The high resolution troposphere model on the area of GBAS system

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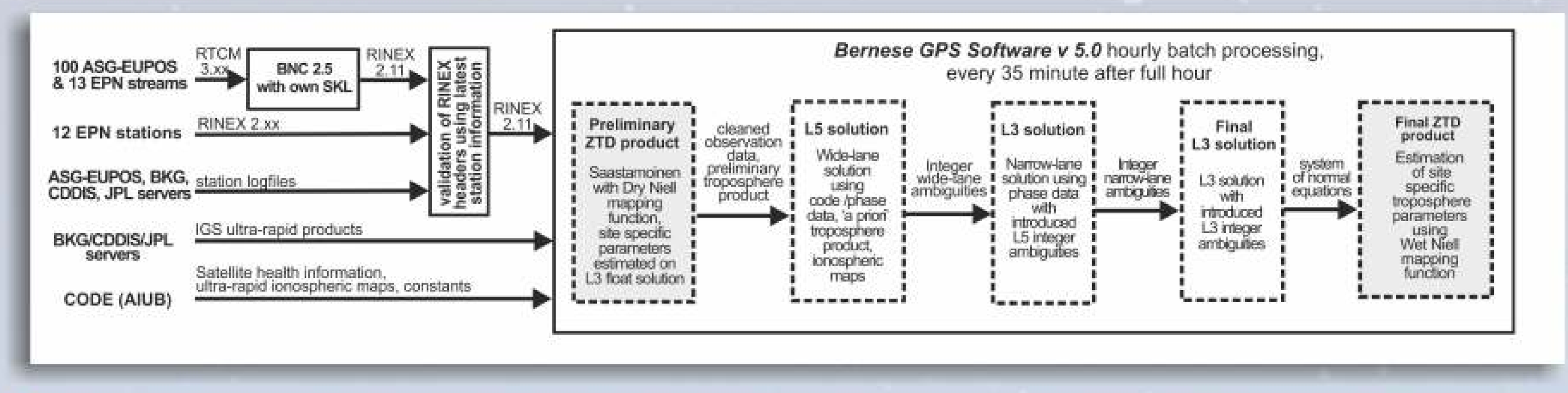
INTRODUCTION

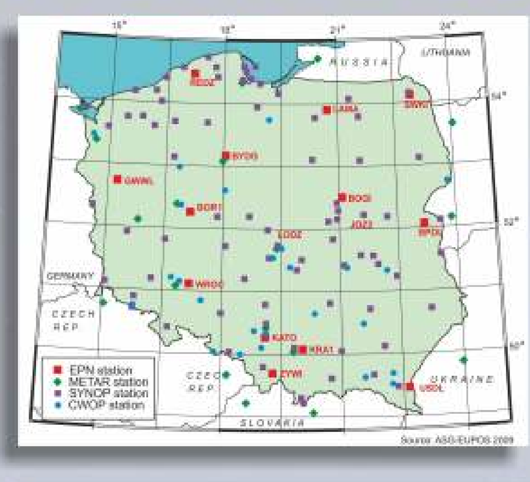
Global Navigation Satellite Systems (GNSS) are designed for positioning, navigation and amongst other possible applications it can also be used to derive information about the state of the atmosphere. Continuous observations from GNSS receivers provide an excellent tool for studying the neutral atmosphere, currently in near real time. The Near Real Time neutral atmosphere and water vapour distribution models are currently obtained with high resolution from Ground Base Augmentation Systems (GBAS), where reference stations are equipped with GNSS and meteorological sensors. Poster presents current status of activities related to the construction of the troposphere model on the area of Poland for E-GVAP support, IWV estimation, 3D troposphere tomography and positioning.

