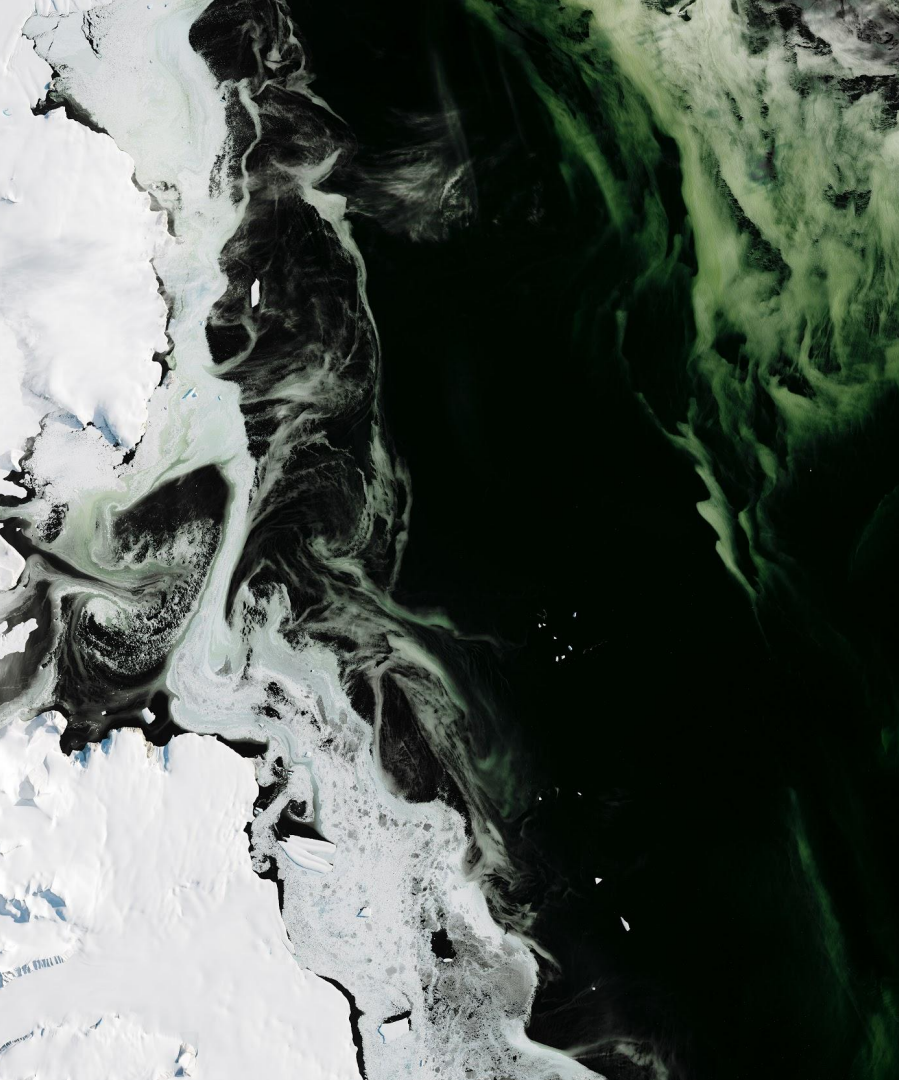

Southern Ocean Phytoplankton Phenology and Sea Ice

