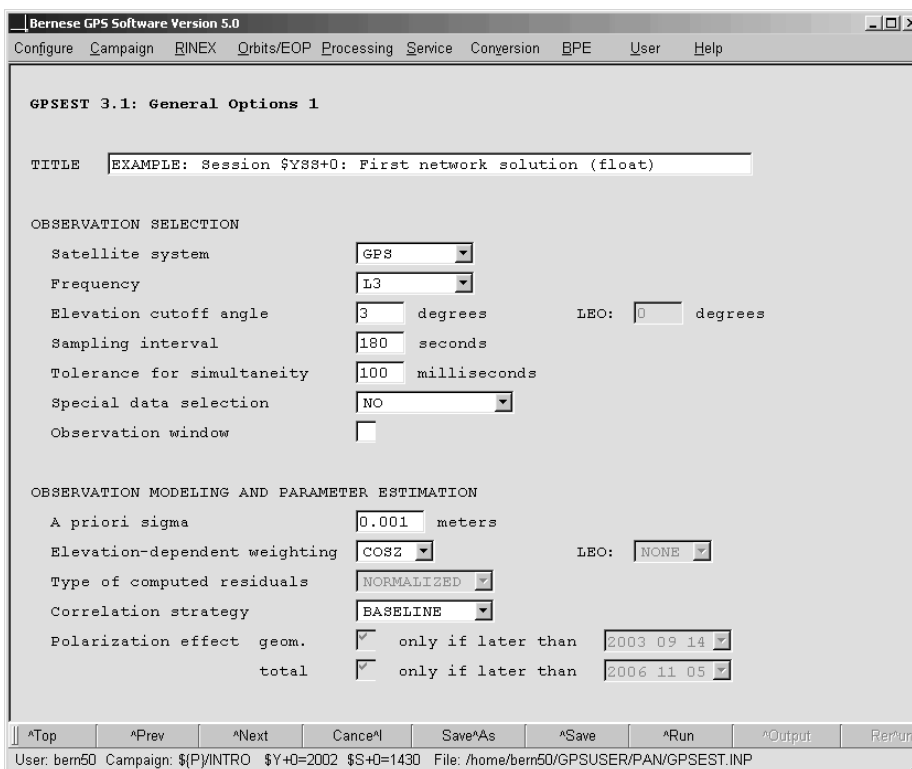
We store the coordinates and troposphere parameters into files to be re-introduced later:



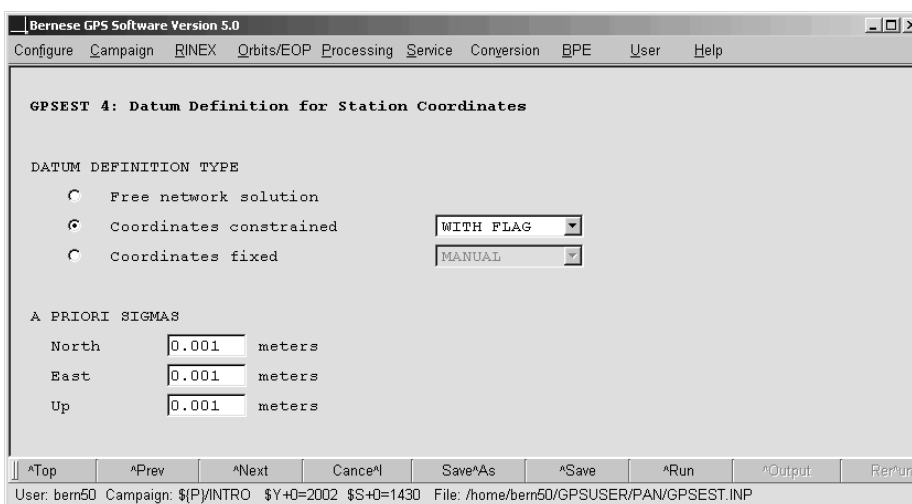
#### 4. Terminal Session: Wednesday

---

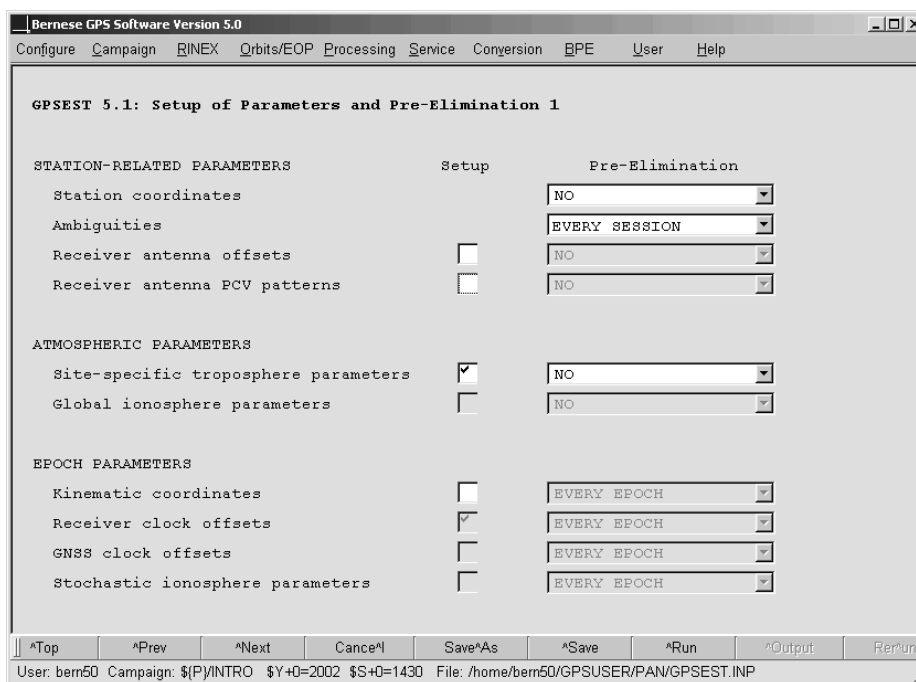
To speed up the processing we increase the sampling rate:



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:



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:

```

13. RESULTS (PART 1)
-----
NUMBER OF PARAMETERS (PART 1):
-----
PARAMETER TYPE                                #PARAMETERS  #PRE-ELIMINATED  #SET-UP  ...
-----
STATION COORDINATES                           24             0                24       ...
AMBIGUITIES                                   419            419 (BEFORE INV) 451       ...
SITE-SPECIFIC TROPOSPHERE PARAMETERS           56             0                56       ...
-----
TOTAL NUMBER OF PARAMETERS                     499            419              531      ...
-----

NUMBER OF OBSERVATIONS (PART 1):
-----
TYPE      FREQUENCY  FILE      #OBSERVATIONS
-----
PHASE     L3         ALL       20415
-----
TOTAL NUMBER OF OBSERVATIONS                   20415
-----

```

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

```

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)           :    19929
CHI**2/DOF                         :     1.22

STATION COORDINATES:                ${P}/INTRO/STA/FLT02143.CRD
-----

NUM  STATION NAME  PARAMETER  A PRIORI VALUE  NEW VALUE  NEW- A PRIORI  RMS ERROR  ...
-----
  6  BRUS 13101M004  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 52.143447  50 47 52.143365 -0.0025    0.0009  ...
                                     LONGITUDE   4 21 33.186467   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.

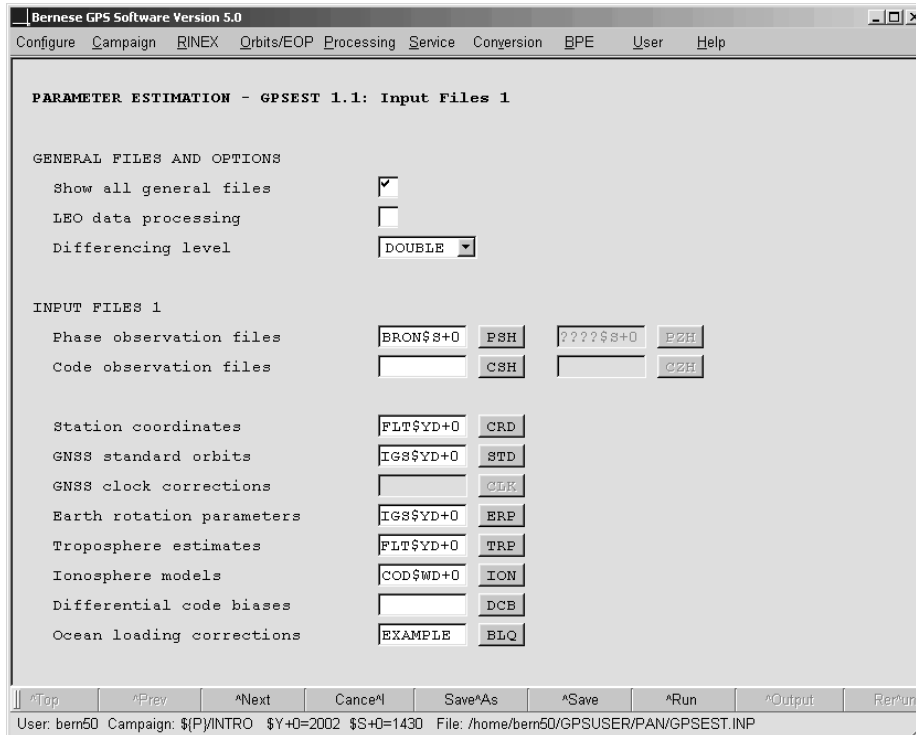
The complete list of baseline observation files of a session (e.g., session 1430 of year 2002) can be generated by listing all phase single-difference header files in the campaign’s observation directory of your campaign:

```

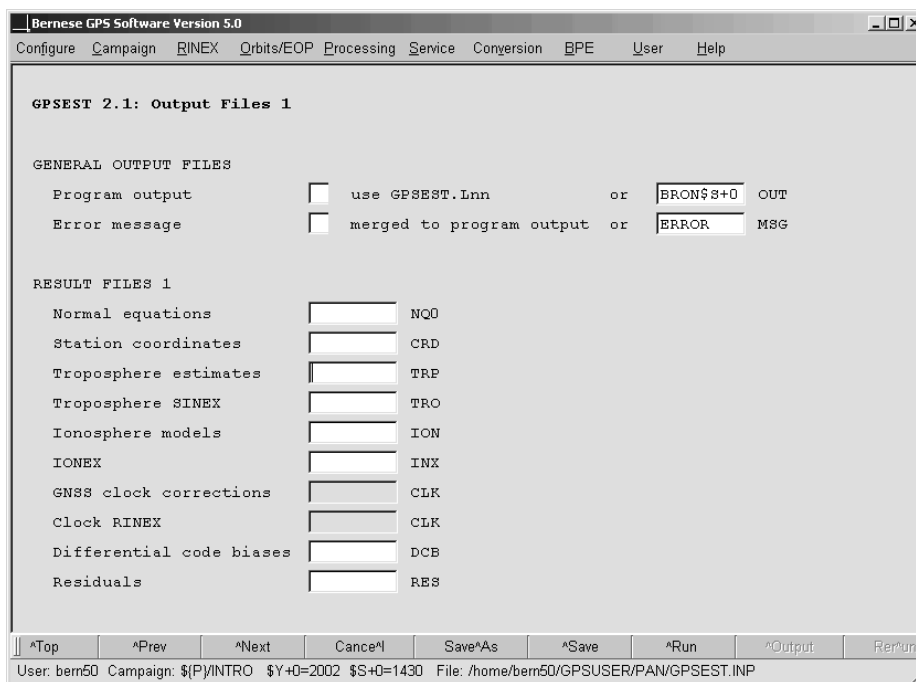
> ls ${P}/INTRO/OBS/????1430.PSH
${P}/INTRO/OBS/BRON1430.PSH
${P}/INTRO/OBS/FFMA1430.PSH
${P}/INTRO/OBS/FFON1430.PSH
${P}/INTRO/OBS/FFZI1430.PSH
${P}/INTRO/OBS/FFZM1430.PSH
${P}/INTRO/OBS/PTZM1430.PSH
${P}/INTRO/OBS/VIZM1430.PSH

```

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\$\$+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

Bernese GPS Software Version 5.0

Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help

**GPSEST 3.1: General Options 1**

TITLE

OBSERVATION SELECTION

Satellite system  LEO:  degrees

Frequency

Elevation cutoff angle  degrees

Sampling interval  seconds

Tolerance for simultaneity  milliseconds

Special data selection

Observation window

OBSERVATION MODELING AND PARAMETER ESTIMATION

A priori sigma  meters LEO:

Elevation-dependent weighting

Type of computed residuals

Correlation strategy

Polarization effect geom.  only if later than

total  only if later than

User: bern50 Campaign: \$(P)/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/GPSEST.INP

Bernese GPS Software Version 5.0

Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help

**GPSEST 3.2: General Options 2**

A PRIORI TROPOSPHERE MODELING

ZPD model and mapping function

HANDLING OF AMBIGUITIES

Resolution strategy

Save resolved ambiguities

Introduce widelane integers

Introduce L1 and L2 integers

SPECIAL PROCESSING OPTIONS

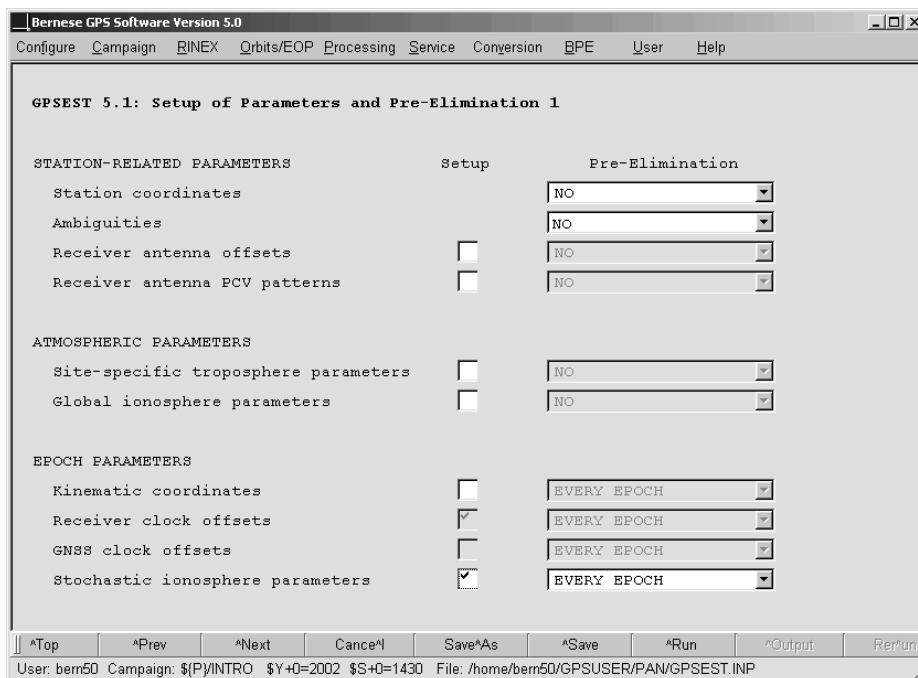
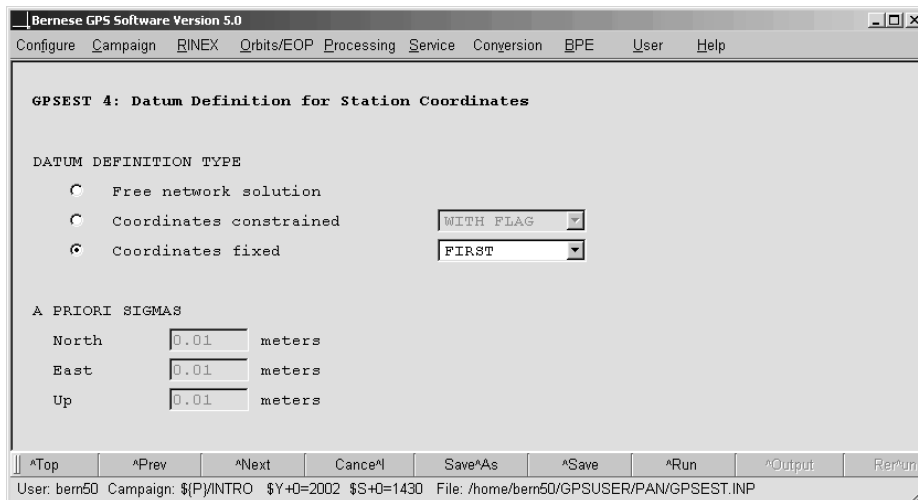
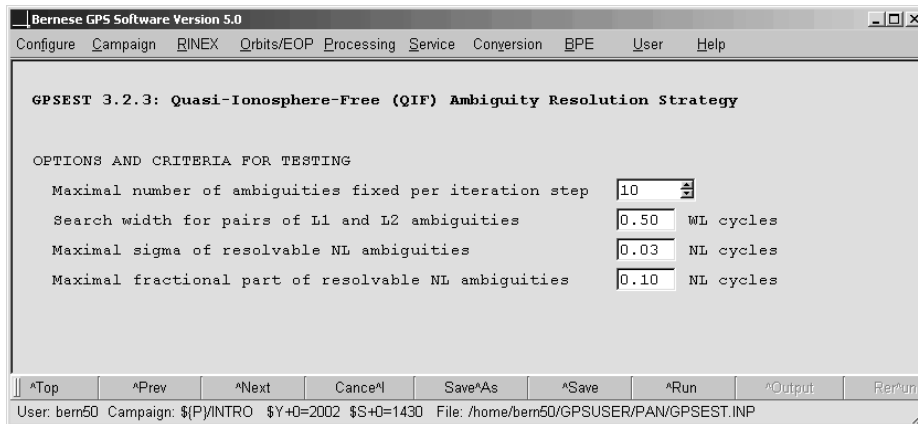
Maximum tolerated O-C term  meters

Var-covar wrt epoch parameters

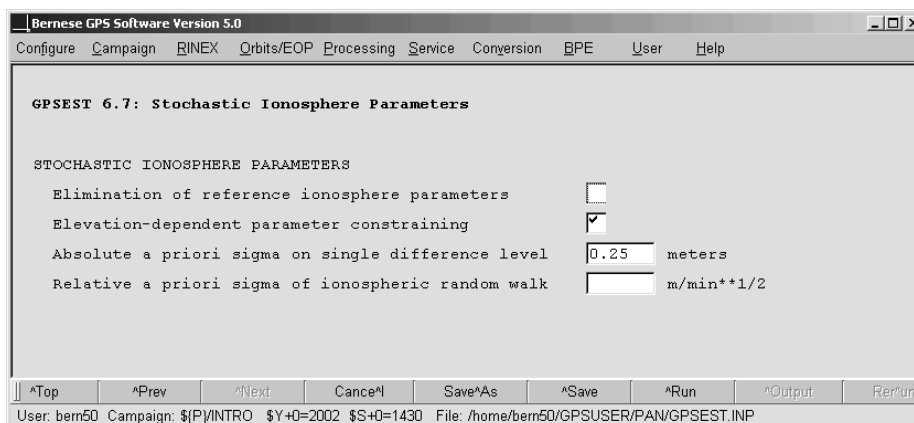
EXTENDED PRINTING OPTIONS

Selection of printing options

User: bern50 Campaign: \$(P)/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/GPSEST.INP



#### 4. Terminal Session: Wednesday



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):
-----

