Comparison of GRACE derived seasonal deformation with hydrology model and GNSS measurements in Poland

Marcin Rajner
Tomasz Liwosz
Jerzy B. Rogowski

Warsaw University of Technology
Department of Geodesy and Geodetic Astronomy

Introduction

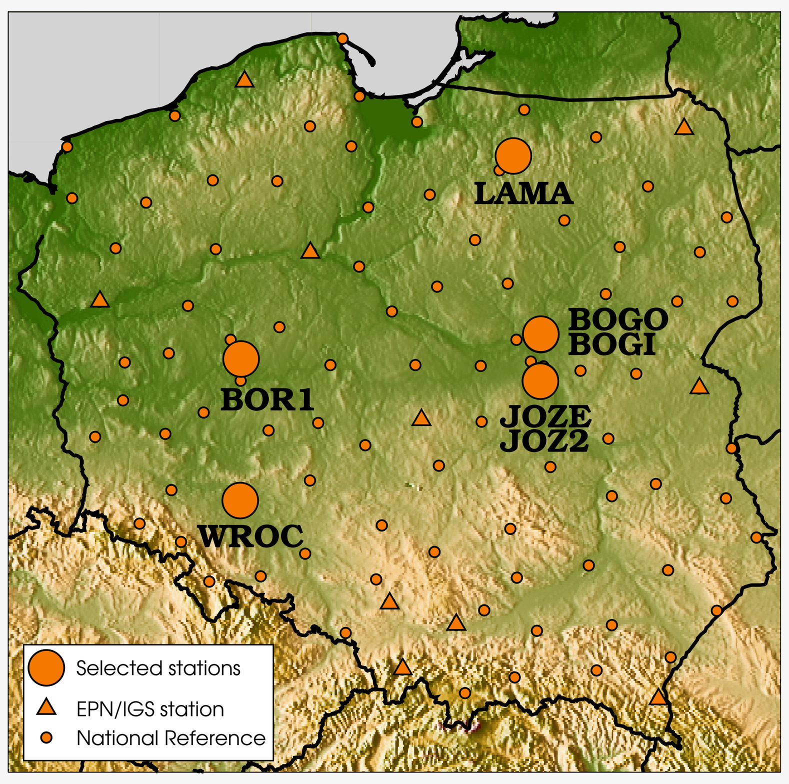

Figure 1: Map of contemporary GNSS sites in Poland. Big circles marks stations used in this study.

- This poster presents studies on consistency between GNSS measurements with modeled seasonal crustal deformation due to mass redistribution
- We used homogeneously reprocessed results from International GNSS Service (IGS) and data reprocessed in our Warsaw University of Technology Local Analysis Center (WUT)
- The information of mass transfer in Earth system stem from two sources: satellite gravimetric mission GRACE and hydrology model

Data

GNSS

- IGS and WUT repro1 results were used
- 8 permanent sites with long observations period (see Fig. 1)
- atmospheric loading was subtracted (model of Petrov and Boy, 2003)

GRACE

- Gravity Recovery and Climate Experiment
- Groupe de Recherche en Géodésie Spatiale (GRGS) Total Water Equivalent (TWE) product
- $1^\circ \times 1^\circ$ spatial resolution
- ten day temporal resolution

Hydrology model

- WaterGAP Hydrology Model (WGHM)
- $0.5^\circ \times 0.5^\circ$ spatial resolution
- monthly temporal resolution

Processing

GNSS (WUT processing details)

- Reprocessing GPS data of the subnetwork of 60 EPN sites performed by WUT EPN LAC within EPN reprocessing project (Volksen, 2009)
- Bernese GNSS Software (Dach et al., 2007)
- IGS repro1 products (satellite orbits and ERPs)
- GPS observations have been processed according to guidelines for EPN Local Analysis Centers

GRACE, GLDAS, WGHM

- The Total Water Equivalent (TWE) was used to compute deformations using Green's functions formalism (Farrell, 1972) The values of Green function for PREM model (Dziewoński and Anderson,1981) were used.

