An Analysis of High-Accuracy Tropospheric Delay Mapping Functions

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- Background
- Mapping Functions
- Assessment of Results
- Conclusions

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Neutral Atmosphere

- Non-dispersive medium at radio frequencies
- Effects:
  - Propagation delay
  - Ray bending
- Troposphere accounts for most of the delay (hence the denomination ‘tropospheric delay’).

- Major modeling error for radiometric techniques, which affects the height component of position.
- Sea-level rise monitoring, postglacial rebound, earthquake hazard mitigation require mm-level accuracy.
Tropospheric Delay

\[ d_{\text{trop}} = d_h^Z \cdot m_h(\varepsilon) + d_w^Z \cdot m_w(\varepsilon) \]

Hydrostatic Zenith Delay

Hydrostatic Mapping Function

Wet Zenith Delay

Wet Mapping Function
Mapping Functions

- **CfA-2.2** (Harvard-Smithsonian Center for Astrophysics)

- **Ifadis** (Chalmers University of Technology)

- **Lanyi** (Jet Propulsion Laboratory)

- **MTT** (Massachusetts Institute of Technology)

- **NMF** (MIT Haystack Observatory)
# Mapping Function Parameterization

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†hydrostatic component only
Tropopause Height and Lapse Rate Prediction (UNB models)

UNB98TH1

\[ H_t (\text{km}) = 7.508 + 2.421 \exp\( \frac{t_s}{22.90} \) \]

UNB98LR1

\[ \alpha (\degree \text{C}/\text{km}) = 5.930 + 0.0359 \ t_s \]

\[ t_s = \text{surface temperature} \ (\degree \text{C}) \]
Locations of the Radiosonde Stations
Assessment Results ($\varepsilon = 10^\circ$)
Assessment Results ($\varepsilon = 6^\circ$)

CfA  | Ifadts | Lanyi | MIT  | NMF
---   | ---    | ---   | ---  | ---
-0.06 | -0.03  | 0.00  | 0.03  | 0.06
Results for Fairbanks ($\epsilon = 10^\circ$)

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CfA
Ifadis
Lanyi
MTT
NMF
Results for Albany (ε = 10°)
Results for Key West ($\varepsilon = 10^\circ$)
Results for Albany (ε = 6°)
Statistics ($\varepsilon = 6^\circ$)
Ranking by r.m.s. Scatter

![Chart showing ranking by r.m.s. scatter with categories CfA-2.2, Ifadis, Lanyi, MTT, and NMF. The chart includes bars for angles 15°, 10°, and 6°.](chart.png)
Conclusions - I

- Ifadis has best overall performance at low elevation angles.
- NMF provides similar or better accuracy than mapping functions using meteorological data.
- Lack of a ‘true’ CfA wet mapping function limits CfA in high-accuracy applications.
- Use of UNB models yields simple and reliable solution for tropopause height and lapse rate determination.
Mean temperature profile parameters give good performances for Lanyi, by improving the r.m.s. scatter.

Lanyi provides the best tuning capability.

No mapping function has absolute supremacy at all elevation angles and at all latitudes.

NMF is the best choice if meteorological data is unavailable or unreliable.