

GAMIT: Daily GPS processing

Lecture 2

Thomas Herring,
tah@mit.edu

GAMIT Overview

- Discuss the setup, operation and options for GAMIT processing with `sh_gamit`
- Areas:
 - Directory structures
 - Main functions in gamit: Programs called that run the gamit processing.
 - Files that are important in processing
 - Summary files
 - Residual plots
 - Problems that can happen and suggestions.

Basics

- The scripts that control gamit and globk all have built in help which can be evoked by typing name. (`~/gg/com` contains all of the scripts used; `~/gg/gamit/bin` and `~/gg/kf/bin` contain the program executables; kf programs also have help output. (gg is a link in your home directory that points to the directory with the gamit/globk software installed).
- Once the software is installed; user selects data to be processed over some interval of time and uses `sh_gamit` for the processing. Globk is used after the daily processing to combine results and set the reference frame.
- Everyone should have completed the installation of the software at this point. Running the example case is a good idea to make sure the installation is OK.

Overview of sh_gamit: Getting started

- To start sh_setup will create /tables, /rinex, /gsoln directories and then local specifics can be set.
 - in ./tables, process.defaults and sites.default are the two main files that need to be edited; sittbl. may also need editing to ensure some constrained stations in the network to be processed; sestbl. is edited if non-standard processing.
 - In ./tables, apriori coordinate file created (name in process.defaults). Additional coordinates are put into ./tables/lfile.
 - in ./rinex, local rinex files need to be copied in; rinex data in archives will automatically be downloaded
- sh_gamit -expt [expt-name] -s [yr] [start-doy] [stop-doy]
- Common options are: -netext -yrent

Directory Structure

- Top level: global tables and survey directories
- Within each survey directory:
/tables /rinex /igs /gfiles /brdc /gsoln /glbf
/day1 /day2 (these directories are created as needed) ...
- Generally 50-60 sites is the largest network processed in GAMIT; larger numbers of stations require sub-netting of sites (see netsel, global_sel and sh_network_sel).
- Tables are linked from day directories to experiment /tables and then to gg/tables
- GAMIT processing occurs in the day directories
- GLOBK processing occurs in /gsoln

sh_gamit internal operation:
The following programs are run by the script.

- *makexp* and *makex* prepare the data
- *fixdrv* prepares the batch control files
- *arc* integrates GPS satellite orbits
- *model* calculates theoretical (modeled) phase and partial derivatives of phase with respect to parameters
- *autcln* repairs cycle slips, removes phase outliers, and resolves the wide-lane ambiguities
- *solve* estimates parameters via least squares, resolving the narrow-lane ambiguities and creating an h-file for globk (user constraints are removed in the h-file to allow reference frame definition)

Steps in the standard GAMIT batch sequence

- *arc, model, autcln, solve* for initial solution
 - 5-minute sampling, no ambiguity resolution (GCR only)
 - update lfile. for coordinates adjusted > 30 cm
 - look at --> autcln.prefit.sum, q<expt>p.ddd
- *model, autcln, solve* for final solution
 - 2-minute sampling, ambiguity resolution
 - Look at --> autcln.post.sum, q<expt>a.ddd
- Final solution repeated if nrms reduced by > 30% from initial solution, to assure good editing and linear adjustment of parameters (original final-solution files overwritten)

Files you need to worry about

RINEX files – local plus list in sites.defaults

Control files

process.defaults – minor edits for each survey

sites.defaults – sites to include/omit; source of metadata

sestbl. – unchanged for most processing

sittbl. – sites constrained for ambiguity resolution

globk_comb.cmd – use_site, apr_neu, apr_svs, apr_wob, apr_ut1,
sig_neu, mar_neu

glorg_comb.cmd – apr_file, pos_org, stab_site

A priori coordinates (apr-file, l-file)

Meta-data (station.info)

