Some Impacts of Sea Ice Micro-structure on Ice Algal Growth

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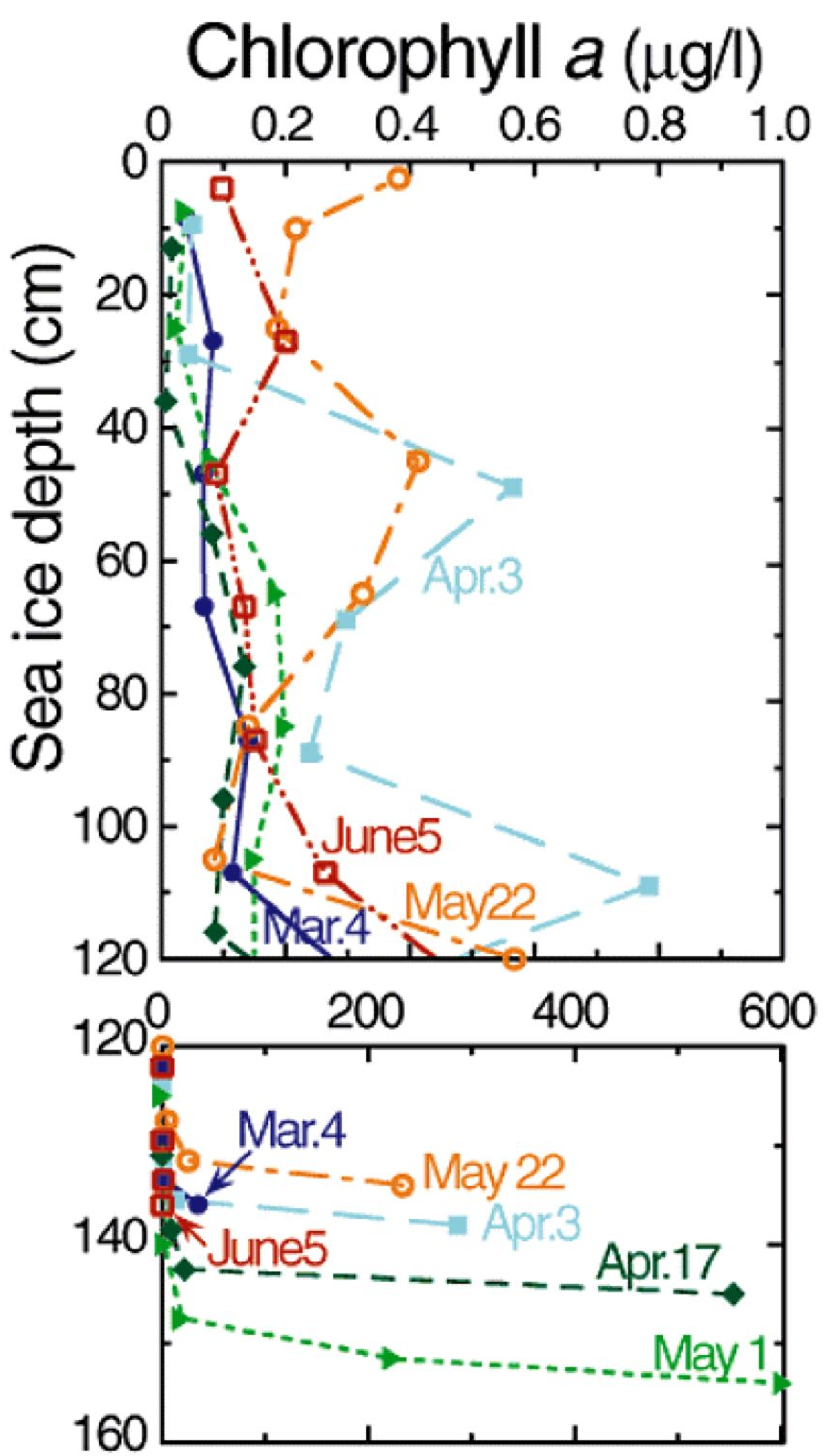
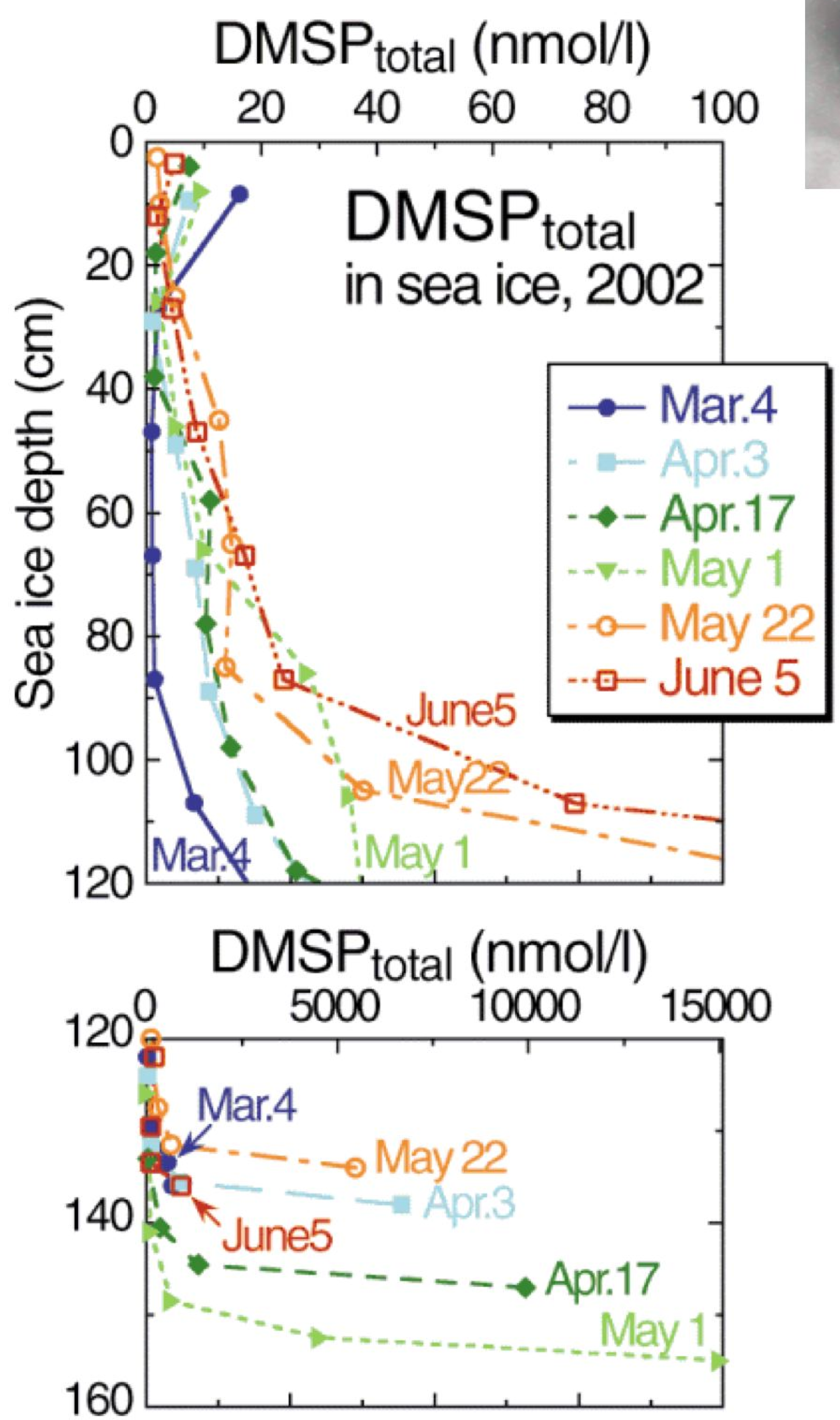
June 16, 2009 14th Annual CCSM Workshop Polar Climate Working Group Meeting

