Dense Water Flows - Effects of rotation

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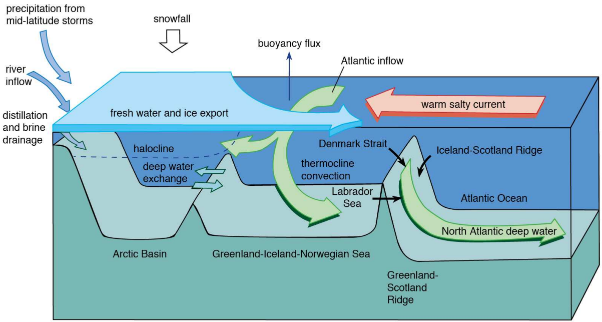
Interactions between watermasses in the Arctic



Small Scale Mixing Processes in the Ocean

From the home page of GFDL, Princeton, 2015

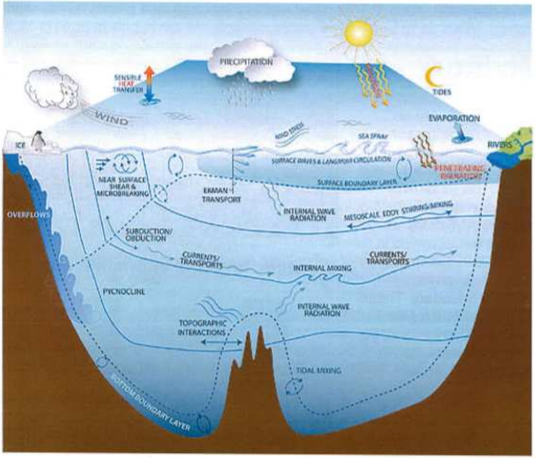


Figure 1. A schematic of the small scale mixing processes in the ocean

Gravity currents

- From the shelves into the deep ocean
- Between ocean basins
- Reservoir of potential energy
- To kinetic energy
- Steering and mixing due to topography
- Non-linear steepening - balanced by non-hydrostatic effects
- The role of secondary circulation
- Important to the overall global mixing
- How shall we parameterize mixing and steering due to unresolved processes in gravity flows?

Overflows in the Faroese Channels - Mauritzen et al. 2005)

884 C. Mauritzen et al. / Deep-Sea Research I 52 (2005) 883–913

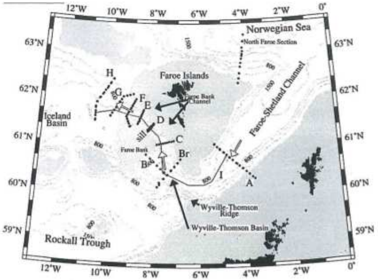


Fig. 1. Map of the Faroese Channels, with place names. Water depths less than 500 m are shaded. Isobaths shown: 650, 800, and every 500 m thereafter. The station locations are indicated with dots, and the various sections are indicated by letters. Also indicated is a crude schematic (open vectors) of the circulation in the region.

Overflows in the Faroese Channels - Borenäs and Lundberg 1988

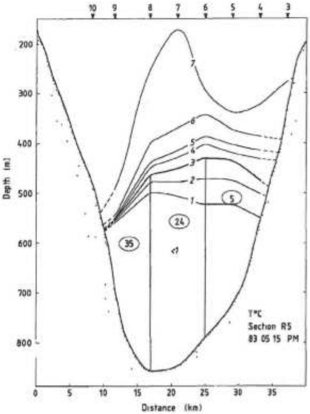


Fig. 4*a*. Thermal structure observed on section R5, May 15, 1983. Low-numbered stations are on the Faroe side of the channel and the dashed curves indicate extrapolation. Averaged downchannel velocities (centimeters per second) below the 3°C isotherm for stations R5-5, R5-7, and R5-9 are shown within ovals.

