TrackRT Installation
Lecture 09

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trackRT/trackRTB Introduction

- trackRT/trackRTB are the real-time version of track that use BNC
- trackRT requires the BKG NTRIP Client (BNC) and QT libraries and include files. Ntrip is the Networked Transport of RTCM via Internet Protocol and the client program BNC provides access to the real-time data streams and casts the data via an internet port. GNSS raw data in a structure that is decoded by trackRT.
- Currently trackRT only uses the GPS data streams. TheNTRIP system is discussed at http://igs.bkg.bund.de/ntrip/. The BNC program can be downloaded from http://igs.bkg.bund.de/ntrip/download. The BNC documentation contains the instructions for obtaining the QT libraries and include files needed for its installation from source files. trackRT only needs the executable version of BNC. The QT software can be obtained directly from Nokia at the site http://qt.nokia.com/downloads
- TrackRTB (binary format) is used for BNC versions before 2.5; Version 2.5 and later versions of BNC use an ASCII format and trackRT is used with this version. The two programs are identical and we will use the name trackRT.
- The trackRT help file contains more instructions

TrackRT operation

- Once trackRT is installed, the basic operation is to start copies of BNC that will cast the data from specific sites of interest.
- Once BNC configuration has been established and saved to a file; BNC can be started to run with no window (-nw option) and a configure file for each network of site e.g., bnc –nw –conf Net01Config.ini
- TrackRT can then process any or all of the sites being cast. So far we have always, paired the BNC and trackRT runs (i.e., once one copy of trackRT is connected to a port, no other copy can access that port.
- trackRT and BNC do not need to be on the same host provided the port is open.

Installing trackRT

- The Makefile for trackRT needs to be modified to point to the correct locations of the Qt libraries and maybe change some of the flags on the compile lines.
- Using qmake in the BNC source file directories to generate the Makefile for BNC
- Linux installs seem OK but MacOSX still has some problems. (On my system this seems to be due to multiple versions of g++ and gfortran which have incompatible options such as –arch).

Installing trackRT

- The Makefile needs to be modified to point to the QtNetwork, QtCore libraries and include files
- The paths to these are set with options like

QTLIB = /opt/local/lib

QTINC = /opt/local/include/

- In the Makefile
- TrackRT main is a c++ program which is linked with gfortran subroutines.

Other operational aspects

- Since trackRT runs continuously, it needs up to data satellite ephemeris data and so a cron is normally run that downloads the latest IGS SP3 orbit files. The help for trackRT contains an example cron script.
- In setting the crontab entries you should run it at the correct UTC times. These times will depend on the configuration of your system time.

TrackRT runstring

Runstring:

% trackRT <options>

where options are

-m <machine> Host name of system with real-time data port (Normally BNC would be running on this system)

(Default local host)

-p <port> Port number on host supplying the data stream (Manadatory input).

-f <command file> trackRT command file (similar to track command file)

-r <ref code> 4-char code for reference site.

-d <list of 4-character codes> list of sites to be processed.

TrackRT runstring

If list of sites is not specified all sites in data stream will be processed (there is a limit on maximum number of sites that can be processed depending on max_site in trackRT. The reference code should NOT be given here.)

-n <root name> Specifies a root name to which output will be directed (.out is appended for stdout output). Use ? in the pos_root, sum_file and csv_file names the ? will be replaced by this string.

Command file name must be given.

TrackRTr runstring

trackRTr is the non-real-time version which runs using rinex files. Other than the data source the versions are the same. (Although real-time streams do not always the saved (in real-time) rinex files which do not always match downloaded data. Loss of data due to latency is the most common problem.)

% trackRTr <options>

Same list of option although -m, -p have no effect

-d <list of rinex files> list of rinex files (site names are generated from the first 4-characters of rinex file names)

-r <4-char code reference site>

Start BNC/TrackRT

- Before starting the lecture on trackRT commands, we will start BNC and trackRT now running on an MIT host.
- The sites to be processed will be some PBO stations.
- Track command
  trackRT -p 3765 -f trackRT_pbo.cmd -r P498 \
  -d P505 P509 P494 P496 -n PBO
- http://chandler.mit.edu/kmeduna/ can be used to view results

TrackRT/TrackRTr commands

- TrackRT and TrackRTr share many commands in common with track but there are some additional commands and some classes of commands that operate differently due to the real-time nature of the processing.

Minimum commands in command file

SP3_DIR : (unless sp3 files are in the current directory)

SITE_POS: Site positions must be given for every site to be processed. (Real time streams do not contain positions (unlike rinex headers in track).

