NATIONAL REPORT OF POLAND TO EUREF 2016

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Symposium of the IAG Subcommission for Europe
European Reference Frame – **EUREF 2016**
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Main geodetic activities at the national level in Poland since 2014

- activities in the vertical control
- maintenance of the gravity control
- maintenance of the magnetic control
- operational work of permanent EPN/IGS stations
- data processing at Local Analysis Centres at WUT and MUT
- activities of MUT and WUT EPN Combination Centre
- status of the ASG-EUPOS network in Poland
- modelling precise geoid
- the use of data from satellite gravity missions
- GNSS for meteorology
- monitoring of ionosphere
- monitoring gravity changes and geodynamics
- activities in SLR

Activities in the vertical control

University of Warmia and Mazury, Olsztyn UWM

Gravity potential difference Δ*W* between

- **the Kronstadt86 local vertical datum in Poland**

and

- **the global vertical datum**

(considered effect of Earth' crust vertical movements; unified tide systems in satellite and levelling networks)

Δ*W*: from 0.158 m^2s^{-2} to 0.606 m^2s^{-2}

corresponds to

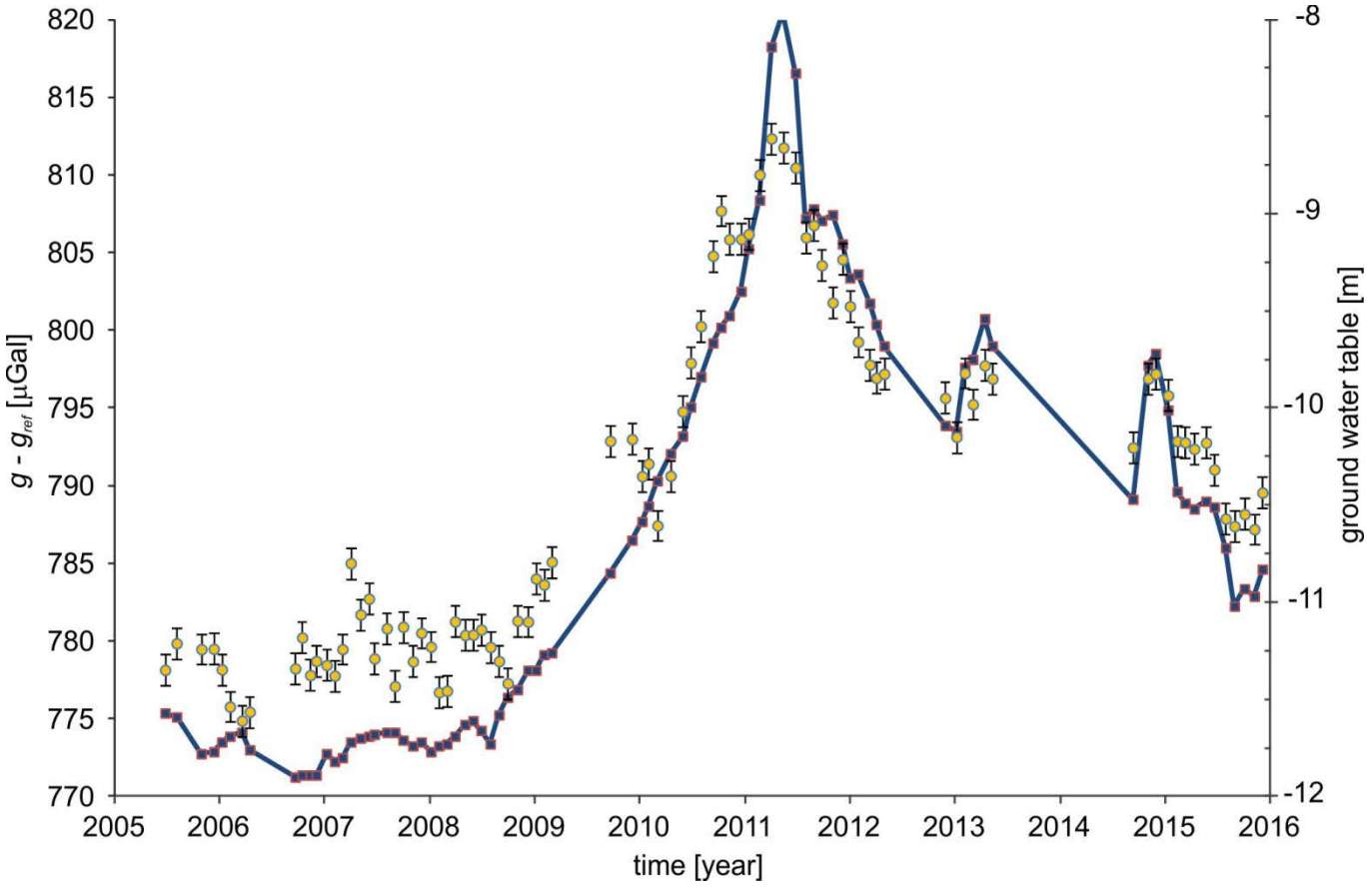
2 – 4 cm in height

there are still unexpected differences in the estimated Δ*W*, computed from three different networks: POLREF, EUVN-DA and ASG-EUPOS

Maintenance of national gravity control (1)

Jozefoslaw Astrogeodetic Observatory, Warsaw University of Technology WUT

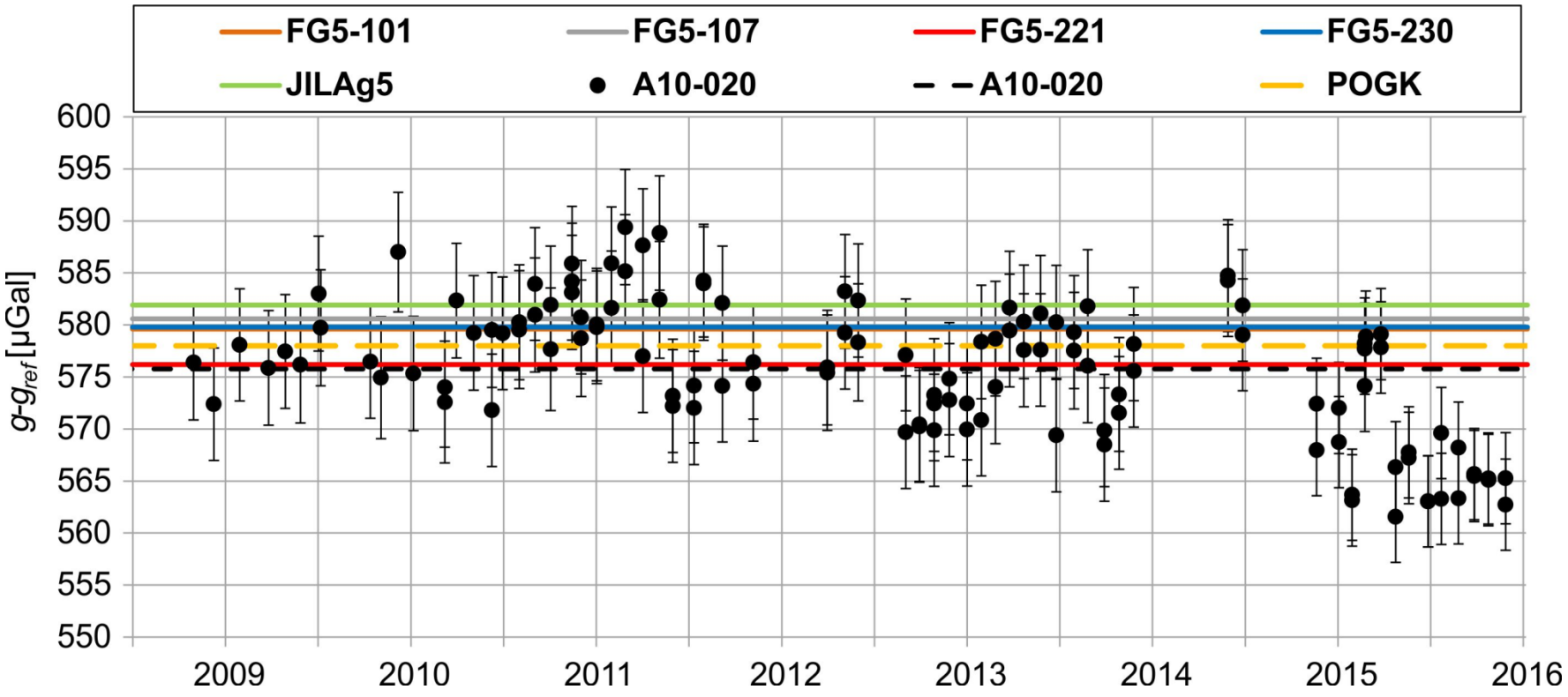
quasi-permanent absolute gravity measurements with FG5-230



Maintenance of national gravity control (2)

