An Analysis of High-Accuracy Tropospheric Delay Mapping Functions

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- Background
- Mapping Functions
- Assessment of Results
- Conclusions

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Motivation

- 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

$$d_{trop} = d_h^z \cdot m_h(\varepsilon) + d_w^z \cdot m_w(\varepsilon)$$

Hydrostatic Zenith Delay

Hydrostatic Mapping Function

Wet Zenith Delay

Wet Mapping Function

Mapping Functions

- **CfA-2.2** (Harvard-Smithsonian Center for Astrophysics)
  - Davis et al. (1985). *Radio Science*, Vol. 20, No. 6, pp. 1593-1607.
- **Ifadis** (Chalmers University of Technology)
  - Ifadis (1986). Tech. Rep. 38, Chalmers University of Technology.
- **Lanyi** (Jet Propulsion Laboratory)
  - Lanyi (1984). TAD Progress Rep. 42-78, JPL, pp. 152-159.
  - Sovers and Jacobs (1996). JPL Publication 83-39.
- **MTT** (Massachusetts Institute of Technology)
  - Herring (1992). Proc. Symp. Refraction of Transatmospheric Signals in Geodesy, Netherlands Geodetic Commission, pp. 157-164.
- **NMF** (MIT Haystack Observatory)
  - Niell (1996). *Journal of Geophysical Research*, Vol. 101, pp. 3227-3246.

Mapping Function Parameterization

	P	T	e	α	H_t	H	φ	H_i	doy
CfA	✓	✓	✓	✓	✓				
IF	✓	✓	✓						
LA	✓	✓		✓	✓			✓	
MTT		✓				✓	✓		
NMF						✓†	✓		✓†

†hydrostatic component only

Tropopause Height and Lapse Rate Prediction (UNB models)

UNB98TH1

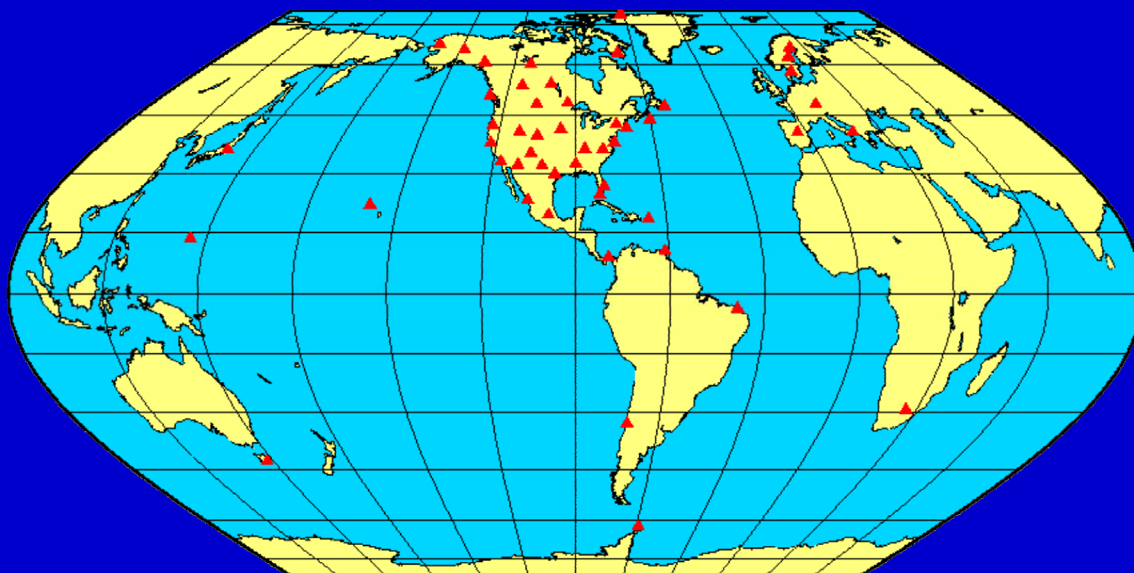
$$H_t\,(\mathrm{km}) = 7.508 + 2.421\,\exp\left(\frac{t_s}{22.90}\right)$$

