

Review of **The circulation and water mass (trans)formations in the Arctic Mediterranean Sea and their impact on the ocean deep circulation: a review** by Rudels and Carmack for Ocean Science

Overall:

This long paper is a comprehensive, interesting review of water pathways and transformations in the Arctic and sub-Arctic seas. It covers the historical development of ideas on circulation and focuses on hydrographic observations, plus some conceptual models. OGCM results are excluded. The authors are pre-eminent authorities on Arctic circulation and transformation, and their perspectives are insightful.

Overall, the paper is well written and accurate, although there are many minor issues to address, and a few major changes to consider. I recommend a minor revision of the paper and reconsideration to publish by Ocean Science.

Major comments:

Some large-scale reorganization would help to make the paper more accessible, bearing in mind that many readers will want to read standalone sections. Therefore, consider moving section 5 on Atlantic inflows into a subsection of section 3 on inflows. Section 8 on circulation in the Amerasian basin could also be moved into a subsection of section 7 on circulation in the Arctic Mediterranean.

Overall, there are few references to recent primary literature (only about 10% of the references are from the last ten years). Adding references is important and will help the reader dig into the primary literature, although a comprehensive bibliography is clearly not needed. A few examples are given below.

Somewhere in section 1 Introduction state the overall purpose of the review article. It would also help to cite related articles, and to delineate the scope of the present article. E.g., what's not covered and why? What's different and what's overlapping in this paper from other works (e.g., the book by the first author in 2021 and the *Oceanography* paper by the same authors in 2022)?

In section 3, consider adding some discussion of indigenous peoples' knowledge of the region, especially when it predates that of European explorers and colonists.

Minor comments:

L 92: Clarify which "two gyres" you're referring to.

L102: It says that Greenland Sea deep convection changes are "perhaps the area where the effects of a warming climate have been most evident". Respectfully, I disagree. I think that September Arctic sea ice extent is the climate variable that is the most obvious example of anthropogenic climate change.

L139–140: It says that in summer the incoming TOA radiation at the poles is greater than at the equator. This seems unlikely, at least if the shortwave flux (in Watts per meter squared) is being considered. The statement should be corrected and qualified if necessary.

L187–188: Clarify “the stagnant North Pacific and the ventilated North Atlantic”. I know what’s meant, but it should be stated more precisely.

L656–669: Cite modern paper(s) on Bering Strait flow, e.g., from Rebecca Woodgate.

L 666/671: Make the depths of the “85m” Bering Strait and the “500m” GSR compatible (i.e., both deepest depth, or both average depth).

L 666: Qualify/explain that “the Pacific inflow....does not carry any oceanic heat”.

L 716–717: Clarify “down to a density gradient caused by an advective input of a denser water mass.”

Section 7.1: Dorr et al (2026, Ocean Sci.) is a useful recent paper on Atlantic Water transformation in the Eurasian Basin that could be cited here.

L 930–931: It says “melts sea ice...the salinity...become(s) higher”. Is this an error? If not, some explanation is needed.

L 970: Clarify “the opposite water mass”

Fig 9: State the data source and the data locations. The final sentence in the caption should be clarified: the increase in AW freshwater content and in the upper layer aren’t clear to me.

L 1082: Explain why “the observations shown in Fig 10 suggest entraining plumes”.

L 1154–1155: Clarify “ice sink”

L 1162–1166: Consider adding some text on satellite observations of sea ice thickness, e.g., Kwok & Rothrock (2009, GRL).

L 1171–1172: The statement about sea ice export through Fram Strait not significantly changing should be updated with more recent papers, e.g., Sumata et al. (2023, Nature).

L 1205–1209: The speculation about Sverdrup balance seems unlikely because of the weakness of the beta effect. E.g., see Yang et al. (2015, JGR).

L 1287–1290: Where it talks about the mysterious source of the deep temperature minimum in the Nansen and Amundsen Basins, what about secular change?

L 1393: There seems to be an error in the size and units of the net salt export.

L 1404–1409: The discussion of flow through Fram Strait could be augmented by citing papers that perform linear inverse calculations to estimate the level of no motion. E.g., Tsubouchi et al. (2024, JPO), Brown et al. (2025, AGU Advances).

Fig 15: Where are the two stations located?

L 1769–1773: Cite (e.g.) von Appen et al. (2017, JPO) on Denmark Strait boluses and pulses.

Fig 19: Where are the two sections on the right located on the map at bottom left?

L 1858: The overflow “mixing ratio of 1 to 4” is significantly less than the 1 to 1 estimate of Dickson & Brown (1994, JGR), although maybe different quantities are being estimated. Clarify and briefly discuss. See also line 2233.

L 1999–2004: I think there are some errors in the equations (5) and (6): (i) In (5) why isn't there an  $H^2$  factor on the RHS, like in equation (4)? The units are wrong otherwise. (ii) in the  $S_1$  formula on line 2001 the units are wrong. It looks like there's a missing salinity factor. (iii) In the first equality in (6), the units are wrong (m should be in meters I think). (iv) I don't see how the 2nd equality in (6) follows. Maybe resolving points (ii) and (iii) will fix this.

Figure 23: Consider cutting this figure, or making a much simpler version. The various symbols aren't used anywhere else, and there's no detailed explanation of what's going on.

L2186: Insert “normalized” before “air pressure difference”. Also, be aware that some NAO definitions are based on SLP EOFs, not just the Azores/Iceland pressure difference.

Figure 25: Consider cutting this figure, or making a much simpler version. The figure isn't described in detail, and most of the information is extraneous.

Typos etc.

L 58: Fix “accelerates or mitigates” to “accelerate or mitigate”

L 117: The text starting “where also....” needs to be fixed. I think there's a missing word, and maybe a grammatical error.

L 160: “condensates” -> “condenses”

Fig 1: “YM” should be “YP”?

L 313: Missing word at “1527”?

L 448: Fix out of place “1972”

L 505: Missing word at “because failures”?

L 565: Grammar error at “A task....”

Fig 5 caption: “present” -> “presence”

L 745: Consider switching “ice and brine” to “brine and ice” to match “salt and freshwater”.

L 788: “Assuming that the deepening.....into the mixed layer” is not a complete sentence.

L 896: “i980s” -> “1980s”

L 910: Fix “in the 1980”

L 959: Fix “taken 1996”

L 1046: Fix “2011,)”

- L 1077: "t. Anna" -> "St. Anna"
- L 1183: Fix "this more than compensate"
- L 1200: "disappear" -> "disappears"
- L 1256: "stagnate" -> "stagnant"
- L 1262: "Ocen" -> "Ocean"
- L 1321: "the westward" -> "then westward"
- L 1322: "abnd" -> "and" and "t5he" -> "the"
- L 1404: "secton" -> "section"
- L 1450: "this mean" -> "this means"
- L 1537: Fix "startsZX"
- L 1703: "source" -> "sources"
- L 1704: Missing word(s) near "its larger reservoir"
- L 1731: "Wywille" -> "Wyville"
- L 1760: "stagnate" -> "stagnant"
- L 1798: "suppling" -> "supplying"
- L 1866: "descend" -> "descent"
- L 1875: "disappear" -> "disappears"
- L 2113–2114: There are grammar errors here.
- L 2138: Fix "exported to Southern Ocean"
- L 2176: Add "current" after "deep western boundary"
- L 2181: "and the into" -> "and then into"
- L 2218: Fix "strongest on in"