SITE_STATS: To set the apriori sigma and process noise for the sites. NOTE: The reference site position should be set to zero for the apriori sigma and process noise. Typical site_stats would be with cit1 as the reference site. (If reference not set to zero, all site positions estimated).

```
site_stats
 all   0.1 0.1 0.1   0.025 0.025 0.025
 cit1  0.0 0.0 0.0   0.0 0.0 0.0
```

ATM_STATS: By default atmospheric delays are not estimated, and normally these should be. Normally the reference site is set to zero when site separations are less the 500-1000km. Typical atm_stats command would be

```
atm_stats
 all   0.20 0.00010 0.000   ! Unit m/sqrt(sec) -> 0.0001 = 0.03 m/sqrt(day)
 cit1  0.00 0.00000 0.000
```

Also often needed commands

If mixed antenna and receiver types are used

ANTE_OFF: To specify the antenna heights and types and receiver types

ANTMOD_FILE: Must be given to get the antenna phase center models

RCV_TYPE: Needed for mixed receiver types (entry can be specified in ANTE_OFF also and this command would not be needed).

DCB_FILE: Up to date, data code bias (DCB) file (part of GAMIT ftp area).

Including

UPDATE_FILE is useful so that trackRT can be controlled on the fly.

Input/output commands

@ SP3_DIR <Directory>

<Directory> -- Directory where sp3 files are stored

 -- Center for orbits (default igs, igr and igu also tested)

IO commands

@ POS_ROOT <root> <duration>
Set the root part of the name for the outout files.
<root> Root part of name. When ? included in the <root>, the ? is
        replaced with the -n string.
<duration> Duration of data in each file. The designations of d, h, or m
        may be used to specify the units of days, hours, minutes.
        Default is d.
The position file names take the form: (see commands below)
<root>.<outtype>.<site>.<start time>.<datatype>
The resolution of the <start time> which is modulo the output interval
depends on the output duration. For output durations greater than or
equal to 1-day, the time is given as YYYYMMDD. For intervals shorter
than 1-day, it is YYYYMMDD:HHMN. Minimum output interval is 1 minute.

IO commands

@ SUM_FILE <root>

Sets the root part of the summary file name. Using ? in the name with be replaced by the -n string. (Default if command is not given is trackRT or the -n string when -n used). File names are time tagged according to the pos_root output interval.

IO commands

@ CSV_ROOT <root>

Set the root part of the name for comma separated values (CSV) output file. These files are used for AmCharts web plots.

@ DCB_FILE <file name>

Set the name of the data-code-bias (DCB) file. This file is part of the GAMIT tables directory and should be updated regularly. It is used to remove biases in the Melbourne-Wubbena widelanes. The receiver type can be specified with the RCV_TYPE or ANTE_OFF commands.

IO commands

@ ANTMOD_FILE <file name>

Sets the name of a standard IGS antex file with phase center models for the GPS ground antennas. Antenna types at specific sites are given with the ANTE_OFF command. This command my be used multiple times for site specific model with new models replacing previously read ones.

@ UPDATE_FILE <file name>

Allows new trackRT commands to be issued during a run. Once the file is

read it needs to be deleted before the trackRT will re-read it. File is only read if it exists. NOTE: File should be removed before trackRT is run or else it will be read when the command file is read (ie., it will overwrite the commands in the command file.

IO commands

@ OUT_TYPE <NEU+GEOD+XYZ+DHU>

Specifies types of output coordinates. All types can specified in a single string with no spaces. The types are

NEU -- North, East, Up differences from the reference site or from the coordinates given in the REF_NEU command.

GEOD -- Geodetic latitude, longitude and height (in the GEOD format, the total atmosheric delay is given, while in the other formats the adjustment to the apriori delay is given).

XYZ -- Cartersian XYZ coordinates

DHU -- Delta horizontal and Up coordinates from the apriori coordinates of each site (default output type)

@ OUT_SIG_LIMIT <sigma (m)>

Sets the maximum sigma of a position estimate for it to be output. If pseudorange data types are used, the default value of 1 m needs to increased to 10-100 meters.

Analysis commands

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

Same as track

@ DATA_TYPE <type>

Same as track (L1 only should be possible but not checked).

@ USE_GPTGMF

Same as track (recommended for all runs)

@ SITE_POS

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

Same as track

Analysis commands

@ ANTE_OFF

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

Specifies the type of antenna and its position of antenna reference point (ARP) at each site. The antenna name including radome should be specified with the official IGS name for a standard ANTEX file or with a unique name that appears in the ANTEX file for site specific calibrations. (Note: There is one additional character in the station.info long antenna and this extra character before the radome name must be removed. The antenna name and radome can be copied directly from the rinex file if present. One more ANTEX files must be specified with the ANTMOD_FILE command for the antenna names to be useful. The receiver type DCB code can be optionally specified here as well (See RCV_TYPE command).

