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Modelled impacts of solar geoengineering on the atmosphere: Do feedbacks between composition and meteorology matter?

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We use the recently developed atmosphere-ocean chemistry-climate model AO-UMUKCA to investigate the impact of an extreme Solar Geoengineering (SG) perturbation that counteracts a strong greenhouse warming. Our focus is on atmospheric composition and circulation changes and the corresponding feedback effects in the Earth system. Starting from pre-industrial conditions, the model is used to simulate (a) a strong climate change scenario by quadrupling atmospheric carbon dioxide ($4xCO_2$) and (b) an idealized SG experiment in which the greenhouse gas induced warming in the global mean surface temperature is offset by reducing the solar constant. Two groups of experiments have been performed, one with and one without interactive chemistry.

We find large changes in key species (e.g. ozone, methane, etc.) under the interactively forced scenarios relative to pre-industrial conditions. This expected chemistry feedback was not accounted for in earlier analogous geoengineering studies. Our experiments demonstrate the potential importance of such stratospheric composition changes for the near-surface temperature signal. We are the first to quantify the differences between interactive and non-interactive simulations. For instance, the interactive run produces about 20% less surface warming under $4xCO_2$. In the SG experiment 1.1 W/m^2 more dimming was needed in the non-interactive case. Finally, we show how this affects other important climate patterns such as the El Nino Southern Oscillation and characterise the drivers of change.