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A consistent theory and laboratory experiments of topographic Rossby waves in a channel with linearly sloping bottom on the f-plane

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Topographic Rossby waves in a channel with linearly slopping bottom on the f–plane are investigated experimentally and theoretically by employing a barotropic linearized shallow water equation model that is solved numerically and analytically. The calculated dispersion relations are shown to be significantly smaller (by a factor of 2-5) than those of the (classical) harmonic theory and the gap increases with the channel width and with the bottom slope.

The numerical calculations were compared to experimental results obtained in the 13m diameter rotating table of LEGI-Coriolis (France). The linear slope in the experiments is 10% and the wave's period and wavenumber were measured using a Particle Imaging Velocimetry (PIV) system. The experimental results regarding the dispersion relation and the radial structure of the radial velocity were in excellent agreement with the (numerically derived) theoretical predictions. These results clearly showed that in wide channels the radial velocity is trapped near the shallow wall.

A new simple formula for the dispersion relation could be derived by approximating the velocity eigenfunctions by Airy function, which agrees with the numerical solution for a wide channels or a steeply sloping bottom. These solutions (that apply for infinitely wide channels as well) mandate that the waves occupy a small part of the channel located close to the shallow wall and vanish throughout most of the channel width, which is filtered out from the problem provided it is sufficiently large. Given the values of the channel slope and the radius of deformation the theory yields a threshold channel width above which the Airy-like theory prevails and below this threshold the harmonic theory provides a more accurate prediction.