On the role of vertical and horizontal model resolution for the simulation of stratospheric transport

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The stratospheric transport circulation, or Brewer-Dobson Circulation (BDC), is often conceptually separated into advection along the residual circulation and two-way mixing. In particular the latter part has recently been found to exert a strong influence on inter-model differences of mean age of Air (AoA), a common measure of the BDC. However, the precise reason for model differences in two-way mixing remains unknown, as many model components in multi-model projects differ. One component that likely plays an important role is model resolution, both vertically and horizontally. To analyse this aspect, we carried out a set of simulations with identical and constant year 2000 climate forcing varying the spectral horizontal resolution (T31,T42,T63,T85) and the number of vertical levels (L31,L47,L90). We find that increasing the vertical resolution leads to an increase in mean AoA. Most of this change can be attributed to aging by mixing. The mixing efficiency, defined as the ratio of isentropic mixing strength and the diabatic circulation, shows the same dependency on vertical resolution. While horizontal resolution changes do not systematically change mean AoA, we do find a systematic decrease in the mixing efficiency with increasing horizontal resolution. Non-systematic changes in the residual circulation partly compensate the mixing efficiency changes, leading to the non-systematic mean AoA changes. The mixing efficiency changes with vertical and horizontal resolution are consistent with expectations on the effects of numerical dispersion on mean AoA. To further investigate the most relevant regions of mixing differences, we analyse height-resolved mixing efficiency differences. Overall, this work will help to shed light on the underlying reasons for the large biases of climate models in simulating stratospheric transport.