ZTD GNSS MODEL

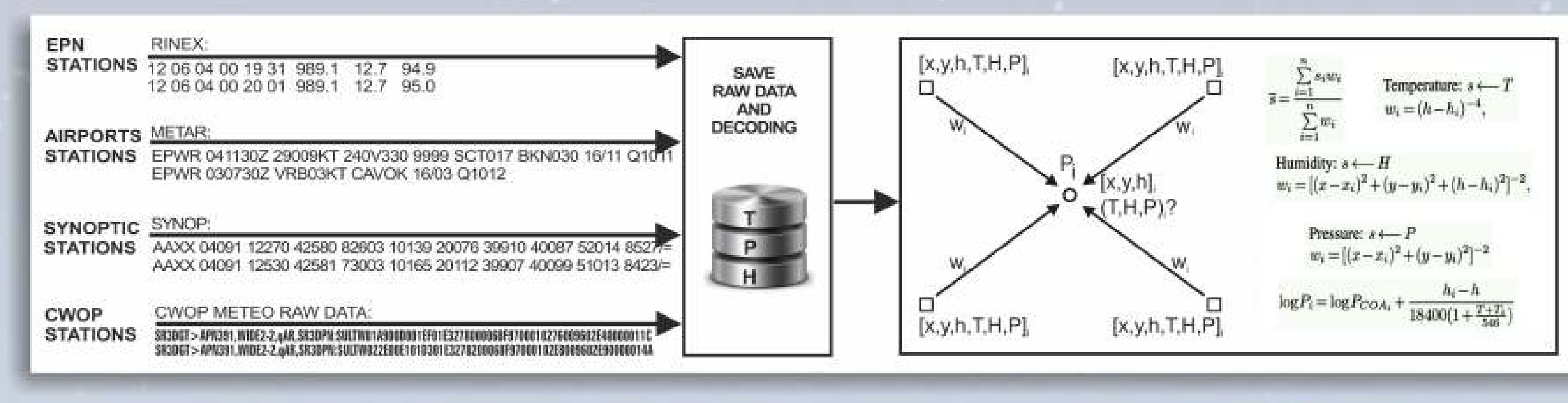
Since 2008 in the territory of Poland a Ground Base Augmentation System called ASG-EUPOS has been established by Head Office of Geodesy and Cartography in frame of EUPOS project. The reference stations network presently consists of 100 Polish and 22 foreign stations.
RTCM 3.x data from 113 stations is recorded in real-time using the BNC 2.5 software and stored in 30s interval using RINEX 2.11 format. Data from 12 stations is downloaded via FTP servers in RINEX 2.11. Processing of hourly RINEX data is being done with half-hour delay by the batch Bernese GPS Software v.5.0 process, which is based on ambiguity fixed double-differenced solution of baselines.



