

LABORATORY MODELING OF TOPOGRAPHIC ROSSBY NORMAL MODES

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Reflections of topographic Rossby waves at horizontal boundaries such as coasts and strong topographic gradients generate rotational normal modes. Their existence in world oceans was revealed only recently by in situ measurements (Miller et al., 1996) and their generating mechanisms and dynamical properties have been investigated in theoretical studies (Pierini, 1990, 1996, 1997, 1998). Such mesoscale motions can play an important role in coastal oceanography as they can contribute to horizontal mixing through chaotic advection. The physical modelling of topographic Rossby normal modes was carried out at the "Coriolis" Rotating Platform in Grenoble (Pierini et al., 1997, 1998, 1999a,b) with the support of the "Large-Scale Facilities-Training and Mobility of Researchers Programme" of the E.C.. The basic feature of the bottom topography (preliminary determined with the help of numerical simulations based on the shallow water equations) was a linear slope of 4.3x2 m delimited by two walls (Fig. 1). Since the studied motions are essentially barotropic, homogeneous water was used. The currents were measured by a series of 8 sonic currentmeters and through the Correlation Imaging Velocimetry (C.I.V.) method (Spedding and Rignot, 1993; Fincham and Spedding, 1997), which is a highly accurate technique relying on the cross correlation of local areas of image texture between two images taken a short time apart. This has permitted an extremely detailed synoptic map of the horizontal velocities in the area of the slope ($\sim 8 \text{ m}^2$) to be measured every 30 seconds (Fig. 2).

Unsheared currents were generated by a simple movement of a wavemaker located in front of the topographic barrier. The conservation of potential vorticity for the currents impinging on the channel slope produced Rossby waves: reflections at the lateral boundaries then led to the formation of propagating barotropic Rossby normal modes whose frequency and spatial structure were selected by the physical system. A variety of experiments were performed in order to provide a complete process study in which the effect of different channel lengths and rotation periods could be tested. Two different lengths of the linear slope, 4.3 and 3.3 m, and rotation periods ranging from 30 to 50 seconds were considered. In most cases the 1st Rossby mode was observed (e.g. Fig. 3a,b,c). Numerical simulations based on the shallow water equations (for a geometry and paddle movements that matched closely the experimental setup) provided dynamical fields to which the C.I.V. images could be compared (Fig. 3a',b',c').

The observed spatial structures were found to be in excellent agreement with the theoretical counterparts obtained from the mathematical model. The eigenperiods also agreed well, although the experimental values were systematically smaller than the theoretical ones by about 10%. This can be explained by the fact that the experimental normal mode experiences a small oscillation in its trajectory so that the effective length covered is a little larger than the theoretical one, with a consequent slight decrease of the eigenperiod. This in turn puts in evidence a dynamical mechanism responsible for fluctuations of Rossby modes that deserves to be investigated further.

CAPTIONS TO FIGURES

Figure 1. The experimental setup. The thick line A shows the position of the external boundary in a set of experiments.

The thin line B shows the region in which the C.I.V. technique was implemented.

Figure 2. Example of velocities measure by C.I.V.. The first Rossby normal mode is in its initial stage of formation (see Pierini et al., 1999a,b for details).

Figure 3. Example of velocities measure by C.I.V and computed by means of the numerical model. (a,b,c): velocities measured by C.I.V. and interpolated onto a regular (20 cm)x(20 cm) grid at times t=1,2,3 min respectively. (a',b',c'): velocities computed by the numerical model on a regular (20 cm)x(20 cm) grid at times t=1,2,3 min respectively (see Pierini et al., 1999a,b for details about this experiment).

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