New NASA data sheds light on climate models

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In this photo taken from the International Space Station, the rising sun casts long shadows across the Philippine Sea. Credit: NASA

Have you ever worn a dark T-shirt on a sunny day and felt the fabric warm in the sun's rays? Most of us know dark colors absorb sunlight and light colors reflect it—but did you know this doesn't work the same way in the sun's non-visible wavelengths?

The sun is Earth's power source, and it emits energy as visible sunlight, ultraviolet radiation (shorter wavelengths), and near-infrared radiation, which we feel as heat (longer wavelengths). Visible light reflects off light-colored surfaces like snow and ice, while darker surfaces like forests or oceans absorb it. This reflectivity, called albedo, is one key way Earth regulates its temperature—if Earth absorbs more energy than it reflects, it gets warmer, and if it reflects more than it absorbs, it gets cooler.

The picture becomes more complicated when scientists bring the other wavelengths into the mix. In the near-infrared part of the spectrum, surfaces like ice and snow are not reflective—in fact, they absorb near-infrared light in much the same way a dark T-shirt absorbs visible light.

"People think snow is reflective. It's so shiny," said Gavin Schmidt, director of NASA's Goddard Institute for Space Studies in New York City and acting NASA senior climate adviser. "But it turns out in the near-infrared part of the spectrum, it's almost black."

Clearly, for climate scientists to get the whole picture of how solar energy enters and exits the Earth system, they need to include other wavelengths besides visible light.

That's where NASA's Total and Spectral Solar Irradiance Sensor (TSIS-1) comes in. From its vantage point aboard the International Space Station, TSIS-1 measures not only the total solar irradiance (energy) that reaches Earth's atmosphere, but also how much energy comes in at each wavelength. This measurement is called spectral solar irradiance, or SSI. TSIS-1's Spectral Irradiance Monitor (SIM) instrument, developed by the University of Colorado Boulder's Laboratory for Atmospheric and Space Physics, measures SSI with an accuracy better than 0.2%, or within 99.8% of the true SSI values.

"With TSIS-1, we have more confidence in the measurements of visible and near-infrared light," said Dr. Xianglei Huang, professor in the department of Climate and Space Sciences and Engineering at the University of Michigan. "How you partition the amount of energy at each wavelength has implications for the mean climate."

Huang and his colleagues at the University of Michigan, NASA's Goddard Space Flight Center in Greenbelt, Maryland, and University of Colorado Boulder recently used TSIS-1 SSI data in a global climate model for the first time. "Several studies used various SSI inputs to analyze the sensitivity of climate models in the past." However, this study was the first to investigate how the new data changed the modeled reflection and absorption of solar energy at Earth's poles, said Dong Wu, project scientist for TSIS-1 at Goddard.

They found that when they used the new data, the model showed statistically significant differences in how much energy ice and water absorbed and reflected, compared to using older solar data. The team ran the model, called the Community Earth System Model, or CESM2, twice: Once with new TSIS-1 data averaged over an 18-month period, and once with an older, reconstructed average based on data from NASA's decommissioned Solar Radiation and Climate Experiment (SORCE).

The team found that the TSIS-1 data had more energy present in visible light wavelengths and less in the near-infrared wavelengths compared to the older SORCE reconstruction. These differences meant that sea ice absorbed less and reflected more energy in the TSIS-1 run, so polar temperatures were between 0.5 and 1.3 degrees Fahrenheit cooler, and the amount of summer sea ice coverage was about 2.5% greater.

"We wanted to know how the new observations compare to the ones used in previous model studies, and how that affects our view of the climate," said lead author Dr. Xianwen Jing, who carried out this research as a postdoctoral scholar in the department of Climate and Space Sciences and Engineering at the University of Michigan. "If there's more energy in the visible band and less in the near-infrared band, that will affect how much energy is absorbed by the surface. This can affect how the sea ice grows or shrinks and how cold it is over high latitudes."

This tells us that in addition to monitoring total solar irradiance, Huang said, we also need to keep an eye on the spectra. While more accurate SSI information will not alter the big picture of climate change, it may help modelers better simulate how energy at different wavelengths affects climate processes like ice behavior and atmospheric chemistry.

Even though the polar climate looks different with the new data, there are still more steps to take before scientists can use it to predict future climate change, the authors warned. The team's next steps include investigating how TSIS data affects the model at lower latitudes, as well as continuing observations into the future to see how SSI varies across the solar cycle.

Learning more about how solar energy interact with Earth's surface and systems—at all wavelengths—will give scientists more and better information to model the present and future climate. With the help of TSIS-1 and its successor TSIS-2, which will launch aboard its own spacecraft in 2023, NASA is shining a light on Earth's energy balance and how it is changing.

Provided by NASA's Goddard Space Flight Center

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