Laboratory simulations of dense flows downslope in the region of an ice front

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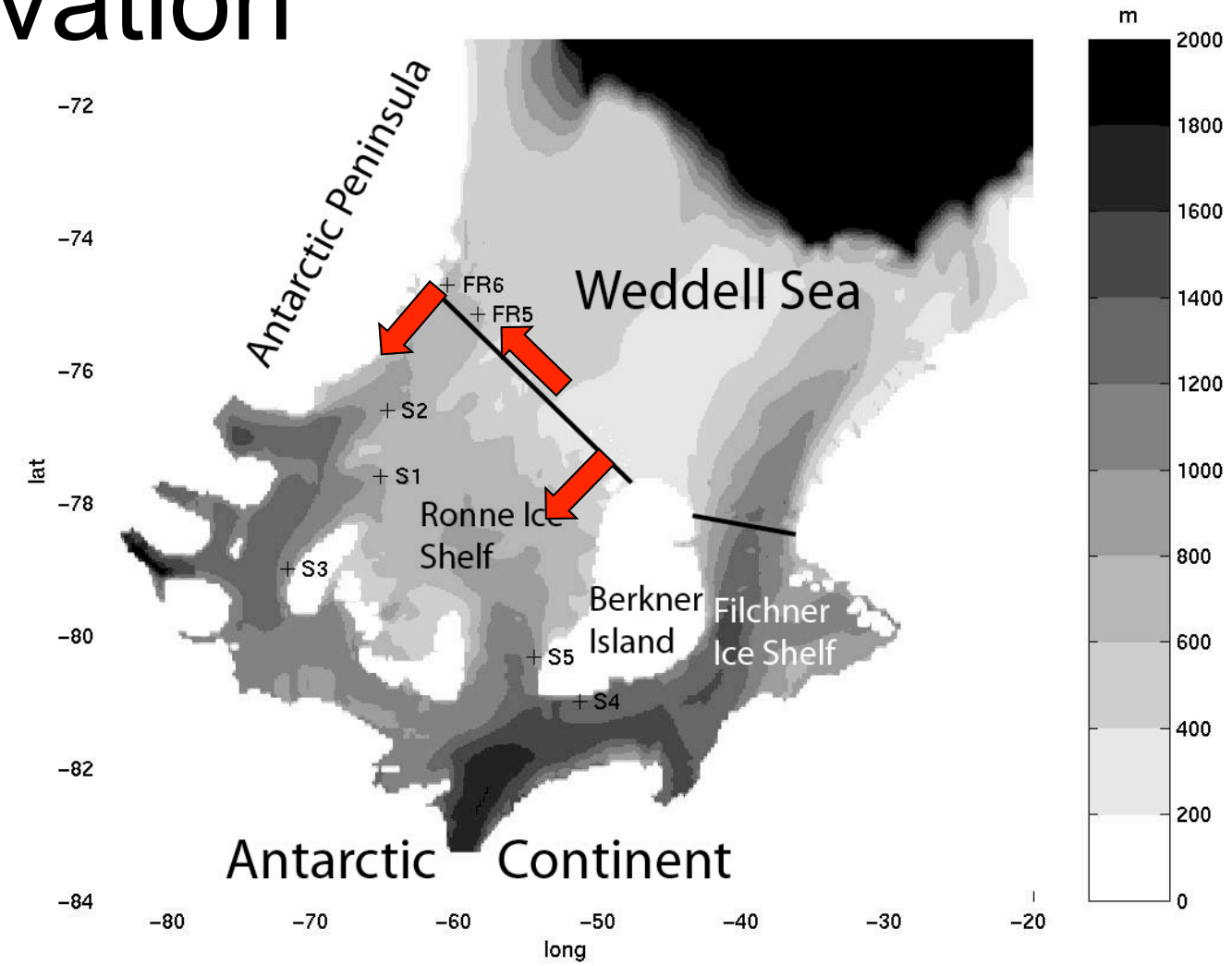
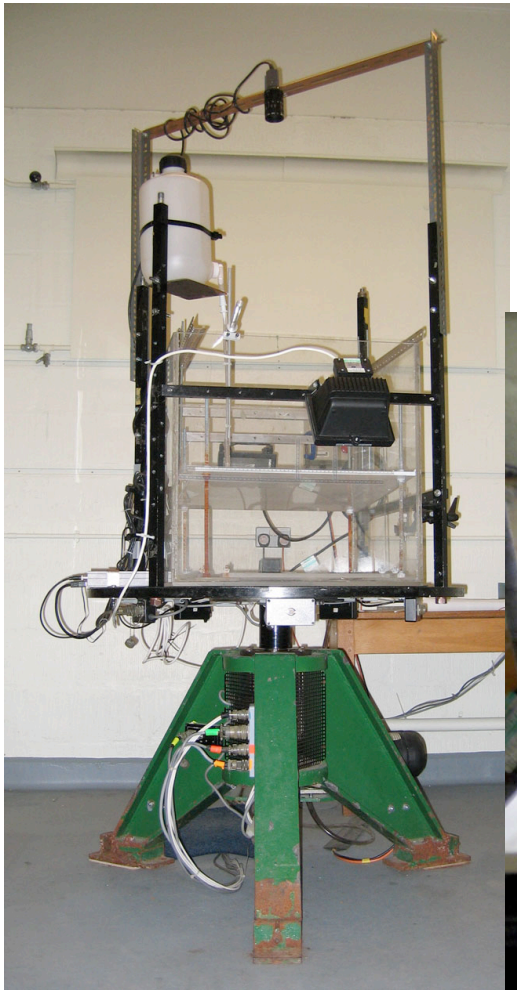
Motivation

