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# RINEX-based GNSS positioning performance data analysis using the open source tool



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# RINEX

## Receiver INdependent EXchange format

Easy exchange of collected, raw GNSS/SNS data

GPS receiver's output data: its position, velocity, heading, ...  
determined in real-time

It is useful/necessary to store the measurements for post-processing

RINEX is a standard format which allows the usage of measurements generated in the receiver, and their further analysis (e.g. disturbances and position degradation identification, development of better ionospheric models, etc)

# RINEX format

File Types	All platforms uncompressed	UNIX compressed	VMS compressed	DOS
Obs Files	.yyO	.yyO.Z	.yyO_Z	.yyY
Obs Files (Hatanaka compressed)	.yyD	.yyD.Z	.yyD_Z	.yyE
GPS Nav Message Files	.yyN	.yyN.Z	.yyN_Z	.yyX
GLONASS Nav Message File	.yyG	.yyG.Z	.yyG_Z	.yyV
Galileo Nav Message File	.yyL	.yyL.Z	.yyL_Z	.yyT
Mixed GNSS Nav Message File	.yyP	.yyP.Z	.yyP_Z	.yyQ
GEO SBAS Nav Message Files	.yyH	.yyH.Z	.yyH_Z	.yyU
GEO SBAS Broadcast Files (sep. doc.)	.yyB	.yyB.Z	.yyB_Z	.yyA
Met Data Files	.yyM	.yyM.Z	.yyM_Z	.yyW
Clock Files (see sep.doc.)	.yyC	.yyC.Z	.yyC_Z	.yyK

The format consists of several file types:

- Observation Data File
- Navigation Message File
- Meteorological Data File
- GLONASS Navigation Message File
- Galileo Navigation Message File
- GEO Navigation Message File
- Satellite and Receiver Clock Date File
- SBAS Broadcast Data File

# RINEX format

```

#rnx: 2013Apr18      CORR-ADM Account      20130420 04:45:00UTC00M / MON BY /
#Satellite #00 5.101800441000 WGS-84 -#name#name#(##)##      COMMENT
# 2      NATIONALION DATA      COMMENT
#KIND#GLOBAL      NATIONALIONIONIC SURVEY      COMMENT
# 2.04890+08 1.49010+08 -1.19210+07 -9.96050+08      ION ALPHA
# 1.18780+05 4.91520+04 -2.42140+05 4.55340+04      ION BETA
# 9.3132257441550-10-2.4445352591000-15 589424 1734 DELTA-UTC: A0,A1,T,1
#END OF HEADERS

```

## Navigation Message file (*ext .n*):

- Predicted satellite ephemeris
- Predicted satellite clock correction model coefficients
- GPS system status information
- The GPS system ionospheric model

```

# 1 15 4 18 18 0 0.0 1.7454382032200+05 3.4278788070900-12 0.0000000000000+00
# 4.5000000000000+01 4.4487500000000+00 4.4773293558800-09 2.3970472192400+00
# 9.9023222387700-07 1.7433270589900-03 9.5718929747400-04 5.1537014639700+03
# 1.0400000000000+05-5.2154044178500-08-7.1403995117900-01-1.4743804343100-08
# 9.4023400317800-01 2.1134230000000+02 2.9111748294000-01-8.0040477497400-09
# 2.3443925315300-10 0.0000000000000+00 1.7340000000000+03 0.0000000000000+00
# 2.0000000000000+00 0.0000000000000+00 8.3819031715400-09 4.5000000000000+01
# 4.0000000000000+00
# 4.0000000000000+00-3.1250000000000-02 4.3833947544800-09-1.7878321832100+00
# 1.249412312300-08 1.7445874759200-03 9.4529241323500-04 5.1534999204500+03
# 9.2478400000000+05-4.4544128730800-08-7.1415344143700-01-2.4077032089200-08
# 9.0000000000000-01 1.9431250000000+02 2.9084615134900-01-7.4488993099300-09
# 1.0000000000000+00-1.0000000000000+00 1.7340000000000+03 0.0000000000000+00
# 2.0000000000000+00 0.0000000000000+00 8.3819031715400-09 4.5000000000000+00