From Davies, Wåhlin, and Guo (2006)

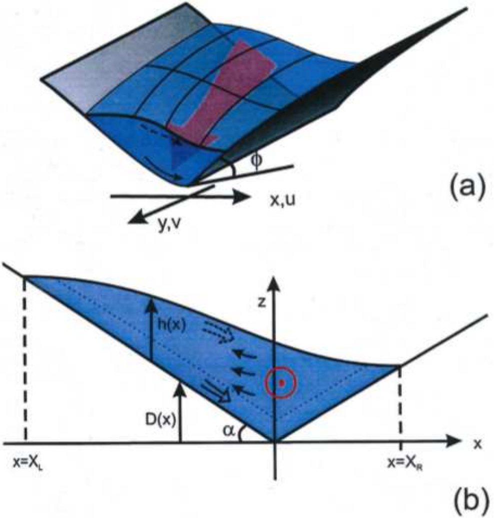
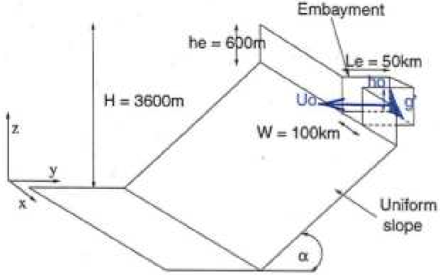


FIG. 9. Sketch of the dense current, showing the main along-channel flow (red), the bottom (solid arrow) and interfacial (dashed arrow) frictional transports, and the secondary return flow (small solid arrows). Also shown is the coordinate system and some of the notations used.

The Dynamics of Overflow Mixing and Entrainment (DOME) test case

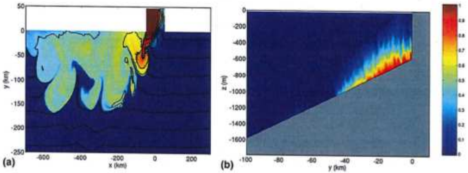
From Legg, Hallberg and Girton (2006)



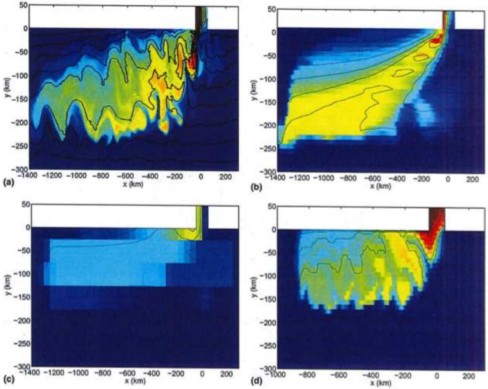
DOME results

MITgcm results DX = 500m, DZ = 30m

Tracer distribution after 13 days (Legg, Hallberg and Girton 2006)



MITgcm results a) DX = 2.5km, DZ = 60m, b) DX = 10km, DZ = 144m
c) DX = 50km, DZ =144m, d) HIM DZ =10km, 25 isopycnal layers



Importance of downslope Ekman drainage

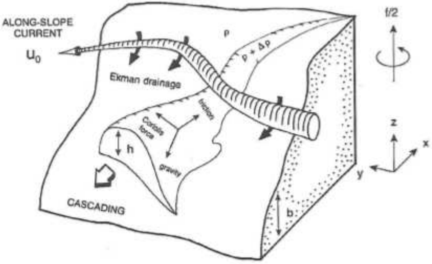
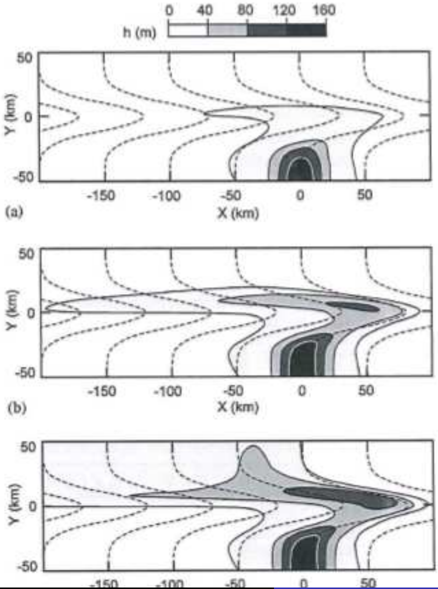


FIG. 1. Schematic of cascading and current-forced Ekman drainage on a continental slope.

