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Spherical shallow water turbulence: cyclone-anticyclone asymmetry, potential vorticity homogenization and jet formation.

J. Shipton (1) and D. G. Dritschel (2)

(1) University of Reading (j.shipton@reading.ac.uk), (2) University of St Andrews (dgd@mcs.st-and.ac.uk)

We present a thorough investigation of the properties of freely decaying turbulence in a rotating shallow water layer on a sphere. A large number of simulations, covering an extensive range of Froude and Rossby numbers, are carried out using a novel numerical algorithm that exploits the underlying properties of the flow. In general these flows develop coherent structures. Vortices interact, merge and migrate polewards leaving behind regions of homogenized potential vorticity separated by sharp zonal jets. We investigate new ways of looking at these structures.

Cyclone-anticyclone asymmetry has long been observed in atmospheric data, laboratory experiments and numerical simulations. This asymmetry is usually seen to favour anticyclonic vorticity with the asymmetry becoming more pronounced at higher Froude numbers (e.g. Polvani et.al. 1994). We find a similar result but note that the cyclones, although fewer, are significantly more intense and coherent. We present several ways of quantifying this across the parameter space.

Potential vorticity (PV) homogenization is an important geophysical mechanism responsible for sharpening jets through the expulsion of PV gradients to the edge of flow structures or domains. We can visualise these sharp PV gradients by plotting the palinstrophy field. The number of jets can be estimated by performing a cluster analysis on the mean latitude of PV contours (as in Dritschel et. al. 2006). This provides an estimate rather than an exact count because the jets meander significantly. We investigate the accuracy of the estimates provided by different clustering techniques.