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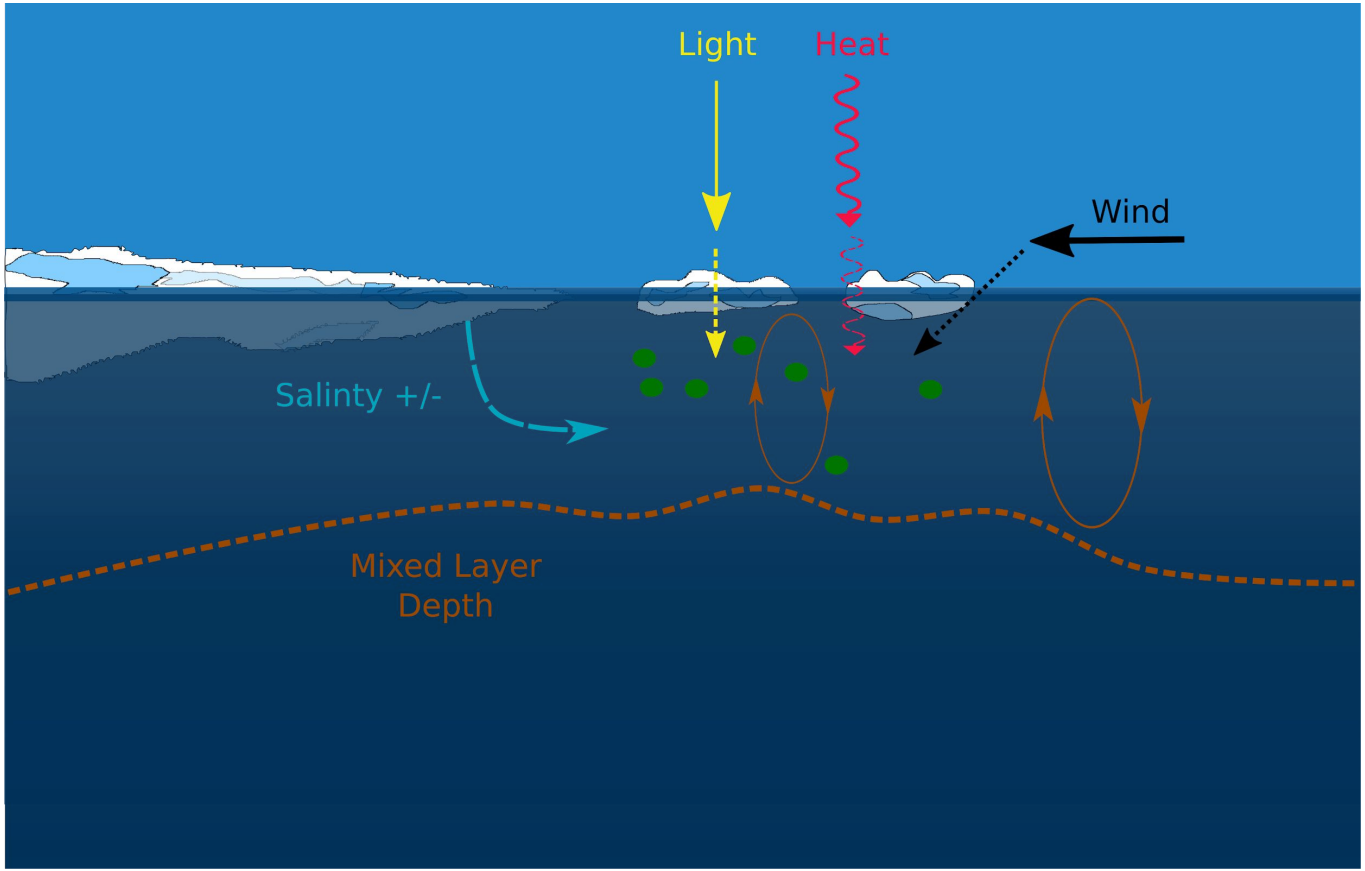
Supervisor: Marcello Vichi

