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Optimisation of an idealised ocean model, stochastic parameterisation of sub-grid eddies.

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An optimisation scheme is developed to accurately represent the sub-grid scale forcing of a high dimensional chaotic ocean system. Using high dimensional linear inverse modelling, the velocity components of a 30km resolution shallow water ocean model are optimised to have the same climatological mean and variance as that of a less viscous 7.5km resolution model. Lag-covariance statistics are also optimised, leading to a more accurate estimate of the high resolution response to forcing using the low resolution model.

The system considered is an idealised barotropic double gyre that is chaotic at both resolutions. Using the optimisation scheme, we find and apply the constant in time, but spatially varying, forcing term that is equal to the time integrated forcing of the sub-mesoscale eddies. A spatially correlated linear stochastic term, independent of the large-scale flow, with a spatially varying amplitude and time scale is used to represent the transient eddies. The climatological mean, variance and lag-covariance of the velocity from a single high resolution integration is used to provide an optimisation target. No other high resolution statistics are required. Additional programming effort, for example to build a tangent linear or adjoint model, is not required either.

The focus of this investigation is on the optimisation scheme and the accuracy of the optimised flow. In addition the forcing can provide insights in the design of deterministic and stochastic parameterisations. In the present study, we found that the stochastic parameterisation correcting the model variance is associated with the spatial pattern of eddy-decorrelation timescales rather than the spatial pattern of the amplitude of the variance. The method can be applied in future investigations into the physical processes that govern barotropic turbulence and it can perhaps be applied to help understand and correct biases in the mean and variance of a more realistic coarse or eddy-permitting ocean model. The method is complementary to current parameterisations and can be applied at the same time without modification.