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UC 307

Convective Flows Under Strong Rotational Constraints

Current models and simulations of fluid turbulence in the atmosphere and oceans are conducted at parameters that do not closely resemble observed realistic values. Thermal and rotational forces are sometimes orders of magnitude too small. Improvements in computing power through Moore's laws will produce minimal advances with present-day models (specifically, a doubling of resolution in each direction every six years for three-dimensional problems). It is therefore clear that advances must occur through new model development and associated simulations utilizing extreme parameter values in an asymptotic manner. This will require a body of knowledge gained from large-scale direct numerical simulations that explore the nature of extreme values in controlled settings.

One such area has been that of convection under the influence rotation. In general numerical simulations of rotationally constrained flows are unable to reach realistic parameter values (e.g., Reynolds Re and Richardson Ri numbers). In particular, low values of Rossby number Ro, defining the extent of rotational constraint, compound the already prohibitive temporal and spatial restrictions present for high-Re simulations by engendering high-frequency inertial waves and the development of thin (Ekman) boundary layers.

Recent work in the development of reduced partial differential equations (PDEs) that filter fast waves and relax the need to resolve boundary layers has been extended to construct a hierarchy of balanced equations that span the stably and unstably stratified limits. By varying the aspect ratio for spatial anisotropy characterizing horizontal and vertical scales, rapidly rotating convection and stably stratified quasi-geostrophic motions can be described within the same framework.

In this talk, the asymptotic PDEs relevant for rotating convection are explored. Special classes of fully nonlinear exact solutions are identified and discussed. Direct numerical solutions that correctly capture the regular vortex columnar and irregular geostrophic turbulence regime of recent laboratory experiments are also presented and discussed.

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