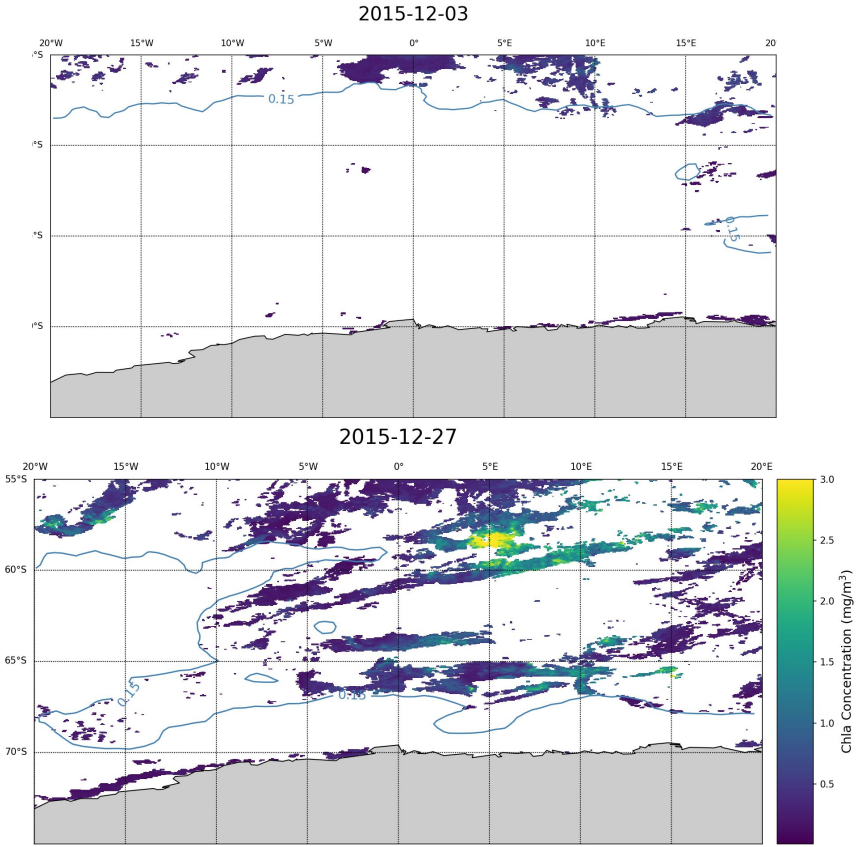
Outline

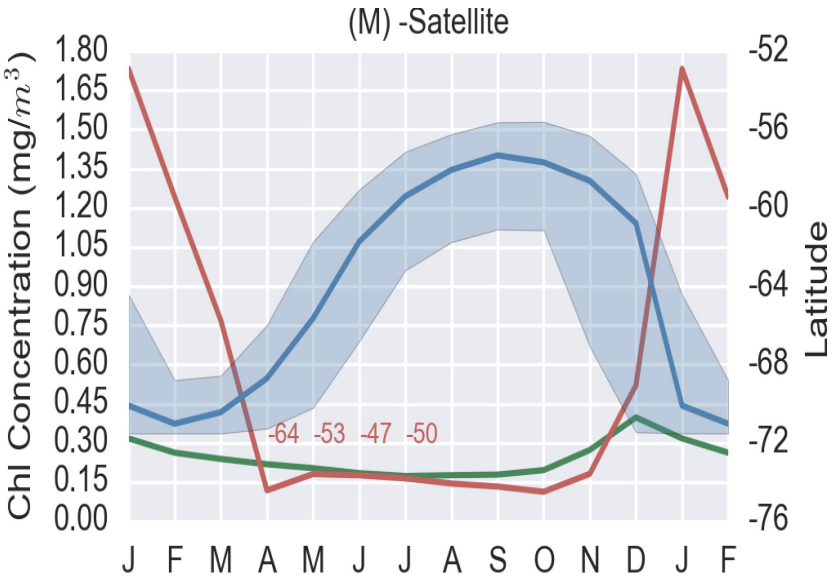
1. Conceptual relationship between phenology and sea ice
2. Representation in Earth System Models vs Satellite
3. More data with Bio-Argo Floats
4. Simple 0D model experiments

