

# Bernese GPS Software Version 5.0

Tutorial Processing Example Introductory Course Terminal Session

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# 1. Introduction to the Example Campaign

Data from eight European stations of the IGS Network are selected for the example campaign. They are listed in Table 1.1 to-gether 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



receiver antennas of only two sites (ONSA **Figure 1.1:** Stations used in example campaign and PTBB) are equipped with radomes (type OSOD resp. SNOW).

The receivers used at the stations BRUS and PTBB are connected to H-Maser. 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 antennatype as well as the antenna height.

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

# 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 RNXOBV3 (section 2.7).

### 2.1 Start the Menu

Start the menu program using the command  $G^1$ .

Navigate through the submenus to become familiar with the structure of the menu. Read the general help (available at "Menu><u>Help>General</u>") 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><u>Campaign>Edit session table</u>" to check the session table. It is recommended to use the wildcard string ???0 for the "SESSion identifier" in panel "SESSION TABLE". The panel below shows the session definition for a typical permanent campaign with 24-hours sessions. The setup of the session table is a very important task when you prepare a campaign. Please read the corresponding online help carefully.

<sup>&</sup>lt;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

Configure	GPS Software <u>C</u> ampaign	Version 5. <u>R</u> INEX		Processing	Service (	Con <u>v</u> ersion	BPE	User		<u> </u>
Sound	Dombordu	Turex	0.0007201	Treesering	2011100 0		<u></u>	2001		Toth
SESSIC	N TABLE									
SES	SION		STAR	T EPOCH			END E	POCH		
IDEN	TIFIER		yyyy mm d	d hh mm	SS	уууу	mm dd	hh mm ss		
?	??0			00 00	00			23 59 59 💻	<b>H</b>	

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:

👿 Date Selection Dialog	×
Year Month Day (YYYY MM DD)	2002 5 23
Modified Julian Date	52417
GPS Week, Day of Week (WWWW D)	1167 4
Year, Day of Year (YYYY DDD)	2002 143
<u>+</u>	1 -1 Compute
Session Char 🔲 Session Tal	ole SESSIONS SES
Job ID	
HelpSet	OK Cancel

## 2.3 Campaign Setup

Usually, a new campaign must first be added to the campaign list ("Menu><u>C</u>ampaign><u>E</u>dit list of campaigns") and set as active campaign ("Menu><u>C</u>ampaign><u>S</u>elect active campaign"), before the directory structure can be created ("Menu><u>C</u>ampaign>Create <u>n</u>ew 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 K/INTRO is used in this document in place of your individual campaign name):

\${K}/INTRO/ATM/	COD11674.ION	COD11675.ION	COD12190.ION	COD12191.ION
\${K}/INTRO/GEN/	DATUM.			
	IONEX.PPP			
	PHAS_IGS.REL	PHAS_COD.REL		
	RECEIVER.			
	SAT_2002.CRX			
	SAT_2003.CRX SATELLIT.	SATELLIT.I01	SATELLIT.105	
	SINEX.PPP	SAILLLII.IUI	SAILLEIT.100	
	SINEX.RNX2SNX			
\${K}/INTRO/OBS/				
\${K}/INTRO/ORB/	BULLET_A.ERP			
, ,,	CODE0205.DCB		CODE0305.DCB	
	IGS11674.PRE	IGS11675.PRE	IGS12190.PRE	IGS12191.PRE
	IGS11677.IEP		IGS12197.IEP	
	P1C10205.DCB		P1C10305.DCB	
	P1P20205.DCB		P1P20305.DCB	
\${K}/INTRO/ORX/	BRUS1430.020	BRUS1440.020	BRUS1380.030	BRUS1390.030
	FFMJ1430.020	FFMJ1440.020	FFMJ1380.030	FFMJ1390.030
	MATE1430.020	MATE1440.020	MATE1380.030	MATE1390.030
	ONSA1430.020	ONSA1440.020	ONSA1380.030	ONSA1390.030
	PTBB1430.020	PTBB1440.020	PTBB1380.030	PTBB1390.030
	VILL1430.020	VILL1440.020	VILL1380.030	VILL1390.030
	ZIMJ1430.020 ZIMM1430.020	ZIMJ1440.020 ZIMM1440.020	ZIMJ1380.030 ZIMM1380.030	ZIMJ1390.030 ZIMM1390.030
	BRDC1430.02N	BRDC1440.02N	BRDC1380.03N	BRDC1390.03N
	IFAG1430.02N	IFAG1440.02N	IFAG1380.03N	IFAG1390.03N
	MATE1430.02N	MATE1440.02N	MATE1380.03N	MATE1390.03N
	VILL1430.02N	VILL1440.02N	VILL1380.03N	VILL1390.03N
	ZIMJ1430.02N	ZIMJ1440.02N	ZIMJ1380.03N	ZIMJ1390.03N
\${K}/INTRO/OUT/	IGS11674.CLK	IGS11675.CLK	IGS12190.CLK	IGS12191.CLK
\${K}/INTRO/RAW/				
\${K}/INTRO/SOL/				
\${K}/INTRO/STA/	EXAMPLE.BLQ			
	EXAMPLE.PLD			
	EXAMPLE.STA			
	IGS_00_R.CRD	IGS_00_R.VEL	IGS_00.FIX	
	SESSIONS.SES			
\${K}/INTRO/TXT/	COD11677.SUM		COD12197.SUM	
,	IGS11677.SUM		IGS12197.SUM	

The directory  ${K}/INTRO/GEN/$  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  ${K}/INTRO/TXT/$  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):

\${K}/INTRO/ATM/	RIMO21430.INX_REF	RIM021440.INX_REF	RIM031380.INX_REF	RIM031390.INX_REF
\${K}/INTRO/GEN/				
\${K}/INTRO/OBS/				
\${K}/INTRO/ORB/				
\${K}/INTRO/ORX/				
\${K}/INTRO/OUT/	PPP021430.PRC_REF PPP021430.CLK_REF PPP021430.OUT_REF	PPP021440.PRC_REF PPP021440.CLK_REF PPP021440.OUT_REF	PPP031380.PRC_REF PPP031380.CLK_REF PPP031380.OUT_REF	PPP031390.PRC_REF PPP031390.CLK_REF PPP031390.OUT_REF
\${K}/INTRO/RAW/				
\${K}/INTRO/SOL/				
\${K}/INTRO/STA/	EXAMPLE.ABB_REF IGS_00.CRD_REF PPP021430.CRD_REF REF021430.CRD_REF	IGS_00.VEL_REF PPP021440.CRD_REF REF021440.CRD_REF	PPP031380.CRD_REF REF031380.CRD_REF	PPP031390.CRD_REF REF031390.CRD_REF
\${K}/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:

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

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

exampi	с.		
Filename	Content	Modification	Download
CONST.	All constants used in the	No	BSW aftp
	Bernese GPS Software		
DATUM.	Definition of geodetic datum	Introducing new reference	BSW aftp
		ellipsoid	
RECEIVER.	Receiver information	Introducing new receiver type	BSW aftp
PHAS_COD.REL	Phase center eccentricities	Introducing new elevation-	BSW aftp
	and variations including	dependent corrections	
	radome codes	New antenna	
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	BSW aftp
		announced by the IERS	
IAU2000.NUT	Nutation model coefficients	No	
IERS2000.SUB	Subdaily pole model	No	
	coefficients		
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.	SINEX header information	Adapt SINEX header for	
SINEX.TRO		your institution	
SINEX.PPP	$\dots$ for the PPP example		
SINEX.RNX2SNX	for the double–diff. example		
IONEX.	IONEX header information	Adapt IONEX header for	
		your institution	
IONEX.PPP	$\dots$ for the PPP example		

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

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 \*. YO (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 co-ordinates. 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.REL 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  $K/INTRO=/aiub_u_camp/INTRO$ . 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  $X=/aiub_sw/BERN50/GPS$ .

Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	Processing	Service	Con <u>v</u> ersion	BPE	User		Help
		_					_			
VARIAB	BLES AVAI	LABLE I	N THE MEN	U FOR IN	TERACTI	VE AND AU	JTOMAT I	C PROCESSI	NG 1	
PREDEF	INED VAP	RIABLES								
(tra	inslated	in the r	menu)							
Vari	able	Current	value	Descrip	tion					
\$ Y	!	02	2	Two dig	it year	of the d	current	session		
\$M	ſ	05	5	Month o	f the c	urrent se	ession			
\$D	)	23	3	Day of month of the current session						
\$J	г			Job ID						
USER-D	EFINED V	/ARIABLE:	S			Eľ	VIRONM	IENT VARIAB	LES	
(tra	inslated	in the r	menu)				(trans	lated in t	he	
Vari	able		Value				main	program)		
\$					<b>=+</b>		K	<b>=+</b>		
							U	-+		
							т	-+		
							X	-+		
							P	<b>=+</b>		
							USER	<b>=+</b>		
AT an	[	. [ .	N	C	[			[	[ cout t	[
^Тор	^Prev		Next	Cance <sup>^</sup> l	Save^		^Save	^Run AN/MENU_VAR	^Output	Remu

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:

RANGES OF 1	PREDEFINED VAR	IABLES			
Minus ra	nge -1 🖡	Plus range	1		
Without ran (n=0,1,!	-	ith ranges	Format	Description	
\$+n	\$-n	\$+-	DDD	Day of Year (DOY)	
\$s+n	\$s-n	\$S+-	DDDS	DOY, Session Charact.	
\$¥+n	\$¥-n	\$¥+-	XXXX	Year	
\$₩+n	\$W-n	\$W+-	WWWW	GPS Week	
\$M+n	\$M-n	\$M+-	¥ ¥MM	Year, Month	
\$JD+n	\$JD-n	\$JD+-	DDDDD	Modified Julian Date	
\$WD+n	\$WD-n	\$WD+-	WWWWD	GPS Week and Day	
\$¥D+n	\$YD-n	\$¥D+-	YYDDD	Year and DOY	
\$¥SS+n	\$¥SS-n	\$¥SS+-	YYDDDS	Year, DOY, Sess. Char.	
\$YMD STR+n	\$YMD_STR-n	\$YMD_STR+-	YYYY MM DD	Year, Month, Day	

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

These variables are automaticall 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":

📰 Bernese GPS Software Version 5.0					_ 🗆 🗵
Configure Campaign RINEX Orbits/	EOP <u>P</u> rocessing <u>S</u> ervice	Con <u>v</u> ersion <u>E</u>	<u>B</u> PE <u>U</u> ser		<u>H</u> elp
PROPAGATE COORDINATES WITH	A GIVEN VELOCITY I	FIELD - COOVI	SL 1: Filenam	es	
GENERAL FILES Show all general files					
INPUT FILES					
Input coordinate file	IGS_00 CRD				
Input velocity file	IGS_00 VEL				
REFERENCE EPOCH		nh mm ss 10 00 00			
RESULT FILE Output coordinate file	APR\$YD+0 CRD				
GENERAL OUTPUT FILES					
Program output	use COOVEL.La	ın	or [000]	VEL OUT	
Error messages	merged to pro	ogram output	or ERR	OR MSG	
TITLE EXAMPLE: Session \$1	SS+D: Coordinate p	propagation		_	
Top ^Prev <b>^Next</b>	Cance^I Save			^Output	Rer^un
User: bern50 Campaign: \${K}/INTRO \$Y+0=	2002 \$S+0=1430 File: /u/:	aiub/bern50/GPSUS	ER/PAN/COOVEL.IN	۱P	11.

"REFERENCE EPOCH"	\$YMD_STR+0	ightarrow 2002 05 23
"Output coordinate file"	APR\$YD+0	$\rightarrow$ APR02143
"TITLE"	Session \$YSS+0:	$\rightarrow$ Session 021430:

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

The header area of the program output is standardized for all programs of the *Bernese GPS Software*, Version 5.0. Furthermore each program has a title line that should characterize the program run. It is printed to the program output and to most of the result files. Many program output files furthermore provide a list of input and output files that have been used or generated.

The COOVEL result of the run of isana priori coordinate file (\${K}/INTRO/STA/APR02143.CRD) containing the positions of the sites to be processed for the epoch of the current session (the lines for the other stations are ignored in the processing):

IGSO	O COORDINATES BAS	ED ON IGS01P37_RS	354.SNX		29-JUN-03
LOCA	L GEODETIC DATUM:	IGSOO	EPOCH: 2002-0	05-23 0:00:00	
NUM	STATION NAME	X (M)	Y (M)	Z (M)	FLAG
6 15 36 42 47 56	BRUS         13101M004           FFMJ         14279M001           MATE         12734M008           ONSA         10402M004           PTBB         14234M001           VILL         13406M001	4027893.7773 4053455.9006 4641949.6104 3370658.5806 3844059.9795 4849833.7343	307045.7760 617729.6193 1393045.3794 711877.1009 709661.2696 -335049.0774	4919475.0809 4869395.6681 4133287.4177 5349786.9189 5023129.5003 4116014.9013	PPP PPP IGS00 IGS00 PPP IGS00
63 64	ZIMJ 14001M006 ZIMM 14001M004	4331293.9550 4331297.0935	567542.0890 567555.8333	4633135.6788 4633133.8919	РРР РРР

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

## 2.7 Importing the Observations

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

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

Bernese	GPS Software	e Version 5	5.0								_ 🗆 X
Configure	<u>C</u> ampaign	<u>R</u> INEX	<u>O</u> rbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Conversion	<u>B</u> PE	<u>U</u> ser	<u>H</u> elp		
TRANSF	ER RINEX (	DBSERVA	TION FILES	INTO BERN	ESE FIL	ES – RXOB <sup>1</sup>	V3 1: Fil	enames.			
GENERA	L FILES										
Shou	all gener	ral file	25		۲						
INPUT	FILES										
e C			observatio observatio		2222\$S 2222\$S						
Stat	ion inform	mation :	file		EXAMPL	E STA					
RESULT	FILES										
Meas	urement ty	ypes to	save								
•	Code	✓ РІ	hase 🎽			C Ra	nge				
Upda	te coordin	nates		CR	D (bl	ank if no	t used)				
GENERA	L OUTPUT I	FILES									
Proc	ram output	t		use RXOBV	3.Lnn		or RXO	\$YD+O	TUC		
Erro	r message:	3	Γ	merged to	progra	m output	or ERF	ROR	MSG		
^Тор	^Prev	/	^Next	CanceA	Sa	ve^As	^Save	^Ru	in^Ot	rtput	Rer^un
User: bern	50 Campaig	n: \${K}/IN	TRO \$Y+0=2	002 \$S+O=1	430 File:	/u/aiub/bern	50/GPSUSE	R/PAN/R>	(OBV3.INP		1

All RINEX observation files fitting K/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:

🔀 Bernese (	GPS Software \	ersion 5.0								_ 🗆 🗵
Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
RXOBV3	2: Input	: Option	ns 1							
TITLE	EXAME	PLE: Se	ssion \$¥S	s+0: RIN	EX to S	INEX				
SATELL	ITE SYSTE	M SELE	CTION							
Sate	llite sys	tem to	be consi	dered			GPS	Ā		
STATIO	N NAMES									
Gath	er static	n name:	s from				MARKER	_NAME	Y	
Acti	on if sta	ation no	ot in abb	reviatio	n list		ERROR	X		
SESSIO	N IDENTIE	TER								
Sess	ion ID us	ed for	Bernese	observat	ion fil	es	\$S+O	(blank:	AUTO)	
DATA S	AMPLING									
Samp	ling inte	erval					30 🜲	seconds		
Samp	ling offs	set to :	full minu	te			0	seconds		
∥_^Тор	^Prev	^	Next	Cance^I	Save^	As 🔤	^Save	^Run	^Outpu	t Rer^un
User: bern5	) Campaign: :	\${K}/INTRO	\$Y+0=2002	\$S+0=1430	File: /u/ai	ub/bern50/GF	SUSER/P/	N/RXOBV3.	INP	

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

Bernese G	PS Software \	Version 5.0								
Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
RXOBV3	3: Obser	vation	Window							
OBSERVA	ATION WIN	IDOW								
Q	Take al	ll obser	vations							
۲	Defined	l by yea	r and se	ssion nur	mber(s)					
	Year	\$¥+0	Sessi	.on \$\$+0	D					
0	Defined	l by sta	rt and e	nd time						
		уууу т	m dd	hh mm sa	s	уууу	mm dd	hh mm	SS	
	Start	\$VMD_S	TR+O	00 00 00	0 En	d \$YMD	STR+0	23 59	59	
^Тор	^Prev	^N	lext	Cance^I	Save^A	\s ^:	Save	^Run	^Output	Rer^ur
Jser: bern50	Campaign: :	\${K}/INTRO	\$Y+0=2002	\$S+0=1430	File: /u/aiu	b/bern50/GPS	SUSER/PA	V/RXOBV3.INP		

Bernese G	iPS Software	Version 5	.0							<u>_                                    </u>
Configure	<u>C</u> ampaign	<u>R</u> INEX	<u>O</u> rbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Conversion	n <u>B</u> PE	<u>U</u> ser <u>I</u>	<u>H</u> elp	
RX0BV3	4: Input	Options	\$ 2							
SIGNAL	STRENGTH	REQUIRE	CMENTS							
Minim	um signal	l strenç	gth			1 4				
Accep	t signal	strengt	h = 0			<b>Y</b>				
Accep	t cycle s	slip fla	ags from R	INEX						
MINIMUM	OBSERVAT	TION NUM	IBER							
Minim	um number	of epo	ochs reque	sted per f	ile		epoch	3		
OPTIONS	CONCERNI	ING ANTE	INNAS							
Consi	der radon	ne code	of the an	tennas		<b>Y</b>				
Corre	ct positi	ion of r	adome cod	e		<b>Y</b>				
Check	phase ce	enter fi	ile for an	tenna type		<b>Y</b>	else E	RROR 💌		
^Тор	^Prev		^Next	Cance <sup>AI</sup>	Sa	ve^As	^Save	^Run	^Output	Rer^un
User: bern5	0 Campaigr	n: \${K}/INT	RO \$Y+0=2	2002 \$S+O=14	430 File	: /u/aiub/ber	n50/GPSUS	ER/PAN/RXO	BV3.INP	

Two more panels provide options to verify the RINEX header information:

Con <u>f</u> igure		Version 5.0								_ <u>_ </u>
	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	BPE	<u>U</u> ser		<u>H</u> elp
RXOBV3	5.1: Ch	eck Con	tent of H	RINEX Hea	der 1					
ACTION	C IN CAC	E OF TH	CONSISTEN	ICTEC						
	ion name			ERROR	Ø	Try also	filonom	~	Ч	
	eiver/ant			ERROR	 	iry arso	TTTenan	6	T.	
	eiver/ant									
	enna posi			NO_CHECK ERROR	<u></u>					
	-	01011			<u></u> 					
nark	er type			WARNING	<u> </u>					
NC	CHECK .	No che	ck is dor	1e						
	_			and conti	nue					
			-	ontinue		evt file				
		-				processing	,			
DI-	. non	write .	error mea	saye anu	scop F	processing	,			
^Top	^Prev	,								
		^	Next	CanceAl	Save	- A -	Save	^Run	^∩utr	ut [ Remun
			Next ( \$Y+0=200;	Cance^I 2 \$S+0=1430	Save File: /u/a		^Save	^Run V/RXOBV3.II	Outp	out Rer^un
User: bern5	0 Campaign:	\${K}/INTRC	) \$Y+0=200;			nAs aiub/bern50/GF				
User: bern5 Bernese (	0 Campaign: GPS Software	\${K}/INTRC	) \$Y+0=200;	2 \$S+0=1430	File: /u/a	aiub/bern50/GF	SUSER/PA	VRXOBV3.II		
User: bern5	0 Campaign:	\${K}/INTRC	) \$Y+0=200;	2 \$S+O=1430	File: /u/a					
User: bern5 X Bernese ( Configure	0 Campaign: GPS Software <u>C</u> ampaign	\${Kj/INTRC	0 \$Y+0=200; <u>O</u> rbits/EOP	2 \$S+0=1430 Processing	File: /u/a <u>S</u> ervice	aiub/bern50/GF	SUSER/PA	VRXOBV3.II		
User: bern5 X Bernese ( Configure	0 Campaign: GPS Software <u>C</u> ampaign	\${Kj/INTRC	0 \$Y+0=200; <u>O</u> rbits/EOP	2 \$S+0=1430	File: /u/a <u>S</u> ervice	aiub/bern50/GF	SUSER/PA	VRXOBV3.II		
User: bern5 <b>Bernese (</b> Configure <b>RXOBV3</b>	0 Campaign: GPS Software Campaign 3 5.2: Ch	\${K}/INTRC Version 5.0 <u>B</u> INEX eck Con	o \$Y+0=200; Orbits/EOP	2 \$S+0=1430 Processing	File: /u/a <u>S</u> ervice	aiub/bern50/GF	SUSER/PA	VRXOBV3.II		
User: bern5 Bernese ( Configure RXOBV3 ADDITI	0 Campaign: GPS Software Campaign 3 5.2: Ch	\$(K)/INTRO Version 5.0 BINEX eck Con	) \$V+0=200; Orbits/EOP tent of I	2 \$S+0=1430 Processing RINEX Hea	File: /u/a <u>S</u> ervice	aiub/bern50/GF	SUSER/PAI	4/RXOB∀3.II ∐ser		
User: bern5 Bernese ( Configure RXOBV3 ADDITI Veri	0 Campaign: GPS Software Campaign 3 5.2: Ch CONAL VER .fy stati	\$(K)/INTRC Version 5.0 BINEX eck Con IFICATIO on name.	) \$V+0=200; Orbits/EOP tent of I ON /number u	2 \$S+0=1430 Processing RINEX Hea	File: /u/a Service der 2	aiub/bern50/GF	SUSER/PAI	VRXOBV3.II	NP	
User: bern5 Bernese ( Configure RXOBV3 ADDITI Veri	0 Campaign: GPS Software Campaign 3 5.2: Ch CONAL VER .fy stati	\$(K)/INTRC Version 5.0 BINEX eck Con IFICATIO on name.	) \$V+0=200; Orbits/EOP tent of I ON /number u	2 \$S+0=1430 Processing RINEX Hea	File: /u/a Service der 2	aiub/bern50/GF	SUSER/PAI	4/RXOB∀3.II ∐ser	NP	
ADDITI Veri	0 Campaign: GPS Software Campaign S 5.2: Ch CONAL VER fy stati fy stati	\${K}/INTRC Version 5.0 BINEX eck Con IFICATIO on name, on name	<pre>&gt; \$∀+0=200; Orbits/EOP tent of I ON /number u using R:</pre>	2 \$S+0=1430 Processing RINEX Hea Ising INEX file	File: /u/a Service der 2	aiub/bern50/GF	SUSER/PAI	4/RXOB∀3.II ∐ser	NP	
User: bern5 X Bernese ( Configure RXOBV3 ADDITI Veri Veri HANDLI	0 Campaign: GPS Software Campaign CONAL VER fy stati fy stati NG OF KN	\$(K)/INTRC Version 5.0 <u>B</u> INEX Reck Con IFFICATION on name on name	<pre>&gt; \$Y+0=200; Orbits/EOP tent of I ON /number u using R: ONSISTEN()</pre>	2 \$S+0=1430 Processing RINEX Hea ssing INEX file	File: /u/a Service der 2	aiub/bern50/GF	SUSER/PAI	V/RXOBV3.II	NP	
User: bern5 X Bernese ( Configure RXOBV3 ADDITI Veri Veri HANDLI	0 Campaign: GPS Software Campaign CONAL VER fy stati fy stati NG OF KN	\$(K)/INTRC Version 5.0 <u>B</u> INEX Reck Con IFFICATION on name on name	<pre>&gt; \$∀+0=200; Orbits/EOP tent of I ON /number u using R:</pre>	2 \$S+0=1430 Processing RINEX Hea ssing INEX file	File: /u/a Service der 2	aiub/bern50/GF	SUSER/PAI	4/RXOB∀3.II ∐ser	NP	
User: bern5 X Bernese ( Configure RXOBV3 ADDITI Veri Veri HANDLI	0 Campaign: GPS Software Campaign CONAL VER fy stati fy stati NG OF KN	\$(K)/INTRC Version 5.0 <u>B</u> INEX Reck Con IFFICATION on name on name	<pre>&gt; \$Y+0=200; Orbits/EOP tent of I ON /number u using R: ONSISTEN()</pre>	2 \$S+0=1430 Processing RINEX Hea ssing INEX file	File: /u/a Service der 2	aiub/bern50/GF	SUSER/PAI	V/RXOBV3.II	NP	
User: bern5 X Bernese ( Configure RXOBV3 ADDITI Veri Veri HANDLI	0 Campaign: GPS Software Campaign CONAL VER fy stati fy stati NG OF KN	\$(K)/INTRC Version 5.0 <u>B</u> INEX Reck Con IFFICATION on name on name	<pre>&gt; \$Y+0=200; Orbits/EOP tent of I ON /number u using R: ONSISTEN()</pre>	2 \$S+0=1430 Processing RINEX Hea ssing INEX file	File: /u/a Service der 2	aiub/bern50/GF	SUSER/PAI	V/RXOBV3.II	NP	
User: bern5 X Bernese ( Configure RXOBV3 ADDITI Veri Veri HANDLI	0 Campaign: GPS Software Campaign CONAL VER fy stati fy stati NG OF KN	\$(K)/INTRC Version 5.0 <u>B</u> INEX Reck Con IFFICATION on name on name	<pre>&gt; \$Y+0=200; Orbits/EOP tent of I ON /number u using R: ONSISTEN()</pre>	2 \$S+0=1430 Processing RINEX Hea ssing INEX file	File: /u/a Service der 2	aiub/bern50/GF	SUSER/PAI	V/RXOBV3.II	NP	
User: bern5 × Bernese ( Configure RXOBV3 ADDITI Veri Veri HANDLI	0 Campaign: GPS Software Campaign CONAL VER fy stati fy stati NG OF KN	\$(K)/INTRC Version 5.0 BINEX ecck Con IFFICATIO on name, on name (WN INCO tion in:	<pre>&gt; \$Y+0=200; Orbits/EOP tent of I ON /number u using R: ONSISTEN()</pre>	2 \$S+0=1430 Processing RINEX Hea ssing INEX file	File: /u/a Service der 2	aiub/bern50/GF Conyersion	SUSER/PAI	V/RXOBV3.II	NP	Leip

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

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: \${K}/INTRO/RAW/FFMJ1430.020 SR R2RDOR: SATELLITES SKIPPED! SYSTEM: "R" ### PG RXOBV3: OBSERVATION DATA FROM OTHER SATELLITE SYSTEM REJECTED RINEX FILE NAME: \${K}/INTRO/RAW/ZIMJ1430.020

The program produces an output file RX002143.0UT in the directory K/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:

lum	Rinex file name	Bernese code header file name Bernese code observ, file name	#epo	
		Bernese phase header file name Bernese phase observ. file name	#epo	
				• • • •
1	\${K}/INTRO/RAW/BRUS1430.020	\${K}/INTRO/OBS/BRUS1430.CZH \${K}/INTRO/OBS/BRUS1430.CZO	2778	
		\${K}/INTRO/OBS/BRUS1430.PZH \${K}/INTRO/OBS/BRUS1430.PZO	2778	
2	\${K}/INTRO/RAW/FFMJ1430.020	\${K}/INTRO/OBS/FFMJ1430.CZH \${K}/INTRO/OBS/FFMJ1430.CZO	2799	
		\${K}/INTRO/OBS/FFMJ1430.PZH \${K}/INTRO/OBS/FFMJ1430.PZO	2799	
3	\${K}/INTRO/RAW/MATE1430.020	\${K}/INTRO/OBS/MATE1430.CZH \${K}/INTRO/OBS/MATE1430.CZO	2880	
		<pre>\${K}/INTRO/OBS/MATE1430.C20 \${K}/INTRO/OBS/MATE1430.PZH \${K}/INTRO/OBS/MATE1430.PZ0</pre>	2880	

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

## 2.8 Daily Goals

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

- (1) a priori coordinates in your campaign's STA directory: file APR02143.CRD, APR02144.CRD, ... (for all 4 days)
- (2) Bernese formatted zero difference observation files in your campaign's OBS directory:BRUS1430.CZH, BRUS1430.PZH, BRUS1430.CZO, BRUS1430.PZO, ... (for all stations).