Borowa Gora Geodetic-Geophysical Observatory of IGiK

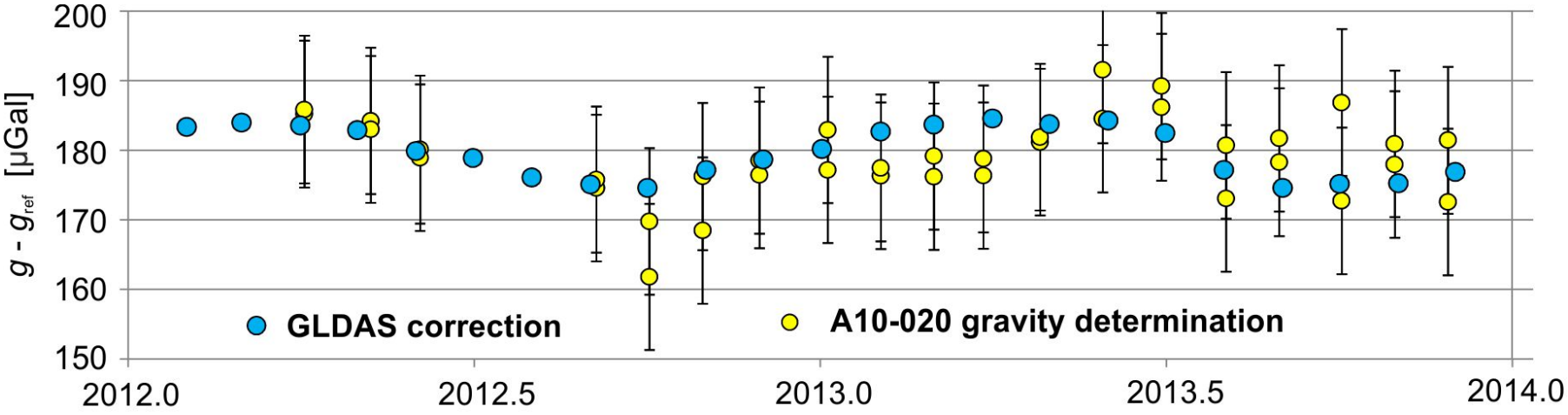
quasi-permanent absolute gravity measurements with A10-020



Maintenance of national gravity control (3)

Borowa Gora Geodetic-Geophysical Observatory of IGiK

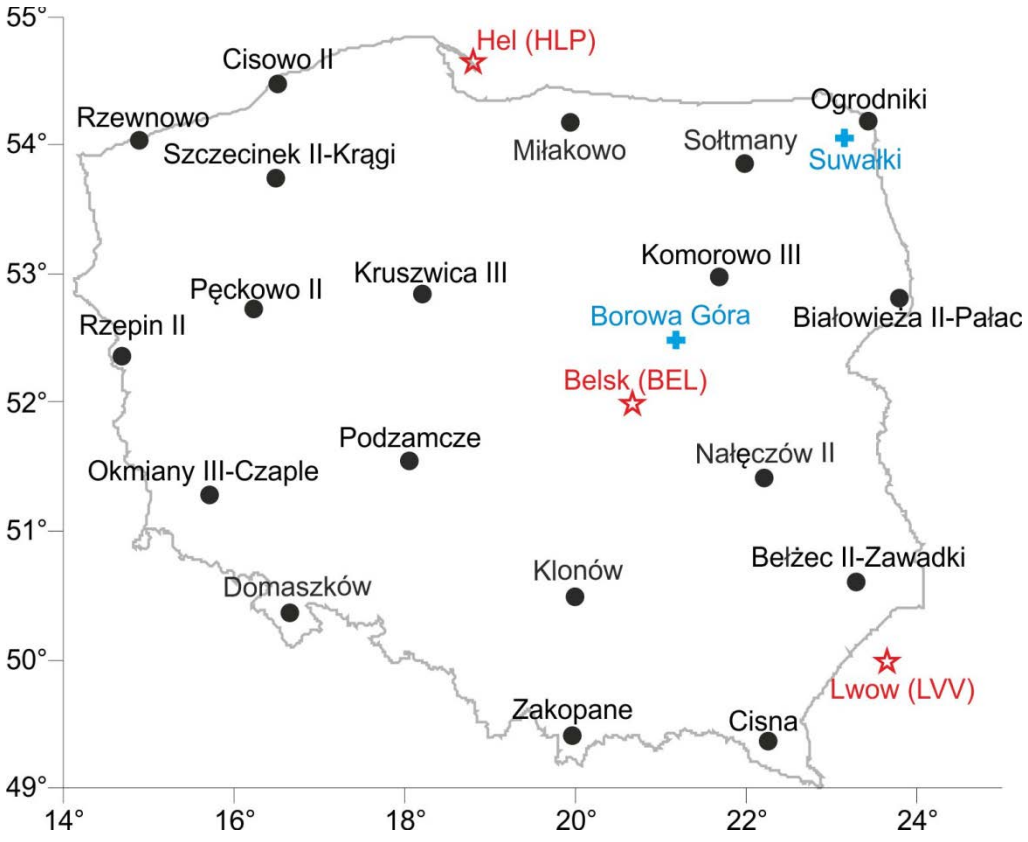
regular monthly absolute determinations of gravity on field station with respect to GLDAS hydrological model correction



Maintenance of magnetic control

Institute of Geodesy and Cartography (IGiK), Warsaw

repeat stations, permanent stations and magnetic observatories



- every 2-4 years
- 3 independent components of the magnetic intensity vector at the repeat stations measured

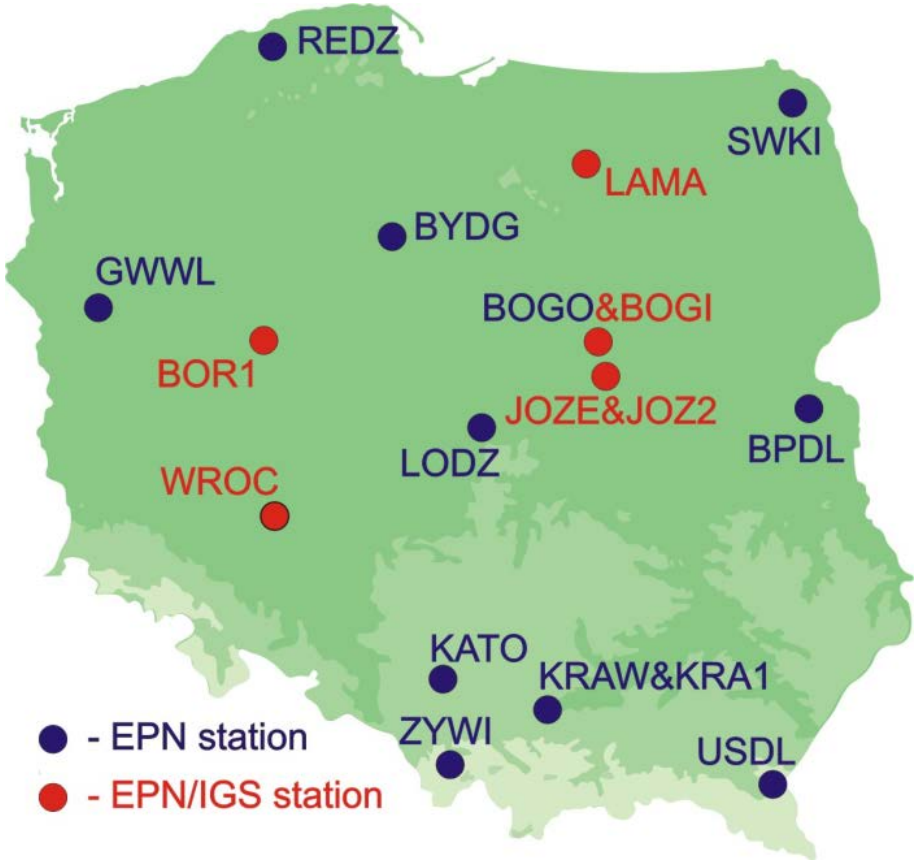
Operational work of permanent GNSS IGS/EUREF stations

EPN stations in Poland

- Biala Podlaska (BPDL)
- Borowa Gora (BOGI)
- Borowa Gora (BOGO)
- Borowiec (BOR1)
- Bydgoszcz (BYDG)
- Gorzow Wielkopolski (GWWL)
- Jozefoslaw (JOZE)
- Jozefoslaw (JOZ2)
- Katowice (KATO)
- Krakow (KRAW)
- Krakow (KRA1)
- Lamkowko (LAMA)
- Lodz (LODZ)
- Redzikowo (REDZ)
- Suwalki (SWKI)
- Ustrzyki Dolne (USDL)
- Wroclaw (WROC)
- Zywiec (ZYWI)

