Title MSc project:

Weather dynamics for rapidly rotating convection

Advisors: Prof. Onno Bokhove and Prof. Steve Tobias

The classic set-up for convection is due to Rayleigh and Bénard: a box or cylinder with an ideal gas is heated from below and cooled from the top. Depending on the temperature gradient the dynamics can become more or less turbulent. We aim to study this dynamics under the extra constraint of strong rotation, which can lead to the formation of Taylor columns. The idealised dynamics described above applies to meso-scale weather in the extra tropics.

The goals of the project are as follows:

- to review derivations of simplified models using asymptotic theory (Julien et al. 1998, 2006, 2012, Sprague et al 2006); relation with stratified quasi-geostrophic (QG) theory;
- to investigate linear instability theory for these models, where possible using the literature, comparison with QG-theory;
- to explore some nonlinear dynamics with numerical models, time permitting; and,
- to investigate the dynamical effects of adding an extra phase to the fluid, as solid (ice/snow) and/or gas (vapour); or, a laboratory analogue thereof with air and iodine (vapour).

References

- JULIEN, K., KNOBLOCH, E., MILLIFF, R. & WERNE, J. 2006 Generalized quasi-geostrophy for spatially anistropic rotationally constrained flows. J. Fluid Mech. 555, 233–274.
- JULIEN, K., KNOBLOCH, E., RUBIO, A. M. & VASIL, G. M. 2012 Heat transport in Low-Rossbynumber Rayleigh–Bénard Convection. Phys. Rev. Lett. 109, 254503.
- JULIEN, K., KNOBLOCH, E. & WERNE, J. 1998 A new class of equations for rotationally constrained flows. Theor. Comput. Fluid Dyn. 11, 251–261.
- SPRAGUE, M., JULIEN, K., KNOBLOCH, E. & WERNE, J. 2006 Numerical simulation of an asymptotically reduced system for rotationally constrained convection. J. Fluid Mech. 551, 141–174.
- BOKHOVE, O., TOBIAS, S. & KENT, T. 2015 On a 3D Model with Anisotropic, Rotating Convection and Phase Changes for DA. http://gmao.gsfc.nasa.gov/events/adjoint_workshop-10/presentations.html poster.

Title PhD project:

Numerical modelling of strongly rotating convection with phase changes

Advisors: Profs. Onno Bokhove and Steve Tobias

Short summary:
Accurate prediction of (rotating) convection is important in numerical weather prediction. Convection is also coupled to the phase changes of water in the atmosphere and, hence, the notoriously difficult prediction of cloud dynamics and precipitation. The aim of the project is to consider numerical modelling of convection under strong rotation. Both spectral and finite element type numerical discretisations will be developed/investigated, for models with and without phase changes, in idealised domains. In this project, we aim to collaborate with the Met Office by extending our current contacts.