Unit 2 – Computing loose constrained solutions using the GAMIT modules

1. OVERVIEW OF GPS DATA PROCESSING

a) Computing loose constrained solutions (quasi-observations) ⇒ GAMIT

First, we estimate GPS station coordinates for each day of data in loosely constrained solutions (h-files). That means that we tightly constraint neither the coordinates of the tracking sites nor the GPS satellites orbits. In our solutions, the orbits of GPS satellites and station coordinates are not in a well-determined reference frame. Baseline lengths are determined very precisely in the loosely constrained solutions and the entire GPS network and GPS constellation can be rotated and translated as a rigid body.

b) Combining global and local quasi-observations ⇒ GLOBK

To use the coordinates derived from these solutions, we need to transform all the loosely constrained solution into a consistent reference frame so that we can derive rates of deformation from the time series of the stations' coordinates. The reference frame defines the origin, scale and orientation of our geodetic coordinates. A reference frame is realized through the coordinate and covariance of a number of reference stations. We include information about the reference stations of the adopted geodetic reference frame (usually the latest realization of the ITRF) by combining our loosely constrained solutions with the IGS global h-files from SOPAC.

c) Defining the reference frame for deformation velocities ⇒ GLORG

Finally, we apply the reference frame constraints and estimate the site velocities (Fig. 2 below).

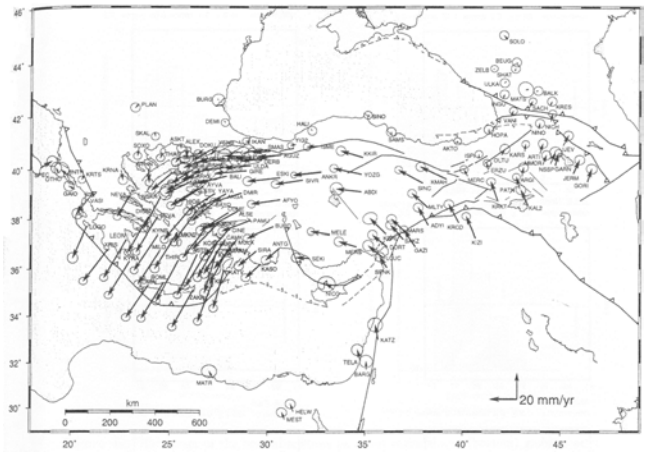
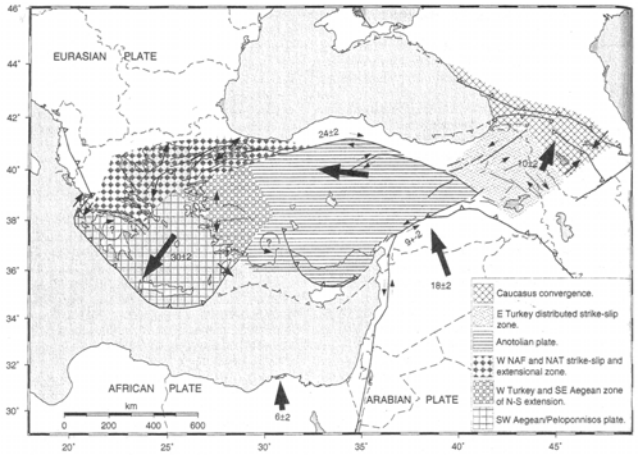


Fig. 2. Eastern Mediterranean GPS horizontal velocities and their 95% confidence ellipses in a Eurasia-fixed reference frame for the period 1988-1997 (after McClusky et al, 2001)



Fi.g 9. Schematic illustration of the kinematics of the Eastern Mediterranean region. Hatching shows areas of coherent motion and zones of distributed deformation (see legend) Heavy arrows indicate generalized regional motions.

2. GAMIT

GAMIT is a comprehensive GPS analysis package developed at MIT and Scripps for the estimation of three-dimensional relative positions of ground stations and satellite orbits. The primary output of GAMIT is a loosely constrained solution (H-) file of parameter estimates and covariances that can be passed to GLOBK for combinations of data to estimate station positions, velocities, orbital and Earth-rotation parameters.