Comparison in frequency domain

GNSS vs GRACE and WGHM

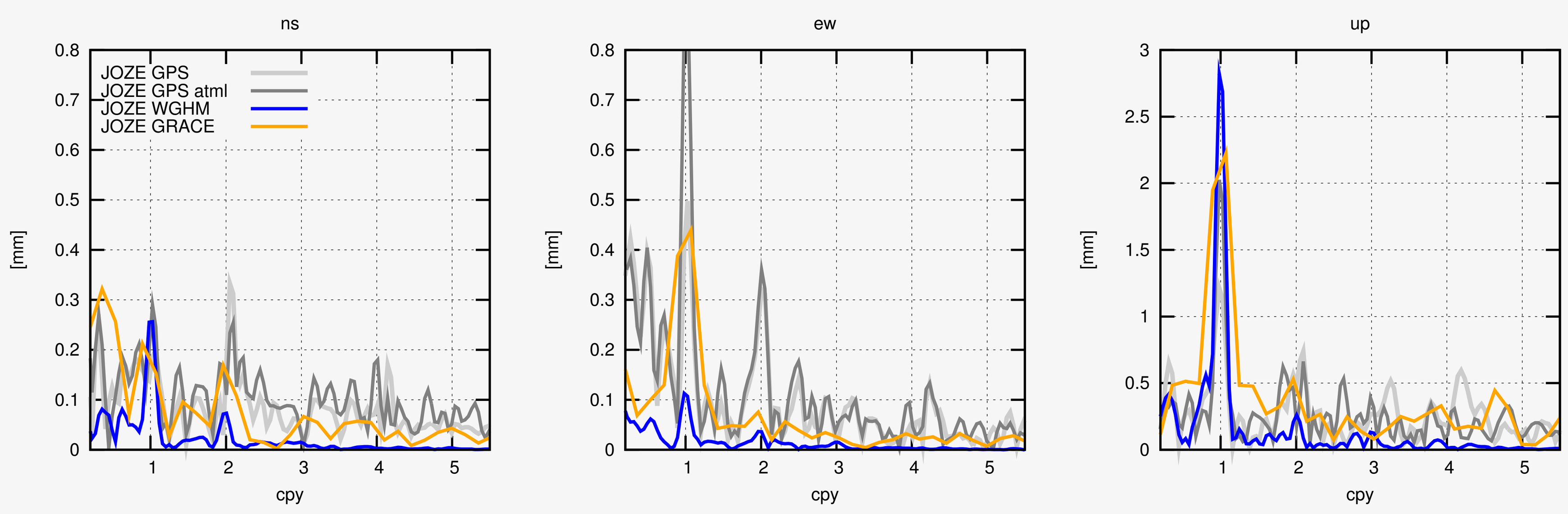

Figure 2: Comparison of amplitude spectra for JOZE site for north (ns), east (ew) and vertical (up) component. The atmospheric loading was subtracted from time series marked with 'atml'

