The Cryosphere Discuss.,
doi:10.5194/tc-2017-39-RC1, 2017

The Cryosphere
Discussions
Open Access

Interactive comment on “Understanding the Mechanism of Arctic Amplification and Sea Ice Loss” *by* Kwang-Yul Kim et al.

Anonymous Referee #1

Received and published: 11 May 2017

The manuscript attempts to address the mechanisms of Arctic amplification of climate warming and sea ice loss. Cyclostationary empirical orthogonal functions are applied on ERA-Interim reanalysis products, and the methodology includes novel aspects. Some interesting results are found on the relationships between turbulent surface fluxes, longwave radiation, and sea ice loss. After substantial revisions the manuscript has potential for a good paper in The Cryosphere.

Major comments

1. The authors focus on the statistical relationships of the spatial patterns of anomalies in wintertime sea ice concentration, turbulent surface fluxes of sensible and latent heat, upward and downward longwave radiation, as well as air temperature, humidity and total cloud cover. Both the Arctic amplification and sea ice loss are, however,

much more complicated processes, involving many factors, such as the large-scale atmospheric transports of heat and moisture from lower latitudes to the Arctic, and oceanic transports of heat and freshwater. Also, the role of clouds in the Arctic climate system cannot be characterized simply by the total cloud cover; the cloud water and ice contents are at least equally important, as are also the complex interactions between the surface fluxes, boundary-layer turbulence, cloud physics and radiative transfer. I don’t mean that the authors should address all these processes, but they should make it clear in the manuscript that they restrict to processes acting in the Arctic, ignoring the forcing from lower latitudes, and they should pay more attention to cloud water and ice contents, which are physically more meaningful variables than the total cloud cover based on reanalysis.

2. Atmospheric reanalyses include serious errors in the Polar regions. This is the case particularly for surface fluxes and near-surface meteorological variables (e.g. Jakobson et al., 2012; Tastula et al., 2013). Hence, to obtain more robust results, I suggest to repeat the calculations using a second reanalysis (e.g. NCEP-CFSR) in addition to ERA-Interim.

3. Several results detected from the reanalysis require a better physical explanation.

(a) Lines 32-33: Why does the region of sea ice loss generates anticyclonic circulation? Figure 3 is not clear in this respect. Show maps of sea level pressure or geopotential height at a relevant pressure level to illustrate this and explain the physical mechanism resulting in an anticyconic circulation.

(b) Page 5, lines 29-30: if the turbulent surface fluxes are upward and net longwave radiation is upwards, they tend to reduce the Earth surface temperature but increase the near-surface air temperature, not decrease it.

(c) Page 6, lines 6-7: Why does a change in 2 m air temperature slightly lead the upward longwave radiation? Further, on lines 8-9: an increase in 2-m air temperature does not have a causal effect of increasing the upward longwave radiation (a statistical relationship may naturally exist). The upward longwave radiation at the surface (which is the product archived in ERA-Interim) is controlled by the surface temperature (and emissivity), not by the 2-m air temperature. Further, on line 10: Instead of a causal effect from upward longwave radiation to sea ice concentration change, a reduction of sea ice concentration in winter must have an immediate effect in strongly increasing the upward longwave radiation.

(d) Page 6, line 13: related to the above, I suggest removing the words “surface air temperature increases and”.

Minor comments

Page 2, line 7: I think Vihma (2014) should be dropped from this line.

Page 2, lines 13-17: During spring and early summer the albedo decreases from roughly 0.85 of dry snow-covered ice to 0.4 of melting ice. Hence, the albedo feedback is important already during the snow and ice melt, already before the appearance of open sea.

Page 2, line 18: the term “oceanic heat transport” is not the best possible, as it may be interpreted as the horizontal transport from lower latitudes to the Arctic. Equation 1 and the text below: explain what is r.

Page 4, line 23: On the basis of Figure 2, I would not write that the sea ice concentration remains nearly stationary throughout the winter.

Page 4, line 25: I cannot detect the 40% decrease from the amplitude time series. Also, better explain what the amplitude represents.

Page 5, line 9: “the little connectivity” between sea ice reduction and total cloud cover may originate from the fact that sea ice reduction generates two effects that compete against each other: increased latent heat flux tends to increase cloudiness but increasing sensible heat flux tends to reduce it.

Page 6, lines 23-25: These are interesting numbers. Please, confirm if these are winter means in 1979-2016 averaged over sea areas north of 60N. It might be interesting to compare them against results of Lupkes et al. (2008), which show air temperature responses to 1% reduction in sea ice cover in different conditions.

Figure 2. Is plot (a) needed at all, as the same line appears in plot (b)?

Figure 4. Add information on colour scales and absolute values. Only the contour intervals are given

Figure 5. Does the shading represent sea ice concentration in all four plots? If yes, why it includes small differences between the plots?

Figure 6. Explain better how the time series in days should be interpreted. It cannot be the mean over 1979-2016. Is it from some selected year?

Figure 8. Referring to my previous comments, I suggest dropping “2m T increase (0.24)” from the figure, and drawing an arrow directly from increased LW-down to sea ice reduction. Otherwise, provide a good explanation on the causality of the link.

References:

Jakobson, E., T. Vihma, T. Palo, L. Jakobson, H. Keernik, and J. Jaagus (2012). Validation of atmospheric reanalyzes over the central Arctic Ocean, Geophys. Res. Lett. 39, L10802, doi:10.1029/2012GL051591.

Tastula, E.-M., T. Vihma, E. L. Andreas, and B. Galperin (2013), Validation of the diurnal cycles in atmospheric reanalyses over Antarctic sea ice, J. Geophys. Res. Atmos., 118, 4194–4204, doi:10.1002/jgrd.50336.

Interactive comment on The Cryosphere Discuss., doi:10.5194/tc-2017-39, 2017.