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On the Way to ECGN Realization in the Czech Republic: a Concept

Supported by the project LO1506 PUNTIS

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Outline

1. ECGN and GGOS
2. ECGN in the Czech Republic
3. Observations : GNSS, heights, gravimetry
4. Some results and comparisons
5. Capabilities of observation techniques
6. Conclusions and outlook

ECGN and GGOS

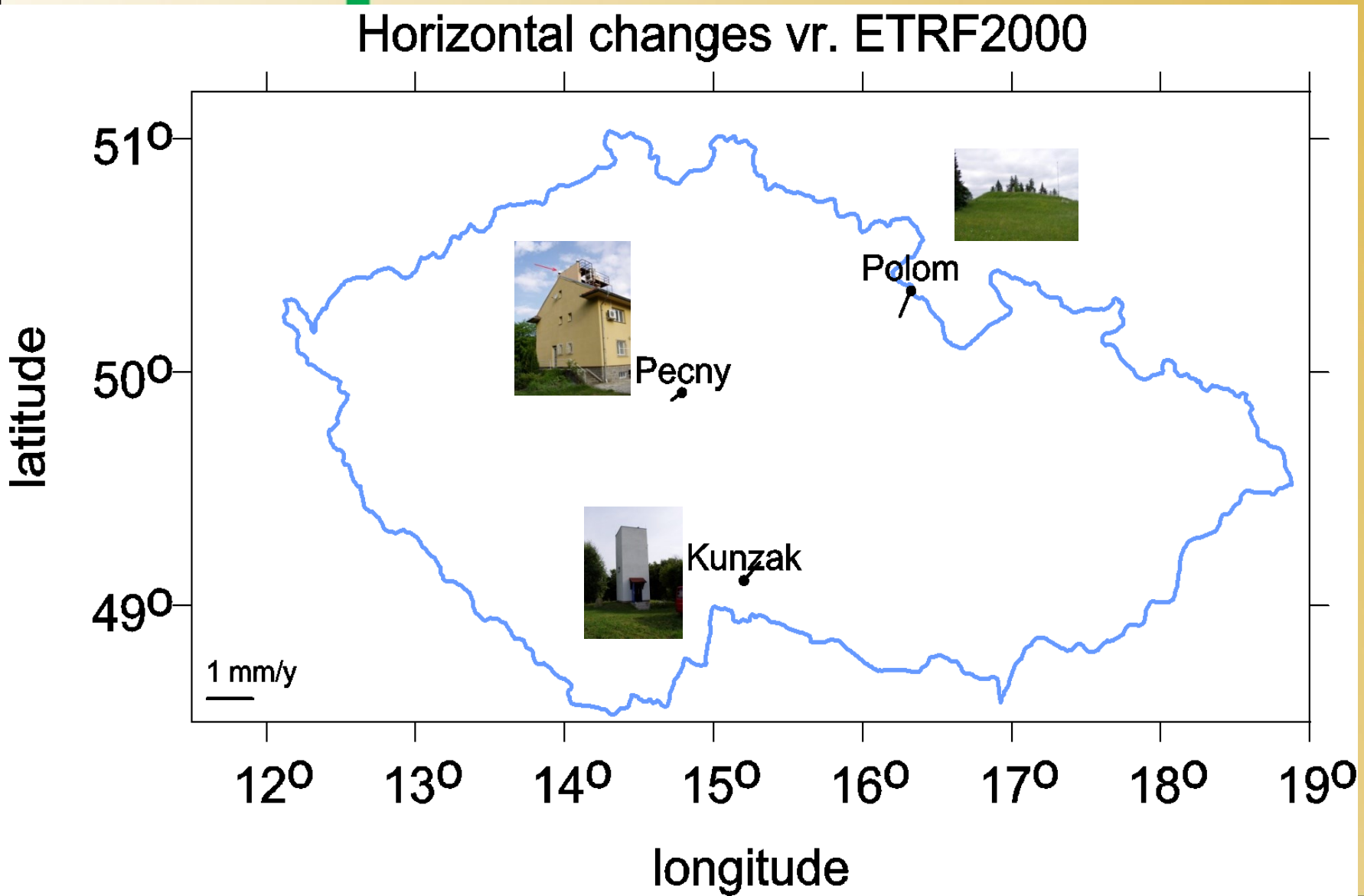
GGOS

- Geometry, gravity field, EOP
- Comprises TRS, CRS
- 5 levels of observation infrastructure:
  1. Terrestrial geodetic infrastructure
  2. LEO satellite missions
  3. GNSS + SLR satellites
  4. Planetary missions
  5. Extragalactic objects

ECGN

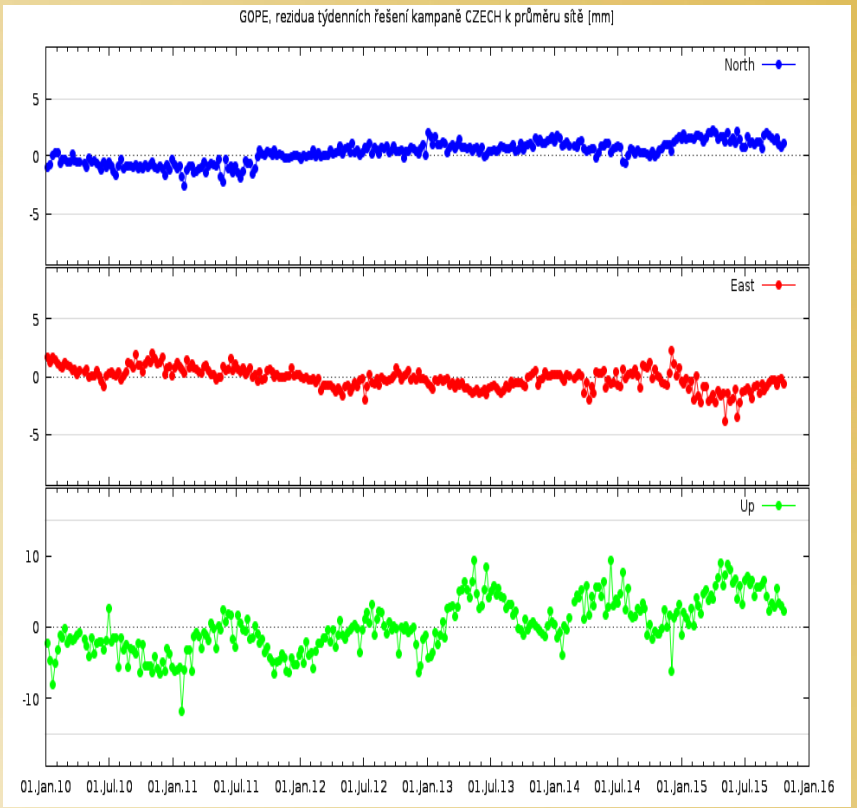
- Contribution to terrestrial geodetic infrastructure
- Maintenance of the long term stability of TRS at the level of 10^{-9}, esp. for the height component … e.g. Ihde et al., 2005, Poutanen et al., 2015
- Combination of geometry (GNSS) and gravity field (heights, gravity,tide gauges)

