



Tour de l'IGS

GNSS Processing based on IGS Products -Troposphere Modelling

Johannes Böhm February 17, 2022



TU Wien Department of Geodesy and Geoinformation Research Division Higher Geodesy



- "Troposphere delays"
 - strictly speaking delays in neutral atmosphere up to 100 km
 - Refractivity as function of pressure, temperature and humidity

 $N = (n-1) \cdot 10^6$

 Separation into hydrostatic and non-hydrostatic ("wet") refractivity





Wikipedia

Definition of tropospheric delay

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• Electric path length L is minimized

$$L = \int_{S} n(s) \, \mathrm{d}s$$



• Tropospheric delays:
$$\Delta L = L - G = \int_S n(s) ds - G = \Delta L_h + \Delta L_w + S - G$$

• Bending effect S – G about 2 dm at 5 degrees elevation (part of hydrostatic mf)





• Refractivity from radiosonde data



• Equation by Saastamoinen (1972)

$$\Delta L_h^z = 0.0022768 \frac{p_0}{f(\theta, h_0)} \approx 2.3 \text{ m (8 nsec) at sea level}$$

- We need the pressure at the site to determine the hydrostatic zenith delay very accurately
 - local recordings at the site (preferable if available)
 - gridded values from numerical weather models
 - empirical (blind) models like GPT2 etc
 - Caveat: do not use atmosphere loading corrections!

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 $\Delta L(e) = \Delta L_h^z \cdot m f_h(e) + \Delta L_w^z \cdot m f_w(e)$

• Zenith wet delays estimated every 20 to 60 minutes

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- Correlation between height, clocks and zenith delays
- Partials are sin(e), 1, and mf(e)
 - Mapping function mf(e) not perfectly known, in particular at low elevations
 - Low elevations necessary to de-correlate heights, clocks, and zenith delays
- Errors via correlations also in station heights (and clocks)
- Trade-off \rightarrow about 5 degrees cut off elevation angle
 - sometimes with down-weighting

• The station height error is about 1/5 of the delay error at 5 degrees elevation

• The decrease of the zenith delay is about half of the station height increase

• Continued fraction form (Herring, 1992)

- Example Vienna Mapping Functions
 - Empirical functions for b and c coefficients
 - Coefficients 'a' by ray-tracing and inversion using 6h data of the ECMWF
 - Available for all IGS sites and on global grid

• Global Mapping Functions GMF (GPT2, ..) is an averaged VMF

VMF1 versus GMF at Fortaleza (Brazil) at 5 deg. elevation

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• Describe asymmetric delays

$$\Delta L(a, e) = \Delta L_0(e) + mf_g(e)(G_n \cos(a) + G_e \sin(a))$$

- Typical gradient: 1 mm (corresponds to 10 cm at 5 deg. elevation)
- Estimated, e.g., every 3 hours
- Caused by weather fronts, coastal situations, atmospheric bulge, ..

- In regional or local network solutions the troposphere parameters may get correlated to the satellite clock parameters and cannot be solved in an absolute sense.
 - In such a case, you may estimate troposphere parameters for all but one station.
 - Alternatively, you may introduce troposphere estimates from an external (preferable global) solution.

- In local network solutions, even a 100% correlation of the troposphere between the stations may occure.
 - If all receivers are located at the same station height, you don't need to estimated any troposphere parameters.
 - If there are significant height differences between the stations, a troposphere bias should be estimated.

Questions?

• Do not hesitate to contact Johannes.Boehm@tuwien.ac.at

- http://vmf.geo.tuwien.ac.at/
- Vienna Mapping Functions coefficients (from analysis and forecast data)
 - including zenith hydrostatic (and wet) zenith delay
- Empirical mapping functions, e.g. GPT3

- <u>ftp://ftp.gfz-potsdam.de/pub/GNSS/products/gfz-vmf1</u>
- Potsdam Mapping Factors @ GFZ Data Server
- UNB-VMF1

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