Geophysical Research Abstracts,
Vol. 10, EGU2008-A-06178, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-06178
EGU General Assembly 2008

Wave attractors and mean flow oscillations in a rotating tank experiment

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Thirty years ago, Plumb and McEwan designed an laboratory experiment that demonstrates that vertically propagating gravity waves can induce a periodically oscillating mean flow. This experiment is believed to capture the fundamental wave-mean flow interaction that is responsible for the quasi-biennal mean flow oscillation (QBO) of the equatorial stratosphere. From a geophysical point of view, the main deficit of the Plumb and McEwan experiment is probably the neglect of rotation, excluding inertial and Rossby waves. It is known today that such waves play a significant role for the QBO.

Our aim is to perform a 'QBO-experiment' that highlights the impact of inertial waves for the development of mean flow oscillations. To keep the experiment simple we fill a homogeneous fluid in between an inner and outer cylinder both fixed on a rotating platform. Obviously, this setting does not allow for vertically propagating gravity waves but for inertial waves. The inertial waves are forced by modulating the rotation rate of the platform. Inertial waves have similar properties than internal gravity waves. Therefore we think that in analogy to the Plumb and McEwan experiment, an oscillating mean flow can be excited by vertically propagating inertial waves.

In equatorial oceans, slowly varying deep currents have been observed, but no QBO-like phenomena. Of course, in the oceans waves cannot propagate freely in the vertical direction but are reflected at the surface and bottom. It was shown already in the sixties that equatorial inertial waves can become trapped on closed loops, later called wave

attractors.

For Ekman-numbers small enough, wave attractors should occur also in the experiment sketched above. For larger Ekman-numbers, boundary wave reflection becomes less important and a QBO-like regime should dominate. In summary, using a range of Ekaman-numbers we expect a regime-transition from a wave attractor regime where wave reflection dominates, to a QBO-like regime, where wave dissipation dominates.