GAMIT: Daily GPS processing
Lecture 2

Thomas Herring,
tah@mit.edu

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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.

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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.
- Once 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.

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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 -yrext

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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

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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)

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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)

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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

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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

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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.

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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

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Ambiquity resolution

- (L2-L1) integers resolved by autcln and passed to solve in the n-file   (LC_AUTCLN option)
  - weak dependence on geometry
  - need current dcb.dat file
  - 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

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sh_gamit_*ddd*.summary (email)

- Contents (Purple is output):

Input options –d 2002 30 31 32 33 –expt ncar –pres ELEV –yrext –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 …

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sh_gamit_*ddd*.summary (email)

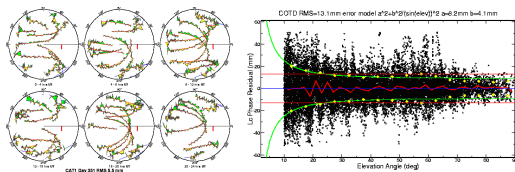- Solution statistics from *solve*

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   Perscent fixed 95% WL 85% NL
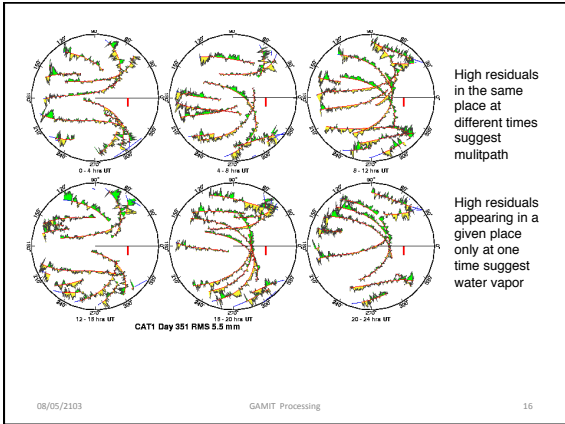Any large adjustments to positions (>0.3 m)

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)

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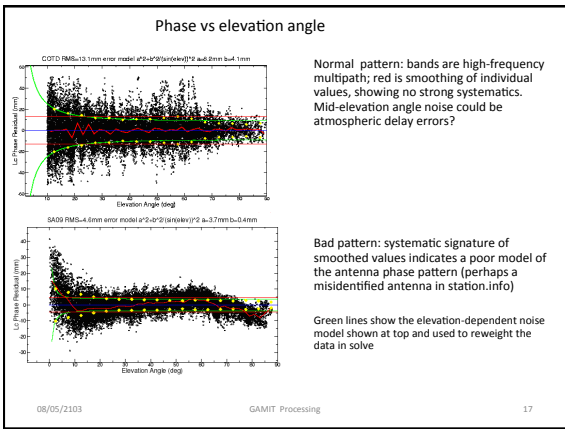
- Set with -pres elev in sh_gamit command line (requires GMT)
- Postscript files in day directory, by default converted to gif in /gifs directory and then erased (needs ImageMagik convert program).
- Use to assess multipath, water vapor, and antenna phase center model

"Sky plot"   Phase vs elevation angle

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High residuals in the same place at different times suggest mulitpath

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

CAT1 Day 351 RMS 5.5 mm

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Phase vs elevation angle

COTD RMS=13.1mm error model a*2+b*2(sin(elev))*2 a=8.8mm b=4.1mm

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?

SA09 RMS=4.6mm error model a*2+b*2(sin(elev))*2 a=3.7mm b=0.4mm

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

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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

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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

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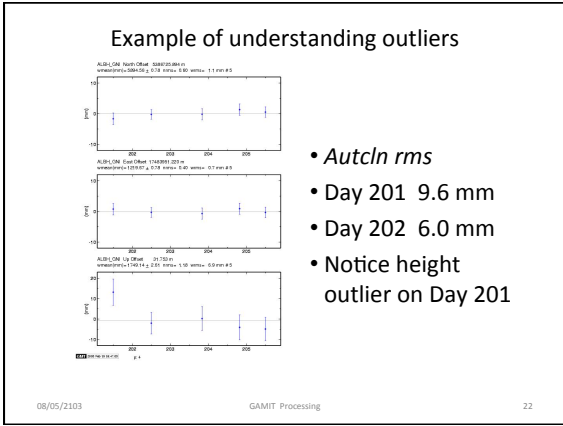## Constraining the GAMIT solution

- Minimal (single-station) constraint is all that's needed for ambiguity resolution, but sittbl. 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
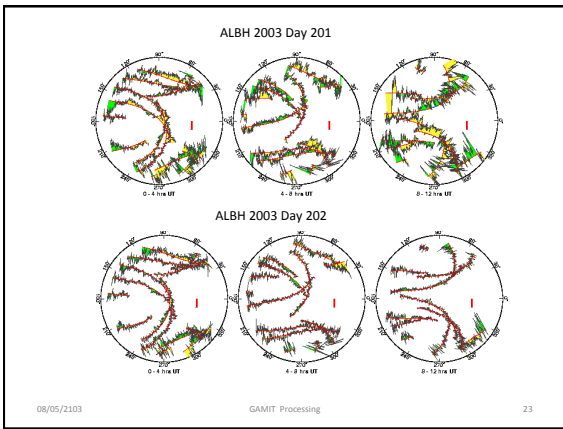
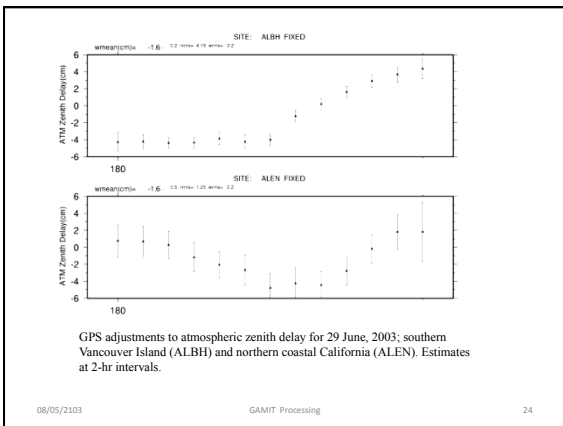08/05/2103   GAMIT Processing   20

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)

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Example of understanding outliers

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

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ALBH 2003 Day 201

ALBH 2003 Day 202

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SITE: ALBH FIXED

SITE: ALEN FIXED

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

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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.

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