UNB98LR1

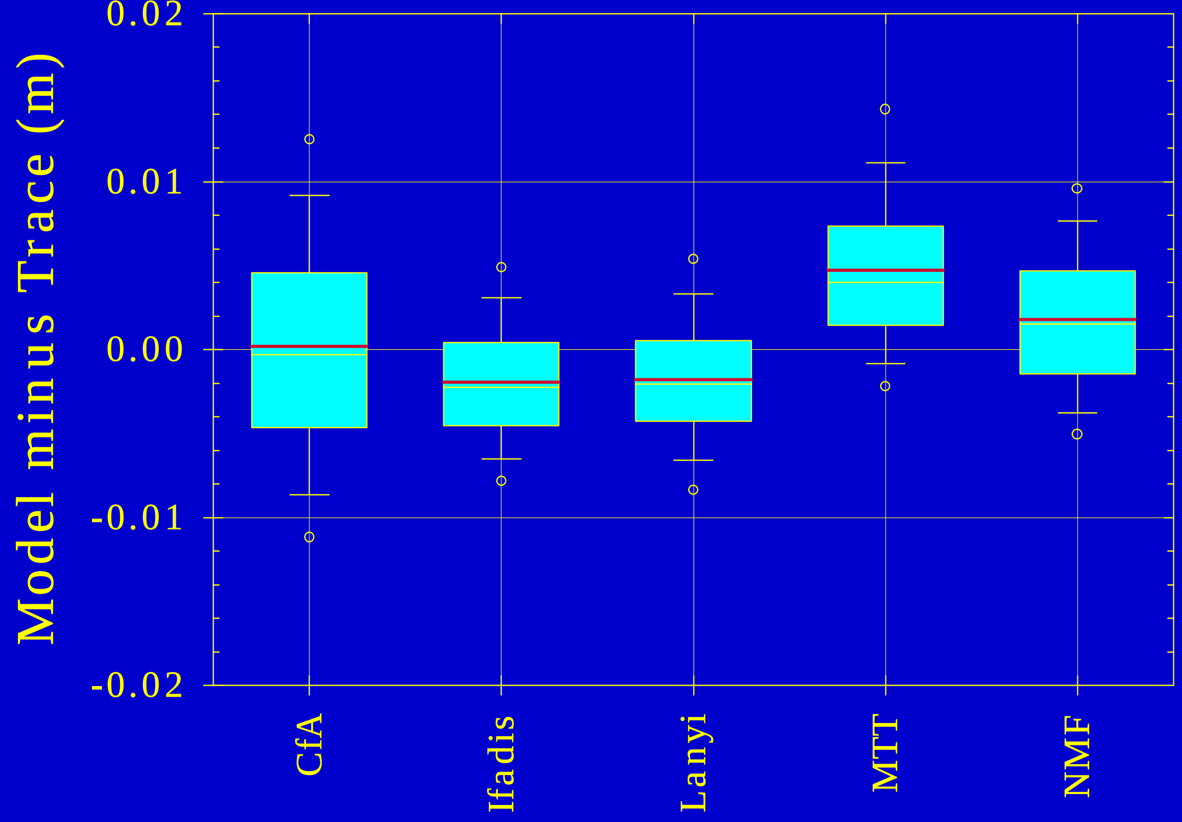
$$\alpha(°\mathrm{C}/\mathrm{km}) = 5.930 + 0.0359\,t_s$$

t_s = surface temperature (°C)

