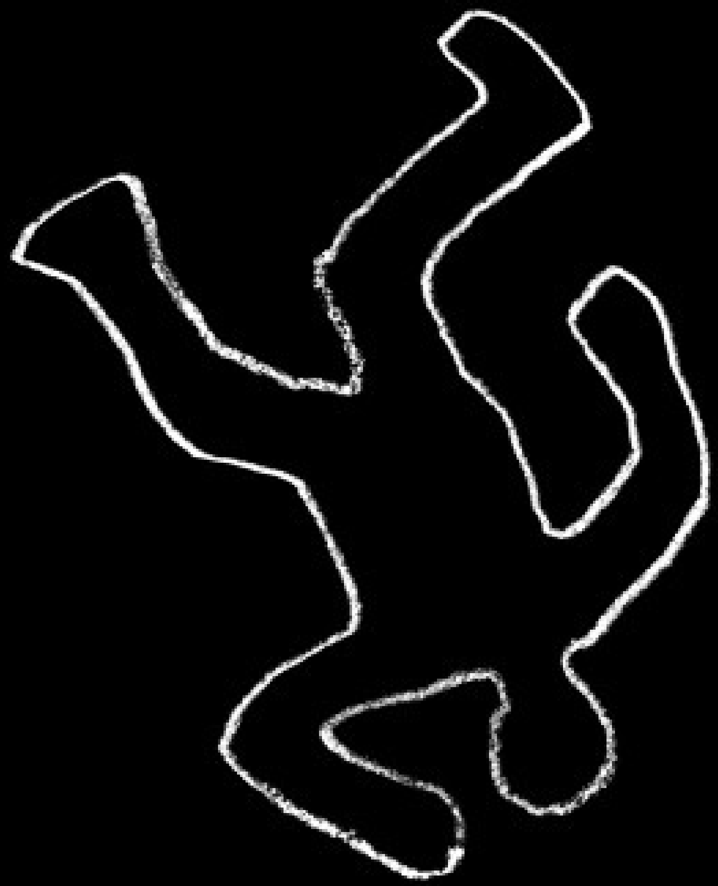
Density Driven Circulation under Antarctic Ice Shelves: An investigation using laboratory experiments

Alon Stern – Courant Institute of Mathematical Science - October, 2013

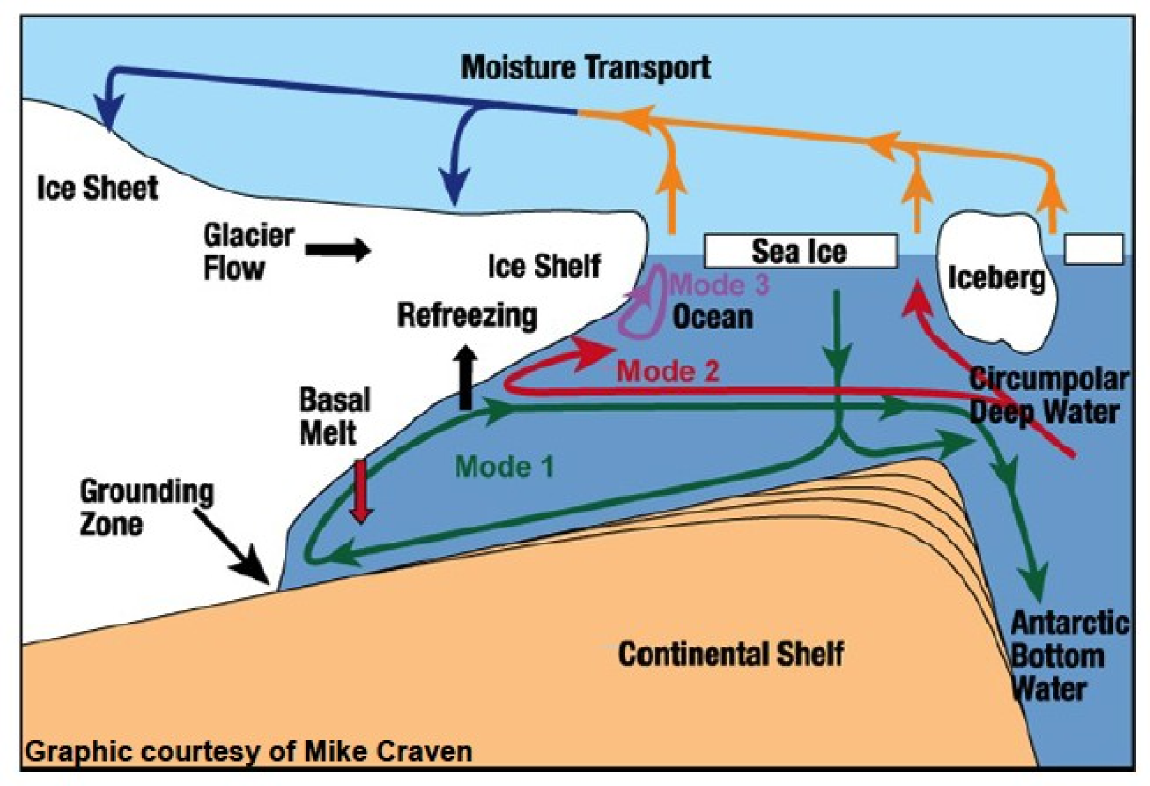
Collaborators: David Holland, Paul Holland, Adrian Jenkins, Joel Sommaria

Outline:

- Motivation and physical setup
- Experimental setup
- Results
- Concluding remarks



Motivation:



Moisture Transport
Ice Sheet
Glacier Flow
Ice Shelf
Sea Ice
Iceberg
Mode 3
Ocean
Refreezing
Mode 2
Circumpolar Deep Water
Basal Melt
Mode 1
Grounding Zone
Antarctic Bottom Water
Continental Shelf
Graphic courtesy of Mike Craven

The "Ice Pump"

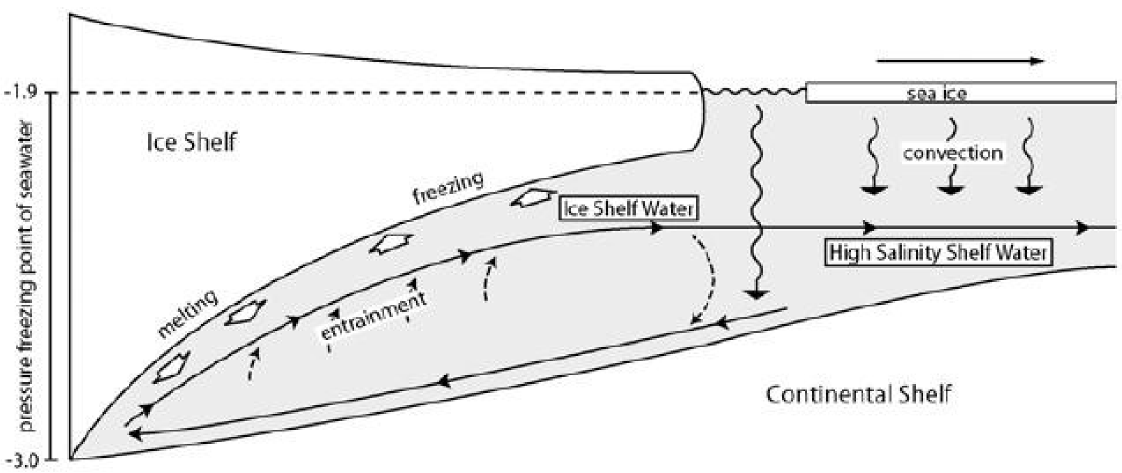
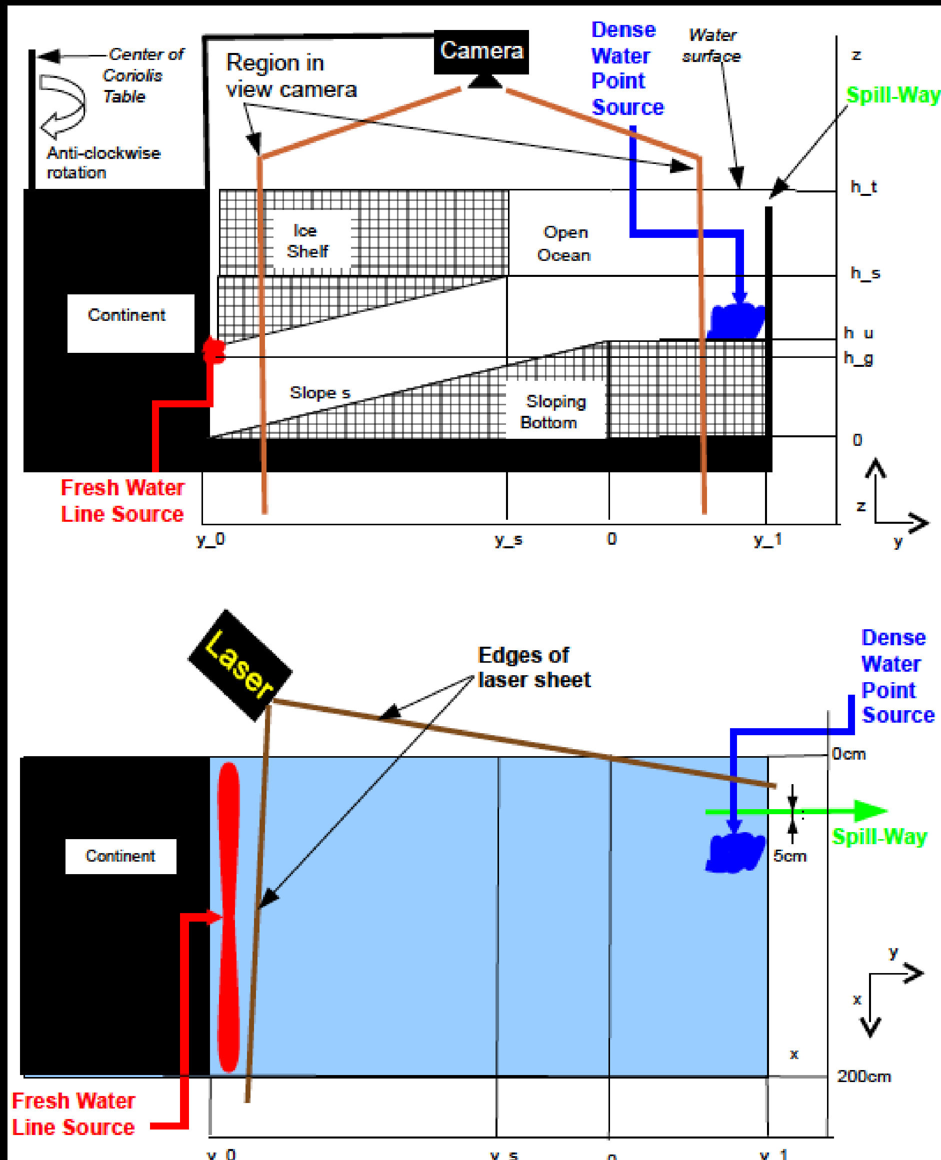


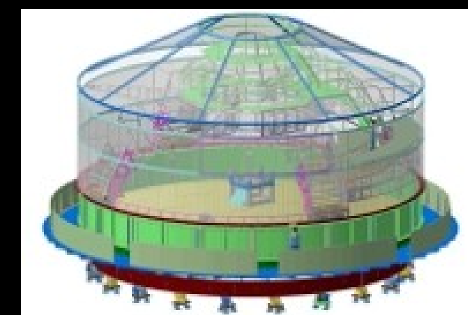
Figure 1: Schematic diagram of processes beneath an idealised ice shelf.

