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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)

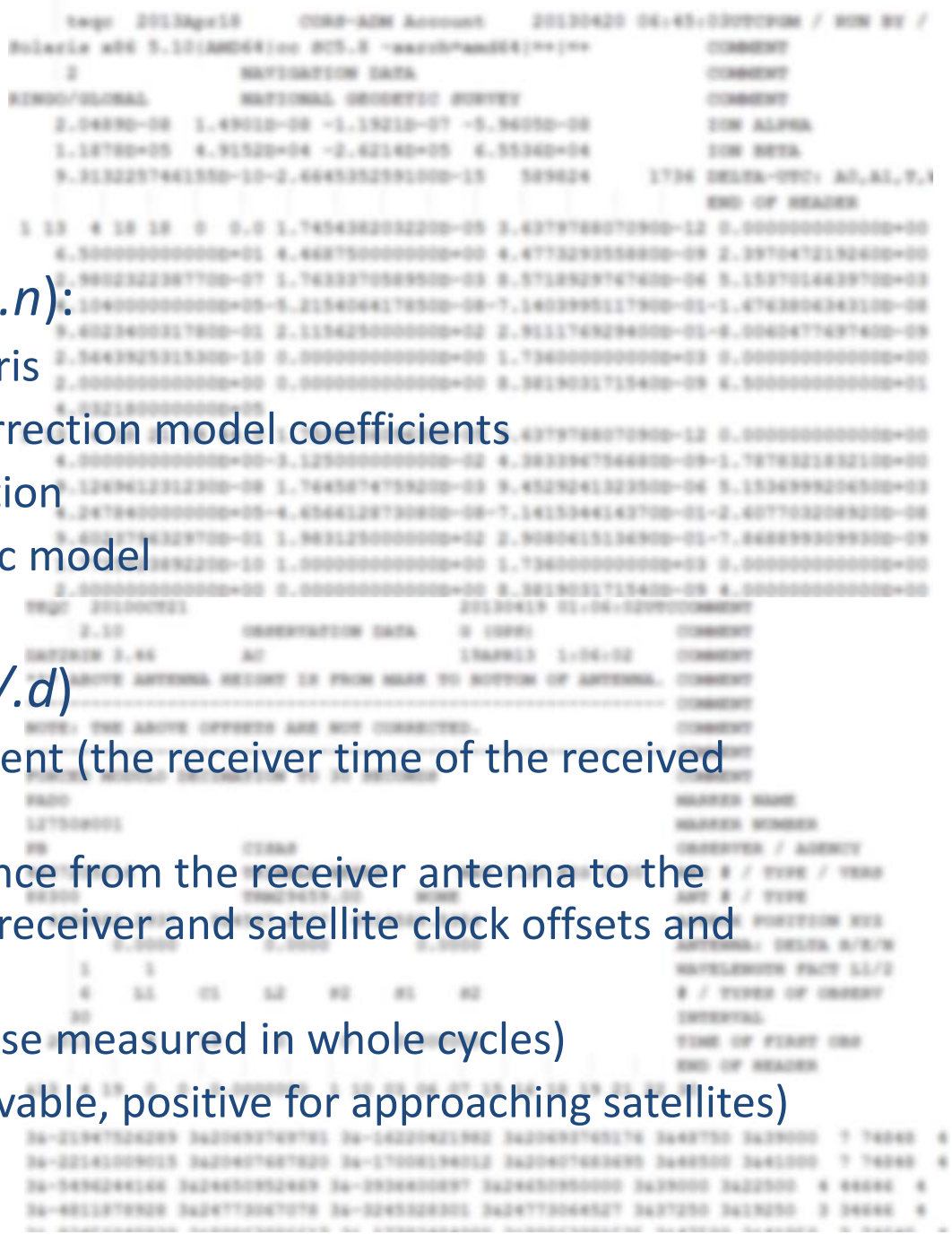
RINEX format

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



Navigation Message file (*ext .n*):

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

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)

