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MESOSCALE MODELING DURING MPACE

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1. Introduction

Although Arctic clouds play an important role in Arctic climate system, they remain one of the least understood cloud systems. Mixed-phase arctic stratus clouds are the predominant cloud type in the Arctic (Intrieri et al., 1999; Curry et al., 2000) and through various feedback mechanisms exert a strong influence on the Arctic climate. Perhaps one of the most intriguing of their features is that they tend to have liquid tops that precipitate ice. Despite the fact that this situation is colloidally unstable, these cloud systems are quite long lived - from a few days to over a couple of weeks. It has been hypothesized that this longevity results from a balance between cloud-top radiative cooling and ice removal by precipitation (Pinto, 1998; Harrington et al., 1999) or from vertical oscillations of cloud parcels (Korolev and Isaac, 2003). Still the Arctic mixed-phase stratus clouds are not quite well understood and are difficult to represent accurately in large-scale models.

The major objective of the Mixed-Phase Arctic Cloud Experiment (M-PACE), conducted in October 2004 over the North Slope of Alaska and the Beaufort Sea, was to collect an extensive set of observational data which will be used to improve our understanding of Arctic mixed-phase clouds and to evaluate and improve current models performance (Verlinde et al., 2005).

During the field experiment the Regional Atmospheric Modeling System (RAMS) was run operationally over the North Slope of Alaska and was used among other forecast models. In this paper, we discuss the performance of RAMS during the experiment.

2. Model configuration

The configuration of RAMS (Cotton et al., 2003) used during MPACE uses the one-moment microphysical scheme of Walko et al. (1995) and the two-stream radiation scheme of Harrington (1997). It also incorporates the Los Alamos National Laboratory sea-ice model (Hunke and Lipscomb, 1999).

The model is configured with three nested grids:

- grid #1 has 64 km resolution and covers the entire state of Alaska – 3392x2368 km;
- grid #2 has a resolution of 16 km and is centered on the North Slope of Alaska, covering a 1296x976 km area;
- grid #3 has 4 km grid spacing, it is centered on the north shore and covers area of 312x212 km.

Vertical grid spacing on all three grids starts with 50 m spacing at the surface and stretches to 1000 at the higher levels.

The model was run for a 48 hours period three times a day – at 00 UTC, 06 UTC and 12 UTC. ETA model analysis fields, DMSP SSM/I daily ice dataset and

NCEP OI SST weekly data were used to initialize the model. In addition, the outer RAMS grid was nudged to the ETA 12-hourly forecasts.

3. Case days

October 5

On October 5, a weak ridge aloft coupled with a surface high pressure system over the Arctic Ocean helped keep temperatures above average across the North slope. In the Gulf of Alaska a 976 mb low was present. Though this did not directly affect the North slope, it did intensify the pressure gradient over the area and ENE winds in the 15-20 mph range were present for the entire day (fig. 1). Overall, the weather pattern was tranquil with light snow falling out of the boundary layer marine cloud decks.

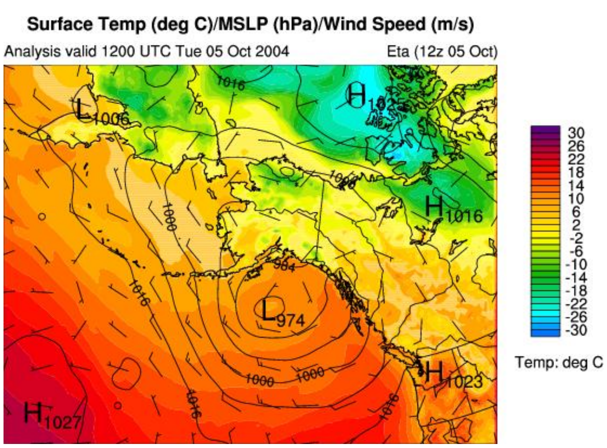

Fig. 1: ETA surface analysis for 12 UTC October 5, 2004

The 6-hours RAMS surface forecast (Fig.2) illustrates basically the same picture. Intensified ENE winds impinging on the northern Alaska coast were the primary source of the cloudiness formed mainly along the shore. The simulated cloud field (Fig. 3, Fig. 4) shows two-layer cloudiness – low-level layer precipitating ice, topped by a liquid layer at about 1.5 km height. The lidar images from the High Spectral Resolution Lidar (HSRL) from the University of Wisconsin, situated in Barrow, confirm the multi-layer cloud structure (Fig. 5).