Why Ice Algae?

1. High concentrations of Chla and DMSP found in skeletal layer of Arctic Sea Ice



Shin et al. 2003



Uzuka et al. 2003

Krembs & Deming
University of Washington

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Why Ice Algae? (cont'd)

2. Modifies sea ice optical and thermodynamic properties. ~ 85% of radiation absorbed through photosynthesis

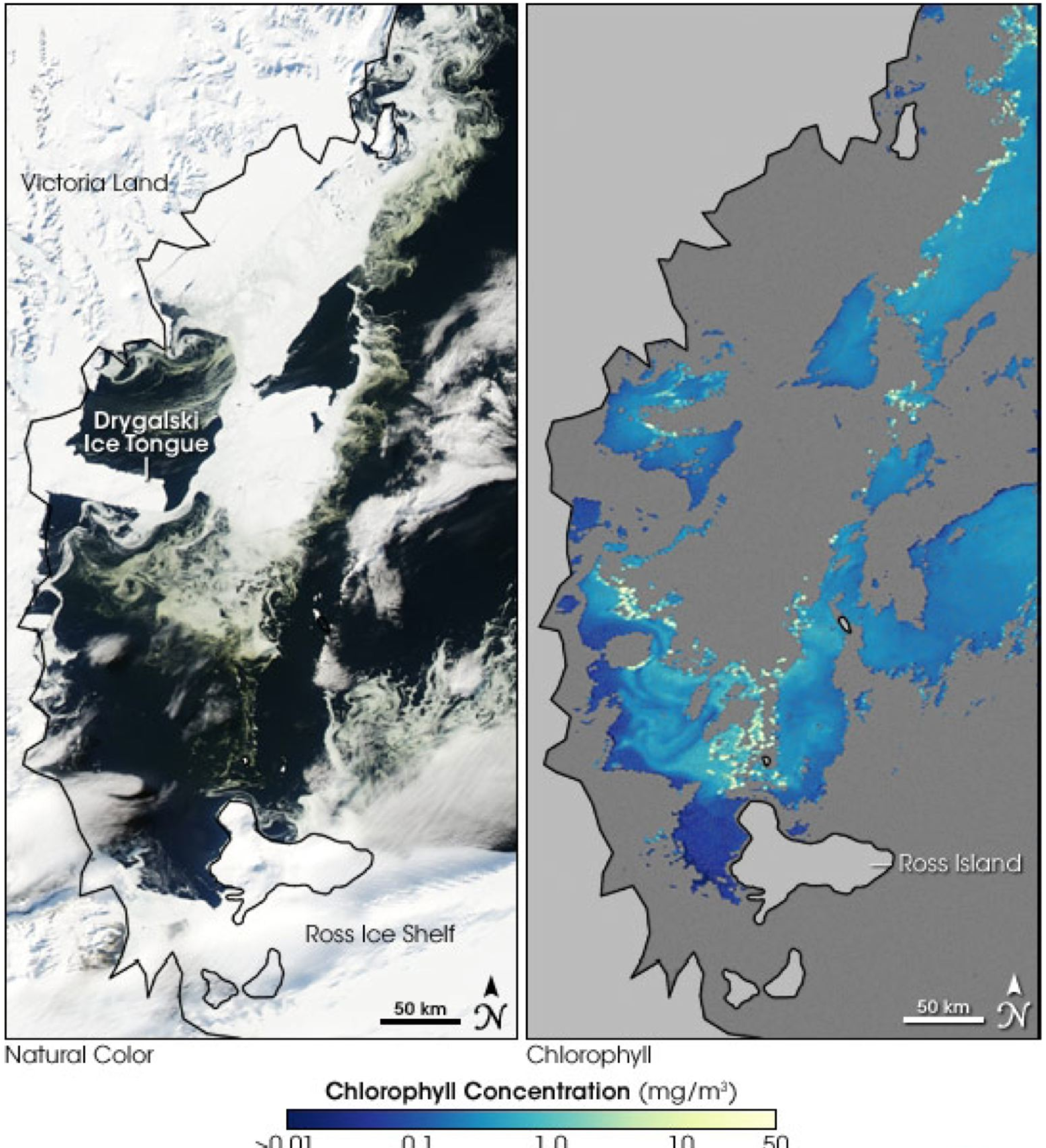