ECGN stations in the CR



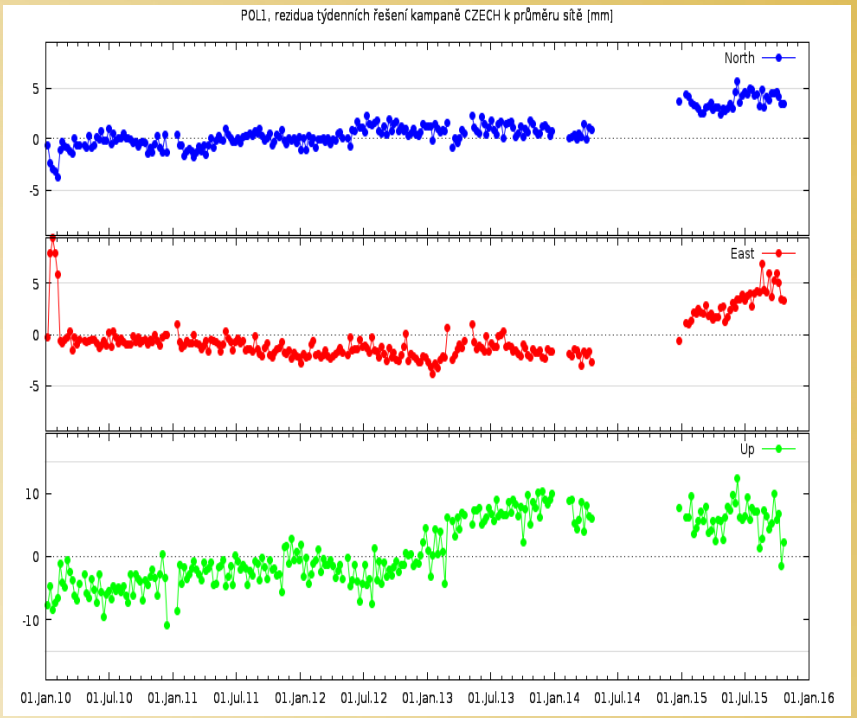
ECGN station Pecny GNSS

- IGS and EPN station
- IGS since 1994
- EPN since 1997
- CEGRN since 1993
- Absolute + SC gravity
- environmental seismology
- Fundamental levelling benchmark



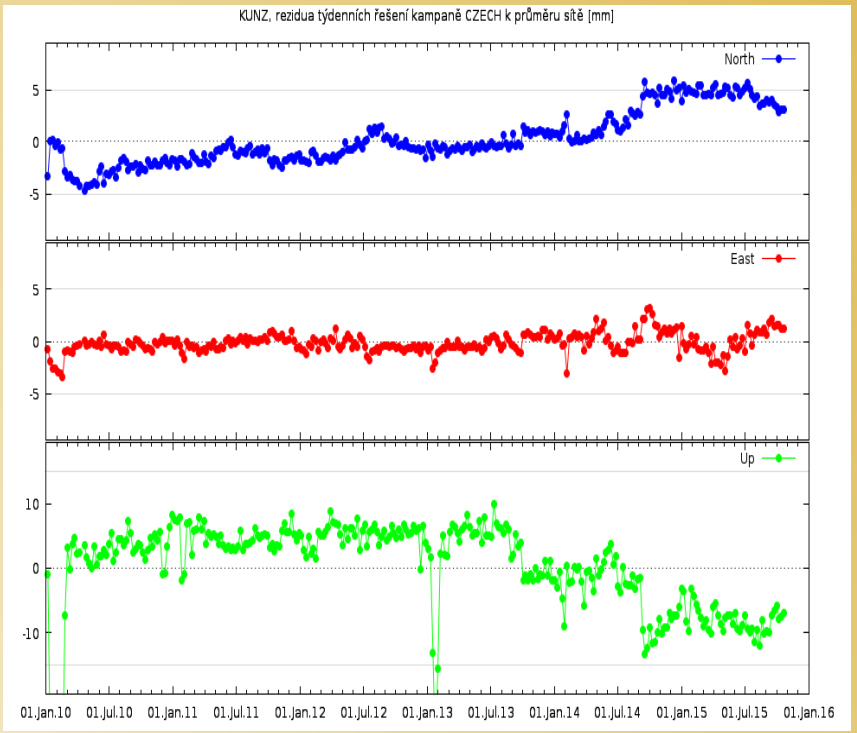
ECGN station Polom GNSS

- CEGRN epoch station since 1993
- Permanent GNSS station since 2006
- Repeated absolute gravity
- Levelling connection
- Local hydrology and meteorology
- seismology

