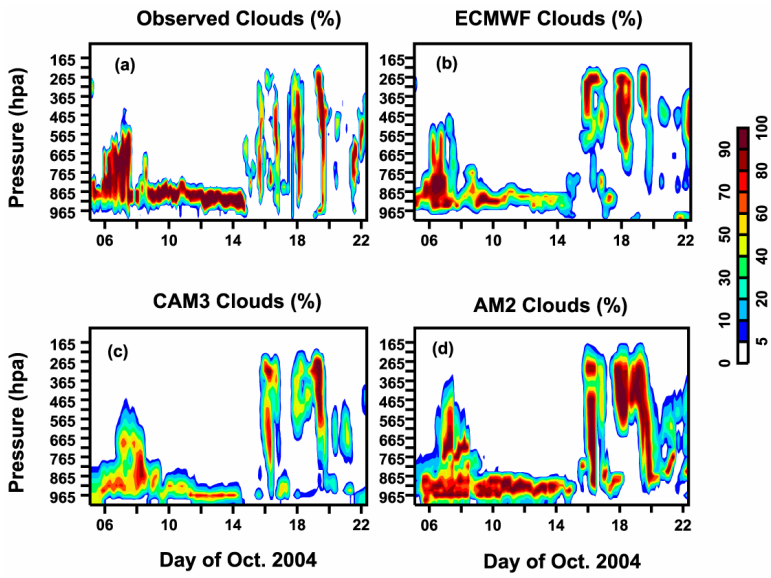
Models Evaluated for Consistency, Accuracy in Simulating Arctic Cloud Systems

Arctic clouds and their influences on radiative feedback processes are very important to global climate change. Accurately representing arctic clouds and interactions between clouds and radiation in global weather forecast and climate models has been a challenging task in the modeling community. This is mainly because of our limited knowledge of the cloud-associated processes due to a lack of sufficient observations and basic cloud studies in the Arctic.

With the data collected from M-PACE (described previously), ARM scientists were able to evaluate the performance of two major U. S. climate models: the Community Atmosphere Model (CAM3) of the National Center for Atmospheric Research, and the Atmosphere Model (AM2) of the NOAA Geophysical Fluid Dynamics Laboratory; as well as the weather forecast model of the European Center for Medium-Range Weather Forecasts (ECMWF) in simulating the Arctic cloud systems observed during M-PACE. The two climate models were evaluated using a framework developed through a joint effort between the DOE's Climate Change Prediction Program and ARM program, called the CCPP-ARM Parameterization Testbed (CAPT). This testbed is a diagnostic tool that allows running climate models in weather forecast mode so that climate models can be directly assessed using ARM data.

Their study revealed that though the models simulated the overall occurrence of clouds fairly consistently, the microphysical properties of the clouds were widely varied and were in substantial error. In particular, the two climate models simulated loud bases that were too low, and significantly underestimated the observed cloud liquid and ice water contents in the mixed-phase boundary layer clouds. These problems are closely related to potential deficiencies with the parameterizations of clouds and cloud microphysical processes in these models. The errors with the simulated cloud fields directly affect the simulation of radiative fluxes. All three models overestimated the outgoing longwave radiation at the top of the atmosphere, and the ECMWF and CAM3 models substantially underestimated the incoming longwave radiation when boundary layer clouds were present. Such biases in simulated radiation impact the simulated surface energy budget. The fine resolution of the ECMWF model allowed a further comparison with ARM observations, and showed that the ECMWF model had a much larger energy loss than observed at the surface during the M-PACE period. ARM data from MPACE will be used to suggest improvements for these models.



Caption: Temporal and vertical distributions of observed and simulated clouds from ECMWF, CAM3, and AM2 at Barrow, Alaska during M-PACE, show good consistency in cloud occurrence, but wide variability in cloud microphysical properties.

Reference: Xie, S., S. A. Klein, J. J. Yio, A. C. M. Beljaars, C. N. Long, and M. Zhang (2006), An assessment of ECMWF analyses and model forecasts over the North Slope of Alaska using observations from the ARM Mixed-Phase Arctic Cloud Experiment, *J. Geophys. Res.*, *111*, D05107, doi:10.1029/2005JD006509.