IDENTIFYING ROBUST CLOUD FEEDBACKS IN OBSERVATIONS AND MODELS

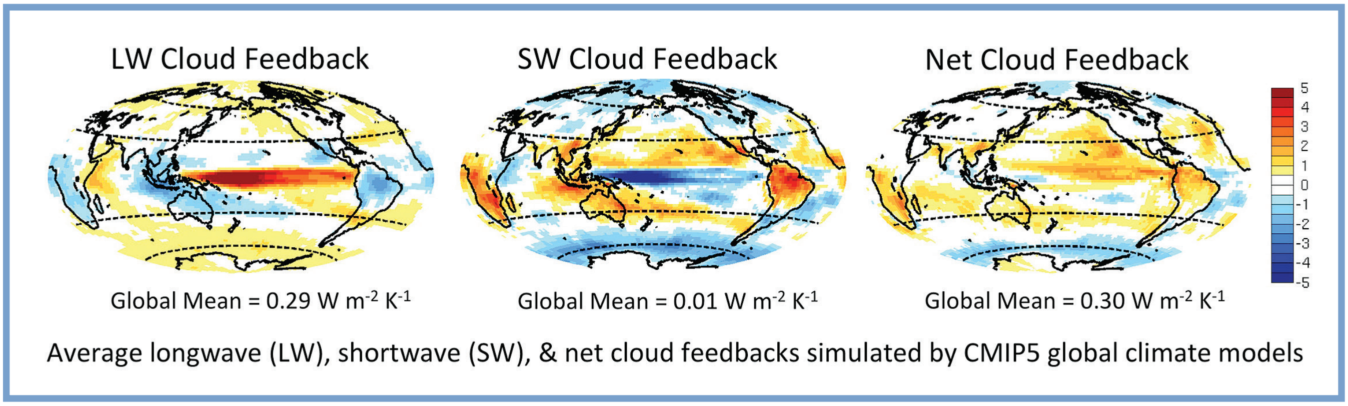
For more than 30 years, scientists have known that the inability to predict how clouds will respond to climate change hinders a confident prediction of the magnitude of global warming resulting from a given increase in greenhouse gases. As a result, they are not able to confidently identify the magnitude of carbon emission reductions necessary to avoid dangerous human influences in the climate system. Thus, research is needed to reduce the uncertainty range associated with the response of clouds to a warming of the planet, also known as the "cloud feedback."

In a project sponsored by the U.S. Department of Energy's Office of Science through the Regional and Global Model Analysis program, a team of researchers at Lawrence Livermore National Laboratory and the University of California at Los Angeles are working to reduce these uncertainties by identifying robust cloud feedbacks in today's climate models and constraining them with available observations. The team scrutinizes the results from simulations of future climate made by the most recent climate models assessed by the Intergovernmental Panel on Climate Change to answer a variety of questions:

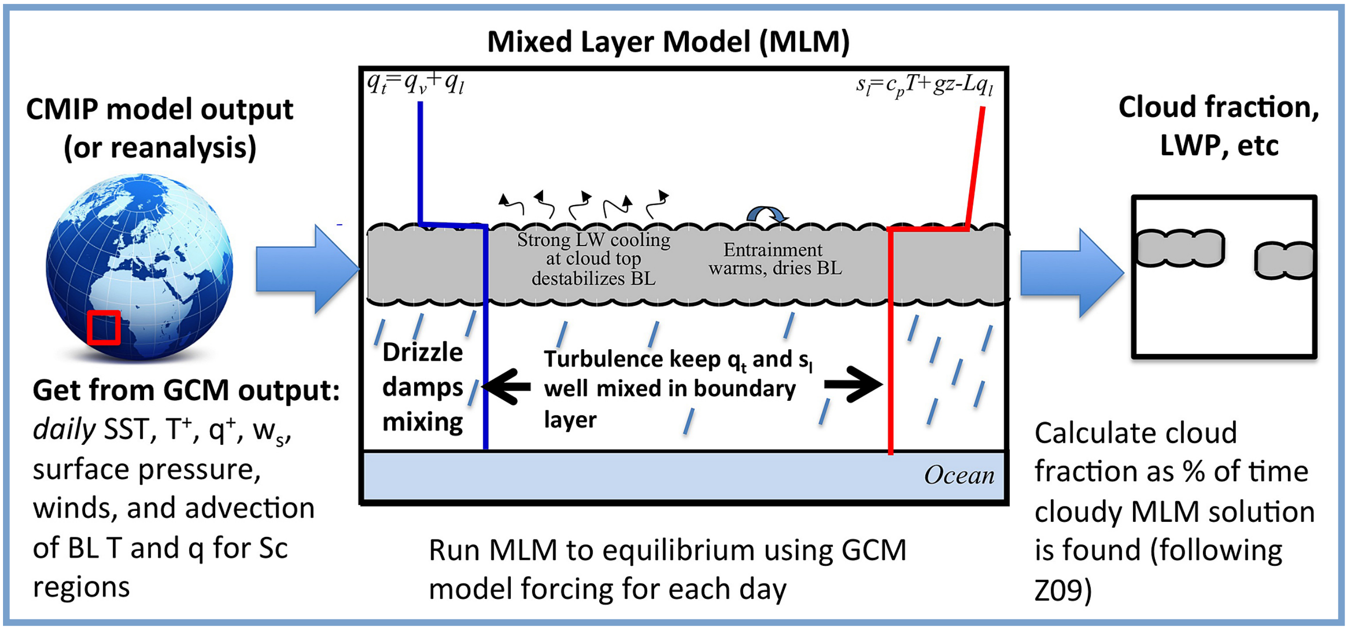
How clouds respond to climate change is one of the key uncertainties in the prediction of future climate. Research is needed to narrow the range of uncertainty due to the cloud feedback so that policy makers can understand how much climate warming will result from a given level of greenhouse gas emissions.

WHICH CLOUD TYPES MATTER FOR CLOUD FEEDBACK?

Cloud feedbacks are extremely variable between different climate models. It is not always clear what is the relative contribution of cloud types from various regions to the global mean cloud feedback and its inter-model spread. Researchers in this project have developed novel techniques to separate the contribution of different cloud types and have found that cloud feedbacks are not the result of a single cloud type, but researchers must consider feedbacks from many cloud types including low clouds, high clouds, mid-latitude clouds, and polar clouds.



Cloud feedbacks simulated in the latest (CMIP5) global climate models. Positive feedbacks (red colors) amplify warming and negative feedbacks (blue colors) dampen warming. Cloud feedbacks result from a wide variety of clouds in diverse climate regimes globally. This requires research aimed at understanding the responses of various cloud types across the globe to climate change. (Source: Zelinka et al., 2013)



Simplified process models driven by boundary conditions from global climate models provide insights in the reasonableness of cloud feedbacks simulated by global climate models. In this case, a Mixed-Layer Model (MLM) is used to understand how one of the key cloud types —namely, low clouds over the subtropical oceans—responds to climate change. (Source: Caldwell et al., 2013)

WHAT ASPECTS OF CLOUD FEEDACK CAN BE CONSTRAINED WITH TODAY'S OBSERVATIONS?

A key aspect of the project is the identification of cloud feedbacks where similarities are found in simulations of both current-climate variability and of projected climate change (so called "timescale invariant feedbacks"). For example, if fluctuations of clouds with day-to-day, or season-to-season, variations of temperature are similar to those shown over climate change time-scales, observations from the current climate could be used to constrain cloud feedbacks. Researchers are working to identify which cloud types exhibit time-scale invariance as well as the observations that can quantitatively constrain these feedbacks.

WHAT PHYSICAL PROCESSES CONTRIBUTE TO CLOUD FEEDBACK AND WHAT FEEDBACKS ARE CORRECT?

Our confidence in any given cloud feedback depends on our ability to understand the physical processes from which the feedbacks result and our confidence in those processes. Researchers are working towards identifying the physical mechanisms of various feedbacks simulated by complex climate models and critiquing their realism. One technique to accomplish this is the application of more realistic models of cloud processes to the changes in the large-scale environment predicted by global climate models.

ACCOMPLISHMENTS

Since the inception of the project in 2010, the project has resulted in eight published papers. Results from some of these papers have been cited in the 5th Assessment Report of the Intergovernmental Panel on Climate Change. Our novel techniques to diagnose cloud feedbacks have been shared with the international research community and facilitate a wide variety of studies.

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http://www-pcmdi.llnl.gov/projects/cloud_feedbacks/index.php