



U.S. DEPARTMENT OF
ENERGY

Office of
Science

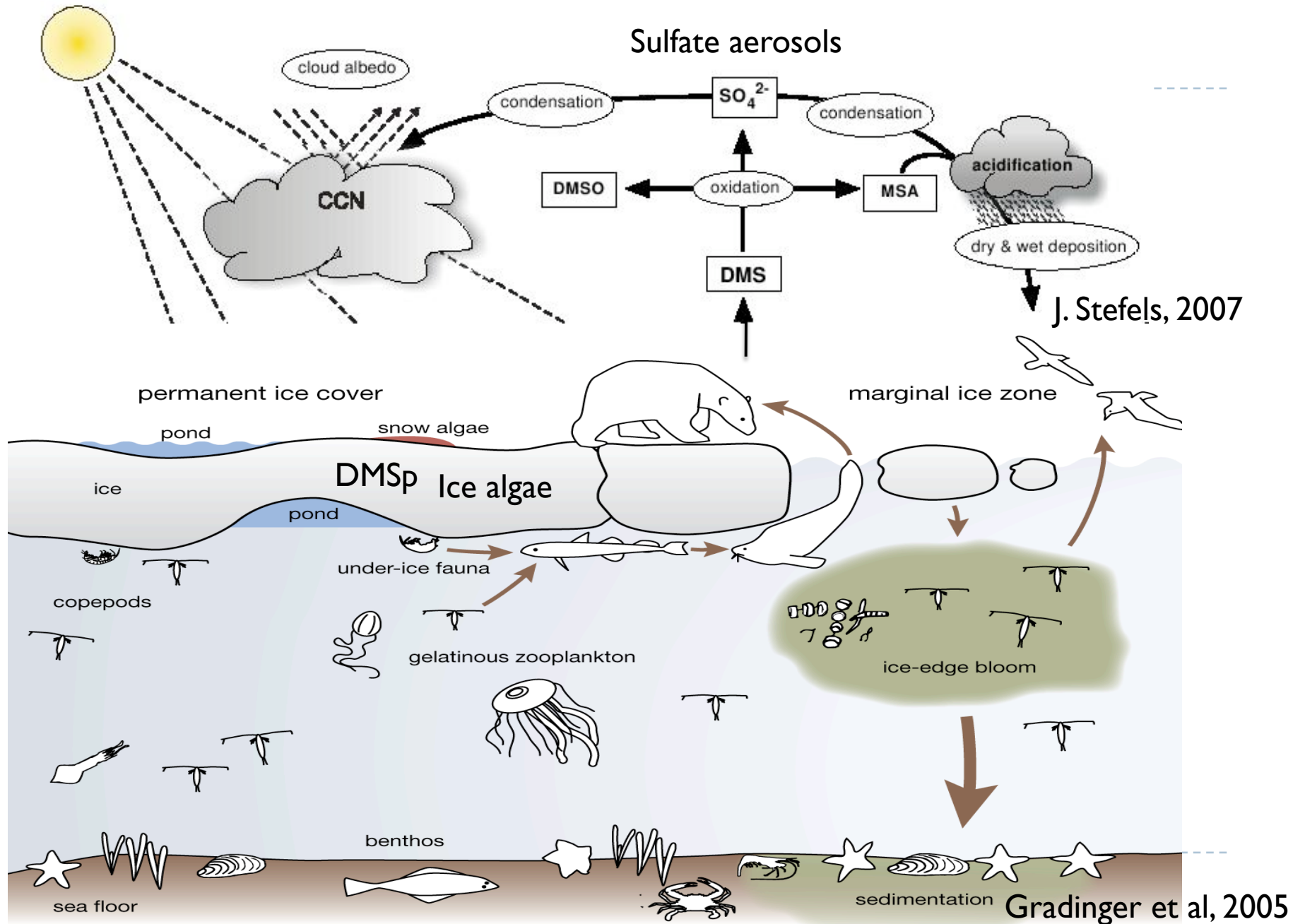


Sea Ice Salinity and Biogeochemistry

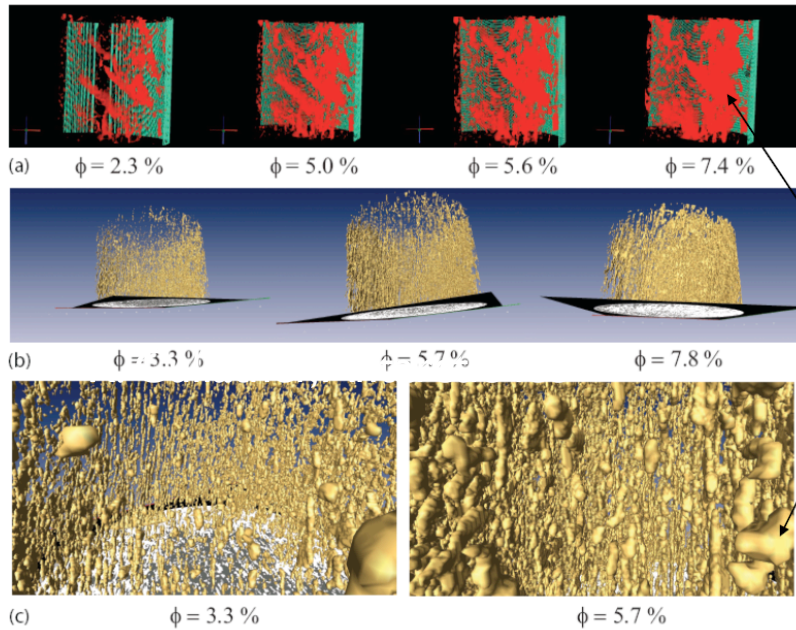
Improving the Characterization of Clouds, Aerosols and the
Cryosphere in Climate Models

Nicole Jeffery, Elizabeth Hunke, Scott Elliott, Mathew Maltrud, & Adrian Turner

The Biogeochemical Role of Sea Ice



Imaged Sea Ice Structures



Lab-grown sea ice: reconstructions of X-ray CT of 1 cm cores
Heaton, Miner, Eicken, Zhu, Golden, *in prep* (2006)



How does sea ice support algal production?

It is a multiphase material with a dynamic microstructure.

