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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Advances in understanding and parameterization of small-scale physical processes in the marine Arctic climate system: a review" *by* T. Vihma et al.

Anonymous Referee #1

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This is a review paper that summarizes recent advances in our understanding of small-scale physical processes in the Arctic atmosphere (section 2), sea ice and snow cover (section 3), and the ocean (section 4), and at the interfaces between. Small-scale processes are understood here to be those that need to be parameterized in climate models. It is an important and timely synthesis that focuses on advances since the start of the IPY. The paper is an impressive compilation of recent work and will be a useful, well-cited, contribution after some improvements.

In general, I found the writing style to be quite scattered. We jump from one topic to the text in this long paper, often with no clear path. To provide an example of this:

continental shelf waves seem to be introduced as an afterthought in the last paragraph of the discussion section, although they are not discussed previously. There are many more examples where the paper could use editing to maintain a clear, logical flow that is particularly expected of a review paper of this type.

Improvements to the figures could help the focus and flow. The multitude of box diagrams were not very helpful here. In a discussion of small scale processes, a schematic that builds on Figure 1 would be much more helpful; Figure 1 is a little too basic to be of much use. I recommend a more detailed schematic that sketches and labels some of the processes discussed. A good example is provided by the schematic in this paper: [Padman, L. (1995). Small-Scale Physical Processes in the Arctic Ocean. Arctic Oceanography: Marginal Ice Zones and Continental Shelves, 97-129]. The authors could think about color coding the processes to be a certain color depending on the section in which they are discussed. A table might also be effective, with separate sections for the atmosphere, sea ice & snow, and ocean and a list of the small scale processes (with relevant temporal and spatial scales) discussed in the paper.

Related to the paper cited above, it would be very helpful if this review paper was set in context with previous papers reviewing some of the small-scale processes discussed here.

Additional comments in no particular order, but with a focus on the discussion of ocean processes:

1. "When sea ice is present, this layer extends down to 300m into the ocean (Dmitrenko et al., 2008)..." Why only when sea ice is present?

2. There are sentences like the following throughout the manuscript. These really need to be much clearer. "Clouds absorb and scatter solar shortwave radiation, and snow cover strongly reflects solar radiation, whereas sea ice has a lower albedo, and the ocean absorbs significant amounts of solar radiation, but only through the ice-free areas and very thin ice (Perovich et al., 2007a, b)."

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3. Section 4.2: Here is a good place to note that the salinity of sea ice is a function of its age/thickness.

4. Section 4.2: Where are dense brine flows observed to ventilate the deep Arctic Ocean (deeper than the halocline)? A reference is required here. The latter part of the first paragraph in this section is poorly constrained and needs citations.

5. "In addition, efficient lateral mixed layer re-stratification also impedes mixed layer deepening (Toole et al., 2010)." The restratification is shown in a manuscript by Timmermans et al. (2012), JPO. This restratification is related to the submesoscale (O(1km)) flow field in the mixed layer, the effects or which are parameterized in GCMs.

6. There is some speculation at the end of section 4.4 (the final three sentences). Related to the purported large steps, the section on double diffusion would not be complete without at least some mention of the double diffusive intrusions (with thicknesses much larger than typical double-diffusive layer thickness) via which AW heat and salt are propagated long distances. The following two papers (and references therein) will help: Rudels, B., Björk, G., Muench, R. D., & Schauer, U. (1999). Double-diffusive layering in the Eurasian Basin of the Arctic Ocean. Journal of marine systems, 21(1), 3-27. Walsh, D., & Carmack, E. (2003). The nested structure of Arctic thermohaline intrusions. Ocean Modelling, 5(3), 267-289.

7. Ocean eddies are brought in only in the discussion section (where there may be differing definitions here of what constitutes "submesoscale" and "mesoscale"). Discussion of eddies (submescale/mesoscale) seems an important omission.

8. An ordered section with a separate title "feedbacks" would be very useful here (reformulating some of the content of section 5.2, for example).

9. I would have liked to see more discussion on the theme of the last paragraph in section 5 related to the relevance of point measurements. This has been discussed in some previous studies (e.g. see a paper by Richter-Menge et al. (2006), Ann.

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Glaciol., that examines this with respect to Ice-Mass Balance buoy measurements); more discussion on this would be practical in the context of recommendations for future studies as outlined in this paper.

10. Finally, there are grammatical errors/missing articles and so on throughout the manuscript. I suggest careful editing.

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