Data assimilation at SHMU

ZTD data assimilation case study and tomography of wet refraction index

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Introduction

Global navigational satellite system (GNSS) signals are delayed and bent when propagating through the atmosphere. We are determining this delay (called zenith total delay ZTD) with network solution in near real time on 59 GNSS stations over the Europe at Slovak University of Technology in Bratislava at Department of Theoretical Geodesy. We are using zenith total delay in data assimilation and as input for spatial reconstruction (called tomography) of water vapour distribution over Slovak area.

Assimilation Case Study

The quality check of zenith total delays was performed over one month period, based on first guess departures. After computation of static bias corrections for all approved stations, we were able to assimilate zenith total delays (#35) in AROME/SHMU with three-dimensional data assimilation system with other data like conventional (#212), radiosonde (#1621), geowind (#10) and hrwind (#106). Technical case study was carried out on 7th February 2018.

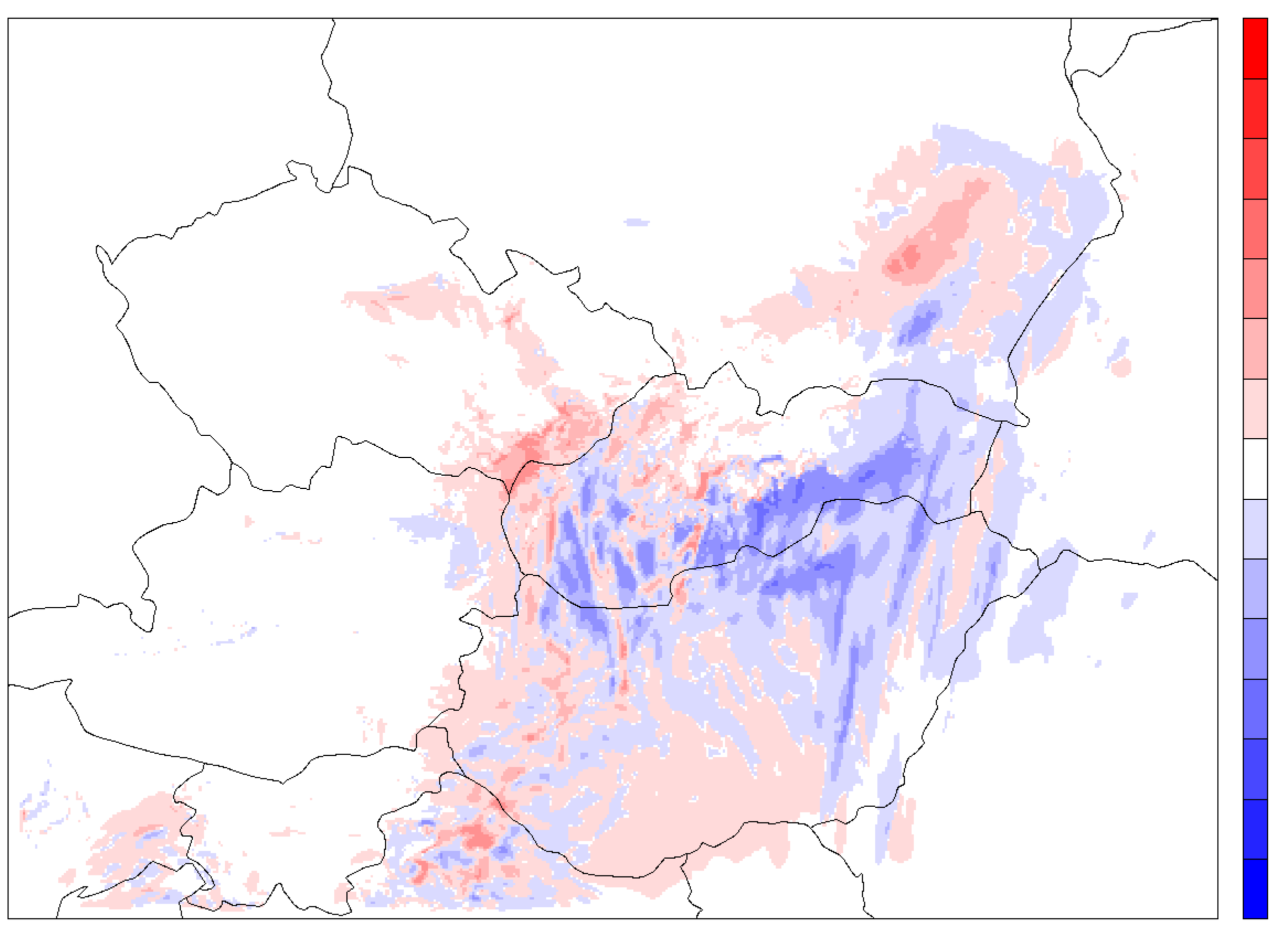

Figure 1: Differences in accumulated rainfall [mm] 12 UTC – 24 UTC between all data and all data without assimilated ZTD.

Despite low amount of GNSS data, impact is still present in 12 hour forecast. Minimal difference is -4.9 mm and maximal difference is +2.7 mm of accumulated rainfall.