Brine inclusions



Chukchi Sea, Alaska, June 2009

Expanding our CICE capability – What we know and what’s lacking

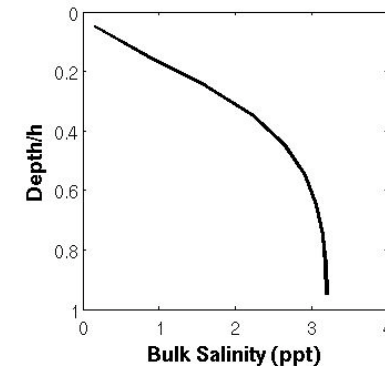
Well understood:

- T evolution
- S and T determine ice porosity (ϕ)
- Ice permeability $\sim \phi^3$ (Golden et al., 2007)
- Ice melting T and thermal conductivity depend on S
- Gravity Drainage and Flushing are primary mechanisms of desalination

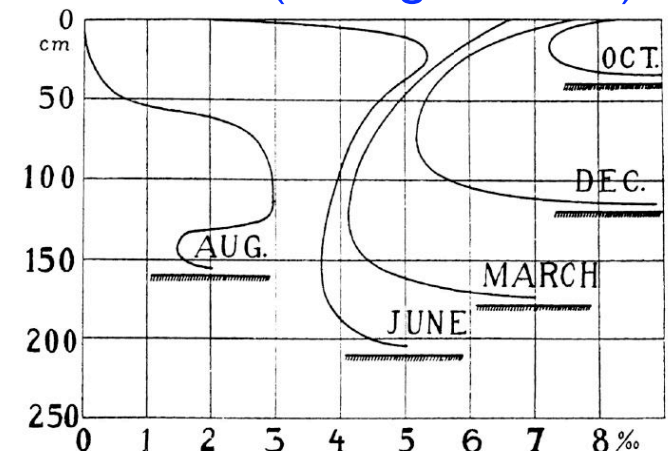
Lacking:

- Upscaled models of Gravity Drainage and Flushing
- A prognostic model of sea ice salinity (i.e. ϕ)
- A transport model for passive tracers
- Consistent snow, snow-ice, meltponds ...