Differential code biases (dcb.dat) – download current values 1/month

Satellite characteristics (svnav.dat) – download current w/ each new launch

Files provided or created automatically

- Satellite orbits
 - IGS sp3-files (tabular) and/or g-files (ICs for GAMIT)
 - ARC integrates to get t-files (tabular)
- Earth Orientation Parameters (ut1., wob.) - downloaded if needed for current day
- Leap-second file -- linked to gg/tables (update ~yearly or when leap second)
- Satellite clock (j-) files – from RINEX navigation (brdc) file
- Rcvr/ant characteristics (rcvant.dat, hi.dat) – linked to gg/tables
- Differential code biases (dcb.dat)—update ~monthly
- Antenna phase center models (antmod.dat) – linked to gg/tables (also needs to be updated when new antennas added).
- Luni-solar ephemerides and nutation (soltab., luntab., nutabl.) linked to gg/tables (need to update yearly)
- Ocean tide grid (optional) – linked to gg/tables
- Atmospheric loading grid (optional) – need to update yearly
- Mapping function grid (optional) – need to update yearly

Options for metadata (station.info)

- Pre-prepared station.info (make_stnfo, sh_upd_stnfo)
 - Must set xstinfo in sites.defaults
- RINEX headers (sh_gamit default: may change soon)
 - Update station.info unless an entry already exists for the day being processed or stinf_unique is set to -u in process.defaults and entry has not changed
 - Can be used with non-standard receiver and antenna names specified in guess_rcvant.dat (ideally your rinex files have the IGS official receiver and antenna names. It is critical that this information is correct.

A priori coordinates (sh_gamit)

- Create l-file in day directory by merging existing lfile. and apr_file from ../tables (apr_file has priority)
- If site not found in l-file
 - Use RINEX header coordinates (use_rxc=Y in process.defaults, good for modern (post SA, in 2000) data.
or
 - Use pseudorange data in RINEX file to estimate point position or differential position relative to a site in sites.defaults (use_rxc=N, default)
- During the sh_gamit run, the coordinates are updated (and copied to ../tables/lfile.) if they are in error by > 30 cm

Ambiguity resolution

- (L2-L1) integers resolved by autcln and passed to solve in the n-file (LC_AUTCLN option)
 - weak dependence on geometry
 - need current differential code bias file dcb.dat
 - use LC_HELP for codeless data (before ~1995) or if problems (default max distance is 500 km)
- Narrow-lane (L1) resolved by solve
 - strong dependence on phase noise and models
 - 5-10 cm constraints on a priori coordinates usually sufficient

sh_gamit_ddd.summary (email)

- Contents (Purple is output):

```
Input options -d 2002 30 31 32 33 -expt ncar -pres ELEV -yrextr -netext a
Processing 2002 031 GPS week 1151 4 Raw 2
/data51/tah/SENH02/glob02/suomi/2002_031a
Disk Usage: 12678.4 Free 76447.4 Mbyte. Used 15%
```

Summary Statistics (from *autcln*)

```
Number of stations used 4 Total xfiles 4
```

```
Postfit RMS rms, to and by satellite
```

```
RMS IT Site All 01 02 03 04 05 06 07 08 09 ...
```

```
RMS 20 ALL 4.8 4 5 6 5 5 4 5 4 5 ...
```

```
Best and Worst two sites:
```

```
RMS 20 TMGO 3.2 3 3 4 4 4 3 3 3 4 ...
```

```
RMS 20 SA09 4.6 4 4 5 4 5 4 4 4 5 ...
```

```
RMS 20 PLTC 5.4 4 5 5 6 5 4 5 5 6 ...
```

```
RMS 20 SA13 5.5 5 5 6 5 5 5 5 5 6 ...
```

sh_gamit_ddd.summary (email)

- Solution statistics from *solve*

Double difference statistics

```
Prefit nrms: 0.31280E+03      Postfit nrms: 0.21324E+00  Constrained free
Prefit nrms: 0.31185E+03      Postfit nrms: 0.21818E+00  Constrained fixed
Prefit nrms: 0.31272E+03      Postfit nrms: 0.20470E+00  Loose free
Prefit nrms: 0.31185E+03      Postfit nrms: 0.20756E+00  Loose fixed
```

