Development of a Lagrangian chemical transport model to understand the mechanism of composition change due to change in atmospheric environment

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Mesospheric chemical composition largely varies caused by environmental changes from the earth inside and outside. Recent studies reported enhancement of NO_x and HO_x and ozone depletion in the polar mesospheric region at a large solar proton event. These suggest that precipitation of other high energy particles such as a high energy electron from the magnetosphere also has influence on the chemical composition in the mesosphere. For these reasons, we have installed millimeter-wave spectrometers in Rikubetsu-cho, Hokkaido (Japan), Syowa Station (Antarctic), Atacama (Chile), Rio Gallegos (Argentine) and Tromso (Norway), and have been observing steady atmospheric minor molecules such as Ozone, NO_x, HO_x and ozone-depleting substances in the stratosphere and mesosphere to understand the atmospheric composition changes caused by natural phenomena such as Energetic Particle Precipitation (EPP).

In addition to these observations, we have been developing a Lagrangian chemical transport model, which is suitable for a simulation of a sudden and a local event to evaluate the influence of the atmospheric composition mechanism in the stratosphere and mesosphere. Our developing model is an extension of the Lagrangian particle dispersion model (FLEXPART) by incorporating meteorological fields data and chemical reactions in the mesosphere. FLEXPART can analyze a trajectory from the ground to about 40 km in altitude using the reanalysis data of NCEP and ECMWF as meteorological fields input data. In this study, we incorporated a new reanalysis dataset (MERRA2) as meteorological fields input data to extend the analysis range toward the mesosphere, and as a result, trajectory a analysis ranging from the ground to about 80 km in altitude can be made. In order to evaluate the analysis accuracy of our developing model, we calculated trajectories for a single position at altitudes of 15, 45, 55, 70 km, and compared the results with another trajectory analysis model. Moreover, only OH reactions are considered in FLEXPART, although it needs to calculate non-linear chemical reactions separately in this study because chemical reactions caused by EPP include not only reactions by natural molecules but also ion-molecular reaction, ionization, dissociation and ion recombination, and so on. For this reason, we incorporated chemical reactions of the stratosphere and mesosphere in FLEXPART using Kinetic Preprocessor (KPP) which is chemical reaction computation software. We previously calculated chemical reactions of the stratosphere and mesosphere using KPP alone and confirmed the amount of mesosphere ozone variation in day and night.
In this presentation, we will report the results of comparison bet between our developing model and other trajectory models as well as the simulation results about some EPP events using our model.

Keywords: mesosphere, ozone, high energy particle, chemical transport model