These files must be generated for all four days.

# 3. Terminal Session: Tuesday

Today's terminal session is to

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

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

### 3.1 Prepare Pole Information

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

Bernese GP5 Software Version 5.0 Configure <u>Campaign</u> <u>RINEX</u> Orbits/EOP	Processing Service Conversion BPE User	_ 🗆 🗙 Help
	A IERS FILE - POLUPD 1: Input/Output Files	
GENERAL FILES Show all general files	<b>V</b>	
INPUT FILES		
Bernese formatted ERP files Foreign formatted ERP files	IGS\$W+07 IEP	
RESULT FILE		
Resulting Bernese formatted	ERP file IGS\$YD+0 ERP	
GENERAL OUTPUT FILES		
Program output	use POLUPD.Lnn or POLUPD OUT	
Error messages	merged to program output or ERROR MSG	
^Top         ^Prev         ^Next           User: bern50         Campaign: \${K}/INTRO         \$Y+0=200	Canceril         SaverAs         ^Save         ^Run         ^Output         2         \$S+0=1430         File: /u/aiub/bern50/GPSUSER/PAN/POLUPD.INP	Rer^un
Bernese GPS Software Version 5.0		
Configure <u>C</u> ampaign <u>B</u> INEX <u>O</u> rbits/EOP	Processing Service Conversion BPE User	<u>H</u> elp
POLUPD 1.1: General Files		
GENERAL INPUT FILES		
Pole offset coefficients		
GPS-UTC seconds	GPSUTC.	
MENU SETTINGS		
Selected campaign	\${K}/INTRO	
Selected session Session table	year 2002 session 1430 \${K}/INTRO/STA/SESSIONS.SES	
^Top         ^Prev         ^Next           User: bern50         Campaign: \${K}/INTRO         \$Y+0=200	Cance^I         Save^As         ^Save         ^Run         ^Output           2 \$\$+0=1430         File: /u/aiub/bern50/GPSUSER/PAN/POLUPD.INP	Rer^un
📰 Bernese GPS Software Version 5.0		_ 🗆 ×
Configure <u>C</u> ampaign <u>R</u> INEX <u>O</u> rbits/EOP	Processing Service Conversion BPE User	<u>H</u> elp
POLUPD 2: Options		
HEADER INFORMATION		
	XSS+0: Import IERS Pole info into Bernese	
Nutation model Subdaily pole model	IAU2000 NUT IERS2000 SUB	
BULLETIN B AS INPUT	x - 51	
Use 1 or 5 day values	<u>1</u> <u>7</u>	
USE ERP RATES	P	
INCLUDE NUTATION OFFSETS	Г	
USE TIME WINDOW	۲	
^Top ^Prev ^Next	Cance^I Save^As ^Save ^Run ^Output [	Rer^un
	2 \$S+0=1430 File: /u/aiub/bern50/GPSUSER/PAN/POLUPD.INP	ner un

🔀 Bernese l	GPS Software	Version 5.0							_ 🗆 ×
Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser	<u>H</u> elp
POLUPD TIME W	3: Time	Window							
	Defined Year	d by tal  \$⊻+0	ole, year Sess			nber			
0	Defined	d by st	art and e	nd time					
	Start		mm dd STR+0				mm dd STR+0	<b>hh mm</b> 23 59	

The last panel for the program POLUPD is an example for the specification of time windows in the *Bernese GPS Software*, Version 5.0. Time windows can be defined by sessions (a single session or a range of sessions). Alternatively, a time window may be specified by a start and an end epoch. By entering either a start or an end epoch the user may define only the beginning or the end of the time interval. We refer to the online help for more details.

The messages

### PG POLUPD: NUTATION MODEL NOT SPECIFIED IN INPUT ERP FILE USING NUTATION MODEL NAME : IAU2000 #### PG POLUPD: SUBDAILY POLE MODEL NOT SPECIFIED IN INPUT ERP FILE USING SUBDAILY POLE MODEL NAME : IERS2000

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

## 3.2 Generate Orbit Files

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

🔀 Bernese C	iPS Software	Version 5.	0							
Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	$Con\underline{v}ersion$	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
CDEATE	<b>77 A D IT A D</b>	ODDIT	FILES USI	NG DDEGI		EDIDEC	חטביייייייייייייייייייייייייייייייייייי	1. Filona	<b>**</b> 2 7	
CREATE	TABULAR	OKBIT	FILES USI	NG PRECI	SE EPHER	ERIDES -	PRETAB	I: Filena	mes	
GENERA	L FILES									
Show	all gen	eral f:	iles 🎽							
INPUT	FILES									
Prec	ise ephe	meris	IG	s\$WD+0	PRE					
Pole	file		IG	S\$¥D+O	ERP					
RESULT										
Tabu	lar file	(s)	IG	S\$YD+O	TAB (bla	nk: same	name as	s input fi	le(s))	
Sate	llite cl	ock fi	le IG	S\$YD+0	CLK					
GENERA	L OUTPUT	FILES								
Prog	ram outp	ut	Y	use PR	ETAB.Lnr	L	or	PRETA	B OUT	
Erro	r messag	es		merged	to prog	fram outp	ut or	ERROR	MSG	
∦ ^Тор	^Prev	[	^Next	Cance^I	Save^	As n	Save	^Run	^Output	Rer^un
User: bern50	Campaign:	\${K}/INTR	O \$Y+0=2002	\$S+0=1430	File: /u/aii	ub/bern50/GP	SUSEB/PAN	PRETAB INP		-

🕱 Bernese GPS Software Version 5.0	_ 🗆 ×
Configure <u>C</u> ampaign <u>B</u> INEX <u>Orbits/EOP Processing Service</u> Conversion <u>B</u> PE <u>U</u> ser	<u>H</u> elp
PRETAB 2: General Options           TITLE         EXAMPLE: Session \$YSS+0: Tabular Orbit/Clock Information	
GENERAL OPTIONS Reference system	
SATELLITE OPTIONS Remove bad satellites Use accuracy codes from SP3-file Exclude sat. with accuracy code 0 Exclude sat. with acc. code exceeding 99 =	
Image: Instant Concerning         Save         Run         Output           User: berrs0         Campaign: \${K}INTRO         \$Y+0=2002         \$S+0=1430         File: /u/aiub/berrs0/GPSUSER/PAN/PRETAB.INP	out Rer^un

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

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

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Con <u>f</u> igure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
CREATE	STANDARD	ORBIT	FILE -	ORBGEN 1	: Input	Files				
GENERA	L FILES									
Show	all gene	eral fi	les		<b>Y</b>					
INPUT	FILES									
۲	Start wit	h tabu	lar orbit	s	IGS\$YD	O TAB				
0	Start wit	h prec	ise orbit	s		PRE				
0	Update st	andard	orbit							
	Orbita	al elem	ents, fil	.e 1		ELE				
	Orbita	al elem	ents, fil	.e 2		ELE				
Pole	file				IGS\$YD	O ERP				
	,	,	,		,	,		,	,	
ii ^Top	^Prev		Next	Cance^I	Save^		Save	^Run	^Output	Rer^un
User: bern50	J Campaign: 8	\${K}/INTRC	\$Y+0=2002	\$\$+0=1430	File: /u/ai	ub/bern50/GP	SUSER/PA	N/ORBGEN.INF	,	11

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.

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Configure <u>C</u> ampaign <u>RINEX</u> <u>Orbits/E</u>	OP <u>P</u> rocessing	<u>S</u> ervice Cor	n <u>v</u> ersion <u>j</u>	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
ORBGEN 1.1: General Files							
GENERAL INPUT FILES							
General constants	CONST.						
Satellite problems	SAT_\$Y+0	CRX					
Satellite information	SATELLIT.						
Planetary ephemeris file	DE200	EPH					
Subdaily pole model	IERS2000	SUB					
Nutation model	IAU2000	NUT					
Coeff. of Earth potential	JGM3.						
Ocean tides file	OT_CSRC	TID					
MENU SETTINGS Selected campaign	\${K}/INTRO						
Selected session	year 2002		on 1430				
Session table	-	)/STA/SESSI					
Session table	\${K}/INIKC	//aia/abaa.	.UND.BED				
TEMPORARY FILES							
Scratch files	OR BGEN \$J	SCR		ORBGE	IN \$J	SC2	
iii ^Top ^Prev ^Next	Cance^I	Save^As	^Sav		^Run	^Output	Rer^un
User: bern50 Campaign: \${K}/INTRO \$Y+0=2	002 \$S+0=1430	File: /u/aiub/b	ern50/GPSU8	SER/PAN	/ORBGEN.INI	>	//

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Con <u>f</u> igure <u>C</u> amp	aign <u>R</u> INEX	<u>O</u> rbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
ORBGEN 2: H	esult and	Output Fi	les						
RESULT FILF Standard Radiatior Residual	orbits 1 pressure		GS\$YD+0	STD RPR RES					
OUTPUT FILI Summary 1		C	RB\$YD+0	LST					
GENERAL OU Program o Error mes	output	Ē	_	RBGEN.Lı d to pro	un ogram outŗ	or out or		OUT MSG	
User: bern50 Camp	Prev   aign: \${K}/INTF	^Next   RO \$Y+0=2002	Cance^I \$S+0=1430	Save^ File: /u/ai		Save   SUSER/PAI	^Run	^Output	Rer^un

Bernese	GPS Software	Version 5.0								_ 🗆 ×
Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
ORBGEN TITLE	3.1: Op		ion \$YSS+	0: Stand	ard orb	it genera	tion		_	
Eart Time	POTENTIA h potent frame y antenn	ial deg	GI							
ORBIT	MODEL ID	ENTIFIE	R <u>B</u>	A B C D E F G	JG li li li li li li	M3 potent ke A + DE3 ke B + Co ke B, but ke B, but ke B, but	ial, E: 200 ep) lombo j EGM96 TEG4 EIGEN:	potential arth tides nem., Ocean parameters potential potential IS or EIGEN parameters		
     ^Top	^Prev		Next	Cance^I	Save?	`As 🏼 ^	Save	^Run	^Output	Rer^un
User: bern5	0 Campaign:	\${K}/INTRO	\$Y+0=2002	\$S+0=1430	File: /u/a	iub/bern50/GPS	SUSER/PA	N/ORBGEN.INP		/

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 ?.

#### 3. Terminal Session: Tuesday

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Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	Processing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
ORBGEN	3.2: Opt	ions								
PRINT	RESIDUALS	8	NO	Ø						
NUMERI	CAL INTEG	RATION								
Numb	er of ite	erations	3	×						
EQUATI	ON OF MOT	TION								
Poly	nomial de	egree	10	<b></b>						
Leng	th of int	erval	1.	0 hou	rs					
VARIAT	IONAL EQU	JATIONS								
Poly	nomial de	egree	12	-						
Leng	th of int	erval	6.	0 hou	rs					
🛛 ^Тор	^Prev	^	Next	Cance^I	Save^	As ^	Save	^Run	^Output	Rer^un
User: bern5	) Campaign:	\${K}/INTRO	\$Y+0=2002	\$S+0=1430	File: /u/ai	ub/bern50/GP	SUSER/PA	N/ORBGEN.IN	IP	11

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Configure	<u>C</u> ampaign	<u>B</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
ORBGEN	4: Param	neter S	election							
DYNAMI	CAL ORBIT	PARAM	ETERS							
Apar	t from si	x oscu	lating el	ements es	stimate	the foll	owing	parameters		
DO (•	direct)	<b>~</b>		Periodic	D terms	(cos, s	in)	<b>Y</b>		
YO (*	y-bias)	<u>۲</u>		Periodic	Y terms	(cos, s	in)	<b>Y</b>		
хО		2		Periodic	X terms	(cos, s	in)	<b>Y</b>		
🛛 ^Тор	^Prev	^	`Next	Cance^I	Save^A	ıs ∫ ′	Save	^Run	^Output	Rer^un
User: bern50	) Campaign: :	\${K}/INTRO	D \$Y+0=2002	\$S+0=1430	File: /u/aiu	b/bern50/GF	SUSER/P	AN/ORBGEN.INP		//

😿 Bernese GPS	5 Software \	Version 5.0								- D ×
Con <u>f</u> igure <u>C</u>	ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
ORBGEN 5	5: Orbit	tal Arc	Definiti	on						
ORBITAL	ARC DEE	FINITION	1							
Number	of arc	s with:	in the ti	me windo	w	1				
	Defined		overed by ar and se Sess	ssion nu	mber	rbits				
J	Defined Start	yyyy r	art and e mm dd STR+0				<b>mm dd</b> STR+0	<b>hh mm</b> 23 59		
    ^Top	^Prev	[ ^	Next	Cance^I	Save	As ·	`Save [	^Run	^Output	Rer^un
User: bern50 (	Campaign: :	\${K}/INTRO	\$Y+0=2002	\$S+0=1430	File: /u/ai	ub/bern50/GF	SUSER/PAI	V/ORBGEN.INP		

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

 INPUT AND OUT	PUT FILENA	MES								
Session table : \${K}/INTRO/STA/SESSIONS.SES General constants : \${X}/GEN/CONST. Pole file : \${K}/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/SAT_2002.CRX Satellite information : \${X}/GEN/DE200.EPH Ocean tides file : \${X}/GEN/OT_CSRC.TID Orbital elements, file 1 : Orbital elements, file 2 : Standard orbits : \${K}/INTRO/ORB/IGS02143.STD Radiation pressure coeff. : Residual file : \${U}/WORK/ORBGEN.SCR Scratch file : \${U}/WORK/ORBGEN.SC2 Program output : \${K}/INTRO/OUT/ORB02143.OUT Error message : \${U}/WORK/ERROR.MSG 										
RMS ERRORS AN	ID MAX. RES	IDUALS	ARC NUMB	ER: 1			ITERATI(	DN: 2		
SAT #POS 	RMS (M)	QUADRA TOTAL	TIC MEAN RADIAL	OF O-C ALONG	(M) OUT	MAX. R RADIAL	ESIDUALS ALONG	5 (M) OUT		
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	0.01 0.01 0.01 0.01	0.01	0.02	0.01	0.01	0.02 0.04 0.03 0.02	0.02 0.02 0.03 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  ${K}/INTRO/OUT/ORB02143.LST$  summarizing the orbit fit rms values may be compared with the corresponding section in the solution reference file  ${K}/INTRO/OUT/R2S021430.PRC_REF$ .

<sup>&</sup>lt;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><u>Processing</u> ><u>Code-based clock synchronization</u>". Its main task is to compute the receiver clock corrections.

Bernese G	PS Software	Version 5.0							_0
onfigure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP Pro	cessing <u>S</u>	ervice Con <u>v</u> ersion	<u>B</u> PE <u>U</u> se	r		<u>H</u> elp
SINGLE	POINT P	OSITION	ING USING CO	DE MEAS	UREMENTS - COI	)SPP 1: File	names		
GENERAI	L FILES								
Show	all gen	eral fi	Les 🚩						
			•						
INPUT C	ORBITS								
0	Broadc	ast orb:	its	BRD					
۲	Standa	rd orbit	s IGS\$¥D+	0 STD	Satellite 🤇	clocks	IGS\$YD+0	CLK	
INPUT H	FILES								
Code	observa	tion fi	les ????\$S+	O CZH	A priori co	ordinates	APR\$YD+0	CRD	
Estir	mated tr	opo.valu	les 🗌	TRP	Site eccent	ricities		ECC	
Pole	file		IGS\$YD+	0 ERP	Kin. input	coordinates		KIN	
Stat:	ion sigm	a facto	rs 🗌	SOS	Code bias :	input files	P1 C1 \$M+0	DCB	
LEO i	files								
Tan	[∧⊡rou		Next Cou		Save^As	^Save ^F	um [ ^0	utaut [	Dom
^Top er: bern50	^Prev			t0=1430 E	ile: /u/aiub/bern50/GF			utput	Rer^

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Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersior	n <u>B</u> PE	Us	er			<u>H</u> elp
CODSPP	1.3: Ou	tput Fi	les									
RESULT	FILES											
Coor	dinate r	esults			CRD							
Kine	matic co	ordinat	es		KIN							
Resi	dual fil	e			RES							
Sate	llite cl	ock res	ults		CLK							
Cloc	k RINEX :	results			CLK							
GNSS	receive	r LC DC	B values		DCB							
-	FILES ut summa ut Summa				SMC SME							
GENERA	L OUTPUT	FILES										
Prog	ram outp	ut		us us	e CODSP:	P.Lnn		or	COD\$Y	D+0	OUT	
Erro	r messag	es		me	rged to	program	output	or	ERROR		MSG	
ii ^Top	^Prev		Next	Cance^I	Save^		^Save		Run	^C	output	Rer^un
User: bern5	u Campaign:	\${K}/INTRC	\$Y+0=2002	\$5+0=1430	File: /u/ai	ub/bern50/G	PSUSER/P/	AN/COE	JSPP.INP			11.

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Configure	<u>C</u> ampaign	<u>B</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser			<u>H</u> elp
CODSPP	2: Input	: Optio	ns								
TITLE	EXAMPLE	I: Sess	ion \$¥SS+	0: Clock	synchro	nization	1				
Cloc Save Esti	uency k polynor clock es mate coor	stimate rdinate	s		L3 E BOT NO		: one	offset	per epoch		
	HERE MODI osphere	5172			CAA	STAMOINE	N Z				
-	sphere					JIANOINE	N <u>-</u>				
					,						
ii ^Тор	^Prev		Next	Cance^I	Save^		^Save	^Rur		utput	Rer^un
User: bern5	) Campaign:	\${K}/INTRC	\$Y+0=2002	\$S+0=1430	File: /u/ai	ub/bern50/GF	SUSER/F	PAN/CODSP	P.INP		11

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.

	GPS Software	Version 5.0								_ 🗆 🗙
Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
	_									
CODSPI	93: Inpu	t Option	ns							
OBGED	VATION SE	LECTION								
	imum elev				3	🗧 degrees	-			
	oling rat				1	) acgrees	-			
	ervation									
	mark fla		observat	ion file:	₅ ′_					
		-								
PRINT	OPTIONS									
Res	iduals									
Elev	vations									
	( -	r			( <b>-</b>		_	_		_
^Top   ser: bern5	^Prev		Next \$V+0=2002	Cance^I \$\$±0=1430	Save*		Save SUSER/PA	^Run N/CODSPP.INP	^Output	Rer^un
	GPS Software				T Ho. T ar a				_	- O ×
Configure	<u>Campaign</u>	RINEX	Orbits/EOP	Processing	<u>S</u> ervice	Conversion	BPE	User		Help
Contiguio	Dembergu	<u>Huter</u>	0.000.201	Licestonig	0011100		2.2			<u>11046</u>
CODSPI	94: Scre	ening Oj	ptions							
ITERA	TIONS									
Max	. number	of itera	ations	10 🗧						
OUTLI	ER DETECT	ION								
Out	lier dete	ction		7						
	to a m d altra	l allow	ed	30.0	mete	rs				
Max	. residua									
	fidence i	nterval		5.0	(in	units of d	one sig	ma)		
Con:			dom	5.0	(in	units of a	one sig	ma)		
Con: Min Max	fidence i . degree . RMS of	of free kin. so:	lution	1 ¥ 5.0	(in mete		one sig	ıma)		
Con: Min Max	fidence i . degree	of free kin. so:	lution	1			one sig	ma)		
Con: Min Max	fidence i . degree . RMS of	of free kin. so:	lution	1 ¥ 5.0			one sig	ma)		
Con: Min Max	fidence i . degree . RMS of	of freed kin. so: s in ob:	lution	1 ¥ 5.0		rs	one sig Save	nma) ^Run	^Output	Rer^un

