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Sensitivity of the atmospheric response to idealized UV solar cycle variations in WACCM

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To date, most (chemistry) climate modeling studies of the 11-yr solar cycle effects on climate use the Lean dataset as input for the spectrally-resolved solar forcing. The variations of the spectral solar irradiance (SSI) estimated by others point at a higher solar cycle amplitude in the UV part of the spectrum which is responsible for heating and ozone chemistry. Recent SORCE-SIM measurements also show a different spectral behaviour of the radiation as previously thought. A major limitation of satellite measurements, upon which empirical models of solar variability are based, is that the instrumental uncertainty becomes comparable or higher than the solar cycle variations at wavelengths longer than 250-300nm.

We test the uncertainty in the atmospheric response to idealized solar forcings with NCAR's Whole Atmosphere Community Climate Model, version 3.5 (WACCM3.5). We performed five time-slice experiments with WACCM-3.5. A 20-years long control run is performed under solar minimum conditions with SSI values according to the standard Lean dataset. Four 20-years long experiments are then performed with solar maximum conditions. One is driven with solar maximum SSI values from the standard Lean dataset. One is driven with solar maximum SSI values with an additional constant 1% increase in the radiation between 300-400nm; one includes a constant 1 % increase in 240-270nm, while the fifth experiment includes a constant 3 % increase in 240-270nm. The artificial increase in UV forcing in these numerical experiments represents the uncertainty in current estimates of UV solar cycle variations at both 300-400 and 240-270 sub-ranges. All other forcings are kept constant (e.g. SSTs, GHGs), and therefore the simulated changes in the model climate can be unambiguously attributed to the imposed changes in the UV solar forcing.

We find that the additional UV at both spectral sub-ranges leads to more absorption at different heights in the tropical stratosphere. This is due to Hartley and Huggins bands, which produce different heating profile than in the usual solar cycle UV variation. We also find that the dynamical response in the winter circulation is highly sensitive to the structure of the tropical ozone-induced heating. Both absorption bands lead to a stronger response in the polar vortex than in the solar cycle UV variation derived from the Lean dataset. The evolution of the stratospheric winter circulation in the Northern Hemisphere is mostly sensitive to the Hartley band absorption. We will also show that the simulated tropospheric changes are linked to the stratospheric response. The results of these experiments and their implications for future studies of solar cycle impacts on climate will be discussed.