```

| PARAMETER TYPE                   | #PARAMETERS | #PRE-ELIMINATED    | #SET-UP | ... |
|----------------------------------|-------------|--------------------|---------|-----|
| STATION COORDINATES              | 3           | 0                  | 3       | ... |
| AMBIGUITIES                      | 120         | 0                  | 138     | ... |
| STOCHASTIC IONOSPHERE PARAMETERS | 20560       | 20560 (EPOCH-WISE) | 20560   | ... |
| -----                            |             |                    |         |     |
| TOTAL NUMBER OF PARAMETERS       | 20683       | 20560              | 20701   | ... |
| -----                            |             |                    |         |     |

```

NUMBER OF OBSERVATIONS (PART 1):
-----

```

| TYPE                         | FREQUENCY | FILE | #OBSERVATIONS | ... |
|------------------------------|-----------|------|---------------|-----|
| PHASE                        | L1        | ALL  | 17787         | ... |
| PHASE                        | L2        | ALL  | 17787         | ... |
| -----                        |           |      |               |     |
| TOTAL NUMBER OF OBSERVATIONS |           |      | 35574         | ... |
| -----                        |           |      |               |     |

```

...

```

### 4.3 Ambiguity Resolution (QIF)

```

...
A POSTERIORI SIGMA OF UNIT WEIGHT (PART 1):
-----

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

DEGREE OF FREEDOM (DOF)           :    17664
CHI**2/DOF                         :     1.58

STATION COORDINATES:                (NOT SAVED)
-----

NUM  STATION NAME    PARAMETER  A PRIORI VALUE    NEW VALUE    NEW- A PRIORI  RMS ERROR  ...
-----
42   ONSA 10402M004  X          3370658.5802     3370658.5804    0.0002     0.0003
                                     Y          711877.1009     711877.1006   -0.0003     0.0005
                                     Z          5349786.9188     5349786.9192    0.0004     0.0003
                                     HEIGHT      45.5658         45.5662        0.0004     0.0004 ...
                                     LATITUDE    57 23 43.074619  57 23 43.074624  0.0002     0.0002 ...
                                     LONGITUDE   11 55 31.859831  11 55 31.859812 -0.0003     0.0005 ...
...
...

AMBIGUITIES:
-----

                                REFERENCE
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:
-----

STRATEGY :  QUASI-IONOSPHERE-FREE AMBIGUITY RESOLUTION (QIF)
-----
AMBIGUITY RESOLUTION ITERATION:    1
-----

                                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 -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
...

```

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  $L_1$  and  $L_2$  ambiguities. The CORRECTIONS IN CYCLES L5 and L3 are of greater interest. The value L5 represents the ionosphere-induced bias expressed in  $L_5$  cycles. These values may not be greater than the maximum value specified in panel “GPSEST 3.2.3: 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  $L_3$  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:

| ...  |      |      |       |     |     |     |           |     |           |      |               |         |
|------|------|------|-------|-----|-----|-----|-----------|-----|-----------|------|---------------|---------|
| AMBI | FILE | SAT. | EPOCH | FRQ | WLF | CLU | REFERENCE |     | AMBIGUITY | RMS  | TOTAL AMBIGU. | DL/L    |
|      |      |      |       |     |     |     | AMBI      | CLU |           |      |               |         |
| 1    | 1    | 18   | 1     | 1   | 1   | 1   | 121       | 25  | -1.07     | 0.74 | 3181808.93    | ...     |
| 2    | 1    | 18   | 803   | 1   | 1   | 2   | 121       | 25  | 3         |      | 5312281.      | 0.00000 |
| 3    | 1    | 18   | 1140  | 1   | 1   | 3   | 122       | 47  | 11        |      | 21539289.     | 0.00000 |
| 4    | 1    | 18   | 2541  | 1   | 1   | 4   | 122       | 47  | 8         |      | 7052711.      | 0.00000 |
| 5    | 1    | 26   | 1     | 1   | 1   | 5   | 121       | 25  | -1        |      | 2789514.      | 0.00000 |
| 6    | 1    | 26   | 2316  | 1   | 1   | 6   | 18        | 18  | 3         |      | 7998338.      | 0.00000 |
| 7    | 1    | 9    | 1     | 1   | 1   | 7   | 121       | 25  | -1        |      | 513985.       | 0.00000 |
| 8    | 1    | 9    | 2580  | 1   | 1   | 8   | 122       | 47  | 8         |      | 5465798.      | 0.00000 |
| 9    | 1    | 5    | 1     | 1   | 1   | 9   | 121       | 25  | -1        |      | 3645131.      | 0.00000 |
| 10   | 1    | 5    | 2774  | 1   | 1   | 10  | 122       | 47  | 8         |      | 11304208.     | 0.00000 |
| 11   | 1    | 21   | 1     | 1   | 1   | 11  | 121       | 25  | 0         |      | 630973.       | 0.00000 |
| 12   | 1    | 21   | 875   | 1   | 1   | 12  | 121       | 25  | -3        |      | 2162194.      | 0.00000 |
| 13   | 1    | 21   | 1140  | 1   | 1   | 13  | 52        | 60  | 1         |      | 24351827.     | 0.00000 |
| 14   | 1    | 21   | 2712  | 1   | 1   | 14  | 47        | 55  | 3         |      | 6301871.      | 0.00000 |
| 15   | 1    | 29   | 1     | 1   | 1   | 15  | 121       | 25  | -1        |      | 2714436.      | 0.00000 |
| 16   | 1    | 29   | 1191  | 1   | 1   | 16  | 122       | 47  | 17.32     | 2.15 | 6067500.32    |         |
| 17   | 1    | 29   | 1213  | 1   | 1   | 17  | 122       | 47  | 12.84     | 2.18 | 6067503.84    |         |
| 18   | 1    | 29   | 2412  | 1   | 1   | 18  | 50        | 58  | 8         |      | 7875520.      | 0.00000 |
| ...  |      |      |       |     |     |     |           |     |           |      |               |         |

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:

```

...
14. RESULTS (PART 2)
-----

NUMBER OF PARAMETERS (PART 2):
-----

PARAMETER TYPE                                #PARAMETERS  #PRE-ELIMINATED  #SET-UP  ...
-----
STATION COORDINATES                            3              0                  3        ...
AMBIGUITIES                                    24              0                  138      ...
STOCHASTIC IONOSPHERE PARAMETERS              20560           20560 (EPOCH-WISE)  20560    ...
-----
TOTAL NUMBER OF PARAMETERS                      20587           20560              20701    ...
-----

NUMBER OF OBSERVATIONS (PART 2):
-----

TYPE          FREQUENCY      FILE          #OBSERVATIONS
-----
PHASE         L1             ALL           17787
PHASE         L2             ALL           17787
-----
TOTAL NUMBER OF OBSERVATIONS                    35574
-----

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

A POSTERIORI SIGMA OF UNIT WEIGHT :    0.0013 M (SIGMA OF ONE-WAY L1 PHASE OBSERVABLE AT ZENITH)
DEGREE OF FREEDOM (DOF)           :    17760
CHI**2/DOF                         :    1.75

STATION COORDINATES: (NOT SAVED)
-----

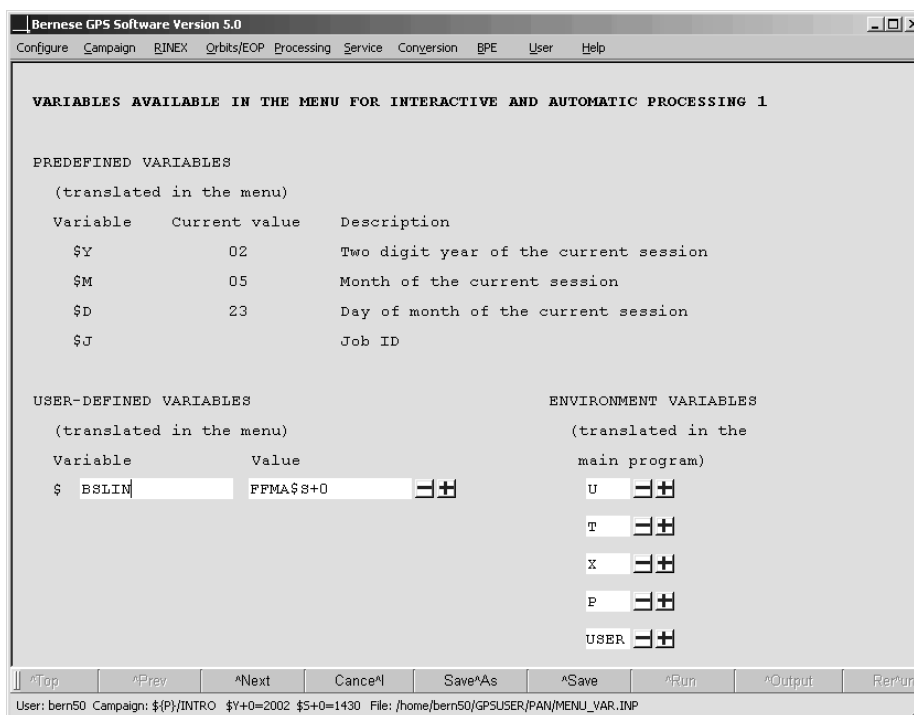
NUM  STATION NAME  PARAMETER  A PRIORI VALUE  NEW VALUE  NEW- A PRIORI  RMS ERROR  ...
-----
42   ONSA 10402M004  X          3370658.5802   3370658.5780  -0.0022     0.0002
                                     Y          711877.1009   711877.0980  -0.0029     0.0001
                                     Z          5349786.9188  5349786.9175  -0.0013     0.0003
                                     HEIGHT     45.5658      45.5632     -0.0026     0.0003  ...
                                     LATITUDE   57 23 43.074619  57 23 43.074669  0.0015     0.0002  ...
                                     LONGITUDE  11 55 31.859831  11 55 31.859690  -0.0023     0.0001  ...
...

```

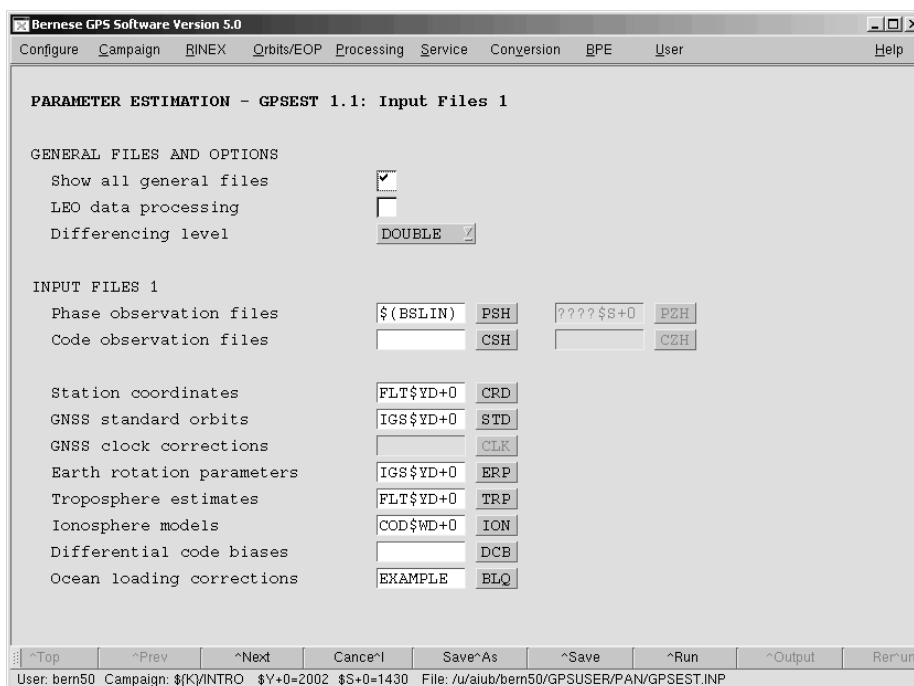
You may see from the output that from a total of 120 ambiguities 96 ambiguities could be resolved (compare part 1 AMBIGUITIES with part 2 AMBIGUITIES).

#### 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:



**Bernese GPS Software Version 5.0**

Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help

**GPSEST 2.1: Output Files 1**

GENERAL OUTPUT FILES

Program output  use GPSEST.Lnn or \$(BSLIN) OUT

Error message  merged to program output or ERROR MSG

RESULT FILES 1

Normal equations  NQ0

Station coordinates  CRD

Troposphere estimates  TRP

Troposphere SINEX  TRO

Ionosphere models  ION

IONEX  INX

GNSS clock corrections  CLK

Clock RINEX  CLK

Differential code biases  DCB

Residuals  RES

^Top ^Prev ^Next Cancel Save\*As ^Save ^Run ^Output Rerun

User: bern50 Campaign: \${K}/INTRO \$Y+0=2002 \$S+0=1430 File: /u/aiub/bern50/GPSUSER/PAN/GPSEST.INP

**Bernese GPS Software Version 5.0**

Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help

**GPSEST 3.1: General Options 1**

TITLE EXAMPLE: Baseline \$(BSLIN): QIF ambiguity resolution

OBSERVATION SELECTION

Satellite system GPS

Frequency L1&L2

Elevation cutoff angle 3 degrees LEO: 0 degrees

Sampling interval 30 seconds

Tolerance for simultaneity 100 milliseconds

Special data selection NO

Observation window

OBSERVATION MODELING AND PARAMETER ESTIMATION

A priori sigma 0.001 meters

Elevation-dependent weighting COSZ LEO: NONE

Type of computed residuals NORMALIZED

Correlation strategy BASELINE

Polarization effect geom.  only if later than 2003 09 14

total  only if later than 2006 11 05

^Top ^Prev ^Next Cancel Save\*As ^Save ^Run ^Output Rerun

User: bern50 Campaign: \${P}/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/GPSEST.INP

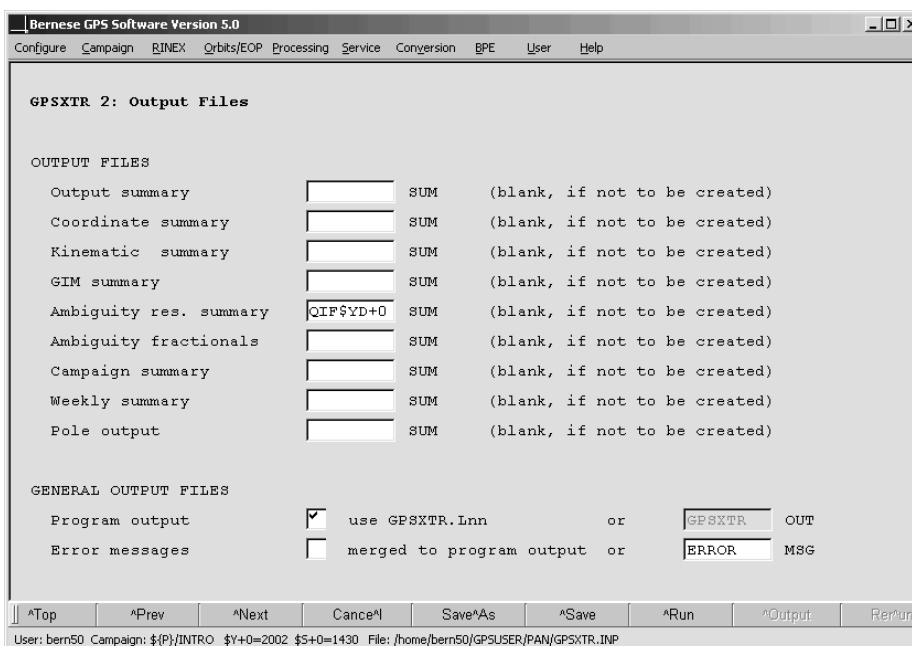
Now, we can easily switch from one baseline to the next by changing the definition of the variable \$(BSLIN) in the menu variables panel, only. The fields in the input files are updated automatically.

