



On the nighttime enhancement in ionospheric electron density over the equatorial region



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Ionospheric Nighttime Enhancement (INE)

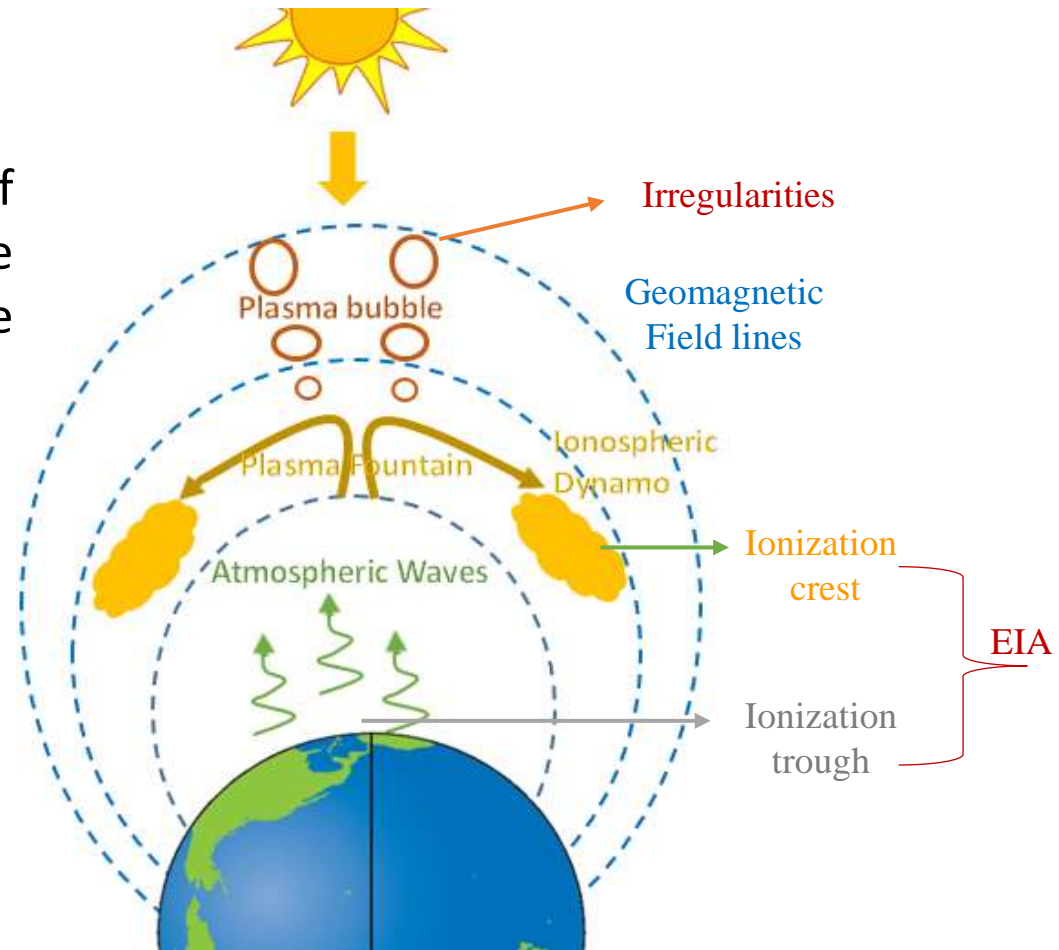
“At nighttime, during the absence of ionization, the ionospheric electron density is generally expected to decay gradually but it does not behave as predicted by the simple notion and show enhancement occasionally”. This phenomenon is called ionospheric nighttime enhancement (INE).

- Based on the time of occurrence, INEs have been classified into two types:
Premidnight and Postmidnight
- According to the geographic region, they can be categorized as:
Mid-latitude, Low-latitude and Equatorial INEs
- The underlying physical mechanism proposed for different INE events are also different.
- The studies regarding INEs over the equatorial region are rather sparse.

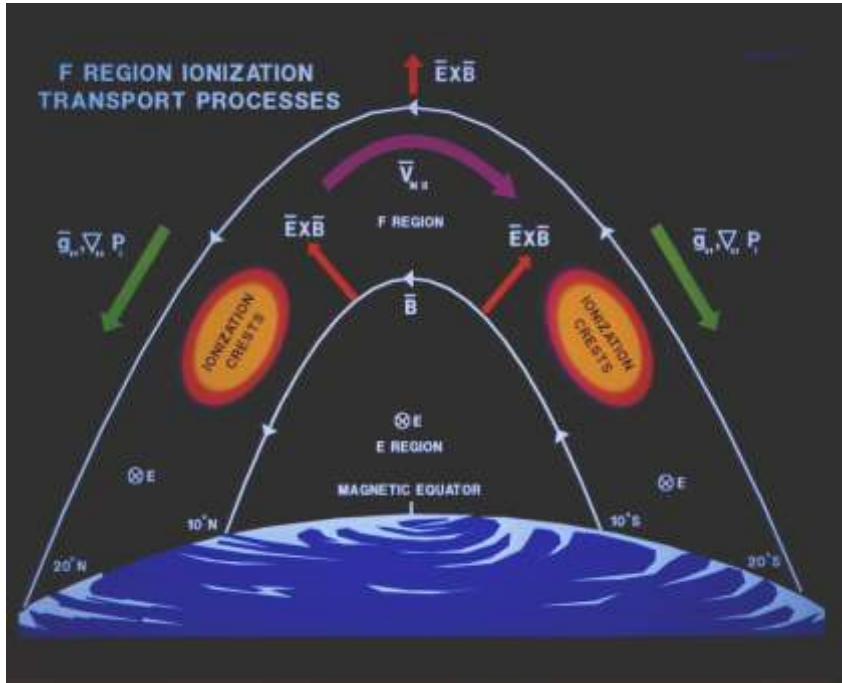
Equatorial and Low-Latitude Ionosphere

The unique configuration of geomagnetic field lines over the geomagnetic equator forms the base for the various plasma processes.

- Equatorial Electrojet (EEJ),
- Equatorial Ionization Anomaly (EIA)
- Equatorial Spread- F (ESF)



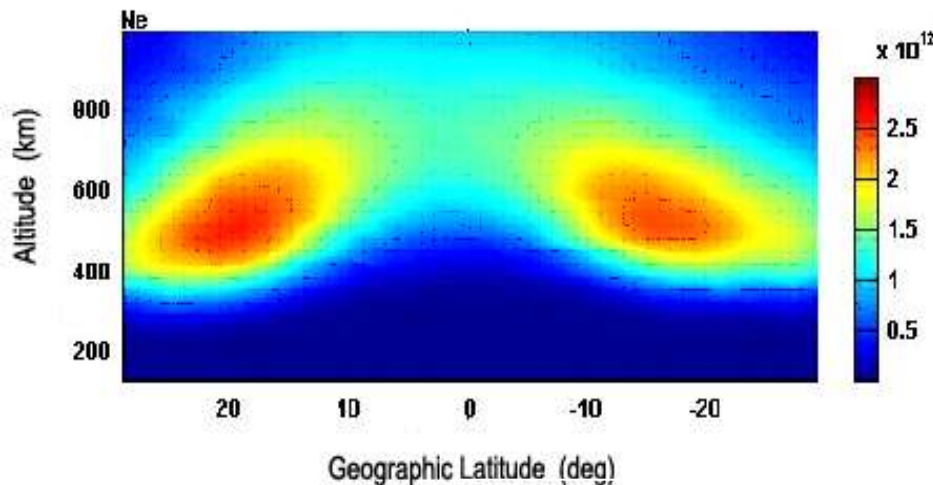
Equatorial Ionization Anomaly



Basu et al., 2002

Fountain effect: During the daytime, the eastward zonal electric field in conjunction with the horizontal N-S component of the geomagnetic field gives rise to the vertical $E \times B$ drift over the geomagnetic equator which in turn lifts the plasma to higher altitudes.

Reverse Fountain Effect: Consequence of the change in the direction of the zonal electric field from eastward to westward and characterized by the movement of the EIA crest towards the equator.



