Ionospheric Impact on GNSS Reflectometry: A correction approach for the PRETTY satellite data

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Sharing is encouraged

1 Background

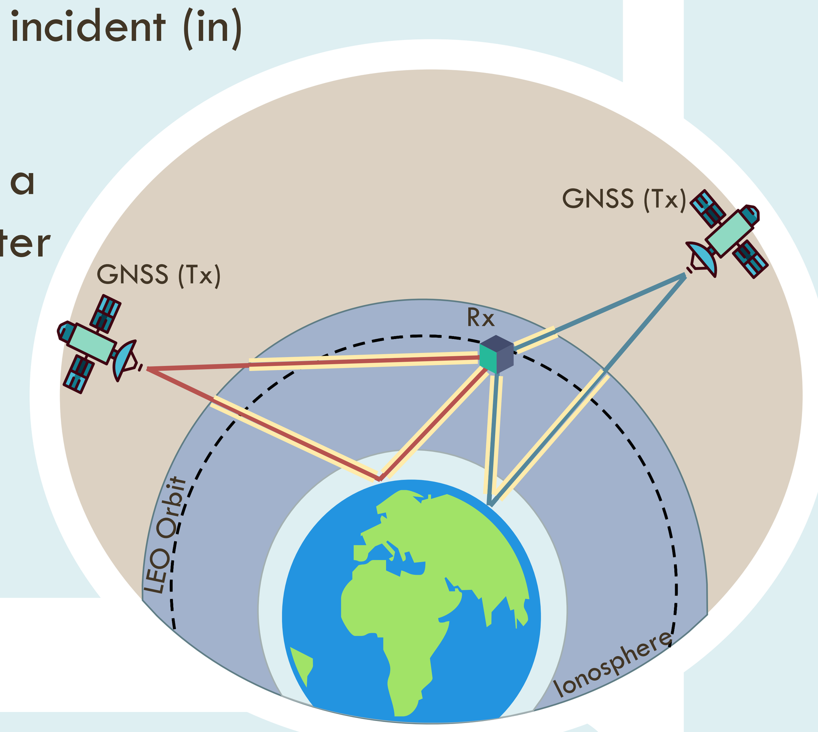
Reflected signals from Global Navigation Satellite Systems (GNSS) that interact with the Earth's surface provide an important opportunity for remote sensing of the atmosphere.

The GNSS Reflectometry **"PRETTY"** mission (in orbit since October 2023) will focus on grazing angles (5°-30°) observations.

At low elevation angles, the atmospheric impact intensifies due to the extended propagation path of the direct (di), incident (in) and reflected (re) signals.

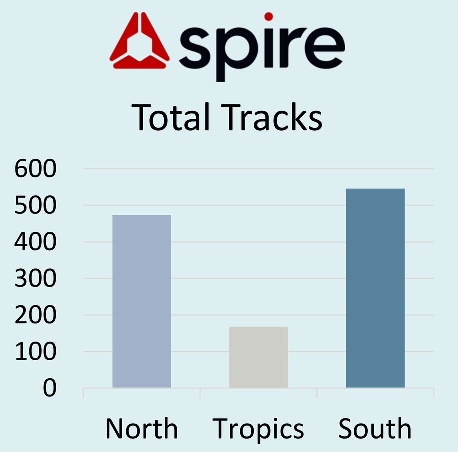
Objective: Characterize ionospheric effects in a **PRETTY-like scenario** under variable parameter conditions:

- Elevation angles in the grazing range
- Latitude-dependent regions (north, tropic, south), and
- Diurnal changes (day and nighttime)



2 Data & Methods

DATA:
LEO Orbit data: Spire Global CubeSat LEMUR-2.
GNSS Constellation: GPS (L1)
Earth Model: Osculation sphere.
Date: 01.03.2021

