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The Cryosphere Discussions

Interactive comment on "Analyzing links between simulated Laptev Sea sea ice and atmospheric conditions over adjoining landmasses using causal-effect networks" *by* Zoé Rehder et al.

Anonymous Referee #2

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This submission examines links between sea ice variations in a small region of the Arctic and atmospheric structure over the neighboring landmasses to the south using a causal analysis approach. The specific Arctic region chosen is the Laptev Sea. The overall message contained in the results, consistent with many other recent studies (both model and observational), is that the sea ice in this broad longitudinal sector is to a great extent regulated by the largescale atmospheric circulation to the south and into the midlatitudes. The paper, for the most part, is well written and the methods and results appropriately presented. However, there are some areas where more explanation and clarity and a broader perspective are needed. The submission has the potential to make a significant contribution to the literature on this important and very timely topic,

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but it is not quite there yet. Before I would be able to recommend acceptance, there are a number of issues which need to be addressed.

A significant proportion of the literature is quite old, and this must be updated. In my review I have pointed to relevant more recent studies in this rapidly evolving topic.

The investigation makes use of Jakob Runge's causal-effect networks approach. Methodologies of this general type are now in fairly common use in numerous fields (including climate analysis). Having said that, the reader who is not immediately familiar with the design and intricacies of such approaches would not be greatly helped by the brief description of the Runge algorithm presented here at Lines 86-99. The authors should present a broader and more informative qualitative and/or quantitative description of the procedure. This important step will make sure the reader fully appreciates the physical meaning of the results to come.

It would also be very helpful to comment on how the structure of Runge scheme compares with other packages which have been used in this sort of investigation. For example, Samarasinghe, S. M., M. C. McGraw, E. A. Barnes and I. Ebert-Uphoff, 2019: A study of links between the Arctic and the midlatitude jet stream using Granger and Pearl causality. Environmetrics, 30, e2540, doi: 10.1002/env.2540 used Granger causality and Pearl causality in their study of links between lower-latitude atmospheric circulation and Arctic temperatures. They stressed the value of comparing a range of different causality methods to fully understand the relevant processes. This important paper should be cited early in the manuscript as it deals with a topic closely related to the one examined here. Many readers may be familiar with the Granger causality paradigm (C. W. J. Granger, 1969: Investigating causal relations by econometric models and cross-spectral methods. Econometrica, 37, 424-438, doi: 10.2307/1912791. C. W. J. Granger, 1980: Testing for causality: A personal viewpoint. Journal of Economic Dynamics and Control, 2, 329-352, doi: 10.1016/0165-1889(80)90069-x). A few words on how the structure of the present approach compares with that of Granger would be very helpful. (See also the paper of Marie C. McGraw, and Elizabeth A. Barnes, 2018:

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Memory matters: A case for Granger causality in climate variability studies. Journal of Climate, 31, 3289-3300, doi: 10.1175/JCLI-D-17-0334.1.)

Lines 17-19: Here also cite the more recent analysis of Simmonds, 2015: Comparing and contrasting the behaviour of Arctic and Antarctic sea ice over the 35-year period 1979-2013. Ann. Glaciol., 56, 18-28.

Line 27-28: The reference relating to this important factor is very old. Update this by also referring here to analyses of Lee, S., S. B. Feldstein, . . ., 2017: Revisiting the cause of the 1989-2009 Arctic surface warming using the surface energy budget: Downward infrared radiation dominates the surface fluxes. Geophys. Res. Lett., 44, 10,654–10,661. Luo B., and co-authors (2017) Atmospheric circulation patterns which promote winter Arctic sea ice decline. Env. Res. Lett. 12, 054017, doi: 10.1088/1748-9326/aa69d0.

Lines 42-47: In this analysis the authors make use of the output of model simulations. They make the argument that they use model data 'to overcome limitations of observations, which are sparse in space and time and not available for all relevant variables'. I find this argument rather weak. Firstly there are a number of quality reanalysis data set which one could argue are the 'best' representation of the 4D atmospheric structure, which use all available observations plus the full gamut of (thermo)dynamic constraints implicit in the assimilating model. These do not extend over a 160-year period used here, but do go back many decades. Another critical issue on this point is that the model used (and indeed any model) will not capture all the appropriate physics, and hence the analysis of causality could be fraught. (Climate model shortcomings are particularly evident in, e.g., air-sea-ice interaction in the MIZ, capturing the Arctic Ocean horizontal and vertical structure, etc.). Overall, the use of model data in investigations such as this can be valuable, and I have no great problem with this here. However, think this justification comment should be presented more honestly, and presented alongside the range of caveats. The authors should remind the reader at appropriate intervals that the results are obtained using simulated data. Also, to make sure that the reader is not misled the words ‘simulated’ or ‘model’ should appear in the title.