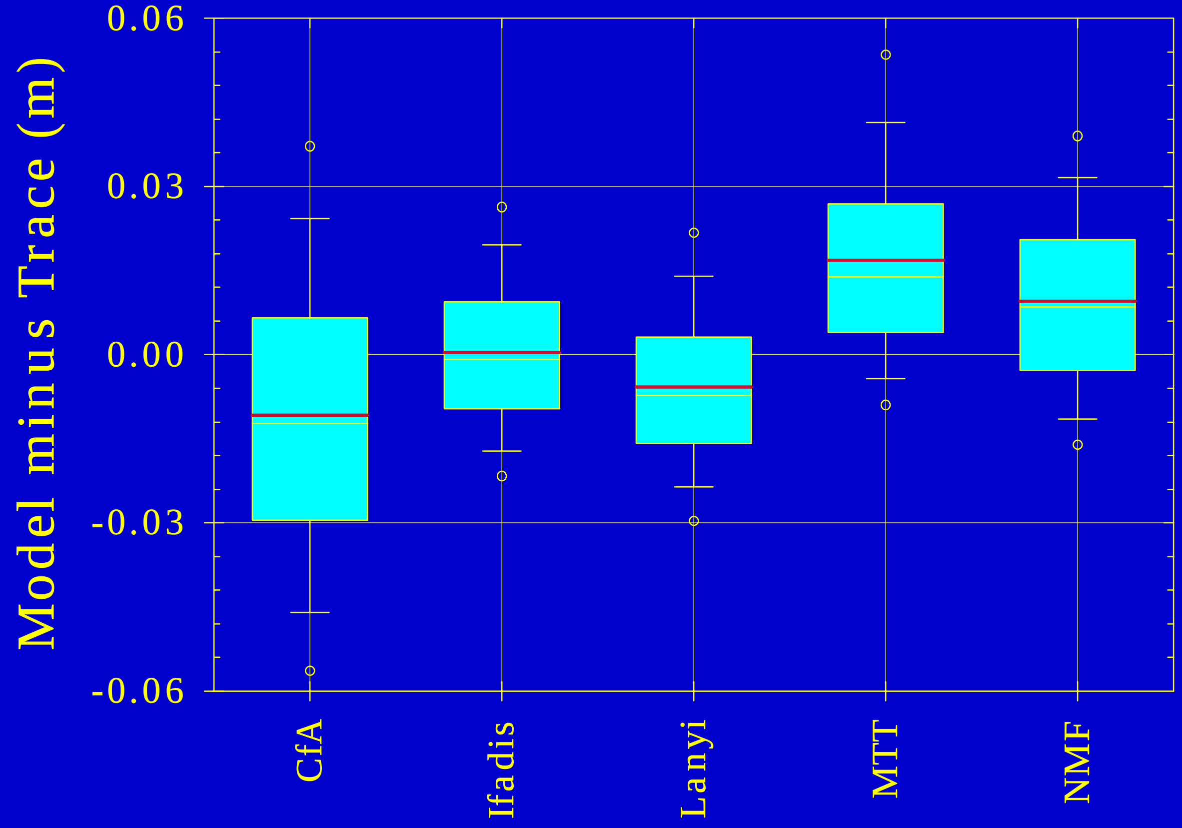
Locations of the Radiosonde Stations



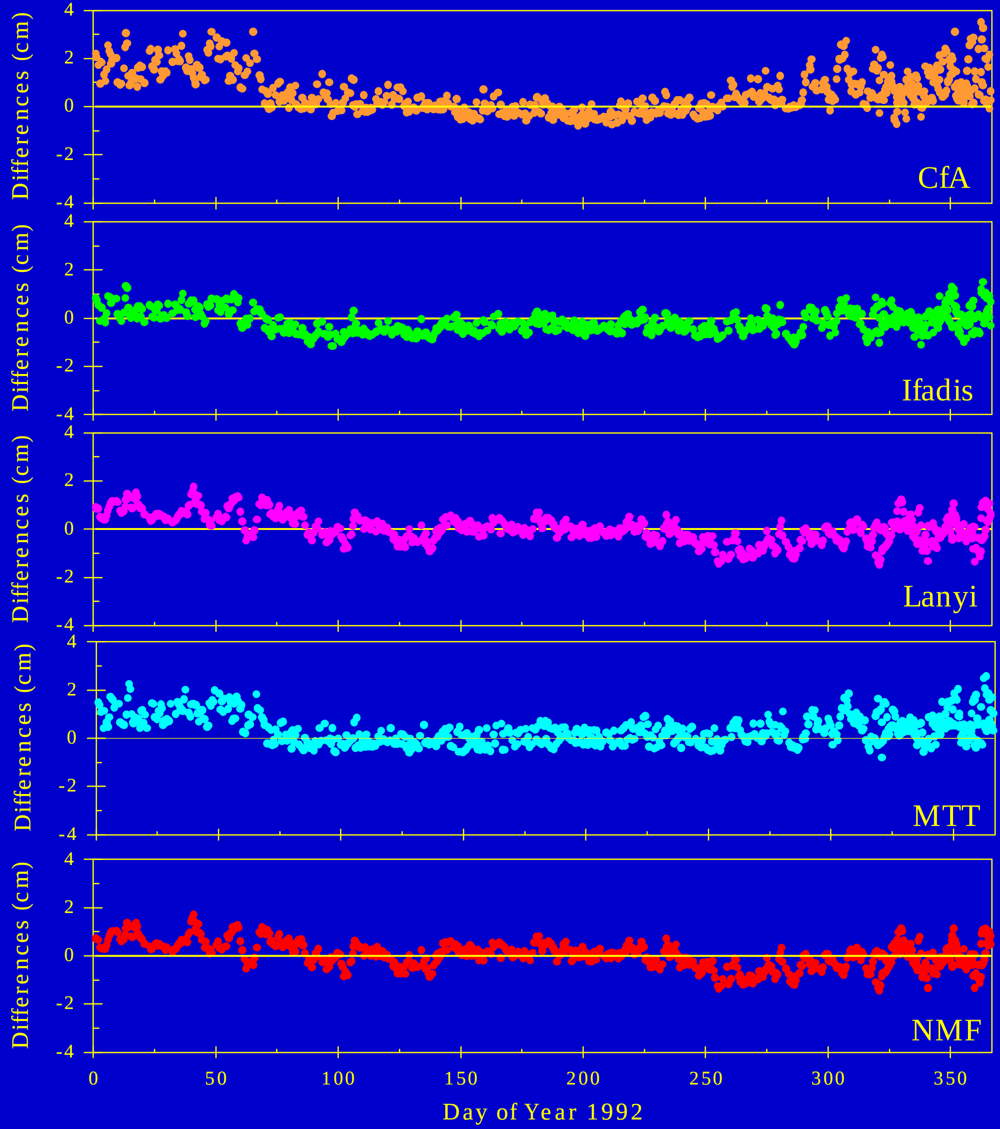
Assessment Results (ε = 10°)