Richard Cullather

3. Extends the growing season and provides an important niche in polar ecosystems

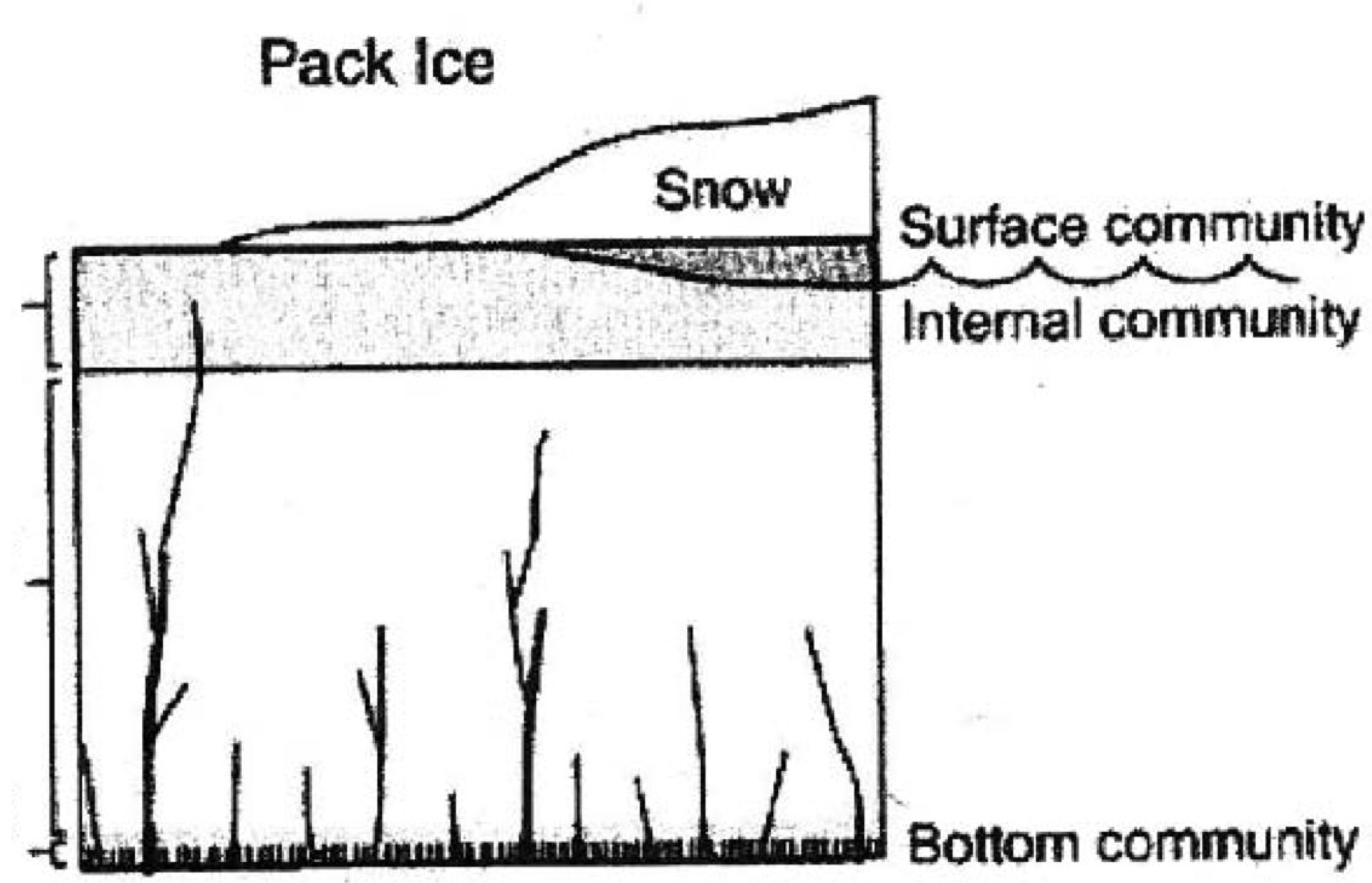
4. Plays a role in ice edge dynamics

Summer Bloom In the Ross Sea

MODIS image NASA's Aqua



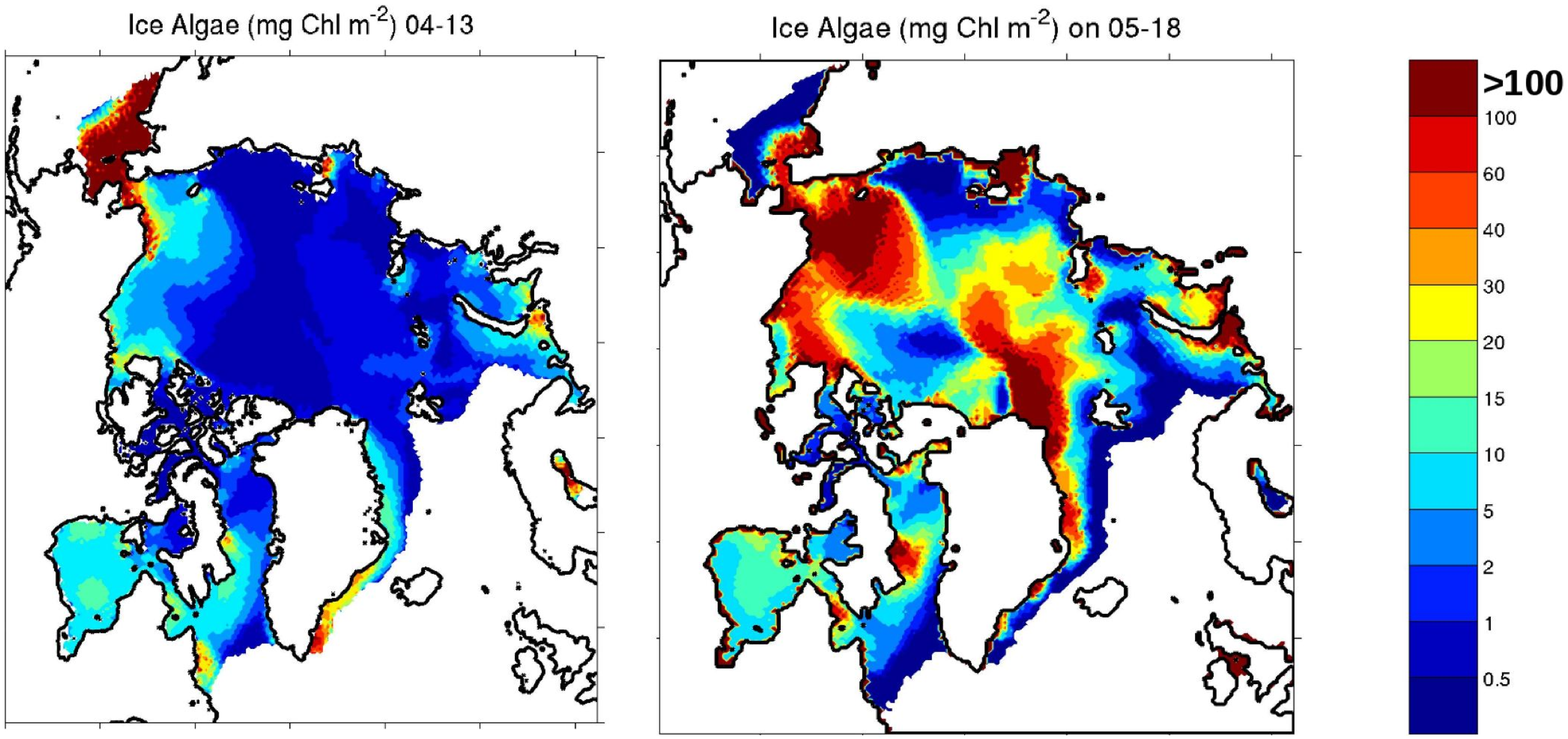
Ice Algae	Annual Prod. (10^{11} g Chla y^{-1})
Surface	5
Freeboard	2
Interior	0.2
Bottom	0.2-1