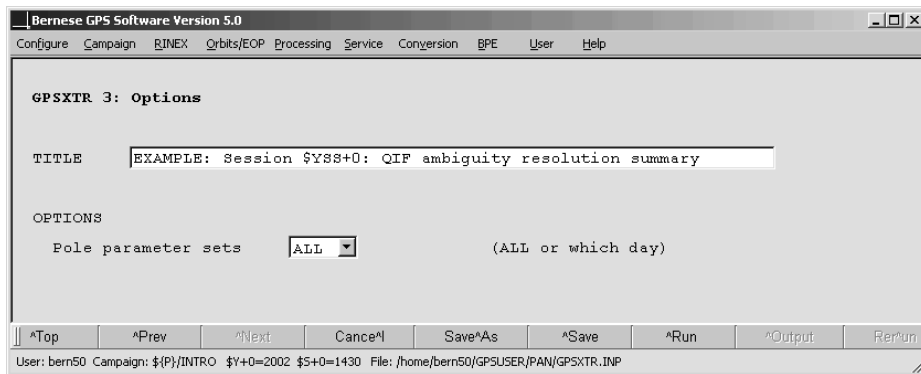
Ambiguity resolution is a typical application for the Bernese Processing Engine (BPE) even if you are going to process the data manually. We have prepared a Perl script that runs

#### 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:





In this summary ( $\${P}/INTRO/OUT/QIF02143.SUM$ ) you may easily see how many ambiguities are resolved for each baseline<sup>1</sup>:

| File     | Length<br>(km) | #Amb  | RMS0<br>(mm) | Max/RMS<br>(L5 Cycles) | L5 Amb | Max/RMS<br>(L3 Cycles) | L3 Amb | #Amb  | RMS0<br>(mm) | #Amb Res<br>(%) |      |
|----------|----------------|-------|--------------|------------------------|--------|------------------------|--------|-------|--------------|-----------------|------|
| BRON1430 | 883.8          | 120   | 1.3          | 0.495                  | 0.151  | 0.093                  | 0.029  | 24    | 1.3          | 80.0            |      |
| FFMA1430 | 1220.4         | 152   | 1.5          | 0.444                  | 0.130  | 0.093                  | 0.030  | 66    | 1.5          | 56.6            |      |
| FFON1430 | 840.1          | 134   | 1.4          | 0.479                  | 0.160  | 0.097                  | 0.031  | 30    | 1.4          | 77.6            |      |
| FFZI1430 | 368.1          | 88    | 1.2          | 0.395                  | 0.132  | 0.092                  | 0.025  | 34    | 1.2          | 61.4            |      |
| FFZM1430 | 368.1          | 128   | 1.1          | 0.384                  | 0.134  | 0.082                  | 0.018  | 30    | 1.2          | 76.6            |      |
| PTZM1430 | 640.1          | 96    | 1.3          | 0.488                  | 0.150  | 0.085                  | 0.025  | 14    | 1.4          | 85.4            |      |
| VIZM1430 | 1162.3         | 100   | 1.3          | 0.487                  | 0.166  | 0.094                  | 0.026  | 22    | 1.4          | 78.0            |      |
| Tot:     | 7              | 783.3 | 818          | 1.3                    | 0.495  | 0.147                  | 0.097  | 0.027 | 220          | 1.3             | 73.1 |

This table is a part of the solution reference file ( $\${P}/INTRO/OUT/R2S02143.PRC_REF$ ), 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
```

<sup>1</sup>You 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.

## 4.4 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 FLTyddd 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:*

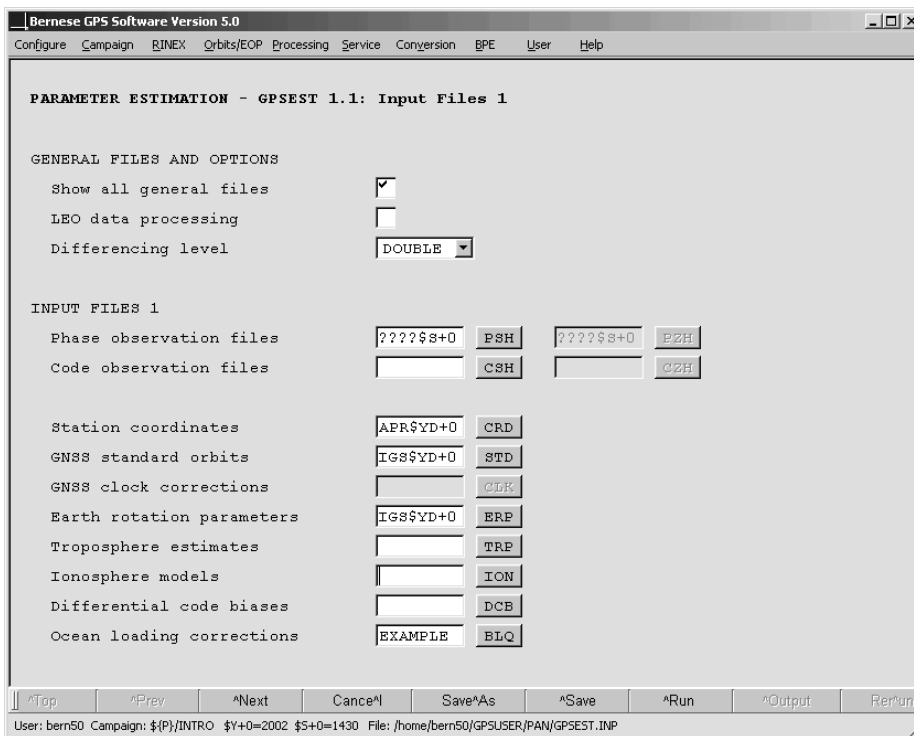
- (1) compute a final network solution of the day (GPSEST),*
- (2) check the coordinates of the fiducial sites (ADDNEQ2, HELMR1),*
- (3) check the daily repeatability (COMPAR),*
- (4) recompute final solution, and generate reduced size normal equation files (ADDNEQ2),*
- (5) (optional) compute velocities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

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

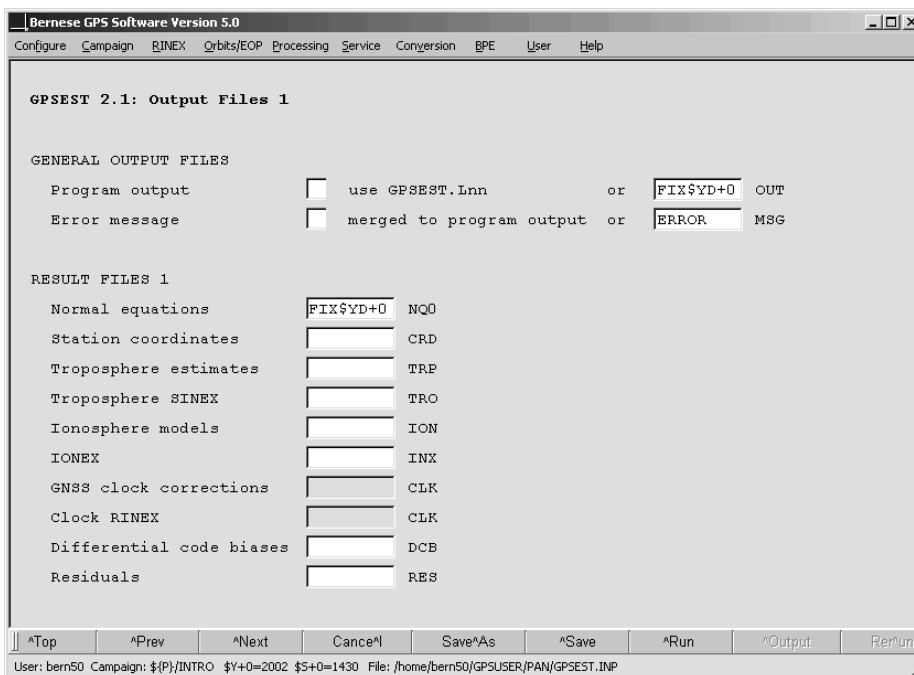
### 5.1 Final Network Solution

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:

5. Terminal Session: Thursday



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:

**Bernese GPS Software Version 5.0**

Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help

**GPSEST 3.1: General Options 1**

TITLE EXAMPLE: Session \$YSS+0: Final network solution (fixed)

OBSERVATION SELECTION

Satellite system GPS

Frequency L3

Elevation cutoff angle 3 degrees LEO: 0 degrees

Sampling interval 180 seconds

Tolerance for simultaneity 100 milliseconds

Special data selection NO

Observation window

OBSERVATION MODELING AND PARAMETER ESTIMATION

A priori sigma 0.001 meters

Elevation-dependent weighting COSZ LEO: NONE

Type of computed residuals NORMALIZED

Correlation strategy CORRECT

Polarization effect geom.  only if later than 2003 09 14

total  only if later than 2006 11 05

|| ^Top ^Prev ^Next Cancel Save^As ^Save ^Run ^Output Ret^un

User: bern50 Campaign: \${P}/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/GPSEST.INP

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

**Bernese GPS Software Version 5.0**

Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help

**GPSEST 3.2: General Options 2**

A PRIORI TROPOSPHERE MODELING

ZPD model and mapping function DRY NIELL

HANDLING OF AMBIGUITIES

Resolution strategy NONE

Save resolved ambiguities

Introduce widelane integers

Introduce L1 and L2 integers

SPECIAL PROCESSING OPTIONS

Maximum tolerated O-C term meters

Var-covar wrt epoch parameters SIMPLIFIED

EXTENDED PRINTING OPTIONS

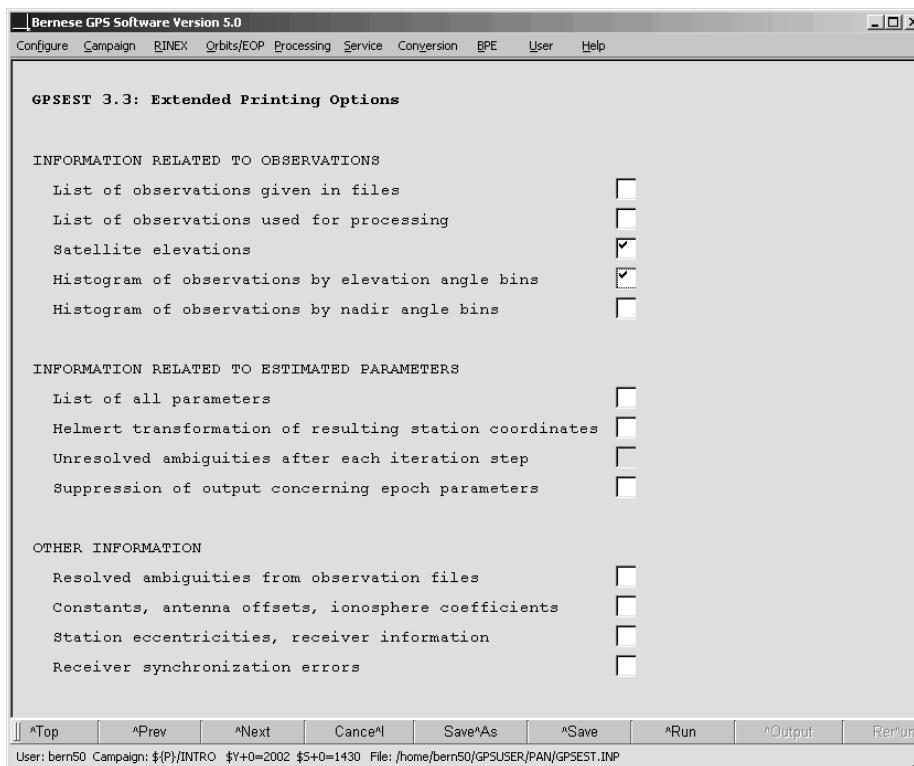
Selection of printing options YES

|| ^Top ^Prev ^Next Cancel Save^As ^Save ^Run ^Output Ret^un

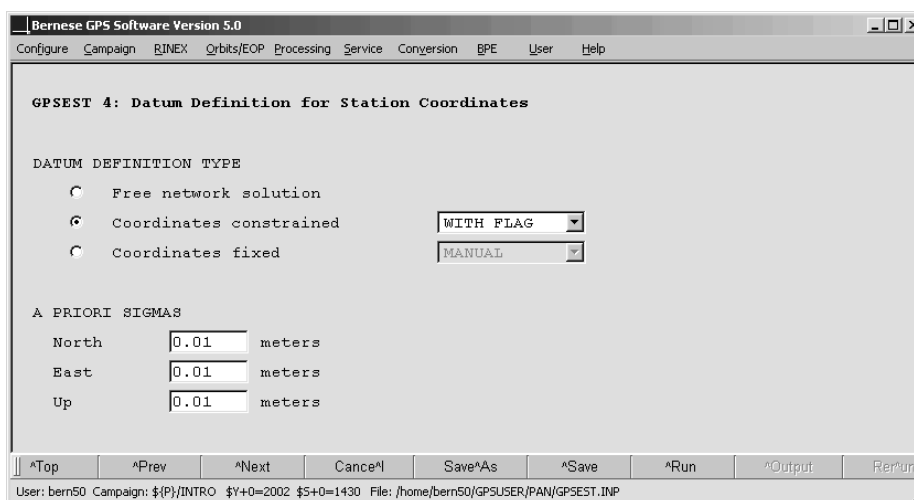
User: bern50 Campaign: \${P}/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/GPSEST.INP

## 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:

**Bernese GPS Software Version 5.0**

Configure Campaign RINEX Qrbits/EOP Processing Service Conversion BPE User Help

**GPSEST 5.1: Setup of Parameters and Pre-Elimination 1**

| STATION-RELATED PARAMETERS    | Setup                    | Pre-Elimination     |
|-------------------------------|--------------------------|---------------------|
| Station coordinates           |                          | NO                  |
| Ambiguities                   |                          | AS SOON AS POSSIBLE |
| Receiver antenna offsets      | <input type="checkbox"/> | NO                  |
| Receiver antenna PCV patterns | <input type="checkbox"/> | NO                  |

| ATMOSPHERIC PARAMETERS               | Setup                               | Pre-Elimination |
|--------------------------------------|-------------------------------------|-----------------|
| Site-specific troposphere parameters | <input checked="" type="checkbox"/> | NO              |
| Global ionosphere parameters         | <input type="checkbox"/>            | NO              |

| EPOCH PARAMETERS                 | Setup                               | Pre-Elimination |
|----------------------------------|-------------------------------------|-----------------|
| Kinematic coordinates            | <input type="checkbox"/>            | EVERY EPOCH     |
| Receiver clock offsets           | <input checked="" type="checkbox"/> | EVERY EPOCH     |
| GNSS clock offsets               | <input type="checkbox"/>            | EVERY EPOCH     |
| Stochastic ionosphere parameters | <input type="checkbox"/>            | EVERY EPOCH     |

User: bern50 Campaign: \$(P)/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/GPSEST.INP

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:

**Bernese GPS Software Version 5.0**

Configure Campaign RINEX Qrbits/EOP Processing Service Conversion BPE User Help

**GPSEST 6.3.1: Site-Specific Troposphere Parameters 1**

ZENITH PATH DELAY PARAMETERS

Mapping function: WET NIELL

Parameter spacing: 01 00 00 (hh mm ss)

HORIZONTAL GRADIENT PARAMETERS

Gradient estimation model: TILTING

Parameter spacing: 24 00 00 (hh mm ss)

A PRIORI SIGMAS

|                      | Absolute | Relative |
|----------------------|----------|----------|
| Zenith path delay    | meters   | meters   |
| Horizontal gradients | meters   | meters   |

EXTRACTION OF PARAMETERS FOR TROPOSPHERE SINEX FILE

Offset: (hhh mm ss) Time resolution: 01 00 00 (hh mm ss)

User: bern50 Campaign: \$(P)/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/GPSEST.INP

## 5. Terminal Session: Thursday

---

The output of a 1-session run of program GPSEST should look like this:

```
...
13. RESULTS (PART 1)
-----
NUMBER OF PARAMETERS (PART 1):
-----
PARAMETER TYPE                                #PARAMETERS  #PRE-ELIMINATED  #SET-UP  ...
-----
STATION COORDINATES                          24            0                24       ...
AMBIGUITIES                                   120           120 (BEFORE INV)  152       ...
SITE-SPECIFIC TROPOSPHERE PARAMETERS         232            0                232       ...
-----
TOTAL NUMBER OF PARAMETERS                    376           120              408       ...
-----

NUMBER OF OBSERVATIONS (PART 1):
-----
TYPE      FREQUENCY      FILE      #OBSERVATIONS
-----
PHASE     L3             ALL       20415
-----
TOTAL NUMBER OF OBSERVATIONS                  20415
-----

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  $\${P}/\text{INTRO}/\text{SOL}$

FIX02143.NQ0, FIX02144.NQ0, and  
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:

**Bernese GPS Software Version 5.0**  
 Configure Campaign RINEX Orbits/EOP Processing Service Convergence BPE User Help

**COMBINATION OF NORMAL EQUATION SYSTEMS - ADDNEQ2 1: Input Files**

GENERAL FILES  
 Show all general files

INPUT FILENAMES  
 Normal equations    
 Variance rescaling factors

Station coordinates    
 Station velocities    
 Station information    
 Troposphere estimates    
 Ionosphere master file    
 Differential code biases    
 Earth rotation parameters    
 Geocenter coordinates

|| ^Top ^Prev ^Next Cancel^ Save^As ^Save ^Run ^Output Rerun^  
 User: bern50 Campaign: \$(P)/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/ADDNEQ2.INP

**Bernese GPS Software Version 5.0**  
 Configure Campaign RINEX Orbits/EOP Processing Service Convergence BPE User Help

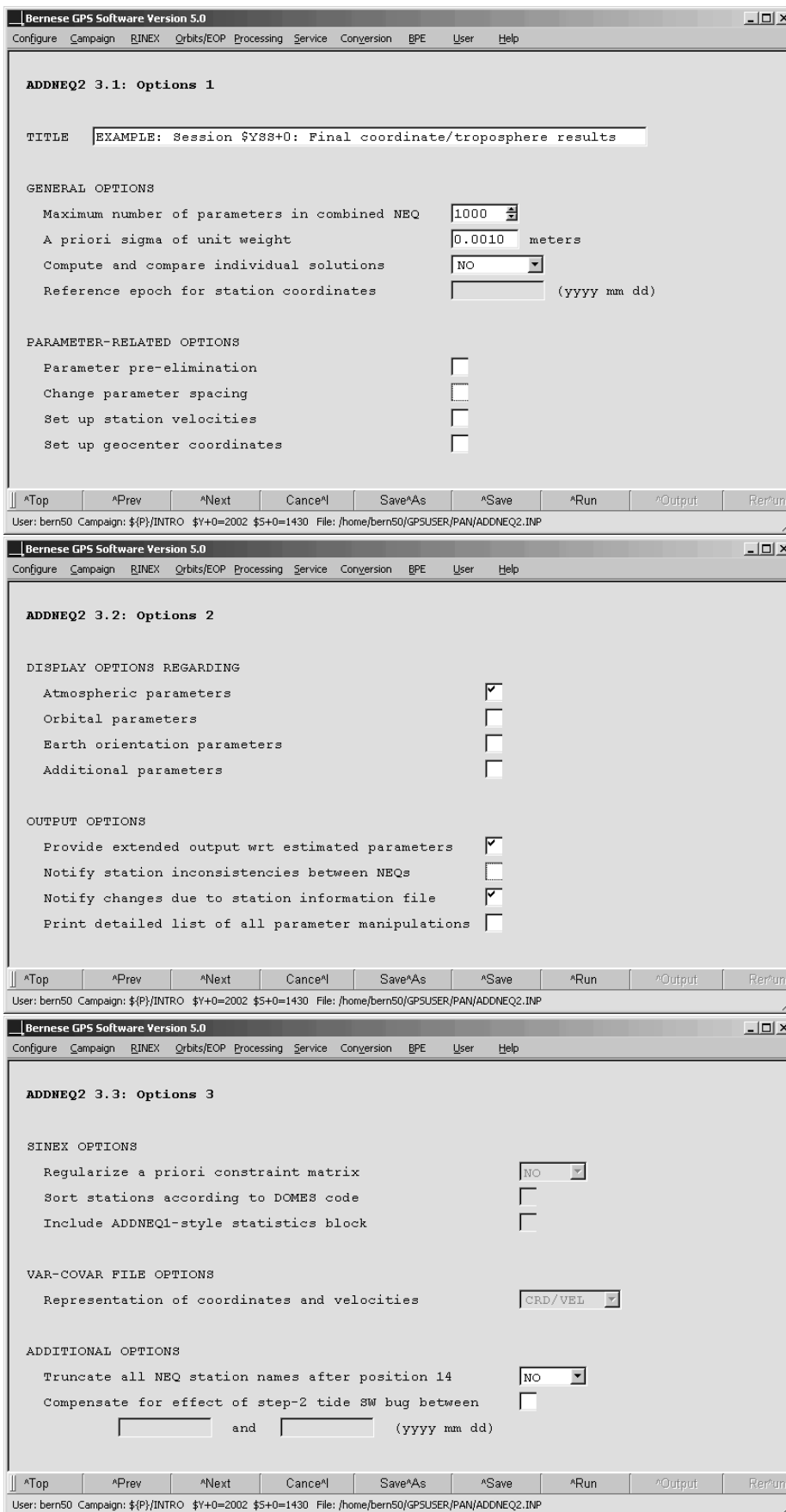
**ADDNEQ2 2: Output Files**

GENERAL OUTPUT FILES  
 Program output  use ADDNEQ2.Lnn or  OUT  
 Error messages  merged to program output or  MSG

RESULT FILES  
 Normal equations  NQO Orbital elements  ELE  
 SINEX with  SNX Bernese ERP file  ERP  
 Station coordinates  CRD IERS ERP file  IEP  
 Station velocities  VEL Geocenter coordinates  GCC  
 Troposphere estimates  TRP Var-covar wrt coord.  COV  
 Troposphere SINEX  TRO Full var-covar matrix  COV  
 Ionosphere models  ION Station residuals  PLT  
 IONEX  INX Weekly summary file  SUM  
 Code biases  DCB

|| ^Top ^Prev ^Next Cancel^ Save^As ^Save ^Run ^Output Rerun^  
 User: bern50 Campaign: \$(P)/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/ADDNEQ2.INP

5. Terminal Session: Thursday



## 5.2 Check the Coordinates of the Fiducial Sites

Bernese GPS Software Version 5.0

Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help

**ADDNEQ2 5: 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 SIGMAS

North 0.001 meters  
 East 0.001 meters  
 Up 0.001 meters

User: bern50 Campaign: \$(P)/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/ADDNEQ2.INP

Bernese GPS Software Version 5.0

Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help

**ADDNEQ2 5.1: Datum Definition for Station Coordinates**

STATIONS CONSIDERED FOR MINIMUM CONSTRAINT CONDITIONS

Manual selection  
 List of stations from file IGS\_00 FIX  
 Stations with specific flags in CRD file

User: bern50 Campaign: \$(P)/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/ADDNEQ2.INP

Bernese GPS Software Version 5.0

Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help

**ADDNEQ2 9: Options for Atmospheric Parameters**

A PRIORI SIGMAS

|                              | absolute | relative   |
|------------------------------|----------|------------|
| Troposphere zenith delays    | meters   | 1.0 meters |
| Troposphere gradients        | meters   | meters     |
| Global ionosphere parameters | TECU     | TECU       |

MAXIMUM TIME INTERVAL BETWEEN PARAMETERS FOR RELATIVE CONSTRAINING

Troposphere zenith delays 3600 sec  
 Troposphere gradients sec  
 Global ionosphere parameters sec

EXTRACTION OF PARAMETERS FOR TROPOSPHERE SINEX FILE

Offset 00 30 00 (hhh mm ss) Time resolution 01 00 00 (hh mm ss)

User: bern50 Campaign: \$(P)/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/ADDNEQ2.INP

## 5. Terminal Session: Thursday

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:
-----

Parameter type                                Adjusted  explicitly / implicitly (pre-eliminated) ...
-----
Station coordinates / velocities              24         24         0 ...
Site-specific troposphere parameters          223        223         0 ...
-----
Previously pre-eliminated parameters          109                                109 ...
-----
Total number                                  356         247         109 ...

Statistics:
-----

Total number of explicit parameters           247
Total number of implicit parameters           109

Total number of adjusted parameters           356
Total number of observations                  20415
Degree of freedom (DOF)                      20059

A posteriori RMS of unit weight               0.00114 m
Chi**2/DOF                                   1.30
...

```

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:
-----

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

Site-specific troposphere parameters:
-----

Station name          Typ      Correction Estimated value  RMS error  A priori value  Unit  ...
-----
BRUS 13101M004        N        -0.0001    -0.0001    0.0001         0.0000 meters ...
BRUS 13101M004        E         0.0006     0.0006    0.0001         0.0000 meters ...
BRUS 13101M004        U         0.1278     2.3945    0.0024         2.2667 meters ...
...

```

## 5.2 Check the Coordinates of the Fiducial Sites

The coordinate solution for the session ( $\{P\}$ /INTRO/STA/FIN02143.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:

**HELMR1 1: Input/Output Files**

GENERAL FILES

Show all general files

INPUT FILES

First coordinate file IGS\_00 CRD  
Velocities for first file IGS\_00 VEL (blank: no veloc. applied)  
Second coordinate file FIN\$YD+0 CRD  
File with list of stations IGS\_00 FIX other stations MARK

RESULT FILES

Coordinates  CRD  
File with list of stations  FIX

GENERAL OUTPUT FILES

Program output  use HELMR1.Lnn or HELMR1 OUT  
Error messages  merged to program output or ERROR MSG

Buttons: ^Top, ^Prev, ^Next, Cance^l, Save^As, ^Save, ^Run, ^Output, Re^run

User: bern50 Campaign:  $\{P\}$ /INTRO  $\{Y+0=2002\}$   $\{S+0=1430\}$  File: /home/bern50/GPSUSER/PAN/HELMR1.INP

**HELMR1 2: Options for Helmert Transformation**

TITLE EXAMPLE: Session  $\{YSS+0\}$ : Check fiducial coordinates

STATION SELECTION

Automatic station selection (all stations or selection from file)  
 Manual station selection

HELMERT TRANSFORMATION

System of transformation, local (N,E,U) or geocentric (X,Y,Z) NEU  
Unit of residuals (meter or millimeter) MM

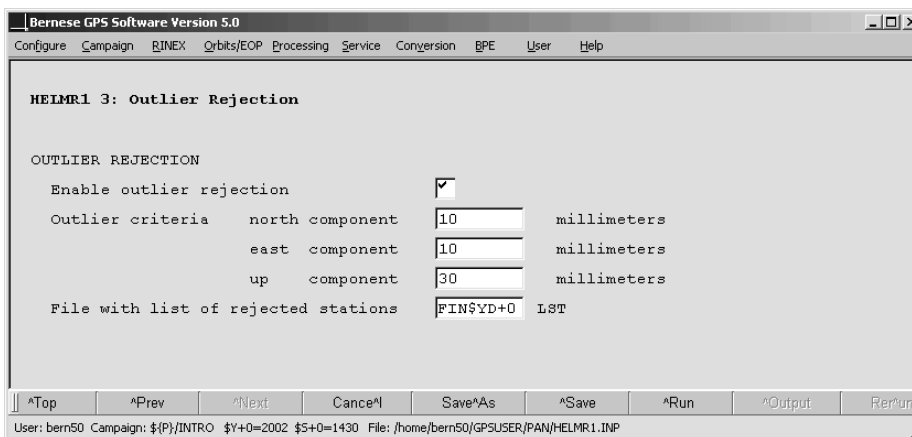
Parameters to be computed

|         |                                     |       |                          |
|---------|-------------------------------------|-------|--------------------------|
| shift 1 | <input checked="" type="checkbox"/> | rot 1 | <input type="checkbox"/> |
| shift 2 | <input checked="" type="checkbox"/> | rot 2 | <input type="checkbox"/> |
| shift 3 | <input checked="" type="checkbox"/> | rot 3 | <input type="checkbox"/> |
| scale   | <input type="checkbox"/>            |       |                          |

Buttons: ^Top, ^Prev, ^Next, Cance^l, Save^As, ^Save, ^Run, ^Output, Re^run

User: bern50 Campaign:  $\{P\}$ /INTRO  $\{Y+0=2002\}$   $\{S+0=1430\}$  File: /home/bern50/GPSUSER/PAN/HELMR1.INP

## 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.

```

=====
Program : HELMR1                               Bernese GPS Software Version 5.0
Purpose : Helmert Transformation
Campaign: ${P}/INTRO                           Default session: 1430 year 2002
Date    : 29-Aug-2011 13:17                    User name      : bern50
=====

EXAMPLE: Session 021430: Check fiducial coordinates
-----

FILE 1: IGS00 COORDINATES BASED ON IGS01P37_RS54.SNX
FILE 2: EXAMPLE: Session 021430: Final coordinate/troposphere results

LOCAL GEODETIC DATUM: IGS00
RESIDUALS IN LOCAL SYSTEM (NORTH, EAST, UP)

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

```

```

...
NUMBER OF PARAMETERS :      3
NUMBER OF COORDINATES :      9
RMS OF TRANSFORMATION :      6.3 MM

BARYCENTER COORDINATES:

LATITUDE           :      46 31 17.52
LONGITUDE          :      7 50  4.94
HEIGHT             :      -99.634 KM

PARAMETERS:

TRANSLATION IN N   :      0.0   +-  3.6   MM
TRANSLATION IN E   :      -0.0   +-  3.6   MM
TRANSLATION IN U   :      -0.0   +-  3.6   MM

NUMBER OF ITERATIONS :      1

NO OUTLIER DETECTED

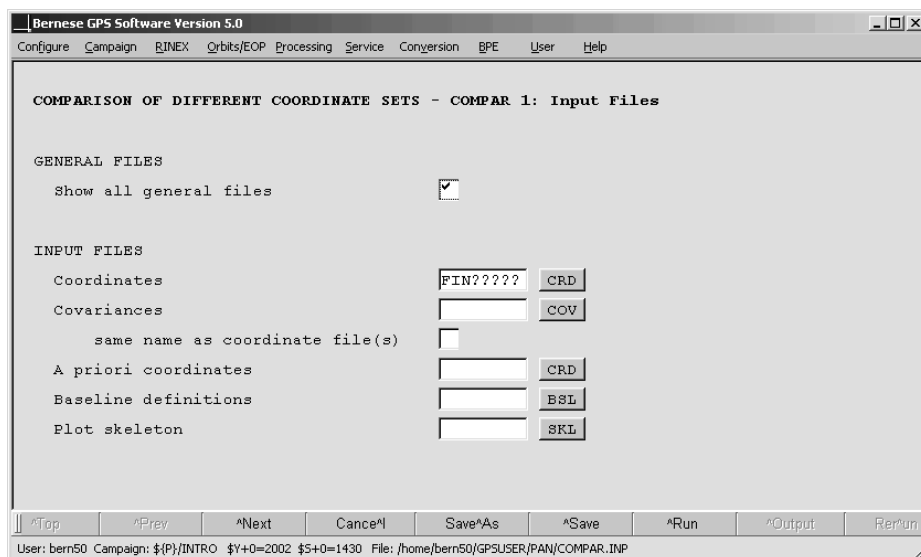
```

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

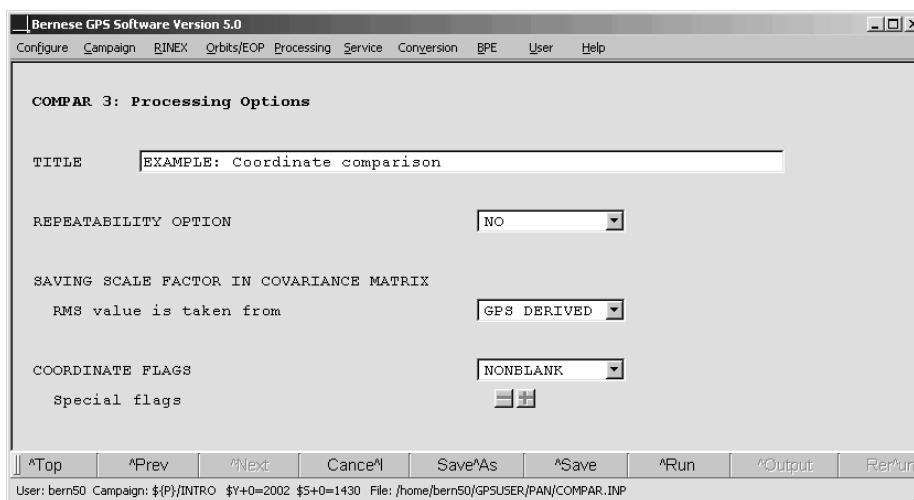
If there were problems, the ADDNEQ2-run needs to be repeated with the problematic station either removed from the file `#{P}/INTRO/STA/IGS_00.FIX` or with manual selection of the stations used for the datum definition in panel "ADDNEQ2 5.1: Datum Definition for Station Coordinates".