CODSPP produces the following output:

```
. . .
STATION: BRUS 13101M004 FILE: ${K}/INTRO/OBS/BRUS1430.CZO RECEIVER UNIT: 0
. . .
. . .
RESULTS:
 ----
OBSERVATIONS IN FILE:21844BAD OBSERVATIONS :0.15 %RMS OF UNIT WEIGHT :0.97 MNUMBER OF ITERATIONS:2
. . .
STATION COORDINATES:
_____
LOCAL GEODETIC DATUM: IGSOO
                              A PRIORINEWNEW-A PRIORIRMSERROR4027893.784027893.780.000.00307045.78307045.780.000.004919475.084919475.080.000.00
BRUS 13101M004 X
 BRUS 1510...
(MARKER) Y
Z

        HEIGHT
        149.66
        149.66
        0.00

        LATITUDE
        50 47 52.143
        50 47 52.143
        0
        0
        0.000

        LONGITUDE
        4 21 33.186
        4 21 33.186
        0
        0
        0.000

                                                                                      0.00
0.0000
                                                                                       0.0000
CLOCK PARAMETERS:
OFFSET FOR REFERENCE EPOCH:
                                          0.00000632 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
                                              2
NUMBER OF BAD OBSERVATION PIECES
                                     :
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. It 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>Codebased clock synchronization") to generate a short summary from the CODSPP program output. This summary is included in the solution reference file (\${K}/INTRO/OUT/R2S021430.PRC\_REF).

### 3.3.2 Form Baselines

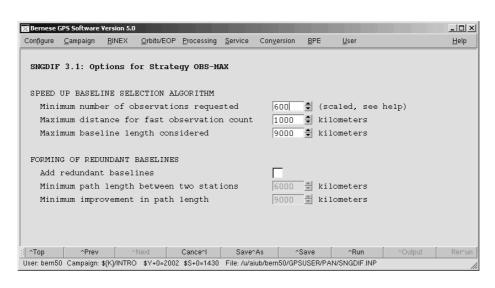
The second processing program is called SNGDIF and may be activated in "Menu>Processing >Baseline file creation". SNGDIF creates the single differences and stores them into files. We use the strategy OBS-MAX for PHASE observation files.

Bernese GPS Software Version 5.0 Configure <u>C</u> ampaign <u>B</u> INEX <u>O</u> rbits/EOP <u>P</u> rocessing		⊡× elp
CREATE SINGLE-DIFFERENCE OBSERV. FILES	- SNGDIF 1: Observation File Selection	
GENERAL FILES Show all general files	<u> </u>	
GENERAL OPTIONS Measurement type Processing strategy	PHASE Z OBS-MAX Z	
AUTOMATED BASELINE CREATION Zero-difference observation files Reference station for STAR strategy	????\$\$+0         PZH         ????\$\$+0         CZH           PZH         CZH         CZH         CZH	
MANUAL BASELINE CREATION First zero-difference input file Second zero-difference input file Single-difference output file	PZH CZH PZH CZH PSH CSH	
Shigle-difference output file	Save^As ^Save ^Run ^Output Re	ir^un

#### 3. Terminal Session: Tuesday

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Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
SNGDIF	2: File	names								
INPUT	FILES									
Stat	ion coor	dinates		APR\$Y	D+0 CR	D				
Site	eccentr	icities			EC	С				
Pred	efined b	aseline:	3		BS	L				
Clus	ter defi	nition			CL	U				
	FILES ing of fo ter/base				BSI	-	s will	be append	ed)	
GENERA	L OUTPUT	FILES								
Prog	ram outp	ut	7	use SN	GDIF.Lnr	ı	or	SNGDI	F OUT	
Erro	r messag	es		merged	to prog	gram outpu	it or	ERROR	MSG	
Top	^Prev		Next	Cance^I	Save^	As ^: ub/bern50/GPS	ave	^Run	^Output	Rer^un

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Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
SNGDIF	3: Optio	ns								
TITLE	EXMAPLE	: Sess	ion \$¥SS+	0: Basel	ine cre	ation				
	ANEOUS OE rance to			ations o	f one e	poch 1.0	)	seconds		
SETTIN	G OF NEW	AMBIGU	ITIES							
Afte	r a gap i	n the	observati	ons larg	er than	20		minutes		
If a	cycle sl	ip fla	g in one	of the i	nput fi	les				
🛛 ^Тор	^Prev		Next	Cance^I	Save^		Save	^Run	^Output	Rer^un
User: bern50	)Campaign: \$	s{K}/INTRO	D \$Y+0=2002	\$S+0=1430	File: /u/ai	ub/bern50/GPS	USER/F	AN/SNGDIF.INP		11.



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	ОК
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  $\geq \underline{P}$ rocessing>Phase <u>preprocessing</u>".

configure <u>Campaign BINEX</u> <u>Orbits/EOP Processing Servic</u>	ce Con <u>v</u> ersion	<u>B</u> PE <u>U</u> ser		<u>H</u> elp
PREPROCESSING OF ZERO-/SINGLE-DIFF. PHASE O	BS. FILES -	MAUPRP 1: Inj	out Files	
GENERAL FILES				
Show all general files	<b>~</b>			
INPUT FILES				
O Zero-difference observation files	???\$\$+0	PZH		
Single-difference observation files	????\$S+0	PSH		
A priori coordinates	APR\$YD+0	CRD		
Site eccentricities		ECC		
Kinematic input coordinates		KIN		
GNSS standard orbits	IGS\$YD+0	STD		
Pole file	IGS\$YD+0	ERP		
Satellite clocks		CLK		
Estimated troposphere values		TRP		
Meteo data files		MET		
Ionosphere models		ION		
Process LEOs				
^Top ^Prev ^Next Cance^I Sa	ave^As ^S	ave ^Run	^Output	Ren

#### 3. Terminal Session: Tuesday

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Configure <u>C</u> ampaign <u>BINEX</u> <u>Orbits/EOP Processing</u> <u>Service</u> Con <u>v</u> ersion <u>BPE</u> <u>U</u> ser	<u>H</u> elp
MAUPRP 3: General Options	
TITLE EXAMPLE: Session \$YSS+0: Phase cleaning	
GENERAL SETTINGS	
Screening mode, frequency to check COMBINED	
Save screened observation files	
TROPOSPHERE MODELING	
ZPD model and mapping function NIELL	
SAVING COORDINATES	
Define the fixed station	
(blank: automatic selection)	
la ∧Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output	Rer^un
User: bem50 Campaign: \$(K)/INTRO \$Y+0=2002 \$S+0=1430 File: /u/aiub/bem50/GPSUSER/PAN/MAUPRP.INP	nor un

👿 Bernese G	PS Software V	ersion 5.0								- D ×	
Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp	
MAUPRP 4: Marking of Observations											
	MARKING OF OBSERVATIONS BEFORE CYCLE SLIP DETECTION Mark if marking flags in observation file										
	observat		-			for stat	ions	3	degrees		
Mark	unpaired	dual i	frequency	observat	tions	for LEOs		0 ÷	degrees		
Minin	num time :	interva	al accept	ed for co	ontinuou	us observ	ations	301	seconds		
Maxim	num gap a	ccepted	d within	continuo	us obsei	rvations		61	seconds		
ii ^Top	^Prev	1	Next	Cance^I	Save^	As ^	Save	^Run	^Output	Rer^un	
User: bern50	Campaign: \$	K}/INTRO	\$Y+0=2002	\$S+0=1430	File: /u/ai	ub/bern50/GP	SUSER/PA	N/MAUPRP.IN	1P	1.	

👿 Bernese GP	95 Software	Version 5.0									- O X
Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser			<u>H</u> elp
MAUPRP	5: Non-I	Paramet	ric Scree	ning							
GENERAL	OPTION	5									
Exten	t of pro	ogram o	utput			SUM	IAR Y	Y			
Maxim	um time	interv	al for po	lynomial	fit	2	minut	tes			
SCREENI	NG ON D	IFFEREN	T DIFFERE	NCE LEVE	LS						
	Origina	al obse	rvations	from fil	e	for ZD-f	iles:	zero d	iff.		
	Poly	ynomial	degree	1 👻		SD-f	iles:	single d	iff.		
	Dis	continu	ity level	0.4	met	ers					
_											
			etween sa					single d			
	Poly	ynomial	degree	1		SD-f	iles:	double d	iff.		
	Dis	continu	ity level	0.01	met	ers					
    ^Top	^Prev	^	Next	Cance^I	Save^	As ^	Save	^Run	^(	Dutput	Rer^un
User: bern50	Campaign:	\${K}/INTRC	\$Y+0=2002	\$S+0=1430	File: /u/ai	ub/bern50/GP	SUSER/F	AN/MAUPRP	.INP		11.

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Configure	<u>C</u> ampaign	<u>B</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersio	n <u>B</u> PE	<u>U</u> ser		<u>H</u> elp
	_		_							
MAUPRP	6: Epoc	h-Differ	rence Sol	ution						
EPOCH-	DIFFEREN	CE SOLU	TION			for 7D-	-files.	double diff		
	uency fo			I	13 🖂			triple diff		
-			e estimat	_	_					
Maxi	mum obse	rved-cor	nputed va	lue 🛛	.5	meters	(0.0)	no check)		
RMS	limit fo	r epoch	solution	. 1	.0	meters	(0.0)	no check)		
	-		inate/bas	_		-				
	X-coord				.1	meters				
	Y-coord Z-coord				1.1	meters meters				
	2-000ru	Inace		Į0	.1	meters				
	,	,			,			(		
^Top	^Prev		Next	Cance^I	Save Eile: /u/a		^Save	^Run AN/MAUPRP.INP	^Output	Rer^un
	GPS Software			φ0+0=1430	, The 707a	adb/bernad/				
Configure	<u>C</u> ampaign	BINEX	Orbits/EOP	Processing	<u>S</u> ervice	Con <u>v</u> ersio	n <u>B</u> PE	User		<u> </u>
	T	<u></u>		2						
MAUPRP	8: Cycl	e Slip I	Detection	/Correct	ion					
CACTE	SLIP DET	ECTION								
	nt of pr	-	-			S	UMMARY	Z		
			slip cor							
			epted cyc	-			) -	cycles		
			ons with				-			
1 12 1	s clean	except 1	for obser	vations	WICH II	ags				
NO CYC	LE SLIP	HYPOTHES	315							
	a for L1					0.	.0020	meters		
-	a for L2						.0020	meters		
Maxi	mum iono	spheric	change f	rom epoc	h to ep	och 40	0	% of L1 cy	cles	
CACTE	SLIP COR	RECTIONS	5							
			d L1 cycl	-			-	integers		
Sear	ch width	to find	d L5 cycl	e slip c	orrecti	on 2	Ē	integers		
/ ^Top	^Prev		Next	Cance <sup>^</sup> l	Save Save		^Save	^Run	^Output	Rer^un
			\$Y+0=2002	. <b>⊅</b> 3+0=1430	File: 70/a	uub/bemau/d	arouser/r	AN/MAUPRP.INP		///
Configure	GPS Software Campaign	Version 5.0 <u>R</u> INEX	Orbits/EOP	Processing	Service	Con <u>v</u> ersio	n <u>B</u> PE	User		<u> </u>
Contriguio	Dambardu	<u>Huter</u>	0.0.00201	Licconnig	0011100	0011201010				<u> </u>
MAUPRP	9: Out1	ier Reje	ection /	Ambiguit	y Setti	ng				
OUTLIE	R REJECT	ION								
Enab	le outli	er reje	ction				<u> </u>	_		
Mark	consecu	tive out	tliers up	to a ti	me inte	rval	181	seconds		
	MULTIPL						_			
		-	s from ob g in obse				-			
			rrection				N N			
	-	-	n gap lar	-			181			
				-						
MARKIN	G OF OBS	ERVATION	NS AFTER	CYCLE SL	IP CORR	ECTIONS				
Mini	mum obse	rved tir	me interv	al per a	mbiguit	У	301	seconds		
Remo	ve satel	lites if	f the fil	e contai	ns more	than	300	ambigui	ties	
    ^Top	^Prev		Next	Cance^I	Save	^As [	^Save	^Run	^Output	Remun
								AN/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 : ${K}/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):
                                                     0.026
                                      0.145 +-
                         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	234	41	0.050	11
1430	2	OK	FFMJ	MATE	1220	18002	0.012	-0.161	0.030	-0.286	36	429	58	0.049	558
1430	3	OK	FFMJ	ONSA	840	20430	0.011	-0.205	0.021	-0.068	101	140	44	0.050	11
1430	4	OK	FFMJ	ZIMJ	368	11610	0.011	-0.020	0.032	-0.071	76	223	24	0.049	11
1430	5	OK	FFMJ	ZIMM	368	19563	0.011	-0.015-	-0.015-	-0.089	46	198	39	0.042	46188
1430	6	OK	PTBB	ZIMM	640	17032	0.013	-0.018-	-0.047-	-0.128	45	96	21	0.049	46188
1430	7	OK	VILL	ZIMM	1162	17990	0.012	0.175	0.080	0.199	54	218	30	0.050	17
Tot:	7				783	17467	0.012				70	220	37		-

This summary file is included in the solution reference file  $({K}/{INTRO}/{OUT}/{R2S021430.PRC}_{REF}$  — the results may be slightly different since the input options were not exactly identical).

## 3.4 Daily Goals

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

- (1) Bernese pole file in the campaign's ORB directory: IGS02143.ERP,
- (2) Bernese standard orbit file in the ORB directory: IGS02143.STD,
- (3) Bernese satellite clock files in the ORB directory: IGS02143.CLK,
- (4) Single difference files (baseline files) in the OBS directory: BRON1430.CSH, BRON1430.PSH, BRON1430.CSO, BRON1430.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 ><u>Processing</u>>Parameter <u>estimation</u>". We use the following options:

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Configure Campaign RINEX Orbits/EOP Proc	essing <u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
PARAMETER ESTIMATION - GPSEST 1.1:	Input File	s 1				
GENERAL FILES AND OPTIONS						
Show all general files	Ľ					
LEO data processing						
Differencing level	DOUBLE Z					
INPUT FILES 1						
Phase observation files	????\$S+0	PSH ?	???\$S+O	PZH		
Code observation files		CSH		CZH		
Station coordinates	APR\$YD+0	CRD				
GNSS standard orbits	IGS\$YD+0	STD				
GNSS clock corrections		CLK				
Earth rotation parameters	IGS\$YD+0	ERP				
Troposphere estimates		TRP				
Ionosphere models		ION				
Differential code biases		DCB				
Ocean loading corrections	EXAMPLE	BLQ				
Top ^Prev <b>^Next Canc</b>			Save	^Run	^Output	Rer^un
User: bern50 Campaign: \${K}/INTRO \$Y+0=2002 \$S+0	)=1430 File: /u/a	iub/bern50/GP	SUSER/PAN	GPSEST.INP		

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Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
GPSEST	72.1: Ou	tput Fi	les 1							
GENERA	L OUTPUT	FILES								
Prog	gram outp	ut	[	use GP	SEST.Ln	n	or	EDT\$YD+0	OUT	
Erro	or messag	e		merged	to prog	gram outpu	it or	ERROR	MSG	
	C FILES 1		_							
	mal equat				NQO					
Stat	ion coor	dinates			CRD					
Trop	osphere	estimat	es		TRP					
Trop	osphere :	SINEX			TRO					
Ionc	osphere m	odels			ION					
IONE	IX.				INX					
GNSS	S clock c	orrecti	ons		CLK					
Cloc	sk RINEX				CLK					
Diff	Terential	code b	iases		DCB					
Resi	iduals		ED	T\$YD+0	RES					
   ^Top	^Prev	· ^	Next	Cance^I	Save^	As 5	Save	^Run	^Output	Rer^un
User: bern5	0 Campaign:	\${K}/INTRC	\$Y+0=2002	\$S+0=1430	File: /u/ai	ub/bern50/GPS	USER/PAN	/GPSEST.INP		

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).

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Configure	<u>C</u> ampaign	<u>R</u> INEX	<u>O</u> rbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser	<u>H</u> elp		
GPSEST TITLE	3.1: Gen		tions 1 on \$¥SS+0:	Save resi	duals						
Sate Freq Elev Samp Tole Spec	ATION SEL llite sys uency ation cut ling inte rance for ial data : rvation w	tem off ang rval simult selecti	aneity	0 sec	v v onds lisecon	LE0 ds	: 0	degrees			
A pr Elev Type Corr	iori sigma	a endent ted res trategy		0.001 m COSZ V NORMALIZI BASELINE V only	eters	r than	: NONE 2003 09 2006 11	14			
∬ ^Тор	^Prev	•	^Next	CanceAl	Sav	/e^As	^Save	^Ru	in 🏼	Dutput	Rer^un
User: bern	50 Campaig	n: \${K}/IN	TRO \$Y+0=2	002 \$S+O=1	430 File:	/u/aiub/bern	50/GPSUS	ER/PAN/GI	PSEST.INP		//

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Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	Processing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
GPSEST	3.2: Gei	neral O	ptions 2							
A PRIC	RI TROPOS	SPHERE 1	MODELING							
ZPD	model and	d mappi	ng functi	on DRY_	NIELL	Y				
Resc Save Intr	NG OF AM Plution st resolved roduce wide roduce L1	trategy d ambig delane	uities integers			<u>7</u>				
Maxi	L PROCES: .mum tole: .covar wr	rated O	-C term	ers SIMP	met	ers Y				
	ED PRINT			is <u>NO</u>		Σ				
     ^Top	^Prev	^	Next	Cance^I	Save^	As ^:	Save	^Run	^Output	Rer^un
User: bern5	0 Campaign:	\${K}/INTRO	\$Y+0=2002	\$S+0=1430	File: /u/ai	ub/bern50/GPS	SUSER/PA	N/GPSEST.INP		11.

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

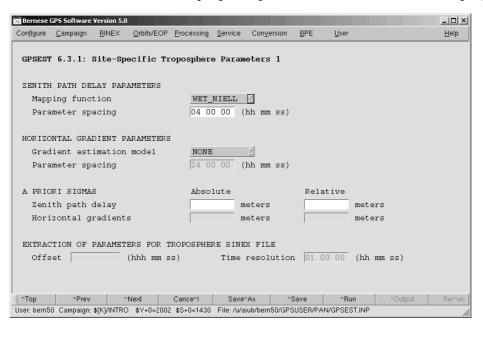
Bernese	GPS Software	e Version 5.0	)							_ 🗆 ×
Con <u>f</u> igure	<u>C</u> ampaign	<u>R</u> INEX	<u>O</u> rbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
GPSESI	'4: Datu	m Defin	ition for	Station	Coordi	nates				
DATUM	DEFINITI	ON TYPE								
0			solution							
۲	Coordi	.nates c	onstraine	d	WITH	[_FLAG	Z			
0	Coordi	nates f	ixed		MANU	IAL	Y			
	ORI SIGMA		_							
Nort		0.01	meters							
East Up		0.01	meters meters							
0p		10.01	mecer a							
	(	ſ			[		_	[		
User: bern5	^Prev 0 Campaign		^Next D \$Y+0=2002	Cance^l \$S+0=1430	File: /u/a		·Save SUSER/PA	^Run N/GPSEST.INP	^Output	Rer^un
Bernese	GPS Software	e Version 5.0	)							×
Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	Processing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
GPSEST	4.1: Da	ntum Def	inition f	or Stati	on Coor	dinates				
			O BE CONS	TRAINED	ſ				l.	
	al selec		nd sigmas	) from f	   10		SIG			
			fic flags.			r <b>⊣</b> +	216			
bout	.10110 .110	in opeer	110 11090	in out						
    ^Top	^Prev		^Next	Cance^I	Save'	AA [ _ A	Save	^Bun	^Output	Rer^un

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

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Configure Campaign RINEX Orbits/EOP Processing	Service Conver	sion <u>B</u> PE <u>L</u>	lser	<u>H</u> elp
GPSEST 5.1: Setup of Parameters and Pro	e-Elimination	1		
STATION-RELATED PARAMETERS	Setup	Pre-Elin	mination	
Station coordinates		NO	V	
Ambiguities		NO	X	
Receiver antenna offsets		NO	Z	
Receiver antenna PCV patterns		NO	Ā	
ATMOSPHERIC PARAMETERS Site-specific troposphere parameters Global ionosphere parameters		NO	<u> </u>	
EPOCH PARAMETERS				
Kinematic coordinates		EVERY_EPOCH	X	
Receiver clock offsets	<u> </u>	EVERY_EPOCH	Z	
GNSS clock offsets		EVERY_EPOCH	Z	
Stochastic ionosphere parameters	Г	EVERY_EPOCH	<u> </u>	
Top ^Prev ^Next Cance^I	Save^As	^Save	^Run Outp	ut Rer^un
User: bern50 Campaign: \${K}/INTRO \$Y+0=2002 \$S+0=1430	File: /u/aiub/bern5	)/GPSUSER/PAN/GP	PSEST.INP	11.

👿 Bernese GPS So	ftware Version 5.0	)							- 🗆 🗵
Con <u>f</u> igure <u>C</u> am	paign <u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	BPE	<u>U</u> ser		<u>H</u> elp
GPSEST 5.2	: Setup of	Parameter	s and Pro	e-Elimir	nation 2				
SATELLITE-	RELATED PAR	AMETERS		Setup	>	Pre-E	limination		
GNSS or	LEO orbit d	leterminat	ion	Г	NO			N	
GNSS ant	enna offset	s			NO			Z	
GNSS ant	enna PCV pa	itterns			NO			<u> Z</u>	
ADDITIONAL	PARAMETERS	1							
Differer	itial code b	iases			NO			<u> Z</u>	
Earth or	ientation p	arameters			NO			Z	
Geocente	er coordinat	es		Ē	NO			N	
TIME OFFSE	T FOR PARAM	ETER INTE	RVALS			(hhh m	m ss)		
^Top		^Next	Cance^I	Save^		iave [	^Run [	^Output	Rer^un
User: bern50 Can	npaign: \${K}/INTR(	D \$Y+0=2002	\$S+0=1430	File: /u/ai	ub/bern50/GPS	USER/PAN	V/GPSEST.INP		11.

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



💓 Bernese GPS Software Version 5.0							_ 🗆 ×
Configure <u>C</u> ampaign <u>R</u> INEX <u>O</u> rbits/B	OP <u>P</u> rocessing	<u>S</u> ervice C	on <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
GPSEST 6.3.2: Site-Specific	Troposphere	e Paramet	ers 2				
STATIONS TO BE EXCLUDED FRO	M TROPOSPHE	RE ESTIMA	TION				
Station selection	NONE	Z					
Station list from file		FIX					
Manual selection							
STATIONS WITH SPECIAL A PRI	ORI SIGMAS						
Station selection	NONE	Σ					
Station list from file		SIG					
Manual selection							
SPECIAL A PRIORI SIGMAS	Absolut	te		Relativ	/e		
Zenith path delay		meter	s		meters		
Horizontal gradients		meter	s		meters		
<b>^Prev</b> ^Next	Cance^I	Save^As	^9	Save	^Run	^Output	Rer^un
User: bern50 Campaign: \${K}/INTRO \$Y+0=	2002 \$S+0=1430	File: /u/aiub	bern50/GPS	SUSER/PAN	I/GPSEST.INP		

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):

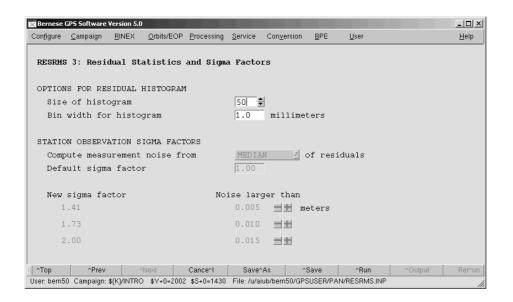
A POSTERIORI SIGMA OF UNIT WEIGHT : 0.0011 M (SIGMA OF ONE-WAY L1 PHASE OBSERVABLE AT ZENITH)
```

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 CODSPP) was not successfully performed.

If the residuals have been stored in the binary residual files ("GPSEST 2.1: Output Files 1") it is possible to have a look on the residuals (program REDISP, "Menu>Service>Residual files>Display residual file"). To screen the residuals automatically use the program RESRMS in "Menu>Service>Residual files>Generate residual statistics".