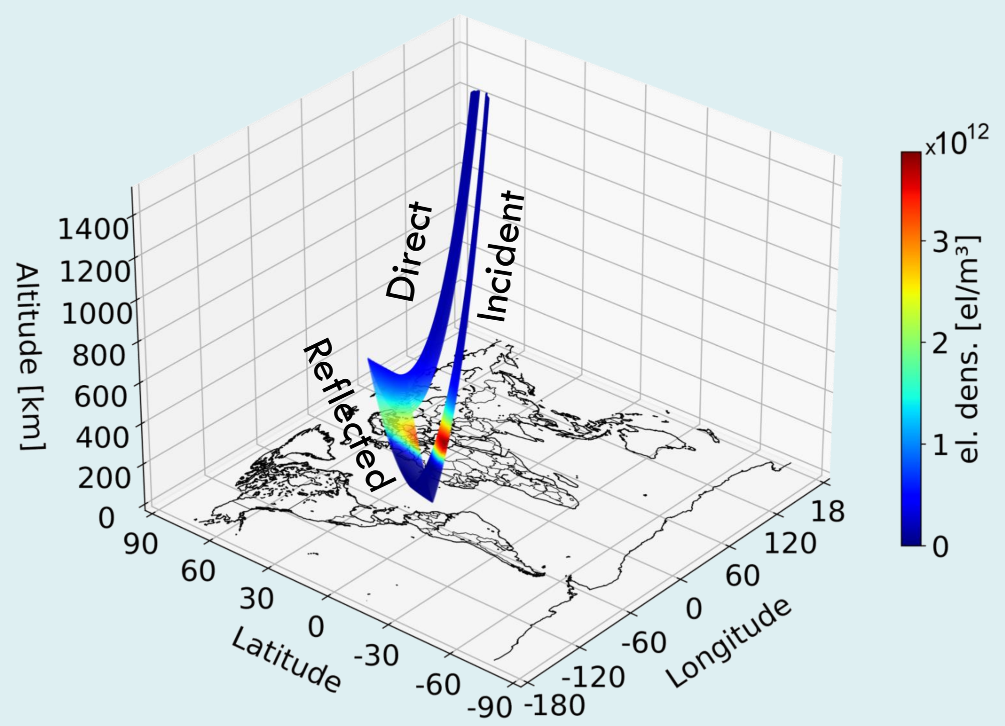


Ne MODELS:
Neustrelitz Electron Density Model NEDM2020 (Hoque, M. et al, 2022)
NeQuick 2 (Nava, B. et al, 2008)

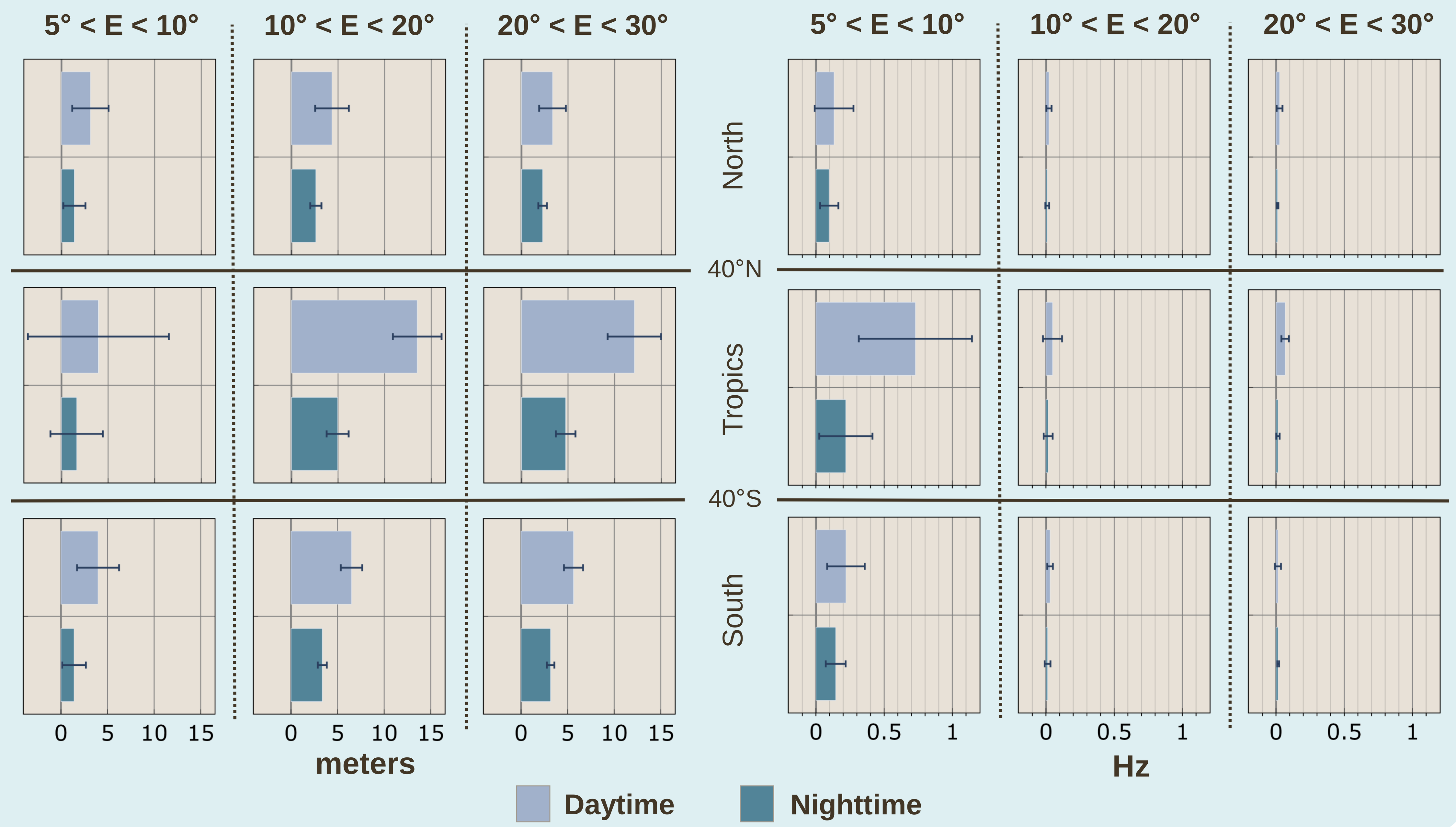
sTEC:
$sTEC_{in}$, $sTEC_{re}$, $sTEC_{di}$

