Assessment of single-frequency observations in GNSS Tropospheric Tomography

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Content

Motivation

GNSS tomography is one of the most valuable tools to reconstruct the Spatio-temporal structure of the troposphere.

but

Locating dual-frequency receivers with a sufficient spatial resolution for GNSS tomography of a few tens of kilometers is not economically feasible.

Possible alternative approach

feasibility of single-frequency data in GNSS tomography???

Tropospheric Tomography

Design Matrix + SWD = Wet Refractivity

$$\mathbf{SWD} = \mathbf{A}\mathbf{N}_w$$

$$\mathbf{A} = \begin{bmatrix} d_{11} & d_{12} & d_{13} & d_{14} & \dots & d_{1m} \\ d_{21} & d_{22} & d_{23} & d_{24} & \dots & d_{2m} \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ d_{n1} & d_{n2} & d_{n3} & d_{n4} & \dots & d_{nm} \end{bmatrix}$$

$$SWD = (ZTD - ZHD).mf(elv) + mf_g(elv).\left[G_{NS}.\cos(\alpha) + G_{EW}.\sin(\alpha)\right]$$

Zero Difference Processing (goGps)

dual Difference Processing (Bernese Software)

Single Frequency Method

Single-frequency Observations (L1)

SEID (Satellite specific Epoch differenced Ionospheric Delay algorithm) Algorithm

