# Patterns and variability in sea ice chlorophyll


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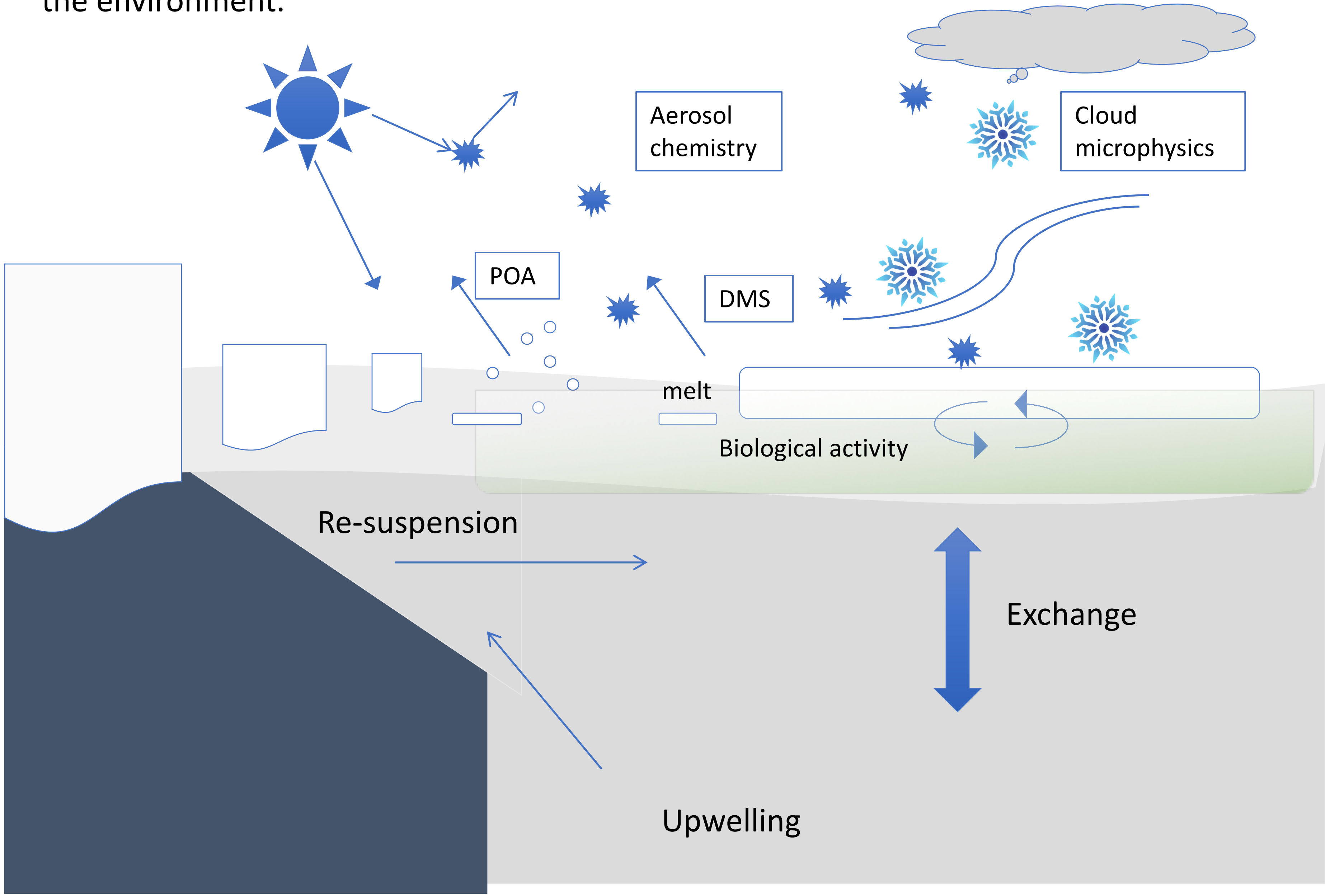
# Outline

1. Ice biogeochemistry in the HiLAT Project
2. Simulations:  ocean-ice bgc coupled runs
3. Key processes in Arctic/Antarctic sea ice
4. Very basic questions for the base run:
   - What are seasonal cycles in ice chlorophyll and primary production in the Arctic/Antarctic?
   - How do they compare with ice volume, irradiance, snow depth…?
   - Is variability in polar chlorophyll correlated with variability in physical processes?
   - How do cycles from early CORE II (1960-1970)  compare with recent decades (1999-2009)?
5. Conclusions

Ocean and Ice biogeochemistry interact with Earth's climate, responding to and modifying the environment.



# Motivation 1

HiLAT: DMS and organic macromolecules–

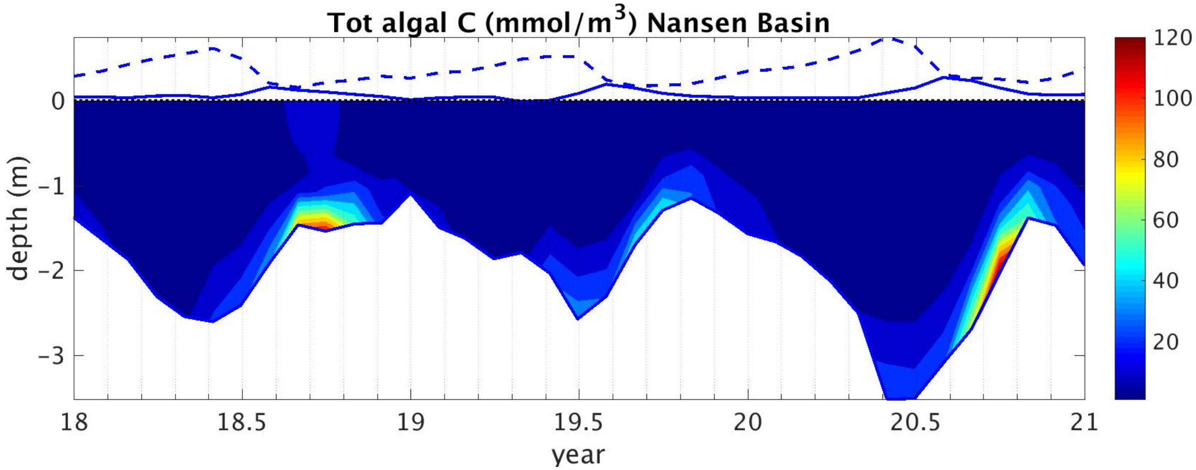
a. How do polar marine DMS and organics emissions change in a future climate (~100 yr timescales)?
b. Under scenarios of enhanced Antarctic melt?
c. What is the impact on marine biogeochemistry?
d. What is the impact on cloud radiative properties?