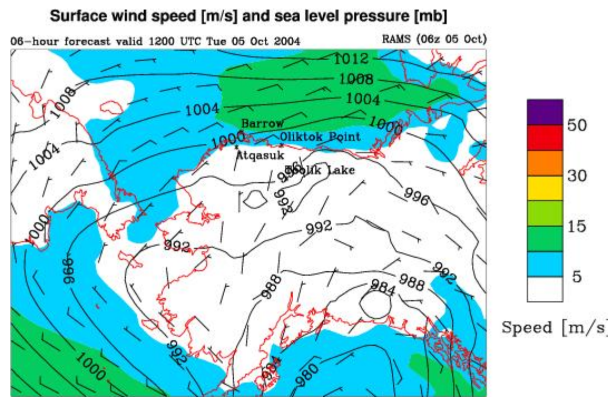

Fig. 2: RAMS 6-hour surface forecast valid for 12 UTC October 5, 2004

Over Barrow, however, as the comparison between fig. 5 and fig. 6 shows, the model almost completely missed the liquid layer (Fig. 6). There are several possible reasons why this is the case and they need to be investigated further.

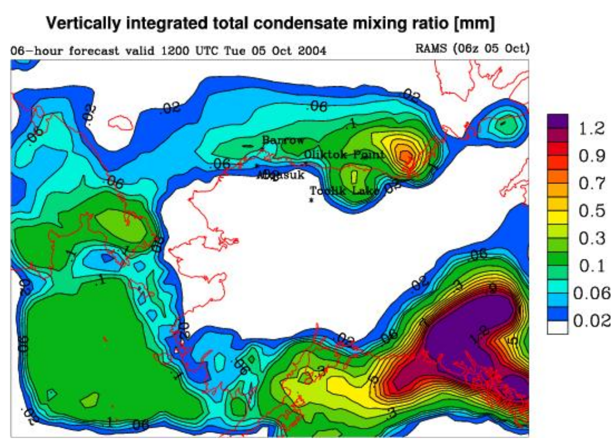

Fig. 3: Vertically integrated condensate mixing ratio valid for 12 UTC October 5, 2004