GNSS for collocated sites

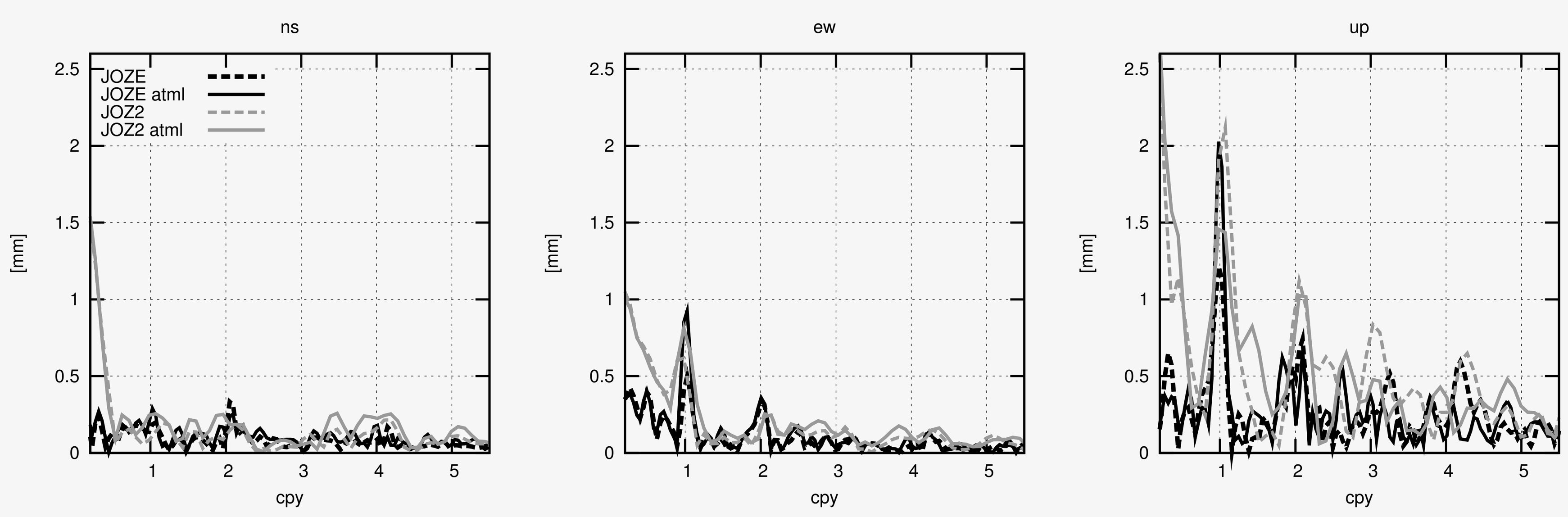

Figure 3: Comparison of amplitude spectra for two collocated sites JOZE and JOZ2 respectively

GNSS from global (IGS) and regional (WUT) solution

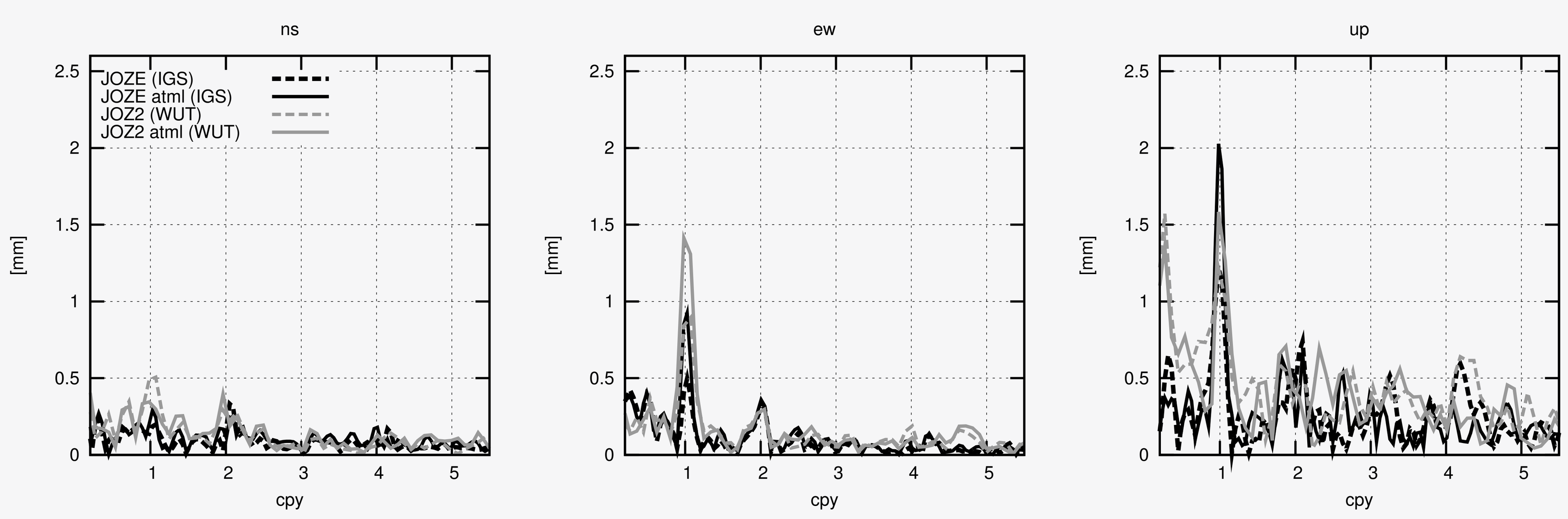

Figure 4: Comparison of amplitude spectra for different solutions, IGS repro1 and our WUT LAC repro1 coordinates