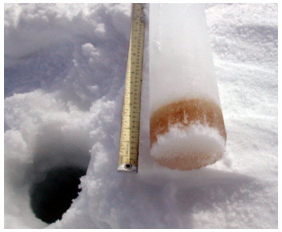
# Motivation 1.2

## HiLAT: Sea ice chlorophyll and primary production (PP) and interactions with the polar ocean biogeochemstry –

a. What are the patterns and variability in polar ice chla and PP over the last 40+ years? Have they changed? Which are the most important physical and biogeochemical processes in determining variability in ice chla/PP? Are they different in different polar regions?
b. What is the impact of ice bgc on ocean biogeochemistry?

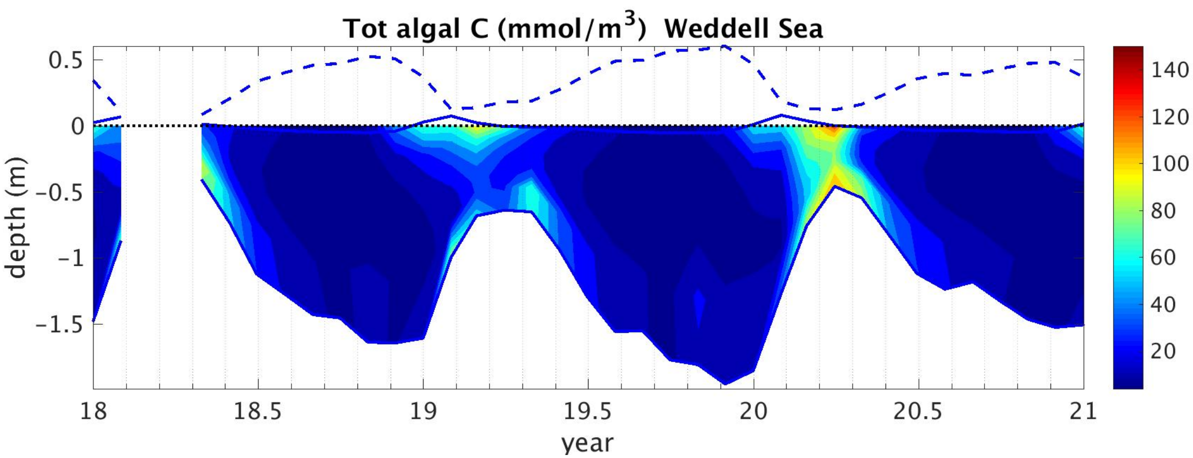
# Sea ice physical-biochemical interactions

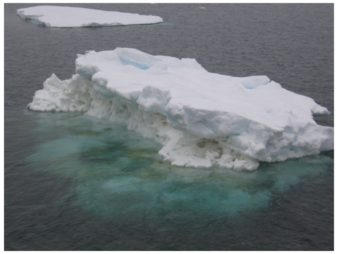


## Arctic

1. Obs: ***bottom*** layer chla peaks
2. ***Micro-scale*** processes – brine dynamics control nutrient supply at the ice ocean interface



## Southern Ocean

1. Obs: ***surface*** chla peaks
2. ***Macro-scale*** processes – heavy snow and flooding enrich the upper ice

ACME Accelerated Climate Modeling for Energy


***Jeffery, Elliott, Wang, Hunke, Weijer, Wolfe, Maltrud***


HiLAT

# Simulations

GCASE Ocean-Ice Runs – Pop2/CICE5+zbgc

a. Base run: 3 core 2 (1948-2009) cycles
   a. ocean and ice biogeochemistry with 2-way bio coupled,
   b. 1deg horizontal grid. 8 layers for cice.
b. 1-way Bio Coupling:
   a. Branched from 1960 of 3rd Base core cycle
   b. Ice bgc receives input from the ocean bgc, but no return fluxes
c. Source of sedimentary iron from ocean:
   a. Branched from 1960 of 3rd Base core cycle
   b. Ocean passes sedimentary iron to ice in shallow shelf areas. Ice bgc accumulates and iron can become bioavailable

