Westward jets and planetary turbulence: from laboratory studies to oceans and to giant planets

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ABSTRACT: Westward jets, such as the South-Equatorial Current and beta-plumes, play important role in ocean circulation. When forced, they become unstable and shed Rossby waves and eddies which often exhibit features of quasi-geostrophic turbulence with inverse energy cascade. These jets are often associated with well-mixed potential vorticity (PV) profiles which, being a part of the PV staircase, render the jets blunt and broad in contrast to the narrow and sharp eastward jets. Turbulent features of such jets have not been studied at depth.

Experimental studies of turbulence and transport properties associated with westward jets are the subject of this presentation. Turbulence and the jet were produced by an electro-magnetic force in a rotating tank filled with an electrolytic saline solution. The parabolic free surface emulated the topographic beta-effect which evoked the zonation. The spectral and transport flow characteristics were highly anisotropic. Turbulence was diagnosed by exploring the analogy between vertical and horizontal turbulent overturns in, respectively, stably stratified and quasi-geostrophic flows which gave rise to a method of potential vorticity (PV) monotonizing. This method yields a length scale, LM, analogous to the Thorpe scale in stably stratified turbulence. This scale allows one to evaluate the rate of the inverse energy cascade and meridional diffusivity coefficient based upon limited amount of data. The method is applied to the atmospheres of Jupiter and Saturn and its results agree quite well with the spectral analysis. The need of paradigm shift in studies of planetary atmospheres will be emphasized: research to understand and evaluate mean zonal velocity profiles on giant planets needs to be extended to include second, third and higher-order moments that will elucidate large-scale turbulence and its effect upon large-scale circulation and transport.

ALL ARE WELCOME!!!