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The response of chemistry and climate to the 11-year solar cycle in UM-UKCA

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It is now generally agreed that the UV variability associated with the 11-year solar cycle leads to changes in ozone and temperature in the upper stratosphere. In addition, a range of observational and modelling studies suggest that such changes are the starting point for a chain of processes (including feedbacks) resulting in circulation changes in many areas of the atmosphere. However, precise details of the interactions between chemistry and meteorology induced by solar variability remain under question.

In our study, we use a version of the UM-UKCA chemistry-climate model with consistent spectrally-resolved solar variability. While the solar cycle in heating rates has been applied with the method used in HadGEM2-ES, fine spectrally-resolved solar variability has been uniquely incorporated into the Fast-JX photolysis scheme. We perform two 50-year-long perpetual year solar maximum and solar minimum integrations and complement them with a three member ensemble of a transient 1960-2010 integration in which boundary conditions correspond by and large to the CCMI Ref-C1 scenario. We show how the inferred solar signals vary between the individual experiments. This indicates high natural variability and the resulting contamination of the solar signal with contributions from other processes as well as the existence of possible non-linearities between the solar cycle and other atmospheric forcings. Therefore, we highlight that long data series are needed to ensure correct attribution of the modelled and observed anomalies.

In addition, we present results from two perpetual year experiments in which the solar cycle was applied exclusively in either short-wave heating or photolysis. We find large non-linearities in the modelled anomalies as compared to the realistic integration with both modulations included. This highlights the subtle nature of the dynamical response to the solar cycle forcing and indicates the need for interactive chemistry with a detailed photolysis scheme for modelling the solar-climate interactions fully.