Biogeochemistry in Sea Ice: CICE model developments

Nicole Jeffery, Elizabeth Hunke, Scott Elliott, Adrian Turner
This Talk

- Motivation: Sea Ice, polar biogeochemistry, ocean, atm, climate …
- Constituents of sea ice
- Salt
  1) Impacts at the micro scale
  2) Impacts at climate scale: Arctic vs Antarctic
- Nitrogen tracers in a simple algal model
  1) Arctic vs. Antarctic
  2) Nitrification on/off
- Conclusions
Sea Ice Algae

Chukchi Sea, Alaska, June 2009

R. Cullather
More generally...
What are the climatically important constituents of sea ice?
A physics based classification of sea ice constituents:

1) **Salt** – modifies Tmlt, conductivity, heat capacity, ice density, ice porosity, and vertical transport physics

2) **Tracers that move like salt** – nitrate, silicate, ammonium, phosphate

3) **Tracers that cling to the ice crystals** – algae, DMSp

4) **Tracers that precipitate** – DIC (Ikaite)

* **Dust (fe), Black Carbon, Methane bubbles**

Atmospheric interactions through DOE Polar Project -- Steve Ghan (PNNL), Phil Rasch (PNNL), Hailong Wang (PNNL), Natalie Mahowald (Cornell), Lynn Russel (Scripps)
Impact of Salt (micro scale)

Imaged Sea Ice Structures

Salinity and Temperature determine the porosity, permeability and the desalination rate.

Lab-grown sea ice: reconstructions of X-ray CT of 1 cm cores

Golden et al., 2007
As the ice desalinates, more sea ice solidifies, which decreases the permeability and slows gravity drainage.
Characteristic ‘C’ Profile

Barrow 2007  C. Petrich (UAF)
Brine Motion during Melt Flushing

1) Flushing — downward flow: low salinity meltwater desalinates ice
2) Snow accumulation — upward flow: ocean water replenishes depleted nutrients
Melting and Multi-year Ice profile

Standard CICE currently assumes a fixed S profile

Cox & Weeks (1974)
Impact of Salinity (climate scale)
7 Year Control Run: **CICE vs CICES**

**Antarctic**

![Graphs showing area and volume changes for Antarctic Sea Ice]

**Arctic**

![Graphs showing area and volume changes for Arctic Sea Ice]

**Ratio of Brine Height to Ice Thickness**

![Graph showing the ratio of brine height to ice thickness over time]

---

17th Annual CESM Workshop  
18 – 21 June 2012  
Breckenridge, CO.
Nitrogen-Based Ice Algal Biogeochemistry
(Tracers that move like S, Tracers that cling)

Tracers: Algal nitrogen, Nitrate, Ammonium and Silicate

- Nitrate/Silicate Arctic ocean climatology
- Maximum growth-rate is 0.5 doublings/day
- Light, Silicate, and Nitrate/Ammonium can limit growth
- Nitrification timescale 67 days
- No additional salinity, light, iron or temperature Inhibition.
Year 4; Monthly Average

Arctic Chla
April

Antarctic Chla
September

Slice

17th Annual CESM Workshop 18 – 21 June 2012 Breckenridge, CO.
Future work

- Coupling with POP/CESM
- Feedbacks between ice constituents/bgc and ice radiative transfer
- Dust (fe), black carbon