Some Remarks On GPS Tropospheric Delay Products And Their Usefulness

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1. Introduction

Our paper deals with some areas of our research in GPS meteorology.
We made many statistical quality analysis of the standard tropospheric solutions and ZTD combined product (EPN and IGS). Factors considered as affecting tropospheric solution are network geometry (e.g. range), solution minutes (e.g. software), latitude (climate), height. This work can be useful not only for interested in combined product but also lead to improved processing strategy guidelines. We present some interesting ideas how to use tropospheric delay in meteorology and climatology (e. g. long IPW series for different climate conditions, IPW distribution maps, TZD in epoch campaigns, correlation of IPW series for different stations and other parameters, IPW time changes). Finally we report current works and experiences leading to start of NRT tropospheric service in WUT LAC. This is of course not a complete work but rather collection of observations and suggestions.

2. Tropospheric Delay products and combination

Total Zenith Delay above all stations in the network became one of the standard products of IGS (1998 by GFZ) and EPN (2001 by BKG and GFZ). It is created as a combination of individual AC solutions. We would like to stress work carried out by staff of EPN Special Project "Troposphere Parameter Estimation" (Wolfgang Söhne, Georg Weber) which our experiments only supplements by some minutes and illustrations.
Below you can see for JOZE average (weekly) AC solutions vs EPN combination differences.

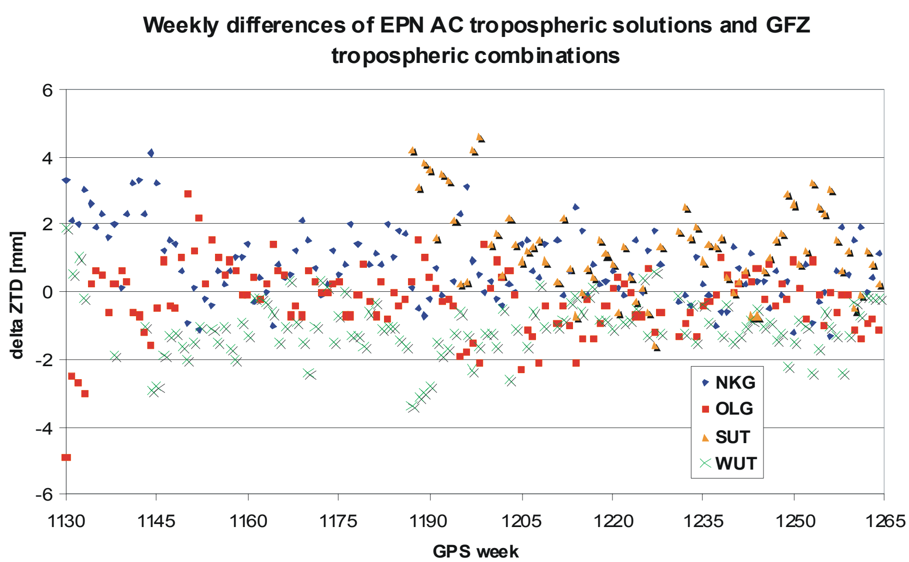

Fig. 1 Weekly differences of AC's ZTD solutions vs. combination for JOZE

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Closer look at some statistical aspects of separate Analysis Centers solutions and combinations for various stations can disclose many interesting regularities. But some features are not visible after weekly averaging. For instance on the next illustration we can notice SUT solution for JOZE was in some points less stable than others.