Bernese GPS Software Version 5.0	_ 🗆 ×
Configure <u>Campaign</u> <u>RINEX</u> <u>Orbits/EOP</u> <u>Processing</u> <u>Service</u> Conversion <u>B</u> PE	<u>U</u> ser <u>H</u> elp
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\$VD+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
i ^Top ^Prev ^Next Cance^I Save^As ^Save	ARUN ^Output Rer^un
User: bern50 Campaign: \${K}/INTRO \$Y+0=2002 \$S+0=1430 File: /u/aiub/bern50/GPSUSER/P/	AN/RESRMS.INP

👿 Bernese (	SPS Software	Version 5.0										- O X
Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ers	ion <u>B</u> l	PE	<u>U</u> ser			<u>H</u> elp
RESRMS	2: Optio											
TITLE	EXAMP	LE: Ses	sion \$YSS	+O: Resi	dual st	atisti	s					
GENERA	L OPTION:	3										
Freq	uency to	check				L	3 🛛					
Samp	ling rat	e of re	sidual fi	les		30	)	sec	ronds			
	LARGE RI e measur(		s	Ч			.mit 004	met	ers			
Code	measure	ments				0.	004	met	ers			
Rang	e measur	ements				0.	3000	met	ers			
DETECT	BAD DATA	A										
Mini	mum cont	inuousl	y observe	d time i	nterval	36	51	sec	conds			
	-		with few									
			bservatio	-	-	- <u>_</u>						
Samp	ling rate	e for c	ounting t	he obser	vations			sec	conds			
∥^Тор	^Prev		Next	Cance^I	Save'		^Save		^Run	^Outp	out [	Rer^un
User: bern5	) Campaign:	\${K}/INTRO	\$Y+0=2002	\$S+0=1430	File: /u/a	iub/bern50	/GPSUSE	ER/PA	N/RESRMS.IN	IP		11



The program output of RESRMS ( $\{K\}/INTRO/OUT/RMS021430.OUT$ ) provides a nice overview on the data quality. In addition, files containing a summary table ( $\{K\}/INTRO/OUT/RMS02143.SUM$  — also included in the reference solution file  $\{K\}/INTRO/OUT/R2S02143.PRC\_REF$ ) — and a histogram ( $\{K\}/INTRO/OUT/RMS02143.LST$ ) of the residuals are available. The most important result file for the data screening is the "Edit information file" ( $\{K\}/INTRO/OUT/RMS02143.EDT$ ) which may be used by the program SATMRK to mark outliers ("Menu>Service>Bernese observation files>Mark/delete observations"):

🕅 Bernese GPS Software Version 5.0	_ 🗆 🗵
Configure Campaign BINEX Orbits/EOP Processing Service Conversion BPE User	<u>H</u> elp
MARK OR SYNCRONIZE SATELLITES IN OBSERVATION FILES - SATMRK 1: Filenames	
GENERAL FILES Show all general files	
OPTIONS	
Desired task EDIT_FILE Z Re-initialize ambiguities ALL Z	
OBSERVATION FILES       Zero diff. code       Single diff. code       CSH       phase       ????\$S+0       PSH       both	
GENERAL OUTPUT FILES	
Program output 🚩 use SATMRK.Lnn or SATMRK OUT	
Error messages 🔽 merged to program output or ERROR MSG	
TITLE EXAMPLE: Session \$VSS+0: Mark bad observations	
Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output	Rer^un
User: bern50 Campaign: \${K}/INTRO \$Y+0=2002 \$S+0=1430 File: /u/aiub/bern50/GPSUSER/PAN/SATMRK.INP	

Bernese	GPS Softwar	e Version 5.0								_ 🗆 ×
Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
SATM	RK 2: Ma	nual and	File Sel	ection						
FILE	SELECTI	ON								
Edi	t infor	mation f	ile	RMS \$ YI	D+0 EE	T				
MANUA	L SELEC	TION								
Typ	e of ch	ange	MARK	Z						
Fre	equency		L1&L2	$\leq$						
Sat	ellite(	s)	ALL		(AL	L: all sa	tellite	s)		
	) Fro	m epoch		(b	lank: f	irst obse	ervation	number)		
	To	epoch		(b	lank: l	ast obse	ervation	number)		
	or									
	© Obs	ervation	window							
	Sta		y mm dd D_STR+0	hh mm 00 00			mm dd			
Top	^Pre	v [^	Next	Cance^I	Save	`As	`Save [	^Run	^Output	Rer^un
· ·		·						N/SATMRK.INP	a nije ste	

## 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:

😿 Bernese GP5 Software Version 5.0							_ 🗆 ×
Configure <u>Campaign</u> <u>BINEX</u> <u>Orbits</u>	/EOP <u>P</u> rocessing	g <u>S</u> ervice	Con <u>v</u> ersion	BPE	<u>U</u> ser		<u>H</u> elp
GPSEST 2.1: Output Files 1							
GENERAL OUTPUT FILES							
Program output	use G	PSEST.Lnr	1	or	FLT\$YD+0	OUT	
Error message	merge	d to prog	gram outpu	it or	ERROR	MSG	
RESULT FILES 1		_					
Normal equations		NQO					
Station coordinates	FLT\$YD+0	CRD					
Troposphere estimates	FLT\$YD+0	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	Cance^I	Save^	As ^S	Save	^Run	^Output	Rer^un
User: bern50 Campaign: \${K}/INTRO \$Y+0	=2002 \$S+0=143	0 File: /u/aii	ub/bern50/GPS	USER/PA	N/GPSEST.INP		

To speed up the processing we increase the sampling rate:

Bernese	GPS Software	Version 5	i.0							_ 🗆 ×
Configure	<u>C</u> ampaign	<u>R</u> INEX	<u>O</u> rbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser	<u>H</u> elp	
	3.1: Gene									
TITLE	EXAMPLE	565310	on \$YSS+0:	First het	work so	lution (1)	oat)			
OBSERV	ATION SELE	CTION								
Sate	llite syst	em		GPS	-					
Freq	uency			L3	-					
Elev	ation cuto	off angl	le	3 deg	rees	LEO:	0	degrees		
Samp	ling inter	val		180 sec	onds					
Tole	rance for	simulta	aneity	100 mil	lisecon	ds				
Spec	ial data s	selectio	on	NO	•					
Obse	rvation wi	ndow		Γ						
OBSERV	ATION MODE	LING AN	ND PARAMETE	R ESTIMAT	ION					
A pr	iori sigma	ı		0.001 m	eters					
Elev	ation-depe	endent u	weighting	COSZ 💌		LEO:	NONE	7		
Type	of comput	ed resi	iduals	NORMALIZE	D 🔻					
Corr	elation st	rategy		BASELINE	-					
Pola	rization e	ffect	geom.	only	if late	r than 🛛	003 09	14 💌		
			total	only	if late	rthan 2	006 11	05 💌		
∬ ^Top	^Prev		^Next	CanceAl	Sav	/e^As	^Save	ARu	n ^Output	Rer^un
User: bern	50 Campaigr	n: \${K}/INT	TRO \$Y+0=2	002 \$S+O=14	430 File:	/u/aiub/bern5	0/GPSUSE	ER/PAN/GF	SEST.INP	

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:

👿 Bernese (	iPS Software	Version 5.0								
Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
GPSEST	4: Datu	n Defin	ition for	Station	Coordin	nates				
DATUM	DEFINITI	ON TYPE								
0	Free n	etwork	solution							
	Coordi	nates c	onstraine	d	WITH	_FLAG	Σ			
0	Coordi	nates f	ixed		MANU	AL	$\leq$			
A PRIO	RI SIGMA	3								
Nort	h 🛛	0.001	meters							
East	Ī	0.001	meters							
Up	ſ	0.001	meters							
    ^Top	^Prev	^	Next	Cance^I	Save^	As ^	Save	^Run	^Output	Rer^un
User: bern50	) Campaign:	\${K}/INTRC	\$Y+0=2002	\$S+0=1430	File: /u/ai	ub/bern50/GP	SUSER/PA	N/GPSEST.INP		11.

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:

Configure       Campaign       RINEX       Orbits/EOP       Processing       Service       Conversion       BPE       User       Help         GPSEST 5.1:       Setup of Parameters and Pre-Elimination 1       Image: Setup of Pre-Elimination	🕱 Bernese GPS Software Version 5.0				- O X
STATION-RELATED PARAMETERS       Setup       Pre-Elimination         Station coordinates       NO       Image: Setup         Ambiguities       EVERY SESSION       Image: Setup         Receiver antenna offsets       NO       Image: Setup         Receiver antenna PCV patterns       NO       Image: Setup         ATMOSPHERIC PARAMETERS       Site-specific troposphere parameters       Image: NO         Global ionosphere parameters       NO       Image: Setup	Configure Campaign RINEX Orbits/EOP Processing	Service Convers	ion <u>B</u> PE <u>U</u> ser		<u>H</u> elp
Station coordinates       NO       Image: Constraint of the second secon	GPSEST 5.1: Setup of Parameters and Pre	∍-Elimination	1		
Ambiguities     EVERY SESSION       Receiver antenna offsets     NO       Receiver antenna PCV patterns     NO       ATMOSPHERIC PARAMETERS       Site-specific troposphere parameters       Global ionosphere parameters	STATION-RELATED PARAMETERS	Setup	Pre-Elimin:	ation	
Receiver antenna offsets     NO     Image: State of the state	Station coordinates		NO	¥.	
Receiver antenna PCV patterns     NO       ATMOSPHERIC PARAMETERS       Site-specific troposphere parameters       Global ionosphere parameters	Ambiguities		EVERY SESSION	Z	
ATMOSPHERIC PARAMETERS Site-specific troposphere parameters NO Z Global ionosphere parameters NO Z	Receiver antenna offsets		NO	Z	
Site-specific troposphere parameters NO Z Global ionosphere parameters NO Z	Receiver antenna PCV patterns		NO	Ţ	
Global ionosphere parameters	ATMOSPHERIC PARAMETERS				
	Site-specific troposphere parameters	M	NO	Z	
EPOCH PARAMETERS	Global ionosphere parameters	Г	NO	Z	
	EPOCH PARAMETERS				
Kinematic coordinates	Kinematic coordinates		EVERY_EPOCH	Z	
Receiver clock offsets Y EVERY_EPOCH Z	Receiver clock offsets	<u> </u>	EVERY_EPOCH	Z	
GNSS clock offsets	GNSS clock offsets	Г	EVERY_EPOCH	Z	
Stochastic ionosphere parameters	Stochastic ionosphere parameters	Γ	EVERY_EPOCH	Z	
					кеr^un

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	13. RESULTS (PART 1)										
NUMBER OF H	NUMBER OF PARAMETERS (PART 1):										
PARAMETER 1	ГҮРЕ		#PARAMETERS	#PRE-E	LIMINATED	#SET-UP					
STATION COU AMBIGUITIES SITE-SPECIE		PARAMETERS	24 419 56	419	(BEFORE INV)						
TOTAL NUMBE	ER OF PARAMETERS		499	419		531	  				
NUMBER OF (	DBSERVATIONS (PA	RT 1):									
TYPE	FREQUENCY	FILE	#OBSERVATIONS								
PHASE	L3	ALL	20418								
TOTAL NUMBE	ER OF OBSERVATIO	NS	20418				 				

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) 19932 : CHI\*\*2/DOF • 1.22 STATION COORDINATES: \${K}/INTRO/STA/FLT02143.CRD A PRIORI VALUE NUM STATION NAME PARAMETER NEW VALUE NEW- A PRIORI RMS ERROR 6 BRUS 13101M004 4027893.7773 4027893.7804 0.0031 0.0016 Х 307045.7760 Y 307045.7753 -0.0007 0.0014 Ζ 4919475.0809 4919475.0800 -0.0009 0.0017 HEIGHT 149.6632 149.6644 0.0012 0.0022 . . . LATITUDE 50 47 52.143447 50 47 52.143352 -0.0029 0.0009 . . . LONGITUDE 4 21 33.186467 4 21 33.186417 -0.0010 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 ambiguties, 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 \${K}/INTRO/OBS/????1430.PSH \${K}/INTRO/OBS/BRON1430.PSH \${K}/INTRO/OBS/FFMA1430.PSH \${K}/INTRO/OBS/FFON1430.PSH \${K}/INTRO/OBS/FFZI1430.PSH \${K}/INTRO/OBS/FFZM1430.PSH \${K}/INTRO/OBS/PTZM1430.PSH \${K}/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\$S+0. The following options were used for the ambiguity resolution step:

🚟 Bernese GP5 Software Version 5.0	
Configure <u>Campaign</u> <u>RINEX</u> <u>Orbits/EOP</u> roc	cessing <u>S</u> ervice Con <u>v</u> ersion <u>B</u> PE <u>U</u> ser <u>H</u> elp
PARAMETER ESTIMATION - GPSEST 1.1:	: Input Files 1
GENERAL FILES AND OPTIONS	
Show all general files	P
LEO data processing	
Differencing level	DOUBLE Z
INPUT FILES 1	
Phase observation files	BRON\$S+0 PSH ????\$S+0 PZH
Code observation files	CSH
Station coordinates	FLT\$YD+0 CRD
GNSS standard orbits	IGS\$YD+0 STD
GNSS clock corrections	CLK
Earth rotation parameters	IGS\$YD+0 ERP
Troposphere estimates	FLT\$YD+0 TRP
Ionosphere models	COD\$WD+0 ION
Differential code biases	DCB
Ocean loading corrections	EXAMPLE BLQ
i ^Top ^Prev <b>^Next Canc</b>	ce^l Save^As ^Save ^Run ^Output Rer^ur
User: bern50 Campaign: \${K}/INTRO \$Y+0=2002 \$S+0	0=1430 File: /u/aiub/bern50/GPSUSER/PAN/GPSEST.INP

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.

Bernese	GPS Software	Version 5.0								- 🗆 🗙
Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	BPE	<u>U</u> ser		<u>H</u> elp
GPSEST	2.1: Ou	tput Fi	les 1							
GENERA	L OUTPUT	FILES								
Prog	ram outp	ut	[	use GP	SEST.Ln:	1	or	BRON\$S+0	OUT	
Erro	r messag	e	Г	merged	to prog	gram outpu	t or	ERROR	MSG	
RESULT	FILES 1									
Norm	al equat:	ions		:	NQ0					
Stat	ion coor	dinates			CRD					
Trop	osphere (	estimat	es		TRP					
Trop	osphere :	SINEX			TRO					
Ione	sphere m	odels			ION					
IONE	X				INX					
GNSS	clock c	orrecti	ons		CLK					
Cloc	k RINEX				CLK					
Diff	erential	code b	iases 🗌	:	DCB					
Resi	duals				RES					
    ^Top	^Prev	^	Next	Cance^I	Save^	As S	ave	^Run	^Output	Rer^un
User: bern5	0 Campaign:	\${K}/INTRC	\$Y+0=2002	\$S+0=1430	File: /u/ai	ub/bern50/GPSI	JSER/PAN	I/GPSEST.INP		11

4. Terminal Session: Wednesday

<mark>Bernese GP5 Software Version 5.0</mark> Configure <u>C</u> ampaign <u>R</u> INEX <u>O</u> rbits/EOP <u>P</u> rocessing <u>S</u> ervice Conversion <u>B</u> PE <u>U</u> ser <u>H</u> elp	
GPSEST 3.1: General Options 1	
TITLE EXAMPLE: Baseline BRON\$S+0: QIF ambiguity resolution	
OBSERVATION SELECTION	
Satellite system	
Frequency L1sL2 Elevation cutoff angle 3 degrees LEO:	
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 V LEO: NONE V Type of computed residuals NORMALIZED V	
Correlation strategy BASELINE	
Polarization effect geom. Y only if later than 2003 09 14 total Y only if later than 2006 11 05	
ATop APrev ANext CanceAI SaveAAs ASave ARun /	'Output Rer*un
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 <u>C</u> ampaign <u>B</u> INEX <u>O</u> rbits/EOP <u>P</u> rocessing <u>S</u> ervice Conversion <u>B</u> PE <u>U</u> ser	Leip
GPSEST 3.2: General Options 2	
A PRIORI TROPOSPHERE MODELING	
ZPD model and mapping function DRV_NIELL	
HANDLING OF AMBIGUITIES Resolution strategy QIF	
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 NO Z	
	^Output Rer^un
Bernese GPS Software Version 5.0 Configure <u>Campaign</u> <u>BINEX</u> <u>Orbits/EOP Processing</u> <u>Service</u> Conversion <u>B</u> PE <u>U</u> ser	
	<u>H</u> elp
GPSEST 3.2.3: Quasi-Ionosphere-Free (QIF) Ambiguity Resolution Strategy	
OPTIONS AND CRITERIA FOR TESTING Maximal number of ambiguities fixed per iteration step 10	
Search width for pairs of L1 and L2 ambiguities 0.50 WL cycles	
Maximal sigma of resolvable NL ambiguities         0.03         NL cycles           Maximal fractional part of resolvable NL ambiguities         0.10         NL cycles	
^Top         ^Prev         ^Next         Cance^I         Save^As         ^Save         ^Run           User: bern50         Campaign: \$/K/INTRO         \$Y+0=2002         \$S+0=1430         File: /u/aiub/bern50/GPSUSER/PAN/GPSEST.INP	^Output Rer^un

Bernese G	PS Software V	ersion 5.0								- 🗆 ×
Configure	<u>C</u> ampaign	<u>R</u> INEX		Processing	Service	Con <u>v</u> ersion	BPE	User		Help
GPSEST	4: Datum	Defin	ition for	Station	Coordi	ates				
	II Duotan									
DATIM I	DEFINITIO	N TYPE								
0			solution							
	Coordin	ates c	onstraine	d	WITH	_FLAG	Z			
۲	Coordin	ates f	ixed		FIRS	Т	Y			
A PRIO	RI SIGMAS									
North	n 0	.01	meters							
East		.01	meters							
Un	· · · ·	.01	meters							
Up	In	.01	meters							
	,	,	,					r		
^Тор	^Prev	^	Next	Cance^I	Save^	As ^	Save	^Run	^Output	Rer^un
User: bern50	Campaign: \$	(K)/INTRO	\$Y+0=2002	\$S+0=1430	File: /u/ai	ub/bern50/GP	SUSER/PA	N/GPSEST.INP		11.

🔀 Bernese GPS Softw	are Version 5.	0							_O×
Con <u>f</u> igure <u>C</u> ampai	gn <u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	BPE	<u>U</u> ser		<u>H</u> elp
GPSEST 5.1:	Setup of	Parameter	g and Pro	-Flimin	nation 1				
Gronor J. I.	Secup of	rarameter	5 anu rit	3 61 10011	ation 1				
STATION-RELA	TED PARAM	IETERS		Setup	>	Pr	e-Elimination	ı	
Station co	ordinates	3			N	D		X	
Ambiguiti	s				N	)		Z	
Receiver a	intenna of	fsets			N	D		$\Xi$	
Receiver a	intenna PO	CV pattern	s		N	)		Z	
ATMOSPHERIC	PARAMETER	s							
Site-spec:	fic tropo	osphere pa	rameters		N	)		$\Xi$	
Global ion	osphere p	parameters			N	)		Z	
EPOCH PARAMI				_					
Kinematic	coordinat	es			E	VER ¥_	EPOCH	Z	
Receiver o	lock offs	sets		×	E	VER ¥_	EPOCH	7	
GNSS clock	offsets			 ק	E	ver¶_	EPOCH	$\overline{\mathbf{X}}$	
Stochastic ionosphere parameters					E	VERY_	EPOCH	Z	
^Top   ^F	rev	^Next	Cance^I	Save^	As	^Save	^Run	^Output	Rer^un
User: bern50 Campa	ign: \${K}/INTR	O \$Y+0=2002	\$S+0=1430	File: /u/ai	ub/bern50/GF	SUSER	/PAN/GPSEST.INP		11.

😿 Bernese GPS Software Version 5.0	-OX
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User	<u>H</u> elp
GPSEST 6.7: Stochastic Ionosphere Parameters STOCHASTIC IONOSPHERE PARAMETERS Elimination of reference ionosphere parameters Elevation-dependent parameter constraining Absolute a priori sigma on single difference level 0.25 meters Relative a priori sigma of ionospheric random walk m/min**1/2	
 E[ ^Top	Rer^un (
User: bern50 Campaign: \$(K)/INTRO \$Y+0=2002 \$S+0=1430 File: /u/aiub/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:

NUMBER OF PAF	AMETERS (							
PARAMETER TYF				#PARAMETERS	#PRE-F	ELIMINATED	#SET-UP	• • •
STATION COORD	DINATES			3 120	0		3 138	
AMBIGUITIES STOCHASTIC IC	NOSPHERE	PARAMETERS				(EPOCH-WISE)		•••
TOTAL NUMBER				20701	20578		20719	· 
								• • •
NUMBER OF OBS								
ТҮРЕ	FREQUENCY	FII	LE #	OBSERVATIONS				
PHASE								
	L1	AI		17805				
PHASE	L2	AI	L	17805 17805				
PHASE	L2	AI						· .
PHASE	L2	AI	L	17805				· . · .
PHASE  TOTAL NUMBER  A POSTERIORI	L2 OF OBSERV SIGMA OF	AI VATIONS	LL  (PART 1):	17805				• •
PHASE TOTAL NUMBER POSTERIORI	L2 OF OBSERV SIGMA OF	AI ATIONS UNIT WEIGHT	LL  (PART 1):	17805 		PHASE OBSERVA	BLE AT ZENITH	· . · .
PHASE TOTAL NUMBER POSTERIORI	L2 OF OBSERV SIGMA OF SIGMA OF	AI VATIONS UNIT WEIGHT UNIT WEIGHT	(PART 1):  : 0.0013 M	17805 	-WAY L1	PHASE OBSERVA	BLE AT ZENITH	 I)
PHASE TOTAL NUMBER POSTERIORI POSTERIORI POSTERIORI DEGREE OF FRE	L2 OF OBSERV SIGMA OF SIGMA OF	AI VATIONS UNIT WEIGHT UNIT WEIGHT	L (PART 1):	17805 	-WAY L1	PHASE OBSERVA	BLE AT ZENITH	 I)
PHASE TOTAL NUMBER A POSTERIORI A POSTERIORI DEGREE OF FRE CHI**2/DOF	L2 OF OBSERV SIGMA OF SIGMA OF SEDOM (DOF	AI VATIONS UNIT WEIGHT UNIT WEIGHT	(PART 1): : 0.0013 M : 17682 : 1.58	17805 35610 (SIGMA OF ONE-	-WAY L1	PHASE OBSERVA	BLE AT ZENITH	 
PHASE TOTAL NUMBER A POSTERIORI A POSTERIORI DEGREE OF FRE CHI**2/DOF	L2 OF OBSERV SIGMA OF SIGMA OF SEDOM (DOF	AI VATIONS UNIT WEIGHT UNIT WEIGHT	(PART 1): 	17805 35610 (SIGMA OF ONE-	-WAY L1	PHASE OBSERVA	BLE AT ZENITH	· . · .
PHASE FOTAL NUMBER POSTERIORI POSTERIORI DEGREE OF FRE CHI**2/DOF	L2 OF OBSERV SIGMA OF SIGMA OF EEDOM (DOF	AI ATIONS UNIT WEIGHT UNIT WEIGHT	(PART 1): : 0.0013 M : 17682 : 1.58	17805 35610 (SIGMA OF ONE-				  I)
PHASE TOTAL NUMBER A POSTERIORI A POSTERIORI DEGREE OF FRE CHI**2/DOF STATION COORE	L2 OF OBSERV SIGMA OF SIGMA OF EEDOM (DOF DINATES: 	AI VATIONS UNIT WEIGHT UNIT WEIGHT T) PARAMETER X	(PART 1): : 0.0013 M : 17682 : 1.58 (NOT SA	17805 35610 (SIGMA OF ONE-	JE 1			· I)
PHASE FOTAL NUMBER POSTERIORI A POSTERIORI DEGREE OF FRE CHI**2/DOF STATION COORE	L2 OF OBSERV SIGMA OF SIGMA OF EEDOM (DOF DINATES: 	AI ATIONS UNIT WEIGHT UNIT WEIGHT 7) PARAMETER	(PART 1): : 0.0013 M : 17682 : 1.58 (NOT SA A PRIORI VALUE	17805 35610 (SIGMA OF ONE- .VED) NEW VALU	JE 1 5804 9999	NEW- A PRIORI	RMS ERROR	· . · .
PHASE TOTAL NUMBER A POSTERIORI A POSTERIORI DEGREE OF FRE CHI**2/DOF STATION COORE	L2 OF OBSERV SIGMA OF SIGMA OF EEDOM (DOF DINATES: NAME	AI VATIONS UNIT WEIGHT UNIT WEIGHT T) PARAMETER X Y	L (PART 1):  : 0.0013 M : 17682 : 1.58 (NOT SA A PRIORI VALUE 3370658.5802 711877.1002	17805 35610 (SIGMA OF ONE- VED) NEW VALU 3370658.E 711877.C 5349786.S 45.E	JE 1  5804 0999 0195 5664	NEW- A PRIORI 0.0002 -0.0003	RMS ERROR 0.0003 0.0005	· . • .

