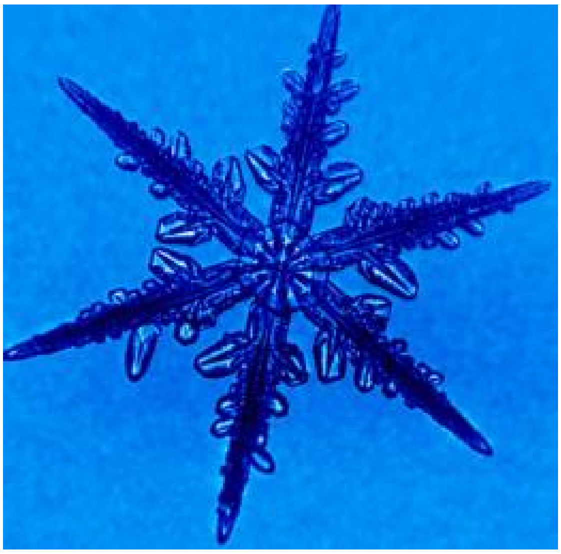
Ice heating up cold clouds

21 September 2011



The mighty cloud ice crystal appears deceptively delicate, but has the power to tip the balance between ice and water in Arctic clouds. This image of an ice crystal was obtained from a Cloud Particle Imager during the ISDAC. The CPI records high-resolution digital images of cloud particles, both water drops and ice crystals. The imager was mounted on aircraft flying through clouds at a speed of 100 m/s. When a particle passed through intersecting lasers inside the probe, a camera automatically flashed to obtain the image. The CPI was developed by the Stratton Park Engineering Company (SPEC Inc.)

In the Arctic, competition within clouds is hot. The small amount of heat released when water vapor condenses on ice crystals in Arctic clouds, which contain both water and ice, determines the cloud's survival, according to scientists from Pacific Northwest National Laboratory and Environment Canada. This heat dries the cloud and leads to the demise of water droplets and eventually, the cloud itself. The study, published in the *Journal of Geophysical Research*, shows how a few ice crystals can overcome numerous water droplets in a heated battle for vapor within cold clouds.

The Arctic is warming faster than any other region of the world. The loss of Arctic sea ice caused by climate warming is having world-wide effects on shipping, fishing, and human life. Clouds are an important part of the Arctic climate because they both reflect sunlight's heat back into the atmosphere and trap warmth from the earth. Scientists are working to understand these clouds and accurately represent them in global climate models. Such improvements are urgently needed to increase the accuracy of climate change projections, particularly in the Arctic region, which may be a bellwether for the planet.

Clouds formed at cold temperatures, such as Arctic mixed-phase clouds, contain both liquid water droplets and ice particles. Although droplets are thousands of times more numerous, previous studies have shown that adding even a small number of ice crystals to these clouds can lead to a fast dissipation of the cloud water. The mechanics of this transition, however, were largely unknown.

Scientists from PNNL, along with colleagues from other U.S. and Canadian institutions, carried out a month-long sampling campaign in 2008 called the Indirect and Semi-Direct Aerosol Campaign. During ISDAC, they collected an unprecedented level of data and detailed observations on Arctic clouds and aerosols, those tiny particles in the atmosphere that act as seeds for cloud droplets and ice crystals. The research team for this study used these data in sophisticated numerical models to examine cloud microphysical processes that are important for cloud maintenance but cannot be directly observed, even with the most advanced instrumentation.

The composition of these mixed-phase clouds is fundamentally unstable. Water droplets, ice crystals and water vapor are constantly changing and able to co-exist only when air in a cloud is constantly moving. Because air motions in these clouds are driven primarily by processes tied to the presence of liquid, when water droplets competing for water vapor lose to ice crystals, an ensuing chain of events drives the cloud toward collapse. The research team found that in this unstable system, growing ice crystals precipitate out of the cloud, warming, drying, and ultimately destroying it.

With this new knowledge of the complex interactions between dynamic and microphysical processes in mixed-phase clouds, researchers can improve the representation of these clouds in climate models.

More information: Ovchinnikov M, et al. "Effects of Ice Number Concentration on Dynamics of a Shallow Mixed-Phase Stratiform Cloud." 2011. *Journal of Geophysical Research*, 116, D00T06, DOI:10.1029/2011JD015888

Provided by Pacific Northwest National Laboratory