Time series example

IGS (repro1, global weekly solution)

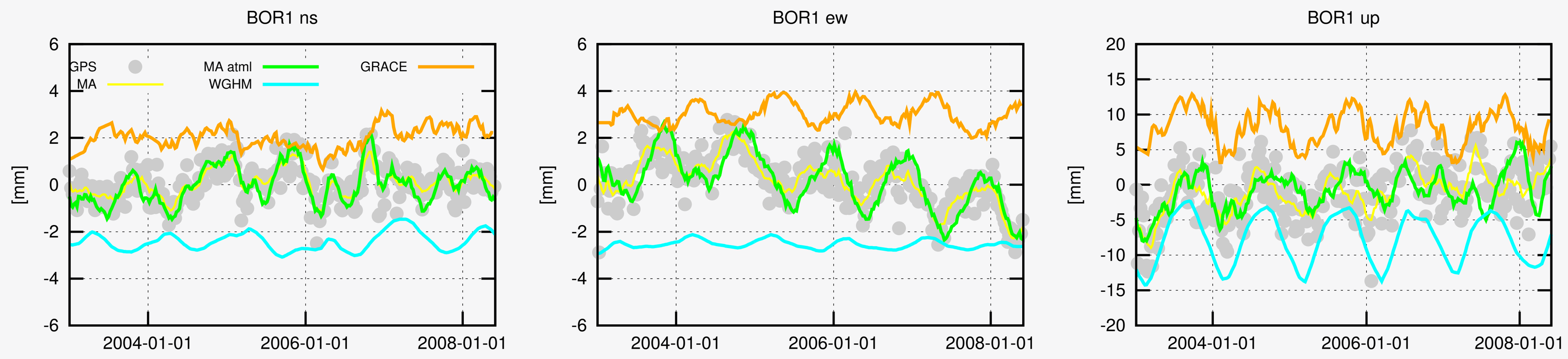

Figure 5: Seasonal signal for Borowiec station. The gray points (GNSS) indicate IGS weekly solution. The yellow line (MA) is moving averaged time series with 9 weeks window length. The green one means same averaging procedure but the atmospheric loading was subtracted from time series. The hydrology model and GRACE solutions are offset for clarity.

WUT (repro1, regional weekly solution)

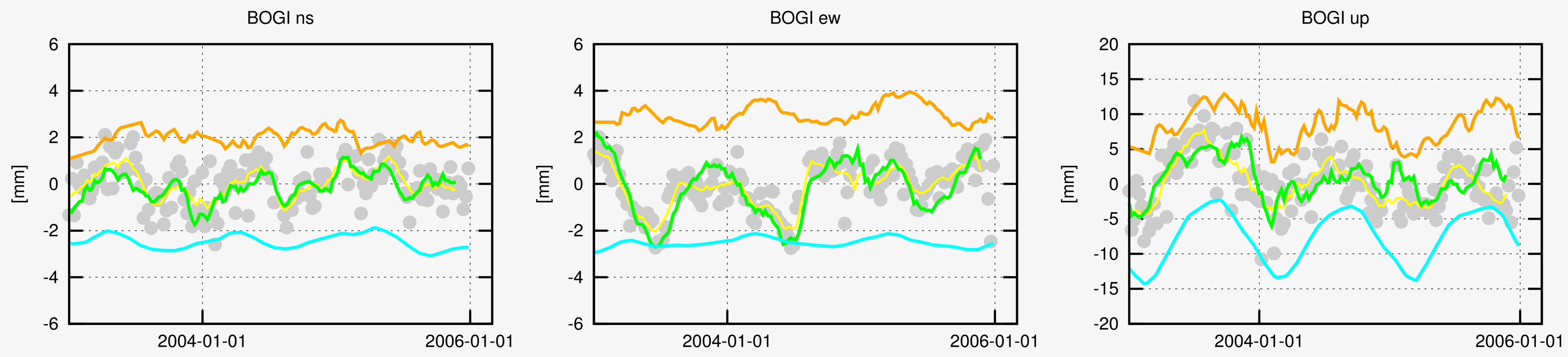

Figure 6: Seasonal signal for Borowa Góra station. The notation is the same as in the figure above.