Holland and Feltham (2006)

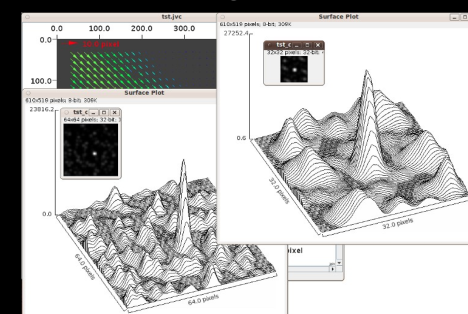
Experimental setup



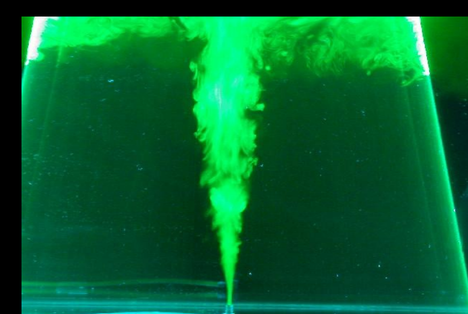
Rotating table at Coriolis Lab



Particle Image Velocimetry

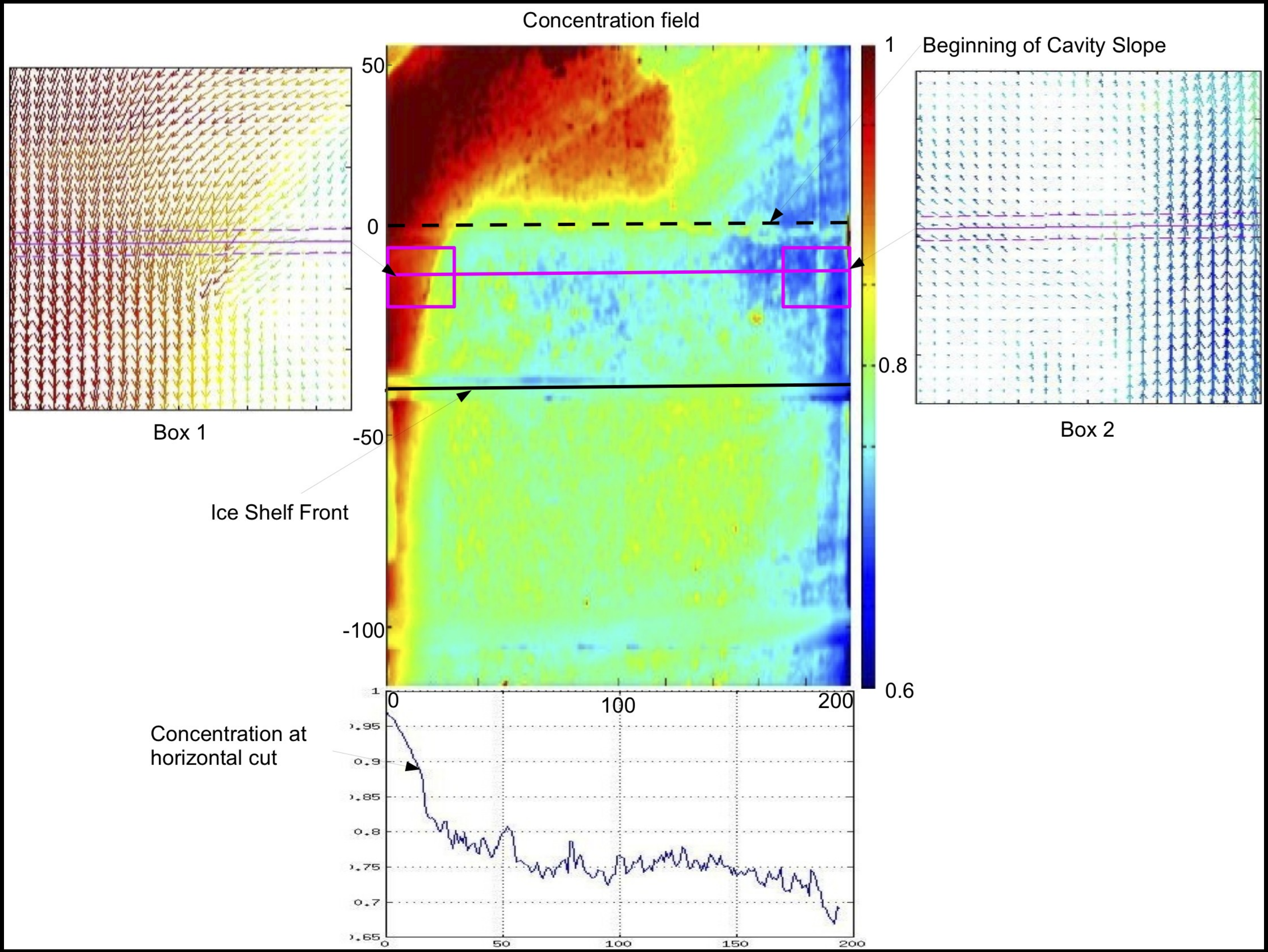


Laser Induced Florescence



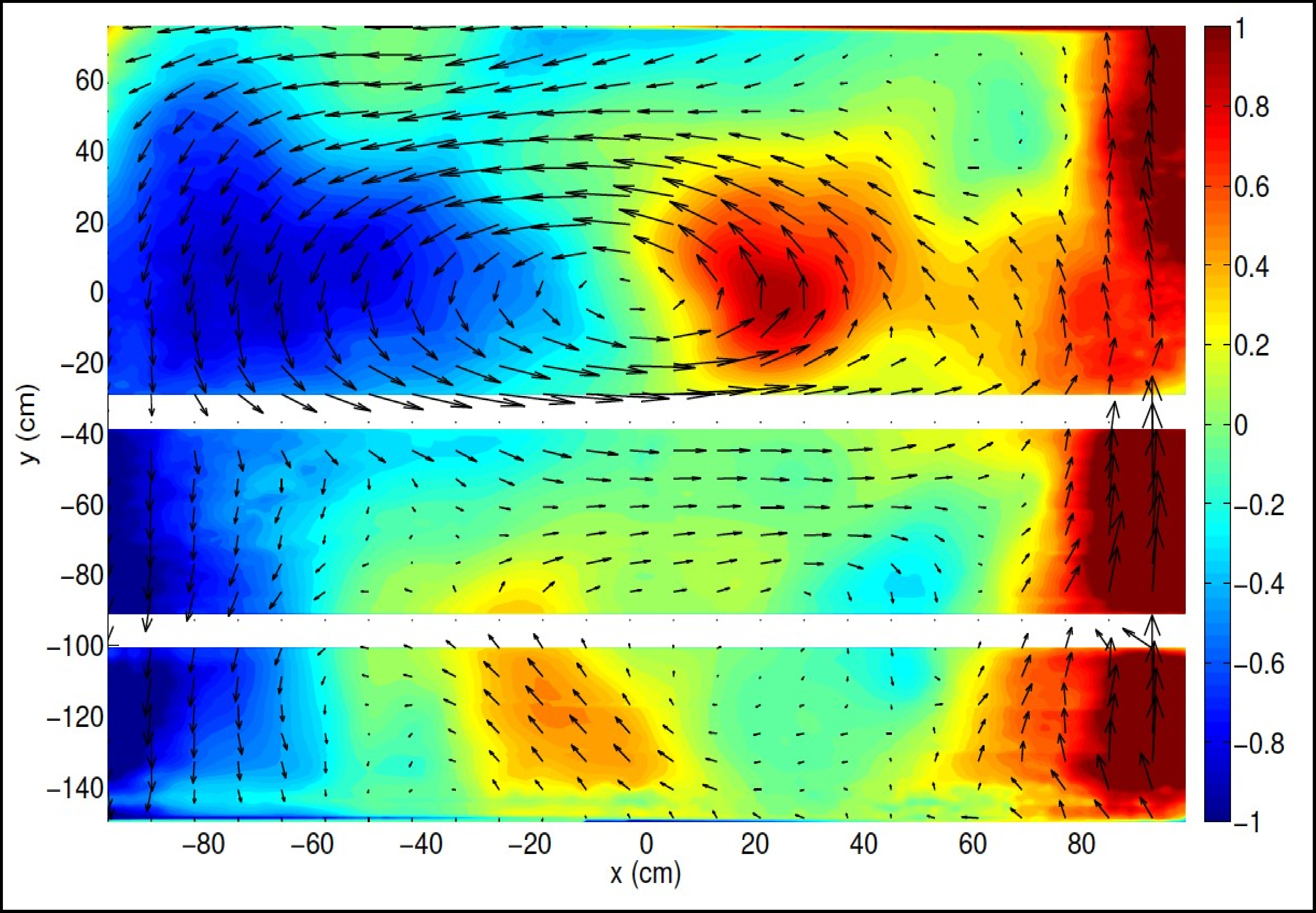
Results

Typical Density Field