### 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").



## 5. Terminal Session: Thursday



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:

| NUM | STATION        | #FIL | C | RMS  | 1     | 2     | 3    | 4    |
|-----|----------------|------|---|------|-------|-------|------|------|
| 6   | BRUS 13101M004 | 4    | N | 11.5 | -10.5 | -9.4  | 8.8  | 11.0 |
|     |                |      | E | 10.7 | -9.9  | -8.6  | 9.5  | 9.1  |
|     |                |      | U | 3.3  | 2.3   | 2.3   | 0.1  | -4.7 |
| 15  | FFMJ 14279M001 | 4    | N | 6.9  | -6.2  | -5.7  | 6.1  | 5.8  |
|     |                |      | E | 10.2 | -8.8  | -8.8  | 8.8  | 8.8  |
|     |                |      | U | 2.3  | 0.8   | -2.0  | 3.0  | -1.8 |
| 36  | MATE 12734M008 | 4    | N | 10.6 | -8.1  | -10.2 | 9.5  | 8.8  |
|     |                |      | E | 13.3 | -12.2 | -10.8 | 10.7 | 12.3 |
|     |                |      | U | 2.5  | 3.6   | -1.4  | -1.9 | -0.2 |
| 42  | ONSA 10402M004 | 4    | N | 7.3  | -6.2  | -6.4  | 6.3  | 6.4  |
|     |                |      | E | 10.2 | -9.2  | -8.5  | 8.7  | 9.0  |
|     |                |      | U | 2.3  | -2.5  | 1.6   | 2.2  | -1.3 |
| 47  | PTBB 14234M001 | 4    | N | 8.9  | -7.4  | -8.0  | 6.7  | 8.7  |
|     |                |      | E | 11.4 | -10.2 | -9.5  | 9.6  | 10.1 |
|     |                |      | U | 2.6  | 1.9   | 2.5   | -1.5 | -2.9 |
| 56  | VILL 13406M001 | 4    | N | 9.2  | -8.3  | -7.6  | 7.3  | 8.6  |
|     |                |      | E | 11.7 | -9.3  | -10.9 | 11.0 | 9.2  |
|     |                |      | U | 1.1  | -0.8  | 0.5   | -0.9 | 1.3  |
| 63  | ZIMJ 14001M006 | 4    | N | 9.4  | -7.7  | -8.5  | 8.3  | 7.9  |
|     |                |      | E | 11.1 | -9.9  | -9.2  | 9.3  | 9.9  |
|     |                |      | U | 1.6  | 2.0   | -0.7  | 0.5  | -1.8 |
| 64  | ZIMM 14001M004 | 4    | N | 9.2  | -7.4  | -8.4  | 8.0  | 7.9  |
|     |                |      | E | 11.5 | -10.0 | -9.9  | 9.8  | 10.1 |
|     |                |      | U | 1.9  | 0.7   | -2.7  | 1.8  | 0.2  |

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).

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 ( $\{\text{P}\}/\text{INTRO}/\text{STA}/\text{EXAMPLE.STA}$ ). 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:

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

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 ( $\{\text{P}\}/\text{INTRO}/\text{STA}/\text{FIN}\$\text{YD}+0.\text{CRD}$ ) 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:

**Bernese GPS Software Version 5.0**  
 Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help

**COMBINATION OF NORMAL EQUATION SYSTEMS - ADDNEQ2 1: Input Files**

GENERAL FILES  
 Show all general files

INPUT FILENAMES

|                            |  |                                    |
|----------------------------|--|------------------------------------|
| Normal equations           | <input type="text" value="FIN\$YD+0"/> | <input type="button" value="NQO"/> |
| Variance rescaling factors | <input type="text"/>                   | <input type="button" value="WGT"/> |
| Station coordinates        | <input type="text" value="FIN\$YD+0"/> | <input type="button" value="CRD"/> |
| Station velocities         | <input type="text"/>                   | <input type="button" value="VEL"/> |
| Station information        | <input type="text" value="EXAMPLE"/>   | <input type="button" value="STA"/> |
| Troposphere estimates      | <input type="text"/>                   | <input type="button" value="TRP"/> |
| Ionosphere master file     | <input type="text"/>                   | <input type="button" value="ION"/> |
| Differential code biases   | <input type="text"/>                   | <input type="button" value="DCB"/> |
| Earth rotation parameters  | <input type="text"/>                   | <input type="button" value="ERP"/> |
| Geocenter coordinates      | <input type="text"/>                   | <input type="button" value="GCC"/> |

|| ^Top ^Prev ^Next Cancel Save^As ^Save ^Run ^Output Rerun  
 User: bern50 Campaign: \$(P);INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/ADONEQ2.INP

**Bernese GPS Software Version 5.0**  
 Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help

**ADDNEQ2 2: Output Files**

GENERAL OUTPUT FILES

|                |   |    |  |     |
|----------------|---|----|--|-----|
| Program output | <input type="checkbox"/> use ADDNEQ2.Lnn          | or | <input type="text" value="RED\$YD+0"/> | OUT |
| Error messages | <input type="checkbox"/> merged to program output | or | <input type="text" value="ERROR"/>     | MSG |

RESULT FILES

|   |  |     |                       |                      |     |
|---|--|-----|-----------------------|----------------------|-----|
| Normal equations                              | <input type="text" value="RED\$YD+0"/> | NQO | Orbital elements      | <input type="text"/> | ELE |
| SINEX with <input type="button" value="COV"/> | <input type="text" value="RED\$YD+0"/> | SNX | Bernese ERP file      | <input type="text"/> | BRP |
| Station coordinates                           | <input type="text"/>                   | CRD | IERS ERP file         | <input type="text"/> | IEP |
| Station velocities                            | <input type="text"/>                   | VEL | Geocenter coordinates | <input type="text"/> | GCC |
| Troposphere estimates                         | <input type="text"/>                   | TRP | Var-covar wrt coord.  | <input type="text"/> | COV |
| Troposphere SINEX                             | <input type="text"/>                   | TRO | Full var-covar matrix | <input type="text"/> | COV |
| Ionosphere models                             | <input type="text"/>                   | ION | Station residuals     | <input type="text"/> | PLT |
| IONEX   | <input type="text"/>                   | INX | Weekly summary file   | <input type="text"/> | SUM |
| Code biases                                   | <input type="text"/>                   | DCB |                       |                      |     |

|| ^Top ^Prev ^Next Cancel Save^As ^Save ^Run ^Output Rerun  
 User: bern50 Campaign: \$(P);INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/ADONEQ2.INP

## 5.4 Compute the Final Solution of the Session

Bernese GPS Software Version 5.0

Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help

**ADDNEQ2 3.1: Options 1**

TITLE

GENERAL OPTIONS

Maximum number of parameters in combined NEQ

A priori sigma of unit weight  meters

Compute and compare individual solutions

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

User: bern50 Campaign: \$(P)/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/ADDNEQ2.INP

Bernese GPS Software Version 5.0

Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help

**ADDNEQ2 5: Datum Definition for Station Coordinates**

DATUM DEFINITION TYPE

Free network solution

Minimum constraint solution

Coordinates constrained

Coordinates fixed

MINIMUM CONSTRAINT CONDITIONS

Translation

Rotation

Scale

A PRIORI SIGMAS

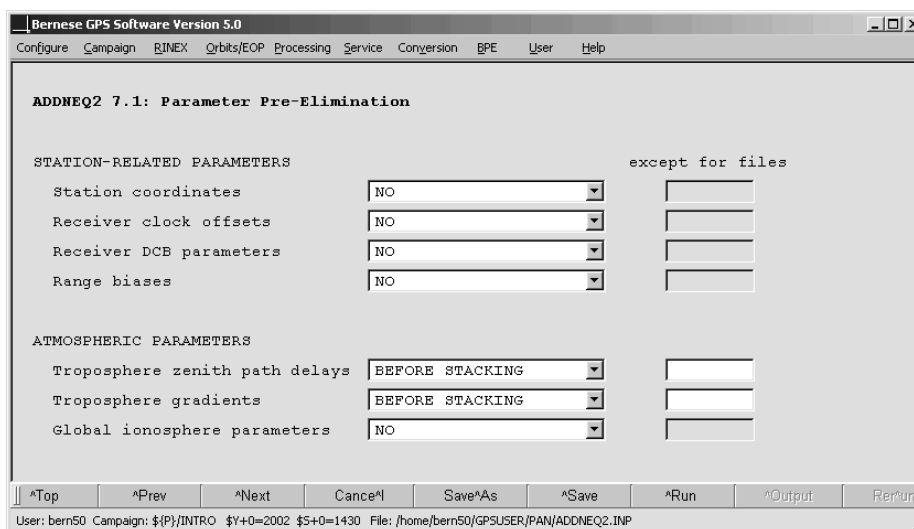
North  meters

East  meters

Up  meters

User: bern50 Campaign: \$(P)/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/ADDNEQ2.INP

## 5. Terminal Session: Thursday



The normal equation file ( $\{P\}/INTRO/SOL/RED02143.NQ0$ ) contains only the station coordinate parameters. The following section of the program output documents the pre-elimination of the troposphere parameters:

```

...
SUMMARY OF RESULTS
-----

Number of parameters:
-----

Parameter type                Adjusted  explicitly / implicitly (pre-eliminated) ...
-----
Station coordinates / velocities      24         24         0 ...
Site-specific troposphere parameters  223         0         223 (before stacking)...
-----
Previously pre-eliminated parameters  109         109 ...
-----
Total number                      356         24         332 ...

Statistics:
-----

Total number of explicit parameters      24
Total number of implicit parameters     332

Total number of adjusted parameters     356
Total number of observations             20415
Degree of freedom (DOF)                 20059

A posteriori RMS of unit weight         0.00114 m
Chi**2/DOF                             1.30
...

```

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):

**Bernese GPS Software Version 5.0**

Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help

**COMBINATION OF NORMAL EQUATION SYSTEMS - ADDNEQ2 1: Input Files**

GENERAL FILES

Show all general files

INPUT FILENAMES

Normal equations

Variance rescaling factors

Station coordinates

Station velocities

Station information

Troposphere estimates

Ionosphere master file

Differential code biases

Earth rotation parameters

Geocenter coordinates

|| ^Top ^Prev ^Next Cancel Save^As ^Save ^Run ^Output Rerun

User: bern50 Campaign: \$(P)/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/ADDNEQ2.INP

**Bernese GPS Software Version 5.0**

Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help

**ADDNEQ2 2: Output Files**

GENERAL OUTPUT FILES

Program output  use ADDNEQ2.Lnn or  OUT

Error messages  merged to program output or  MSG

RESULT FILES

Normal equations  NQD Orbital elements  ELE

SINEX with   SNX Bernese ERP file  BRP

Station coordinates  CRD IERS ERP file  IEP

Station velocities  VEL Geocenter coordinates  GCC

Troposphere estimates  TRP Var-covar wrt coord.  COV

Troposphere SINEX  TRO Full var-covar matrix  COV

Ionosphere models  ION Station residuals  PLT

IONEX  INX Weekly summary file  SUM

Code biases  DCB

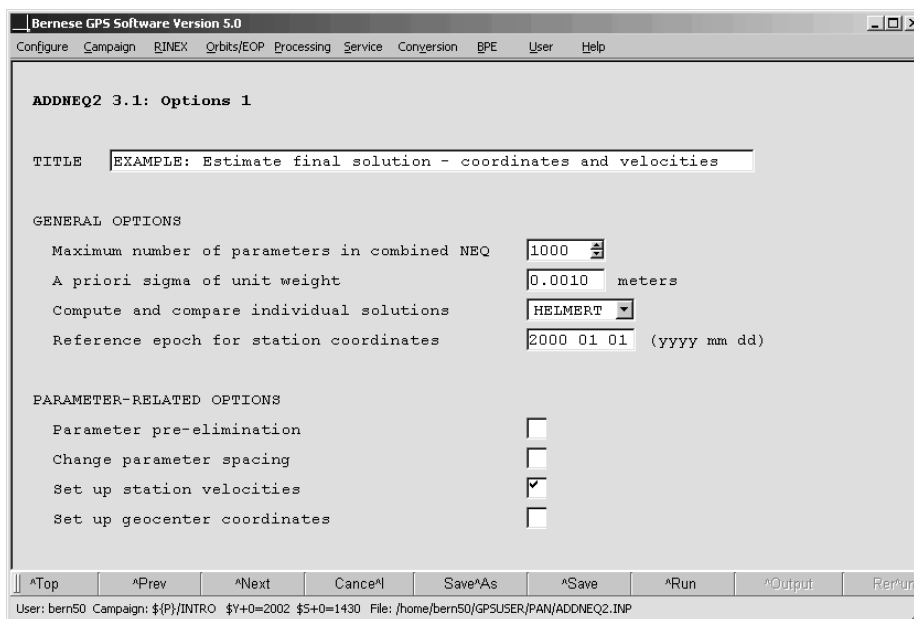
|| ^Top ^Prev ^Next Cancel Save^As ^Save ^Run ^Output Rerun

User: bern50 Campaign: \$(P)/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/ADDNEQ2.INP

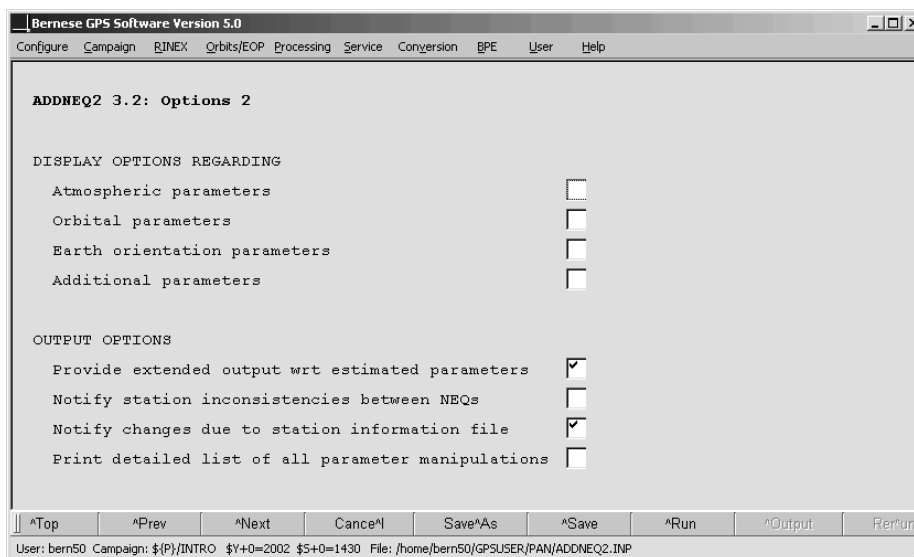
## 5. Terminal Session: Thursday

---

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.



