A study on data assimilation using the ensemble Kalman filter and simulation of a sudden stratospheric warming

*Dai Koshin[1], Kaoru Sato[2], Kazuyuki Miyazaki[3]

1.Department of Earth and Planetary Science, School of Science, The University of Tokyo, 2.Department of Earth and Planetary Science, The University of Tokyo, 3.Japan Agency for Marine-Earth Science and Technology

There are many important phenomena in the middle atmosphere, such as sudden stratospheric warmings (SSW), and the quasi-biennial oscillation (QBO). It is suggested that these phenomena affect global atmosphere through stratospheric and mesospheric circulations respectively from the equator to the pole and from the summer pole to the winter pole. With the aid of technology development, resolutions of observations and numerical models have become higher. Most analysis data are mainly made by meteorological centers by assimilating observation data up to the stratosphere. Data assimilation for the mesosphere is not yet very common. Thus, we performed a preliminary study for the data assimilation from the ground to the mesosphere, so as to make realistic grid data and simulation of the middle atmosphere.
First, using a global model called MIROC, whose top is in the upper stratosphere (~40km), we examined impacts of assimilation of satellite observations in the stratosphere. The PREPBUFR data (ground-based observations including these by aircrafts, balloons, and wind profilers) data from NCEP, and temperature retrieval data in the stratosphere by Aura MLS from NASA were used as conventional and satellite observations, respectively. The model has horizontal resolution of T42 and 32 vertical levels. We used the method of ensemble Kalman filter (EnKF) for data assimilation, and made analysis data for January and February 2014, when an SSW occurred in the northern hemisphere. As SSWs are highly non-linear phenomena, their simulation is generally difficult.
We made two kinds of analysis data. One is the data in which only PREPBUFR data are assimilated, and the other in which both PREPBUFR and MLS data are assimilated. In both analysis data, timing of the SSW onset was realistic. However, the data with MLS observation have higher accuracy in the middle atmosphere than that only with PREPBUFR data. It is seen from standard deviation of ensemble members that assimilation of satellite data is more effective (i.e. small standard deviation) in the stratosphere.
Second, we made ensemble forecast experiments using analysis data on February 1, several days before the SSW onset. The prediction using analysis data assimilated with both MLS and PREPBUFR was more accurate than that assimilated only with PREPBUFR. It is seen that there is significant difference in the stratospheric wave activity between the two prediction experiments, although the tropospheric wave activity is not so different. This fact suggests that accurate background fields around the tropopause are important so as to simulate realistic propagation of planetary waves from the tropopause to the stratosphere. For future studies, we will optimize each parameter at data assimilation, and use a hi-top model so that highly accurate data assimilation can be made in the middle atmosphere.

Keywords: data assimilation, sudden stratospheric warming, ensemble Kalman filter