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
```

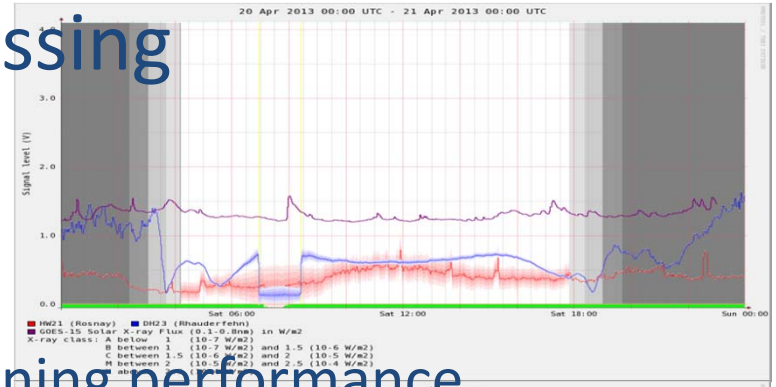
Navigational Message + Observation Data = POSITIONING SOLUTION

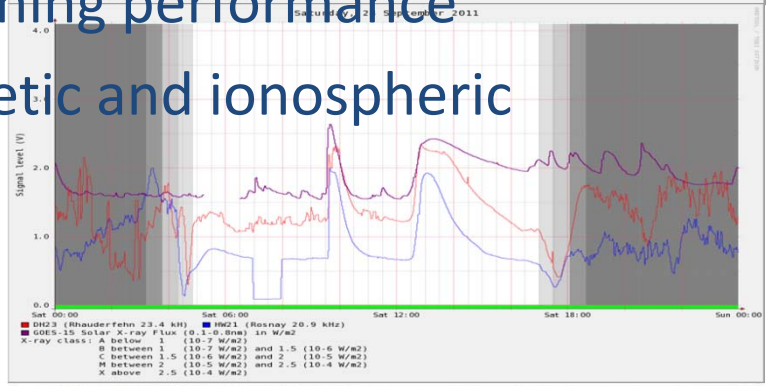
Positioning Solution File (*ext* .pos):

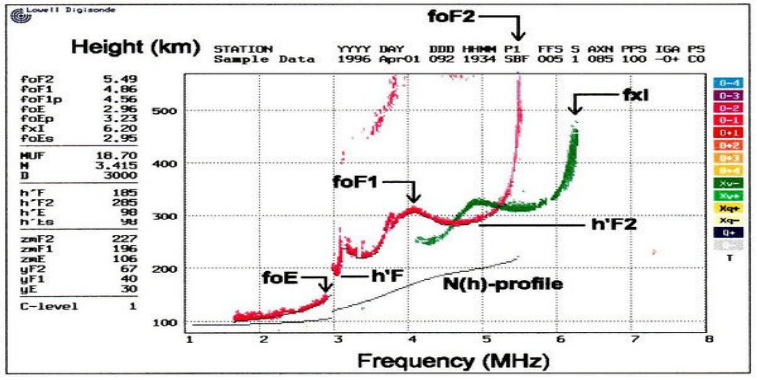
- Latitude (deg), longitude (deg), height (m)
- Quality solution (Q), Number of satellites (ns)
- Basic statistic parameters, ...

