Journal of Geophysical Research: Space Physics / Volume 124, Issue 10 / p. 8110-8124

Research Article

Three-Dimensional Fourier Analysis of the Phase Velocity Distributions of Mesospheric and Ionospheric Waves Based on Airglow Images Collected Over 10 Years: Comparison of Magadan, Russia, and Athabasca, Canada

Satoshi Tsuchiya, Kazuo Shiokawa, Hatsuki Fujinami, Yuichi Otsuka, Takuji Nakamura, Martin Connors, Ian Schofield, Boris Shevtsov, Igor Poddelsky

First published: 12 October 2019
https://doi.org/10.1029/2019JA026783
Citations: 2

Abstract

We studied atmospheric gravity waves (AGWs) and nighttime medium-scale traveling ionospheric disturbances (MSTIDs) using a three-dimensional spectral analysis technique for airglow images at wavelengths of 557.7 nm (altitude: 90–100 km for AGWs) and 630.0 nm (200–300 km for MSTIDs), obtained from Athabasca (ATH), Canada (55°N, 247°E, 2005–2017), and Magadan (MGD), Russia (60°N, 151°E, 2008–2017), over 10–13 years. The AGW propagation direction in summer was from northwestward to northward in ATH and northeastward in MGD with phase speeds of 20–60 m/s. In winter at ATH, they are more omnidirectional with weak preference from northwestward to southward with a speed less than 40 m/s, while another weaker power exists from northeastward to southeastward from 70 to 120 m/s. In winter at MGD, there was no dominant direction in the phase-velocity spectra with spectral power an order smaller than ATH. We suggest that these AGW characteristics were caused by wind filtering and intensity and locations of tropospheric sources. The MSTIDs at ATH propagated southwestward in spring and winter and northeastward in summer and fall. The MSTIDs at MGD propagated northeastward, eastward, and westward in spring, fall, and winter, respectively, with weaker power than that at ATH. The phase speeds are mostly less than 100 m/s except for fall. The propagation direction tends to change from south-southwestward in the evening to north-northeastward after the midnight at both ATH and MGD. We discuss possible reasons for these MSTID characteristics at high latitudes based on Perkins and

E-F coupling instabilities, high-latitude plasma convection, and thermospheric neutral winds.

Plain Language Summary

This paper focuses on propagation characteristics of atmospheric gravity waves (AGWs) in the mesopause region and nighttime medium-scale traveling ionospheric disturbances (MSTIDs) in the ionosphere, using a three-dimensional spectral analysis technique for airglow images at wavelengths of 557.7 nm (altitude: 90–100 km for AGWs) and 630.0 nm (200–300 km for MSTIDs), obtained from Athabasca (ATH), Canada (55°N, 247°E), and Magadan (MGD), Russia (60°N, 151°E), over 10–13 years. These waves are prevailing in the mesosphere and thermosphere and control global dynamics of the upper atmosphere. The MSTIDs affects accuracy of GNSS positioning. We show seasonal, local time, and yearly variations of propagation directions and phase speeds of AGWs and MSTIDs at high latitude Canada and Russia, and discuss their possible causes in relation to the wave sources in the lower atmosphere, their propagation in the middle and upper atmosphere, and ionospheric plasma instabilities.

PUBLICATION INFO