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Brewer-Dobson circulation trend, stratospheric shrinkage and wave driving in climate projections

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Climate model simulations robustly project acceleration of the Brewer-Dobson circulation (BDC) in the course of climate change. While the mechanisms for the BDC strengthening are well understood, there are still open questions concerning its dynamical driving. Mean age of stratospheric air (AoA) is a useful transport diagnostic for accessing changes of the BDC. Analysing AoA from a subset of Chemistry Climate Model Initiative part 1 climate projection simulations, we find a remarkable agreement between most of the models in simulating the largest negative AoA trends in the extratropical lower to middle stratosphere of both hemispheres. We show that the existence of localized minima of the AoA trend is sensitive to an upward shift of the circulation in response to a climate change. Also other factors like a reduction of aging by mixing and residual circulation transit times contribute to the AoA distribution changes by widening of the AoA isolines.
Further we show that after the correction for a vertical shift of pressure levels, there is not any direct link between wave driving, residual circulation and AoA trends in the extratropical stratosphere. This indicates that additional causative factors may influence the AoA trends. Namely, we postulate a possible influence of stratospheric shrinkage, which can cause additional AoA changes over time. Finally, we discuss the missing connection between wave driving trends and BDC acceleration after the subtraction of the vertical shift. A specific role of the gravity wave drag for the stratospheric transport in the extratropics is highlighted and it is argued, that the gravity wave drag effects cannot be properly analyzed from the traditional zonal mean monthly mean output.