EPN Stations participating in EUREF-IP

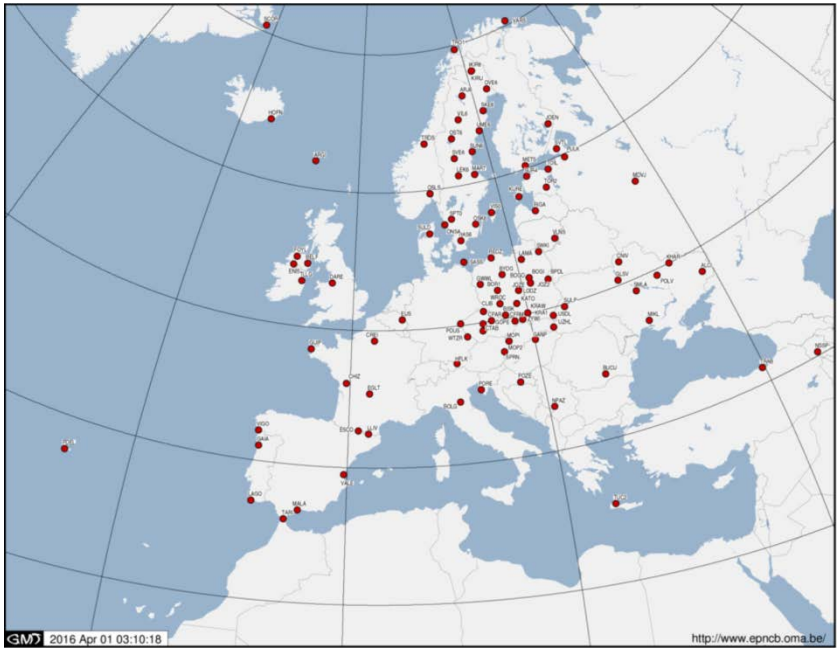
♥ BOG ♥ BOR1 ♥ JOZ2 ♥ KRA1 ♥ KRAW ♥ LAMA ♥ WROC



Data processing at LACs

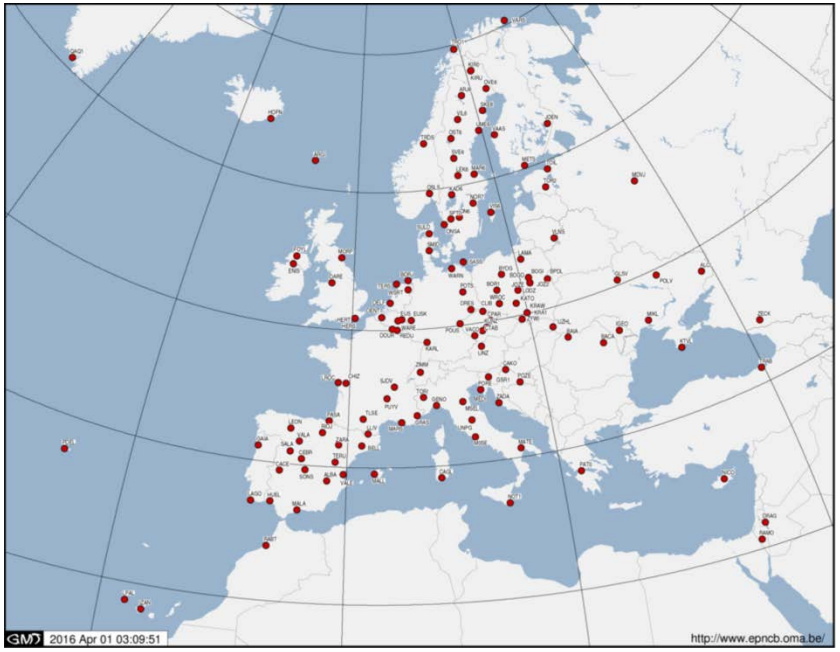
WUT

data from 103 EPN stations routinely processed



MUT

data from 138 EPN stations routinely processed



MUT – WUT EPN Combination Centre

- **16 of 18 existing ACs were submitting SINEX solutions for the weekly EPN combination**
- **all combinations are performed with Bernese v.5.2**
- **products**
  - **final positions weekly and daily**
  - **rapid daily solutions**
  - **ultra-rapid solutions**
- **information for the final combinations**
  - **agreement between ACs solutions (horizontal & vertical),**
  - **Helmert transformation parameters of all solutions with respect to the combined solution**
  - **time series of all stations residuals**

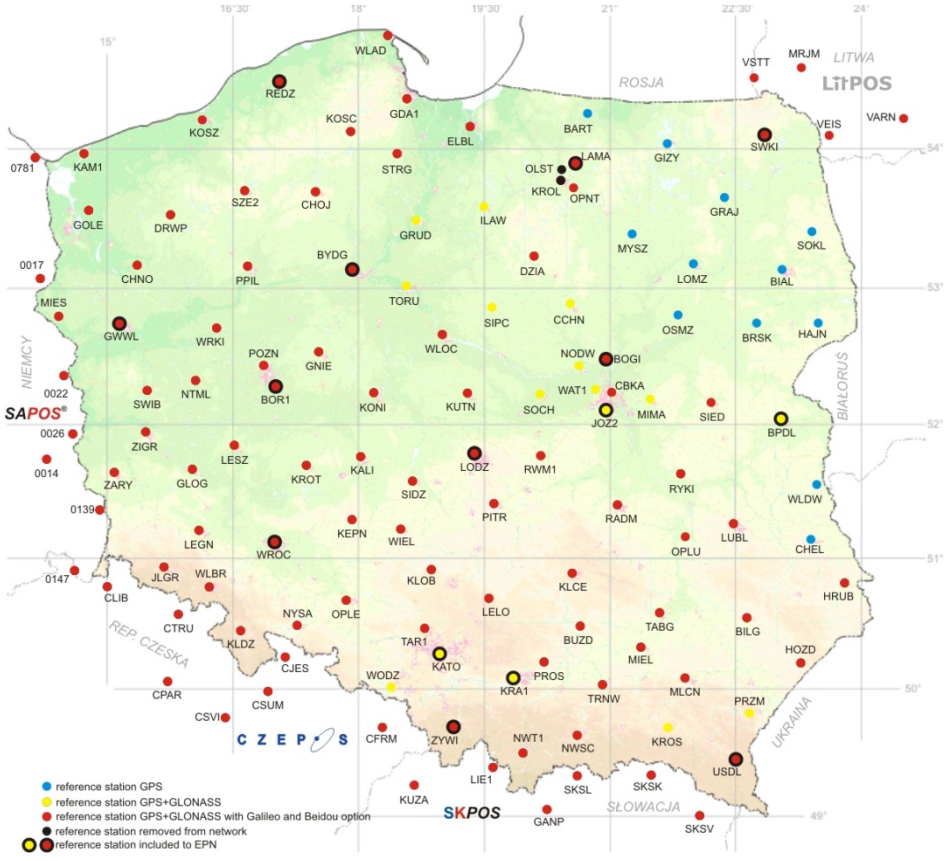
Results of final, rapid and ultra-rapid combinations on web page (http://www.epnacc.wat.edu.pl)

ASG-EUPOS network in Poland

Head Office of Geodesy and Cartography

reference stations of ASG-EUPOS network

- **125 stations**



- **1 station excluded**
- **1 new station established**
- **34 stations – new receiver and antenna**

- **4 new RTN data streams for providing GPS+GLONASS Network RTK data for most area of Poland**

- **RTK service - 3100 active licenses**

Modelling precise geoid

IGiK - new gravimetric quasigeoid model GDQM-PL15 for Poland

Data: • 1'×1' mean Faye Δ*g* (new gravity data from Czech Republic & Slovakia)
• deflections of the vertical (Poland)
• Δ*g* (neighbouring countries)
• EGM2008

Method: • remove-compute-restore (RCR)
• least squares collocation with planar logarithmic covariance function of Δ*g*

Fit to GNSS/levelling: • 1.7 – 1-8 cm

UWM - gravimetric geoid model for Poland

Data: • terrestrial Δ*g*
• EGM2008
• SRTM)

Method: • least squares modification of Stokes' formula with additive corrections method developed at the KTH in Stockholm, Sweden

Fit to GNSS/levelling: • 2 cm

WUELS - local quasigeoid modelling using the geophysical gravity data inversion technique

Use of data from satellite gravity missions (1)

IGiK

- **evaluation of 1st and 5th release GOCE-based global geopotential models (GGMs) over the area of Poland**
  - **EGM2008**
  - **high precision GNSS/levelling data (2.8 – 3.4 cm fit)**
- **estimation of contribution of GOCE mission to the long/medium wavelength component (approximately 100 km half wavelength spatial resolution) of the Earth gravity field**
  - **Poland**
  - **Sudan**
  - **Saudi Arabia**
- **modelling the temporal gravity field variations over the area of Poland using 5th release GRACE-based GGMs**
  - **Vistula river basin & the Odra river basin**
  - **optimum filter for reducing the noise**

