

Track Tuning

Lecture 08

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Track Output Files

- Track outputs progress directly to the screen and this output can be re-directed with `>` to a file. (Generally `track_xxx.out`)
- Summary file (`track.sum` by default)
- Position files (`NEU,GEOD,DHU,XYZ`)
- Phase residual files (optional)
- Wide-lane value files: (optional, sometime useful if cycle slip missed)
- Meaning of output entries discussed in help file.

Summary file

- This file is a short summary of the run. It lists
 - files and parameters that were used for the run
 - Process noise values
 - Any editing specified by the user
 - FINAL bias flag report. The Fixd column indicates if the bias was fixed (denoted by value 3).
 - Summary of residual scatter as function of site and satellite and versus elevation angle (These are RMS differences from fixed station)
 - Generally residual RMS should be less than 10 mm although values up to 20 mm can be OK.

Output file from track

- Track outputs extensive information during its run.
 - The initial output is status during reading of the rinex files. Errors in the files are reported here and a summary of satellites seen.
 - Most common problem here is no sampling rate given in rinex file. Command INTERVAL needs to be used.
 - An initial pseudorange solution establishes the trajectory of the kinematic sites and statistics on differences from apriori coordinates and RMS scatter of trajectory are given.
 - Bias flags being added due to jumps in wide-lanes are reported.
 - Bad apriori coordinates can lead to BAD PREFIT data (see site_pos)

Output continued

- Summary of Bias flags needed with estimates of numbers of cycles. These are reported by site, satellite and epoch range. Initial set are labeled INITIAL.
- Estimates of mean MW-WL and Mean Ionospheric delay (EX-WL) along with sigma estimates are given. (A correlation time is assumed in the sigma calculation).
- Dependences of biases are given with the 'DD bias refs' entries. Although listed as one ways, values are double differences.

Output continued

- Iteratively, track tries to resolve the ambiguities to integer values.
 - Floating point estimates of the biases as they are estimated.
 - RMS fit of the double difference residuals
 - Any bad double differences are reported and removed (repeating values can be indication of missed cycle slip).
 - Bias flag fixing report: Fix column (T or F) indicates if bias was successfully fixed. The Fcode column indicates why it was not fixed.
- This sequence is repeated until an iteration when no new biases are fixed.
- The final position estimates are then computed and output in the requested formats.

Fcode Interpretation

- For float_type LC the Fcode is
- S -- Floating point estimate sigma too large (Sig Limit)
- W -- MW WL sigma too large
- R -- Relative rank not large enough
- C -- Chi**2 increment too large for the best choice of ambiguities
- O -- One other bias in the double differences not fixed yet.

```
* BF S PRN Epoch Range F Estimate dLC Sig Limit Relative Rank Fix Fcode Change L1 L2 Residual L1 L2 Fits Best LC WL LG
175 5 PRN 15 1 43 1 1.86 +- 0.24 SL 0.25 RR 2.36 F F --R-- dL1,2 3 3 dL12 0.31 -0.08 Fits 11.7 0.8 0.3 105.7
48 2 PRN 07 1 429 1 -0.16 +- 0.74 SL 0.25 RR 9660.51 F F S--O dL1,2 0 0 dL12 -0.28 -0.02 Fits 0.4 0.1 0.1 2.1
```

Improving ambiguity resolution

- The Fcodes can indicate how to fix ambiguities that track by default is not able to fix.
- Common fixes:
 - S and W indicate that the estimated sigmas on the float estimates and/or MW-WL are too large. If the relative ranks are large, the the sigma tolerances can be increased with the Float_type command,
 - If ambiguities seem to have the same value then user_delbf can be used to remove an extra one but care should be taken because some receivers can have 1/1 L1 L2 cycle slips.
 - Chi-squared increments may be too large (especially LG (ionosphere) and sometime WL so by down weighting in the float_type command, relative rank can be improved.