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

**Bernese GPS Software Version 5.0**

Configure Campaign RINEX Qrbits/EOP Processing Service Conversion BPE User Help

**ADDNEQ2 4: Comparison of Individual Solutions**

NOTIFICATION OF POSSIBLE OUTLIERS

Maximum tolerated residual

|       |                                 |             |
|-------|---------------------------------|-------------|
| North | <input type="text" value="15"/> | millimeters |
| East  | <input type="text" value="15"/> | millimeters |
| Up    | <input type="text" value="30"/> | millimeters |

Maximum tolerated root-mean-square error

|       |                                 |             |
|-------|---------------------------------|-------------|
| North | <input type="text" value="10"/> | millimeters |
| East  | <input type="text" value="10"/> | millimeters |
| Up    | <input type="text" value="20"/> | millimeters |

Minimum number of solutions for each station

|| ^Top ^Prev ^Next Cancel Save\*As \*Save \*Run ^Output Rerun

User: bern50 Campaign: \${P}/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/ADDNEQ2.INP

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

**Bernese GPS Software Version 5.0**

Configure Campaign RINEX Qrbits/EOP Processing Service Conversion BPE User Help

**ADDNEQ2 5: Datum Definition for Station Coordinates**

DATUM DEFINITION TYPE

Free network solution

Minimum constraint solution

Coordinates constrained

Coordinates fixed

MINIMUM CONSTRAINT CONDITIONS

Translation

Rotation

Scale

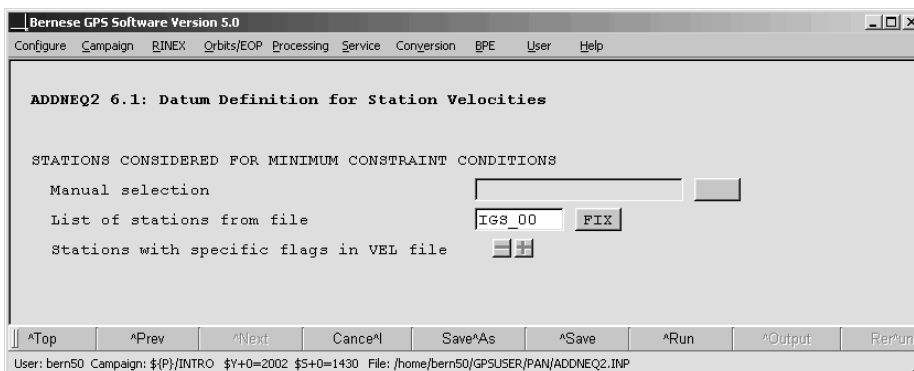
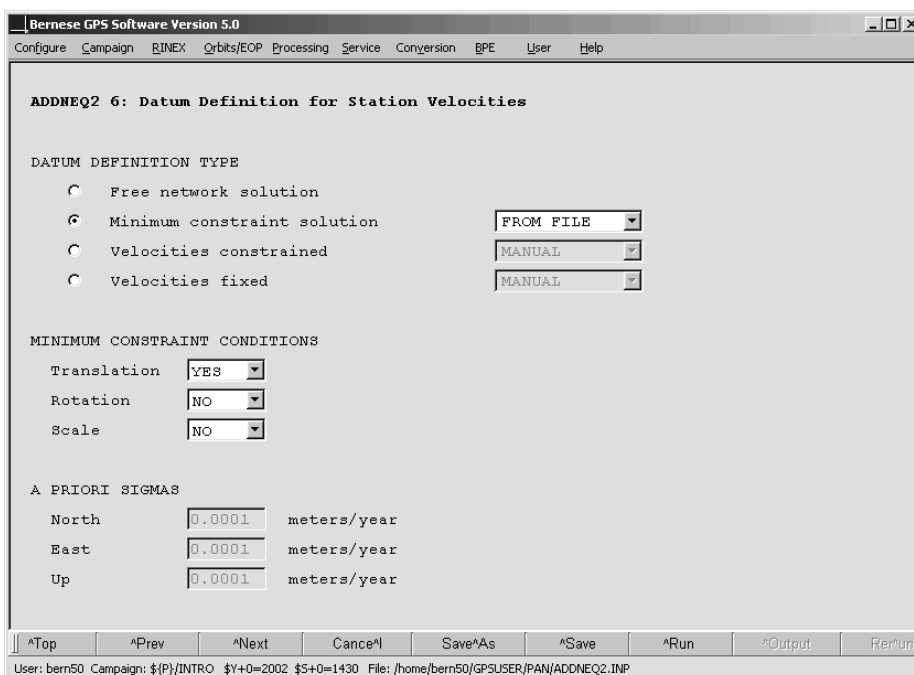
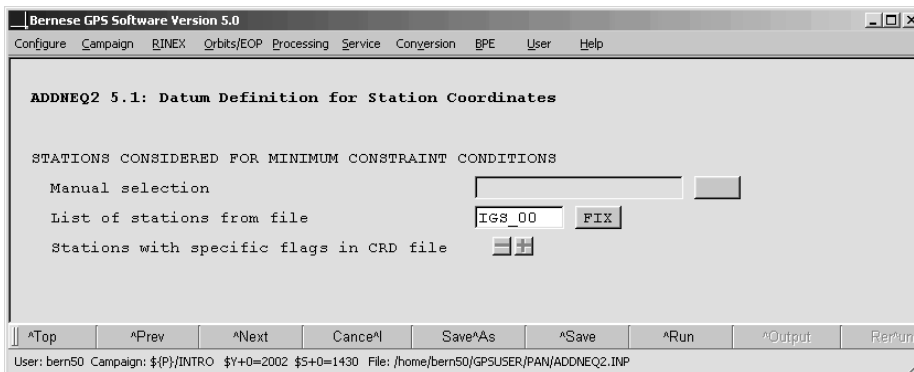
A PRIORI SIGMAS

|       |                                    |        |
|-------|------------------------------------|--------|
| North | <input type="text" value="0.001"/> | meters |
| East  | <input type="text" value="0.001"/> | meters |
| Up    | <input type="text" value="0.001"/> | meters |

|| ^Top ^Prev ^Next Cancel Save\*As \*Save \*Run ^Output Rerun

User: bern50 Campaign: \${P}/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/ADDNEQ2.INP

5. Terminal Session: Thursday



After the velocity estimation the repeatability of the coordinates solutions from the individual normal equations looks like:

```

...
Comparison of Individual Solutions:
-----
BRUS N   0.64   -0.48   0.48  -0.64   0.60
BRUS E   0.33   -0.31   0.38   0.21  -0.19
BRUS U   0.91    0.41  -0.38   1.04  -1.05

FFMJ N   0.47   -0.31   0.33   0.39  -0.55
FFMJ E   0.30   0.33  -0.32   0.16  -0.19
FFMJ U   1.34    1.04  -1.19   0.75  -1.53

MATE N   0.04    0.00   0.02   0.05   0.04
MATE E   0.66   -0.30   0.33  -0.75   0.75
MATE U   0.66   -0.65   0.76  -0.33   0.42

ONSA N   0.64    0.17  -0.25   0.76  -0.75
ONSA E   0.39    0.22  -0.24   0.44  -0.41
ONSA U   1.11   -1.01   1.27  -0.57   0.85

PTBB N   0.50    0.29  -0.32  -0.52   0.54
PTBB E   0.11    0.12  -0.11   0.08  -0.07
PTBB U   0.81   -0.44   0.22  -0.86   1.00

VILL N   0.59   -0.32   0.27  -0.66   0.65
VILL E   0.35    0.05  -0.10   0.40  -0.45
VILL U   0.98   -0.86   0.97  -0.71   0.83

ZIMJ N   0.38    0.38  -0.18   0.39  -0.32
ZIMJ E   0.24   -0.19   0.12  -0.25   0.24
ZIMJ U   0.64    0.65  -0.59   0.51  -0.45

ZIMM N   0.36    0.26  -0.35   0.32  -0.31
ZIMM E   0.18    0.17  -0.13  -0.14   0.16
ZIMM U   0.80    0.87  -1.06   0.18  -0.08

```

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.

5. Terminal Session: Thursday

---

If you compare the velocities obtained for the two GPS receivers in Zimmerwald (ZIMJ and ZIMM) you will find small differences:

```

...
Station coordinates and velocities:
-----
Reference epoch: 2000-01-01 00:00:00

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

```

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)
-----
STATION NAME 1      STATION NAME 2      RELATIVE CONSTR. POSITION      RELATIVE CONSTR. VELOCITY
NORTH      EAST      UP      NORTH      EAST      UP
*****
ZIMM 14001M004      ZIMJ 14001M006      **.,***** **.,***** **.,***** **.,***** **.,***** **.,*****
0.00001      0.00001      0.00001

```

(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:

```

...
Station coordinates and velocities:
-----
Reference epoch: 2000-01-01 00:00:00

Station name      Typ      A priori value    Estimated value  Correction    RMS error    ...
-----
...
ZIMJ 14001M006   VX       -0.0129          -0.0141         -0.0012       0.0009
                  VY        0.0182           0.0182          -0.0000       0.0003
                  VZ        0.0098           0.0115           0.0017       0.0009
                  VU        0.0000           0.0004           0.0004       0.0012    ...
                  VN        0.0143           0.0163           0.0020       0.0004    ...
                  VE        0.0197           0.0198           0.0001       0.0003    ...
...
ZIMM 14001M004   VX       -0.0129          -0.0141         -0.0012       0.0009
                  VY        0.0182           0.0182          -0.0000       0.0003
                  VZ        0.0098           0.0115           0.0017       0.0009
                  VU        0.0000           0.0004           0.0004       0.0012    ...
                  VN        0.0143           0.0163           0.0020       0.0004    ...
                  VE        0.0197           0.0198           0.0001       0.0003    ...
...

```

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

```

EXAMPLE: Estimate final solution - coordinates and velocities    29-AUG-11 14:39
-----
LOCAL GEODETIC DATUM: IGS00          EPOCH: 2000-01-01  0:00:00

NUM  STATION NAME          X (M)          Y (M)          Z (M)          FLAG
-----
  6  BRUS 13101M004        4027893.8381   307045.7406    4919475.0651   A
 15  FFMJ 14279M001        4053455.9398   617729.5776    4869395.6488   A
 36  MATE 12734M008        4641949.6613   1393045.3341   4133287.3894   W
 42  ONSA 10402M004        3370658.6188   711877.0653    5349786.9057   W
 47  PTBB 14234M001        3844060.0434   709661.2312    5023129.4994   A
 56  VILL 13406M001        4849833.7467  -335049.1277   4116014.8642   W
 63  ZIMJ 14001M006        4331294.0069   567542.0459    4633135.6597   A
 64  ZIMM 14001M004        4331297.1400   567555.7887    4633133.8682   A

```

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

```

EXAMPLE: Estimate final solution - coordinates and velocities    29-AUG-11 14:58
-----
LOCAL GEODETIC DATUM: IGS00