AMBIG	UITIES	3: -										
AMBI	FILE	SAT.	EPOCH	FRQ	WLF	CLU		RENCE CLU	AMBIGUITY	RMS	TOTAL AMBIGU.	DL/L
												·····
1	1	18	1	1	1	1	121	25	-1.69	0.72	3181808.31	
2	1	18	803	1	1	2	121	25	0.56	0.27	5312278.56	
3	1	18	1140	1	1	3	122	47	9.10	0.37	21539287.10	
4	1	18	2541	1	1	4	122	47	8.43	0.29	7052711.43	
121	1	30	1	1	1	25			REFERENCE		4265891.	
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 -2 -1 0.66 0.85 -0.189 -0.005 0.004 

 1
 26
 29
 1
 121
 25
 1
 1
 2
 0.08
 0.10
 -0.020
 0.010
 0.004

 1
 33
 38
 1
 122
 47
 1
 6
 9
 0.74
 0.96
 -0.219
 -0.035
 0.004

 1
 6
 6
 1
 18
 1
 3
 5
 0.11
 0.15
 -0.034
 -0.006
 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 54 62 1 122 47 1 -1 -3 1.09 1.39 -0.305 0.009 0.004 10 12 -0.14 -0.18 0.037 -0.007 0.005 1 25 28 1 122 47 2 33 44 0.11 0.14 -0.029 0.012 0.005 59 67 1 60 69 1 -11 -13 0.15 0.19 -0.043 0.000 0.005 1 45 53 1 -3 -0.24 -0.32 1 36 41 1 0 0.071 0.004 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:

								RENCE				
AMBI	FILE	SAT.	EPOCH	FRQ	WLF	CLU	AMBI	CLU	AMBIGUITY	RMS	TOTAL AMBIGU.	DL/L
												····
								~-				
1	1	18	1				121	25		0.74		0.0000
2	1	18	803		1		121	25	2		5312280.	0.00000
3	1	18	1140	1	1		122	47	11		21539289.	
4	1	18	2541	1	1	4		47	8		7052711.	
5	1	26	1	1	1	5	121	25	-2		2789513.	0.00000
6	1	26	2316	1	1	6	18	18	3		7998338.	0.00000
7	1	9	1	1	1	7	121	25	-2		513984.	0.00000
8	1	9	2580	1	1	8	122	47	8		5465798.	0.00000
9	1	5	1	1	1	9	121	25	-2		3645130.	0.00000
10	1	5	2774	1	1	10	122	47	8		11304208.	0.00000
11	1	21	1	1	1	11	121	25	-1		630972.	0.00000
12	1	21	875	1	1	12	121	25	-4		2162193.	0.00000
13	1	21	1140	1	1	13	52	60	0		24351826.	0.00000
14	1	21	2712	1	1	14	47	55	3		6301871.	0.00000
15	1	29	1	1	1	15	121	25	-2		2714435.	0.00000
16	1	29	1191	1	1	16	122	47	17.34	2.16	6067500.34	
17	1	29	1213	1	1	17	122	47	12.88	2.18	6067503.88	
18	1	29	2412	1	1	18	50	58	8		7875520.	0.00000
19	1	7	1	1	1	19	121	25	-1		-2727952.	0.00000
20	1	7	1434	1	1	20	122	47	12.15	0.18	-2701064.85	
20	1	7	2657	1	1	21	122	47	5	0.10	2332618.	0.00000
21	1	14	10	1	1	23	122	25	-8		-1371335.	0.00000
22	1	14	1231	1	1		121	25 47	-8 14		8192805.	0.00000
23 24	1	4	1231	1	1	24		25	14		-2682162.	
		-			1							
25	1	4	1650	1	1	28	122	47	33		-4511289.	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 PARAMETER							
PARAMETER TYPE			#PARAMETERS	#PRE-E	LIMINATED	#SET-UP	
STATION COORDINATES			3	0		3	
AMBIGUITIES STOCHASTIC IONOSPHE	RE PARAMETERS		24 20578	0 20578	(EPOCH-WISE)	138 20578	· · · · · · ·
TOTAL NUMBER OF PAR	AMETERS		20605	20578		20719	 
NUMBER OF OBSERVATI	DNS (PART 2):						
TYPE FREQUE	NCY FII	.E #0	BSERVATIONS				_
PHASE L1 PHASE L2	IA IA		17805 17805				
TOTAL NUMBER OF OBS	ERVATIONS		35610				
A POSTERIORI SIGMA	OF UNIT WEIGHT						
A POSTERIORI SIGMA			SIGMA OF ONE-	-WAY L1	PHASE OBSERVA	BLE AT ZENIT	TH)
DEGREE OF FREEDOM () CHI**2/DOF	DOF)	: 17778 : 1.76					
STATION COORDINATES		(NOT SAV	ED)				
NUM STATION NAME	PARAMETER	A PRIORI VALUE	NEW VALU	JE N	EW- A PRIORI	RMS ERROR	
42 ONSA 10402M004	X Y Z	3370658.5802 711877.1002 5349786.9190	3370658.5 711877.0 5349786.9	0976	-0.0022 -0.0026 -0.0013	0.0002 0.0001 0.0003	
	HEIGHT LATITUDE LONGITUDE	45.5659 57 23 43.074626 11 55 31.859790	45.8 57 23 43.0 11 55 31.8		-0.0025 0.0015 -0.0020	0.0003 0.0002 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).

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):

Bernese GP	5 Software Ver	sion 5.0							-OX
Configure <u>(</u>	<u>C</u> ampaign <u>R</u>	INEX <u>O</u> rbit	s/EOP <u>P</u> rocessing	Service (	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
VARIABLI	ES AVAILAI	BLE IN TH	E MENU FOR IN	TERACTIVE	E AND AUT	'OMATIC	PROCESSING	¥ 1	
PREDEFII	NED VARIA	BLES							
(trans	slated in	the menu)							
Variał	ble Cun	rrent valu	le Descrip	tion					
\$¥		02	Two dig	it year o	of the cu	irrent	session		
\$M		05	Month o	f the cur	rrent ses	sion			
\$D		23	Day of	month of	the curr	ent se	ession		
\$J			Job ID						
	FINED VAR: slated in	IABLES the menu)					ENT VARIABLE		
Variał	ole	Valu	1e			main p	orogram)		
\$ BSI	LIN	FFM	\\$S+O	<b>=</b> +		ĸ	<b>=±</b>		
						U	<b>-+</b>		
						T	-+		
						Х	-+-		
						P	-+		
						USER	<b>-+</b>		
∭ ^Тор	^Prev	^Next	Cance^I	Save^A:	s [ ^S	Save	^Run	^Output	Rer^un
User: bern50	Campaign: \${K	3/INTRO \$Y+	0=2002 \$S+0=1430	File: /u/aiub	/bern50/GPS	USER/PA	N/MENU_VAR.IN	P	1

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 Proce	ssing <u>S</u> ervice Con <u>v</u> ersion <u>B</u> PE	<u>U</u> ser <u>H</u> elp
PARAMETER ESTIMATION - GPSEST 1.1:	Input Files 1	
GENERAL FILES AND OPTIONS		
Show all general files	<b>×</b>	
LEO data processing		
Differencing level	DOUBLE Z	
INPUT FILES 1 Phase observation files	\$(BSLIN) <b>PSH</b> ????\$8	+0 P2H
Code observation files	CSH	CZH
Station coordinates GNSS standard orbits	FLT\$YD+0 CRD IGS\$YD+0 STD	
GNSS clock corrections	CLK	
Earth rotation parameters	IGS\$YD+0 ERP	
Troposphere estimates	FLT\$YD+0 TRP	
Ionosphere models	COD\$WD+0 ION	
Differential code biases	DCB	
Ocean loading corrections	EXAMPLE BLQ	
II ^Top ^Prev ^Next Canc		Run ^Output Rer^un
User: bern50 Campaign: \${K}/INTRO \$Y+0=2002 \$S+0	=1430 File: /u/aiub/bern50/GPSUSER/	PAN/GPSEST.INP

Bernese GP5 Software Version 5.0 Configure <u>Campaign</u> <u>RINEX</u> <u>Orbits/E</u>	OP <u>P</u> rocessing <u>S</u> ervic	e Con <u>v</u> ersion <u>F</u>	IPE <u>U</u> ser		<u>_   ×</u> Help
GPSEST 2.1: Output Files 1					
GENERAL OUTPUT FILES					
Program output	use GPSEST.	Lnn	or \$(B	SLIN) OUT	
Error message	merged to p	rogram output	or ERR	OR MSG	
RESULT FILES 1					
Normal equations	NQO				
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		ve^As ^Sav			Rer^un
Jser: bern50 Campaign: \${K}/INTRO \$Y+0=2	:002 \$S+0=1430 File: /u	J/aiub/bern50/GPSUS	ER/PAN/GPSE	ST.INP	
Bernese GPS Software Version 5.0					_ 🗆 ×
Con <u>fig</u> ure <u>C</u> ampaign <u>R</u> INEX <u>O</u> rbits/EO	P Processing Service	Con <u>v</u> ersion <u>B</u> PE	<u>U</u> ser	<u>H</u> elp	
GPSEST 3.1: General Options 1					
GESEST 5.1: GENERAL OPTIONS I					
TITLE EXAMPLE: Baseline \$(BSL	IN) . OIF embiguitt	, regulation			
TILL JEAANPLE: Deseline ((DSL	in): Or ambiguity	resolution			
OBSERVATION SELECTION					
Satellite system	GPS 💌				
	L16L2 V				
Frequency		LEO:			
Elevation cutoff angle		PFO: 10	aegrees		
Sampling interval	30 seconds				
Tolerance for simultaneity	100 millisecon	.ds			
Special data selection	NO 💌				
Observation window					
OBSERVATION MODELING AND PARAME	TER ESTIMATION				
A priori sigma	0.001 meters				
Elevation-dependent weighting		LEO: NO	NE 🔻		
Type of computed residuals	NORMALIZED V		_		
Correlation strategy	BASELINE VI				
Correlation strategy Polarization effect, geom.	BASELINE	r than 2002 C	19 14		
Polarization effect geom.	only if late	-			
		-			
Polarization effect geom.	only if late	-	11 05 💌	n ^Output	Rerhun

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 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 Bernese.

#### 4. Terminal Session: Wednesday

For each observation file a corresponding program output file is generated. Using the program  $\mathsf{GPSXTR}$  you may generate a summary of the ambiguity resolution for all baselines of the session:

OUTPUT EXTRACTION OF GPSEST AND ADDNEQ2 - GPSXTR 1: Extractions         GENERAL FILES         Show all general files         INPUT FILENAMES         INPUT FILENAMES         Import FILES         Configure Campaign: BINEX OrbitwEOP Processing Service Conversion BPE User         GPSKTR 2: Output Files         OUTPUT FILES         OUTPUT FILES         OUTPUT FILES         OUTPUT FILES         OUTPUT FILES         OUT (blank, if not to be created)         Ambiguity fractionals         SUM       (blank, if not to be created)         Ambiguity fractionals       SUM         SUM       (blank, if not to be created)         Ambiguity fractionals       SUM         SUM       (blank, if not to be created)         Ambiguity fractionals	🔀 Bernese GPS Software Version 5.0							_ 🗆 ×
GENERAL FILES Show all general files TIPUT FILENAMES  TOPUT FILENAMES  TOPUT FILENAMES  TOPUT FILENAMES  TOPUT PROV TNext Cancel SaverAs TSave TRUE COUPUT)  TOPUT PROV TNext Cancel SaverAs TSave TRUE COUPUT Recur User.bem50 Campaign: %(K/MTRO \$V+0-202 \$S+0-1430 File: Au/alub/bem50/GPSUSER/PAN/GPSXTRINP  TOPUT FILES  OUTPUT	Con <u>figure C</u> ampaign <u>R</u> INEX <u>O</u> rbit	s/EOP <u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	BPE	<u>U</u> ser		<u>H</u> elp
GENERAL FILES Show all general files TIPUT FILENAMES  TOPUT FILENAMES  TOPUT FILENAMES  TOPUT FILENAMES  TOPUT PROV TNext Cancel SaverAs TSave TRUE COUPUT)  TOPUT PROV TNext Cancel SaverAs TSave TRUE COUPUT Recur User.bem50 Campaign: %(K/MTRO \$V+0-202 \$S+0-1430 File: Au/alub/bem50/GPSUSER/PAN/GPSXTRINP  TOPUT FILES  OUTPUT	OUTPUT EXTRACTION OF GPSES	ST AND ADDNEC	)2 - GPS	XTR 1: E	ctracti	ons		
Show all general files   INPUT FILENAMES  Prove Prev Next Canceri SaverAs ^Save PRun routput Renur User.bernS0 Campaign %(%)NTR0 %Y+0-2002 %S+0-1430 File: /u/siut/hernS0/GPSUSER/PAN/GPSXTR.NP  Prev Next Canceri SaverAs ^Save PRun routput Renur User.bernS0 Campaign %(%)NTR0 %Y+0-2002 %S+0-1430 File: /u/siut/hernS0/GPSUSER/PAN/GPSXTR.NP  Prev Prev Prev Prev Canceri SaverAs ^Save PRun routput Renur User.bernS0 Campaign %(%)NTR0 %Y+0-2002 %S+0-1430 File: /u/siut/hernS0/GPSUSER/PAN/GPSXTR.NP  Prev Prev Prev Prev Prev Processing Service Conversion BPE User Prev Prev Prev Processing Service Conversion BPE User Prev Prev Prev Processing Service Conversion BPE User Prev Prev Prev Prev SUM (blank, if not to be created) Coordinate summary SUM (blank, if not to be created) Coordinate summary SUM (blank, if not to be created) Ambiguity res. summary SUM (blank, if not to be created) Ambiguity fractionals SUM (blank, if not to be created) Ambiguity fractionals SUM (blank, if not to be created) Compaign summary SUM Compaign su			,					
INPUT FILENAMES	GENERAL FILES							
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	3: Option									
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User: bern50	) Campaign: \${	K}/INTRO	\$Y+0=2002	\$S+0=1430	File: /u/ai	ub/bern50/GPS	SUSER/P	AN/GPSXTR.INP		11.

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

File	Length (km)	#Amb	RMSO (mm)	Max/RMS L5 Amb (L5 Cycles)	Max/RMS L3 Amb (L3 Cycles)	#Amb	RMSO (mm)	#Amb Res (%)
BRON1430	883.8	110	1.2	0.498 0.144	0.096 0.025	16	1.3	85.5
FFMA1430	1220.4	116	1.4	0.487 0.158	0.098 0.028	28	1.5	75.9
FFON1430	840.1	116	1.3	0.474 0.165	0.094 0.025	20	1.4	82.8
FFZI1430	368.1	62	1.2	0.368 0.135	0.089 0.022	10	1.3	83.9
FFZM1430	368.1	116	1.1	0.389 0.122	0.072 0.019	18	1.2	84.5
PTZM1430	640.1	96	1.3	0.489 0.154	0.085 0.021	14	1.4	85.4
VIZM1430	1162.3	96	1.3	0.497 0.166	0.085 0.023	18	1.3	81.2
Tot: 7	783.3	712	1.3	0.498 0.150	0.098 0.023	124	1.3	82.6

This table is a part of the solution reference file  $(\{K\}/INTRO/OUT/R2S02143.PRC\_REF)$ , 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.

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

### 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: BRON143.OUT, FFMA143.OUT, etc. for all baselines,
- (6) used GPSXTR to create a summary of the ambiguity resolution, created file: QIF02143.SUM

ideally, files for all sessions should be screened (generation of FLTyyddd files).

# 5. Terminal Session: Thursday

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

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

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

### 5.1 Final Network Solution

After the loop over all baselines is completed and the ambiguities are resolved you will use the program  $\mathsf{GPSEST}$  in session mode. In panel " $\mathsf{GPSEST}$  1.1: Input Files 1" you may now select all single difference files of the corresponding session:

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PARAME	TER ESTI	MATION	- GPSEST	1.1: Inp	ut File	s 1				
GENERA	L FILES .	AND OPT	IONS							
Show	all gen	eral fi	les	<b>Y</b>						
LEO	data pro	cessing								
Diff	erencing	level		DOU	BLE					
INPUT	FILES 1									
Phas	e observ	ation f	iles	???	?\$S+O	PSH	????\$S+O	PZH		
Code	observa	tion fi	les			CSH		CZH		
Stat	ion coor	dinates		APR	\$YD+0	CRD				
GNSS	standar	d orbit:	s	IGS	\$YD+0	STD				
GNSS	clock c	orrecti	ons			CLK				
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ser: bern5	0 Campaign:	\${K}/INTRO	\$Y+0=2002	\$S+0=1430	File: /u/a	iub/bern50/G	PSUSER/PAN	I/GPSEST.IN	P	

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

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GPSEST 2.1: Output Files 1							
GENERAL OUTPUT FILES							
Program output	use GI	SEST.Lnn		or	FIX\$YD+0	OUT	
Error message	mergeo	l to prog	ram outpu	t or	ERROR	MSG	
RESULT FILES 1							
Normal equations	FIX\$YD+0	NQO					
Station coordinates		CRD					
Troposphere estimates		TRP					
Troposphere SINEX		TRO					
Ionosphere models		ION					
IONEX		INX					
GNSS clock corrections		CLK					
Clock RINEX		CLK					
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For the final run of GPSEST we consider the correlations between the observations correctly:

Bernese	GPS Software	Version 5	5.0								
Con <u>fig</u> ure	<u>C</u> ampaign	<u>R</u> INEX	<u>O</u> rbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser	<u>H</u> elp		
GPSEST TITLE	3.1: Gene	_	tions 1 on \$YSS+0:	Final net	work so	lution (f:	ixed)				
OBSERV	ATION SELE	CTION									
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Freq	uency			L3	•						
Elev	ation cuto	off angl	le	3 deg	rees	LEO:	0	degrees			
Samp	ling inter	val		180 sec	onds						
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Spec	ial data s	selectio	on	NO	•						
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Type	of comput	ed resi	iduals	NORMALIZI	ED 🔻						
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			total	only	if late	rthan 🛛	2006 11	05 🔽			
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User: bern	50 Campaigr	n: \${K}/INT	TRO \$Y+0=2	002 \$S+O=1	430 File:	/u/aiub/bern5	50/GPSUS	ER/PAN/GF	SEST.INP		1

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

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Configure <u>Campaign</u> <u>BINEX</u> <u>Orbits/EOP</u> <u>Processing</u> <u>Service</u> Conversion <u>BPE</u> <u>User</u>	<u>H</u> elp
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	
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SPECIAL PROCESSING OPTIONS	
Maximum tolerated O-C term meters	
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User: bern50 Campaign: \${K}/INTRO \$Y+0=2002 \$S+0=1430 File: /u/aiub/bern50/GPSUSER/PAN/GPSEST.INF	P //.

#### 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.

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Configure Campaign BINEX Orbits/EOP Processing Service Conversion BPE User	<u>H</u> elp
GPSEST 3.3: Extended Printing Options	
INFORMATION RELATED TO OBSERVATIONS	
List of observations given in files	
List of observations used for processing	
Satellite elevations	
Satellite elevations of proceeding Histogram of observations by elevation angle bins Histogram of observations by nadir angle bins	
Histogram of observations by nadir angle bins	
INFORMATION RELATED TO ESTIMATED PARAMETERS	
List of all parameters	
Helmert transformation of resulting station coordinates	
Unresolved ambiguities after each iteration step	
Suppression of output concerning epoch parameters	
OTHER INFORMATION	
Resolved ambiguities from observation files	
Constants, antenna offsets, ionosphere coefficients	
Station eccentricities, receiver information	
Receiver synchronization errors	
    ^Top	Rer^un
User: bern50 Campaign: \$(K)/INTRO \$Y+0=2002 \$S+0=1430 File: /u/aiub/bern50/GPSUSER/PAN/GPSEST.INP	

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):

🔀 Bernese (	GPS Software	Version 5.0								_ 🗆 ×
Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
GPSEST	4: Datu	m Defin	ition for	Station	Coordi	nates				
DATUM	DEFINITI	ON TYPE								
) o	Free n	etwork	solution							
۲	Coordi	nates c	onstraine	d	WITH	_FLAG	X			
0	Coordi	nates f	ixed		MANU	AL	Z			
A PRIO Nort East Up	[	s D.01 D.01 D.01	meters meters meters							
    ^Тор	^Prev	^	Next	Cance^I	Save^	As	`Save	^Run	^Output	Rer^un
User: bern5	) Campaign:	\${K}/INTRO	) \$Y+0=2002	\$S+0=1430	File: /u/ai	ub/bern50/GF	SUSER/PA	N/GPSEST.INP		11.

The unresolved ambiguities are pre–eliminated:

🕱 Bernese	GPS Software	Version 5.0									_O×
Configure	<u>C</u> ampaign	<u>R</u> INEX	<u>O</u> rbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ers	ion <u>B</u> PB	E	<u>U</u> ser		<u>H</u> elp
	_			_							
GPSEST	5.1: Set	cup of	Parameter	s and Pr	e-El 1111 1	nat ion	1				
STATIC	N-RELATEI	) PARAM	ETERS		Setuj	<u>p</u>	Pr	e-Eli	minatio.	n	
Stat	ion coord	linates					NO			V	
Ambi	guities						AS SOO	N AS	POSSIBL	ΕZ	
Rece	iver ante	enna of	fsets				NO			Σ	
Rece	iver ant	enna PC	V pattern	IS			NO			Σ	
ATMOSE	HERIC PAR	RAMETER	S								
Site	-specifi	e tropo	sphere pa	rameters	7		NO			Z	
Glob	al ionosp	ohere p	arameters		Г		NO			Z	
EPOCH	PARAMETER	۲S									
Kine	matic coo	ordinat	es				EVERI	EPOCH	H	Z	
Rece	iver clo	ck offs	ets		Y		EVERY_	EPOCH	Н	Z	
GNSS	clock of	fsets			Г		EVER Y_	EPOCH	H	Z	
Stoc	hastic id	onosphe	re parame	eters	Г		EVERY_	EPOCH	H	Z	
∥_^Тор	^Prev		Next	Cance^I	Save^	As	^Save	[	^Run	^Output	Rer^un
User: bern5	0 Campaign:	\${K}/INTRO	\$Y+0=2002	\$S+0=1430	File: /u/ai	ub/bern50	/GPSUSEF	R/PAN/0	GPSEST.INP		1.

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								_O×
Con <u>f</u> igure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE <u>U</u> ser			<u>H</u> elp
GPSEST	6.3.1:	Site-Sp	ecific Tr	opospher	e Param	eters 1				
ZENITH	PATH DE	LAY PAR	AMETERS							
Mapp	ing func	tion		WET_	NIELL	X				
Para	meter sp	acing		01 0	0 00 (	hh mm ss)				
Grad	NTAL GRA ient est meter sp	imation	ARAMETERS model	TILT		∑ hh mm ss)				
	RI SIGMA			Abso	lute		Relative			
Zeni	th path	delay			m	eters		meters		
Hori	zontal g	radient	s		m	eters		meters		
EXTRAC			ERS FOR T (hhh mm s				01 00 00	(hh mm	ss)	
i ^Top	^Prev		Next	Cance^I	Save <sup>2</sup>			un	^Output	Rer^un
User: bern5	0 Campaign:	\${K}/INTRO	\$Y+0=2002	\$S+0=1430	File: /u/a	iub/bern50/GPS	USER/PAN/GPSE	ST.INP		11

The output of a 1-session run of program  $\mathsf{GPSEST}$  should look like this:

 13. RESULTS	S (PART 1)							
NUMBER OF 1	PARAMETERS (PART	1):						
PARAMETER	ГҮРЕ			#PARAMETERS	#PRE-E	LIMINATED	#SET-UP	
STATION COU AMBIGUITIES SITE-SPECIN		PARAMETERS		24 120 232		(BEFORE INV)	24 152 232	· · · · · · · · · · · · · · · · · · ·
	ER OF PARAMETERS			376	120		408	· 
	DESERVATIONS (PAR			#OBSERVATIONS				·
PHASE	L3	ALL		20418				
TOTAL NUMBI	ER OF OBSERVATION			20418				·
	RI SIGMA OF UNIT		1):					
	RI SIGMA OF UNIT	:		(SIGMA OF ONE	-WAY L1	PHASE OBSERVABL	E AT ZENIT	TH)

After four runs of  ${\sf GPSEST}$  in session mode the following normal equation files should be available in the directory  ${\rm K}/{\rm INTRO}/{\rm SOL}$ 

FIX02143.NQ0, FIX02144.NQ0, and FIX03138.NQ0, FIX03139.NQ0.

## 5.2 Check the Coordinates of the Fiducial Sites

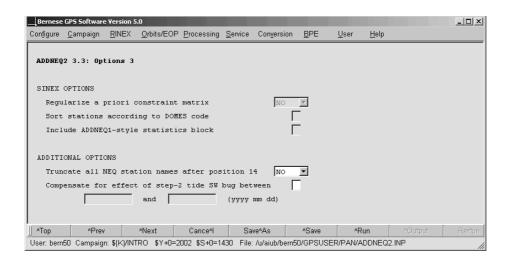
To check the consistency of our data with the coordinates of the IGS core sites we generate a minimum constraint solution for the network using program ADDNEQ2 ("Menu>Processing >Normal equation stacking") with the following options:

Bernese	GPS Software	e Version 5	5.0								- 🗆 ×
Configure	<u>C</u> ampaign	<u>R</u> INEX	<u>O</u> rbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser	<u>H</u> elp		
COMBIN	ATION OF I	IORMAL I	EQUATION SY	ISTEMS – A	DDNEQ2	1: Input F	iles				
GENERA	L FILES										
Show	all gener	cal file	25	M							
INPUT	FILENAMES										
Norm	al equatio	ons		FIX\$YD+O	NQO						
Vari	ance resca	aling fa	actors		WGT						
Stat	ion coord:	inates		IGS_00	CRD						
Stat	ion veloc:	ities		IGS_00	VEL						
Stat	ion inform	mation		EXAMPLE	STA						
Trop	osphere es	stimates	з		TRP						
Iono	sphere mas	ster fi	le		ION						
Diff	erential (	code bia	ases		DCB						
Eart	h rotation	n parame	eters		ERP						
Geoc	enter coo	dinate:	3		GCC						
 ∥ ^⊤ор	^Prev	[	^Next	Cance <sup>4</sup>	Sav	/e^As	^Save	^Ru	Jn (	^Output	Rer^un
User: bern	50 Campaig	n: \${K}/INT	TRO \$Y+0=2	002 \$S+O=1	430 File:	/u/aiub/bern5	0/GPSUSE	R/PAN/A	DDNEQ2	.INP	1

🕱 Bernese GPS Software Version 5.0								_ 🗆 ×
Con <u>f</u> igure <u>C</u> ampaign <u>R</u> INEX <u>O</u>	rbits/EOP <u>P</u> roc	essing <u>s</u>	<u>S</u> ervice C	on <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
ADDNEQ2 2: Output Files								
GENERAL OUTPUT FILES								
Program output	use A	.DDNEQ2	2.Lnn		or	FIN\$YD+0	OUT	
Error messages	merge	d to p	program d	output	or	ERROR	MSG	
RESULT FILES								
Normal equations	FIN\$YD+0	NQO	Orbital	elemen	ts		ELE	
SINEX		SNX	Bernese	e ERP fi	le		ERP	
Station coordinates	FIN\$YD+0	CRD	IERS EF	RP file			IEP	
Station velocities		VEL	Geocent	er coor	dinates		GCC	
Troposphere estimates	FIN\$YD+0	TRP	Var-cov	var wrt	coord.		COV	
Troposphere SINEX		TRO	Full va	ar-covar	matrix		COV	
Ionosphere models		ION	Statior	n residu	als		PLT	
IONEX		INX	Weekly	summary	file		SUM	
Code biases		DCB						
^Top ^Prev ^Nex	t Canc	e^l	Save^As	^ ^S	ave	^Run	^Output	Rer^un
User: bern50 Campaign: \${K}/INTRO \$	Y+O=2002 \$S+0	)=1430 F	File: /u/aiub/l	oern50/GPSI	JSER/PAN/	ADDNEQ2.INP		1.

