Abstract

Dense ocean water is primarily produced in marginal seas, such as the Mediterranean or the Nordic Seas. These areas are connected to the ocean via narrow straits located above or intersecting the continental slope. After passing the strait the dense water flows over the sloping topography, transporting the newly formed water towards the deep sea. These currents determine the distribution of salinity and temperature in the ocean interior and, hence, they play an important role in the global ocean circulation.

As the heavy water enters the continental slope it is steered to the right (in the northern hemisphere) by the Earth's rotation. Observations of such currents show that they are often wide compared to the internal Rossby radius, the natural length scale of these dense layers. Such flows are geostrophically balanced, i. e. the pressure gradient is balanced by the Coriolis force, to leading order and the flow is basically directed along the depth contours.

The geostrophically balanced flow is modified by bottom friction, entrainment and to some extent by inertial accelerations. Bottom friction makes the current descend downhill and lose potential energy. The nature of this downward motion is not obvious, and it has been treated with a variety of approaches in the literature. As the current flows along the continental slope it will also be affected by interfacial friction in that it entrains water from above and becomes diluted. This process is often associated with supercritical flow, i. e. flow in which the velocity exceeds the speed of long internal gravity waves.

The inertial forces promote the formation of anti-cyclonic eddies in the flow. It is shown how the flow may break up into a train of eddies. This occurs primarily if the slope is small, while a wide current flowing over a relatively steep topography is much less vulnerable.

Streamtube models are commonly used for simulating dense outflows on the continental slope. The limitations of this approach is explored in paper I, and it is demonstrated that a minimum requirement for these models to be valid is that the initial outflow is not too far from geostrophic balance.

In papers II and III the frictional adjustment of a geostrophic current is examined. In paper II focus is on the moving lateral boundaries and the downward migration. The upper edge adjusts to a state with level interface and only slow downward motion, while the lower moves downhill with a constant velocity, forming the tip of a widening sheet of fluid.

In paper III the converging Ekman transport in a topographic depression is explored. It is shown that a sufficiently deep and/or narrow canyon can 'channel' dense water downhill.

The transient behaviour of dense bottom currents are analysed and it is found that perturbations (small as well as finite) penetrate along depth contours with the characteristic speed found by Nof (1983) for the translation of eddies along a sloping bottom.

The obtained results are compared with data from the Mediterranean Outflow in paper IV. The observed splitting of this outflow is attributed to a combination of topographic irregularities and diverse entrainment rates.

Keywords: Dense outflows, Frictional transport, Geostrophic current, Topographic steering.

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