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Beyond model spread: a process-based attribution of uncertainties in stratospheric ozone modelling

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Intercomparisons between Chemistry-Climate Models (CCMs) have highlighted shortcomings in our understanding and/or modeling of long-term ozone trends, and there is a growing interest in the impact of stratospheric ozone changes on tropospheric chemistry via both ozone fluxes (e.g. from the projected strengthening of the Brewer-Dobson circulation) and actinic fluxes. Advances in this area require a good understanding of the modelling uncertainties in the present-day distribution of stratospheric ozone, and a correct attribution of these uncertainties to the processes governing this distribution: photolysis, chemistry and transport. These processes depend primarily on solar irradiance, temperature and dynamics.

Here we estimate model uncertainties arising from different input datasets, and compare them with typical uncertainties arising from the transport and chemistry schemes. This study is based on four sets of tightly controlled sensititivity experiments which all use temperature and dynamics specified from reanalyses of meteorological observations. The first set of experiments uses one Chemistry-Transport Model (CTM) and evaluates the impact of using 3 different spectra of solar irradiance. In the second set, the CTM is run with 4 different input reanalyses: ERA-5, MERRA-2, ERA-I and JRA-55. The third set of experiments still relies on the same CTM, exploring the impact of the transport algorithm and its configuration. The fourth set is the most sophisticated as it is enabled by model developments for the Copernicus Atmopshere Monitoring Service, where the ECMWF model IFS is run with three different photochemistry modules named according to their parent CTM: IFS(CB05-BASCOE), IFS(MOCAGE) and IFS(MOZART).

All modelling experiments start from the same initial conditions and last 2.5 years (2013-2015). The uncertainties arising from different input datasets or different model components are estimated from the spreads in each set of sensitivity experiments and also from the gross error between the corresponding model means and the BASCOE Reanalysis of Aura-MLS (BRAM2). The results are compared across the four sets of experiments, as a function of latitude and pressure, with a focus on two regions of the stratosphere: the polar lower stratosphere in winter and spring - in order to assess and understand the quality of our ozone hole forecasts - and the tropical

middle and upper stratosphere - where noticeably large disagreements are found between the experiments.