Ocean Sci. Discuss.,
https://doi.org/10.5194/os-2017-98-AC1, 2018
© Author(s) 2018. This work is distributed under
the Creative Commons Attribution 4.0 License.

Ocean Science Discussions

Interactive comment on "Volume and temperature transports through the main Arctic Gateways: A comparative study between an ocean reanalysis and mooring-derived data" *by* Marianne Pietschnig et al.

Marianne Pietschnig et al.

mp586@exeter.ac.uk

Received and published: 25 January 2018

Response to the issue of ambiguity of "temperature transports" in a non-closed system, as raised in RC1 and SC1

We thank both Ursula Schauer and referee Takao Kawasaki for their comments on this sensitive issue. In the following, we will lay out why we believe that it is valuable to investigate the spatial co-variance of velocity and temperature, as long as one keeps the well-known caveats in mind. At the same time, we admit that we initially were not

Printer-friendly version

Discussion paper

careful enough in the formulation of the present manuscript and interpretation of our results. Therefore, we will propose several improvements further below

Strictly speaking, the only “allowed” comparison between heat transports through the Arctic gateways from different data products is the comparison of integrated net heat transport, since it is independent of the reference temperature provided the net volume flux is zero. However, it is obvious that it will be almost impossible to gain a better understanding of the found differences from looking solely at the single integrated numbers resulting from this approach. It therefore seems natural to aim for a better understanding of the found differences by looking at cross-sections of V and T, but also by very carefully interpreting the cross sections of V*T. In the wider context it should be noted that, while it is a reasonable approximation to close the Arctic mass budget by summing up the lateral transports across all straits (assuming P-E is zero or known), this is clearly impossible for other much-investigated sections in the world’s ocean, like that covered by the RAPID array or the Indonesian Throughflow. Nevertheless, significant scientific insight has been gained by considering also “heat transports” across these sections (England and Huang 2005; Johns et al., 2011; Trenberth and Fasullo 2017), although these are ambiguous due to the non-zero mass budget of these sections.

For investigation of co-variability of T and V, it is unavoidably necessary to choose a reference temperature. Although this choice is arbitrary, there can be sensible choices, depending on the question one wishes to address by computing these fluxes (Woodgate, 2017). As noted by referee #1, our choice of a reference temperature of 0°C might not be ideal as it does not address a specific question. The reason for this choice was to allow for comparison to results from the vast body of existing literature where the authors made the same choice (see references in the manuscript). However, we now see that such a quantitative comparison to other studies is not meaningful, due to the arbitrariness of the values. As also noted by referee #1, the freezing temperature of sea water may be a sensible choice when addressing the contribution of ocean

CC BY

circulation to the melting of sea ice. For this choice, one needs to assume that all heat goes into melting of sea ice. The mean temperature across the Arctic boundary may be the best choice if both datasets happen to have the same mean temperature. The mean temperature of the Arctic Ocean would be a sensible choice to study the contribution of the ocean circulation to warming / cooling of the Arctic Ocean (as done by Lique and Steele, 2013).

Proposed changes to the manuscript:

In our case, the main aim is to assess volume and heat transports through the Arctic main gateways in an ocean reanalysis, C-GLORS. We propose to choose the mean temperature of the Arctic Ocean (taking into account the energy required for melting all Arctic sea-ice) as the reference temperature for the cross-section plots of V*T (the third row of the cross-section plots for each strait). This enables us to qualitatively understand whether a certain current contributes more or less strongly to warming/cooling the Arctic Ocean in one data set than in the other (which is our main motivation for presenting cross-sections of V*T).

However, as mentioned above, the actual numbers of regional warming or cooling contributions are indeed ambiguous, and we therefore also propose to remove any quantification of 'heat transports' that are dependent on the choice of reference temperature from the manuscript, i.e. we will remove the single strait contributions but not the net heat transport from Fig. 2b and the corresponding annual mean values from Table 1. In addition, we propose to move the plots showing V*T cross-sections (based on the proposed Arctic mean reference temperature) to a separate subsection. The focus would then be on the uncontroversial volume transports/velocities and temperatures and we can discuss the caveats associated with the interpretation of the V*T plots in more depth in the subsection. By choosing the Arctic mean temperature as reference, we can also avoid using the term 'temperature transports' and instead speak of the 'contribution to heating/cooling the Arctic Ocean'. We think that the proposed suggestions will improve the interpretability of our results and at the same time help to prevent false

Printer-friendly version

Discussion paper

CC BY

conclusions drawn from the numbers as they are currently provided in the manuscript. We also hope this discussion will raise awareness about the potential danger, practical difficulty and sensible approach about the choice of reference temperature.

References:

England, M. H., and F. Huang, 2005: On the interannual variability of the Indonesian Throughflow and its linkage with ENSO. J. Clim., 18, 1435–1444, doi:10.1175/JCLI3322.1.

Johns, W. E., Baringer, M. O., Beal, L. M., Cunningham, S. A., Kanzow, T., Bryden, H. L., et al. (2011). Continuous, Array-Based Estimates of Atlantic Ocean Heat Transport at 26.5°N. Journal of Climate, 24(10), 2429–2449. http://doi.org/10.1175/2010jcli3997.1

Lique, C., and M. Steele (2013), Seasonal to decadal variability of Arctic Ocean heat content: A model-based analysis and implications for autonomous observing systems, J. Geophys. Res. Oceans, 118, 1673–1695, doi: 10.1002/jgrc.20127

Trenberth, K. E., and J. T. Fasullo, 2017: Atlantic meridional heat transports computed from balancing Earth's energy locally. Geophys. Res. Lett.,.

Woodgate, R. A., 2017: Increases in the Pacific inflow to the Arctic from 1990 to 2015, and insights into seasonal trends and driving mechanisms from year-round Bering Strait mooring data. Prog. Oceanogr.,.

Interactive comment on Ocean Sci. Discuss., https://doi.org/10.5194/os-2017-98, 2017.

CC BY