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How robust are stratospheric age of air trends from different reanalyses?

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An accelerating stratospheric Brewer-Dobson circulation (BDC) is a robust signal of climate change in model predictions but has been questioned by trace gas observations. We analyze stratospheric mean age of air and the full age spectrum as measures for the BDC and its trend. Age of air is calculated with the Chemical Lagrangian Model of the Stratosphere (CLaMS) driven by ERA–Interim, JRA–55 and MERRA–2 reanalysis data to assess the robustness of the representation of the BDC in current generation meteorological reanalyses. The Lagrangian CLaMS model uses an isentropic vertical coordinate and the reanalysis diabatic heating rates for driving vertical transport. The age of air spectrum, the distribution of transit times through the stratosphere, is calculated from multiple inert pulse tracers in the model, with pulses applied at the surface.

We find that climatological mean age significantly depends on the reanalysis, with JRA–55 showing the youngest and MERRA–2 the oldest mean age. Consideration of the age spectrum indicates that the older age for MERRA–2 is related to a stronger spectrum tail, likely related to weaker tropical upwelling and stronger recirculation. Seasonality of stratospheric transport is robustly represented in reanalyses, with similar mean age variations and age spectrum peaks. Long-term changes over 1989–2015 turn out to be similar for the reanalyses with mainly decreasing mean age accompanied by a shift of the age spectrum peak towards shorter transit times, resembling the forced response in climate model simulations to increasing greenhouse gas concentrations. For the shorter periods 1989–2001 and 2002–2015 age of air changes are less robust. Only ERA–Interim shows the hemispheric dipole pattern in age changes during 2002–2015 as viewed by recent satellite observations. Consequently, the representation of decadal variability of the BDC in current generation reanalyses appears less robust and a major uncertainty of modelling the stratospheric BDC.