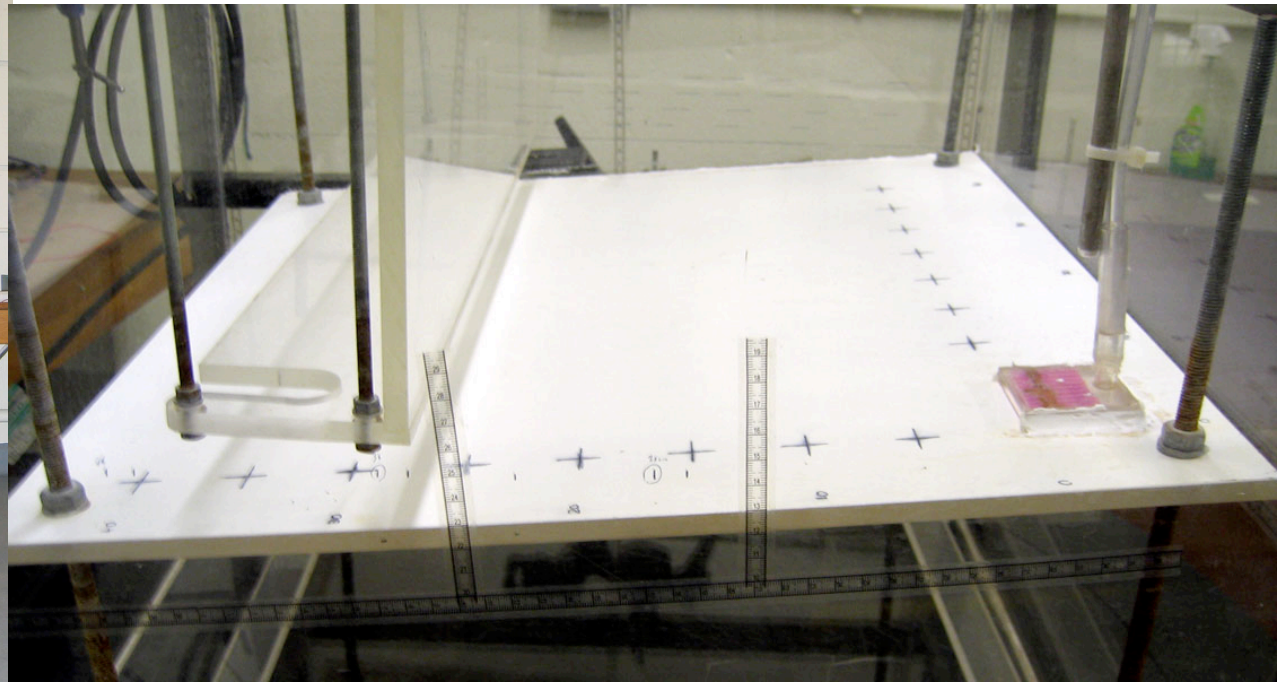

Antarctic Peninsula
Weddell Sea
FR6
FR5
S2
S1
S3
S5
S4
Ronne Ice Shelf
Berkner Island
Filchner Ice Shelf
Antarctic Continent
lat
long
m
2000
1800
1600
1400
1200
1000
800
600
400
200
0
−72
−74
−76
−78
−80
−82
−84
−80
−70
−60
−50
−40
−30
−20