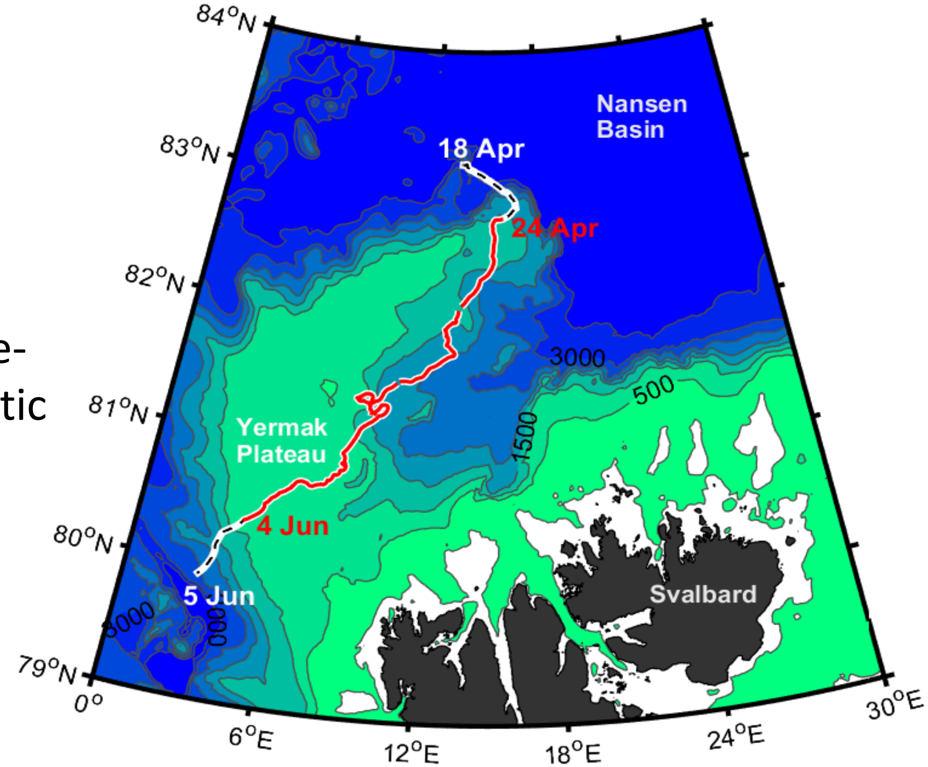
# Ice BGC tracers

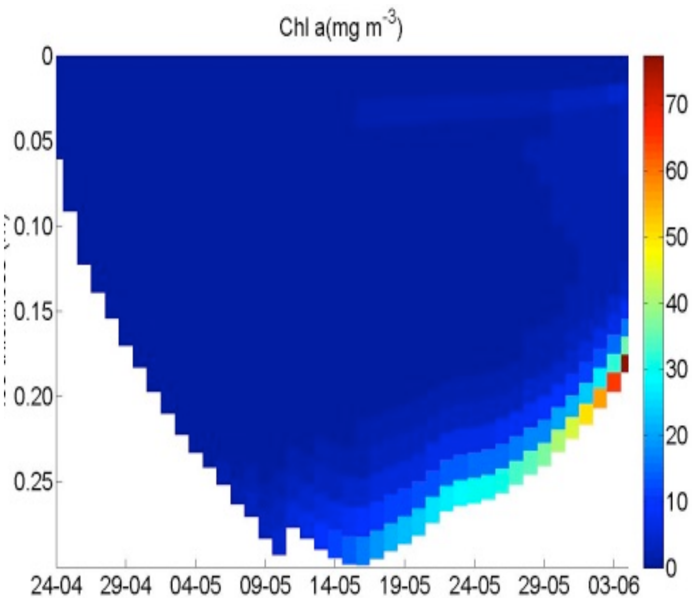
3 Algal groups – Diatoms, small plankton, *Phaeocystis* sp.
3 dissolved organics pools – lipids, saccharids and proteins/amino acids
3 macronutrients – nitrate, ammonium, silicate
1 micronutrient – iron
DMS and DMSPd
humics

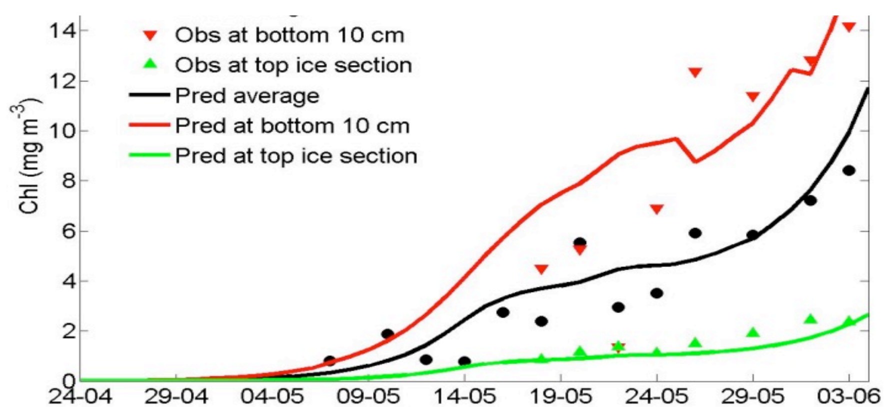
* Chlorophyll/Primary Production → Ice Diatoms

# N-ICE 2015
# Stand alone CICE

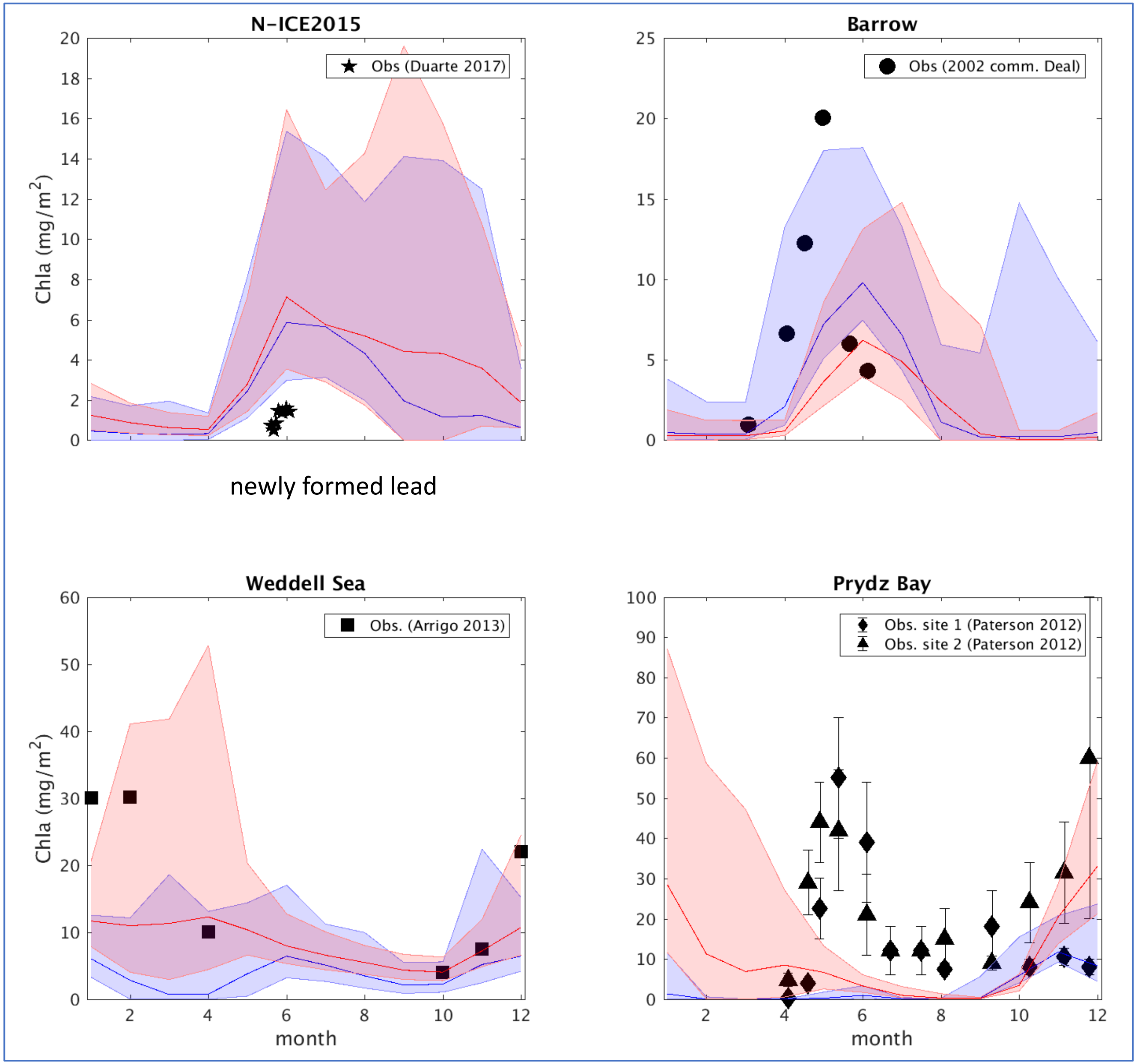
(Duarte et al., 2017. Sea-ice thermohaline-dynamics and biogeochemistry in the Arctic Ocean: empirical and model results, JGR, submitted)