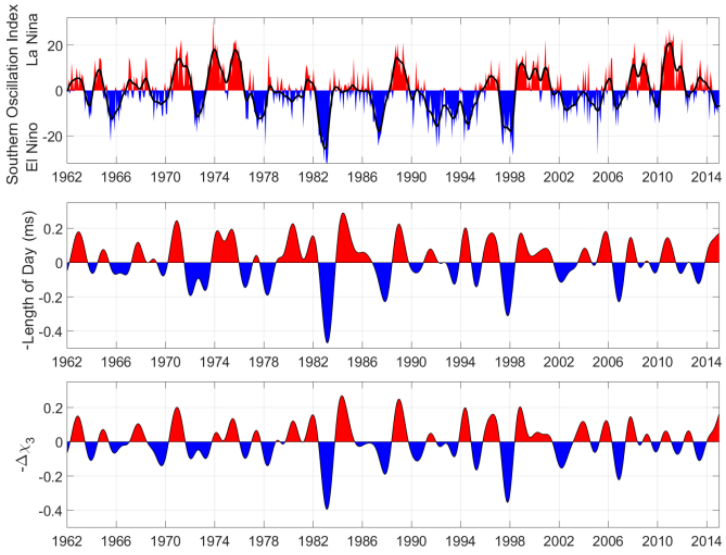
Use of data from satellite gravity missions (2)

Wroclaw University of Environmental and Life Sciences (WUELS)

Analysis of Earth rotation parameters (e.g. the LOD parameter) and the temporal changes of the Earth's gravity field as a consequence of the mass redistribution.

- **SLR GGMs**
- **GRACE GGMs**

- **the impact of El Nino occurrence was found in geodetic parameters, such as LOD, geocenter coordinates, as well as in the low-degree gravity field parameters**



southern oscillation index

intradecadal variations of LOD

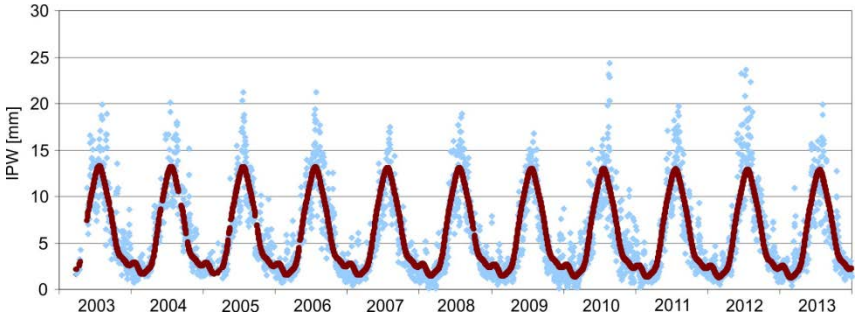
intradecadal variations of the effective axial angular momentum function

GNSS for meteorology (1)

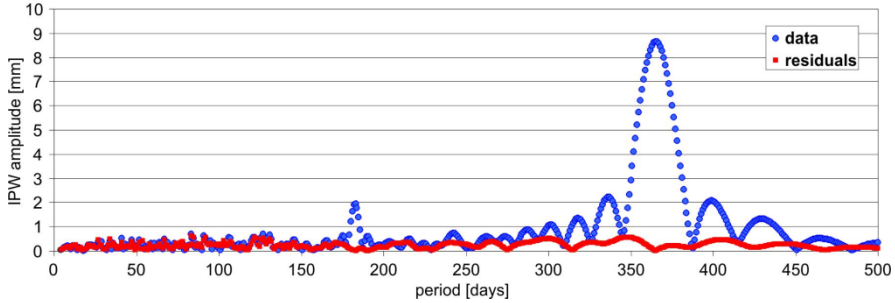
WUT

The seasonal model of IPW change

IPW for THU2 (Thule, Greenland) and a model with 3 oscillations (annual and 1/2, 1/3 of a year) for 2003-2013 period

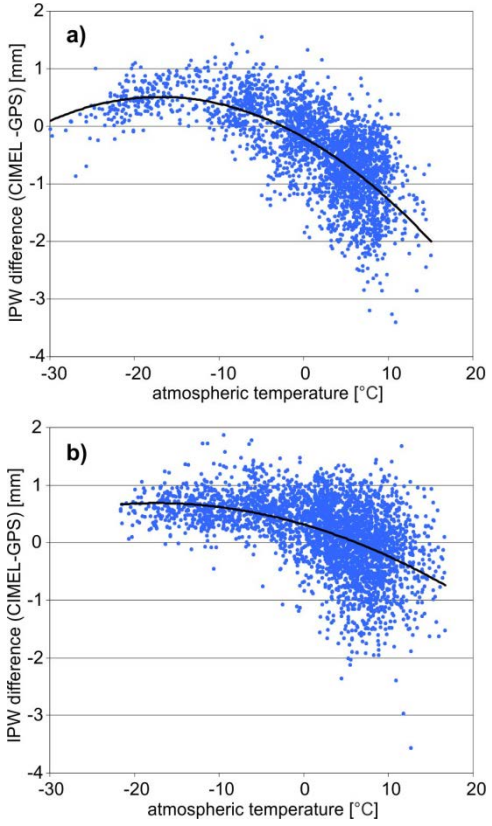


Periodogram of IPW series and residuals after subtracting annual and semiannual oscillations for JOZE multi-year series: 1997-2013



IPW from GNSS, radiosounding and CIMEL sunphotometer jn Greenland

IPW difference (CIMEL-GPS) for Thule-THU2 for 2009–2011 a) and Ittoqqortoormiit - Scoresbysund (SCOR) for 2012–2014 b) as a function of atmospheric temperature, IGS tropospheric solution



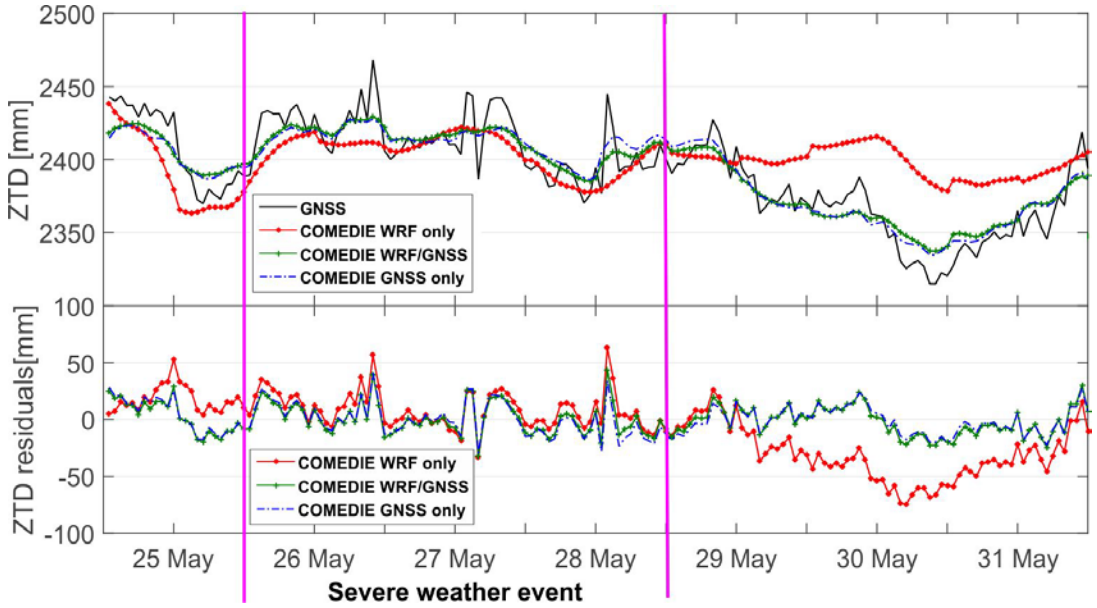
GNSS for meteorology (2)

WUELS

Developing the integrated model of troposphere

- **intercomparison of NWP model outputs with the reference data consisting of: high-quality ground-based meteorological observations, radiosonde profiles and GNSS products**
- **integration of total refractivity profiles and ZTDs**

Comparison of ZTD from GNSS station KRAW with ZTDs from COMEDIE from 3 data sets: WRF only, WRF/GNSS and GNSS only (top) with corresponding residuals of ZTDGNSS-ZTDCOMEDIE [mm] for all data sets (bottom); data period 25 – 31.05.2014

