Comparisons and validation of the TIDs occurrence in the ionospheric tilt measurements with the GNSS observations (CVTIDs)

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Outline

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- Data and Methodology
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- Summary and conclusion

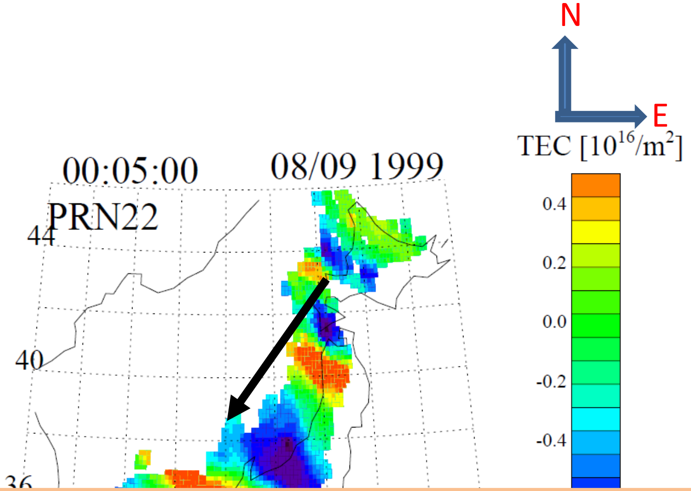
Introduction and motivation

Traveling ionospheric disturbances (TIDs) are wave like fluctuations of the electron density induced by gravity waves in the neutral atmosphere (Hines, 1960; Francis, 1974).

Types of TIDs

1) Large scale traveling ionospheric disturbances (LSTIDs)

- ✓ Period: 30 minutes-3 hours
- ✓ Horizontal speed: 400-1000 m/s
- ✓ Horizontal wavelength: 1000 km and above