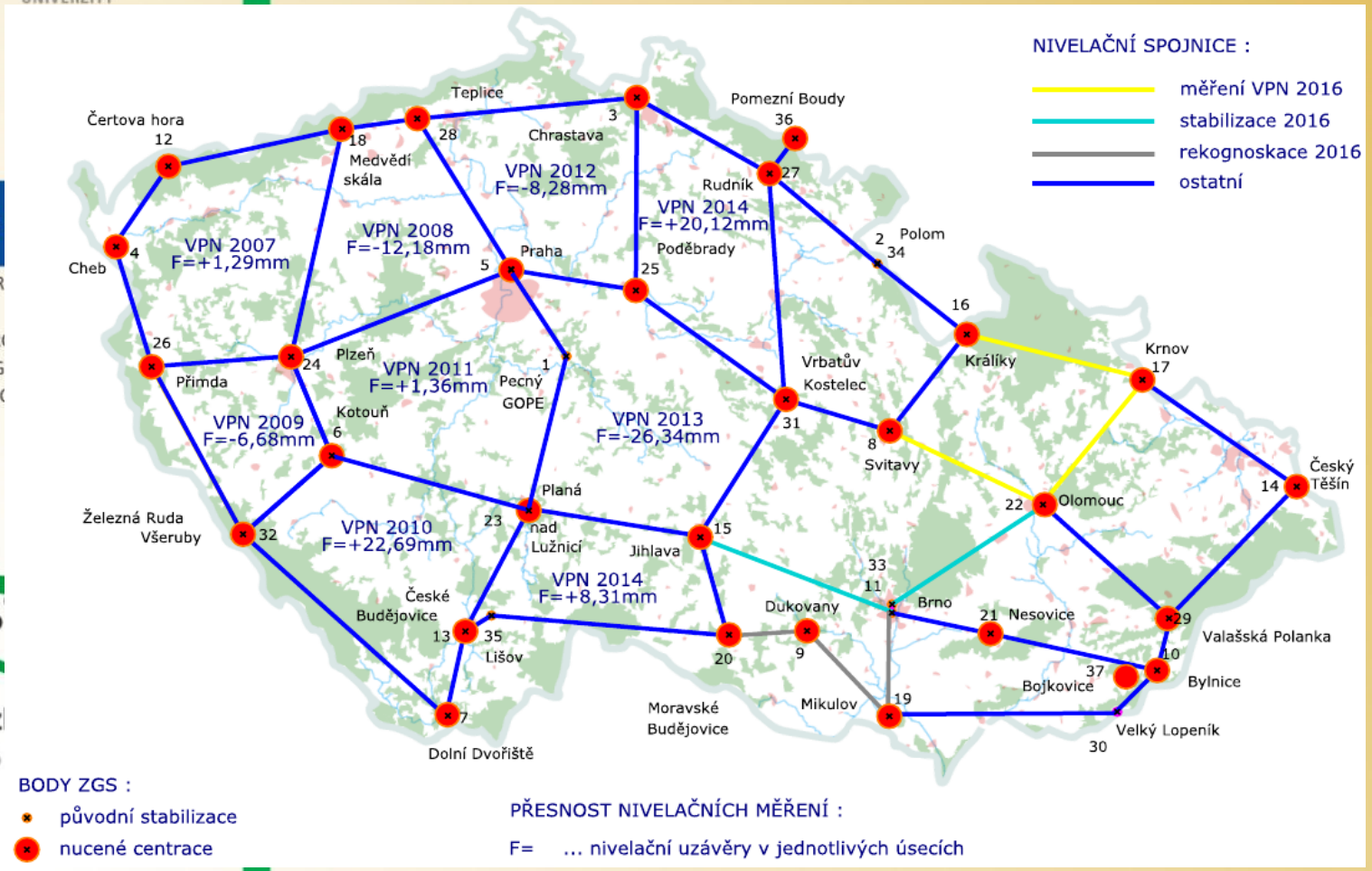


ECGN station Kunžak GNSS

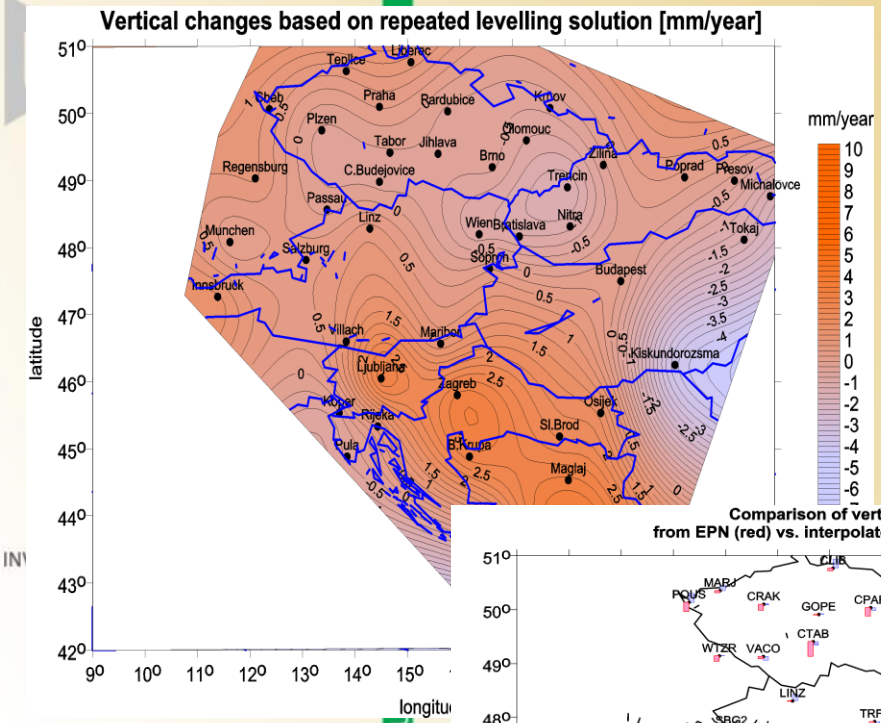
- Permanent GNSS since 2005
- EPN since 2012
- Repeated absolute gravity
- Local hydrology and meteorology
- Levelling connection

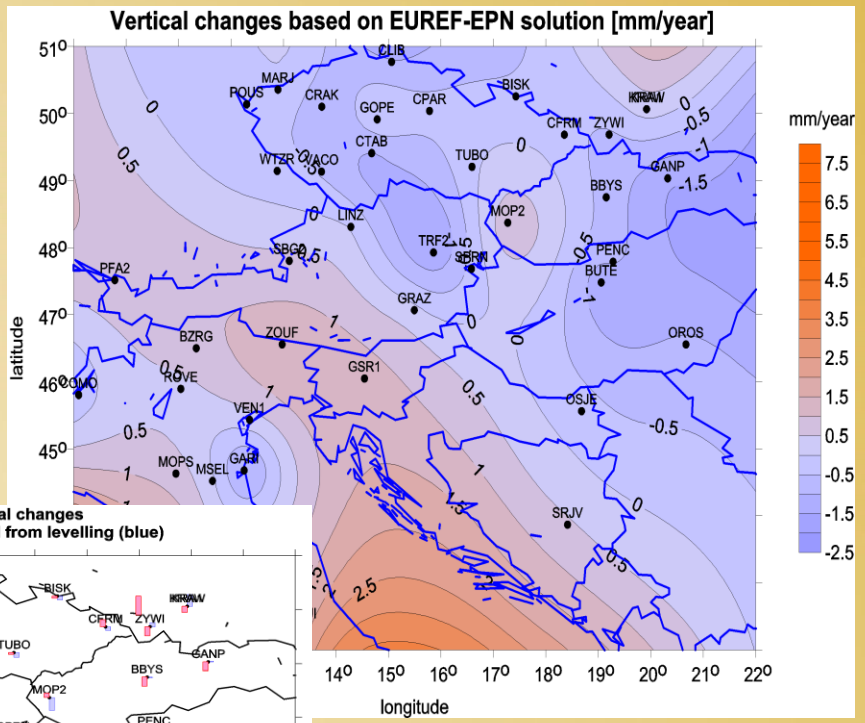


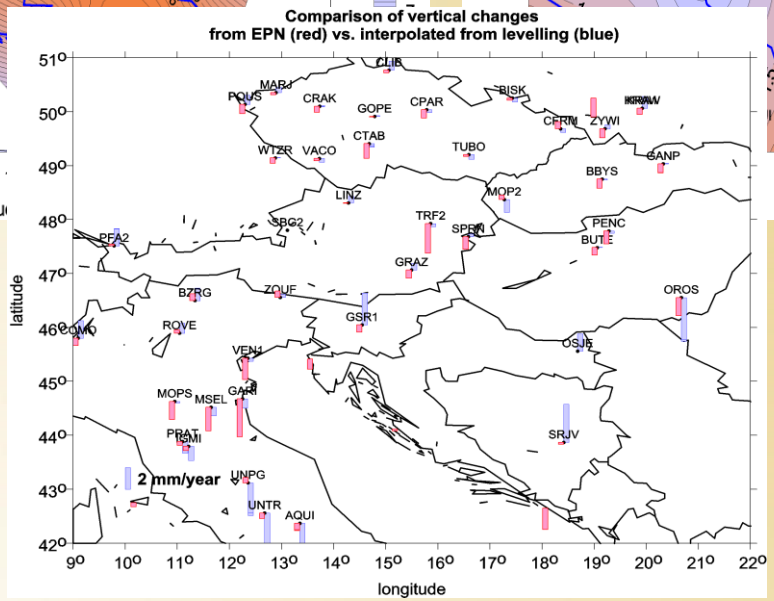
Heights above sea level: ECGN stations included into Fundamental Geodynamic Network