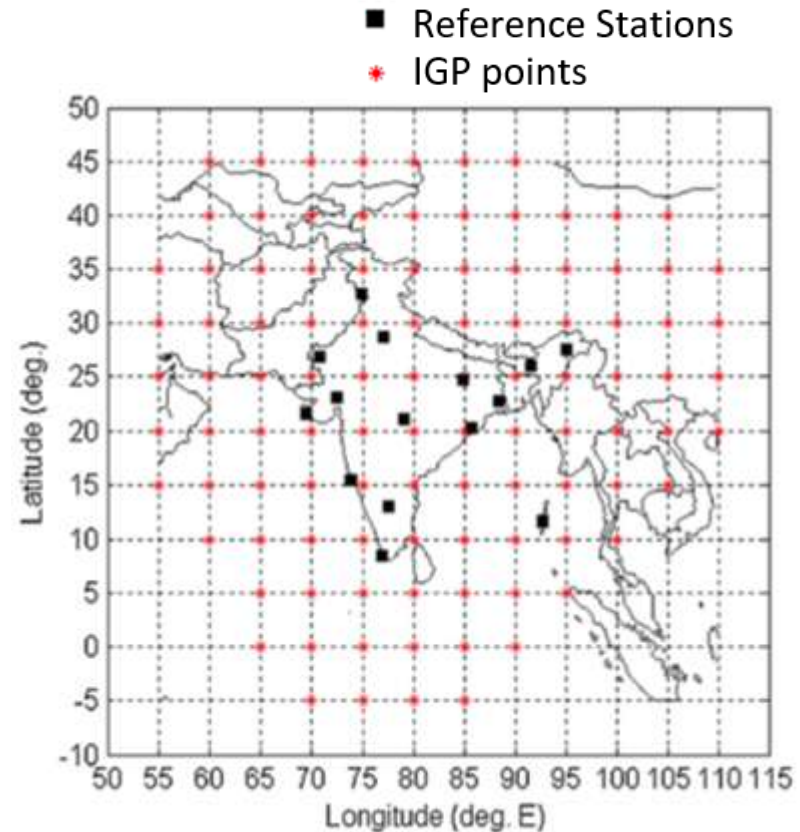
Watthanasangmechai et al., 2013

GPS Aided Geo Augmented Navigation (GAGAN)

INDIAN SBAS

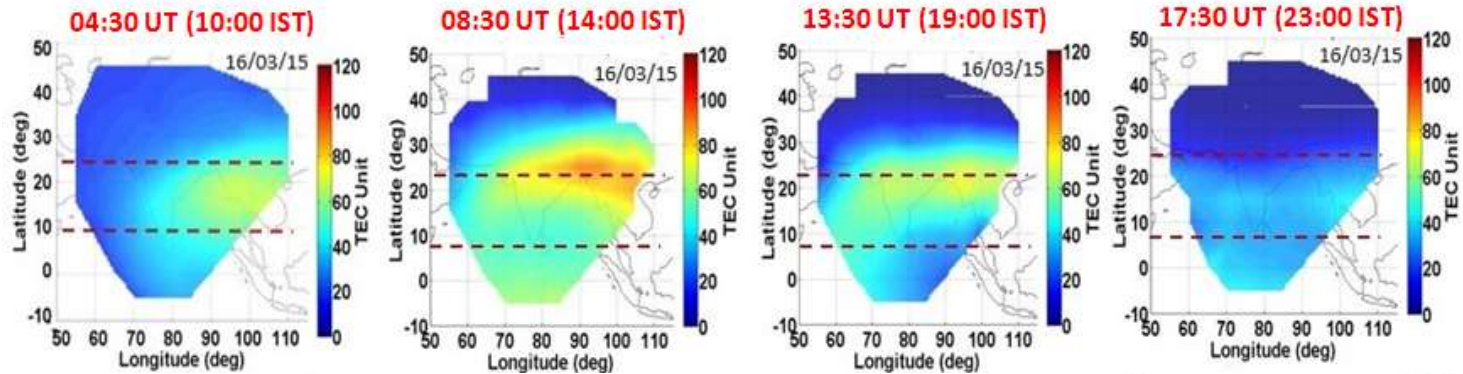
- There are 15 reference stations under SBAS-GAGAN.
- A unique iono model was developed for GAGAN to broadcast the vertical delay (GIVD) at IGPs.
- GAGAN is broadcasting the ionospheric corrections over 102 (IGP) ionospheric grid points (5° Lat x 5° Long) through Geostationary satellites.

→ A very simplistic and novel approach as suggested by Sunda et al., [2015] has been used to generate the spatio-temporal TEC maps over the Indian region using GAGAN.

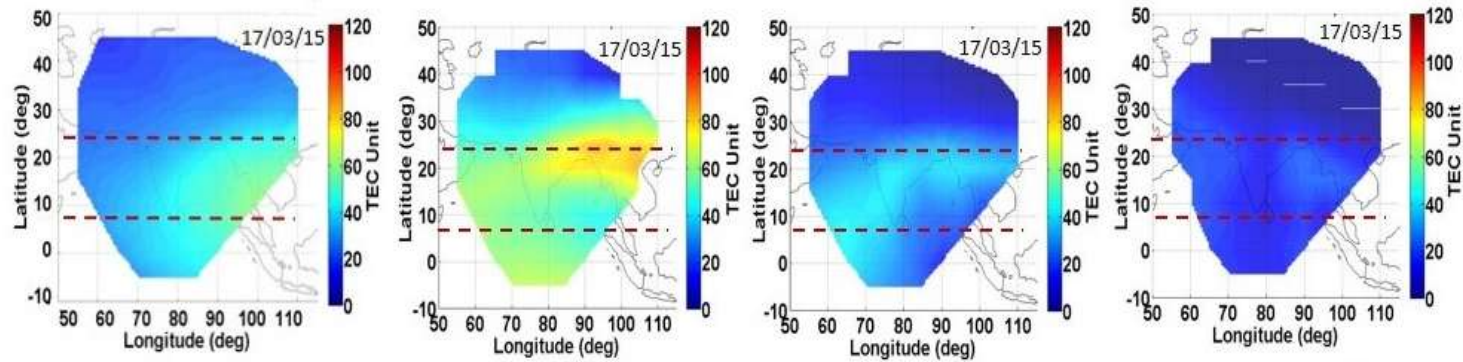


GAGAN generated 2D-TEC Maps

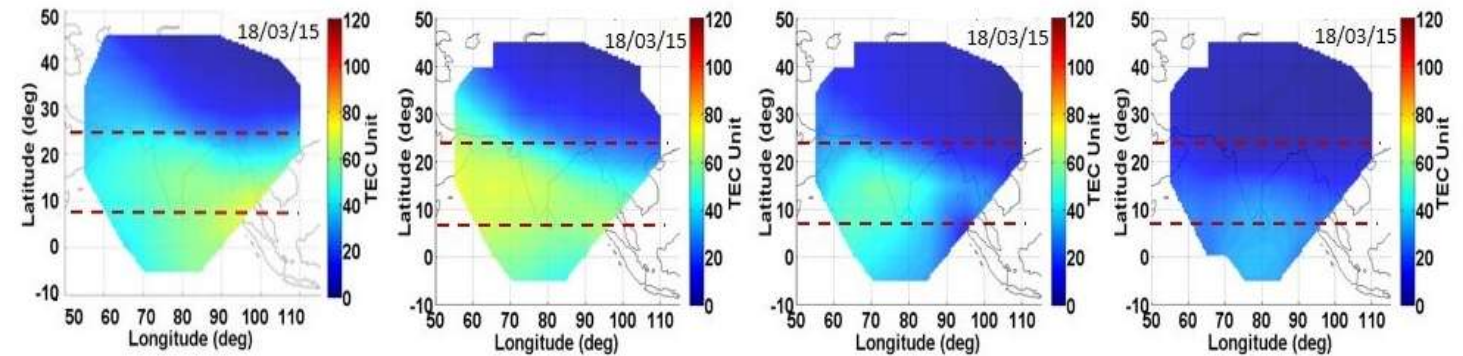
16 March 2015 →
Quiet Day



17 March 2015 →
Geomagnetic storm day



18 March 2015 →
Recovery day



Dataset

Indian Space Weather Ionospheric Monitoring stations



GPS measurements

Trivandrum

(8.5°N, 77.1°E, 0.5°N)

Bengaluru

(12.9°N, 77.6°E, 4.1°N)