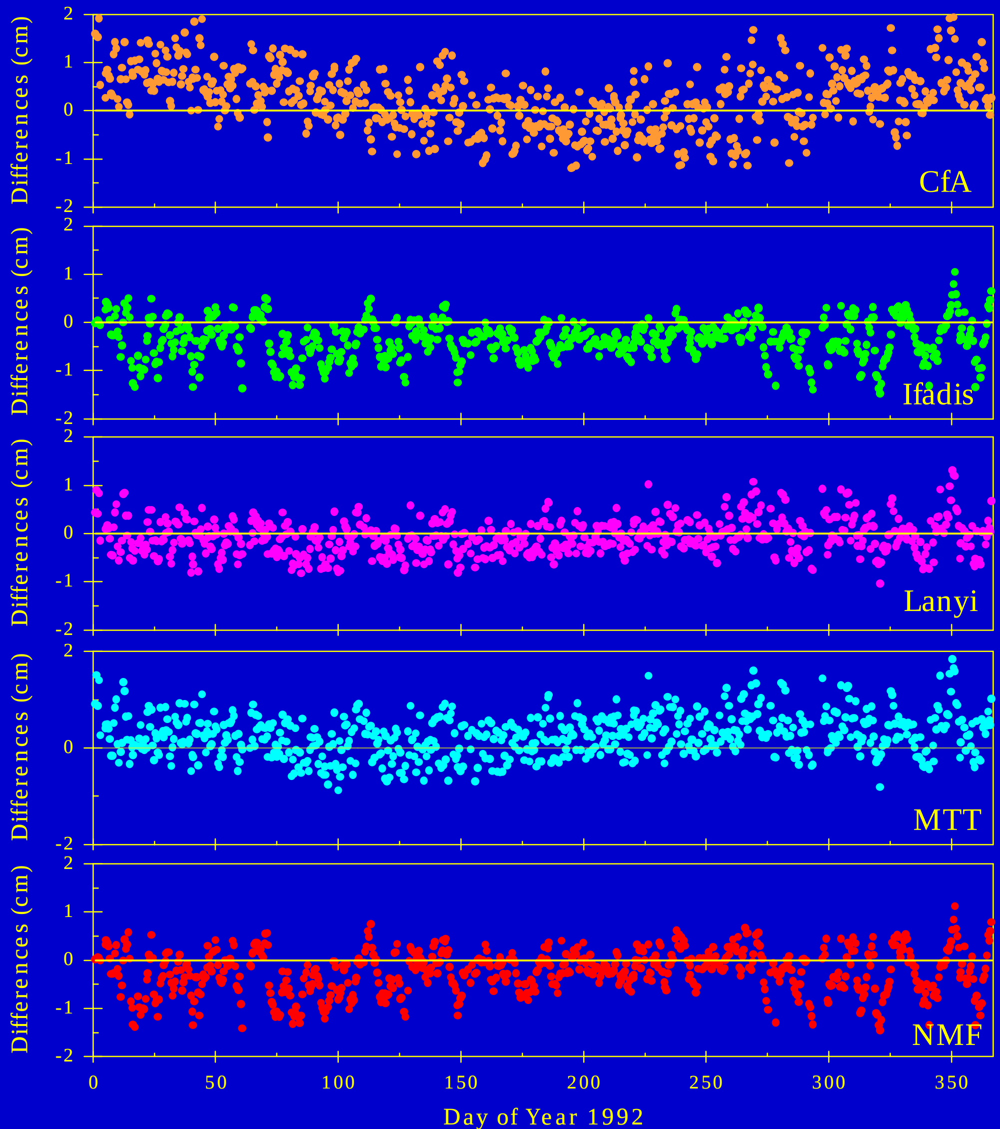
Assessment Results (ε =6°)



