Bistability and equilibrium statistical mechanics in quasi-geostrophic flows

Sommeria Joel [1], Mathur Manikandan [1]

1 : Laboratoire des écoulements géophysiques et industriels (LEGI)
Université Joseph Fourier - Grenoble IInstitut polytechnique de Grenoble (Grenoble INP)CNRS : UMR5519
1025 Rue de la piscine - BP 53 38041 GRENOBLE CEDEX 9
http://www.legi.grenoble-inp.fr/

Equilibrium statistical mechanics predicts that 2D turbulence confined to a bounded domain self-organises into a mean flow as the inverse energy cascade piles up at the largest available scale. The choice between two symmetric states can result in a phase transition with symmetry breaking. In the presence of forcing and dissipation we expect the occurrence of random switching between the two states separated by long periods of persistence. Examples from laboratory experiments and numerical simulations will be given.

Bistability is observed in the atmosphere as a switch between a blocked state, during which a big anticyclone persists on a continent, and the more usual propagating planetary waves. Similarly the Kuroshio oceanic current near Japan switches between two configurations over a typically ten year time period. In these geophysical examples, Coriolis effects in the presence of large scale topography play an important role. Bistability has been previously reproduced in a annular tank by Tian et a. (1997) where an azimuthal jet interacts with a radial topography superimposed to a conical bottom aimed at reproducing the azimuthal propagation of planetary waves. Infrequent switches between these two sates have been observed. We have reproduced similar experiments leading also to bistability, but remarkably no switches are observed in spite of intense fluctuations. A third regime has been also identified with a more complex step-like features in phase ropagation.
Preliminary comparisons with a numerical model will be discussed. This problem is quite difficult because of the long time scale involved and the importance of boundary layer detachment from the lateral walls, which seems to be involved in the switching mechanism.