Number of double differences: 12447

Numbers of WL and NL biases 120 Percent fixed 95% WL 85% NL

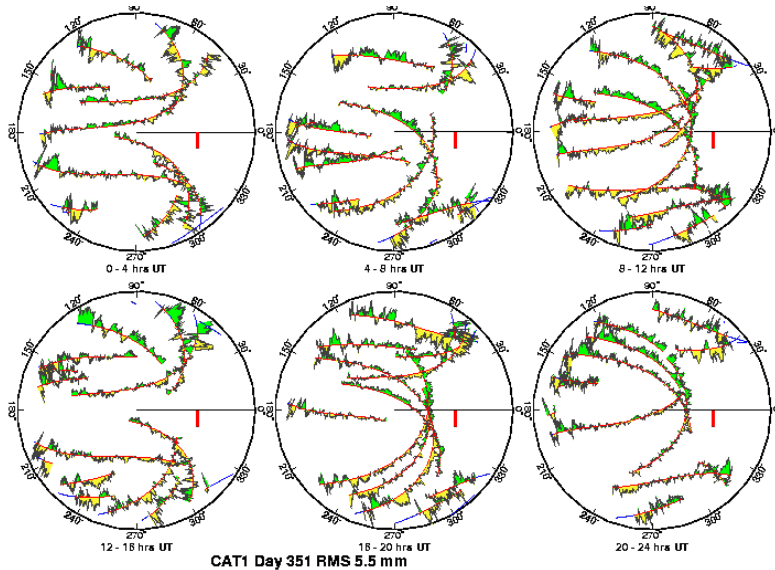
Any large adjustments to positions (>0.3 m)

Things to note:

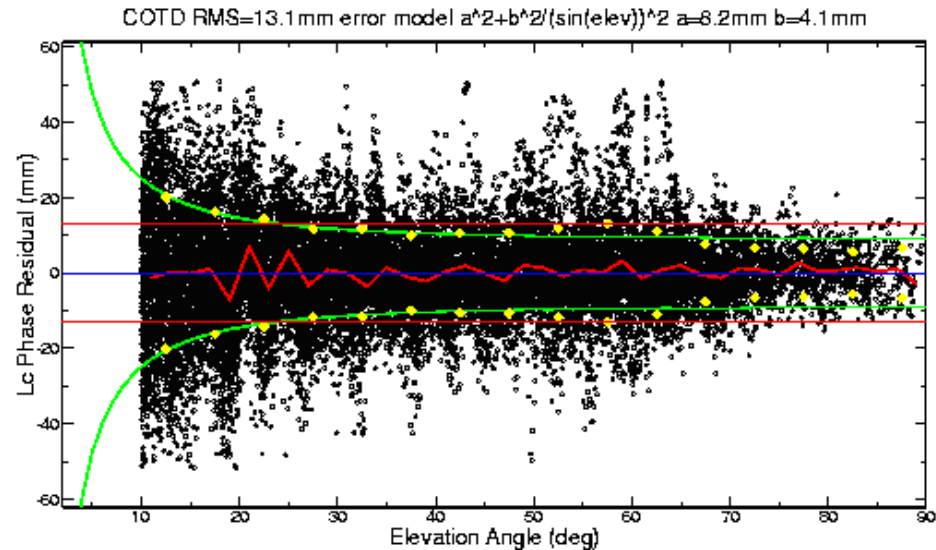
- Number of stations matches expectation
- Site postfit RMS values 3-10 mm
- No stations with RMS = 0 (implies no data retained by *autcln*)
- Postfit nrms from *solve* ~0.2 for constrained and loose solutions
- “Most” ambiguities resolved (70-85% for noisy days, > 90% for best)