ADDNEQ2 3.1: Options 1 TITLE EXAMPLE: Session \$YSS+0: Final coordinate/troposphere results GENERAL OPTIONS Maximum number of parameters in combined NEQ 1000 * A priori sigma of unit weight 0.0010 meters Compute and compare individual solutions NO / Reference epoch for station coordinates (yyyyy mm dd) PARAMETER-RELATED OPTIONS Parameter pre-elimination ( Change parameter spacing Set up station velocities Set up geocenter coordinates (	🔀 Bernese G	PS Software V	ersion 5.0								_ 🗆 🗵
TITLE EXAMPLE: Session \$YSS+0: Final coordinate/troposphere results  GENERAL OPTIONS Maximum number of parameters in combined NEQ A priori sigma of unit weigh Compute and compare individual solutions Reference epoch for station coordinates  PARAMETER-RELATED OPTIONS Parameter pre-elimination Change parameter spacing Set up station velocities Set up geocenter coordinates	Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
GENERAL OPTIONS Maximum number of parameters in combined NEQ A priori sigma of unit weight Compute and compare individual solutions Reference epoch for station coordinates  PARAMETER-RELATED OPTIONS Parameter pre-elimination Change parameter spacing Set up station velocities Set up geocenter coordinates	ADDNEQ:	2 3.1: Op	tions :	L							
Maximum number of parameters in combined NEQ       1000 €         A priori sigma of unit weight       0.0010 meters         Compute and compare individual solutions       NO ✓         Reference epoch for station coordinates       (yyyy mm dd)         PARAMETER-RELATED OPTIONS       Parameter pre-elimination         Change parameter spacing       Set up station velocities         Set up geocenter coordinates       Image: Set up geocenter coordinates	TITLE	EXAMPLE	: Sess:	ion \$YSS+	0: Final	coordir	ate/tropo	sphere	e results		
Parameter pre-elimination Change parameter spacing Set up station velocities Set up geocenter coordinates	Maxin A pr Comp	num numbe iori sigm ute and c	a of ur ompare	nit weigh individu	t al solut	ions	0.001			dd)	
Change parameter spacing	PARAME	TER-RELAT	ED OPT:	IONS							
Set up station velocities	Para	meter pre	-elimir	nation							
Set up geocenter coordinates	Chang	ge parame	ter spa	acing							
	Set 1	up statio	n veloo	cities							
Top Prev ONext Cancent SavenAs Save Run Output Recture	Set	up geocen	ter coo	ordinates							
User: bern50 Campaign: \${{}/INTRO \$Y+0=2002 \$\$+0=1430 File: /u/aiub/bern50/GPSUSER/PAN/ADDNEQ2.INP	^Top					00.10				^Output	Rer^un

🔀 Bernese I	GPS Software \	ersion 5.0								-D×
Configure	<u>C</u> ampaign	<u>B</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
ADDMEC	2 3.2: Op	tiong	<b>n</b>							
ADDREY	2 J.2. Op	it folis	2							
DISPLA	Y OPTIONS	REGAR	DING							
Atmo	spheric p	aramet	ers				<u> </u>			
Orbi	tal param	leters				Г				
Eart	h orienta	tion p	arameters			Γ				
Addi	tional pa	ramete	rs			Γ	_			
OUTPUI	OPTIONS									
Prov	ide exter	ided ou	tput wrt	estimate	d parame	ters 🖡	-			
Noti	fy static	n inco	nsistenci	es betwe	en NEQs	Γ				
Noti	fy change	s due	to static	n inform	ation fi	le 🖡	·			
Prin	t detaile	d list	of all p	arameter	manipul	ations 🛛	_			
Top	^Prev		Next	Cance^I	Save^/	۹s ( ^s	Save	^Run	^Output	Rer^un
User: bern5	) Campaign: 8	K)/INTRO	\$Y+0=2002	\$S+0=1430	File: /u/aiu	b/bern50/GPS	USER/P	AN/ADDNEQ2.IN	P	



🛒 Bernese G	PS Software V	ersion 5.0/								-OX
Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
ADDNEQ2	? 5: Datu	m Defin	ition fo	r Statio	n Coord	inates				
DATUM I	DEFINITIC	N TYPE								
0	Free ne	etwork s	olution							
۲	Minimum	1 constr	aint sol	ution		FROM_F	ILE	Y		
0	Coordin	nates co	nstraine	d		MANUAL		Y		
0	Coordin	nates fi	xed			MANUAI		<u> </u>		
Trans Rotat Scale	e RI SIGMAS	YES NO NO	DITIONS							
Up		0.001								
		,								
^Top	^Prev		Jext [	Cance^I \$S+0=1430	Save^		^Save	^Run AN/ADDNEQ2.I	Output	Rer^un

👿 Bernese G	PS Software Ve	ersion 5.0								
Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
STATION Manua List	? 5.1: Dat NS CONSIDI al select: of static lons with	ERED Fo ion ons fro	OR MINIMU om file	IM CONSTR.	AINT CON		FIX			
^Top	^Prev	^	Next	Cance^I	Save^A	s [ ^	Save	^Run	^Output	Rer^un
User: bern50	Campaign: \${	KJ/INTRC	\$Y+0=2002	\$S+0=1430	File: /u/aiul	b/bern50/GP	SUSER/PA	N/ADDNEQ2.INF	•	11

🔀 Bernese GPS Software Versio	n 5.0							_ 🗆 ×
Configure <u>C</u> ampaign <u>R</u> INE	EX <u>O</u> rbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	BPE	<u>U</u> ser		<u>H</u> elp
ADDNEQ2 9: Options	for Atmosph	eric Par	ameters					
A PRIORI SIGMAS		absolu	te		rel	ative		
Troposphere zeni	th delays		me	ters	1.0		meters	
Troposphere grad	ients		me	ters			meters	
Global ionospher	e parameters		TE	CU			TECU	
MAXIMUM TIME INTER Troposphere zeni Troposphere grad Global ionosphere EXTRACTION OF PARA	th delays ients e parameters	3600	se se se	c c c	CONSTRA	INING		
Offset 00 30 0				solution	04 00	00 (1	hh mm ss)	
orrset  00 30 0		1 557	rime re	Solucion	lor oo	1) 00		
^Top     ^Prev	^Next	Cance^I	Saver		Save	^Run	Output	: Rer^un
User: bern50 Campaign: \${K}/IN	VIRO \$Y+0=2002	\$5+0=1430	File: /u/al	ub/bern50/GP	SUSER/PAI	WADDNEQ	Z.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:

Number of parameters:				
Parameter type	•		/ implicitly	(pre-eliminated)
Station coordinates / velocities		24		
Site-specific troposphere parameters	223			
Previously pre-eliminated parameters			109	
Total number	356	247	109	
Statistics:				
Total number of explicit parameters Total number of implicit parameters	247 109			
Total number of adjusted parameters	356			
Total number of observations	20418			
Degree of freedom (DOF)	20062			
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:

Sol				Estimated value		•		
1		X		4027893.7914		4027893.7773		•••
1	BRUS 13101M004	Y	0.0051	307045.7812	0.0004	307045.7761	meters	
1	BRUS 13101M004	Z	0.0059	4919475.0868	0.0013	4919475.0809	meters	
1	FFMJ 14279M001	Х	0.0141	4053455.9147	0.0009	4053455.9006	meters	
			0.0111					• • •
Site	 -specific tropos	sphere pai	rameters:					
Site	-specific tropos	sphere pai	rameters:	Estimated value				
Site	-specific tropos	sphere par Typ	cameters:  Correction		RMS error	A priori value		
Site	-specific tropos  ion name 	sphere par Typ N	cameters:  Correction	Estimated value 	RMS error 0.0001	A priori value 	Unit	

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

🔀 Bernese GPS Software Version 5.0						_ 🗆 🗵
Configure Campaign RINEX Orbits/EOP	Processing Service	Con <u>v</u> ersion	<u>B</u> PE <u>U</u>	ser		<u>H</u> elp
HELMERT TRANSFORMATION - HELME	1 1: Input/Out	put Files				
GENERAL FILES						
Show all general files						
INPUT FILES						
First coordinate file	IGS_00 CRI	d				
Velocities for first file	IGS_00 VEI	(blank:	no veloc.	applied)		
Second coordinate file	FIN\$YD+0 CRI					
File with list of stations	IGS_00 FIX	other st	ations	MARK	Y	
RESULT FILES Coordinates File with list of stations	CRD FIX					
GENERAL OUTPUT FILES						
Program output	🔽 use HELMR	1.Lnn	or	HELMR1	OUT	
Error messages	merged to	program ou	itput or	ERROR	MSG	
Top ^Prev <b>^Next</b>	Cance^I Sav	enAs 🔤 nS	ave	^Run	^Output	Rer^un
User: bern50 Campaign: \${K}/INTRO \$Y+0=200	2 \$S+0=1430 File: /u/	aiub/bern50/GPS	USER/PAN/HE	LMR1.INP		//

🔀 Bernese (	GPS Software	Version 5.0								_ 🗆 ×
Con <u>f</u> igure	<u>C</u> ampaign	<u>R</u> INEX	<u>O</u> rbits/EOF	Processing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
HELMR1				<b>Transfor</b>		al coordi	nates		_	
STATIO ©	110,000	atic st	ation se on selec		all sta	tions or	select:	ion from fi	le)	
Syst		ansform	ation, 1	ocal (N,E millimet		geocentri	.c (X,Y,	.Z) <u>NEU</u> MM	IN IN	
Para	meters to	o be co:	-	shift 1 shift 2 shift 3 scale	7	rot 1 rot 2 rot 3				
************************************	^Prev Campaign:		Next	Cance^I 02 \$S+0=1430	Save File: /u/a		^Save 'SUSER/PA	^Run	^Output	Rer^un

💌 Bernese (	GPS Software	Version 5.0								-DX
Configure	<u>C</u> ampaign	<u>B</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
HELMR1	3: Outl	ier Rej	ection							
OUTLIE	R REJECT	ION								
Enab	le outli	er reje	ction		<b>Y</b>					
Out1	ier crit	eria	north co	mponent	10	n	illimet	ers		
			east co	mponent	10	n	illimet	ers		
			up co	mponent	30	n	illimet	ers		
File	with li	st of r	ejected s	tations	FIN\$	ZD+0 LSI				
    ^Top	^Prev	-	Next	Cance^I	Save^	As 🤇	Save	^Run	^Output	Rer^un
User: bern5	) Campaign:	\${K}/INTRO	\$Y+0=2002	\$S+0=1430	File: /u/ai	ub/bern50/GP	SUSER/PA	N/HELMR1.INP		1

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.