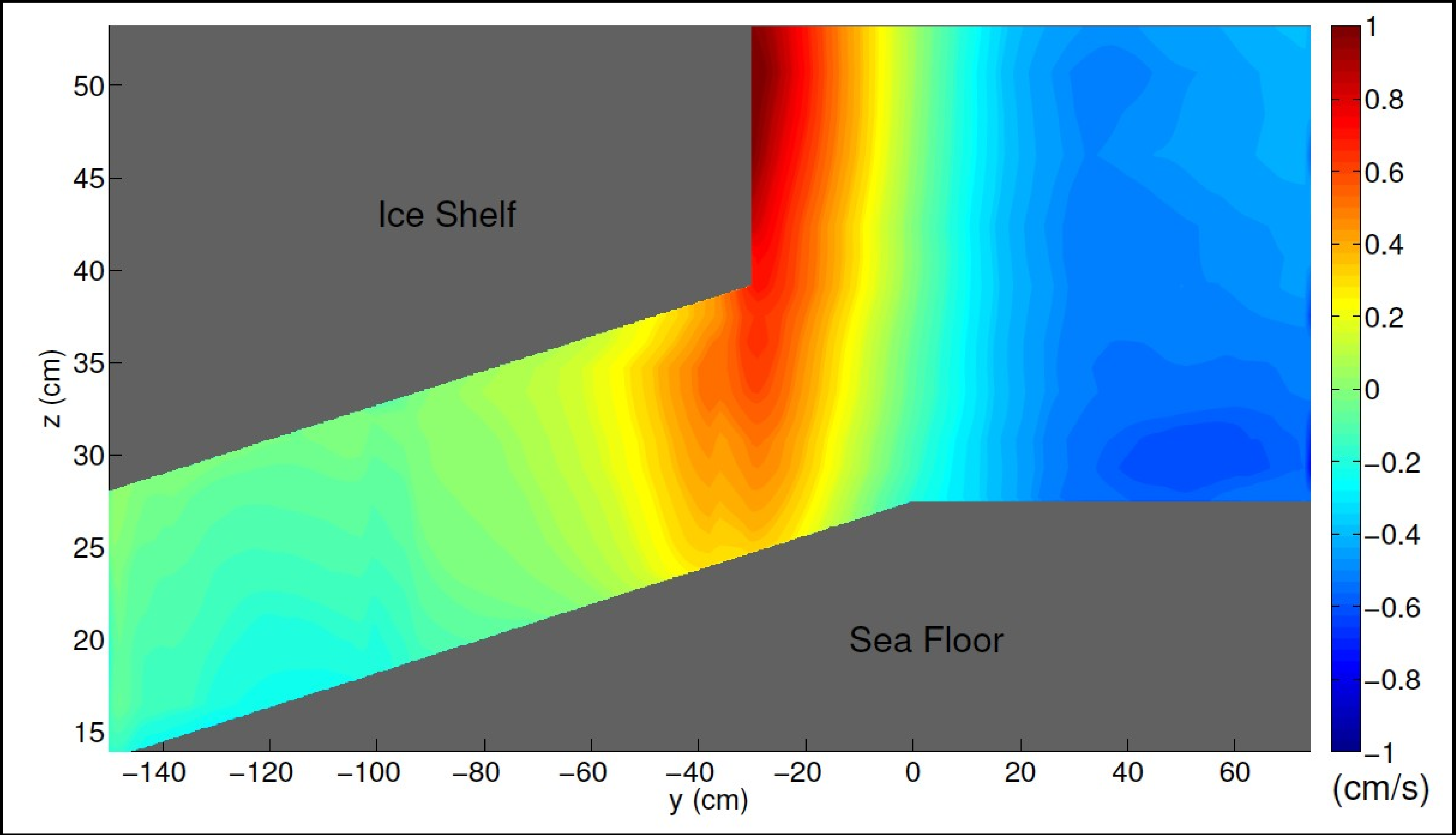


Depth integrated vorticity

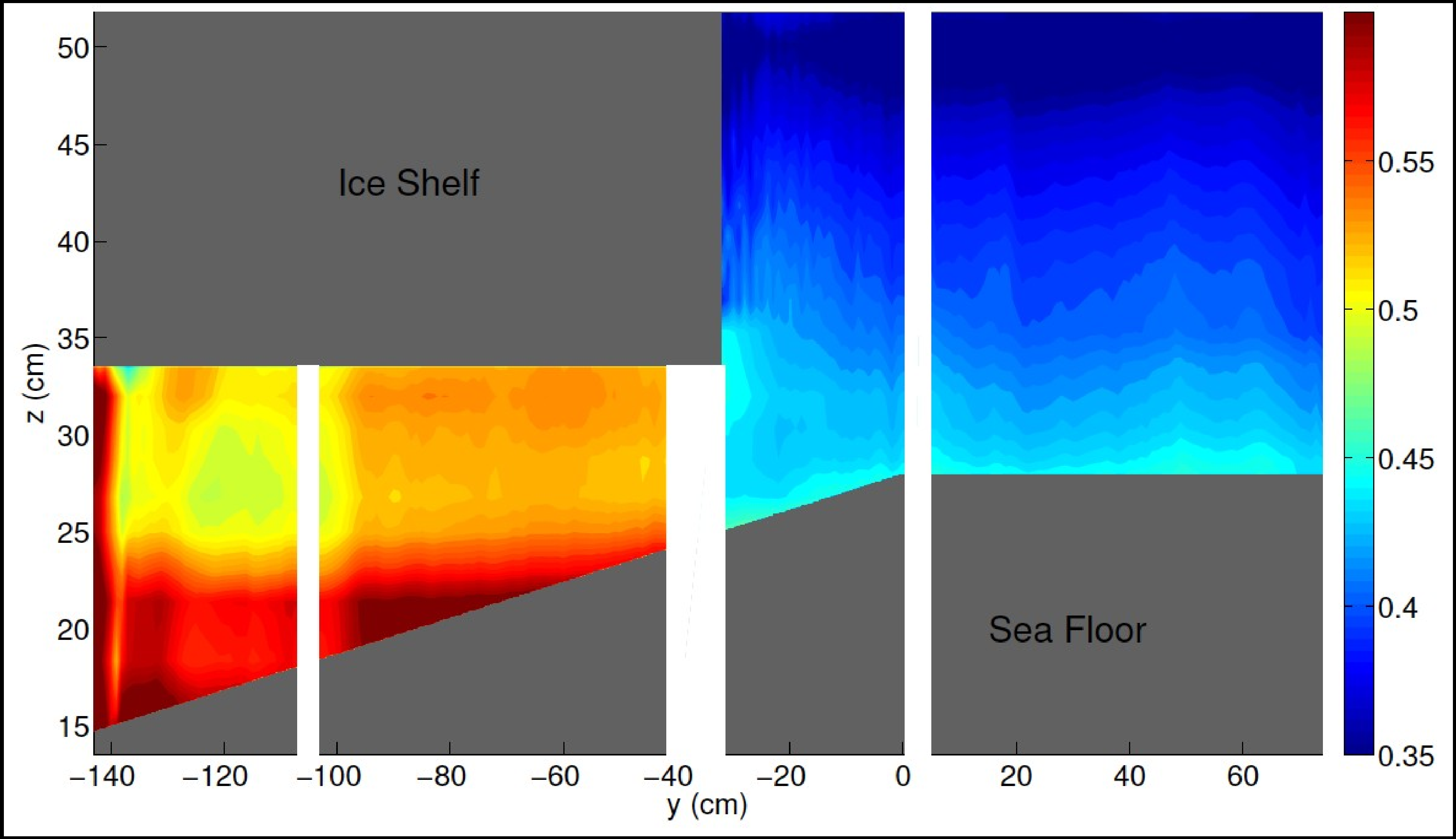
Time mean meridional Velocity Field



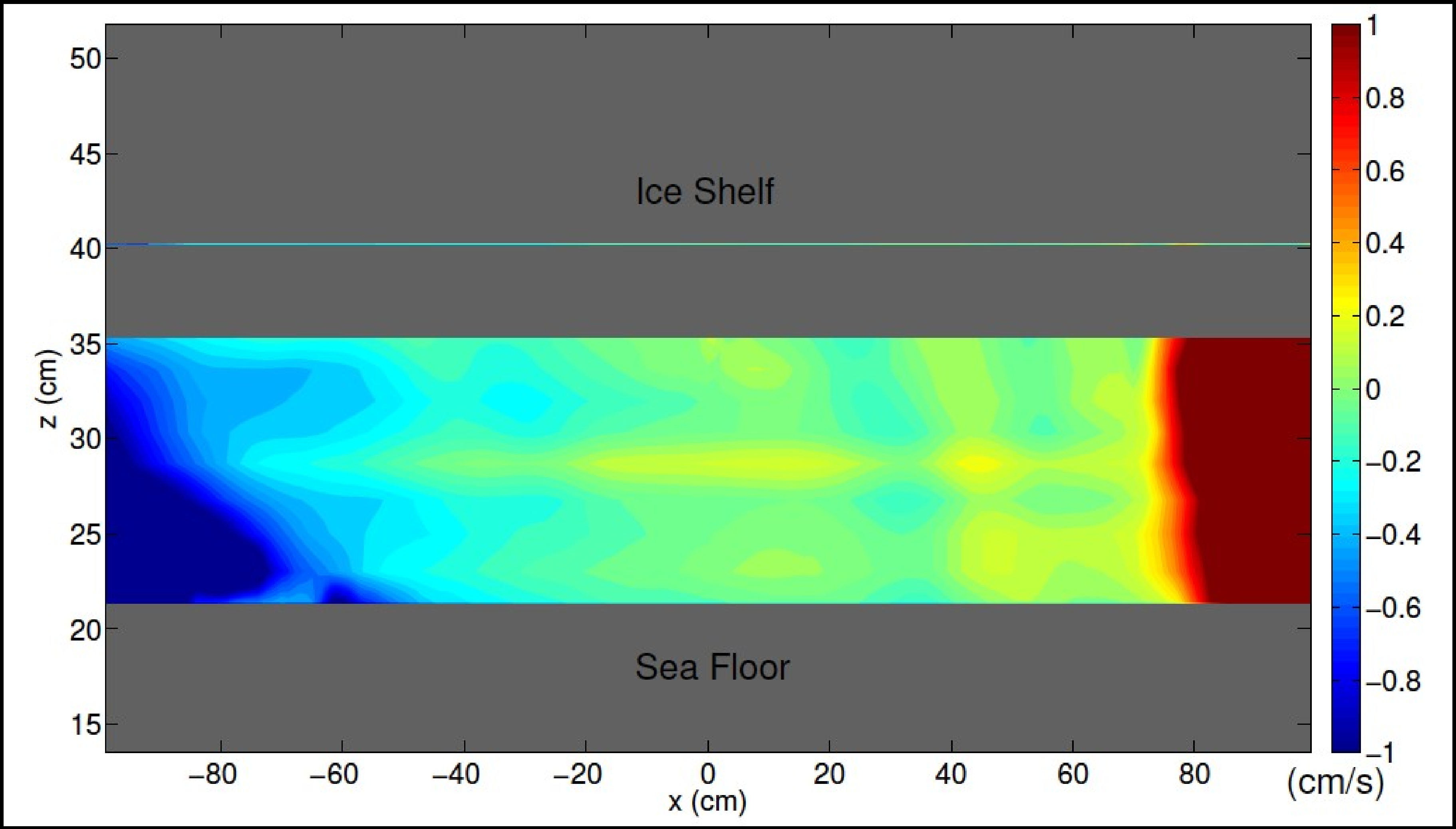
Zonal Velocity



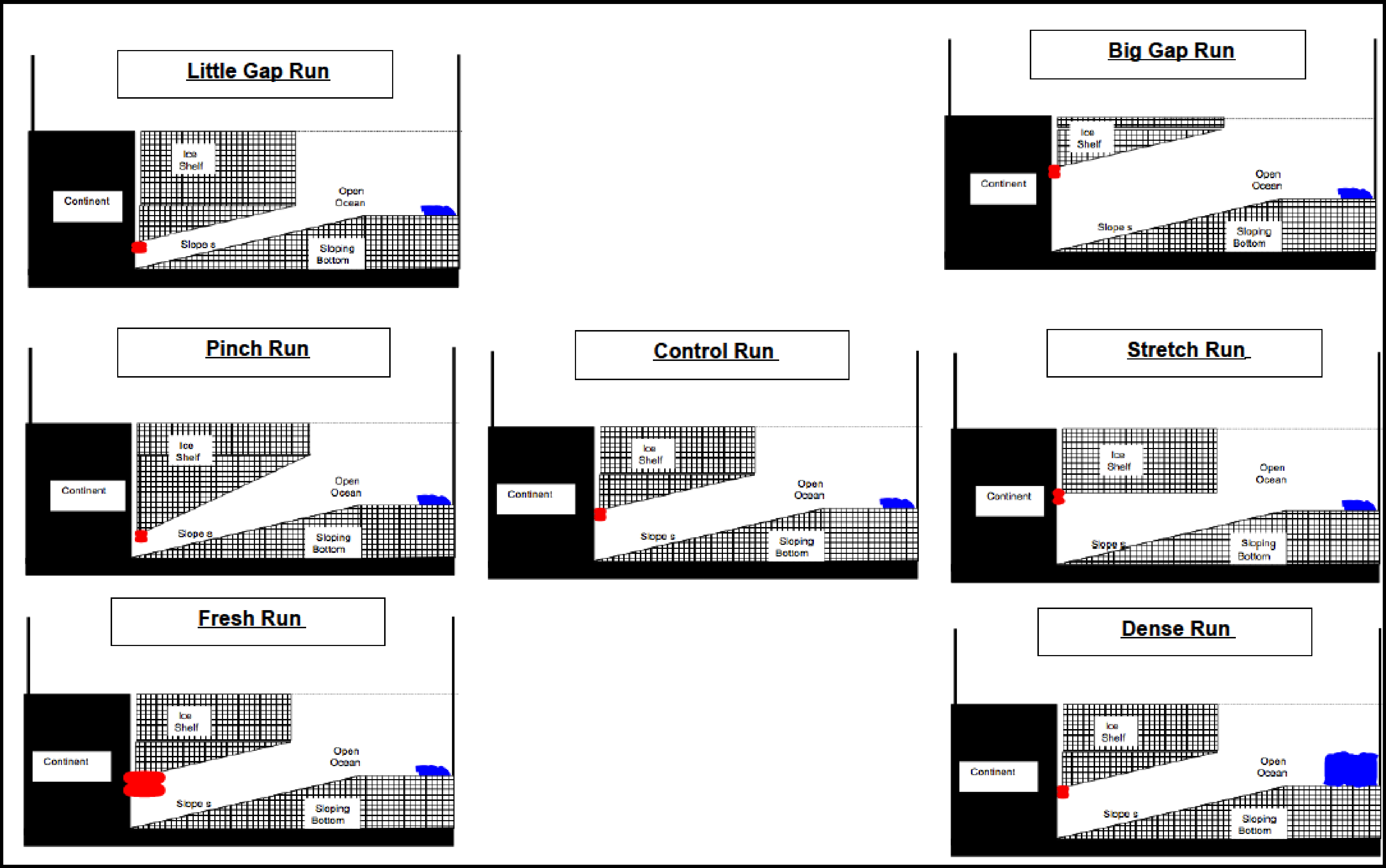
Time mean density field



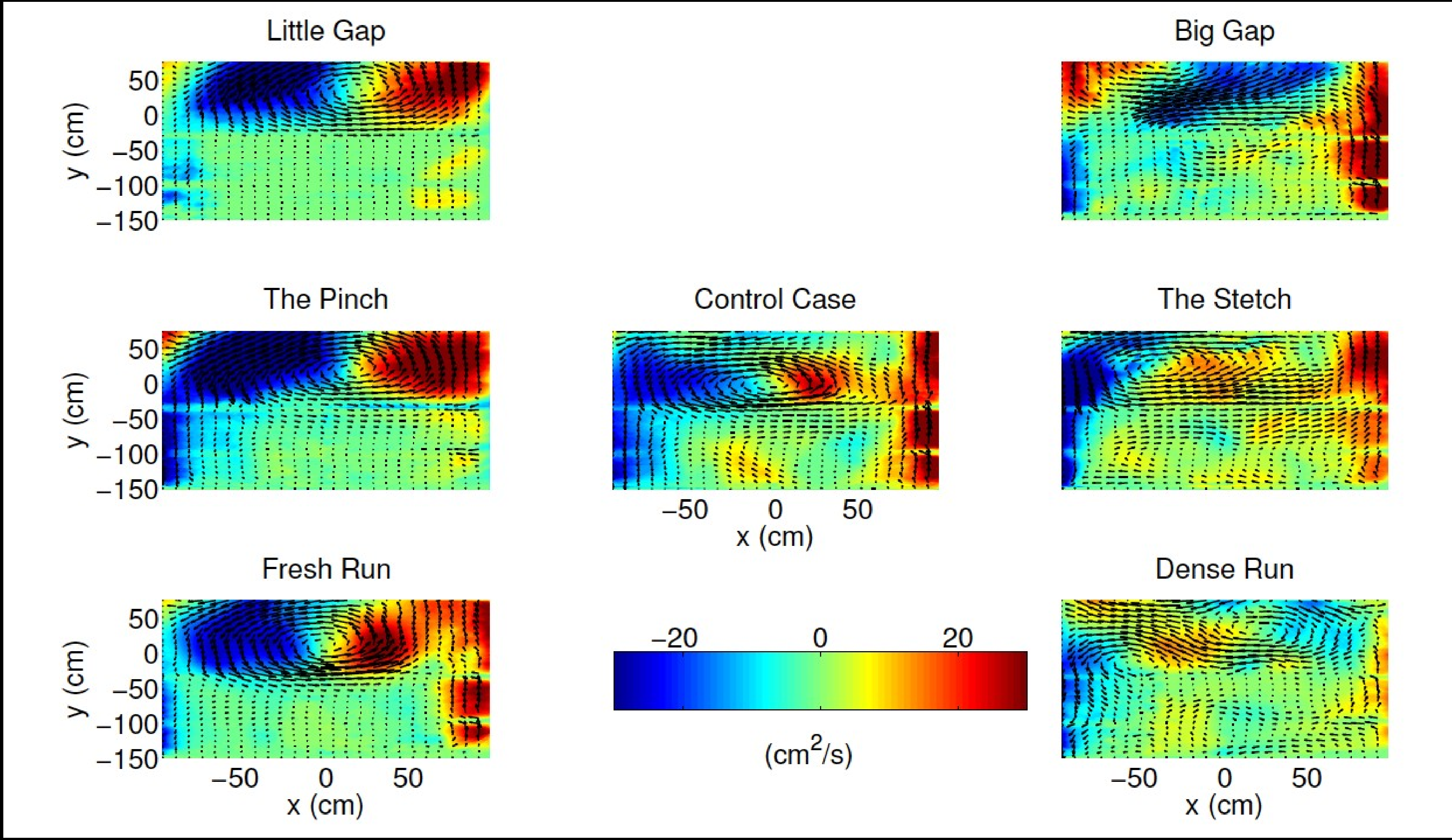
Dense and Fresh Plumes