(Arrigo et al. 2004)

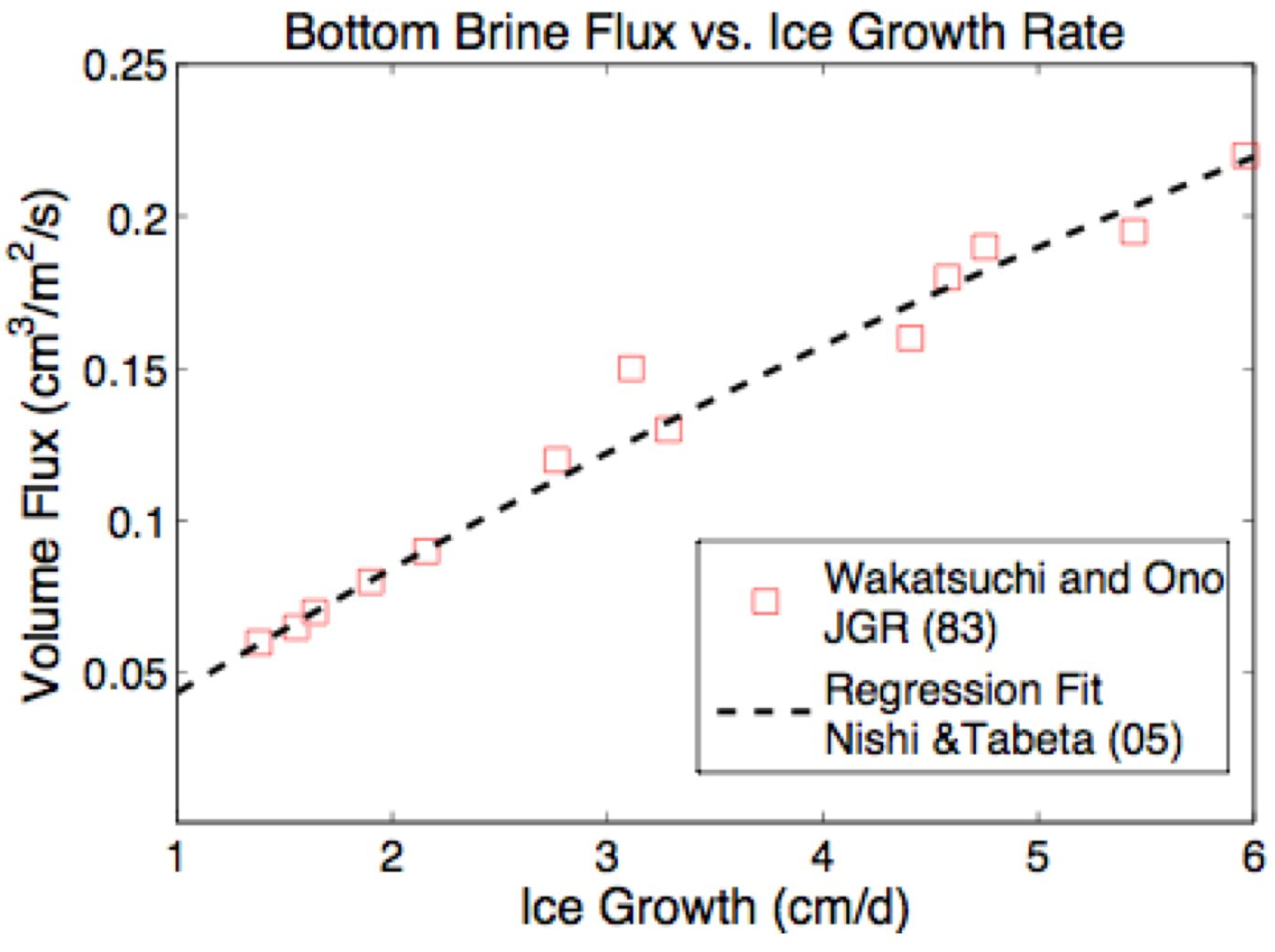
Ice Edge Dynamics

Skeletal Layer Model



Deal, Jin and Elliott

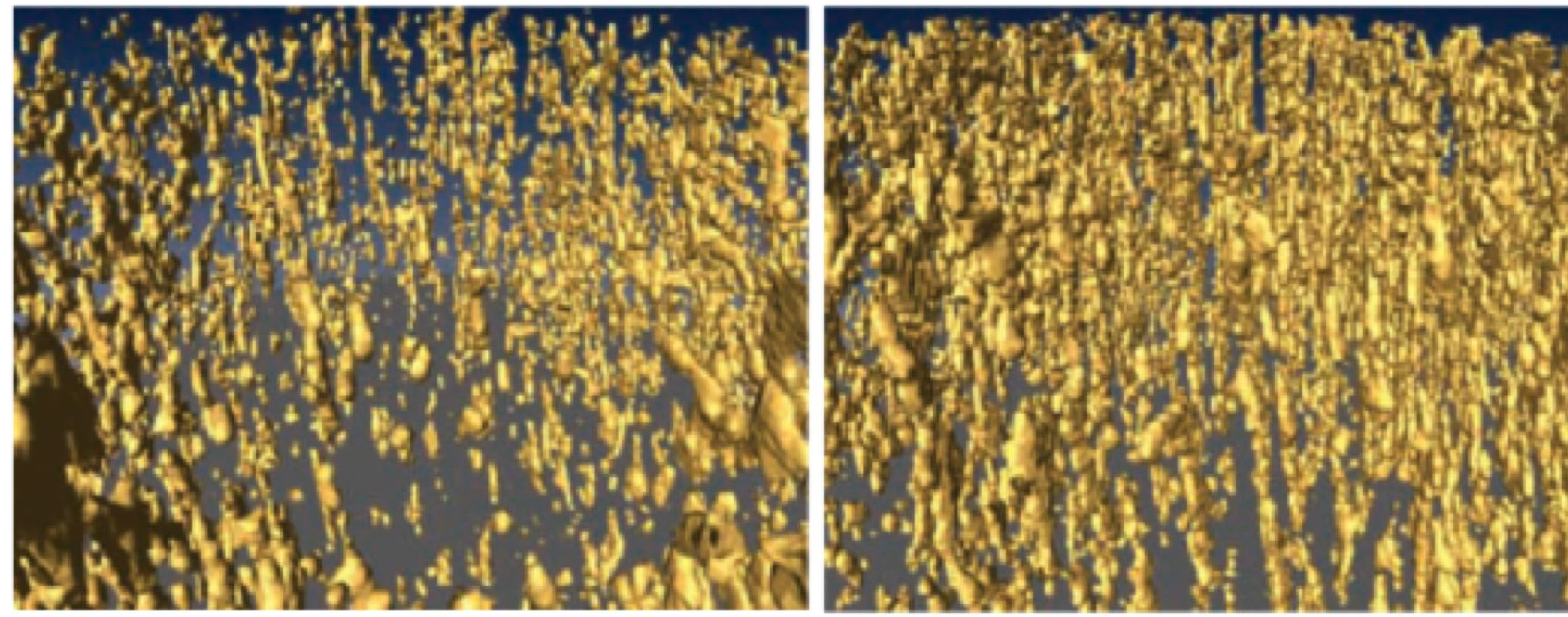
- Ice thickness (PAR)
- Ice extent (2 cm skeletal layer)
- Ocean nutrient climatology
- Biogeochemical reactions
- Brine driven bottom flux



