Generation of nighttime medium-scale traveling ionospheric disturbance during geomagnetic storms and its characteristic variations caused by substorms

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Aim & purpose of the visit

The ongoing work here focuses on the investigation of nighttime medium-scale traveling ionospheric disturbance (MSTID) generated during geomagnetic storms over mid-latitudes. Previously, only a few studies reported observations of nighttime MSTIDs during geomagnetic storms over mid and high latitudes (Kelley et al., 2023; Liu et al., 2020; Nishioka et al., 2009; Zhang et al., 2019, 2022). The present work conducted investigations of an atypically aligned (northeast-southwest) MSTID observed on 17 March 2003 during the recovery phase of a moderate geomagnetic storm. The alignment of the observed MSTID was unusual compared to typical nighttime MSTIDs during geomagnetic quiet nights and has not been observed in the previously reported studies. Effects of substorm-induced electric fields on the observed MSTIDs were also investigated.

Datasets used

Primarily, detrended total electron content (DTEC) maps have been used to study spatiotemporal evolution of TEC perturbations caused by MSTID on 17 March 2003. TEC data are obtained from over 1000 dual-frequency (1.57542 and 1.22760 GHz) GPS receivers in Japan operated by the Geospatial Information Authority of Japan. Different ionospheric parameters were obtained from ionosonde stations, Wakkanai (45.39°N, 141.69°E), Kokubunji (35.71°N, 139.49°E), Yamagawa (31.20°N, 130.62°E), and Okinawa (26.68°N, 128.16°E) which are located in Japanese sector. Data from a geomagnetic conjugate ionosonde station, Townsville (19.3°S, 146.7°E), Australia were also utilized in this study. Additionally, cross-track wind data of CHAMP and vertical ion drift measurements by ROCSAT-1 were utilized to examine the background thermospheric wind and vertical ion drifts, respectively.

Results

Atypically aligned MSTID observed during the recovery phase of a storm

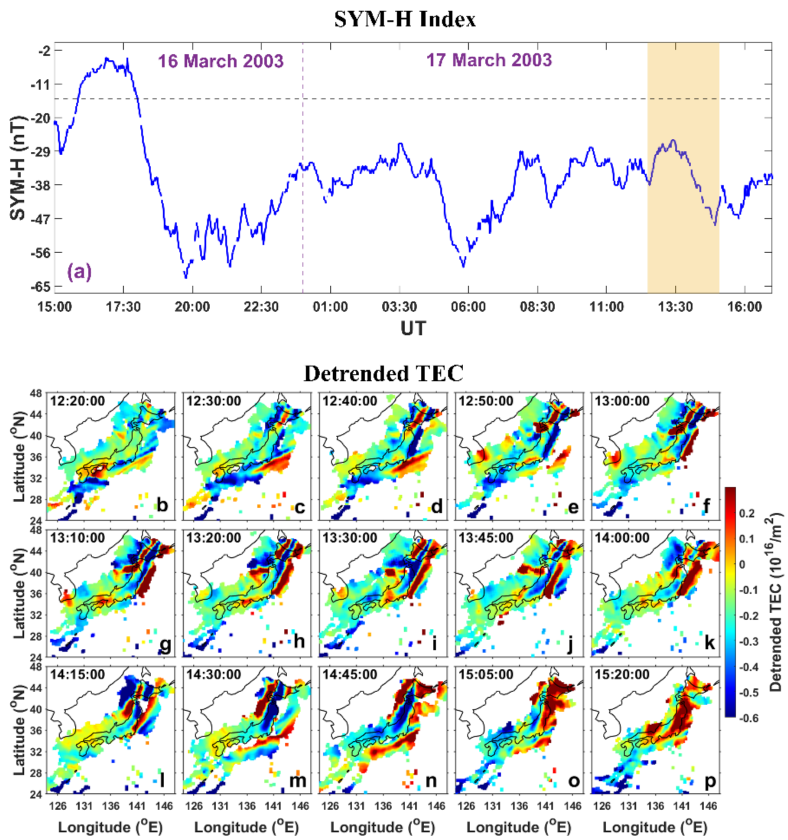

Figure 1: (a) SYM-H values during 16-17 March 2003. (b-p) DTEC maps over Japan on 17 March 2003. Shaded area in (a) represents the duration of MSTID perturbation observation.