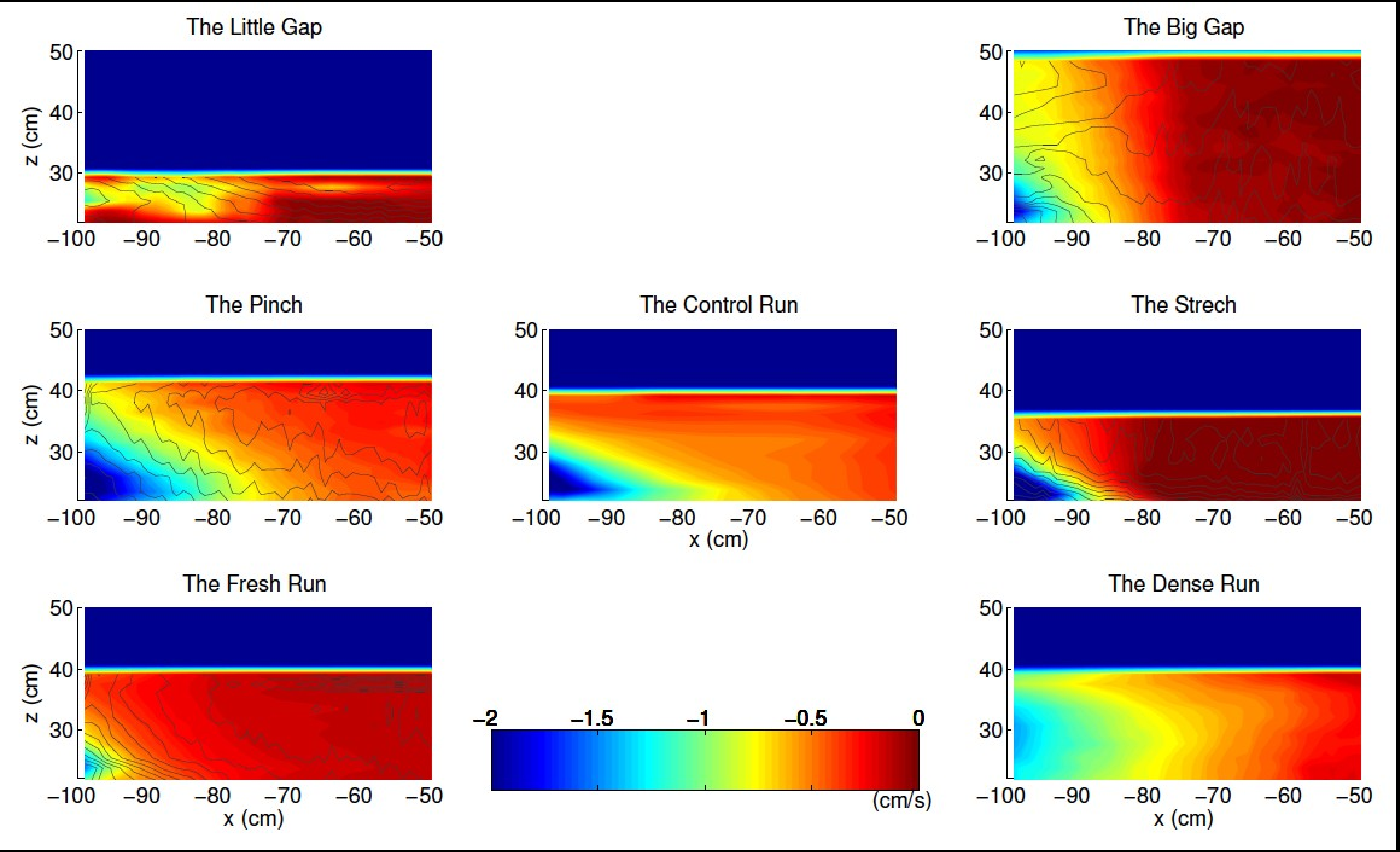
Shelf geometries and buoyancy fluxes



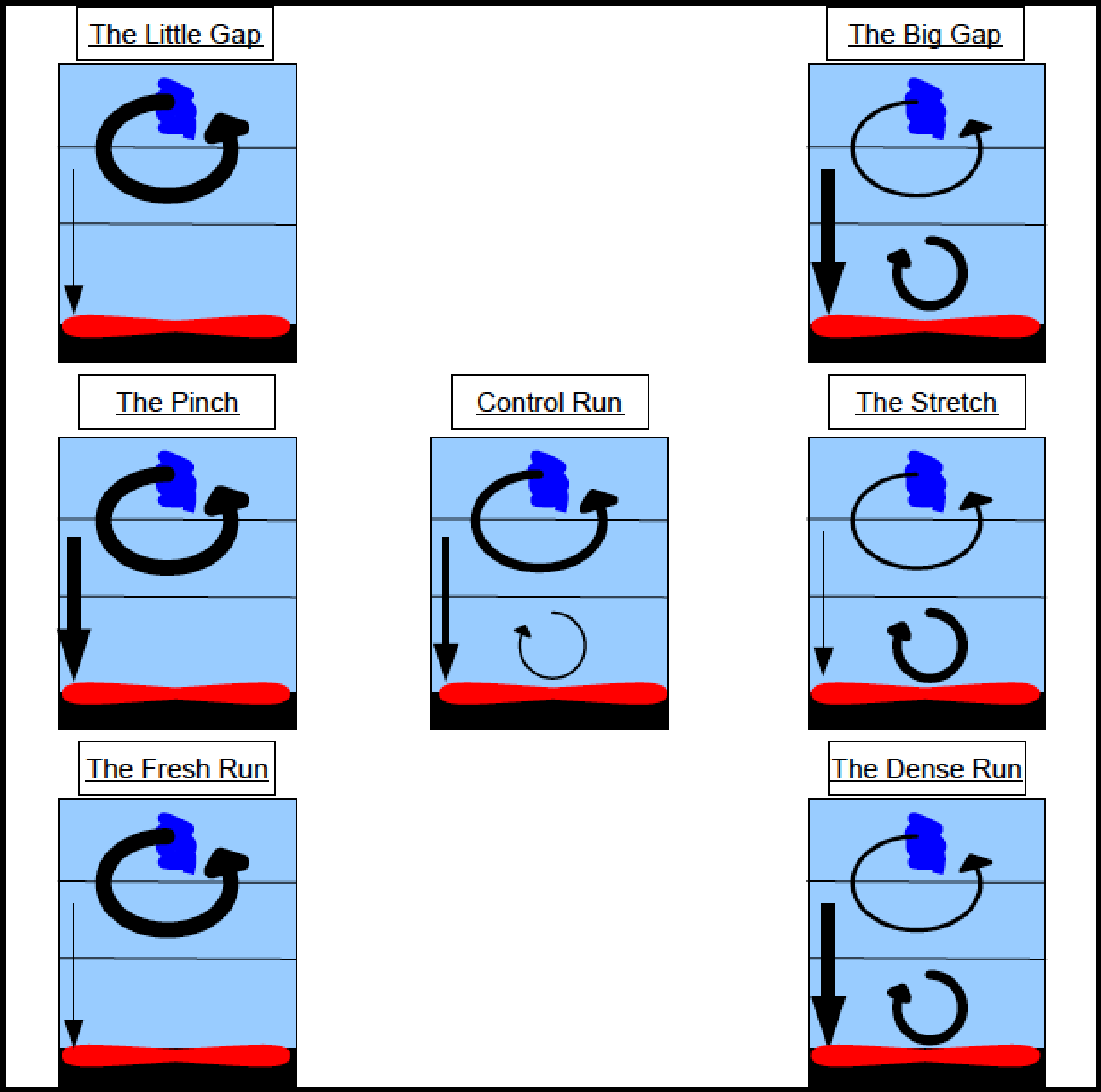
Time mean meridional volume flux for different geometries



Dense plumes for different geometries



Schematic summarizing the results

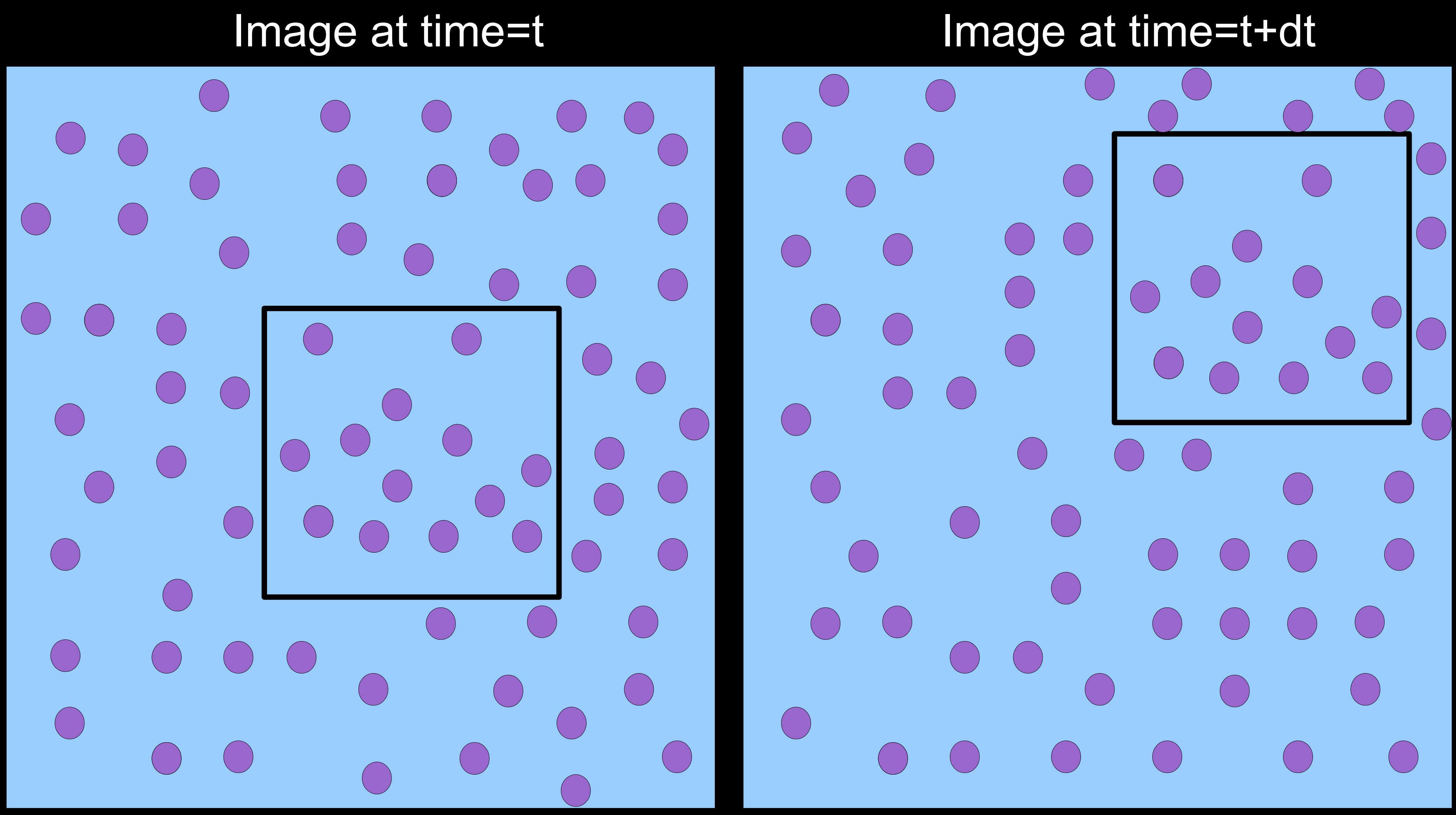


Conclusions

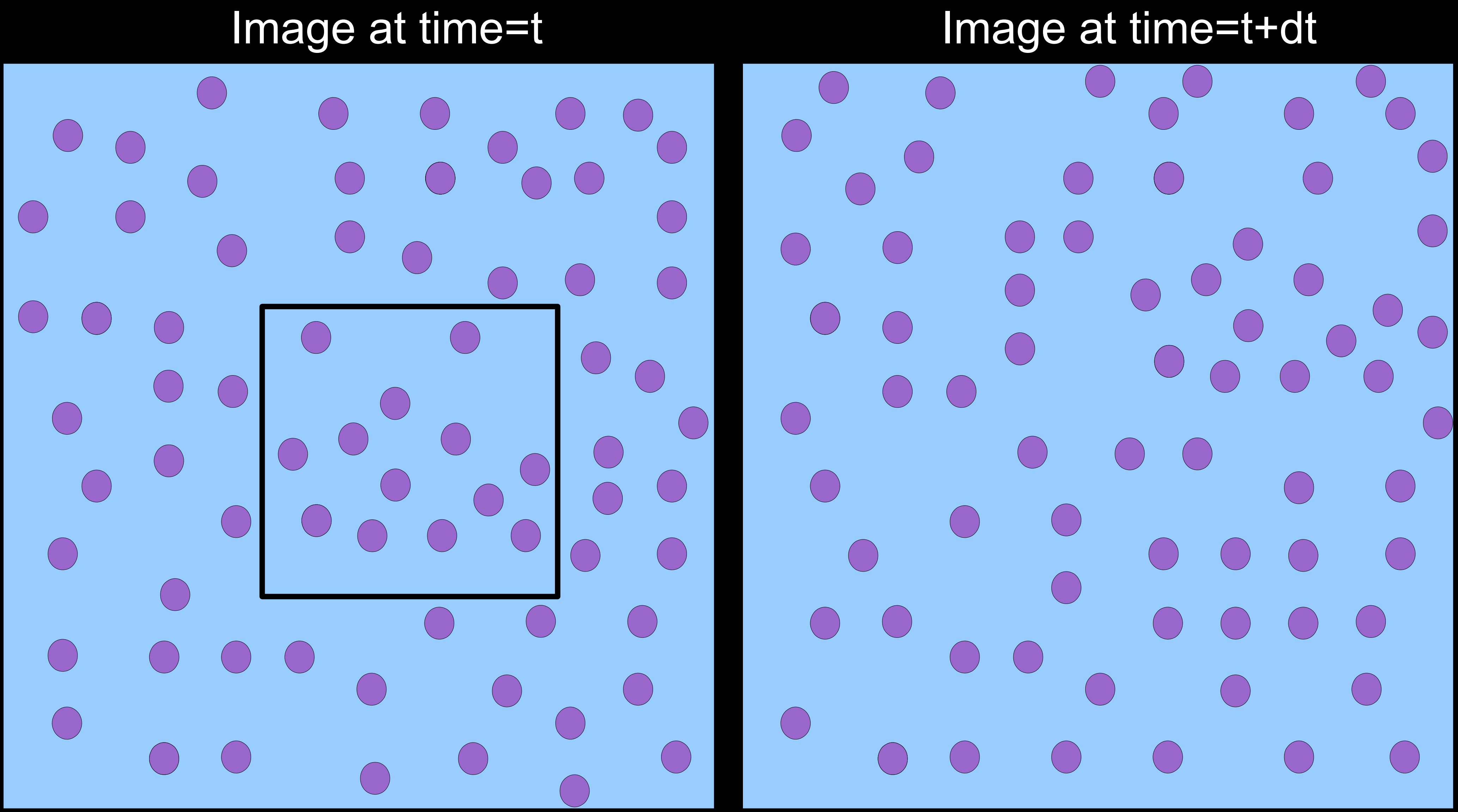
- A density driven current under an “ice shelf” has been successfully reproduced in a laboratory setting.
- Results confirm the dynamic significance of the ice shelf front as a dynamical barrier.
- Strong boundary currents which run along the sides of the domain are responsible for a large percent of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

