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Stochastic modelling of primitive equation and quasi-geostrophic subgrid turbulence

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A general method for stochastic and deterministic modelling of subgrid scale turbulence is presented and applied to primitive equation and quasi-geostrophic models of atmospheric and oceanic flows. Dynamical and thermodynamical subgrid-scale parameterisations of eddy drain, net dissipation and stochastic backscatter are calculated for a multi-level primitive equation atmospheric general circulation model. The parameterisations have only moderate variability with height and a cusp behaviour with peaks near the largest retained wavenumber. They are compared with corresponding results for quasi-geostrophic models of the atmosphere and ocean for which the parameterisations are shown to satisfy scaling laws. Large-eddy simulations (LES) with the subgrid terms very closely reproduce the results of higher resolution direct numerical simulations. The method is shown to produce parameterisations and LES with similar skill for three-dimensional turbulence in boundary layer channel flow.