1. How might sea ice affect phenology?

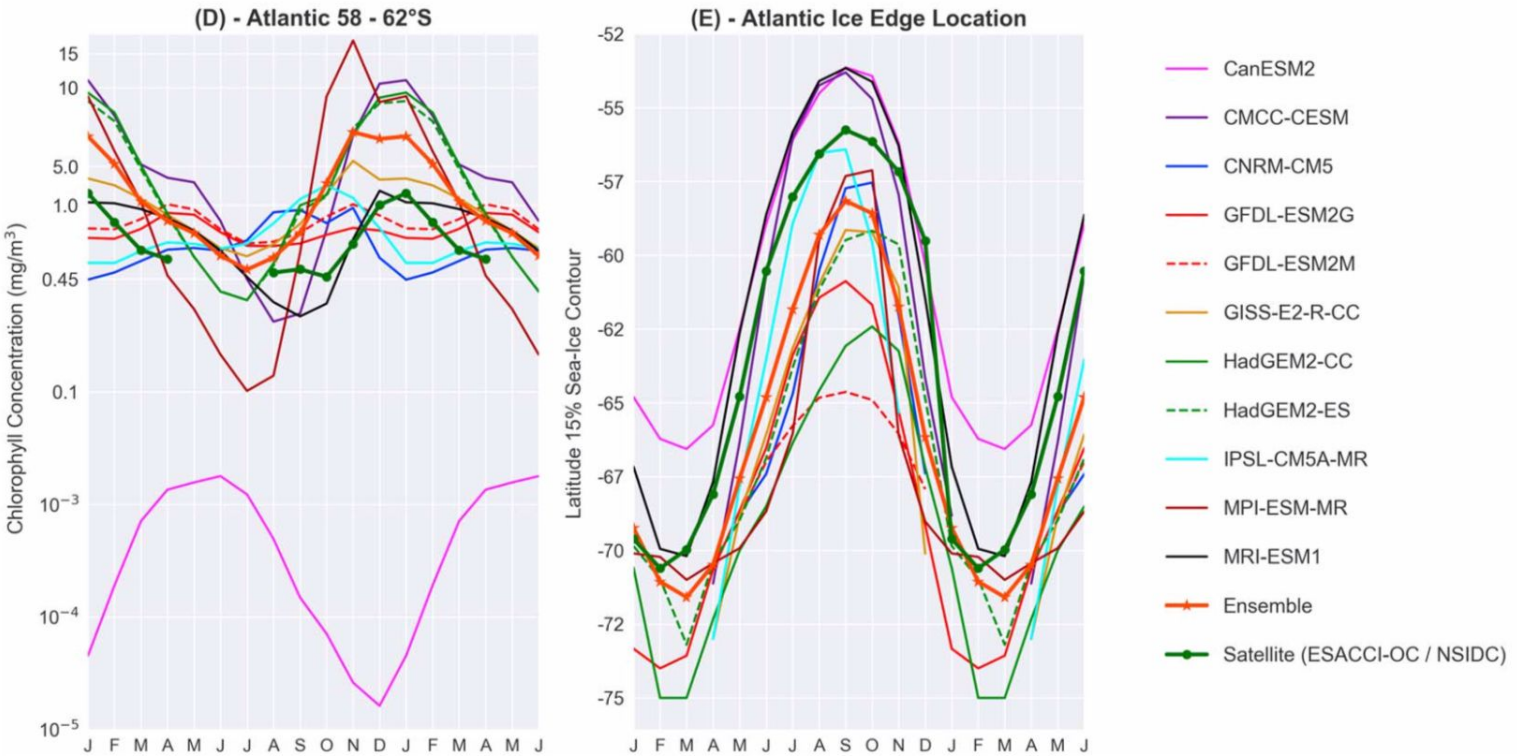


2. Satellite Phenology



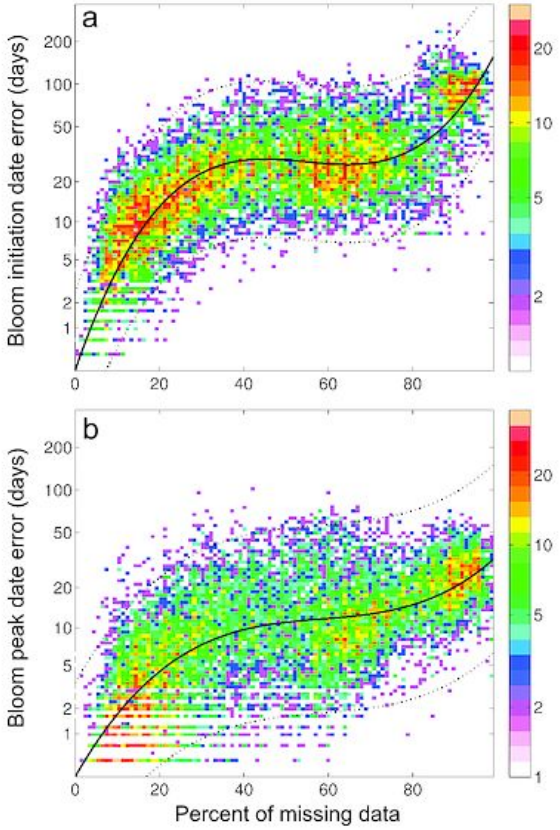


2. Earth System Model Phenology



Hague & Vichi (2018). *Geophysical Research Letters*

The problem with Satellite Phenology...