Heights and vertical velocities

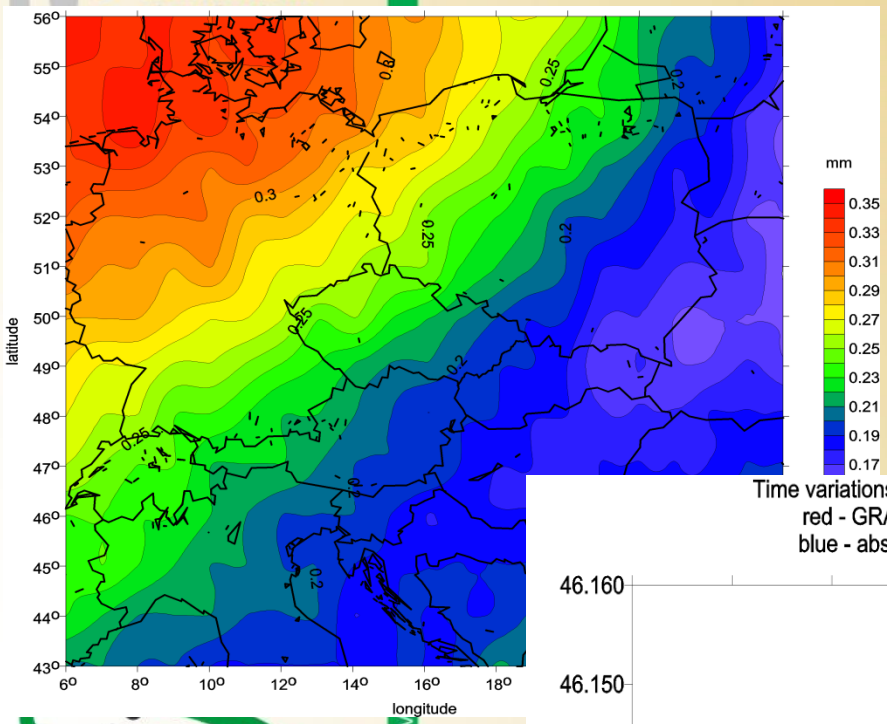




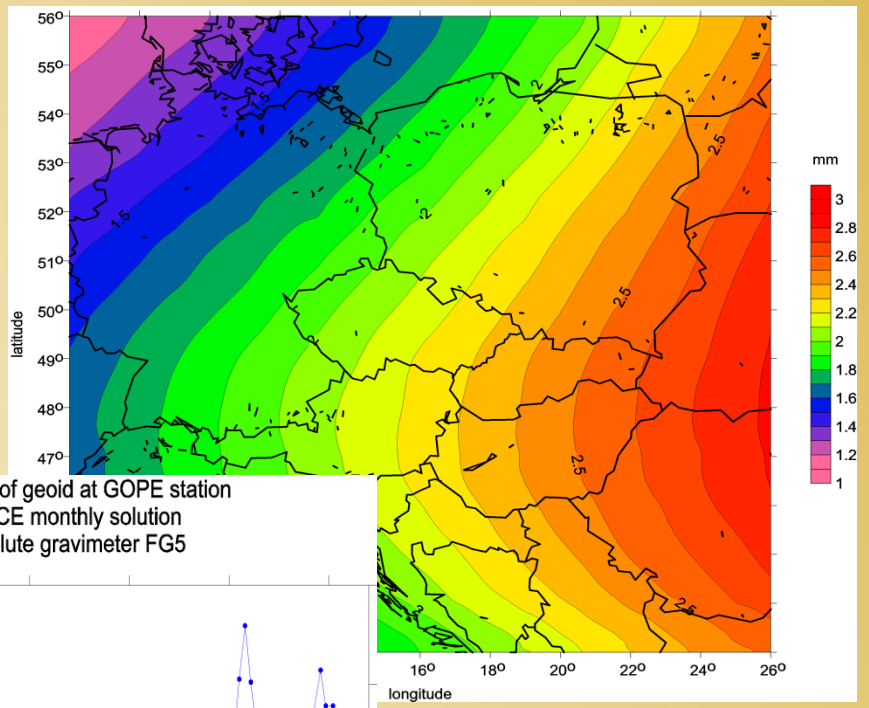


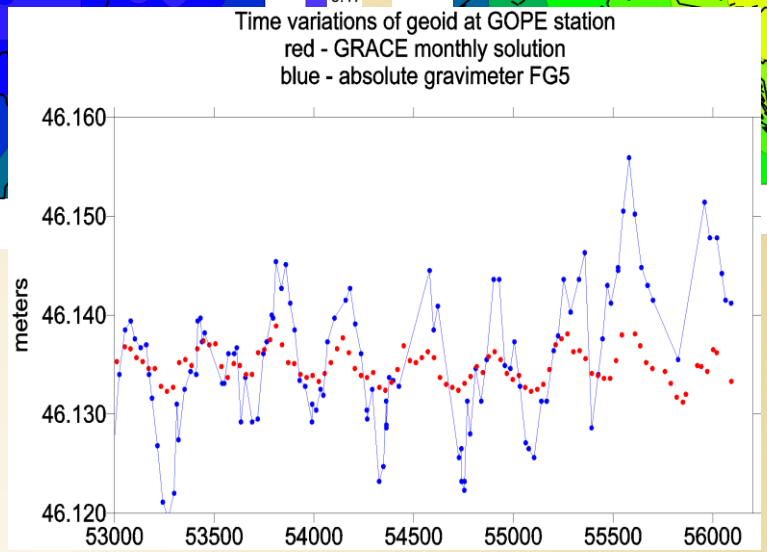
Geoid changes from GRACE

Amplitude - semi-annual

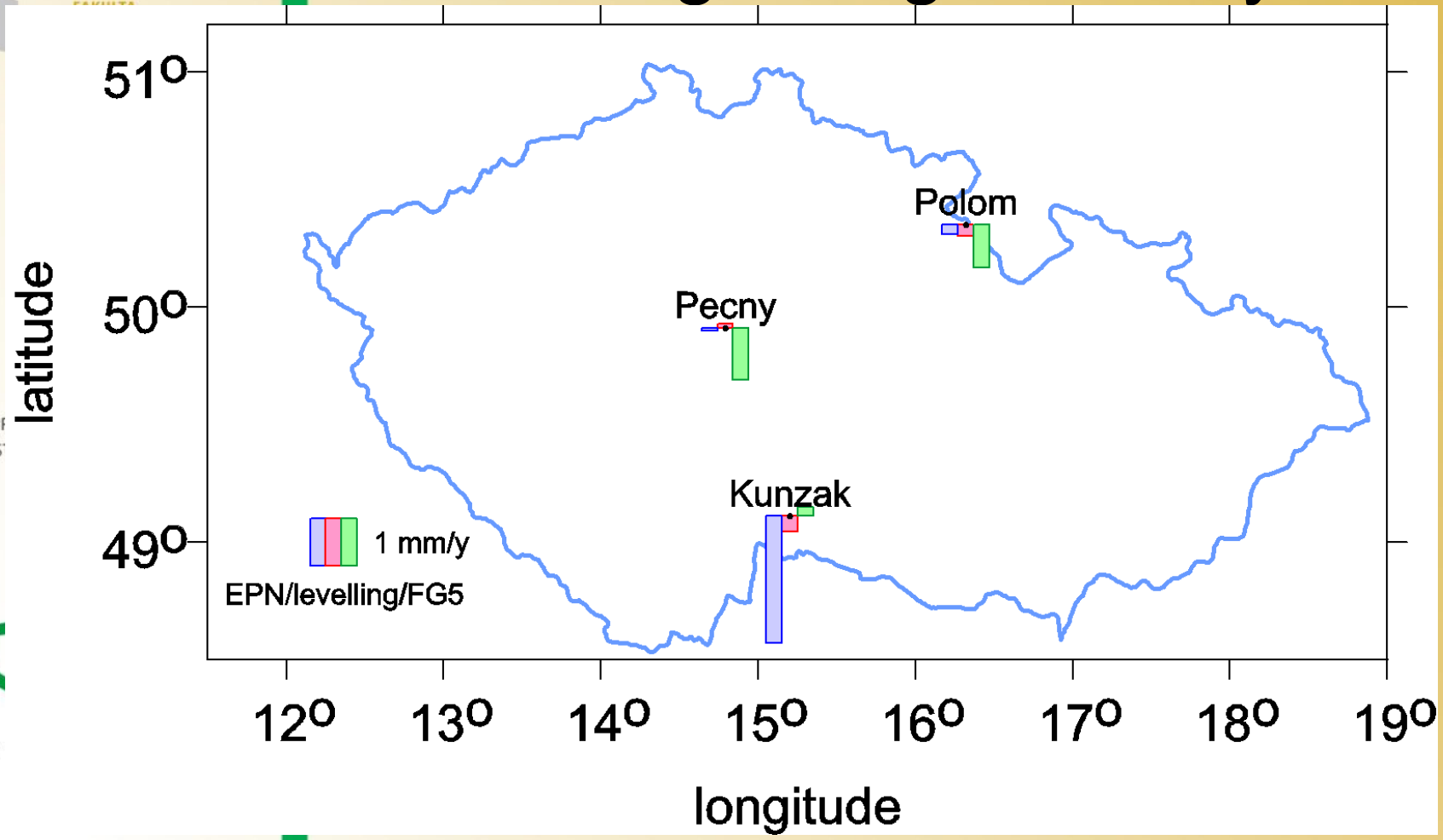