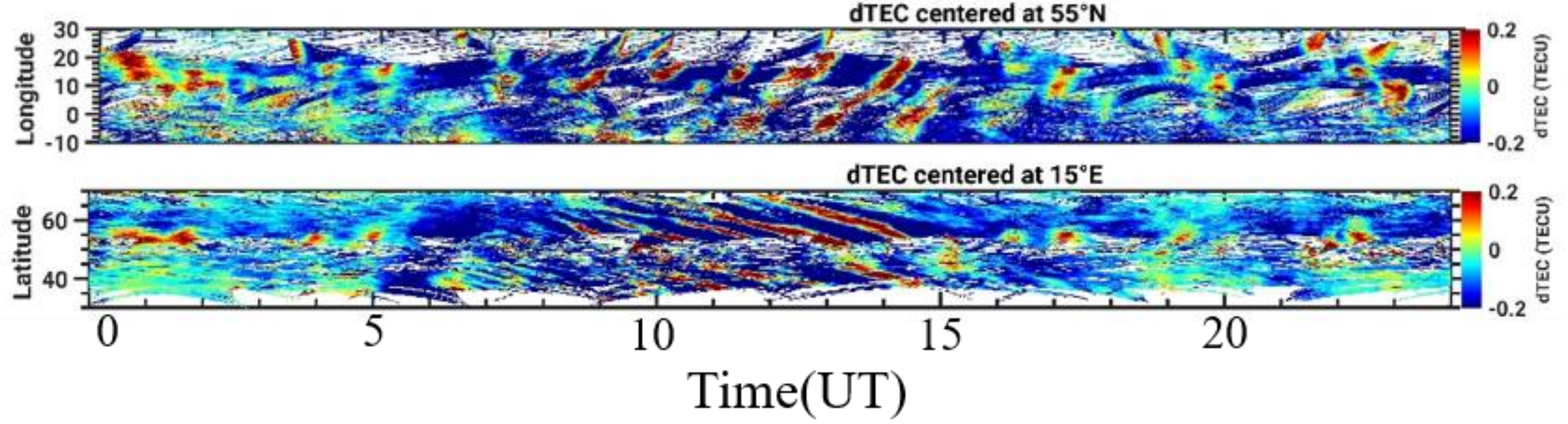


Characteristics of MSTIDs are studied using various instruments such as GNSS-dTEC, airglow imagers, ionosonde, Continuous Doppler Sound Systems (CDSS) etc. Each of these measurements have its own advantages and limitation. Cross validating the ability of different observational techniques will be necessary to understand the real characteristics of MSTIDs beyond the observational limitation. Therefore, in this project we focus to validate the ionosonde tilt measurement capability to study the TIDs (MSTIDs) and also investigate the role of Es layer and F region coupling on the generation of the MSTIDs.

Data and Methodology

- 1. GNSS-dTEC data

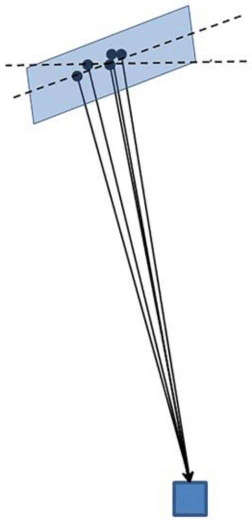
- The temporal and spatial resolution of the TEC data is 30 seconds and Latitude-Longitude grid of 0.25° × 0.25°.