Equipment

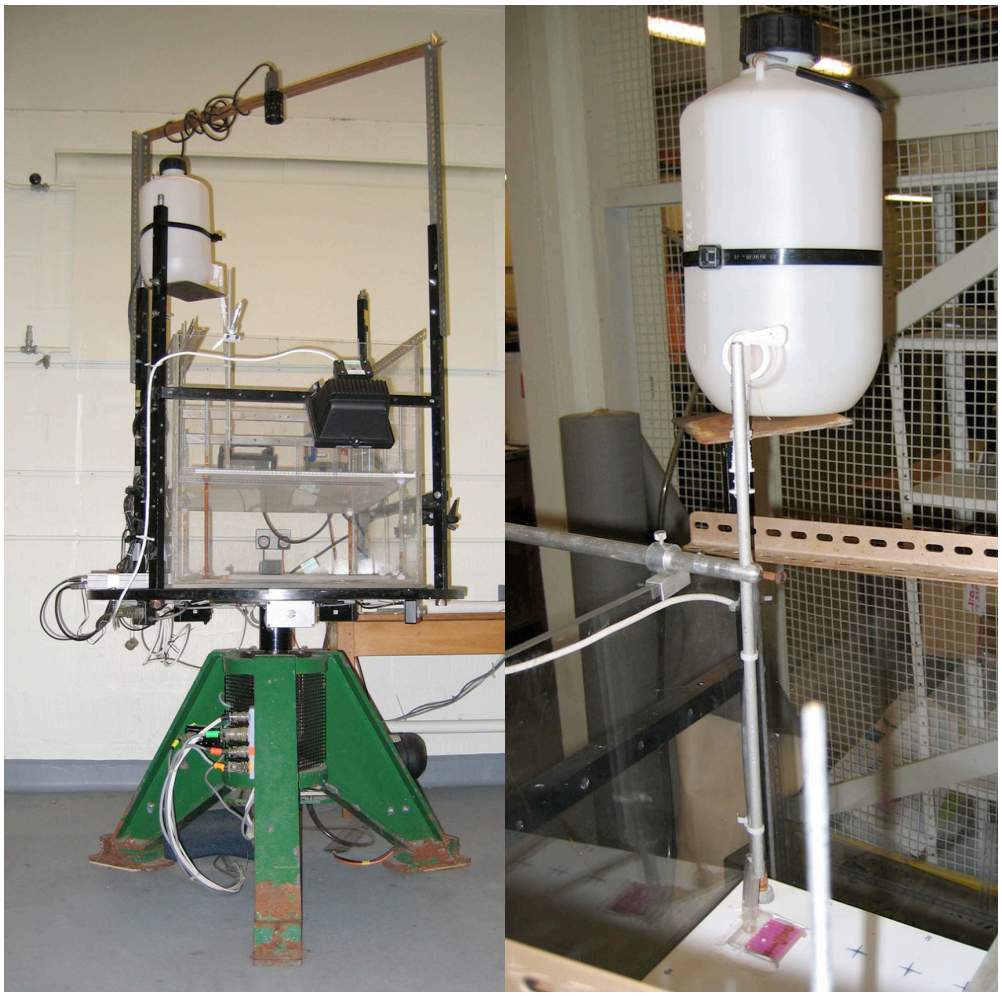


Slope fixed at 1 in 10

Shelf position and height adjustable



Equipment

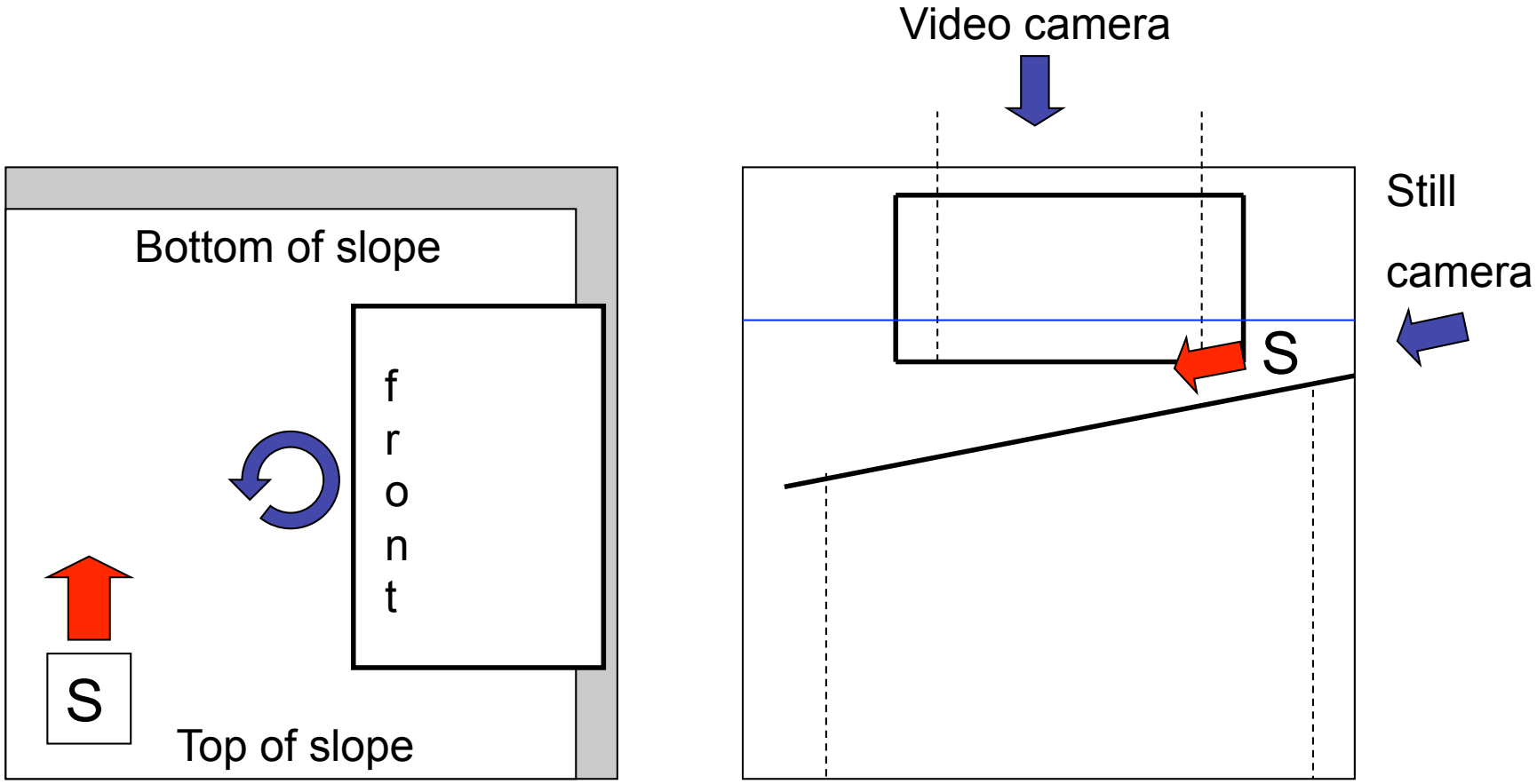


Gravity fed source