Tomography

We have developed new system for determination of water vapour distribution in troposphere via tomography reconstruction based on slant total delays from stations in Slovakia. Slant total delays are determined from zenith total delays, corresponding north and east gradients, azimuth and elevation angle to a satellite. So we are able to compute 20 – 30 slant total delays for one station in one instant. As the apriori initial field of wet refraction we have used the Global model of pressure and temperature (climate spectral model). Spatial resolution for tomography is 25x25 km in horizontal and 1 km in vertical direction. The normal equations are ill-posed, so the multiplicative algebraic reconstruction technique MART1 is used for estimation of wet refraction index of tropospheric voxels.

$$x_j^{k+1} = x_j^k \cdot \left(\frac{m_i}{\langle \boldsymbol{A}^i \boldsymbol{x}^k \rangle}\right)^{\frac{\lambda A_j^i}{\sqrt{\langle \boldsymbol{A}^i \boldsymbol{A}^i \rangle}}}$$

where x is wet refraction index of voxel, k is index of iteration, i is observation index, j is voxel index, m is observation, λ is relaxation parameter, $\boldsymbol{A}^i$ is i-th row of design matrix and $\langle\rangle$ is scalar product of two vectors.

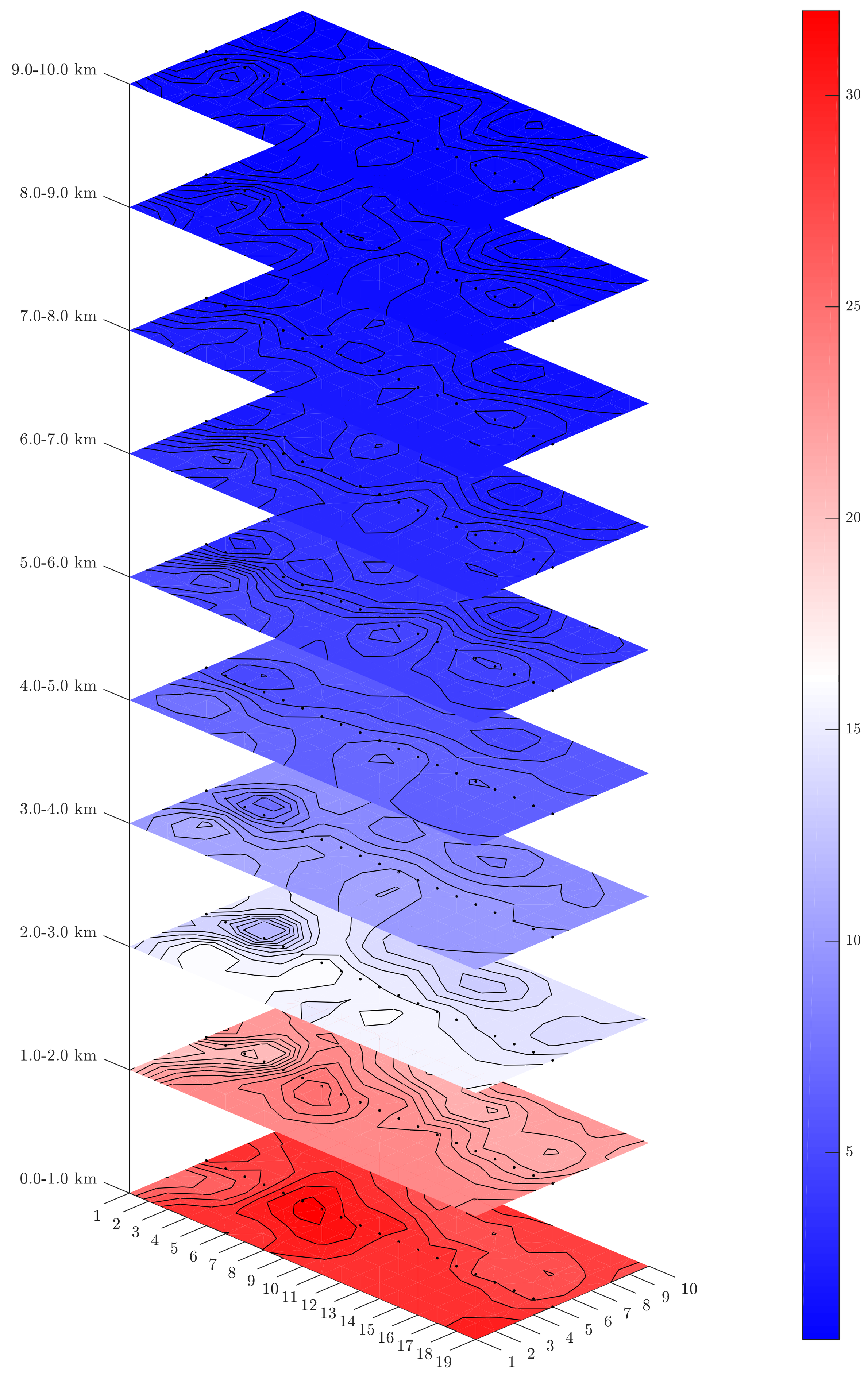

Figure 2: Wet refraction index $[(n_{wet}-1)*10^6]$ – Horizontal cross section of troposphere.

Conclusions and Forthcoming Research

- It will be necessary to replace Global model of pressure and temperature with actual AROME/SHMU forecast in tomography as initial field of wet refraction.
- It is planed to extend our tomography domain to whole AROME/SHMU domain with higher space resolution.
- Add data assimilation cycle to routine processing of AROME/SHMU and to introduce new data types like AMDAR.
- Assessment of impact of assimilation to forecast in longer term.
- We will focus our research on nowcasting and assimilation of **slant total delays in AROME**, in order to profit from its high potential benefit in data assimilation.

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