Comparison between PPP and DD processing techniques using Bernese 5.2
Computation of displacements and velocities of Marussi FVG and FredNet GNSS networks and visualization on GeoServer: first results

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Summary

- Modernization of GNSS Systems
- **Scientific Bernese Software** – main features
- Implementation of a WebGIS on a GeoServer platform
- Case studies
  - Applications on computation of displacements and velocities
    Marussi FVG and FredNet GNSS networks
  - Analysis on different temporal series
GNSS – GPS, GLONASS

GPS (Global Positioning System):
- New civil codes: L2C – L1C (interoperability GNSS) – L5C.
- New military code: M
- New signals: L5

GLONASS (GLObal NAvigation Satellite System):
- New civil codes: L1OC, L2OC, L3OC
- New military codes: L1SC, L2SC
- New signals: G3
**GNSS – GALILEO**

- 27 satellites on 3 orbits equidistant inclined of 56°, “Medium Earth Orbit (MEO)” approximately 23,222 km.


- Open Service (OS), Public Regulated Service (PRS), Commercial Service (CS), Search and Rescue (SAR), Safety-of-Life (SoL).

<table>
<thead>
<tr>
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<th>Channel or sig. comp.</th>
<th>Services</th>
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</table>
BERNESE – Introduction

Main features:

• Elaboration of GNSS (GPS, GLONASS, GALILEO) code and phase data
• Automatic elaborations of networks and permanent stations
• Phase ambiguity resolution with baselines longer than 2000 km
• Monitoring of ionospheric and tropospheric data
• Satellite orbits determination, clock errors and Earth parameters estimation
BERNESE – Structure

ORBIT PART
- EOP preparation
- orbit generation

SIMULATION
- simulation of observations

TRANSFER / CONVERSION PART
- import/export of observations
- extraction of meta-information from external sources

PROCESSING PART
- preprocessing of observations
- session solution
- multi-session solution

SERVICE PART
- tools to
  - manage observation files
  - browse/analyse residual files
  - manipulate/verify coordinate files

orbit data
- e.g., precise orbits, navigation RINEX

EOP data
- IERS or Bernese format

observation data
- Rinex format

meta data
- e.g., SINEX containing ITRF resp. station information, ANTEX, etc.
• **GPSEST** – "Menu > Processing > Parameter estimation": main function for parameter estimation based on Ordinary Least Squares (coordinates, ambiguities, troposphere, ionosphere, orbital elements...).

• **ADDNEQ2** – "Menu > Processing > Combine normal equation system": function to elaborate many Normal Equation (NEQ) from GPSEST (coordinates and velocities estimation on temporal series).

• **COOVEL** – “Menu > Service > Coordinate tools > Extrapolate coordinates”: function to spread coordinates from a reference epoch to a custom epoch, using station velocities.
BPE (Bernese Process Engine): function to automatize processes using scripts from RINEX observations to results. Possible to configure a cluster to realize parallel computations.
**BPE (Bernese Process Engine):** function to automatize processes using scripts from RINEX observations to results. It is possible to configure a cluster to realize parallel computations.
Marussi and FredNet GNSS data processing

- Precise Point Positioning (PPP) and Double Differences (DD) processing techniques were used on different set of geodetic GNSS data, relative to some vertexes belonging to Marussi FVG and OgS FredNet GNSS permanent networks, using Bernese 5.2 software.

- Marussi PORD (Pordenone, Italy) vertex
- OgS FredNet AFAL vertex
The recorded data sets have been divided in different time intervals:

- a daily subdivision relative to December 2014
- a weekly subdivision relative to the first week of December from 2010 to 2014 and
- yearly for the data from 31th December 2003 to 31th December 2014.
FredNet vertexes velocities were obtained to respect to the Euroasiatic Plate.

The coordinates of the network vertexes were computed in the ITRS2000 Reference System.

Data analyses, storing, visualization and sharing were performed using GIS tools:
- QGIS for geographical data processing,
- GeoServer for geographical data sharing,
- PostGIS for the database linking and
- GeoExplorer for data visualization.
WebGIS Structure
Case studies - Permanent Station Networks

“The GNSS permanent network Marussi (Regione Friuli Venezia Giulia), composed by 10 stations and realized in order to provide assistance for determination of geographical elements, useful in regional cartography.”

“The OGS (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale, Sgonico) FReDNet network (Friuli Regional Deformation Network) is a monitoring system for Earth crustal deformation over the Friuli - Venezia Giulia region”
**Precise Point Positioning** is a “zero-difference” technique, using which it is possible to calculate an absolute position using code measurements smoothed with phase and errors modeling.