NUM  STATION NAME          VX (M/Y)        VY (M/Y)        VZ (M/Y)        FLAG  PLATE
-----
  6  BRUS 13101M004        -0.0199         0.0174          0.0093          A    EURA
 15  FFMJ 14279M001        -0.0109         0.0165          0.0092          A    EURA
 36  MATE 12734M008        -0.0199         0.0185          0.0126          W    EURA
 42  ONSA 10402M004        -0.0136         0.0154          0.0079          W    EURA
 47  PTBB 14234M001        -0.0185         0.0169          0.0060          A    EURA
 56  VILL 13406M001        -0.0089         0.0210          0.0123          W    EURA
 63  ZIMJ 14001M006        -0.0141         0.0182          0.0115          A    EURA
 64  ZIMM 14001M004        -0.0141         0.0182          0.0115          A    EURA

```

## 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.NQO (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 NQOs, created file: RED02143.NQO 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:*

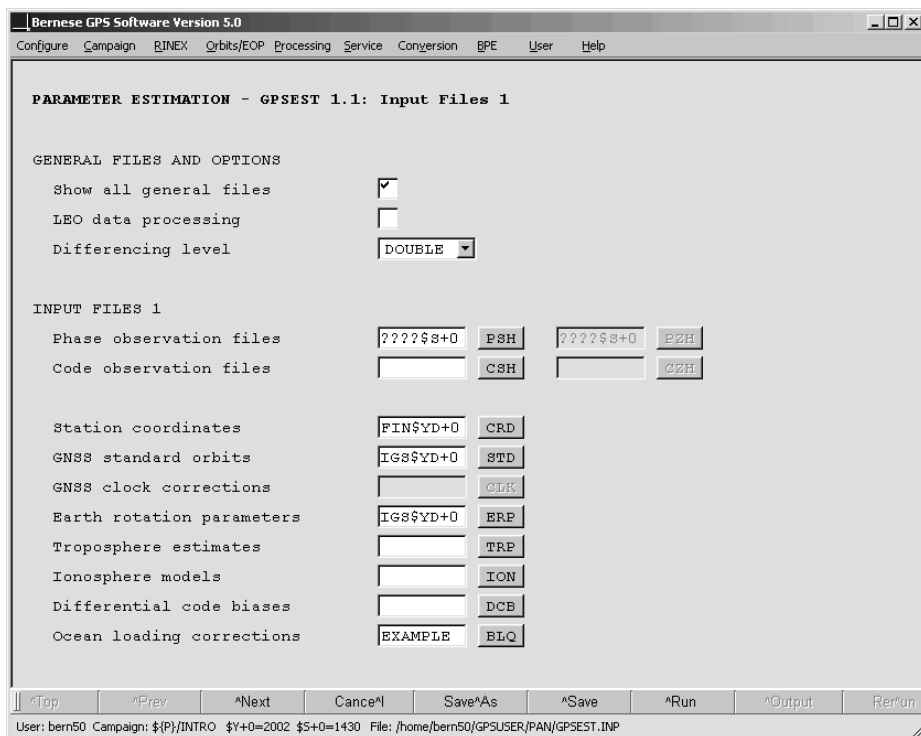
- *kinematic positioning for a station,*
- *zero-difference processing to estimate clocks, or*
- *use of the Bernese Processing Engine.*

### 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.

## 6. Terminal Session: Friday

---



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").

Because the number of parameters for the kinematic positioning may become very large we select only a short data interval for this kinematic positioning:

**Bernese GPS Software Version 5.0**  
 Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help

**GPSEST 3.1: General Options 1**

TITLE EXAMPLE: Session \$YSS+0: Kinematic positioning of station FFMJ

OBSERVATION SELECTION

Satellite system GPS  
 Frequency L3  
 Elevation cutoff angle 3 degrees LEO: 0 degrees  
 Sampling interval 300 seconds  
 Tolerance for simultaneity 100 milliseconds  
 Special data selection NO  
 Observation window

OBSERVATION MODELING AND PARAMETER ESTIMATION

A priori sigma 0.001 meters  
 Elevation-dependent weighting COSZ LEO: NONE  
 Type of computed residuals NORMALIZED  
 Correlation strategy CORRECT  
 Polarization effect geom.  only if later than 2003 09 14  
 total  only if later than 2006 11 05

|| ^Top ^Prev ^Next Cancel Save^As ^Save ^Run ^Output Rerun  
 User: bern50 Campaign: \${P}/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/GPSEST.INP

**Bernese GPS Software Version 5.0**  
 Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help

**GPSEST 3.1.1: Observation Window**

OBSERVATION WINDOW

Defined by year and session number  
 Year \$Y+0 Session \$S+0

Defined by start and end time

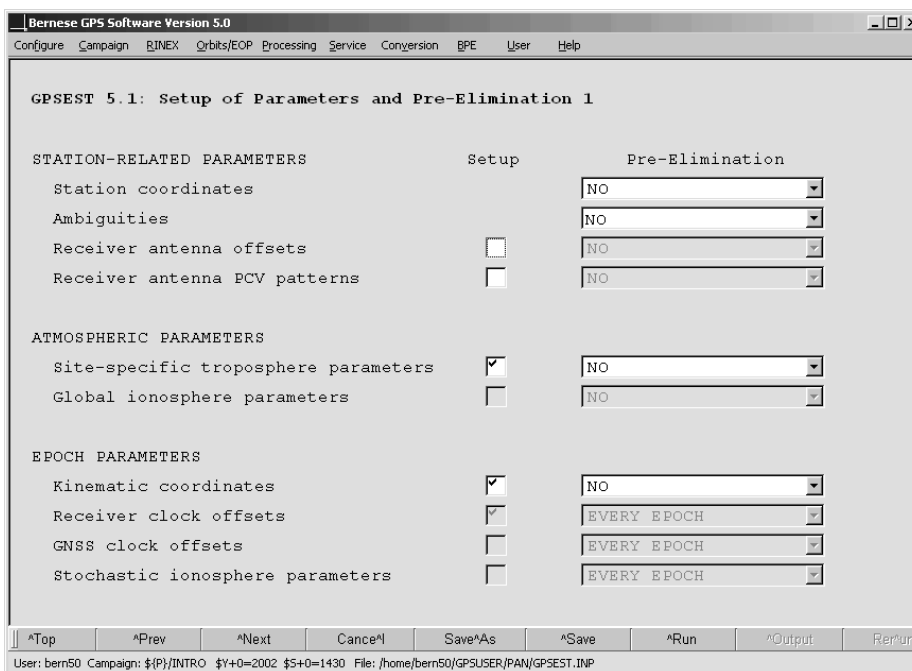
yyyy mm dd hh mm ss yyyy mm dd hh mm ss  
 start \$YMD\_STR+0 02 00 00 End \$YMD\_STR+0 02 59 59

|| ^Top ^Prev ^Next Cancel Save^As ^Save ^Run ^Output Rerun  
 User: bern50 Campaign: \${P}/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/GPSEST.INP

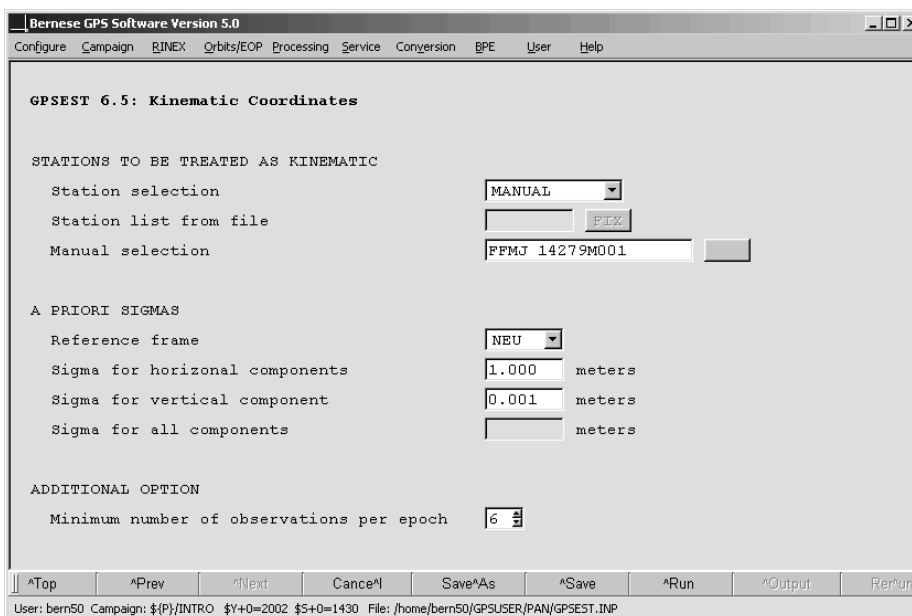
## 6. Terminal Session: Friday

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:



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

| KINEMATIC COORDINATES:                                   |                | \${P}/INTRO/STA/KIN02143.KIN |      |                  |                  |                  |     |
|--|----------------|------------------------------|------|------------------|------------------|------------------|-----|
| -----  |                |                              |      |                  |                  |                  |     |
| EPO: EPOCHS SINCE 2002-05-23 02:00:00 (SAMPLING 300 SEC) |                |                              |      |                  |                  |                  |     |
| CORRECTION AND RMS IN METER                              |                |                              |      |                  |                  |                  |     |
| EPO  | EPOCH(MJD)     | #OBS                         | STA  | LATITUDE         | LONGITUDE        | HEIGHT           | ... |
| -----  |                |                              |      |                  |                  |                  |     |
|  | FFMJ 14279M001 |                              |      | 50 5 26.079481   | 8 39 53.878622   | 178.1970         |     |
| 1  | 52417.083333   | 21                           | FFMJ | -0.0297 +- 0.011 | -0.0171 +- 0.007 | -0.0001 +- 0.001 | ... |
| 2  | 52417.086806   | 21                           | FFMJ | -0.0148 +- 0.009 | -0.0048 +- 0.006 | -0.0000 +- 0.001 | ... |
| 3  | 52417.090278   | 22                           | FFMJ | -0.0041 +- 0.009 | -0.0059 +- 0.006 | 0.0002 +- 0.001  | ... |
| 4  | 52417.093750   | 23                           | FFMJ | -0.0020 +- 0.010 | -0.0055 +- 0.007 | -0.0001 +- 0.001 | ... |
| 5  | 52417.097222   | 23                           | FFMJ | -0.0048 +- 0.012 | -0.0014 +- 0.009 | -0.0000 +- 0.001 | ... |

Further suggestions:

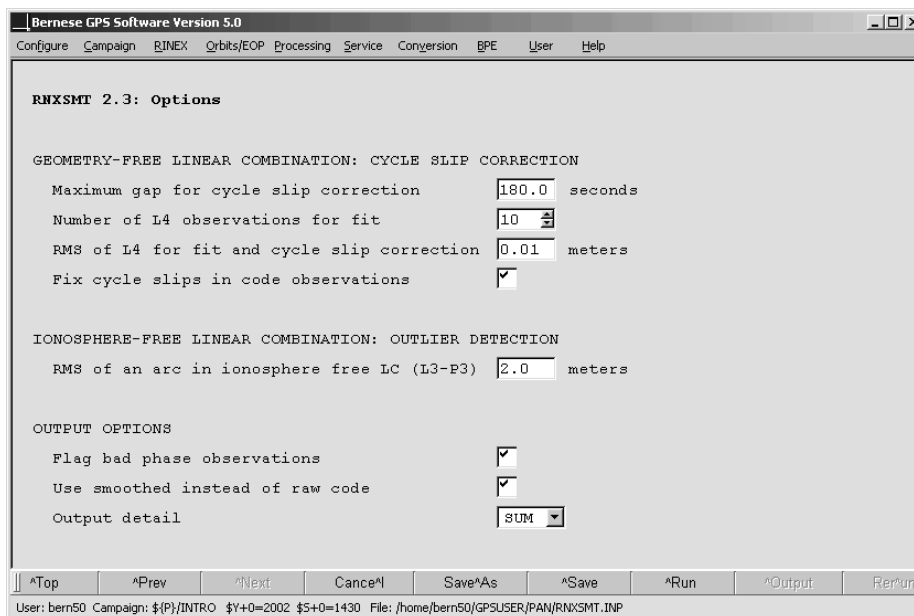
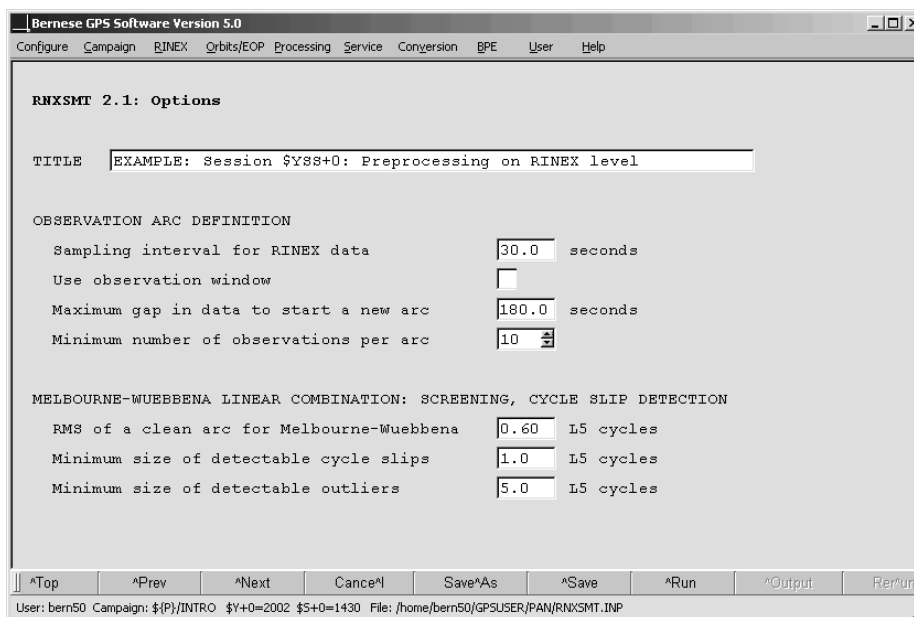
- Introduce the result file with kinematic coordinates as an input file for another run of GPSEST. If the estimates become zero it is a confirmation that the file was correctly considered as the a priori kinematic positions for the station FFMJ.
- Use the pre-elimination EVERY\_EPOCH for the “Kinematic 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 CODSP 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:



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

**Bernese GPS Software Version 5.0**

Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help

**TRANSFER RINEX OBSERVATION FILES INTO BERNESE FILES - RXOBV3 1: Filenames**

GENERAL FILES

Show all general files

INPUT FILES

original RINEX observation files

smoothed RINEX observation files

Station information file

RESULT FILES

Measurement types to save

Code  Phase  Range

Update coordinates   (blank if not used)

GENERAL OUTPUT FILES

Program output  use RXOBV3.Lnn or  OUT

Error messages  merged to program output or  MSG

User: bern50 Campaign: \$(P)/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/RXOBV3.INP

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):

**Bernese GPS Software Version 5.0**

Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help

**RXOBV3 4: Input Options 2**

SIGNAL STRENGTH REQUIREMENTS

Minimum signal strength

Accept signal strength = 0

Accept cycle slip flags from RINEX

MINIMUM OBSERVATION NUMBER

Minimum number of epochs requested per file  epochs

OPTIONS CONCERNING ANTENNAS

Consider radome code of the antennas

Correct position of radome code

Check phase center file for antenna type  else

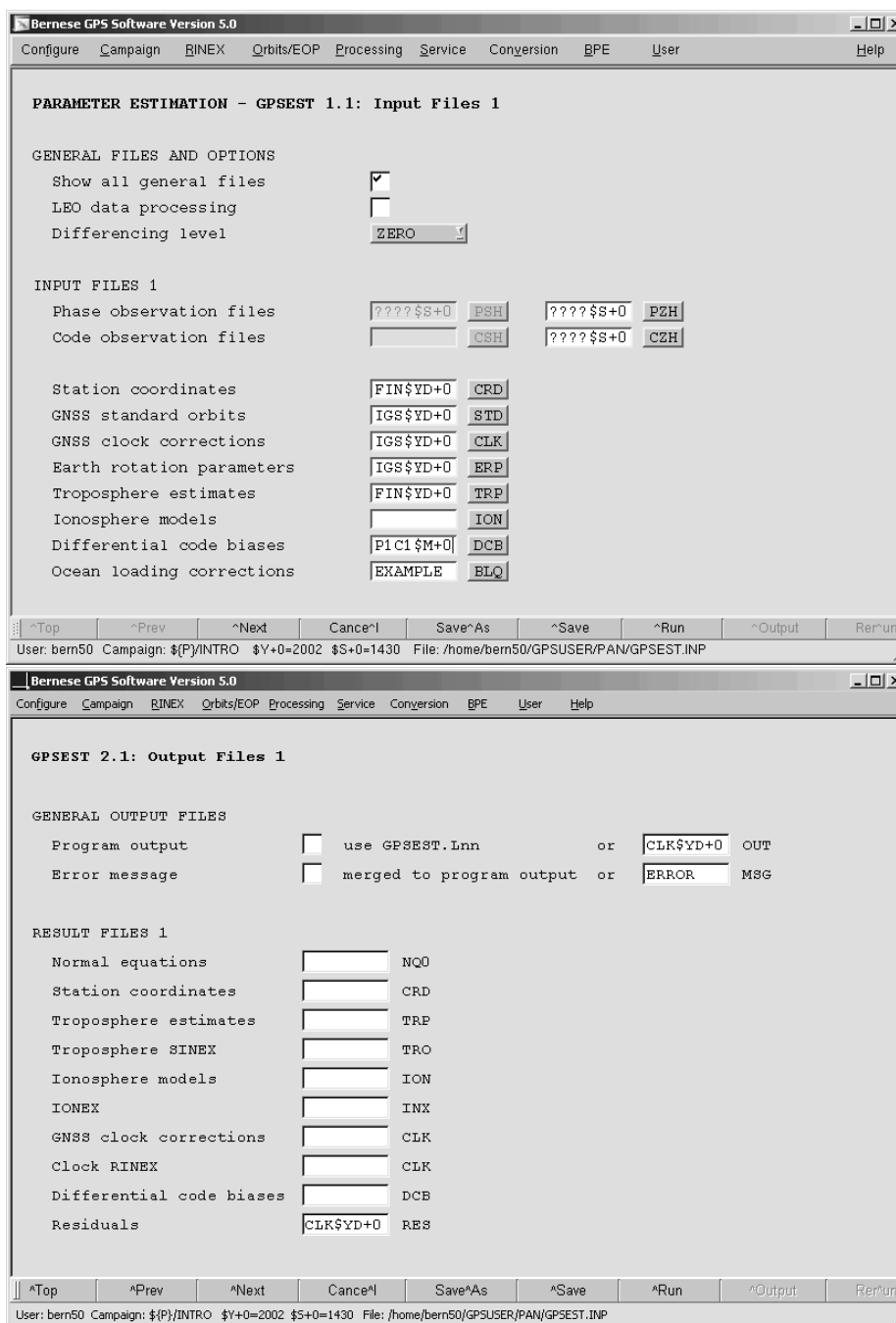
User: bern50 Campaign: \$(P)/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/RXOBV3.INP

After importing the data into the Bernese format you have to repeat the receiver clock synchronization with program CODSP. 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.



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Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help

**GPSEST 3.1: General Options 1**

TITLE

OBSERVATION SELECTION

Satellite system

Frequency

Elevation cutoff angle  degrees LEO:  degrees

Sampling interval  seconds

Tolerance for simultaneity  milliseconds

Special data selection

Observation window

OBSERVATION MODELING AND PARAMETER ESTIMATION

A priori sigma  meters

Elevation-dependent weighting  LEO:

Type of computed residuals

Correlation strategy

Polarization effect geom.  only if later than

total  only if later than

User: bern50 Campaign: \$(P)/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/GPSEST.INP

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**GPSEST 3.2: General Options 2**

A PRIORI TROPOSPHERE MODELING

ZPD model and mapping function

HANDLING OF AMBIGUITIES

Resolution strategy

Save resolved ambiguities

Introduce widelane integers

Introduce L1 and L2 integers

SPECIAL PROCESSING OPTIONS

Maximum tolerated O-C term  meters

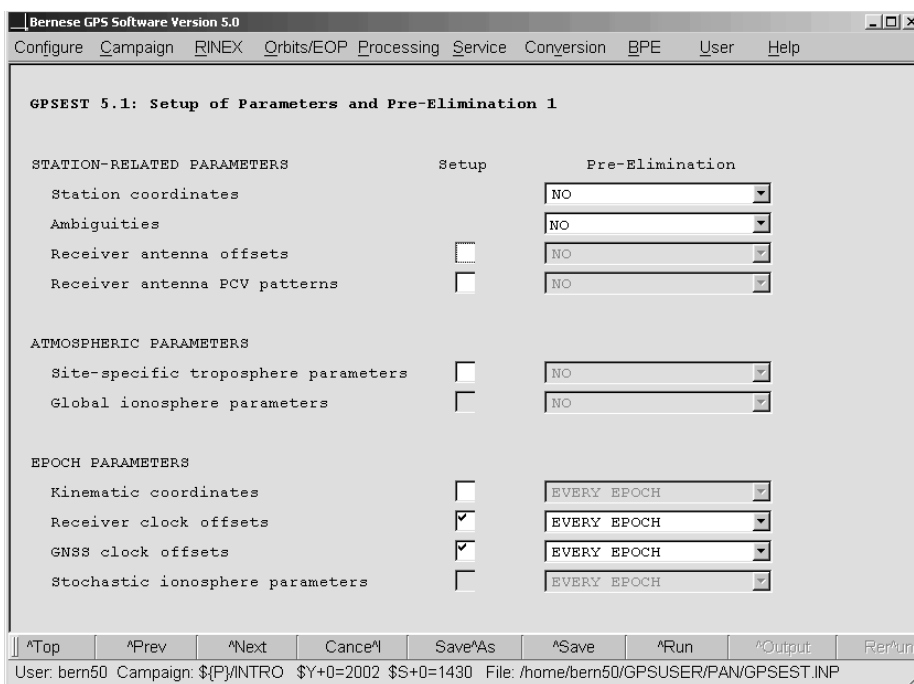
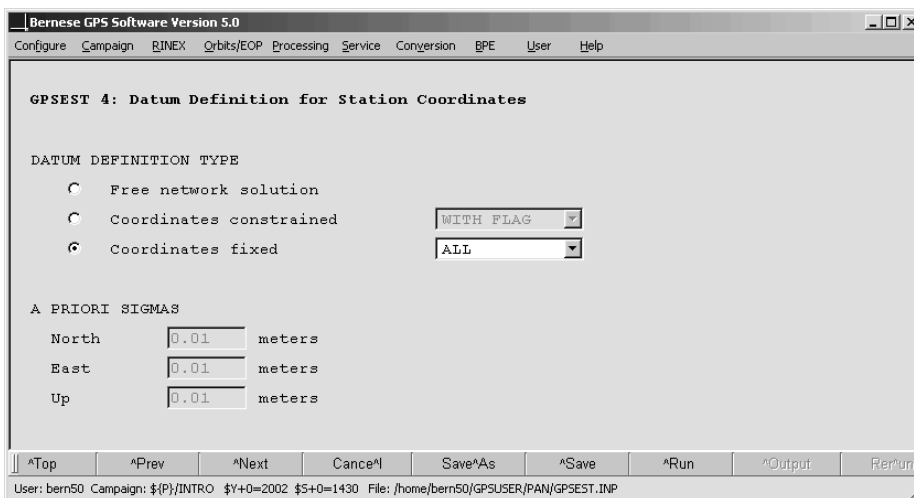
Var-covar wrt epoch parameters

EXTENDED PRINTING OPTIONS

Selection of printing options

User: bern50 Campaign: \$(P)/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/GPSEST.INP

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**GPSEST 6.6.1: Clock Estimation 1**

DATUM DEFINITION FOR CLOCK ESTIMATION

Type of datum definition

REFERENCE STATIONS

Selection of reference stations

Manual station selection

Station list from file

REFERENCE SATELLITES

Selection of reference satellites

Manual satellite selection

Satellite list from file

ADDITIONAL OPTIONS

Minimum number of obs per station clock

Minimum number of obs per satellite clock

Skip observations w/o satellite clocks

User: bern50 Campaign: \${P}/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/GPSEST.INP

The residuals are stored in the file `${P}/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):

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Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User Help

**RESRMS 2: Options**

TITLE

GENERAL OPTIONS

Frequency to check

Sampling rate of residual files  seconds

DETECT LARGE RESIDUALS limit

Phase measurements   meters

Code measurements   meters

Range measurements   meters

DETECT BAD DATA

Minimum continuously observed time interval  seconds

Detect ambiguities with few observations

Minimum number of observations per ambiguity

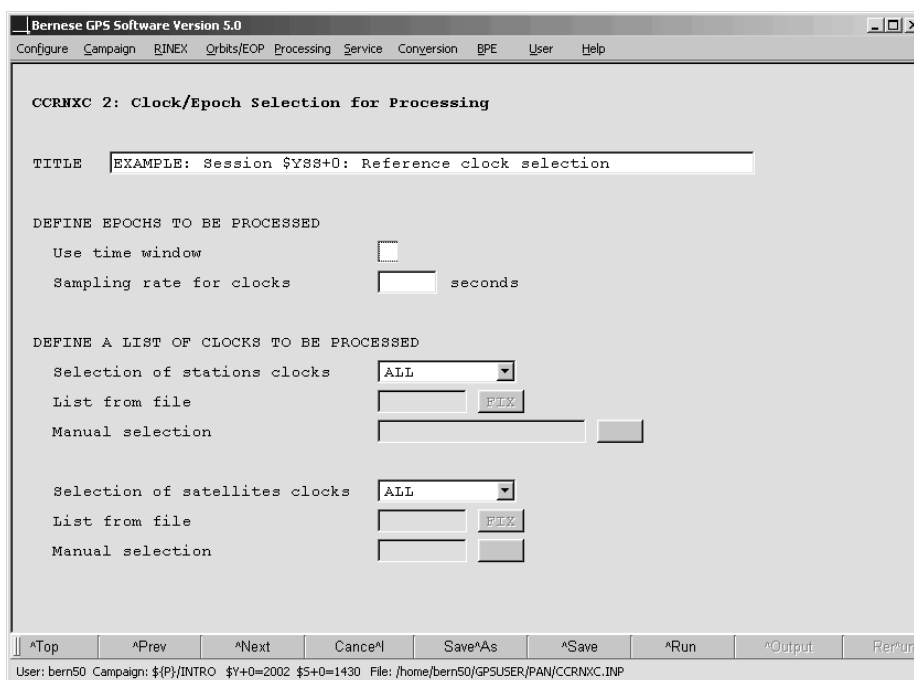
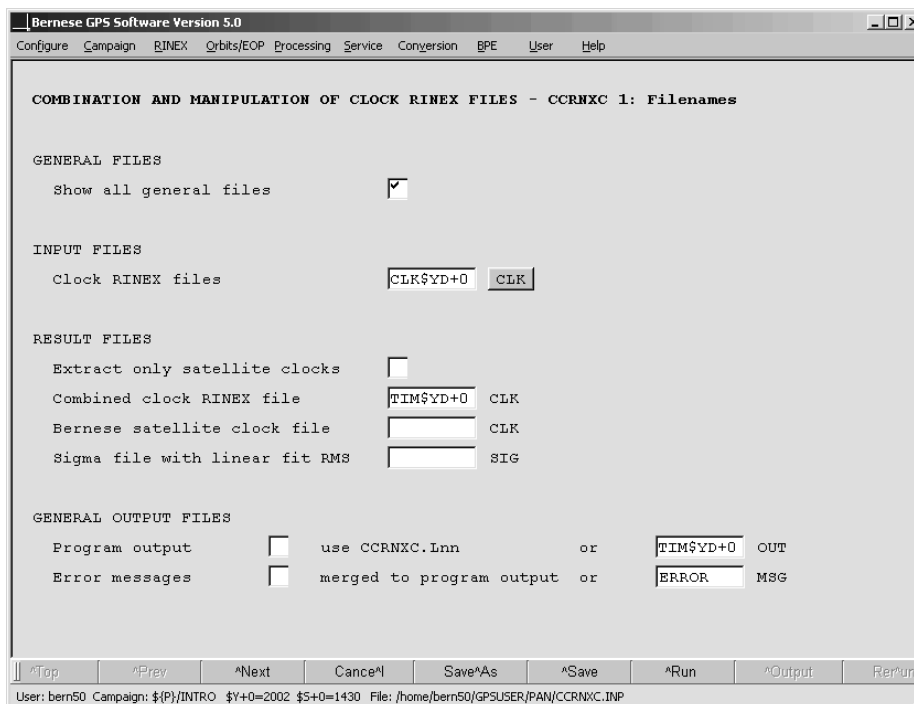
Sampling rate for counting the observations  seconds

User: bern50 Campaign: \${P}/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/RESRMS.INP

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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”):



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**CCRNXC 3: Options for Clock RINEX File Combination**

CLOCK RINEX FILE OFFSET ESTIMATION

Use all station clocks

Use all satellite clocks

Use only reference clocks

A priori sigma of unit weight  nanoseconds

Maximum residuum allowed  nanoseconds

OPTIONS FOR CLOCK COMBINATION

Strategy for computation of mean value

Maximum deviation from mean  nanoseconds

Minimum number of valid clocks for mean  for stations

for satellites

Compute sigma in resulting clock RINEX file from

|| ^Top ^Prev ^Next Cancel Save^As ^Save ^Run ^Output Rerun

User: bern50 Campaign: \$(P)/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/CCRNXC.INP

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**CCRNXC 4: Select Program Functions, Program Output**

REFERENCE CLOCK SELECTION

Select a new reference clock for the output file

Retain the reference clock from an input file  CLK

ENABLE OTHER PROGRAM FUNCTIONS

Enable clock jump detection

Enable extrapolation

PROGRAM 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

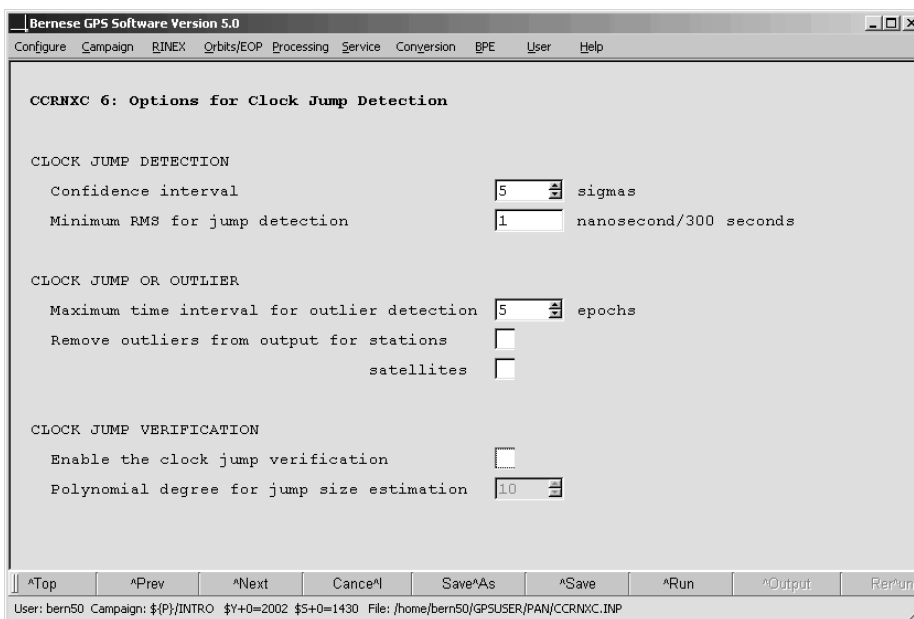
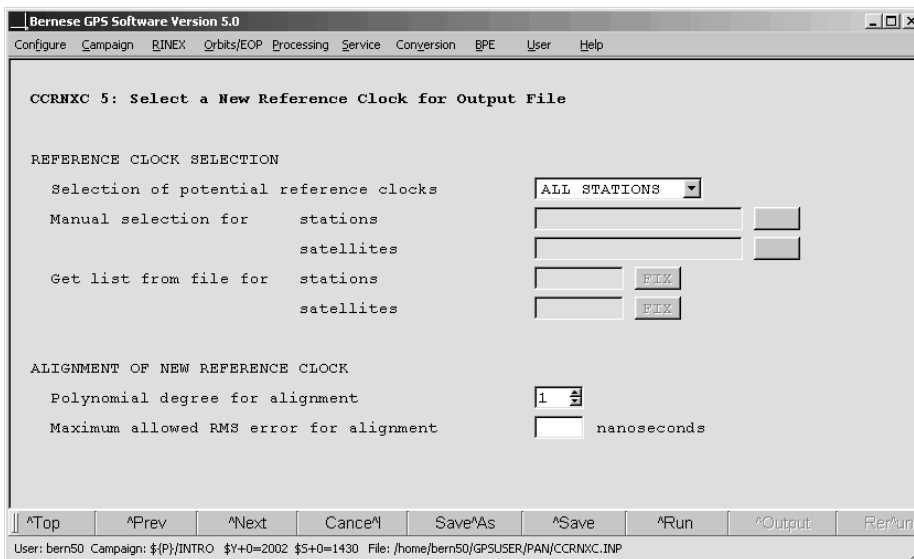
Statistic about the resulting clocks

Sort order for clock statistics

|| ^Top ^Prev ^Next Cancel Save^As ^Save ^Run ^Output Rerun

User: bern50 Campaign: \$(P)/INTRO \$Y+0=2002 \$S+0=1430 File: /home/bern50/GPSUSER/PAN/CCRNXC.INP

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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
-----