ZTD METEOROLOGICAL MODEL

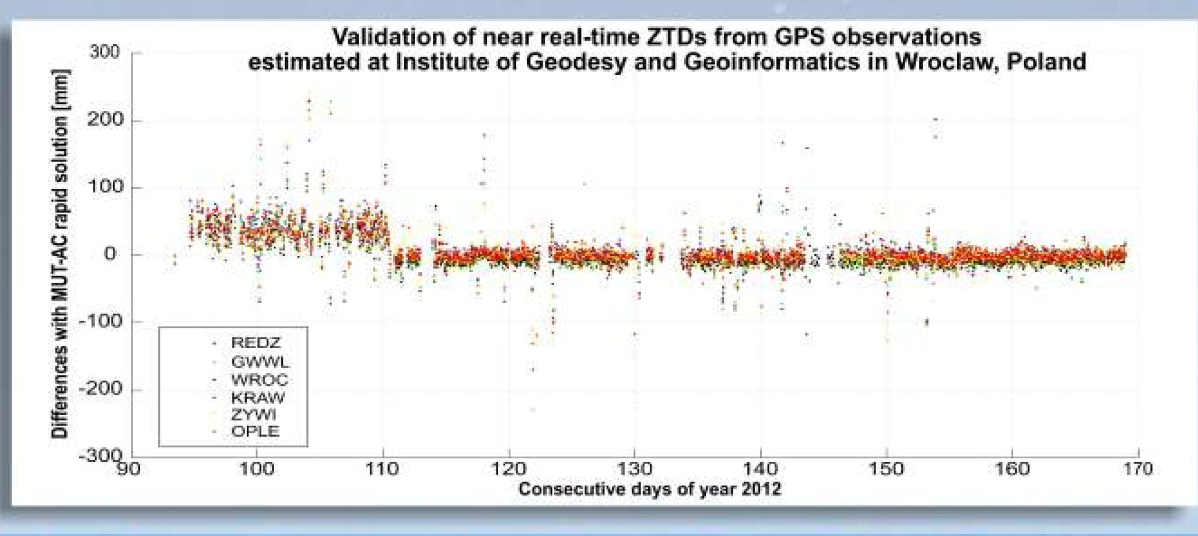


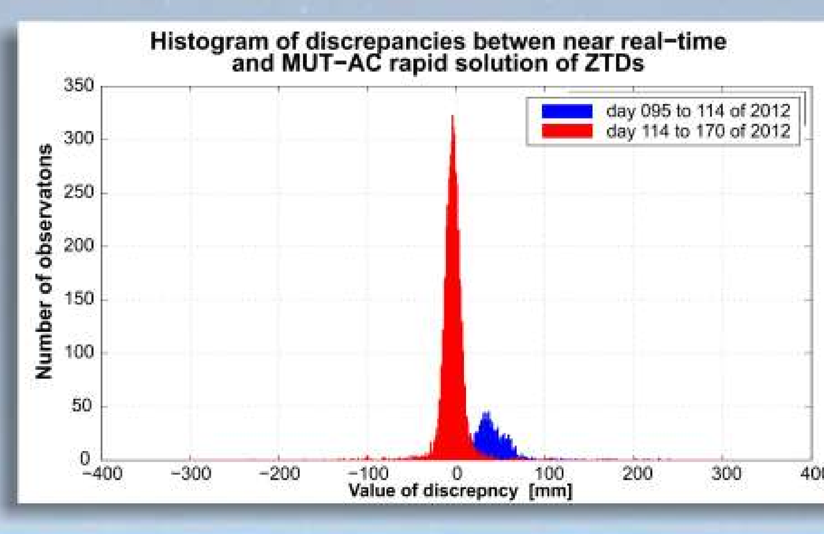
There are 15 EUREF Permanent Network (EPN) stations in Poland, equipped with new uniform meteorological infrastructure Paroscientific, Inc. MET4A or equivalent (BOR1). Meteorological data is supplied with airports (METAR) and synoptic (SYNOP) stations located in Poland.
Three basic meteorological parameters are measurred: pressure, temperature and relative humidity. The meteorological data are available with different time resolution, so the integration and cross-validation is required, as well as space interpolation procedure.
After interpolation of meteorological parameters into specific location, the ZTD value is obtained from Saastamoinens model.



E-GVAP SUPPLY DATA

The next goal in developing the system of monitoring troposphere by the use of GPS data is supporting the E-GVAP service. Comparison of estimated ZTDs with the rapid solution made by Military University of Technology Analysis Centre (MUT-AC) in Warsaw shows significant outliers (see right figures). This is mainly caused by the breaks in availability of the data from different stations and changes in baselines design. Currently diffrent baselines configuration strategies are tested to achieve more stable solution.
The estimated ZTD values shoud be delivered to E-GVAP in 15 minutes interval and no longer then 1hour 45 min after the receiving of data. Our results meets both of this criteria, so as soon as the translating service from troposphere SINEX to COST-716 format will be established, the ZTD product will be uploaded to E-GVAP.





