

Updates on developments in CICE ice biogeochemistry

Nicole Jeffery
Los Alamos National Lab

Scott Elliott, Elizabeth Hunke, Mathew Maltrud, Adrian Turner, Shanlin Wang,
Clara Deal, Meibing Jin

This Talk

- What's in CICE.v5 A quick description of skl-bgc and update on work in progress
- *The zbgc development branch*: Getting ready for prime time...
- Two hypotheses for the drivers of ice algal production
- A Weddell Sea test case
- Extrapolation to the poles

CICE.v5 ice biogeochemistry

Skeletal Layer BGC Model



3 cm porous layer during ice growth

Ice BGC components

- 1) Algal Nitrogen
- 2) Nitrate+Nitrite
- 3) Ammonium
- 4) Silicate

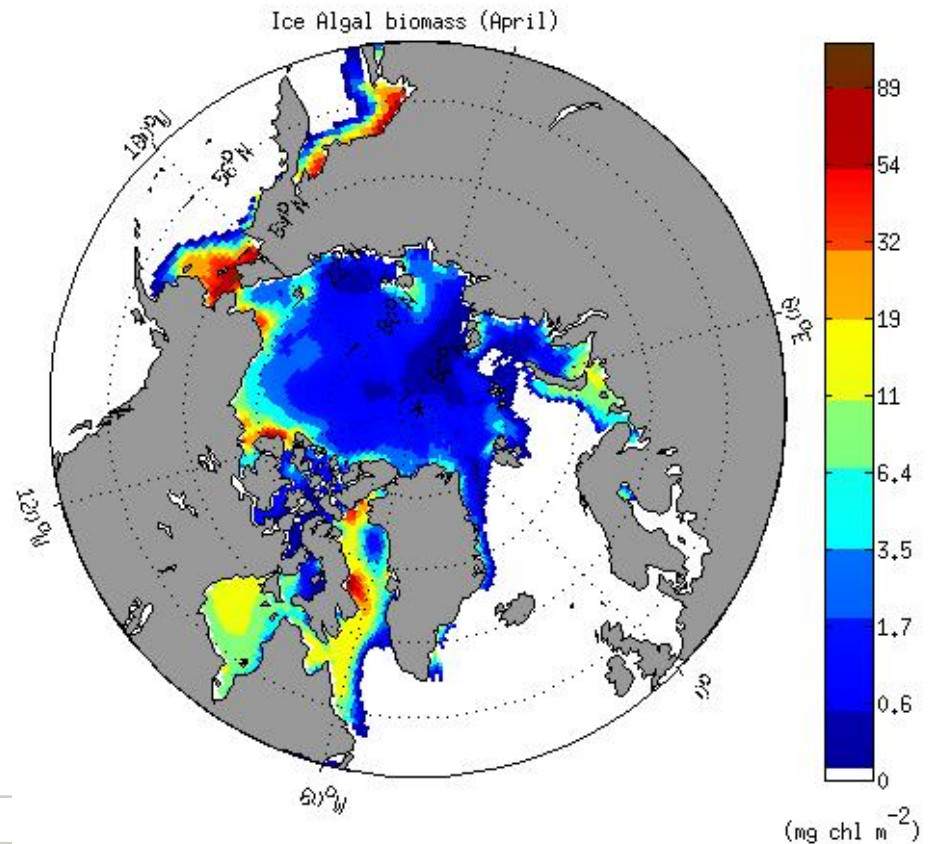
Skl physics

bgc_flux_type:

- 1) 'jin2006'
- 2) 'constant'

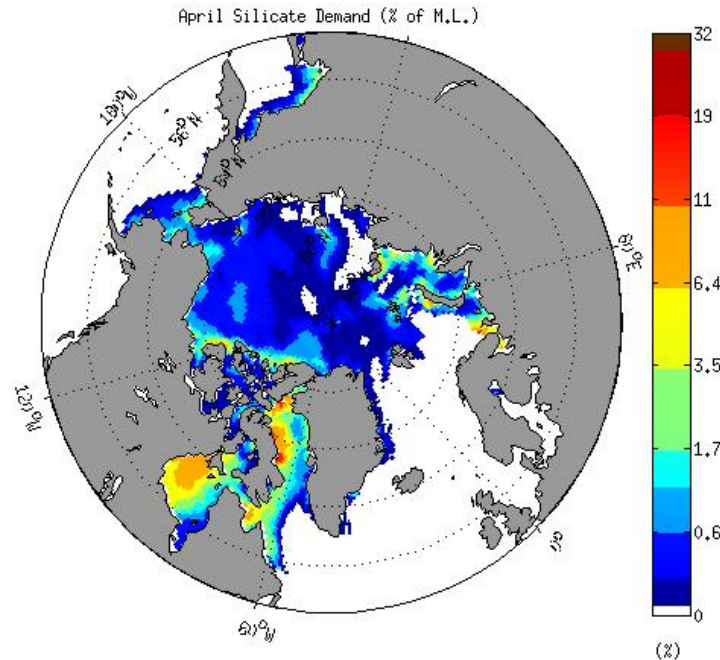
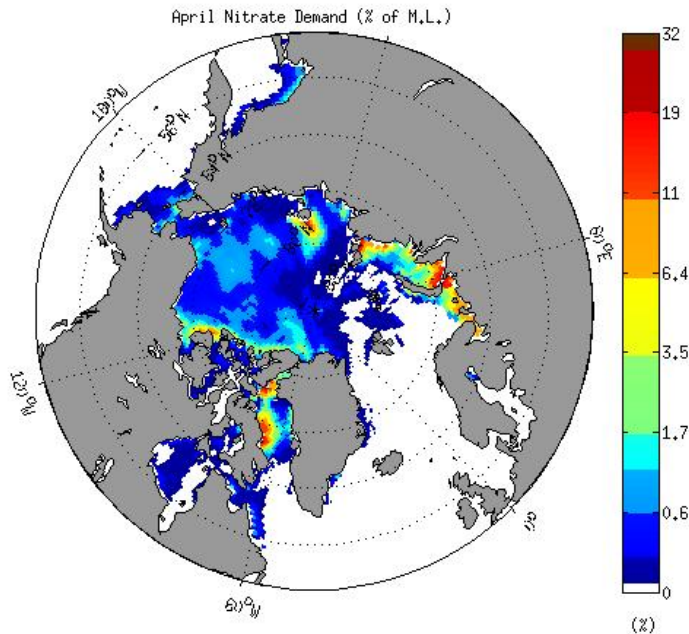
Specify a priori

- 1) Skeletal layer thickness
- 2) Skeletal layer porosity



What is the ice algal demand for M.L. nutrients?

