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Spurious ocean heat uptake by numerical diapycnal mixing in the ocean component of climate models

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The ocean plays a crucial role in the climate system in taking up heat, transporting it vertically and laterally, and eventually releasing it back to the atmosphere. For a numerical ocean model to simulate heat uptake from the atmosphere realistically on decadal timescales, it needs to simulate (or parameterise) adequately the diapycnal mixing processes that contribute to carrying heat downwards from surface waters to intermediate and deep waters. However, it is well known that the default class of depth-coordinate ocean models such as NEMO and MOM5, as used in many state-of-the art climate models and earth system models, have excessive numerical diapycnal mixing, mainly resulting from irreversible advection across coordinate surfaces.

Megann and Nurser (2017) used the isopycnal watermass analysis of Lee et al (2002) in an eddy-permitting NEMO configuration to show that, in watermasses below the seasonal mixed layer, the diagnosed diapycnal velocities are up to ten times larger than the diapycnal velocities produced by the mixing scheme used by the model. It will be shown that these spuriously high watermass transformation rates lead to a significantly enhanced drawdown of heat in this model, along with biases in temperature and salinity, both at the surface and in the ocean interior. The implications for climate projections of this unphysical heat uptake will be discussed.