GPT2w: A new global blind model for slant tropospheric delays

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Summary

GPT2w ("Global Pressure and Temperature 2 wet") is a blind troposphere delay model providing the mean values plus annual and semi-annual amplitudes of pressure, temperature and its lapse rate, water vapor pressure and its decrease factor λ, weighted mean temperature T_m, as well as hydrostatic and wet mapping function coefficients of the VMF1 (Vienna Mapping Function 1). All climatological parameters have been derived consistently from monthly mean pressure level data of ERA-Interim fields (European Centre for Medium-Range Weather Forecasts Re-Analysis) with a horizontal resolution of one degree, and the model is suitable to calculate slant hydrostatic and wet delays down to three degrees elevation at sites in the vicinity of the Earth surface using the date and approximate station coordinates as input. The wet delay estimation builds upon gridded values of the water vapor pressure, the weighted mean temperature, and the water vapor decrease factor, with the latter being tuned to ray-traced zenith wet delays. Comparisons with zenith delays at 341 globally distributed GNSS (Global Navigation Satellite Systems) stations show that the mean bias over all stations is below 1 mm and the mean standard deviation is about 3.6 cm.

Table 1. Main features of GPT2w

Numerical weather model	Monthly mean profiles from ERA-Interim (37 pressure levels) from 2001 to 2010
Representation	1-degree grid at mean ETOPO5-based heights
Temporal variability	Mean, annual, and semi-annual terms, with fitted phases
Temperature reduction	Mean, annual, and semi-annual terms of temperature lapse rate, with fitted phases
Water vapor reduction	Mean, annual, and semi-annual terms of λ, with fitted phases
Pressure reduction	Exponential approach with scale heights based on grid point-wise virtual temperature values
Output parameters	Pressure, temperature and its lapse rate, water vapor pressure and λ, T_m, hydrostatic and wet mapping function coefficients

Download:
http://ggosatm.hg.tuwien.ac.at/Delay/Source/GPT2w

References:

J. Böhm, et al. (2014) Development of an improved model for slant delays in the troposphere (GPT2w), submitted to GPS Solutions

E. Krueger, et al. (2004) Galileo tropospheric correction approaches developed within GSTB-V1, Proceedings of the ENC-GNSS 2004, Rotterdam, The Netherlands

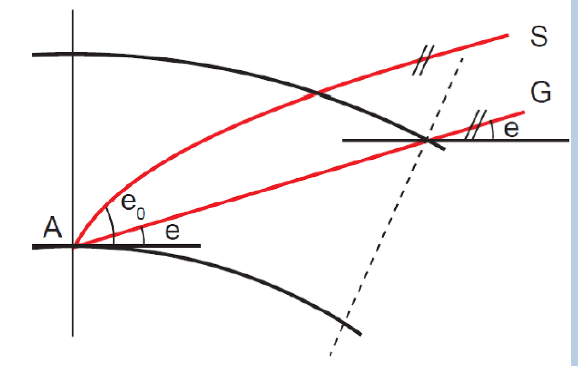
K. Lagler, et al. (2013) GPT2: Empirical slant delay model for radio space geodetic techniques, Geophys. Res. Lett. Vol. 40(6):1069-1073

RTCA-MOPS (1999) Minimum operational standards for global positioning system/wide area augmentation system airborne equipment, RTCA/DO-229 B. RTCA, Washington, U.S.A.

GPT2w features

$$\Delta L(e) = \overbrace{\Delta L_h^z \cdot mf_h(e)}^{\text{Hydrostatic part}} + \overbrace{\Delta L_w^z \cdot mf_w(e)}^{\text{Wet part}}$$

Zenith delay · mapping function



$$\Delta L_w^z = 10^{-6}\left(k_2' + \frac{k_3}{\boxed{T_m}}\right)\frac{R_d e_s}{(\boxed{\lambda}+1)g_m}$$

$\boxed{\lambda}$ ... water vapor pressure decrease factor

$$\boxed{T_m} = \frac{\int_H^\infty e/T\,\mathrm{d}z}{\int_H^\infty e/T^2\,\mathrm{d}z}$$ ... mean temperature of water vapor