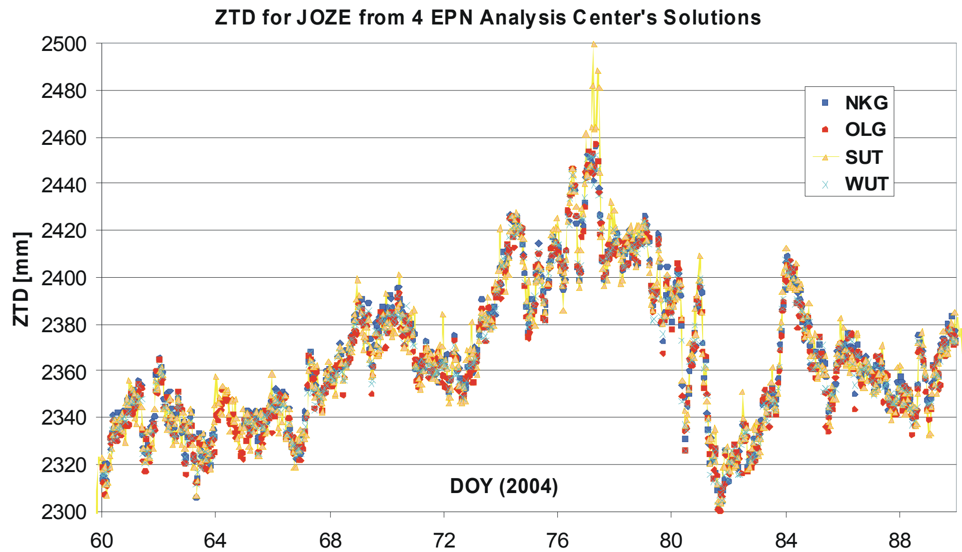

Fig. 2 Standard EPN AC's ZTD solutions for JOZE during March 2004

Comparing combined product from two combination centers we found some discrepancies.

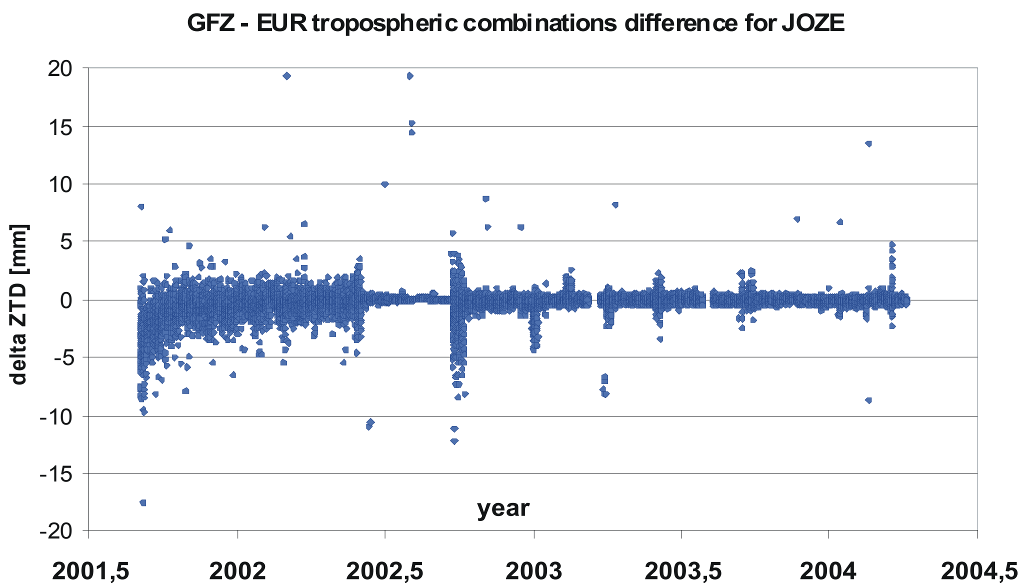

Fig. 3 ZTD EPN combinations difference (GFZ-BKG) for JOZE

Results coming from comparisons of EPN vs. IGS combinations are not so vivid to be illustrated such way but it is worth to mention that analysing the differences of global IGS and European combination (ZPD – EUR) for Central Europe stations we get negative bias of -4 mm and difference STDEV of about 3 mm during 2003. Additionally we got similar results comparing 2 CODE solutions (COD – COE): bias about -2.5 mm.

We used differences generated in EPN combination files to calculate averaged differences of ZTD solution for different stations and Analysis Center. We can also assess changes of this discrepancies in time. Below you can see maps of ZTD differences between EUR combination and all AC's solutions for the whole years 2002 and 2003.