Phase Residual Plots

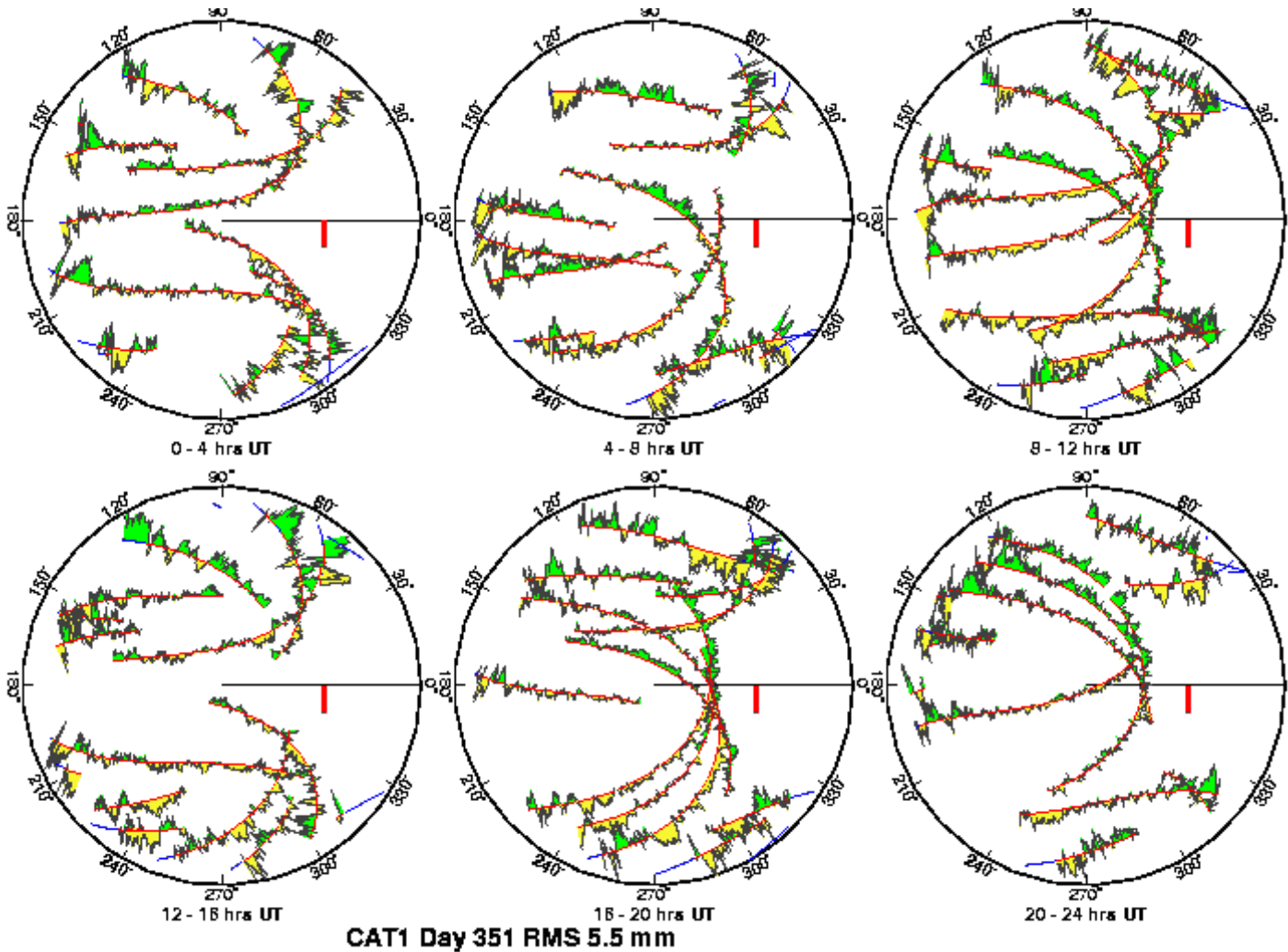
- Set with `-pres elev` in `sh_gamit` command line (requires GMT)
- Postscript files in day directory, by default converted to gif in `/gifs` directory and then erased (needs ImageMagik convert program).
- Use to assess multipath, water vapor, and antenna phase center model



“Sky plot”