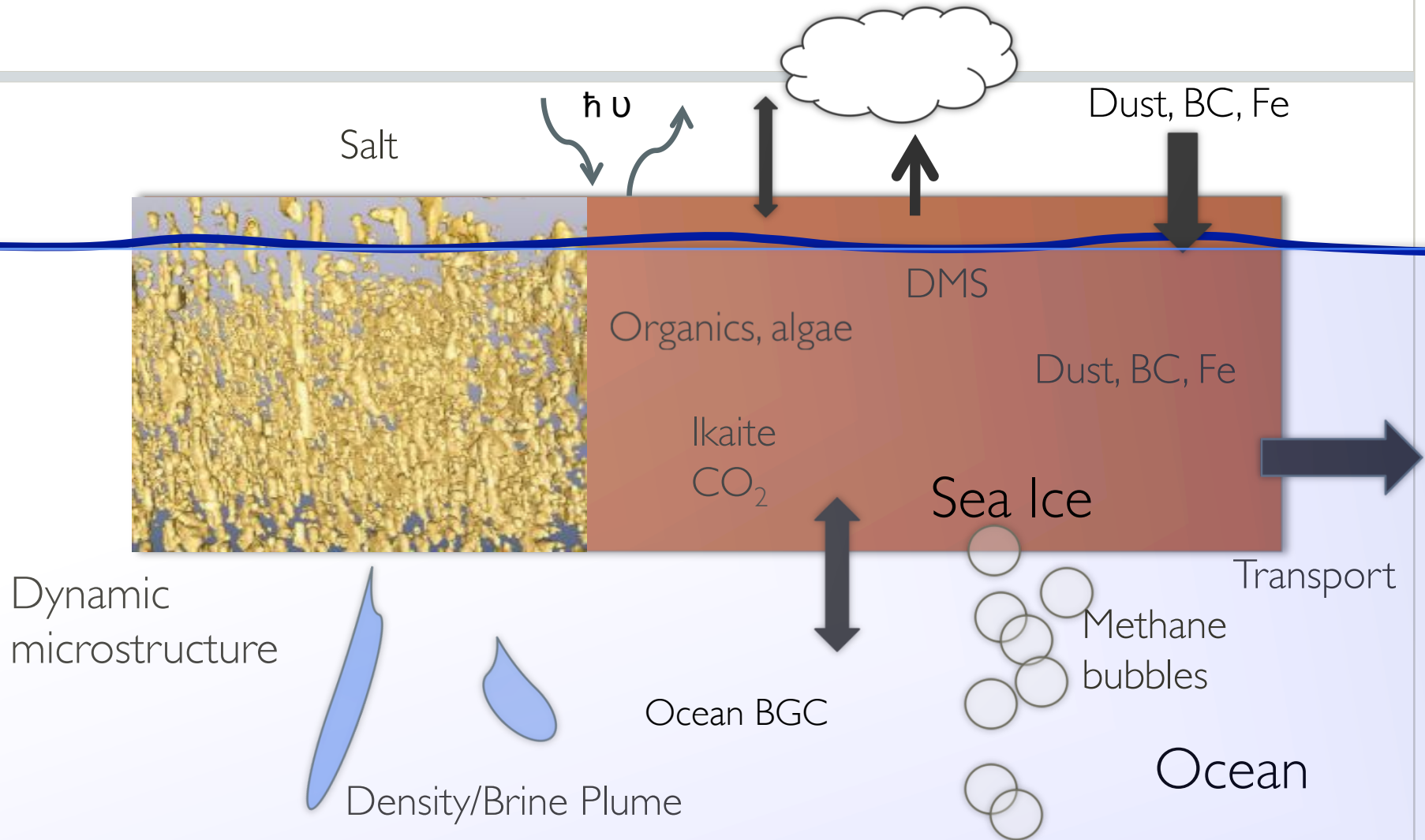
% of M.L. Nitrate/Silicate required by ice algae in April



Still needed
*Ice-ocean coupling

New momentum for coupling!
*rbgc-RASM Project
(Meibing Jin)

Hopes, Dreams and Developments

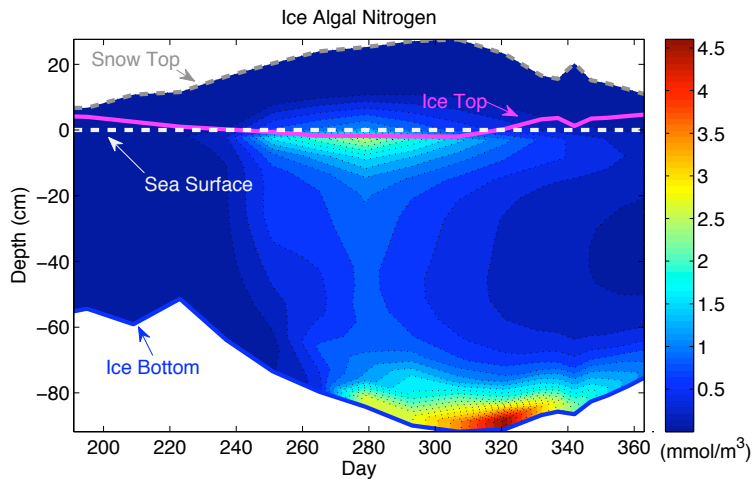


zbgc Branch updates

- Passive tracer transport scheme: *Now positive preserving and flux-corrected*
- Transports aerosols (2 black carbon, 4 dust types) and reactive biochemistry
- New “bipolar” biochemistry module (Scott Elliott): variable complexity (specified at runtime), works with skl and zbgc
- Ready to merge with the CICE trunk (after the next release).

zbgc vs skl

Vertically resolved BGC Model (zbgc)



zbgc only:

- 1) Ice tracers can accept atmospheric fluxes
- 2) Chlorophyll absorption coupled to Delta-Eddington ice/snow IOPs: alters ice growth and under ice PAR

zbgc and skl

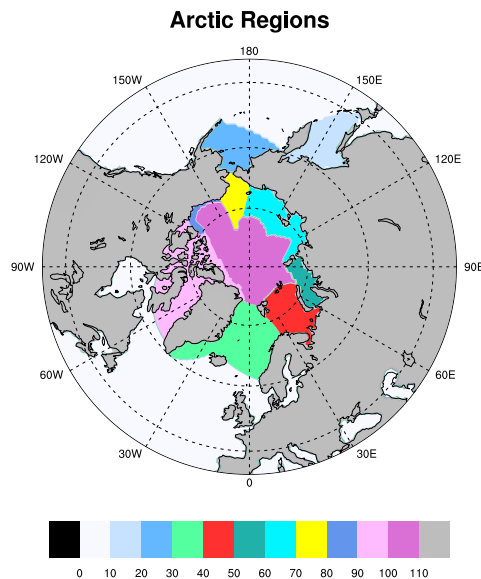
Expanded (Scott's bi-polar) biogeochemistry

