Integrated geodetic infrastructure as a support of national and international GNSS projects: case study of the Geodetic Observatory Pecný (CZE)

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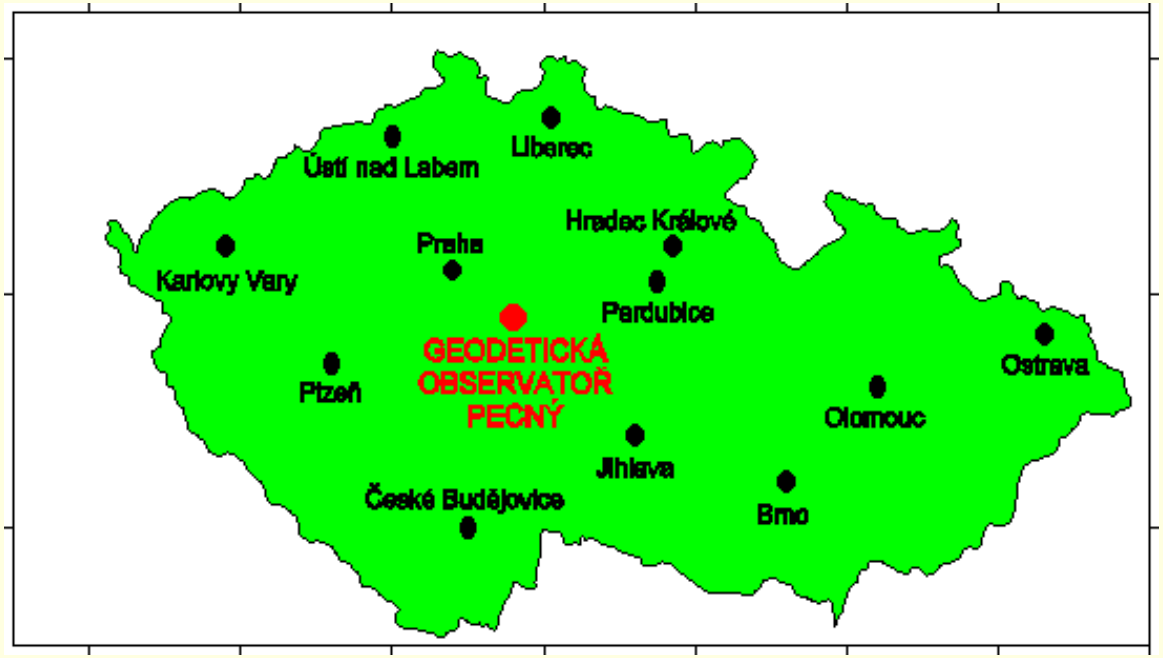
Geodetic Observatory Pecný

- one component of the RIGTC
- observatory founded in 1957
- located in Ondřejov 35 km SE from Prague



Research activities

- development of the observation system and of analysis centres at GOP
- theory of detailed gravity field modelling
- improved ETRS national realization and NGC integration into European frames
- monitoring permanent GNSS array in the Czech Republic
- development of the GOP scientific database
- mandatory reference frames in the Czech Republic