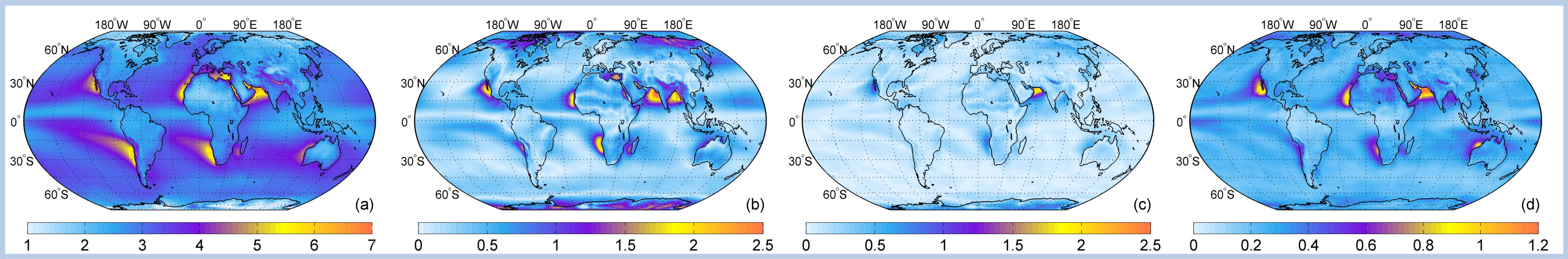


*Figure 1. Mean values (a), annual amplitudes (b), semi-annual amplitudes (c), and standard deviation of the residuals of the least-squares adjustment (d) of the **water vapor decrease factor λ**. Note the difference in color scale.*

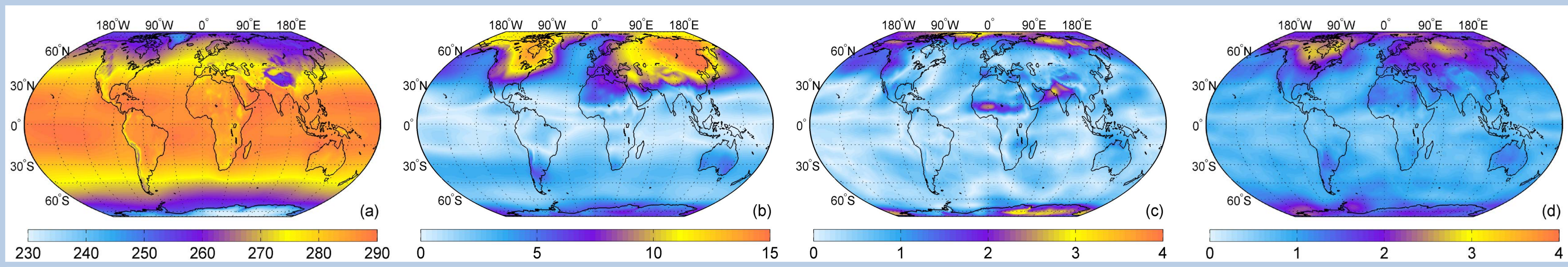


*Figure 2. Mean values (a), annual amplitudes (b), semi-annual amplitudes (c), and standard deviation of the residuals of the least-squares adjustment (d) of the **weighted mean temperature T_m** in Kelvin. Note the difference in color scale.*

Comparison with zenith delays from IGS (341 stations for the year 2012)

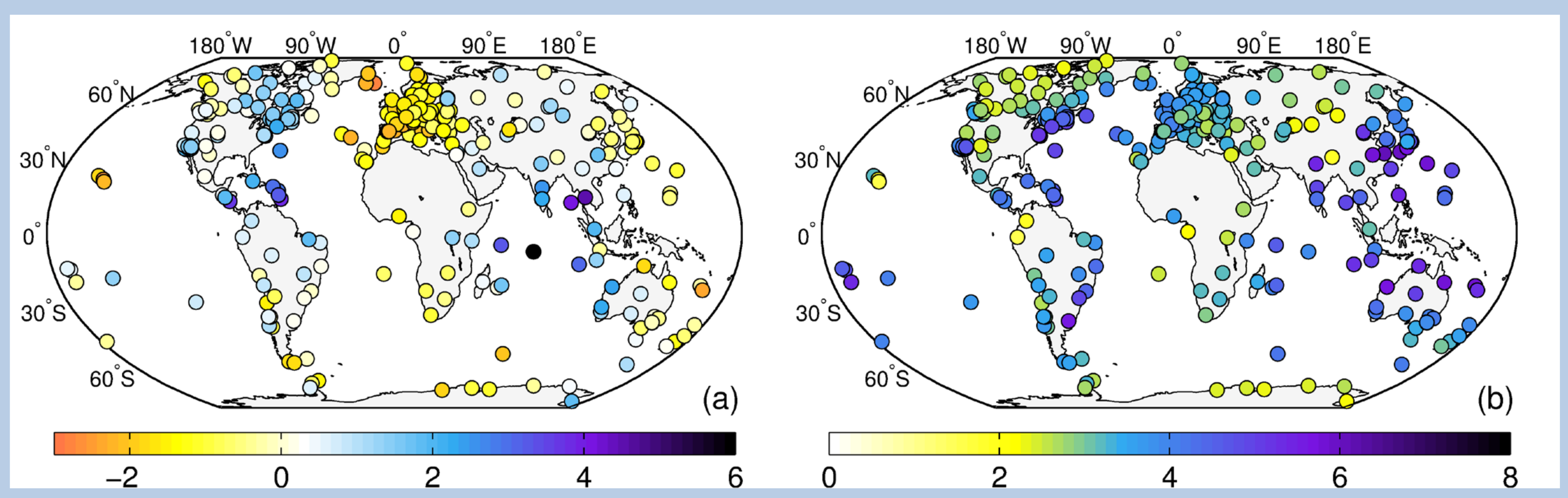


Figure 3. Biases (a) and standard deviations (b) between the zenith total delays provided by IGS and GPT2w in cm for 341 GNSS sites analyzed during 2012