Generate a synthetic set of L2 observation with reference stations

Establishment of ionosphere-free linear combination

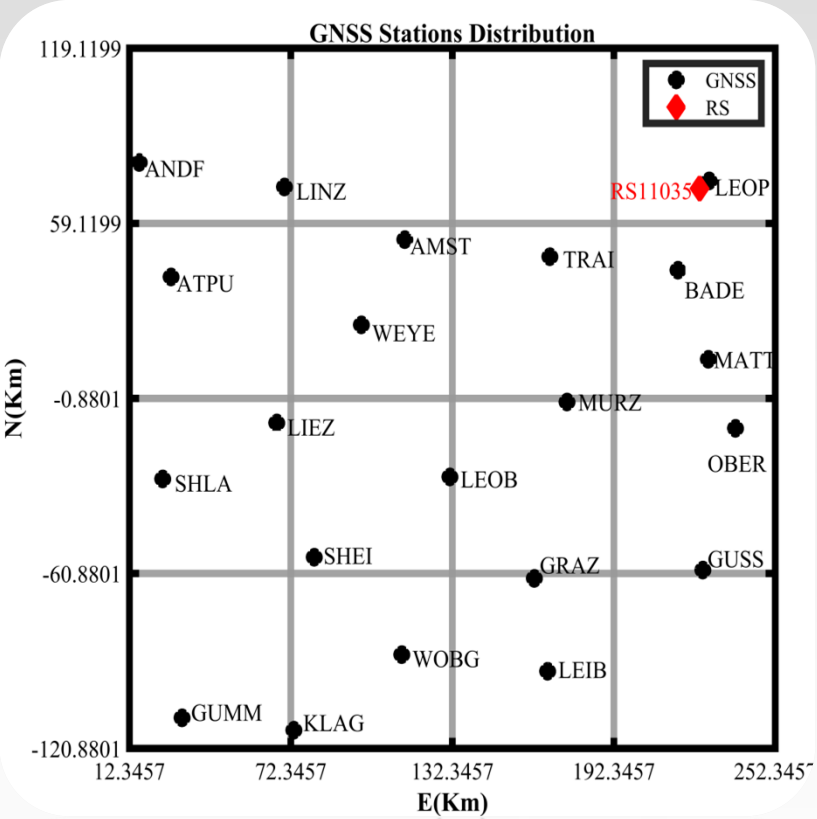
PPP Method

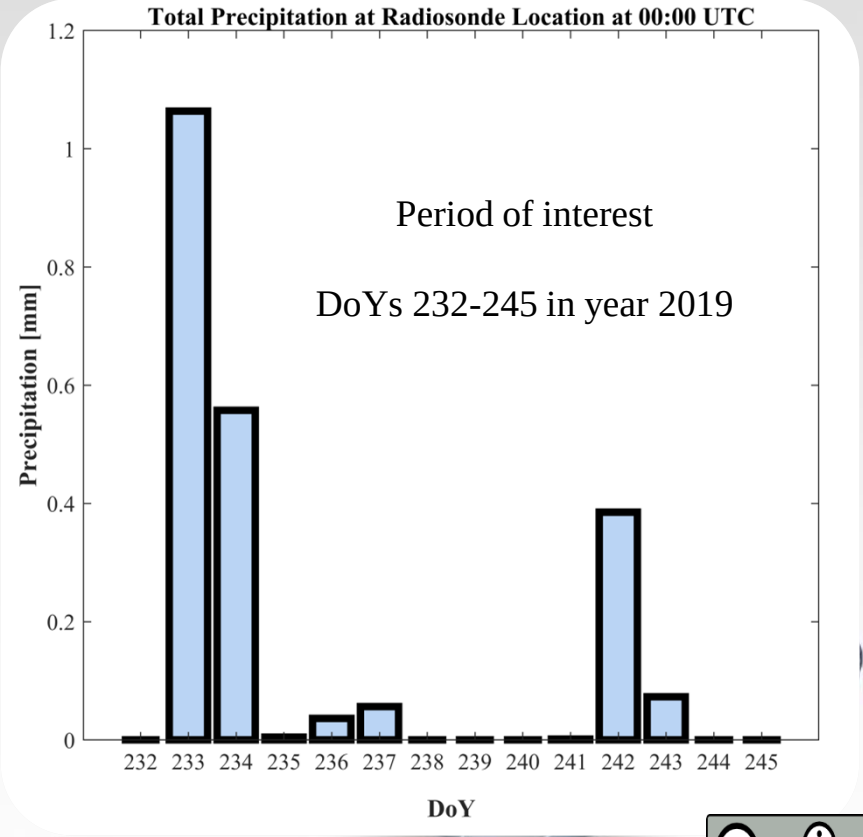
goGPS Software was used for this purpose.

Case Study and Time of Interest

The region used in this study covers the area of the EPOSA (Echtzeit Positionierung Austria) GNSS network with 21 multi GNSS stations, which are mostly located in the eastern part of Austria:

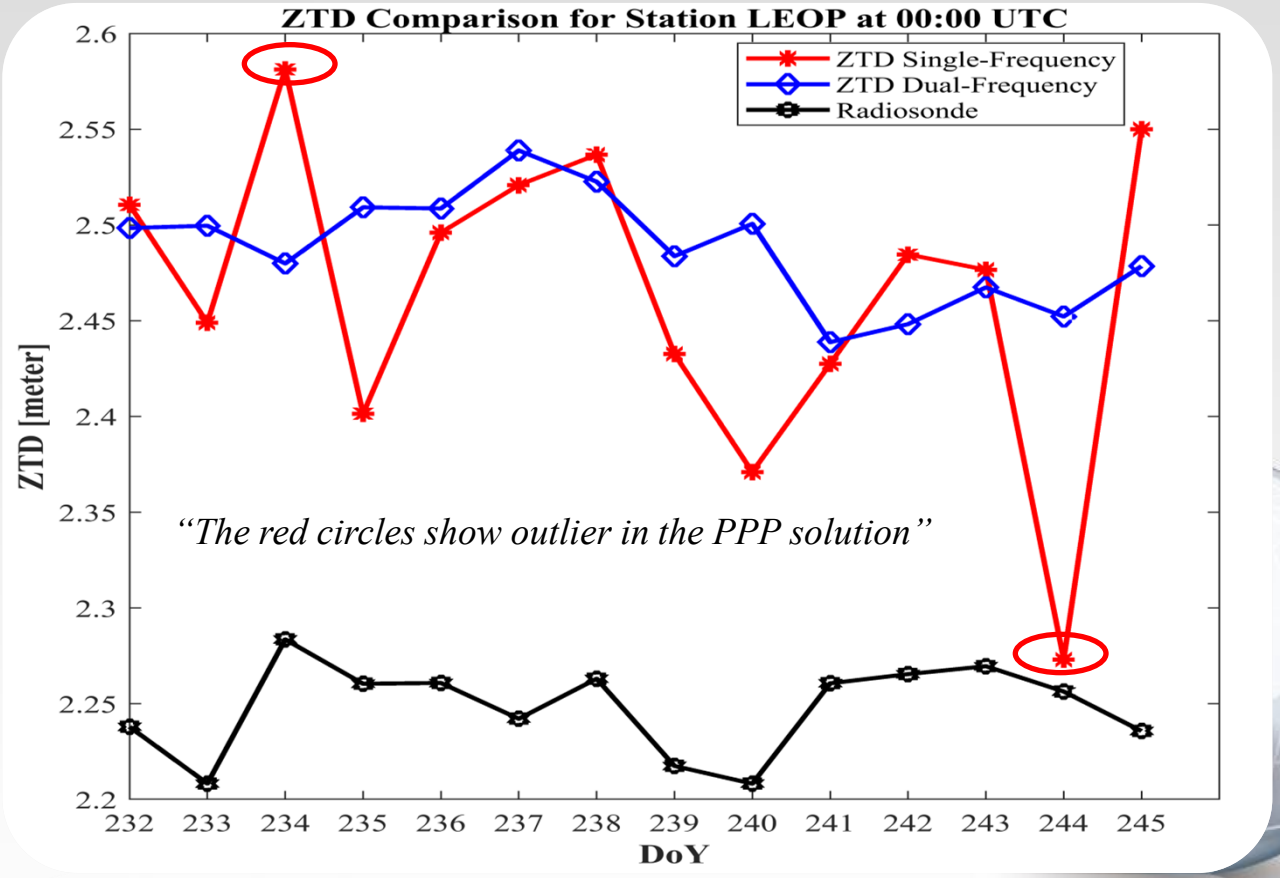
- The mean inter-station distance of about 60 km
- The height of the GNSS stations varies from 220 meters to 860 meters