- 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:

Continous monitoring of the SNS positioning performance

Advanced monitoring of solar, geomagnetic and ionospheric activity

Disturbance identification

Time series statistical analysis

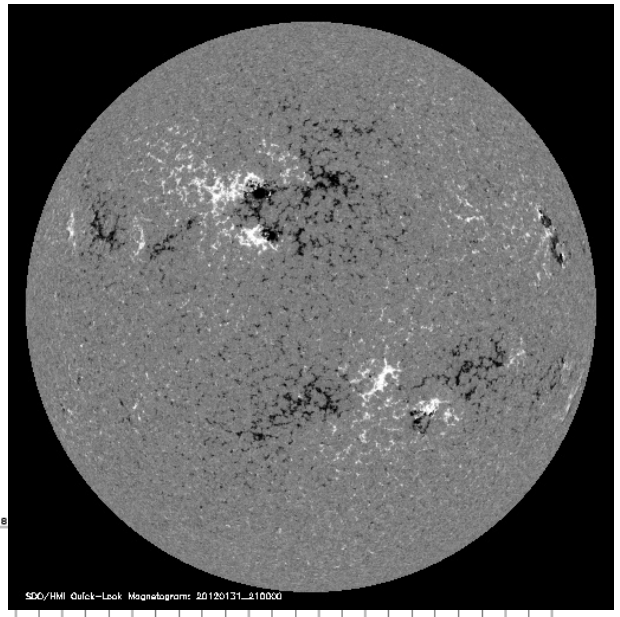
SNS positioning performance cor/relation with outer effects

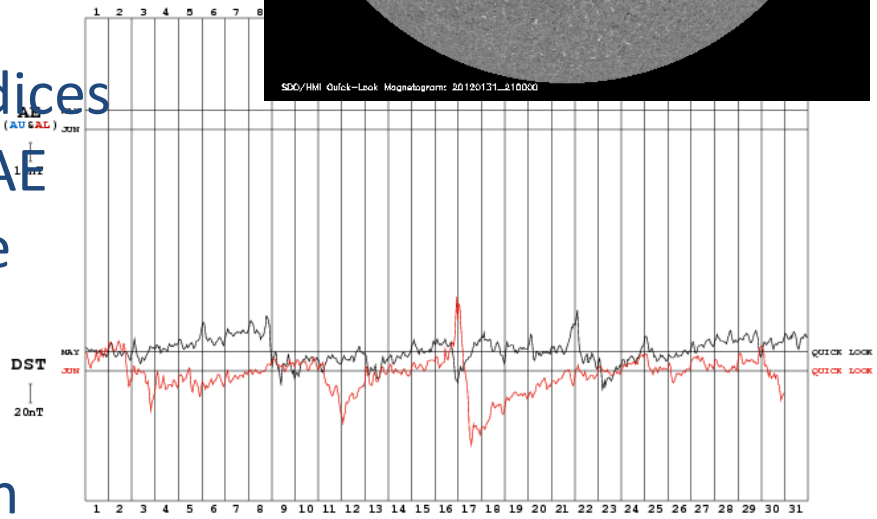
Basic space weather indices