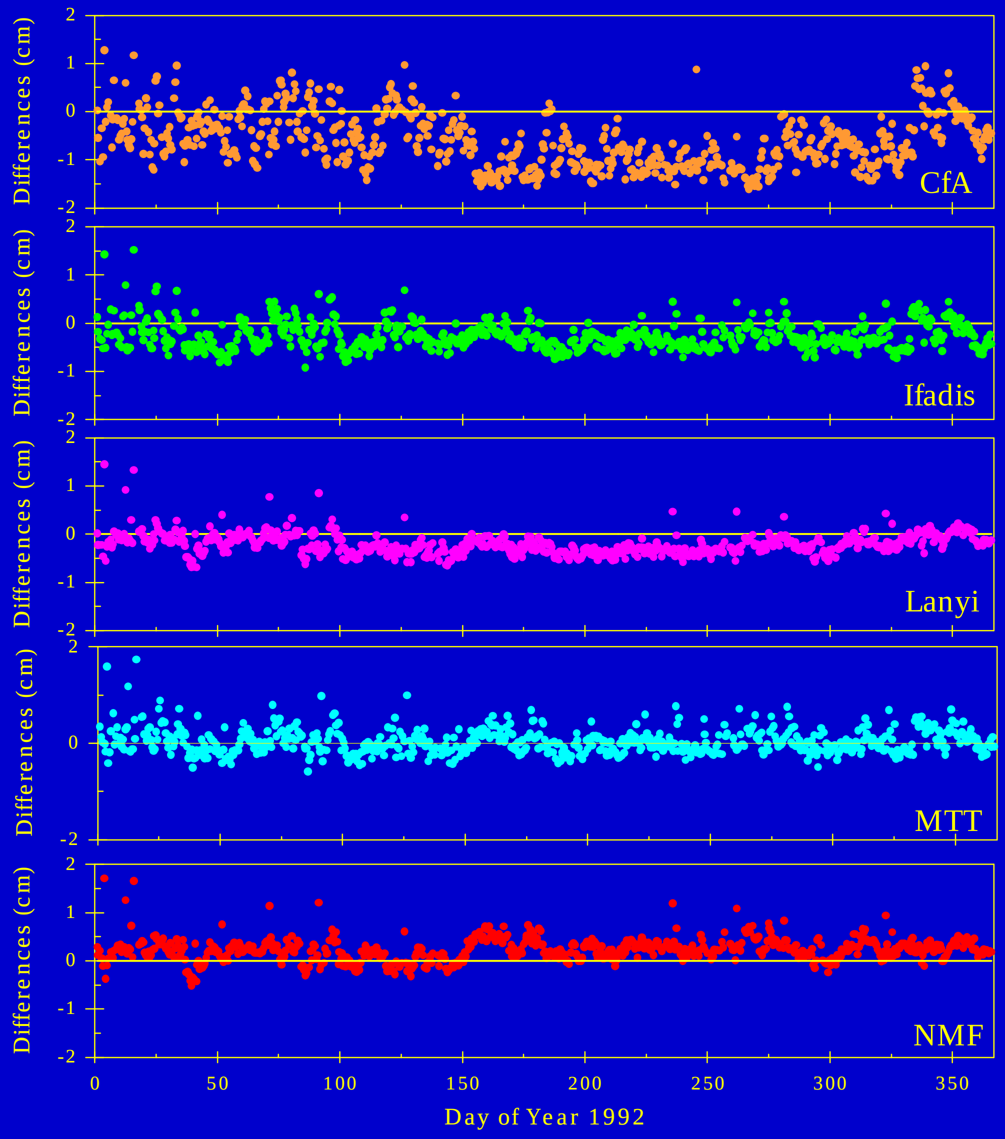
Results for Fairbanks (ε = 10°)



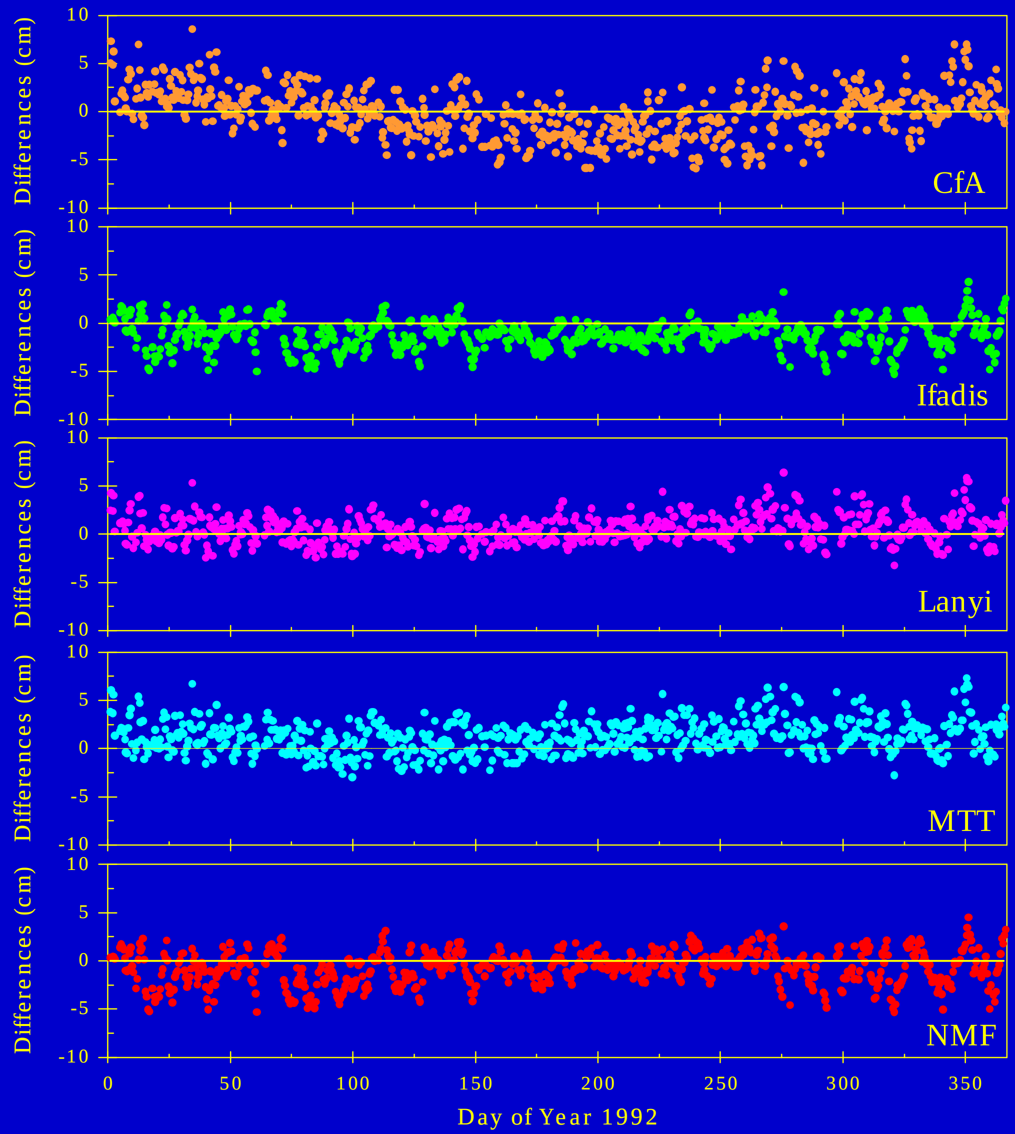
Results for Albany (ε = 10°)



