Observations of ionospheric and mesospheric wave structures by a low-cost airglow imaging system

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In the last two decades, all-sky airglow imagers with cooled CCD cameras have widely been used to observe large-scale wave structures in the F-region ionosphere, for example medium-scale traveling ionospheric disturbances (MSTIDs). Such wavy features are seen in the oxygen emission at 630.0 nm from altitudes slightly below the F-region peak. Similar optical observations of OH band emission have also enabled us to visualize atmospheric gravity waves at the mesospheric height. Deploying airglow imagers in multiple places is one of the cost-effective ways to visualize the large-scale structure of these wave structures at both the F-region ionosphere and mesosphere [e.g., Kubota et al., 2001; Suzuki et al., 2013]. However, ground-based airglow imagers equipped with a cooled CCD camera is still expensive; thus, it is rather difficult to deploy such systems in a wide area and carry out a network observation. To overcome this limitation, we recently developed a low-cost airglow imaging system (Low-Cost Airglow imaging System: LCAS) which consists of a small camera (WAT-910HX), fisheye lens and optical filter. We then confirmed its capability of imaging the spatial structure of polar cap patches and plasma bubble in the 630.0 nm emission from the F-region. But, still, it is unclarified if the system is also capable of detecting the two-dimensional structure of MSTIDs. On the night of May 12, 2018, we identified a weak wavy signature in the 630.0 nm airglow images from one of our LCAS stations in Ishigaki Island, Japan. The wave structure in the 630.0 nm images was smoothly connected to the structure of MSTIDs in the GPS-TEC data, which confirmed the ability of LCAS for detecting MSTIDs. We also identified smaller scale wave structures in the 630.0 nm images, showing characteristic concentric wave fronts. We speculate that gravity waves in the mesosphere were captured in the 630.0 nm images as a contamination of the OH airglow. This is mainly because we make use of an optical filter having 10 nm FWHM, which enables us to detect several spectral peaks of OH emission near the 630.0 nm oxygen emission. We have estimated the center of the concentric wave structures by using the curvature of the wave fronts, and then confirmed that active rain fall took place in a localized area close to the estimated center of the concentric waves. This result supports our hypothesis that the OH emission containing signatures of mesospheric gravity waves were detected in the 630.0 nm images. In summary, the 630.0 nm airglow observation of LCAS is able to observe MSTIDs and mesospheric gravity waves. This will allow us to monitor such wavy structures at two different altitudes by distributing the similar system in a wide area.

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