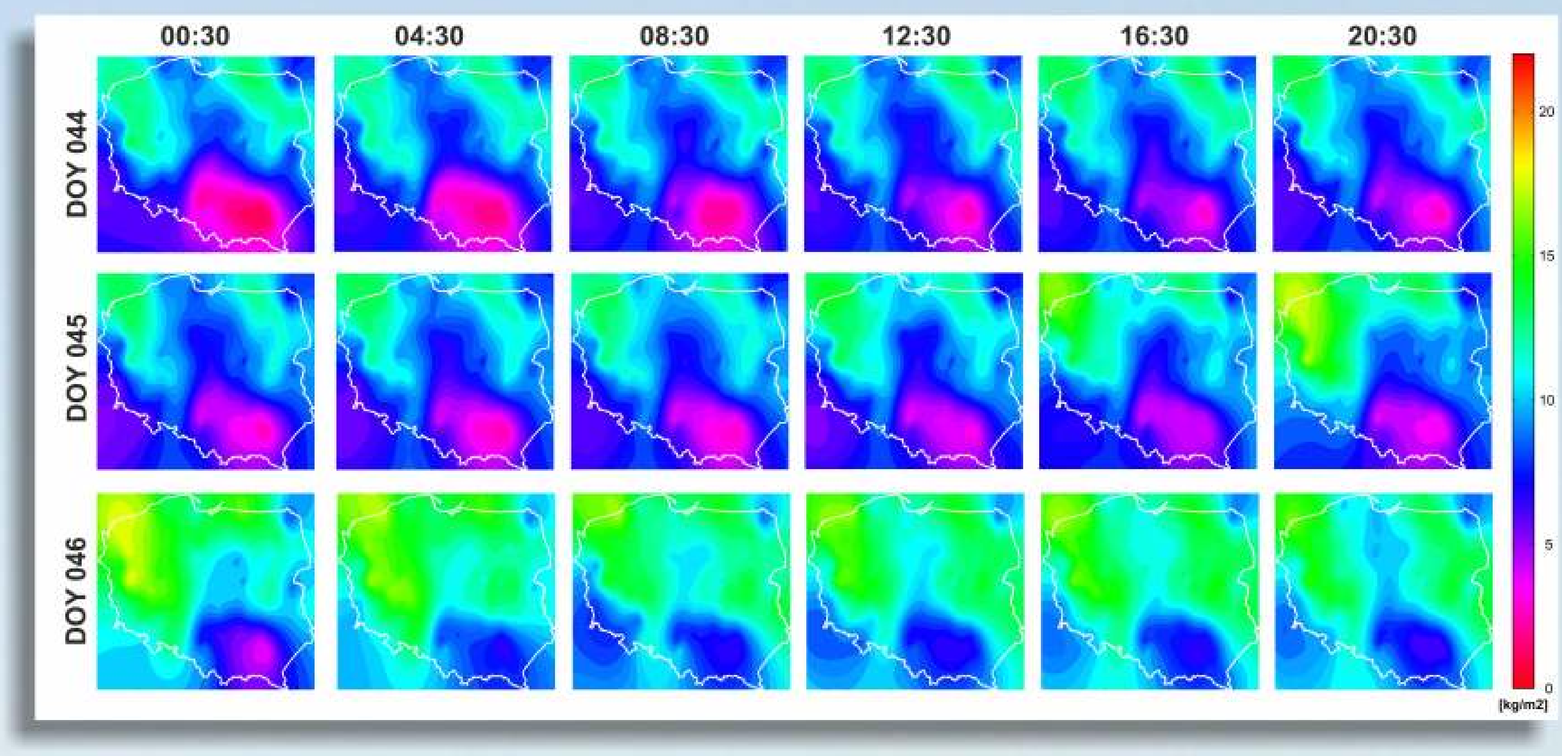
2D INTEGRATED WATER VAPOUR

The information about contents of water vapour (2D model) above GNSS stations, represented by Integrated Water Vapour IWV, is obtained directly from ZWD, according to the equation:

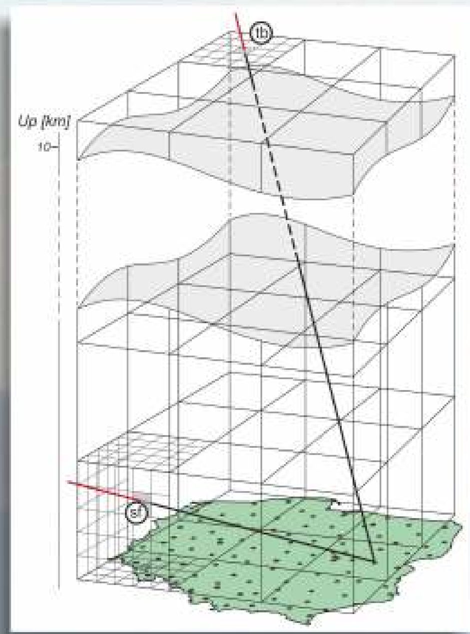
$$IWV = \frac{ZWD}{10^{-6} \cdot R_v}\left(k_2' + \frac{k_3}{T_M}\right)^{-1}$$

where R_v=461.525±0.003 [J kg^{-1} K^{-1}] is the specific gas constant for water vapour, k'_2= 24±11 [K hPa^{-1}], k_3 = 3.75±0.03 [105 K2 hPa^{-1}] are refraction constants and T_M = 70.2±0.72 T_0 is weighted mean water vapour temperature of the atmosphere, T_0 is the surface temperature.

The *ZWD* values are derived from subtraction of *ZHD* (derived from Saastamoinen model) from *ZTD* (estimated using near real time products). The input parameters for *ZHD* calculations are surface meteorological parameters (temperature, pressure) interpolated for ASG-EUPOS stations as described earlier. Therefore it is possible to derive *IWV* for any location inside the GBAS network. There are no assumption about the temperature or air-pressure profiles, since only surface values are used.



