Mesoscale Simulations of Polar Clouds During M-PACE

Amy Solomon, Ola Persson, Matthew Shupe (CIRES), Hugh Morrison (NCAR), Jian-Wen Bao (NOAA)

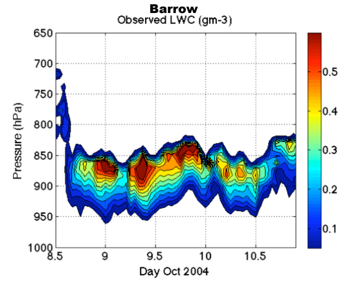
1. Introduction

In this study we use the Weather Research Forecast (WRF) model to study the microphysical properties of Arctic stratus clouds.

Intensive ground, remote sensing, aircraft, and radiosonde measurements taken during the ARM Mixed-Phase Arctic Cloud Experiment (M-PACE) on the North Slope of Alaska, during October 6-10 2004, are used to verify the microphysical characteristics of the model's simulation of mixed-phase clouds.

We identify to what extent the model is able to simulate: the maintenance of liquid water in clouds at low temperatures, the role of ice nuclei concentrations in glaciating Arctic clouds, vertical air motions within the clouds, and the direct and indirect radiation effects of aerosols.

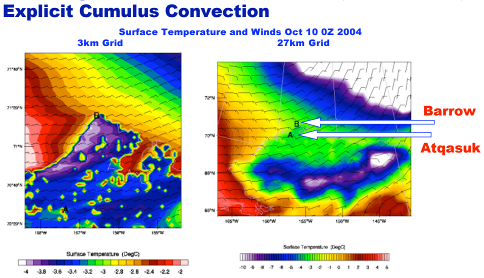
A double moment cloud scheme is compared to a simpler cloud scheme to identify whether a more realistic treatment of liquid water in clouds allows for a better representation of the Arctic boundary layer.



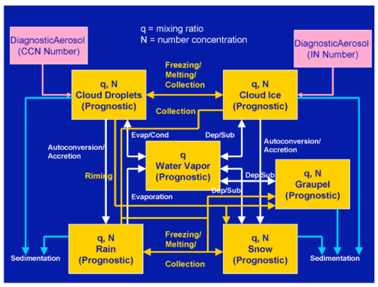
2. Model Configuration

Simulated atmospheric fields were generated using WRF V2.2, initialized at 12 UTC 8 Oct 2004 using 1° GFS data. The simulations were run for 60 hours with 27/9/3 km horizontal grid spacing and 50 vertical levels (20 levels below 800 hPa).

Including: CAM Radiation, YSU PBL, NOAH LSM, Explicit Cumulus Convection

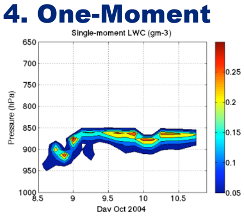


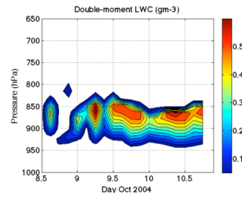
3. Double-moment microphysics



Prognostic variables include mixing ratios and number concentrations of cloud ice, cloud droplets, snow, and rain.

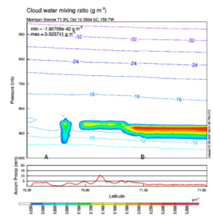
4. One-Moment vs Two-Moment Simulation

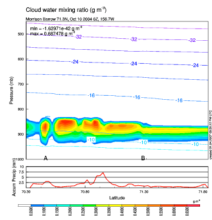




Liquid Water Content at B

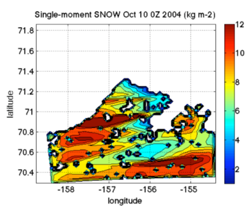
Two-moment microphysics causes liquid water to be maintained in the cloud at low temperatures (similar to observations shown above)

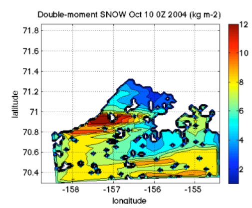




Cloud Formation over Land

The reduced LWC in the one-moment scheme causes clouds to form primarily over open ocean and near the land-sea boundary (point B (Barrow) is on the coast)





Impact on Snow Cover

The one-moment scheme has ~2X snow accumulation since the LW falls out away from the coast

6. Conclusions

•A double-moment microphysics scheme is shown to simulate the observed liquid water content in Arctic mixed-phase stratus clouds.

•Previous model studies have shown that liquid water in Arctic clouds plays a critical role in determining the structure of the planetary boundary layer, primarily through radiative feedbacks.

•We therefore conclude that the double-moment microphysics scheme allows for more realistic representations of Arctic cloud-radiation-land surface interactions.

Morrison, H., J. A. Curry, and V I. Khvorostyanov, 2005: A new double-moment microphysics scheme for application in cloud and climate models. Part I: Description. *J. Atmos. Sci.*, 62, 1665-1677.

Morrison, H., and J. O. Pinto, 2005: Mesoscale modeling of springtime arctic mixed-phase stratiform clouds using a new two-moment bulk microphysics scheme. *J. Atmos. Sci.*, 62, 3683-3704.

Skamarock, W. C., J. B. Klemp, J. Dudhia, D. O. Gill, D. M. Barker, W. Wang and J. G. Powers, 2005: Description of the Advanced Research WRF Version 2. http://www.wrf-model.org.