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Educing the emission mechanism of internal gravity waves in the differentially heat rotating annulus

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Understanding the lifecycle of gravity waves is fundamental to a good comprehension of the dynamics of the atmosphere. In this lifecycle, the emission mechanisms may be the most elusive. Indeed, while the emission of gravity waves by orography or convection is well understood, the so-called spontaneous emission is still a quite open topic of investigation [1]. This type of emission usually occur very near jet-front systems in the troposphere. In this abstract, we announce our numerical study of the question.

Model systems of the atmosphere which can be easily simulated or built in a laboratory have always been an important part of the study of atmospheric dynamics, alongside global simulations, *in situ* measurements and theory. In the case of the study of the spontaneous emission of gravity waves near jet-front systems, the differentially heated rotating annulus set up has been proposed and extensively used. It comprises of an annular tank containing water: the inner cylinder is kept at a cold temperature while the outer cylinder is kept at a warm temperature. The whole system is rotating. Provided the values of the control parameters (temperature, rotation rate, gap between the cylinders, height of water) are well chosen, the resulting flow mimics the troposphere at midlatitudes: it has a jet stream, and a baroclinic lifecycle develops on top of it. A very reasonable ratio of Brunt-Väisälä frequency over rotation rate of the system can be obtained, so as to be as close to the atmosphere as possible. Recent experiments as well as earlier numerical simulations in our research group have shown that gravity waves are indeed emitted in this set up, in particular near the jet front system of the baroclinic wave [2].

After a first experimental stage of characterising the emitted wavepacket, we focused our work on testing hypotheses on the gravity wave emission mechanism: we have tested and validated the hypothesis of spontaneous imbalance generated by the flow in geostrophic balance. For the first stage of this investigation, we separated the flow between a balance and an imbalanced part at first order in Rossby number: the balanced pressure field was computed through an inversion of the potential vorticity equation [3]. The balanced horizontal velocity field and buoyancy were then computed using the geostrophic and hydrostatic balance conditions. We first checked that this decomposition gave on the one hand a large scaled balanced flow, comprising mostly of the baroclinic wave, and on the other hand a small scale flow comprising mostly of the gravity wave signal. We then proceeded with the central stage of the validation: we simulated the tangent linear dynamics of the imbalanced part of the flow [4]. The equations are linearised about the balanced part, and any imbalances forces the modeled imbalanced part. The output of this simulation compares very well with the actual imbalanced part, thus confirming that the observed gravity waves are indeed generated through spontaneous imbalance. To our knowledge, this is the first demonstration of emission by this mechanism in a flow which is not idealised: a flow which can be obtained as a result of a numerical simulation of primitive equations or actually observed in a laboratory experiment.

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