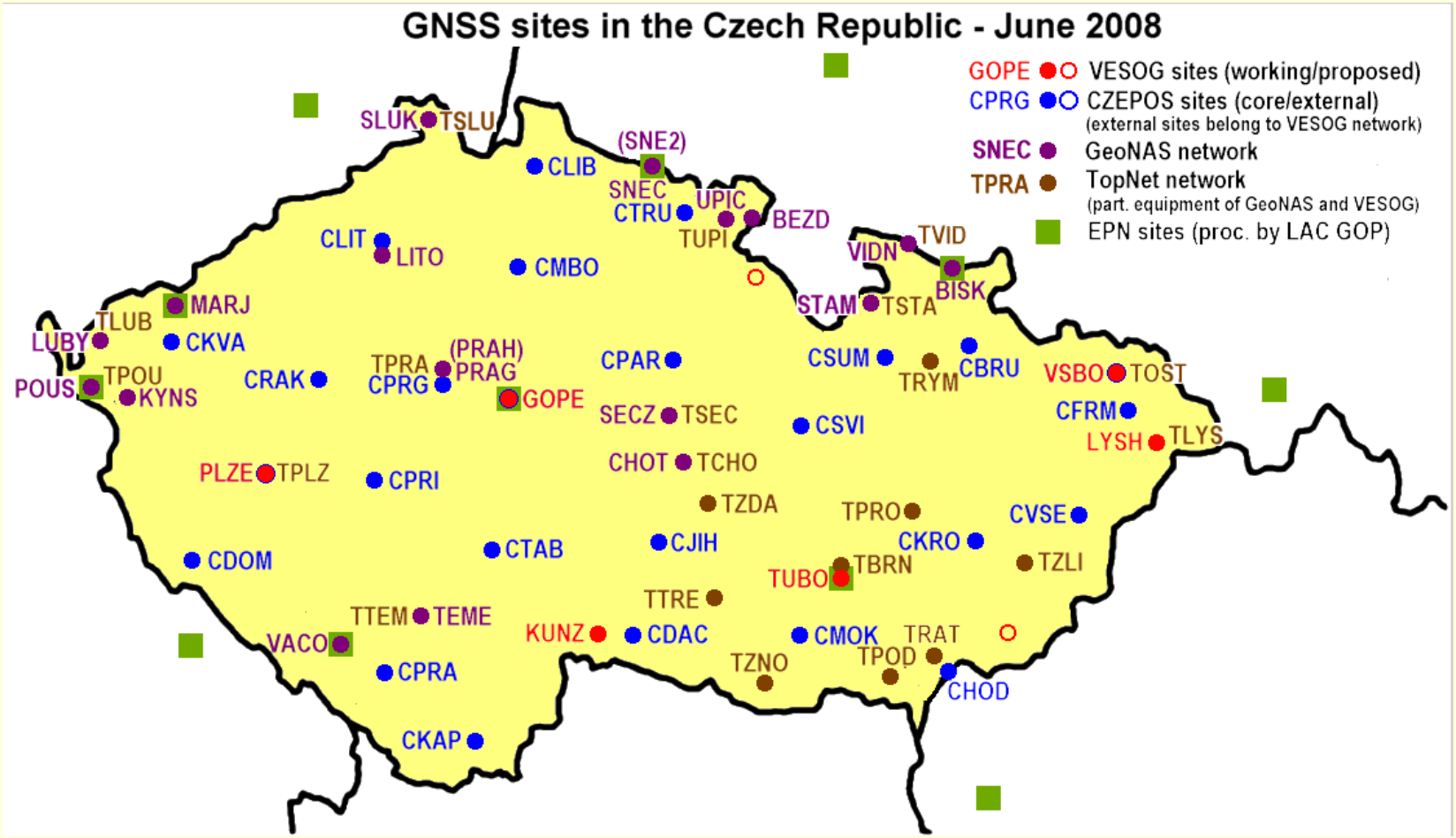
Reference frames in CZ

- ETRS
- WGS-84 (Czech Armed Forces)
- S-JTSK (principal civil user system)
- old (Austrian-Hungarian) cadastral systems
- vertical reference system „Baltic“ (BVP)
- Gravity system 1995
- S-42 (former military system)