Ionosonde measurements over Trivandrum:

foF2: F2 region critical frequency

h'F: F-region base height

hmF2: peak electron density height of the F2 region

Vz: Vertical drift

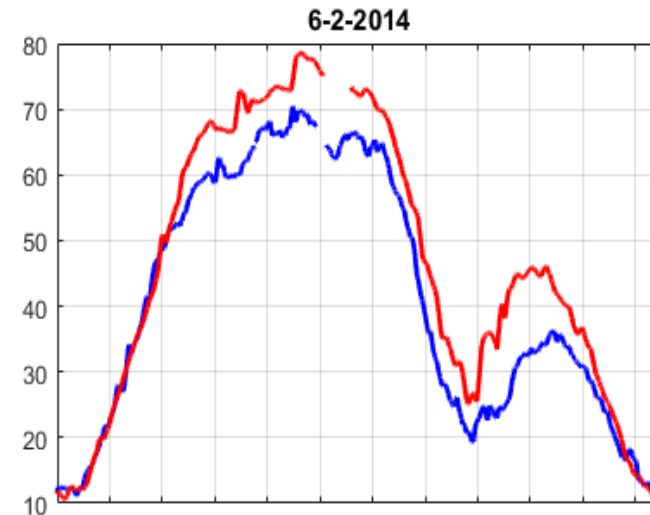
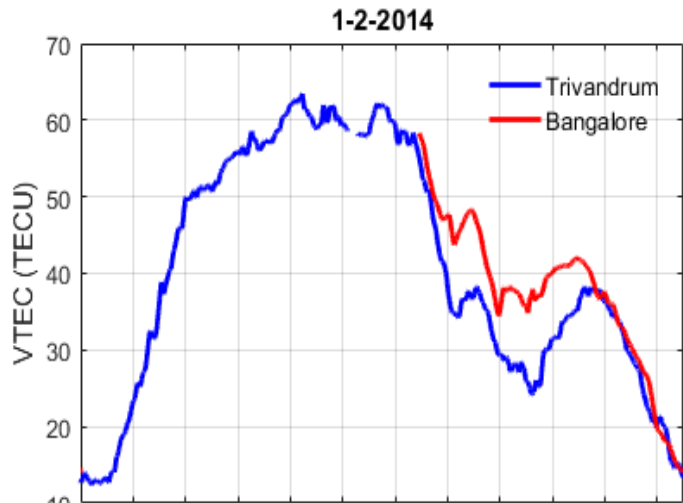
Satellite Based Augmentation System (SBAS):

To study the motion of EIA

Case Study

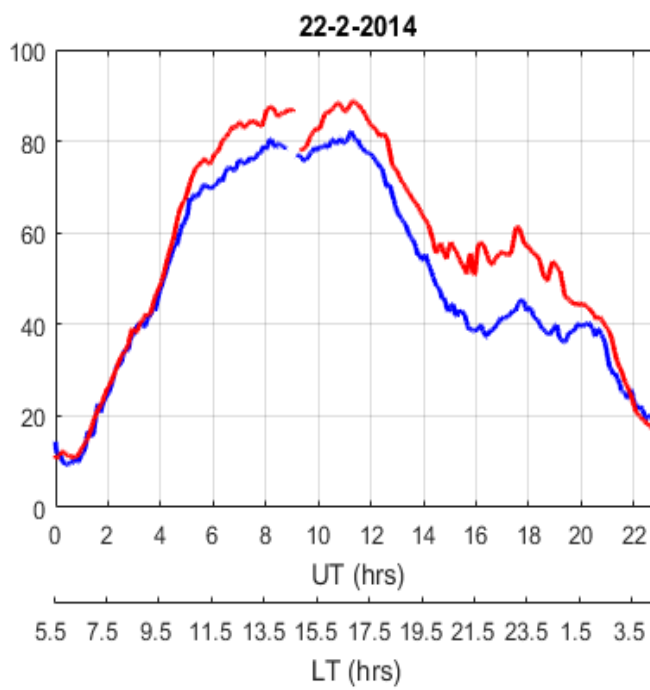
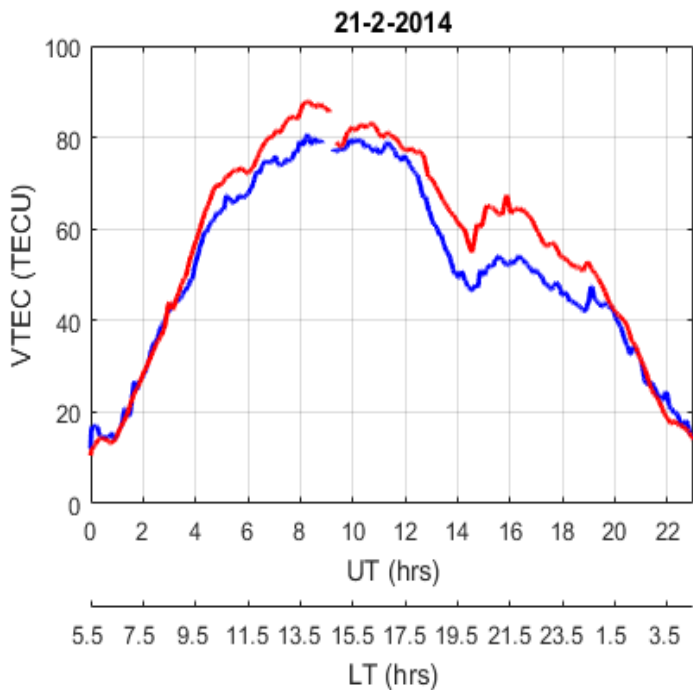
Based on the common availability of the dataset

Typical Examples of INE



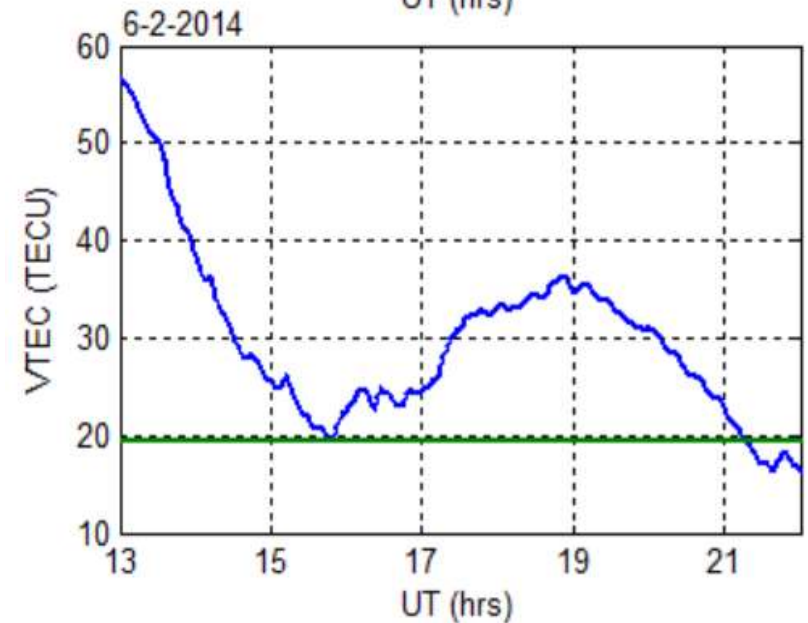
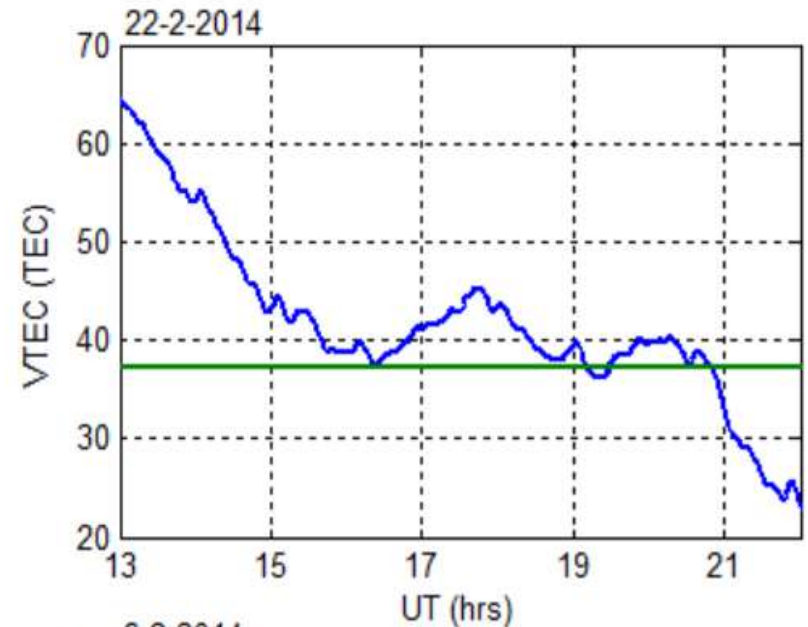
Trivandrum
(8.5°N, 77.1°E, 0.5°N)