Extra Slides

Particle Image Velocimetry



Particle Image Velocimetry



Particle Image Velocimetry

Integration box at time=t

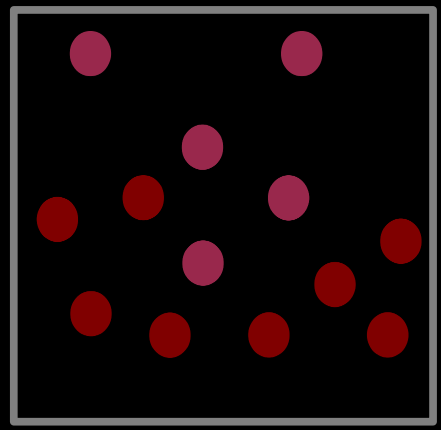
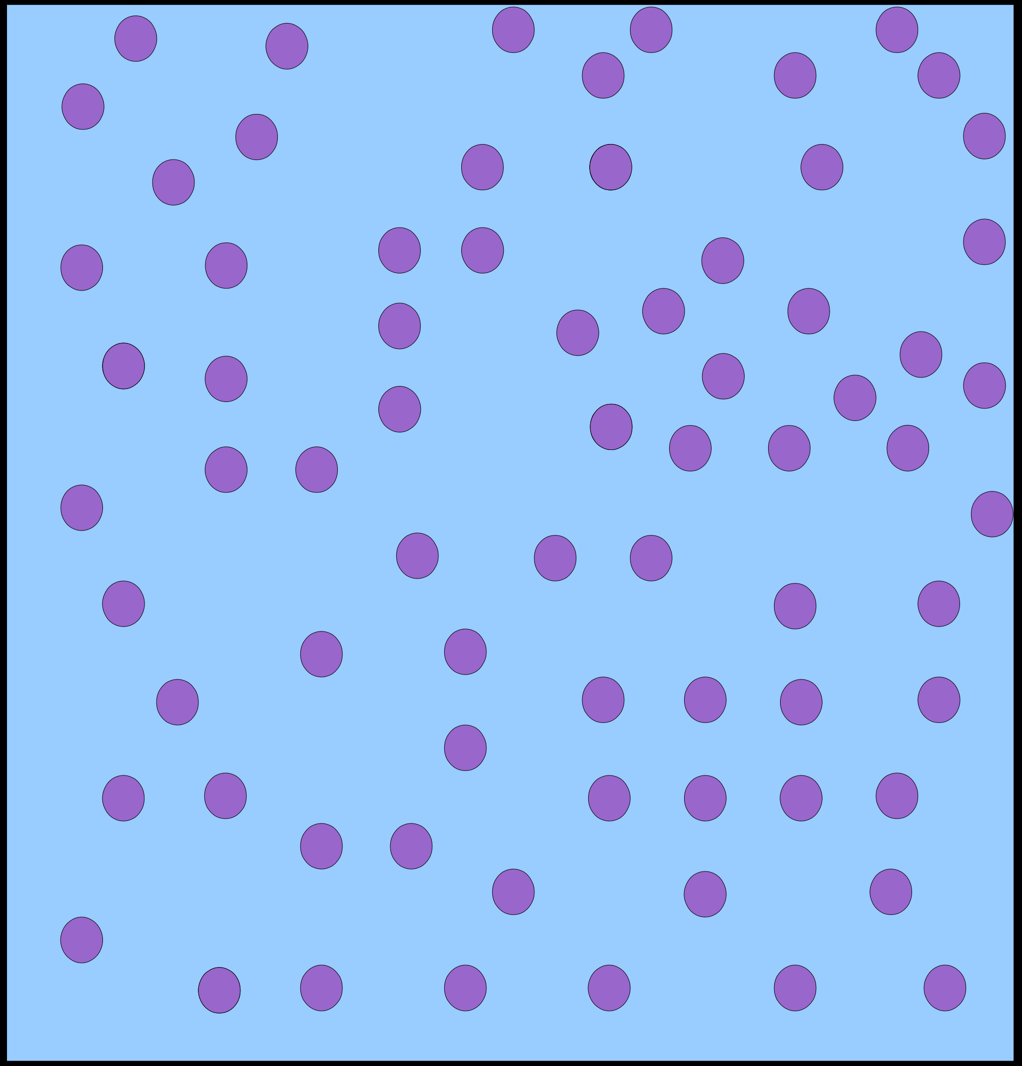
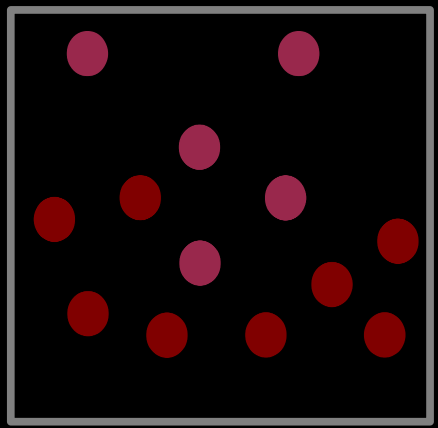


Image at time=t+dt



Particle Image Velocimetry

Integration box at time=t



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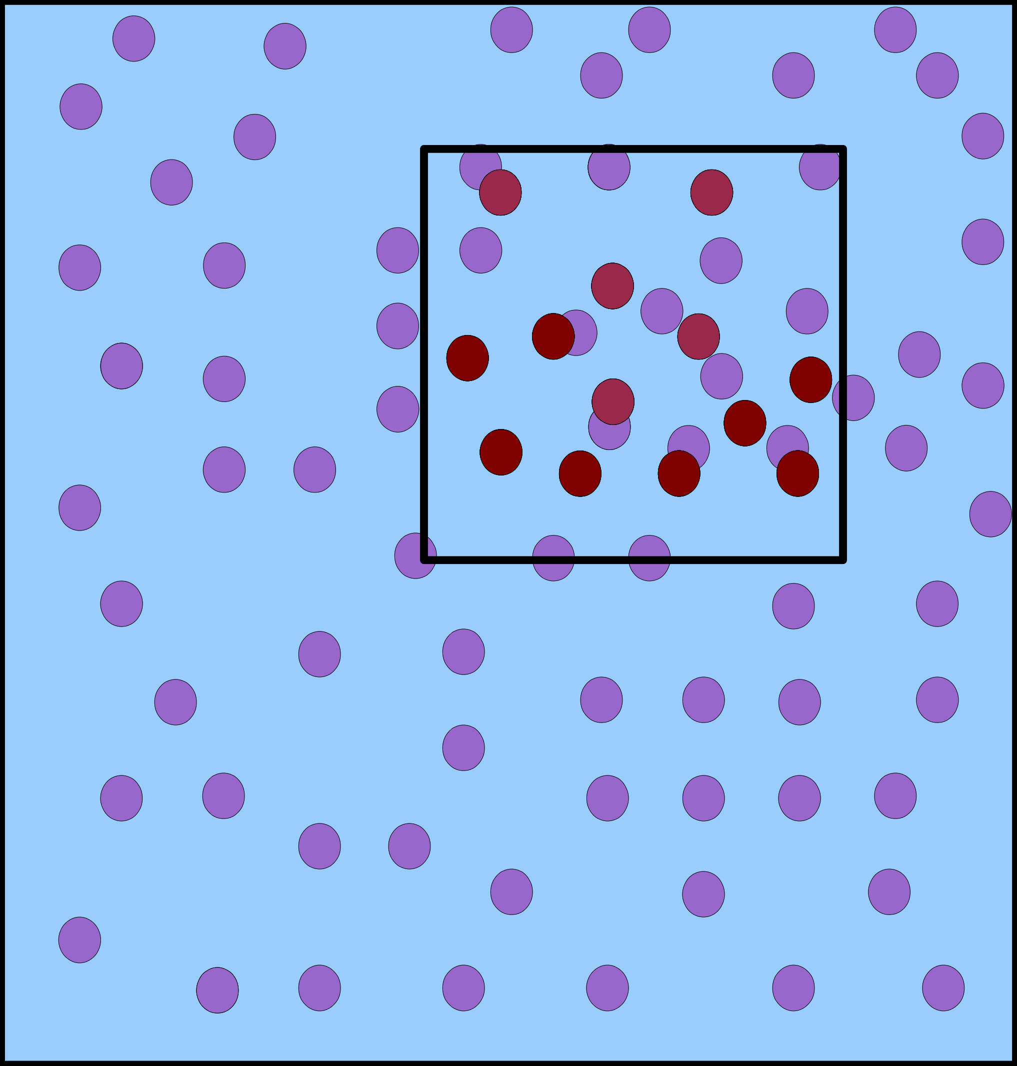