The analysis software is composed of distinct modules, which:

1. Generate reference orbits for the satellites

	INPUT	OUTPUT
NGSTOT	- SP3-file (earth-fixed ephemeris)	- T-file (earth-fixed tabular ephemeris) - G-file (orbital initial conditions)
ARC	- arc.bat - G-file (orbital initial conditions)	- T-file (inertial tabular ephemeris) - G-file (interpolated from inertial T-file)
ORBFIT	- T-file (inertial tabular ephemeris)	- G-file

2. Prepare the data for processing

	INPUT	OUTPUT
MAKEXP	- RINEX files - Station.info (antenna, receiver info)	- D-file (FIXDRV input file) - Session.info - Input batch file for MAKEX, MAKEJ
MAKEJ	- RINEX nav file	- J-file (satellite clock file)
MAKEX	- RINEX files - Station.info - Session.info - RINEX nav file - J-file (satellite clock file) - L-file (initial stations coordinates)	- K-file (receiver clock) - X-file (input observations)
FIXDRV	- D-file (defines the input and output) - sestbl. (session control) - sittbl. (site control) - T, J, L, X input	- B-file (bexpy.bat ; primary batch file) - B-file (bexpy.nnn ; secondary batch file) - I-file (rcvr clock polynomials)

3. Compute residuals and partial derivatives of the observations ("observables")

	INPUT	OUTPUT
MODEL	- L-file (initial stations coordinates) - Station.info (antenna, receiver info) - X, T, I, J	- C-file (observed-computed, partial derivatives)

4. Detect outliers or breaks (cycle-slips) in the data

	INPUT	OUTPUT
AUTOCLN	- C-file	- C-file (cleaned)

5. Perform a least square analysis to estimate the positions of a set of stations and more

	INPUT	OUTPUT
SOLVE	- M-file (control merging of data - C-file (data)	- Q-file (contain a record of the analysis) - H-file (loose constrained solution) - G, L (update)

3. USING GAMIT TO COMPUTE QUASI-OBSERVATIONS

a) Setup program and processing directories

```
STEP 1 - SETUP THE ENVIRONMENTAL VARIABLES IN .CSHRC ====================================
source /data/gps7/gps/PARAMETERS
setenv GAMIT    /data/gps3/GAMIT_10.06
setenv TABLES   $GAMIT/tables
setenv HELP_DIR $GAMIT/help/
setenv INSTITUTE UCB
setenv GMT /data/gps4/mmurray/Gmt

set lpath = ( ~/bin /data/gps7/gps/bin /data/gps3/bin )
set gpath = ( $GAMIT/com $GAMIT/gamit/bin $GAMIT/kf/bin )
set path = ( . $lpath $gpath $ppath $upath /usr/ccs/bin )
=========================================================================
STEP 2 - LINK THE DIRECTORY ~/gg TO $GAMIT  ==========================================
Run this only once the first time.
$GAMIT = /data/gps3/GAMIT_10.06 is the directory of GAMIT/GLOBK

Example: ln -s $GAMIT gg
=========================================================================
STEP 3 - CREATE WORKING DIRECTORIES FOR THE PROCESSING ===================================
Same structure used by sh_gamit
```

/expt					
/doy	/rinex	/brdc	/igs	/tables	/templates
Processing directoy	RINEX files	RINEX nav files	IGS SP# files	GAMIT tables	Tables and data files relevant for processing

```
Copy the GAMIT /templates directory in /templates

Copy the following files from /templates to /tables
autcln.cmd, sestbl., station.info, sittbl., lfile.
```