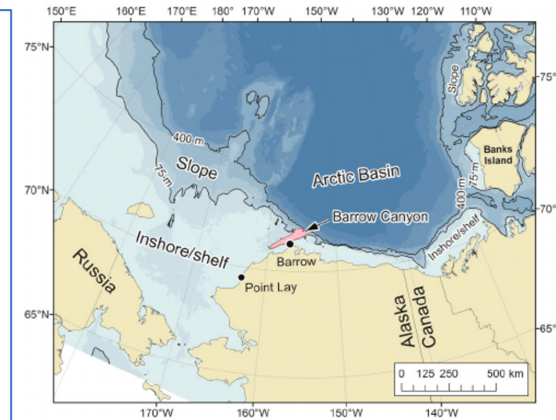


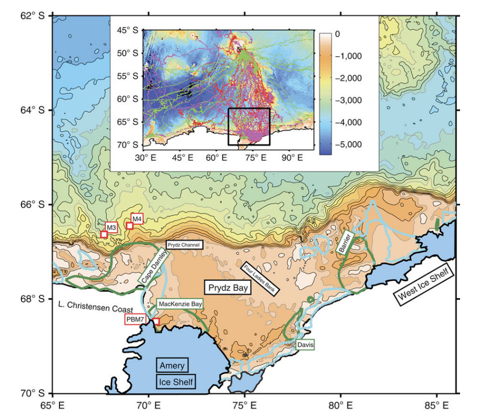



— BCASE (fully coupled spinup, 10 year avg)
— GCASE (ice-ocean 30 year average)
*Envelopes indicate min/max monthly values



