

Interactive comment on “Problems with estimating oceanic heat transport – conceptual remarks for the case of Fram Strait in the Arctic Ocean” by U. Schauer and A. Beszczynska-Möller

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SUMMARY

This paper provides a reminder that advective heat transports are often calculated with respect to somewhat arbitrary reference temperatures, which can sometimes result in erroneous conclusions. What we really care about is actually the heat flux divergence, for which we need to compute the difference in heat (or temperature) flux between two well-defined areas. In order to do this, the authors introduce the concept of treating part of the Arctic circulation as if it were made up of a collection of tubes that interact only minimally with the surrounding water, but may lose heat to the atmosphere. Thus

C346

the heat transport can be calculated from the change in flux from one end of the tubes to the other. Although there are no huge leaps in our understanding of heat transport into the Arctic, I feel this is an interesting idealization that is helpful in understanding the possible role of advective heating in rapid Arctic change. Anyone who is trying to estimate heat transport needs to be reminded of these issues.

GENERAL COMMENTS

Overall, the paper is well organized and fairly straightforward to understand, though it took a couple of readings before I got a grasp on the range of assumptions made. The most significant by far is that all flow that enters the Arctic through Fram Strait also exits there (no stream tube leakage), and this is clearly stated. Perhaps the authors should consider expressing other assumptions in a similar way: there are 2 tubes entering the Arctic through Fram (WSC water and deeper than 500m water) and there are 4 tubes exiting (WSC, deep, Barents Sea, surface Polar Water). The deep tube is trivial—it enters and exits with zero net volume and heat flux. The WSC also has zero net volume flux. This leaves only the Barents and surface Polar Water flows (which are always defined to be colder than the WSC water, no matter what the lower bound on WSC is) to contribute to the net volume flux, emphasizing that this conceptual model only makes sense for net southward flow. Once I started thinking with this image in my mind, the paper was much clearer.

The stream tube construct appears to work fairly well for Fram Strait; I'm curious if the authors believe there is anywhere else this might be applied. Apart from marginal seas (such as the Mediterranean) the only example I could think of was the Indonesian Archipelago.

I commend the authors for the candid discussion of the limitations of this method, including the definition of temperature thresholds to define water masses. I realize that data is very sparse, but I would like to know if it is possible to constrain the definitions more by using salinity and/or passive tracers. I also appreciated the simplified Arctic

C347

example of how different reference temperatures can cause problems in calculating heat transports.

SPECIFIC SCIENTIFIC COMMENTS

Line 9 of Abstract: the results only apply to the portion of the North Atlantic Water that passes through Fram Strait (not the Barents Sea part), so this is a bit misleading. maybe replace "Atlantic water flow" with "the portion of the Atlantic water flow that passes through Fram Strait".

Line 14, page 1010: "...exchange with the atmosphere and sea ice". I notice that sea ice isn't mentioned at all, which is mostly ok since fresh water fluxes are not the subject of the paper, but I think it should be added here.

Line 15, page 1015: It is confusing to call T_{DI} the "distinction between intermediate and deep water". It actually is the criterion for defining incoming WSC water and should be called that.

Lines 25-27, page 1017: Numerical models often show a pretty strong relationship between the flow through Fram and the Barents; if one increases, the other decreases by the same amount. Monthly variations (again, in models) can easily be on the order of 1-2 Sv, so I don't think variations of this kind should be immediately ruled out as unphysical.

SPECIFIC TECHNICAL COMMENTS

Line 2 of Abstract: replace "known since long" with "well known".

Line 23, page 1008: remove "as compared".

Line 25, page 1008: remove "also".

Line 1, page 1009: replace "is described" with "has been described", then later in the sentence replace "since" with "for".

C348

Line 8, page 1009: I'm not sure what is meant by "respective"; maybe remove it.

Line 22, page 1009: replace "compiles" with "combines".

Line 22, page 1014: remove second "the" in "the returning the WSC".

Lines 9-10, page 1015: While I appreciate creating a sentence that includes all compass directions and "center", this is pretty confusing to read. Please try to make this paragraph clearer, maybe by breaking up the first sentence into at least 2 parts.

Line 10, page 1016: replace "looses" with "loses".

Lines 14-15, page 1016: replace "would Barents" with "if Barents" and later in the sentence "enter" with "entered".

Line 18, page 1016: remove "are" from the end of the sentence.

Line 24, page 1016: I think "zero" should be added in front of "monthly".

Lines 5-6, page 1019: "...tubes and that have therefore..." with "...tubes and therefore have zero net volume flow, allowing the heat transport divergence to be derived."

Lines 15-16, page 1019: replace "of" with "for", remove "so far", replace "only way for time series" with "only practical way to observe time series" (or something similar).

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C349