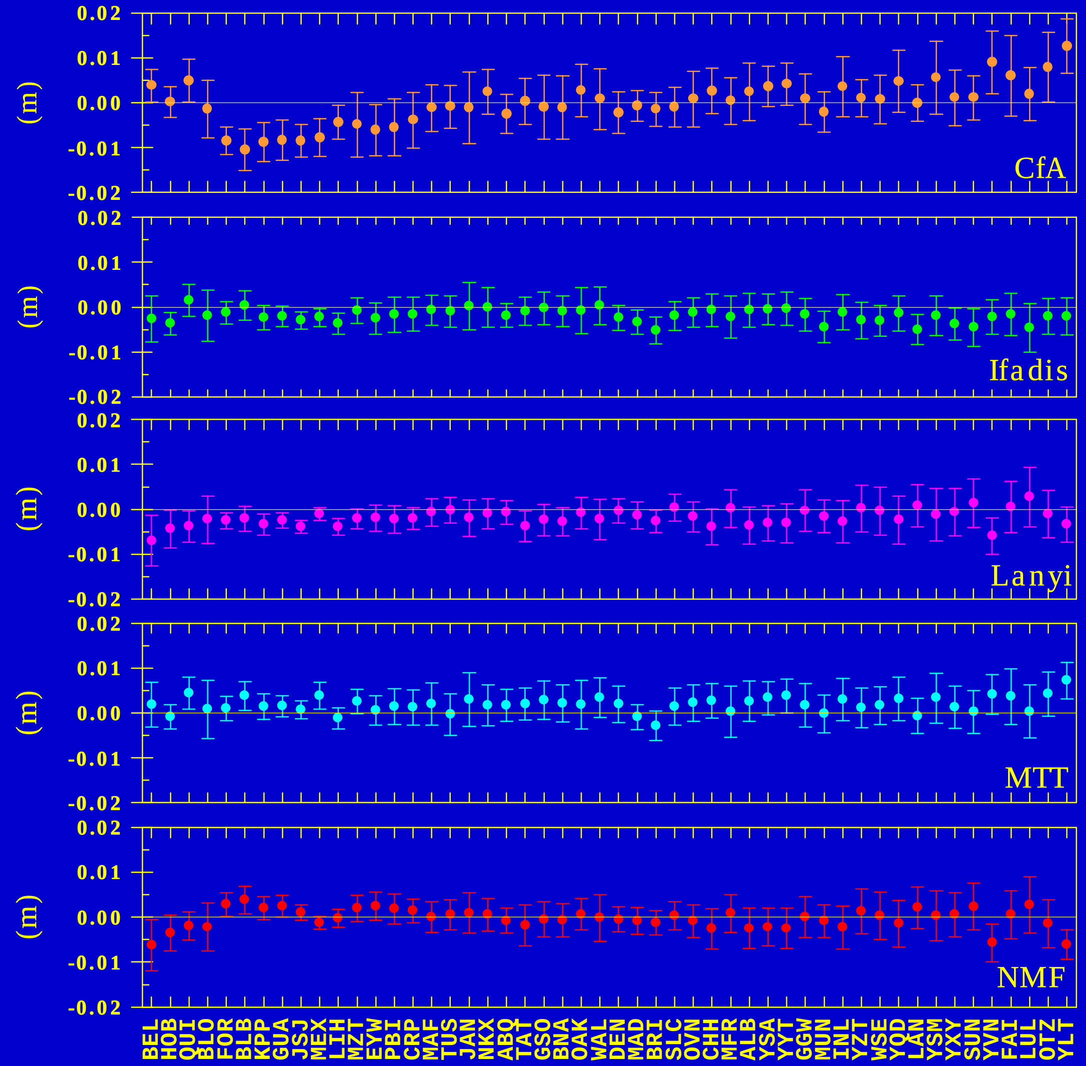
Results for Key West (ε = 10°)