- 1) 3 Algal types : diatoms, flagellates, *Phaeocystis* (for Shanlin's ocean *Phaeocystis*)
- 2) DON: proteins
- 3) 2 DOC: polysaccharides, lipids (aerosol connection and SO iron)
- 4) 1 DIC: with the potential for more (CO₂...)
- 5) Nitrate+Nitrite
- 6) Ammonium
- 7) Silicate
- 8) DMSPd (thanks Clara and Meibing!)
- 9) DMS (anticipating ocean coupling)

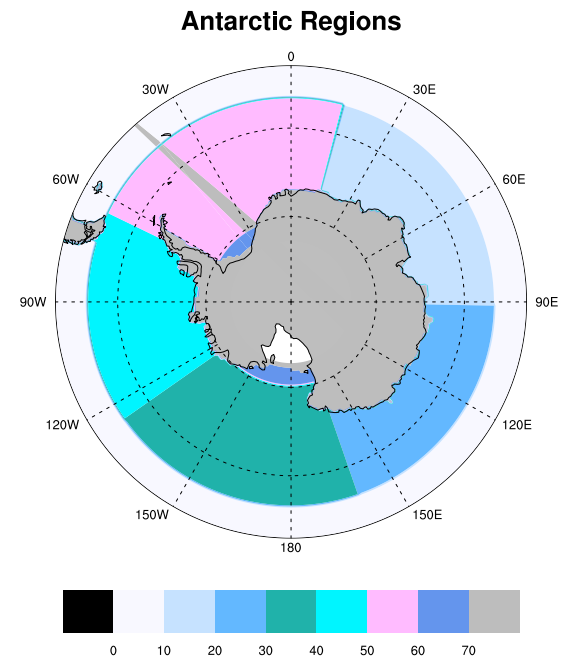
Validation of BGC module: “order of magnitude”

1) Weddell Sea Test Bed: 1D (rct grid) simulation of ISPOL field study

2) Polar scale simulations: Extrapolation of bgc assumptions. CICE stand alone, 1° grid

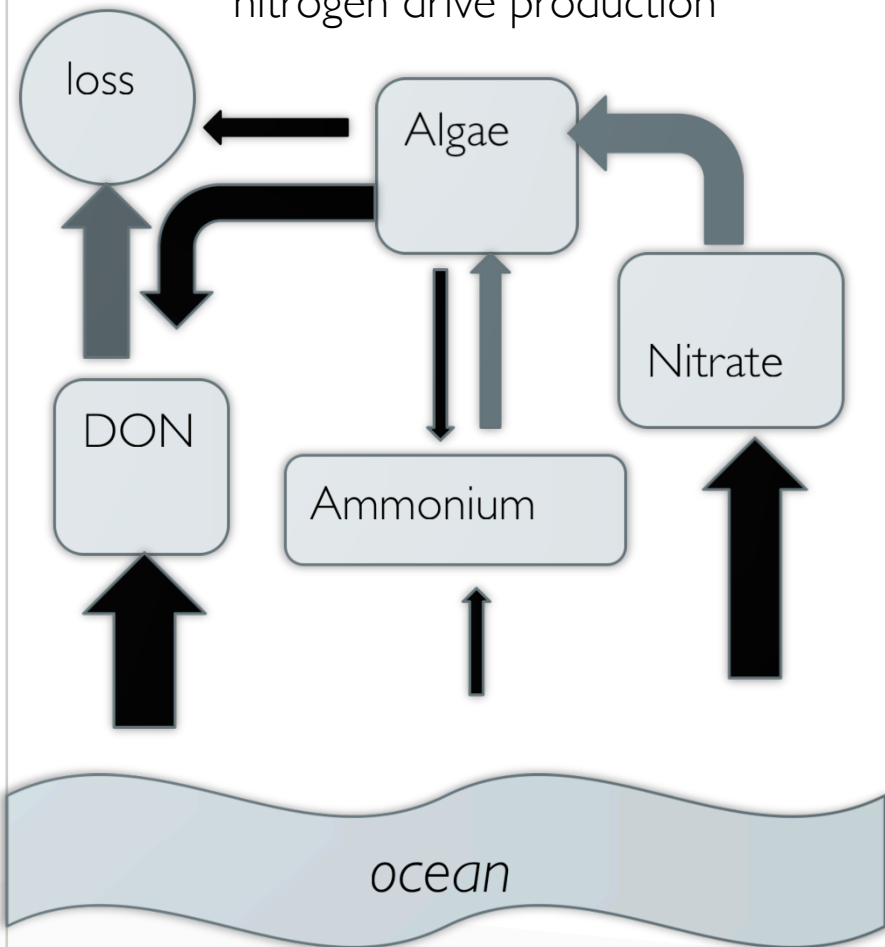


3) Regional scale, off-line simulations based on algal communities (i.e. upper, interior, skeletal layer communities)
*Scott Elliott