Analysis commands

@ RCV_TYPE

@ Site <Receiver code N/P/C>

Specifies the type of data-code-bias (DCB) correction needed for the receiver. Code specifies the type of L1 and L2 ranges being measures. The choices are

P -- Pcode, C -- C/A and N C/A with cross correlation for L2 range. The codes can be found in gamit/tables/ rcvant.dat. These codes can also be given in the ante_off command. An up-to-date DCB_FILE command must be used to specify the DCB biases. The files are available from the MIT ftp site and update once per month.

Analysis commands

@ SITE_STATS

@ Site <Apriori Sigmas in XYZ (m)> <RW noises in XYZ (m/sqrt(sec))>

Same as track except units here are per sqrt (seconds) always (not time_unit command here).

@ ATM_STATS

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

Same as track with second as time unit.

Ambiguity Resolution

- trackRT uses a combination of the Melbourne-Wubbena widelane (MW-WL), the extra widelane (EX-WL) and the floating point estimates of the ionospheric free ambiguity (LC) to resolve integer ambiguities.
- If we denote the number of integer cycle ambiguities at L1 and L2 by N1 and N2,
  - MW-WL is an estimate of N1-N2 based on phase and range data;
  - EX-WL = N1 - f1/f2 N2 and is an integer for L1 cycles, but 1.283 N2 for L2 cycles;
  - LC = 2.546 N1 - 1.984 N2.
- The EX-WL is unaffected by geometric ranges changes, but does depend on the ionospheric delay.
- For short baselines, the EX-WL should be near zero for correct choices of N1 and N2.
- The LC residual should also be near zero when N1 and N2 are correct.

Ambiguity Resolution

- The problem in ambiguity resolution is that different choices of N1 and N2 can make different linear combinations small.
- For example, errors in N1 and N2 of 3 and 4 cycles will change LC by 0.298 cycles (56.6 mm), MW-WL by 1 cycle and EX-WL by 2.132 cycles (405 mm).
- On long baselines, at low elevation angles, ionospheric delays of 400 mm (2 cycles) are common.
- The most common error is a N1=N2=1 cycle error. For this combination, the MW-WL is unaffected and LC changes by 0.562 cyc (107 mm) and EX-WL by 0.283 cyc (54 mm). Even on relative short baselines, 54 mm ionospheric delays are common

Commands to control ambiguity resolution

@ AMB_SET <RelRank> <FloatSigma (2)> <MWWL Fact> <EXWL Fact> <Min AmbSig> <MaxChi>

Sets parameters for ambiguity resolution. The input parameters are:

<RelRank>

<WL min> Minumum of values need to allow bias fixing

<WL avN> Maximum number to be used in computing sigma of mean MW-WL

<FloatSigma (2)> Minimum sigma for LC and MW-WL for ambiguity fixing

<MWWL Fact> Weighting factor for MW-WL in chi**2

<EXWL Fact> Weighting factor for extra-wide lange

<Min AmbSig> Minimum sigma to assigned to float estimates of ambiguities.

<MaxChi> Max chi**2 value allowed for ambiguity to be resolved.

This command is similar to the float_type command in track

Commands to control ambiguity resolution

@ EXWL_SET <Jump> <Min Sigma> <Scale> <Elev Fact>

<Jump> -- magnitude of jump in EX-WL to have cycle slip added (default 0.10)

<Min Sigma> -- minimum sigma for mean ex-wl (cycles, default 0.02 cycles)

<Scale> -- Scaling factor for length. Scale 0.1 results in 0.1 cycles over 100 km (default)

<Elev Factor> -- Elevation angle factor that increases sigma as (1 + factor/sin(elev))

This command is set tolerances for adding a new cycle slip to the processing. The length dependent term of different length baselines in the processing.

Commands to control ambiguity resolution

@ MWWL_SET <Jump> <Min Sigma> <Max Averaging number> <Min number>

<Jump> -- magnitude of jump in MW-WL to have cycle slip added (default 5.0)

<Min Sigma> -- minimum sigma for mean MW-WL (cycles, default 0.10 cycles)

<Max Averaging number> -- Maximum number of values to use to compute mean sigma

<Min number> -- Minimum number needed to resolve ambiguity

Cycle slip detection based on the MW-WL lines

Commands to control ambiguity resolution

@ DD_SET <Jump (cycle)> <Min Number>

Sets parameters for double difference processing.

