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Self-Similar, Self-Replicating, Critical Layers and Vortices in Rotating, Horizontally Shearing, Vertically-Stratified Flows SUYANG PEI, CHUNG-HSIANG JIANG, PHILIP MARCUS, PEDRAM HASSANZADEH, UC Berkeley — In a rotating,uni-directional flow with a vertical Brunt-Väisälä frequency $N(z)$ and horizontal shear σ, baroclinic critical layers (a form of neutrally stable eigenmode) form at cross-stream locations that are functions of N and the eigenmode's stream-wise wavenumber and temporal frequency. The critical layers, which are easily excited by waves or vortices, grow in amplitude, roll-up and create new vortices at the critical layers. These vortices, in turn create new critical layers. In flows with uniform σ, the process of excitation, critical layer growth, roll-up and vortex creation can self-similarly self-replicate so that the entire 3D computational domain fills with a spatially periodic lattice of large-amplitude vortices. This self-replication occurs in flows that are linearly stable (in particular, they are convectively and centrifugally stable with a uni-directional flow with no inflection points). Thus, a small, but finite-amplitude perturbation in the form of a wave or vortex fills the entire flow with large-amplitude coherent structures. This phenomenon was serendipitously discovered in calculations of linearly stable Keplerian disks and of planetary vortices in zonal flows, but also applies to large Reynolds number lab flows such as Couette flow.

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