Validating DORIS meteo data

Vangelis Zacharis*, Myrto Tsichlaki, Xanthos Papanikolaou, Maria Tsakiri

Dionysos Satellite Observatory, National Technical University of Athens

Introduction

With the adoption of the RINEX format to share DORIS data, it is now possible to provide meteorological data collected at system stations. This data (atmospheric pressure, temperature and relative humidity) are currently not used by the scientific community and are generally considered to be of low quality.

Meteorological data from the DORIS/RINEX files are validated against the discrete (VMF3) and empirical (GPT3) tropospheric models provided to the scientific community, in order to assess their credibility in determining the troposhperic delay, by comparing the tropospheric delay values provided by these models to the values produced when actual measured data are introduced.

Data & methodology

DORIS/RINEX [1] data were downloaded for stations ADHC, DIOB, HBMB, KRWB, THUB and TLSB, collected by the DORIS receiver onboard the JASON-3 mission, in the year 2021. Additionally, the grid files for models VMF3 and GPT3 [2] were acquired from [3], as well as SINEX/TRO [4] solutions for IGS stations DUMG, HARB, KOUG, THU2 and TLSG, co-located with the DORIS beacons. These raw data (from RINEX files and model grids) were interpolated to produce evenly spaced time series of meteorological data with an interval of 3h.

Moreover, estimates for Hydrostatic and Wet Zenith Delays (ZHD & ZWD) were computed from the grid files of the VMF3 and GPT3 models. These estimates were added to produce Total Zenith Delay values (ZTD), comparable with the values obtained from IGS, which were used as reference in this evaluation.

Now, the dataset consists of:

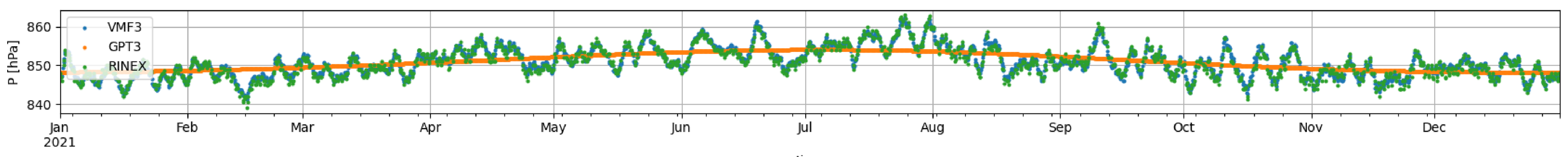
- Zenith Total Delay from the VMF3 model; designated as *VMF3*
- Zenith Total Delay from the GPT3 model [5], [6]; designated as *GPT3*
- Zenith Total Delay from the GPT3 model as above, with the addition of “corrections” for the wet component, using the formula

$$zwd_{aug.} = zwd_{GPT3} + 0.00049 \times (T_{meas.} - T_{GPT3}) + 0.00920 \times (e_{meas.} - e_{GPT3})$$

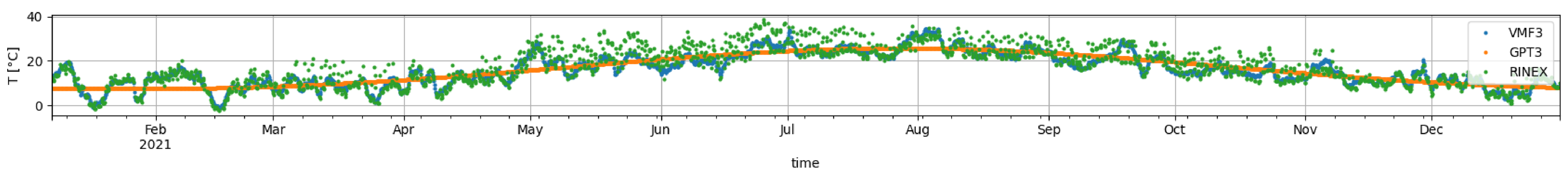
  where T and e are temperature and water vapour pressure, respectively, and the subscripts denote the origin of the values (*meas.*: DORIS/RINEX, *GPT3*: model) [7]. This dataset is designated as *GPT3 aug.*
- Lastly, the values provided by IGS, are designated as *ref.*