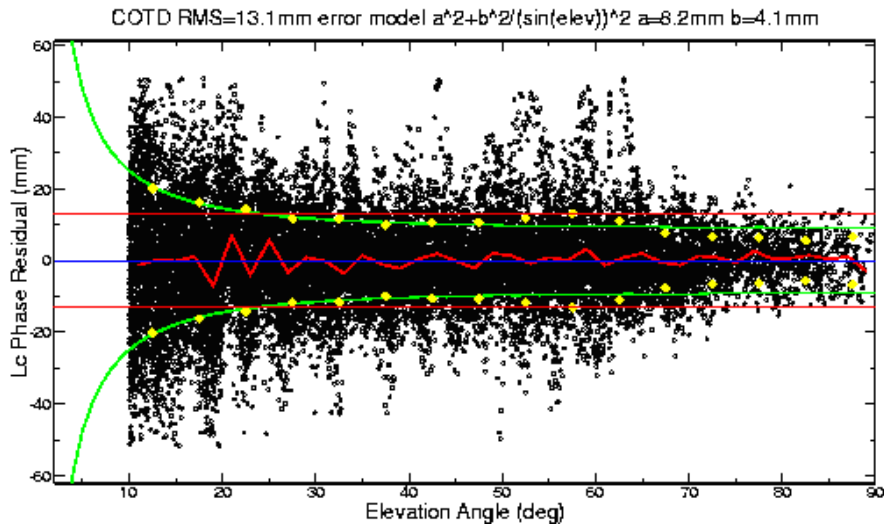
Phase vs elevation angle



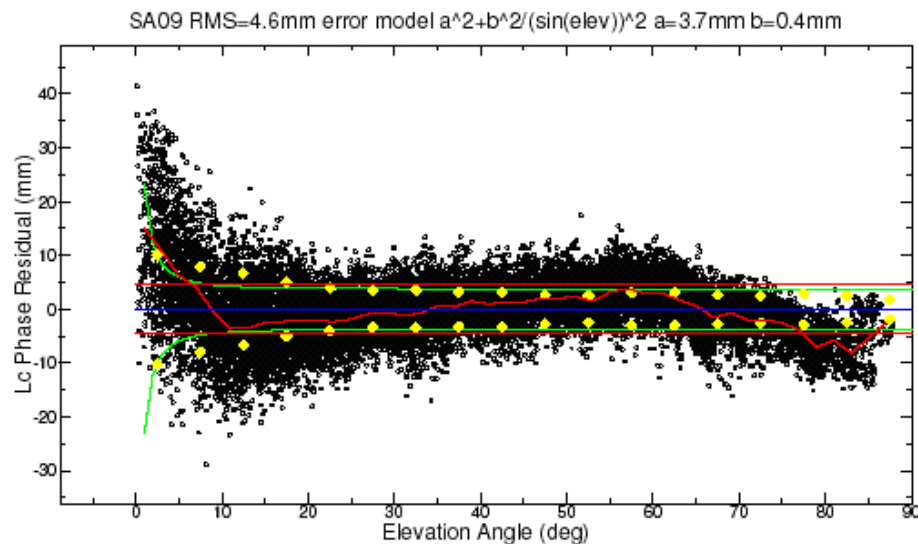
High residuals in the same place at different times suggest multipath

High residuals appearing in a given place only at one time suggest water vapor

Phase vs elevation angle



Normal pattern: bands are high-frequency multipath; red is smoothing of individual values, showing no strong systematics. Mid-elevation angle noise could be atmospheric delay errors?



Bad pattern: systematic signature of smoothed values indicates a poor model of the antenna phase pattern (perhaps a misidentified antenna in station.info)

Green lines show the elevation-dependent noise model shown at top and used to reweight the data in solve

What can go wrong?

- Site missing (not listed)
 - no RINEX data within session span: check RINEX file and/or makex.expt.infor
 - too few data, x-file too small and not used: check RINEX file size, change minxf in process.defaults
- Site in solution but no data or adjustment
 - a priori coordinates > 10 m off: check range rms in autcln.prefit.sum,
 - run sh_rx2apr differentially for several RINEX files
 - bad receiver: examine RINEX files or initial c-files with cview
- Q-file nrms > 0.2
 - solution over-constrained: check GCX vs GLX nrms, rerun with only one site constrained

Problems with a priori coordinates

- Need to be good to < 10 m to get through autcln
- Safest source is a previous solution or a pseudorange solution using svpos/svdiff (sh_rx2apr)
- Range rms and bias flags added from autcln summary file are a useful check
- Convergence is 1:100 to 1:1000 (1 m error in apr can lead to 1-10 mm error in adjustment)—hence automatic update of L-file for GAMIT 2nd solution
- Watch for repeated updates in email summary as a sign of bad data