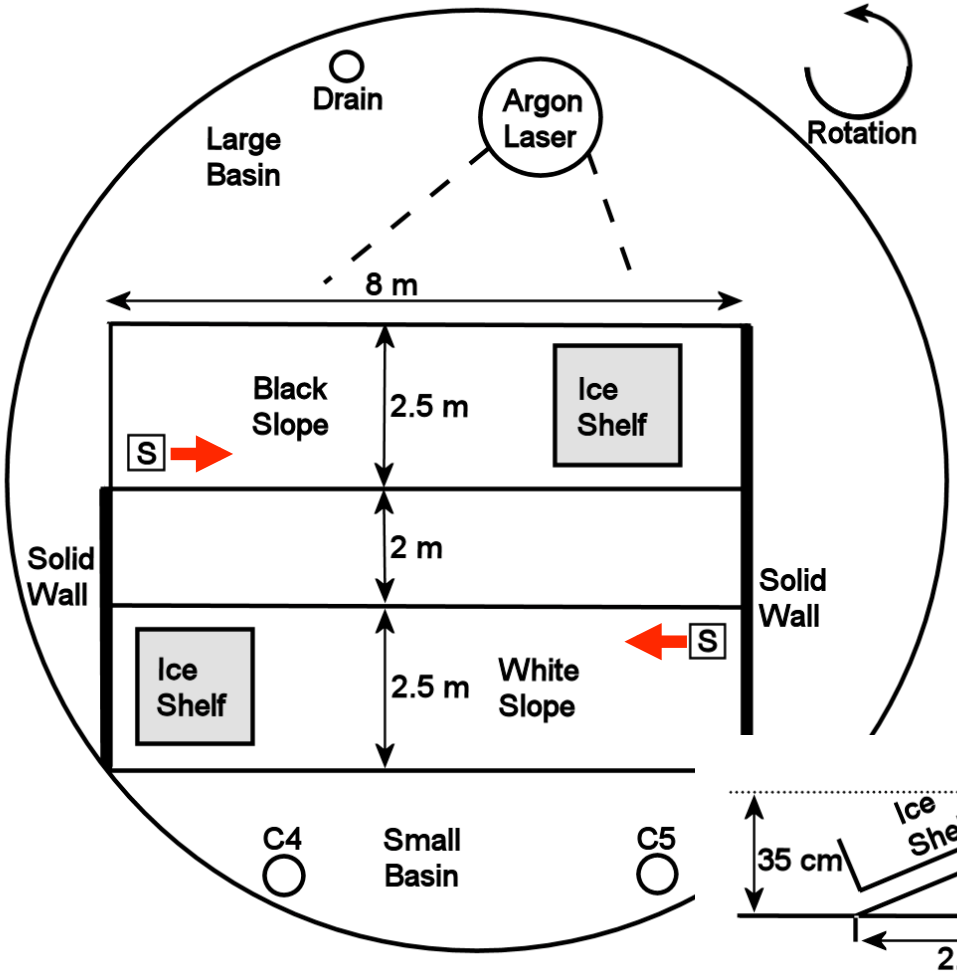
Flow rates of 5-7 $cm^3\ s^{-1}$

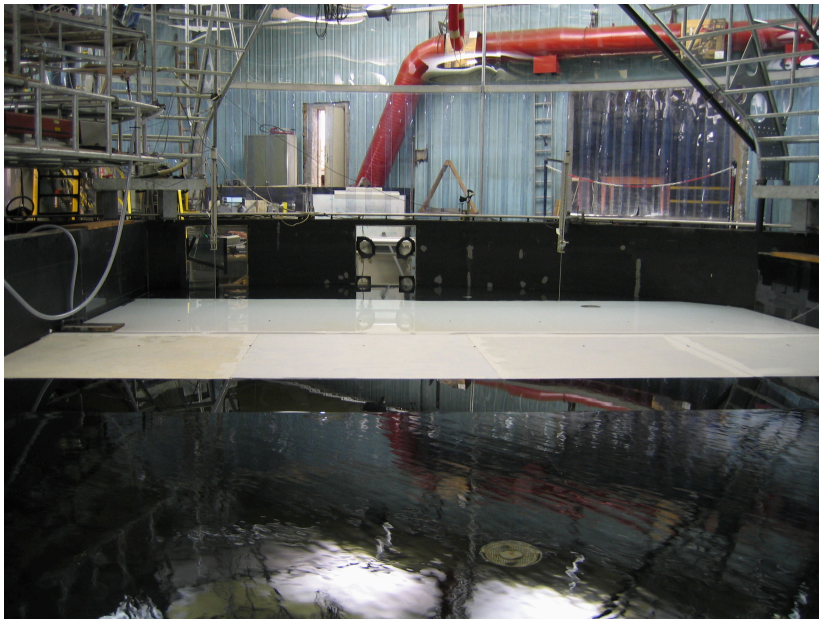
Nozzle is a 5 mm high plate with a honeycomb to reduce turbulence

