Generating mechanism of Medium-Scale Traveling Ionospheric Disturbance using a GPS network in Alaska

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In our previous study, using global positioning system (GPS) data taken from GPS receivers in Alaska in 2012 and in Northern Europe in 2008, we investigated two-dimensional maps of total electron content (TEC) perturbations with a time resolution of 30-s and a spatial resolution of 80 km80 km in longitude and latitude to disclose statistical characteristics of Medium-Scale Traveling Ionospheric Disturbance (MSTID) at high-latitudes. Based on the statistical characteristics of MSTID at high-latitudes, we have found that the observed MSTIDs are divided into three groups: 1. daytime MSTID occurring in winter in Alaska and Northern Europe, 2. nighttime MSTID occurring in summer in Northern Europe, and 3. dusk MSTID occurring in winter in Alaska. The daytime and nighttime MSTIDs at high-latitudes are consistent with those observed at mid-latitudes in terms of local time dependence of their occurrence rate and propagation direction, but the dusk MSTID has not been observed at mid-latitudes. In this presentation, we focus on the generation mechanisms of the dusk MSTID which occurs in winter in Alaska by investigating whether the MSTID is generated by the same mechanism as those at mid-latitudes, from the view point of electrodynamics and neutral atmosphere dynamics.
At first, we consider the generation mechanisms of MSTIDs from a standpoint of electrodynamics. We find that vertical component of plasma motion is restricted and amplitude of TEC perturbation by $E \times B$ drift is small because magnetic field line is close to vertical at high-latitudes. We discuss the theory that polarization electric fields in sporadic E layer play an important role in generating that MSTID through E- and F-region coupling process. According to this theory, MSTID occurs simultaneously at conjugate points in the northern and southern hemisphere connected by geomagnetic field lines. However, the observational results show that local time dependence of MSTID in Alaska and New Zealand is different. Therefore, we conclude that MSTID observed dusk in winter in Alaska could not be generated by electrodynamics.
Secondly, we research whether the dusk MSTID is generated by atmospheric gravity waves (AGWs) or not. Previous studies suggest that MSTIDs could be caused by AGWs excited by auroral activities. In this study, we have investigated various indicators which could represent auroral activity, such as ROTI (Rate of TEC change Index), AE index and Kp index. We have found that there is no clear correlation between occurrence rate of MSTID and these indices.
To determine the location of the AGW sources, we apply the backward ray tracing method of AGWs. Results of a backward ray tracing analysis show that the AGWs can reach ionosphere from an altitude of 10 km in 24 of 34 events. In a few cases, AGWs traced backward from the ionosphere reach a critical level at an altitude of the stratosphere. This result indicates a possibility that AGWs excited by polar vortex in the stratosphere propagate to the ionosphere and generate the MSTIDs. We need further studies about source region of AGWs to reveal generation mechanisms of MSTIDs at high-latitudes.

Keywords: ionosphere, traveling ionospheric disturbance, GPS

