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A Study on the Structure of Instability in the Mesosphere Using a High Resolution General Circulation Model

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It is well known that in the winter mesosphere, a necessary condition of barotropic and/or baroclinic instability, i.e., negative latitudinal gradient of potential vorticity (PV), is frequently satisfied. This study examines dynamical mechanism of the formation of such instability condition in boreal winter using high-resolution general circulation model data. This model does not include gravity wave (GW) parameterizations and hence all GWs are resolved, allowing us to analyze GWs directly. This is a strong advantage of our study because GWs are quite important for the momentum budget in the mesosphere. First, the 2-d TEM analysis was made. It is shown that the negative PV gradient is regarded as an enhanced PV maximum. This maximum is due to the poleward shift of the westerly jet in associated with strong EP-flux divergence caused by planetary waves from the troposphere. Strong GW drag slightly above the westerly jet shifts poleward as well, which can be understood by a selective GW-filtering mechanism. It seems that this GW-drag shift induces strong upwelling in the middle latitudes and adiabatically cools the middle mesosphere. Resultant enhanced static stability is the main cause of the PV maximum in the upper mesosphere. Because of the dominance of planetary waves during this event, this process may not be zonally uniform. Thus, the 3-d analysis was made using recent theoretical formula by Kinoshita and Sato (2013). As expected, the GW drag is distributed depending on the longitude. The zonal structure of PV maximum is consistent with the GW drag distribution. An interesting fact is that the spatial distribution of GW drag is not largely correlated with that of the zonal wind at the same level but highly correlated with that in the stratosphere. This result indicates that the mesosphere reflects the zonal structure of the stratosphere via the selective GW filtering.