SOWER (Soundings of Ozone and Water in the Equatorial Region): Application of data assimilation to the study of TTL dehydration

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Intensive efforts have been made to understand the dehydration in the tropical tropopause layer (TTL) since the proposal of the "cold-trap" hypothesis by Holton and Gettelman (2001). Lagrangian descriptions based on trajectory calculations have been conveniently used focusing the temperature history along the advective excursion of air parcels. Thermodynamic trajectories that rely on the thermodynamic equation in the diagnosis of vertical displacement and dynamic trajectories that use 3D wind field have been applied. The former could be improved by introducing realistic diabatic heating, while the latter have a limitation in that instantaneous vertical velocity diagnosed at gridpoints is not always suitable for such calculations. Assimilation of observed field to GCMs and CTMs is a common approach to obtain realistic meteorological and constituents fields. The assimilation of millions of observed data to a model that is suitable for studying TTL dehydration, however, is not an easy task. In the present study, six-hour interval gridpoint values from NCEP global analyses are assimilated to CCSR/NIES/FRCGC AGCM as if they were observed values. Radiative fields and parameterized subgrid scale properties can be obtained from AGCM in the time interval shorter than that of the analysis field. The period of study has been set from December 20, 2007 to January 25, 2008. The assimilated field has proved to be similar to the original analysis field except for some intensification of subtropical jets and slightly warmer UT/LS. Trajectories of each air parcel are calculated by using 36 air segments originally distributed in the 1.0 x 1.0 degree latitude-longitude region with the interval of 0.2 degrees. Thermodynamic trajectories with diabatic heating are not much different from those calculated by isentropic condition in most cases in the TTL. However, dynamic trajectories occasionally exhibit appreciable difference from thermodynamic ones. The reason is found to be due to the warm bias in the assimilated field that causes artificial diabatic cooling through nudging term. The effect of subgrid scale convection has been taken into account by using a stochastic method. Such treatment may work reasonably well by increasing the number of segments consisting of each air parcel. The problems to be left for future studies are the reduction of model bias, the use of more sophisticated assimilation scheme, and realistic description of convective activities. The analysis will be extended by using the spread of meteorological fields from ensemble forecasts that may help estimating the reliability of trajectory calculations and associated dehydration. Possible influence of penetrating deep convection will be also assessed. The assimilation of water vapor sonde data will be another challenge for improving our understanding of TTL dehydration.