Tropospheric correction model in support of Precise Point Positioning

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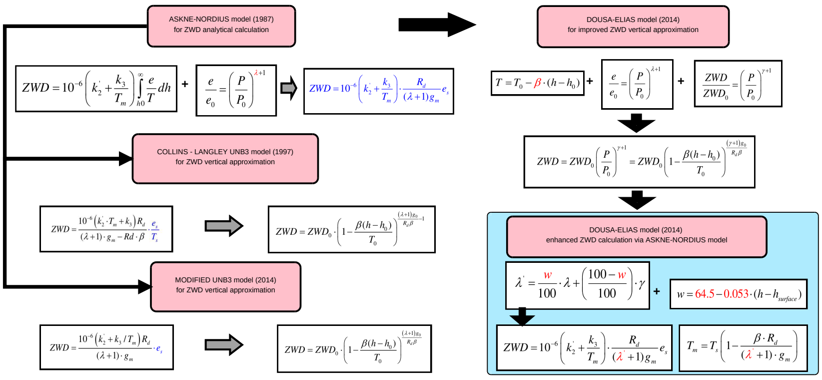
Abstract

New tropospheric correction model was developed at the Geodetic Observatory Pecny (GOP) based on a) numerical weather data field and b) new concept of the zenith wet delay modelling. The model provides parameters for precise calculation of zenith hydrostatic and wet tropospheric delays at the surface and at any altutude up to 10 km. The correction model supports a flexible parametrization including benefit of in situ meteorological observations.

First, we demonstrate the performace of new ZWD approximations and analytical calculation when applying a closed loop with a numerical weather field considered as the reference. Additionally, we compared numerical weather field with respect to results from GNSS final tropospheric product provided by IGS. Finally, we study a potential of the model to support GNSS applications like kinematic Precise Point Positioning.

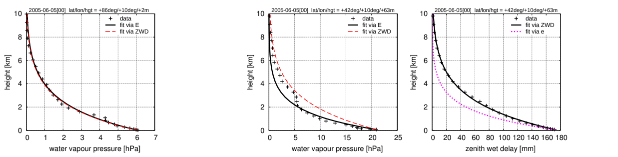
Enhanced Zenith Wet Delay (ZWD) model development based on Askne-Nordius model



Although developed in 1987, the analytical model of Askne and Nordius remains one of the most precise models for calculating ZWD. New strategy based on improved ZWD vertical approximation is described in Dousa and Elias (2014). Here, we provide several remarks only:

- Askne-Nordius model is based on the knowledge of the temperature and its lapse rate (beta) and partial water vapour pressure and its exponential decay parameter (lambda).
- We introduced new ZWD vertical approximation (gamma), which follows the definition of the water vapour decay parameter.
- Both parameters are fitted via full NWP or radiosonde profile using original formula and Levenberg-Marquardt algorithm (1963).
- Optimal combination of both decay parameters was developed for improving the ZWD model of Askne-Nordius (1987).
- Flexibility of the new model includes potential utilization of in situ observed meteorological parameters.

New ZWD vertical approximation

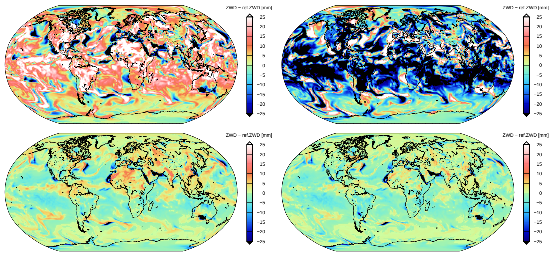


Left figure shows water vapour profile (crosses) and approximation (line). Right figures top right display water vapour and ZWD profiles at other location showing a typical unfolding character of both approximations.

ZWD vertical approximations using: 1+2) original and modified UNB3 model; 3+4) new model as a function of pressure and height.