Bangalore
(12.9°N, 77.6°E, 4.1°N)

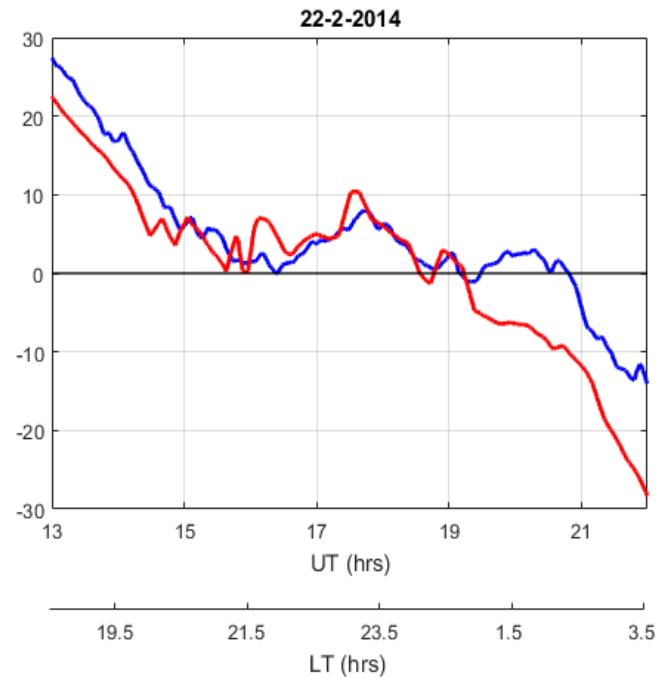
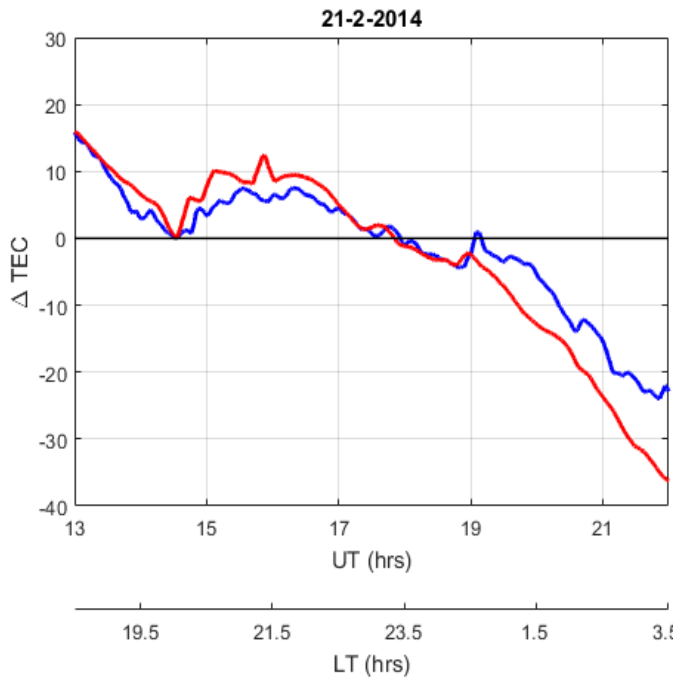
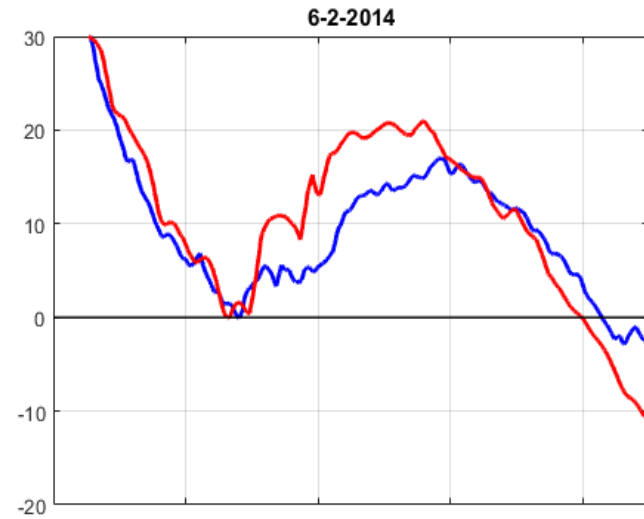
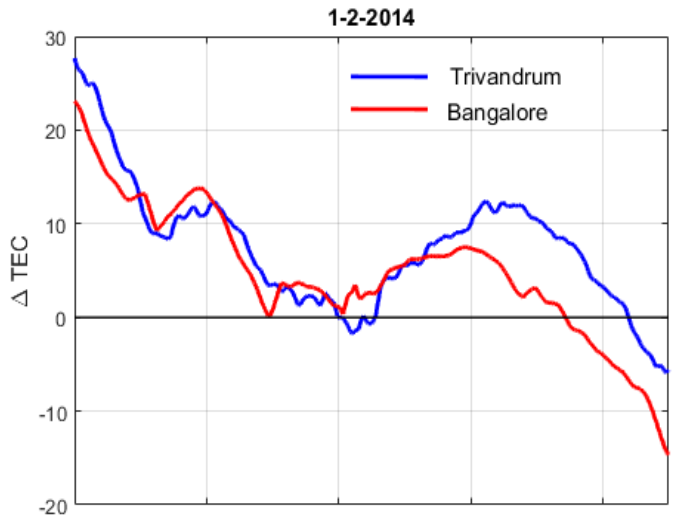


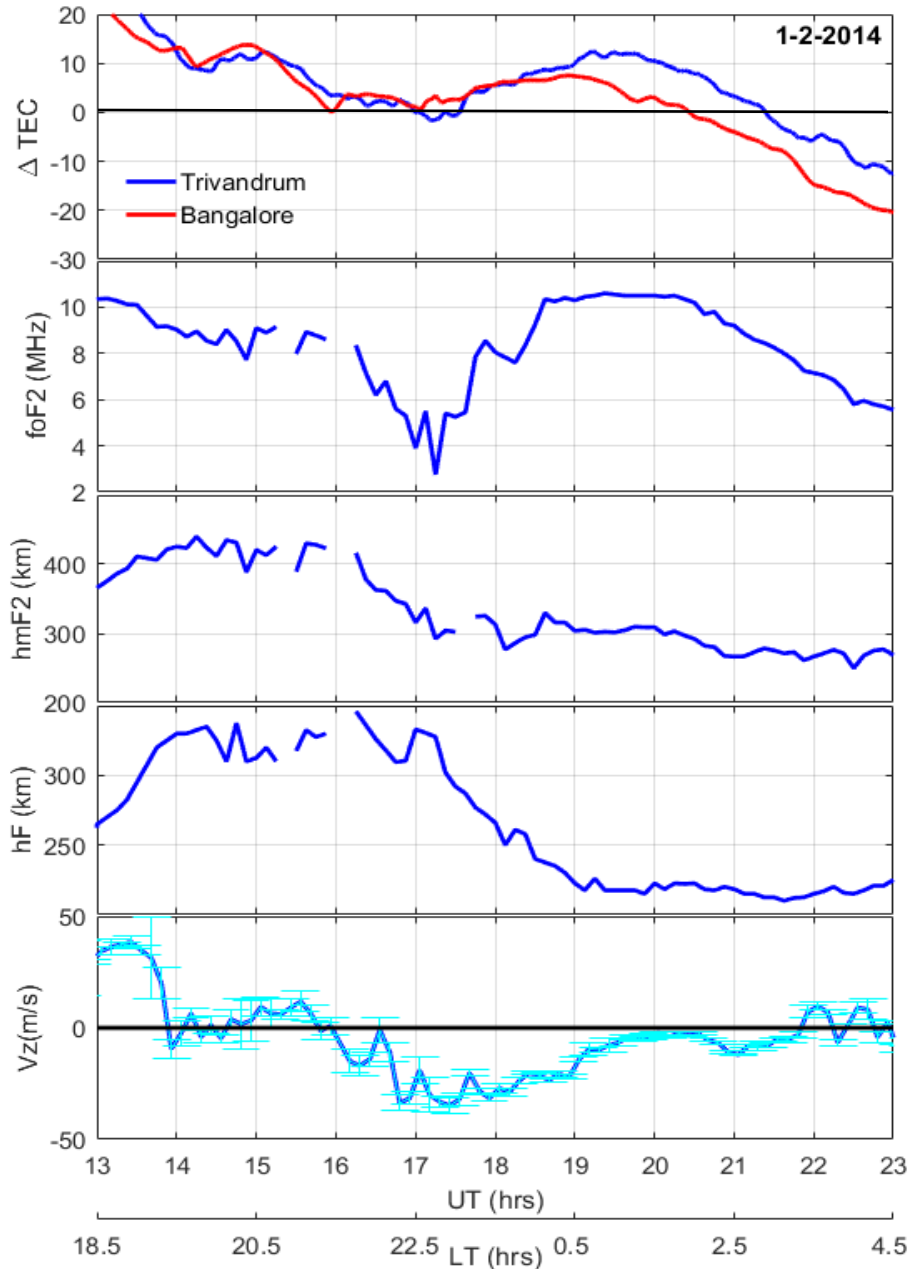
Night-time Enhancement Event Identification