Figure 1a denotes the symmetric-horizontal index (SYM-H) index during 16-17 March 2003. The signature of a moderate geomagnetic storm on 16 March was evident from a decrease in SYM-H values. Figures 1b-p represent the DTEC maps on 17 March. TEC perturbations caused by MSTID with the northeast-southwest alignment of the wavefronts were evident from Figures 1c-o. MSTID was observed during the recovery phase of the storm, and the duration is indicated by the shaded area in Figure 1a.

Variations of MSTID amplitudes by substorm-induced electric fields

CHAMP wind data showed that before MSTID observation, the neutral wind had strong eastward components at all latitudes with significantly smaller southward (northward) meridional components at latitudes higher (lower) than 31°N (Figure 2a). During the MSTID observation, the zonal wind turned westward with minimal southward component around the latitudes of MSTID observation (Figure 2b).

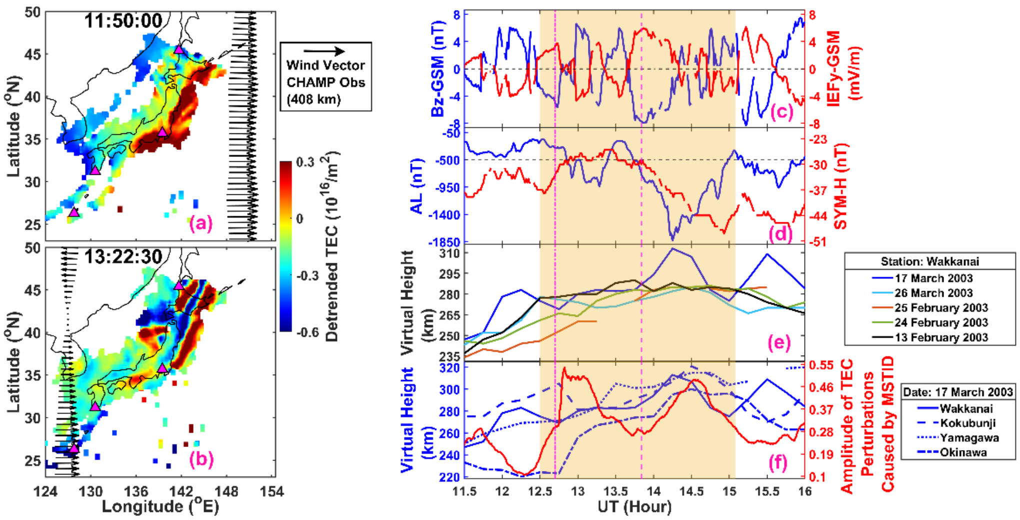

Figure 2: (a-b) Arrows over DTEC maps represent wind direction measured by CHAMP. Temporal variations of (c) IMF-Bz (blue) and IEFy (red), (d) AL (blue) and SYM-H (red), (e) h'F from Wakkanai on 17 March (blue), 23, 24, and 25 February (cyan, orange, & green), and 26 March 2003 (black), (f) h'F from Wakkanai (solid), Kokubunji (dashed), Yamagawa (dotted), & Okinawa (dashed-dotted), and MSTID perturbations amplitude (red-solid), respectively. Triangles in (a-b) & vertical lines and shaded area on (c-f) represent the locations of four ionosondes & onset times of two substorms and duration of MSTID observation, respectively.

During the expansion and recovery phases of the second substorm, h'F at Wakkanai on 17 March significantly enhanced and decreased, respectively, compared to other quiet nights (Figures 2d-e). Additionally, h'F at four stations and TEC perturbations amplitude caused by MSTID showed enhancement and decrement concurrently during the expansion and recovery phases of the substorm (Figures 2f).

References

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