Long time changes in Zenith Tropospheric Delay above Europe based on data obtained from Repro 2 campaign

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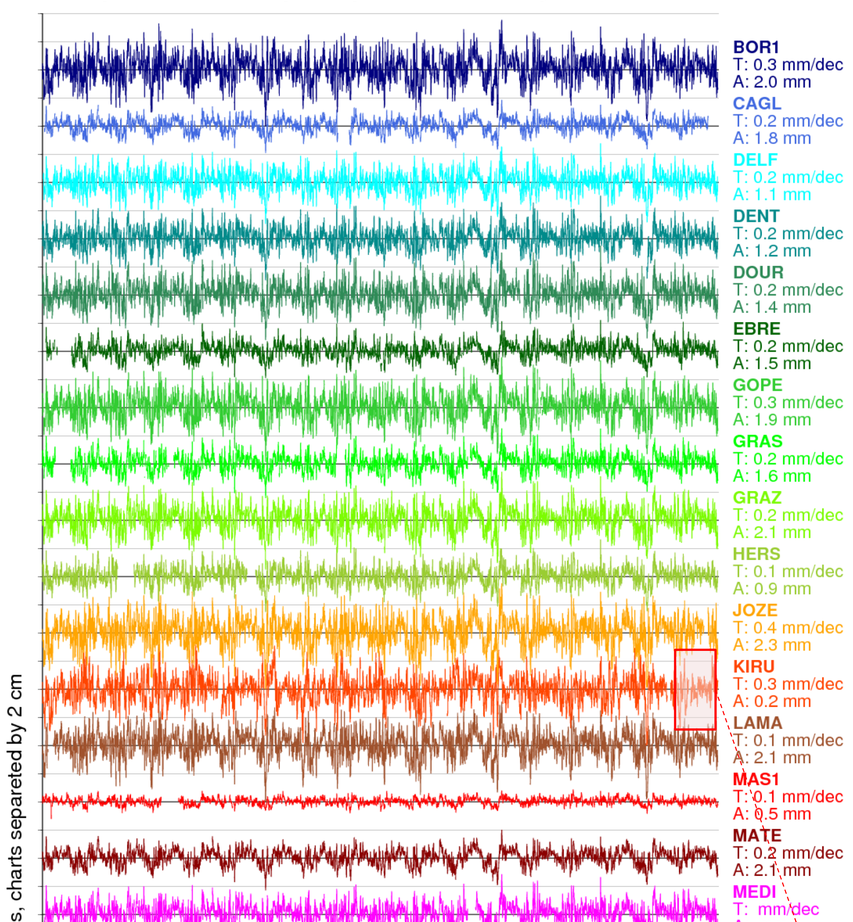
Abstract

Global Positioning System (GPS) has started play a key role in researches related to the climate monitoring. This is due to the fact that advanced processing of observations allows to obtain tropospheric parameters, which reflects physical properties of atmosphere, with very high temporal and spatial distribution. A common computational strategy applied to all observations ensure long (at least 16-year) and homogeneous Zenith Tropospheric Delay (ZTD) time series, which are essential for climate applications. This paper presents results of analysis of 16-year and 18-year ZTD time series obtained from the EPN (EUREF Permanent Network) Repro2 campaign, performed by the Military University of Technology Local Analysis Centre (MUT LAC). For all stations involved in the analysis, assessments and screening of data was conducted. In order to obtain information about occurring seasonal oscillations in time series, Lomb-Scargle periodogram for every station was performed. Linear trend and seasonal components were estimated using LSE approach (Least Square Estimation) and Mann-Kendall trend test were used to confirm the presence of linear trend designated by LSE method.

Proccessing in Repro2 campaign

Software	Gamit 10.50
GNSS system	GPS
Observation	double differences
Antenna calibration	Type mean (igs08_1822.atx)
Elevation mask	5°
Troposphere modeling	• ZTD (1h) and gradients (24h) based on daily coordinates • VMF1 mapping functions (ECMWF)
Ionosphere modeling	• I-order eliminated by linear combination • II-order and III-order modeled based TEC maps (CODE) and IGRF11 model
Loadings corrections	• Oceans tidal loading applied (FES2004) • Atmospheric tidal loading applied (ECMWFCMT) • Atmospheric nontidal loadings applied (FNCEP)

