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Zonal asymmetries in atmospheric transport and their effects on stratospheric ozone and water vapor

Deniz Demirhan Bari, Axel Gabriel, and Dieter H.W. Peters
Leibniz-Institut für Atmosphärenphysik e.V., Germany (denizbari@gmail.com)

The longitudinal differences in the atmospheric circulation and the zonal asymmetries in stratospheric ozone and water vapor are not fully understood up to now. We examine the zonal asymmetries in mean transport, including mean advection and mean eddy mixing processes due to stationary and transient waves forced from troposphere, to explain the zonally asymmetric structures of ozone and water vapor. The mean transport characteristics driven by the atmospheric waves can be summarized in the concept of wave-driven three-dimensional (3D) Brewer-Dobson circulation. In this study we use a slight variation of the theoretical formulae of 3D residual circulation following Kinoshita et al. (Kinoshita et al., 2010, J. Met. Soc. Japan, 88, No. 3), which describes the 3D mass transport analogously to the framework of 2D Transformed Eulerian Mean equations (TEM). The formulations are adapted to HAMMONIA, ECMWF ERA-INTERIM, ODIN and AURA-MLS data from 2001 to 2006 to get a complete picture of the mean January three-dimensional Brewer-Dobson circulation (BDC) and eddy mixing processes. Zonal asymmetries in 3D Brewer-Dobson circulation, ozone and water vapor are being examined in detail. The longitudinal distributions of eddy heat fluxes, residual mean wind and atmospheric ozone and water vapor indicate a wave-1 structure in the zonal distribution of eddy heat fluxes, ozone and water vapor at 60°N. Especially the variability of zonal asymmetries in the residual circulation over the Atlantic and the Pacific part of the Earth is analyzed separately and an evident link between them is captured. The results demonstrate that the zonally asymmetric structures of the residual circulation generate the zonal asymmetries in ozone and water vapor. The results also suggest that examining the zonal asymmetries in mean 3D wave-driven transport and their effects on ozone and water vapor may be a suitable tool for validation and improvement of general circulation and chemistry-climate models.