Input ionospheric delay model

- Version 1.26 and greater of track have the ability to read a gridded ionospheric delay model. The format of this model is expected to match the current IGS global ionospheric models available from cddis.gsfc.nasa.gov in the `gps/productions/ionex/<yyyy>/<ddd>` directory.
- Command
IONEX_FILE <file name>
invokes the features. The EX-WL estimates are affected by this model and its inclusion should help ambiguity resolution on long baselines (>100 km).

Use of input ambiguity file

- For certain analyses, it can be useful to manually supply ambiguity file to track using either the `-a` option or the `amb_file` command.
- The ambiguity file can be generated by `grep`'ing `FINAL` in the track summary or output file and re-directing into an

Other tunable parameters

- Process noise to be used on the atmospheric delay is variable
 - If noise is too large, then height estimates and atmospheric delay estimates are highly correlated
 - If noise is too small, then atmospheric delay variations map into height variations
 - For aircraft, track now has process noise that depends on the rate of change of altitude.
 - Units of process noise are random-walk change in meters per unit time (standard deviation grows as square of number of epochs), where the default unit time is the sampling interval, but the unit can be set with the `time_unit` command

Track Commands: “Rules”

- Track command files share the properties as globk command files:
 - All command lines must start with a less one blank space; arguments are separated by spaces
 - Order of commands is generally not important except that later versions of a command replace the previously assigned arguments
 - Site dependent commands in track issue the command name first and then lines that contain station names and arguments (all is a valid name).

Track commands

(The @ denotes at least one blank in the lines below).

@ OBS_FILE

@ Site RX_file Type

Command gives the site 4-char codes and the corresponding rinex file name. The

<Type> is set to F for a fixed site, and K for a kinematic site.

e.g.,

obs_file

bish bisha289.97o F

t39a t391a289.97o K

Track Commands

@ NAV_FILE <name> <SP3/NAV>

Gives the name of the SP3 or NAV file with orbits and clock information (e.g., igs SP3 files).

When processing 24-hours of data, SP3 files from the preceding and postceding days should be concatenated together (headers removed at the day boundaries).

e.g.,

```
nav_file igs09274.sp3 SP3
```

(GAMIT program doy can be used to get GPS week and day number from calendar date).

If NAV is used as the type then a broadcast ephemeris file is used.

Track Commands

@ MODE <Type>

The MODE command allows the setting of defaults for the type of data being processed. These settings can then be overwritten if desired by use of the commands below. Three default setting modes are supported for <Type>:

AIR -- Assumed to be high-sample rate aircraft. Sets the analysis_type to LC, and allows gaps of 4-epochs, and minimum data of 120 epochs (1 minute for 2Hz data).

SHORT -- Short baseline static data (<1 km). Sets analysis type to L1+L2 and minimum data of 20 epochs (10 minutes of 30 second sampled data). Data is still processed as kinematic data.

LONG -- Long baseline static data (>1 km). Sets search and analysis type to LC and minimum data of 20 epochs. Atmospheric delay estimation is turned on with 0.1 m a priori sigma, and process noise variance of $1.0 \times 10^{-6} \text{ m}^2/\text{epoch}$ (~1 mm changes every 30 seconds for 30 second sampled data which accumulates to +/- 5 cm in a day). These settings are the same as atm_stats 0.1 0.001

Track Commands

@ SITE_POS

@ Site <X (m)> <Y (m)> <Z (m)> <Vx (m)> <Vy (m)> <Vz (m)>
<Epoch (yrs)>

Site is the four character name of the site (more characters can be included but only the first 4 are checked). Site names that do not appear in the list of sites to be processed are ignored). The remainder of the line contains position and velocity and the epoch in decimal years to which the position refers.

- Velocity is optional
- If this command not used, rinex header coordinates are used (can be a problem with true kinematic sites that move large distances. In these cases position should be for start of data. BAD PREFIT clock error messages are an indication that coordinates may be bad).