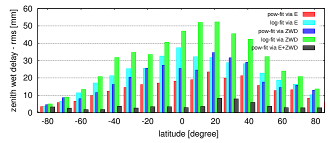
HEIGHT	0-1 km	1-2 km	2-3 km	3-4 km	4-5 km	5-6 km	6-7 km	7-8 km
Original	11.4	20.7	20.2	19.9	15.3	13.2	10.4	7.9
Modified	10.8	19.1	18.6	18.0	13.6	11.4	8.7	6.5
New f(P)	8.2	7.4	5.5	6.5	5.6	5.6	5.0	3.7
New f(H)	8.3	7.4	5.5	6.5	5.7	5.6	5.0	3.7

Improved ZWD calculation (global assessment)

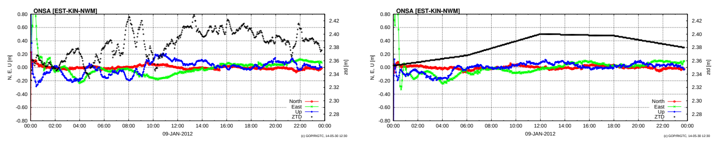


Four figures show global ZWD differences for ZWDs calculated using A-N model with vertical approximations using: a) water vapour pressure decay parameter (lambda), b) ZWD decay parameter (gamma), c) combination of both decay parameters, Tm calculated (A-N), d) combination of both decay parameters, Tm integrated.

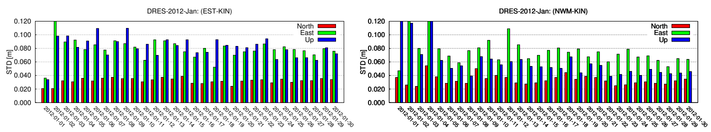
Figure right shows ZWD accuracy in a latitudinal dependence when using various vertical approximation variants for the partial water vapour pressure and ZWD: log-fitting, pow-fitintg and new combined approach.



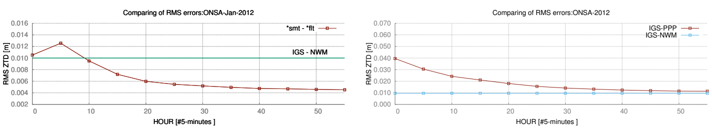
Model application - initial study for positioning



Plots above demonstrate PPP pseudo-kinematic positioning (ONSA) for two scenarios: a) with simultaneously estimated coordinates and tropospheric parameters (left); b) with coordinates estimated after introducing tropospheric parameters from the global ERA Interim model (right). Left figure demonstrates a correlation between height and troposphere which time-to-time significantly weakens the solution.

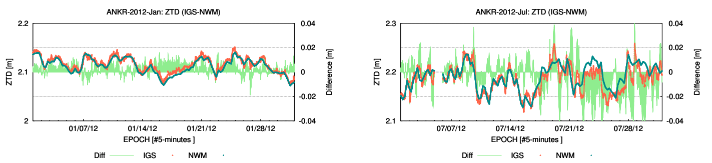


Figures above show monthly coordinate repeatabilities (DRES) demonstrating the better performance for height with tropospheric delays introduced from the external model and when compare to simultaneously estimated ZTDs and coordinates.



Last plots compare ZTD accuracies during the PPP initialization (ONSA) and ZTD accuracies from the ERA Interim model. Note the results are from the winter period; ZTD accuracy of ERA Interim can be double worse.

ERA Interim ZTD assessment



Comparison of ERA Interim global numerical weather data field and IGS final tropospheric products. Plots display ZTDs (and ZTD differences) between IGS final product and ZTDs calculated from the ERA Interim numerical weather data field during two months (seasons): January and July, 2013.

Reference

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3. Dousa J, Elias M (2014) An improved model for calculating tropospheric wet delay, Geophysical Research Letters (accepted on 6 June, 2014)
4. Marquardt, D. (1963) An algorithm for least-squares estimation of nonlinear parameters, J Soc Ind Appl Math, 11(2):431–441

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