```

## Observation Data File (*ext .o/.d*)

- The TIME of the measurement (the receiver time of the received signals)
- The PSEUDO-RANGE (distance from the receiver antenna to the satellite antenna including receiver and satellite clock offsets and other biases)
- The PHASE (the carrier-phase measured in whole cycles)
- DOPPLER (additional observable, positive for approaching satellites)

```

#rnx: 2013Apr18      CORR-ADM Account      20130419 01:04:00UTC00M
# 2.10      OBSERVATION DATA      0 CORR      COMMENT
#ANTENNA 5.44      AC      17APR13 1:04:00      COMMENT
#ANTENNA ANTENNA HEIGHT IS FROM BASE TO BOTTOM OF ANTENNA.      COMMENT
#-----      COMMENT
#NOTE: THE ABOVE OFFSETS ARE NOT CORRECTED.      COMMENT
#TIME      RECEIVER TIME OF MEASUREMENT IN UTC.      COMMENT
#PRN      SATELLITE PRN NUMBER.      COMMENT
#L2TS0001      SATELLITE NUMBER.      COMMENT
#FB      TRACK      COMMENT
#EPOCH      TRACK      COMMENT
#EPOCH      TRACK      COMMENT
# 1 5      TRACK      COMMENT
# 4 5L 0L 1L 2L 3L 4L 5L      TRACK      COMMENT
# 30      TRACK      COMMENT
# 18 4 18 0 0.0 0.0000000000000+00 0.0000000000000+00 0.0000000000000+00 0.0000000000000+00
# 04-21047524209 342049749791 04-24220421992 342049749516 3448750 343900 7 74940 4
# 04-22141009015 342049749792 04-17008194012 342049749349 3448950 3441000 7 74940 4
# 04-0496244144 342049749793 04-093490097 342049749000 3439000 3422500 4 44940 4
# 04-441187828 342049749794 04-024524901 342049749492 3437250 3419250 3 34940 4

```

# POSITIONING SOLUTION

```
% (lat/lon/height=WGS84/ellipsoidal,Q=1:fix,2:float,3:sbas,4:dgps,5:single,6:ppp,ns=# of satellites)
```

```
% GPST          latitude(deg) longitude(deg) height(m)  Q  ns  sdn(m)  sde(m)  sdu(m)  sdne(m)  sdeu(m)  sdun(m)  age(s)  ratio
2013/04/19 00:00:00.000  45.411162451  11.896061098  64.8116  5  7  3.8714  2.1509  8.5211  1.1569  -1.2690  3.5370  0.00  0.0
2013/04/19 00:00:30.000  45.411160648  11.896061561  64.2096  5  7  3.8719  2.1484  8.5536  1.1428  -1.2257  3.5627  0.00  0.0
2013/04/19 00:01:00.000  45.411157373  11.896056721  63.8906  5  7  3.8721  2.1461  8.5849  1.1288  -1.1803  3.5869  0.00  0.0
```

## Navigational Message + Observation Data = POSITIONING SOLUTION

Positioning Solution File (*ext .pos*):

- Latitude (deg), longitude (deg), height (m)
- Quality solution (Q), Number of satellites (ns)
- Basic statistic parameters, ...
- Satellite derived position in particular (observed) period
- Daily GPS positioning pattern of the specific site
  - Northing, easting and altitude deviations
  - Arithmetic mean, Standard deviation, Area of confidence
  - Histogram, Probability function estimation
  - Spectrum, autocorrelation, cross-correlation of potentially related physical quantities
  - Comparison and correlation research with SW indices

