Performance Evaluation of Cloud Microphysical Pararmeterizations for Mixed-Phase Stratus Clouds

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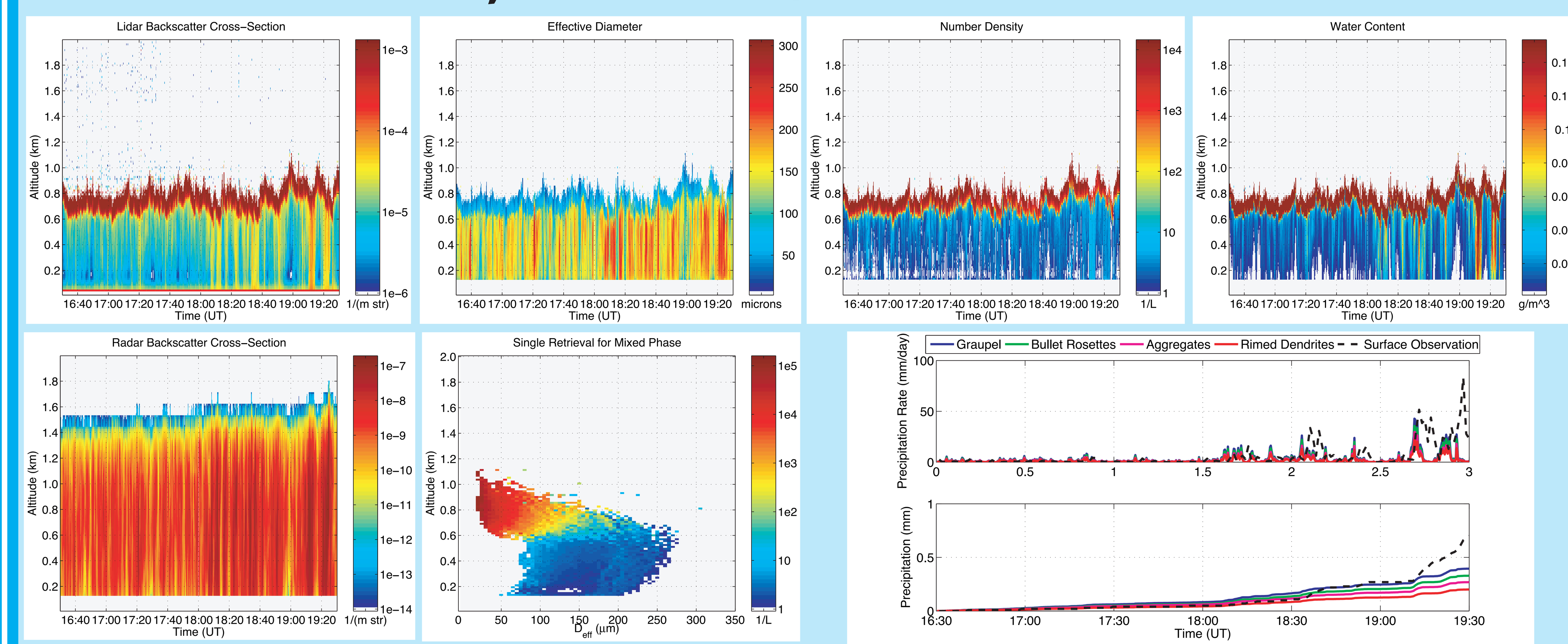
Introduction

Mixed-phase clouds, such as those found in the Arctic have presented quite a challenge to the modeling community. Without modification, models have struggled to maintain the delicate balance between liquid and ice that must exist in order to maintain these clouds for extended time periods, as they are observed in the atmosphere. In conjunction with the ARM Cloud Modeling working group we are investigating the ability of the University of Wisconsin Non-Hydrostatic Modeling System (UW-NMS) and its two microphysical parameterizations (bin (AMPS, Hashino) and bulk (RAMS, Flatau et al.)) to accurately simulate these clouds. Validation is completed using data collected during the Mixed-Phase Arctic Clouds Experiment (M-PACE). Shown here are results from simulations completed with different microphysical setups, and how they compare to observations from ground-based and in-situ sensors.

