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Study on upward propagating atmospheric gravity waves in the polar MLT region using the Tromsoe sodium LIDAR data

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Atmospheric gravity waves (AGWs) propagating upward from the lower atmosphere dissipate and provide significant amount of energy and momentum into the upper mesosphere and the lower thermosphere. These mechanisms play an important role for momentum balance and energy budget in the upper mesosphere and (possibly) lower thermosphere (MLT). Additionally at high latitudes, dissipation of the electromagnetic energy from the magnetosphere comes into play. Both contributions are equivalently important for energy balance in the polar MLT region. However, effects from the lower atmosphere can be dominant for periods of geomagnetically quit condition. In this case energy/momentum dissipation by upward propagating AGWs is one of major mechanisms to take atmospheric balance in the MLT region. However, our knowledge about AGWs in the polar MLT region has not yet reached maturity because of few observations.

Temperature variations measured with a sodium LIDAR installed at Tromsoe (69.6 deg N, 19.2 deg E), Norway showed wave-like structures on October 29, 2010 in the height region from 80 to 105 km during geomagnetically quit periods. Spectral analysis provided oscillation period and vertical wavelength of about 4 hours and about 8.8 km, respectively. The amplitude had a peak at 85 km with 15 K. Of particular interest is temporal development of the height where AGWs reach. While wavelike structures appeared to propagate up to about 95 km from 1630 UT to 2100 UT, they seemed to propagate to higher level (at least 100 km) from 2100 to 0030 UT. Two candidate mechanisms to produce the temporal development were evaluated: wave dissipation and wind filtering. The temperature in the wave dissipating region increase from the background level, resulting in atmospheric instability, which can be evaluated by the Brunt-Vaisala frequency and the Richardson number. The wind filtering process works at which the phase velocity of AGWs is equal to the background wind velocity (this height is called critical layer). AGWs do not propagate further upward beyond the critical layer. Comparison of these two mechanisms from 1700 UT to 2400 UT concluded that wind filtering effect was predominant for this event rather than the wave dissipation process.

Theoretical predication regarding the wind filtering and wave dissipation processes has already proposed. However, we need more observational works to assess the validity of the theory, particularly at high latitudes. This study presented a clear example that LIDAR-derived AGWs are successfully explained by the theory at high latitude.

Keywords: gravity wave, filtering effect, sodium LIDAR, MLT region