0	n : HELMR1 e : Helmert Transfo	ormat	ion		Bernese G	PS Softwar	re Ve	ersion 5.		
	gn: \${K}/INTRO	JIMat	,1011		Default session: 1430 year 2002					
	: 13-Feb-2007 14	:49			User name					
			====							
XAMPLE	E: Session 021430:	Chec	k f	iducial coordi	nates					
	: IGSOO COORDINATES									
ILE 2:	: EXAMPLE: Session	0214	130:	Final coordin	ate/tropos	sphere re	sults	5		
	GEODETIC DATUM: IG	300								
		300								
		и (ма	IRTH	EAST UP)						
	ALS IN LOCAL SYSTEM	M (NC	ORTH	, EAST, UP)						
		M (NC	ORTH	, EAST, UP)						
		M (NC	)RTH	, EAST, UP)						
ESIDU/					IN MILLI					
ESIDU/	ALS IN LOCAL SYSTEM				IN MILLI	METERS	 I I			
ESIDUA NUM	ALS IN LOCAL SYSTEM	FI   I	.G   .G	RESIDUALS			 			
ESIDUA NUM   6	ALS IN LOCAL SYSTEM NAME	FI     P	_G    A	RESIDUALS	-9.9	-14.6	   M			
NUM   6   15	ALS IN LOCAL SYSTEM NAME BRUS 13101M004 FFMJ 14279M001	FI     P   P	.G     A   A	RESIDUALS 6.5 7.2	-9.9 -2.4	-14.6 -12.3	   M     M			
NUM 6 15 36	ALS IN LOCAL SYSTEM NAME BRUS 13101M004 FFMJ 14279M001 MATE 12734M008	FI     P   P   I	.G     A   A   W	6.5 7.2 0.3	-9.9 -2.4 2.0	-14.6 -12.3 -6.3	   M     M     M			
NUM   6   15   36   42	ALS IN LOCAL SYSTEM NAME BRUS 13101M004 FFMJ 14279M001 MATE 12734M008 ONSA 10402M004	FI     P   P   I   I	.G   A   A   W   W	6.5 7.2 0.3 0.5	-9.9 -2.4 2.0 -0.0	-14.6 -12.3 -6.3 -6.0	   M     M   			
NUM 6 15 36 42 47	ALS IN LOCAL SYSTEM NAME BRUS 13101M004 FFMJ 14279M001 MATE 12734M008 ONSA 10402M004 FTBB 14234M001	FI     P   P   I   I   P	_G   A   A   W   W   A	6.5 7.2 0.3 0.5 4.4	-9.9 -2.4 2.0 -0.0 -4.7	-14.6 -12.3 -6.3 -6.0 -22.4	   M     M   			
NUM 6 15 36 42 47 56	ALS IN LOCAL SYSTEM NAME BRUS 13101M004 FFMJ 14279M001 MATE 12734M008 ONSA 10402M004 PTBB 14234M001 VILL 13406M001	FI   P   P   I   I   P   I	_G   A   A   W   W   A   W   W	RESIDUALS 6.5 7.2 0.3 0.5 4.4 -0.8	-9.9 -2.4 2.0 -0.0 -4.7 -1.9	-14.6 -12.3 -6.3 -6.0 -22.4 12.3	   M     M           M			
NUM 6 15 36 42 47 56 63	ALS IN LOCAL SYSTEM NAME BRUS 13101M004 FFMJ 14279M001 MATE 12734M008 ONSA 10402M004 PTBB 14234M001 VILL 13406M001 ZIMJ 14001M006	FI   P   P   I   I   P   I   P	_G   A   A   W   W   A   W   A	RESIDUALS 6.5 7.2 0.3 0.5 4.4 -0.8 6.9	$ \begin{array}{r} -9.9 \\ -2.4 \\ 2.0 \\ -0.0 \\ -4.7 \\ -1.9 \\ -4.9 \end{array} $	-14.6 -12.3 -6.3 -6.0 -22.4 12.3 -20.3	   M     M     M     M     M			
NUM 6 15 36 42 47 56 63	ALS IN LOCAL SYSTEM NAME BRUS 13101M004 FFMJ 14279M001 MATE 12734M008 ONSA 10402M004 PTBB 14234M001 VILL 13406M001	FI   P   P   I   I   P   I   P	_G   A   A   W   W   A   W   A	RESIDUALS 6.5 7.2 0.3 0.5 4.4 -0.8 6.9	$ \begin{array}{r} -9.9 \\ -2.4 \\ 2.0 \\ -0.0 \\ -4.7 \\ -1.9 \\ -4.9 \end{array} $	-14.6 -12.3 -6.3 -6.0 -22.4 12.3 -20.3	   M     M     M     M     M			
NUM 6 15 36 42 47 56 63 64	ALS IN LOCAL SYSTEM NAME BRUS 13101M004 FFMJ 14279M001 MATE 12734M008 ONSA 10402M004 PTBB 14234M001 VILL 13406M001 ZIMJ 14001M006	FI   P   P   I   P   I   P   P 	LG     A   W   W   A   W   A   A   I	RESIDUALS 6.5 7.2 0.3 0.5 4.4 -0.8 6.9 6.0	-9.9 -2.4 2.0 -0.0 -4.7 -1.9 -4.9 -4.2	-14.6 -12.3 -6.3 -6.0 -22.4 12.3 -20.3 -12.1	   M     M     H     M     M     M			

```
. . .
NUMBER OF PARAMETERS :
                           3
NUMBER OF COORDINATES :
                           9
RMS OF TRANSFORMATION :
                           6.3 MM
BARYCENTER COORDINATES:
                          46 31 17.52
LATITUDE
                     :
LONGITUDE
                          7 50 4.94
                     :
HEIGHT
                               -99.634 KM
                     :
PARAMETERS:
TRANSLATION IN N
                                0.0
                     :
                                         +- 3.6
                                                    MM
                                        +- 3.6
TRANSLATION IN E
                     :
                                -0.0
                                                    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  $K/INTRO/STA/IGS_00.FIX$  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").

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COMPAR	3: Proc	essing	0ptions							
TITLE	EXA	MPLE: C	oordinate	compari	son					
REPEAT	ABILITY	OPTION				LOCAL	Ţ			
SAVING	SCALE F.	ACTOR I	N COVARIA	NCE MATR	іх					
RMS	value is	taken	from			GPS_DERIV	ED Z			
COORDI	NATE FLA	GS				NONBLANK	Z			
Spec	ial flag	S				==				
^Top	^Prev		`Next	Cance^I	Save		Gave	^Run	^Output	Rer^un
User: bern50	) Campaign:	\${K}/INTRO	D \$Y+0=2002	\$S+0=1430	File: /u/a	iub/bern50/GPS	USER/PAN	V/COMPAR.INF	)	111

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	С	RMS	1	2	3	4
6	BRUS 13101M004	4	N	11.6	-10.5	-9.4	8.9	11.1
				10.7				
			U	4.1	2.9	2.5	0.6	-6.0
15	FFMJ 14279M001	4	N	7.2	-6.5	-6.0	5.8	6.7
			Е	10.3	-8.9	-8.8	8.8	9.0
			U	2.1	-0.2	-2.8	2.2	0.8
36	MATE 12734M008	4	N	10.6	-8.2	-10.2	9.5	8.8
			Е	13.3	-12.2	-10.8	10.7	12.3
			U	2.5	3.6	-1.4	-2.0	-0.2
42	ONSA 10402M004	4	N	7.3	-6.2	-6.4	6.3	6.3
			Е	10.2	-9.2	-8.6	8.7	9.1
			U	2.2	-3.2	1.1	1.6	0.5
47	PTBB 14234M001	4	N	9.0	-7.5	-8.1	6.6	8.9
			Е	11.3	-10.2	-9.4	9.6	10.0
			U	3.1	2.1	2.9	-1.2	-3.8
56	VILL 13406M001	4	N	9.1	-8.2	-7.5	7.4	8.2
			Е		-9.2			
			U	0.6	-0.3	1.0	-0.3	-0.3
63	ZIMJ 14001M006	4	N	9.3	-7.6	-8.5	8.3	7.8
			Е		-9.9			
			U	2.1	2.3	-0.4	0.8	-2.7
64	ZIMM 14001M004	4	N	9.1	-7.4	-8.4	8.1	7.6
			Е	11.4	-10.0	-9.9	9.8	10.0
			U	2.0	0.9	-2.5	2.0	-0.4

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 ( $\{K\}/INTRO/STA/EXAMPLE.STA$ ). All parameters of this station will be pre–eliminated before the normal equations are stacked and, therefore, also before the solution is computed.

## 5.4 Compute the Final Solution of the Session

If one or more stations have to be excluded from the session solution or if the datum definition of the solution is still not acceptable, the final solution of the session has to be re-computed. Repeat the execution of ADDNEQ2 corresponding to Section 5.2. Finally, the result files for the final solution of the session are:

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

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

It is preferable for the velocity estimation to have smaller normal equation files containing only the coordinate parameters for each session. In addition, in order to generate a coordinate SINEX file as the final solution of the day, the troposphere parameters have to be pre-eliminated before the solution is computed. To avoid singularities when writing the SINEX file all station coordinates have to be constrained. We introduce the station coordinates (K/INTRO/STA/FINYD+0.CRD) obtained with the minimum constraint solution in the previous run of ADDNEQ2 and constrain the solution to these coordinates.

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

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Station coordinates	FIN\$YD+0	CRD					
Station velocities		VEL					
Station information	EXAMPLE	STA					
Troposphere estimates		TRP					
Ionosphere master file		ION					
Differential code biases		DCB					
Earth rotation parameters		ERP					
Geocenter coordinates		GCC					
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## 5. Terminal Session: Thursday

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SINEX RED\$YD+0 SNX Bernese ERP file ERF	?
Station coordinates CRD IERS ERP file	?
Station velocities VEL Geocenter coordinates GCC	
Troposphere estimates TRP Var-covar wrt coord. COV Troposphere SINEX TRO Full var-covar matrix COV	
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IONEX INX Weekly summary file SUM	
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ADDMEQ2 3.1. Options 1	
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Reference epoch for station coordinates       (yyyy mm dd)         PARAMETER-RELATED OPTIONS       Parameter pre-elimination       Image: Set up station velocities         Set up station velocities       Image: Set up geocenter coordinates       Image: Set up geocenter coordinates         ^Top       ^Prev       ^Next       Cance^1       Save^ As       ^Save       ^Run       ^Out         set: bern50       Campaign: %(K/INTRO %V+0=2002 %S+0=1430       File: /u/alub/bern50/GPSUSER/PAN/ADDNEQ2.INP         Bernese GPS Software Version 5.0       onfigure       Campaign: %(K/INTRO %V+0=2002 %S+0=1430       File: /u/alub/bern50/GPSUSER/PAN/ADDNEQ2.INP         Bernese GPS Software Version 5.0       onfigure       Campaign: %(K/INTRO %V+0=2002 %S+0=1430       File: /u/alub/bern50/GPSUSER/PAN/ADDNEQ2.INP         Bernese GPS Software Version 5.0       onfigure       Campaign: %(K/INTRO %V+0=2002 %S+0=1430       File: /u/alub/bern50/GPSUSER/PAN/ADDNEQ2.INP         Bernese GPS Software Version 5.0       onfigure       Campaign: %(K/INTRO %V+0=2002 %S+0=1430       File: /u/alub/bern50/GPSUSER/PAN/ADDNEQ2.INP         Bernese GPS Software Version 5.0       onfigure       Campaign: %(K/INTRO %V+0=2002 %S+0=1430       File: /u/alub/bern50/GPSUSER/PAN/ADDNEQ2.INP         Bernese GPS Software Version 5.0       onfigure       Campaign: %(K/INTRO %V+0=2002 %S+0=1430       Enterno         DATUM DEFINITION TYPE       Onfigure	// ×
Reference epoch for station coordinates       (yyyy mm dd)         PARAMETER-RELATED OPTIONS       Parameter pre-elimination       Image parameter spacing         Parameter pre-elimination       Image parameter spacing       Image parameter spacing         Set up station velocities       Image parameter coordinates       Image parameter spacing         *Top       ^Prev       Next       Cancerl       SaverAs       ^Save       ^Run       ^Out         *Top       _Prev       Next       Cancerl       SaverAs       ^Save       ^Run       ^Out         *Top       _Prev       Next       Cancerl       SaverAs       ^Save       ^Run       ^Out         *Top       _Prev       Next       Cancerl       SaverAs       ^Save       ^Run       ^Out         <	// ×
Reference epoch for station coordinates       (yyyy mm dd)         PARAMETER-RELATED OPTIONS       Parameter pre-elimination       Image: Set up station velocities         Parameter parameter spacing       Image: Set up station velocities       Image: Set up station velocities         Set up station velocities       Image: Set up geocenter coordinates       Image: Set up geocenter coordinates         *Top       ^Prev       ^Next       Cance^1       Save^As       ^Save       ^Run       ^Out         *ter: bern50       Campaign: \${(K)/INTRO \$Y+0=2002 \$S+0=1430       File: /u/alut/bern50/GPSUSER/PAN/ADDNEQ2.INP         Bernese CPS Software Version 5.0       Image: Set up geocenter coordinates         Datum Definition for Station Coordinates         DATUM DEFINITION TYPE       Image: Set up geocenter solution         Image: Coordinates constraint       Image: Align: Align: Set up geocenter solution         Image: Coordinates fixed       Image: Align:	// ×
Reference epoch for station coordinates       (yyyy mm dd)         PARAMETER-RELATED OPTIONS       Parameter pre-elimination       Image: Set up station velocities         Parameter spacing       Image: Set up station velocities       Image: Set up station velocities         Set up station velocities       Image: Set up geocenter coordinates       Image: Set up geocenter coordinates         Top       ^Prev       ^Next       Cance^1       Save^As       ^Save       ^Run       ^OU         er. bern50       Campaign: \$(K)INTRO \$Y+0=2002 \$5+0=1430       File: /u/alub/hern50/GPSUSER/PAN/ADDNEG2.INP         Demese CPS Software Version 5.0       Image: Set up geocenter coordinates         Dampure Campaign: BINEX       Orbits/EOP Processing Service       Conversion       Image: Set up set         ADDNEQ2       5: Datum Definition for Station Coordinates         DATUM DEFINITION TYPE       Image: Set up coordinates fixed       Image: Set up set         IMINIMUM CONSTRAINT CONDITIONS       Translation       Image: Set         Translation       Image: Set up set       Image: Set         A PRIORI SIGMAS       North       0.001       meters         Bast       0.001       meters       Image: Set up set	Help

📰 Bernese GPS Software Version 5.0			<u>_0×</u>
Configure Campaign RINEX Orbits/EOP Pro	cessing <u>S</u> ervice Con <u>v</u> ersio	n <u>B</u> PE <u>U</u> ser	<u>H</u> elp
ADDNEQ2 7.1: Parameter Pre-Elimin	ation		
STATION-RELATED PARAMETERS		except f	for files
Station coordinates	NO	Y	
Receiver clock offsets	NO	Z	
Receiver DCB parameters	NO	Z	
Range biases	NO	Z	
ATMOSPHERIC PARAMETERS Troposphere zenith path delays Troposphere gradients Global ionosphere parameters	BEFORE_STACKING BEFORE_STACKING NO	X X X	=
ii  ^Top   ^Prev   ^Next   Can	ce^I Save^As	^Save ^Run	^Output Rer^un
User: bern50 Campaign: \${K}/INTRO \$Y+0=2002 \$S-	0=1430 File: /u/aiub/bern50/0	GPSUSER/PAN/ADDNEG	22.INP

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

SUMMARY OF RESULTS				
Number of parameters:				
Parameter type	•			(pre-eliminated)
Station coordinates / velocities		24	0	
Site-specific troposphere parameters			223	
Previously pre-eliminated parameters			109	
Total number		24		
Statistics:				
Total number of explicit parameters	24			
Total number of implicit parameters	332			
Total number of adjusted parameters	356			
Total number of observations	20418			
Degree of freedom (DOF)	20062			
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 NQO-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	e Version S	5.0								_D×
Configure	<u>C</u> ampaign	<u>R</u> INEX	<u>O</u> rbits/EO	P <u>P</u> rocessing	<u>S</u> ervice	Conversion	<u>B</u> PE	<u>U</u> ser	<u>H</u> elp		
COMBIN	ATION OF 1	NORMAL	EQUATION	SYSTEMS – A	DDNEQ2	1: Input F	'iles				
GENER	L FILES										
Show	all gene:	ral fil	es	~							
INPUT	FILENAMES										
Norn	al equation	ons		RED*	NQO						
Vari	ance resc	aling f	actors		WGT						
Stat	ion coord	inates		IGS_00	CRD						
Stat	ion veloc:	ities		IGS_00	VEL						
Stat	ion inform	mation		EXAMPLE	STA						
Trop	osphere e	stimate:	s		TRP						
Ione	sphere ma	ster fi	le		ION						
Diff	erential (	code bi	ases		DCB						
Eart	h rotatio:	n param	eters		ERP						
Geod	enter coo	rdinate:	3		GCC						
∬ ^Тор	^Prev	/ [	^Next	Cance <sup>4</sup>	Sa	ve^As	^Save	^RI	un 🛛	^Output	Rer^un
User: berr	50 Campaig	n: \${K}/IN	TRO \$Y+0:	=2002 \$S+O=1	430 File:	/u/aiub/bern5	0/GPSUSE	ER/PAN/A	DDNEQ2	.INP	/

🕱 Bernese GPS Software Version 5.0						_ 🗆 ×
Con <u>f</u> igure <u>C</u> ampaign <u>R</u> INEX	<u>Orbits/EOP</u> rocessir	ig <u>S</u> ervice Con <u>v</u> ersion	n <u>B</u> PE	<u>U</u> ser		<u>H</u> elp
ADDNEQ2 2: Output Files	5					
GENERAL OUTPUT FILES						
Program output	use ADDI	IEQ2.Lnn	or	FINAL	OUT	
Error messages	merged t	o program output	or	ERROR	MSG	
RESULT FILES Normal equations	N	)0 Orbital elem	ents		ELE	
SINEX		UX Bernese ERP			ERP	
Station coordinates		D IERS ERP fil			IEP	
Station velocities		L Geocenter co	- ordinates	;	GCC	
Troposphere estimates	s TI	P Var-covar wr	t coord.		cov	
Troposphere SINEX	TI	O Full var-cov	ar matris	:	cov	
Ionosphere models	I	N Station resi	duals		PLT	
IONEX	II	Weekly summa	ry file		SUM	
Code biases	D	Э				
		(	-	_		
ATOP APREV AN		Save^As	^Save	^Run	^Output	Rer^ur
Jser: bern50 Campaign: \${K}/INTRO	\$Y+U=2002 \$S+U=14	30 File: /u/alub/bern50/G	PSUSER/PAN	ADDINEQ2.INP		

Station velocities are set up by marking the checkbox:

😿 Bernese	GPS Software	Version 5.0	)							- O X
Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	BPE	User		<u>H</u> elp
ADDNEÇ	)2 3.1: Oj	otions	1							
TITLE	EXAMPL	3: Esti	mate fina	al soluti	on – coc	rdinates	s and ve	elocities		
Maxi A pr Comp	L OPTION mum numb iori sign oute and erence epo	er of p na of u compare	nit weigh individu	nt Mal solut	ions	0.00 HEL		1	ı dd)	
PARAME	TER-RELA	red opt	IONS							
Para	ameter pro	e-elimi	nation							
Char	ige param	eter sp	acing							
Set	up statio	on velo	cities			7				
Set	up geocei	nter co	ordinates	3						
	,	,			,			,		_
ii ^Top	^Prev		Next	Cance^I	Save^		^Save	^Run	^Output	Rer^un
User: bern5	u campaign:	\${K}/INTRO	J \$Y+0=200	2 \$5+0=1430	File: /u/ait	10/bern50/GF	SUSER/PA	N/ADDNEQ2.I	NP	1

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

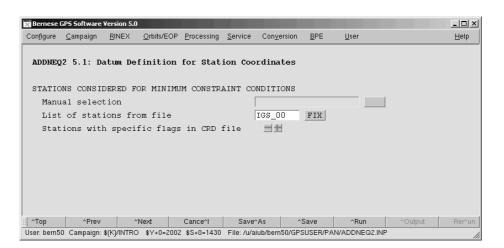
👿 Bernese (	GPS Software	Version 5.0								- 🗆 ×
Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	BPE	User		<u>H</u> elp
ADDNEQ	2 3.2: Oj	otions	2							
DISPLA	Y OPTION:	5 REGAR	DING							
Atmo	spheric p	paramet	ers			ſ				
Orbi	tal para	neters				[	_			
Eart	h orient:	ation p	arameters			[	_			
Addi	tional pa	aramete	rs			[	_			
Prov Noti Noti	fy statio fy change	on inco es due	tput wrt nsistenci to statio of all p	es betwe n inform	en NEQs ation f	ile [	5			
🗐 ^Тор	^Prev		Next	Cance^I	Save^		Save	^Run	^Output	Rer^un
User: bern5	) Campaign:	\${K}/INTRC	\$Y+0=2002	\$S+0=1430	File: /u/ai	ub/bern50/GP	SUSER/PA	N/ADDNEQ2.	INP	11.

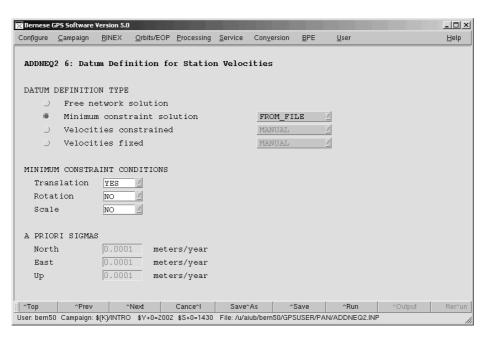
The following panel provides options to detect bad daily solutions based on the repeatability:

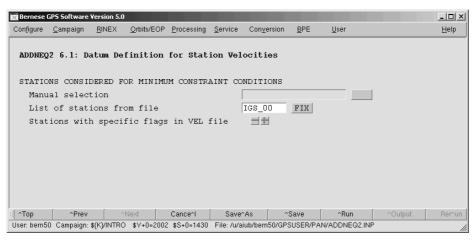
👿 Bernese (	GPS Software	Version 5.0									- 🗆 🗙
Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> e	ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
ADDNEQ	92 4: Comj	parison	of Indiv	idual So	lutions						
NOTIFI	CATION OF	F POSSI	BLE OUTLI	ERS							
Maxi	mum toler	rated r	esidual		N	orth	15	mi	llimeters		
					E	ast	15	mi	llimeters		
					U	р	30	mi	llimeters		
Maxi	mum toler	rated r	oot-mean-	square e	rror N	orth	10	mi	llimeters		
					Е	ast	10	mi	llimeters		
					U	р	20	mi	llimeters		
Mini	mum numbe	er of s	olutions	for each	statio	n	0	×			
^Top	^Prev		Next	Cance^I	Save <sup>2</sup>		^Sa		^Run	^Output	Rer^un
User: bern5	0 Campaign:	\${K}/INTRC	\$Y+0=2002	\$S+0=1430	File: /u/a	iub/bern	50/GPSL	JSER/PA	N/ADDNEQ2.I	NP	11

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

🔀 Bernese G	PS Software	Version 5.0								_ 🗆 🗵
Configure	<u>C</u> ampaign	<u>R</u> INEX	<u>O</u> rbits/EOP <u>P</u>	rocessing 🖇	<u>S</u> ervice C	on <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
ADDNEQ2	! 5: Dat	um Defin	ition for	Station	Coordin	ates				
DATUM I	EFINITI	ON TYPE								
0	Free n	etwork s	olution							
۲	Minimu	m constra	aint solut	ion		FROM_FII	ΞE	Y		
0	Coordi	nates com	nstrained			MANUAL		Y		
0	Coordi	nates fi:	xed			MANUAL		N		
	lation ion	AINT CON YES NO NO	DITIONS V V							
A PRIOF	I SIGMA	S								
North	1	0.001	meters							
East		0.001	meters							
Up		0.001	meters							
^Тор	^Prev	^N	ext C	ance^l	Save^As	S	iave	^Run	^Output	Rer^un
User: bern50	Campaign:	\${K}/INTRO	\$Y+0=2002 \$	S+0=1430	File: /u/aiub/	/bern50/GPS	USER/PA	N/ADDNEQ2.IN	IP	//







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

			Solution:	_	
BRUS N	0.59	-0.47	0.47	-0.56	0.52
BRUS E	0.31	-0.29	0.36	0.20	-0.18
BRUS U	1.53	0.62	-0.58	1.80	-1.75
FFMJ N	0.27	-0.32		0.00	
FFMJ E	0.26	0.33		0.01	
FFMJ U	0.95	0.99	-1.14	-0.48	0.44
MATE N				0.04	0.01
MATE E	0.58	-0.32	0.35	-0.64	0.60
MATE U	0.63	-0.61	0.72	-0.35	0.42
ONSA N	0.76	0.19	-0.27	0.90	-0.90
		0.23			
ONSA U	1.34	-1.04	1.30	-1.10	1.19
PTBB N	0.55	0.29	-0.32	-0.60	0.60
PTBB E	0.16	0.12	-0.11	0.17	-0.16
PTBB U	0.32	-0.49	0.27	0.01	-0.05
		-0.33			
		0.05			
VILL U	1.13	-0.90	1.00	-0.98	1.04
ZIMJ N		0.36			
ZIMJ E	0.23	-0.19		-0.23	
ZIMJ U	0.83	0.60	-0.56	0.77	-0.89
ZIMM N		0.25		0.43	
ZIMM E	0.17	0.17		-0.13	
ZIMM U	0.81	0.83	-1.01	0.34	-0.40

Below this table all bad daily solutions according to the settings in panel "ADDNEQ2 4: Comparison of Individual Solutions" are summarized. if bad daily solution are detected. In that case we have no additional section and, therefore, no outliers.

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

Reference epoch: 2	000-01-01	00:00:00				
Station name	Тур	A priori value	Estimated value	Correction	RMS error	
ZIMJ 14001M006	VX	-0.0129	-0.0156	-0.0027	0.0011	
	VY	0.0182	0.0175	-0.0007	0.0004	
	VZ	0.0098	0.0099	0.0001	0.0011	
	VU	0.0000	-0.0018	-0.0019	0.0015	
	VN	0.0143	0.0164	0.0021	0.0004	
	VE	0.0197	0.0194	-0.0003	0.0003	
ZIMM 14001M004	VX	-0.0129	-0.0131	-0.0002	0.0010	
	VY	0.0182	0.0185	0.0003	0.0004	
	VZ	0.0098	0.0120	0.0022	0.0011	
	VU	0.0000	0.0015	0.0015	0.0014	
	VN	0.0143	0.0159	0.0016	0.0004	
	VE	0.0197	0.0201	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 K/INTRO/STA/EXAMPLE.STA and add the following line to this copy

TYPE 004: STATION	COORDINATES AND VELOCITI	ES (ADDNEQ)	)				
STATION NAME 1	STATION NAME 2	RELATIVE NORTH	CONSTR. H EAST	POSITION UP	RELATIVE NORTH	CONSTR. V EAST	ELOCITY 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:

Reference epoch: 2	000-01-01	00:00:00				
Station name	Тур	A priori value	Estimated value	Correction	RMS error	···
ZIMJ 14001M006	VX	-0.0129	-0.0143			
	VY	0.0182	0.0181			
	VZ	0.0098	0.0110	0.0012	0.0009	
	VU	0.0000	-0.0000	-0.0001	0.0012	
	VN	0.0143	0.0162	0.0019	0.0003	
	VE	0.0197	0.0198	0.0001	0.0003	
 ZIMM 14001M004	vx	-0.0129	-0.0143	-0.0014	0.0009	
	VY	0.0182	0.0181	-0.0001		
	VZ	0.0098	0.0110	0.0012	0.0009	
	VU	0.0000	-0.0000	-0.0001	0.0012	
	VN	0.0143	0.0162	0.0019		
	VE	0.0197	0.0198	0.0001		

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

EXAM	PLE: Estimate fina	al solution - coc	ordinates and ve	elocities 13	-FEB-07 14:59				
LOCA	LOCAL GEODETIC DATUM: IGS00 EPOCH: 2000-01-01 0:00:00								
NUM	STATION NAME	X (M)	Y (M)	Z (M)	FLAG				
6	BRUS 13101M004	4027893.8398	307045.7403	4919475.0665	A				
15	FFMJ 14279M001	4053455.9388	617729.5767	4869395.6460	A				
36	MATE 12734M008	4641949.6604	1393045.3349	4133287.3899	W				
42	ONSA 10402M004	3370658.6174	711877.0633	5349786.9038	W				
47	PTBB 14234M001	3844060.0446	709661.2309	5023129.5007	Α				
56	VILL 13406M001	4849833.7491	-335049.1265	4116014.8656	W				
63	ZIMJ 14001M006	4331294.0075	567542.0461	4633135.6607	Α				
64	ZIMM 14001M004	4331297.1406	567555.7889	4633133.8693	A				

and  ${K}/INTRO/STA/FINAL.VEL$ 

EXAM	PLE: Estimate fina	l solution - coord	inates and velo	ocities 13	-FEB-07	/ 14:59
LOCA	L GEODETIC DATUM:	IGS00				
NUM	STATION NAME	VX (M/Y)	VY (M/Y)	VZ (M/Y)	FLAG	PLATE
6	BRUS 13101M004	-0.0205	0.0173	0.0086	А	EURA
15	FFMJ 14279M001	-0.0105	0.0167	0.0104	Α	EURA
36	MATE 12734M008	-0.0199	0.0184	0.0126	W	EURA
42	ONSA 10402M004	-0.0130	0.0156	0.0088	W	EURA
47	PTBB 14234M001	-0.0190	0.0167	0.0056	Α	EURA
56	VILL 13406M001	-0.0096	0.0208	0.0114	W	EURA
63	ZIMJ 14001M006	-0.0143	0.0181	0.0110	А	EURA
64	ZIMM 14001M004	-0.0143	0.0181	0.0110	А	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.NQ0 (for all sessions),
- (2) checked the coordinates of the fiducial sites using ADDNEQ2 and HELMR1, created files: FIN02143.CRD,FIN02143.TRP, FIN02143.OUT, and HELMR1.OUT,
- (3) used COMPAR to check the daily repeatabilities, created file COMPAR.OUT,
- (4) used ADDNEQ2 to create a final session solution, and reduced size NQ0s, created file: RED02143.NQ0 and RED02143.SNX,
- (5) if possible, used ADDNEQ2 for velocity estimation, created files: FINAL.CRD and FINAL.VEL.

# 6. Terminal Session: Friday

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

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

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

## 6.1 Kinematic Positioning

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

Renese GPS Software Version 5.0		_ 🗆 🗙
Configure <u>Campaign</u> <u>RINEX</u> <u>Orbits/EOP</u> <u>Pro</u>	ocessing <u>Service</u> Con <u>v</u> ersion <u>B</u> PE <u>U</u> ser	<u>H</u> elp
PARAMETER ESTIMATION - GPSEST 1.1	1: Input Files 1	
GENERAL FILES AND OPTIONS		
Show all general files	M	
LEO data processing	Γ	
Differencing level	DOUBLE	
INPUT FILES 1		
Phase observation files	????\$S+0 PSH ????\$S+0 PZH	
Code observation files	CSH	
Station coordinates	FIN\$YD+0 CRD	
GNSS standard orbits	IGS\$YD+0 STD	
GNSS clock corrections	CLK	
Earth rotation parameters	IGS\$YD+0 ERP	
Troposphere estimates	TRP	
Ionosphere models	ION	
Differential code biases	DCB	
Ocean loading corrections	EXAMPLE BLQ	
al contra transfer and	nceni SavenAs nSave nRun nOutput	Rer^un
