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The role of the gravity wave on the middle atmospheric circulation

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The roles of atmospheric gravity waves on both a formation of the mesospheric residual circulation and mechanisms of the maintaining and revolution of the upper flank of the polar night jet are investigated using gravity wave-resolved middle atmosphere general circulation model (GCM). The GCM has a T213 spectral horizontal resolution and 256 vertical levels with vertical intervals of 300 m. The model simulated explicitly resolved gravity waves generated by the spontaneous adjustment processes, convection, jets, topography, instability, and so on with no gravity wave parameterization.

The mesospheric residual circulation in terms of the stream function is examined by the downward control analysis. In the solstitial mesosphere, the residual circulation is one-celled, flowing from the summer hemisphere to the winter hemisphere, while the residual circulation consists of two cells of tropical upwelling and extratropical downwelling in the stratosphere. The downward control analysis reveals that the Rossby waves including the planetary scale waves and synoptic scale waves are the main driver of the stratospheric residual circulation. On the other hand, the gravity waves are the most important driver in the mesosphere and summer stratosphere. The gravity wave forcing in the mesosphere makes the meridional flow and associated upwelling in the summer hemispheric polar region and downwelling in the winter polar region, which leads to a local temperature maximum in the winter polar mesosphere at the height of 70 km by the strong adiabatic heating/cooling. The maximum descends in seasonal march and gets to the summer stratopause at the height of 50 km.

Air flows avoiding the polar night jet core: The residual velocity is poleward and downward along the upper and poleward edge of the polar night jet and poleward and upward along the upper and equatorward edge of the jet in the mesosphere. This increases the temperature gradient so that the upper flank of polar night jet weakens and then its core descends, which can affect the change in the path of the residual velocity along the edge of the jet. These changes lead to feedback to the descent in the jet core.

The jet core descent also influences the time lag in appearance of peaks in the residual velocity because the residual velocity can be large above jet core. For example, in the southern hemisphere, a peak in the meridional velocity averaged in the height region of 70–80 km is located during June or July, although a peak in that averaged in 55–70 km appears during September.

On the other hand, the residual meridional velocity is small in the lower mesosphere and large and poleward in the middle mesosphere especially in the mid-latitudes. The residual vertical velocity is large and upward in the polar region of the middle mesosphere. As in the case of winter, the residual velocity seems to curve around the middle-mesospheric easterly jet core.

In the presentation, the role of gravity waves on changes in the structure of the polar night jet, easterly jet, the residual circulation, and the relation in them are explained in detail.

Keywords: middle atmosphere, residual circulation, gravity wave, polar night jet