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Towards a General Turbulence Model for Planetary Boundary Layers Based on Direct Statistical Simulation[1] BRAD MARSTON, BAYLOR FOX-KEMPER, JOE SKITKA, Brown University — Sub-grid turbulence models for planetary boundary layers are typically constructed additively, starting with local flow properties and including non-local (KPP) or higher order (Mellor-Yamada) parameters until a desired level of predictive capacity is achieved or a manageable threshold of complexity is surpassed. Such approaches are necessarily limited in general circumstances, like global circulation models, by their being optimized for particular flow phenomena. By using direct statistical simulation (DSS) that is based upon expansion in equal-time cumulants we offer the prospect of a turbulence model and an investigative tool that is equally applicable to all flow types and able to take advantage of the wealth of nonlocal information in any flow. We investigate the feasibility of a second-order closure (CE2) by performing simulations of the ocean boundary layer in a quasi-linear approximation for which CE2 is exact. As oceanographic examples, wind-driven Langmuir turbulence and thermal convection are studied by comparison of the statistics of quasi-linear and fully nonlinear simulations. We also characterize the computational advantages and physical uncertainties of CE2 defined on a reduced basis determined via proper orthogonal decomposition (POD) of the flow fields.

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