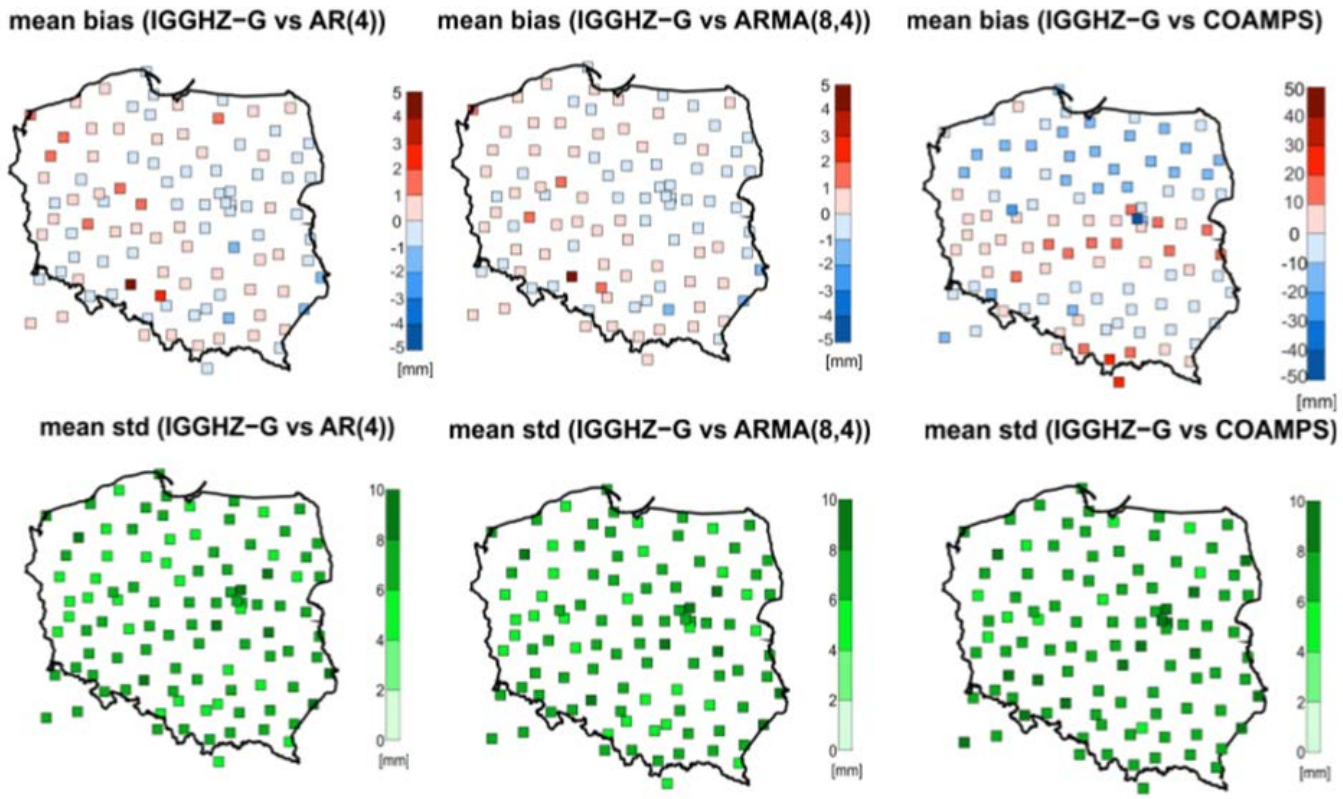


GNSS for meteorology (3)

WUELS

Real-time ZTD estimates

Mean biases and standard deviations from residuals ZTDIGGHZ-G – ZTD model for 121 ASG-EUPOS stations; data are averaged between 1.12.2012 – 15.03.2013

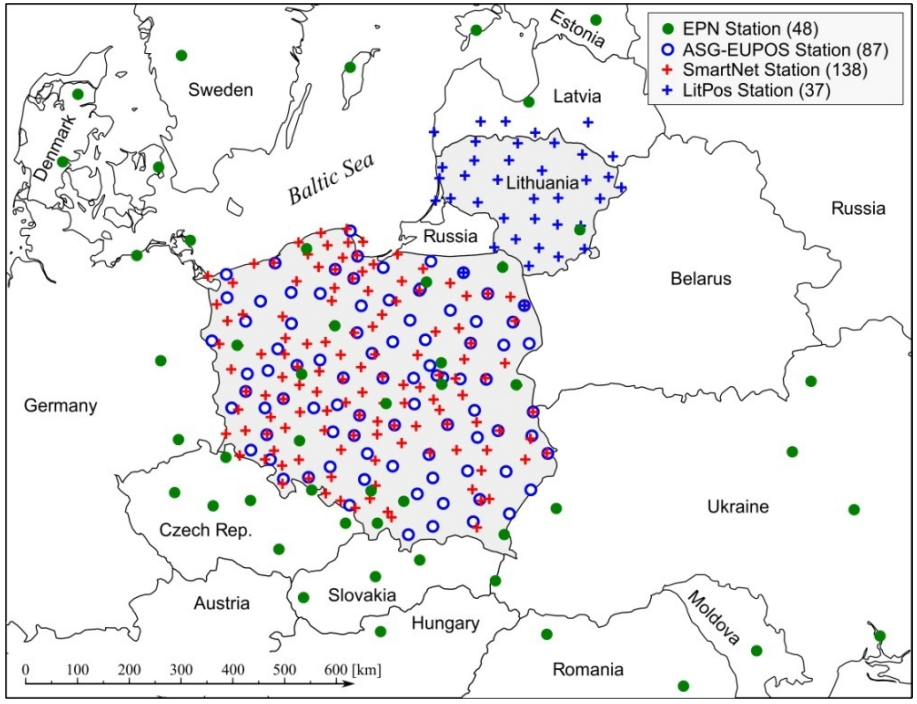


GNSS for meteorology (4)

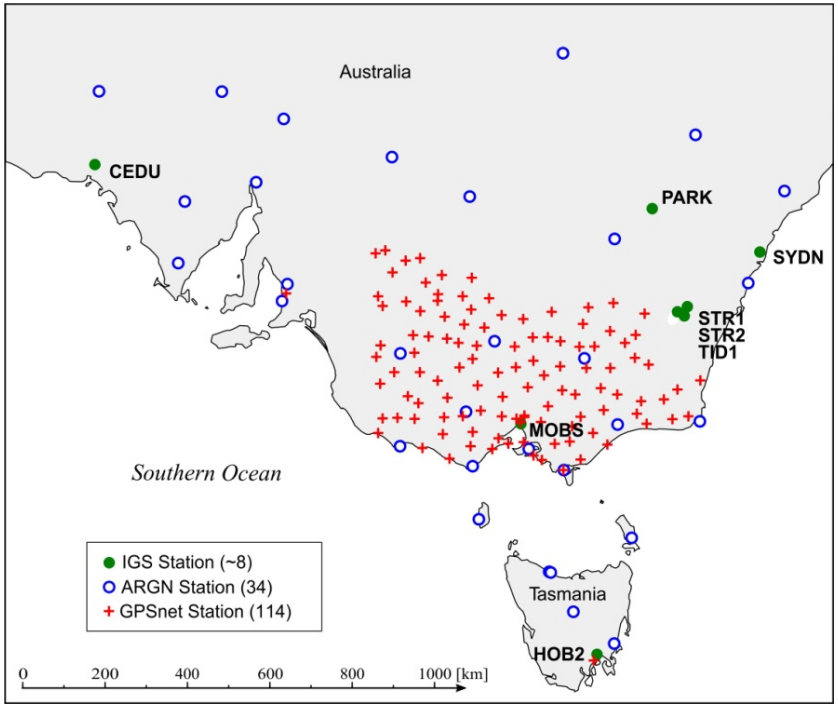
WUELS

Real-time ZTD estimates

GNSS network processed by the WUELS AC in NRT mode for troposphere parameter estimation



GNSS network processed in NRT mode for troposphere parameter estimation by the RMIT University in cooperation with WUELS



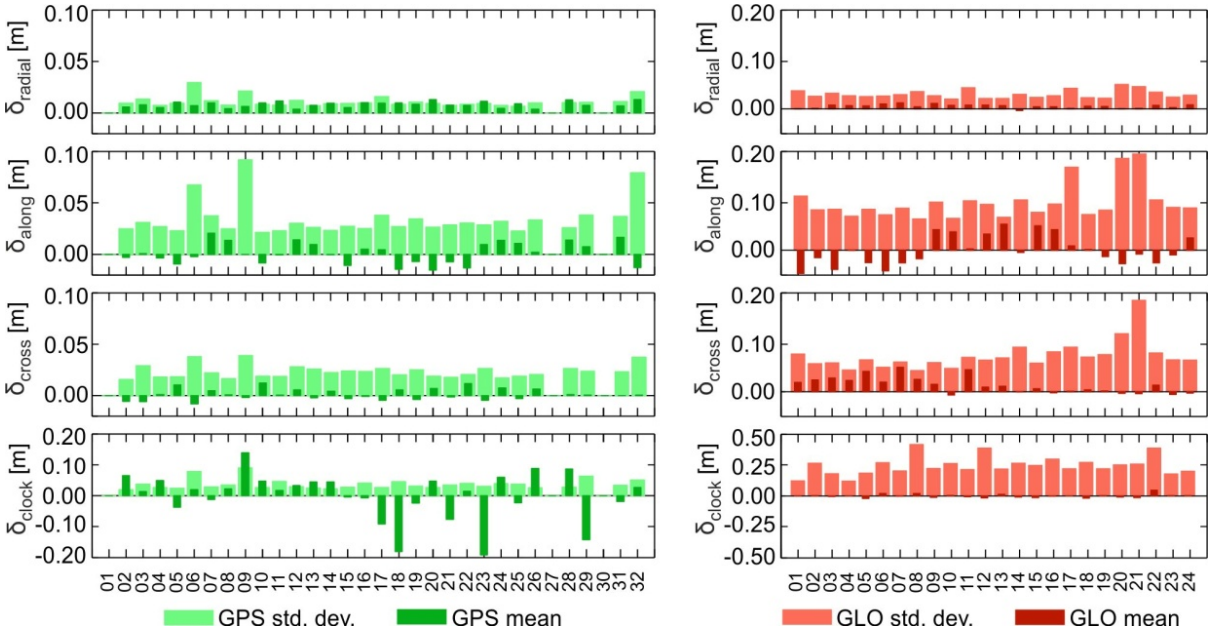
Advanced methods for satellite positioning (1)