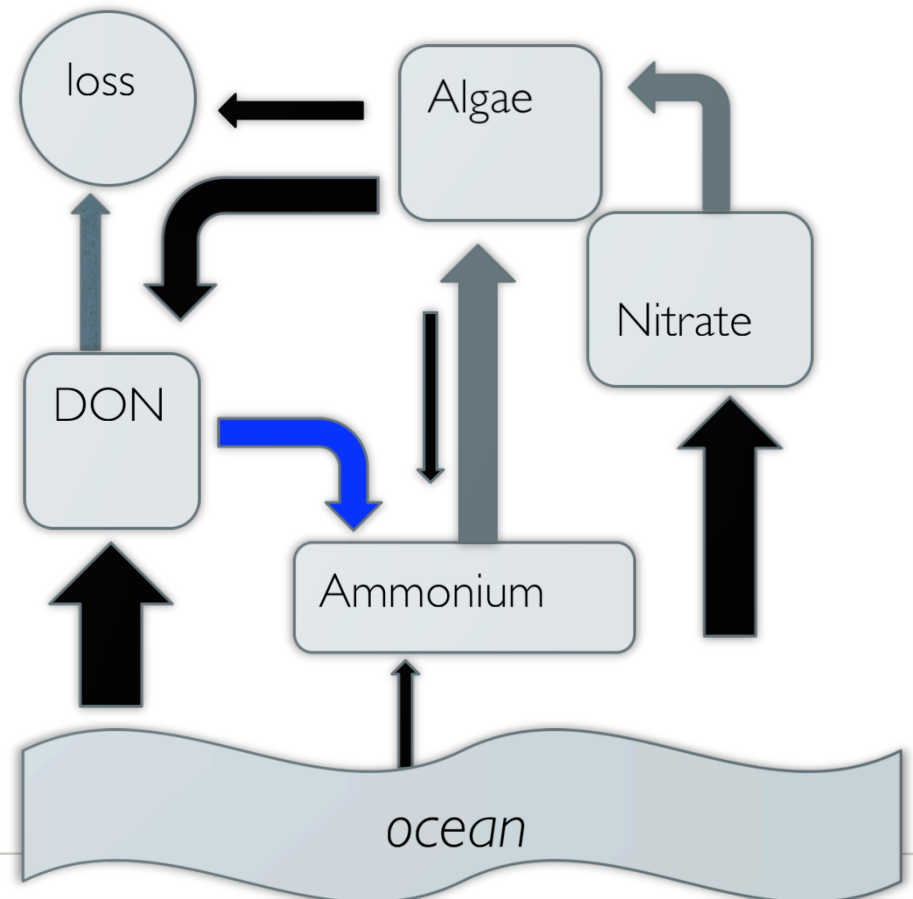


Hypotheses: drivers of ice algal production in the Southern Ocean

1. "New" sources of inorganic nitrogen drive production



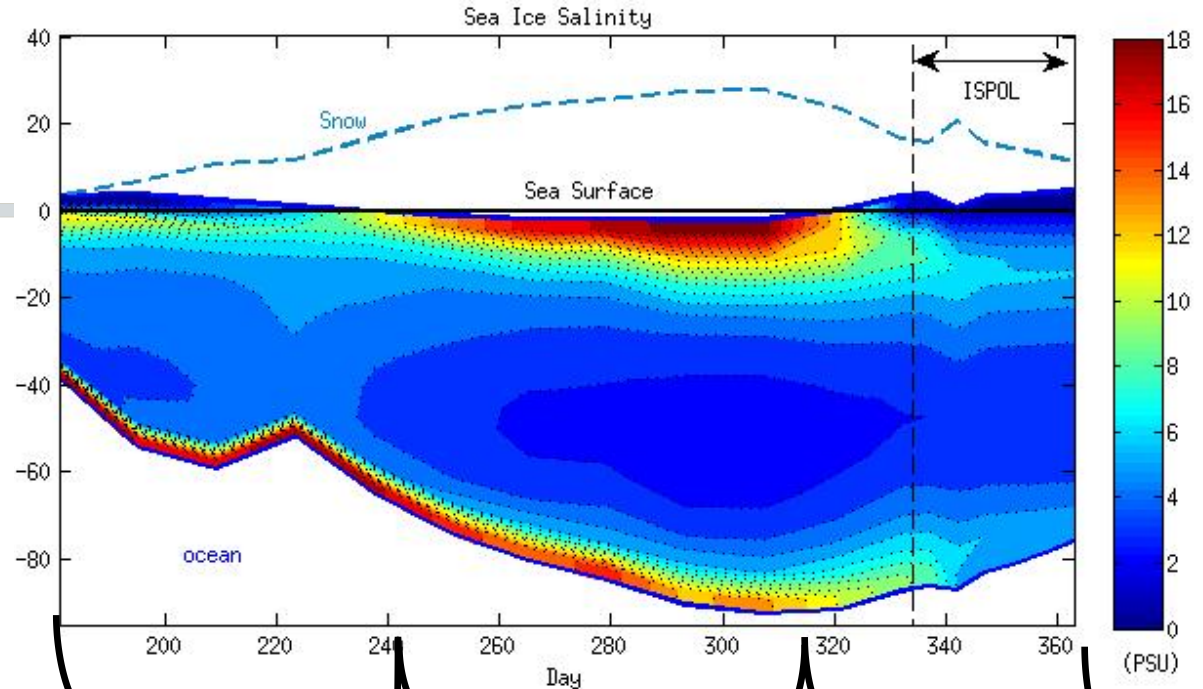
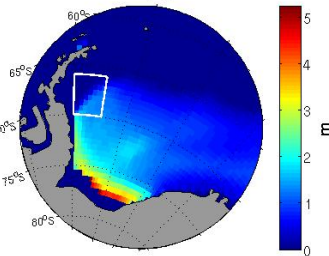
2. The remineralization (Rem) pathway dominates production



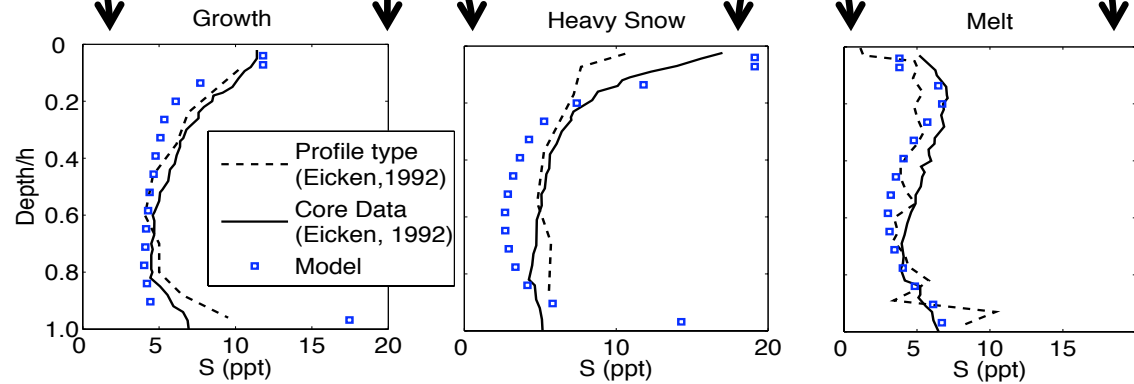
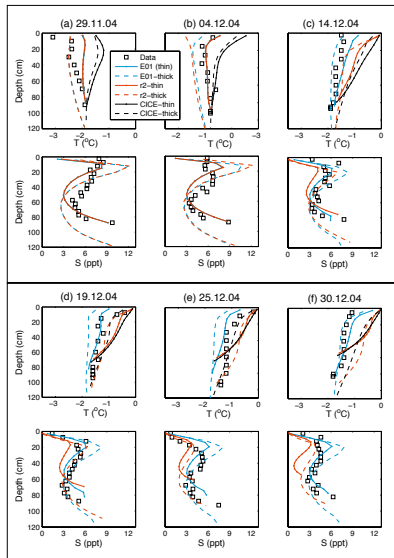
Weddell Sea Test Case