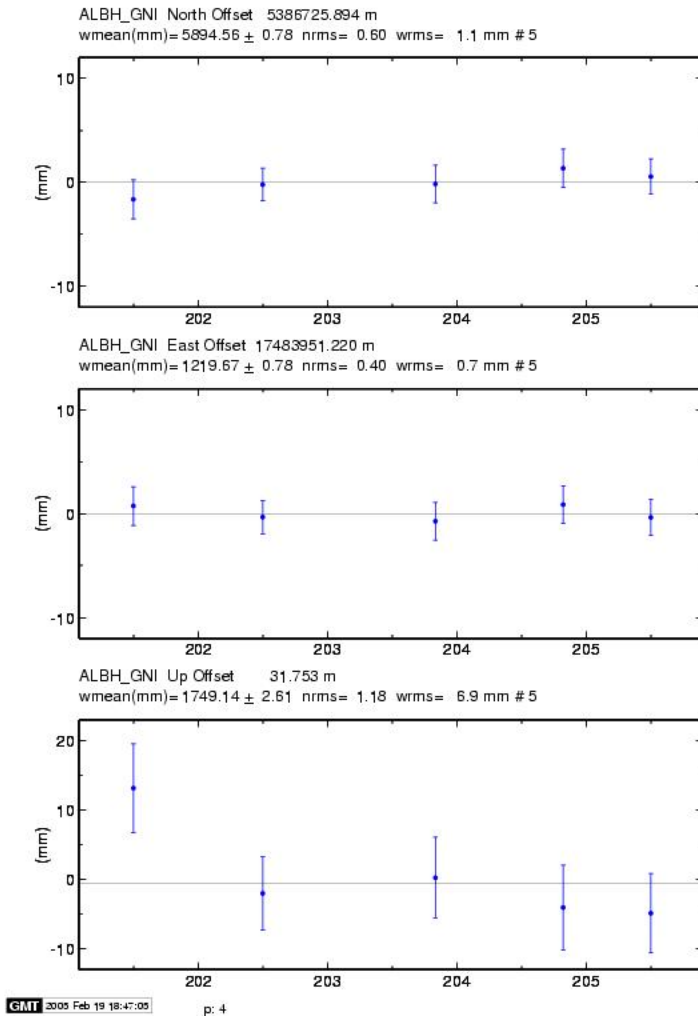
Constraining the GAMIT solution

- Minimal (single-station) constraint is all that's needed for ambiguity resolution, but sirtbl. can list several to assure one
- Orbits can be fixed or tightly constrained (.005 ppm) for IGS orbits since at least 1996. Use of baseline mode (no orbit estimated now recommended for regional processing.
- Look for good (~ 0.2) loose (GLR/GLX) nrms but elevated constrained nrms (GCR/GCX) as indication of an over-constrained solution