WUELS

quality of IGS RTS products that affects the accuracy and precision of PPP

- **analysis of the quality of real-time static and kinematic PPP using GPS and GPS+GLONASS data**
- **application of high-resolution troposphere delay models into real-time kinematic positioning**

RTS orbits and clocks quality with respect to ESOC final products during DOYs 208-214, 2013

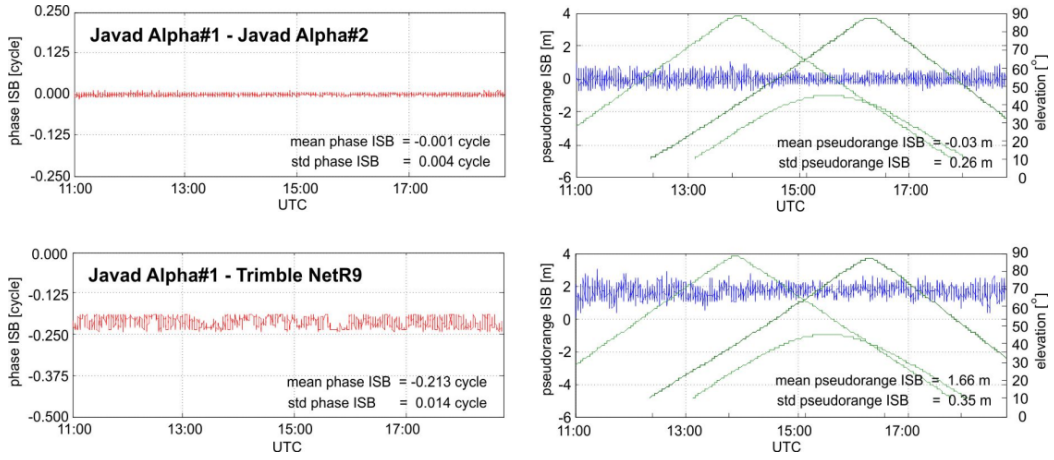


Advanced methods for satellite positioning (2)

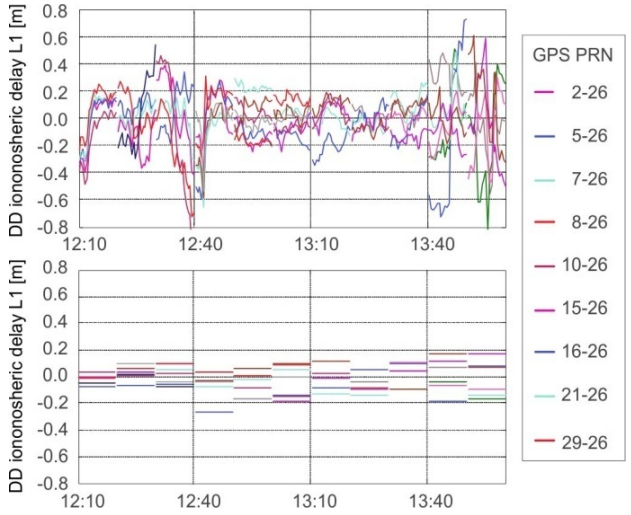
UWM

- development of algorithms and software for precise relative positioning with the use of multiple GNSS antennas and receivers configuration on a common moving platform
- study on integration of multi GNSS observations in relative positioning was continued

Phase and code ISB time series obtained using all available GPS and Galileo satellites for different receiver pairs: 1st row – homogenous receivers (Javad Alpha), 2nd row inhomogeneous receivers (Javad Alpha – Trimble NetR9)



Double-differenced ionospheric delays on L1 frequency for TREO–LYNS baseline obtained from geometry-free solution with fixed ambiguities for original observations (top) and RTC-corrected observations (bottom)

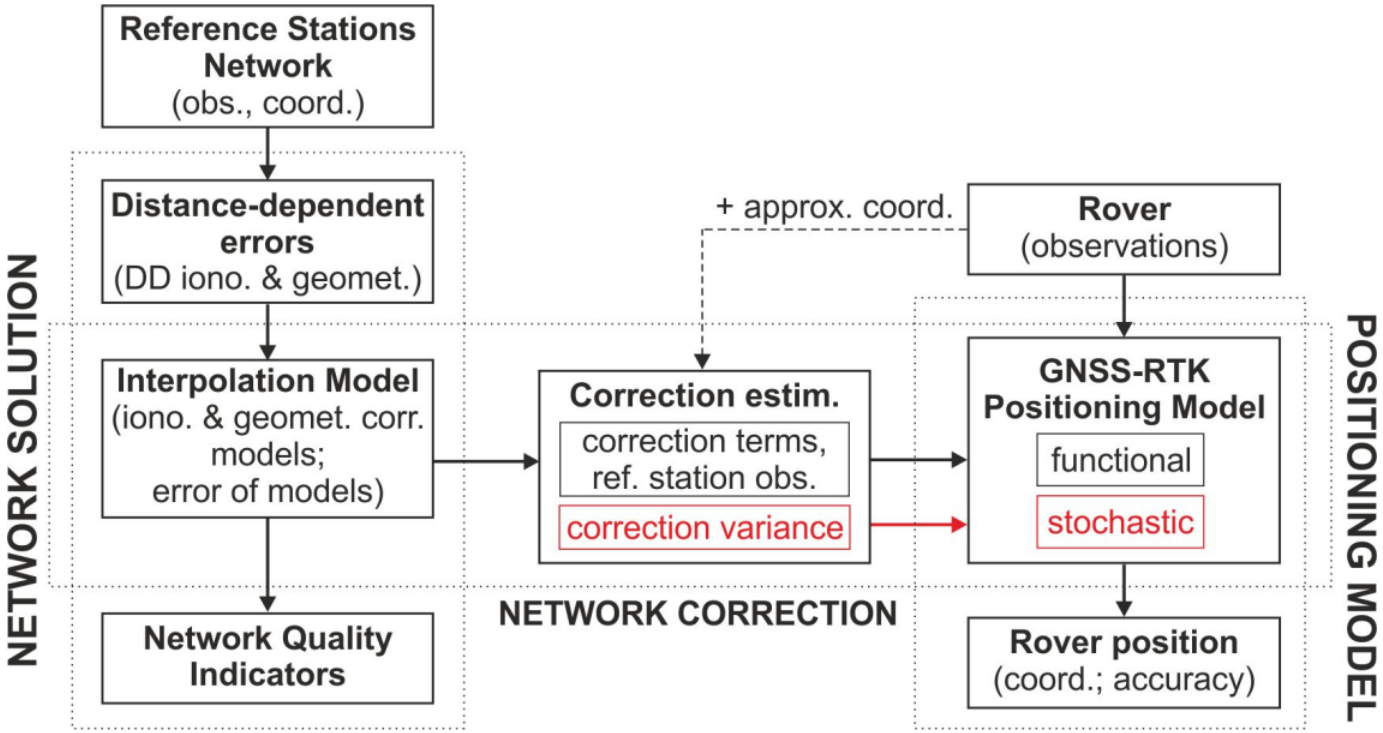


Advanced methods for satellite positioning (3)

WUT

- research on stochastic properties of correction terms in GNSS Network RTK positioning

Network RTK positioning model based on NBSM; in red - new elements of the model added by NBSM