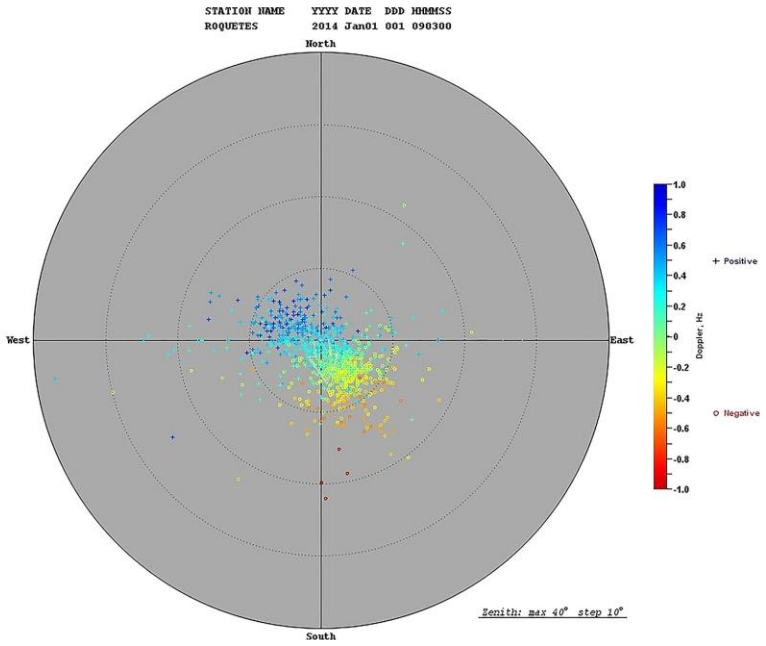


East-west and North-south keogram on 02 December 2020

Data and Methodology

- 2. Ionosonde tilt measurement

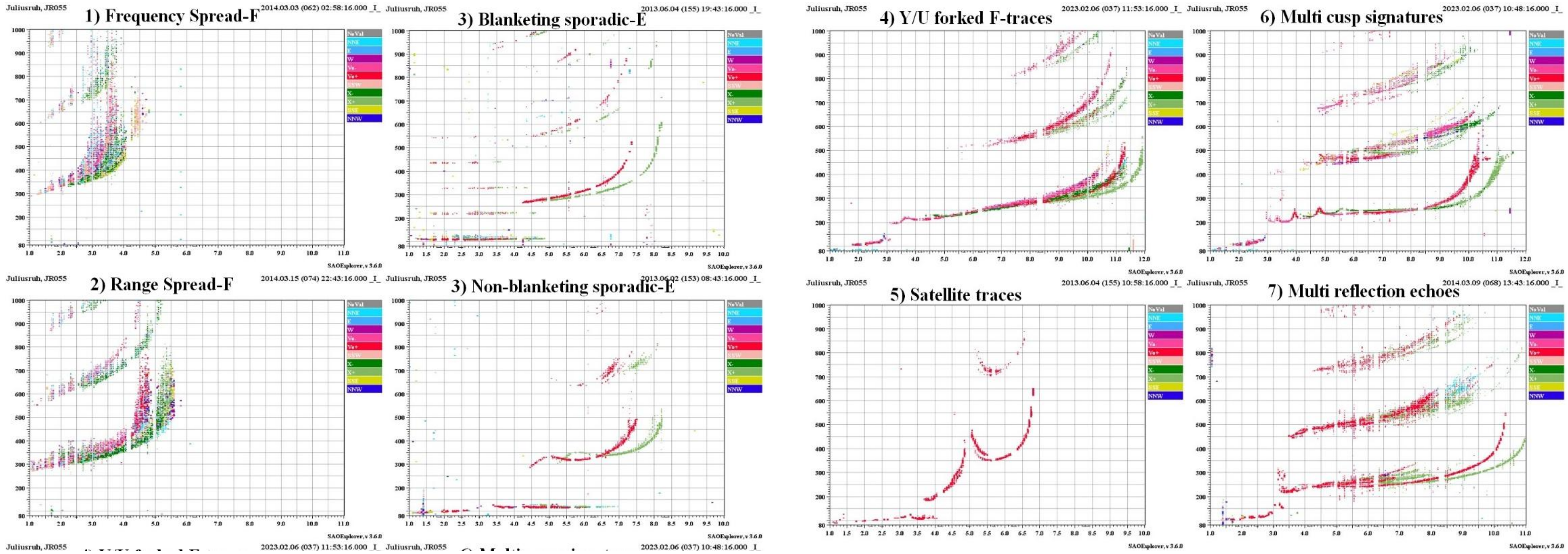




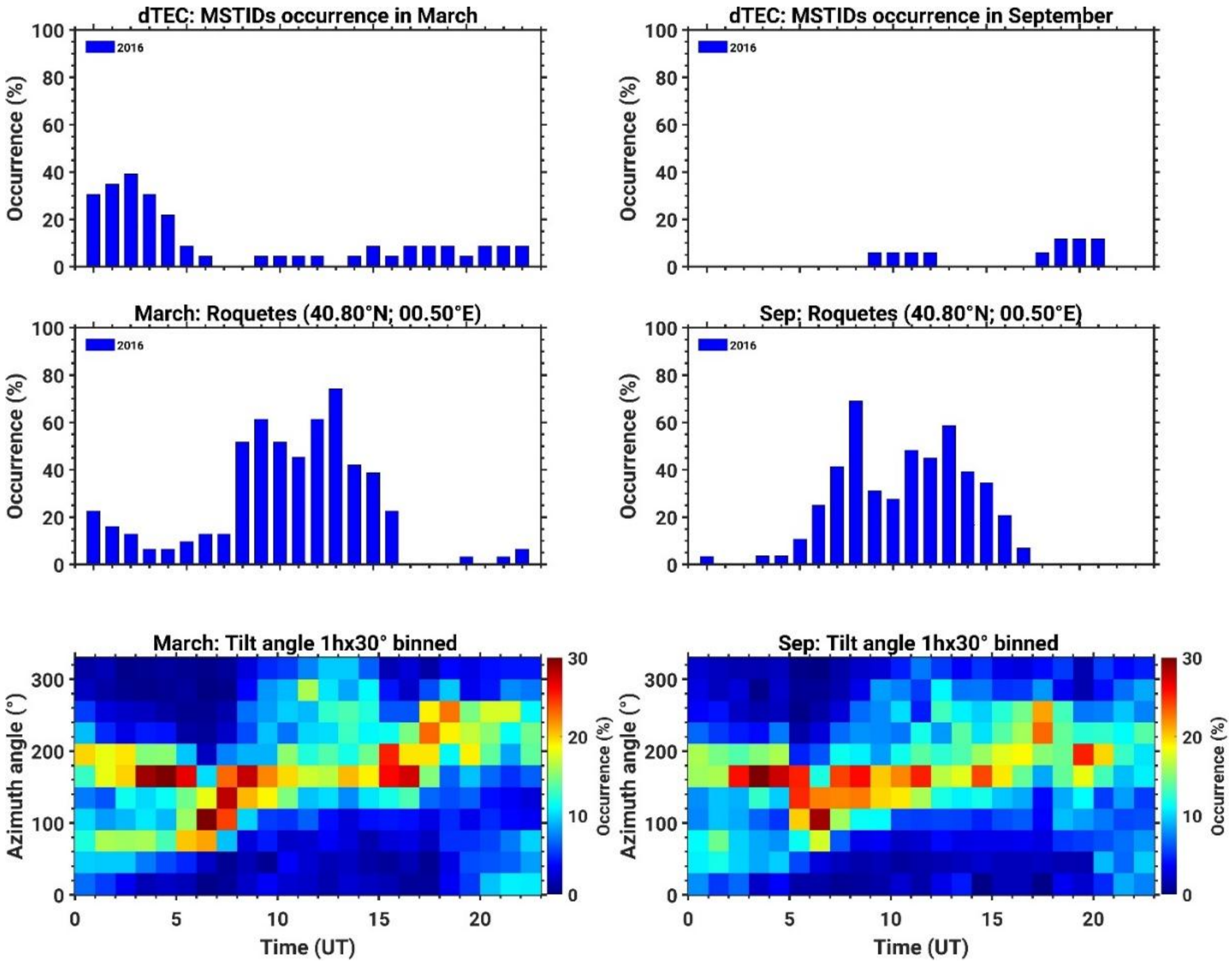
- Under a simplified model for TIDs, it is possible to estimate parameters of ionospheric waves from the digisonde tilt measurements.
- Considering that the orientation of the tilt normal vector represents a perpendicular to the “imaginary” ionospheric plane or local electron density contour, the tilts measurements relate to electron density gradients.
- Therefore, if we assume that most off-zenith reflections are associated with the propagating disturbances which in the case of the TIDs are characterized with the plane wavefront, then the azimuthal direction of the tilt vectors characterizes the propagation direction of the TID waves.
- Of course, this argumentation is valid only under the assumption of the mirror model reflection (Paznukhov et al., 2020).