More Subtle Problems

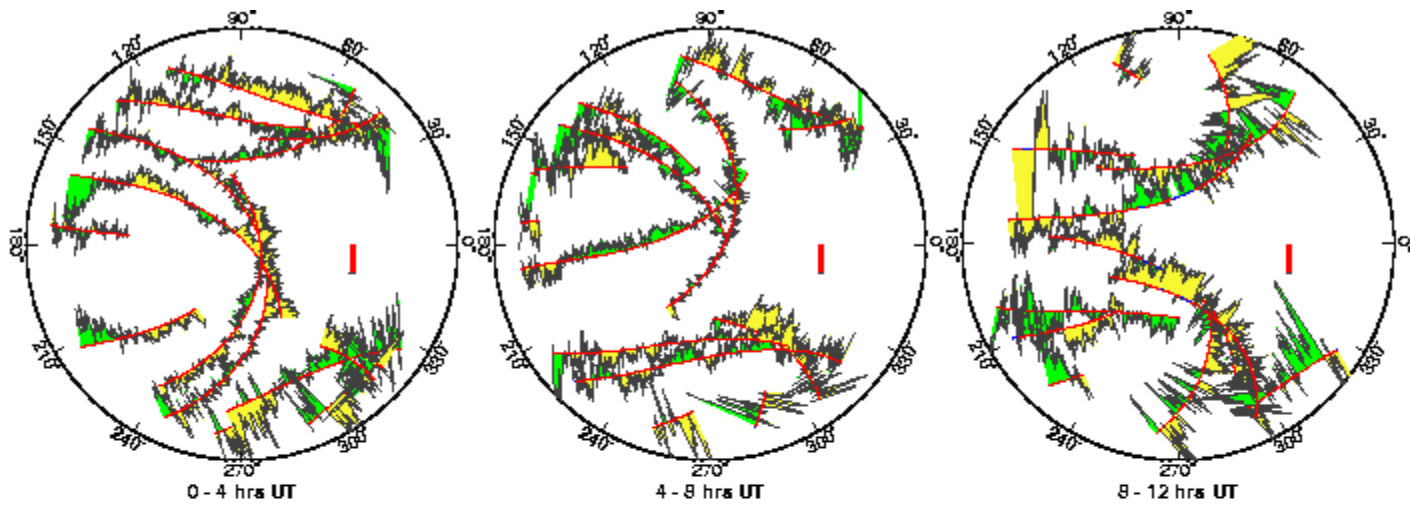
- Site with high rms in autcln.post.sum
 - high multipathing or water vapor: check sky plots of phase
 - bad receiver: examine RINEX files or initial c-files with cview
- Phase vs elevation angle plot large and systematic
 - misidentified antenna (wrong PCV model)
 - coupling between antenna and mount (discussed during height section)
- GAMIT results within normal range but time series shows outlier
 - survey-mode: antenna not leveled and centered over mark
 - change in multipath (water, objects) or water vapor
 - snow on antenna
 - incorrect ambiguity resolution (east component except for high latitudes)

