

Generating time series with `glred`

T. A. Herring M. A. Floyd R. W. King
Massachusetts Institute of Technology, Cambridge, MA, USA

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Material from R. W. King, T. A. Herring, M. A. Floyd (MIT) and S. C. McClusky (now at ANU)

sh_glred

- `glred` is just a way of invoking `globk` to process one day at a time; `sh_glred` is a script to invoke `glred` easily for a sequence of days
- Once you've run `sh_gamit` for a sequence of days, you will have on each day an h-file of loosely constrained parameter estimates and covariances. If you have appropriately constructed command files for `globk` (`globk_comb.cmd`) and `glorg` (`glorg_comb.cmd`) in `[expt]/gsoln/`, you can obtain time series using

```
sh_glred -expt [expt] -s [start yr] [start_doy] [stop yr] [stop doy] -opt H G T
```

which will translate the GAMIT plain text h-files into GLOBK binary h-files (H), run GLOBK (G) and run `sh_plot_pos` (T)

- The lectures on GLOBK, references frames and survey-mode GPS will guide you in constructing the command files, and there are self-guided templates to make this easy

Manual sequence

- `htoglb` (i.e. `sh_glred -opt H`)
 - Converts plain text h-files output from GAMIT to binary h-files (in `glbf/`) for input to GLOBK
- `ls`
 - Create list of binary h-files to process (in `gsoln/`)
- `glist`
 - Create chronological list of h-files to process and associated information
- `glred` (i.e. `sh_glred -opt G`)
 - Create “.org”-file(s) with individual solutions
- `sh_plot_pos` (i.e. `sh_glred -opt T`)
 - Create “.pos” (time series) file(s) and time series plots
- `globk`
 - Create combined (or velocity) solution
- `glorg`
 - Additional `glorg` runs for different reference frames

htoglb

- Creates binary h-files for input to GLOBK
 - All metadata etc. carried forward from GAMIT
- Not restricted to plain text h-files from GAMIT
 - May also use SINEX (Software INdependent EXchange format), GIPSY's "stacov" files, etc.
 - But beware of constraints implicit in solutions from other software/processing runs!
- For example, from glbf/

```
htoglb . /dev/null ../[0-3][0-9][0-9]/h*a.*
```

GLOBK checks

- List files to be processed by GLOBK, e.g. from gsoln/
`ls ../glbf/h*.glx > expt.glx.gdl`

- Run pre-processing checks using `glist`

```
glist expt.glx.gdl 201407_NSFBay.sum +1 ~/gg/tables/itrf08_comb.eq:A 201407_NSFBay.gdl
```

- This will also calculate if any over-lapping h-files should be combined with `glred` (e.g. multiple networks on the same day)
- Inspect any errors (e.g. site name clashes)

Create time series

- `glred` simply runs the main program, `globk`, once per interval (e.g. daily) to combine data over that interval into one solution and one effective time series point

```
glred 6 glred_20150811.prt glred_20150811.log 201407_NSFBay.gdl globk_long.cmd
```

- Assess solution by looking at “POS STATISTICS” lines
- Old example using `sh_glred` with “`-opt E`” creates:
 - “mb”-files (time series) with `multibase`
 - “psbase”-files (PostScript) with `sh_baseline`
- Updated, preferred method is `sh_glred` with “`-opt T`”:
 - `tssum` to create “.pos”-files (time series)
 - `sh_plot_pos` to create PostScript plots
 - “.org”-file may be input to `sh_plot_pos`, which will run `tssum` for you, e.g.
`sh_plot_pos -f glred_YYYYMMDD.org -d figs ...`

Time series solution files

Old scheme

- “.org”-file
- ensum
 - “VAL”-file (time series values)
 - “SUM”-file (statistics)
- multibase
 - “mb”-files
- sh_baseline
 - Time series plots

→ sh_plotcrd

Current scheme

- “.org”-file
- tssum
 - “.pos”-files
 - tsfit
 - “.res”-files
- sh_plot_pos
 - Time series plots

sh_plot_pos ←

Recommended strategy for stabilization

- In the template files, `globk_long.cmd` and `glorg_long.cmd`:
 - default apr-file is `~/gg/tables/itrf08_comb.apr`
 - default eq-file is `~/gg/tables/itrf08_comb.eq`
 - default stab-file is `~/gg/tables/igb08_hierarchy.stab_site`
- `itrf08_comb.apr` is a combined apr-file, using many publicly available coordinate sources, all aligned to ITRF2008
- `itrf08_comb.eq` is the associated eq-file with defined discontinuities
 - equipment changes
 - earthquakes
 - etc.
- `igb08_hierarchy.stab_site` uses the established IGS core network hierarchy to choose stabilizing sites, e.g.
 - “`stab_site DRAO/BREW/NANO/ALBH/HOLB`” means use DRAO if available in the solution (e.g. h-files), otherwise use BREW if available, otherwise use NANO, etc.
- Equivalent files for ITRF2014 (“`itrf14...`”, “`igs14...`”) now available

