Sign in

AMERICAN METEOROLOGICAL SOCIETY
AMS Journals Online

AMS Home | Journals Home | Journal Archive | Subscribe | For Authors | Help | Advanced Search | Search | Go

Abstract View

Volume 27, Issue 2 (February 1997)

Journal of Physical Oceanography
Article: pp. 340–356 | Full Text | PDF (284K)

Adjustment of Stratified Flow over a Sloping Bottom*

David C. Chapman and Steven J. Lentz

Woods Hole Oceanographic Institution, Woods Hole, Massachusetts

(Manuscript received January 9, 1996, in final form August 5, 1996)

DOI: 10.1175/1520-0485(1997)027<0340:AOSFOA>2.0.CO;2

Options:
- Create Reference
- Email this Article
- Add to MyArchive
- Search AMS Glossary

Search CrossRef for:
- Articles Citing This Article

Search Google Scholar for:
- David C. Chapman
- Steven J. Lentz

ABSTRACT

The evolution of a steady stratified along-isobath current flowing cyclonically (shallower water on the right looking downstream) over a sloping frictional bottom is examined using an idealized model. The flow is assumed to consist of an inviscid vertically uniform geostrophic interior above a bottom boundary layer in which density is vertically well mixed. Within the bottom boundary layer, vertical shear in the horizontal velocities is assumed to result only from horizontal density gradients. Density advection is included in the model, but momentum advection is not. The downstream evolution of the current is described by two coupled nonlinear partial differential equations for surface pressure and boundary layer thickness, each of which is first order in the along-isobath coordinate and can be easily integrated numerically.

An initially narrow along-isobath current over a uniformly sloping bottom spreads and slows rapidly owing to the effects of bottom friction, much like the unstratified case. However, as the bottom boundary layer grows, the resulting horizontal density gradients reduce the bottom velocity, which in turn, decreases both the transport in the bottom boundary layer and the spreading of the current. An equilibrium is reached downstream in which the bottom velocity vanishes everywhere and the current stops spreading. This equilibrium flow persists indefinitely despite the presence of a frictional bottom. The width of the equilibrium current scales as $W \sim (f/N\alpha)(F_0/f)^{1/2}$, where f is the Coriolis parameter, N the buoyancy frequency, α the bottom slope, and F_0 the inflow volume flux per unit depth. The thickness of the bottom boundary layer scales as αW, while the along-isobath velocity scales as $(N\alpha/f)(F_0 f)^{1/2}$. Surprisingly, the downstream equilibrium flow is independent of the magnitude of bottom friction. Good approximations for the equilibrium scales are obtained analytically by imposing conservation of mass and buoyancy transports. Generalizations to variable bottom slope, nonuniform stratification, and coastal currents are also presented.

top

© 2008 American Meteorological Society Privacy Policy and Disclaimer
Headquarters: 45 Beacon Street Boston, MA 02108-3693
DC Office: 1120 G Street, NW, Suite 800 Washington DC, 20005-3826
amsinfo@ametsoc.org Phone: 617-227-2425 Fax: 617-742-8718
Allen Press, Inc. assists in the online publication of *AMS* journals.