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Transient climate simulations from the Maunder Minimum to present day: the role of the stratosphere

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Two transient climate simulations are performed with an extended version of the ECHO-G coupled ocean-atmosphere general circulation model that also includes a detailed representation of the stratosphere (EGMAM). The simulations cover the time period from 1630 to 2000 and are started from the same initial conditions taken from a long pre-industrial control simulation. The first simulation is driven with changes in total solar irradiation due to solar activity and volcanic eruptions and changes in greenhouse gas (GHG) concentration. The second simulation additionally includes prescribed changes in stratospheric ozone concentration representing solar induced changes in photochemical ozone production. The simulated change in NH near surface temperature and winter North Atlantic Oscillation (NAO) is compared to reconstructions and other transient simulations with the ECHO-G and CCSM3 model.

Results indicate that the inclusion of the stratosphere does only play a moderate role for the simulated climate sensitivity. Whereas a shift of the NAO to a more positive phase can be attributed to increase in GHG concentrations, there is also indication that the dynamical troposphere-stratosphere coupling counteracts the GHG induced strengthening of the tropospheric westerlies over the North-Atlantic/European sector. On the multi-decadal to centennial time scale the simulation with solar forcing of ozone reveals a stratospheric solar signal similar to what is known from 11-year solar cycle studies when compared to the simulation with fixed ozone. The stratospheric solar ozone forcing substantially contributes to the climate change signal in the stratosphere and there is also evidence for an impact on the tropospheric circulation.