Long-term statistical analysis of phase velocity distribution of mesospheric and ionospheric waves in airglow images obtained in Japan and Canada

*Satoshi Tsuchiya[1], Kazuo Shiokawa[1], Hatsuki Fujinami[1], Yuichi Otsuka[1], Takuji Nakamura[2], Mamoru Yamamoto[3], Schofield Ian[4], Connors Martin[4]

1. Institute for Space-Earth Environmental Research, Nagoya University, 2. National Institute of Polar Research, 3. Research Institute for Sustainable Humanosphere, Kyoto University, 4. Athabasca University

Airglow imagers give a powerful tool to obtain two-dimensional images of waves in the upper atmosphere. Atmospheric gravity waves (AGWs) in the mesosphere and medium-scale traveling ionospheric disturbances (MSTIDs) in the ionosphere are typical wave structures seen in the 557.7-nm (emission altitude: 90-100 km) and 630.0-nm (200-300 km) airglow images, respectively. AGWs transport momentum from the troposphere into the mesosphere and the lower thermosphere (MLT). Momentum deposition through wave breaking is part of the cause of the large-scale pole-to-pole circulation. The vertical propagation of AGWs depends on the horizontal phase velocity. Thus, investigation of the horizontal phase-velocity characteristics of AGWs is essential for understanding the dynamical variation of middle and upper atmosphere. The latitudinal difference of propagation direction of MSTIDs has not been well understood.

A new spectral analysis technique has been developed to obtain power spectra in the horizontal phase velocity of these waves seen in airglow images by using the 3-D FFT technique [Matsuda et al., JGR, 2014]. Takeo et al. [JGR, 2017] studied horizontal parameters of AGWs and MSTIDs over 16 years by using airglow images at wavelengths of 557.7 nm and 630.0 nm obtained at Shigaraki, Japan (34.8N, 136.1E). We have applied the same spectral analysis technique to the airglow images obtained at Rikubetsu (43.5N, 143.8E), Japan [Tsuchiya et al., JpGU Meeting, 2017].

In this study, we have also applied the 3D FFT spectral analysis technique to the 557.7 nm and 630.0 nm airglow images obtained from 2005 to 2017 at Athabasca, Canada (54.7N, 246.7E before 25 September, 2012 and 54.6N, 246.3E after 27 September, 2012). We examined similarities and differences of horizontal wave spectra between Shigaraki, Rikubetsu and Athabasca over ten years to see their dependence on locations. The propagation direction of AGWs is north and northeastward in summer and southward and westward in winter at all the three stations. This seasonal variation of zonal (east-west) AGW propagation direction is probably caused by the wind filtering of the AGWs by the mesospheric jet. We also discuss the possible cause of the common seasonal variation of meridional (north-south) AGW propagation direction in the presentation.

Keywords: Airglow, Atmospheric gravity wave, Medium-scale traveling ionospheric disturbance

