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Stochastic data-driven model of mesoscale and submesoscale eddies in gyre circulation

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Planetary flows and large scale circulation systems are characterised by an interaction between scales that range over several orders of magnitude, with contributions given by mesoscale and submesoscale dynamics. Resolving numerically such interactions for realistic configuration is, however, far beyond reach. Any large-scale simulation must then rely on parameterizations of the effects of the small scales on the large scales. In this work, a stochastic parameterization is proposed based on a decomposition of the flow in terms of a smooth-in-time large-scale contribution and a random fast-evolving uncorrelated small-scale part accounting for mesoscales and submesoscales unresolved eddies. This approach, termed modelling under location uncertainty (LU) [4], relies on a stochastic version of Reynolds Transport Theorem to cast physically meaningful conservation principles in this scale-separated framework. Such a scheme has been successfully applied to several large-scale models of the ocean dynamics [1, 2, 3, 5]. Here a LU version of the hydrostatic primitive equations is implemented within the NEMO community code (https://www.nemo-ocean.eu) with a data-driven approach to establish the spatial correlation of the fast evolving scales. In comparison to a corresponding deterministic counterpart, this stochastic large-scale representation is shown to improve, in terms of the eastward jet resolution and variabilities, the flow prediction of an idealized wind forced double gyre circulation. The results are assessed through several statistical criterion as well as an energy transfer analysis [2,5].
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