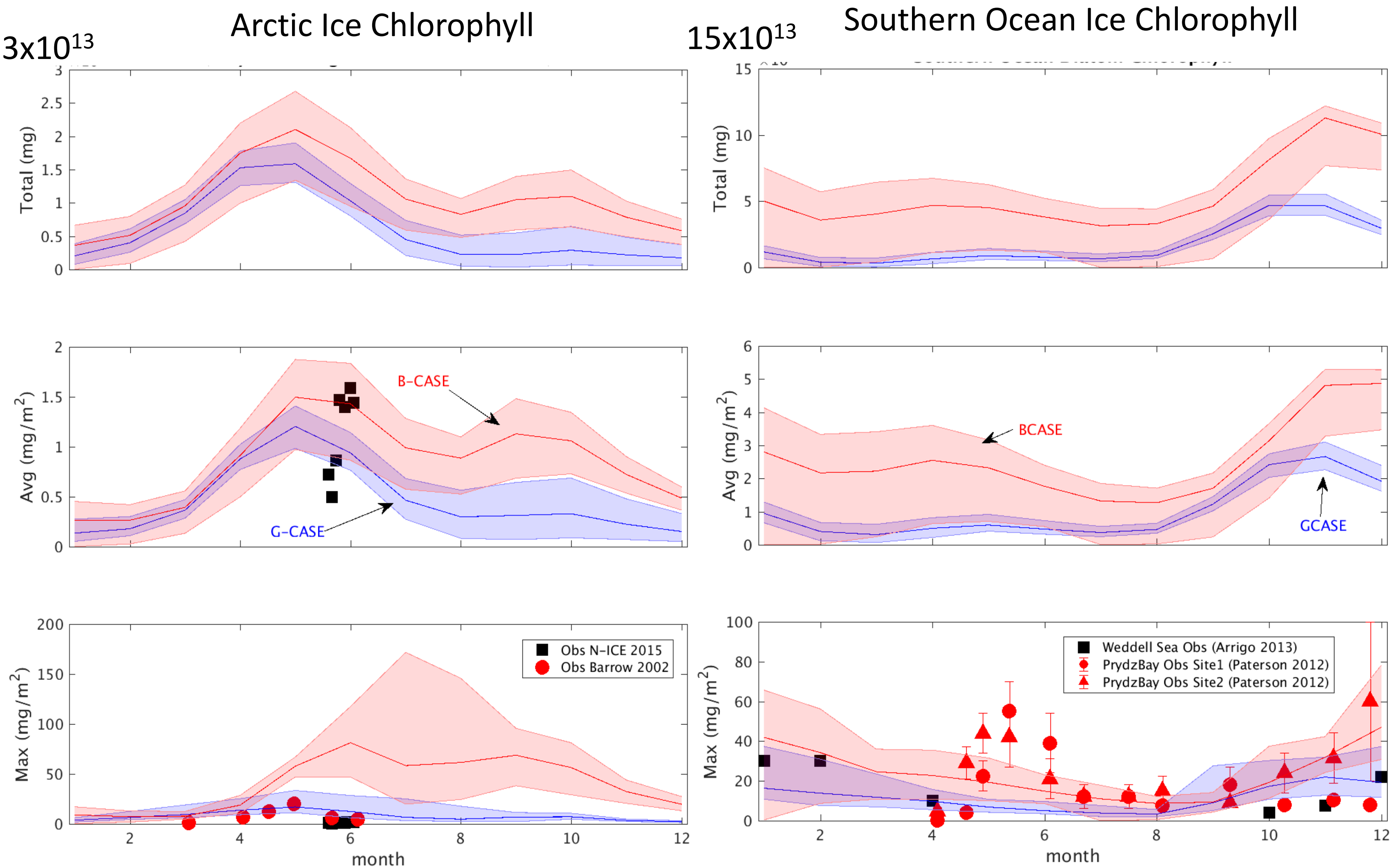




Barrow Canyon

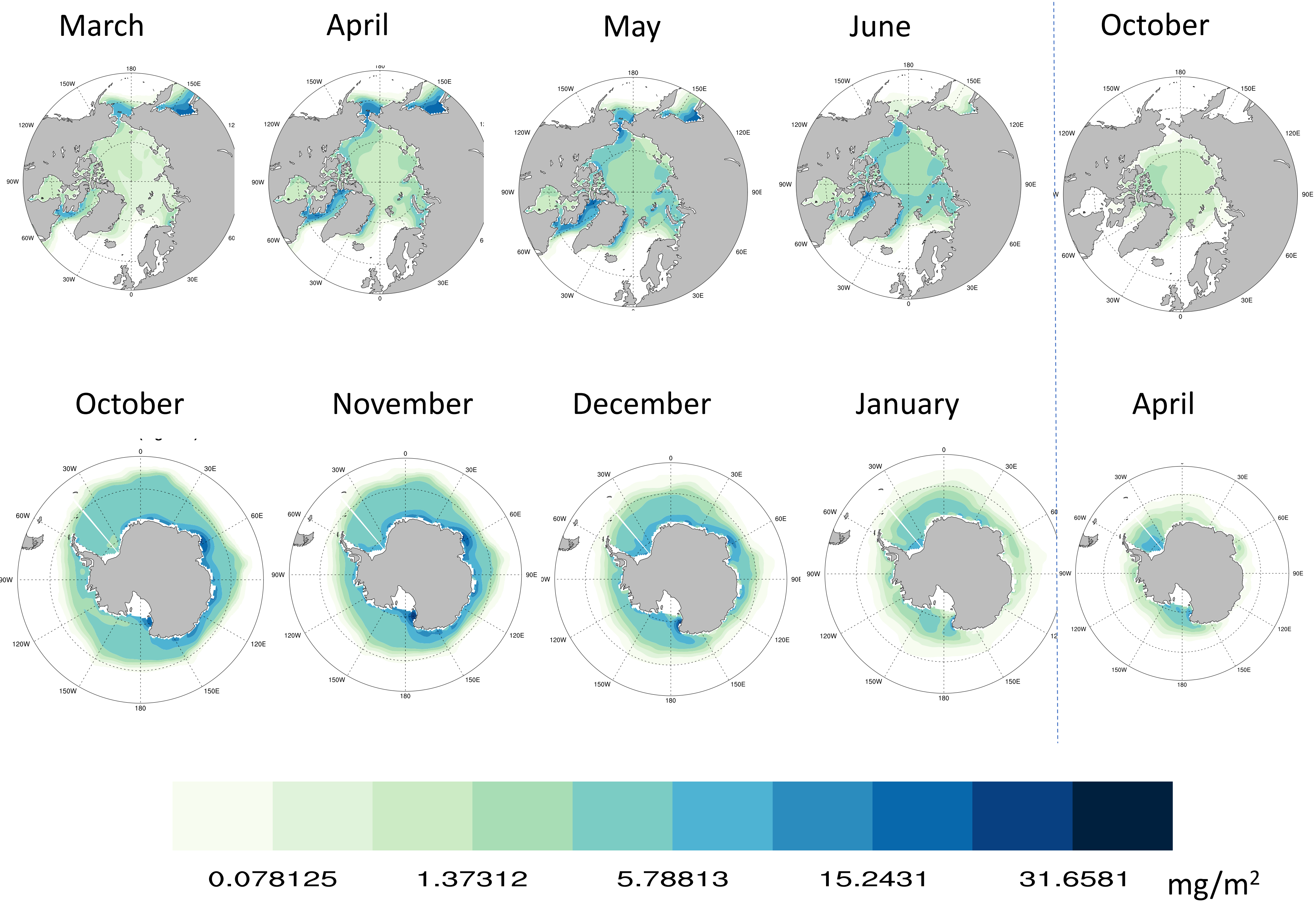



Prydz Bay

BCASE (fully coupled spinup, 10 year average)