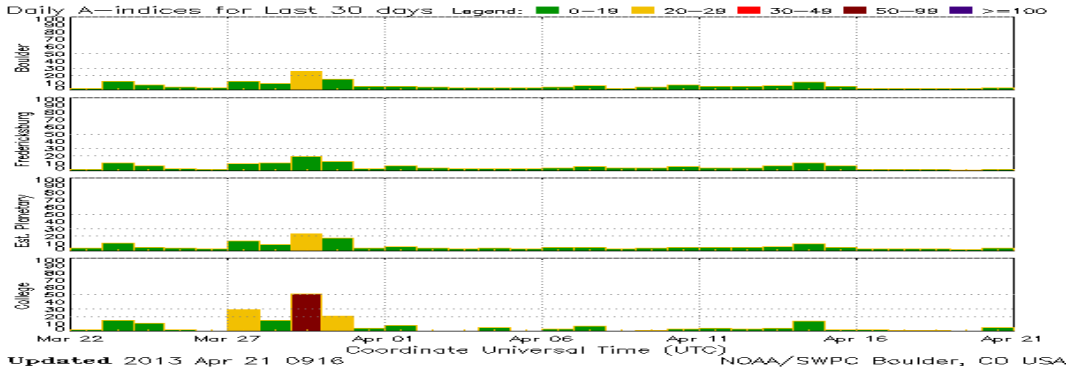
Solar activity: Solar Radio Flux, Sunspot Number, Energetic Particle Flux, Solar Flares, Coronal Mass Ejections

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)



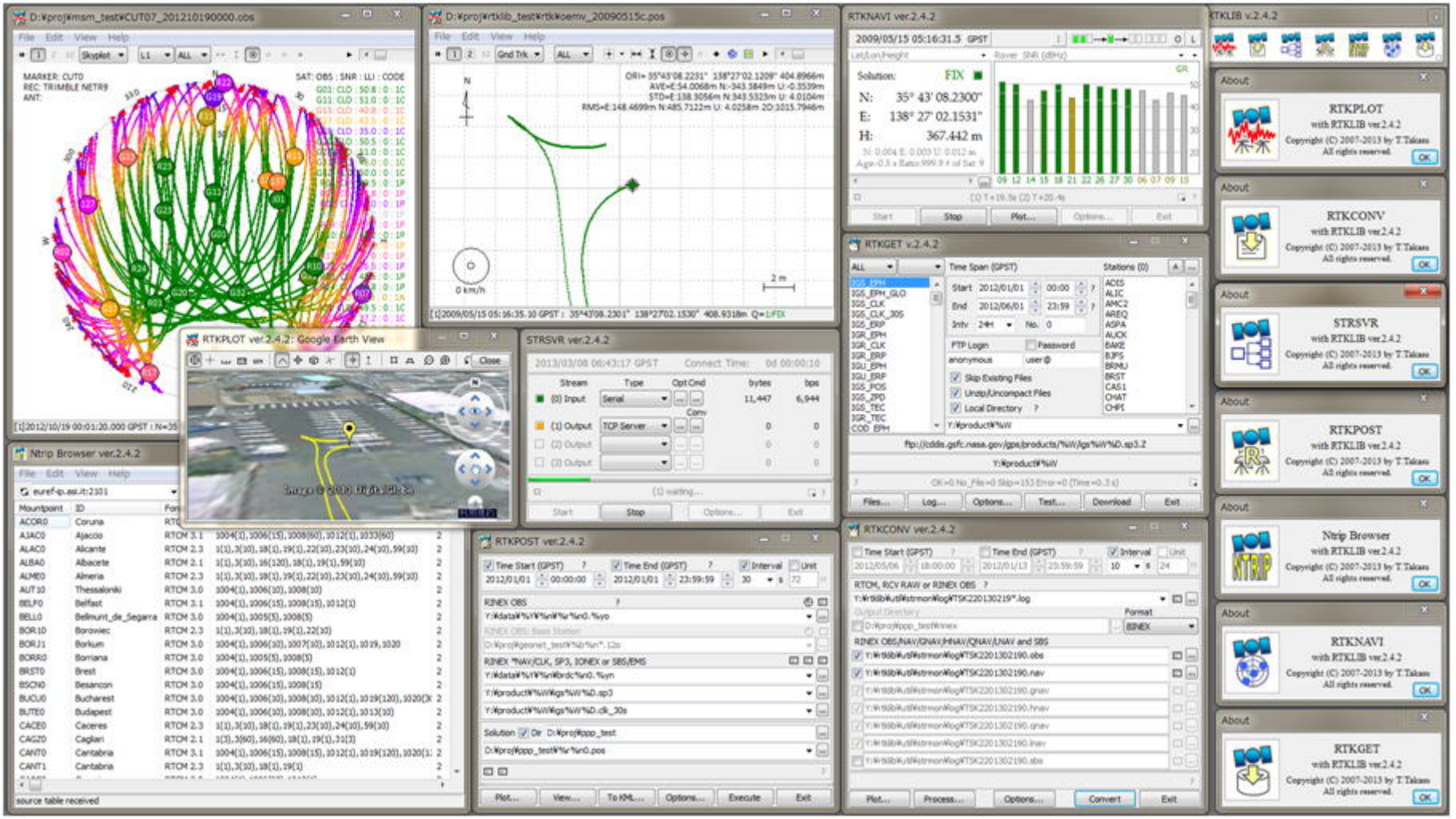




NO MORE STORIES

1. RTKLIB Software download:

http://www.rtklib.com/



2. Observation Data file download

International GNSS Service