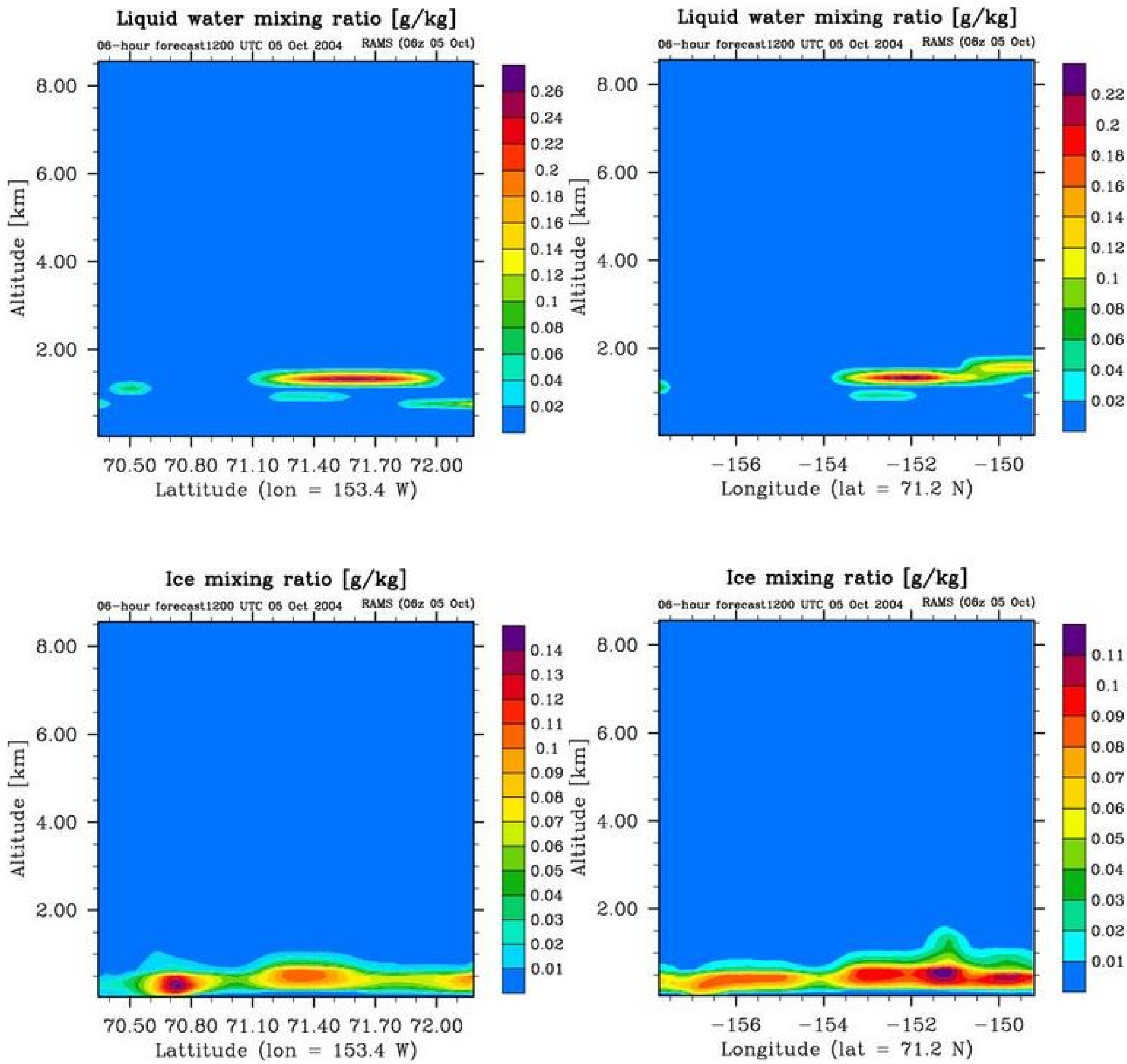

Fig. 4: North-south and east-west cross-sections of RAMS grid #3 showing liquid and ice mixing ratio at 12UTC October 5, 2004

