# Climatological study of GPS total electron content variations caused by medium-scale traveling ionospheric disturbances

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**Introduction**

Medium-scale traveling ionospheric disturbances (MSTIDs) are phenomena of the electron density perturbations in the ionosphere with horizontal scale sizes of 100–500 km (e.g., Hunsucker [1982] for a review). From the observational results, MSTIDs have been thought to be caused by atmospheric gravity waves [Hines, 1960]. Since the latter half of the 1990s, the Global Positioning System (GPS) has been used to measure the total electron content (TEC) along a ray path between the satellite and the receiver. In this paper, we report a statistical study of MSTIDs using GPS-TEC data obtained at different longitudes and latitudes. Most of this study have been reported by Kotake *et al.* [2006].

**Data and Method of Analysis**

Using global positioning system (GPS) data taken from the International GNSS Service (IGS), we investigated total electron content (TEC) perturbations associated with MSTIDs. We analyzed TEC data taken from four or five GPS receivers in each of six regions (Japan, Europe, eastern United States, western United States, Australia, and South America) in 3 years (1998, 2000, and 2001). To derive perturbation components of TEC (I'), we subtracted the 1-hour running average form the time sequence of TEC for each satellite–receiver pair. Standard deviation of I' within 1 hour, dI, was calculated every hour, and MSTIDs activity were defined as $dI/I_0$ , where $I_0$ is the 1-hour average of absolute vertical TEC.

**Results and Discussion**

We have statistically investigated TEC variations observed by GPS receivers in six regions (Japan, Europe, eastern and western United States, Australia, and South America) at midlatitudes in 3 years (1998, 2000, and 2001) to reveal local time, seasonal, longitudinal, and latitudinal variations of MSTIDs activity. The results can be summarized as follows.

1. The difference between MSTID activity during daytime and nighttime can be seen with respect to their seasonal, solar activity, longitudinal, and latitudinal dependences.
2. Daytime MSTID activity is high in winter in all six regions. This result suggests that the daytime MSTIDs are caused by acoustic gravity waves propagating upward from middle atmosphere and that the seasonal variation of daytime MSTIDs occurrence is controlled by the altitude gradient of the neutral temperature near the mesopause. In summer, some gravity waves cannot propagate through the region of the steep temperature gradient near the mesopause.
3. Seasonal variation of the nighttime MSTID activity is coupled with its longitudinal variation. At the Japanese and Australian longitudinal sector, the nighttime MSTIDs are most active near the June solstice, whereas they are most active near the December solstice at the European longitudinal sector. Seasonal variation of the nighttime MSTIDs activity in Japan is almost identical to that in Australia. This result indicates the geomagnetic conjugate occurrence of nighttime MSTIDs.

**Conclusion**

The statistical characteristics of the MSTIDs suggest that the mechanisms causing MSTIDs are different between daytime and nighttime. Daytime MSTIDs could be generated by atmospheric gravity waves in the thermosphere. On the other hand, electro-dynamical forces could play an important role in causing the nighttime MSTIDs.

**REFERENCES**

Hines, C. O. (1960), Internal atmospheric gravity waves at ionospheric heights, Can. J. Phys., 38, 1441– 1481.

Hunsucker, R. (1982), Atomospheric gravity waves generated in the highlatitude ionosphere: A review, Rev. Geophys., 20, 293–315.

Kotake, N., Y. Otsuka, T. Tsugawa, T. Ogawa, and A. Saito (2006), Climatological study of GPS total electron content variations caused by medium-scale traveling ionospheric disturbances, J. Geophys. Res., 111, A04306, doi:10.1029/2005JA011418.