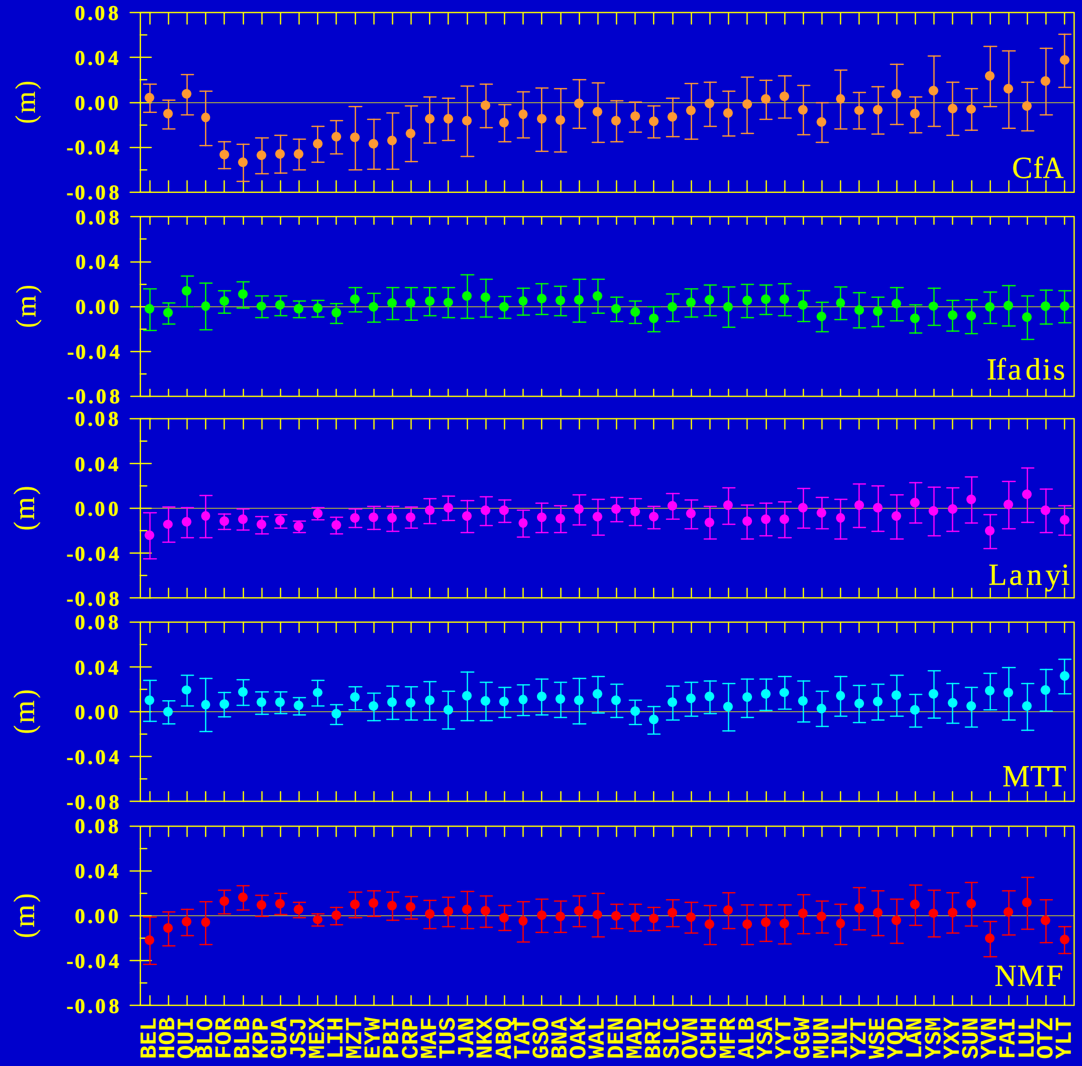
Results for Albany (ε = 6°)