WUT (repro1, regional daily solution)

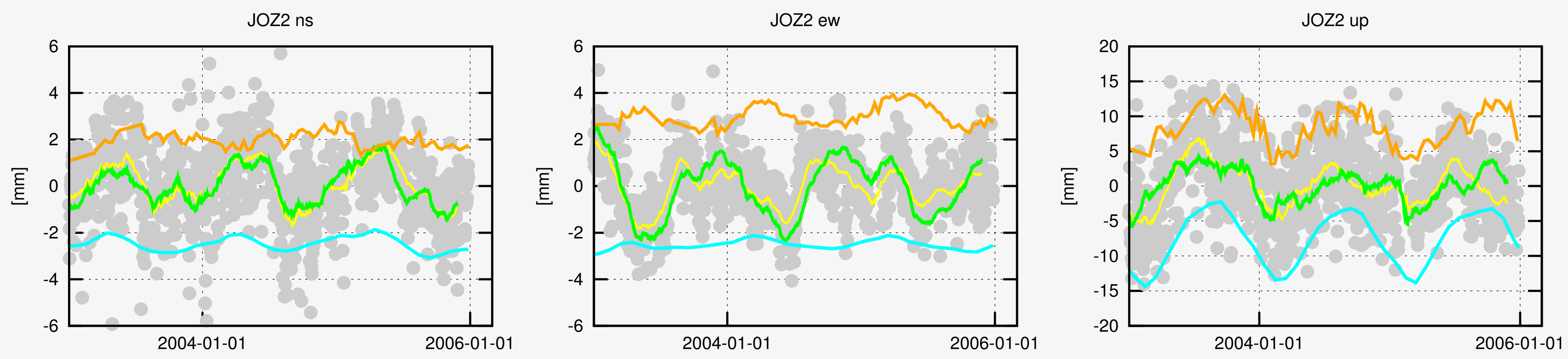

Figure 7: Seasonal signal for Borowa Góra station. The notation is the same as in the figure above. The moving average window length was 60 days.

Multiyear stacking example

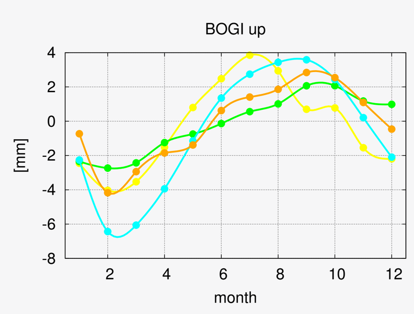

Figure 8: Seasonal signal from multiyear Borowa Góra station

- multi-year data stacking of vertical component variations for every station was performed
- example for BOGI presented here is representative for other stations
- applying atmospheric loading slightly decrease amplitude and modify the observed phase
- higher value for WGHM than GRACE is typical for Polish sites

Regional vs global solution

It should be pointed out that our repro1 solution gives reliable seasonal signal. Below is example of vertical component of Józefosław site with IGS and our results. It is clear that this time series contains similar loading signal.