b) Prepare the data

```
STEP 1 - COPY RINEX OBSERVATION FILES (SSSSDDD0.YYO) IN /rinex ==========================
You can
 -  copy the files from an internal archive:
    /data/sam/gps/rinex/YYYY/YYYY.DDD                  (BARD & some IGS RINEX files)
    /data/sam/gps/survey/usgs/orinex/YYYY/YYYY.DDD     (USGS North Bay RINEX files)
 -  download the data from a FTP archive like SOPAC (Scripp), BKG (Euref), CCDIS
    (Nasa), ASI (Italian space agency), IGN (French GPS data center)
    To download the data use the shell script sh_get_rinex.
    Type sh_get_rinex with no argument to get the "on-line" shell script manual
================================================================================
STEP 2 - COPY RINEX NAVIGATION FILES (brdcDDD0.YYn) IN /brdc ===========================
You can
 -  copy the files from an internal archive:
    /data/sam/gps/rinex/YYYY/YYYY.DDD                  (brdc RINEX nav files)
 -  download the data from the CCDIS or SOPAC FTP archive using the shell script
    sh_get_nav. Type sh_get_nav with no argument to get the "on-line" shell script
    manual
================================================================================
STEP 3 - COPY IGS SP3 EPHEMERIS FILES (igsWWWWD.sp3) IN /igs ===========================
You can
 -  copy the files from an internal archive:
    /data/gps4/orbit/WWWW                  (igp, Igr and igs sp3 ephemeris files)
 -  download the data from the CCDIS or SOPAC FTP archive using the shell script
    sh_get_orbits. Type sh_get_orbits with no argument to get the "on-line" shell script
    manual
================================================================================
STEP 4 - EDIT THE station.info FILE IN /tables ==========================================
Use information from the RINEX header or site logs.

Station.info header ---------------------------------------------------------------
pgga pgga
(A1,2(A4,1X),A16,F7.4,2(1X,F8.4),2(1X,A6),1x,a5,1X,F5.2,1X,I4,1X,I3,1x,I2,6(1X,I2))
TRCK  SITE  StationName AntHt   AntN    AntE    Rcvr    AntCod HtCod  Vers  Year  Doy  SN Start   Stop
2353  2353  Wairakei    1.4116 0.0000  0.0000  TRMSST  TRMSST DHPAB  4.10  1990  334  0  000000  240000
--------------------------------------------------------------------------------

Project     Orbit-file name          change to   Project     Orbit-file name
pgga        pgga                                 expt        igsf

Use grep to extract information from the RINEX header

TRAK SITE Station Name         grep -h "MARKER NAME" <RINEX_file>
Ant Ht   Ant N    Ant E        grep "ANTENNA: DELTA H/E/N" <RINEX_file>

GAMIT receiver (Rcvr) and antenna codes (AntCod) with IGS 20-character codes and
description are available in tables/rcvant.dat or templates/rcvant.dat

Receiver_name     grep "REC # / TYPE / VERS" <RINEX_file>
                  ASHTECH Z-XII3
Rcvr              grep <Receiver_name> tables/rcvant.dat

AntType           grep "ANT # / TYPE" <RINEX_file>
                  ASH700936D_M
AntCod            grep <AntType> tables/rcvant.dat
HtCod             a list of antennas and corresponding height codes is in
                  $GAMIT/gamit/lib/hisub.f

Firmware/software versions  are in $GAMIT/gamit/makex/settim.f
```

```
version_code            grep "REC # / TYPE / VERS" <RINEX_file>
                        CB00
Vers                    grep CB00 $GAMIT/gamit/makex/settim.f

Year and doy            Year and UTC day of survey
Start   Stop            00 00 00 24 00 00

*** SOPAC compiles a station.info file (called station.info.db) for most of the
    world continuous GPS stations
================================================================================
STEP 5 - EDIT THE L-FILE IN /tables ============================================
Find the most up-to-date positions for your stations
Use tform to transform coordinates from XYZ to Spherical (see Chapter 4.2 -
Preparing the coordinate (L-) file. tform is interactive
================================================================================
STEP 6 - CREATE LINKS TO THE DATA FILES AND TABLES NECESSARY FOR THE BATCH PROCESSING ==========
1st In the /tables directory, execute the script links.tables which will create links
    for GAMIT global files to ~/gg/tables
    [ gdetic.dat, luntab., soltab., …]
2nd From each /doy directory, execute links.day, which will create links to global
    files and survey-specific files to /tables
    [ station.info, sestabl., sittbl., autcln.cmd, lfile.]

NOTE: If you plan to run MAKEXP to produce session.info from input, you must remove
the link (rm session.info) after running this script and before running MAKEXP
================================================================================
STEP 7 - LINK RINEX FILES TO THE PROCESSING DAY DIRECTORY ======================

sh_link_rinex1 scans all the RINEX files in the directory and compiles a list of the
data available from each one. The script takes a long time to run (1 minute per
file on a Sparc2) the first time it is executed for a RINEX directory since every
file is scanned, but for subsequent days, it is very quick.

USAGE:    sh_link_rinex1  -year <yr>  -day <doy>  -dir <dir>
 -  <yr> is the 4 char year of observations. [ Required]
 -  <doy> is the 3 char day of the year to be linked. [ Required]
 -  <dir> the absolute or relative path to the rinex files [ default ../rinex]

Example:   sh_link_rinex1 -year 1999 -day 180 -dir ../rinex
================================================================================
STEP 8 - LINK RINEX NAV (brdc) FILES TO THE PROCESSING DAY DIRECTORY ============
Run this from the /doy directory

Usage: ln -s ../brdc/brdc<doy>0.<yy>n .
 -  <doy> is the 3 char day of the year to be linked. [ Required]
 -  <yy> is the 2 char year of observations. [ Required]

Example:  ln -s ../brdc/brdc1800.99n .
================================================================================
STEP 9 - LINK THE SP3 ORBIT FILE TO THE PROCESSING DAY DIRECTORY ================
Run this from the /doy directory

Usage: ln -s ../igs/<file>.sp3 .
- <file> orbit file name

Example: ln -s ../igs/igs10961.sp3 .
================================================================================
```