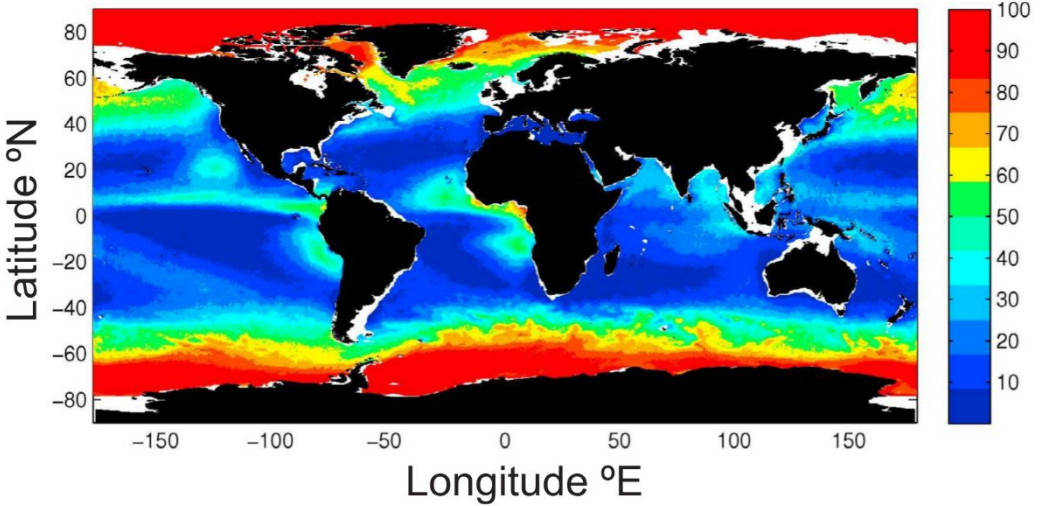
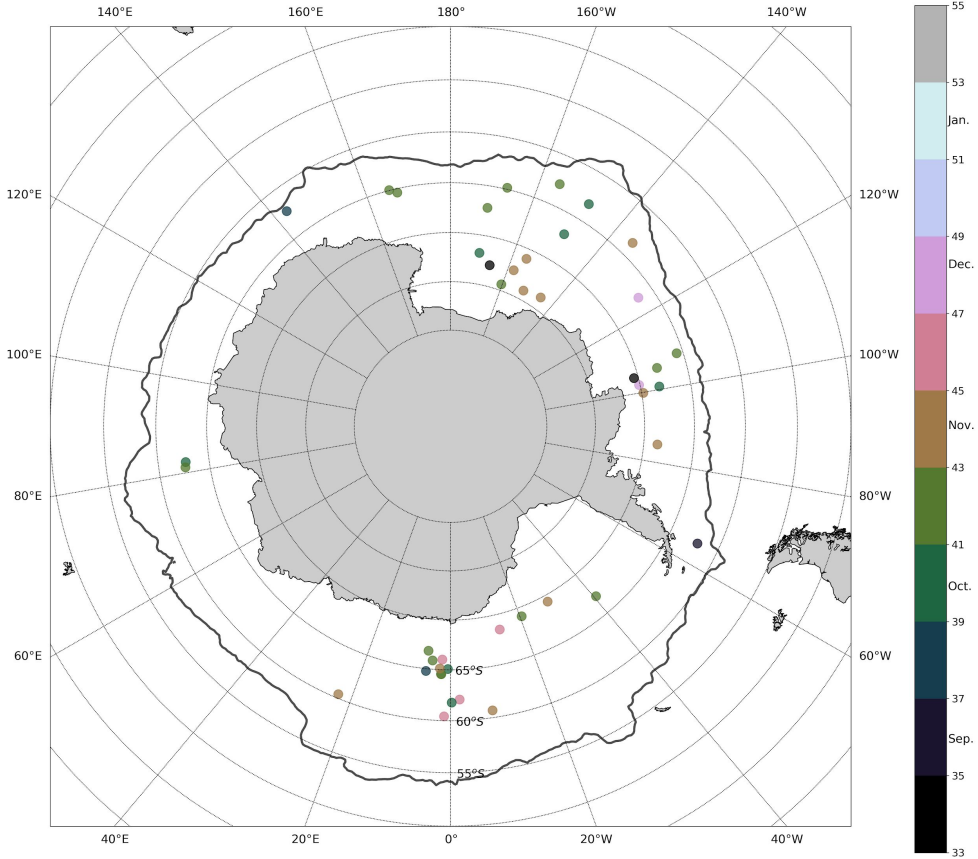


Figure 2. Map of the percentage of missing data at each pixel in the GlobColor data set using 8 day composites over the time span 2002–2006.

