R E V I E W

of the manuscript entitled
" The circulation and water mass (trans)formation in the Arctic Mediterranean Sea and their impact on the ocean deep circulation: a review"
by Bert Rudels and Eddy Carmack

Recommendation: Minor revision

The manuscript by Bert Rudels and Eddy Carmack provides a comprehensive and insightful synthesis of the circulation and water mass transformations in the Arctic Mediterranean Sea and their implications for the global ocean. The paper stands out as a thoughtful and physically grounded review that integrates decades of observational knowledge into a coherent conceptual framework.

A key strength of the manuscript is its clear focus on water mass pathways and transformations as the organizing principle. By tracing the inflow of Atlantic and Pacific waters, their modification within the Arctic, and their eventual export, the authors construct a compelling narrative that links regional processes to the global overturning circulation. This approach is both intuitive and powerful, allowing the reader to follow the evolution of the system in a physically meaningful way. The emphasis on the Arctic Mediterranean as a "double estuary" system is particularly effective, providing a unifying concept that connects freshwater inputs, sea ice processes, and density-driven circulation.

The manuscript also excels in its process-based interpretation of observations. Rather than simply summarizing existing knowledge, the authors critically assess mechanisms such as cooling, brine rejection, and mixing, and explain how these processes shape the vertical and horizontal structure of the Arctic Ocean. The discussion of how water mass transformations occur "beyond a ridge," allowing for the build-up of density contrasts that influence overflow waters, is especially insightful and highlights the broader climatic relevance of the region.

Another notable strength is the integration of historical and modern perspectives. The manuscript places contemporary understanding in the context of early theoretical and observational work, demonstrating how ideas about Arctic circulation have evolved over time. This historical dimension enriches the review and underscores the continuity of key scientific questions, while also illustrating how improved observations have refined earlier concepts.

The treatment of Arctic–global connectivity is particularly strong. The authors clearly articulate how transformations within the Arctic Mediterranean influence exchanges with the subpolar North Atlantic and, ultimately, the global overturning circulation. By emphasizing both dense overflows and buoyant outflows, the paper captures the dual role

of the Arctic as both a source and modifier of water masses that impact lower latitudes. This perspective is highly relevant in the context of ongoing climate change and evolving Arctic conditions.

The manuscript is also commendable for its conceptual clarity. Complex processes are distilled into understandable frameworks, often supported by schematic reasoning and physically intuitive arguments. The focus on observations and their interpretation lends credibility to the synthesis and ensures that conclusions are firmly grounded in empirical evidence.

Overall, this paper represents a valuable contribution to Arctic oceanography. It provides a coherent, physically consistent, and well-articulated synthesis that will be useful to both specialists and a broader audience interested in high-latitude processes and their global implications. The emphasis on water mass transformations as a central organizing theme is particularly effective and gives the manuscript a strong and distinctive identity.

Shortcomings / Points for Improvement

- Limited engagement with recent changes
  While the manuscript acknowledges that the Arctic is rapidly changing, the discussion of recent observational trends and emerging phenomena remains relatively limited and could be expanded.
- Density of presentation
  The manuscript is at times text-heavy and conceptually dense, which may challenge readers who are not already familiar with Arctic water mass terminology and circulation pathways.
- Limited use of schematic/summary figures
  Given the complexity of the circulation and transformation pathways, additional high-quality schematic figures would greatly improve clarity and accessibility.
- Regional imbalance: The treatment of different Arctic basins is somewhat uneven, with stronger emphasis on Atlantic inflow pathways compared to other regions.