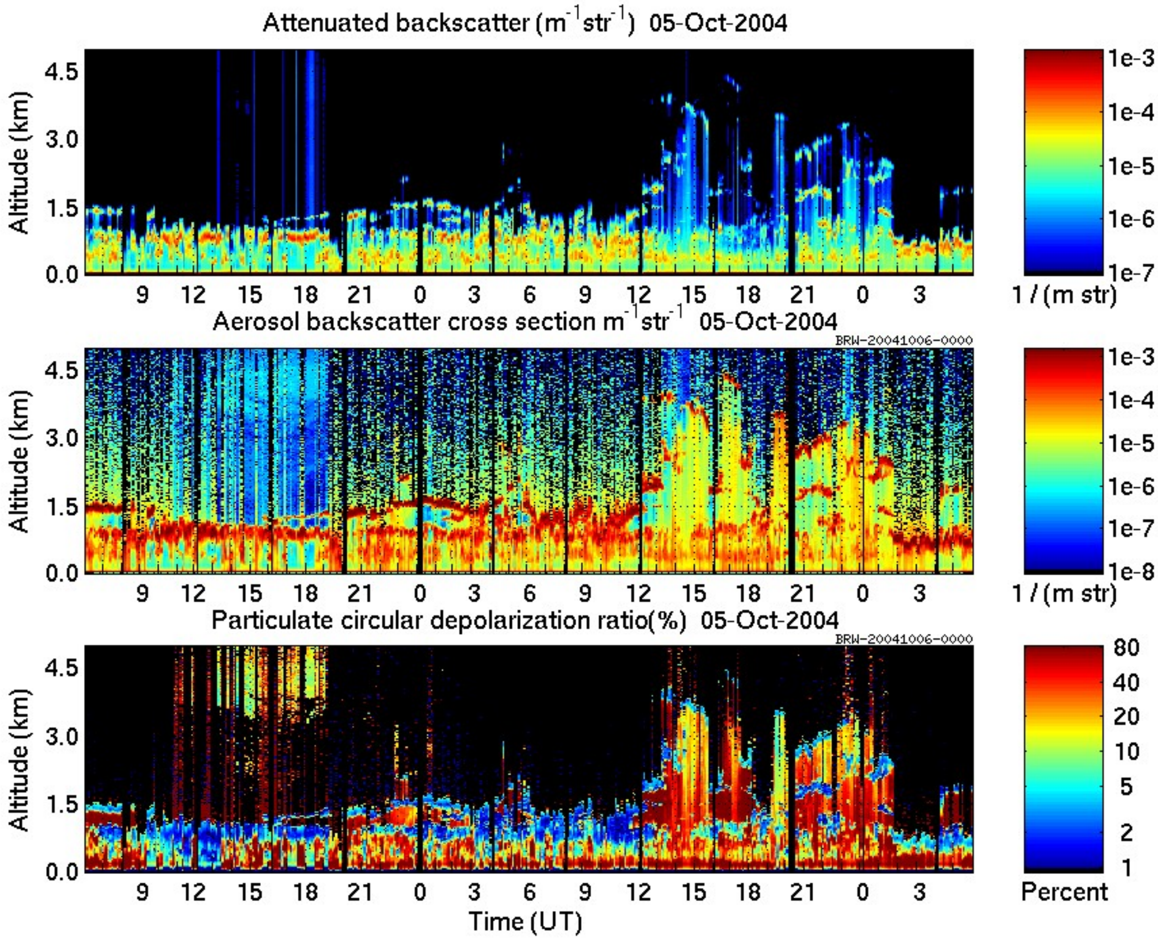

Fig. 5: Attenuated backscatter, aerosol backscatter and depolarization ratio as measured by the University of Wisconsin HRSL

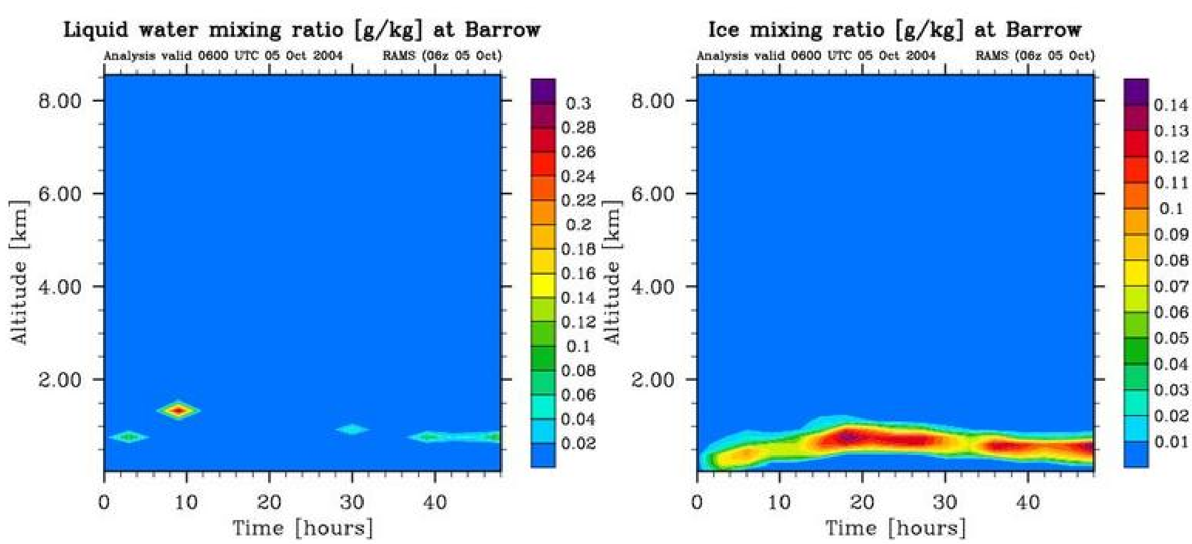

Fig. 6: RAMS simulated liquid and ice mixing ratio over Barrow

October 12

On October 12, a much stronger high (1038 mb) associated with the sea-ice pack was present over the Arctic ocean (Fig. 7). This high coupled with a 977 mb surface low over the Aleutians made for breezy conditions across the area. Easterly winds persisted throughout the day at 15-25 mph.

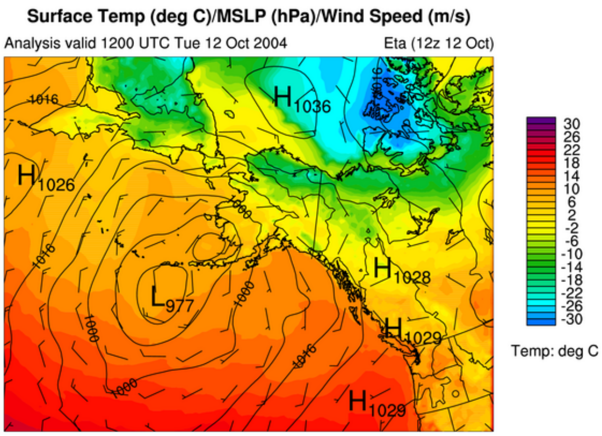

Fig. 7: ETA surface analysis for 12 UTC October 12, 2004

The 24-hour RAMS surface forecast depicts essentialy the same picture - Fig. 8.