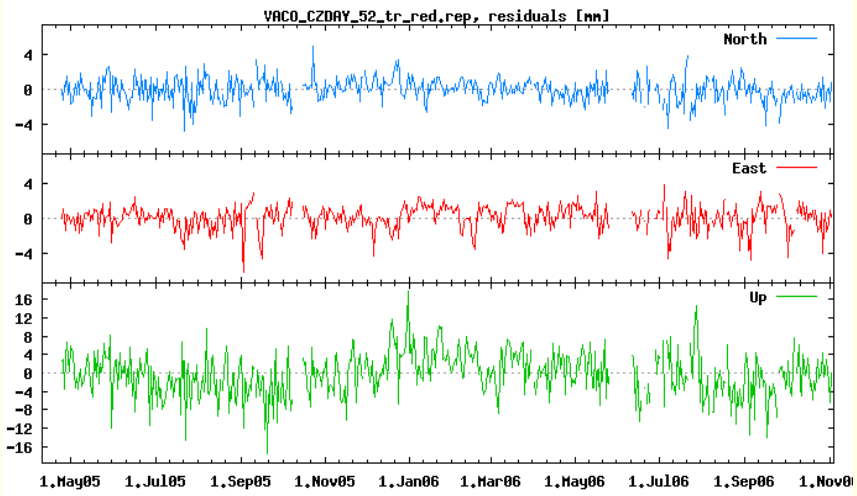
Horizontal geodetic points in CZ

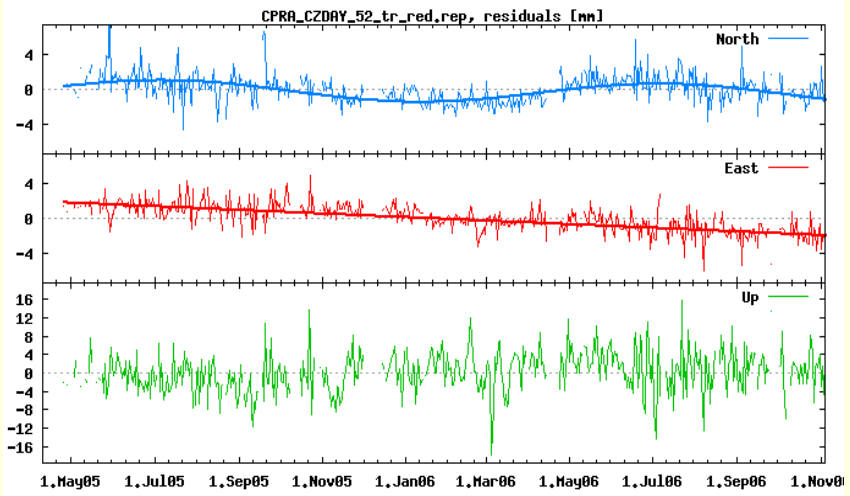
- national permanent GNSS array (CZEPOS)
- scientific and research GNSS network (VESOG)
- GNSS reference network (DOPNUL)
- GNSS/triangulation stations (about 3,500) selected for periodical maintenance
- triangulation stations (1st – 5th order)
- GNSS/terrestrial densification points (about 35,000)

Permanent GNSS Stations in CZ



Stability of GNSS stations





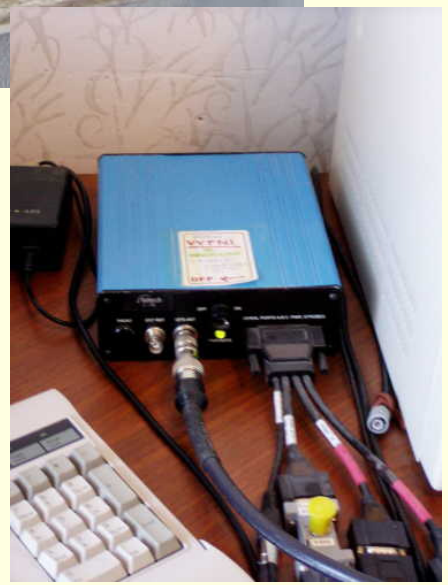
Category	CZEPOS	VESOG	GeoNAS	total
Stable	8	-	1	9
Outliers	0	2	2	4
Unsure	7	1	1	9
Periodicity	5	1	1	7
Trend	2	-	-	2

IGS permanent station GOPE

- located on the roof of the main observatory building
- beginning of measurements: September 1993, for IGS 1995, for EPN 1996
- now used receiver Ashtech Z18 and antenna Topcon CR3-GGD
- GNSS used: GPS NAVSTAR + GLONASS
- measurement interval: 1 sec decimated for IGS/EPN to 30 sec
- data:

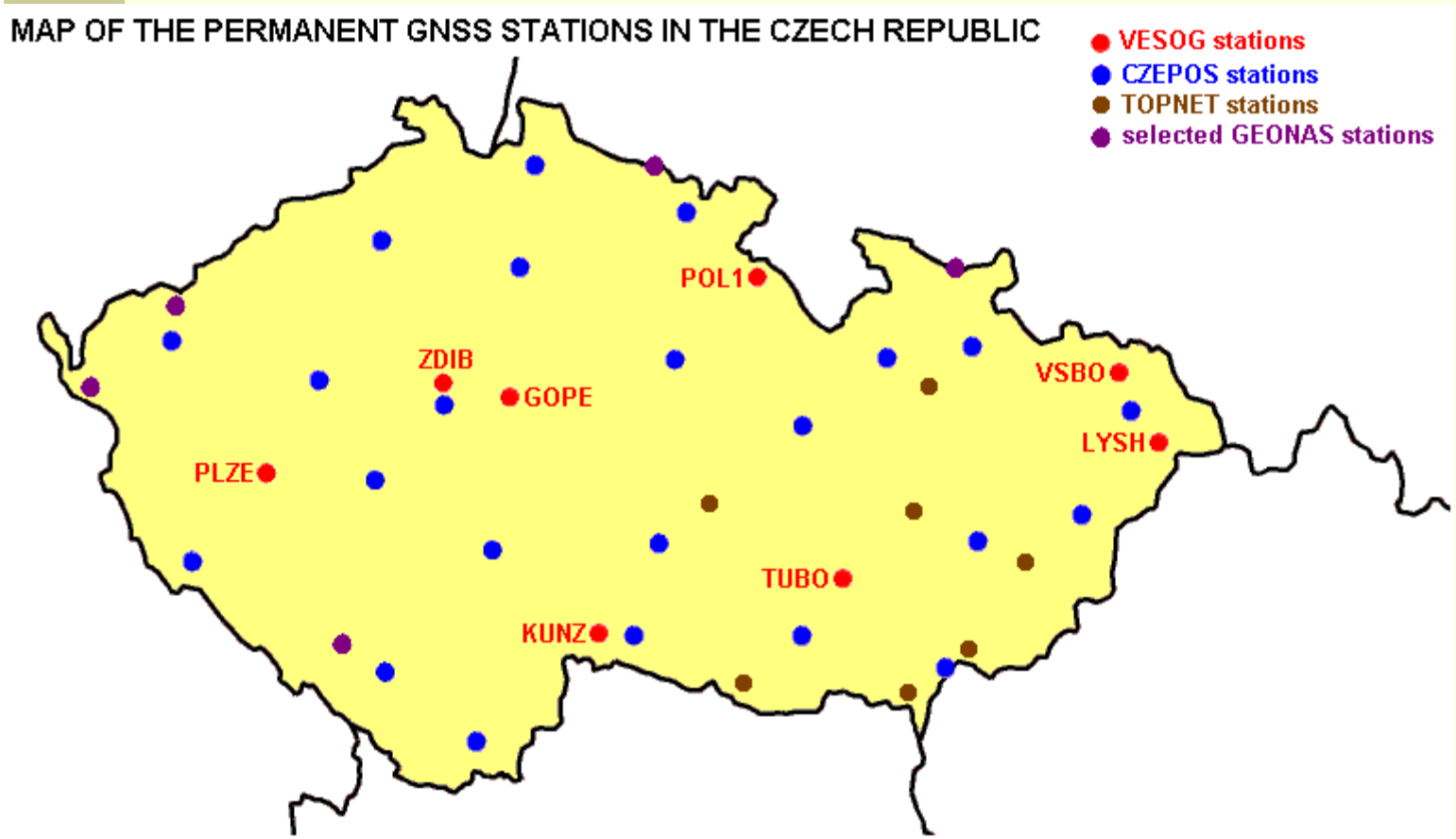
  - files in RINEX format every 15min/1 hour/1 day
  - real-time data stream RTCM v.2 (DGPS, RTK)
- used Ashtech software GBSS with own software superstructure

Antenna Topcon CR3-GGD with conical radome



Receiver Ashtech Z18

VESOG – Research and Experimental Network for Observations of Satellites



- eight permanent stations of research, academic or military institutions (red on the picture)
- GO Pecny supplies to VESOG with 3 stations and operation center for data transfer and checking of station operations

