EGU2020-7432
https://doi.org/10.5194/egusphere-egu2020-7432
EGU General Assembly 2020

N2O-based climatology of the Brewer-Dobson Circulation in WACCM, a chemical reanalysis and a CTM driven by four dynamical reanalyses

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The Brewer-Dobson Circulation (BDC) plays a major role in the stratospheric dynamics in terms of tracer transport through the mean residual meridional advection and the isentropic 2-way mixing. The climatological BDC in the Whole Atmosphere Community Climate Model (WACCM) is separated in its components and evaluated through a comparison with a chemical reanalysis of the Aura Microwave Limb Sounder version 2 (BRAM2) and with a chemistry-transport model driven by four modern reanalyses (ERA-Interim, JRA-55, MERRA and MERRA2). The BDC seasonal means and climatological annual cycle are addressed using the Transformed Eulerian Mean (TEM) analysis of the long-lived tracer N2O. The N2O TEM budget terms considered in this study are the vertical residual advection and the horizontal two-way mixing terms.
WACCM presents a general underestimation of the horizontal mixing term in the wintertime Northern Hemisphere with respect to the reanalyses throughout the stratosphere.In the wintertime antarctic region the mid-low stratospheric horizontal mixing term in WACCM does not agree with the reanalyses: it shows near-zero positive values, while all the reanalyses show a consistent negative contribution. This disagreement between WACCM and the reanalyses is located in the region and period of the polar vortex development, and can be related to a different representation of the polar jet. In this region the reanalyses are nevertheless affected by large uncertanties of the TEM analysis: the residual term of the budget has the same magnitude as the horizontal mixing term.Even though the residual term can be interpreted as the effect of sub-grid mixing processes, caution must be exerted when considering these regions because the N2O TEM budget is not completetely closed.
The mid-stratospheric arctic region are characterized by smaller uncertanties of the TEM budget together with large differences among the datasets during winter: the WACCM realizations, characterized by a large internal variability, show a smaller horizontal mixing contribution with respect to the reanalyses.
The agreement among datasets is generally improved when considering the middle and low latitudes, especially in the Northern Hemisphere: those regions are characterized by smaller

differences among datasets and a well-closed TEM budget.
The inter-annual variability of the horizontal mixing term and the vertical advection term is highly latitude-dependent: the horizontal mixing term presents a large variability, together with a large dataset spread, in the antarctic region in the austral fall and during boreal winter in the Arctic; the vertical advection shows large variability in the arctic region and large model spread in the Tropical regions.