Carbon and Chlorophyll in the Oceanic Ice Domain

LANL: S. Elliott, N. Jeffery, E. Hunke, M. Maltrud, S. Wang
PNL: H. Wang, Y. Qian, P. Rasch
IARC: C. Deal, M. Jin

Universities: UAF, Laval, Netherlands

Abstract

Bleaching channels of the global pack ice system import nutrients from below, provide habitat for primary producers and constitute a reservoir for organic detritus. Our ice biogeochemistry team is currently developing a global three-dimensional simulation capability for these processes. Bleaching enterolar ice from the marine mixed-layer chloring photosynthetic given light availability. The ensuing pack internal ecosystem generates carbonaceous waste with several critical effects on the polar environment: dissolved organic matter determines brine network permeability in Arctic ice, plus trapping and retention of iron in the Antarctic counterparts. In parallel with this work, DOE aerosol modelers are now improving distributions of soot deposition onto the pack. But in many locations, ice algal chlorophyll is likely to compete as an absorber. In a second phase, we will transport bleaching carbon through layer snow cover and onto a common biogeochemical marine transport system. Absorption by the biopersistent material will be compared with that of the ice algae themselves. We will map areas of soot versus bio-pigment dominance in the sense of single scattering. Then couple into a full radiation transfer scheme to evaluate the various contributions to polar climate change amplification. Early progress will be described in both these areas. The work prepares us to study more traditional issues such as chlorophyll warming of the pack periphery and carbonate expulsion from the ice bottom.

Shakhova, Golden and company –Land ice extracted, inverted and dye-loaded. Ackley and carbonate expulsion from the ice bottom. us to study more traditional issues such as chlorophyll warming of the pack periphery and amplification. Early progress will be described in both these areas. The work prepares

Initial Ice Algal Simulations: The Bottom Layer

- Habitat definitions from Argo series plus some fundamental parameter settings
- Ecodynamics structure also Argo but add JIN, Levies, receptor for regional scales
- LANL/IARC couple N. Si with full C and CH4, also DMS aerosol source

Full coupling: Nutrients and Carbon, Ocean to Ice

- N, Si, C flow from mixed layer into the bottom layer and back, along with organophosphates, to photosynthetic, sink layers and detritus tracked in both media simultaneously
- Here a ten year time series with statistics and trends, full maps available on request

COUPLED DMS PRODUCTION AS WELL

Coupled DMS Production as Well

- Early IARC attempts to track ice DMS after release into open water were successful
- Measurements reproduced above available – mainly Berge, Chloutz, Arribelga
- As yet unpublished but obtained results from the authors on request, as time permits

Three Dimensional Ice Algae Coming Soon

- LANL has developed dynamic tracer transport through the CICE brine system
- Mixing length theory with variable permeability/boudary in the channel network
- Already handling nutrients, carbon and chlorophyll but tracer vector can extend
- Global (ocean) approach to the ice algae and its aerocline coming very soon
- Will entail the light absorbing pigment as usual but also:
  - Emphasis to be place on dissolved organic carbon – the detrital side of the equation
  - Plans for calculation of organic effects on pore structure through colloids, gels
  - The detritus also contains strong non-binding ligands and they are surface active
  - We will analyze their effects in the Southern Ocean pack and ice domain

Application: DMS Production in Arctic Ice

LARC, LANL

LARC/LANL fully coupled ocean and bottom ice biogeochemistry

Left: Tests and validation of LANL mixing length theory-based brine transport. Major laboratory studies are matched. Right: Early tests of nutrient inflow driven chlorophyll buildup inside of Arctic CICE. Section shown runs from Bering to the pole. Soot and chlorophyll distributions inside pack will be connected interactively to radiation transfer:

Soot and Chlorophyll absorption

- PNI, LANL has recently improved CAM soot transport, deposition on Arctic sea ice
- LANL has capability to transport soot downstream and into ice
- Note the above calculations of 3D chlorophyll distributions can be simultaneous
- Under LANL IGPP support, we will keep key areas of soot and pigment absorption
- Use Delta-Eddington scheme to evaluate competition, polar climate amplification

Current Plans: Organics Within the Ice

- We will simulate the chemical speciation of DMS as delimiters within brine channels
- Based on current macro/molecular aerosol sources – sulfates, chlors
- Get the substance to plug pores in brine channels and after internal transport
- We will evaluate effects on the structure and transport of the large-scale pack
- A strongly overlapping set of compounds could be included within the ice
- Hence LANL can also determine the stability and biodegradation/availability during melt

Feedbacks: The Ultimate Goal

- Inorganic iron carbon will experience rapid transport to the thermocline in brine slugs
- Iron regeneration in ocean waters continues development after the melt in Southern spring
- Chlorophyll generated internally amplifies ice losses if habitats are at upper levels
- Soot will complete and must be transported into the pack for radiation calculations
- All the above require coupled ocean-ice biogeochemistry for full analysis

Relevant Recent Publications