user: bernou Campaign: \${K}/INTRO \$Y+0=2002 \$5	+0=1430 File: /u/aiub/bern50/GPSUSER/PAN/GPSEST.INP	

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	- U ×
GPSEST 3.1: General Options 1 TITLE EXAMPLE: Session \$755+0: Kinemetic 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 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 💌	
ATop APrev ANext CanceA SaveAs ASave ARun AOutput	Rer^un
User: bern50 Campaign: \$(K)/INTRO \$Y+0=2002 \$S+0=1430 File: /u/aiub/bern50/GPSUSER/PAN/GPSEST.INP	1.
Bernese GPS Software Version 5.0	-D×
Configure Campaign BINEX Orbits/EOP Processing Service Conversion BPE User	Help
GPSEST 3.1.1: Observation Window	
GPSEST 3.1.1: Observation Window OBSERVATION WINDOW	
OBSERVATION WINDOW	
OBSERVATION WINDOW O Defined by year and session number Year \$Y+0 Session \$\$+0	
OBSERVATION WINDOW → Defined by year and session number Year \$Y+0 Session \$S+0 ● Defined by start and end time	
OBSERVATION WINDOW         J Defined by year and session number         Year       \$Y+0         Session       \$S+0         Image: Session       Session         Image: Session       Session	
OBSERVATION WINDOW         J Defined by year and session number         Year       \$Y+0         Session       \$S+0         Image: Session       Session         Image: Session       Session	
OBSERVATION WINDOW         J Defined by year and session number         Year       \$Y+0         Session       \$S+0         Image: Session       Session         Image: Session       Session	
OBSERVATION WINDOW         J Defined by year and session number         Year       \$Y+0         Session       \$S+0         Image: Session       Session         Image: Session       Session	Remun

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  $4.2^{\circ}$ ).

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

🛒 Bernese (	PS Software '	ersion 5.0								-OX
Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EO	Processing	<u>S</u> ervice	Con <u>v</u> ersior	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
GPSEST	5.1: 561	upor	Paramete	rs and Pr	e-E1 1m 1	nation I				
STATIO	N-RELATEI	) PARAM	ETERS		Setuj	p	Pre-	-Elimination	1	
Stat	ion coord	linates				P	i0		Z	
Ambi	guities					N	0		Z	
Rece	iver ante	enna of	fsets			ľ	0		Σ	
Rece	iver ante	enna PC	V patter	ns		ľ	0		Z	
ATMOSP	HERIC PAP	RAMETER	S							
Site	-specific	tropo	sphere p	arameters	7	ľ	10		<u> </u>	
Glob	al ionosp	bere p	arameter	s		Þ	í0		Z	
	PARAMETER				_					
Kine	matic coo	ordinat	es		<u>۲</u>	<u>I</u>	0		Z	
Rece	iver cloo	ck offs	ets		~	E	VERY_E	POCH	Σ	
GNSS	clock of	fsets				E	VERY_E	POCH	X	
Stoc	hastic io	onosphe	re param	leters		E	VERY_E	POCH	Y	
^Top	^Prev	^	Next	Cance^I	Save^	As	^Save	^Run	^Output	Rer^un
User: bern50	Campaign:	\${K}/INTRO	\$Y+0=20	02 \$S+0=1430	File: /u/ai	ub/bern50/G	PSUSER/P	AN/GPSEST.INP		1

Let us assume only horizontal movements for this site:

👿 Bernese (	iPS Software	Version 5.0								_ 🗆 🗙
Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
GPSEST	6.5: Ki	nematic	Coordina	tes						
STATIO	NS TO BE	TREATE	D AS KINE	MATIC						
Stat	ion sele	ction				MANUAL	Y			
Stat	ion list	from f	ile				FIX			
Manu	al selec	tion				FFMJ 142	79M001			
Refe Sigm Sigm		ame rizonal rtical	componen component nents			NEU Z	meters meters meters			
ADDITI	ONAL OPT	ION								
Mini	mum numb	er of o	bservatio	ns per ej	poch	6				
aoT^	^Prev	[ ^	Next	Cance^I	Save	As a	Save	^Bun	^Output	Rer^un
<u>et 1</u>						iub/bern50/GPS				//

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

KINEMA	ATIC COORDINATE	ES : 		\${K}/INT	RO/STA/KINO2143.KIN		
EP0:	EPOCHS SINCE	2002-0	5-23 0	2:00:00 (SAMPLING	300 SEC)		
				CORRE	CTION AND RMS IN MET	ΓER	
EPO	EPOCH(MJD)	#OBS	STA	LATITUDE	LONGITUDE	HEIGHT	
	FFMJ 14279M00	01		50 5 26.079483	8 39 53.878597	178.1970	
1	52417.083333	21	FFMJ	-0.0297 +- 0.011	-0.0170 +- 0.007	-0.0001 +- 0.001	
2	52417.086806	21	FFMJ	-0.0147 +- 0.009	-0.0047 +- 0.006	-0.0000 +- 0.001	
3	52417.090278	22	FFMJ	-0.0040 +- 0.009	-0.0058 +- 0.006	0.0002 +- 0.001	
4	52417.093750	23	FFMJ	-0.0020 +- 0.010	-0.0054 +- 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-substituded by the program in order to get a solution also for those parameters). Compare the results with the first solution.
- Switch the "Var-covar wrt epoch parameters" in panel "GPSEST 3.2: General Options 2" from SIMPLIFIED to CORRECT. Compare the results again with the first solution.
- Compute kinematic coordinates for the full day using the epoch–wise pre–elimination and back–substitution algorithm. To save computing power we recommend to sample the data to 300 s.
- You may also run the pre–processing programs CODSPP and MAUPRP for "kinematic stations".

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

## 6.2 Clock Estimation

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

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

🔀 Bernese (	GPS Software	Version 5.0								_ 🗆 🗙
Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
RNXSMT	2.1: Opt	tions								
TITLE	EXAMPLE	E: Sess	ion \$¥SS+	0: Prepr	ocessing	g on RINH	EX level			
TITLE EXAMPLE: Session \$YSS+0: Preprocessing on RINEX level OBSERVATION ARC DEFINITION Sampling interval for RINEX data 30.0 seconds Use observation window Maximum gap in data to start a new arc 180.0 seconds Minimum number of observations per arc 10 •										
MELBOU	RNE-WUEBR	BENA LI	NEAR COME	INATION:	SCREEN	ING, CYCI	LE SLIP I	DETECTION		
RMS	of a clea	an arc	for Melbo	urne-Wuel	bbena	0.60	L5 cycl	es		
Mini	mum size	of det	ectable c	ycle slij	ps	1.0	L5 cycl	es		
Mini	mum size	of det	ectable c	utliers		5.0	L5 cycl	es		
ii ^Тор	^Prev		Next	Cance^I	Save^		^Save	^Run	^Output	Rer^un
User: bern5	) Campaign:	\${K}/INTRC	\$Y+0=2002	\$S+0=1430	File: /u/ai	ub/bern50/GF	PSUSER/PAN	J/RNXSMT.INP		//

😿 Bernese (	GPS Software	Version 5.0								-OX
Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
RNXSMT	2.3: Opt	tions								
GEOMET	RY-FREE 1	LINEAR	COMBINATI	ON: CYCLI	E SLIP (	CORRECTIO	ON			
Maxi	mum gap :	for cyc	le slip c	orrection	n	180.0	seconds			
Numb	er of L4	observ	ations fo	r fit		10 🗘				
RMS	of L4 for	r fit a	nd cycle	slip cor	rection	0.01	meters			
Fix	cycle sl:	ips in	code obse	rvations		<b>Y</b>				
			R COMBINA nosphere				meters			
OUTPUT	OPTIONS									
Flag	bad phas	se obse	rvations			<u>۲</u>				
Use	smoothed	instea	d of raw	code		<b>Y</b>				
Outp	ut detai	1				SUM Z				
∥ ^Тор	^Prev	^	Next	Cance^I	Save^	As	^Save	^Run	^Output	Rer^un
User: bern5	) Campaign:	\${K}/INTRO	\$Y+0=2002	\$S+0=1430	File: /u/ai	ub/bern50/GF	PSUSER/PA	N/RNXSMT.INP		11

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	_ 🗆 ×
Con <u>f</u> igure <u>C</u> ampaign <u>R</u> INEX <u>O</u> rbits/EOP <u>P</u> rocessing <u>S</u> ervice Con <u>v</u> ersion <u>B</u> PE <u>U</u> ser <u>H</u> elp	
TRANSFER RINEX OBSERVATION FILES INTO BERNESE FILES - RXOBV3 1: Filenames	
GENERAL FILES	
Show all general files	
INPUT FILES	
original RINEX observation files 222288+0     smoothed RINEX observation files 222288+0     SMT	
Station information file EXAMPLE STA	
RESULT FILES	
Measurement types to save	
🕫 Code 🍸 Phase 🎽 C Range	
Update coordinates CRD (blank if not used)	
GENERAL OUTPUT FILES	
Program output use RXOBV3.Lnn or RX2\$YD+0 OUT	
Error messages merged to program output or ERROR MSG	
ATop APrev ANext CanceAl SaveAAs ASave ARun AOutput	Rer^un

Because we want to compute clock values with a sampling of 5 min. only in GPSEST 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 G	PS Software	e Version 5	5.0								_ 🗆 🗙
Configure	<u>C</u> ampaign	<u>R</u> INEX	<u>O</u> rbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser	<u>H</u> elp		
RX0BV3	4: Input	Option	s 2								
SIGNAL	STRENGTH	REQUIR	EMENTS								
Minim	um signa.	l streng	gth			2 #					
Accep	t signal	strengt	th = 0								
Accep	t cycle s	slip fla	ags from R	INEX		7					
	OBSERVAT um number		MBER ochs reque:	sted per f	ile		epochs	3			
OPTIONS	CONCERN	ING ANTI	ENNAS								
Consi	der rador	ne code	of the and	tennas		7					
Corre	ct posit:	ion of 1	radome code	2		Y					
Check	phase ce	enter f:	ile for and	tenna type		7	else E	rror 💌			
_ ^Top	^Prev		^Next	CanceAl		ve^As	^Save	^Run		rtput	Rer*un
User: bern5	) Campaigr	n: \${K}/INT	TRO \$Y+0=2	002 \$S+O=1	430 File:	/u/aiub/berr	50/GPSUSE	ER/PAN/RX0	BV3.INP		11.

After importing the data into the Bernese format you have to repeat the receiver clock synchronization with program CODSPP. The options are identical to the settings in Section 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:

📰 Bernese GPS Software Version 5.0	- 🗆 🗵
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User	<u>H</u> elp
PARAMETER ESTIMATION - GPSEST 1.1: Input Files 1	
GENERAL FILES AND OPTIONS	
Show all general files	
LEO data processing	
Differencing level ZERO Z	
INPUT FILES 1 Phase observation files ????\$S+0 PSH ????\$S+0 FZH Code observation files CSH ????\$S+0 CZH Station coordinates FIN\$YD+0 CRD GNSS standard orbits IGS\$YD+0 STD GNSS clock corrections IGS\$YD+0 CLK Earth rotation parameters IGS\$YD+0 ERP Troposphere estimates FIN\$YD+0 TRP Ionosphere models ION Differential code biases DCB Ocean loading corrections EXAMPLE BLQ	
diatan atau atau Concett Saucete Asue Atun Coulout	Damun
OTOP         ^Prev         ^Next         Cance^1         Save^As         ^Save         ^Run         ^Output           User: bern50         Campaign: \${K}/INTRO         \$Y+0=2002         \$S+0=1430         File: /u/aiub/bern50/GPSUSER/PAN/GPSEST.INP	Rer^un

🔀 Bernese GPS Software Version 5.0							<u>_     ×</u>
Configure <u>C</u> ampaign <u>R</u> INEX <u>O</u> rbits/E	EOP <u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
GPSEST 2.1: Output Files 1							
GENERAL OUTPUT FILES							
Program output	use GI	SEST.Lnn		or	CLK\$YD+0	OUT	
Error message	mergeo	l to prog	ram outpu	t or	ERROR	MSG	
RESULT FILES 1							
Normal equations		NQO					
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	CLK\$YD+0	RES					
Top ^Prev ^Next	Cance^I	Save^/		iave	^Run	^Output	Rer^un
User: bern50 Campaign: \${K}/INTRO \$Y+0=	2002 \$S+0=143	) File: /u/aiu	ıb/bern50/GPS	USER/PA	N/GPSEST.INP		1.

Bernese	GPS Software	Version 5	5.0							_ 🗆 ×
Con <u>f</u> igure	<u>C</u> ampaign	<u>R</u> INEX	<u>O</u> rbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser	<u>H</u> elp	
GPSEST TITLE	3.1: Gene		t <b>ions 1</b> on \$YSS+0:	Save resi	duals f	or clock	estimatio	on		
OBSERV	ATION SELF	CTION								
Sate	llite syst	em		GPS	•					
Freq	uency			L3	•					
Elev	ation cuto	off ang	le	5 deg	rees	LEC	: 0	degrees		
Samp	ling inter	rval		300 sec	onds					
Tole	rance for	simult	aneity	100 mil	lisecon	ds				
Spec	ial data s	selectio	on	NO	•					
Obse	rvation wi	indow								
OBSERV	ATION MODE	ELING AN	VD PARAMETH	R ESTIMAT	ION					
A pr	iori sigma	a		0.001 m	eters					
Elev	ation-depe	endent (	weighting	COSZ 💌		LEC	: NONE	7		
Type	of comput	ed res	iduals	NORMALIZI	ED 💌					
Corr	elation st	rategy		CORRECT	<b>T</b>					
Pola	rization e	effect	geom.	only	if late	r than	2003 09 :	14 💌		
			total	only	if late	r than	2006 11 (	05 💌		
∬ ^Top	^Prev	[	^Next	Cance <sup>AI</sup>	Sa	/e^As	^Save	ARui	n ^Output	Rer^un
User: bern	50 Campaigr	n: \${K}/INT	「RO \$Y+O=2	002 \$S+O=1	430 File:	/u/aiub/berr	50/GPSUSE	ER/PAN/GF	SEST.INP	1

🕅 Bernese GPS Software Version 5.0				_0,	×
Configure Campaign RINEX Orbits/EOP Proce	ssing <u>S</u> ervice Co	n <u>v</u> ersion <u>B</u> PE	<u>U</u> ser	<u>H</u> elp	
GPSEST 3.2: General Options 2 A PRIORI TROPOSPHERE MODELING					
ZPD model and mapping function	DRY_NIELL				
HANDLING OF AMBIGUITIES					
Resolution strategy	NONE	Z			
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	X			
EXTENDED PRINTING OPTIONS					
Selection of printing options	NO	X			
Top ^Prev ^Next Canc		^Save	ARun (	^Output Rer^u	in
User: bern50 Campaign: \${K}/INTRO \$Y+0=2002 \$S+0	1430 File: /u/aiub/b	ern50/GPSUSER/P/	AN/GPSEST.INP		111

## 6. Terminal Session: Friday

Bernese GPS Software	Version 5.0									-O×
on <u>fig</u> ure <u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	Processing	<u>S</u> ervice	Con <u>v</u> ersi	on <u>B</u> PE	<u>U</u> ser			<u>H</u> elp
GPSEST 4: Datum	n Defini	tion for	Station	Coordi	nates					
DATUM DEFINITIO	ON TYPE									
	etwork s									
		onstraine	d		I_FLAG	<u> </u>				
Coordir	nates fi	.xed		ALL		<u> </u>				
A PRIORI SIGMAS	3									
_	0.01	meters								
East	0.01	meters								
Up 🛛	0.01	meters								
^Top ^Prev	1^	Vext	Cance^I	Save	^As	^Save	^R	un [	^Output	Remun
er: bern50 Campaign:	\${K}/INTRO	\$Y+0=2002	\$S+0=1430	File: /u/a	iub/bern50/	GPSUSER/F	PAN/GPSE	ST.INP		1.
Bernese GPS Software		Othin (SOR	Duesersing	Comilao	Gammanul					
onfigure <u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	Processing	<u>S</u> ervice	Con <u>v</u> ersi	on <u>B</u> PE	<u>U</u> ser			Help
æpsest 5.1: Set	tup of P	arameter	s and Pr	e-El imi	nation	1				
STATION-RELATE	) PARAME	ITERS		Setu	ıp	Pre	-Elimir	ation		
Station coord	linates					NO			Z	
Ambiguities				_		NO			Z	
Receiver ante			_			NO			<u> </u>	
Receiver ante	anna PCV	pattern	8	J		NO			<u></u>	
ATMOSPHERIC PAR	AMETERS	,								
Site-specific	: tropos	phere pa	rameters			NO			X	
Global ionosp	phere pa	rameters		Γ		NO			N	
EPOCH PARAMETER				_			DOOT		-	
Kinematic coo Receiver cloo				 		EVERY_E			<u></u>	
GNSS clock of		.05		ן יע		EVERY_E			 	
Stochastic id		e parame	ters	Ĺ		EVERY_E			Z	
^Top ^Prev		Vext	Cance^I	Save		^Save	^R		^Output	Rer^un
er: bern50 Campaign: :		\$Y+0=2002	\$S+0=1430	File: /u/a	iub/bern50/	GPSUSER/F	PAN/GPSE	ST.INP		//
Bernese GPS Software ' onfigure <u>C</u> ampaign	Version 5.0 <u>R</u> INEX	Orbits/EOP	Processing	<u>S</u> ervice	Con <u>v</u> ersi	on <u>B</u> PE	<u>U</u> ser			<u>_   ×</u> <u>H</u> elp
GPSEST 6.6.1: (	Clock Es	stimation	1							
DATUM DEFINITIO Type of datum			IMATION		7 FDO-MI	AN_COND	TTION			
Type of data		CION			anto m		11101			
REFERENCE STATI	IONS									
Selection of	referen	ice stati	ons		ALL			Z		
Manual static										
Station list	from fi	le.				FIX				
REFERENCE SATEI	LITES									
Selection of		ice satel	lites		NONE			Σ		
Manual satell	lite sel	.ection								
Satellite lis	st from	file				FIX				
ADDIMIONIA OFFI	ONG									
ADDITIONAL OPT		e nor at	ation al	ock	A A					
Minimum numbe	er of ob	-			4					
	er of ob er of ob	s per sa	tellite	clock	4 <b>↓</b> 4 <b>↓</b>					
Minimum numbe Minimum numbe	er of ob er of ob	s per sa	tellite	clock						
Minimum numbe Minimum numbe	er of ob er of ob tions w/	s per sa	tellite	clock	4	^Save	[^R		^Output	Rer^un

The residuals are stored in the file  ${K}/INTRO/OUT/CLK02143.RES$ . Use program RESRMS to screen for outliers bigger than 2 cm for code and phase data (remember that code residuals are scaled to phase residuals — 2 cm in the input field correspond to a 2 m threshold for code residuals):

Bernese GPS Software Version 5.0	
Configure <u>Campaign</u> <u>BINEX</u> <u>Orbits/EOP</u> <u>Processing</u> <u>Service</u> C	Con⊻ersion <u>B</u> PE <u>U</u> ser <u>H</u> elp
RESRMS 2: Options	
TITLE EXAMPLE: Session \$YSS+0: Residual stat	istics
GENERAL OPTIONS	
Frequency to check	<u>L3 Z</u>
Sampling rate of residual files	300 seconds
DETECT LARGE RESIDUALS	limit
Phase measurements	0.020 meters
Code measurements	0.020 meters
Range measurements	0.3000 meters
DETECT BAD DATA	
Minimum continuously observed time interval	901 seconds
Detect ambiguities with few observations	Γ
Minimum number of observations per ambiguity	3
Sampling rate for counting the observations	seconds
^Top ^Prev ^Next Cance^I Save^As	s <b>^Save ^Run</b> ^Output Rer^un
User: bern50 Campaign: \${K}/INTRO \$Y+0=2002 \$S+0=1430 File: /u/aiub	/bern50/GPSUSER/PAN/RESRMS.INP //

Mark the corresponding observations using program SATMRK and repeat the GPSESTrun. 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  $>\underline{R}INEX>RINEX \underline{u}tilities>Combine/manipulate clock data"$ ):

🔀 Bernese GPS Software Version 5.0	- 🗆 ×
Configure Campaign RINEX Orbits/EOP Processing Service Conversion BPE User	<u>H</u> elp
COMBINATION AND MANIPULATION OF CLOCK RINEX FILES - CCRNXC 1: Filenames	
GENERAL FILES	
Show all general files 🔽	
INPUT FILES	
Clock RINEX files CLK \$YD+0 CLK	
RESULT FILES Extract only satellite clocks Combined clock RINEX file Bernese satellite clock file Sigma file with linear fit RMS SIG	
GENERAL OUTPUT FILES	
Program output use CCRNXC.Lnn or TIM\$YD+0 OUT	
Error messages merged to program output or ERROR MSG	
Top ^Prev ^Next Cance^I Save^As ^Save ^Run ^Output	Rer^un
User: bern50 Campaign: \${K}/INTRO \$Y+0=2002 \$S+0=1430 File: /u/aiub/bern50/GPSUSER/PAN/CCRNXC.INP	11

🔀 Bernese G	PS Software Ver	rsion 5.0							-OX
Configure	<u>C</u> ampaign <u>F</u>	RINEX <u>O</u> rbits/	EOP <u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
CCRNXC	2: Clock/	Epoch Selec	tion for Pr	ocessing					
TITLE	EXAMPLE:	Session \$1	SS+0: Refer	ence clo	ck select	ion		-	
Use t	ime windo	BE PROCES: w for clocks	ED	seco	nds				
DEFINE	A LIST OF	CLOCKS TO	BE PROCESSE	D					
Selec	tion of s	tations clo	cks ALI	ı.	Z				
List	from file			F	IX	_			
Manua	al selection	on				_	]		
List	stion of s from file al selection	atellites ( on	blocks <u>ALI</u>		<u>X</u> XI				
Top	^Prev	^Next	Cance^I	Save^A	.s [ ^S	iave	^Run	^Output	Rer^un
User: bern50	Campaign: \${k	()/INTRO \$Y+0	2002 \$S+0=1430	File: /u/aiul	b/bern50/GPS	USER/PA	N/CCRNXC.INP		

🔀 Bernese I	GPS Software	Version 5.0								-OX
Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
CCRNXC	3: Opti	ons for	Clock RI	NEX File	Combin	ation				
CLOCK	RINEX FI	LE OFFSI	ET ESTIMA	TION						
Use	all stat	ion clo	cks				~			
Use	all sate	llite c	locks				<b>Y</b>			
Use	only ref	erence	clocks							
Apr	iori sig	ma of u	nit weigh	t			0.02	nanosecc	nds	
Maxi	mum resi	duum al	lowed				5	nanoseco	nds	
Stra Maxi Mini	mum devi mum numb	comput: ation f: er of v:	ation of	ks for m	ean	from	COMBINZ 5 1 1 INPUT_1	nanoseco for stat for sate	ions	
III ^Top User: bern5	^Prev 0 Campaign:		Next ( \$Y+0=2002	Cance^I \$S+0=1430	Save^ File: /u/ai		Save SUSER/PAN	^Run /CCRNXC.INP	^Output	Rer^un

<mark>⊠ Bernese</mark> Con <u>f</u> igure	GPS Software Campaign		orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersio	in <u>B</u> PE	<u>U</u> ser		Leip
CCRNX	C 4: Sele	ct Progra	m Funct	ions, Pr	ogram O	utput				
REFERI	ENCE CLOC	K SELECTI	ON							
۽ ک	Select a	new refer	ence cl	ock for	the out	put file	Э			
) I	Retain th	e referen	ce cloc	k from a	n input	file		CLK		
ENABLE	E OTHER P	ROGRAM FU	NCTIONS	:						
		jump det	ection				2			
Enab	ole extra	polation								
	M OUTPUT						_			
	-	ort on in ort on cl			files		-			
	-	ort on ci ort on re			electio	n	E.			
Deta	ailed rep	ort on cl	ock jum	ıp detect	ion					
		ort on cl			on					
		out the r for cloc		-			SIGM2	<u> </u>		
άTen	Drou	( Abla	t. [	Canaadi	[ Sauce	[	650U0	( Our		Domiun
^Top Iser: bern5	^Prev i0 Campaign:	*Ne \${K}/INTRO		Cance^I \$S+0=1430	Save <sup>2</sup> File: /u/ai		^Save GPSUSER/P	^Run AN/CCRNXC.INI	Output	Rer^un
	GPS Software									_ 🗆 🗵
Con <u>f</u> igure	<u>C</u> ampaign	<u>R</u> INEX <u>(</u>	Orbits/EOP	Processing	<u>S</u> ervice	Con <u>v</u> ersic	in <u>B</u> PE	<u>U</u> ser		Help
CCRNX	C 5: Sele	ct a New	Referen	ice Clock	for Ou	tput Fi	le			
REFERE	ENCE CLOC	K SELECTI	ON							
		potentia		ence clo	cks	A	LL_STATI	ons 🗹		
Manu	ual selec	tion for		tions						
Get	list fro	m file fo		ellites tions				FIX		
000	1100 110			ellites				FIX		
		EW REFERE egree for				1	÷			
		wed RMS e			ent			oseconds		
^Тор	^Prev	^Ne	×t [	Cance^I	Save	As	^Save	^Run	^Output	Rer^un
	i0 Campaign:	\${K}/INTRO	\$Y+0=2002	2 \$S+0=1430	File: /u/ai	ub/bern50/(	GPSUSER/P	AN/CCRNXC.INI	>	//
Bernese Configure	GPS Software		orbits/EOP	Processing	<u>S</u> ervice	Con <u>v</u> ersio	in <u>B</u> PE	<u>U</u> ser		Leip
CCRNX	C 6: Opti	ons for C	lock Ju	mp Detec	tion					
CLOCK	JUMP DET	ECTION								
	fidence i					5	🖨 sigma			
Mini	imum RMS	for jump	detecti	.on		1	nanos	econd/300	seconds	
CLOCK	JUMP OR	OUTLIER								
		interval				5	🖨 epoch	s		
Remo	ove outli	ers from	output		ions llites					
				Suce		1				
		IFICATION								
		lock jump egree for			mation	10	A V			
101	u		,p 5			120				
^Тор	^Prev	^Ne		Cance^I	Save		^Save	^Run	^Output	Rer^un
Jser: bern5	i0 Campaign:	\${K}/INTRO	\$Y+0=2002	\$S+0=1430	File: /u/ai	ub/bern50/	GPSUSER/P	AN/CCRNXC.INI	D	11

The table at the end of the program output provides an overview of the clock quality:

REFERENCE CLOCK SELEC	TION FOR	OUTPUT I	FILE								
Selected reference station: MATE 12734M008											
STATISTICS ON THE CLO	CKS IN TH	E OUTPU	[ FILE								
	# per	file	rms of	poly. fi	t (ns)						
			n = 0								
MATE 12734M008			57.543								
ONSA 10402M004	288	288	36.041	0.100	0.093						
PTBB 14234M001	288	288	1.222	0.138	0.072						
BRUS 13101M004	278	278	2.497	1.600	1.358						
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	19.792	0.161	0.161						
G14	106	106	52.600	0.183	0.154						

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

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><u>B</u>PE><u>S</u>tart BPE process":

👿 Bernese GPS Software Version 5.0					
Configure Campaign BINEX Orbits/EOP B	rocessing <u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE <u>U</u> se	r	<u>H</u> elp
Bernese Processing Engine - BPE	1: Client Env	ironment/Se	ssion Sel	ection	
CLIENT FILES/ENVIRONMENT					
Client script	\${BPE}/RUNBPE	.pm			
Client's environment file	\${X}/EXE/LOAD	GPS.setvar			
MENU SETTINGS Campaign Session table	\${K}/INTRO \${K}/INTRO/STA	A/SESSIONS.:	SES		
SESSION PROCESSING OPTIONS Start processing Number of sessions to be proc Run sessions in parallel Continue with next session in			Session	1430	
	ance^l Save			Run Output	Rer^un
User: bern50 Campaign: \${K}/INTRO \$Y+0=2002 :	\$S+0=1430 File: /u/ai	ub/bern50/GPSU	SER/PAN/RUNE	BPE.INP	11.

👿 Bernese (	GPS Software	Version 5.0								_ 🗆 ×
Configure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser		<u>H</u> elp
BPE 2:	Process	Contro	l Options							
	NTROL control : k for fr		every	USE 10	र seco	CPU				
BPE TA	SK SELEC	TION								
Proc	ess cont:	rol fil	e	PPP		PCF				
Star	t with s	cript								
Skip	scripts									
Repo			t communi rary user		nent	F				
∥ ^Тор	^Prev		Next	Cance^I	Saver		Save	^Run	^Output	Rer^un
User: bern5	0 Campaign:	\${K}/INTRC	\$Y+0=2002	\$S+0=1430	File: /u/ai	ub/bern50/GPS	SUSER/F	PAN/RUNBPE.INP		11.

#### 6. Terminal Session: Friday

	PS Software			-		-				<u>×</u>
Con <u>f</u> igure	<u>C</u> ampaign	<u>R</u> INEX	Orbits/EOP	<u>P</u> rocessing	<u>S</u> ervice	Con <u>v</u> ersion	BPE	<u>U</u> ser		<u>H</u> elp
BPE 3:	Output I	Filenam	es							
OUTPUT	FILES									
Task	ID	[	PP							
Stat	us file	[	PPP.RUN							
Prog	L OUTPUT ram outpu r message	ut .	✔ merge	d to prog	gram out	put	or	PPP ERROR	out MSG	
			Next	Cance^I	Save^A	. ſ.	Save	^Run	^Output	Rer^un

_	oftware Version 5.0 paign <u>R</u> INEX <u>O</u> rbit	s/EOP <u>P</u> rocessing <u>S</u> er	vice Con <u>v</u> ersion	<u>B</u> PE	<u>U</u> ser	<u>H</u> elp	_0×
BPE 4: Serv	ver Variables Sent	to Client					
Variable	Value	Description					
V_A	APR	A priori informa	tion		ヨヨ		
V_B	IGS	Orbit/ERP, DCB,	CLK informat	Ξ±			
V_C	PPP	CRD/TRP/TRO/SNX	and CLK resu	lts	Ξ±		
V_E	REF	CRD results refe	rred to epoc	h 2000.0	ΞĦ		
V_F	ION	Station-specific	: ION/DCB res	ults	ΞĦ		
V_G	RIM	Regional ION/INX	/DCB results		ΞĦ		
V_STAINF	EXAMPLE	Station informat	ion file nam	2	ΞĦ		
V_PLDINF	EXAMPLE	Tectonic plate d	lefinition fi	le name	ΞĦ		
V_BLQINF		Ocean loading co	prrection file	e name	ΞĦ		
V_ABBINF	EXAMPLE	Station name abb	reviation fi	le name	Ξ±		
V_CRDREF	IGS_00_R	Naster/reference	CRD/VEL file	e name	Ξ±		
V_CRDMRG	IGS_00	Merged CRD/VEL f	ile name		Ξ±		
V_PCV	101	Relative/absolut	e PCV		Ξ±		
	^Prev //vext	Cance <sup>A</sup>	Save^As	^Save		n ^Output	Rer^u
		Y+0=2002 \$S+0=1430					Remu

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.