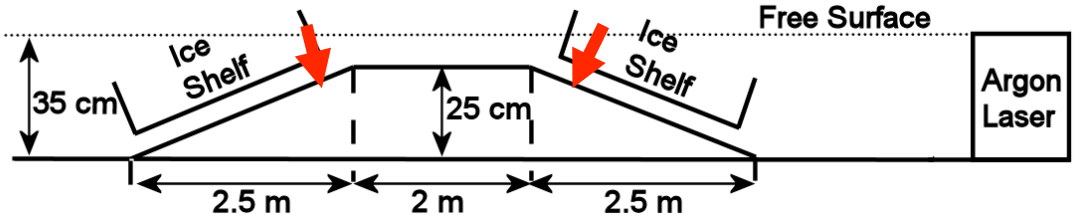
Small scale configuration



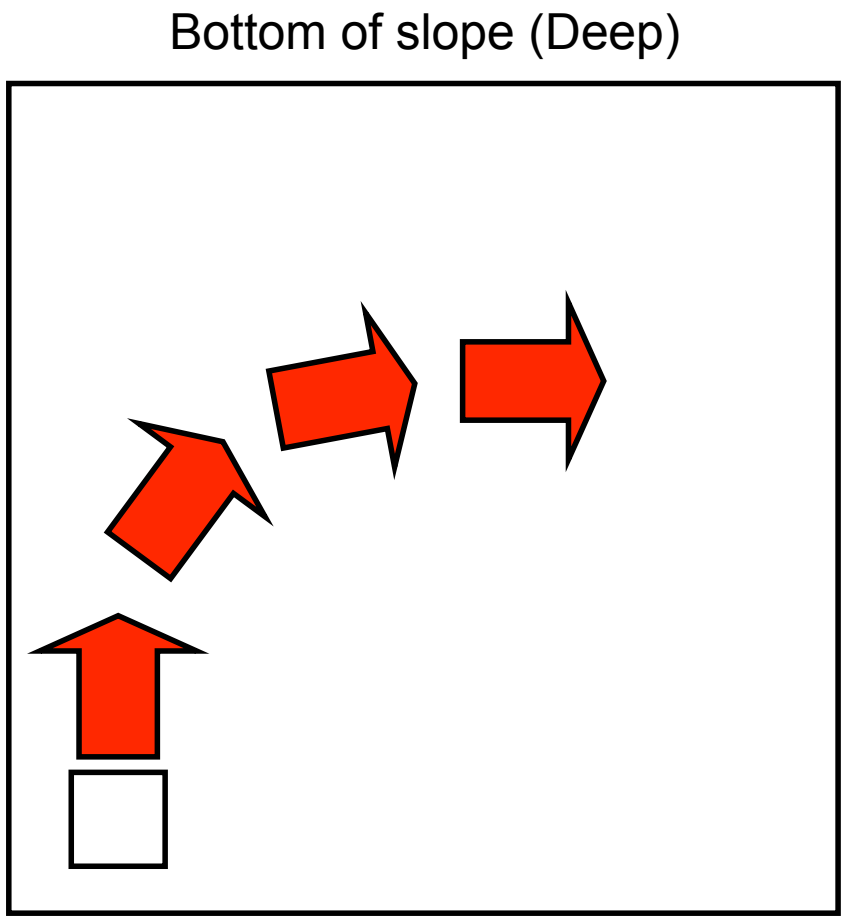
Large scale configuration







Simple plume 1

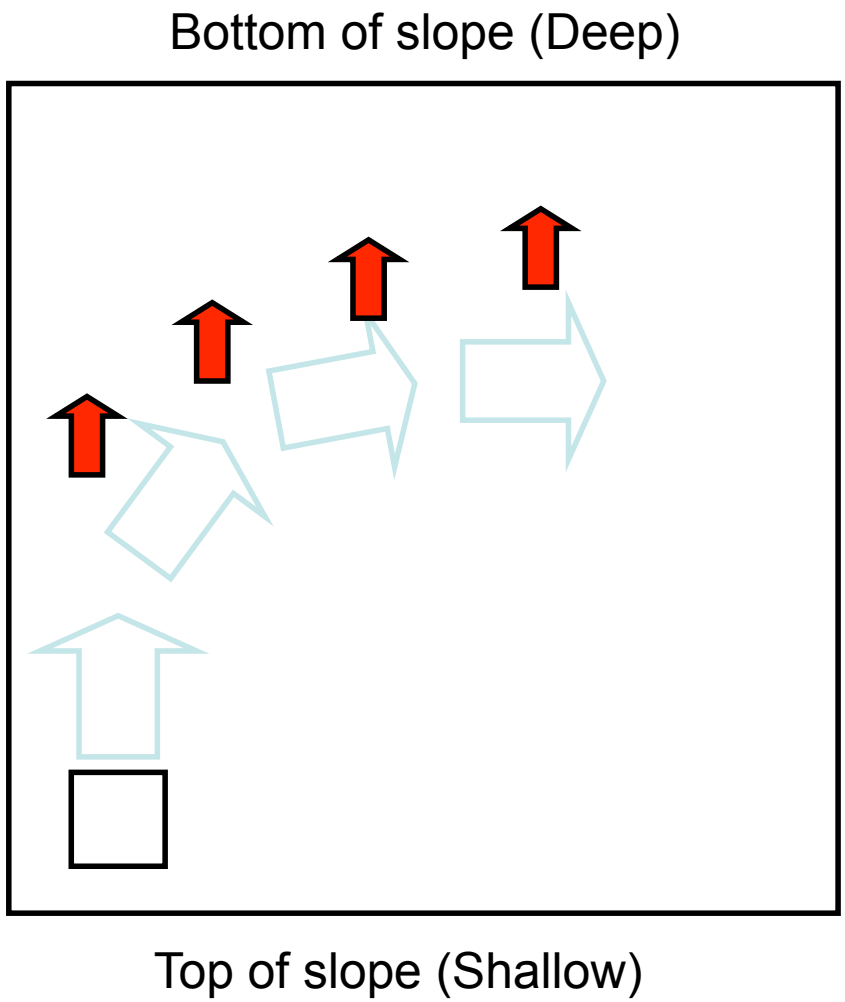


1) Adjustment to geostrophic balance

Over the a length scale of the Rossby radius of deformation

Rotation direction

Simple plume 2

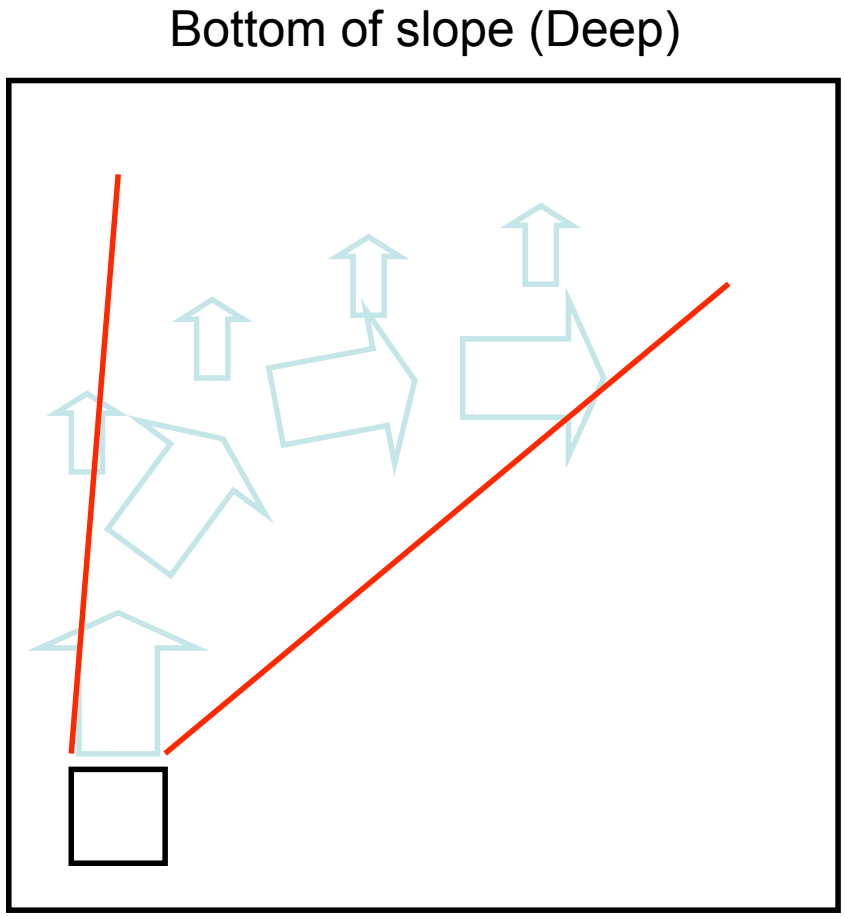


2) Ekman drainage