GCASE (ice-ocean 10 year average)
*Envelopes indicate min/max monthly values



# Monthly Mean Climatology



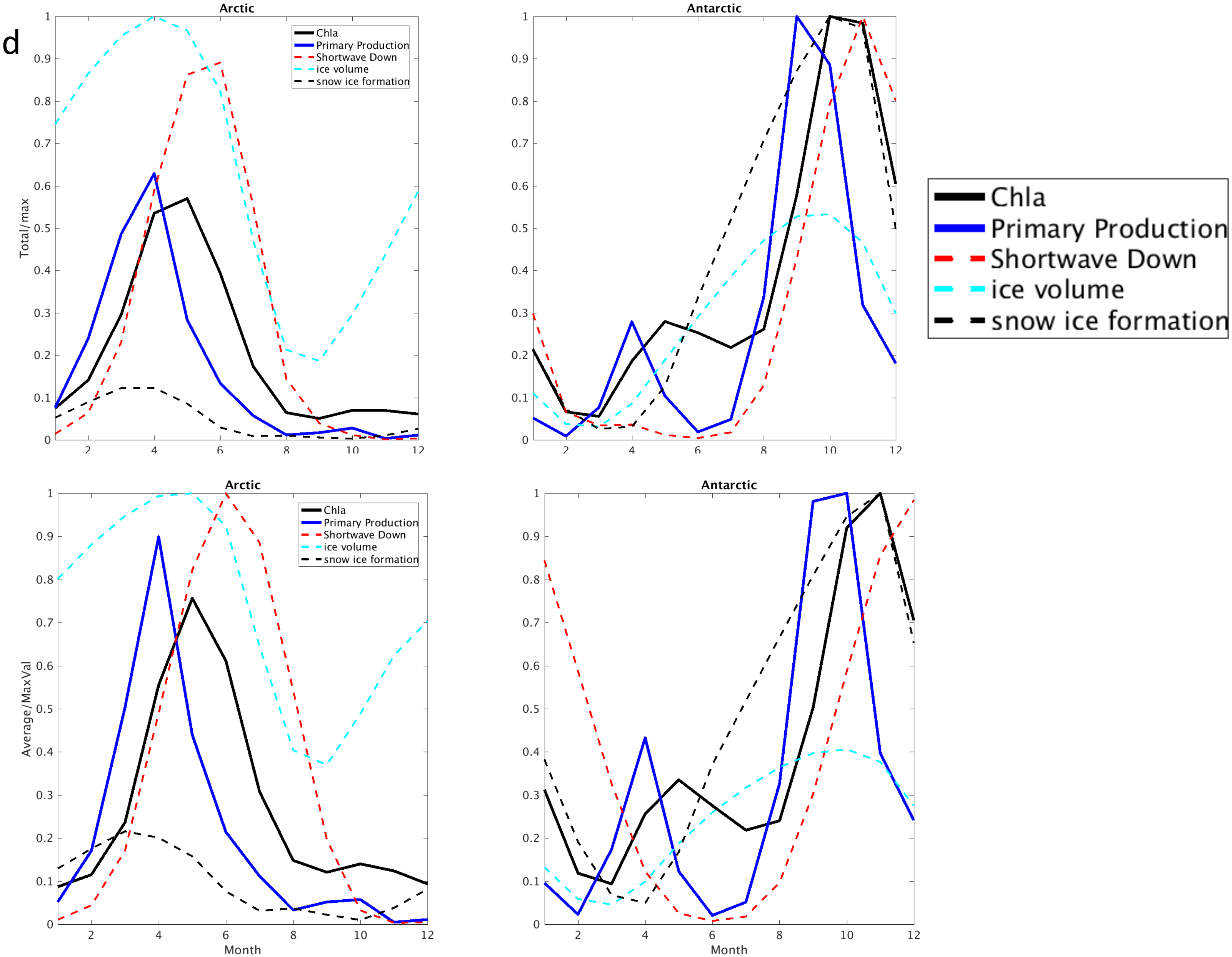
# Mean Monthly Cycles (30 years)

