Geophysical Research Abstracts
Vol. 12, EGU2010-12586-1, 2010
EGU General Assembly 2010

Predictability of a laboratory analogue for planetary atmospheres

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The first quantitative forecasts of the rotating annulus experiment are presented. Predictability of the second kind (predicting the climatological state of the system, given certain boundary conditions) has been studied in some detail for the rotating annulus, but we believe this is the first study to measure predictability of the first kind (deterministic predictability from initial conditions).

The predictability of this experiment is studied by using similar techniques to those used in weather forecasting. A forecasting system has been developed which starts forecasts from analyses of rotating annulus data produced by the Met Office analysis correction method, and uses the breeding method to generate ensembles of initial conditions around these analyses.

The results show that flow regimes over a range of complexity can be predicted in this experiment, with varying success. Forecasts in the steady wave flow regime verify well against observations, and are predictable until the end of the available data. Forecasts in the amplitude and structural vacillation flow regimes lose quality and skill by a combination of wave drift and wavenumber transition. Amplitude vacillation is predictable up to several hundred seconds ahead, and structural vacillation is predictable for a few hundred seconds.

The annulus is firmly established as an insightful laboratory analogue for certain kinds of atmospheric dynamical behaviour, and is also a useful testbed for the methods used to study them. The laboratory setting allows baroclinic flow to be studied in a reproducible manner in a system where the complexity of the flow can be controlled. Few attempts have taken advantage of these properties of laboratory systems to inform the development of operational forecasting techniques, and this work is also intended to demonstrate a proof-of-concept: that the annulus could be used as a testbed for meteorological techniques under laboratory conditions.