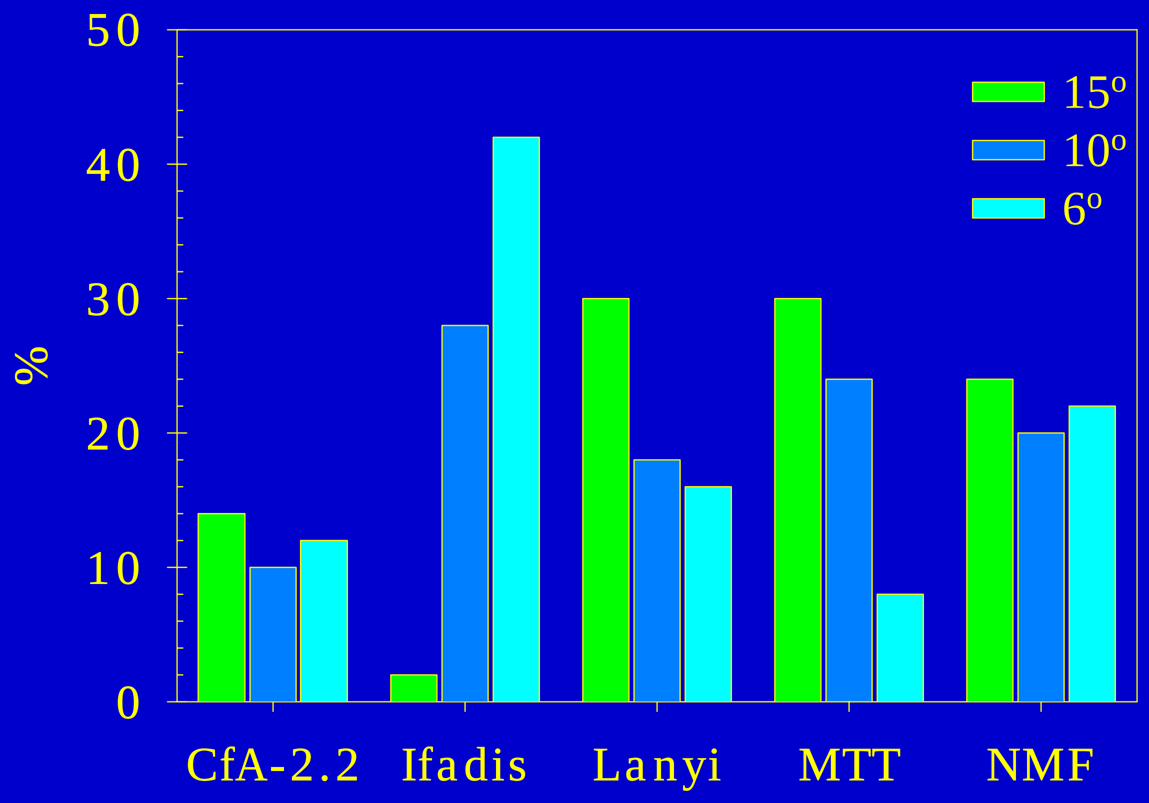
Statistics (ε = 10°)



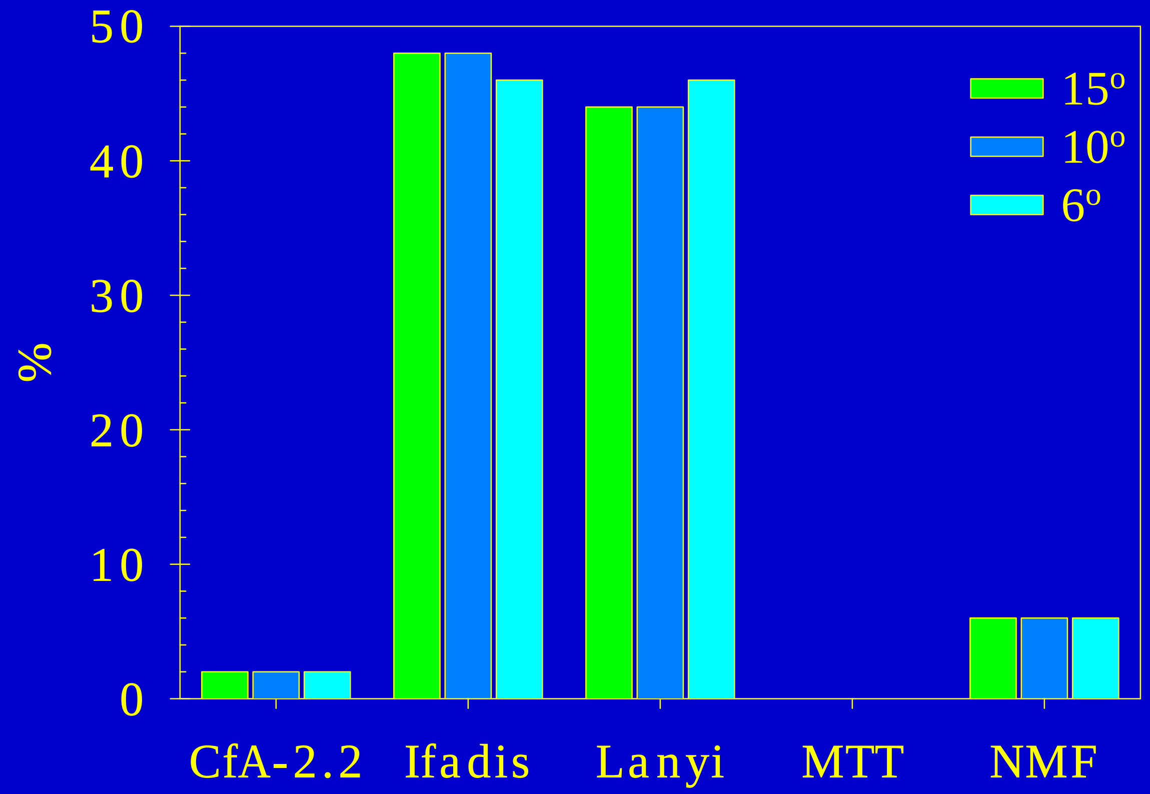
Statistics (ε = 6°)



Ranking by Bias



Ranking by r.m.s. Scatter



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.

Conclusions - II

- 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.