Inspect consistency of stabilization statistically

- It is a good idea to have thought about your reference frame stabilization when setting up your experiment, e.g. sites.defaults, before running `sh_gamit`
- Desire as many well-defined (e.g. IGS) sites as possible for redundancy
 - Recommended to use some of the sites (preferring the first column) in `~/gg/tables/igb08_hierarchy.stab_site` when selecting your processing network, e.g. additional sites listed in your sites.defaults
 - But remember trade-off with processing time, e.g. processing time scales proportionally to n^3

```
grep '^POS S' glred_20150811.org
```

```
POS STATISTICS: For 51 RefSites WRMS ENU 2.15 2.55 6.19 mm
NRMS ENU 0.71 0.84 0.63 L0104260000_tgla.glx

POS STATISTICS: For 54 RefSites WRMS ENU 2.17 2.42 6.03 mm
NRMS ENU 0.74 0.80 0.63 L0104270000_tgla.glx

POS STATISTICS: For 50 RefSites WRMS ENU 2.12 2.25 6.34 mm
NRMS ENU 0.71 0.75 0.67 L0104280000_tgla.glx

POS STATISTICS: For 54 RefSites WRMS ENU 2.19 2.31 5.23 mm
NRMS ENU 0.80 0.81 0.58 L0104300000_tgla.glx

POS STATISTICS: For 54 RefSites WRMS ENU 1.83 2.17 6.34 mm
NRMS ENU 0.64 0.75 0.68 L0105010000_tgla.glx

POS STATISTICS: For 54 RefSites WRMS ENU 2.09 2.63 6.47 mm
NRMS ENU 0.80 0.98 0.75 L0105020000_tgla.glx
```

“.pos”-files

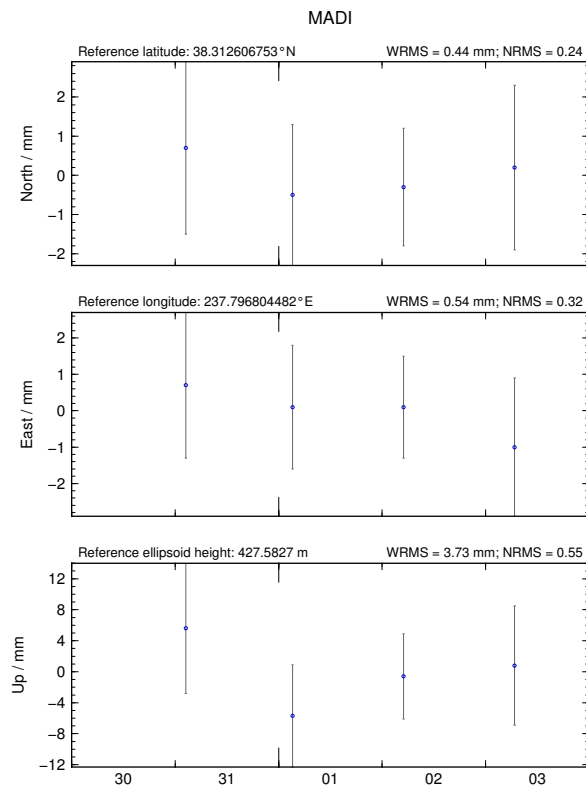
- These contain your time series solution
- Long format in various coordinate systems
 - Geocentric (X, Y, Z)
 - Geodetic (lon., lat., height)
 - Local (east, north, up)
- Can be input to `tsfit` (interactive version of GGMatlab tool “`tsview`”), `sh_cats` (requires CATS) and `sh_hector` (requires Hector)
- Both “.pos”-files and “.res”-files can be plotted with `sh_plot_pos`

