Multi-timescale variations of modelled stratospheric water vapor derived from different reanalysis products

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Meteorological reanalyses are best estimates of the true state of the whole atmosphere in the past. As such, they are widely used to examine the atmospheric processes and variabilities, to detect changes in the climate system and to provide meteorological states for both forecast and historical model runs. Because stratospheric water vapor (SWV) plays an important role for the radiative budget and ozone chemistry and for understanding of stratosphere transport, it is necessary to evaluate the consistence and uncertainties of modelled SWV due to the input meteorological states. In this study, we evaluate the representation of SWV and its multi-scale variations using the Chemical Lagrangian Model of the Stratosphere (CLaMS), which is driven by horizontal winds and diabatic heating rates from recent reanalyses: ERA-Interim, JRA-55 and MERRA-2. The analysis is based on CLaMS simulations of monthly zonal mean H_2O from 1980-2013 and an inter-comparison of model results with observations provided by the Stratospheric Water and Ozone Satellite Homogenized (SWOOSH) database.

Using the multi-linear regression, we decompose the monthly zonal mean H2O mixing ratios into the annual cycle (AC) and the quasi-biennial oscillation (QBO), the long-term trends as well as the remaining residuum. A reasonable consistency is found among the AC and QBO patterns from modelled H_2O in the lower stratosphere with those from SWOOSH database. However, pronounced disagreements in AC and QBO amplitudes are found in the tropical middle to upper stratosphere among the CLaMS runs. This is possibly related to the large spread among the tropical upwelling from the reanalysis data, especially in the lower to middle stratosphere. The long-term trend of modelled SWV demonstrates large uncertainties. The sign and significance of the trend is sensitive to the dynamical parameters from reanalyses and the period under consideration. CLaMS run driven by ERA-Interim shows the better agreement of SWV trend in the lower to middle stratosphere with that from Frost Point Hygrometer (FPH) record over Boulder from 1980 to 2013. The residuum from the regression shows a good agreement among all the simulations and the observation data with significant 5-10 years variations. Finally, we discuss the robustness of these results and the possible reasons for their differences with respect to the used meteorological reanalysis.

Key words: stratospheric water vapor, multiple reanalyses, multi-timescale variations, Brewer-Dobson Circulation