In-situ gravity wave generation by shear instability in the MLT region

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Gravity waves (GWs) play a significant role in the mesosphere and lower thermosphere (MLT), which is their ability to give strong wave forcing to drive the summer-to-winter-pole circulation in the upper mesosphere. Although GWs are mainly generated in the troposphere and propagate into the MLT region, the importance of GW generation in-situ in the MLT region has been pointed out by recent studies. Likely mechanisms of the in-situ generation in the MLT region are radiation from the forcing given by GWs originating from the lower atmosphere (e.g., Becker and Vadas, 2018) and a spontaneous adjustment around jet imbalance. In this study, another likely mechanism of the in-situ GW generation in the MLT region is shown using simulation data covering a period of over ~11 years from GAIA, which is a whole atmosphere model.

First, Eliassen-Palm flux and its divergence (EPFD) are examined. In spite of the relatively coarse model resolution, GWs with large amplitudes are resolved in the MLT region. The EPFD associated with the resolved GWs is eastward (westward) in the summer (winter) hemisphere, similar to the parameterized GW forcing. In addition, a pair of positive and negative EPFD due to the resolved GWs is observed in the summer MLT region. These results suggest that the resolved GWs are generated in situ in the MLT region.

In the summer MLT region, the mean zonal winds have a strong vertical shear that is likely formed by parameterized GW forcing. The Richardson number frequently becomes less than a quarter in the strong-shear region. Moreover, the percentage of GWs propagating energy downward is enhanced below the regions with the high occurrence frequency of shear instability. These results strongly suggest that the forcing by GWs originating from the lower atmosphere causes the shear instability and that the resolved GWs are generated in situ by the shear instability in the MLT region.

The shear instability also occurs in the low (middle) latitudes of the summer (winter) MLT region, although the zonal mean zonal wind does not have strong vertical shear there. A plausible candidate causing the shear instability is tides with large amplitudes in the low and middle latitude of the MLT region because the occurrence frequency of shear instability has strong diurnal (semi-diurnal) variability. The region with the high occurrence frequency of the shear instability follows phase movement of diurnal tides with zonal wavenumber 1 (DW1) and semi-diurnal tides with zonal wavenumber 2 (SW2), and the percentage of GWs propagating energy downward is enhanced in the region where each tide is dominant. These results indicate that large-amplitude DW1 and SW2 significantly contribute to the formations of the shear instability radiating GWs in the low and middle latitudes in the MLT region, respectively.

Key words: MLT region, Gravity waves, Tides, Shear instability

Reference

Becker, E., and S. L. Vadas, 2018: *Journal of Geophysical Reseach: Atmospheres*, 123.