Ionospheric response to the 17-18 March 2015 geomagnetic storm

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Abstract

The ionospheric response to the strongest (Sym-H~-234 nT) geomagnetic storm of 17-18 March 2015 in the 24th solar cycle so far have been presented. The TEC data derived from GPS measurement over Dibrugarh (27.4°N, 95°E), Kohima (25.6°N, 94.1°E) and Ahmedabad (23.0°N, 72.5°E) is used to examine the signature of storm around the low-mid latitude ionosphere in the Indian longitude sector. Almost similar TEC variation has been observed over Dibrugarh and Kohima. The maximum TEC on 18 March over Dibrugarh and Kohima is reduced by ~80% compared to that on geomagnetically quiet day. On the otherhand ~30% reduction in TEC is observed from ~72°E longitude (Ahmedabad) during 17-18 March 2015 storm in comparison to the quiet day averaged TEC. The NmF_2 obtained from a chain of Ionosonde measurements along ~95-100°E longitude showed reduced electron density variation in low-mid latitude of both the hemisphere and strong enhancement over near equatorial station on 18 March. The observed electron density variation along 95-100°E longitude sector will be discussed in terms of electrodynamics and neutral dynamics.

Key words: TEC, NmF_2, Geomagnetic storm

Introduction

Geomagnetic storm is characterized by the increased energy as well as momentum deposition over high latitudes due to the particle precipitation, Joule heating and the convection electric fields, these enhancements, subsequently, can couple to equatorial and low latitude ionosphere and may cause significant changes in the plasma density re-distribution and drift motions in those regions. The ionospheric response to the geomagnetic storm of 17-18 March 2015 has very recently reported by a number of authors e.g., [1], [3] and [4]. Hemispheric asymmetry in the ionospheric response due to offset between the geographic and magnetic poles and composition changes of the St. Patrick's day 2015 storm is explained by [1]. The suppression of EIA on the subsequent day of the 17 March storm caused by the complex role of disturbance dynamo electric field along Indian longitude sector is reported by [3]. [4] presented the enhancement of duskside equatorial zonal electric field in terms of large gradient in E region conductivity across the sunset terminator at low latitudes. However the storm time effects over northern edge of EIA crest along 95°E have not been addressed extensively. As each geomagnetic storm have its individual unique characteristics with different geographic locations. The effects of electro dynamical/neutral dynamical and compositional changes for strong geomagnetic disturbance condition will be discussed during 17-18 March 2015. The present exercise is a modest attempt to address the low-mid latitude ionospheric electron density variations along 95-100°E sector derived using ground based Ionosonde and GPS observations during 17-18 March 2015 which is the strongest (Sym-H~-234 nT) geomagnetic storm in the 24th solar cycle so far. The results are presented and discussed in the subsequent sections.

Data

VTEC observations from GPS measurement using GNSS receiver at Dibrugarh (27.5°N, 95°E; MLAT 17.06°N) and Kohima (25.6°N, 94.1°E; MLAT 15.02°N) and GSV4004B receiver at Ahmedabad (23.02°N, 72.51°E; MLAT 14.63°N) are considered to investigate the response of low-mid latitude ionosphere during the storm of 17-18 March 2015. The procedure used to estimate the TEC is explained in [2]. The VTEC (here after TEC) data from all the visible satellites with elevation mask of 50° has been considered for reduced multipath effect. In addition to TEC, the hourly averaged NmF_2 from Canadian Advanced Digital Ionosonde (CADI) over Dibrugarh and Cocos Island (12.2°S, 96.8°E; MLAT 23°S) which is considered to be magnetically conjugate of Dibrugarh are presented. The NmF_2 datas for Chumphon (10.7°N, 99.3°E; MLAT 3°N), Chiang Mai (18.7°N, 98.9°E; MLAT 12.7°N) and Kototabang (0.2°S, 100.3°E; MLAT 10.1°S) are obtained from SEALION (South East Asia Low Latitude Ionosphere Observation Network).

Results and Discussion

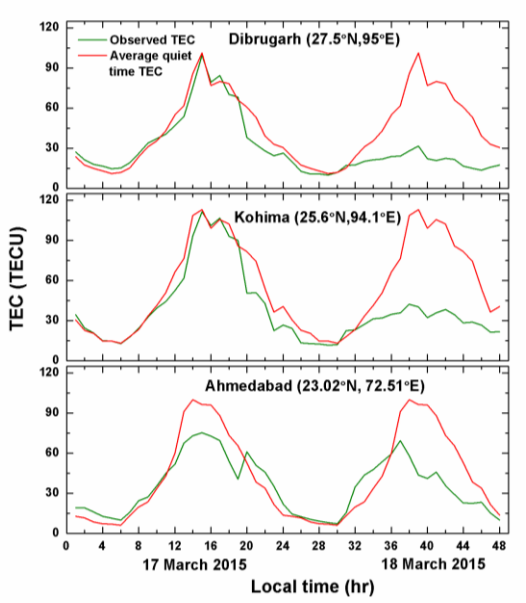

Figure 1. Variations of TEC measured by ground based GPS measurements in Dibrugarh, Kohima and Ahmedabad during 17-18 March 2015 storm (Green curves). As a quiet time reference, averaged five days before the storm is considered (Red curves).