Data and Methodology

- 3. Ionosonde characteristics



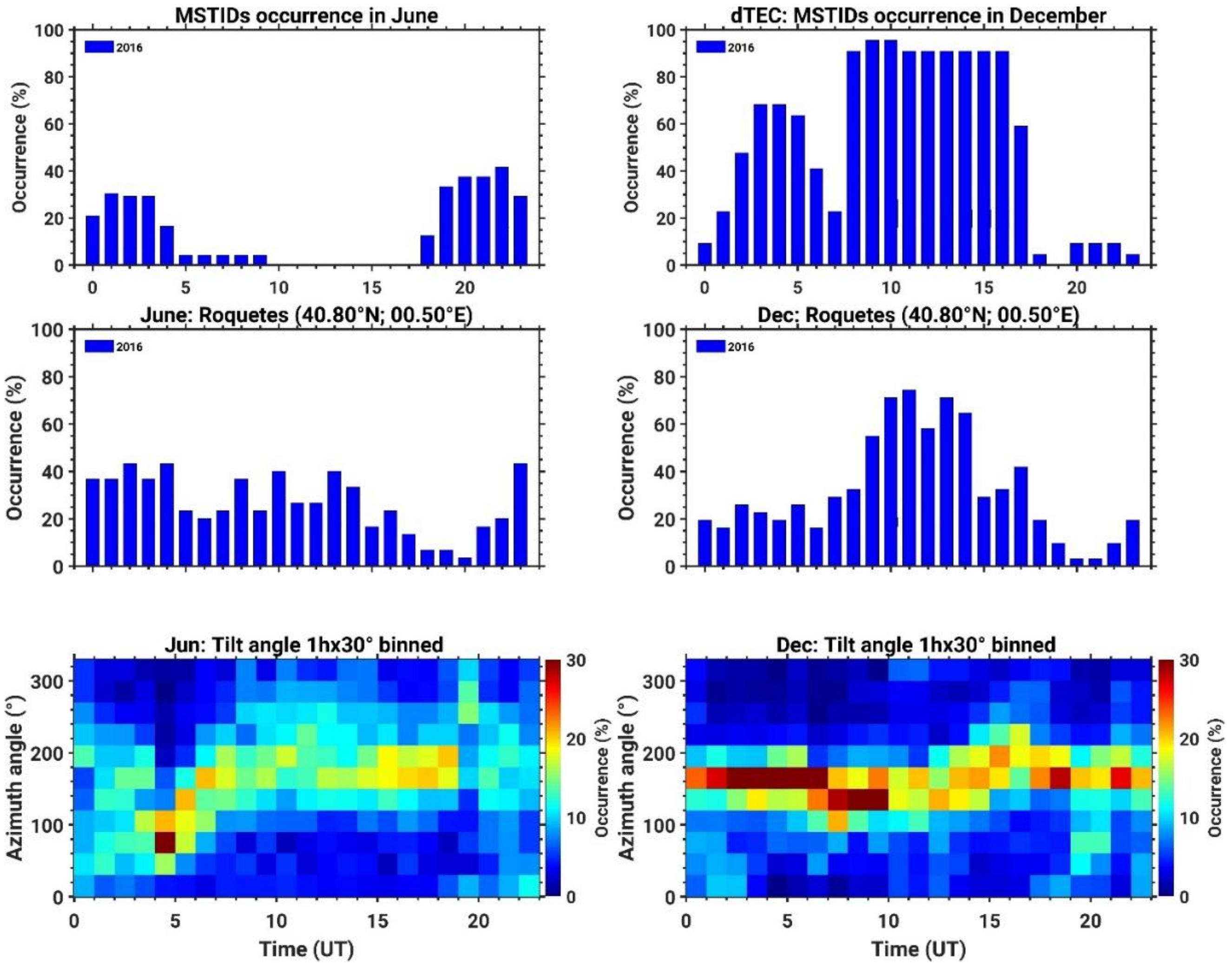
Results: Comparison of dTEC and ionosonde tilt in 2016



