# Investigating possible causes for observed ozone changes between the late seventies and nineties in the northern hemisphere UTLS using a coupled chemistry-climate model

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Ozone is a particularly strong greenhouse gas in the tropopause region, and therefore trends in this altitude are important for changes in radiative forcing. Information on long-term changes of ozone in this region stem from different kinds of observations such as regular balloon measurements or measurements from commercial aircraft programmes. While changes can be detected using observational data, they do not give insight into the causes for the changes found.

To investigate possible causes for observed midlatitude UTLS ozone changes between the late seventies and nineties deduced from the GASP and MOZAIC aircraft programmes and ozone sondes (cf. abstract "Ozone trends (1975-2000) in the northern hemisphere UTLS using measurements from ozone sondes and regular aircraft"), model data from a transient simulation of the period 1960-1999 of the coupled chemistry-climate model E39/C have been analysed in an analogous way as the observational data. The simulation includes observed sea-surface temperature, three major volcanic eruptions, the solar cycle, the Quasi-Biennial Oscillation, emissions of $NO_x$, and prescribed concentrations of greenhouse gases including CFCs.

To assess the reliability of the model performance in the UTLS, modelled temperature and ozone climatologies and their long-term changes were compared with respective results from the GASP and MOZAIC data. Results of this model validation will be discussed. To separate the impacts of various processes and emissions on UTLS ozone, a $NO_x$-ozone tracking diagnosis considering the major $NO_x$ sources was applied. In the model, midlatitude ozone increases in the UTLS between the late seventies and nineties. In the upper troposphere, these changes are dominated by increased $NO_x$ emissions from industry and land transport. Further contributions can be attributed to stratospheric ozone produced by $N_2O$ degradation and $O_2$ photolysis. In the lower stratosphere, the modelled ozone changes are mostly controlled by $N_2O$ and $O_2$ photolysis with effects from industry and land transport also playing a role.