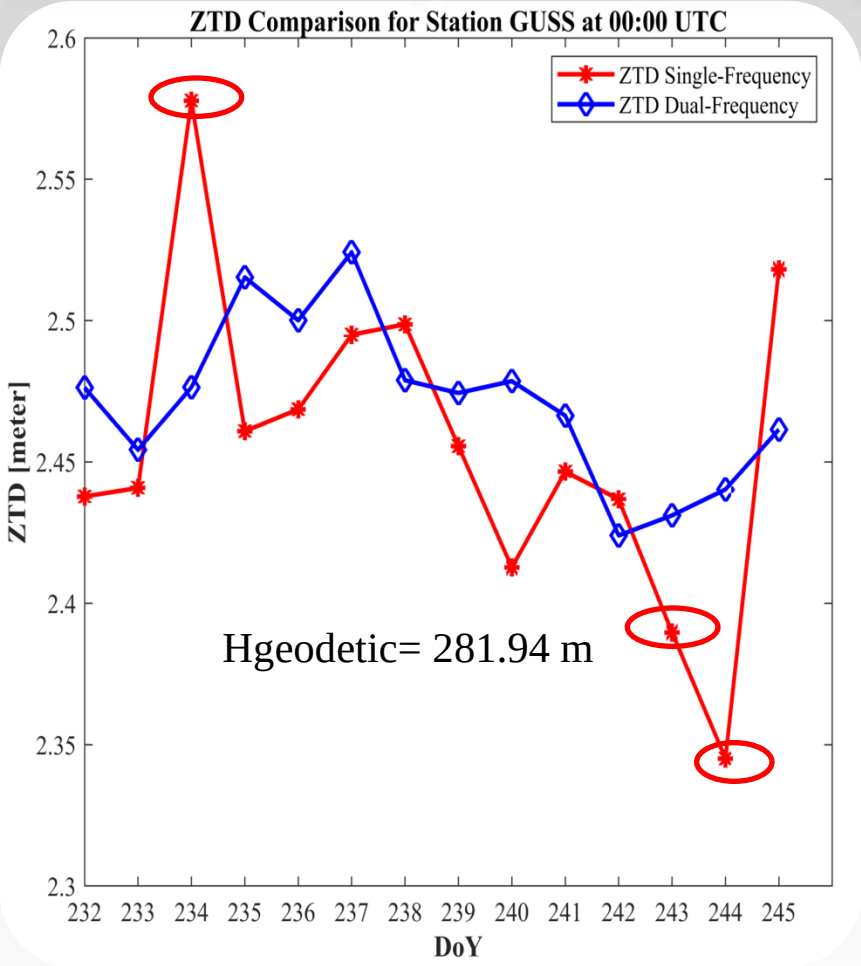


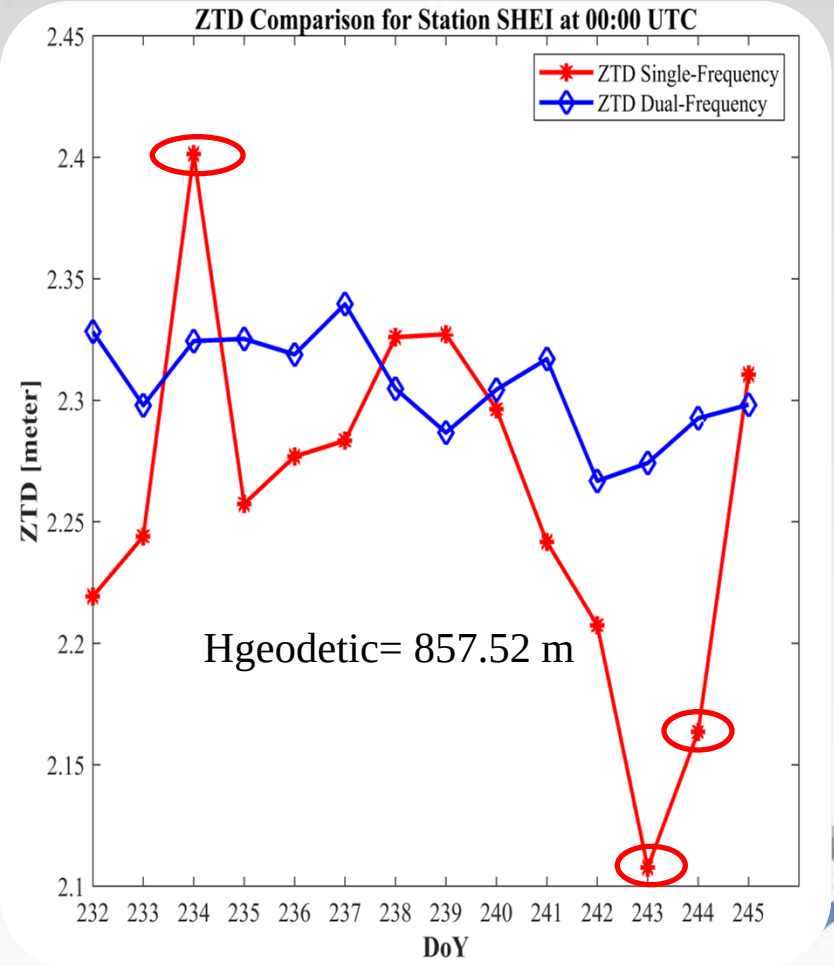
ZTD Comparison

As shown in the figure below, the inconsistency between ZTDs calculated in the PPP (based on SF data + SEID) and the dual-frequency approach is at the few cm-level. The accuracy of the PPP ZTDs is affected by the quality of the SEID ionospheric model, especially at the day boundaries, which can lead to a reasonable variability of ZTD, even though there are no considerable weather changes. Moreover, the RS ZTD is less than the GNSS ZTD, as the Radiosonde balloon observes meteorological values to a limited height.

