Density Driven Circulation under Antarctic Ice Shelves: An investigation using laboratory experiments

Alon Stern – Courant Institute of Mathematical Science - October, 2013
Collaborators: David Holland, Paul Holland, Adrian Jenkins, Joel Sommaria
Outline:

- Motivation and physical setup
- Experimental setup
- Results
- Concluding remarks
Motivation:
The “Ice Pump”

Figure 1: Schematic diagram of processes beneath an idealised ice shelf.

Holland and Feltham (2006)
Experimental setup

- Laser Induced Fluorescence
- Particle Image Velocimetry
- Rotating table at Coriolis Lab
Typical Density Field

- Box 1
- Ice Shelf Front
- Concentration at horizontal cut
- Box 2
- Beginning of Cavity Slope

Concentration field
Depth integrated vorticity
Time mean meridional Velocity Field
Time mean density field
Dense and Fresh Plumes

[Graph showing the distribution of plumes with color coding and labels for Ice Shelf and Sea Floor]
Shelf geometries and buoyancy fluxes
Time mean meridional volume flux for different geometries
Dense plumes for different geometries
Schematic summarizing the results

- The Little Gap
- The Pinch
- The Fresh Run
- Control Run
- The Big Gap
- The Stretch
- The Dense Run
Conclusions

- A density driven current under an “ice shelf” has been successfully reproduced in a laboratory setting.
- Results confirm the dynamic significance of the ice shelf front as a dynamical barrier.
- Strong boundary currents which run along the sides of the domain are responsible for a large percent of the flow into the ice shelf cavity.
- The strength of the dynamical barrier is sensitive to the ice shelf geometry and the flux of dense and fresh water.
- Recent advancements in quantitative velocity and density measurement techniques mean that laboratory experiments could be a useful way to learn about ice shelf cavity circulation.
Particle Image Velocimetry

Image at time $t$

Image at time $t + dt$
Particle Image Velocimetry

Integration box at time = t

Image at time = t + dt
Particle Image Velocimetry

Integration box at time = t

Image at time = t + dt
Particle Image Velocimetry

Integration box at time = t

Image at time = t + dt
Integration box at time=$t$

Image at time=$t+\Delta t$
Particle Image Velocimetry

Integration box at time=$t$

Image at time=$t+dt$
Particle Image Velocimetry
An idealized ice shelf