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4DVAR assimilation of GNSS zenith path delays into a numerical weather prediction model

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The GNSS data assimilation aspects are widely discussed with respect to various applications in meteorology and numerical weather models. Data assimilation combines atmospheric measurements with knowledge of atmospheric behaviour as codified in computer models. With this approach, the “best” estimate of current conditions consistent with both information sources is produced. Some approaches allow assimilating also the non-prognostic variables, including remote sensing data from radar or GNSS (Global Navigation Satellite System). These techniques are named variational data assimilation schemes and are based on minimization of the cost function which contains the differences between the model state (background) and the observations.
This paper shows the results of the assimilation of GNSS data into numerical weather prediction model WRF (Weather Research and Forecasting). The WRF model offers two different variational approaches: 3DVAR and 4DVAR, both available through WRF Data Assimilation (WRFDA) package. We apply the Zenith Troposphere Delay (ZTD) from GNSS network in Poland into the 3DVAR and 4DVAR assimilation schemes. The WRFDA default operators were altered to properly represent observation errors of GNSS estimates.. The investigated case studies include 1 month of 2013 with severe weather events. The obtained data are validated against radiosonde profiles and surface meteorological measurements, including air temperature, humidity and daily rainfall. The assimilated data have a visible impact on the WRF’s temperature and water vapour field.
Our long-term plan is to assimilate the STDs (Slant Total Delays), firstly using 3DVAR technique. At the moment, the 2D raytracing algorithm is implemented and working on each forecast issued by University of Wrocław. We are developing the optimal observation covariance matrix based on the ZTDs, gradients, partial derivatives of mapping functions as well as variance - covariance matrix as produced by Bernese 5.2. Processing Software.