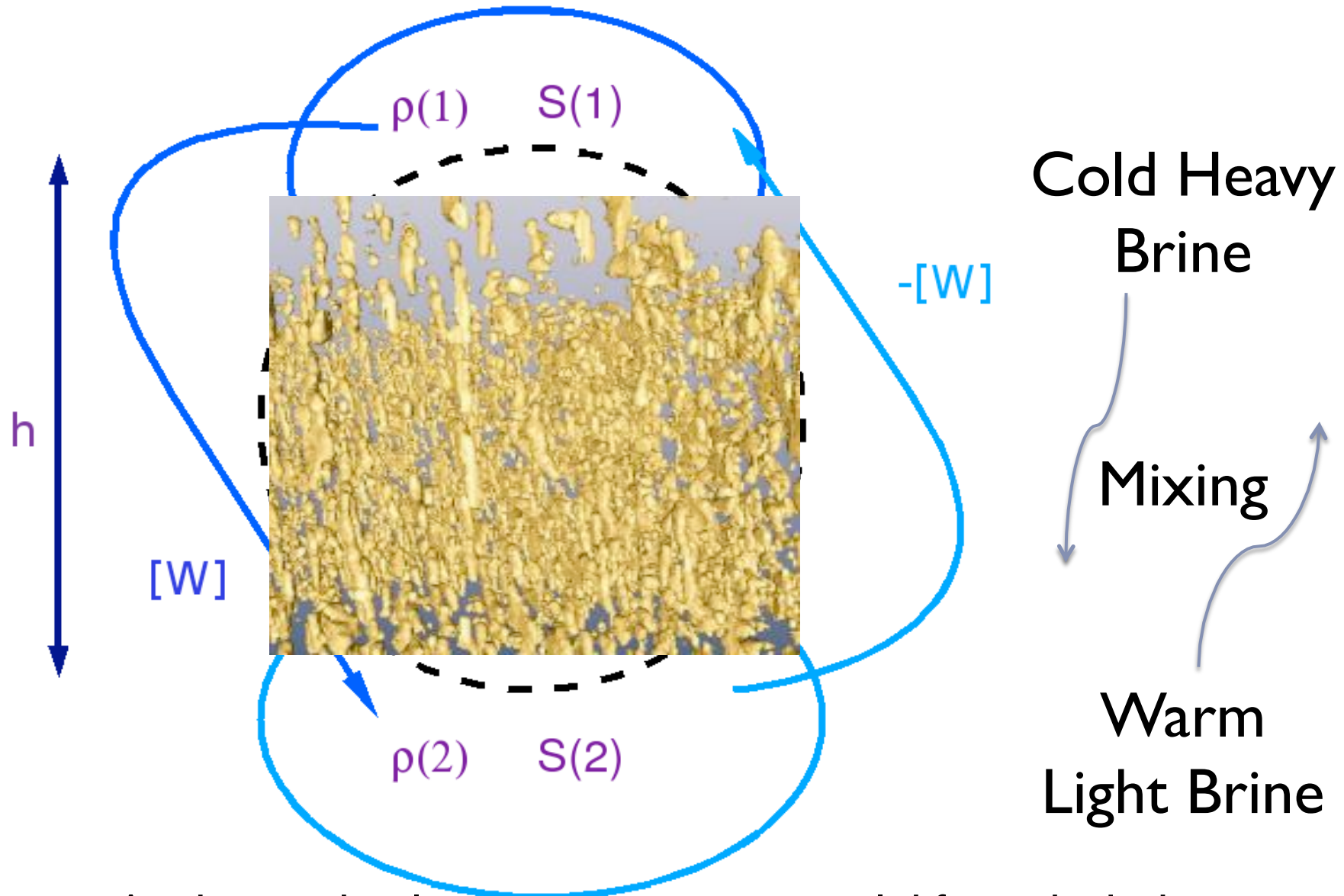
Vertical Salinity profile in CICE



Schematic of typical S variability in Arctic Ice (Malmgren, 1927)



