ON LARGE-SCALE PROPERTIES OF PLANETARY AND OCEANIC CIRCULATIONS

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One of the possible explanations of the banded appearance of the giant planets’ disks relies on the shallow water theory and properties of the quasi-two-dimensional turbulence. It has been shown by Sukoriansky et al. (2002) that in the barotropic limit, flows in thin shells on the surface of a rotating sphere develop strongly anisotropic flow regime with steep, $n^{-5}$, zonal spectrum and Kolmogorov-Kraichnan, $n^{-5/3}$, residual spectrum. The $n^{-5}$ zonal spectrum, regarding both the slope and the amplitude, was found on all four giant planets of our solar system. Although the scope of the barotropic model is limited as it cannot explain, for example, such phenomena as the different directions of the equatorial jets on Jupiter and Saturn vs. Uranus and Neptune, this model, nevertheless, can be used to obtain some basic energetic and other characteristics of planetary circulations.

Recently, it was found that the mid-depth ocean currents in the North Pacific ocean also reveal banded structure and obey the same zonal and residual spectra as the barotropic currents in Sukoriansky et al. (2002). The main characteristic of the planetary and oceanic flows under consideration is the smallness of the Burger number, $Bu = (L_d/R)^2$, where $L_d$ is the first baroclinic Rossby radius of deformation and $R$ is the planetary radius. The fact that the oceanic results were obtained using a realistic, fully-three-dimensional ocean model is indicative of the fact that the barotropic model does, indeed, capture some basic properties of large-scale circulations for small $Bu$.

The connection between the planetary and Earth circulations sheds some new light on the basic properties of stability and variability of their zonal jets and allows one to establish a set of critical parameters that could characterize various patterns of circulation on extra-solar planets.
Reference