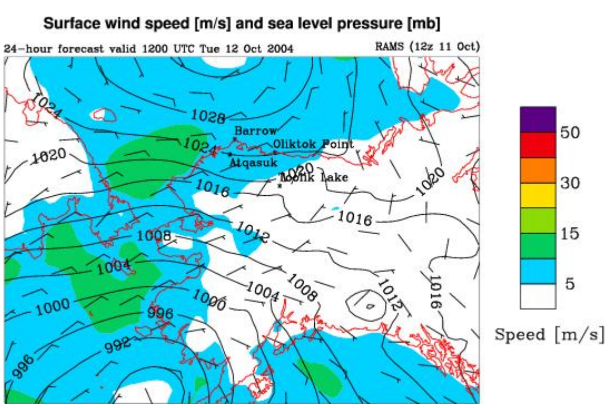

Fig. 8: RAMS 24-hour surface forecast valid for 12 UTC October 12, 2004

The air flow coming off the ice pack created favorable conditions for development of boundary layer roll clouds which started to form parallel to the shore – Fig. 9.

Fig. 9: MODIS visible image on October 12, 2004

Although the finest RAMS grid has a resolution of 4 km, the model produced quite similar to Fig. 9 cloud field. Fig. 10 shows the vertically integrated total condensate mixing ratio over the north coast of Alaska . The structure of the simulated boundary layer convective rolls

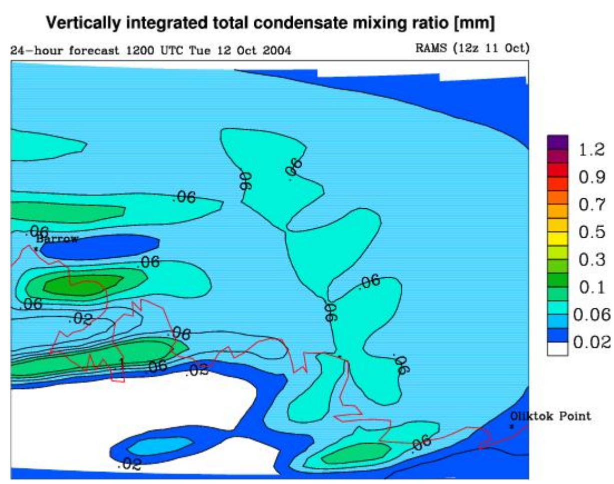

Fig. 10: RAMS forecasted vertically integrated condensate mixing ratio valid for 12 UTC October 12, 2004

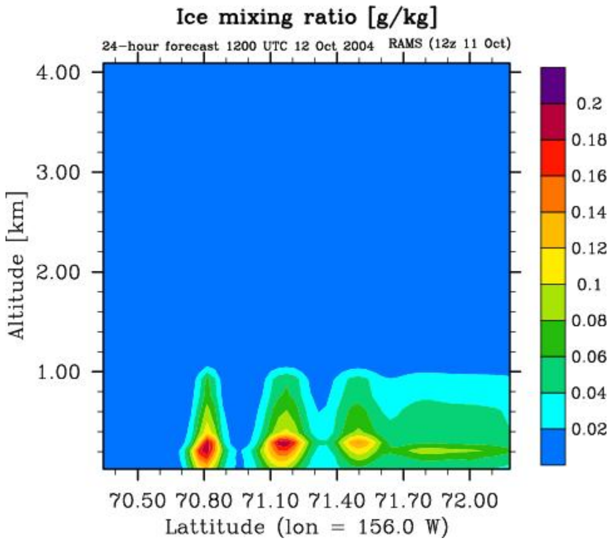

Fig. 11: North-south cross-section of grid #3, showing simulated liquid and ice mixing ratio at 12UTC October 12, 2004

is even better illustrated on Fig. 11 which shows the north-south crossection of grid #3.

Summary

During M-PACE the Regional Atmospheric Modeling System was run operationally over the North Slope of Alaska and Beaufort Sea. The RAMS forecast output was compared both to ETA analysis fields and lidar/radar measurements taken at Barrow and Oliktok point. In most of the cases the agreement between RAMS simulated cloud fields and the observations was quite good. It should be noted however, that this is just a preliminary comparison and more in depth analysis will be conducted at the next stage. Also, the in situ data collected during the M-PACE will be used extensively in the following numerical simulations.

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