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Baroclinic waves and gravity waves in a finite-volume model of the differentially heated rotating annulus

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The differentially heated rotating annulus is a classical experiment for the investigation of baroclinic flows and can be regarded as a strongly simplified laboratory model of the atmosphere in mid-latitudes. Data measured at the BTU Cottbus-Senftenberg (Harlander et al, 2011) are used to validate a new numerical finite-volume model (cylFloit). The model employs the Adaptive Local Deconvolution Method (ALDM) (Hickel et al, 2006) to parameterize unresolved subgrid-scale turbulence. The validation compares the azimuthal mode numbers of the dominant baroclinic waves and does a principal component analysis of time series of the temperature field observed in the experiment and the model simulation. One part of the laboratory procedure that is commonly neglected in simulations is the annulus spin-up, during which the annulus is accelerated from a state of rest to a desired angular velocity. We investigate whether including the spin-up phase in the simulation improves the agreement with the experiment.

In addition we use the model to investigate gravity waves (GWs) in the rotating annulus. These waves play an important role in atmospheric dynamics by transporting momentum over large distances, affecting daily weather as well as the climate. Our focus is on GWs spontaneously emitted by the baroclinic waves. By simulating a wide and shallow annulus with relatively large temperature difference between inner and outer cylinder walls, we are able to explore a more atmosphere-like regime where the Brunt-Vaisala frequency is larger than the inertial frequency. Various analyses suggest there is distinct GW activity in these simulations, as well as indications of spontaneous GW emission.

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