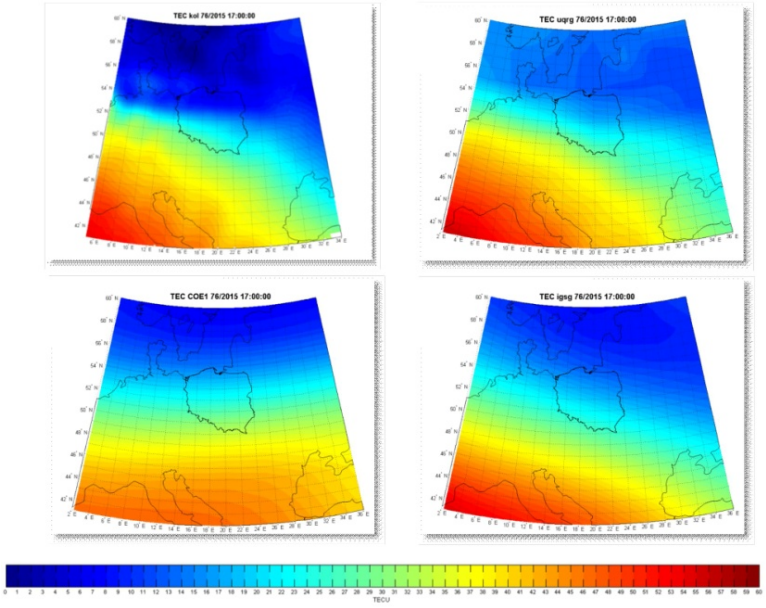


Monitoring ionosphere (1)

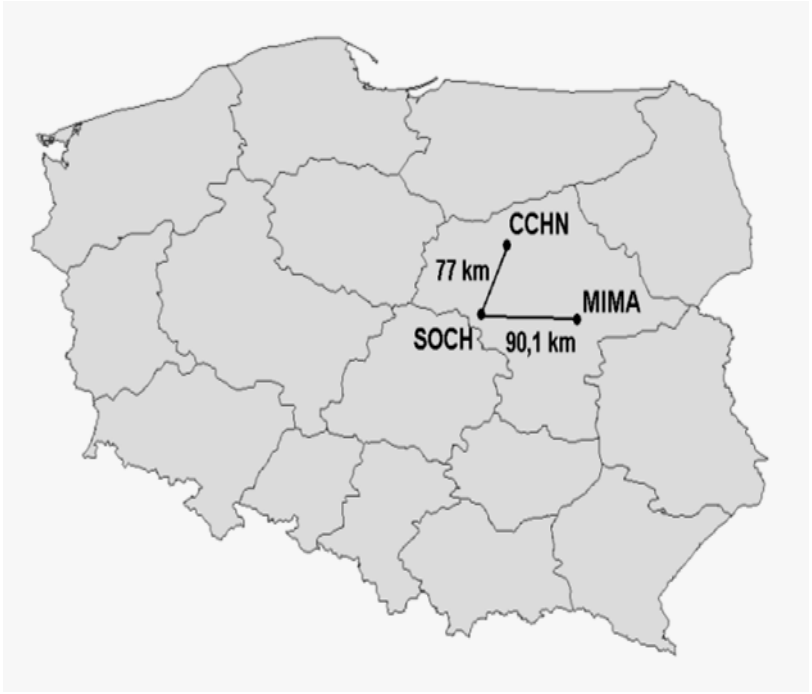
UWM

• developed **a new method for accurate regional ionospheric TEC modelling** based on processing of GPS carrier phase data and TEC interpolation with least squares collocation

Comparison between the ionosphere maps derived using the new regional TEC model UWM-rc1, IGS, COE and UQRG model for the active day (17 March 2015)



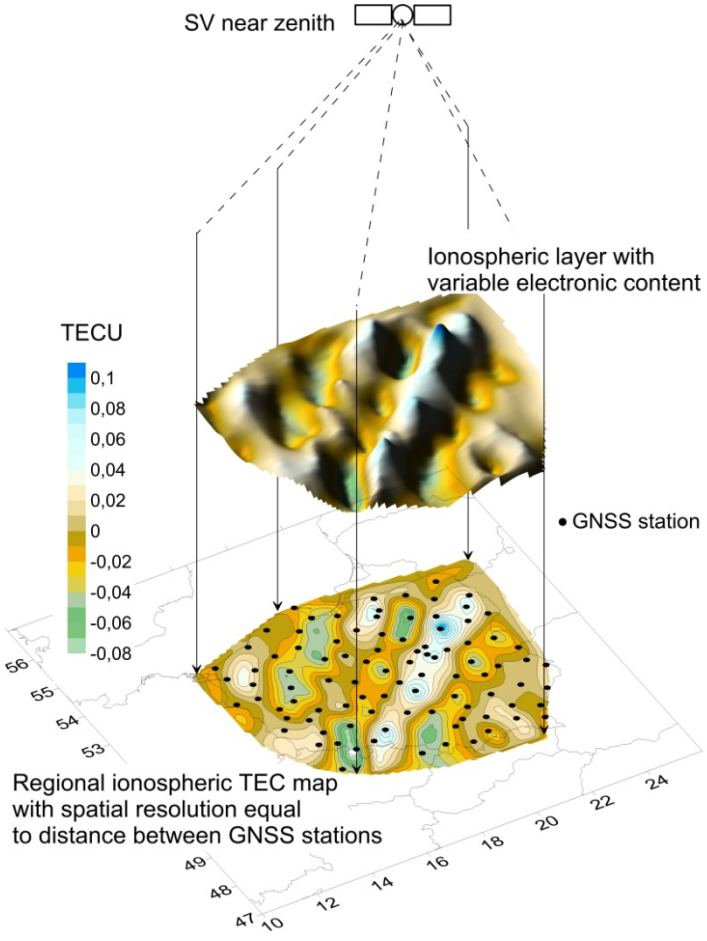
Test baselines for investigating the quality of the UWM-rc1 regional TEC model



Monitoring ionosphere (2)

MUT & Institute of Radio Astronomy NAS of Ukraine, Kharkiv

- **developed a new technique of the orthogonal projection of variations of electronic content of the ionosphere (OPVECI) for the mapping of TEC**



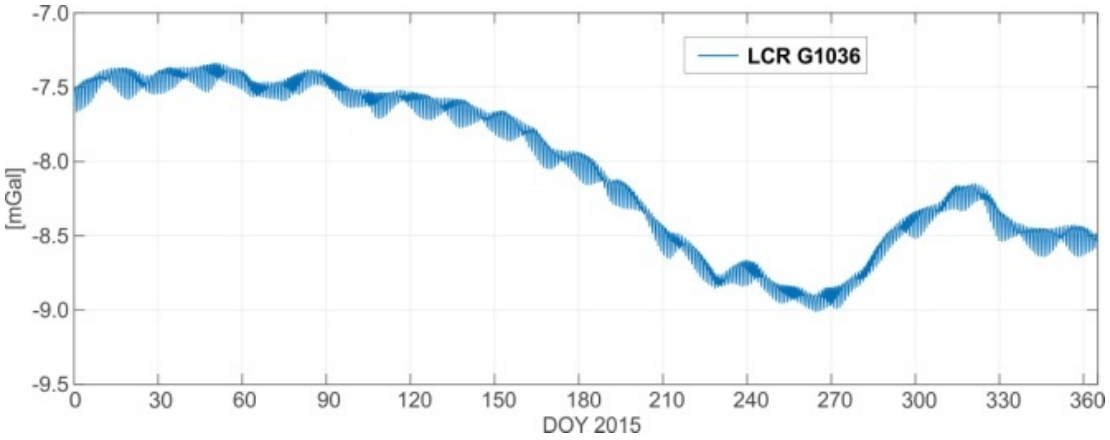
Use of observational data from the ASG-EUPOS network for

- **detection of travelling ionospheric disturbances (TIDs)**
- **modelling and measuring TIDs' parameters**
  - **direction**
  - **speed of movement**
  - **spatial period**

Monitoring gravity changes

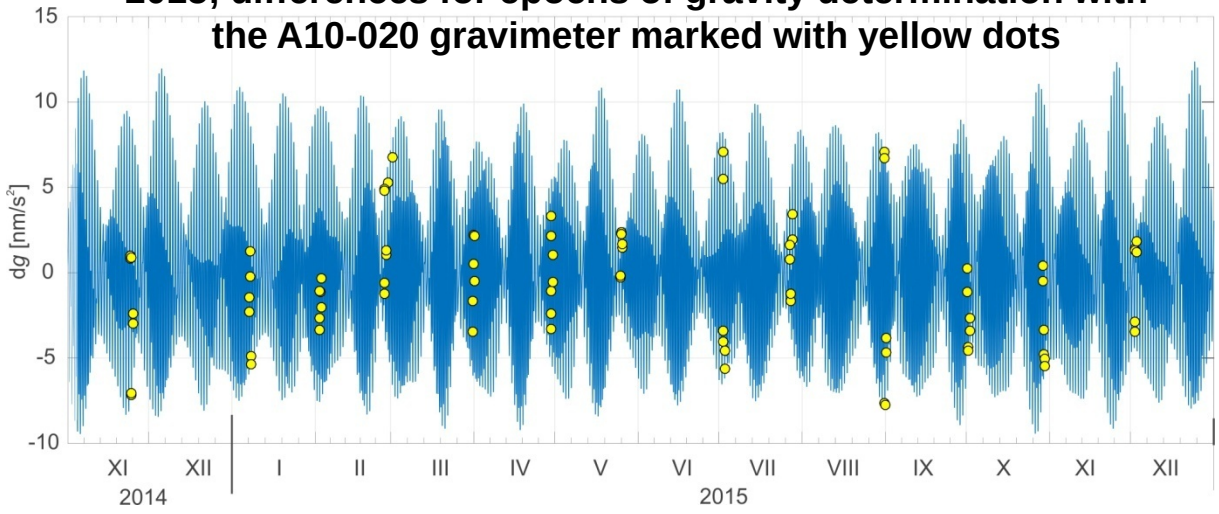
Borowa Gora Geodetic-Geophysical Observatory of IGiK