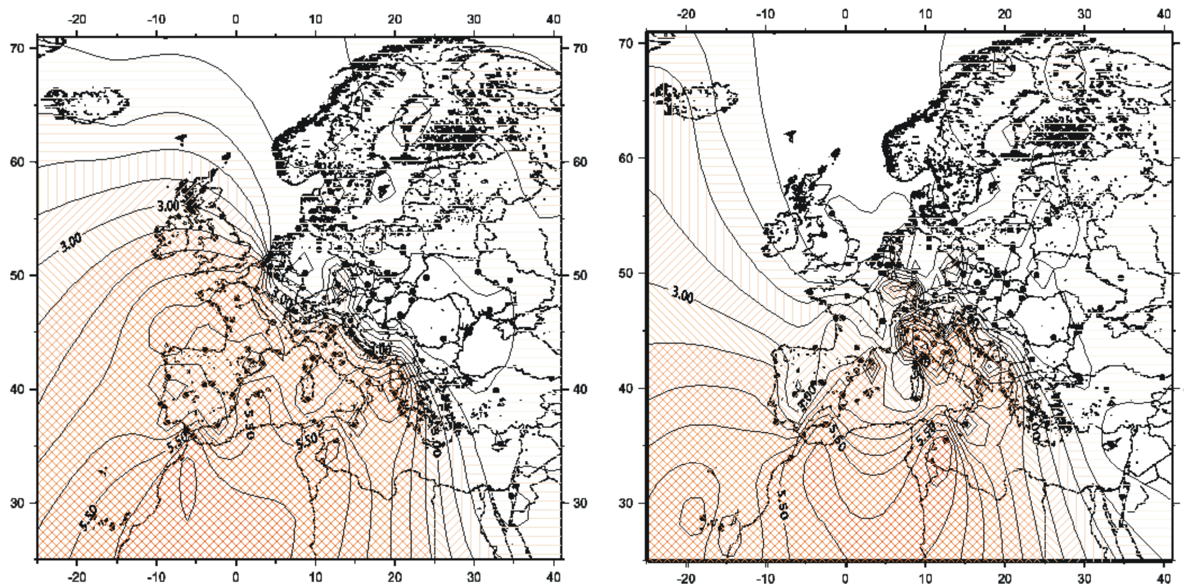

Fig. 4 ZTD calculated by all EPN AC's vs combination differences maps for the whole 2002 and 2003

Next you can compare averaged differences and absolute differences for all Analysis Centers in the subsequent three years.