Meteo data

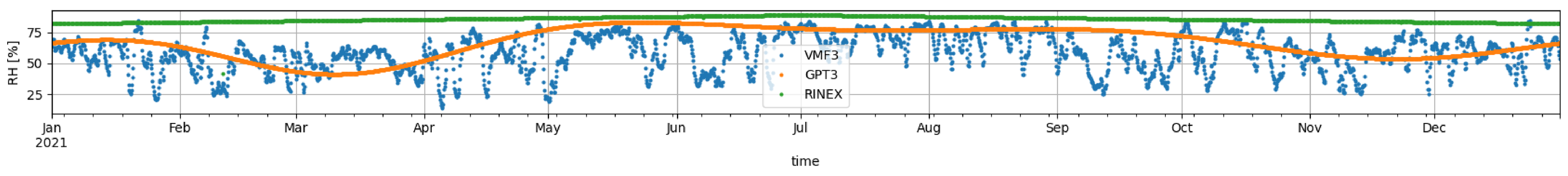
Raw meteorological data were compared with the values acquired from the models, at an interval of 3h. Figures (1a) to (1c) show raw values at various stations, while their differences are shown in figures (2a) to (2c).



(a) Atmospheric pressure at station HBMB

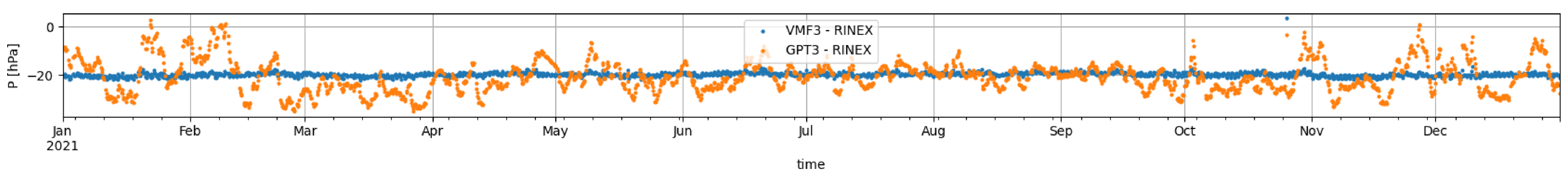


(b) Air temperature at station DIOB

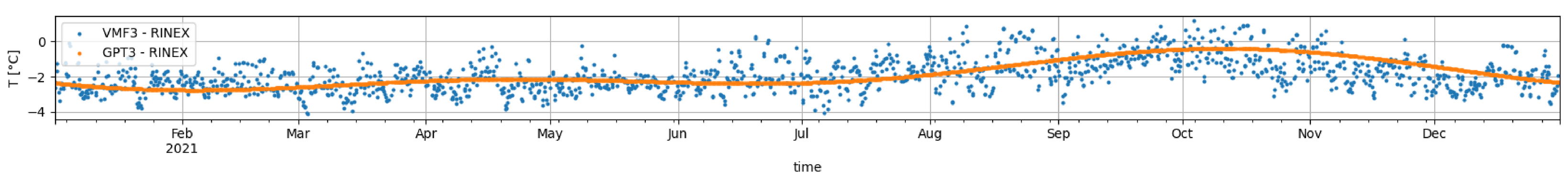


(c) Relative humidity at station THUB

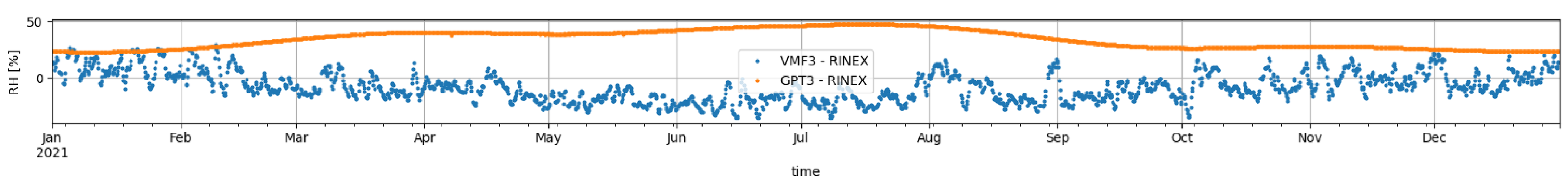
Figure (1) Raw values of meteorological data



(a) Atmospheric pressure differences at station TLSB



(b) Air temperature difference at station KRWB



(c) Relative humidity differences at station ADHC

Figure (2) Differences of meteorological data

It is evident that the raw values agree with the VMF3 model, as shown in figures (2a) to (2c) and table 1.

