McGill Computational Science and Engineering Seminar

Thursday March 15th at 15:00 in Burnside Hall room 1205

Applying rotating-stratified turbulence theory to numerical methods in geophysical fluid dynamics

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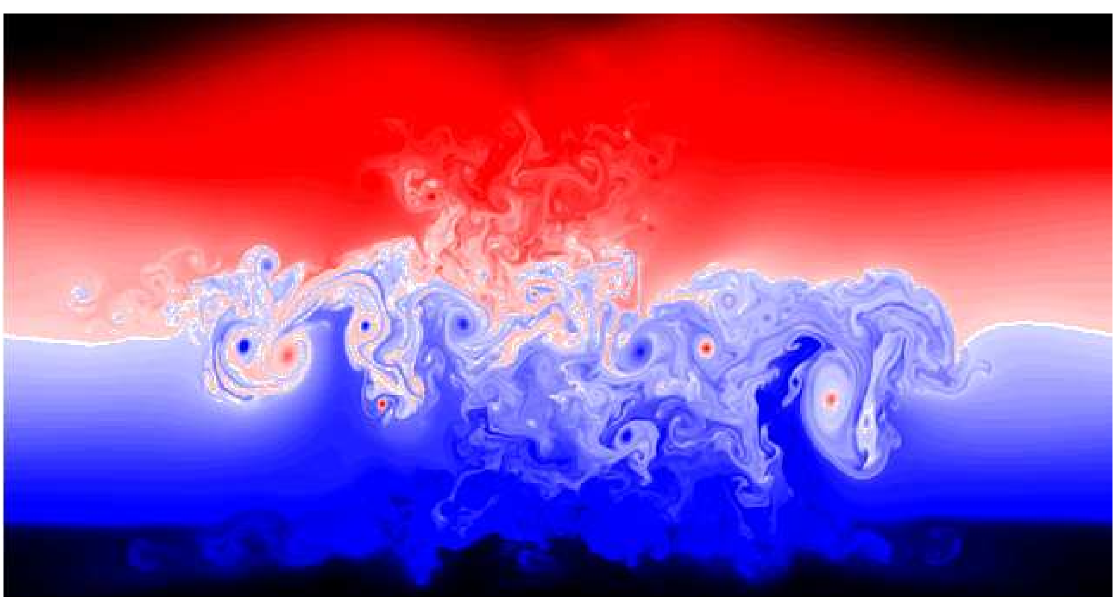
In the past two decades spatial truncation scales in numerical models of fluid flow have decreased by an order of magnitude. Over the range from large-scale quasigeostrophic eddies to boundary-layer turbulence the nature of atmosphere/ocean dynamics changes a great deal. This dynamical range is just beginning to be resolved by current numerical models. Such issues as the breakdown of the various balances and the interaction between the turbulence and the wave field are not completely understood. This study examines a series of recent theoretical and numerical explorations of rotating stratified turbulence in order to suggest future directions for numerical methods in models with fast waves and slower turbulence.

The various sets of nonlinear interactions between modes possessing potential vorticity (vortices) and those that do not (mostly waves) have been examined in unbalanced rotating stratified turbulence. The nonlinear wave/vortex interactions which are permitted by the conservation properties may be rendered weak if they are far from resonance, i.e. if their frequencies are sufficiently mismatched. For many applications, wave timescales are considered too short to be physically significant. Two common methods to avoid the resulting CFL instability are the semi-implicit method and the split explicit method. When these are implemented the numerical wave frequencies are severely reduced, but differently in the two cases. In an attempt to go beyond the usual linear analysis of discretisation schemes, the same resonance/conservation analysis is now applied to the numerical frequencies. This yields some surprising results concerning the climatological cascades of fast and slow energy and of potential enstrophy in models employing these schemes. Whereas a reduced wave/vortex frequency separation can be maintained with semi-implicit methods, this is not always possible with split-explicit schemes. These points will be illustrated with numerical simulations and the consequences for numerical modellers will be discussed.



The temperature field in a numerical simulation of stratified turbulence. Red corresponds to warmer (lighter) fluid. Blue regions are colder and heavier.