



# GNSS data from receiver to processing input

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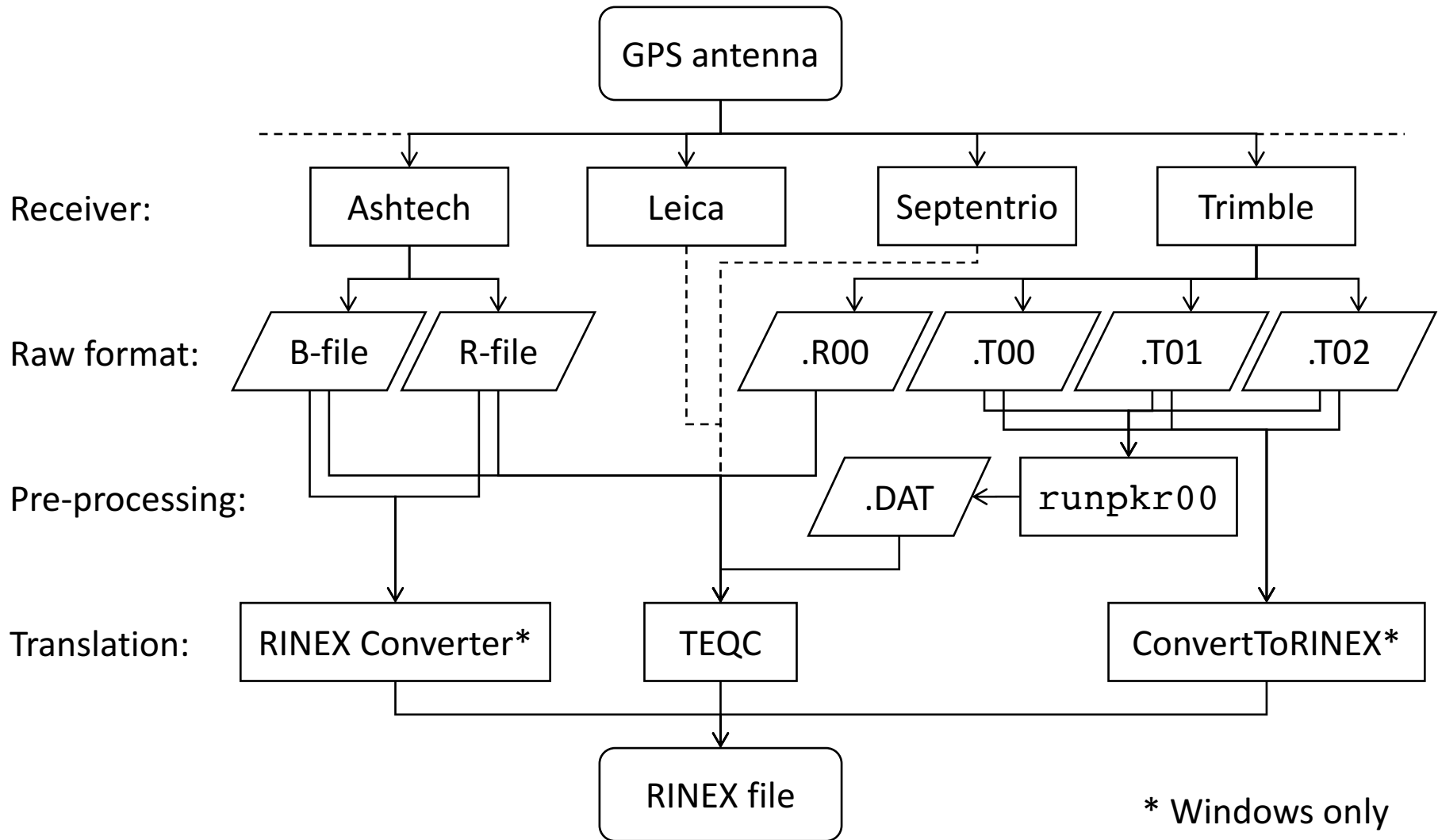
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[http://geoweb.mit.edu/~floyd/courses/gg/201711\\_AAU/](http://geoweb.mit.edu/~floyd/courses/gg/201711_AAU/)

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 as of GAMIT/GLOBK 10.61
  - 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”)
  - navigation (“n”) } most important for most users
  - 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”:
    - ssssdddt.yyo (RINEX observation file, i.e. the site’s phase and code records)
    - ssssdddt.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