VESOG stations

LYSH

VSBO

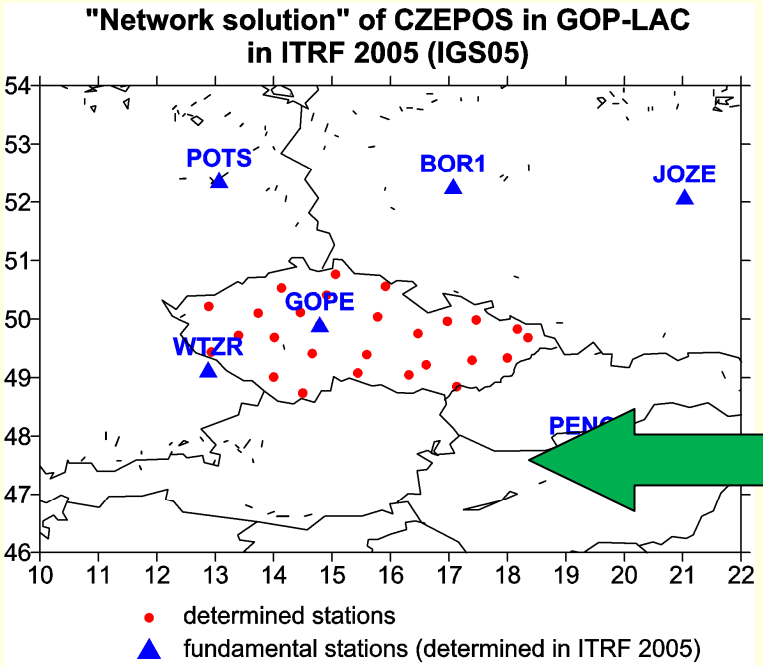
TUBO

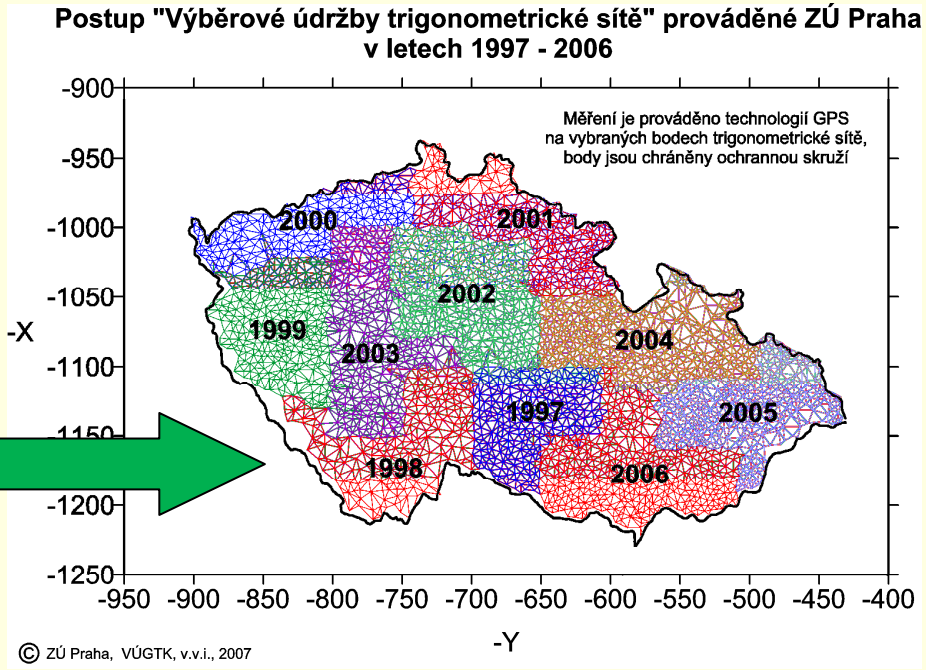
PLZE

KUNZ

POL1

Improving the national reference system S-JTSK

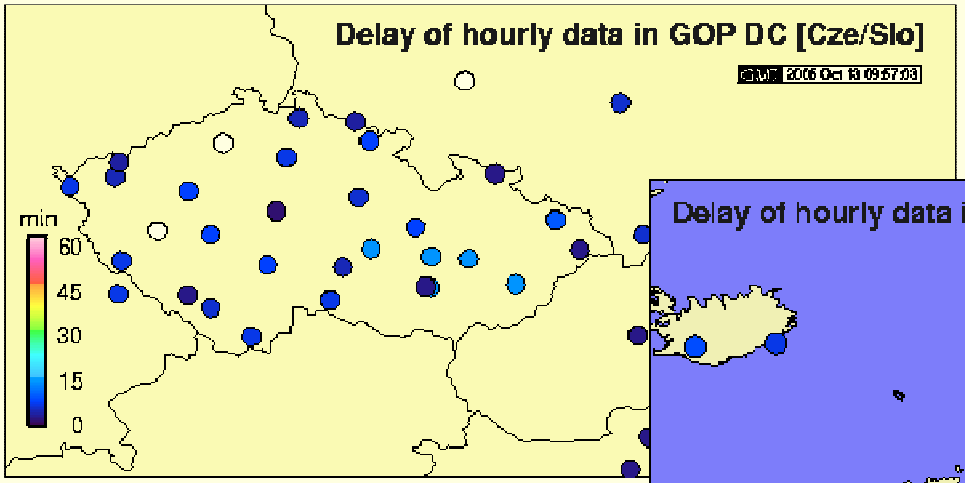


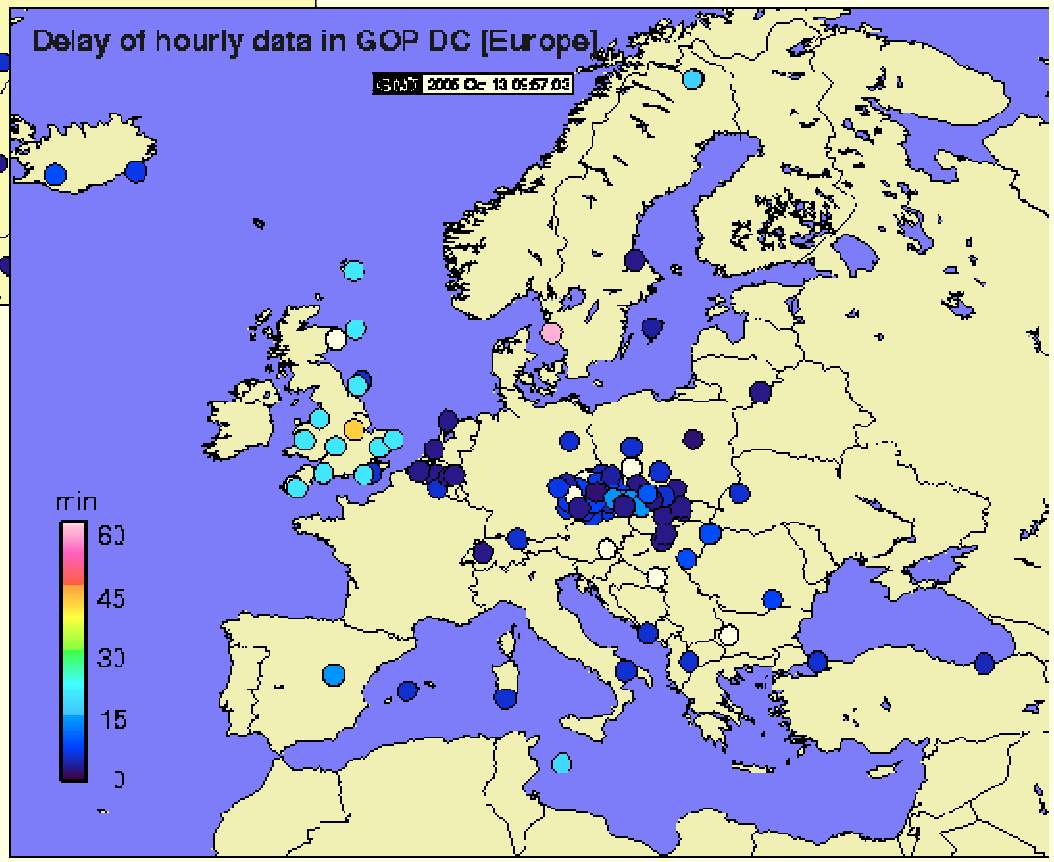


implementation of ETRS89 (R05) by CZEPOS network

new “GPS network”, measured 1997 – 2006 by Surveying Office

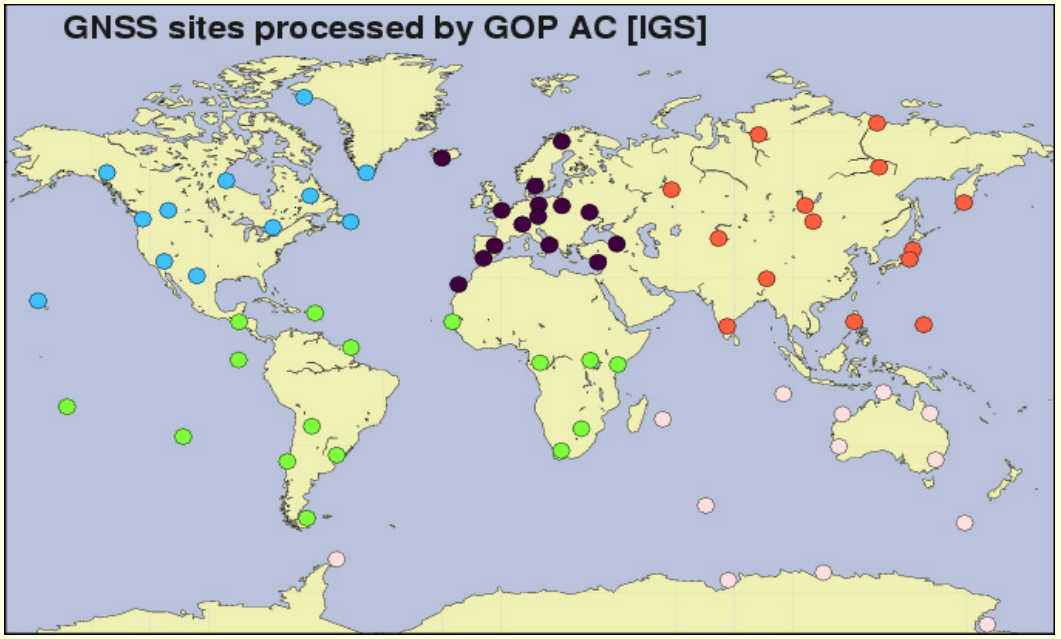
GNSS Data Centre Pecný





- observation files for more than 150 globally distributed stations
- GNSS RINEX data,
- IGS, EPN, IERS, CODE
- products, information about GNSS permanent stations etc.

Local Analysis Centre Pecný



- regular processing 55 EPN stations
- regular processing of 39 GNSS permanent stations from the Czech Republic (CZEPOS, TOPNET, VESOG)
- regular processing of 79 GNSS stations within the projects of GPS meteorology – TOUGH, E-GVAP)

Absolute gravimeter

- absolute gravimeter FG5 No. 215 was purchased in August 2001 from Micro-g Solutions
- since March 2008 national standard of gravity (metrology)
- principe: free-fall gravity acceleration is determined from track of free-falling corner cube in vacuum (measurement of distance by interferometer using iodine stabilized He-Ne laser beam and measurement of time by rubidium atomic oscillator)
- overall accuracy about 2 μgal ($2.10^{-8} m.s^{-2}$)
- repeated at least one-day observations with one-month period

