Abstract View

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Multilayer Hydraulic Control with Application to the Alboran Sea Circulation

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ABSTRACT

The flow of a single layer of fluid along a channel of variable dimensions is hydraulically controlled when long gravity waves can no longer propagate upstream at the cross-section of minimum area. For a multilayer fluid, it is shown that a controlled situation exists when there is a separate geometrical extremum for each of the gravity wave modes. The structure of each control section must be different, reflecting the different vertical structures of the internal modes.

A channel with three layers of different density is studied in some detail as an analogue to the principal water masses in the Alboran Sea and Strait of Gibraltar. With the lowest layer at rest and the surface rigid, the control for the slowest second internal mode is primarily a width contraction while that for the first mode must also involve a reduction in bottom depth. The problem separates into control problems for each mode. That for the first mode is a classic lock exchange problem with just two layers (controlled at the Strait of Gibraltar) while that for the second mode reduces to that for a single layer (suggested to be controlled at Alboran Strait).

For the Alboran Sea rotational effects are important, particularly at the second-mode control point. With these included the principal qualitative features of the circulation are reproduced. Anticyclonic vorticity is produced in both the Atlantic Water and the Levantine Intermediate Water as both are vertically compressed upon entering the Western Alboran Sea through the two control points. The Deep Mediterranean Water is uplifted at the second-mode control point (Alboran Strait) and is banked against the southern wall thereafter as the intermediate water separates from the wall. A secondary circulation is forced in the upper layer which causes southward, cross-channel flow to the west of Alboran Island.

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