Causes flow of dense fluid down slope out of geostrophic balance

Rotation direction

Simple plume 3

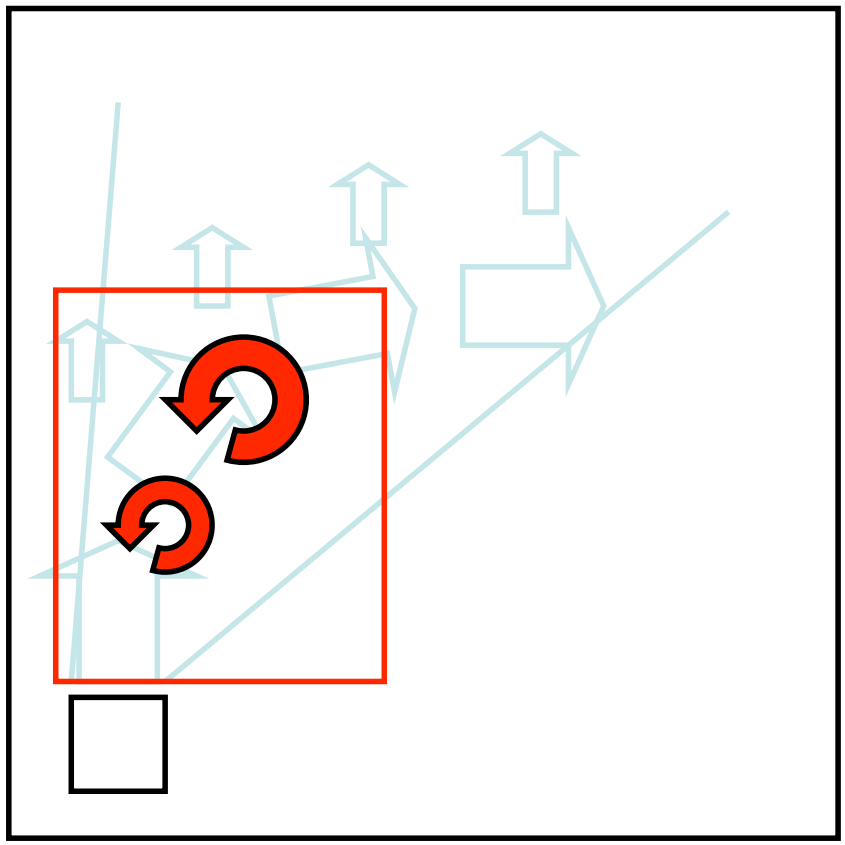


2) Ekman drainage

Causes flow of dense fluid down slope out of geostrophic balance

Rotation direction

Simple plume 4



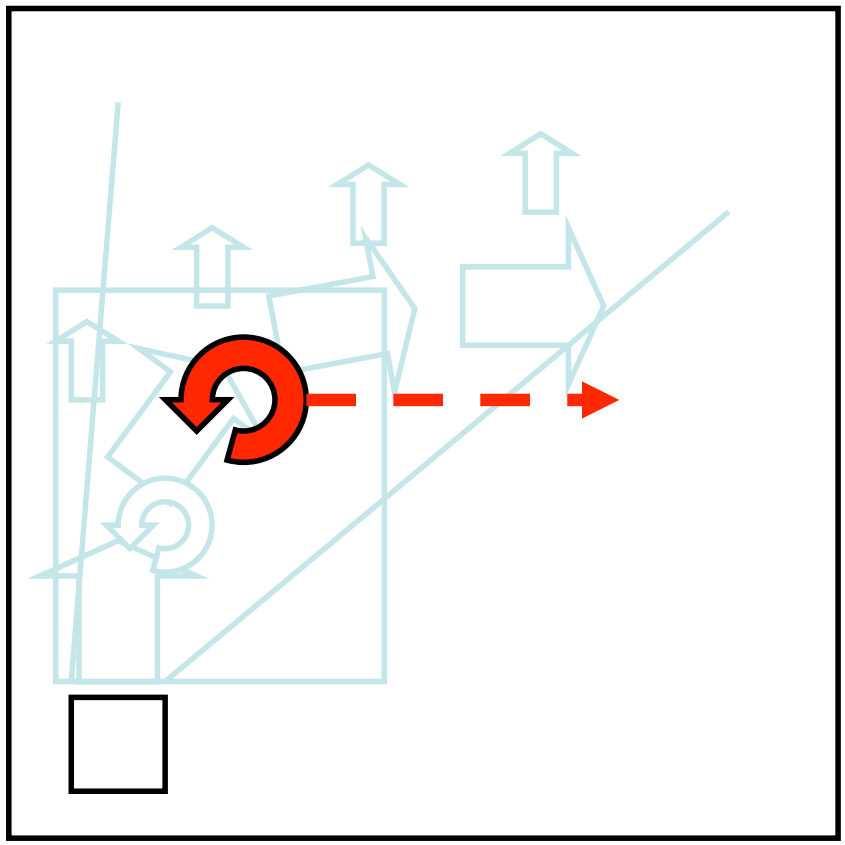
3) Capture

4) Propagation downslope

5) Vortex stretching induces cyclonic vorticity

Rotation direction

Simple plume 5