Lines 53-55: Related to the point of using model data, the authors have not really given us an idea of how realistically the means (and variability) are simulated. The only reference we are given for this is the mean SIC in July, with indications of the max and min (over the 160 years?) in Fig. 2. At least some comment should be made of how realistic this SIC simulation is. Also, the paper the sea ice melt and freeze periods – how well is the SIC simulated at those times of the year? The reader needs to know how well this basic parameter is represented. A worded comparison with the ‘climatology’ of Cavalieri, D. J., and C. L. Parkinson, 2012: Arctic sea ice variability and trends, 1979-2010. The Cryosphere, 6, 881-889, doi: 10.5194/tc-6-881-2012 should be presented.

Line 86: Python (sp.)

lines 132-133: A nice aspect of the paper is that it deals with both monthly and daily timescales. This dual perspective is a very important, as dealing only with the timescales beyond the synoptic time scale misrepresents the important associated with the presence of cyclones and fronts. These synoptic features exert great impact on the surface-atmosphere flues and sea-ice distribution. I strongly suggest this significant part of the analysis be emphasised here, and make reference to the following very relevant papers – Screen JA et al. (2011) Dramatic interannual changes of perennial Arctic sea ice linked to abnormal summer storm activity. J. Geophys. Res. 116: D15105 doi: 10.1029/2011JD015847 Simmonds et al. (2012) The Great Arctic Cyclone of August 2012. Geophys. Res. Lett. 39: L23709 doi: 10.1029/2012GL054259. Rudeva and co-authors (2014) A comparison of tracking methods for extreme cyclones in the Arctic basin. Tellus 66A: 25252 doi: 10.3402/tellusa.v66.25252.

Line 139-141: At some places in the text the authors make appropriate comments regarding the links when related, and confounding, processes are considered (e.g., at lines 207-213). This is a case in point here. The authors state that ‘All these links have a negative sign: higher sea-ice cover is associated with a decrease in specific humidity, thermal downward radiation . . .'. The ambiguity here is that the specific humidity is directly related physically to the thermal downward radiation, and hence these parameters are not independent. On this connection valuable to reference the remarks of Screen, J. A. et al., 2018: Polar climate change as manifest in atmospheric circulation. Current Climate Change Reports, 4, 383-395, doi: 10.1007/s40641-018-0111-4 and a few words should be added as to how this can be disentangled.

Line 141: Change 'less links' to 'fewer links'

Lines 170-174: This observation in connection with the Greenland High etc. is consistent with the results shown by Luo et al., 2019: Weakened potential vorticity barrier linked to recent winter Arctic sea ice loss and midlatitude cold extremes. J. Climate, 32, 4235-4261. Beneficial to the argument to make reference to that paper here.

Lines 285-293: The authors remind us here that the study has considered the sea ice only in the Laptev Sea. It would be beneficial here (and elsewhere) to keep in mind that the nature of sea ice-atmospheric circulation relationships are known to depend strongly on the particular subregion of the Arctic that is being considered. In particular, sea ice in the Barents and Kara Seas to the west have considerable interactions with the Eurasian land mass of interest here, as distinct from the Laptev results presented in the paper. This is an important point to make, with some specific cases. In this context make reference to the recent studies of . . . Li, M . . .., 2020: Anchoring of atmospheric teleconnection patterns by Arctic sea ice loss and its link to winter cold anomalies in East Asia. Int. J. Climatol., doi: 10.1002/joc.6637. Luo, Wu, and . . ., 2019: The winter midlatitude-Arctic interaction: Effects of North Atlantic SST and high-latitude blocking on Arctic sea ice and Eurasian cooling. Climate Dyn., 52, 2981-3004. Yao and co-authors (2017) Increased quasi-stationarity and persistence of winter Ural Blocking and Eurasian extreme cold events in response to Arctic warming. Part I: Insights from observational analyses. J. Climate 30: 3549–3568

Lines 394-395: Please to present full details of this paper . . . James E. Overland, Jennifer A. Francis, Edward Hanna and Muyin Wang, 2012: The recent shift in early summer Arctic atmospheric circulation. Geophysical Research Letters, 39, L19804, doi: 10.1029/2012GL053268.

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