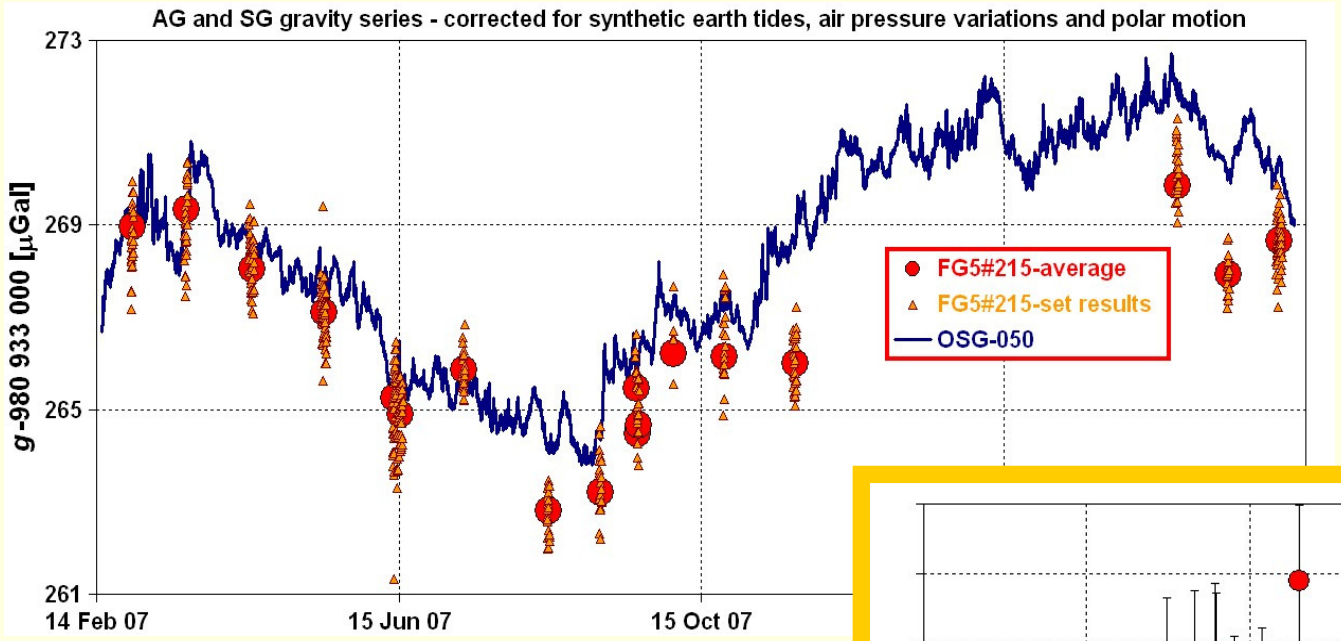
Relative gravimeters

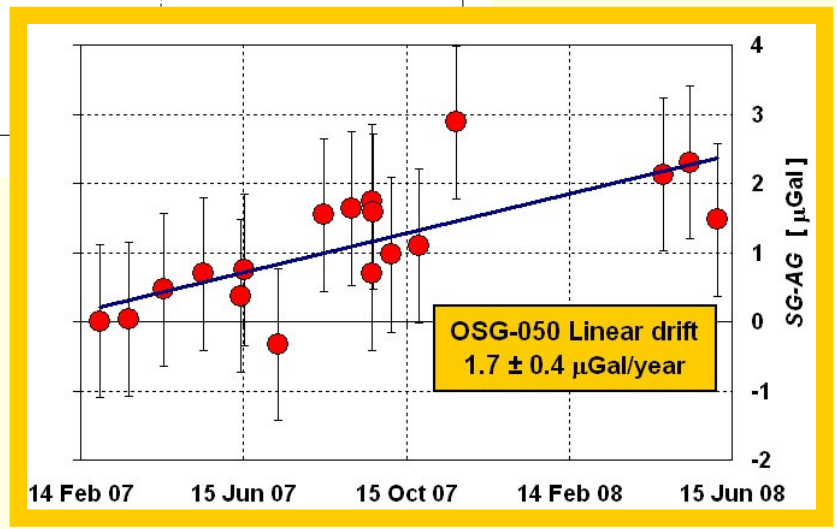
- relative gravimeters determine tidal and non-tidal gravity variations
- principe: mass on spring – gravity variations cause the position change of mass on the spring (measurement of changed position or measurement of additional force used for keeping the mass in the same position)
- spring relative gravimeters use usually metallic or quartz spring
- tidal station Pecny works from 1970 in basement of main building
- now two spring gravimeters are there: Askania Gs15 No. 228 and LaCoste-Romberg G No.137

Superconducting gravimeter

- the superconducting relative gravimeter was installed in tidal station in February 2007
- OSG No. 050 from GWR, USA
- principe is similar to relative gravimeters but the spring is defined by magnetic field of two superconducting coils – it is very stable and the gravimeter has very small drift (change of measurement in time due to changing of physical characteristic of measurement system)
- possibility to observe the long-period tidal waves and hydrological effects

Comparison of AG and SCG





- accurate detection of systematic error variations for absolute gravimeters
- drift determination for superconducting gravimeters

Meteorology

- basic set of meteorological sensors (air temperature, relative humidity and atmospheric pressure) is installed on all VESOG permanent GNSS stations
- first measurements from 1996
- mobile climatologic station of Faculty of Nature of Charles University Prague was installed in 2002 on the top of hill Pecny
- climatologic station also measures the wind direction and velocity, sunshine, rain and surface and sub-surface temperatures.

Meteorological chamber at TUBO station

Mobile climatologic station

Water in soil

VIRRIB LP A

rain gauge

old well

- rain gauge ANEMO S50 V measures rain fall automatically from 2002
