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Abstract for an Invited Paper  
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**DCOMP Award Lecture (Metropolis): A 3D Spectral Anelastic Hydrodynamic Code for Shearing, Stratified Flows<sup>1</sup>**  
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We have developed a three-dimensional (3D) spectral hydrodynamic code to study vortex dynamics in rotating, shearing, stratified systems (eg, the atmosphere of gas giant planets, protoplanetary disks around newly forming protostars). The time-independent background state is stably stratified in the vertical direction and has a unidirectional linear shear flow aligned with one horizontal axis. Superposed on this background state is an unsteady, subsonic flow that is evolved with the Euler equations subject to the anelastic approximation to filter acoustic phenomena. A Fourier-Fourier basis in a set of quasi-Lagrangian coordinates that advect with the background shear is used for spectral expansions in the two horizontal directions. For the vertical direction, two different sets of basis functions have been implemented: (1) Chebyshev polynomials on a truncated, finite domain, and (2) rational Chebyshev functions on an infinite domain. Use of this latter set is equivalent to transforming the infinite domain to a finite one with a cotangent mapping, and using cosine and sine expansions in the mapped coordinate. The nonlinear advection terms are time integrated explicitly, whereas the Coriolis force, buoyancy terms, and pressure/enthalpy gradient are integrated semi- implicitly. We show that internal gravity waves can be damped by adding new terms to the Euler equations. The code exhibits excellent parallel performance with the Message Passing Interface (MPI). As a demonstration of the code, we simulate vortex dynamics in protoplanetary disks and the Kelvin-Helmholtz instability in the dusty midplanes of protoplanetary disks.

<sup>1</sup>In collaboration with Philip Marcus