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Parameterizing ocean eddies: Kinetic energy injection via stochastic and deterministic approaches

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Correctly representing the ocean mesoscale in ocean models at eddy-permitting resolution is a challenging task. Due to overdissipation and insufficient resolution, eddy energy tends to be significantly underestimated, which has implications for the overall representation of the ocean circulation. In this study, both stochastic and deterministic ocean eddy parameterizations are introduced that aim at an improved representation of mesoscale ocean turbulence. They reduce the overdissipation at eddy-permitting resolutions by utilizing the inverse energy cascade and energy conversions between potential and kinetic energy.
Mesoscale eddies cascade energy across scales, transport tracers and heat, and interact with the mean currents and the atmosphere. At eddy-permitting resolutions which are close to the Rossby radius of deformation, eddies are barely resolved but such grids are still commonly applied for decadal climate simulations. They will also remain state-of-the-art at high latitudes for years to come. Due to their excessive dissipation of kinetic energy, these simulations feature reduced eddy variability, eddy formation and eddy-mean flow interactions. One option to reduce overdissipation is the optimization of viscous closures. An alternative is the reinjection of parts of the overdissipated energy back into the resolved flow via so called kinetic energy backscatter parameterizations. In our study, we will introduce different viscous and backscatter schemes and how to complement them with stochastic components, to account for unresolved chaotic variations of dissipative processes and for scale interactions across the resolution limit. For this purpose, we use both data informed and theoretical approaches to drive the development of both stochastic and deterministic backscatter parameterizaions. Our results show that incorporation of such schemes can help to substantially improve the kinetic energy and mean flow characteristics. When tuned with caution, these schemes provide a means to incorporate model uncertainty and to reduce systematic biases in ocean models, both in idealized configurations as well as global ocean simulations.

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