Amplitude - annual term

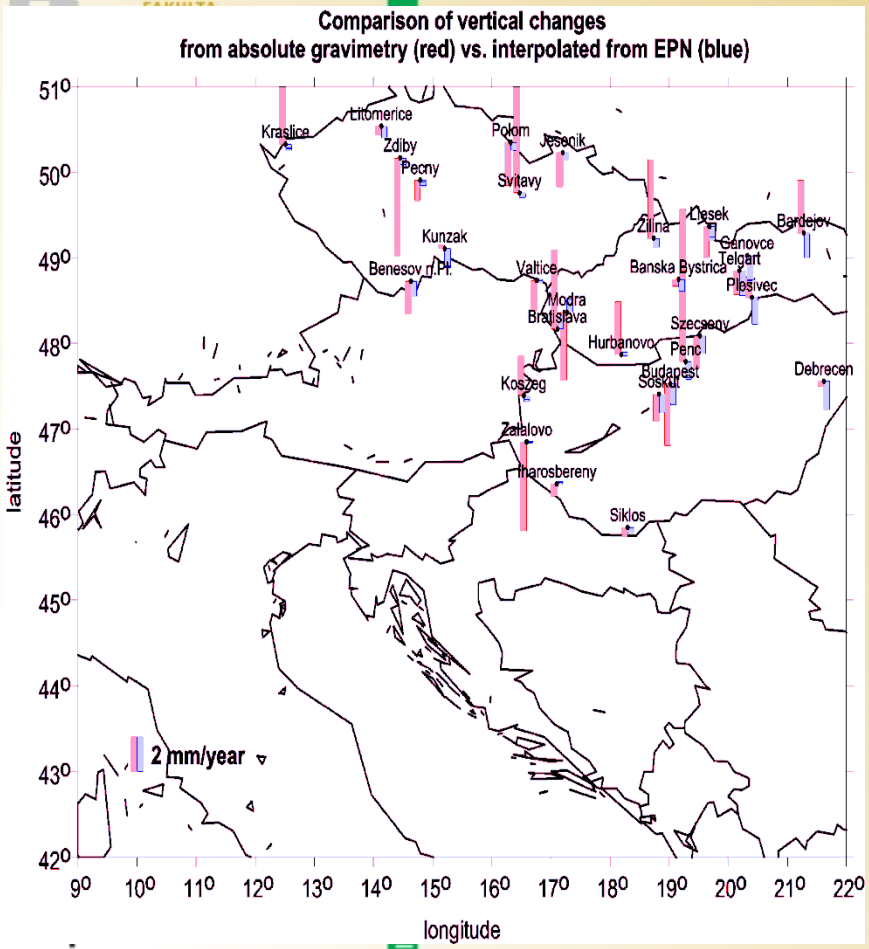


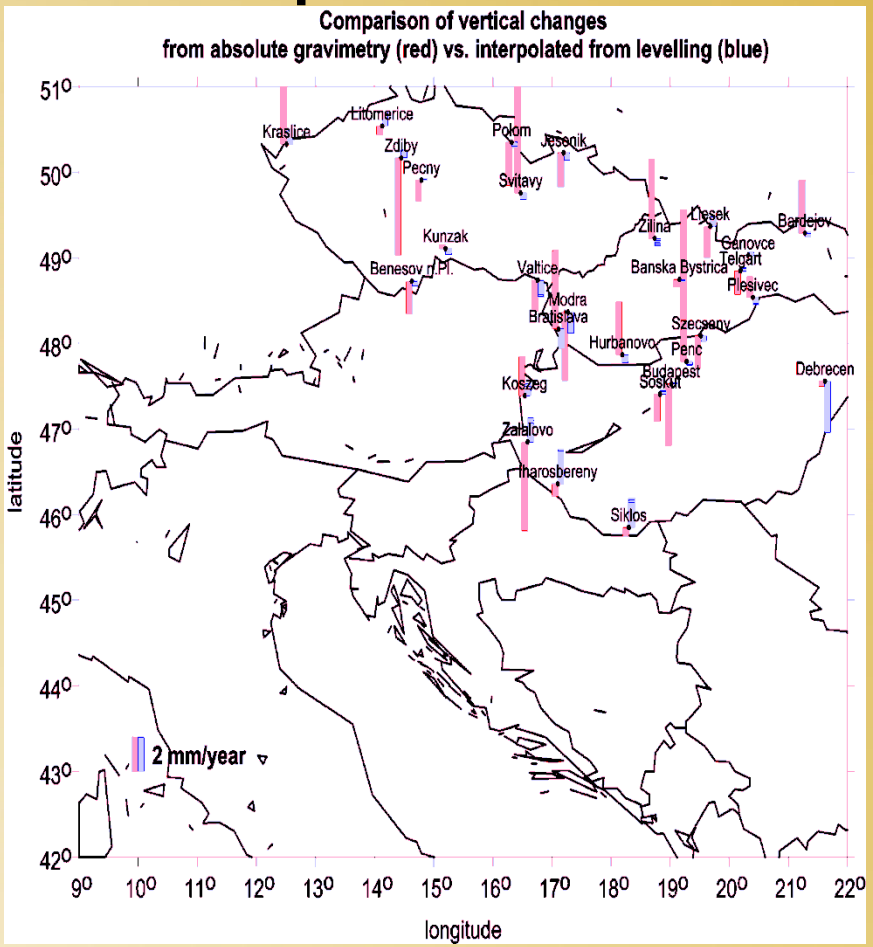


Height changes at ECGN stations from GNSS, levelling and gravimetry



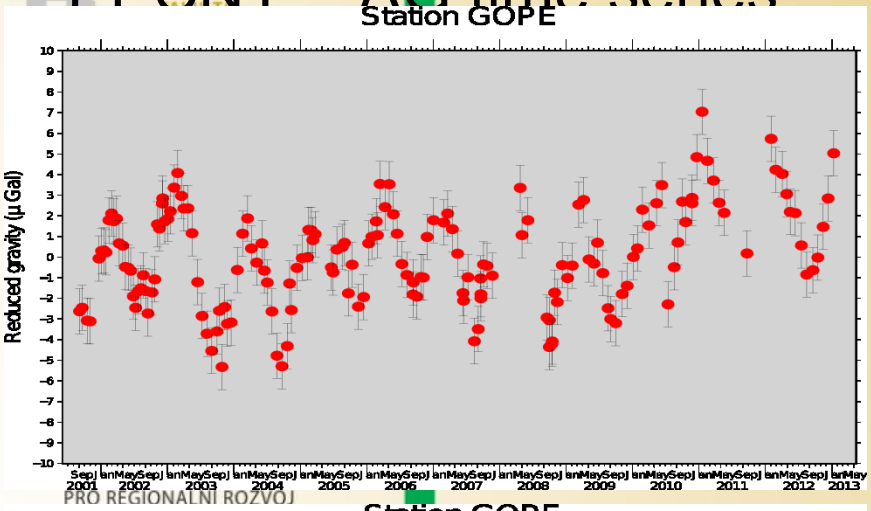
Vertical changes from different observation techniques