c) Set up and execute batch processing

```
STEP 1 - CHECK PARAMETER IN SESSION TABLE sestbl. (IF APPROPRIATE) ========================
================================================================================
STEP 2 - RUN makexp IN BATCH MODE FROM /doy DIRECTORY ==================================
Required:     Station.info file.
Output:       Batch files generated by makexp

Usage: sh_makexp  -expt <expt> -orbt <orbt> [ -yr <yr>] [ -doy <doy>] [ -seses <sess>]
[ -srin] [ -nav <file>] [ -xver <char>] [ -sinfo <sinfo>]
-expt          4-character survey name for d-, i-, l-file names [ required]
-orbt          4-character orbit name for g-, j-, t-file names  [ required]
-yr <yr>       4 char year of the data to be processed. (yyyy) [ default from session.info]
-doy <doy>     Starting day of year of data to be processed. (ddd) [ default from session.info]
-sess <sess>   Session to be searched*. Enter 99 to search all sessions. [ Default is 99]
-srin          Search all rinex files, for data matching ddd.
-nav <file>    Name of rinex navigation file to be used. [ Default eorbty.ddd]
-xver <char>   1-character x-file version (6th character of x-file). [ Default is single-digit year]
-sinfo <sinfo> Processing interval (secs), start time (hh mm), number of epochs (num).

If -sinfo is specified, the existing session.info will be deleted and a new one
will be created by makexp. If -sinfo is not specified, the existing session.info is
used to set sinfo parameters. If -default is used then the last record in the
session.info file is used to set the year, doy of the session and the sinfo
parameters.

* Note RINEX sessions 0 and 1 are assumed to be the same by makexp

Example:
sh_makexp -expt eurf -orbt igsf -yr 1999 -doy 180 -sess 99 -srin -nav brdc1800.99n -sinfo 30 00 00 2880
================================================================================
STEP 3 NOW RUN, IN ORDER: ======================================================

 -  sh_sp3fit -f <sp3 file> OR sh_bcfit bctot.inp OR copy a g-file from SOPAC
 -  sh_check_sess -sess 180 -type gfile -file <g-file>
 -  makej brdc1800.99n   jbrdc9.180
 -  sh_check_sess -sess 180 -type jfile -file jbrdc9.180
 -  makex eurf.makex.batch
 -  fixdrv deurf9.180 OR  run interactively

NOTE 1: sh_orbit - see STEP 3) of Part b)- computes the g-files as well copy a g-
        file from /igs
NOTE 2: the list of commands above is the output of makexp (equivalent to
        sh_makexp, but interactive)
================================================================================
STEP 4 - BATCH PROCESSING ======================================================

Usage:
To run this job in the foreground enter: csh beurf9.bat
To run his job and minimize output enter: csh beurf9.bat       > /dev/null
To run this job in the background enter: gbat beurf9.bat

NOTE: the list of commands above is the output of fixdrv deurf9.180
================================================================================
```