



## **Variability of stratospheric mean age of air linked to residual circulation and eddy mixing**

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We analyze the effects of the stratospheric residual circulation and eddy mixing on the variability of mean age of air (AoA) within the framework of the isentropic zonal mean continuity equation. The AoA for the period 2002-2012 has been simulated with the Lagrangian chemistry transport model CLaMS driven by ERA-Interim winds and diabatic heating rates.

We find that throughout the stratosphere the effects of the residual circulation and of eddy mixing on AoA are opposite and cancel to a large degree, with the net AoA changes resulting from this delicate balance. Mixing increases AoA equatorwards of about 40 degrees by mixing in aged mid-latitude air, whereas it decreases AoA at higher latitudes. Throughout the tropical stratosphere and in the polar upper stratosphere AoA variability is dominated by the residual circulation. In the subtropics and mid-latitudes AoA variability is dominated mainly by eddy mixing and AoA is not a unique proxy for variability in the residual circulation.

The simulated AoA change during the last decade shows a nonuniform pattern, with a significant AoA increase in the northern hemisphere consistent with recent satellite observations by MIPAS, and decreasing AoA in the lowest stratosphere. Interpreting these AoA changes requires careful consideration of both changes in the residual circulation and changes in eddy mixing. The AoA decrease in the lowest stratosphere results from a strengthening residual circulation, related to an accelerating shallow residual circulation branch. Above about 450K simulated AoA evolves differently than below, with a clear increase in the northern subtropics and mid-latitudes and a decrease in the southern hemisphere. This AoA change pattern during the last decade appears to be related to a southward shift of the subtropical mixing barriers, in good agreement with recent analysis of MIPAS mean age and tracer data.