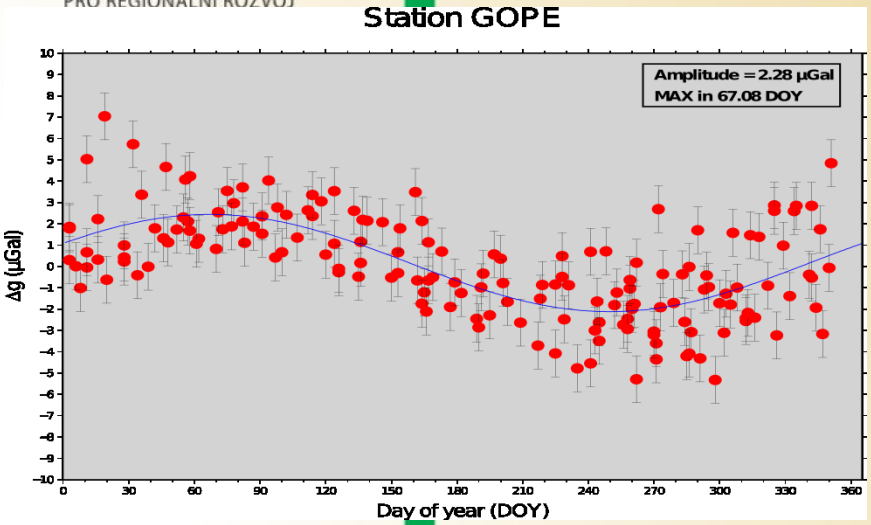




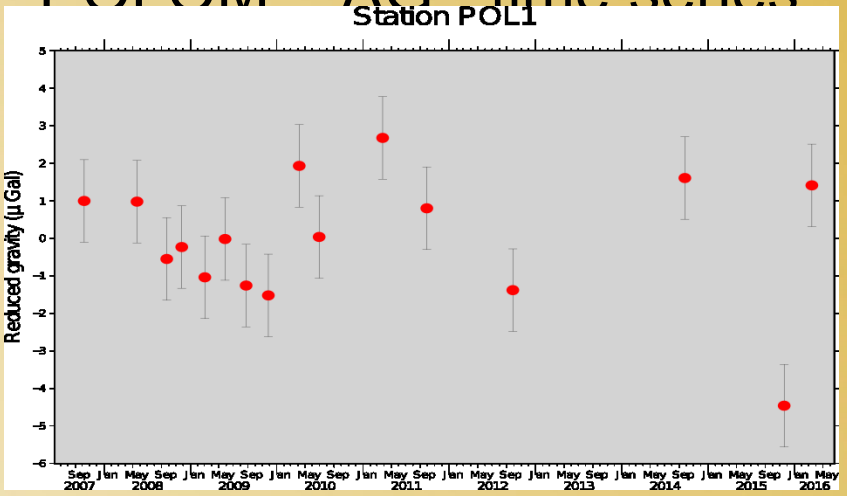
Absolute gravimetry at ECGN stations

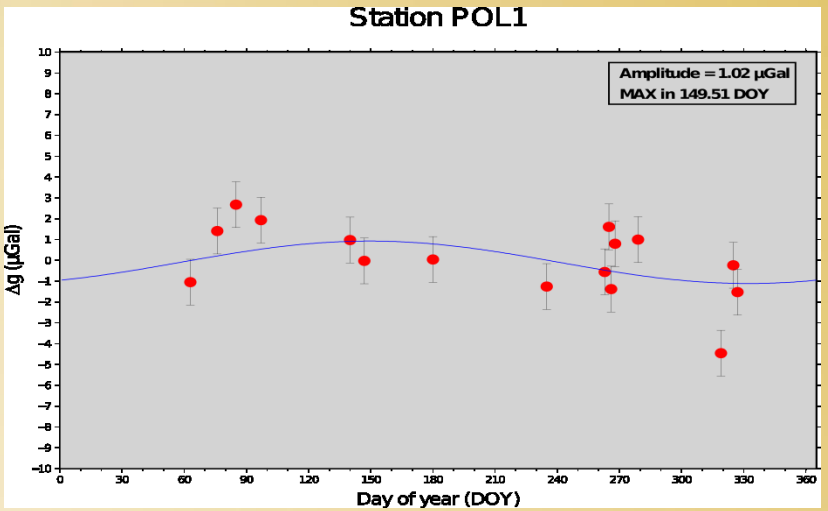
PECNY – AG time series





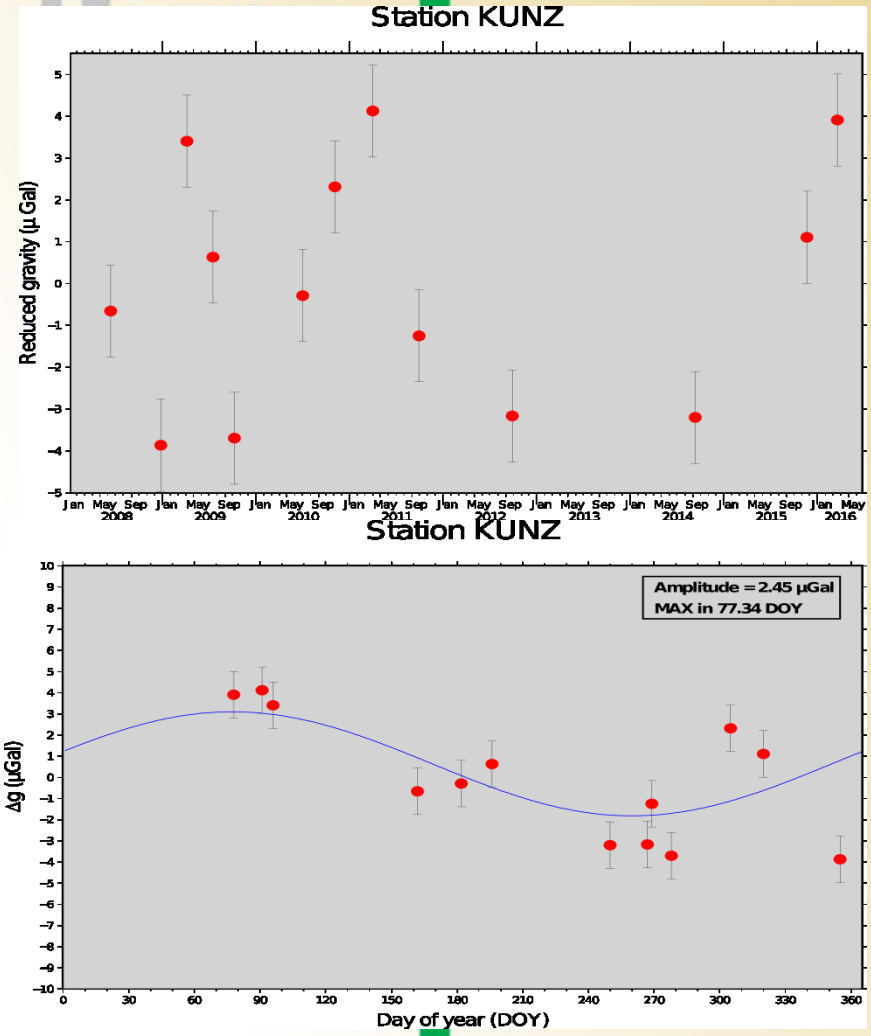
POLOM – AG - time series



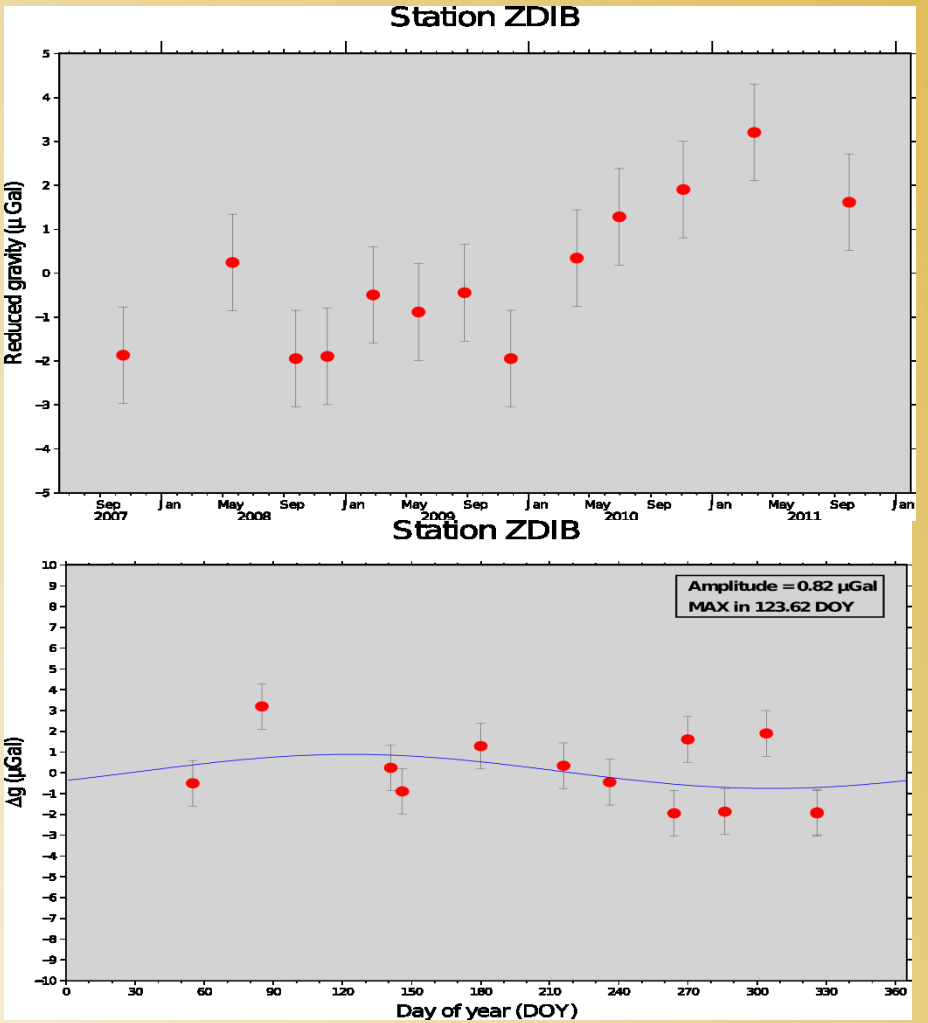


Absolute gravimetry at ECGN stations

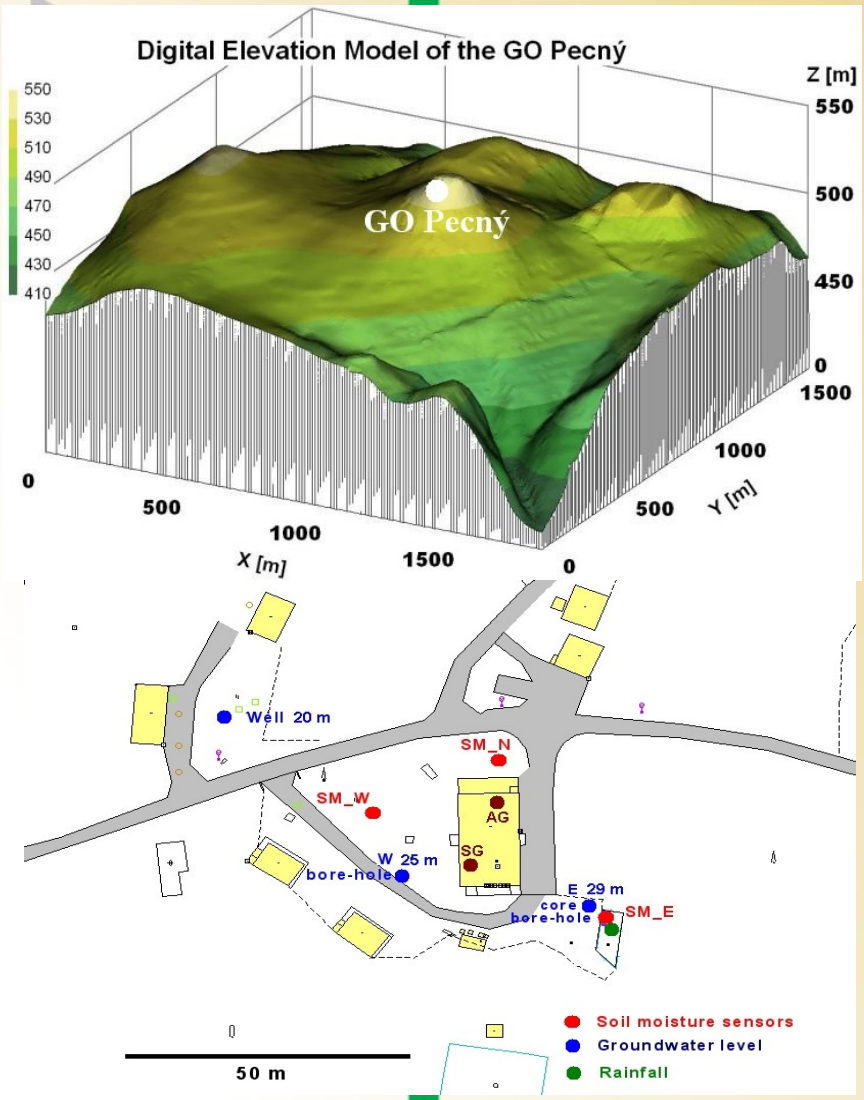
KUNŽAK – AG time series

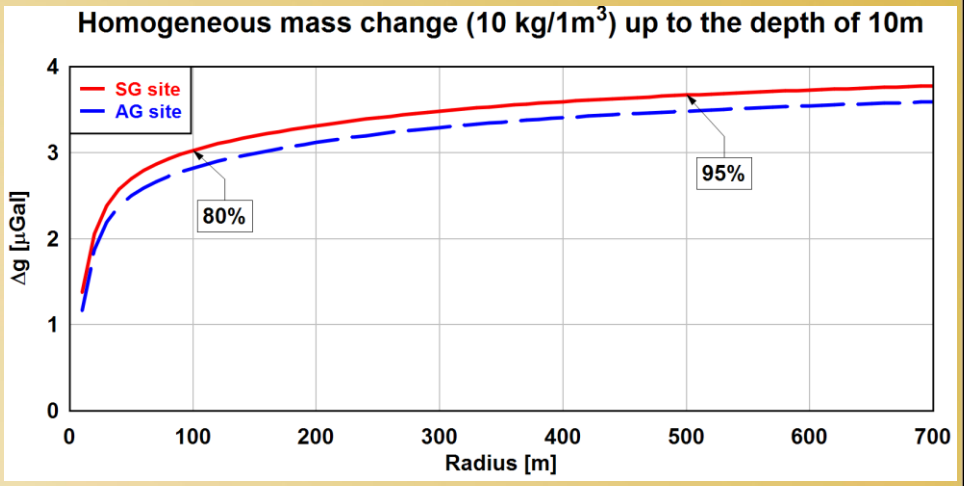


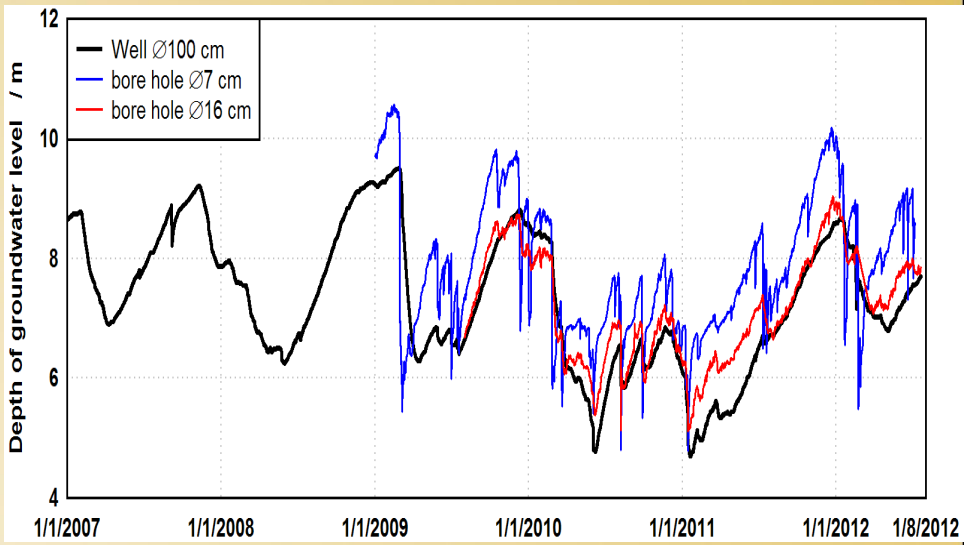
ZDIBY – AG time series



Local hydrology and gravity: Case study PECNY







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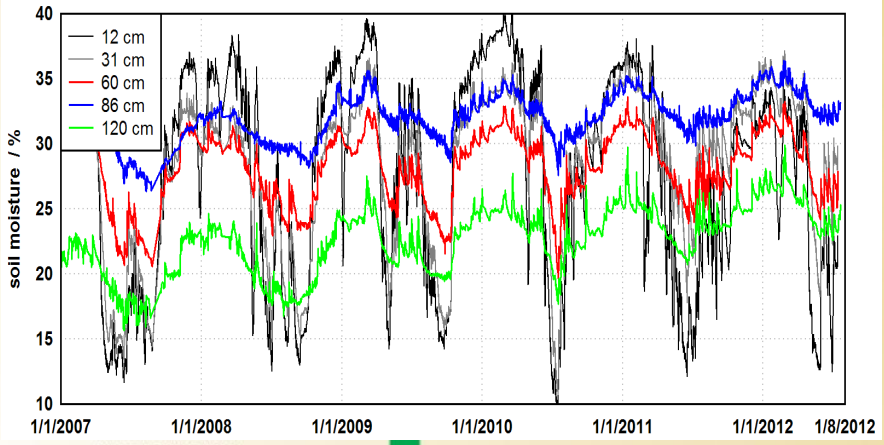

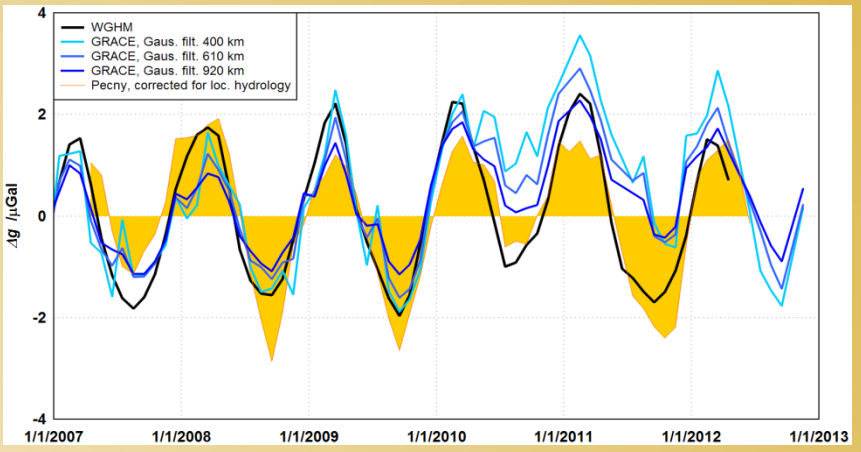

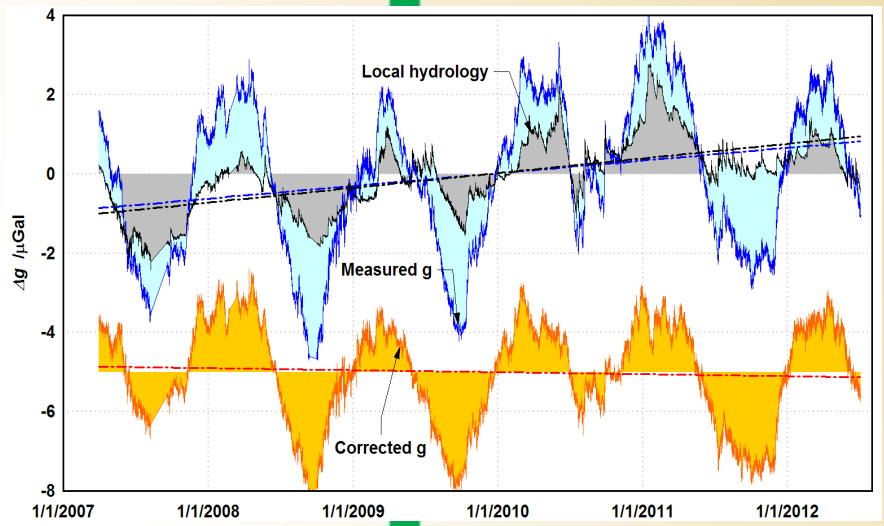

TREND:

GRACE: 0.43 ± 0.09 μGal/year

PE : 0.39 ± 0.17 μGal/year

WGHM : 0.12 ± 0.11 μGal/year

PE_cor : -0.04 ± 0.12 μGal/year

AGREEMENT (std of differences):

PE_cor vs. **WGHM: ± 0.63 μGal**

PE_cor vs. **GRACE_920 : ± 0.87 μGal**

PE_cor vs. **GRACE_400 : ± 1.11 μGal**

WGHM vs. **GRACE_400 : ± 1.32 μGal**

Observations: Levelling

- Accuracy <1 mm x $km^{-1/2}$; for 20 y interval between epochs velocities of height differences 0.07 mm x $km^{-1/2}$
- Demanding methodology (observations, monumentations, equipment calibrations)
- Long realization time
- Homogenity of the networks consisting of national blocks
- Error propagation in networks
- Detection of systematic effects
- Demanding detection of disturbing effects (exogenous deformations)

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Observations: GNSS

- Daily repeatabilities N/E/U → 2 mm/2 mm/6 mm, std of velocities is < 1 mm/y
- Accuracy of GNSS-based heights rms 7 mm