Ice Station *Polarstern*
 Western Weddell Sea
 Nov 28-Dec 31, 2004

Ice Thickness (a) 29.11.04

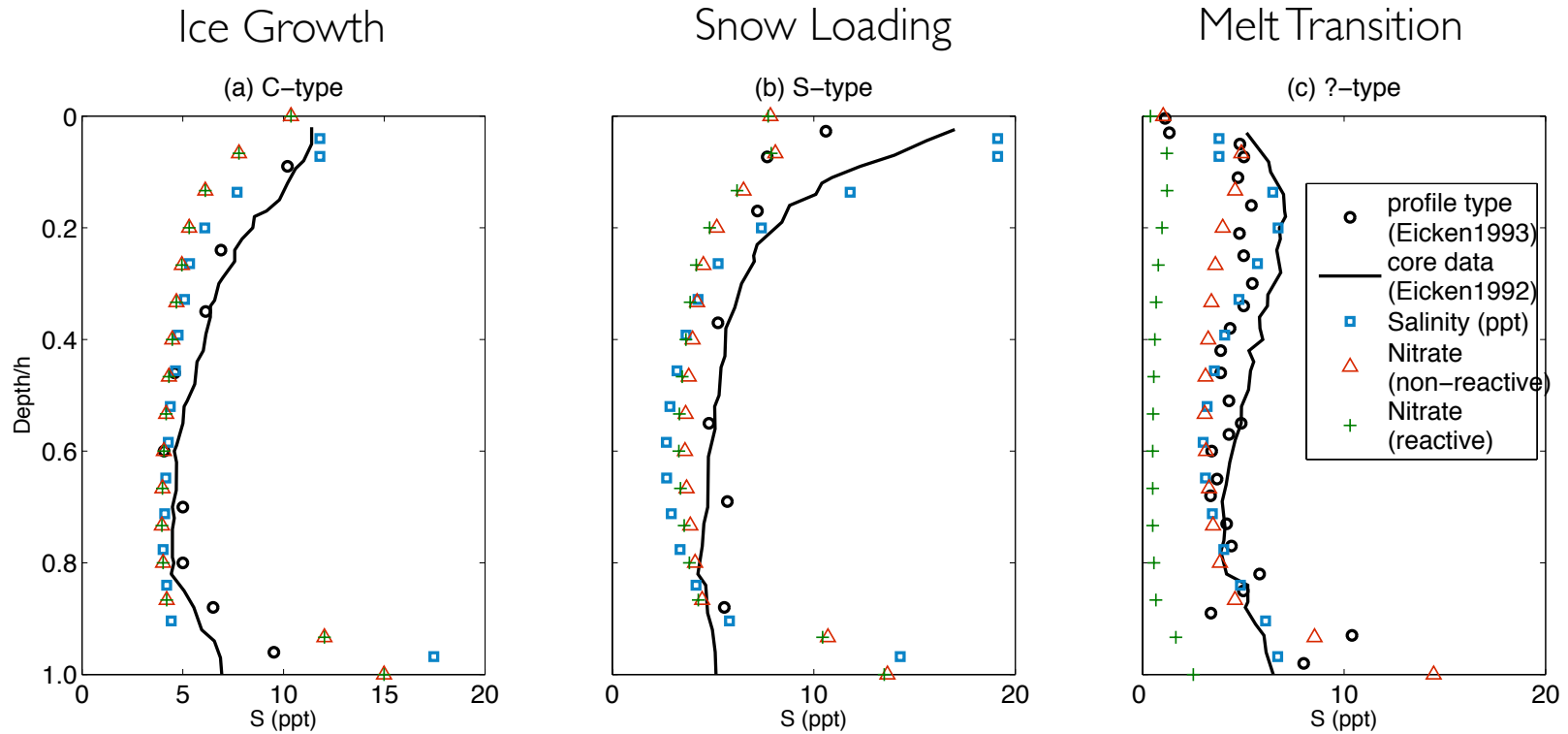


Core sample comparison



Characteristic profile comparison

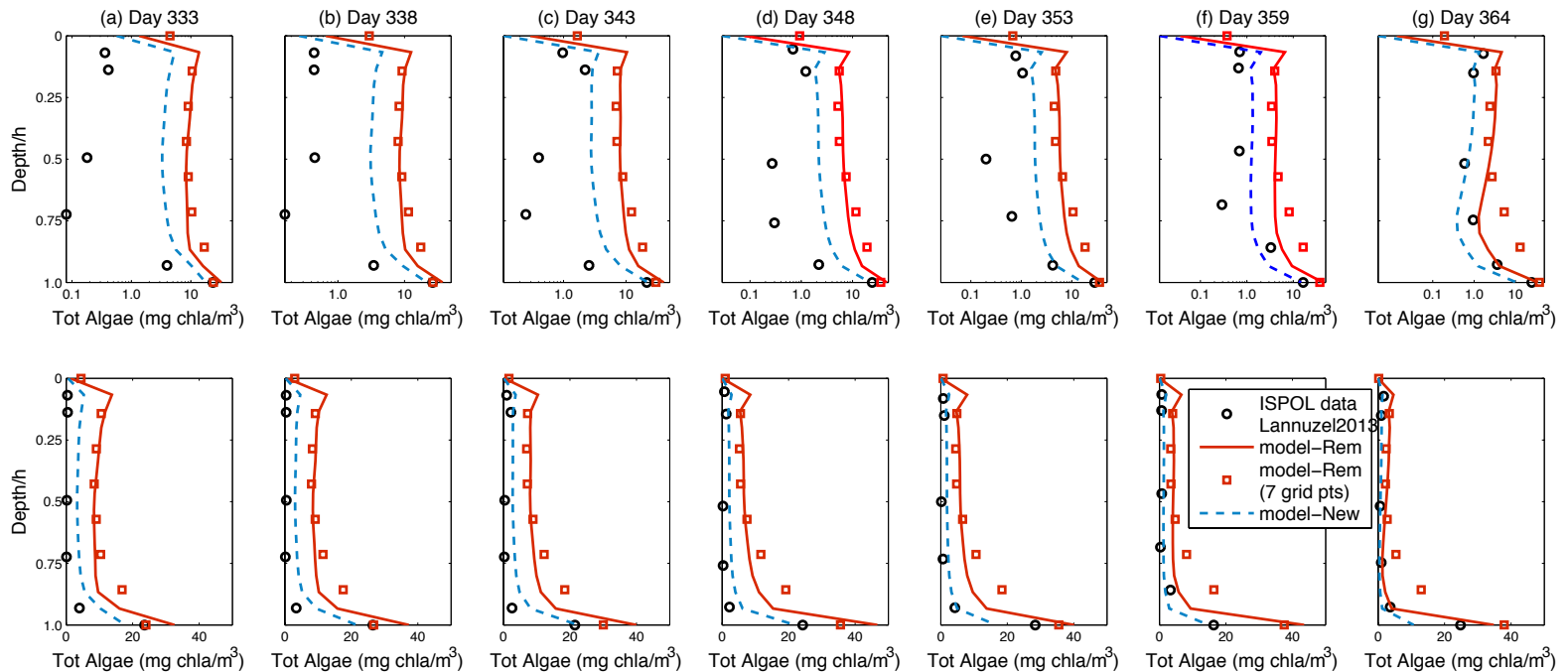
Tracer Transport Validation



+ Passive tracer with
Reaction terms

