Project Details

ROSES ID: NNH15ZDA001N
Selection Year: 2015
Program Element: SCOSTEP/VarSITI

Project Title:
The Effects of Solar Minimum Irradiance Variability on Whole Atmosphere Climate

PI Name: Han-Li Liu
PI Email: atn@g.ucla.edu
Affiliation: University Corporation For Atmospheric Research (UCAR)
Project Member(s):
- McInerney, Joe M.; Co-I
- Solomon, Stanley C.; Co-I; University Corporation For Atmospheric Research (UCAR)
- Rempel, Matthias ; Co-I; University Corporation For Atmospheric Research (UCAR)
- Qian, Liying ; Co-I; University Corporation For Atmospheric Research (UCAR)

Summary:
Using a state-of-the-art solar radiation MHD model, we will estimate the photospheric total solar irradiance (TSI) and chromospheric ultra-violet (UV) emissions under extreme quiet solar conditions. The proposed simulation employs very high spatial resolution to calculate changes in TSI from photospheric variations with different magnetic field configurations, and solar spectral irradiance (SSI) by performing radiative transfer in a few frequency bands. The total chromospheric variation will be estimated from these models by using the upward directed Poynting flux above the photosphere as a proxy, and can be related to the variation of photospheric TSI variation. These physically self-consistent estimates will then be used to drive the National Center for Atmospheric Research (NCAR) Whole Atmosphere Community Climate Model with thermosphere and ionosphere extension (WACCM-X) to study the implications for the climate of the whole atmosphere system, including the bottom-up and top-down interactions of the ionosphere, thermosphere, mesosphere, stratosphere and troposphere. This will enable us to quantify the atmospheric climate state under extreme quiet solar conditions using physically-based minimum irradiance estimates, and will provide insights into the solar-climate connection. The solar TSI and SSI estimates will first be validated against existing observations under nominal solar minimum conditions, and these observed solar spectra be used to drive WACCM-X baseline simulations. The WACCM-X baseline simulations will be compared to the Chemistry-Climate Model Initiative (CCMI) results for validating the stratosphere, and to measurements of the mesosphere and lower thermosphere by the SABER instrument on the TIMED satellite. We will then perform WACCM-X simulations under extreme quiet solar conditions, using estimates obtained from the solar radiation MHD simulation. The WACCM-X simulations will be compared with the baseline simulations, to analyze the differences in the lower, middle and upper atmosphere. The unique capability of WACCM-X will enable us to investigate the mechanisms responsible for these changes, including direct radiative impact, and upward and downward coupling processes.

The purpose of this work is to constrain the lower limits of solar irradiance and create a grand minimum scenario based on a well-characterized photospheric magnetic field distribution using a small-scale dynamo MHD simulation, and to apply these constraints on the irradiance to study the whole atmosphere climate state. We will elucidate the mechanisms by which the middle and upper atmosphere influence tropospheric climate, and estimate the global and regional climate response to Grand Minimum conditions. Although it is not yet possible to accurately calculate actual solar irradiance under these conditions, it is feasible and timely to attempt to constrain the problem. Therefore, we will address basic questions concerning solar forcing and the response of the whole-atmosphere climate system:

(1) What lower limit constraint on TSI and SSI during Grand Minimum can be provided through solar modeling?

(2) How would the terrestrial atmosphere respond to this reduced irradiance, and what are the solar signals in space and terrestrial climate?

(3) What are the mechanisms of interaction between the upper and lower atmosphere, and between the atmosphere and ocean, that could amplify or reduce the terrestrial response to solar forcing?

The proposed study addresses strategic objectives of the Living With a Star (LWS) Sun-climate theme, and will contribute to the international Role Of the Sun and Middle-atmosphere-thermosphere-ionosphere In Climate (ROSMIC) project of SCOSTEP/VarSITI.

Publication References:

no references