station	P [hPa]		T [℃]		RH [%]	
	VMF3 - RINEX	GPT3 – RINEX	VMF3 - RINEX	GPT3 - RINEX	VMF3 - RINEX	GPT3 - RINEX
ADHC	1.3 ± 2.3	7.1 ± 10.7	-0.4 ± 4.4	-4.1 ± 2.7	-8.0 ± 13.0	34.3 ± 8.2
DIOB	4.1 ± 4.7	2.6 ± 3.8	-0.9 ± 3.5	-1.0 ± 4.7	-6.8 ± 11.8	-3.6 ± 14.0
HBMB	0.2 ± 0.7	0.3 ± 2.9	2.0 ± 3.8	2.2 ± 1.0	-6.7 ± 20.8	-12.3 ± 7.3
KRWB	-0.2 ± 0.8	-0.5 ± 1.6	-1.9 ± 0.9	-1.8 ± 0.8	-1.7 ± 5.9	-8.5 ± 5.0
THUB	2.9 ± 15.4	3.2 ± 10.9	1.9 ± 6.5	-0.5 ± 4.8	-27.2 ± 14.4	-18.3 ± 10.9
TLSB	-19.7 ± 0.9	-20.6 ± 6.6	-0.3 ± 2.8	-0.4 ± 4.6	-9.3 ± 11.7	-6.7 ± 15.4

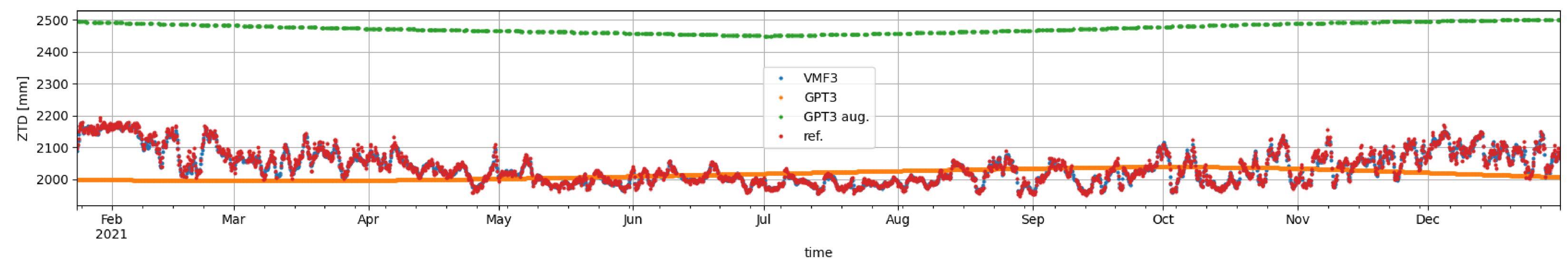
Table (1) Mean and standard deviation of meteo differences

Contact Information

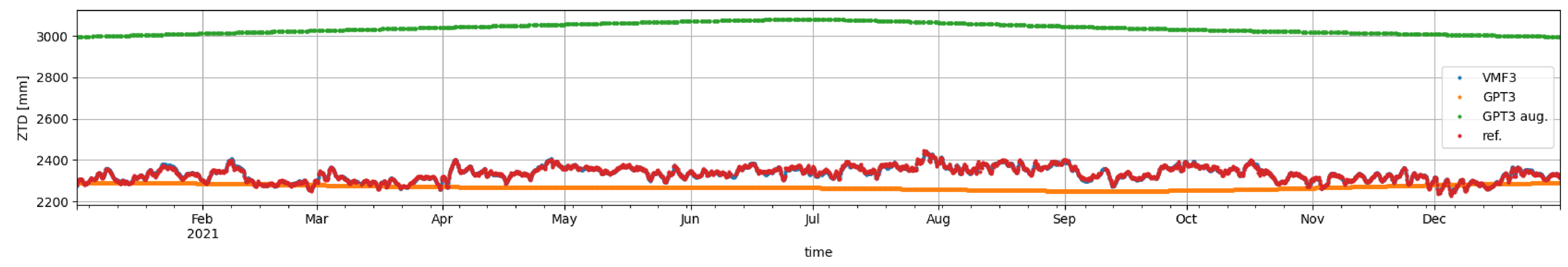
web: dionysos.survey.ntua.gr email: vanzach@mail.ntua.gr

Zenith delay analysis

The values for Total Zenith delay and their differences are shown in figures (3a), (3b) and (4a) to (4d), respectively.