3) Capture

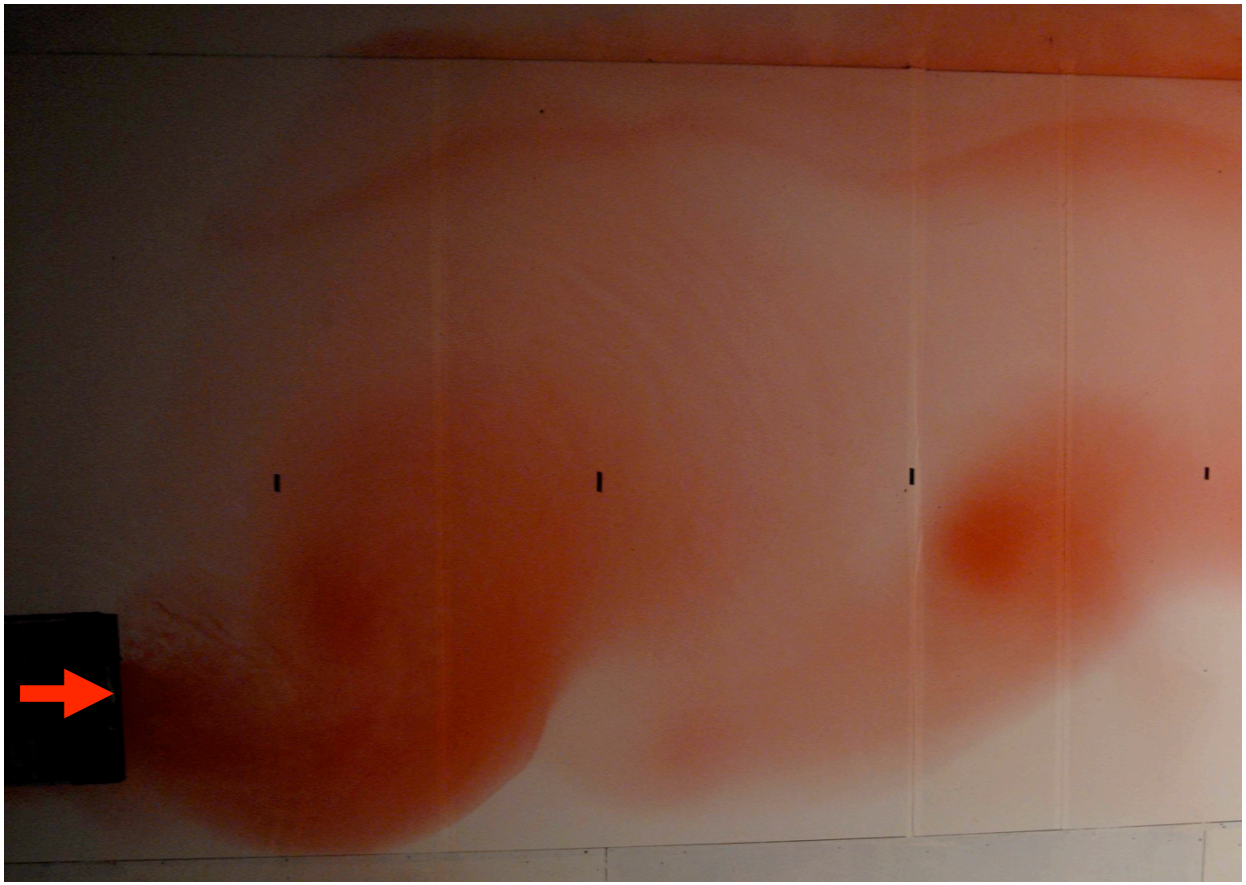
4) Propagation downslope

5) Vortex stretching induces cyclonic vorticity

6) Eddy moves along the slope

Rotation direction

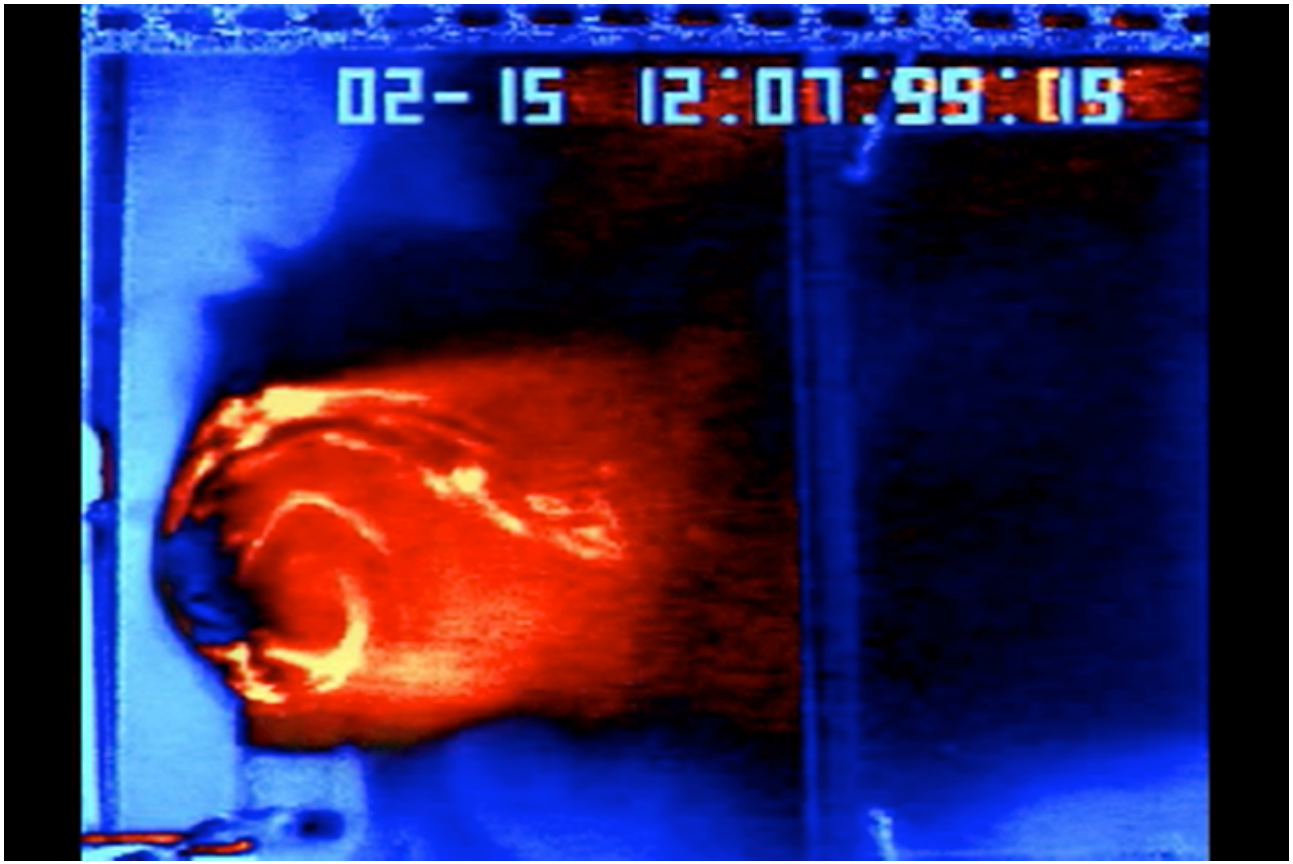
Example eddies



Bottom of slope

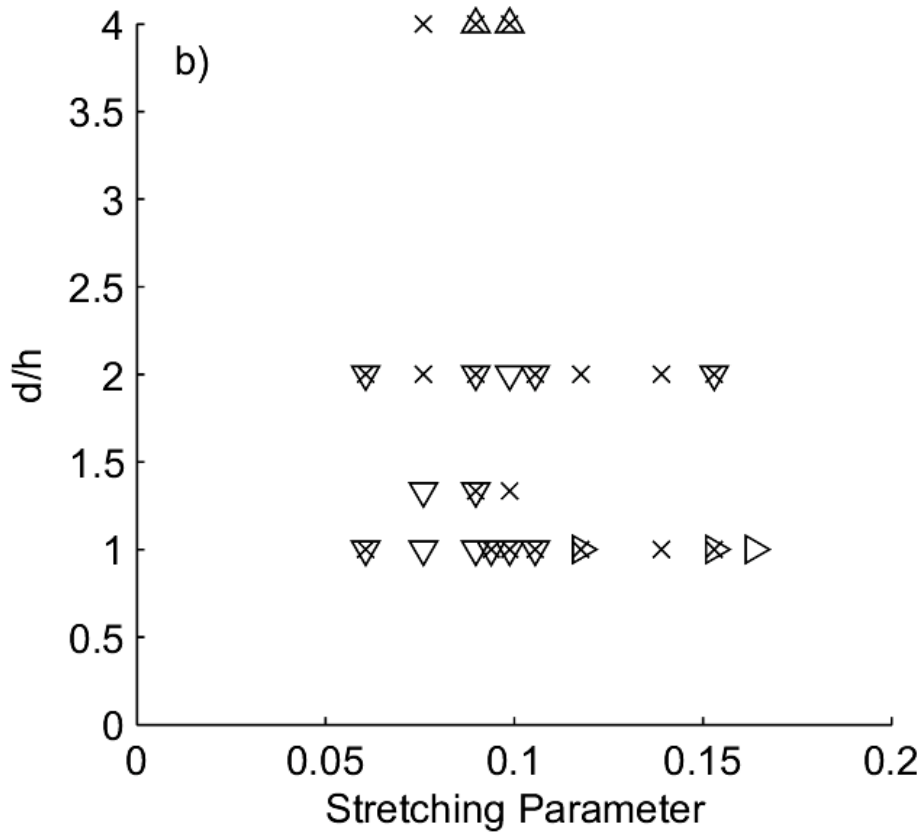
Top of slope

Small scale experiment



- Bottom of slope
- Rotation is anticlockwise
- Frame every 10 seconds
- Top of slope

