

GNSS data from receiver to processing input

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GNSS Data Processing and Analysis with GAMIT/GLOBK and track

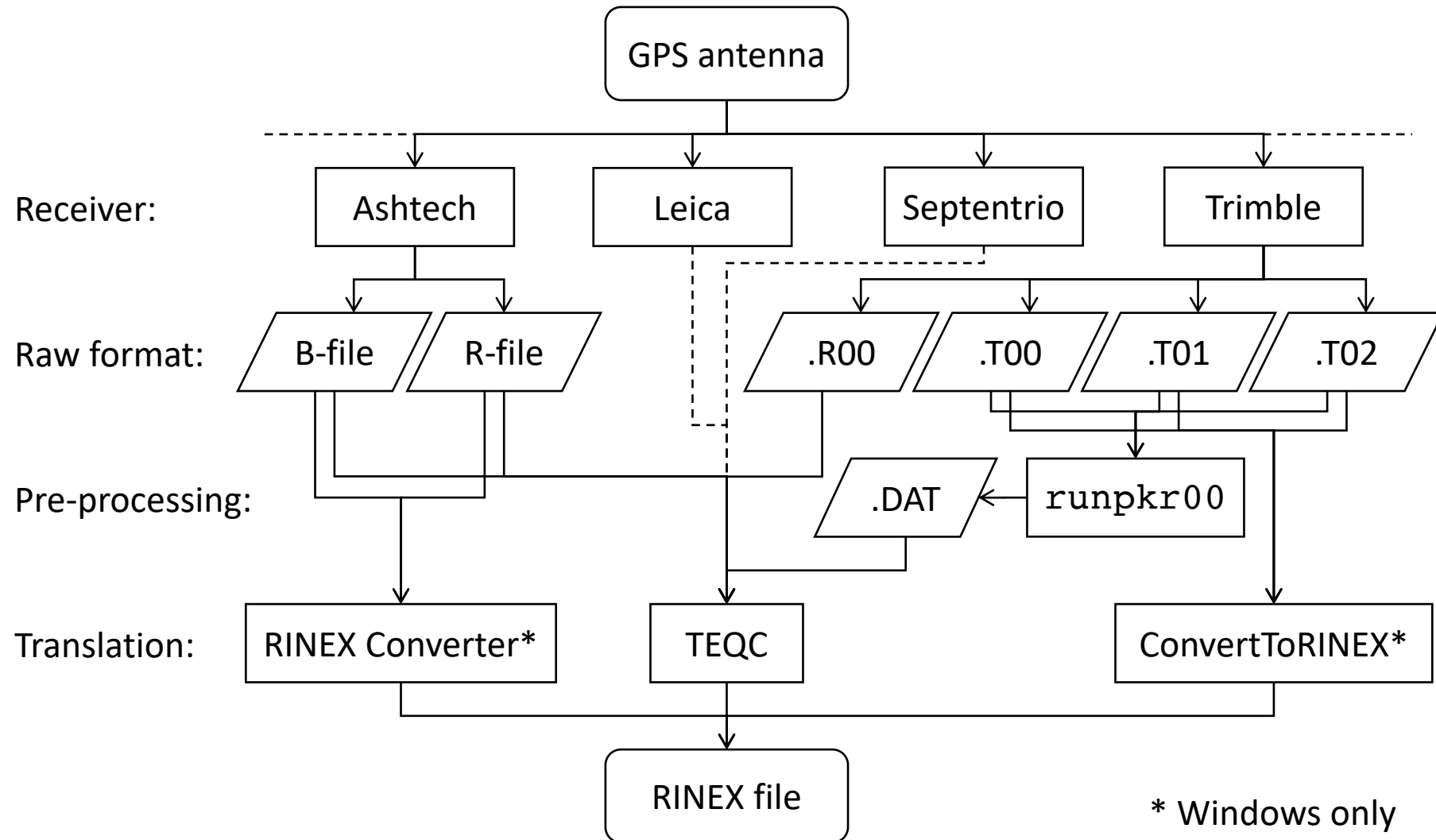
UNAVCO Headquarters, Boulder, Colorado, USA

24–28 August 2020

http://geoweb.mit.edu/~floyd/courses/gg/202008_UNAVCO/

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

Raw data formats



Motivation for Receiver INdependent EXchange (RINEX) format

- All manufacturers have developed their own proprietary file formats for data storage specific to their receivers and processing software
 - Problems occur when processing data from another manufacturer's receiver
- RINEX developed by the Astronomical Institute of the University of Berne to allow easy and universal exchange of raw GPS data
 - Principal driver was the large European GPS campaign EUREF 89 - involved more than 60 GPS receivers of 4 different manufacturers.

