

## ***Interactive comment on “Moisture and dynamical interactions maintaining decoupled Arctic mixed-phase stratocumulus in the presence of a humidity inversion” by A. Solomon et al.***

### **Anonymous Referee #2**

Received and published: 20 July 2011

#### Major comments:

The authors conducted nested LES simulations of decoupled Arctic Mixed-Phase Stratocumulus (AMPS) clouds observed during the DOE Atmospheric Radiation Measurement Program’s Indirect and SemiDirect Aerosol Campaign (ISDAC) to analyze budgets of water components, potential temperature, and turbulent kinetic energy. Through those analyses, the processes that maintain the decoupled are quantified. This kind of thorough analysis of the cloud and environmental fields is very useful for us to better understand AMPS clouds, although the quantification of the processes is kind of case-dependent. This reviewer believe some qualitative conclusions such as the importance

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of the humidity inversion at cloud top to maintain the mixed-phase clouds and the roles of longwave cooling may be applied to other AMPS clouds. Before it can be accepted as a publication in ACP, some revisions are recommended.

My major comment is that the case has not been fully evaluated by the observations. Since the focus of the paper is in quantifying microphysical, dynamics and radiative processes through budget analysis, it is very important to show the simulated cloud case reproduce the observed cloud properties, especially in cloud microphysical properties and radiative fluxes. With ISDAC field campaign, the big advantage is that the in-situ aircraft measurements of cloud properties are available to validate cloud simulations. Therefore, this reviewer would like to see the comparisons of the simulated LWC, IWC and droplet number concentrations compared with the aircraft measurements. In addition, based on my impression, the cloud top and base heights from the aircraft measurements are much lower than the simulated values in this study.

Another main concern is that the authors used IN observation from another case (MPACE) which is a fall time mixed-phase cloud case and aerosol properties could be very different, but no any justification and validation are provided for it. The aircraft measurements of Ni can be used to justify or validate this assumption.

The writing of the manuscript is kind of sloppy. In section 5, it gives readers an impression that each subsection are randomly put here and they are not coherent with a theme. In addition, I often had a hard time to get a main point from a paragraph after reading it. Also, some of the details are very minor which can be removed. Then, the paper would be much shorter and the discussion would be much more succinct.

Specific comments:

1. Abstract: “The results show the maintenance of liquid clouds in both the shallow upper entrainment zone. . . , should be “the maintenance of liquid water” or you can say “the maintenance of mixed-phase clouds”.

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2. P 13471: "...when the open ocean produces large fluxes of heat and moisture into...", the heat and moisture fluxes are never large even if it is open water, especially the heat fluxes. Check the MPACE case. So, "large" is not appropriate here.
3. P 13471: Morrison et al. MPACE study should be Morrison et al. 2009
4. P 13473: You spent two paragraphs in discussing the subtropical Sc. I do not your point there (i.e., why it is that important to take such large space). I'd suggest simplifying it with a couple of sentences.
5. P 13473: You can not jump to Figure 5 from Figure 1 without introducing Figures 2-4 when they appear at the first time.
6. P 13474: In 15-17, the logic of these two sentences does not sound right. Please reword.
7. P 13476: "...with AMPS near the base and up into the inversion...": do you mean cloud base? If so, you need to be specific and also need to give the value of the height.
8. P 13476: In 21-25: did you check the correlation between LWC and IWC from aircraft observations and your simulation? Basically the correlation between LWP and IWP does not mean much since vertically the LWC and IWC maximum at very different altitudes in the mixed layer. In many single mixed phase clouds, correlation between LWC and IWC is very poor from both observations and simulations.
9. P 13477: In 21-24: what is the justification to use the IN observations from the MPACE field campaign, which was from a very different season? IN measurements are also available for ISDAC. In addition, it is even better justified to set the IN based on the in-situ observed ice crystal number concentrations than using the data from MPACE. This could be the one of reasons why the simulated cloud ice is underestimated much since IN in the ISDAC (spring) could be much higher than MPACE (fall).
10. P 13478: In 7-8: The sentence is misleading. Do you mean besides ammonium bisulfate there is 30% for the other component? If it is, what is the component (gen-

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erally it would be organics). If not, you can not assume 30% of ammonium bisulfate is insoluble since it is an soluble component. In addition, did you really account for the insoluble composition for your droplet activation (this is the purpose to consider the composition in cloud models)?

11. Please add one or two sentences to state the necessity for the details of eqs in p 13479-80.

12. P 13481: first paragraph, the retrieved IWC has large uncertainty. You should compare with aircraft data for LWC,  $N_c$ , IWC and  $N_i$ . Since you are using M-PACE IN measurements, it is important to look at the modeled  $N_i$  to see if they are close to the observed values (for size larger than 200 microns).

13. Section 5.1, again, aircraft measurements should be compared. In addition, I do not quite understand the last sentence of this section.

14. P 13481: In 8-10, please check if it is ice-supersaturated near the surface. Looks like you got a thick moist layer there (300 m) from Figure 7. is it real?

15. P 13498: last sentence of (3), that is a common feature for the mixed-phase or even ice phase clouds, and it is nothing special or new.

16. Figure 5, suggest to plot the model and observed results in the same panel.

17. Figure 8 and other figures, what do you mean about total cloud domain? Do you mean cloudy points in the entire domain? But in the text it is said averaged over the square box in Figure 6?

18. Figure 9, where is the gray shading in the figure?

19. Suggest changing “Water” in figure legends to “Liquid”.

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Interactive comment on Atmos. Chem. Phys. Discuss., 11, 13469, 2011.