Rel. iono. Delay:
$$\Delta_{iono} = d_{in} + d_{re} - d_{di}$$

Doppler Shift:
$$f_d = \frac{d\phi_{iono}}{dt}$$

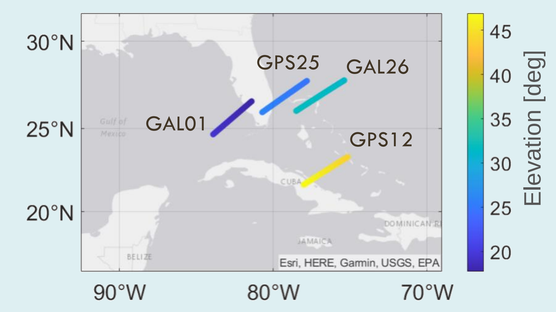


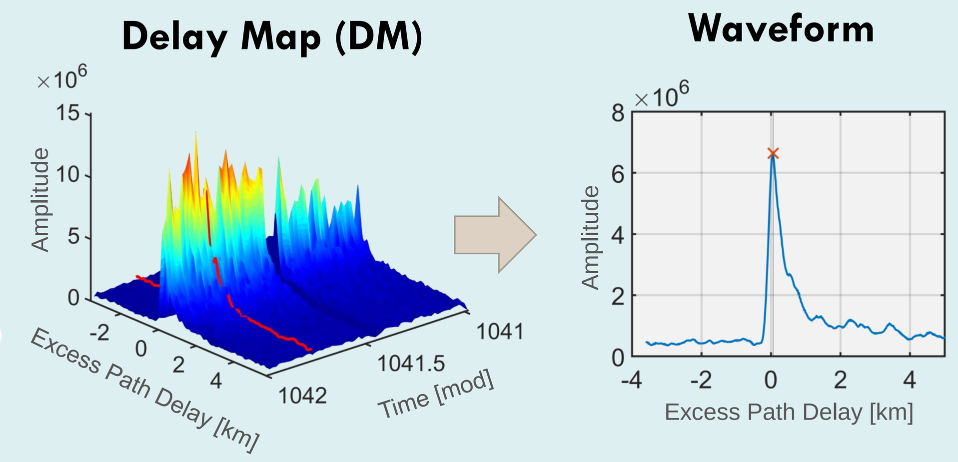
3 Results



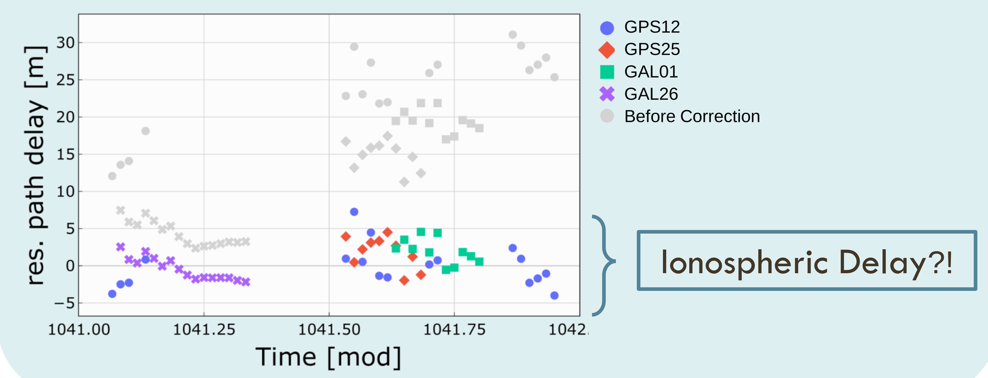
Group Delay Observations

DATA:
GNSS-R NASA CYGNSS
GNSS: GPS and GAL
Date: 09.20.2017
Local Time: 12h

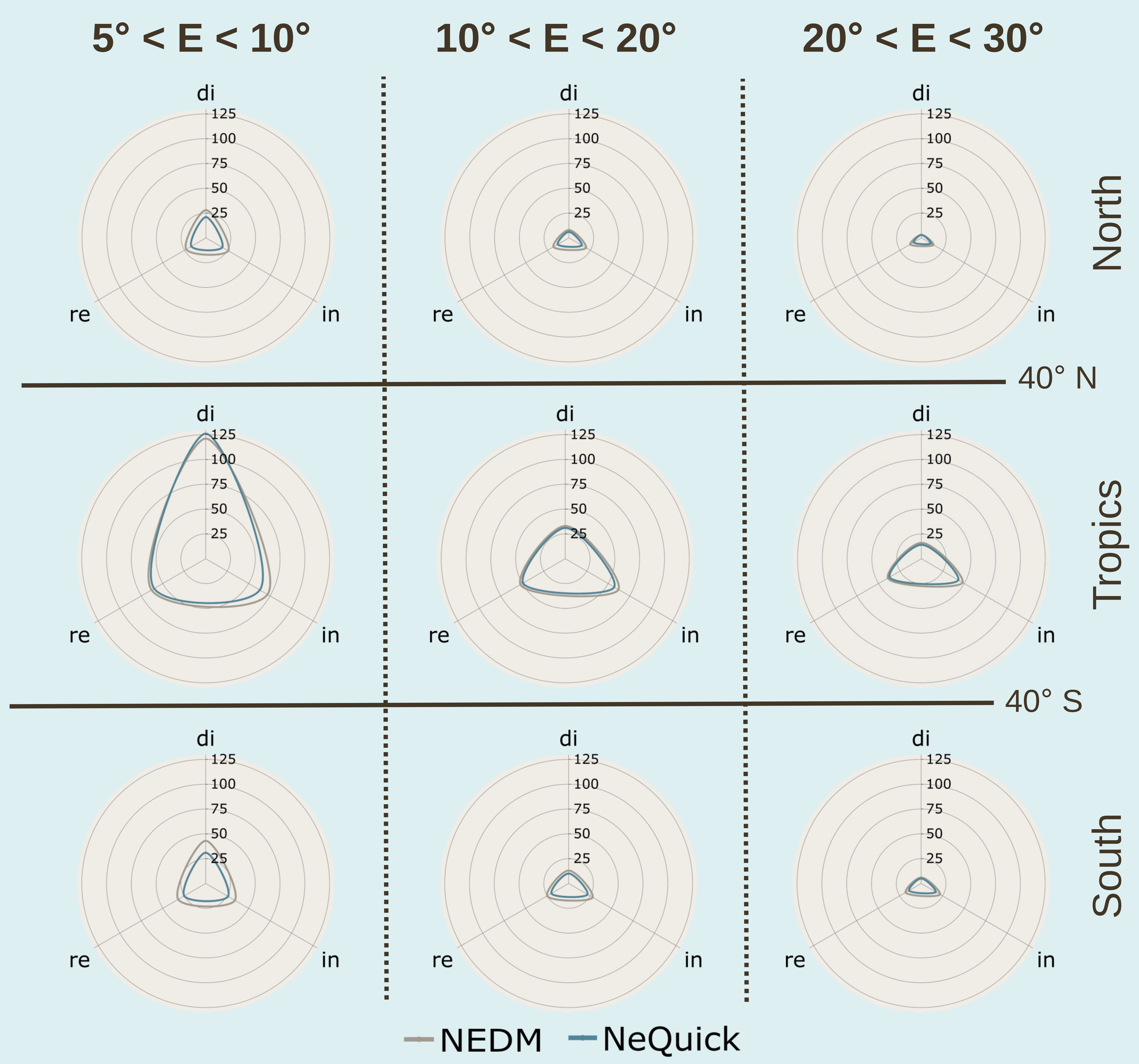




- ✓ Land Mask
- ✓ Coherence Filter
- ✓ SNR Filter
- ✓ Surface Height Correction
- ✓ Tropospheric Correction
- ⚠ Precise Orbits



NEDM & NeQuick sTEC (in, re, di) [TECU]



4 Conclusions

- As elevation decreases below 20°, median ionospheric delay reduces due to direct signal contribution. However, increased standard deviation, especially in Doppler shift, challenges model-based correction in GNSS reflectometry at grazing angles.
- The **ESA PRETTY** mission pioneers L5 frequency altimetry, highlighting the need for precise ionospheric correction. As a single-frequency GNSS-R mission, PRETTY relies on models to ensure accurate sea surface height measurements. Addressing significant ionospheric effects in altimetry applications is crucial for mission success.
- Upon correcting orbit solutions, surface height, 'surface effects', and tropospheric delay, the residual excess path delay may represents the measurement of ionospheric delay, albeit with unmodeled or mis-modeled errors and noise. This measurement holds the potential to retrieve ionospheric TEC measurements.

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