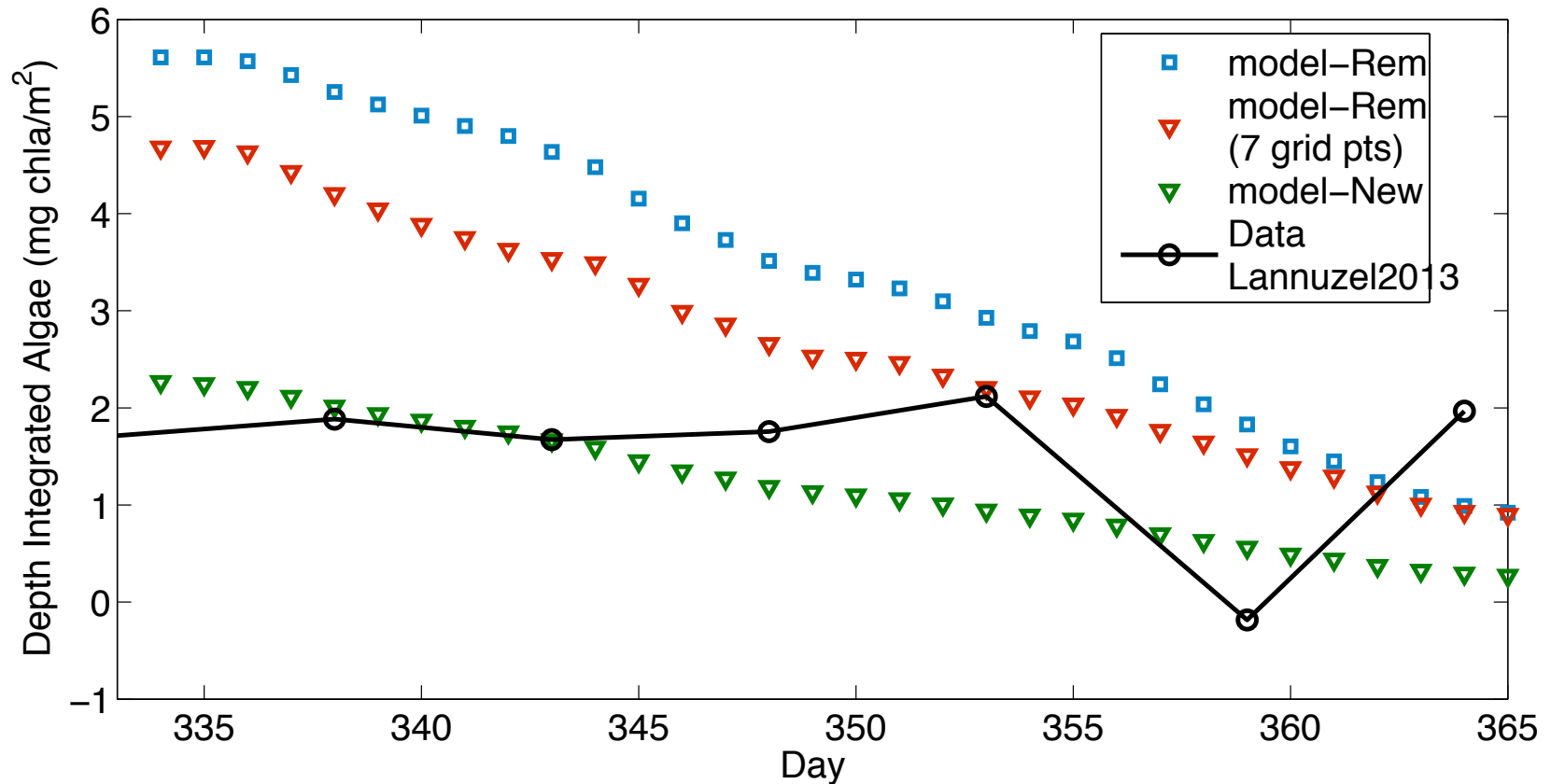
△ Passive tracer

Total algal chlorophyll



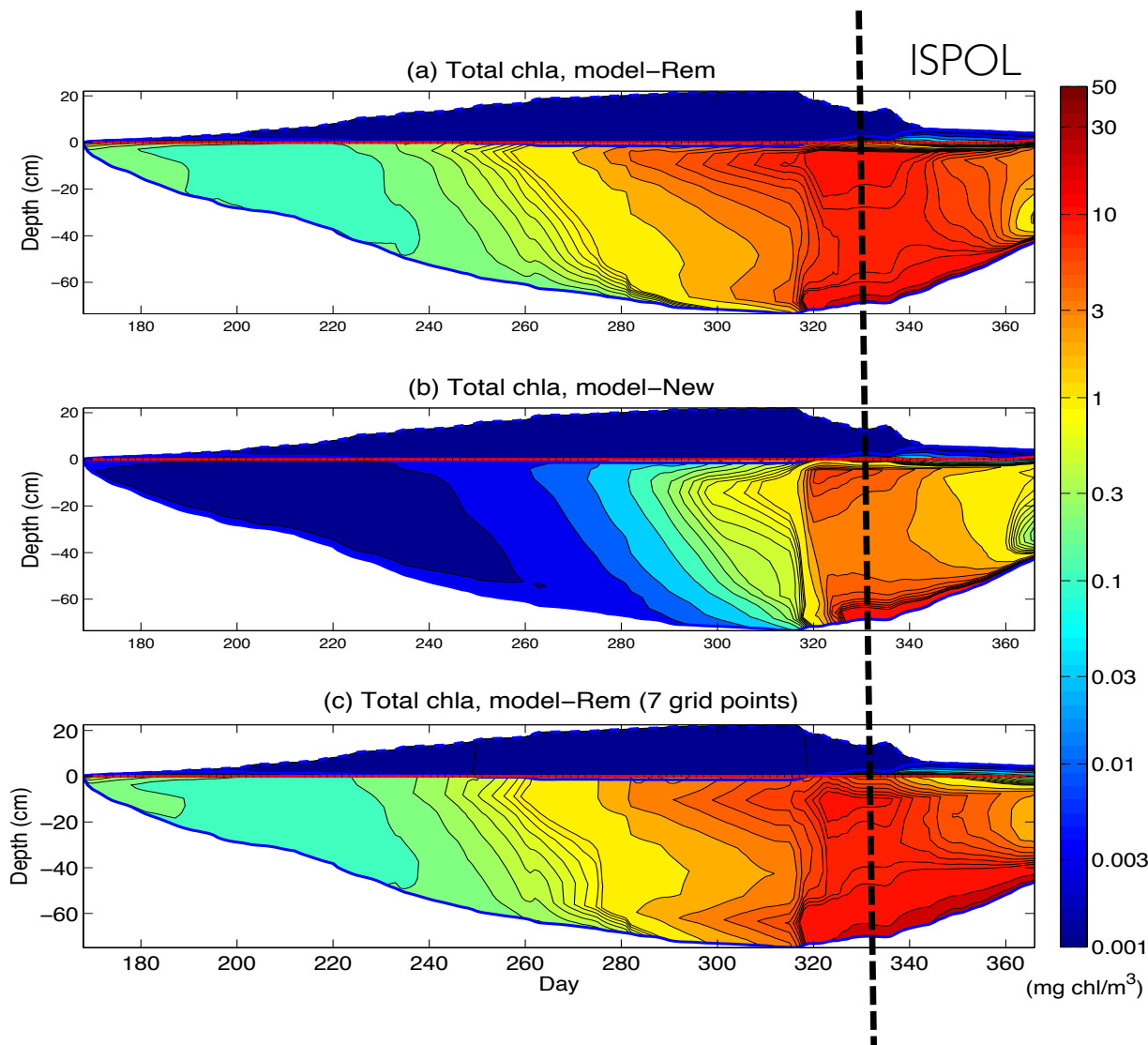
- Bottom maximum reasonably well simulated (with 15 grid points, ok with 7)
- Both “New” and “Remineralized” overestimate interior biomass (particularly Nov to mid-Dec)