Example of understanding outliers

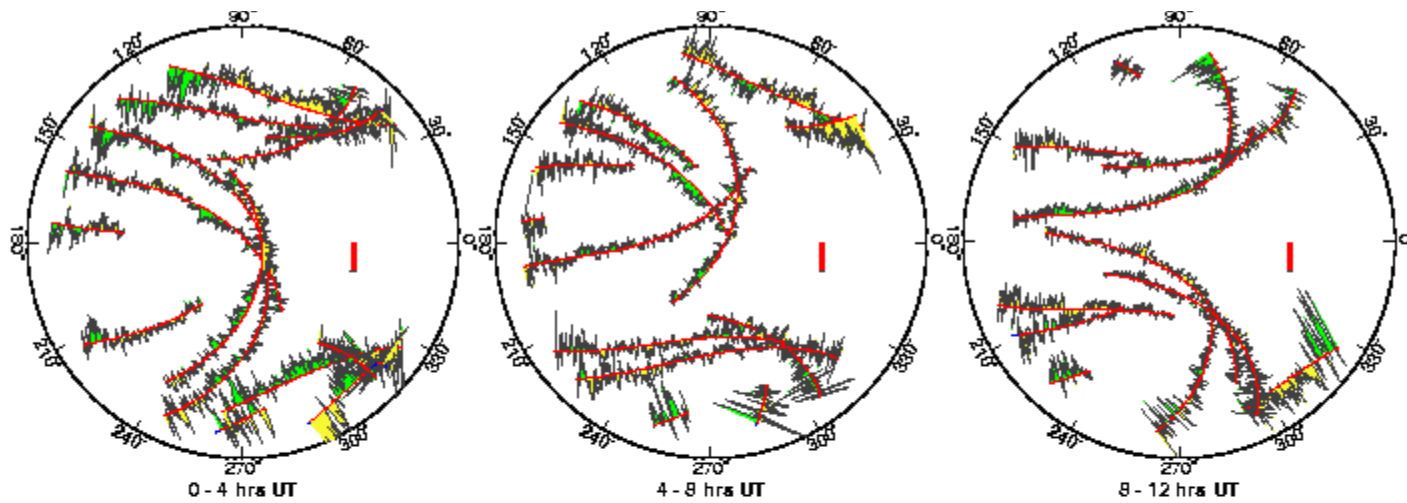


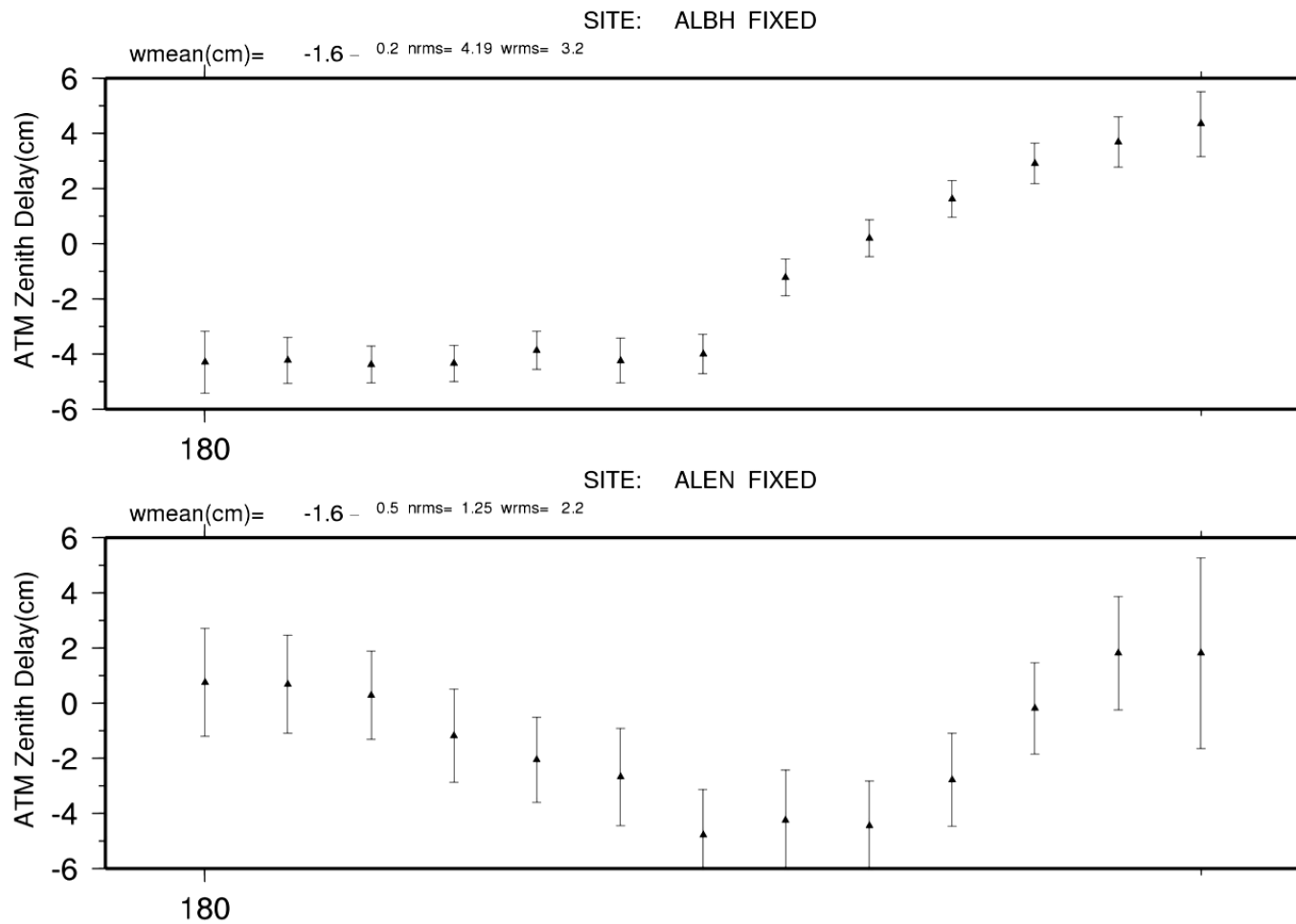
- *Autcln rms*
- Day 201 9.6 mm
- Day 202 6.0 mm
- Notice height outlier on Day 201

ALBH 2003 Day 201



ALBH 2003 Day 202





GPS adjustments to atmospheric zenith delay for 29 June, 2003; southern Vancouver Island (ALBH) and northern coastal California (ALEN). Estimates at 2-hr intervals.

Summary

- The `sh_gamit` script is used to automate processing and once set-up usually operates with no human interaction.
- In tutorial session, we will set up run to illustrate operation.