Center for Multiscale Modeling of Atmospheric Processes (CMMAP), Colorado State University - A National Science Foundation (NSF) Science and Technology Center

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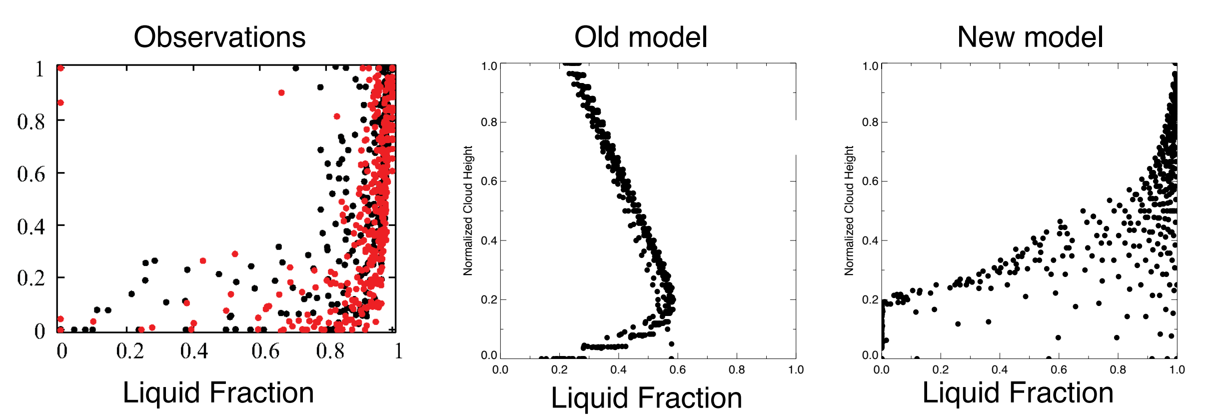
# The Effects of Ice Nuclei on Clouds and Climate

The global atmosphere contains "mixed-phase" clouds, which are made up of both liquid water droplets and ice crystals. The ratio of liquid water to ice is critical for determining how long the cloud lasts, how much rain or snow falls from it, and also its properties. The many such clouds in the Earth's atmosphere strongly influence both weather and climate.

CMMAP's "Multiscale Modeling Framework," or MMF, explicitly simulates cloud formation in the global atmosphere by embedding a fine-grid cloud-resolving model within each of a global atmospheric model's much larger grid columns. The amount of ice is determined as a function of the cloud temperature and the relative humidity over ice. Recent research by CMMAP scientists shows that the concentration of ice nucleating particles also plays a critical role.

Ice nuclei (IN) are atmospheric particles, sometimes called "aerosols," that act as nuclei for the formation of ice crystals in the atmosphere. CMMAP scientist Dr. Paul DeMott and colleagues at Colorado State University have used laboratory and field measurements to compile a large database documenting the concentration and distribution of ice nuclei in the atmosphere. They have used their growing database to identify the simplest and strongest links between ice nuclei and cloud properties. Their studies show that ice nuclei predict the onset of ice formation in clouds. This result can be expressed as a formula relating the ice crystal concentration as a function of the aerosol concentration and the cloud temperature.

The formula was tested by incorporating it into a CMMAP cloud-resolving model, and using the model to simulate highly detailed observations collected in a recent Arctic cloud study. The major result, as




*Comparison of observations (left) of the cloud liquid fraction, which is the ratio of condensed water to ice amount, to the old model result (middle) and the new result (right) based on the formulation by Dr. Paul DeMott. The different colored points in the observations are data from two different aircraft profiles of the same cloud layer.*

shown in the attached figure, is that the formula leads to a huge improvement in the vertical distribution of the liquid and ice concentrations within the simulated clouds. Increasing liquid water and decreasing ice water content in the cloud layer in the new simulations leads to a decrease in shortwave radiation reaching the Earth's surface, while simultaneously increasing downward longwave radiation which can lead to warmer surface temperatures. Getting the correct cloud vertical structure can also impact the timing, rate, and total precipitation from such clouds.

The next step will be to test the new methods in a simulation of the global climate, using the MMF.