- Vertical velocity 1.0 mm/y is significantly detectable after 3 years GNSS observation period
- General availability
- Continuously operating networks
- Variations of position in space
- Vertical component less accurate than horizontal positions: hope for improvement thanks to NWP models and multi-GNSS constallation
- Many error sources affecting the height: correlation between parameters and satellite distribution, tropospheric refraction, reference frame, geocenter, orbit errors, site displacements due to ocean and atmospheric loading and due to exogenous deformations, antenna PCV, multipath)
- Network solution vs. PPP

Observations: Gravimetry

- Long-term reproducibility of FG5 < 1.6 μGal
- Standard uncertainty 2.5 μGal
- std of offsets obout 1.0 μGal; offset range up to 10 μGal
- Absolute gravimetry is methodologically quite independent (purely physical quantity)
- Independent of any reference frame (frame of itself)
- No network effect (error propagation) in the processing
- Reliable detection of gravity changes needs parallel observations with AG and SG
- Results affected by environmental effects associated with the near-surface mass re-distribution (especially with hydrology)
- It is difficult to separate disturbing effects from the signal
- Instrumental effects (e.g. offset) enter directly to the measured quantity
- Instruments and observations are very expensive and demanding

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Conclusions (1)

- GNSS is an essential tool for detection of spatial surface deformations; better estimates of up-component are needed
