Using Enstrophy Transport as a Diagnostic to Identify Flow Regime Transformation

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Previously obtained results conjectured that, in an atmosphere that is barotropic or approximately so, the sum of the positive Lyapunov exponents in the attractor would be approximately equal to the area integrated enstrophy. As such, area integrated enstrophy (IRE) can be viewed as a measure of the stability or the predictability within a flow regime. Low values represent a more stable, predictable regime. Subsequent studies demonstrated the utility of IRE in identifying the onset and decay of blocking events. In identifying block onset and decay it was found that IRE increases dramatically over a small window of time, and then decreases again when the flow stabilizes. The IRE may also have utility as a variable that can identify flow regime transformation in a general sense. However, the weakness in this technique is that it is unclear whether there is a certain rate of increase or a threshold value that must be crossed in order to successfully identify regime transformation. The barotropic Vorticity Equation can be multiplied by vorticity to get an enstrophy equation, and then integrated with time. Applying the conjecture above, the sum of the Lyapunov exponents can be set approximately equal to the advection or flux of enstrophy in a Cartesian atmosphere with pressure as the vertical coordinate. As a result, the transport or flux of enstrophy can also be used for a diagnostic of flow instability. This was tested using a case study of blocking and shown to be a useful diagnostic for regime transformation.