Displacements of Up component caused by nontidal ATML

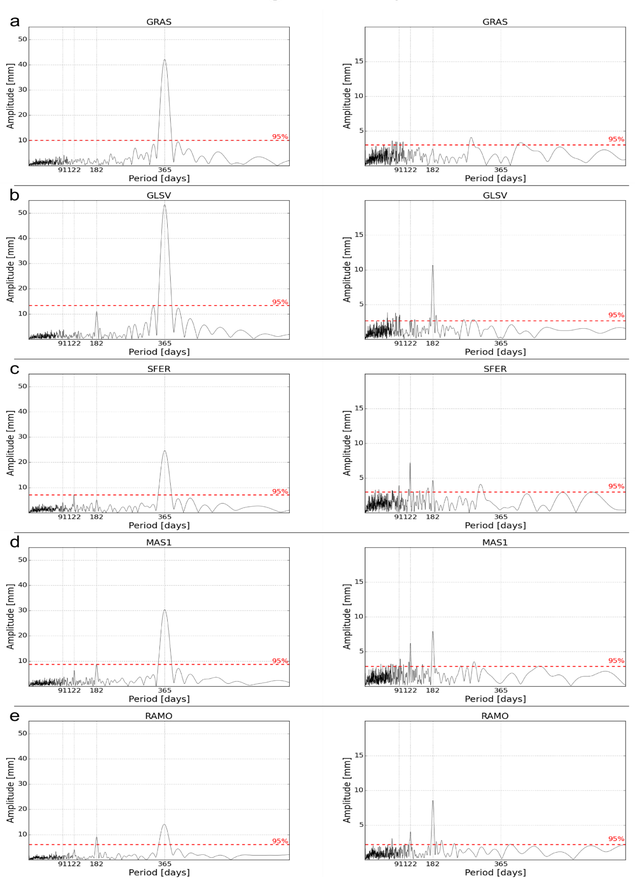


ZTD Analysis

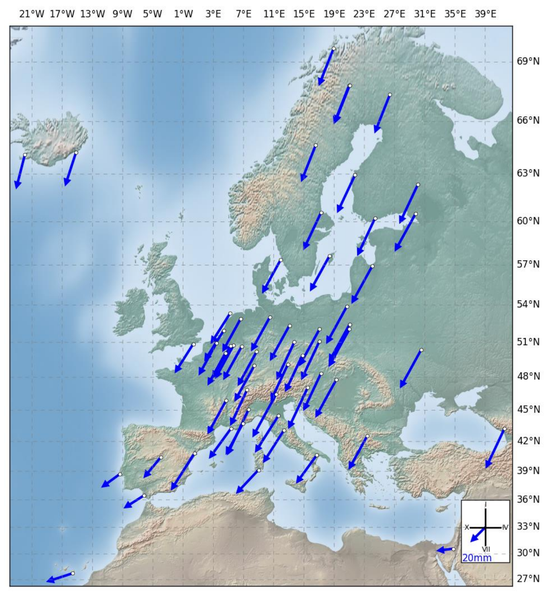
In order to determine a linear trend using Least Square Estimation approach, occurrence of oscillations with a specify frequency, should be properly assumed and therefore Lomb-Scargle periodogram was performed for every station. All stations which we investigated had a clear annual oscillation, and most of them had clear semi-annual oscillations. Due to strong annual oscillations which disturb the character of oscillations with smaller amplitude and thus hinder their investigation, second periodogram (after removal annual oscillation) was performed. Because for some stations linear trend obtained from LSE method was very small, Mann-Kendall trend test was performed in order to confirm the presence of a linear trend designated by LSE method.

Results

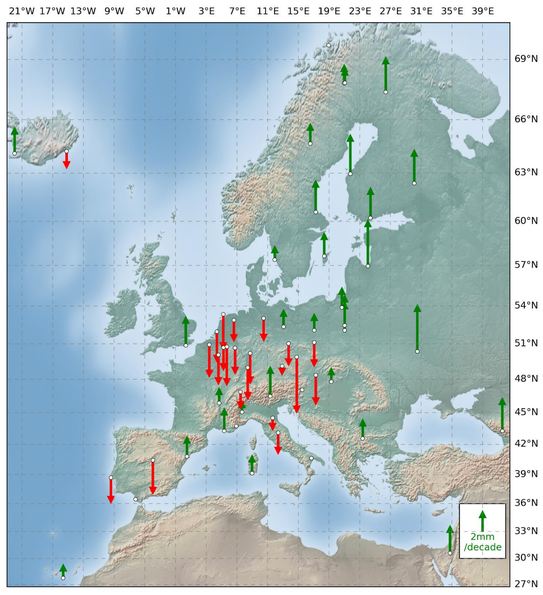
In the case of a linear trend, results should be considered in two categories: 16-year time series and 18-year time series to assess the impact of additional two years. This is due to the fact that for small value of the trend and time series not long enough, an additional one or two seasons with stronger or weaker weather conditions than usual, may noticeably affect the size or character of trend.