- Traditional GNSS products based on network solution should be completed by PPP products when necessary, esp. with regard to improved IGS products (orbits, clocks) and upcoming multi-GNSS constallations; new troposphere models can contribute to improving height component
- Levelling is the only terrestrial tool that can provide potential differences and, thus, it is inevitable in realization of height system(s)
- For detecting physical height changes over large areas levelling provides very poor time resolution; in this case a combination of GNSS with geoid changes based on data of satellite missions and SAR data might be more promissing

Conclusions (2)

- Gravimetry is a purely physical tool capable of detecting mass re-distributions in the Earth´s body, but it is affected by environmental disturbing effects (mainly hydrology); instrumental effects play also an important role; about 50% of variations may be caused by local hydrology
- The local hydrology model can provide real-time corrections for ground water level and soil moisture data
- SG record is necessary for calibration of local hydrology model whereas global hydrology model is necessary for determination of longer periods
- Basic tendencies of vertical surface movements detected from repeated levellings and from GNSS observations coincide; results of repeated absolute gravity measurements do not generally coincide with levelling and GNSS, absolute values differ significantly; problem is probably in instrumental systematic effects and in hydrology

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Thank you for your attention!

Acknowledgment: This work was supported by the project LO1506 PUNTIS – Sustainability of the NTIS – Centre (New Technologies for Information Society)