Clouds' Role in Sunlight Stopping

Research Highlight

Clouds are energy traffic cops, controlling how much sunlight reaches Earth. Pacific Northwest National Laboratory (PNNL) researchers used long-term observations to show that the sunlight stopping power of each type of typical tropical cloud, and how frequently they occur, must be accurately simulated in climate models. Otherwise, understanding of the true impact of clouds on the Earth's energy balance will be uncertain. Their research was published in the Journal of Applied Meteorology and Climatology.

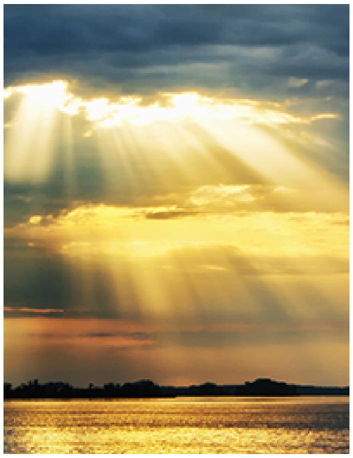
While researchers found that tall storm clouds have the largest impact on the amount of incoming solar energy that reaches the surface, these clouds are infrequent tropical visitors.

The PNNL team used long-term observations from the three Atmospheric Radiation Measurement (ARM) Climate Research Facility sites in the Tropical Western Pacific (TWP) region to quantify how each cloud type impacts the surface energy budget. Using the vertically-pointing radars and lidars, they determined the cloud type present at a given time and then related that dataset to longwave and shortwave radiative flux measurements made at the same time. This allowed them to attribute changes in the flux data to a specific type of cloud and then to determine which types of clouds have the largest conditional and mean impacts on the surface energy budget. The research showed how small errors in modeled cloud frequency could cause large biases in the surface energy budget simulated by the model.

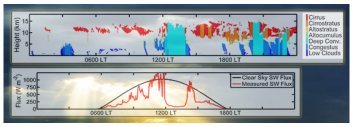
The statistical analysis in this research was possible largely because of the long-term data record, in some cases over 20 years, that is available from the ARM sites in the TWP region.

Energy from the sun fuels Earth's heat engine. Cloud characteristics determine whether sunlight is either turned back toward space, bounced around the atmosphere like a demolition derby, or allowed to travel through to be soaked up by the Earth's surface.

To understand how clouds do this important job, scientists take measurements of energy from the sun (radiation) and cloud properties. But when it comes time to analyze clouds' role using climate simulations, many climate models fail to produce the right clouds in the right place at the right time. This means that the simulations often have large biases in how clouds impact the surface energy in/out balance. Model biases in the magnitude of these cloud radiative effects directly lead to uncertainty in future climate states projected by the models. The research in this work established clear physical targets that can be used to evaluate models and improve the simulation of clouds in climate models.



Sunlight streaks through clouds over the tropical landscape. Energy from the sun fuels Earth's heat engine. PNNL research provided new insight into the climate influence of different types of clouds and their frequency in the tropics.



The top figure shows the cloud type classification derived from radar reflectivity over a 24-hour period. Bottom figure shows daylight measured (red line) and estimated clear sky (black line) shortwave radiative flux – the amount of solar energy, measured in Watts per meter2, reaching the surface. Data are captured from the ARM Climate Research Facility's Manus site on November 7, 2011, and the x-axis is in local standard time (LT).

Reference(s)

Burleyson CD, CN Long, and JM Comstock. 2015. "Quantifying diurnal cloud radiative effects by cloud type in the Tropical Western Pacific." Journal of Applied Meteorology and Climatology, , doi:10.1175/JAMC-D-14-0288.1. ONLINE.

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Cloud Life Cycle