October 9, 2004 Lidar/Radar Measurements

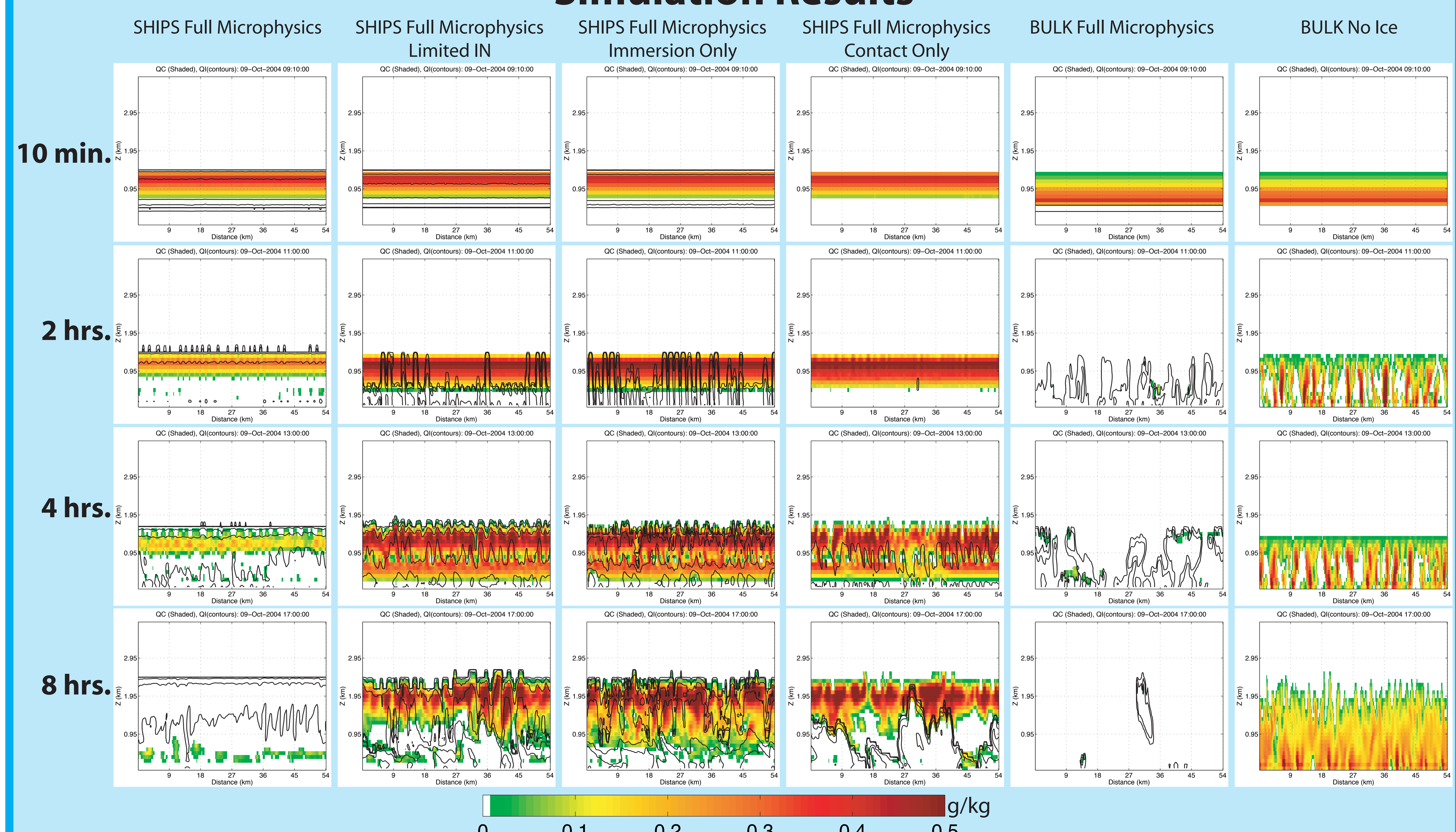


Backscatter measurements taken using the Wisconsin Arctic High Spectral Resolution Lidar (AHSRL) and NSA Millimeter Cloud Radar (MMCR) (left, top and bottom) show a cloud layer extending from ~600 m-1600 m. Very visible in the lidar data are the periodic precipitation columns. These are shown to be predominantly ice. Microphysical retrievals made using these measurements are also shown (clockwise from top of second column: Effective diameter, particle number density, water content, rain rate and cumulative precipitation, and a plot of size vs. altitude shaded by concentration. For more information on these retrievals, please see Ed Eloranta's poster.