Integrated Production



Model exhibits a stronger trend not than data. Seen in ice thickness, salinity, temperature...
(Values as high as 48-50 mg chl a/m² have been observed in SO (Arrigo 1997))

Ice Algal Chlorophyll Contours (mg/m^3)



- Chla peak occurs before ISPOL
- Model can produce high interior and surface (freeboard blooms)
- Upper ice blooms are seen in both the “Remineralized” and “New” hypotheses
- 7 grid points looks ok.

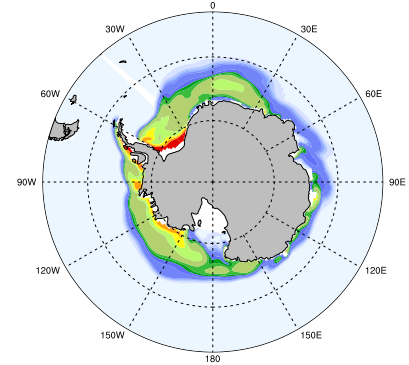
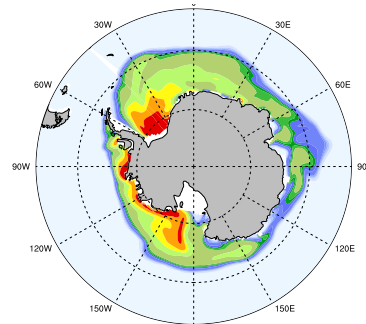
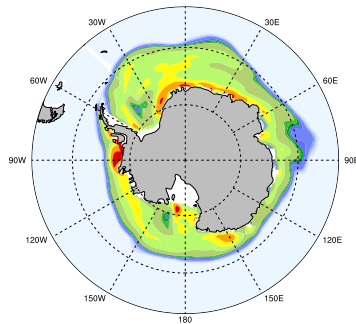
2000-2005 Monthly Average chlorophyll (mg/m²)

November

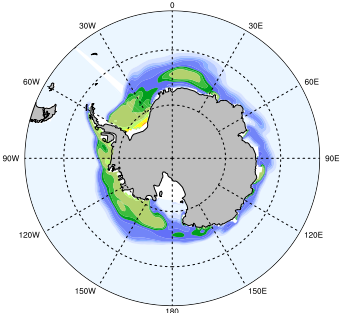
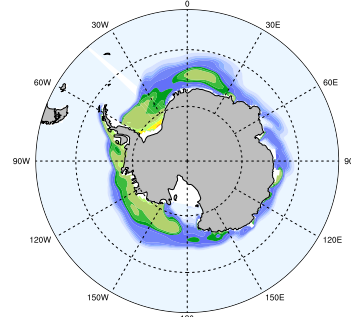
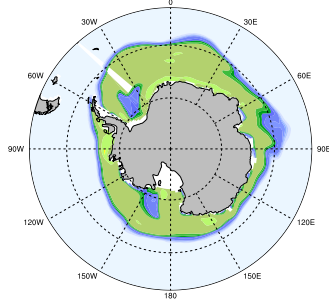
December

January

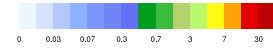
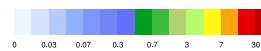
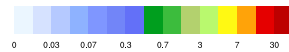
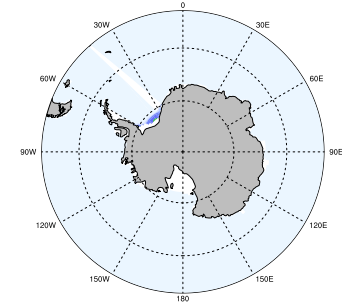
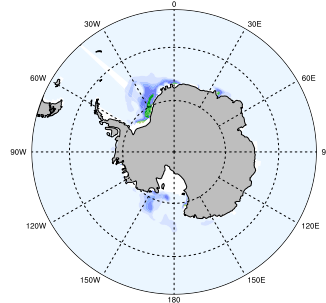
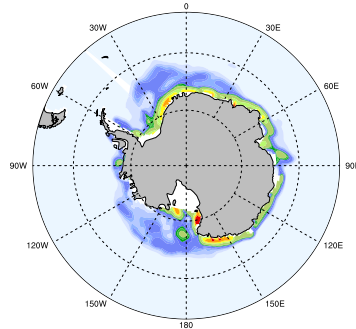
Rem



