Outline

- Recap
- Tutorial
- Example
  - What parameters did we use?
  - What results did we get?
  - What could we have done better?
- Where do we go from here?
Previously in geodesy seminar...

- **Ingredients:**
  - Rinex files for campaign stations
  - A few continuous stations for anchoring the solution
  - Log sheets
  - Tables

- **Simplified recipe:**
  - `sh_gamit` – obtain positions
  - `sh_glred` – compute repeatabilities
  - `globk` – velocities
Sources of error:

- Troposphere (mainly water vapor)
- Ionosphere
- Multipath
- Unmodeled motions of the station
- Misbehaving receiver
- Stabilization
Previously in geodesy seminar...
Previously in geodesy seminar...
Previously in geodesy seminar...
- Obtain daily positions
  - Choose continuous sites (as many as you can!)
  - Constrain solution for one station (or more, but be careful!)
  - Get good *a priori* coordinates for continuous and campaign stations
  - Iterative solution
GLRED/GLOBK

- GLOBK is a smoothing Kalman filter and can incorporate random walk process noise in its estimation (method for accounting for temporally correlated noise in time series).
- Combines daily solutions into survey average. Combines many years of data to generate position, velocity, offset, and postseismic parameter estimates. Not uncommon to have 10000 parameters in these solutions.
- GLRED and GLOBK are the exact same thing.
- To do most of the dirty work, GLOBK invokes GLORG.
Applies constraints.
Performs stabilization.
Aligns sites to chosen reference frame.
Computes covariance matrices for your Kalman filter.
For a small network, pos_org and rate_org: xtran ytran ztran, NOT xrot, yrot, zrot

To down-weight noisy segments or equalize continuous and survey-mode data in a combined h-file, can add random noise (units are m)
- sig_neu all .001 .001 .003
- sig_neu ankr .005 .005 .020 2002 10 1 0 0 2002 11 30 24 0
- sig_neu EMED0504 .010 .010 .1

To account for temporal correlations in time series we typically use random-walk (RW) process noise with the mar_neu command (units m²/yr)
This is a way of tying your solution to a reference frame.

Need 4 or more stabilization sites for estimating translation.

A stabilization site should have

- high quality data over the full span of your study
- coordinates well-known in ITRF2008, to tie your solution to the global network.

You can use sites that do not have well-known ITRF coordinates, if you are sure they are of high quality and you included them in your GAMIT solution.
Stabilization

- **stab_site**: list of sites used in stabilization.
- **stab_it**: number of iterations, and sigma-cutoff to remove a site.
Non-linear effects

- Earthquakes
- Non-documented effects
- Use eq_file to get updated position and velocity solutions.
- Make sure eq_file matches your data.

2010-04-04 $M_w$7.2
What can go wrong?

- **globk**
  - H-files not used: removed automatically for high chi2, coordinate adjustment, or rotation (max_chii command)
  - High chi2 increment: inconsistent data. Can be an issue when estimating orbits (RELAX mode) if MIT GLX file use different modelling (e.g. Albedo, gravity field)
  - Station “missing”: not present in h-file or renamed out (use glist)

- **glorg**
  - Stabilization fails: too-few sites in stabilization
  - Large uncertainties: poor stabilization
  - Too-small uncertainties for some stabilization sites: rotation parameters absorbing coordinate adjustment
  - High chi2 in equate: inconsistent data
  - Wrong velocity for equated sites: unmatched apriori
Where’s the fault?
Previously in geodesy seminar...
Velocities
Velocities

Missing sites?
What could we do better?

- Choose more continuous sites at the beginning.
- Include more sites with well-known a priori coordinates in stab_site list (4 or more).
- Add 0.5 of white noise to the continuous GPS estimates to avoid overweighting continuous GPS position estimates (sig_neu)
- Apply random walk to campaign solutions to approximate correlated noise. (mar_neu)
- Constrain campaign solution.
- Play with various parameters until it works.
### Velocities

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**VEL STATISTICS:** For 2 Sites WMRMS ENU 2.86 0.28 0.72 mm/yr NRMMS ENU 0.78 0.07 0.29 hw78.gsl
What’s up with these uncertainties?
Velocities

What are these arrows pointing to?
Reference Frames

- Align the estimated site positions and possibly velocities to a set of well-defined locations.
- By default, ITRF08 is used.
- Popular options for campaign GPS:
  - North American ref. frame
  - Regional ref. frame
  - Local ref. frame
- Apr files for certain ref. frames are included in GAMIT/GLOBK, you can specify them instead of ITRF.
- Use “velrot” to rotate velocities into a reference frame that you like.
What now?

- We need velocities in the fault-parallel direction to quantify deformation.
- Use velrot to rotate velocities to fault azimuth (46 degrees West).
Deformation across southern SJF

- Elsinore Fault
- Coyote Creek Fault
- San Andreas Fault
Questions