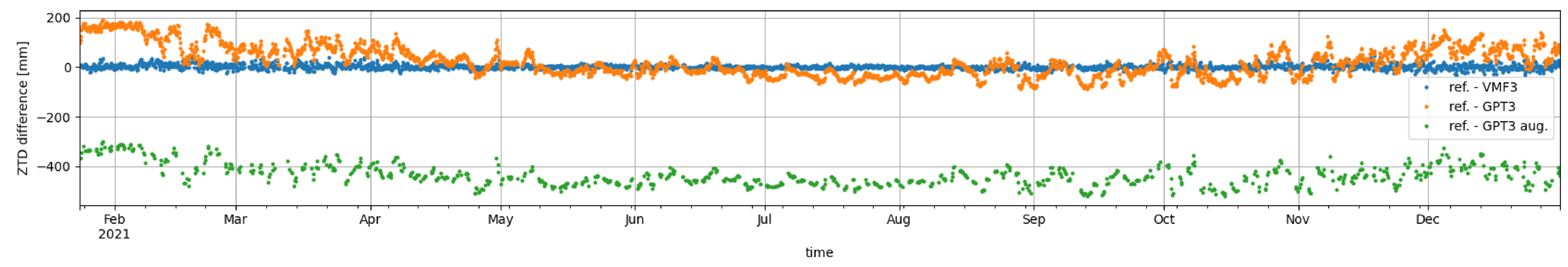


(a) Zenith total delay at station HBMB

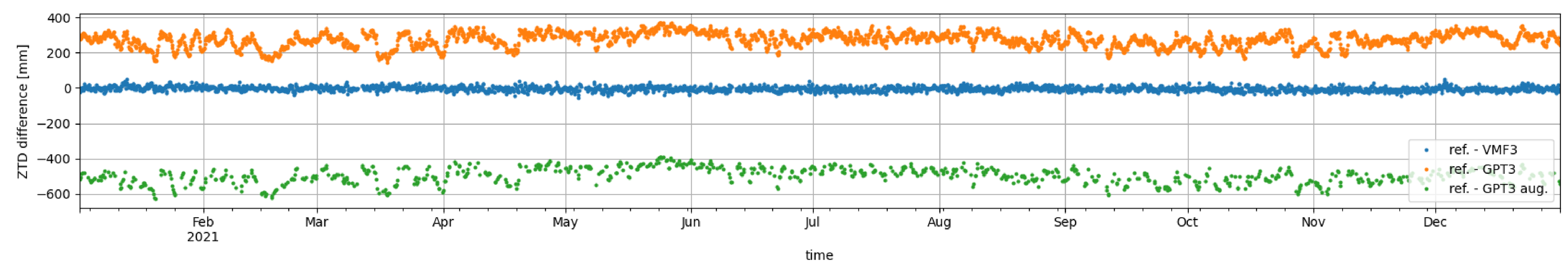


(b) Zenith total delay at station THUB

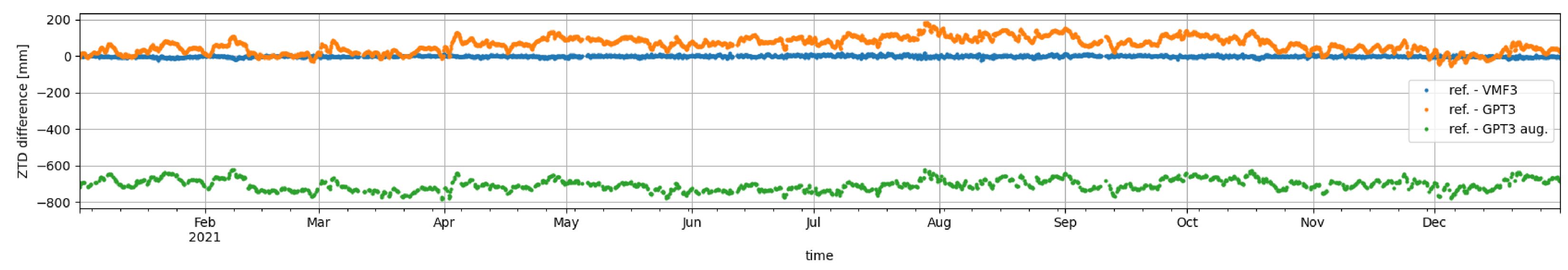
Figure (3) Zenith total delays



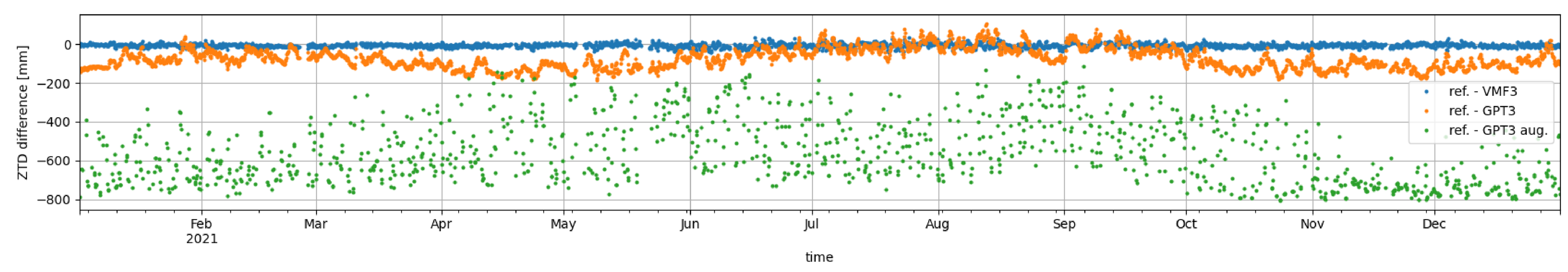
(a) Zenith delay differences at station HBMB



(b) Zenith delay differences at station KRWB



(c) Zenith delay differences at station THUB



(d) Zenith delay differences at station TLSB

Figure (4) Differences of total zenith delay

Table 2 shows the mean values and the standard deviation of the differences.

station	Zenith Total Delay [mm]		
	ref. - VMF3	ref. - GPT3	ref. - GPT3 aug.
HBMB	1.6 ± 9.3	22.6 ± 60.5	-435.7 ± 43.8
KRWB	-4.1 ± 13.0	274.1 ± 40.6	-496.7 ± 44.8
THUB	0.1 ± 4.9	64.3 ± 40.9	-703.6 ± 30.9
TLSB	-5.3 ± 10.7	-72.0 ± 52.7	-559.6 ± 161.2

Table (2) Mean and standard deviation of zenith delay differences

Conclusion

It is clear that, in most sites, the values of the meteo parameters derived from the discrete model (VMF3) are closer to the measured ones, than the values of the empirical model (GPT3).

It is also evident that the values of the VMF3 model are in good agreement, in the order of a few millimeters, with the “reference”, i.e. the computed values for the Zenith Total Delay using GNSS data (SINEX/TRO files). This is the expected finding, since the VMF3 model is widely used in standard GNSS analysis schemes by the IGS Analysis Centers.