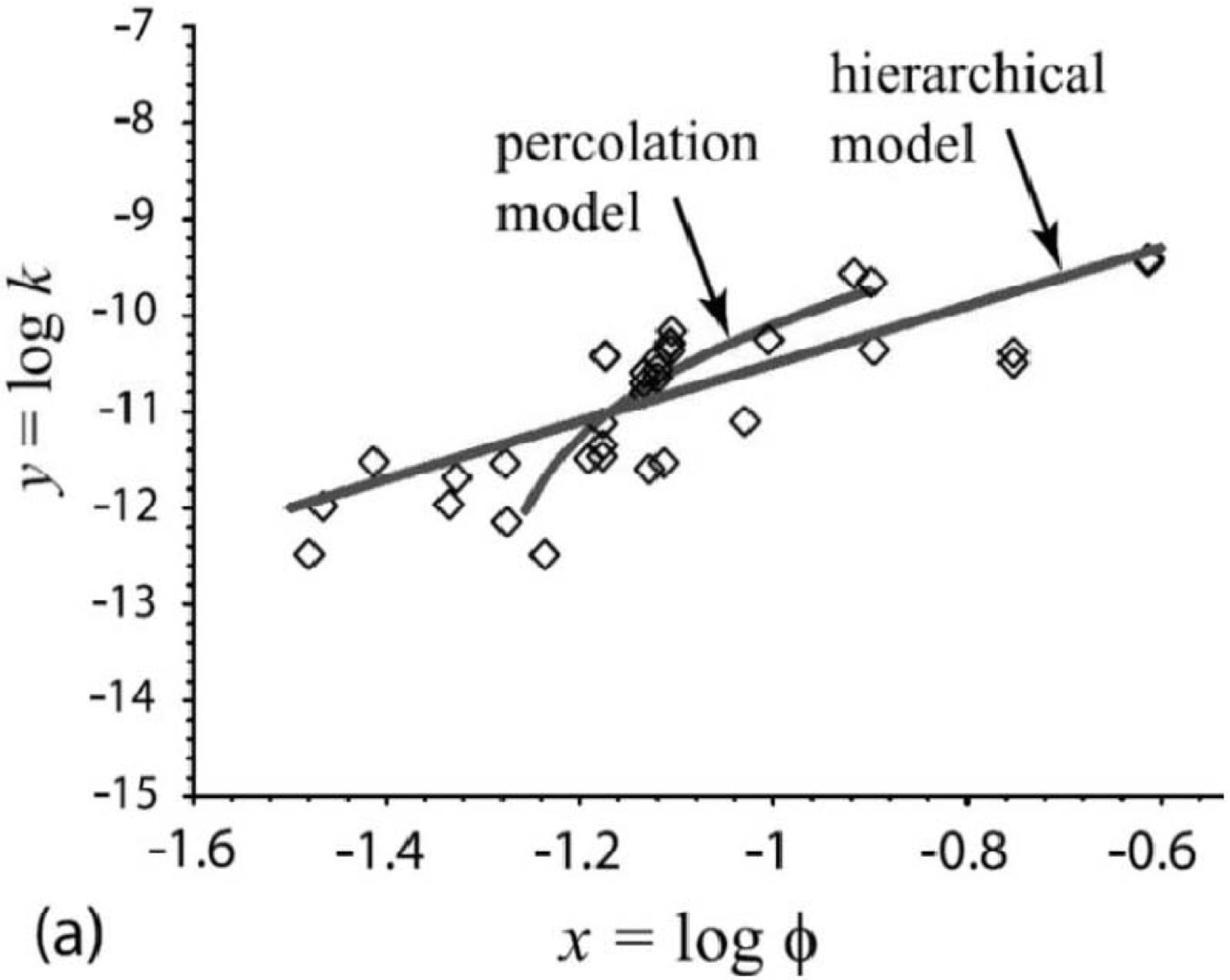
Multi-layer Ice Algal Model

- Sea ice porosity (ϕ) and permeability (k) as functions of T and S

GOLDEN ET AL.: PERMEABILITY AND MICROSTRUCTURE IN SEA ICE



$\phi = 0.033$ $\phi = 0.075$



- Gravitationally unstable Brine motion: brine density as function of T
- Nutrient transport model based are Darcy's Flow and Mixing length theory

