Statistical analysis of the horizontal phase velocity distribution of mesospheric and ionospheric waves observed in airglow images in Hawaii

*Hideto Naito[1], Kazuo Shiokawa[1], Yuichi Otsuka[1], Takeshi Sakanoi[2], Akinori Saito[3], Takuji Nakamura[4]

1. Institute for Space-Earth Environmental Research, Nagoya University, 2. Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University, 3. Department of Geophysics, Graduate school of science, Kyoto University, 4. National Institute of Polar Research

Matsuda et al. [JGR, 2014] proposed a method of deriving the horizontal phase velocity and propagation direction of the power spectral density of waves found in images using three-dimensional fast Fourier transform. Takeo et al. [JGR, 2017] and Tsuchiya et al. [JGR, 2018] applied this method to the airglow images obtained at Shigaraki and Rikubetsu, Japan, and reported 16-year variability of atmospheric waves at middle latitudes. However, there is no report using this method for analyzing airglow images obtained at low latitudes near the equator. In this study, we applied the analysis method of Matsuda et al. [2014] to airglow images obtained at wavelengths of 557.7 and 630.0 nm during the three years from 2013 to 2016 at Haleakala (20.7°N, 203.7°E) in Hawaii, where the latitude, longitude and orography are greatly different those of Shigaraki (34.8°N, 136.1°E) and Rikubetsu (43.5°N, 143.8°E). We clarified the statistical features of atmospheric gravity waves (AGWs) and medium-scale traveling ionospheric disturbances (MSTIDs) in the low latitude region near the equator, and compared it with features seen in Shigaraki and Rikubetsu (Takeo et al., JGR, 2017 and Tsuchiya et al., JGR, 2018).

The three-year average of the phase velocity spectra of AGWs observed in airglow images at wavelength of 557.7 nm show less propagation in due eastward and due westward in summer. The dominant propagation direction was southward in winter. The power spectral density was strongest in spring and summer, and weakest in winter. In Shigaraki and Rikubetsu, the direction of propagation changes from east in summer to west in winter, while in Haleakala there was no such seasonal change in the propagation in summer and winter. This is probably because Haleakala is located at latitudes away from the peak of the mesospheric jet, so the wind filtering effect by the mesosphere jet is smaller than that at Rikubetsu and Shigaraki.

The MSTIDs observed in airglow images at wavelength of 630.0 nm showed strong spectra in four particular nights, and we found that the average spectra largely affected by these strong spectra. Thus we removed these strong nights and calculated the three-year average horizontal phase velocity spectra for four seasons. From the average spectra, MSTIDs propagate from northwestward to southward in summer and from northward to southeastward in fall. In winter, the power spectral density was strongest, and the MSTIDs propagate mainly in the east-west direction. Spring power spectrum density was weakest. We note that dominant propagation direction of MSTIDs at Shigaraki and Rikubetsu was southwestward regardless of the season, which is very different from Haleakala. The power spectral density was weaker at Haleakala than those at Shigaraki and Rikubetsu. These results may be because polarization electric fields

associated with MSTIDs tends to be attenuated by the equatorial ionization anomaly crest, which exists at low latitudes before midnight and by the MBW (Midnight Brightness Wave) moving poleward from low latitudes associated with the MPB (midnight pressure bulge) even after midnight, as suggested by Narayanan et al. [JGR, 2014].

Keywords: Atmospheric gravity waves, Medium-scale traveling ionospheric disturbances, Hawaii