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Discussions

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Interactive comment on "Clouds damp the impacts of Polar sea ice loss" *by* Ramdane Alkama et al.

Anonymous Referee #2

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The study investigates the correlation and covariation between cloud radiative effect (CRE) and sea ice in the Arctic and Antarctic using satellite and climate model data. It is found that clouds play a significant role in damping the net change in radiation absorbed at the surface as a result of sea ice changes.

It is an interesting study, but I have issues with the interpretation and the manuscript is not particularly well written. There are language issues that need to be worked on and the methodology and logical steps need to be explained better. The results are interesting and potentially of some importance for our interpretation of the ensemble spread in polar climate responses in the CMIP-archives. While I do not think many new analyses are needed, I do fear that some of the interpretations are to bold and need to be moderated. Therefore, I cannot advise to accept without major revisions of the manuscript.

Major points

You write in the abstract that "years with less sea ice and a larger net surface radiative flux are also those that show an increase in sunlight reflected back to space by clouds." I am not convinced that this is, in fact, what you find. I would rather say that they are the years with a larger CRE. This is not the same, since as you point out when discussing mechanism (I) in L157 onwards: Even if cloud properties are held constant, the CRE can change due to the changes in clear-sky radiation induced by changes in sea ice decline and surface albedo.

When surface albedo is lowered, more of the sunlight passing through the atmosphere is absorbed at the surface resulting in greater SW_total. But SW_clear increases even more since the lower albedo allows a larger fraction of the extra downwelling SW at the surface to be absorbed. This means that the quantity SW_cre = SW_total – SW_clear is decreased even in the absence of cloud changes – a purely surface-related effect.

I believe the above quoted statement ignores this; a point which is reflected in the next sentence: "An increase in absorbed solar radiation when sea ice retreats (surface albedo change) explains 66 ± 2% of the observed signal". As I understand your analyses, these 66% are exactly this surface-only effect. So the "observed signal" referred to in this sentence is the signal in CRE and not in "sunlight reflected back to space by clouds" as the previous sentence suggests.

I believe this is not just a matter of wording. I think it really is an important part of how the results are interpreted and served to the reader. I will therefore give more examples where this distinction is not made clearly enough throughout the manuscript:

L187: "We estimate that the cloud changes in the Antarctic system are damping by 56% . . .". Here, "cloud changes" should be replaced by "the existence of clouds and the changes therein" or something to that effect, since as I understand it, the existence accounts for two thirds of the effect and the changes for only one third. Right?

L223: "polar sea ice and cloud covarying in a way that substantially reduces the overall impact of the sea ice loss". Again, as far as I can see, only a third of the effect is due to the covariance. Two thirds is just due to clouds being present.

L245:" We argue that the strong increase of SWcre under decreased sea ice observed during summer is induced by larger values of cloud optical depth (Fig. 7a)". Again, what about process (I)?

L309 (conclusion): "Satellite data indicates that the increased cloud cover/thickness correlates with sea ice melting, reducing by half the potential increase of net radiation at the surface". I think your results show that, only 33% of the by-half-reduction is due to changed clouds, while the remaining 66% is due to the mere presence of clouds.

Minor points

L37 Introduction: You should look into the results of Qu and Hall (2006, JClimate) who in their figure 6a illustrate that across a climate model ensemble, planetary albedo variations resulting from surface albedo variations are muted by half. While this study focused on terrestrial albedo variations due to snow changes, the point is the same: The mere existence of clouds damp the TOA effect of surface albedo variations. This is similar enough to your findings that they ought to be discussed in the context of your results. Either in the intro, discussion or conclusions.

Figure 1: In the equations below panel b, I believe you have ordered the terms on the RHS wrong: Shouldn't it be SWtotal-SWclear, and LWtotal-LWclear?

L72 "Methods and data": As this section is currently, you talk a lot about the data but not really about the methods you will use. Then you go directly to the "Results and discussions" section which is difficult to read because the entire methodology is left in the supplement. I believe your statistical methods and your plots are so non-standard, and not least completely central to your analyses and conclusions, that they should be lifted from the supplement and into the "Methods and data" section.

L78-80: You need to explain the sign convention of the fluxes explicitly. I assume all fluxes are taken positive downwards, but it does not say so anywhere and while Figure 1 does say, for instance, LWclear at the end of a red arrow, this does not explain the sign convention. If anything, it is a bit confusing since this makes it look as if the LW's are taken positive upward.

Figure 3: How are the models ordered? Not alphabetically, it seems.

L157: Mechanism (I) is really important to the paper (as discussed above). Given this major importance, the explanation of the mechanism is not clear enough, so that all readers understand it. It becomes too easy for the reader to misunderstand it and think that is actually has something to do with the clouds when it really is a surface-only phenomenon. Please restructure the paragraph explaining mechanisms I and II such that you give yourself room enough to do it properly. Also, you have made the nice schematic in Figure 1. Use this and point to it in your explanations.

L164-166: This sentence assumes the reader is familiar with how to read Fig 4, something we are not until we have read the supplement. Lifting this into Section 2 would help a lot – but at least be clear and tell the reader that the supplement is, in fact, a prerequisite for understanding the entire paper.

L183-184: Units on the equations?

L190-191: Here you just add the errors but I am unsure whether you shouldn't, in fact, be adding them in quadrature. This, of course, depends on whether you believe the errors to be correlated or not. Please consider this carefully.

Figure 7: Is the data (or the methodology behind it) in this figure taken directly from Taylor et al? If so, please say so. Otherwise, the reader searches this paper for details in vain.

L294/Figure 8gh: You do not discuss the red cross in Figure 8 gh. Why then show it? If you have a point with this information, you need to discuss it in the text. Otherwise,

remove it from the figure.

L296: "This analysis suggests that the models showing a larger trend in cloud cover also show larger decreases in sea-ice extent and clearly demonstrate the strong coupling of these two variables.": Yes, but do you propose anything in terms of causality between the two? If not, you should be clear about this. Otherwise, the reader may try and read between the lines here.

L316: "that show smaller trends in surface". Shouldn't this be larger trends? That is, at least, what I get out of L295.

Figure 8: The time series are anomalies, but with respect to which period?

Suppl. L54: optical depth.

Suppl. L73: What are M and N? You do not seem to say so.

Suppl L78: A_i is the total area of all grid cells with a particular SIC change, right? Please explain this better.

Suppl L90: What is SX_p?

Language:

There are many examples of language that is not quite at an acceptable level. I cannot list them all, but I urge you to have a native English-speaker go carefully through the manuscript. Examples are

L 20: clouds ->cloud

L21: responding

L23: "manner of the" sounds weird. Please rephrase.

L45: determines

L58: Alternatively -> On the other hand

TCD

Interactive
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Discussion paper