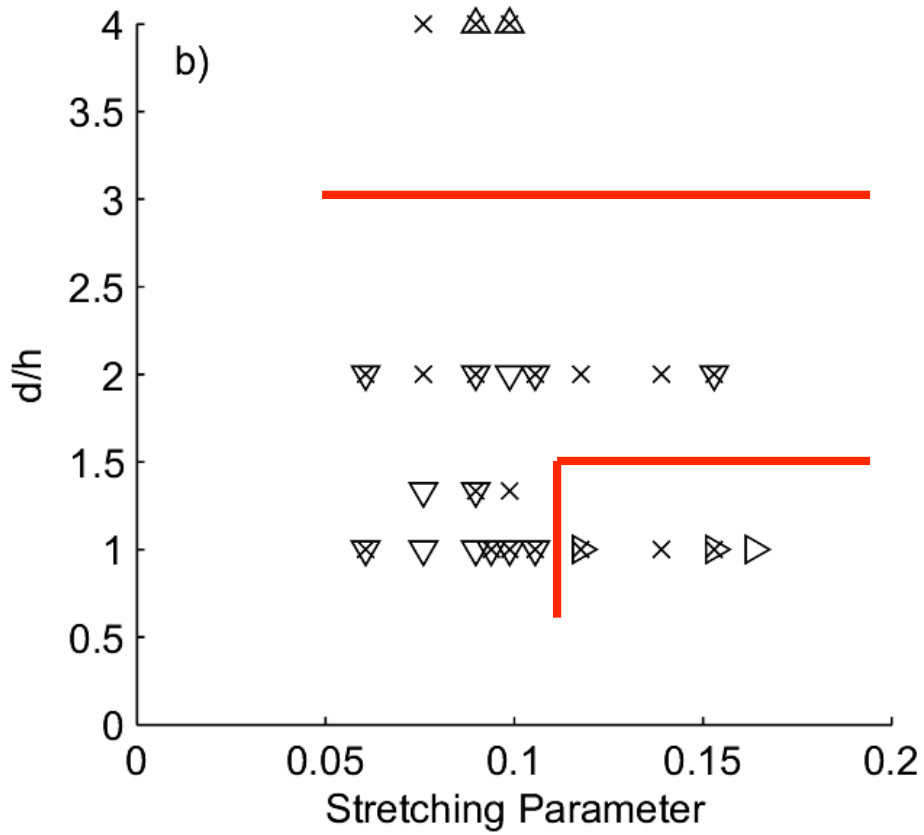
Small scale results



Key
Triangle(down) - Propagates downslope
Triangle(right) - Enters Cavity
Triangle(up) - Propagates upslope
X-Mark - Breaks up
Star - Splits
Circle - Stops

$$Stretching = L\alpha / D$$

Small scale results



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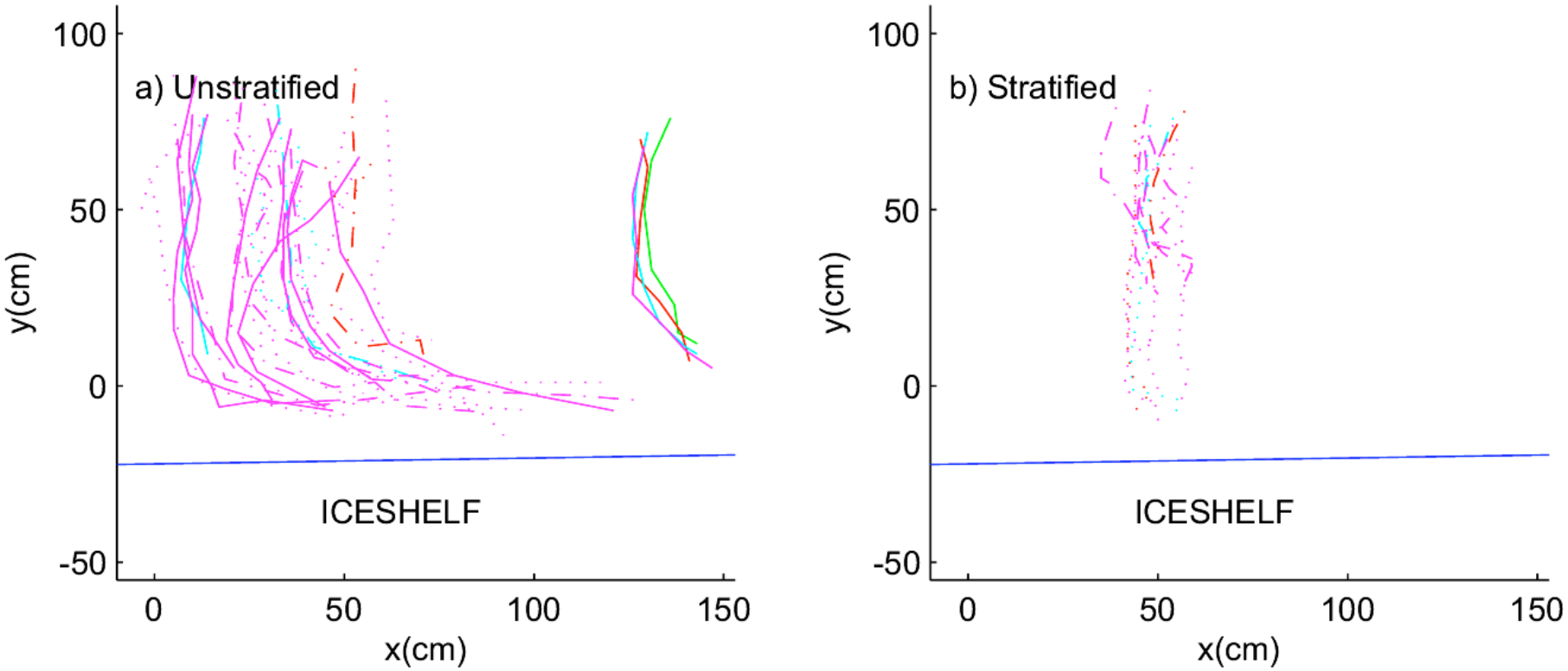
Large scale results



MANCHESTER 1824

The University of Manchester

Experimental Summary

- Focused on the behaviour of eddies
- Only a relatively small barrier required to alter the eddy propagation
- Increasing strength of eddies counteracts this
- If the eddies are affected by the ice shelf
  - Propagate up or down slope in small scale experiments
  - Propagate downslope in the large scale experiments
- Stratification may reduce the impact of the ice shelf

Oceanographic context

- Unstratified ambient fluid
  - Ice shelf front represents a significant topographic barrier to the eddies
  - Eddies unlikely to enter the ice shelf cavity
- Stratified ambient fluid
  - Topographic effect of the ice shelf reduced
  - Eddies likely to enter the cavity if stratification permits
- This means there will be a seasonal difference of the inflows into the Ronne Ice Shelf cavity

Acknowledgements

I have received assistance in various forms from the following:

- University of Manchester, MACE Department
- Coriolis Laboratory, Grenoble
- European Hydrolab III funding
- British Antarctic Survey
- AutoSub Under Ice project