In order to obtain high precision measurements (centimetric accuracy), it is necessary to use satellite ephemeris, Earth parameters and satellite clock offsets.

Final precision is less than “Double Difference Technique”, because of impossibility to solve phase ambiguities.
Case studies - Precise Point Positioning

MARUSSI NETWORK – SESSION 274 – YEAR 2014

<table>
<thead>
<tr>
<th>Stazione</th>
<th>X (m)</th>
<th>Y (m)</th>
<th>Z (m)</th>
<th>RMS X (m)</th>
<th>RMS Y (m)</th>
<th>RMS Z (m)</th>
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Data shown as geocentric cartesian coordinates and displacement velocities from .OUT file.
FREDNET NETWORK – SESSION 274 – YEAR 2014

Data shown as geocentric cartesian coordinates (above) and displacement velocities (left) from .OUT file.
Marussi Network

<table>
<thead>
<tr>
<th>Stazione</th>
<th>$\Delta X$ (mm)</th>
<th>$\Delta Y$ (mm)</th>
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FredNet Network

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Precise Point Positioning and Double Difference processing DIFFERENCES. Maximum difference is **16 mm**.
### Case studies – AFAL and PORD

<table>
<thead>
<tr>
<th>Stazione</th>
<th>Informazioni</th>
<th>Latitudine (gradi)</th>
<th>Longitudine (gradi)</th>
<th>Quota (cell.)</th>
<th>RMS Latitudine (m)</th>
<th>RMS Longitudine (m)</th>
<th>RMS Quota (m)</th>
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<tbody>
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<td>AFAL 12766M001</td>
<td>Alpe Faloria, Cortina d’Ampezzo (BL)</td>
<td>46.5271447387</td>
<td>12.1745183079</td>
<td>2284.095</td>
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<td>0.00011</td>
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<td>PORD 00000M000</td>
<td>Pordenone (PN)</td>
<td>47.0671313989</td>
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<td>GRAZ 11001M002</td>
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Data obtained from daily data of December 2014, using Double Difference technique and referred to 01/02/2015 (COOVEL).
1) Daily elaborations from 1st to 31th of December 2014
Case studies – AFAL e PORD

AFAL AND PORD – IGS/EUREF NETWORKS
Case studies – 30 days

Stazione PORD - Variazione NORD

PORD STATION
DECEMBER 2014
PPP AND DD
Case studies – 30 days

PORD STATION
DECEMBER 2014
PPP AND DD

Stazione PORD - Variazione EST

-0.020
-0.015
-0.010
-0.005
0.000
0.005
0.010
0.015
0.020

EST (metri)

Giorni

PPP
DD
Case studies – 30 days

Stazione PORD - Variazioni NORD - EST - QUOTA

PORD STATION
DECEMBER 2014
Case studies – 2010-2014
Case studies – 2010-2014

AFAL STATION

Stazione AFAL - Variazione EST - 2010-2014

Giorni

EST (metri)

Valori EST
Case studies – 2010-2014

AFAL STATION

Stazione AFAL - Variazione QUOTA - 2010-2014
Case studies – 2010-2014

QGIS presentation of AFAL movement, period 2010-2014.
Data shown in table were obtained on 365 (366) day, period 2003 - 2014, using Double Difference technique and referred to 01/02/2015 (COOVEL).
Case studies – 2003-2014

FREDNET NETWORK
PLANIMETRIC VELOCITIES
Case studies – 2003-2014

FREDNET NETWORK
ALTIMETRIC VELOCITIES
"Bernese" GNSS scientific software is a powerful tool to analyze geodetic GNSS data.

In this Research work (eng. Federico Morsut Degree Thesis), it was used for:

- Computation of station positions using displacement velocities and precise observations.

- Confirmation of experimental convergence between Precise Point Positioning and Double Difference (24 hours data).

- Confirmation of displacement velocities of FReDNet Network, in comparison with OGS official data.

- WebGIS are a powerful tool to share and to understand geodetic data, using different overlays on digital cartography and graphical visualizations.
THANKS FOR YOUR ATTENTION!

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NEW ADVANCED GNSS AND 3D SPATIAL TECHNIQUES APPLICATIONS to CIVIL and ENVIRONMENTAL ENGINEERING, GEOPHYSICS, ARCHITECTURE, ARCHEOLOGY and CULTURAL HERITAGE

In memory of Professor Giorgio Manzoni