```

| Clock name     | # per file |     | rms of poly. fit (ns) |         |         |
|----------------|------------|-----|-----------------------|---------|---------|
|                | out        | 001 | n = 0                 | n = 1   | n = 2   |
| MATE 12734M008 | 288        | 288 | 57.544                | 0.000   | 0.000   |
| ONSA 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                 | 1.596   | 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 | 52.606                | 0.169   | 0.149   |
| ...            |            |     |                       |         |         |

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

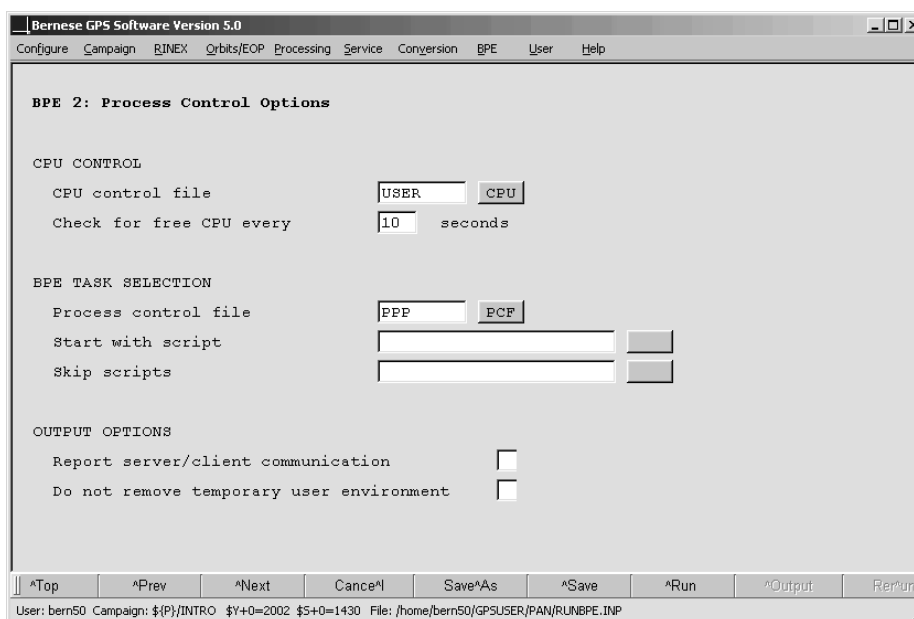
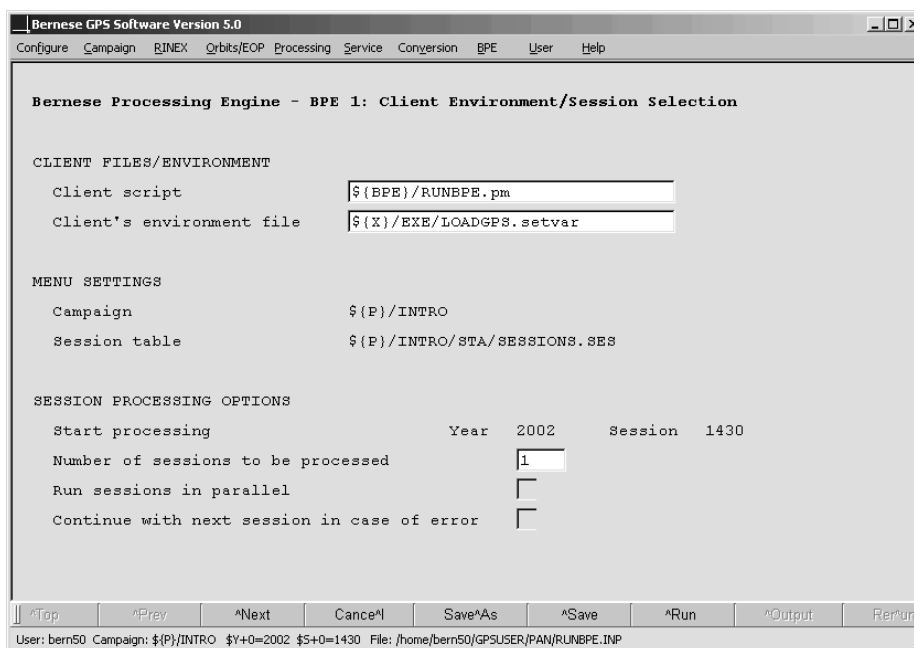
## 6. Terminal Session: Friday

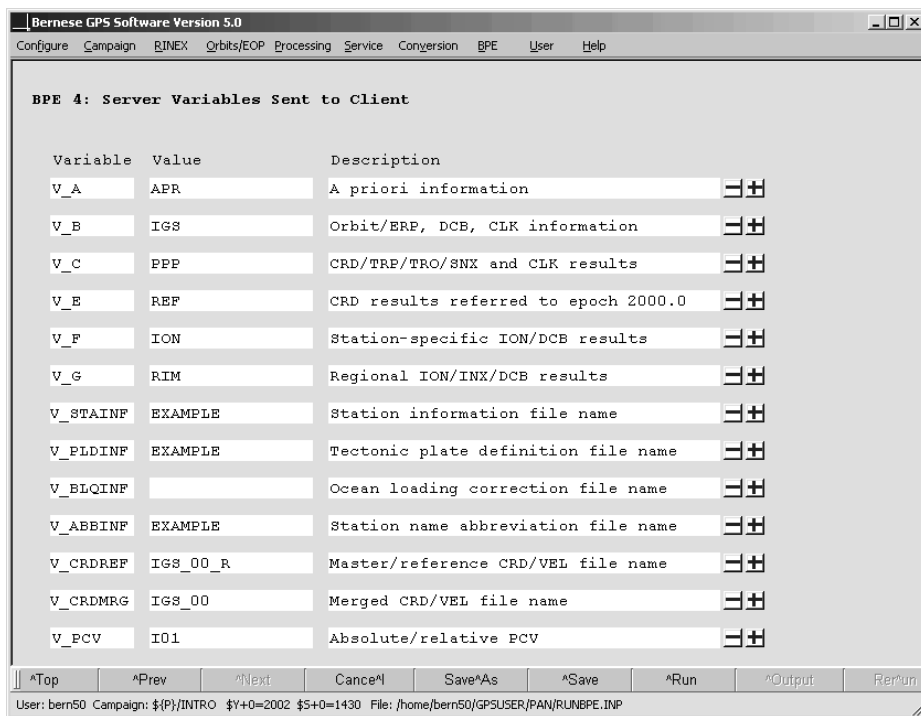
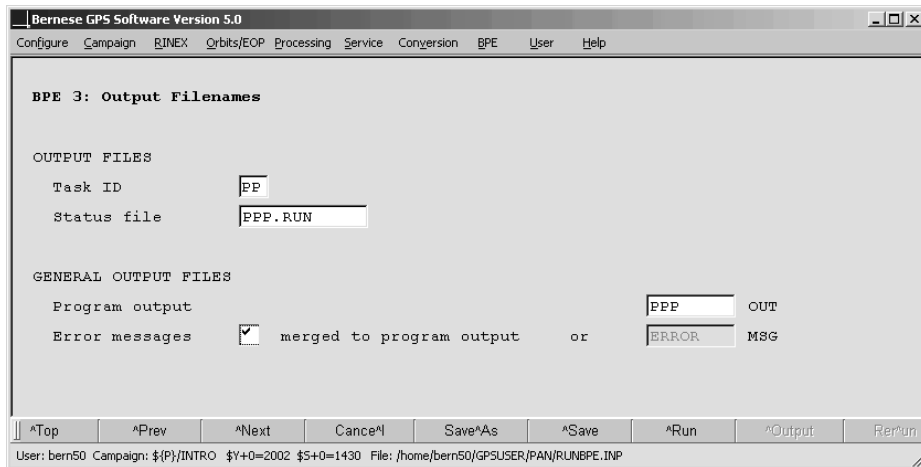
The reference files for the solution are also available in your campaign directories.

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":





In addition we suggest to become 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.

