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Modelling future changes in climate, ozone-depleting substances and ozone precursor emissions using the whole-atmosphere UM-UKCA model

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Using the recently upgraded whole-atmosphere UM-UKCA chemistry-climate model, we investigate the atmospheric response to future changes in a) greenhouse gases under the RCP4.5 and 8.5 scenarios for climate change, b) ozone-depleting substances (ODS) and a recovery of the ozone layer and c) ozone precursor emissions and tropospheric oxidising capacity. In addition, we combine these scenarios in order to explore the interactions between individual perturbations. Within this framework, the coupled stratosphere-troposphere system and whole-atmosphere chemistry allows us to study the impact of changes in composition of the stratosphere on the troposphere and vice versa. We find that by the year 2100: 1) the stratosphere significantly impacts the troposphere via changes in stratosphere-troposphere exchange (STE) but the chemical changes induced in the troposphere do not impact the stratosphere, 2) perturbations are linearly additive with regard to the total ozone column and tropospheric odd oxygen budget, 3) while the Brewer-Dobson Circulation strengthens under climate change (with an increase in the DJF 70hPa tropical upwards mass flux of $\sim$20% at RCP4.5 and exceeding 30% at RCP8.5), this strengthening is offset by ozone recovery (which on its own leads to a decrease in the mass flux of $\sim$10%) and 4) tropospheric ozone decreases given mitigation of its precursor emissions (with a 10% decrease in ozone burden) but this can be offset by climate change at both RCP4.5 and 8.5 and stratospheric ozone recovery (increasing the burden by 6-13%).