Gravity Drainage



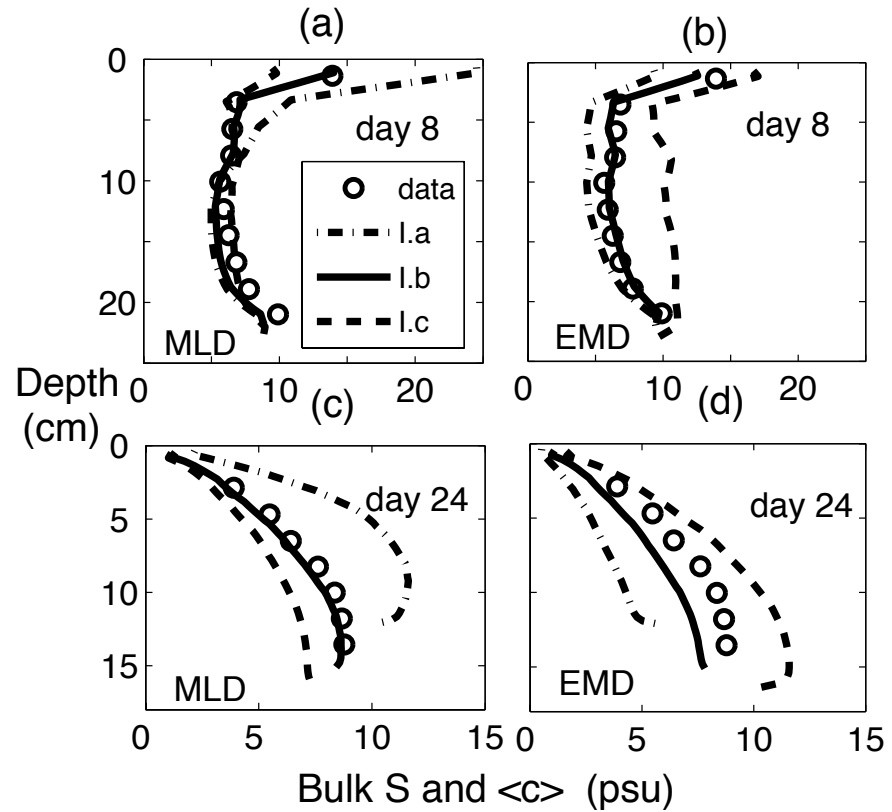
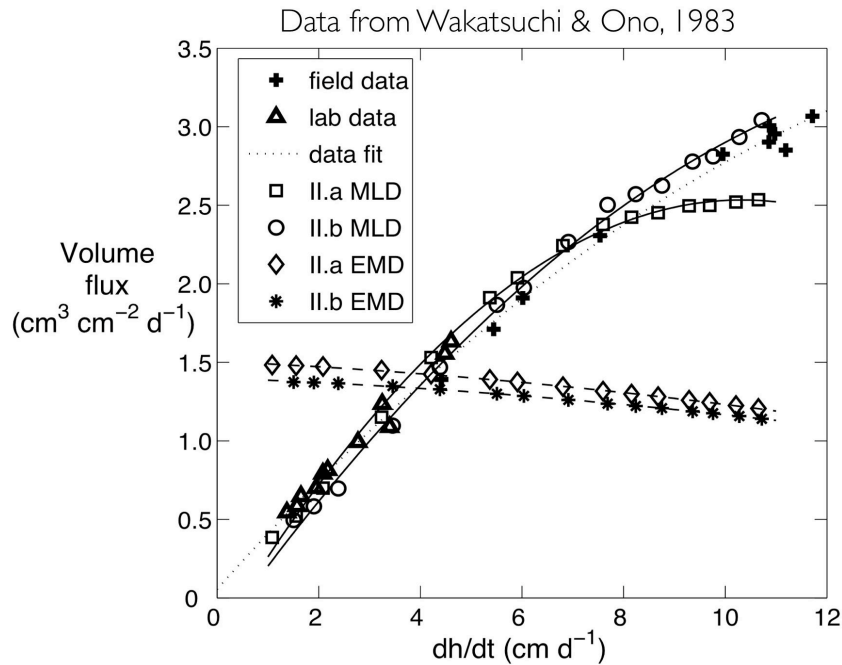
As the ice desalinates, more sea ice solidifies, which decreases the permeability and slows gravity drainage.