- The preceding minimum of electron densities after sunset has been chosen as the reference to quantify the nighttime enhancement.
- The TEC values are subtracted from this reference level.



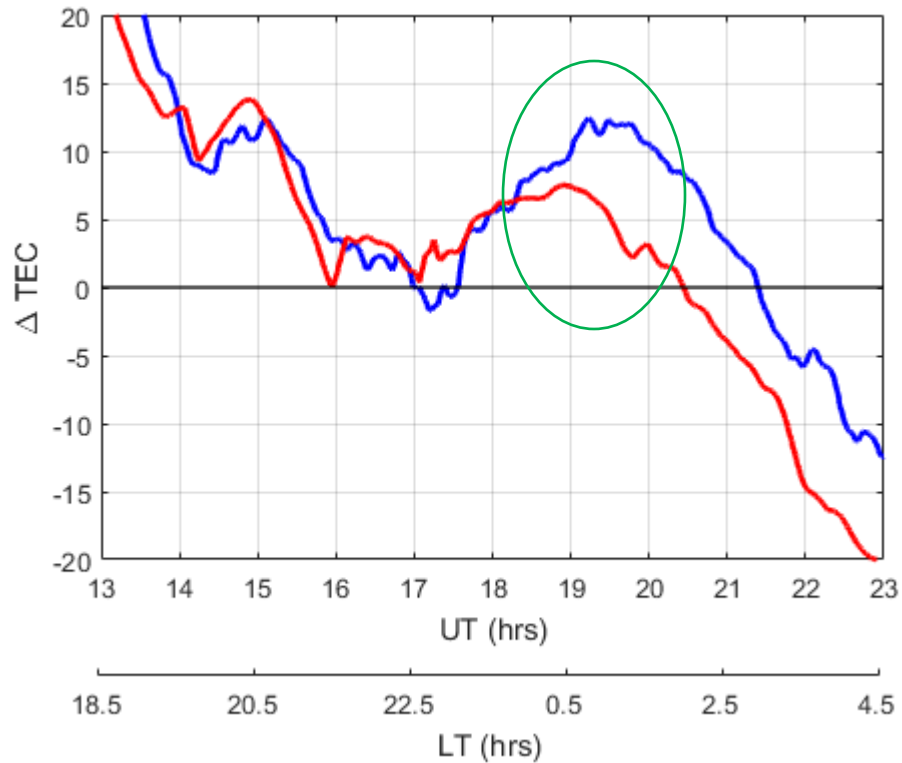
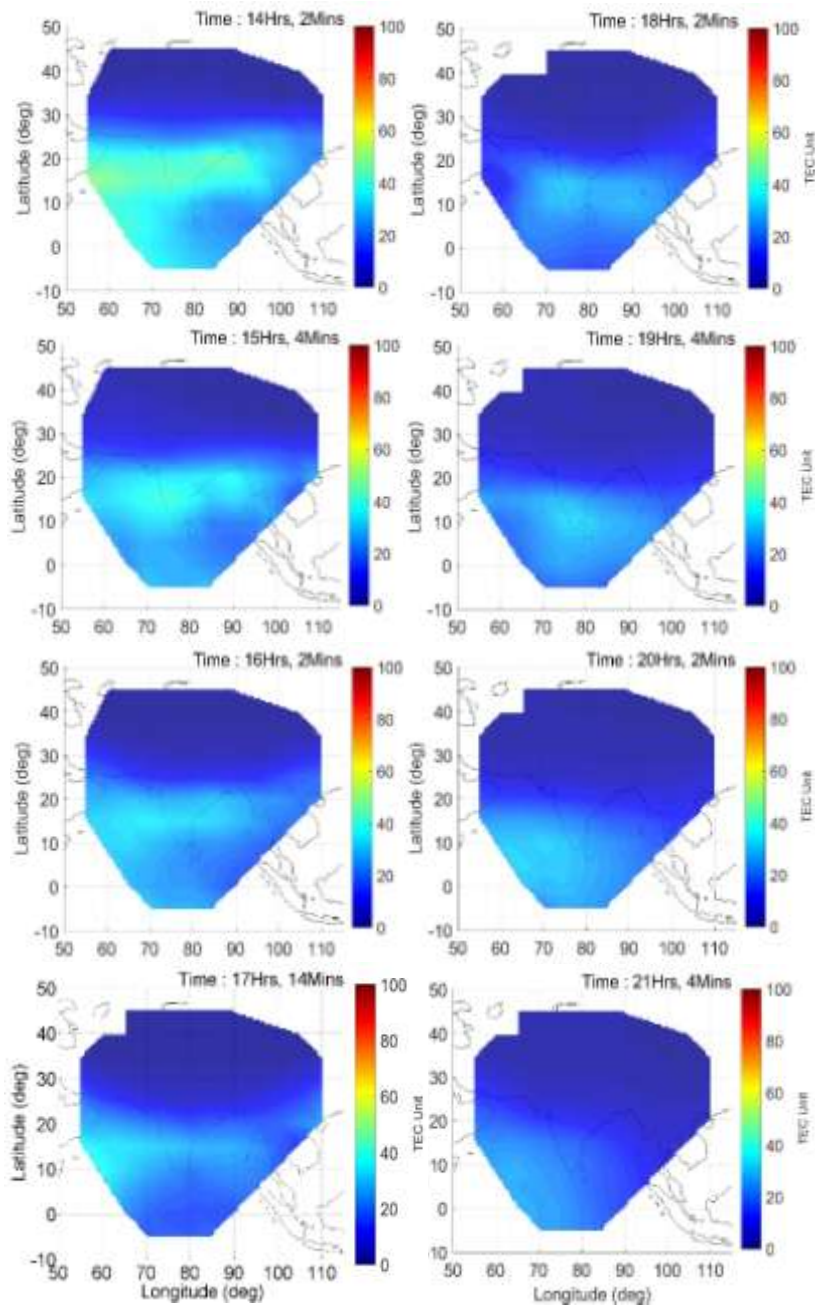
Typical Examples of INE