## Arctic

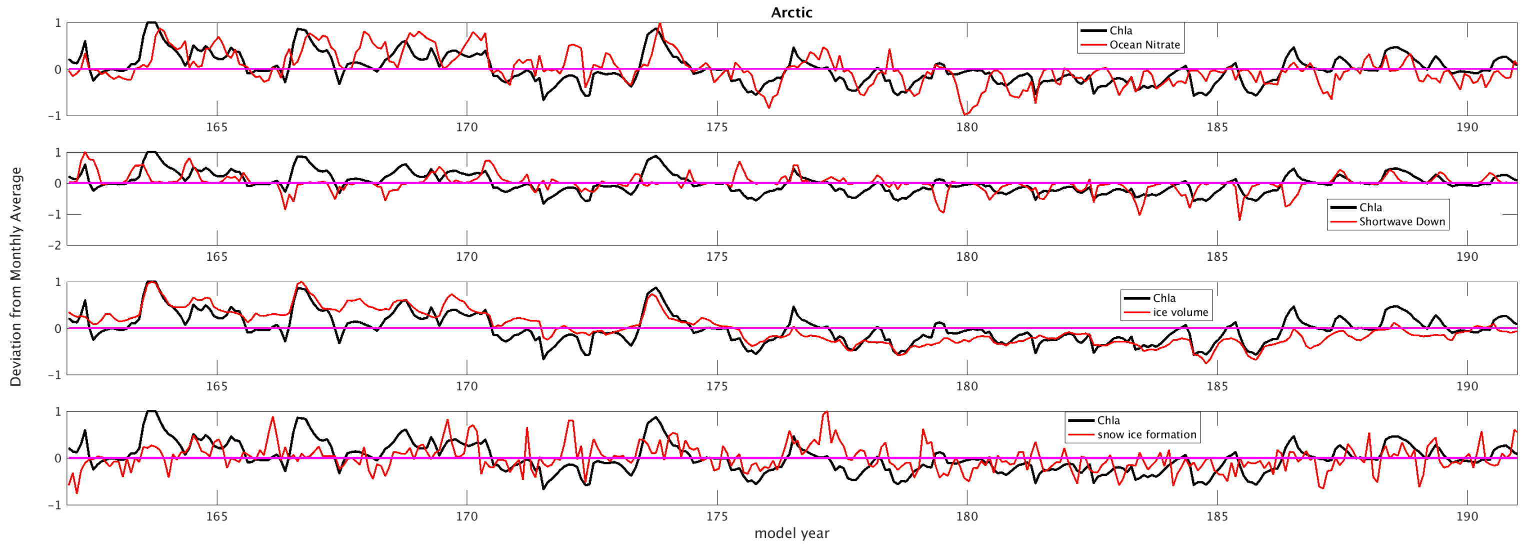
## Antarctic

**Volume Integrated**

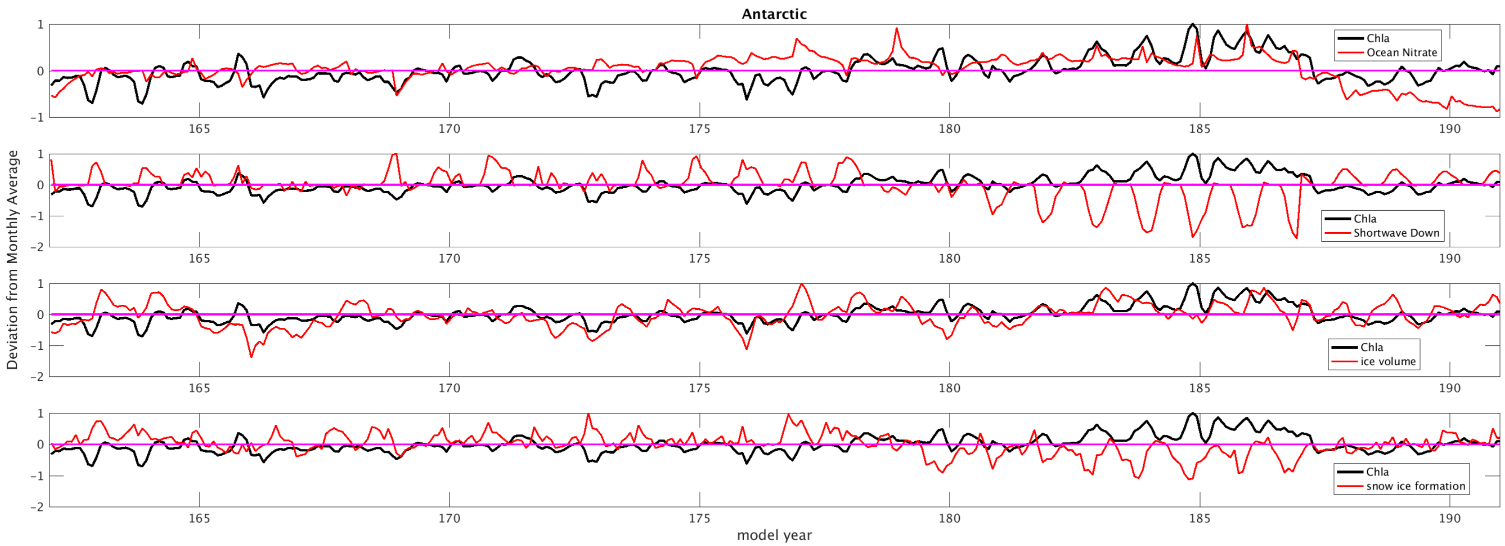
**Average**



# Arctic




# Antarctic



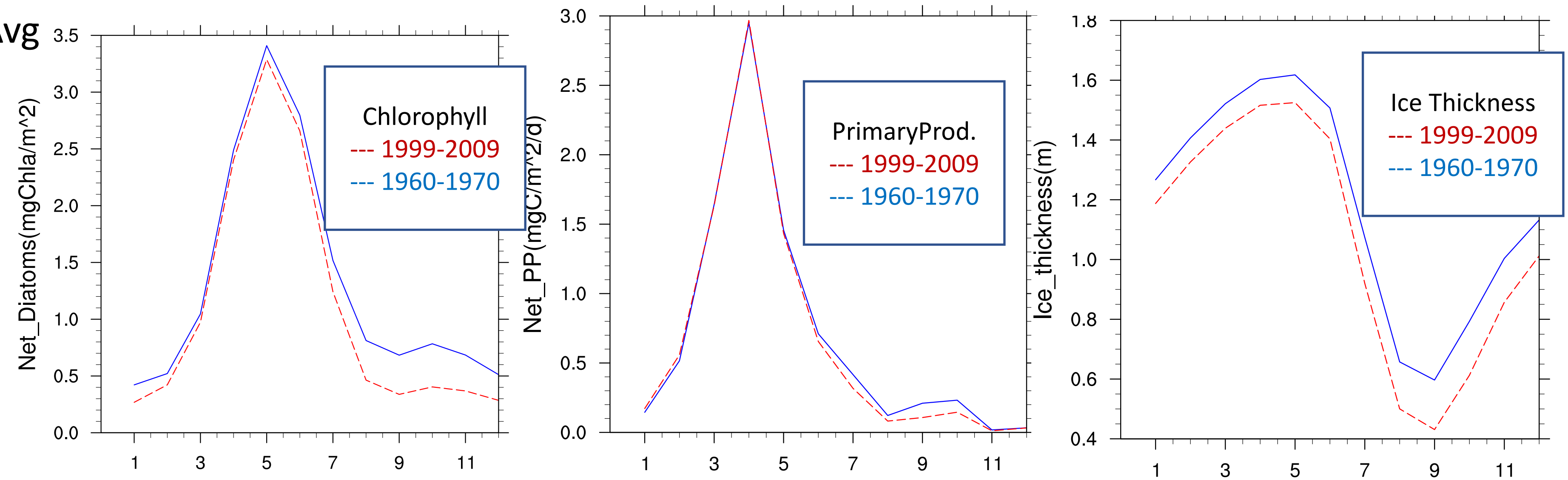
Average Polar Values

| | Arctic | | | | Antarctic | | | |
|---|---|---|---|---|---|---|---|---|
| | Chla. | | PP | | Chla | | PP | |
| | **r** | **p** | **r** | **p** | **r** | **p** | **r** | **p** |
| **chla** | 1 | 0 | 0.4616 | 0.000 | 1 | 0 | 0.5424 | 0.000 |
| **PP** | 0.4616 | 0.000 | 1 | 0.000 | 0.5424 | 0.0000 | 1 | 0 |
| **Fsw** | 0.2477 | 0.000 | 0.2989 | 0.000 | -0.5260 | 0.0000 | -0.2363 | 0.0000 |
| **IceArea** | 0.6818 | 0.000 | 0.3851 | 0.000 | 0.3727 | 0.0000 | 0.2652 | 0.0000 |
| **Hice** | 0.7701 | 0.000 | 0.3236 | 0.000 | 0.4169 | 0.0000 | 0.1681 | 0.0014 |
| **SnowIce** | 0.2735 | 0.000 | 0.1176 | 0.026 | -0.4959 | 0.0000 | -0.4090 | 0.0000 |
| **Hsnow** | 0.7062 | 0.000 | 0.1805 | 0.0006 | -0.2787 | 0.0000 | -0.3389 | 0.0001 |
| **OceanNit** | 0.5524 | 0.000 | 0.2012 | 0.0001 | 0.2889 | 0.0000 | 0.1438 | 0.0063 |

