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A physics-based stochastic approach to representing unresolved scales in ocean models

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Recently, there has been an enormous development to represent unresolved scales by stochastic processes. But current stochastic techniques remain imperfect because the physical properties of the subgridscale processes are either introduced a posteriori as in data-based approaches, or they are prescribed ad hoc by Gaussian closures as in order reduction techniques. In a unifying approach, we combine elements from deterministic physics-based parameterizations and stochastic techniques to give a self-contained stochastic representation of subgridscale interactions. In a nutshell, the largely fixed spatial patterns of the subgridscale interactions are represented by the interactions of the most-unstable modes, whereas the amplitudes of these interactions are assumed to be stochastic with their statistics given via the amplitude equations of the most-unstable modes. For an efficient implementation, we exploit new, powerful tools such as generalized eigenvalue solvers suited to compute targeted eigenmodes of large dimensional systems, and the Dynamical Orthogonal Field method to solve the stochastic differential equations which yields the entire probability distribution of the flow field. As a first demonstration, we discuss the stochastic representation of baroclinic turbulence in the double gyre circulation.