GNSS 3D TOMOGRAPHY



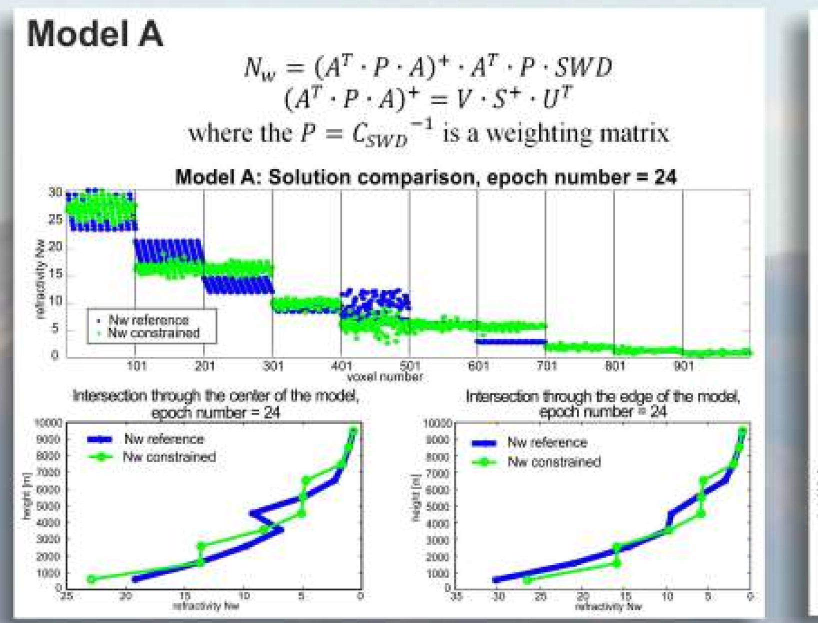
To estimate the 3D distribution of water vapour in the troposphere, tomography method was applied. The input data of GNSS tomography are: the signal Slant Wet Delays *SWD*, which are the results of the GNSS data processing, the meteorological observations from synoptic stations and the Numerical Weather Prediction (*NWP*) models data. The *STD* can be separated like into hydrostatic *SHD* and wet *SWD* components and represented by the well-known relation:

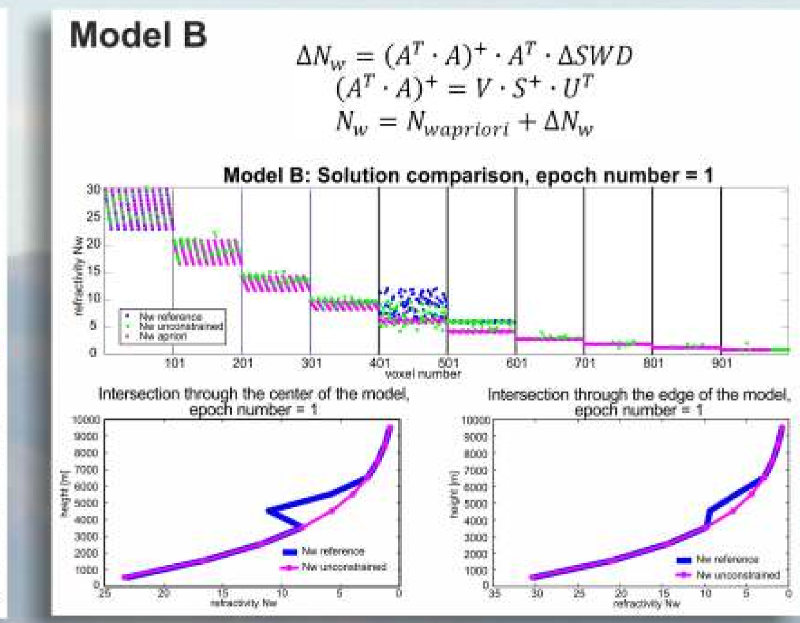
$$STD = SHD + SWD = m_d(\varepsilon)ZHD + m_w(\varepsilon)ZWD$$

where ε is the satellite elevation angle and $m_d(\varepsilon)$ and $m_w(\varepsilon)$ are the mapping functions. In the GNSS tomography *SWD* extracted from above equation is linked with the wet refractivity N_w by the given equation:

$$SWD = A \cdot N_w$$

where *A* is the design matrix.





APPLICATION INTO GNSS PRECISE POINT POSITIONING *(Hadaś T. et. al. Regional troposphere models application into GNSS Precise Point Positioning technique)*

CONCLUSIONS

Two parallel services producing ZTDs are established at Institute of Geodesy and Geoinformatics of Wroclaw University of Environmental and Life Sciences. Both of them requires further improvement. Resultant ZTDs and IWV may be included into weather prediction and monitoring services like E-GVAP. The use of estimated ZTDs in PPP-RTK processing (see poster: Hadaś T. et. al. Regional troposphere models application into GNSS Precise Point Positioning technique) proves their utility in improving positioning accuracy.

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