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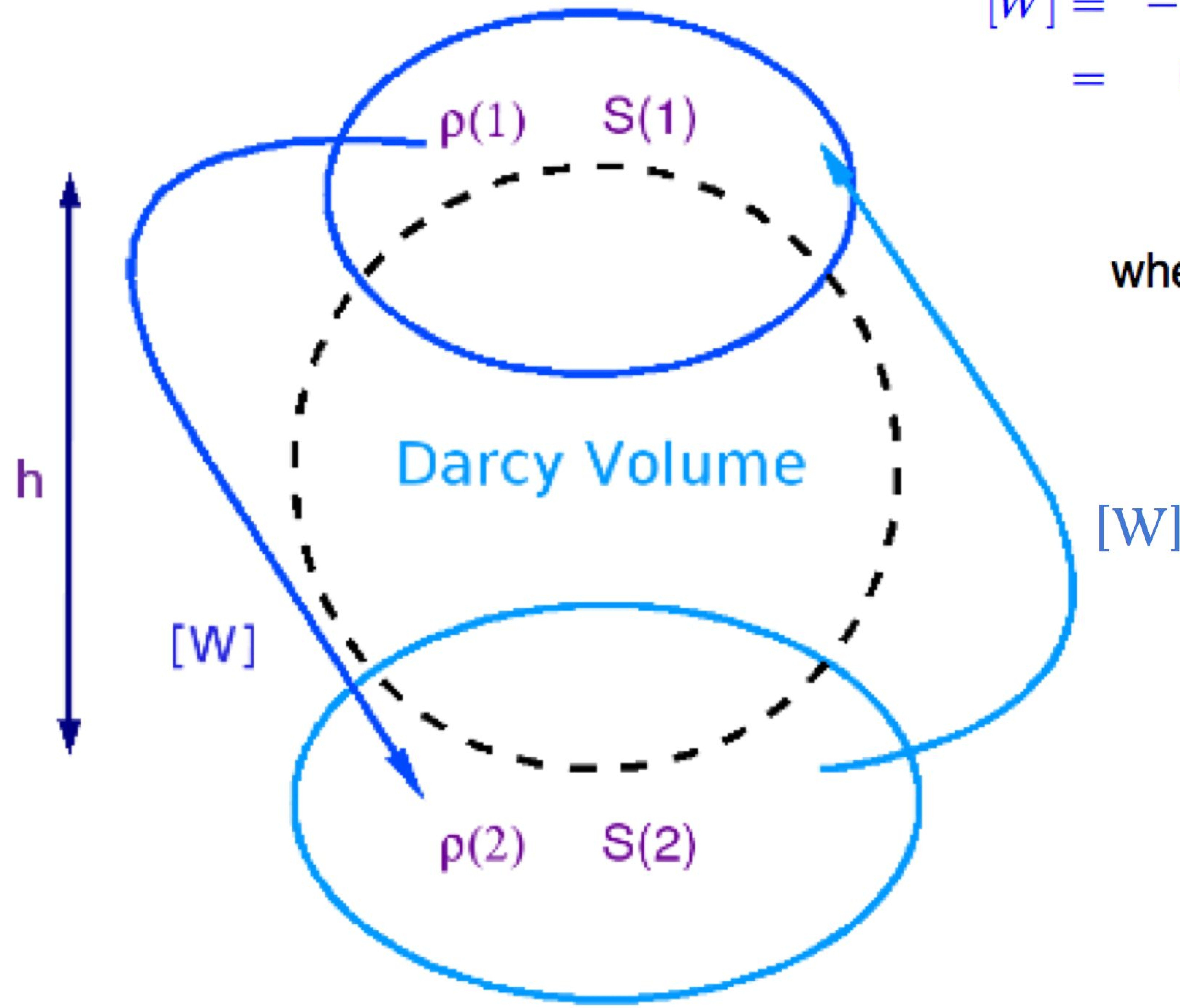
Mixing Length Theory

$$[W] = -\frac{kg}{\mu}[\triangle\rho]^i \quad \text{for unstable profiles}$$
$$= 0 \quad \text{for stable profiles}$$

where $[\triangle\rho]^i = \frac{d[\rho]^i}{dz}h$



Advection $\frac{\partial}{\partial z}(|[W]|\Delta[S]^i) \rightarrow \frac{\partial}{\partial z}\left(|[W]|h\frac{\partial[S]^i}{\partial z}\right)$ Diffusion

