Project Details

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Topic: Long Term Variability and Predictability of the Sun-Climate System

Project Title:
Understand the effect of solar spectral irradiance partition between the visible and near-IR on high-latitude surface climate through a bottom-up mechanism

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Summary:
The importance of total solar irradiance (TSI) on Earth's climate has been long recognized and studied. What has not been equally studied is how the solar spectral irradiance (SSI) over the different spectral regions affect our climate. Absorption and scattering of solar radiation by Earth s atmosphere and surface are spectrally dependent. Thus, how the climate responds to the SSI variation might not be simply scaled with TSI variation.

So far, most SSI-climate connection studies have been focused on the UV. Visible and near-IR consist of about 48% and 45% of the TSI, respectively; thus, a small fractional change in the visible and near-IR SSI can still matter for our climate. The partition of SSI between the visible and near-IR (hereafter referred to as VIS-NIR partition for brevity) is especially relevant to Earth's climate because both water vapor absorption and sea ice reflectance vary significantly from the visible to near-IR. As a result, a different VIS-NIR partition of the same TSI value can lead to different amounts of solar absorption and reflection by the climate system.

NASA TSIS-1 mission launched in 2017 has provided more accurate SSI measurements than ever before. Compared to the SSI used in the recent IPCC climate model simulations, the TSIS-1 SSI for a given VIS or NIR band can differ as much as 4 W/m^2. Such VIS-NIR partition differences can cause statistically significant differences in the simulated polar climate, as shown by our recent study using the NCAR new flagship climate model, CESM2. Such change is caused by the response of surface energy budget to the VIS-NIR partition difference and a variety of atmospheric radiative feedbacks, which we termed as a bottom-up mechanism for the SSI to influence our climate. Such findings motivate us to propose a series of studies to address the following questions:
1. When the actual TSIS-1 SSI is used in the simulations with prescribed sea surface temperature and sea ice, how does the simulation compare to the simulation done with the default SSI used by the climate modeling community? How do model simulations compare to the observations over the same period? The answer will help us understand the fast atmospheric responses to the VIS-NIR partition difference.
2. How does the fully coupled CESM2 simulation over multiple decades respond to the SSI VIS-NIR partition difference between the TSIS-1 observation and the data used by the IPCC community? Can we quantify the strengths and spatial distributions of radiative feedbacks caused by such VIS-NIR partition difference?
3. Based on the TSIS-1 measurement uncertainty, what would be the uncertainty in the TSIS-1 VIS-NIR partition? How can such uncertainty be propagated to the uncertainty in the simulated climate? Can we express such propagation as a Jacobian sensitivity matrix?
4. Based on #2 and #3, using CESM2 time slice run, can we estimate the impact of VIS-NIR SSI partition on the IPCC historical and future simulations? This will elucidate to what extent the bottom-up mechanism can affect the simulated climate change.

We propose to carry out a series of CESM2 simulations with different SSI configurations to address the above questions. CU-Boulder team specializes in SSI observation, uncertainty quantification, and reconstruction, and the Michigan team specializes in climate model simulations and solar physics. The proposed study aims for FST #4. It addresses two specific topics, "radiative process and forcing including the absorption and scattering of total and spectral solar irradiance" and "variations in atmospheric temperature." The goal is to understand the physics behind how the climate system responds to the variations of SSI VIS-NIR partition. Doing so will advance our physical understanding of the SSI-climate connection and help improve the predictability of the earth system models. It will pave a road to further integrate NASA SSI observations into the climate modeling community.

Publication References:

no references