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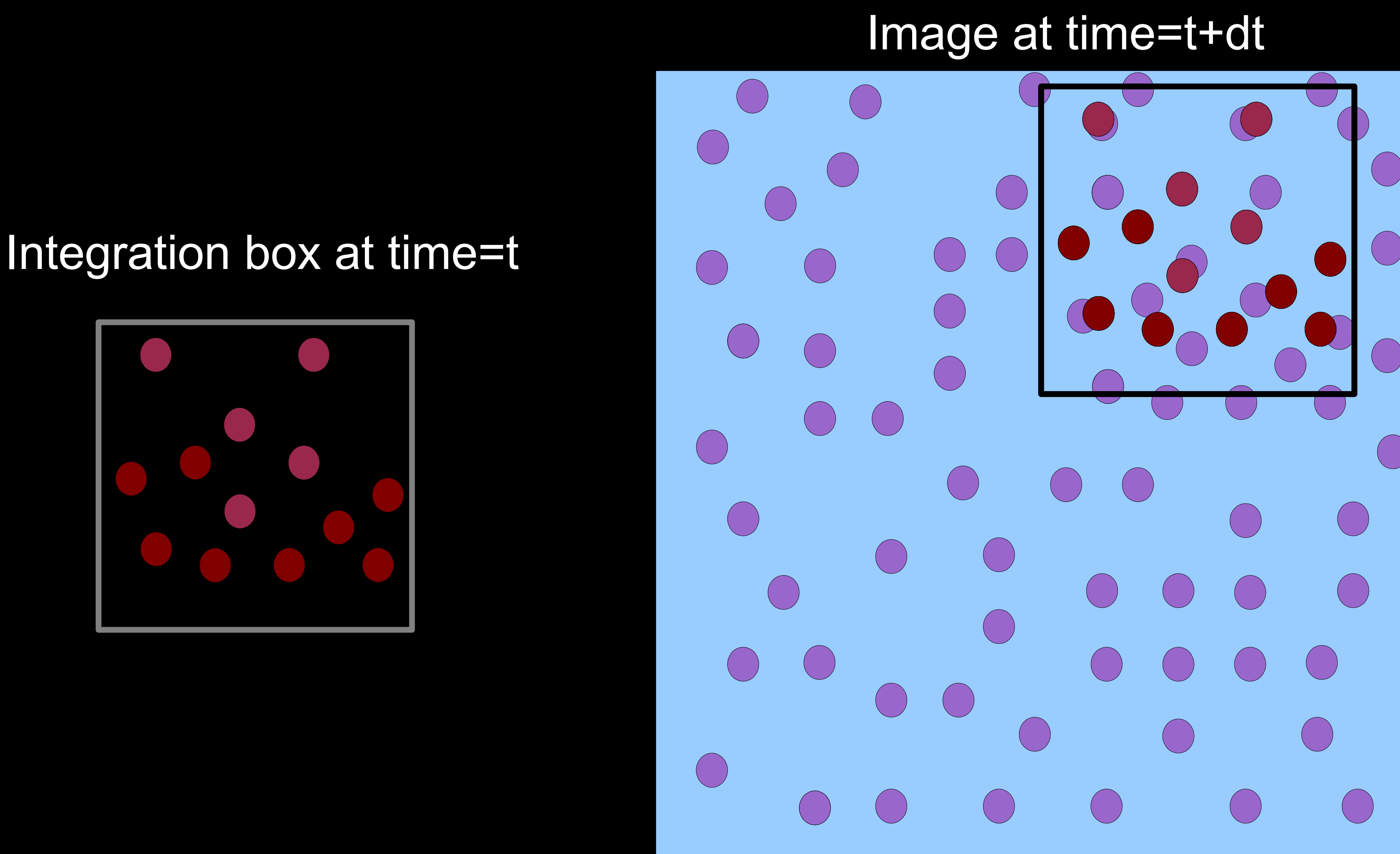

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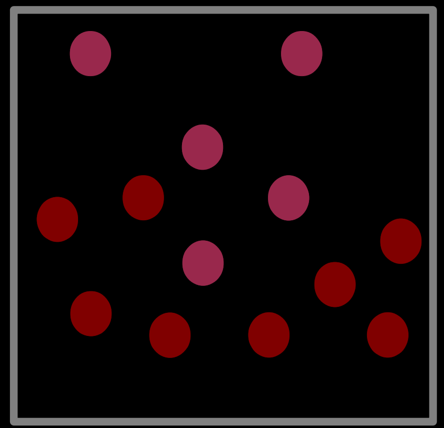
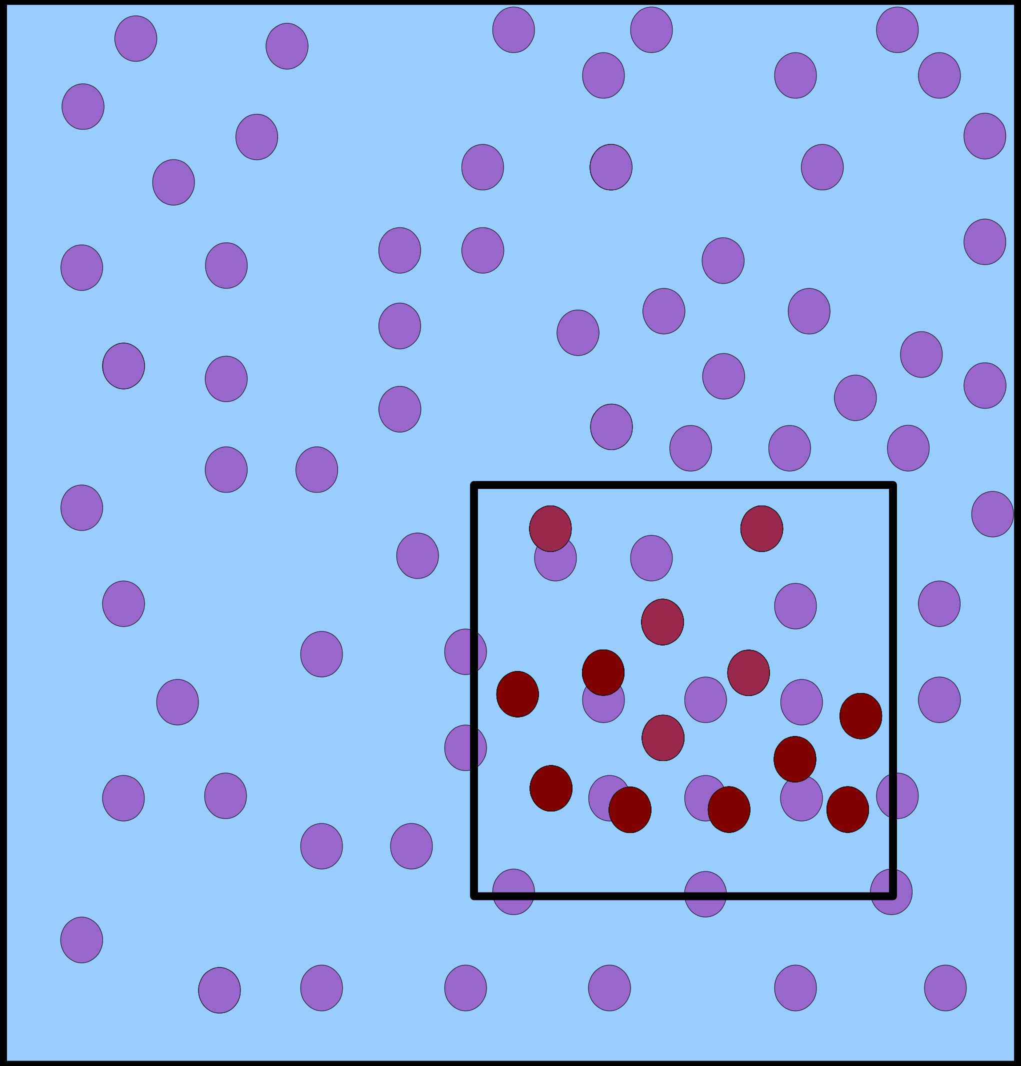




