Researchers develop technique to understand how tiny atmospheric particles change elusive ice clouds

27 October 2014

The fragile appearance of wispy cirrus clouds disguises their substantial influence on the climate. Depending on the density of their ice crystals, these clouds can scatter or reflect sunlight back into space or allow light to pass through to affect the energy lost to outer space. Scientists are developing ways to simulate these elusive clouds to better understand their influence on the climate.

Thin and wispy cirrus clouds skirt the scrutiny of current climate models. To uncover that missing information, Pacific Northwest National Laboratory is leading an international effort to run coordinated numerical experiments on major climate models from all over the world. PNNL scientists and their collaborators at the University of Wyoming, the University of California, San Diego, and ETH Zurich in Switzerland refined a widely used numerical strategy called "nudging" so that the original model characteristics are correctly revealed. The technique offers a better way to study how atmospheric particles influence ice formation in clouds that affect the Earth's energy budget and influence precipitation.

Most of Earth's rain and snow originates in ice clouds. These clouds can also reduce the loss of energy to outer space, keeping the Earth warm. This important role of ice clouds influences the Earth's energy in-and-out equation and the amount of precipitation. However, exactly how ice clouds form and affect climate is not yet well understood. Clouds, consisting of droplets and ice crystals of miniscule sizes, may cover just a small portion of a typical climate model grid space and often exist for just a blip of time compared to the months to years a global model covers. The goal of these model comparison improvement projects is to test methods to closely match model results with observations, which will allow better future climate projections.

Led by scientists at PNNL, the researchers employed the Newtonian relaxation of meteorological fields toward pre-defined conditions, a model-nudging technique. They found that although the traditional nudging strategy—applied to both winds and temperature—is effective in constraining the model meteorology, the simulated energy budget at the top of the atmosphere and the cloud's ice amount can be significantly different from the unconstrained model estimate.

Using a number of sensitivity simulations in two global climate models—Community Atmosphere Model version 5 (CAM5) and the aerosol-climate model ECHAM6-HAM2—the researchers explored alternative nudging methods showing that constraining horizontal winds, but not temperature, is a convenient strategy to provide a good balance between constraining the model's meteorology and preserving its mean climate characteristics. The study also provides insight for useful ways to analyze model results.

The proposed experimentation strategy is being used in the international model intercomparison project led by the PNNL and University of Wyoming scientists.

More information: Zhang K, H Wan, X Liu, SJ Ghan, GJ Kooperman, P-L Ma, PJ Rasch, D Neubauer, and U Lohmann. 2014. "Technical Note: On the Use of Nudging for Aerosol-Climate Model Intercomparison Studies." *Atmospheric Chemistry and Physics* 14(16): 8631-8645. DOI: 10.5194/acp-14-8631-2014