PPP GNSS processing

Interactive session

Jan Douša, Pavel Václavovic

jan.dousa@pecny.cz, pavel.vaclavovic@pecny.cz

Geodetic observatory Pecný,
Research Institute of Geodesy, Topography and Cartography

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Session requirements

- **CD with data**

  or **access to internet: http://www.pecny.cz/COST**

- **Laptop with Linux OS**
  - **Linux architecture type: 'uname -a' (x86_32 | x86_64)**
  - **shell: bash**
  - **script language: perl**
  - **text editor: jed, emacs, vi, pico, nano, …**
  - **plotting tool: gnuplot**
  - **display EPS figures: gv, evince, …**
  - **pdf viewer: acrobat, pdfview, …**

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Outline

- Brief introduction to PPP
- Browsing the CD
- G-Nut software introduction
- Interactive session
  - Processing data with various configurations
  - Output visualisations and comparisons

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Brief introduction to PPP

- Basic characteristics
  - PPP is an autonomous technique => a single station is involved in the processing
  - Processing undifferenced observations
  - Applying SSR concept
  - Precise products must be available (satellite orbits, clocks, antenna models, etc.)
- Advantages
  - PPP involves only one station
  - PPP is fast and efficient for massive or distributed processing and independent of reference stations
- Disadvantages
  - A long initialization period (tens of minutes)
  - Ambiguities are usually solved as float values (additional uncalibrated phase biases must be introduced for successful ambiguity integer resolution)

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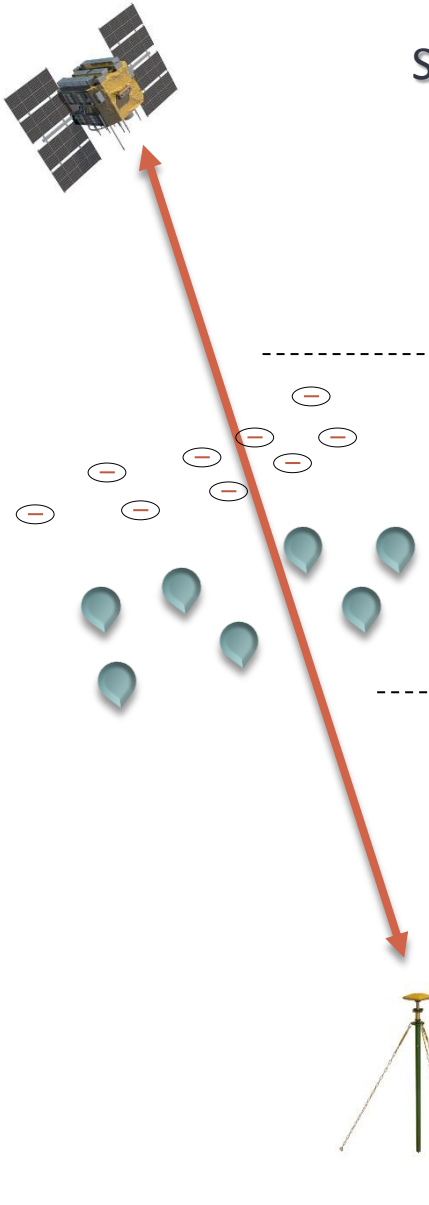
Error sources and effects



Satellite orbit and clock products

Satellite antenna models

Phase wind-up correction

Satellite hardware delays

Satellite-specific effects

Ionosphere delay

Troposphere delay

Atmospheric effects

Multipath effect

Receiver clock corrections

Receiver antenna models

Receiver hardware delays

Site-specific effects

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Error sources and effects (cont.)

- Site displacement effects
  - Solid Earth tides
  - Ocean loading
  - Atmospheric pressure loading
  - Deformation due to polar motion
- Relativistic effects

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OSR vs SSR approaches

- Observation Space Representation (OSR)
  - All the errors are lumped to one parameter -

    - observation correction
  - Employed in RTK network solution
  - The correction accuracy depends on a distance from a reference station (or inter-station distances in a Network RTK)

- State Space Representation (SSR)
  - Employed in the Precise Point Positioning
  - Each effect is modeled separately, provided to a rover site
  - Independent from need a nearby reference station(s)

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CD content

- **00README_32b (or 00README-64b)**
  - commands for x86_32 (or x86_64) computer architecture

- **bin/** software tools (TefnutPP, plot_POST, filter_TEF)
- **conf/** configuration files
- **data/** input data, models and products
  - **gen/** general information and models
  - **obs/** GNSS observations
  - **prod/** products (orbits, clocks)
- **db/** reference ZTD products from IGS or EUREF
- **docu/** documents
- **OUT/** output files (results of G-Nut/Tefnut software)
- **EPS/** output plots (results of visualizations)
- **perl/** perl modules (results processing)

G-Nut sw library

- G-Nut – GNSS software library developed at GOP
- Developed in C++ following object-oriented programming concept and multi-threading approach
- Supports all constellations
- Post-processing (files) and real-time (streams)
- End user applications derived from G-Nut library:
  - G-Nut/Tefnut - troposphere monitoring
  - G-Nut/Geb – precise positioning
  - G-Nut/Anubis – data quality monitoring tool
  - G-Nut/Shu – numerical weather data processing
  - G-Nut/Apep – time-series analysis tool

