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Baroclinic Critical Layers and the Zombie Vortex Instability (ZVI) in Stratified, Rotating Shear Flows: Where They Form and Why MENG WANG, PATRICK HUERRE, CHUNG-HSIANG JIANG, SUYANG PEI, MARYANN RUI, PHILIP MARCUS, University of California, Berkeley — It has been found recently that baroclinic critical layers are responsible for a new finite-amplitude instability, called the Zombie Vortex Instability (ZVI), in stratified (with Brunt–Väisälä frequency N) flows, rotating with angular velocity Ω and shear σ. ZVI occurs via baroclinic critical layers that create linearly unstable vortex layers, which roll-up into vortices. Those vortices excite new baroclinic critical layers, which form new generations of vortices, resulting in "vortex self-replication" that fills the fluid with turbulent vortices. To understand the role of baroclinic critical layers in ZVI, we analyze their structures with matched asymptotic expansions, assuming viscosity determines the magnitude and thickness of the critical layer. We verify our analytically obtained leading order inner and outer layer solutions with numerical simulations. In addition, maps of the control parameter space (Reynolds number, N/Ω and σ/Ω) are presented that show two regimes where ZVI occurs, and the physics that determines the boundaries of the two regimes is interpreted. The parameter map and its underlying physics provide guidance for designing practical laboratory experiments in which ZVI could be observed.

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