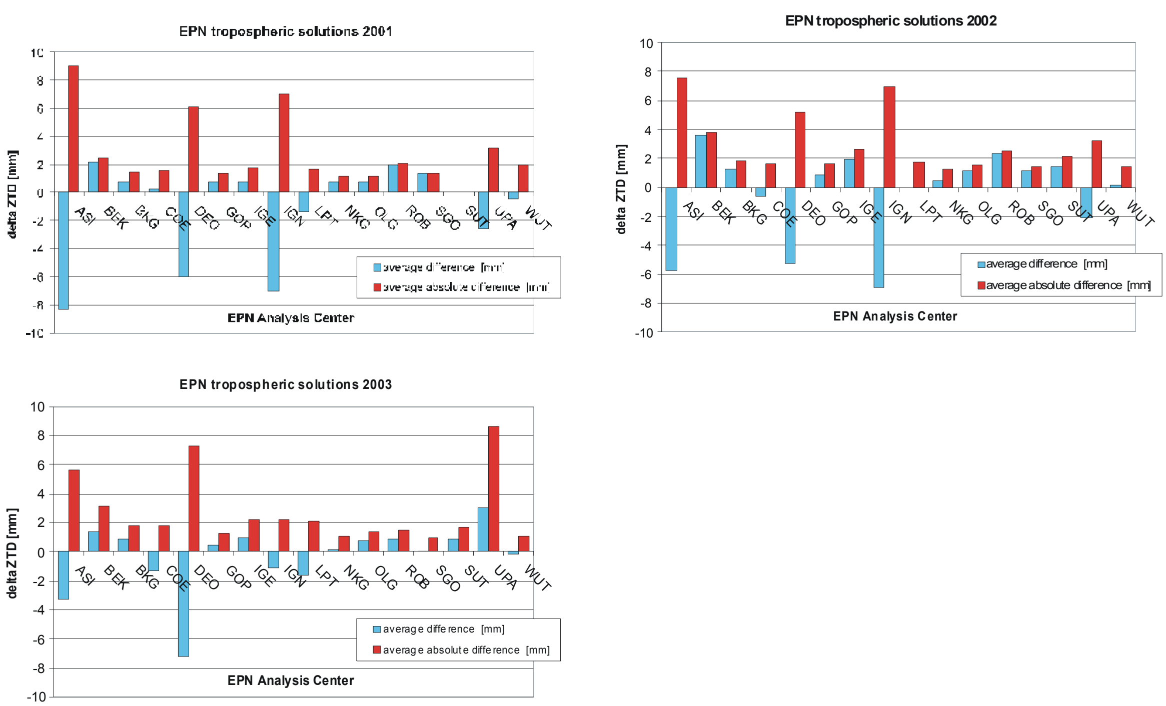

Fig. 5 Yearly averaged ZTD differences calculated by all EPN AC's vs combination values

3. Some examples of GPS meteorology potential

Epoch campaigns are good example of denser network which should be used in synoptic tasks like numerical weather prediction. Below you can see maps of IPW distribution over Central Europe during CERGOP-2 2003 campaign.

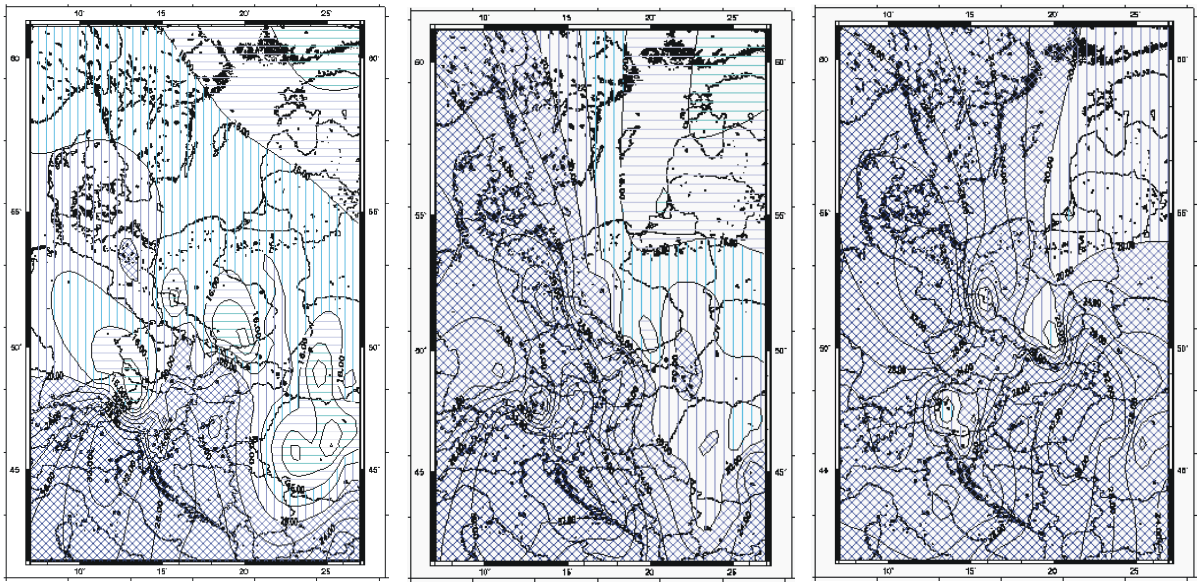

Fig. 6 Each map shows ZTD values estimated in WUT CERGOP-2 2003 solution for the period of 8.00 - 9.00 UT in subsequent days: DOY 168, 169, 170

IPW series of permanent stations show clear similarities depending on spatial separation e.g. in Poland

- BOGO and JOZE – Warsaw vicinity, 42 km distance, 0.96 correlation
- LAMA and JOZE – about 180 km distance, 0.74 correlation