# Satellite and Terrestrial monitoring

## Advanced statistical signal processing

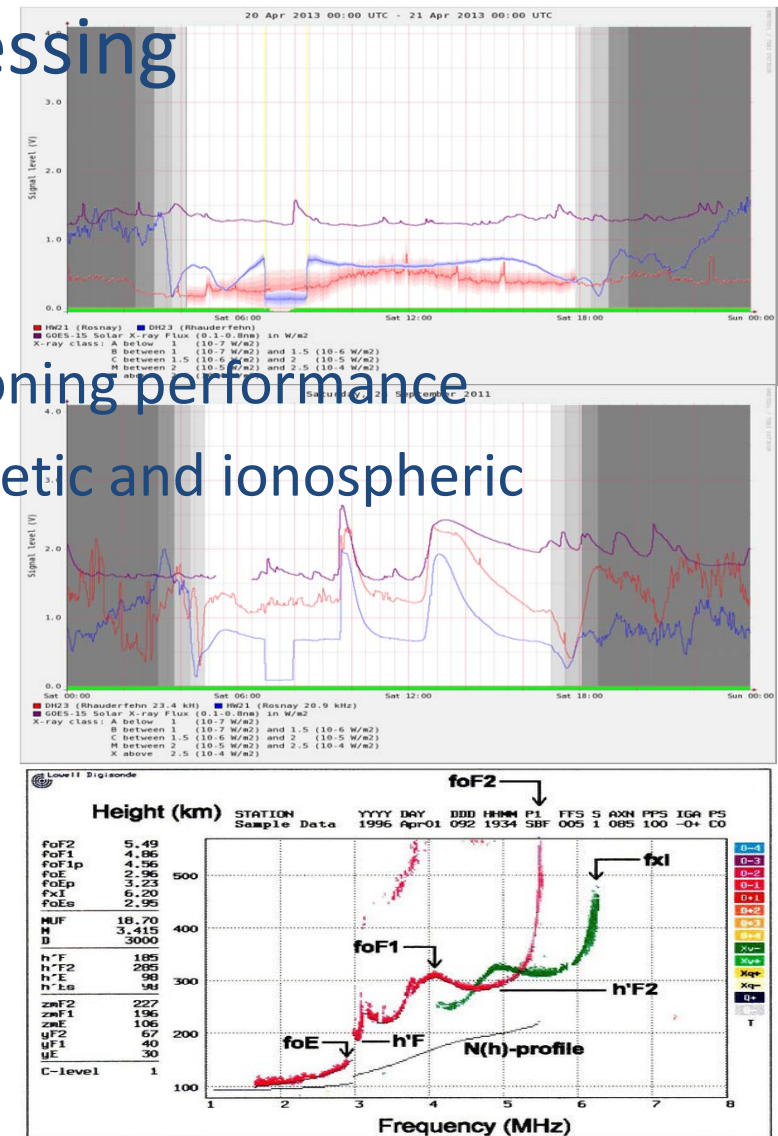
The basic procedures:

Continuous monitoring of the SNS positioning performance

Advanced monitoring of solar, geomagnetic and ionospheric activity

Disturbance identification

Time series statistical analysis



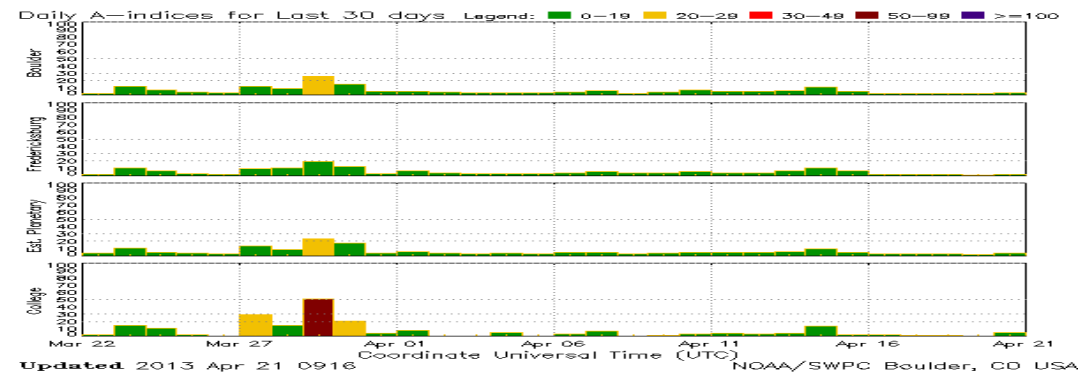
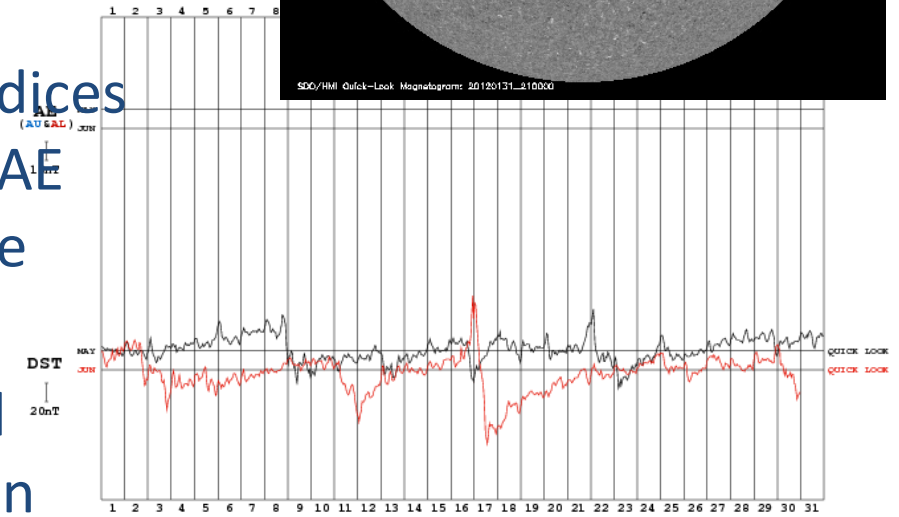
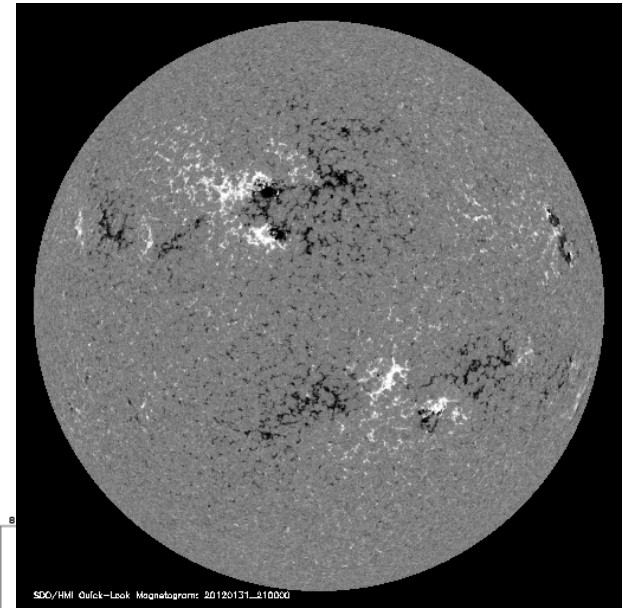
SNS positioning performance cor/relation with outer effects

# Basic space weather indices

Solar activity: Solar Radio Flux, Sunspot Number, Energetic Particle Flux, Solar Flares, Coronal Mass Ejections

Geomagnetic activity: K/Kp indices (horizontal EMF disturbances), A/a indices (daily geomagnetic activity average), AE (Auroral Electrojet) index, Disturbance storm time (Dst) index,

Ionosphere dynamics: F-layers critical frequencies (foF1, foF2), Total Electron Content (TEC, VTEC)



**NO MORE STORIES**



# 1. RTKLIB Software download: <http://www.rtklib.com/>

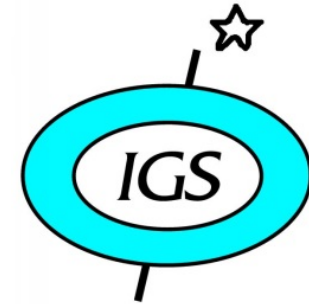
The image displays a collage of screenshots for various RTKLIB software tools. The tools shown include:

- RTKNAVI ver.2.4.2**: Shows a solution for a station with coordinates N: 35° 43' 08.2300", E: 138° 27' 02.1531", and H: 367.442 m. It includes a bar chart showing signal strength over time.
- RTKCONV ver.2.4.2**: A utility for converting data formats, showing a list of stations and their coordinates.
- STRSVR ver.2.4.2**: A stream server interface showing a table of streams with columns for Stream, Type, Opt Cond, bytes, and kps.
- RTKGET ver.2.4.2**: A utility for downloading data from Ntrip servers, showing a list of stations and their coordinates.
- RTKPOST ver.2.4.2**: A utility for post-processing data, showing a table of streams and their coordinates.
- Ntrip Browser ver.2.4.2**: A utility for browsing Ntrip servers, showing a list of stations and their coordinates.
- RTKCONV ver.2.4.2**: A utility for converting data formats, showing a list of stations and their coordinates.
- RTKPOST ver.2.4.2**: A utility for post-processing data, showing a table of streams and their coordinates.
- RTKCONV ver.2.4.2**: A utility for converting data formats, showing a list of stations and their coordinates.
- RTKGET ver.2.4.2**: A utility for downloading data from Ntrip servers, showing a list of stations and their coordinates.

The screenshots also show a Google Earth View of a station location, a table of station coordinates, and a list of station names and coordinates.

## 2. Observation Data file download

### *International GNSS Service*



- 'Observation Data File' - for specific reference station:  
<ftp://igs.eng.ign.fr/pub/igs/data/2013/>; entrance in current (or any other) year directory and selection of desired day GNSS calendar, not a date. *The last available number represents **yesterday**.* GNSS calendar:  
(<http://www.rvdi.com/freebies/gpscalendar.html>).
- Entering the directory, there is a list of IGS stations, each containing Observation Data file for the specific day
- Station selection: the LIST and the MAP of IGS stations can be found at: LIST - <http://igscb.jpl.nasa.gov/network/list.html> /  
MAP - <http://igscb.jpl.nasa.gov/network/complete.html>

### 3. Navigation Message download

*NOAA National Geodetic Survey*

*Continuously Operating Reference Stations*



- 'Navigation Message File' for the required day:  
<http://www.ngs.noaa.gov/CORS/standard1.shtml>
- Global Navigation (*Option – Non Site Specific*) - date/day in year (priority!) – Find Files – Save (same directory as before)



Congratulations!

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Chris Rizos (1999). The GPS Navigation Message, Satellite Navigation and Positioning Laboratory, School of Surveying and Spatial Information Systems, University of New South Wales, Australia. Available at: [http://www.gmat.unsw.edu.au/snap/gps/gps\\_survey/chap3/331.htm](http://www.gmat.unsw.edu.au/snap/gps/gps_survey/chap3/331.htm)

IGS (2013). International GNSS Service, GPS pseudorange observables in RINEX format, available at: <http://igsceb.jpl.nasa.gov/>

National Oceanographic and Atmospheric Association (2013): Space Weather Prediction Center (SWPC). Available at: <http://www.swpc.noaa.gov/>

NOAA National Geodetic Survey (2013): Continuously Operating Reference Stations (CORS). Available at: <http://www.ngs.noaa.gov/CORS/standard1.shtml>

RTKLIB (2007). An open-source program package for GNSS Positioning, Copyright © 2007 – 2013 by T. Takasu. Available at: <http://www.rtklib.com/>

Werner Gurtner (2007). RINEX: The Receiver Independent Exchange Format, Version 3.01, Astronomical Institute, University of Bern, Switzerland. Available at: <http://igsceb.jpl.nasa.gov/igsceb/data/format/rinex210.txt>

World Data Center for Geomagnetism (WDC) (2013): Dst Index Service. Kyoto, Japan. Available at: [http://wdc.kugi.kyoto-u.ac.jp/dst\\_realtime/index.html](http://wdc.kugi.kyoto-u.ac.jp/dst_realtime/index.html)