Contribution ID: **14** Type: **Oral**

Evaluation of the chemistry and climate impact of the new solar forcing dataset for CMIP7 using the Whole Atmosphere Community Climate Model

Monday 16 September 2024 09:40 (20 minutes)

The solar forcing dataset prepared for the 6th round of the Coupled Model Intercomparison Project (CMIP6) has been used extensively in climate model experiments. Recently, an International Space Science Institute (ISSI) Working Group was established to revisit the solar forcing recommendations in order to define a roadmap for building a revised solar forcing dataset for the upcoming 7th round of CMIP (Funke et al., 2023). This new dataset will introduce changes in the radiative forcing of climate either directly, or indirectly via changes in atmospheric composition. In CMIP6, the solar forcing consisted of both a total solar irradiance (TSI), along with a spectrally resolved solar irradiance (SSI). The TSI for solar minimum was set to 1360.8±0.5Wm-2 and the SSI covered the 10nm to 100mm spectral region. A similar approach is proposed for CMIP7 except for two major aspects of the reconstruction: 1) the definition of the reference spectrum for the quite Sun; 2) the temporal variability. The major difference between the proposed CMIP7 SSI quiet sun reference spectrum and that used for CMIP6 is the spectral shape. The new SSI spectrum has an irradiance that is 1-5% higher in the visible band and lower by 1-2% in the Near-IR wavelength range (1000-2000nm).

In this work we used the Whole Atmosphere Community Climate Model (WACCM) to examine the chemical and climate implications of the proposed CMIP7 solar forcing updates compared to the CMIP6 approach. WACCM is a chemistry-climate model that extends from the surface to 140km and has a detailed representation of chemical and dynamical processes from the troposphere through the lower thermosphere. We present two sets of results derived from two numerical experiments: 1) "chemical only"impacts of the solar forcing choice in WACCM run in the specified dynamics mode using NASA Modern-Era Retrospective analysis for Research and Applications Version 2 (MERRA2) and 2) "climate"impacts in simulations with the model free-running with interactive dynamics coupled to a deep ocean. We find stratospheric ozone and temperature differences caused by changes in the SSI forcing to be similar in magnitude to changes simulated over the solar cycle. The stratospheric surface climate is cooler everywhere and largest near the poles where statistically significant increases are sea ice fraction are simulated. This highlights the need for modelling centres to use the new SSI dataset as early as possible in their model development cycle for CMIP7.

Funke, B., Dudok de Wit, T., Ermolli, I., Haberreiter, M., Kinnison, D., Marsh, D., Nesse, H., Seppälä, A., Sinnhuber, M., and Usoskin, I.: Towards the definition of a solar forcing dataset for CMIP7, Geosci. Model Dev. Discuss. https://doi.org/10.5194/gmd-2023-100.

Solicited or Contributed

Contributed

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Session Classification: CMIP-7 forcing and implementation in Earth system models

Track Classification: CMIP-7 forcing and implementation in Earth system models