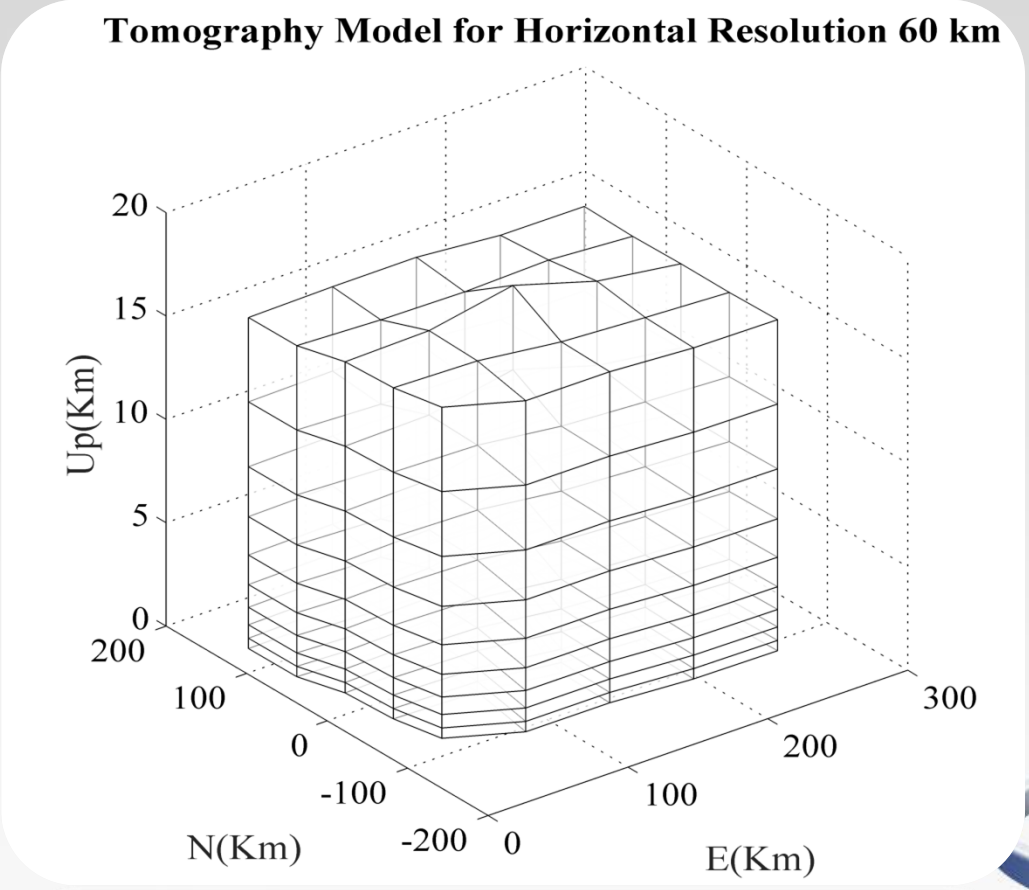


ZTD Comparison



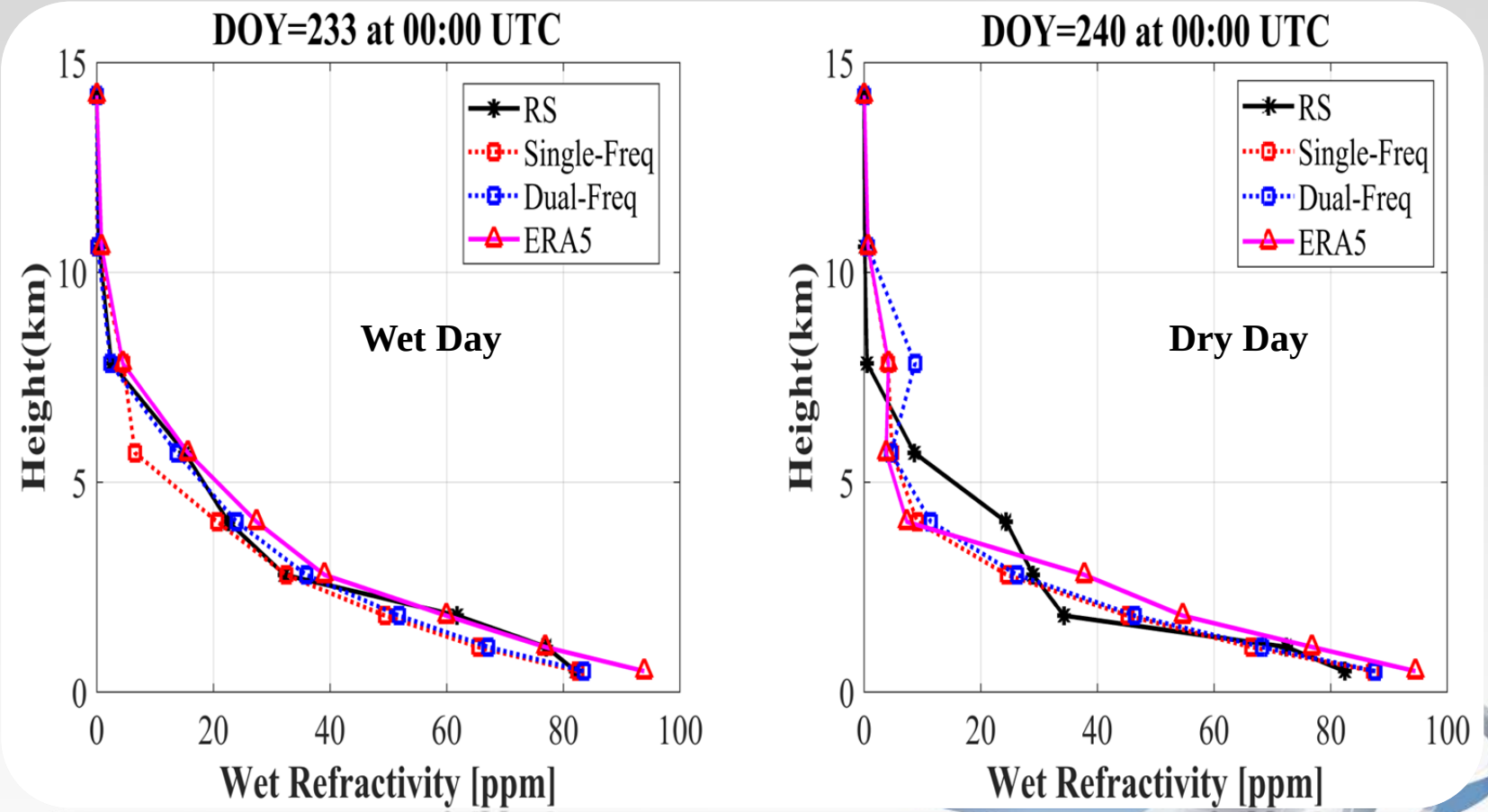


Tomography Model



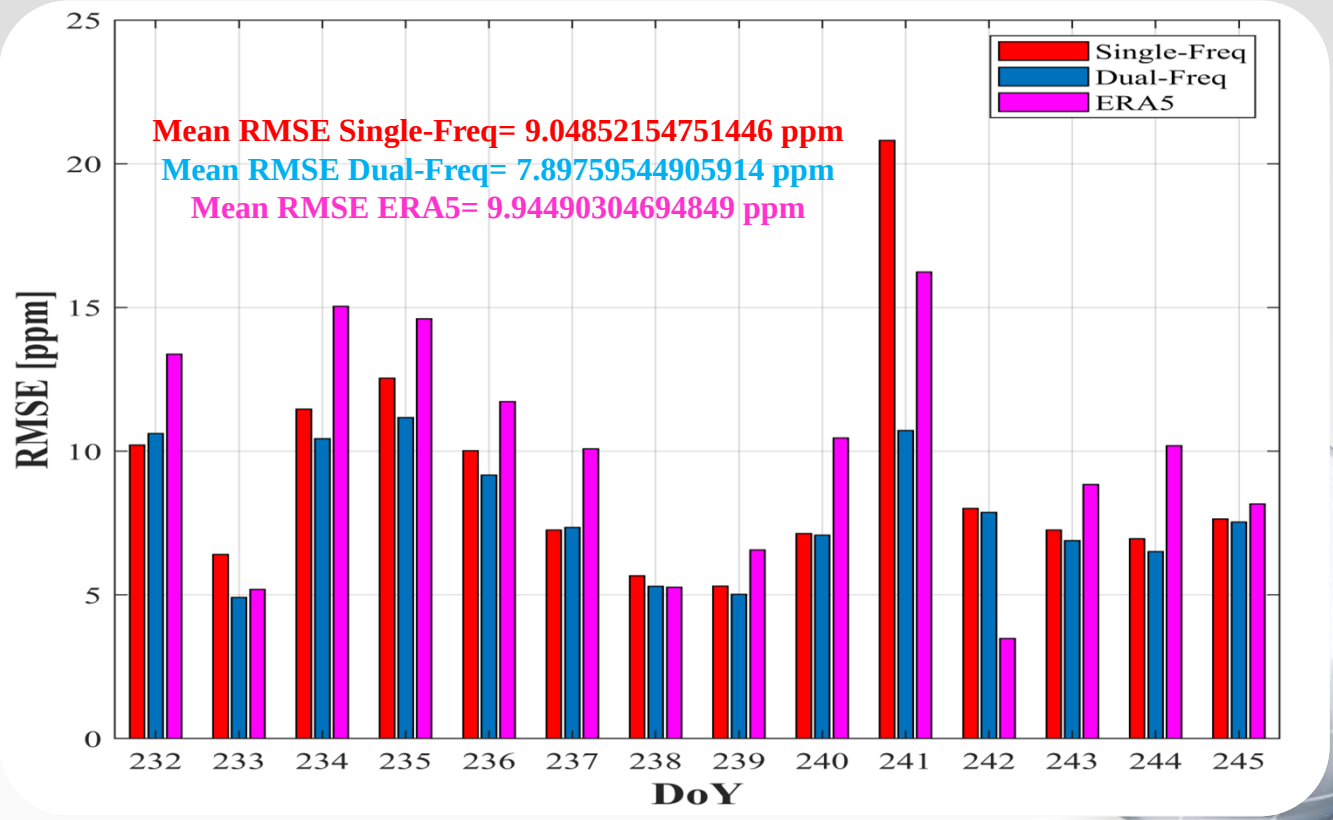
- Horizontal Resolution : 60 km
- Exponential Model in Vertical direction
- Time Resolution: 1 hour

Tomography Profiles



RMSE Comparison

As shown in the following figure, the average RMSE in single-frequency is about 9.04 ppm. Moreover, the average RMSE for the dual-frequency and ERA5 are 7.89 ppm and 9.45 ppm. Therefore, as we can expect, the accuracy of dual-frequency is generally better than single-frequency. It maybe returns to the effect of L1 observation quality. Nevertheless, if the quality of L1 observations is appropriate, the single-frequency observation can be an acceptable alternative approach to compute ZTD for meteorological applications such as GNSS tomography.



Conclusion

- ✓ Comparing ZTD of single frequency (SEID+PPP) and dual-frequency observations:

  -The agreement between both methods are cm level

  -The quality of the L1 observation will be fine; the problem is the quality of the applied ionospheric correction (e.g. DoY 241)

- ✓ Comparing reconstructed wet refractivity using single-frequency and dual frequency observations

  - Single frequency method can be a promising alternative method when the quality of L1 observation is acceptable.

- ✓ Applying AROME model as an initial field is expected to improve results.


Many Thanks for you attention
Questions?