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DOI
10.5194/egusphere-egu25-3724

Publication date
2025

Document Version
Final published version

Citation (APA)
Vermeulen, D. H. A., Gelderloos, R., & Katsman, C. A. (2025). *Process-based decomposition of North Atlantic local water mass transformation using volume transport budgets* . Abstract from EGU General Assembly 2025, Vienna, Austria. https://doi.org/10.5194/egusphere-egu25-3724

EGU25-3724, updated on 19 Mar 2025
https://doi.org/10.5194/egusphere-egu25-3724
EGU General Assembly 2025

Process-based decomposition of North Atlantic local water mass transformation using volume transport budgets

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The Atlantic Meridional Overturning Circulation (AMOC) is vitally important for regulating global climate through the redistribution of heat, salt, carbon and other tracers across latitudes, yet the precise role of its governing physical processes in the subpolar North Atlantic (SPNA) remains poorly understood. This knowledge gap is significant to address, given the AMOC's sensitivity to anthropogenic climate change and its potential for dramatic weakening or collapse, with profound global implications. Here, we adopt a three-dimensional dynamical perspective, focusing on lateral exchange between the boundary current (BC) and basin interiors, ridge exchange over sills bordering the north of the SPNA, and shallow convection within the BC itself. We do so by analysing water mass transformation in density space, using segmented volume transport budgets in the eddy-resolving global ocean reanalysis GLORYS12 (1/12°). Our findings reveal that: (1) during the BC's circumvention around the subpolar gyre alongstream intensification and densification takes place, and overflow waters from the Iceland–Scotland Ridge and Denmark Strait are added to the system; (2) vertical recirculation cells due to lateral exchange are not immediately evident; (3) residual water mass transformation can be partly explained by shallow convection driven by surface buoyancy fluxes; and (4) substantial spatial variability in local overturning contributions exists. These insights highlight the importance of further quantification of the relative contribution of each governing process to water mass transformation and subsequent overturning in the SPNA.