Track Commands

@ SITE_STATS

@ Site <Apriori Sigma in XYZ> <RW noise in XYZ>

Gives statistics to assign to the kinematic station positions. The <Apriori Sigma in XYZ> are the three sigmas in XYZ for the initial position and <RW noise in XYZ> are the three sigmas in XYZ for the change in position between epochs of data. Since the motion of the kinematic sites is modeled as random walk (RW), the sigma of the change in position grows as the sqrt(number of epochs) Ver 1.21 and later: RW noise is sigmas (m)/sqrt(time unit) where time_unit command is used to set time unit.

ALL can be used for the station name and the same statistics will be applied to all kinematic sites (NOTE: the fixed site do not change position).

e.g.

```
site_stats
```

```
all    20 20 20  20 20 20
```

(20 meters apriori sigmas and changes of 20 meters between epochs).

Feature 1.24: Added POST as entry after the Apriori sigma values, to allow specification aposterioi sigma for position at the end of the data span.

Track commands

@ TIMEDEP_PROCNS

@ Site Sig XYZ (m/sqrt(t)) Start YY MM DD MN Sec End
YY MM DD MN Sec

Allows time dependent process noise to be added the statistics of a site or to all sites. The noise sigmas are added (in a variance sense) to the noise processes specified in the SITE_STATS command. Note only the random walk process noise is changed.

This command is useful for long-baseline processing of surface wave arrivals (process noise increased during surface wave arrivals).

Track commands

@ ATM_STATS

@ Site <Apriori Zenith delay sigma> <RW noise in Zenith delay> <RW dH/dt noise/SCALE>

Gives the statistics for the atmospheric delays by site. The values are the initial sigma in meters, RW changes in meters per epoch and (added version 1.2) a dH/dt variance term so that during rapid height changes more process noise can be added to zenith delay estimate. The process noise variance is ($\text{<RW dH/dt noise> * abs(dh/dt)^2$) per epoch where dh/dt is m/s. Typical value is 0.00023

e.g.,

atm_stats

t39a 0.1 0.0003 0.00023

Set the apriori sigma as 10cm and allows the delay to change 0.3 mm every epoch (for 1Hz data, this lead to 18 mm noise in 1hr) and 2.3 mm per epoch when height is changing at 10 m/s (fast ascent or descent)

The SCALE option instead of the dH/dt term, estimates an atmospheric delay scale factor as a function of the height difference between the base-station and aircraft. If the base station is far from the aircraft starting location, then a constant atmospheric delay term at the base station should be estimated.

Track Commands

@ REF_NEU <X (m)> <Y (m)> <Z (m)>

Set the the XYZ coordinates of the point relative to which NEU offsets are computed. Default is the coordinates of the first site in the obs_file list.

@ TIME_UNIT <epoch/sec/min/hour/day>

Sets the time unit for process noise. Choices are epoch (default), seconds, minutes hour or day. Interval command must be used to specify sampling interval before this command is used. (Even when the interval is given in the rinex files).

Track Commands

@ DATA_NOISE <L1> <L2> <P1> <P2> <Elev Weight> [PRN]

Allows specification of the noise in the L1 phase, L2 phase, P1 range and P2 range, and the weight given to elevation angle dependence (at ver 1.20); variance is scaled by $(1+(W/\sin(el))^2)$ where W is the <Elev Weight>.

These values affect the sigmas printed for the position determinations (Units: m for all, except weight)

Optional: PRN may be added and noise assigned to that PRN (if non-PRN form is used, this will replace all PRN specific values so use the non-PRN first followed by specific PRN values)

Track commands

@ DATA_TYPE <choice 1> <choice 2> ...

Allows specification of data types to be used in generating position estimates. The choices are:

L1 -- L1 only phase

L2 -- L2 only phase

LC -- Ionospheric delay corrected phase

P1 -- L1 pseudo-range

P2 -- L2 pseudo-range

PC -- Ionospheric delay corrected pseudo-range.

The data types may be combined in each of the choices, e.g.,

L1+L2 would use both L1 and L2 while assuming that the ionospheric delay is negligible. Example: `data_type l1 l1+l2 lc+p1`

This commands allows multiple solutions to be output from the one run.