sh_plot_pos

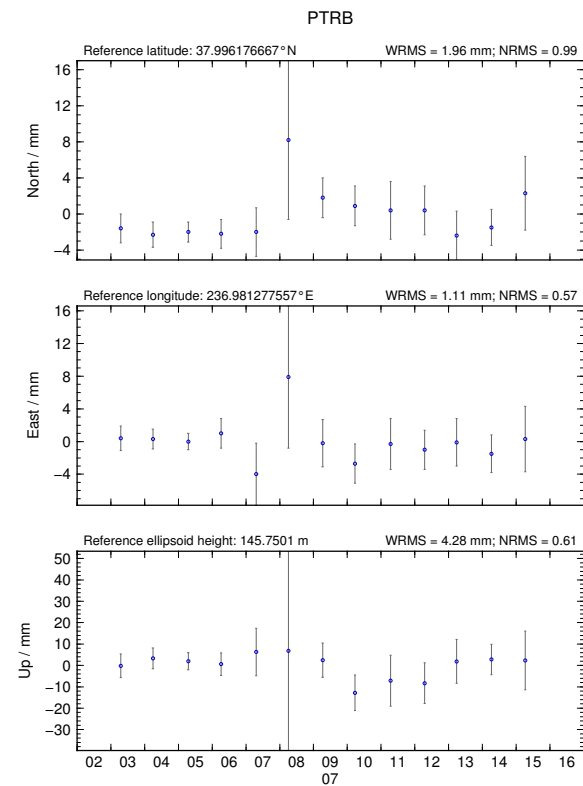
- Uses GMT and has many features including options to:
 - Read in “.org”-files, “.pos”-files (output of tssum) and “.res”-files (output of tsfit) [-f option]
 - Run tsfit (GLOBK’s curve-fitting module) on input “.pos”-files [-t option]
 - Calculate basic statistics (e.g. WRMS, NRMS)
 - Add vertical lines at epochs specified by renames, earthquakes or user [-b, -e and -l options, respectively]
 - Specify fixed start and end times of time series [-t1, -t2 options]
 - etc.

Inspect consistency of time series

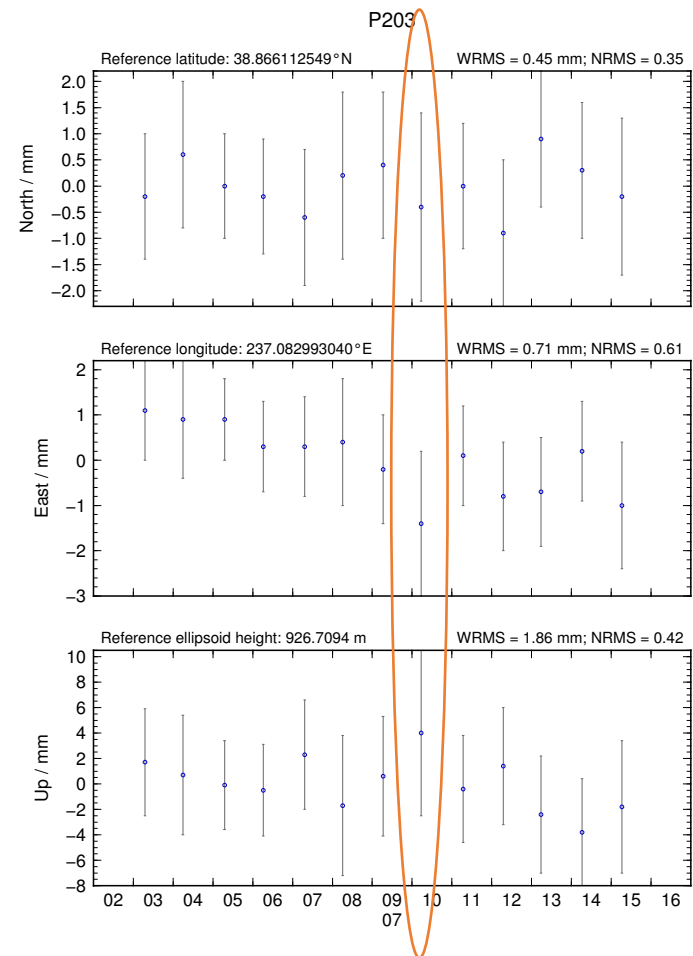
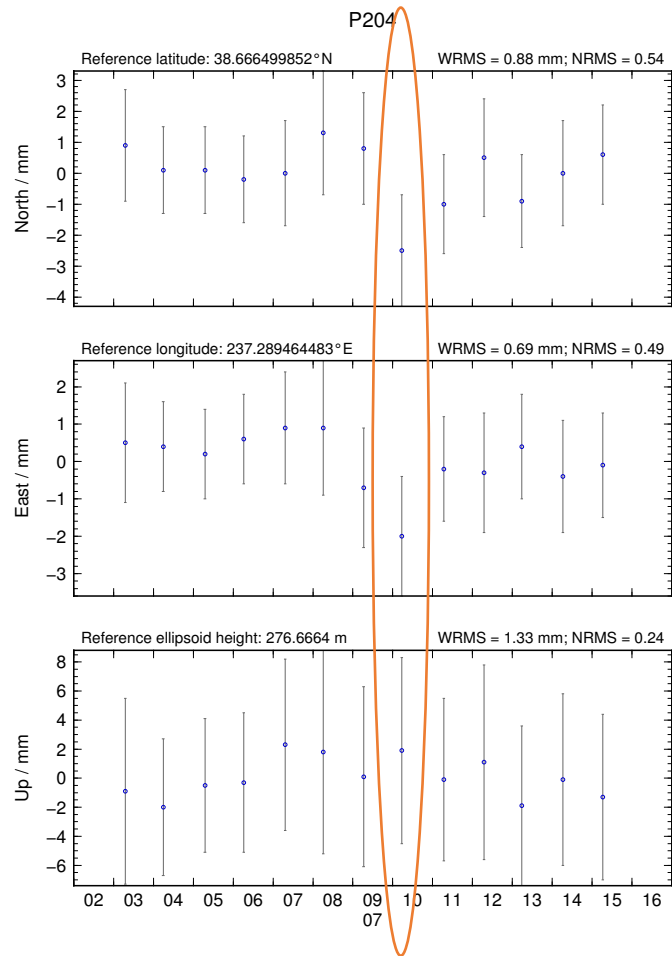
Good repeatability