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G-Nut/Tefnut: configuration

```
<?xml version="1.0" encoding="UTF-8" standalone="yes" ?>
<!DOCTYPE config>
<config>

 <gen>
   <beg> "2012-01-03   00:00:00"  </beg>
   <end> "2012-01-03   23:59:30"  </end>
   <sys>   GPS   GLO                 </sys>
   <rec>   GOPE WTZR                 </rec>
   <int>    30                       </int>
 </gen>

 <inputs>
   <rinexo>  GOPE1030.12o    WTZR1030.12o      </rinexo>
   <rinexc>   igs16692.clk_30s                 </rinexc>
   <sp3>      igs16692.sp3                     </sp3>
   <atx>      gen/I05.ATX                      </atx>
   <blq>      gen/ITRFCODE.BLQ                 </blq>
 </inputs>

 <outputs append="false" verb="1" >
   <log>    log/geb_2012-01-03.log         </log>
  <ppp>     log/$(rec)_2012-01-03.ppp      </ppp>
    <flt>   out/$(rec)_2012-01-03.flt      </flt>
  <smt>     out/$(rec)_2012-01-03.smt      </smt>
 </outputs>
```

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G-Nut/Tefnut: configuration (2)

```
<process
   phase="true“
   tropo= "true"
   tropo_model=“saastamoinen"
   tropo_mf="gmf"
   gradient=“true"
   grad_mf="chh"
   sig_init_crd="100.0"
   sig_init_ztd="0.1"
   minimum_elev=“3"
/>

<filter
   method_flt="srcf"
   noise_crd="100.0"
   rndwk_ztd=“3"
   rndwk_grd="0.1"
/>

</config>
```

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G-Nut/Tefnut: inputs

- **Observations**
  - RINEX(O) file (offline)
  - NTRIP stream - RTCM, BNC OBS format (real-time)
- **Orbits**
  - SP3 file – 15 min sampling (offline)
  - RINEX(N) - navigation file/stream (real-time)
  - NTRIP stream - RTCM corrections (real-time)
- **Clocks**
  - SP3 file – 15 min sampling (low-rate, limited accuracy) (offline)
  - RINEX(C) – 30 or 300 sec sampling (high-rate) (offline)
  - NTRIP stream - RTCM corrections (high-rate, real-time) (real-time)
- **Antenna models**
  - ANTEX file
- **Ocean tide loading**
  - BLQ file

G-Nut/Tefnut: outputs

- Estimated parameters (<flt> *file*.flt </flt>)

# EPOCH	X[m]	Y[m]	Z[m]	ZTD	N/E-grad		dCLK	rms: X/Y/Z/ZTD				nSat	GDOP
2014-04-15 00:00:00	4075579.7493	931853.7050	4801567.4067	2.1141	-0.0001	-0.0001	-118.5835	5.0375	2.9782	7.8704	0.9372	11	2
2014-04-15 00:15:00	4075580.7847	931853.7657	4801568.5549	2.2021	-0.0448	0.0251	-117.9964	0.0959	0.0911	0.0859	0.0091	10	1
2014-04-15 00:30:00	4075580.5968	931853.8963	4801568.3560	2.2134	0.5254	0.2303	-118.2738	0.0513	0.0586	0.0551	0.0059	10	1
2014-04-15 00:45:00	4075580.6036	931853.9070	4801568.3867	2.2052	1.0576	-0.3061	-118.3055	0.0403	0.0552	0.0413	0.0045	9	1

Columns ordering: Epoch X Y Z ZTD GRN_N GRD_E CLK_REC RMS_X RMS_Y RMS_Z RMS_ZTD sat_num GDOP

- Log files
  - Program log: <log> file.log </log>
  - Processing log: <ppp> file.ppp </ppp>

G-Nut/Tefnut: running

- Correct functionality (selection of Linux architecture)
  - **bin/TefnutPP.??b –h** *(get help)*
- Command for starting a processing

  (see example commands in 00README)
  - **bin/TefnutPP.64b –x conf/<file>.xml**
  - **bin/TefnutPP.32b –x conf/<file>.xml**

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Basic task sequence

- Process data with the configuration *conf/<config>.xml*
- Display achieved coordinates in a time series plot

  bin/plot_POST OUT/<file>.flt SITE

  (have a look at the 00README)
- Modify conf/config.xml for a static/kinematic solution
  - Static coordinate solution: <filter noise_crd="0" />

    you can use *conf/PP_FIX_LOOSE.xml*
  - Kinematic coordinate solution: <filter noise_crd="100" />

    you can use *conf/PP_KIN_LOOSE.xml*
- Make plots of the both solutions and compare them

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Additional tasks

- *Effect of ZTD constraining in stochastic modeling*
  - Tight ZTD: <filter rndwk_ztd="1" />
    you can use ***conf/PP_FIX_TIGHT.xml***
  - Loose ZTD: <filter rndwk_ztd="10" />
    you can use ***conf/PP_FIX_LOOSE.xml***
- Generate plots of both ZTD estimates and compare results
- Real-time processing for all the mentioned variants
- Observe input differences between PP and RT

  RT_FIX_TIGHT.xml

  RT_KIN_TIGHT.xml

  RT_FIX_LOOSE.xml

  RT_KIN_LOOSE.xml
- Observe input differences between PP and RT

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Additional tasks (2)

- Include GLONASS satellites

  <sys> GPS **GLO** </sys>

  <rinexn> data/obs/**brdm1000.14p** </rinexn>

  you can use ***conf/RT_KIN_LOOSE_GLO.xml***

- Application of the backward smoothing

  <smt> OUT/$(rec)_PP_KIN_LOOSE_SMT.smt </smt>

  you can use ***conf/PP_KIN_LOOSE_SMT.xml***

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