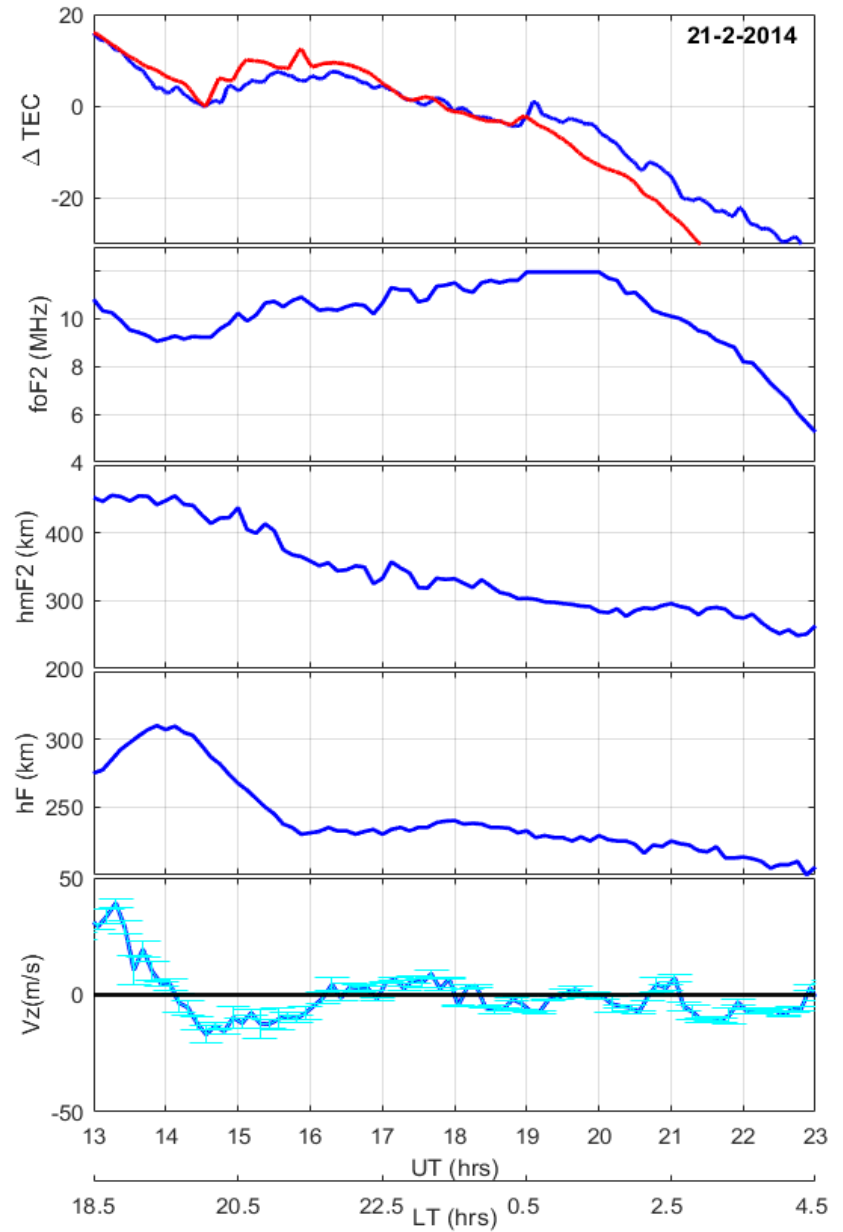
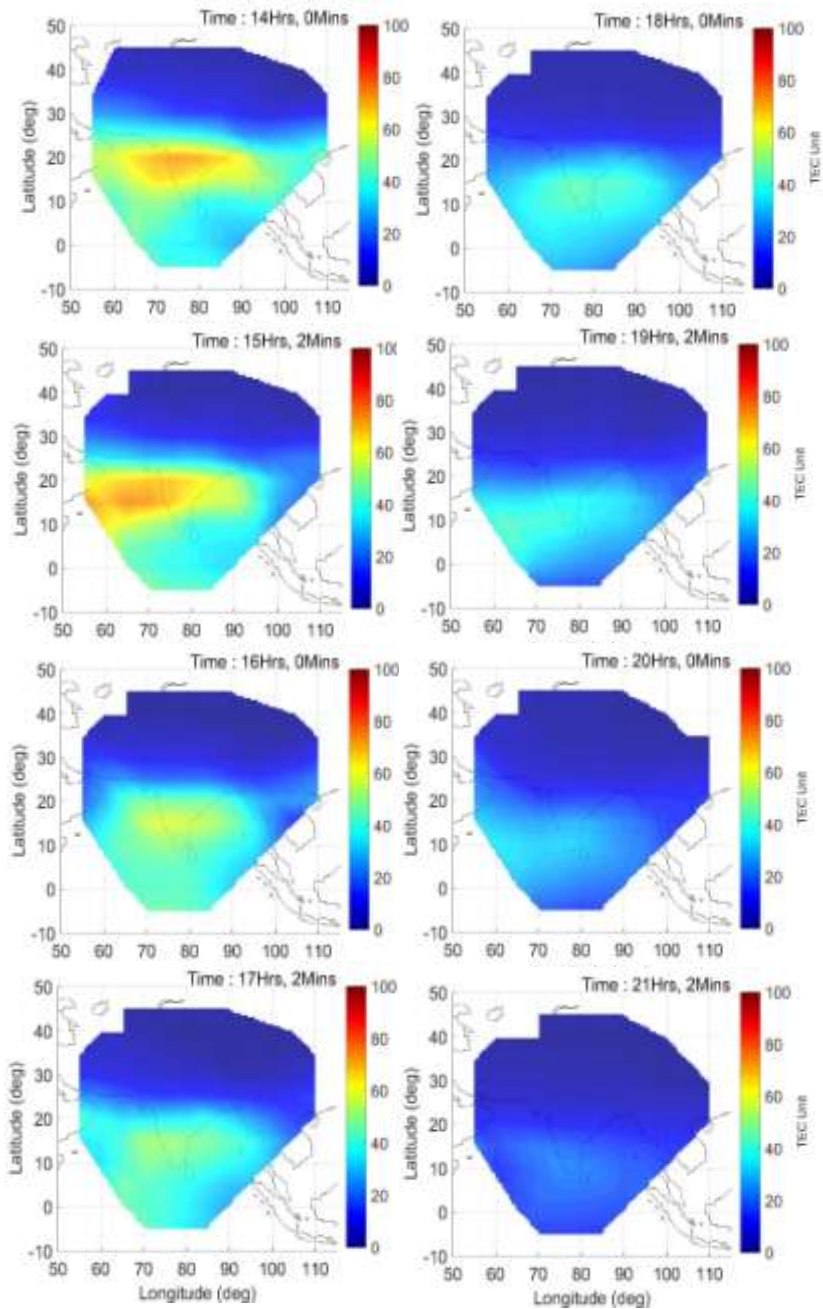


