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Interactive comment on "Synthesis and evaluation of historical meridional heat transport from midlatitudes towards the Arctic" *by* Yang Liu et al.

Anonymous Referee #2

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How much of the variability and recent decline of Arctic sea ice can be attributed to local processes, versus energy import by the ocean or atmosphere, is an important question. One problem is that energy-consistent coupled climate models tend to have large biases in the region, while it is hard to get good observations of integrated energy transport due to the extensive coverage required. This paper examines the latter approach, by comparing the meridional energy transports and their low-frequency variability in different reanalyses datasets in the atmosphere and ocean. It then briefly addresses the impacts on Arctic climate.

This topic is important, and the paper potentially very useful in helping if, and which dataset to use to study these questions; however it has a number of problems : mostly the computation of the atmospheric transport seems flawed except in one case, and

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Discussion paper

the last section (impact on the Arctic) is not enough developed to be useful. I therefore recommend major revisions to address these issues.

Major points :

(A) Computation of atmospheric transport (AMET)

Computation of an energy transport from reanalysis can be difficult due to lack of mass /energy conservation, sampling problems, or numerical schemes different from the original. It seems from figure 2 that MERRA2 and JRA55 suffer from large errors ("noise" on the curves) of the order of O.1-0.2 PW for the long-term mean.

Unfortunately, this means these products will be unusable to study the variability of the transport. Indeed, it is evident on Fig. 3 that the interannual variability at 60°N is of the same order as this long-term noise.

There are 2 possibilities :

- This problem comes from the reanalysis themselves : the conclusion is then that only ERA-interim is useable. This would be a useful result in itself; but the study of the differences between ERA and the other reanalyses becomes pointless and the paper could instead concentrate more on the impacts on the Arctic.

- This is a problem in the calculations from the reanalysis data, which then has to be solved, and the other results corrected accordingly.

(B) Impacts on the Arctic (section 3.3) The problem of this section is that it gives a few quick examples of regressions of characteristics of the Arctic climate on energy transports, but that they are too short to be really useful. - Show at least the winter and summer seasons, as results could be quite different. - Why show SLP and temperature for AMET, but sea-ice for OMET ? Why not show the same variables for both for comparison ? (at least sea ice and slp).

Other remarks : - p.3 line 24 : "it is preferable that they incorporate the latest..."

- p.3 line 25 : "they better not resemble each other" well, you certainly hope that different reanalyses would be consistent with each other !

- section 2.3.1 : what is the value of Lv used here ? Lv varies with T in nature, but not necessarily in models... Not sure what's used in reanalyses.

- p.7 : there may also be issues due to different horizontal advection schemes used in the reanalysis and in the post-treatment.

- p.8, line 6 : unit should be J/(kg°C) or J.°C-1.kg-1.

- p.8 : reference temperature. If the unit of potential temperature Theta is in °C, then substracting a reference temp. of 0°C does not accomplish anything. Are you instead converting Theta from K to °C to avoid cancellation of large terms problems ? This is very unclear.

- p.9, l25 : The differences in resolution are actually small. There must be another explanation to these variations, which are key (main point A)

- p.10, l10 : In ocean models that are not eddy-resolving, there is both an eddy-advection (Gent-McWilliams) and a diffusive heat transport, which can be significant compared to the resolved one. How were these incorporated in these analyses ? They absolutely need to be taken into account.

- section 3.2 and the accompanying figures for the atmosphere is a bit pointless given the low quality except for ERA-interim.

- p11, bottom : Are we looking in this section at the total OMET, or only the Atlantic OMET ? It would probably be more interesting to look at Atlantic only at 60°N (in line with section 3.3), although knowing the relative roles could be good. Same question for page 13.

- p12 : any idea about why ORAS4 seems to work best ?

- p13, l28 : why 5-years timescale ? Is it specific to the Arctic ? Are the regressions on

Fig.13 for 5-yr filtered data, or just year-to-year ?

- Figure 1 :this is hardly commented in the text: seasonal cycle, low contribution of LH (especially to the seasonal cycle)... By the way, I would replace this figure by either the components of the time-mean transport as a function of latitude, or by the mean seasonal cycle at 60°N of the different components. (With figures for the interannual variance if needed)

- Figure 2: The dashed-line is built using annual means ?

- Figure 3 : panel b) needs confidence intervals, based on interannual variance. For panel a), do the standard deviations include the seasonal cycle or are they for interannual anomalies ?

- Figure 4 : not sure what is the point of these figures, apart from showing that the high-res analyses have eddies ? It would be easier to copare maps integrated to the same low resolution, or time-means, and also to see the GM components.

- Figure 6 could easily be replaced by the figures given in the text. Note that latent heat transport may not contribute much to the differences because it's low to begin with, but also because it's concentrated in the near-surface layers, so does not suffer too much from slight mass flux imbalances.

- Figure 11, caption : I guess it is "interannual" time-scale ? (i.e. year-to-year variability)

- Figures 11-13 : consistent time-scales and variables, with different seasons would be nicer. Also, the green shading masks the color underneath, making it hard to read. Same-color shading maybe ?

- Figure 13b : there are strange-looking colors (opposite the rest of the Arctic...) near the pole in all 3 plots (abrupts changes of sign...) Is this an artefact ?

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