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Hemispheric asymmetries in recent changes of the stratospheric circulation

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Despite the expected opposite effects of ozone recovery, the stratospheric Brewer-Dobson circulation (BDC) has been found to weaken in the Northern hemisphere (NH) relative to the Southern hemisphere (SH) in recent decades, inducing substantial effects on chemical composition. We investigate hemispheric asymmetries in BDC changes since about 2000 in simulations with the transport model CLaMS driven with different reanalyses (ERA5, ERA-Interim, JRA-55, MERRA-2) and contrast those to a suite of free-running climate model simulations. We find that age of air increases robustly in the NH stratosphere relative to the SH in all reanalyses considered. Related nitrous oxide changes agree well between reanalysis-driven simulations and satellite measurements, providing observational evidence for the hemispheric asymmetry in BDC changes. Residual circulation metrics further show that the composition changes are caused by structural BDC changes related to an upward shift and strengthening of the deep BDC branch, resulting in longer transit times, and a downward shift and weakening shallow branch in the NH relative to the SH. All reanalyses agree on this mechanism. Although climate model simulations show that ozone recovery will lead to overall reduced circulation and age of air trends, the hemispherically asymmetric signal in circulation trends is small compared to internal variability. Therefore, the observed circulation trends over the recent past are not in contradiction to expectations from climate models. Furthermore, the hemispheric asymmetry in BDC trends imprints on the composition of the lower stratosphere and the signal might propagate into the troposphere, potentially affecting composition down to the surface.