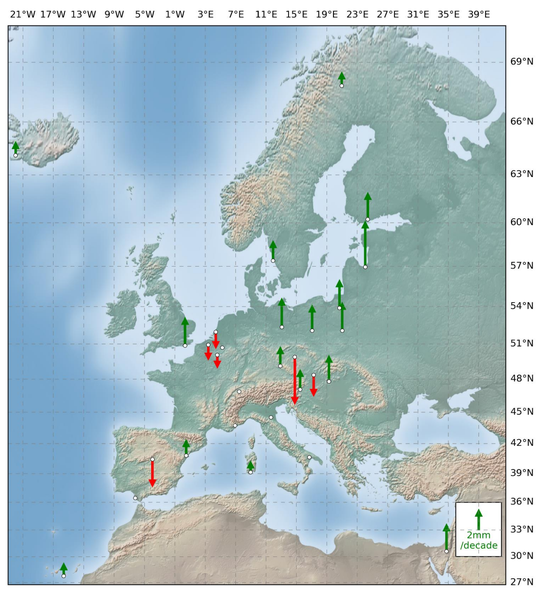
Lomb-Scargle periodograms for GRAS (a), GLSV (b), SFER (c), MAS1 (d) and RAMO (e) stations



Amplitude and phase shift for annual ZTD oscillations.



ZTD trend for 16-year time series (01.1998 - 12.2013).

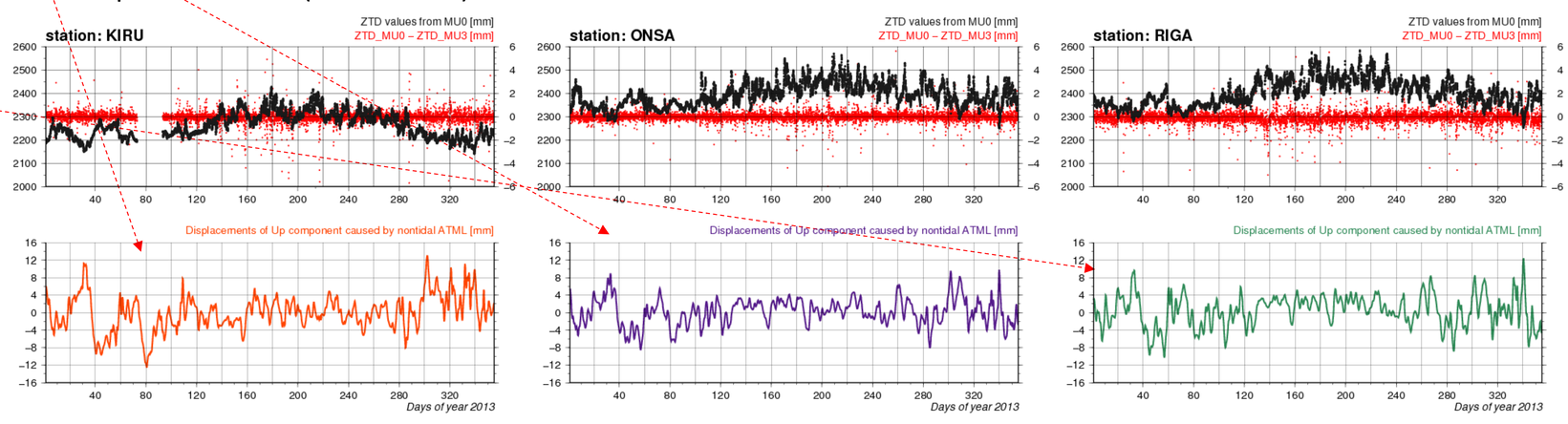


ZTD trend for 18-year time series (01.1996 – 12.2013).

Impact of the use nontidal ATML (preliminary results)

Impact of atmospheric pressure loading corrections (ATML) applied to GPS data is most visible for Up component, where it cause displacement at level of few centimeters. For selected 29 EPN stations amplitude (on the left **A**) of annual oscillation of displacements caused by nontidal ATML vary from 0.5 (station MAS1) to 4.4 mm (station RAMO). This may also affect the troposphere parameters and may reduce amplitude of long time changes of ZTD. For this reason we started another reprocessing (named MU3), for which nontidal ATML and also diurnal and semi-diurnal atmospheric tides are not applied. Processing is running, but first results (below) for Nordic region based on data from year 2013 show that impact of ATML correction to troposphere estimation is negligible. Differences between ZTD estimated in MU0 and MU3 solutions are practically „zero”. Days for which displacements caused by ATML are the greatest do not coincide with values of obtained differences. There is only a correlation between variation of displacement of Up component and variation of ZTD time series, which seems understandable given the relationship of both indicators with atmospheric pressure.

Due to the small/negligible trend (on the left **T**) of displacements caused by nontidal ATML (~0.2 ± 0.1 mm/decade), there is no reason to assume that this phenomena affect also ZTD trends. However, further studies will be conducted based on the full period of time (1996 - 2013).



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