Inertia gravity waves linked to baroclinic waves in a rotating, differentially heated annulus with an upper free surface

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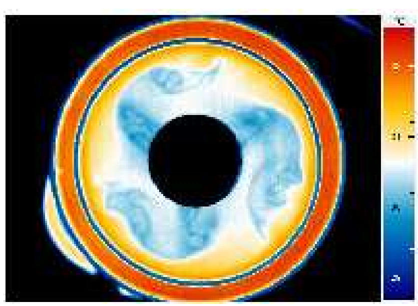
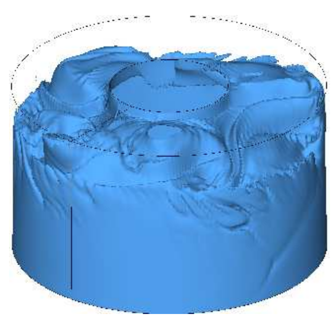
Inertia gravity waves (IGWs) are ubiquitous in the atmosphere and oceans, and are known to play a fundamental role in a wide variety of processes, among others the induction and modulation of turbulence. Observations and simulations have revealed their spontaneous occurrence simultaneously with the onset of baroclinic instability, recognized to be one of the dominant energetic processes in the large-scale atmospheric and oceanic circulations. In spite of intensive research activities these last decades, the generation mechanism and the propagation of IGWs, as well as their interaction with large-scale structures triggering locally chaotic motions, remain poorly understood. A better understanding of these phenomena is therefore mandatory for the development of IGWs parameterization schemes actually required for numerical global weather prediction.

A combined laboratory experiment and direct numerical simulations study is proposed for the detailed investigations of instabilities arising within a differentially heated rotating annulus, the baroclinic cavity. The configuration corresponds to an experimental setup used at BTU, Cottbus Senftenberg, Germany [1], characterized by an open upper surface and filled with water ($Pr = 7$). Infrared thermography and simultaneous kalliroscope visualization in horizontal planes, illuminated by a laser sheet, have been applied to detect the surface signatures of IGWs (Figure 1.a). These findings confirmed the computations carried out by three different numerical approaches, using either spectral methods (Figure 1.b), high order compact finite difference scheme (M2P2, Marseille), or the EULAG code (Freie Universitaet Berlin). These small-scale features have been observed in addition to those developing along the inner cold cylinder, previously identified by simulations in a closed cavity, filled with a liquid defined by $Pr = 16$ [2]. These new IGWs show characteristics similar to the ones obtained by [3] at the exit of the meandering jet between the cyclonic and anticyclonic parts of the baroclinic waves.



(a) Thermographic image



(b) Isosurface DNS

Fig. 1: Temperature at the upper open surface.

References

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