<Jump (cycle)> -- Magnitude of jump in double differences on bias fixed data that will introduce a cycle slip

<Min Number> -- Minimum number of double differences for an epoch to be processed. (If too few double differences than errors in the data can not be detected and this can cause large position errors, default of 4 double differences allows redundancy).

Commands to control ambiguity resolution

@ RMS_EDIT_TOL <n-sigma Tolerance> <min sigma> <Reset number>

<n-sigma tolerance> is an n-sigma condition where sigma is based on data noise model.

<min sigma> Minimum phase sigma to use so that no phase residual less than <min sigma>*<n-sigma tolerance> are deleted

<Reset number> number of sequential delete data, before ambiguity and cycle slips are reset (assumed missed cycle slip).

This a post-fit editing option to remove bad data. Data epoch is re-processed if data are deleted.

Testing and Evaluation

@ STATUS <type> <# epoch>

Writes status information to the current summary file at <# epoch> intervals

The types of reports are given by "type"

P -- Parameter estimates

A -- Ambiguity resolution report (shows resolved and unresolved)

W -- Widelanes (Melbourne-Wubbena and Extra-widelanes)

R -- Postfit residuals are current epoch

C -- Report current A and W entries only

type PAWR will output all reports.

Testing and Evalutions

@ NUM_EPOCHS <number>

<number> is the number of epochs of data to be processed before stopping. When short duration files are output (POS_ROOT command) the number of epochs may not be reached because the epoch counter is reset with each new file.

@ START_TIME <yy mm dd hh min sec.>

Used to set the start time. Useful with trackRTr to have the processing start at the same time as the realtime stream.

Testing and Evaluation

@ DEBUG <Up to 10 epoch numbers in pairs>

Sets which epochs will report detailed debug and status information (see STATUS command

as well). The pairs are used as:

1,2 -- Mostly model information. Useful if data are generating large residuals

3,4 -- Parameter estimates, widelanes, residuals

5,6 -- One-way OMC and single differences

7,8 -- Not Used

9,10 -- When 9 is non-zero, antenna model and SP3 information is output.

This command is often used in the update_file command file.

Testing and Evaluation

@ RESET <ALL/list of sites>

Reset command. Resets the filter state vector and resolved ambiguities for a list of sites or ALL sites (generally used in the update_file to fix problems)

@ EXCLUDE_SVS <list of PRN numbers to be excluded>

Excludes satellites from being processed. Useful when a satellite is not in an SP3 file or not available during the times there are data.

Example: exclude_svs 26 22 13

Testing and Evalution

@ UPDATE_FILE <file name>

Allows new trackRT commands to be issued during a run. Once the file is read it needs to be deleted before the trackRT will re-read it. File is only read if it exists.

NOTE: File should be removed before trackRT is run or else it will be read when the command file is read (ie., it will overwrite the commands in the command file.

Generally, we keep a file of a different name and then copy it to the <file name> here when we want it to be used.

Lines written to summary file

- Cycle slip detection:
  CSLIP Ep 540 Site THMG G 29 DMW-WL/Tol 4.31 4.00 DEX-WL/Tol 1.78 0.20 cyc, Elev 10.00 deg
- This case show a slip detected with MW-WL and EX-WL jumps. The values of the jump and the current tolerance are reported.
- Double difference residual slip

CSLIP Ep 12 Site P496 G 15 DD RESID -4.80 Tol 0.50 cyc, Elev 23.45 deg

Lines written to summary file

- Resolve ambiguities:
  When ambiguities are resolved, three lines are output giving the statistics (lines are wrapped here)
- AMBFIX WMAP PRN29 EP 599 RelRank 101.76 FC ------ dL12 4 3 Dchi 6.54 691.02 AMB 36
- AMBWLS WMAP PRN29 EP 599 RG 133 599 FX 3 iL12 0 0 Means -0.16 -0.05 RMS 0.74 0.06 # 467 eN12 -0.54 -0.38 AzEl 274.32 12.35
- AMBCON WMAP PRN29 EP 599 NCont 3 MW Res -0.159 0.185 Chi2 0.74 EX Res -0.051 0.068 Chi2 0.55 LC Res -0.046 0.020 Chi2 5.25
- Help file explains entries: RG is range of data used.

Other outputs

- Other outputs from the STATUS command are explained in the help file
- Lines are too long to effectively show here but in the tutorial session we can look at the results.
- We now look at some results generated during the talk and from earlier trackRT runs