Geophysical Research Abstracts
Vol. 15, EGU2013-4637, 2013
EGU General Assembly 2013

Inertial waves in a spherical shell induced by librations of the inner sphere: experimental and numerical results

Sandy Koch (1), Uwe Harlander (1), Rainer Hollerbach (2), and Christoph Egbers (1)

(1) Department of Aerodynamic and Fluid Mechanics, Brandenburg University of Technology (BTU) Cottbus, (2) Institute of Geophysics, ETH Zürich, Switzerland

In geophysical fluids, such as the atmosphere, the oceans or the liquid core of the earth, periodic flows can be found on all scales. Due to multiple reflection, e.g. on the curved boundaries of the spherical shell, wave energy can be focused on certain orbits [1,2], called wave attractors. These detached internal boundary layers have been studied experimentally in a rotating box [1], or a rotating cylindrical gap [3] since about 10 years.

We begin with an experimental investigation of the flow induced in a rotating spherical shell. The shell globally rotates with angular velocity Ω. A further periodic oscillation with angular velocity $0 \leq \omega$g= 2Ω, a so-called longitudinal libration, is added on the inner sphere's rotation. The primary response is an inertial wave spawned at the critical latitudes on the inner sphere, and propagating throughout the shell along inclined characteristics. For sufficiently large libration amplitudes the higher harmonics also become important. Those harmonics whose frequencies are still less than 2Ω behave as inertial wave themselves, propagating along their own characteristics. The steady component of the flow consists of a prograde zonal jet on the cylinder tangent to the inner sphere and parallel to the axis of rotation, and increases with decreasing Ekman number. The jet becomes unstable for larger forcing amplitudes as can be deduced from preliminary particle image velocimetry observations. Finally, a wave attractor is experimentally detected in the spherical shell as the pattern of largest variance.

These findings are reproduced in a 2D numerical investigation of the flow, and certain aspects can be studied numerically in greater detail. One aspect is the scaling of the width of the inertial shear layers and the width of the steady jet. Another is the partition of the kinetic energy between the forced wave, its harmonics, and the mean flow. Finally, the numerical simulations allow for an investigation of instabilities, too local to be found experimentally. For strong libration amplitudes the boundary layer on the inner sphere becomes unstable, triggering localised Görtler vortices during the prograde phase of the forcing. This instability is important for the transition to turbulence of the spherical shell flow.

References

[1] L.R.M. Maas, J. Fluid Mech. 437, 13-28, 2001

[2] U. Harlander and L.R.M.Maas, Dynamics of Atmospheres and Oceans 44, 1-28, 2007

[3] Swart, A. and Manders, A. and Harlander, U. and Maas, L.R.M., Dynamics of Atmospheres and Oceans, Vol. 50, 16-34, 2010