Gravity Drainage Parameterization in...

Passive Tracer Transport

For BGC. Bulk to Brine

Best parameterization captures obs.
Increase in gravity drainage with ice growth rate

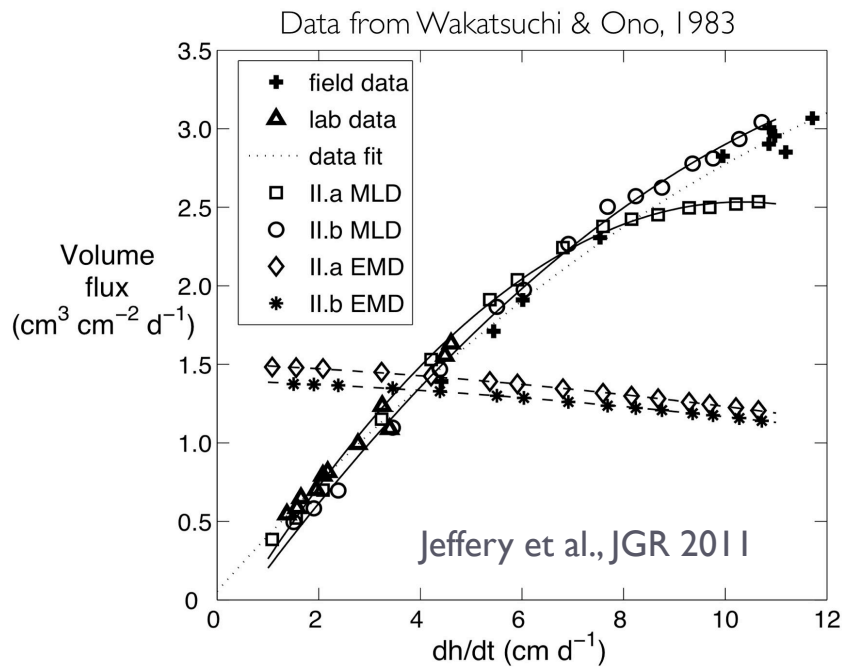


Gravity Drainage Parameterization in...

Passive Tracer Transport

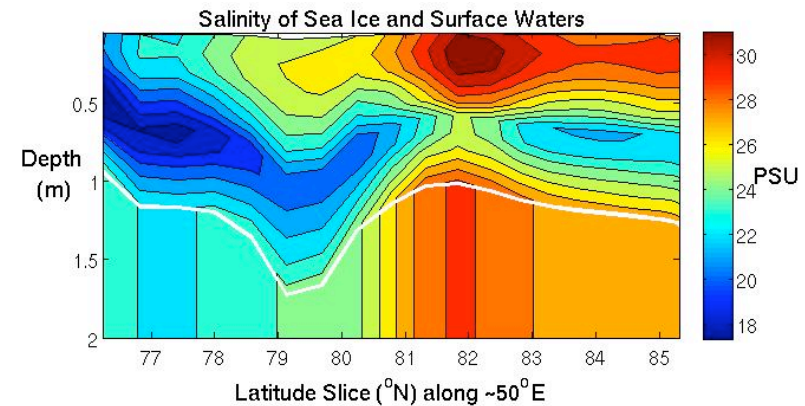
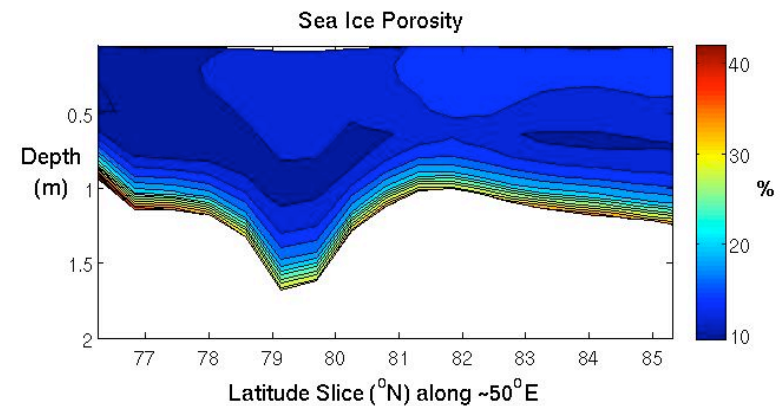
For BGC. Bulk to Brine