New

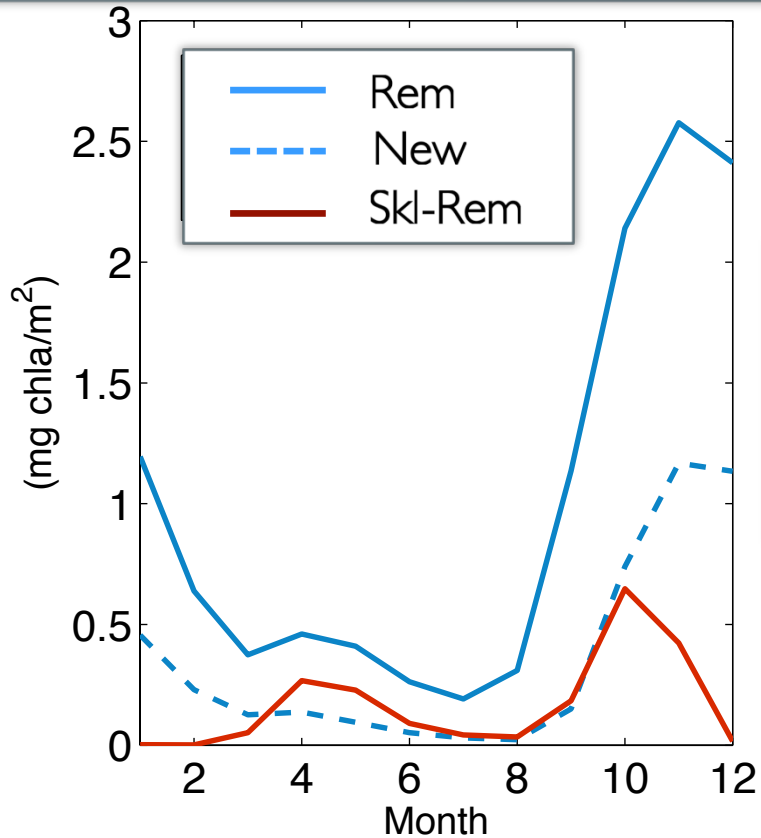


CICE.v5
Skl-Rem

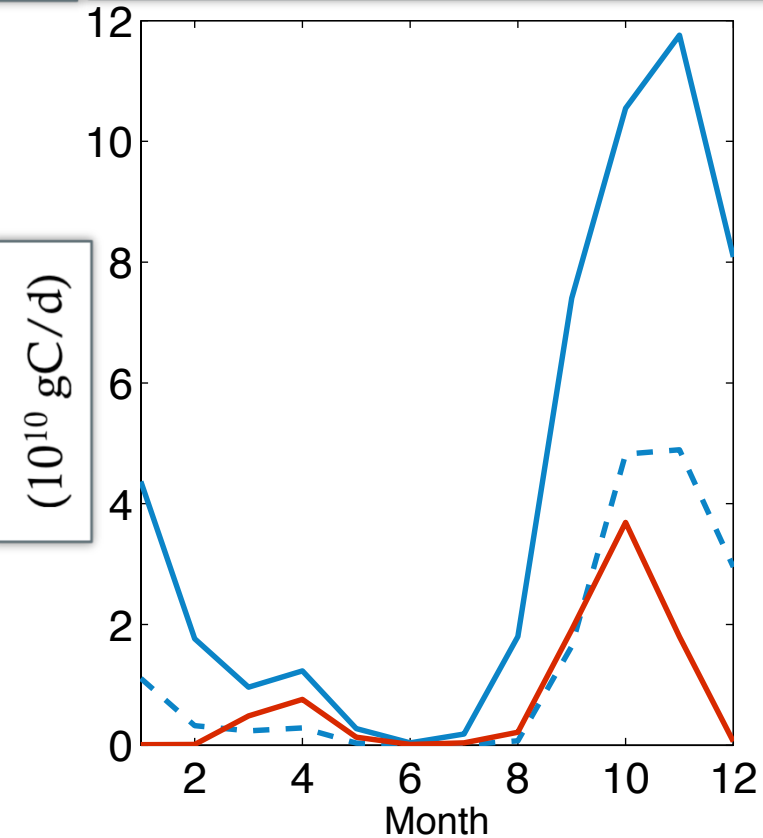


Southern Ocean Ice Algal Annual Cycle

(2000-2005) Total Southern Ocean Ice Chla

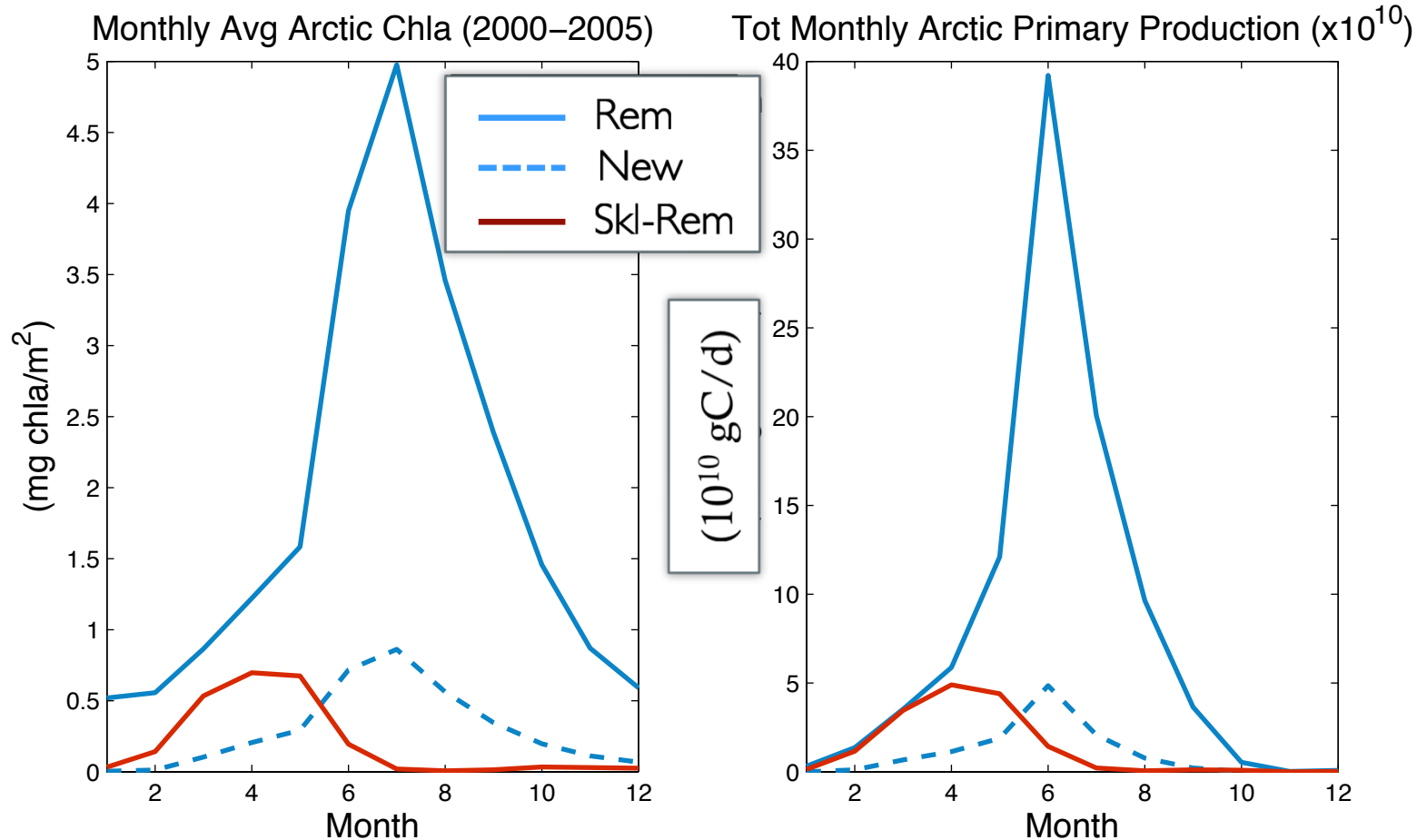


Total Southern Ocean Primary Production



Estimate for peak production for open water plankton in Southern Ocean MIZ 150×10^{10} gC/d (Arrigo2008)

Arctic Ice Algal Annual Cycle



Maximum Arctic chl biomass range 5-160 mg chla/m² (Arrigo2003, Deal2011)

*a few mg chla/m² in central Arctic (Gradinger 2008)

Avg PP_Net (mg C/m²/d) 2000-2005, Month4

