Multi-year analysis using the data assimilation system in the middle atmosphere

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In the mesosphere, the roles of gravity waves, which are ageostrophic motions, are relatively important, compared with those in the troposphere and stratosphere. Recently, the presence of the interhemispheric coupling through the mesosphere has been suggested and the role of the gravity waves has been focused on. However, there are few observational evidences of the gravity wave modulation. In addition, the importance of in-situ generations of the gravity waves and Rossby waves in the mesosphere is recently indicated. Although the mesosphere is observed by satellites and radars, the observational frequency and density are not sufficient for the global analysis. Reanalysis data provided by meteorological organizations cover only up to the middle stratosphere thus, there are several attempts including the upper stratosphere and mesosphere, although they are developing and focus on short terms, several months at most. In this study, we are making the analysis data for about 15 years, when the Aura MLS data, which observes the mesosphere, are available.

We have improved the data assimilation system developed by Koshin et al. (GMDD, 2019), by applying the incremental analysis update (IAU). TIMED SABER (z=25–110 km) and DMSP SSMIS (z=25–80 km) data are added as the observation data for the assimilation. The GCM used for the data assimilation system has a horizontal resolution of T42 (˜300 km) and a vertical resolution of about 1 km. The number of ensembles is taken 50. As the analysis becomes better through the consecutive analysis cycle, a continuous period should be as long as possible. However, as the assimilation needs much computational cost, thus the period for the assimilation was split into three: 13 August 2004–31 December 2008 (Stream 1), 15 November 2008–31 December 2013 (Stream 2), and the time period after 15 November 2013 (Stream 3).

Figure 1 shows the zonal mean temperature (70–80N) and zonal wind (60–70N) of Stream 2 for which the assimilation run was finished. Strong sudden stratospheric warming in January 2009 was nicely captured. The stratopause lowers to the height of z˜30 km and the zonal wind turns to easterly above z˜20 km in mid-January 2009. After that, the elevated stratopause appears at the height of z˜85 km, then it lowers over two months. Figure 2 shows the vertical structure on the SSW, 24 January 2009. In the height range of about 30–80 km, the polar vortex splits into two, almost barotropically. It tilted westward with height for z=˜80–100 km. Above z=˜100 km, there are planetary waves whose phases are not continuous to those at the lower levels.

Using obtained global data, dynamics in the whole middle atmosphere such as interhemispheric coupling, and the effects of the middle atmosphere to the troposphere will be examined. By using the global data as the initial values, hindcasts using gravity wave resolving GCM are also planned.

Figure 1. Time-height cross section of the northern polar region. Color: T (70–80N) Contour: U (60–70N)

Figure 2. Geopotential heights for the height range of about 30–110 km on 12UTC, 24 January 2009. The contour interval is 500 m. The region where the anomaly from the zonal mean is larger than +500 m (-500 m) is shown by red (blue) shade. The longitude is 0 (180) degree at the front (back), The north pole and latitude circles of 30 and 60 degrees are shown by green.

Keywords: Middle atmosphere, Data assimilation, Interhemispheric coupling

Figure 1

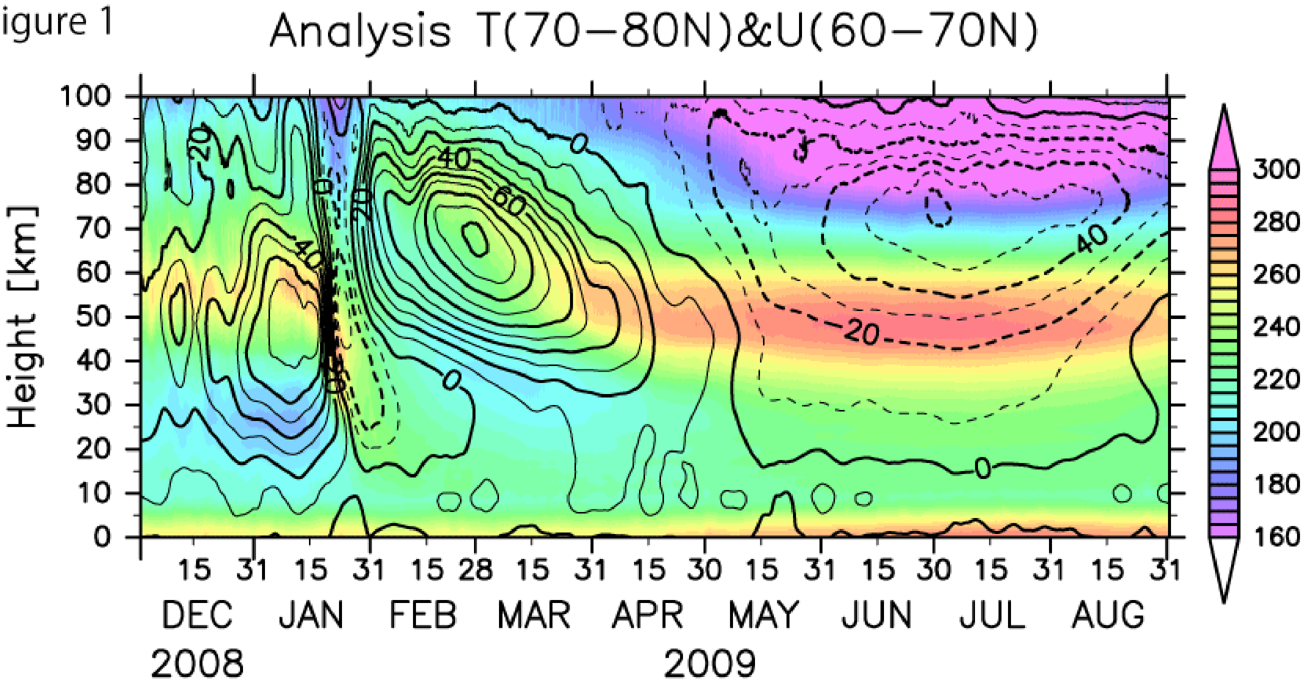

Figure 2