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Discretizing the Gent-McWilliams velocity and isopycnal diffusion with a discontinuous Galerkin finite element method

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The discretization of the Gent-McWilliams velocity and isopycnal diffusion with a discontinuous Galerkin finite element method is presented. Both processes are implemented in an ocean model thanks to a tensor related to the mesoscale eddies. The antisymmetric part of this tensor is computed from the Gent-McWilliams velocity and is subsequently included in the tracer advection equation. This velocity can be constructed to be divergence-free. The symmetric part that describes the diapycnal and isopycnal diffusions requires a special treatment. A stable and physically sound isopycnal tracer diffusion scheme is needed. Here, an interior penalty method is chosen that enables to build stable diffusion terms. However, due to the strong anisotropy of the diffusion, the common-usual penalty factor by Ern et al. (2008) is not sufficient. A novel method for computing the penalty term of Ern is then proposed for diffusion equations when both the diffusivity and the mesh are strongly anisotropic. Two test cases are resorted to validate the methodology and two more realistic applications illustrate the diapycnal and isopycnal diffusions, as well as the Gent-McWilliams velocity.