Outlier



Some “outliers” may be stability issues



Excluding outliers or segments of data

- Create “rename” file records and add to GLOBK command file’s “eq_file” option, e.g.

```
rename PTRB      PTRB_XPS h1407080610_nb4a
rename PTRB      PTRB_XPS 2014 07 07 18 00 2014 07 08 18 30
rename ABCD      ABCD_XCL 2013 07 08 00 00
```

- “XPS” will not exclude data from `glred` (so still visible in time series) but will exclude data from `globk` (combination or velocity solution)
- “XCL” will exclude data from all `glred` and `globk` runs

Iterating your solution

- First time series may only be stabilized by previously well-defined sites, e.g. ITRF sites
- Once a high-quality position (and velocity) estimate for a previously unknown or new site is available, we can use all sites to stabilize
- This approach may be used with both time series (e.g. `glred`) and velocity (e.g. `globk`) solutions

Short- v long-term time series

- Exactly the same procedure is used for short (e.g. survey) and long (e.g. years of continuous data) time series
- The only difference may be the number and type of input h-files, e.g.
 - Daily survey h-files (short-term time series)
 - Combine into one solution (short-term position combination)
 - Several combined survey files over years (long-term time series)
 - Several combined survey files over years (long-term velocity combination)

tsfit and tsview

- `tsfit` is the command-line tool for fitting time series and generating statistics
 - Input “.pos”-files, optionally eq-files
 - Fits linear rate and choice of common parameters
 - Periodic terms
 - Discontinuities and earthquakes
 - Post-seismic decays
 - Outputs
 - statistics of fit
 - standard (position and velocity) apr-files
 - extended (periodic, logarithmic decay, etc.) apr-files
 - Residuals to fit (“.res”-files)
- `tsview` is an alternative that, via a MATLAB interface, allows interaction

Summary

- `sh_glred` is post-processing equivalent to `sh_gamit`
- `.pos`-file format now standard GLOBK output for time series
- Visual inspection of time series very important for identifying outliers, bad segments of data or other problems like incompatible site IDs
 - `sh_plot_pos` (GMT) and `tsview` (MATLAB)
 - Populate `eq`-file(s) with “`rename`” commands or use “`sig_neu`” commands to mitigate impact of poor or incompatible data points during velocity
 - Be aware that some “outliers” may be stabilization issues if they persist across a large part or all of a network at the same time, so check stabilization using “`POS STATISTICS`” lines in `.org`-file(s)
 - Numbers of stabilizing sites should be consistent and at least as many as the number of parameters estimated in `glorg` (e.g. three components of rotation and translation)
 - Numbers for `wrms` should be consistent from day-to-day and small (< 5 mm)
- Batch tools are available for longer, denser, continuous time series where point-by-point visual inspection is unreasonable
 - `tsfit` and `tsview`