Table 2. Global statistics of the differences between zenith total delays provided by IGS and four models calculated as mean values over 341 sites for the year 2012: RTCA-MOPS, ESA blind model, GPT2 (using the approximate equation by Saastamoinen (1972) for the zenith wet delay), and GPT2w

	mean bias	mean standard deviation
RTCA-MOPS (1999)	-2.50 cm	4.55 cm
ESA (Krueger et al. 2004)	0.83 cm	3.82 cm
GPT2 (Lagler et al. 2013)	-0.28 cm	3.79 cm
GPT2w (Böhm et al. 2014)	-0.02 cm	3.61 cm

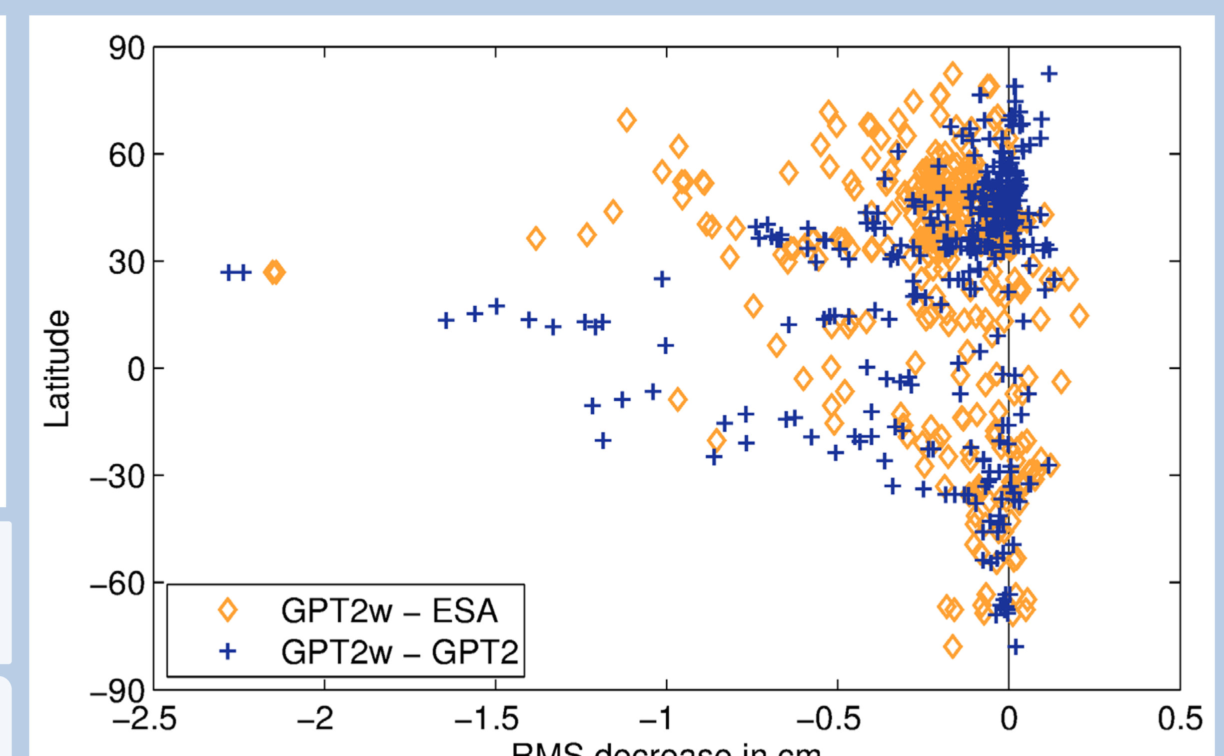


Figure 4. Station-wise differences in standard deviations with respect to IGS zenith total delays during 2012 as a function of latitude. Residuals are shown for two model combinations "GPT2w minus ESA" (orange diamonds) and "GPT2w minus GPT2" (dark blue crosses). Hence markers with negative values indicate stations where GPT2w supplies more realistic blind predictions.

Outlook

GPT2w contains values of the weighted mean temperature. This is an important quantity for the determination of the integrated water vapor as required in GNSS meteorology. Detailed studies on that application still have to be carried out. Another future application of GPT2w is the combination with local meteorological observations at the site. It will be investigated whether e.g. a local measurement of water vapor pressure can be connected to climatological values of weighted mean temperature and the water vapor decrease factor.

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