Figure 1 presents the TEC variation from GPS measurement at Dibrugarh (27.5°N, 95°E; MLAT 17.06°N), Kohima (25.6°N, 94.1°E; MLAT 15.02°N) and Ahmedabad (23.02°N, 72.51°E; MLAT 14.63°N). A strong reduction in TEC ~70 TECU in comparison to averaged quiet day TEC is observed over Dibrugarh on 18 March. TEC showed almost similar range of reduction on 18 March over Kohima which is situated just 2°×2° difference from Dibrugarh. In contrast, at Ahmedabad TEC variation on 18 March is not so much different from the previous day of 17 March. The observed TEC on both days of 17-18 March is reduced by 30% in comarision to the averaged quiet day TEC. Reduction in TEC (~50%) over Lucknow (26.85°N, 80.92°E; MLAT 17.69°N) is also reported by [3]. But, uniquely ~80% reduction is observed over almost same latitudinal station Dibrugarh. This observed significant longitudinal variation may be because of the combined effect of the storm time disturbance dynamo electric field and thermospheric neutral wind effect. Simultaneous variation of NmF_2 along 95-100°E longitude sector is shown in Figure 2. Reduction in electron density is observed over low-mid latitude stations Dibrugarh, Chiang Mai and Cocos Island on 18 March. In contrast, enhancement of electron density is observed on 18 March in comparison to the quiet time averaged value over near equatorial stations Chumphon and Kototabang. This unique behaviour of electron density may be due to the suppression of EIA during storm time.

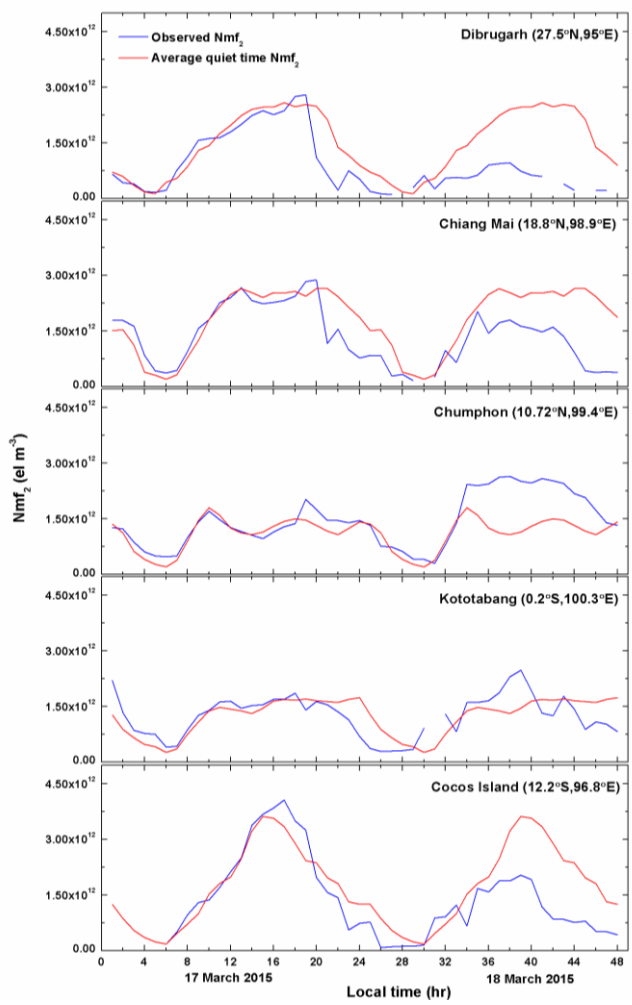

Figure 2. Variations of NmF_2 measured by the ground-based ionosondes along 95-100°E longitude sector during 17-18 March 2015 storm (Blue curves). The quiet time value represented by blue curve, averaged Nmf_2 before five days of the storm.

References

[1] Astafyeva E., Zakharenkova I. Förster M., (2015). Ionospheric response to the 2015 St. Patrick's Day storm: A global multi-instrumental overview, Journal of Geophysical Research, Space Physics, doi: 10.1002/2015JA021629.

[2] Bhuyan, P.K., Hazarika, R., (2013). GPS TEC near the crest of the EIA at 95°E during the ascending half of solar cycle 24 and comparison with IRI simulations. Adv. Space Res. 52, 1247–1260.

[3] Singh R., Sripathi S., Sreekumar S., Banola S., Emperumal K., Tiwari P., Kumar S., (2015). Low latitude ionosphere response to super geomagnetic storm of 17/18 March 2015: Results from a chain of ground based observations over Indian sector, Journal of Geophysical Research, Space Physics, doi:10.1002/2015JA021509**.**

[4] Tulasi Ram S., Yokoyama T., Otsuka Y., Shiokawa K., Sripathi S., Veenadhari B., Heelis R., Ajith K. K., Gowtam V. S., Gurubaran S., Supnithi P., Le Huy M., (2015). Duskside enhancement of equatorial zonal electric field response to convection electric fields during the St. Patrick's Day storm on 17March 2015, Journal of Geophysical Research, Space Physics, dio: 10.1002/2015JA021932.