RINEX formats

- RINEX 2
 - Short file names (explained in following slides)
- RINEX 3
 - Long file names (explained in following slides)
- GAMIT formerly worked with the RINEX 2 format and GPS observations only
- Support for RINEX 3 and GNSS (e.g. Galileo, BeiDou, etc.) observations are now available with GAMIT/GLOBK 10.61 and later
 - But RINEX 3 files need to be renamed, copied or linked with a RINEX 2 file name convention to be used (e.g. sh_rename_rinex3)

RINEX 2 data format

- Includes text file formats for:
 - observation (“o”) } most important for most users
 - navigation (“n”) }
 - meteorological (“m”)
 - ionospheric data (“i”)
- Latest definition at <ftp://igs.org/pub/data/format/rinex211.txt>
- Each file type consists of a header section and a data section
- Header section contains global information for the entire file and is placed at the beginning of the file.
 - Contains header labels in columns 61–80 for each line contained in the header section
 - These labels are mandatory and must appear exactly as per format description
- RINEX 2 filename convention:
 - For site “ssss”, on ordinal date (day-of-year) “ddd”, session “t” and year “yy”:
 - ssssdtdt.yyo (RINEX observation file, i.e. the site’s phase and code records)
 - ssssdtdt.yyn (RINEX navigation file, i.e. the broadcast ephemeris)
 - e.g., hers1270.03o is observation data for Herstmonceux, day 127, session 0, year 2003
- All dates and times in GPST, *not* UTC, by convention

An example of RINEX 2 observation data

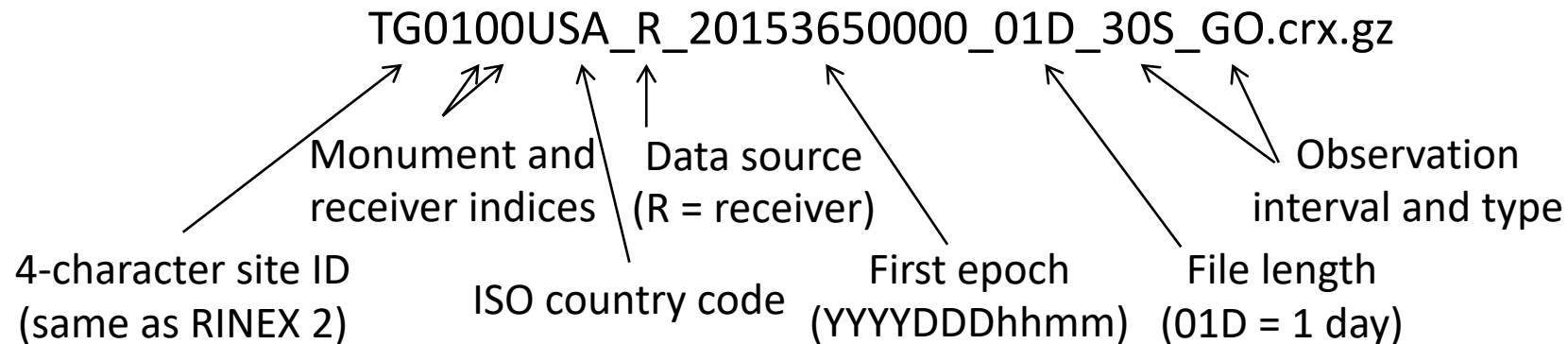
```

      2              OBSERVATION DATA      G (GPS)              RINEX VERSION / TYPE
CCRINEXO V2.3.1 LH  NERC SLRF UK           08-MAY-03 00:05      PGM / RUN BY / DATE
CONCATENATED OBSERVATION FILES           COMMENT
ASRINEXO V2.9.10LH NERC SLRF UK           07-MAY-03 01:03      COMMENT
                                           COMMENT
BIT 2 OF LLI (+4) FLAGS DATA COLLECTED UNDER "AS" CONDITION COMMENT
HERS                                       MARKER NAME
13212M007                                 MARKER NUMBER
SLR HERSTMONCEUX      NERC UK             OBSERVER / AGENCY
LP03373               ASHTECH Z-XII3      CD00          REC # / TYPE / VERS
CR16688               ASH700936E                               ANT # / TYPE
4033462.3686          23668.4540  4924295.3147      APPROX POSITION XYZ
0.0096                0.0000      0.0000          ANTENNA: DELTA H/E/N
1                     1                     WAVELENGTH FACT L1/2
7                     C1                    L1                    L2                    P1                    P2                    S1                    S2      # / TYPES OF OBSERV
30                                                              INTERVAL
2003                   5                    7                    0                    1                    0.000000      TIME OF FIRST OBS
03  5  7  0  1  0.0000000  1  9  14 05 26 07 09 23 28 29 18  END OF HEADER
PRN14 24932856.904      -1781095.387  7  -1105164.20444  24932855.004  24932862.7814
      201.000          130.000
PRN05 22107202.735      -16063454.741  8  -12490326.44046  22107202.172  22107208.2924
      233.000          186.000
PRN26 22363532.304      -13299541.376  8  -10336679.45446  22363532.099  22363538.2454
      231.000          184.000
PRN07 22661645.377      -12116901.554  8  -9422108.07946  22661644.520  22661651.0584
      230.000          182.000
PRN09 20117144.686      -22534891.328  9  -17538374.49548  20117144.311  20117149.7184
      247.000          219.000
:
:

```

RINEX 3 data format

- Must be able to accommodate increased number and complexity of observations from multi-GNSS observations (GPS, GLONASS, Galileo, BeiDou, etc.)
- Latest definition at <ftp://ftp.igs.org/pub/data/format/rinex304.pdf>
- Each file type consists of a header section and a data section
- Header section contains global information for the entire file and is placed at the beginning of the file.
 - Contains header labels in columns 61–80 for each line contained in the header section
 - These labels are mandatory and must appear exactly as per format description
- RINEX 3 filename convention is longer and more complicated than for RINEX 2, e.g.



An example of RINEX 3 observation data

```

3.02          OBSERVATION DATA      GPS(GPS)          RINEX VERSION / TYPE
cnvtToRINEX 2.29.0 Michael A Floyd  07-Jan-16 17:28 UTC PGM / RUN BY / DATE
-----
TG01          MARKER NAME
GEODETTIC    MARKER TYPE
M.Floyd / G.Funning MIT / UC Riverside OBSERVER / AGENCY
5049K72210    TRIMBLE NETR9          4.62 REC # / TYPE / VERS
60222738      TRM41249.00          NONE ANT # / TYPE
-2698262.9000 -4182116.4000 3976198.2000 APPROX POSITION XYZ
-0.0160      0.0000          0.0000 ANTENNA: DELTA H/E/N
G 16 C1C C2W C2X C5X D1C D2W D2X D5X L1C L2W L2X L5X S1C SYS / # / OBS TYPES
      S2W S2X S5X                                     SYS / # / OBS TYPES
2015 12 31 0 0 0.00000000 GPS TIME OF FIRST OBS
2015 12 31 23 59 30.00000000 GPS TIME OF LAST OBS
0 RCV CLOCK OFFS APPL
G L1C 0.00000 SYS / PHASE SHIFT
G L2X -0.25000 SYS / PHASE SHIFT
G L5X 0.00000 SYS / PHASE SHIFT
17 LEAP SECONDS
31 # OF SATELLITES
END OF HEADER
> 2015 12 31 00 00 0.00000000 0 9
G01 23837864.086 7 23837874.082 4 23837874.383 7 23837870.934
5 125268876.649
7 97612114.300 4 97612120.067 7 93544938.844
5 42.000 24.500 41.600 31.200

```

System now listed along with observation types

Observation codes more complicated than RINEX 2 (see Tables 4–10 of current RINEX 3(.04) document)