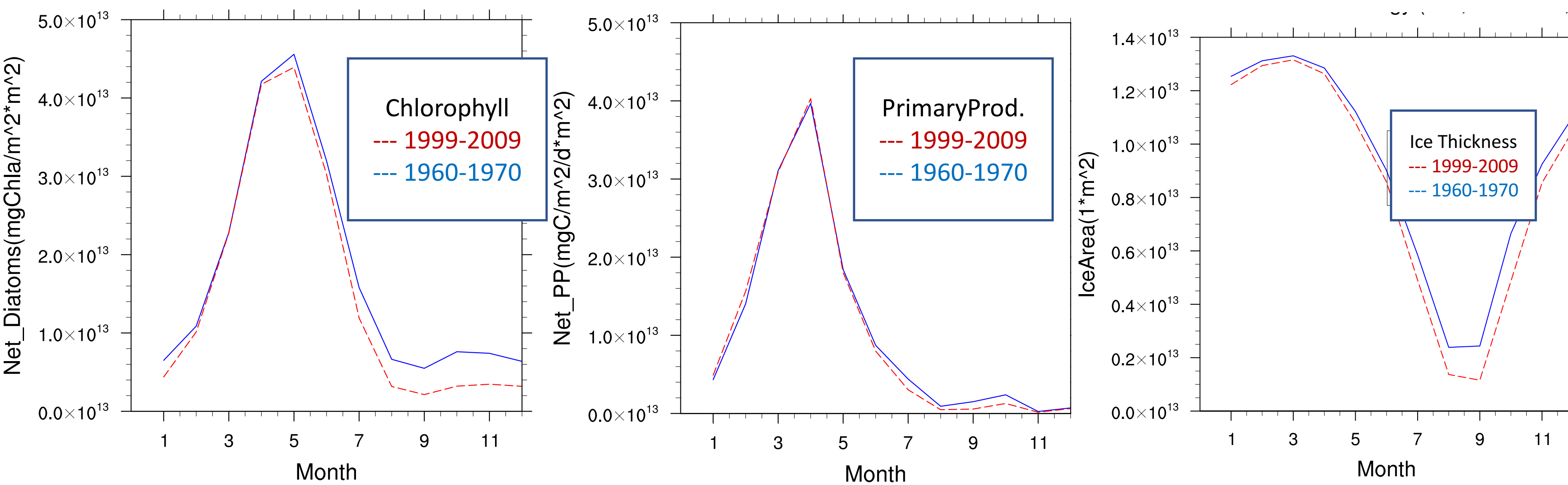
Caveat… all related by ice area

# Arctic

## Avg

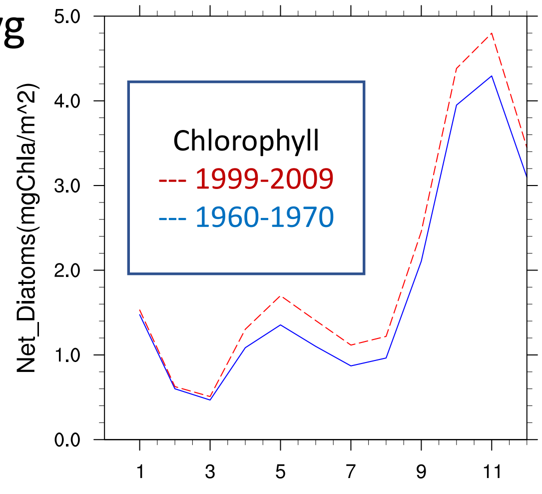


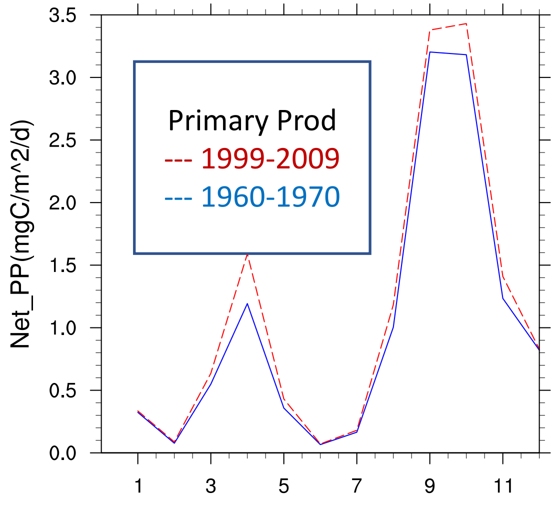

## Tot

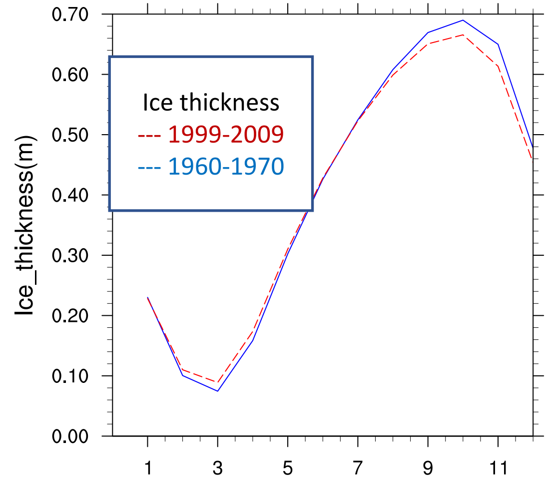


# Antarctic

## Avg

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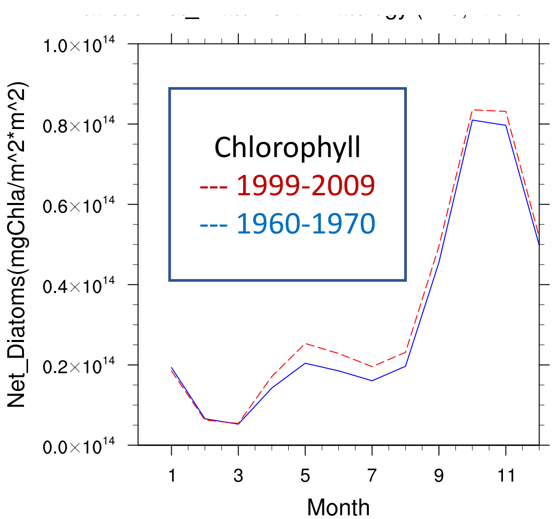


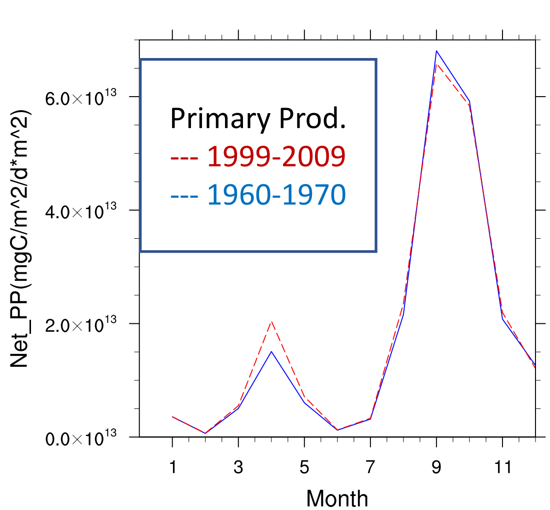


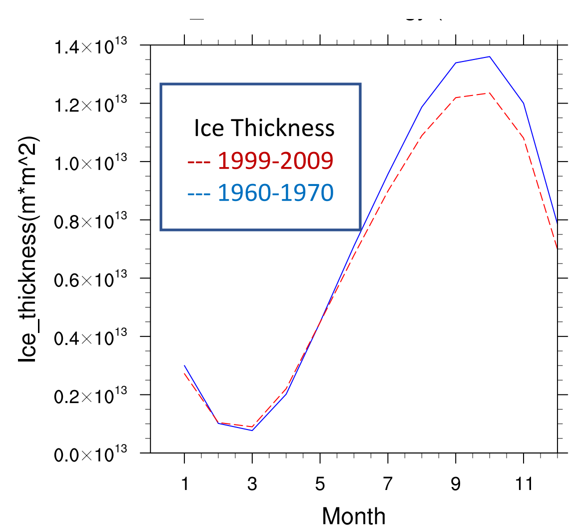

# Much to do…

- Take Jen's class
- Compare additional observations with model points, neighbours and regions
- Regional correlation maps of Ice growth/melt, bottom PAR, ocean nutrients, snow depth, ice area …
- Go beyond chla and PP to macro- and micronutrients, DMS…