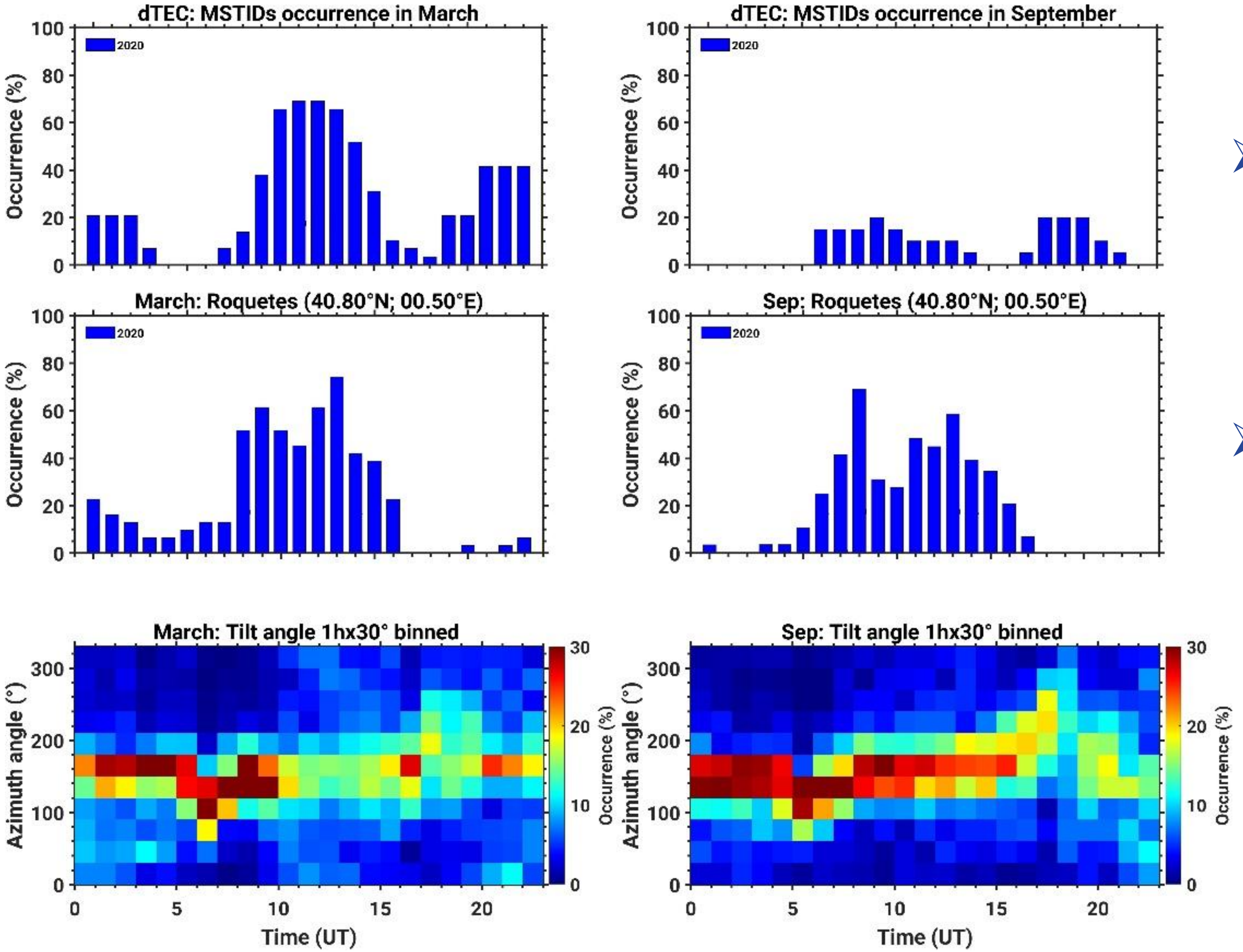
- Except the early morning, nighttime and evening hours, TID occurrence in the ionogram signature and tilt measurement are in good agreement during June and September 2016
- There is a notable difference between the dTEC estimated MSTIDs and ionosonde data derived MSTIDs

Results: Comparison of dTEC and ionosonde tilt in 2016

- MSTIDs occurrence (all three methods) during December 2016 is in good agreement with each other.
- In June 2016, there is good agreement between these three method during nighttime however in daytime dTEC estimated MSTIDs is very less that other two method.



