Summary: The problem of defining oceanic mesoscale eddies remains generally unresolved because there is no unique local spatio-temporal filter that can be used for extracting the eddies, and it is unclear what part of the eddy field cannot be actually resolved and needs to be parameterized in a coarse-grid model. We propose using of the coarse-grid model itself for reconstructing dynamically unresolved eddies, which are actually field errors on the top of the dynamically resolved, large-scale reference flow. The novelties and strengths of the approach are that (i) no spatio-temporal filtering is ever needed, (ii) field errors are dynamically translated into the error-correcting forcing and (iii) the latter exactly augments the coarse-grid model solution towards the reference flow. After implementation of the proposed approach, we study statistical properties of the field errors, show their robustness and reveal their significant differences from the locally filtered eddies. We argue that dynamical effects of unresolved eddies can be ultimately parameterized by emulating field errors and closing them on the dynamically resolved flow. So far, our results are limited to the quasigeostrophic approximation, but this serves as a proof of concept and starting point for the follow-up extension into the primitive equations, which are used routinely in the comprehensive oceanic general circulation models.

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References:

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