Best parameterization captures obs.
Increase in gravity drainage with ice growth rate



Active Tracer Transport

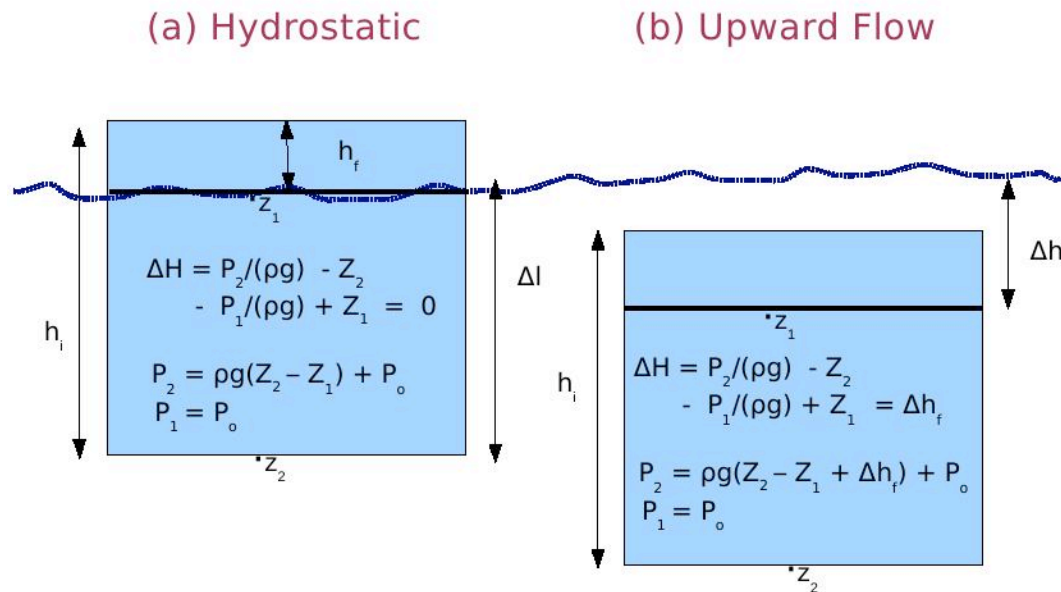
For Salinity. Brine to Bulk



Work in Progress

- 1) **Flushing — downward flow**: low salinity meltwater desalinates ice during
- 2) **Snow accumulation — upward flow**: ocean water replenishes depleted nutrients

Hydraulic Gradient: $\Delta H / \Delta l$



Work in Progress

- 1) **Flushing — downward flow**: low salinity meltwater desalinates ice during
- 2) **Snow accumulation — upward flow**: ocean water replenishes depleted nutrients
- 3) **Biogeochemistry** — M. Jin and C. Deal

Future Pieces of the Puzzle

- 1) **Radiative Transfer**
- 2) Consistent representations of brine motion, **snow-Ice formation** and **meltponds**
- 3) **Snow** with tracers
- 4) **Ocean** treatment of brine fluxes