- **gravity record** using LCR G gravimeter since January 2010



- **analysis of tidal record**

Differences between local and global tidal ephemeris in 2015; differences for epochs of gravity determination with the A10-020 gravimeter marked with yellow dots



need for considering those differences when interpreting the results of absolute gravity determination

Satellite Laser Ranging (1)

Space Research Centre, Polish Academy of Sciences (SRC PAS)

SRC PAS Borowiec station operates within ILRS and EURULAS

- **SLR observations restarted in March 2015 (after 5 years break)**
- **from 1 February 2016 observations are available in SLR data banks**

In 2015

- **248 699 observed raw points tracking 377 successful passes of 21 satellites with the single shot average RMS of 24 mm**
- **participation in Space Surveillance Tracking programme of space debris laser observations**
- **computed new station positions and velocities for all 149 SLR stations from September 1983 to December 2012**

Satellite Laser Ranging (2)

WUELS

- research on LAGEOS sensitivity to ocean tides
- analysis of the impact of the atmospheric drag on STARLETTE, STELLA, AJISAI, and LARES orbits

WUT

- analysis of SLR data with GNSS data

Geodynamics (1)

UWM

- models of relative vertical crustal movements in Poland using data from ASG EUPOS

SRC PAS

- study of mechanisms of contemporary tectonic activity of the Sudetes region

IGiK

- developing the integrated system of surface deformation monitoring caused by man-made factors, based on satellite interferometry, GNSS and precise levelling

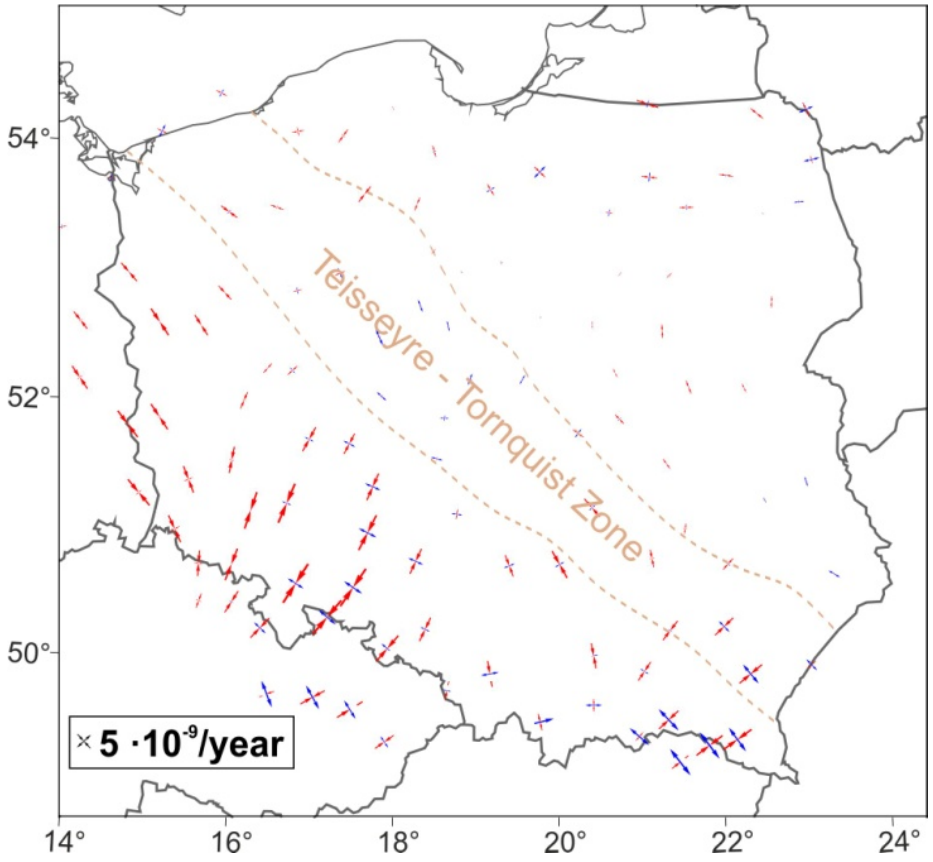
AGH University of Science and Technology, Cracow (AGH)

- monitoring surface deformations and mining induced seismic events at Legnica–Głogów Copper District using GPS data
- relation of deformations with tectonic stress and tectonic structures in the area of Bochnia salt mine

Geodynamics (2)

MUT

- **new GNSS strain rates map based on long-term observations from ASG-EUPOS**

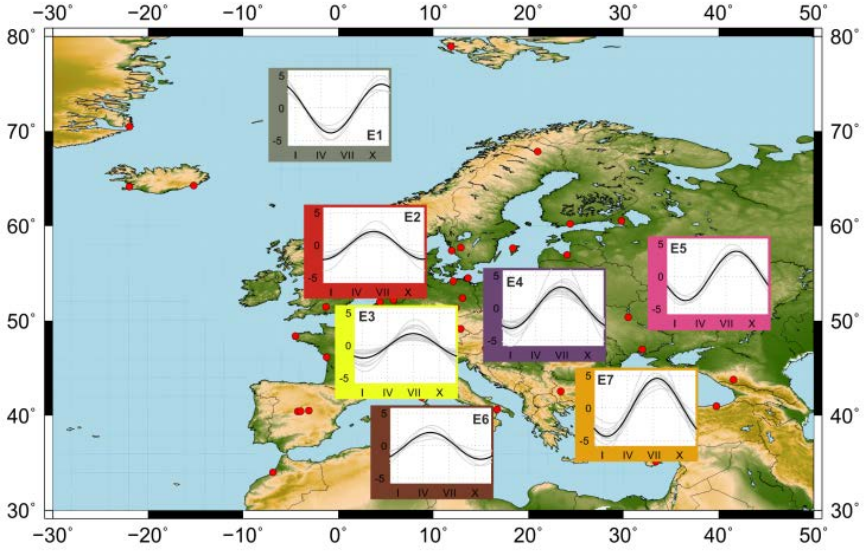


Geodynamics (3)

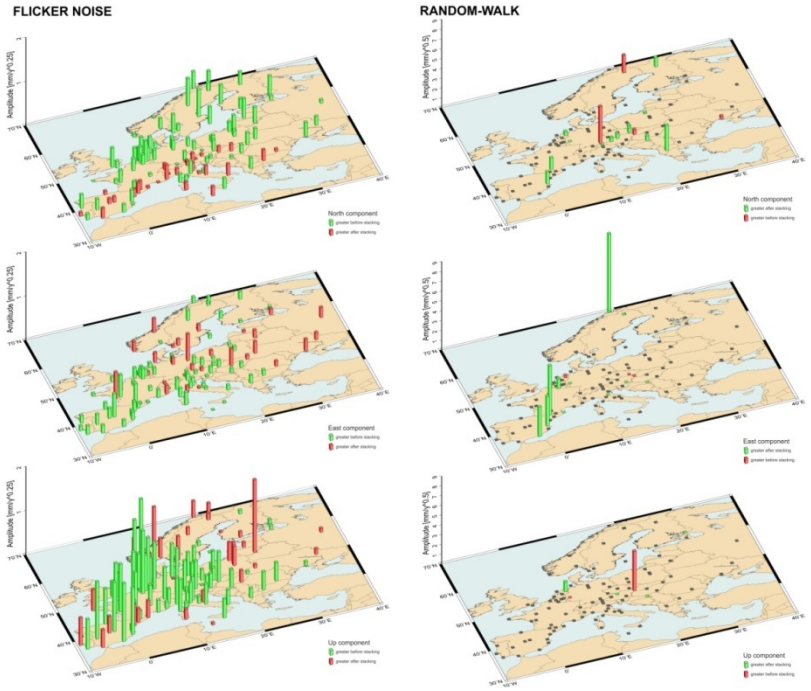
MUT

- **seasonal signals from the time series of permanent GNSS stations coordinates**

The mean quasi-annual signal for individual European clusters



Amplitudes of flicker (left) and random-walk (right) processes for selected EPN network stations' time series before and after filtering with stacking



Geodynamics (4)

MUT

- **non-linear motion of GNSS stations**

Variations of UNSA (Salta, Argentina) East (left) and Up (right) components; the solid line represents the wavelet approximation, while the dashed line - a linear fit