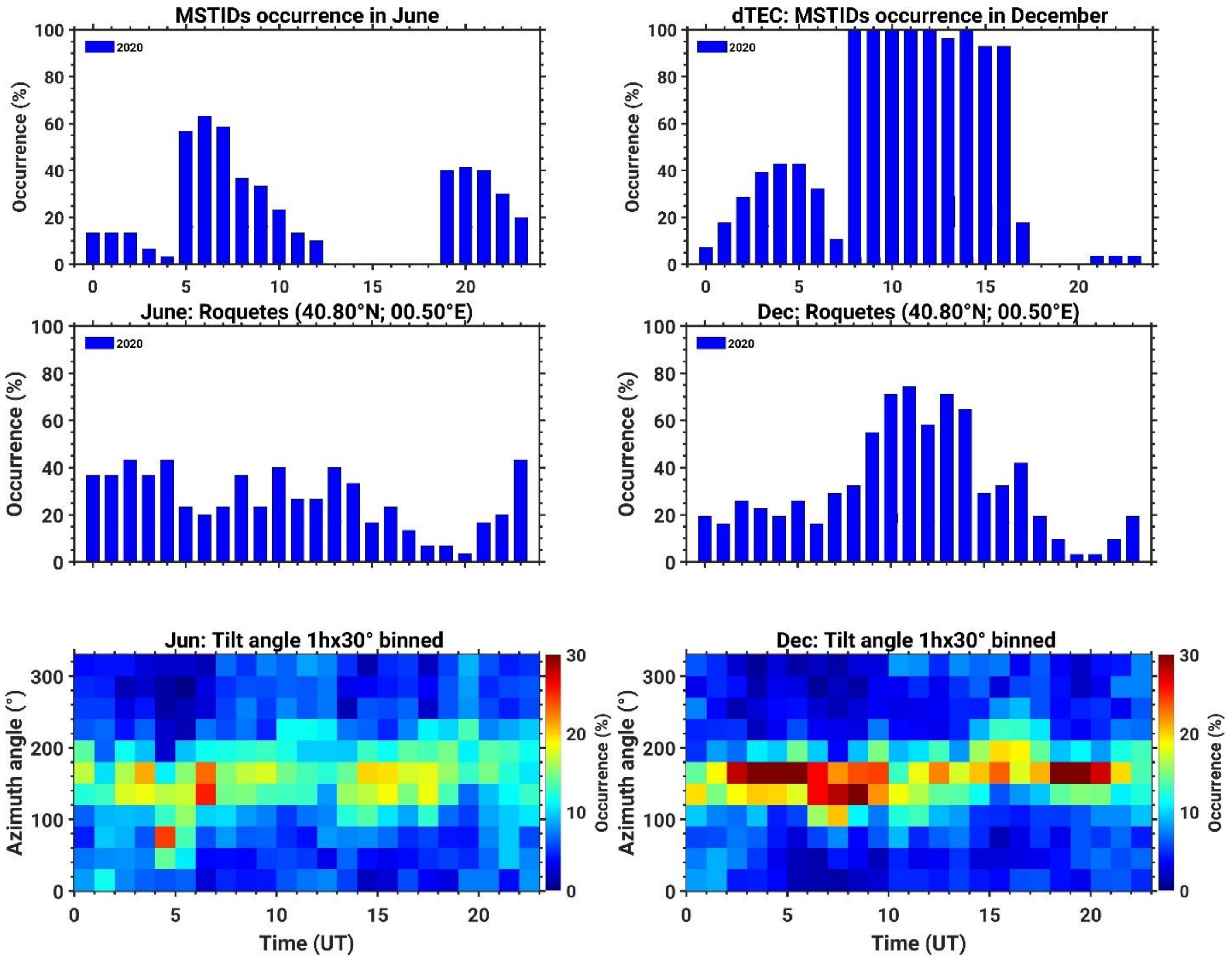
Results: Comparison of dTEC and ionosonde tilt in 2020



