MS6L_11152

XXI International Congress of Theoretical and Applied Mechanics
Warsaw, Poland, August 15–21, 2004

Anisotropic Large-Scale Turbulence on Giant Planets and in the Ocean

B. Galperin(1), S. Sukoriansky(2), H. Nakano(3)

(1) *Marine Science, USF, St. Petersburg, Florida, USA*
(2) *Mechanical Engineering, BGU, Beer-Sheva, Israel*
(3) *Oceanographic Research Department, MRI, Ibaraki, Japan*

Barotropic two-dimensional turbulence with Rossby waves is distinguished by strong anisotropy and energetic zonal jets in alternating directions. Flows on the beta-plane and in thin shells on the surface of a rotating sphere develop strongly anisotropic spectrum with steep, n^{-5}, slope for the zonal flows and Kolmogorov–Kraichnan, $n^{-5/3}$, slope for the residuals. The n^{-5} zonal spectrum was found on all four giant planets of our solar system, both with regard to its slope and the amplitude. This spectrum can be used to analyze some basic characteristics of large-scale circulations on giant planets and for interplanetary comparisons. Recently, it was found that the mid-depth ocean currents in the north Pacific ocean also develop a system of alternating zonal jets and build up the same n^{-5} and $n^{-5/3}$ zonal and residual spectral distributions. The main characteristic of the planetary and oceanic flows under consideration is the smallness of their Burger number, $Bu = (L_d/R)^2$, where L_d is the first baroclinic Rossby radius of deformation and R is the planetary radius. Exploring the planetary-ocean analogy, we conclude that the fine-scale oceanic zonal jets are driven by strongly nonlinear, anisotropic dynamics of quasi-2D turbulence with Rossby waves and argue that the latitudinal scaling of these jets is determined by the large-scale friction processes.

View the extended summary