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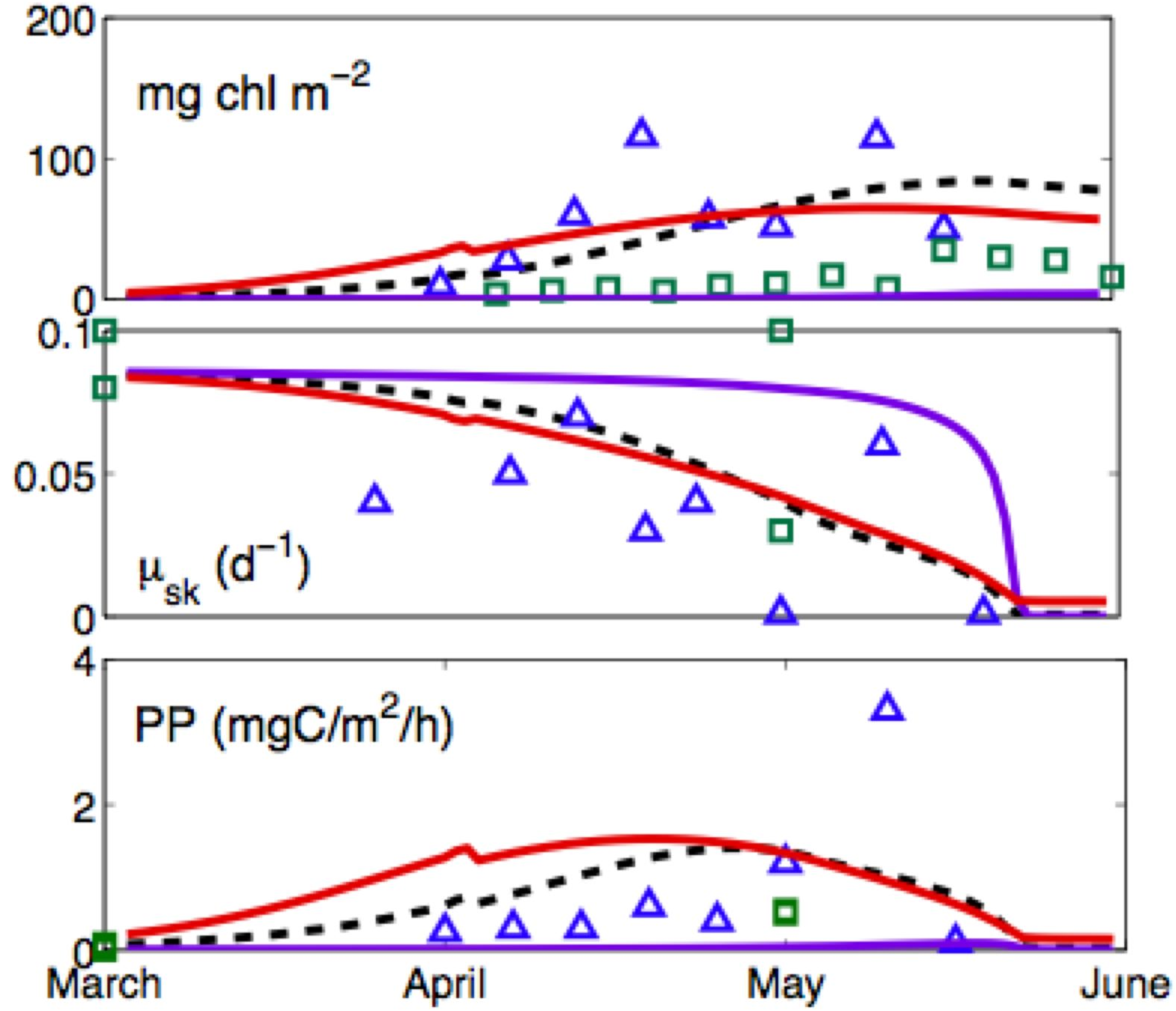
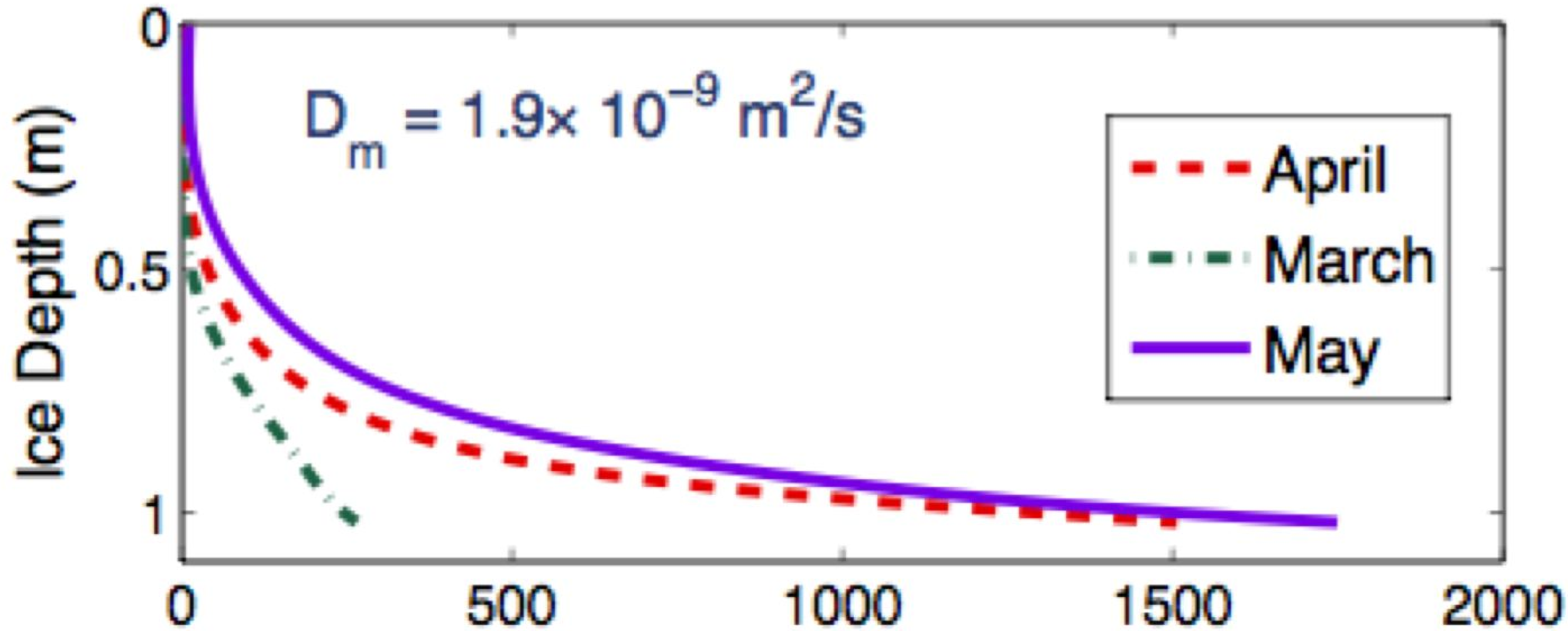
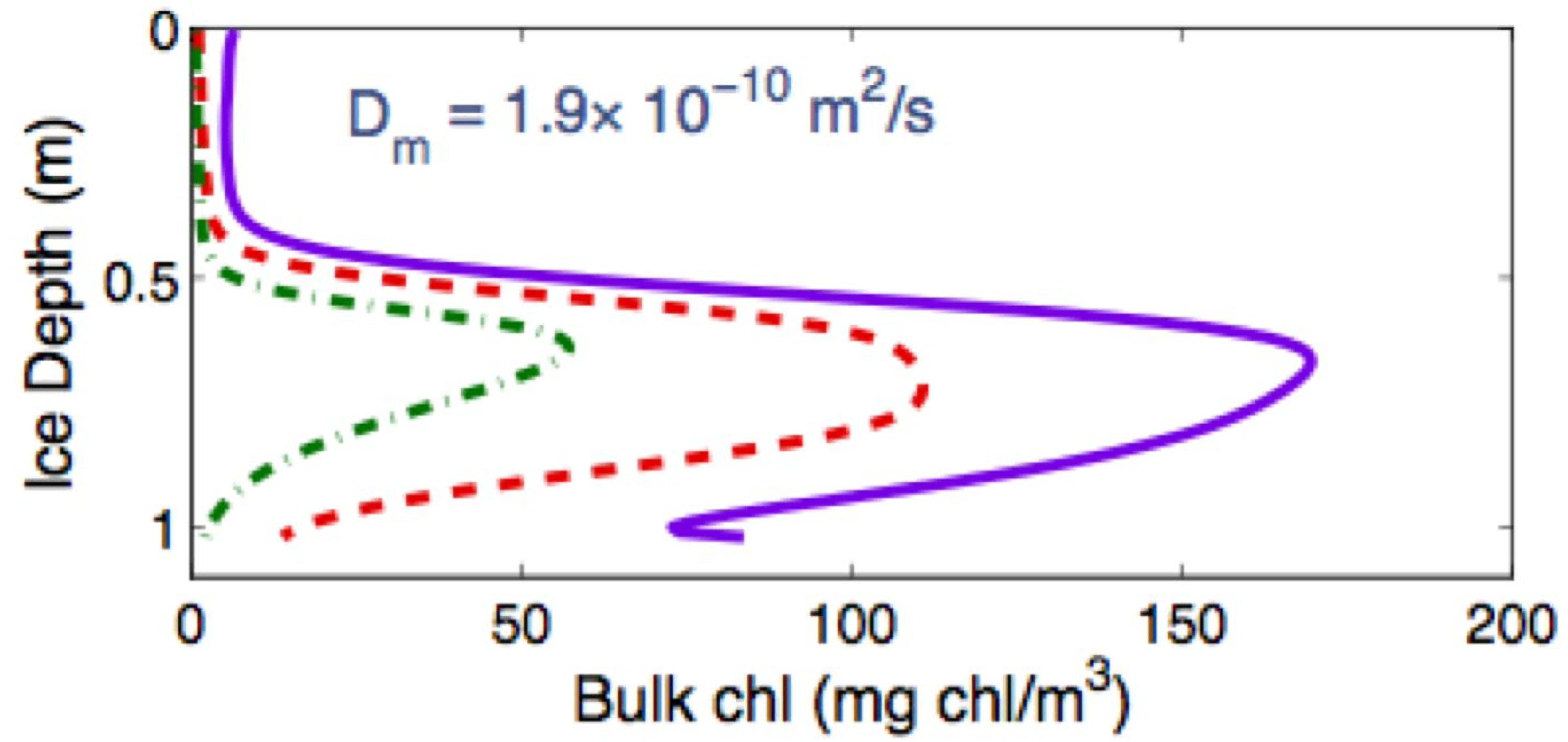
Model Sensitivity: Example, D_m