Steering in Canyons - Wåhlin 2002

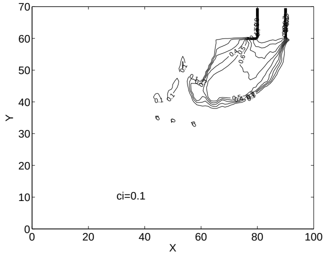
Ekman trannsports converge inside topographic depressions



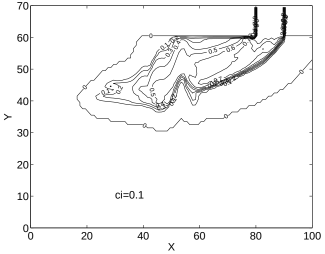
Dense water cascading on a steep slope

- Wobus, Shapiro, Maqueda, Huthnance 2011
- POLCOMS and laboratory experiments on rorating table
- Necessary conditions for correct representation of the descending plume:
- - No slip bottom boundary condition - Traditional square drag law fails
- - Increased resolution over the BBL
- Note: Non-hydrostatic model not necessary to capture main features
- The role of secondary circulation
- They point at the need for improved parameterizations

50 equidistant sigma-layers



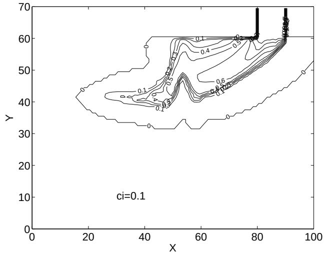
Results after 50 days - No-slip BC



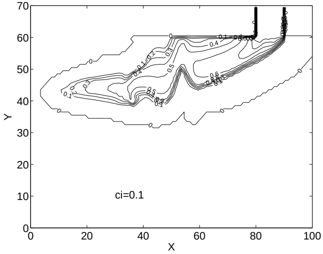
Results after 50 days - Usual drag law

DOME experiments BOM DX = 10 km - with wide canyon

340 sigma-layers - very fine over the BBL



Results after 50 days - No-slip BC

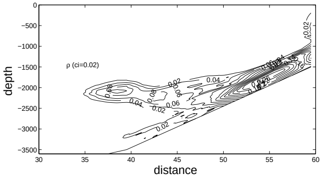


Results after 50 days - Usual drag law

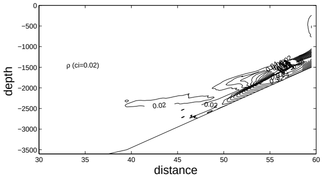
DOME experiments BOM DX = 10 km - with wide canyon

340 sigma-layers - very fine over the BBL

Results along mid-canyon of ρ'



Results after 50 days - No-slip BC



Results after 50 days - Usual drag law

The DOME experiments - reflections

- When will the plume be steered down the canyon?
- Focusing of dense water in the canyon
- Ekman drainage down slope weak
- Many parameters: The flux, the width and depth of the canyon
- Rossby number
- Ekman number

From Østerhus, Sherwin, Quadfasel, and Hansen (2008)

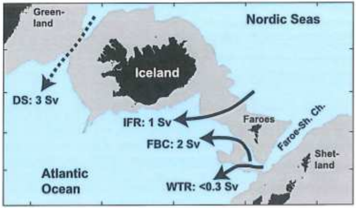


Fig. 18.1 The overflow of dense water between Greenland and Shetland consists of the Denmark Strait (DS) overflow (dashed arrow) and the three eastern overflows: the Iceland–Faroe Ridge (IFR), the Faroe Bank Channel (FBC), and Wyville Thomson Ridge (WTR) overflows. (Based on Hansen and Østerhus 2000)

Open questions

- The IF overflows - Pathways - Hansen and Østerhus
- Entrainment- detrainment downstream of the FBC
- Merging of the FBC and IF branches
- Ability of models to capture the water mass transformations

A range of model regimes

From Vidar Lien (2015)

Regime	Model application
Not plume permitting	Climate models
Plume permitting	Regional models
Plume resolving	High-res regional models
Secondary circulation permitting	Ultra-high res models
Secondary circulation resolving	Idealized models

- We need to ensure that the water mass transformations across are 'correct'