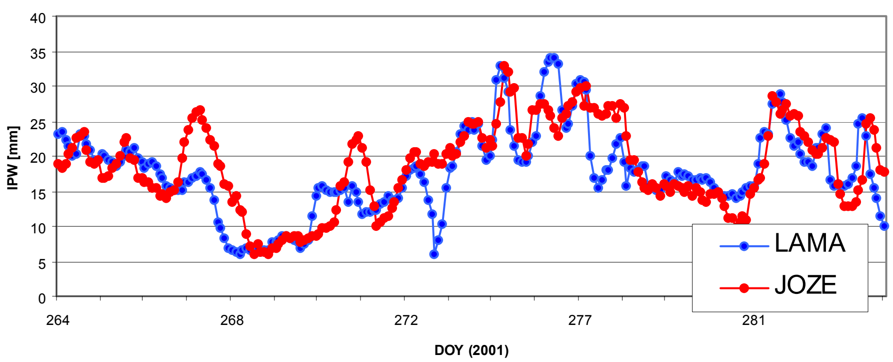

Fig. 7 Integrated Precipitable Water Vapour for 2 Polish permanent stations located in N-S direction

Using IPW derived in the GPS network we can find some interesting meteorological regularities. In Europe atmospheric phenomena migrations are dominated by western circulation.
Dresden (DRES) and Wroclaw (WROC) are placed also on the same parallel. We can calculate correlation factor for this two series of hourly spaced IPW (here 1850 points from EPN combination were used). Applying time delay of DRES series with greater steps we see slightly increase of correlation during 4 hours. See figure below.

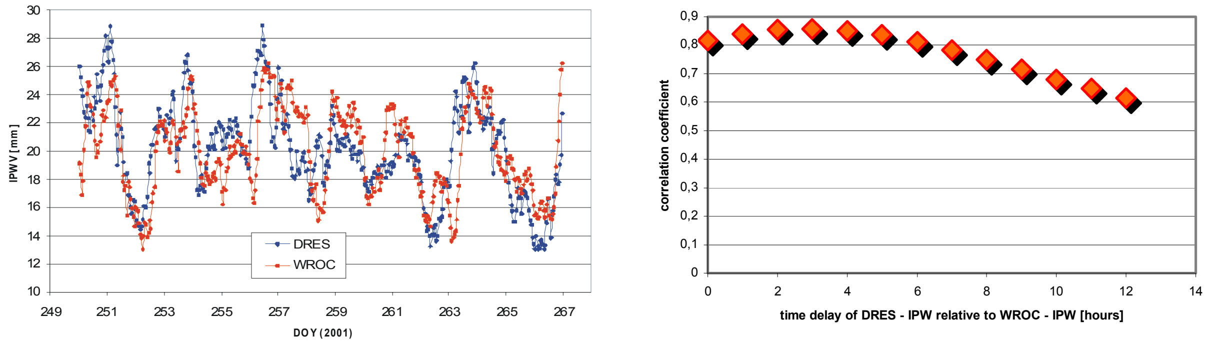

Fig. 8 IPWV for 2 permanent stations located in W-E direction and correlation coefficient using time step simulating air mass wander

To demonstrate value of IPW as climatological parameter (e. g. global warming indicator) we have show below daily averaged values of IPWV in the course of 7 years for JOZE.