- 'Observation Data File' - for specific reference station: ftp://igs.ensg.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

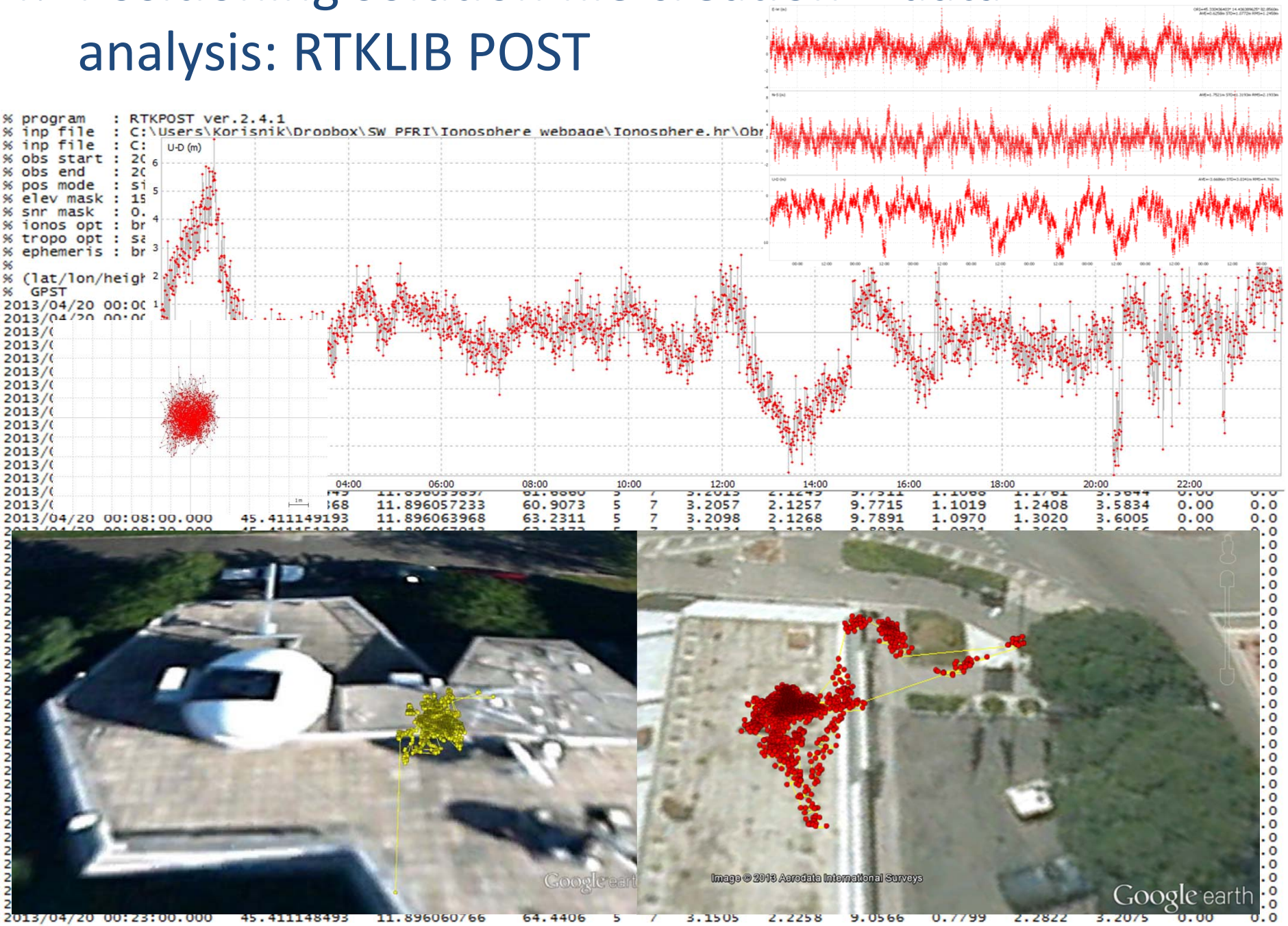
3. Navigation Message download

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)

4. Positioning solution file creation – data analysis: RTKLIB POST



Congratulations!

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