# An example of RINEX 2 observation data

```

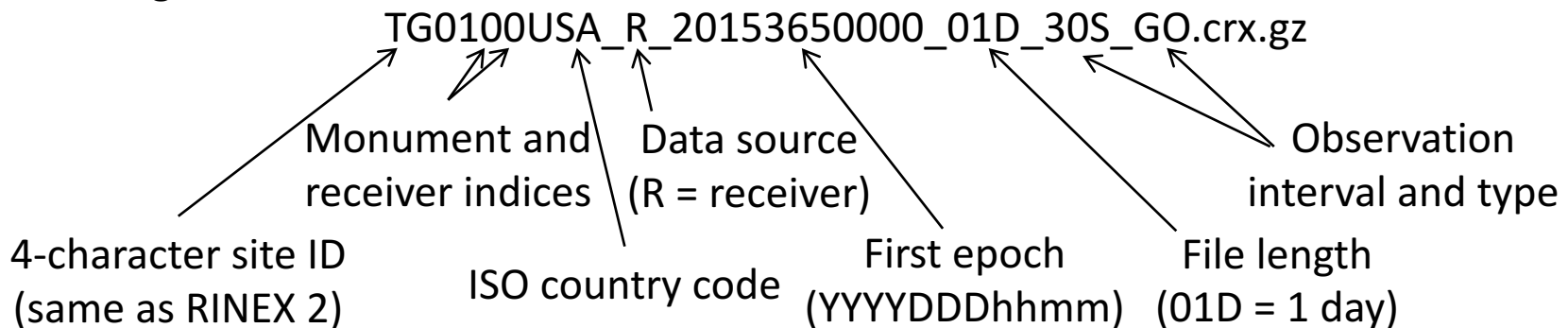
2          OBSERVATION DATA      G (GPS)          RINEX VERSION / TYPE
CCRINEXO V2.3.1 LH  NERC SLRF UK   08-MAY-03 00:05    PGM / RUN BY / DATE
CONCATENATED OBSERVATION FILES                                COMMENT
ASRINEXO V2.9.10LH NERC SLRF UK   07-MAY-03 01:03    COMMENT
                                                    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
                                                                END OF HEADER
03  5  7  0  1  0.0000000  1  9  14 05 26 07 09 23 28 29 18
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
:
:

```

- PRN14
- PRN05
- PRN26
- PRN07
- PRN09
- :

# 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://igs.org/pub/data/format/rinex303.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
GEODETTIC
M.Floyd / G.Funning MIT / UC Riverside
5049K72210    TRIMBLE NETR9          4.62
60222738     TRM41249.00          NONE
-2698262.9000 -4182116.4000  3976198.2000
  -0.0160    0.0000    0.0000
G  16 C1C C2W C2X C5X D1C D2W D2X D5X L1C L2W L2X L5X S1C
      S2W S2X S5X
2015  12  31    0    0    0.0000000    GPS
2015  12  31   23   59  30.0000000    GPS
0
G L1C 0.00000
G L2X -0.25000
G L5X 0.00000
17
31
> 2015 12 31 00 00 0.0000000 0 9
G01 23837864.086 7 23837874.082 4 23837874.383 7 23837870.934
5
7 97612114.300 4 97612120.067 7 93544938.844
5 42.000 24.500 41.600 31.200 125268876.649
  
```

Annotations in the image include:
 

- Red circles around observation codes: C1C, C2W, C2X, C5X, L1C, L2W, L2X.
- Red labels "L2" and "L2C" above the L2W and L2X codes.
- Red arrows pointing from the circled codes to their corresponding values in the data lines.
- A blue box around the header line "SYS / # / OBS TYPES".
- A blue box around the observation code "G01".
- A blue box containing the text "System now listed along with observation types" with an arrow pointing to the "G01" code.

Observation codes more complicated than RINEX 2 (see Tables 4–10 of current RINEX 3(.03) 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
  - <http://facility.unavco.org/kb/questions/744/>
- 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”)
    - **T**ranslate, **E**dit, **Q**uality **C**heck
    - 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  
<http://www.unavco.org/facility/software/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

1. Run `teqc` to create RINEX observation and (broadcast) navigation files, e.g.

```
teqc +nav abcd3650.14n +obs abcd3650.14o -tr d 12343650.dat
```

2. 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**  
<http://kb.unavco.org/kb/article/trimble-runpkr00-v5-40-latest-version-mac-osx-10-7-windows-xp-7-linux-solaris-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**  
[http://www.trimble.com/support\\_trl.aspx?Nav=Collection-40773&pt=Trimble RINEX](http://www.trimble.com/support_trl.aspx?Nav=Collection-40773&pt=Trimble RINEX)