Project Details

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Project Title:
Consistent simulations of radiative and particulate impacts of solar activity on climate

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Summary:
Our investigations will focus on answering the question of whether we can understand the processes producing solar-related variance in climate observations using our best simulations of the physical drivers, and what the relative importance of the different mechanisms are on a variety of timescales. We propose to utilize the Goddard Institute for Space Studies (GISS) ModelE to examine the impact of quasi-decadal and longer-term changes in solar activity in the historical context of the 20th and early 21st Century climate. ModelE is uniquely appropriate for this task since it has well-tested whole-atmosphere chemistry (up to the mesosphere) that produces a good match to solar-cycle variability in atmospheric composition and surface regional climate responses. Additionally, new versions of the model with higher vertical resolution (and/or a model top near the mesopause) are able to self-generate a quasi-biennial oscillation (QBO), which has been hypothesized to be a key modulating factor in coupling upper and lower atmospheric impacts of solar change. Furthermore, using the MATRIX aerosol microphysical scheme we have the capacity to simultaneously assess the impact of changes in ionization (via the solar modulation of Galactic Cosmic Rays (GCR)) on fine aerosols and the subsequent growth into cloud condensation nuclei.

We will develop a set of coherent solar-related drivers that can be used simultaneously or separately consisting of time-series of total solar irradiance (derived from the SORCE-based reconstruction), with full variations in the relevant spectral bands and time and space variations in ionization. We propose to perform an ensemble of historical (1850-2014) coupled ocean-atmosphere simulations using (at minimum) four subsets of forcings: an all-forcing case (including GHGs, ozone depleting substances, aerosols, volcanoes, land use/land cover change, short-lived reactive gases and all solar factors), an all-forcing case only including radiative solar effects, and two solar-only cases with purely radiative, and with radiative and ionization changes. These simulations and input datasets will be publicly archived with complementary simulations performed under the auspices of the Coupled Model Intercomparison Project (CMIP6).

Simulations will be compared to solar cycle variance inferred from SABER O3 and temperature in the upper atmosphere, Modern-Era Atmospheric Reanalyses (MERRA), and SAGE, MLS and SBUV retrievals. In addition, we will compare the output to the HALOE water vapor and MSU/AMSU/SSU temperatures where they are coherent with the solar cycle. We will be particularly focused on transient impacts on stratospheric sudden warmings, tropospheric annular modes (impacting regional climate and ocean circulation), and changes in tropical precipitation in order to improve attribution and forecasts of solar-related climate change and assess the relative importance of irradiance vs. energetic particle impacts.

Publication References:

no references