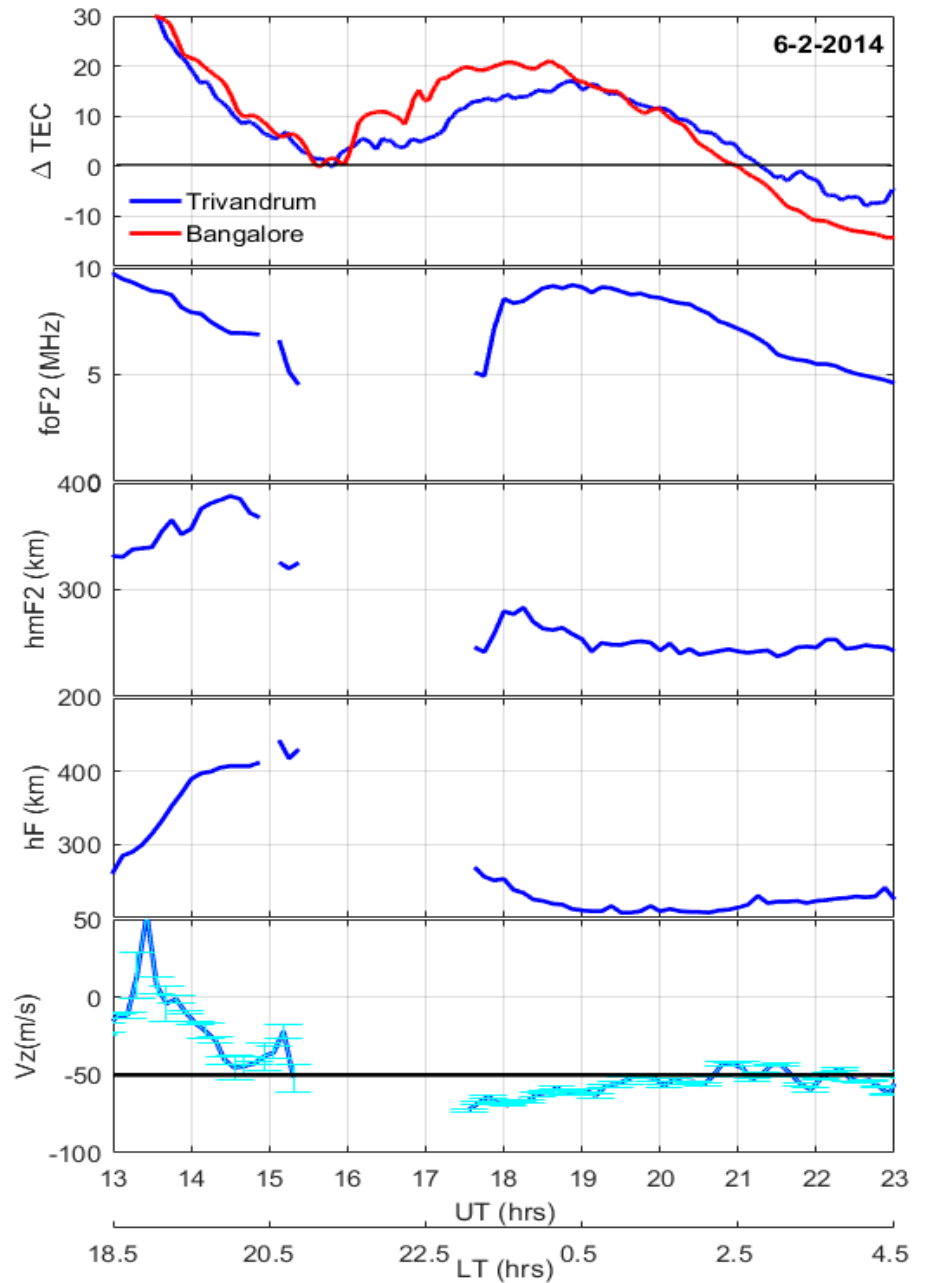
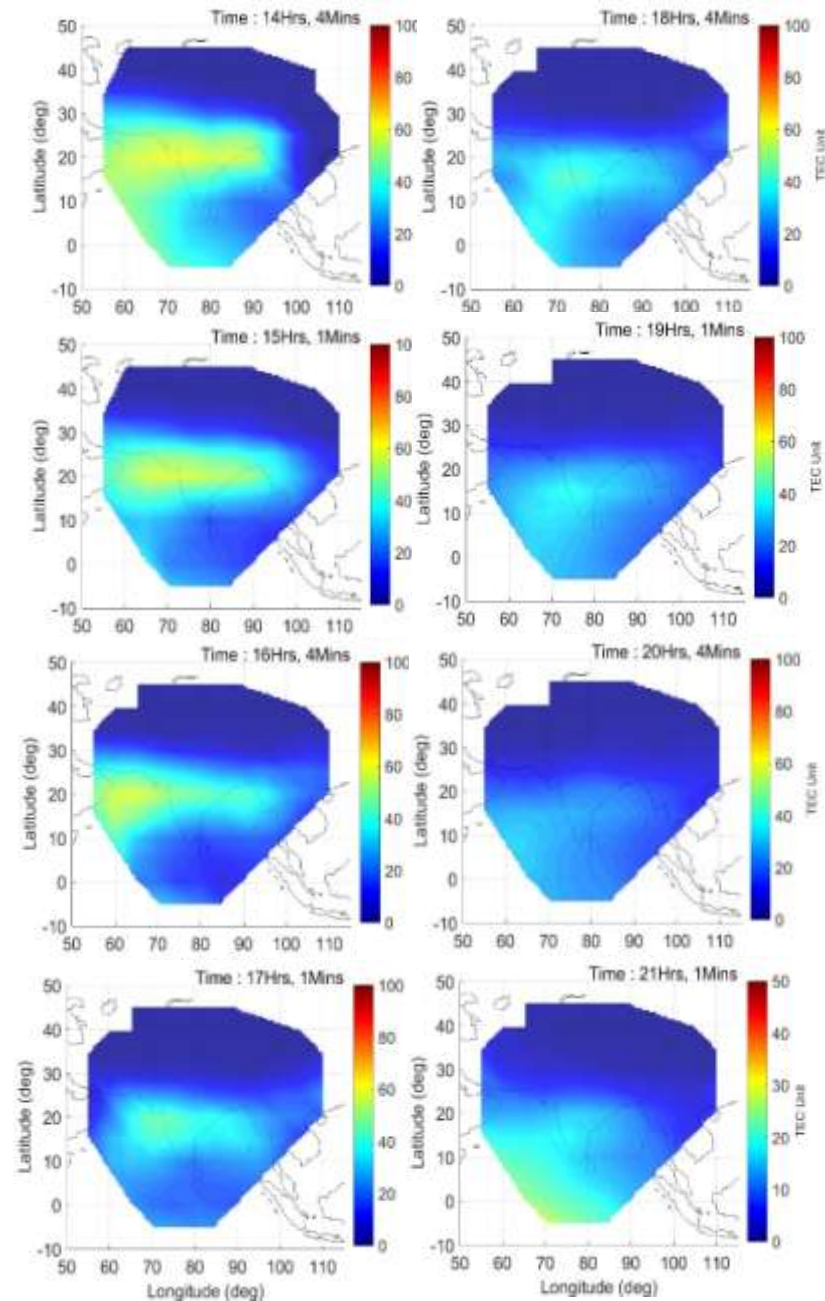
- The two humps in the Δ TEC values over both the station is well discernible from the figure.
- The enhancement in the postmidnight Δ TEC values appears first over Bangalore and then over Trivandrum.
- The vertical drift remains westward from \sim 16 to 19 UT with a maximum value of -25m/s.