NOTE: The `float_type` command determines the data type used to resolve ambiguities.

Complete list commands

@ OBS_FILE

@ Site RX_file Type

@ Site RX_file Type

@ NAV_FILE <name> <SP3/NAV>

@ MODE <Type>

@ SITE_POS

@ Site <X (m)> <Y (m)> <Z (m)>

@ REF_NEU <X (m)> <Y (m)> <Z (m)>

@ TIME_UNIT <epoch/sec/min/hour/day>

@ SITE_STATS

@ Site <Apriori Sigma in XYZ> <RW noise in XYZ>

@ TIMEDEP_PROCNS

@ Site Sig XYZ (m/sqrt(t)) Start YY MM DD MN Sec End YY MM DD MN Sec

Complete list commands

@ ATM_STATS

@ Site <Apriori Zenith delay sigma> <RW noise in Zenith delay> <RW dH/dt noise/SCALE>

@ ATM_BIAS

@ Site <Atmospheric delay offset (m)>

@ ATM_FILE <File name>

@ USE_GPTGMF <Relative humidity (0-1)>

@ ANTE_OFF

@ Site <ARP dN (m)> <ARP dE (m)> <ARP dU (m)> <Antenna Name>

@ BF_SET <Max gap> <Min good>

@ DEBUG <Start EP> <End EP>

@ DATA_NOISE <L1> <L2> <P1> <P2> <Elev Weight> [PRN]

Complete list of command

@ DATA_TYPE <choice 1> <choice 2> ...
@ OUT_SIG_LIMIT <sigma (m)>
@ RMS_EDIT_TOL <n-sigma limit>
@ EDIT_SSV <site> <prn #> <start time> <stop time>
@ USR_ADDDBF <site> <prn #> <time (ymdhms)>
@ USR_DELBF <site> <prn #> <time (ymdhms)>
@ AMBIN_FILE <file name>
@ ANTMOD_FILE <file name>
@ FLOAT_TYPE <Start> <Decimation> <Type> <Float sigma Limits(2)>
 <WL_Fact> <Ion_fact> <MAX_Fit> [RelRank]
@ MIN_TOLS <min LC sig> <WL Tau>
@ BACK_TYPE <string>
@ ION_STATS <Jump> <ION PPM> <ION Weight> <ION height> <ION spatial>
@ POS_ROOT <string>

Complete list of commands

@ RES_ROOT <string>
@ SUM_FILE <string>
@ WLS_ROOT <string>
@ RWL_ROOT <string>
@ OUT_TYPE <string>
@ IONEX_FILE <file name>
@ CUT_OFF <min elevation angle>
@ START_TIME <Year Month day hour min sec>
@ INTERVAL <seconds>
@ NUM_EPOCHS <number>
@ EXCLUDE_SVS <list of PRN numbers to be excluded>
@ STOPGO_MODE <Variance reduction>
@ MWWL_JUMP <tol cycles>

Plotting track results

- `sh_plot_track` is a script (using GMT) that can plot track results. Features are still being added to this script.
- For quick plots we use the `gamt/globk` X-windows program `cplotx`.
- I also use Kaleidagraph (commercial program), Matlab and GMT
- Output files are ASCII with a variety of time tags (YY MM DD HR MIN SEC, Fractional Day and Epoch number)

Final comments

- The most common parameters that need to be changed in track are:
 - The data gap that will automatically be treated as a cycle slip (default is 1) but most high rate data ($\geq 1\text{Hz}$) has gaps due to recording problems.
 - The sigma limits for the LC estimate and MW-WL estimates often need to be increased. Track has a correlation time in sigma calculation that for the default setting can make the sigmas too large.
 - Make sure antenna and receiver information (if mixed) are correct.
 - Treatment of the atmospheric delay. There is a high correlation between the atmospheric delay and height when both are stochastic (RhoUA column in output time series).
 - Weight for the EX-WL (effected by the ionosphere) on long baselines and when the ionosphere is active. Ionex_file command may help.