Compressing/Uncompressing RINEX

- File compression
 - “*.zip” files
 - Unzip using “unzip”, “pkzip” or “WinZip”
 - See <http://www.pkware.com/> or <http://www.winzip.com/>, or <http://www.7-zip.org/>
 - “*.??o.Z” (RINEX 2) and “*.rnx.gz” (RINEX 3) files (UNIX compress or gzip)
 - e.g. hers1270.03o.Z, TG0100USA_R_20153650000_01D_30S_GO.rnx.gz
 - Uncompress using “uncompress”, “gunzip”, “7zip”, “WinZip” or similar
 - “*.??d.Z” (RINEX 2) and “*.crx.gz” (RINEX 3) files (Hatanaka compression)
 - e.g. hers1270.03d.Z, TG0100USA_R_20153650000_01D_30S_GO.crx.gz
 - Need to uncompress as above to get *.??d and *.crx files
 - Then need to “unHatanaka” using CRX2RNX from <http://terras.gsi.go.jp/ja/crx2rnx.html>
 - Leica Geo Office uncompresses files automatically when using “Internet Download” tool
 - For manual import you need to uncompress the files manually

runpkr00 (Trimble raw to dat)

- Proprietary software from Trimble
- Maintained by UNAVCO nowadays
 - <https://kb.unavco.org/kb/article/trimble-runpkr00-latest-versions-744.html>
- Converts raw data from Trimble receiver to teqc-compatible input “dat”-file, e.g.

```
runpkr00 -g -adeimv <raw file> [dat-file root]
```
- Always use “-g” option and separately from other options

Pre-processing data

- Some level of data quality control may be performed prior to any data processing
- Utilities are available to perform simple but valuable tests
 - The most common example is TEQC (pronounced “tek”)
 - Translate, Edit, Quality Check
 - Translates common binary formats to RINEX format
 - Header editing, windowing, splicing of RINEX data
 - Quality check in “lite” mode (no navigation file) or “full” mode (navigation file available)
 - Download for free from <https://www.unavco.org/software/data-processing/teqc/teqc.html#executables>

Using teqc

- Be sure to use correct raw format

```
teqc -tr d <Trimble .dat file>
teqc -ash d <Ashtech B-file, etc.>
```
- Ability to control observations using “-O.obs” option

```
teqc -O.obs L1L2C1P2 -tr d <Trimble .dat file>
```
- Ability to control header information with other “-O.xxx” options

```
teqc -O.o "M. Floyd" -O.obs L1L2C1P2 -tr d
<Trimble .dat file>
```
- May create and use a teqc configuration file for consistent information

```
teqc -config teqc.cfg -tr d <Trimble .dat file>
```
- Use a script or command line loop to create RINEX files in batch

Using teqc

- Quality Control (QC)

- In “lite” mode, teqc doesn’t know anything about the satellite positions

```
teqc +qc site1891.02o > teqc.log
```

- 7 files generated; use the -plots option to prevent all but the summary (‘S’) file being generated

- In “full” mode, additional information is available based on the satellite positions

```
teqc +qc -nav site1891.02n site1891.02o > teqc.log
```

- 9 files generated (elevation and azimuth of satellites)

- Full solution if navigation file matches observation file, e.g. site1891.02o and site1891.02n

```
teqc +qc site1891.02o > teqc.log
```

Approximate position

- Accurate a priori coordinates necessary for good GNSS processing
- Run `teqc` to create RINEX observation and (broadcast) navigation files, e.g.

```
teqc +nav abcd3650.14n +obs abcd3650.14o -tr d  
12343650.dat
```
- Run `teqc` in `qc`-mode on observation file with navigation file to get pseudorange-derived estimate of approximate coordinate, e.g.

```
teqc +qc -nav abcd3650.14n abcd3650.14o
```
- May also be done using GAMIT/GLOBK's `sh_rx2apr`

Links to software

- runpkr00
<https://kb.unavco.org/kb/article/trimble-runpkr00-latest-versions-744.html>
- RINEX Converter
<ftp://ftp.ashtech.com/Spectra-precision/Utility%20Software/RINEX%20Converter/>
- TEQC
<https://www.unavco.org/software/data-processing/teqc/teqc.html>
- ConvertToRINEX
https://www.trimble.com/support_trl.aspx?Nav=Collection-40773&pt=Trimble%20RINEX