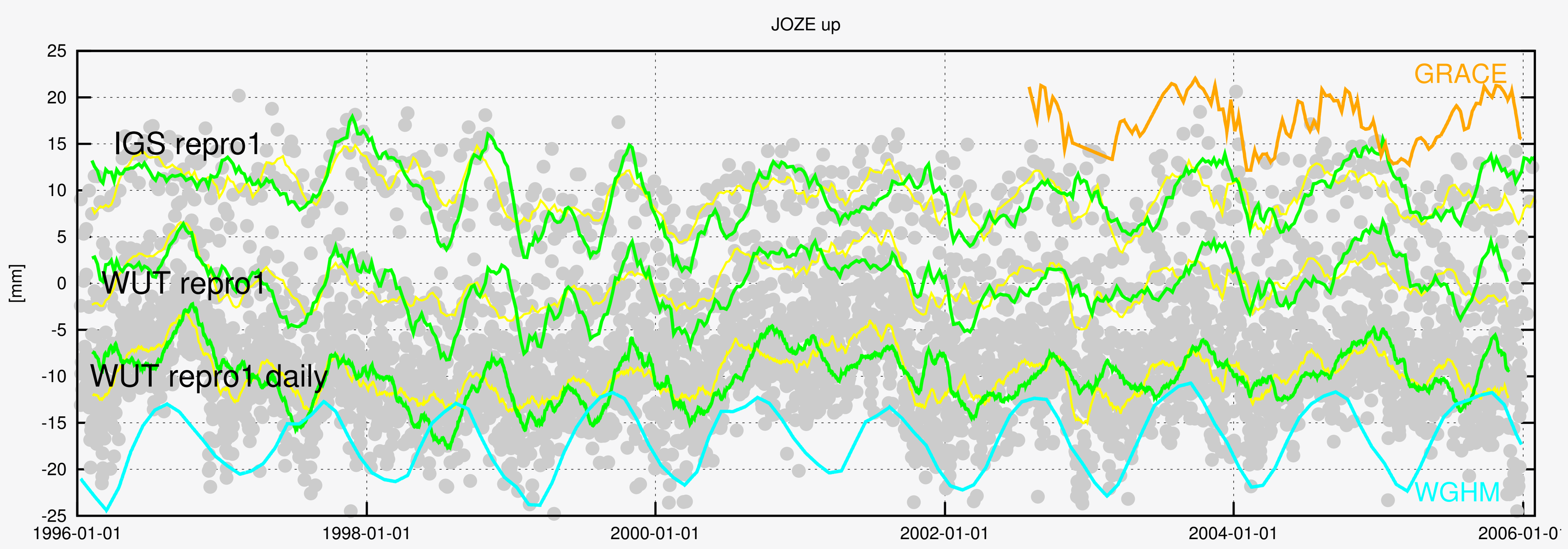

Figure 9: Seasonal signal for Józefosław site - IGS repro1 weekly solution, WUT repro1 weekly and daily solution along with modeled deformation from GRACE and WGHM

Conclusions

- there are more than hundred national reference permanent sites in Poland (ASG Eupos) which will give some more insight in near future
- the computed seasonal deformation agree very well in amplitude and phase for vertical component. For the horizontal component the interpretation is ambiguous but some peaks for north component can be attributed to hydrology loading. The amplitude of east component from GNSS measurement is much higher than modeled hydrological loading.
- the GRACE agreement with GNSS measurements for vertical component is better then for hydrology model which gives overestimated amplitude
- some local effects lead to significant discrepancies
- our regional solution gives similar seasonal variation as global results

References and acknowledgments

- Dach R., U. Hugentobler, P. Fridez and M. Meindl (2007). Bernese GPS Software Version 5.0. Astronomical Institute, University of Berne, Switzerland.
- Dziewoński, A. and D. Anderson (1981), Preliminary reference Earth model, *Phys. Earth Planet. Int.*, 25, 297-356.
- Farrell, W. E. (1972). Deformation of the Earth by surface loads, *Rev. Geophys and Space Phys.*, 10, 761-797.
- Petrov, L. and Boy J. (2004), Study of atmospheric pressure loading signal in very long baseline interferometry baseline observations, *J. Geophys. Res.*, 109, B03405.
- van Dam, T., J. Wahr, P. Milly, A. Shmakin, G. Blewitt, D. Lavallée, and K. Larson (2001). Crustal displacements due to continental water loading, *Geoph. Res. Let.*, 28, 651-654.
- Volksen C. (2009). Charter for the EUREF working group on reprocessing. Document available on `http://epn-repro.bek.badw.de/Documents/charter_repro.pdf`

A. Güntner is acknowledged for sharing WGHM model.The data from stations, IGS and GRACE products were indispensable.

mrajner@gik.pw.edu.pl