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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Contributions from intrinsic low-frequency climate variability to the accelerated decline in Arctic sea ice in recent decades" *by* Lejiang Yu and Shiyuan Zhong

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General comments:

The authors have applied a self organising maps (SOM) algorithm to gridded Arctic sea ice concentration anomaly data for Sep-Oct-Nov 1979-2016 – a quantity that has a strong negative trend in this period – to obtain 9 spatial patterns (nodes). Nodes 1 and 9 have similar spatial distribution but opposite sign: node 9 (positive anomalies) is prominent early in the analysed period, and node 1 (negative anomalies) late in the period, and these two nodes account for much of the observed negative trend. Composites of sea surface temperature anomalies and several atmospheric variables are made using the 9 years for which node 1 is most prominent, and likewise for mode 9

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Discussion paper

(also 9 years). Features in the node 1 (node 9) composites are consistent with processes that reduce (increase) sea ice. It is claimed that the SOM-based composites provide a better depiction of patterns that influence sea ice trends, but there is no comparison with other representations to justify this claim. It is stated that the results 'help highlight the large contribution from the decadal-scale natural climate variability to Arctic climate change', but this is not clear from the results presented. On the evidence presented, the SOM approach does not seem to provide new insight. Further investigation is needed to demonstrate that the use of SOM is advantageous.

Specific comments:

Representation of sea ice concentration anomalies with 9 SOM spatial patterns (nodes, provided in Fig. 1) was selected. It is stated that results are similar with larger numbers of nodes, while smaller numbers are less representative. It is not clear how the spatial correlation coefficient (Table 1) was calculated however, and a change from 0.59 (2x4 nodes) to 0.64 (3x3 nodes) does not seem 'large' as stated on line 84.

For each of the 38 seasons available the best-matching node is tabulated (Fig 2). The 'frequency of occurrence' is defined as the number of times a pattern is thus selected, divided by 38: thus both node 1 and node 9 have a frequency of occurrence of 23.7% (9/38) in Fig. 1.

Nodes 1 and 9 have similar spatial distribution but opposite sign: node 9 (positive anomalies) is prominent early in the analysed period, and node 1 (negative anomalies) late in the period.

Fig. 3 shows trends associated with each node: this seems to be the node spatial pattern multiplied by a rate. (It is not clear how the rate is determined: possibly temporal linear regression of the projections of each pattern each season?) Nodes 1 and 9 are the main contributors. Fig. 4 illustrates how much of the total observed trend is associated with the SOM nodes. (It is not clear how this is calculated, but the text states about 60% in all is associated with the selected SOM nodes.)

Composites of sea surface temperature anomalies and various atmospheric quantities (anomalies from ERA-interim: 500hPa geopotential height, 850hPa wind, surface air T, surface downward longwave radiation, surface-to-750hPa water vapour) are made using years indicated in Fig. 2 for node 1 (2007-2013, 2015-2016), and, separately, for node 9 (1980-1982, 1986-1989, 1992, 1996). Effectively the SOM analysis provides the basis for these composites, which are illustrated in Figs. 5-7.

The composites are likely quite similar to composites of years when autumnal Arctic sea ice coverage was high versus low according to various other criteria: this should be discussed. The authors claim SOM allows 'better depiction of atmospheric circulation patterns that have significant impact on sea ice trends' (line 175), but no evidence is provided to support this claim, and this is a major weakness of this article.

With a relatively small number of cases (9) in each composite, some discussion of whether the composites are dominated by a few 'extremes' should be provided.

The analysis is largely descriptive. Various features in the composites are noted that are consistent with Arctic changes: e.g. for node 1 there are influences that favour sea ice reduction. Although suggestive in appearance, it is not evident that the SST anomalies and geopotential height anomalies in Fig. 5 are related as described. A zonal wavenumber 2 wavetrain (lines 134, 152) is not obvious.

Regarding downward longwave radiation and water vapour, how reliable are the ERA analyses in the Arctic?

While the analyses demonstrate associated changes in sea ice and in SST and atmospheric circulation, they do not in themselves seem to indicate cause and effect, so it is difficult to draw conclusions regarding mechanisms. The 'important finding' relating sea ice changes to asymmetry in North Pacific SST anomalies (lines 184-188) is not well justified. The claim of 'large contributions from the decadal-scale natural climate variability to Arctic climate change' (lines 193-194) does not seem well justified.

Other suggestions for technical corrections:

The term ‘explained’ is often used, but in the sense of statistical rather than physical explanation, which should be made clear.

The acronyms PDO, AMO, AD, AO are used without definition.

The title is rather misleading: the article is more about ‘SST and atmospheric patterns associated with reductions in sea ice cover in recent decades’

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