Summary

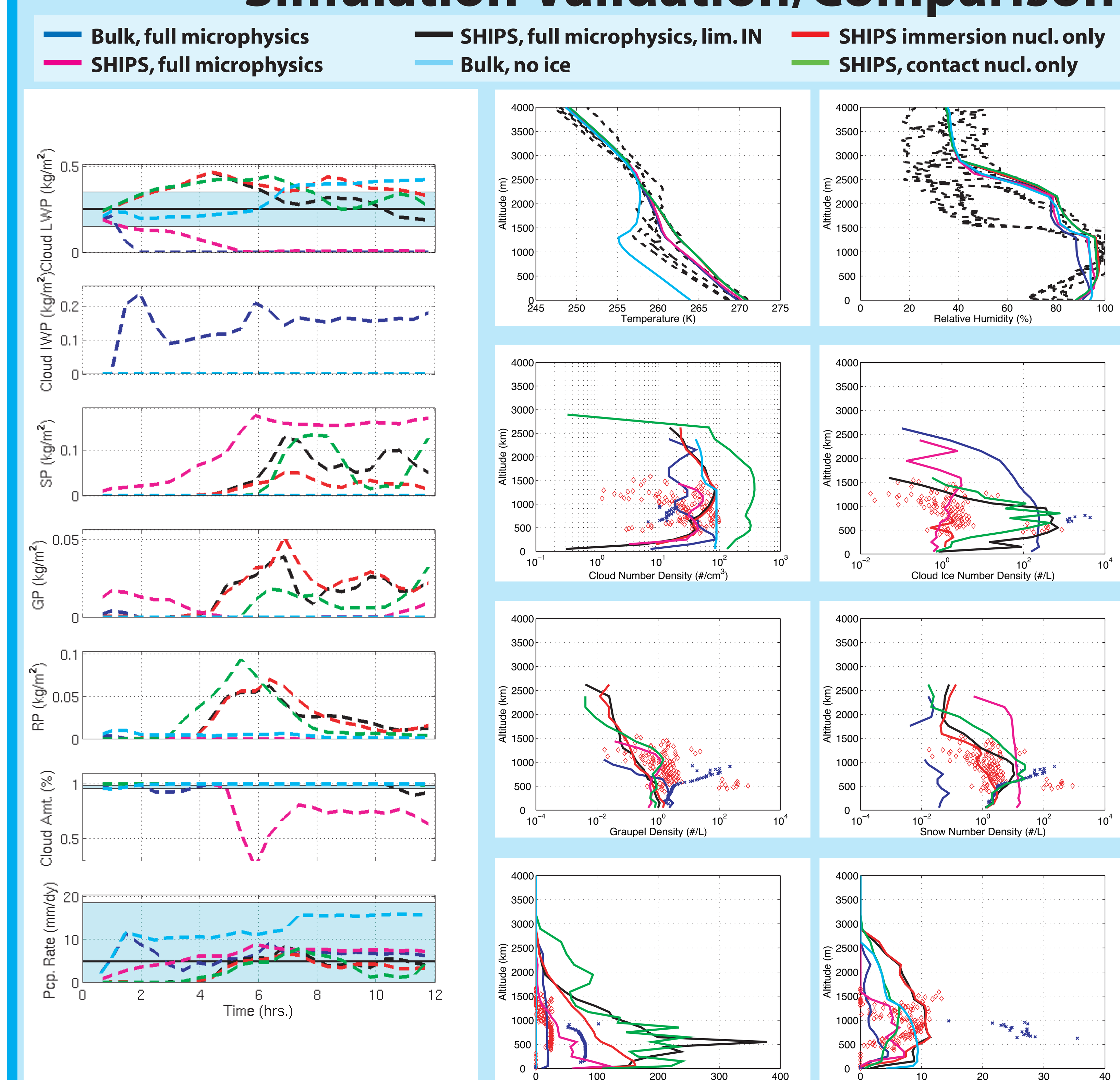
- Bulk microphysics over-predicts conversion to ice hydrometeors.
- SHIPS ice nucleation is dominated by the deposition mode.
- Ice nuclei availability strongly regulates conversion of liquid cloud to frozen hydrometeors in SHIPS.
- Observations show moderate agreement between SHIPS simulations and the measured atmospheric state.
- The SHIPS bin microphysics shows strong improvement over traditional bulk microphysics.
- Further analysis of simulations needs to be completed to better understand the strengths and weaknesses of individual processes within the microphysical parameterizations.
- Future studies will investigate the ability of SHIPS to accurately predict crystal growth and habit.

Simulation Results



Simulated cloud water mixing ratio (shaded, g/kg) plotted at different simulation times along with total ice mixing ratio (contoured logarithmically from 1e-6 to 1 g/kg). Note the short life span of water in the bulk microphysics simulation (right), and the way in which deposition nucleation dominates.

Simulation Validation/Comparison



Key to Observations

Period Mean (bold line) +/- Std. Dev. (blue area) for:

- **LWP:** Microwave Radiometer (Turner)
- **Cloud Amount:** Total Sky Imager (Long)
- **Precipitation Rate:** NSA 40m Tower

Barrow Radiosonde Measurements from 10/09.

Average vertical profiles of microphysical retrievals made using a combination of the AHSRL and NSA MMCR (see Lidar/Radar section, top). For these retrievals, graupel was assumed as the habit type.

Average vertical profiles of in-situ microphysical measurements for two Oct. 9 flights made on board the Citation aircraft obtained using the FSSP, 1DC, 2DC and King probes. (McFarquhar and Zhang)

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