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The Cryosphere Discussions

Interactive comment on "The emergence of surface-based Arctic amplification" *by* M. C. Serreze et al.

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Review of Serreze et al.: The emergence of surface-based Arctic amplification.

This is a study on the Arctic surface-air-temperature amplification. On the basis of NCEP reanalysis data the linkage between recent sea-ice retreat and Arctic warming is investigated. The focus is especially on autumn, which is the season following the period of the year where the largest ice-retreat has been observed. The paper concludes that retreating sea-ice plays a major role for the Arctic amplification. It is indicated that especially in autumn and during the latest years, the Arctic warming is linked to a surface source of energy. A strong candidate for this surface source is that associated with retreating sea-ice.

The paper is very interesting and contributes with important perspectives to the ongoing discussion on the mechanisms behind the Arctic warming. I have one major suggestion in order to improve the paper. After this has been taken into account, I think the paper should be published.

Major suggestion:

The study is to a large extent based on observational data, and here you use only NCEP data to explore the Arctic warming. Unless you have good arguments for using NCEP only, I suggest that you also base your analysis on e.g. other reanalysis data, for instance JRA-25 which is updated to close to real time. (Another option is the new 4D-variational reanalysis "Interim" from ECMWF, but it may not be updated to real time before the end of this year.)

In the supplementary informations associated with Graversen et al. (2008), we compared ERA-40, JRA-25, and NCEP and found that NCEP gives a rather different picture compared to the two other reanalyses as regard the vertical structure of the Arctic temperature trends. We compared all three with temperature observations from Arctic soundings and found that ERA-40 and JRA-25 are closer to the observations than is NCEP.

On page 605, lines 15-19 you state that NCEP warming in autumn is consistent with the expected response to reduction of sea-ice cover. As far as I understand, one of the reasons why you expect this response is that the warming signal over the retreating sea-ice resembles that simulated with CCSM3. However, by comparing NCEP and CCSM3 in the Arctic you may be comparing basically two sets of model results since NCEP is constraint only little by observations over the Arctic ocean; surface observations are not used, soundings are lacking, and, as far as I know, satellite retrievals are to a large extent rejected. (I noticed, you mentioned the last aspect yourself at page 606 line 11-12 without a reference, I neither have one, I have only heard it).

At the same time, you mention (page 604 line 17-23) that the observed ice retreat

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being faster than the models predict could be a result of circulation changes (natural variability) which the models do not simulate. Couldn't that also be the case for the vertical structure of the warming? Couldn't it be that warming above the surface in the Arctic is caused by e.g. circulation changes which are not captured by the models? In any case, in ERA-40 and JRA-25, surface temperature observations (from e.g. Buoys) and satellite radiances (not retrievals) were assimilated. Therefore I think that there are reasons to believe that these newer reanalyses are closer to observations than is NCEP. As mentioned above, this is also indicated by a comparison with radiosonde data. And therefore I also think that ERA-40 and JRA-25 cannot be disregarded only because they do not produce the same signal as the models.

Minor comments:

1. Page 602, lines 22-24: The finding that land trends are smaller than ocean trends is based on model results referred to earlier (line 13-14), I assume. So far observations on land show rather large trends in the Arctic. Over the Arctic ocean, observations are few and it is difficult to obtain trend estimates there. However, land trends show a large high-latitude amplification during winter (when the snow-albedo effect is not effective), which can be seen from Fig. 10 in Serreze and Francis (2007) and Fig. 2 in Graversen et al. (2008). Will you comment on this aspect?

2. Page 603, line 9: Perhaps add "which is dominating" after "source". Regarding Fig. 1a, it could be interesting to see a corresponding plot of an average over Arctic land points only.

3. Page 604, lines 10-12: Can you update this?

4. Page 605, lines 5-6: ERA-40 shows no surface amplification in summer. Also for autumn, trends aloft are comparable with those near the surface (not larger).

5. Page 605, lines 24-25: 2m-temperature observations are assimilated into ERA-40 and JRA-25, but not into NCEP.

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6. Page 608, first paragraph: Obviously you carefully took into account the shortcomings of the ice treatment in NCEP. But wouldn't it be better to directly show the NSIDC ice data instead of those from NCEP in Figs. 2a and 5?

7. Page 608 last paragraph and Fig. 3: Maybe you could show corresponding plots of the sea-ice-extent anomalies.

8. Page 612 , lines 17-20: This sentence need to be reformulated ("most closely associated" doesn't sounds as the right phrase to me). By studying the mean over the IPCC models, Sorteberg et al., Clim. Dyn. (2007) find that the autumn increase in the turbulent fluxes is larger than the net change in long-wave flux at the surface for a future projection. Lines 20-24: Why is the autumn change small while summer, by contrast, shows an increase in the net surface heat flux? If there is a net increase downward at the surface over the year, it must mean that the the Arctic ocean is gaining energy and/or the meridional ocean heat transport is reduced.

9. Part of the amplification may be linked to processes that you don't mention. For instance, it has been argued the weak vertical mixing in the Arctic plays a role. The lower atmosphere is most often (and especially during the cold seasons) more stably stratified in the Arctic than at lower latitudes which results in Arctic surface-temperature amplification under CO2-induced global warming conditions (e.g. Manabe and Wetherald, J. Atmos. Sci., 1975). Also changes in cloud cover may have an effect. Cloud changes are believed to explain a significant part of an observed increase of the downward long-wave radation over the Arctic (Francis and Hunter, Environmental Research Lett., 2007)

Text suggestions:

1. Page 602, lines 15-17: Something is wrong in this sentence. Perhaps change "in expanding" to "expands", and add "and" in front of "increases". Maybe you should add something like "causes melting hereby" after "solar energy".

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2. Page 602. line 18: Add a comma after "atmosphere".

3. Page 606, line 17: remove "which".

4. Page 608, line 19-20: "specified ... period" not necessary.

5. Page 610, line 4: remove "of".

Interactive comment on The Cryosphere Discuss., 2, 601, 2008.