Particle Image Velocimetry

Integration box at time=t

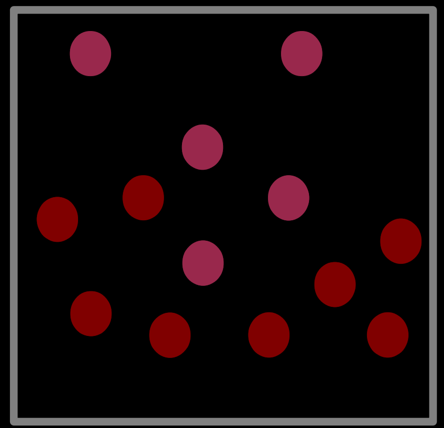
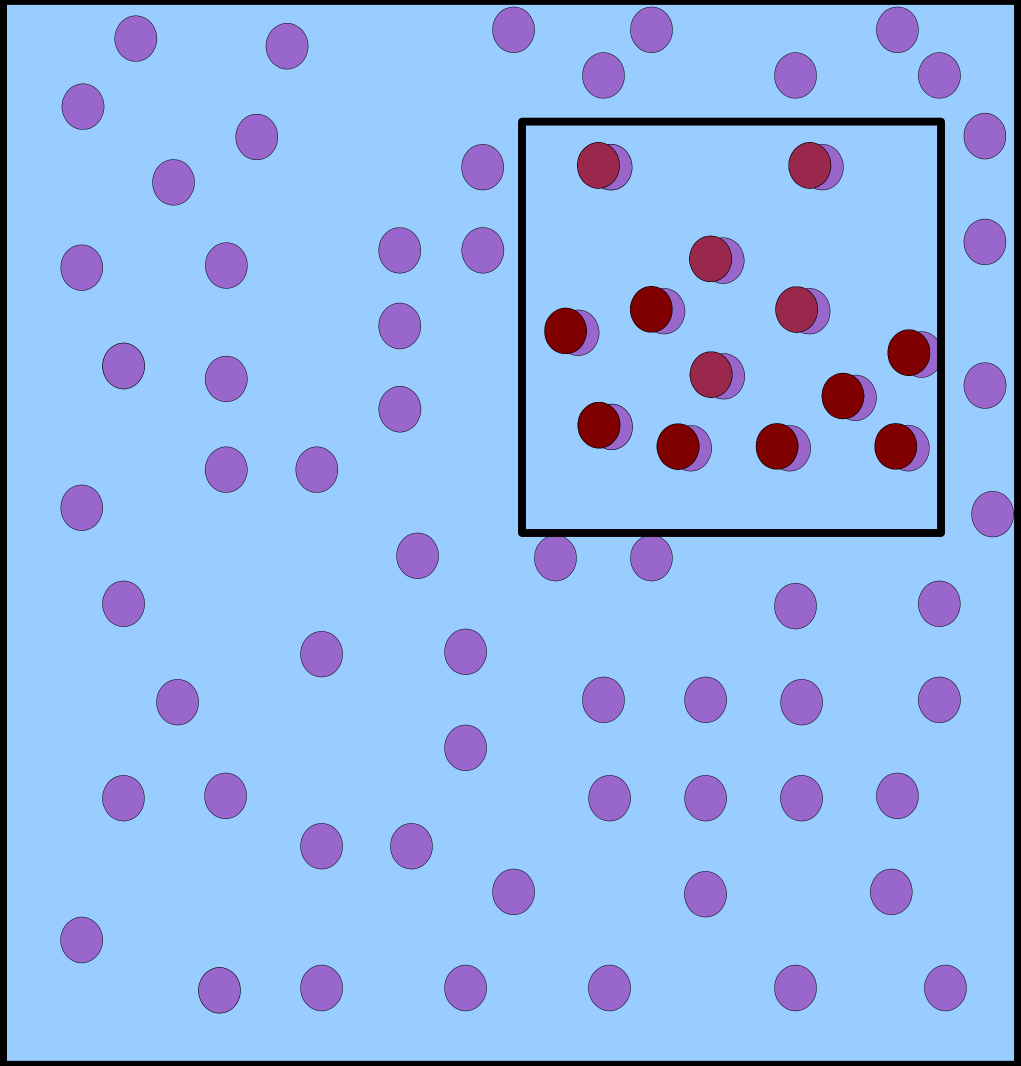
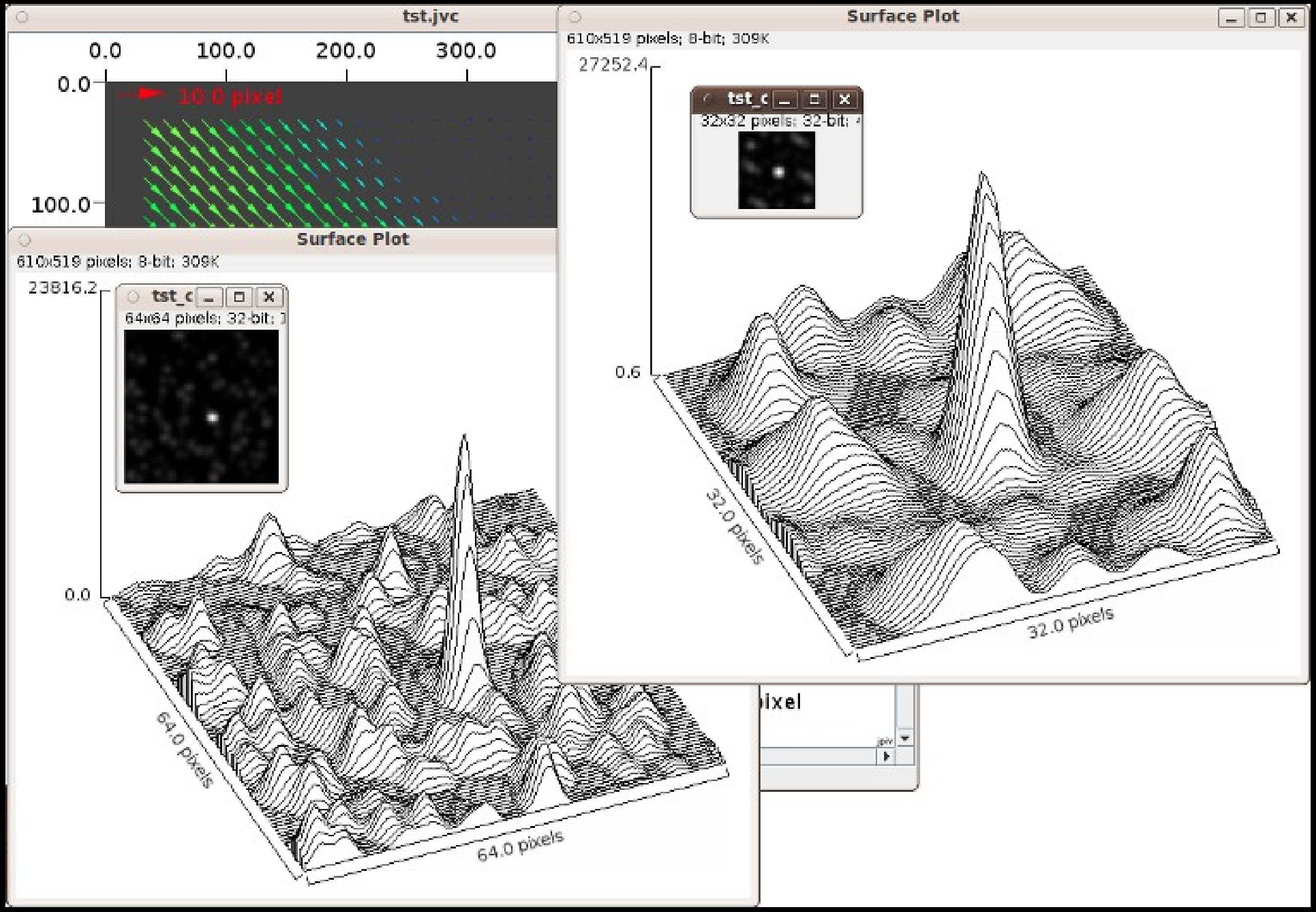
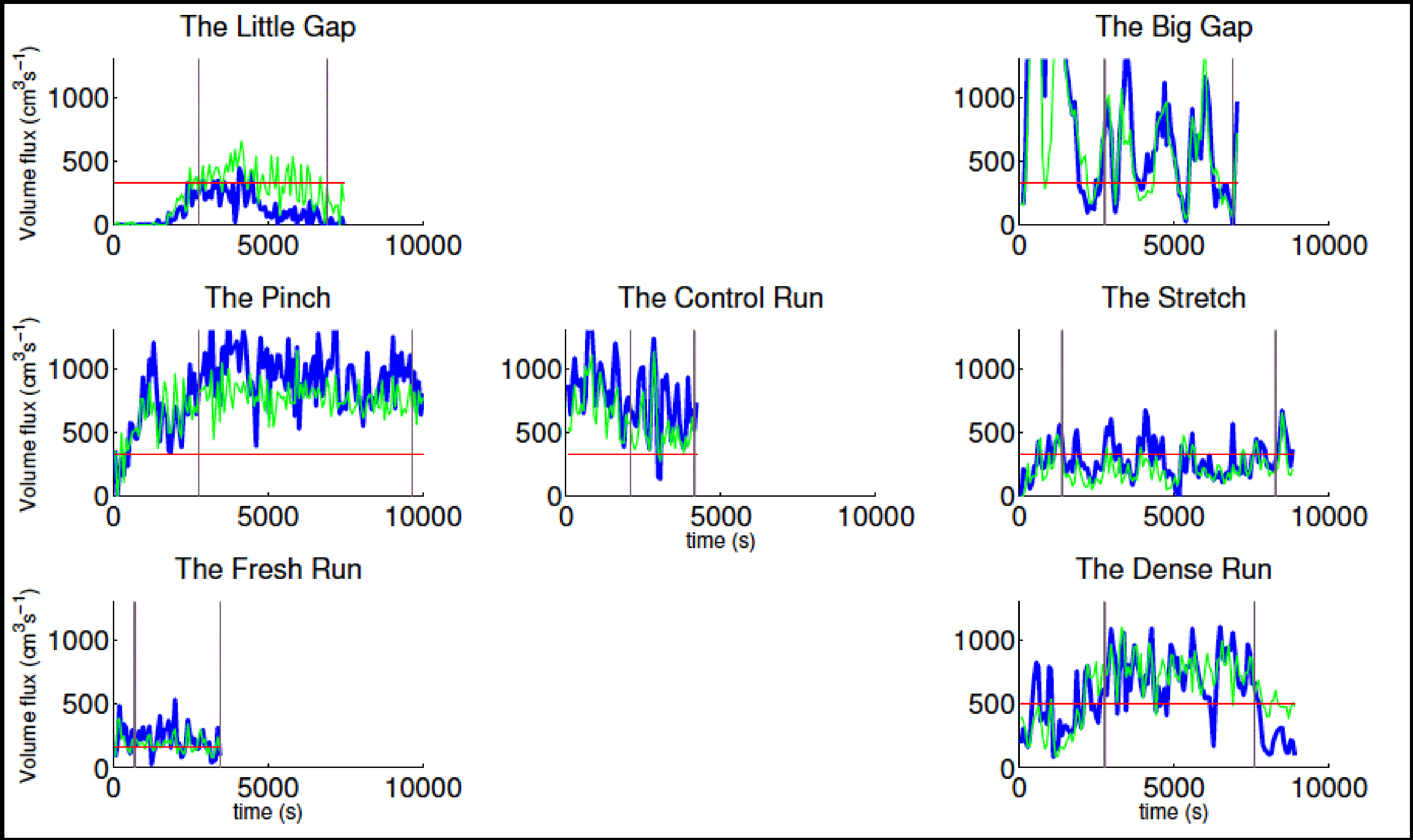


Image at time=t+dt

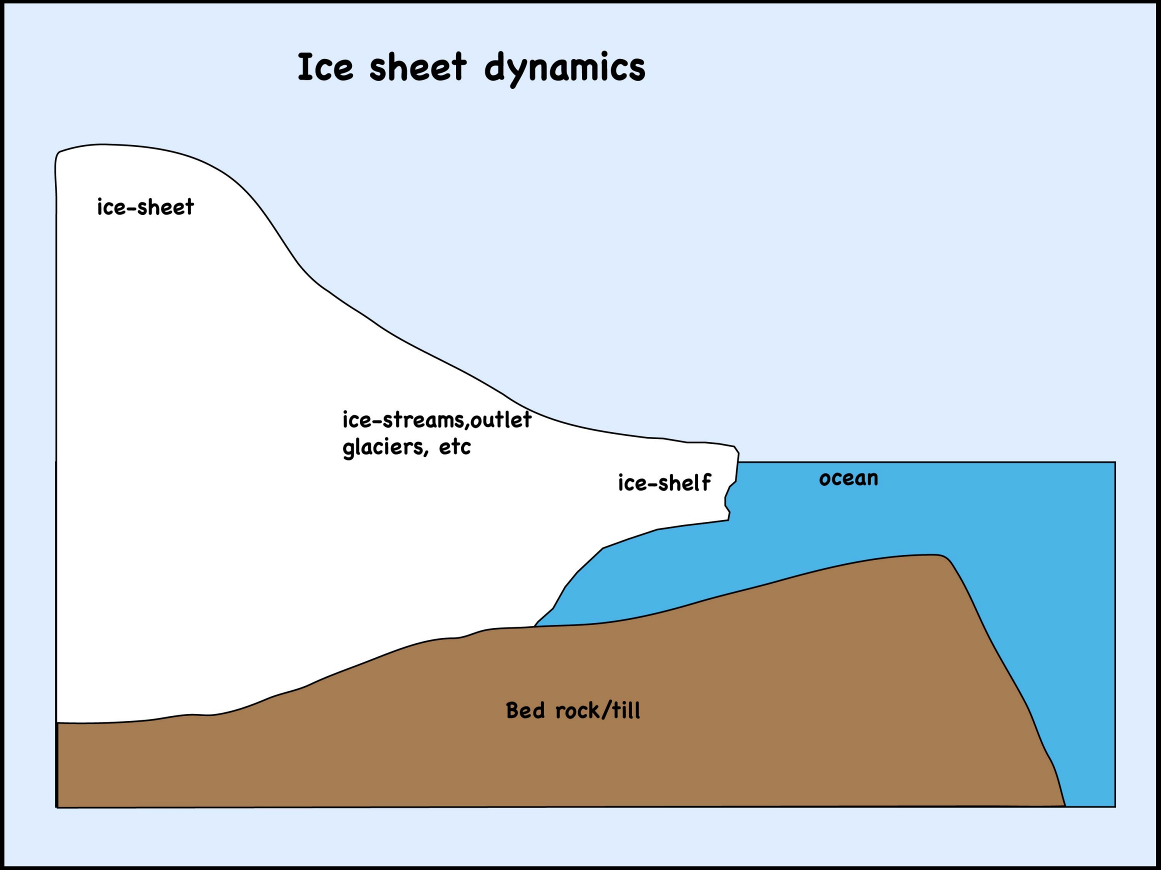


Particle Image Velocimetry




The Little Gap
The Big Gap
The Pinch
The Control Run
The Stretch
The Fresh Run
The Dense Run
Volume flux (cm^{3}s^{-1})
time (s)
0
500
1000
5000
10000

An idealized ice shelf



Ice Shelves around Antarctica