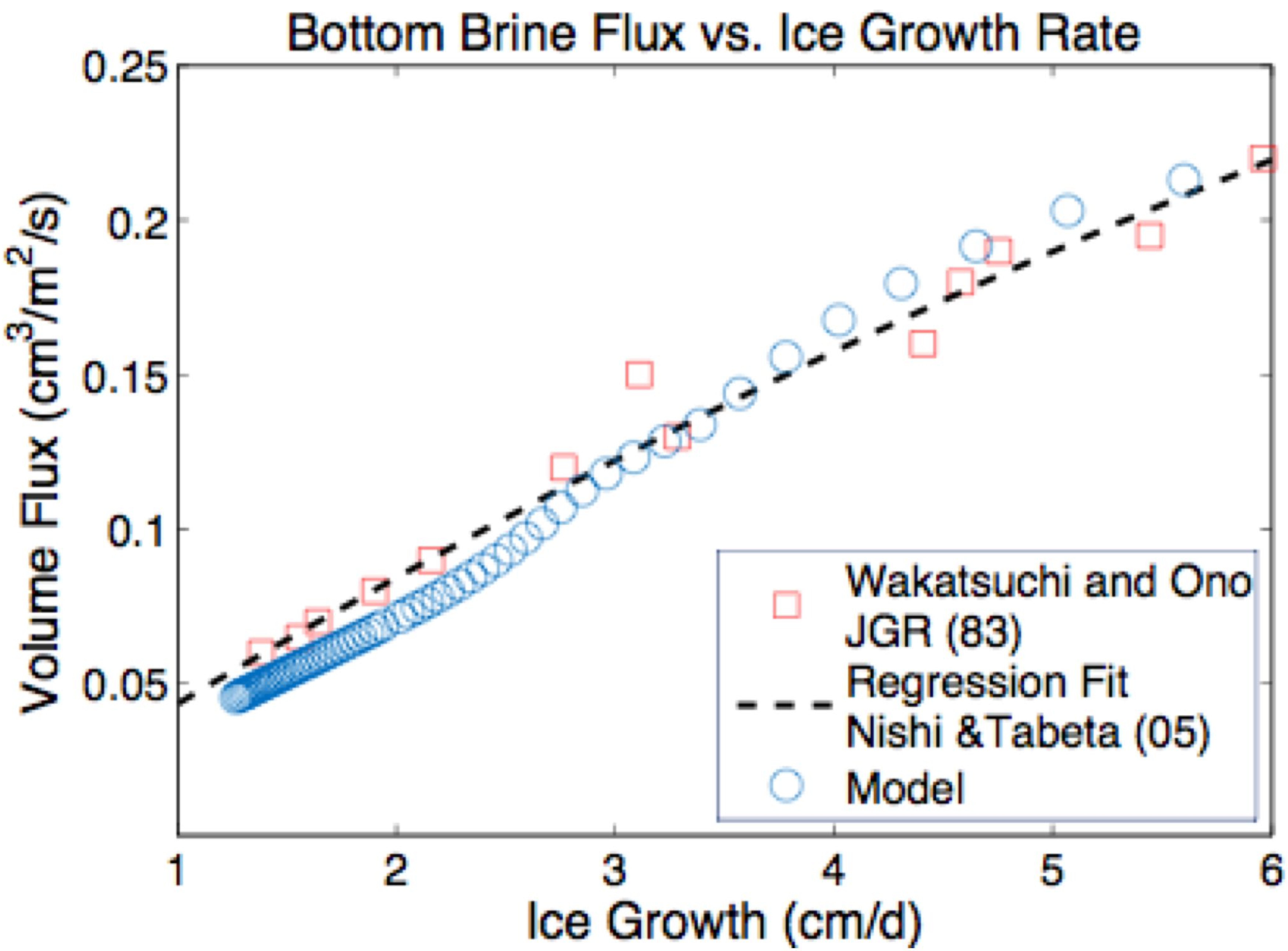
- $D_m = 1.9\times10^{-8}$ m^2/s
- $D_m = 1.9\times10^{-10}$ m^2/s
- $D_m = 1.9\times10^{-9}$ m^2/s Standard run

- Smooth polynomial forcing of Tair, and PAR
- -- Standard run: $D_m = 1.9\times10^{-9}$ m^2/s
- Skeletal layer integration (5cm)
- D_m varied 2 orders of magnitude





Model Support: Is D ∝ Brine Flux?



- A crude comparison, but possibly
- Thickness dependence?
- Multi-layer model is consistent with skeletal layer flux assumptions
- Results are encouraging

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Continuing Research

- Sensitivity studies and data comparisons
- Include Darcy velocity driven by non-hydrostatic pressure gradients. Eg, snow loading, melt-ponds
- Prepare code for global simulations

Sea Ice diatoms