The differences of empirical model (GPT3) with the “reference”, is in the order of a few centimeters, but the interesting finding is that the “augmented” GPT3 values differ from the reference quite a lot (in the order of half a meter).

References

- CNES and IDS.
  RINEX DORIS 3.0 (issue 1.7).
  Technical report, Centre National d'études Spatiales.
- Daniel Landskron and Johannes Böhm.
  VMF3/GPT3: refined discrete and empirical troposphere mapping functions.
  Journal of Geodesy, 92(4):349–360, Apr 2018.
- re3data.org: VMF Data Server; editing status 2021-08-24; re3data.org - Registry of Research Data Repositories.
  http://doi.org/10.17616/r3rd2h.
  https://vmf.geo.tuwien.ac.at/.
- R. Pacione and J. Douša.
  SINEX_TRO – Solution (Software/Technique) INdependent EXchange Format for TROpospheric and meteorological parameters (version 2.00).
  Technical report, e-GEOS/ASI-CGS, Italy and GOP/RIGTC, Czech Republic, Dec. 2020.
- J. Saastamoinen.
  Atmospheric Correction for the Troposphere and Stratosphere in Radio Ranging Satellites, pages 247–251.
  American Geophysical Union (AGU), 1972.
- J. Askne and H. Nordius.
  Estimation of tropospheric delay for microwaves from surface weather data.
  Radio Science, 22(3):379–386, 1987.
- D. Landskron, G. Möller, A. Hofmeister, J. Böhm, and Weber R.
  Site-augmentation of empirical tropospheric delay models in GNSS.
  Österreichische Zeitschrift Für Vermessung Und Geoinformation (VGI), 104(3):128–135, 2016.