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Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Effect of retreating sea ice on Arctic cloud cover in simulated recent global warming" *by* M. Abe et al.

Anonymous Referee #1

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Effect of retreating sea ice on Arctic cloud cover in simulated recent global warming

The paper presents analyses of trends in cloud cover, sea ice area and sensible and latent heat fluxes over the Arctic ocean in October using historical runs with the MIROC5 climate model. The authors discuss increases in cloud cover and find some hints for differences between thermodynamically driven increases near the retreating ice edge and dynamically driven increases over the central Arctic ocean. Understanding the interaction between clouds, boundary layer and sea ice in the Arctic is an important research topic, and the above-mentioned distinction between thermodynamic and dynamic effects may well lead to an important advance in this field. I regret to say that the present manuscript does not exploit that opportunity. The authors present a number of conclusions or a priori assumptions about the interactions between sea ice and

clouds that are neither established scientific understanding nor underpinned by the presented data and arguments. In particular, the authors do not convincingly demonstrate a causal relationship, let alone a mechanism for such a relationship, between sea ice changes and cloud changes beyond some overlap in the corresponding maps. The two main diagnostics used – cloud cover and CRE – may both be misleading in the Arctic: Some models tend to produce 'empty clouds' at cold temperatures, which lack condensate and thus do not affect radiative fluxes, and the CRE may change purely through temperature changes without any change in cloud properties. The authors do not discuss to what extent these problems affect their results. Nevertheless, the approach and research question underlying the manuscript is promising, and I encourage the authors to deepen their research in order to resubmit a substantially improved manuscript. Some questions and thoughts that might help guide further research:

- Cloud cover appears to transition from a high summertime to a lower wintertime state in autumn. Is the increase in October just a delay in that seasonal cycle or does a new state emerge in a changing climate? How does cloud height change over the seasonal cycle?

- Is there a clear dynamical distinction between areas with increasing cloud cover with and without sea ice retreat? Moisture convergence also occurs in some of the areas with sea ice retreat.

- Increases in cloud cover are substantial around Bering strait, but much weaker (or shifted to November) in the Barents sea, and very weak near Greenland. Why?

- Related to the above: Is there a spatial pattern in the seasonal cycle of cloudiness? If so, is that pattern related to sea-ice cover?

- Can you demonstrate the thermodynamic effect of later refreezing of the sea surface on clouds e.g. in a single-column model?

- To what extent are changes in LW CRE at the surface caused by temperature changes, and to what extent by changes in cloud properties?

Besides these suggestions for further research, the following mayor issues should be addressed before resubmission or submission of a revised version.

1. attribution of causality: as mentioned above, the visual match between changes in two quantities does not establish a causal relationship. Please make sure to only claim causality where this has been convincingly demonstrated in your own manuscript or in elsewhere in the literature.

2. significance: I recommend reserving the use of “significant” for instances where a formal statistical significance test has been carried out. In these cases, the significance level (e.g. the p-vale obtained) should be documented.

3. definition of Arctic amplification: AA refers to larger temperature change in the Arctic compared to lower latitudes. To make a statement on how a feedback affects Arctic amplification, one therefore needs to assess the feedback both in the Arctic and at lower latitudes. This is trivial for the albedo feedback, which is absent at low latitudes, but non-trivial for cloud and water vapour changes, which also affect low-latitude warming. It may thus be more specific to discuss cloud effects on Arctic warming rather than on AA.

4. SW vs. LW effects: How relevant is the shortwave effect of increases in cloudiness in October compared to the LW effect (again, CRE is a dangerous measure as it strongly depends on the underlying albedo)?

5. comparison between areas of increasing/decreasing sea ice: where are the grid-points with positive trends in sea ice located? Atmospheric profiles between both groups of points already differ in the earlier period – are those points dynamically different? Could this affect differences in the trends in cloud cover as well as sea ice trends?

6. temperature vs. moisture changes: You seem to argue that because of the steeper

lapse rate for temperature than humidity, the latter can more easily be mixed into the free troposphere. However, in the absence of phase changes, turbulent mixing should influence temperature and moisture alike. This is at least misunderstandable. Furthermore, I do not understand the claim that there is no steady moisture sink in the Arctic – is there no (relevant) precipitation in the months and regions you analyse?

These papers might be helpful regarding the last point: Joseph Sedlar, Matthew D. Shupe, and Michael Tjernström, 2012: On the Relationship between Thermodynamic Structure and Cloud Top, and Its Climate Significance in the Arctic. J. Climate, 25, 2374–2393. doi: http://dx.doi.org/10.1175/JCLI-D-11-00186.1 Nygård,ÂăT., Valkonen,ÂăT., and Vihma,ÂăT.: Characteristics of Arctic low-tropospheric humidity inversions based on radio soundings, Atmos. Chem. Phys., 14, 1959-1971, doi:10.5194/acp-14-1959-2014, 2014.

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