Abstract View

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Equilibrium Geostrophic Turbulence I: A Reference Solution in a β-Plane Channel

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ABSTRACT

A numerical solution is calculated for quasi-geostrophic, adiabatic, baroclinic, wind-driven flow in a β channel. The rates of driving and dissipation are such that the solution is turbulent in equilibrium. The equilibrium state is characterized by vigorous turbulent transports of momentum (by isopycnal form drag and horizontal Reynolds stress divergence), mass and heat. Eddy generation is by baroclinic conversion of mean potential energy. A well-defined inertial range with power-law wavenumber spectra develops in a numerical approximation of the limit of vanishing rates of interior diffusion. In that same limit, mean potential vorticity gradients and eddy enstrophy also vanish. The diagnostic eddy diffusivity for heat (i.e., the ratio $-\overline{v'T}/\tilde{T}_y$) is found to be nearly uniform in space. Eddy energies are in approximate equipartition between kinetic and potential over a wide range of horizontal scales. The mew jet is only slightly supercritical, by a global linear instability criterion, but it is highly supercritical by a local stability criterion or a criterion of distance (in a Reynolds' number) from transition; thus, it is suggested that the degree of supercriticality is not as useful a summary characterization of the turbulent equilibrium as are various transport rates. The decay of predictability (i.e., the growth of initially small differences) is found to be exponential for small and intermediate times at a rate related to the energetic eddy turn-around time. Univariate probability distributions are found to be approximately Gaussian at all scales except the dissipation range where the kurtosis becomes quite large (i.e., the flow is intermittent).

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