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Eddy-driven jets and vortices in convectively forced geostrophic turbulence on a topographic beta-plane

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We present here new results from large-scale laboratory experiments on forced-dissipative geostrophic turbulence in a large rotating tank. In an earlier series of experiments, small-scale convection was driven by a steady flux of dense salty water onto the top surface of a rotating water tank. In the new work, convection was driven by continuous direct heating of the lower boundary. The whole tank rotates at constant angular velocity Ω and dynamical effects equivalent to the spherical curvature of a planetary atmosphere are emulated by use of a radially-sloping bottom. The experiments were carried out on the 13 m diameter rotating Coriolis platform in Grenoble, France. Results demonstrate the formation of multiple, undulating, parallel, barotropic zonal jets, in which $\overline{u'v'}$ fluxes maintain the jets against viscous (Ekman) dissipation. In the new experiments, use of widely different rotation rates of the tank confirms the dual role of planetary vorticity gradients (β) and bottom friction in governing the jet separation scale, approximated by the well-known Rhines scale ($L_R = \pi(2U/\beta)^{1/2}$) under certain conditions. The jets formed are also frequently found robustly to violate the Rayleigh-Kuo barotropic stability criterion, leading to formation of larger-scale waves and eddies and influencing the kinetic energy spectrum. These experiments serve to elucidate mechanisms for jet formation and saturation that may apply to gas giant planet atmospheres and, more controversially, the terrestrial oceans, and suggest a number of new diagnostics to be investigated in observations and models of both Jovian and terrestrial ocean circulations.