

Review of the manuscript entitled “Heat transport to the central Arctic is reduced by the Barents Sea cooling machine” by S.A. Eisner, J.A. Carton, L. Chafik and L. H. Smedsrud.

Using a mesoscale permitting reanalysis spanning 40 years, the authors estimate the transports at the Barents Sea opening, the export through the St Anna Trough and the evolution of the temperature in the Arctic Boundary Current. They suggest that the positive trend of the temperature in the Arctic Boundary Current is linked to the trend in the export through St Anna Trough. Furthermore, they also tested the ocean feedback mechanism proposed by Smedrud (2013). The authors present interesting results; however, the methodology needs to be more clarified. Therefore, I recommend major revisions before publication

Major comments :

The definition of the “SSH curl” index is not convincing. Why do the authors not use a simple SSH difference instead? The various links in the ocean feedback mechanism should be described in more detail. The authors could compute the time evolution of the volume of dense water in the formation area, or the water mass transformation, to more clearly demonstrate an increase in dense water formation.

The authors should describe how they compute the temperature index of the boundary current. What are the horizontal and vertical extents of the section? Does the section encompass both the Barents Sea Branch and the Fram Strait Branch? The authors could also map the temperature trend at each point or within sub-regions of the vertical section to determine which layer is most affected by the trend.

The list of references is short and should be completed. Here are some examples. For the observation in Saint Anna Trough, the authors should at least cite Schauer et al 2002 (DSR). For the discussion of the origin of the trend in the heat transport at BSO (Wang et al. GRL, 2019). Cai et al. 2022 ERL, for the role of the surface heat fluxes on the Barents Sea warming. Some papers of Arthun could also be cited. Beszczynska-Möller et al. 2012 for the trend in temperature at Fram Strait. Ruiz-Castillo et al. 2023 (JGR) for the structure of the Arctic Boundary Current North of Severnaya Zemlya. Richards et al. 2022 (JGR) for the trend in the temperature of the Atlantic Water core in the Eurasian basin.

The discussion could be more detailed. In particular, the authors find that the trend in the heat transport at BSO is entirely due to warming temperature. How does this result compare with previous study of the heat transport at BSO?

Minor Comments:

L.11: “we present the first observational evidence”: sounds a bit odd since the authors are using a model.

L.18: “cooling machine” add a reference.

L.19: “into denser cooler Barents Shelf Water”. Add a reference.

L.45: already said L.23-24.

L. 62: “coupled model”: Could the authors be more specific: ice-ocean coupled model?

L.63 references for “World Ocean Database, ICOADS 3.0 and NOAA nighttime L3 Sea surface temperatures.

L.63. The authors might specify the number of profiles assimilated in the Barents Sea and St Anna Trough.

L.64 Are the ERA5 surface fluxes imposed? Or is the ERA5 surface air temperature imposed and the turbulent fluxes recomputed based on the SST of the SODA model?

L. 72. Since the authors compute difference between the first and the last period why do they not use 2 periods of the same length (i.e 1980-1989 for the first period and 2015-2024 for the second one).

L.77: STA. not defined.

L.78-81: clarify your definition of “SSH curl” or use a simple SSH difference.

L.80 “1000m” specify what does it mean in term of water mass for the Fram Strait Transport. Does the Fram Strait section encompass the EGC? Could the authors be more specific about the method used to compute the heat transport? Furthermore, the transports through Fram Strait could be compared with observations (Beszczynska-Möller et al. 2012).

L.102: It seems that a time derivative is missing in the formulae.

L. 107. Could the authors indicate the NB section in figure 1.

L. 111: The title of the section is a bit general

L. 116: replace “greather” by greater.

L.115. Without any analysis of the surface heat fluxes and heat transports at the boundaries, it is premature to conclude that the increase in heat content is due to warmer inflows.

L. 120. Fig 4a is cited before figure 3.

L. 122: Are the Kola section data included in the world ocean data?

L. Figure S2. Cited before figure S1.

L. 120-132.I suggest to move this section at the head of the paragraph (as a validation of the model).

L.136: replace fig 4b,c by fig.5

L. 140 . Beszczynska-Möller et al. 2012 suggested that the temperature of the AW core displays a trend in Fram Strait. Is this trend present in the SODA model? It might be easier to compare equivalent quantities. If the heat transport at St Anna Trough is dominated by the temperature variations, it would be easier to directly compare the variations of temperature at St Anna Trough and in boundary current.

Figure 2. Could the authors add standard deviations ?

L.147 The authors could include a reference to fig. 4b.

L.149: The authors could include a reference to fig. 4c

L. 154: accommodate.

L. 155: A time series of the surface fluxes would help.

Figure 4: Why do the time series stop in 2020?

Figure 6: Indicate that positive values correspond to a heat loss for the ocean.

Figure 7: a mean state of the mixed layer depth could help better understand the changes in MLD.