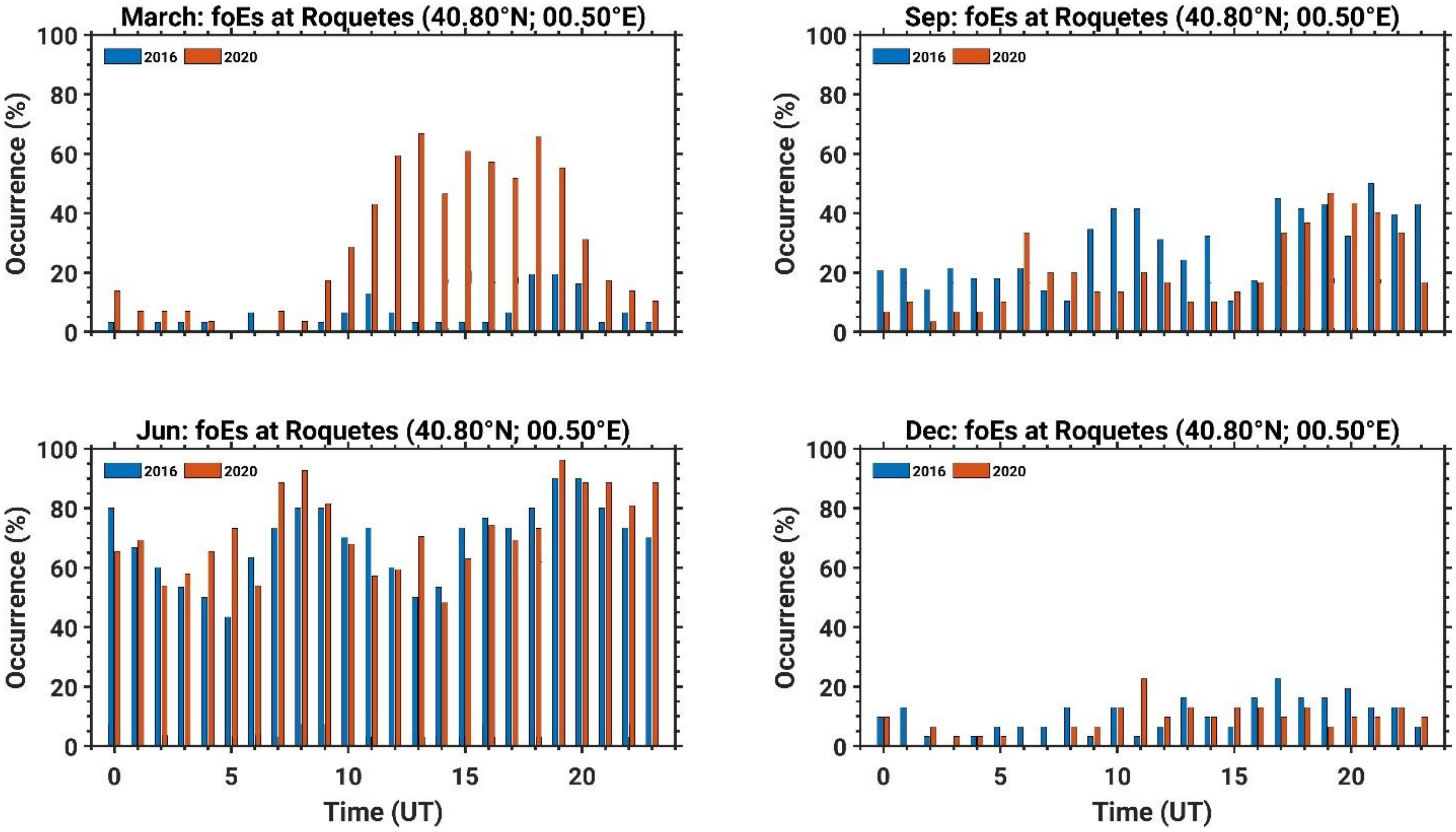
- ➢ In March 2020, except sunrise and sunset time MSTIDs occurrence (all three methods) is in good agreement with each other.
- ➢ In September 2020, there is good agreement between these three method during nighttime however in daytime dTEC estimated MSTIDs is very less that other two method.

Results: Comparison of dTEC and ionosonde tilt in 2020

- In June 2020, evening hours dTEC estimated MSTIDs and ionosonde observations
- In December 2020, there is good agreement between these three method during the daytime dTEC estimated MSTIDs however the nighttime MSTIDs occurrence show different.



Es layer occurrence characteristics



Summary and conclusion

1. We found a notable difference between the dTEC and ionogram feature based TIDs estimation during the daytime in the equinox months of March and September in 2016.

2. During the solstice months in 2016, diurnal variation of the TIDs observed in the dTEC, ionogram features and tilt angle estimated TIDs are in agreement with each other.

3. In 2020, TIDs observed in all these three methods are in good agreement with each other.

4. Nighttime MSTIDs occurrence during June might be associated with the Es layers.

These results support that the ionosonde tilt measurement results can be used to investigate the TIDs.

Acknowledgement

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