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Title: The viability of trajectory analysis for diagnosing dynamical and chemical influences on ozone concentrations in the UTLS

The viability of trajectory analysis for diagnosing the interplay between chemistry and dynamics is investigated by comparing ozone mixing ratios modelled using air-parcel pathways to values observed along flight tracks during ATTREX. Trajectories are initiated at the locations of ozone observations and tracked backward in time to their 'sources' at termini of backward trajectories. The modelled values of ozone utilize 3-dimensional 'analysis' fields from WACCM (a chemical-climate model with dynamical fields nudged towards MERRA reanalysis) and ERA-interim to determine source mixing ratios with chemical production and loss terms derived from the ozone chemistry used in WACCM. A statistical base of modelled ozone is constructed with 6 trajectory platforms (adiabatic, diabatic, and kinematic forced by ERA-interim and MERRA), two chemical models (WACCM chemistry and no chemistry), and 4 trajectory lengths (5, 10, 20, and 30 d).
Linear regression is employed to separate systematic errors from random errors and to characterize the impact of source mixing ratios, path length, vertical motion, and chemistry on modelled ozone errors. Errors in the analysis ozone fields are large, if not dominant, contributors to model error. Random errors are particularly large for point-by-point comparisons, however averaging over 800 km (75 min) flight segments substantially reduces random error and exposes systematic errors. Of the two analysis ozone data sets, WACCM, which incorporates detailed chemistry, provides the smaller systematic errors while ERA-interim, which has crude chemistry but assimilates observational data, has the smaller random errors. Of the different trajectory platforms, adiabatic calculations produce the smaller random errors (irrespective of the use of chemistry) but both vertical motion and chemistry are required to optimally reduce systematic errors. These results suggest: that meaningful analysis of dynamical and chemical interactions that control ozone mixing ratios are viable on spatial scales larger than a few reanalysis grid spaces, that errors in the analyzed ozone data sets are large but not prohibitively so, and that vertical velocities and heating rates from reanalysis data, while problematic, contain useful information.