TEM analysis and comparison on the BDC using several reanalysis data sets

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The Brewer-Dobson circulation is approximated by the residual circulation in the Transformed Eulerian mean (TEM) system except for the region where the mixing processes are dominant. We compare climatology, trend, seasonal variation, and interannual variability of the TEM residual circulation in the lower stratosphere diagnosed from several reanalysis data sets, JRA-25, ERA-40, ERA-Interim, MERRA, and NCEP CFS. In the lower stratosphere, the climatologies of annual mean residual circulation are generally quite similar, although significant difference is observed for the meridional structure of the circulation in some reanalysis data.

The total upward mass flux on a pressure surface of 70 hPa, which is an index of the stratosphere-troposphere exchange, is defined by the maximum and minimum of the residual mean mass stream function because the zonal mean meridional circulation is two-celled which consists of tropical upwelling and extratropical downwelling in the stratosphere. Little significant trend of the annual mean total upward mass flux is observed in the period of 1980-2010 in all datasets. Contributions of the resolved wave forcing and unresolved wave forcing to the total upward mass flux are estimated by the downward control analysis by the method of Okamoto et al. (2011). The result shows that the contribution of gravity waves is 25-50% of the total mass flux. This shows that the gravity wave forcing is as important for the stratosphere-troposphere mass exchange as the large-scale wave forcing even in the lower stratosphere. These results imply significant impacts of the gravity wave parameterizations on the BDC, which may explain the difference in the BDC structure between the different reanalysis data.

References

Okamoto, K., K. Sato, and H. Akiyoshi, A study on the formation and trend of the Brewer-Dobson circulation, J. Geophys. Res., 116, D10117, 2011.