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The representation of stratospheric transport today and in the future in CCMI model simulations

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Through analysis of mean age of air (AoA), we study the capabilities of the Chemistry Climate Models (CCMs) from the CCMI (Chemistry-Climate Model Initiative) project to simulate transport along the Brewer-Dobson circulation. The reason for the well-known large model spread in stratospheric AoA can be investigated by untangling the effects of the different mechanisms that control AoA. For this reason, we analysed the influences of mean transport along the residual circulation and of two-way mixing on AoA. Residual transport is assessed through the residual circulation transit time (RCTT) and the difference between AoA and RCTT is then interpreted as aging by mixing, which includes mixing on the resolved and on the subgrid scale.

In the hindcast simulations, we find that the AoA model spread is caused to a small extent only by differences in residual circulation strength, the main reason is the difference in mixing. As possible reasons for this, we discuss subgrid scale mixing, advection schemes, resolution dependence and the relative contribution of resolved versus parametrised wave forcing, but must accept that the individual influences of these specific features are hard to disentangle with the given methodological approach.

Furthermore, we analyse the climate projection simulations to study the trends of the stratospheric circulation across the 21st century. Most model simulations consistently predict a decrease in AoA throughout the stratosphere. This trend can be explained by both, an increasing strength of the residual circulation and less ageing by mixing through recirculation of air in the stratosphere, with large regional differences in the ratio of the two mechanisms. Also the relative mixing strength, which has so far been assumed to be constant under various climate conditions, shows a clear drift in most model simulations. We seek to analyse possible reasons for the trends in AoA, RCTTs and mixing and discuss the differences among the models.