- soil moisture sensors are installed in differential depths from 0.1 till 1.2 m since 2004
- six VIRRIB LP A sensors measure soil moisture every 10 min.
- pressure sensor is used for measurement of groundwater level in the old unused well since 1998, from 1988 till 1998 the manual system was used

Water vapour radiometer

- water vapour radiometer TP/WVP No. 3025 was manufactured by Radiometrics, USA and it was installed in September 2006 at the rail on the roof of main building beside the GOPE permanent station
- from brightness temperatures of molecule of oxygen, water and water vapour are derived the profiles of temperature, relative humidity and water content in the nearest atmosphere to height 10 km
- due to GPS options the water vapour and liquid water profiles are measured also in the directions to GPS satellites

Radiometer without cover

Frequency standard

Caesium atomic clock

Time GPS receiver

- main part of frequency system is a caesium atomic clock Symmetricom 5071A
- for connection of time and frequency to international time scale the GPS receiver for time-keeping applications will be used
- precise frequency is used for comparison of frequency of rubidium oscillator inside absolute gravimeter and for GNSS receiver at the GOPE permanent station

Seismometer

- very-broad band seismometer Guralp CMG-3TD with band between 360 s – 50 Hz will be installed in the new 60 m depth borehole on the top of hill
- build of surface object above borehole is near to finish

Conclusions

- improved ETRS national realization
- monitoring permanent GNSS arrays in CZ
- activities of the observatory important for many international projects and campaigns
- collocation between geometric and gravity field reference frames
- data collected / analyses performed by the observatory allow for integration of national geodetic controls into European and international reference frames

Thank you for your attention