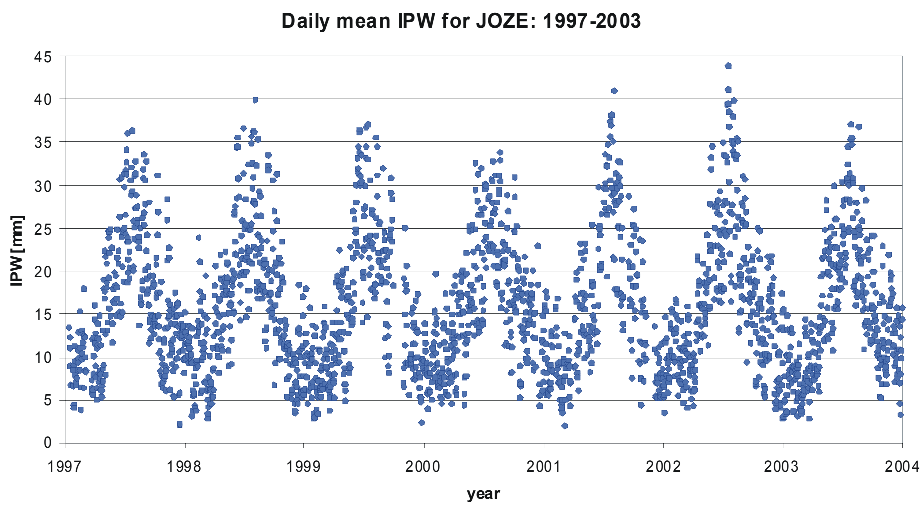

Fig. 9 Daily averaged values of IPWV for JOZE

IPW fields derived from GPS network solution can be assimilated to Numerical Weather Prediction models to improve precipitation forecasts.
This will becomes standard activity of GPS Analysis Centers on national (e.g. NOAA/FSL network in US, German GASP) and international level (TOUGH action, SomiNet).
In our Institute we are working on automatic NRT GPS processing system.
First experiments aiming at establishing all software links and solution minutes are under way.
To show essential difference between different approaches to time basis in the process of ZTD estimation we show below two experiments:

- compare ZTD calculated in 1 Hour and 30, 20, 10 minutes intervals (Fig. 10)
- calculate ZTD differences for subsequent hours (some kind of derivative) - such derivatives for classical hourly solution for JOZE (first hour jump) and NRT solution (see it on the Fig. 11)

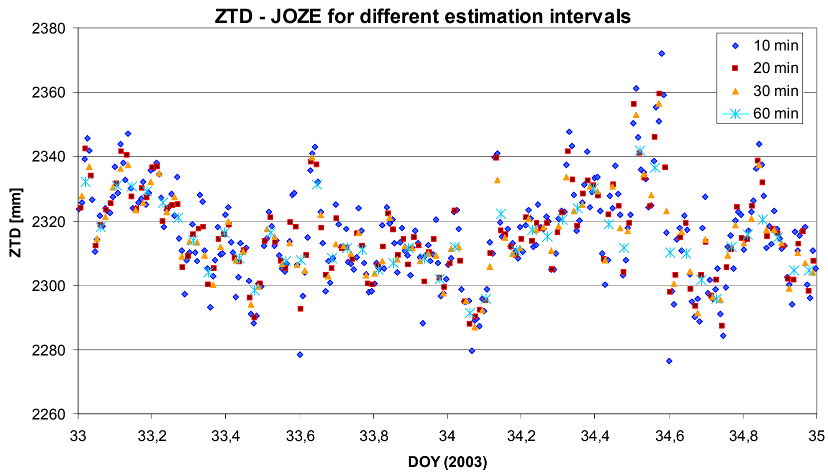

Fig. 10 ZTD from small test network for different estimation intervals (strategy unchanged)

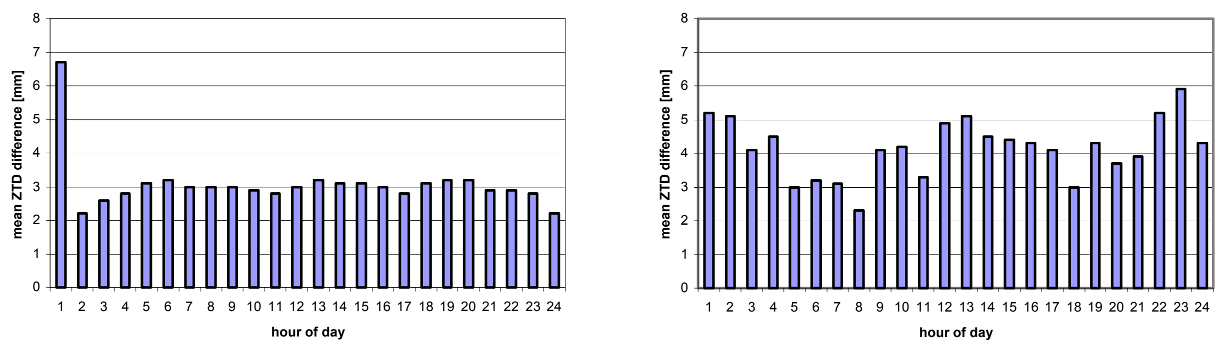

Fig. 11 ZTD differences for subsequent hours for daily (left) and hourly (right) ZTD solution

4. Literature

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