What Data Assimilation Increments of an Eddy-Permitting Global Ocean Reanalysis Tell Us about Deep Convection in the Labrador Sea

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The Labrador Sea is an area of high climatic importance since the water masses that are created there play a crucial role in the Atlantic meridional overturning circulation. Labrador Sea Water is formed by deep convection caused by strong winter surface cooling. The convection patch reaches as deep as 2000 m but is geographically limited to areas where adequate pre-conditioning occurs. Indeed, after winters of deep-reaching convection, a re-stratification of the ocean occurs that is strongly driven by ocean eddies. The long-lived eddies (typically 2 years) Irminger Rings, that originate from the warm and salty West-Greenland boundary current and extend to great depth, continuously transport heat and freshwater from the boundary current to the Labrador Sea interior. They result from an unstable local interaction between the boundary current and the bottom topography near Cape Desolation. Shorter lived baroclinic eddies, that are formed through baroclinic instability all along the boundary current, extract a significant amount of heat from the boundary current. Finally, the convective patch itself generates eddies which also contribute to the lateral mixing when the patch re-stratifies.

In this paper, we use the global eddy permitting global ocean reanalysis GLORYS1 (period 2002-2009), and free simulations (no data assimilation) to understand the contribution of data assimilation increments in the representation of the convection cycle and its variability. First, it is shown that data assimilation enables to better represent the seasonal and inter-annual variability of deep convection, when compared to simulations with no data assimilation. The reanalysis compares very favorably with the observations collected in the region. Then, we use empirical orthogonal modes of the temperature increments from the data assimilation to describe how the ocean model is corrected in the reanalysis. It is shown that the pattern and variability of the assimilation-induced corrections have striking similarities with those of the horizontal eddy heat transport induced by the baroclinic eddies that form along the West Greenland boundary current. As the grid resolution of the eddy permitting ocean circulation model used in GLORYS1 (1/4° resolution) is still not fine enough to let mesoscale eddies grow in a realistic manner, our results suggest that data assimilation locally acted as missing dynamical processes. It finally shows that ocean reanalyses are a potential source of information for better understanding ocean processes and identifying shortcomings in ocean models.

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