Motion of EIA during Night-time over the Indian longitudes

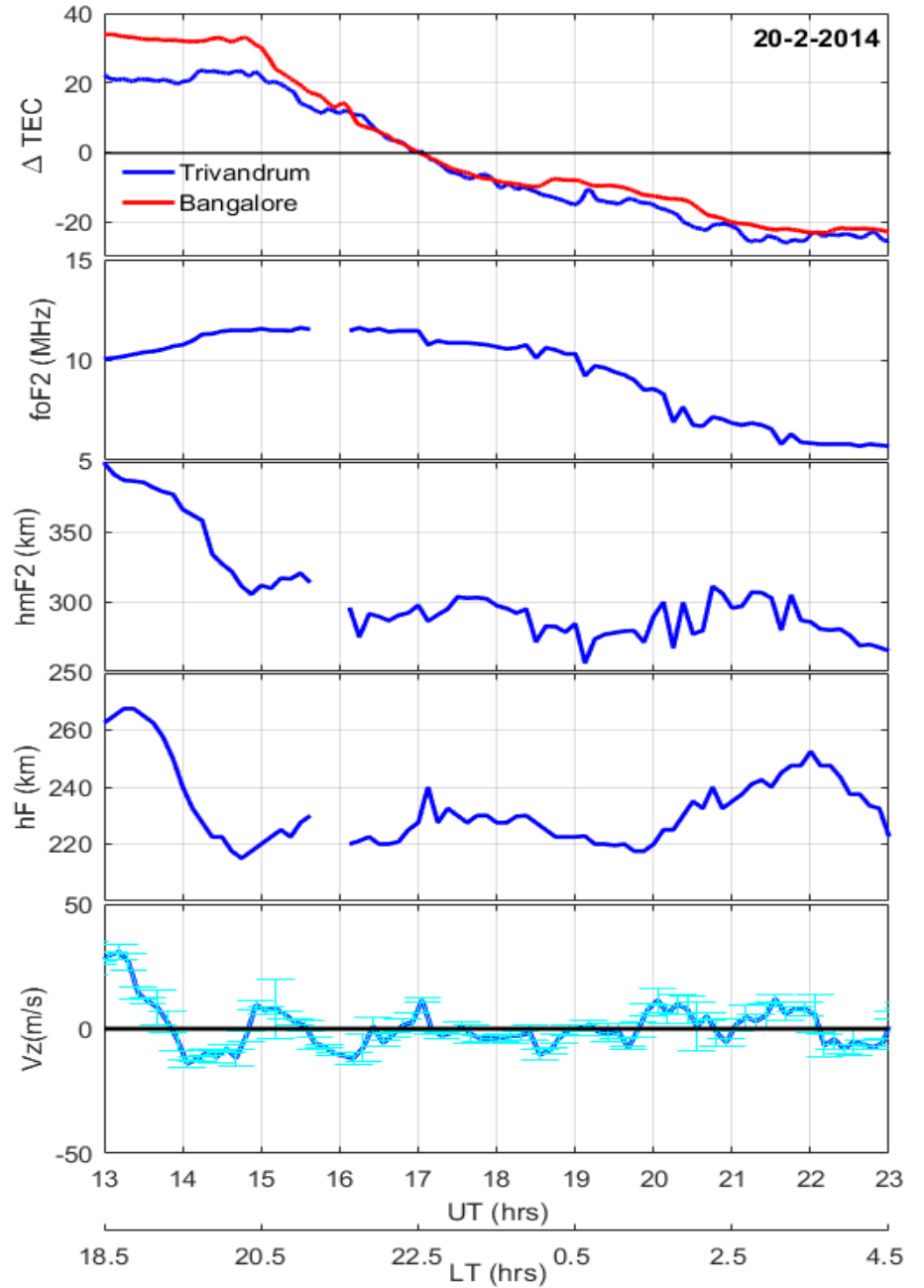
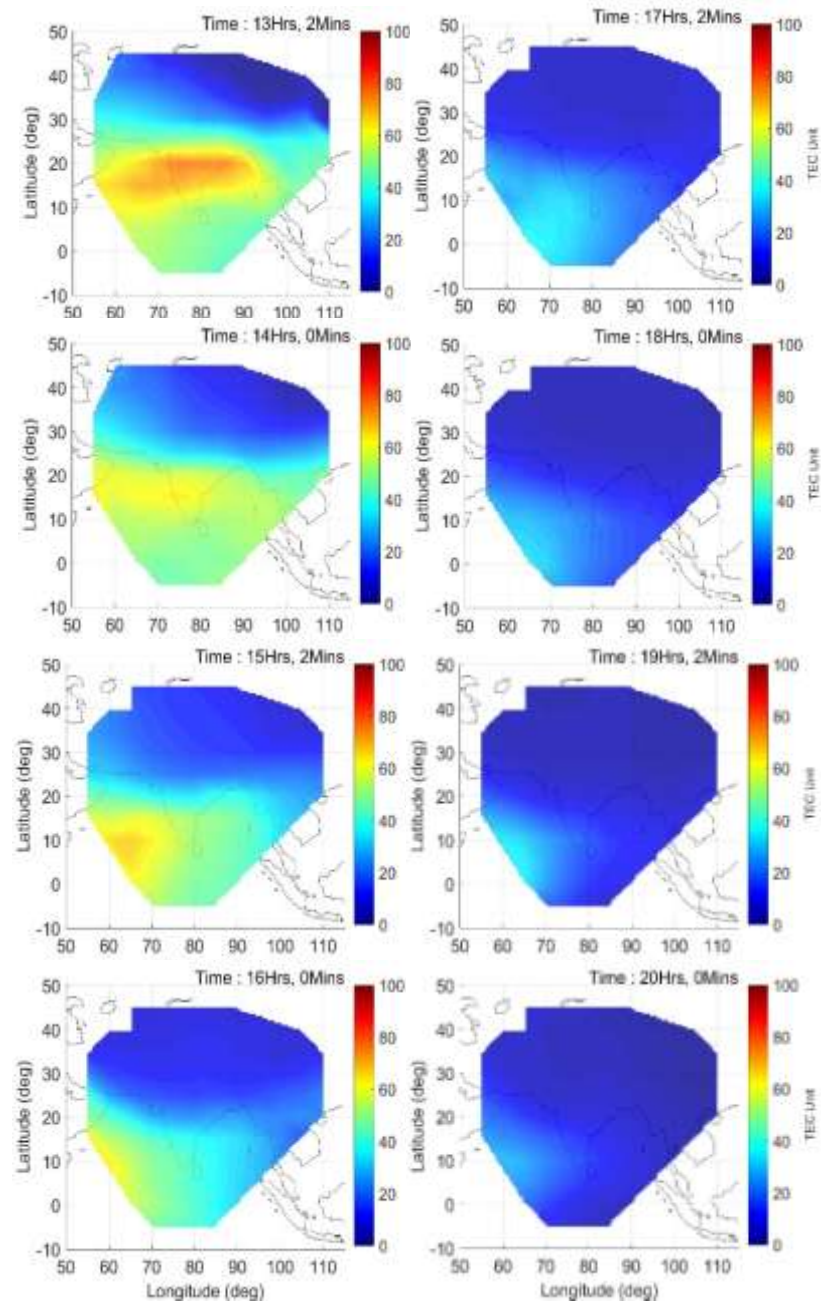


CASE2: 21 Feb 2014

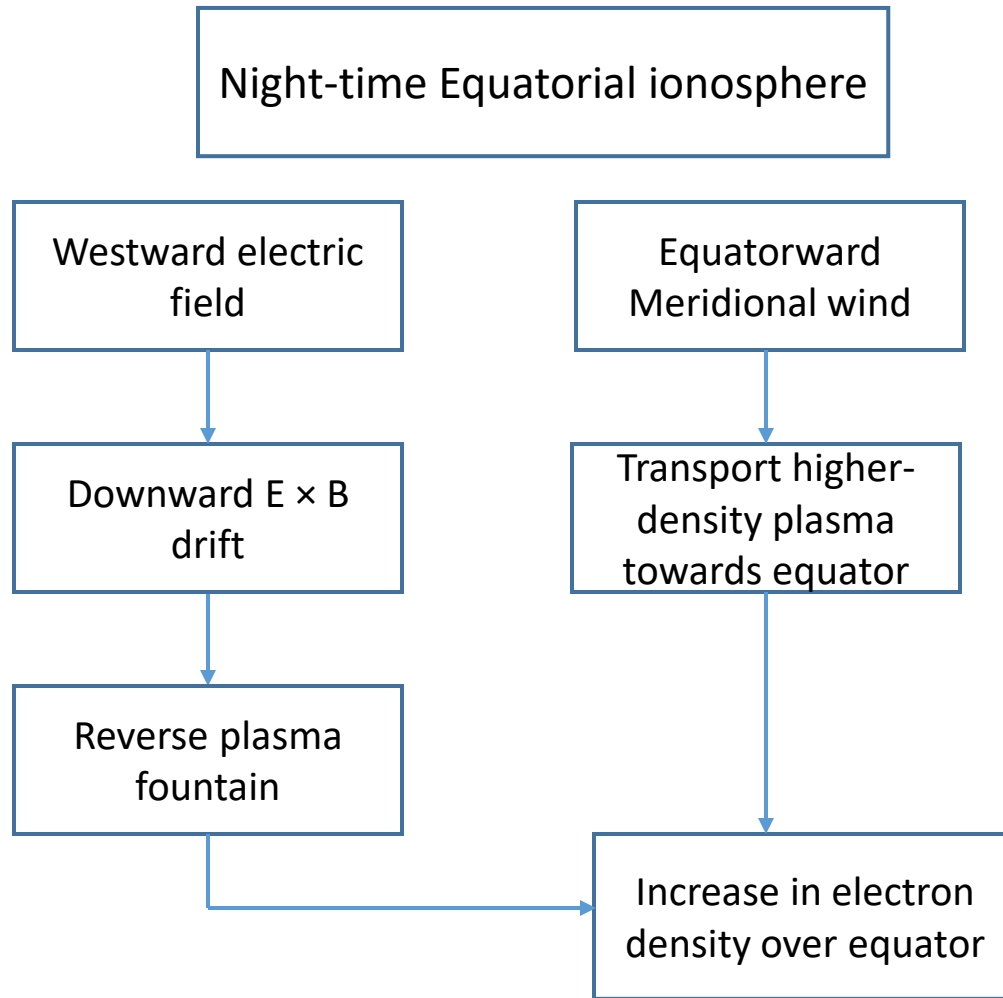




CASE5: 20 Feb 2014



Mechanism responsible for INE



Summary

- The GAGAN (Indian SBAS) generated maps are effective in studying in the reverse fountain effect.
- Results enable visualizing the association of mid-night enhancement in the electron density over the equatorial region with the reverse fountain effect.
- Results suggests that the combined effect of downward $E \times B$ plasma drift due to westward electric field and equatorward meridional at night are the main driving force for the nighttime enhancement over equatorial regions.

Thank You !