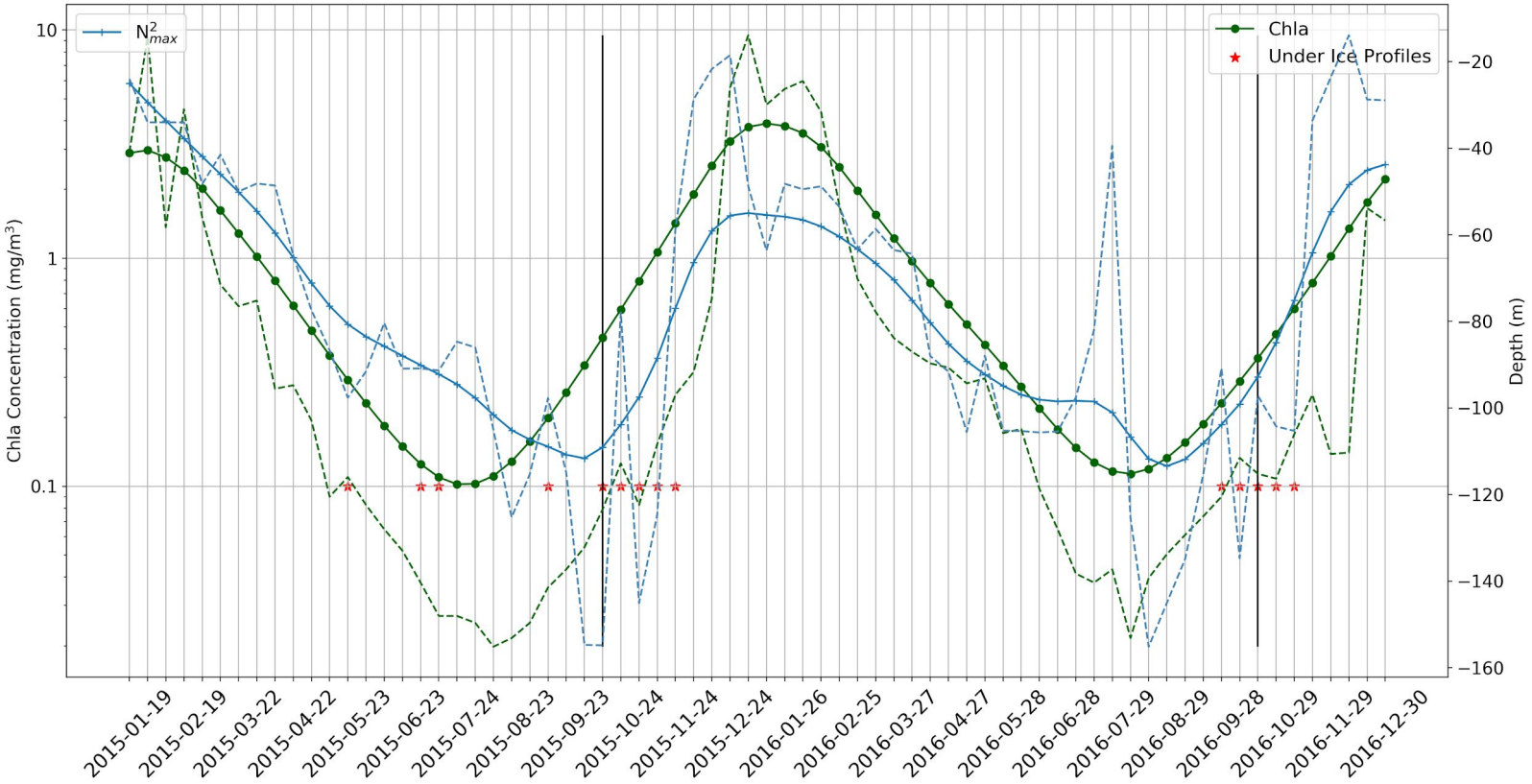
Cole *et al (2012)*

3. Bio-ARGO Floats Sampling Under Ice

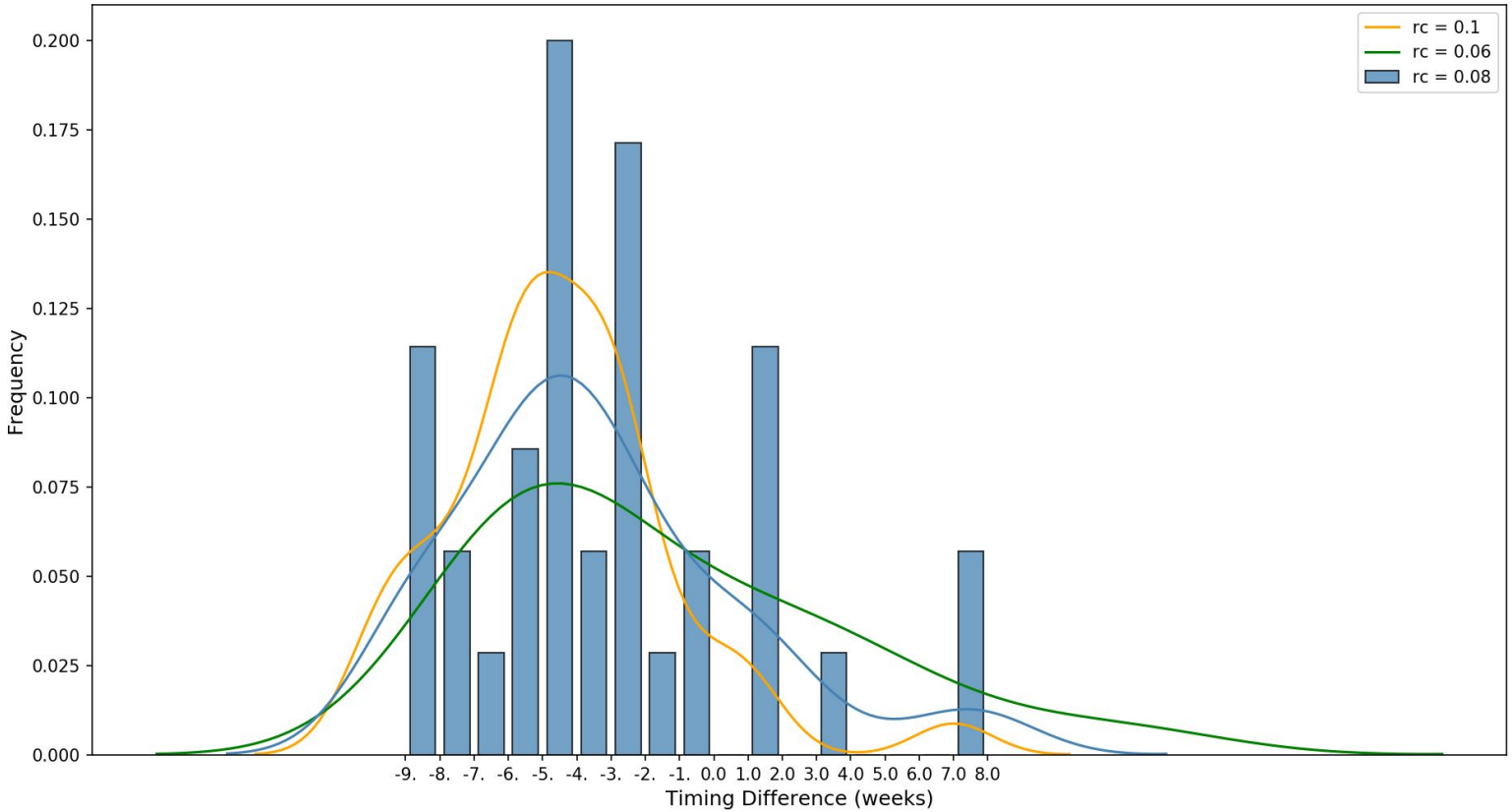


- 24 Floats with at least 3 consecutive under ice profiles.
- Campaign started in late 2014 - 4 under ice floats have sampled 4 seasons so far.
- 44 melt events captured with simultaneous chlorophyll data.
- 3 “clusters” of floats in the Weddell, Amundsen and Ross Seas.
- Growth initiation is generally much earlier than expected.

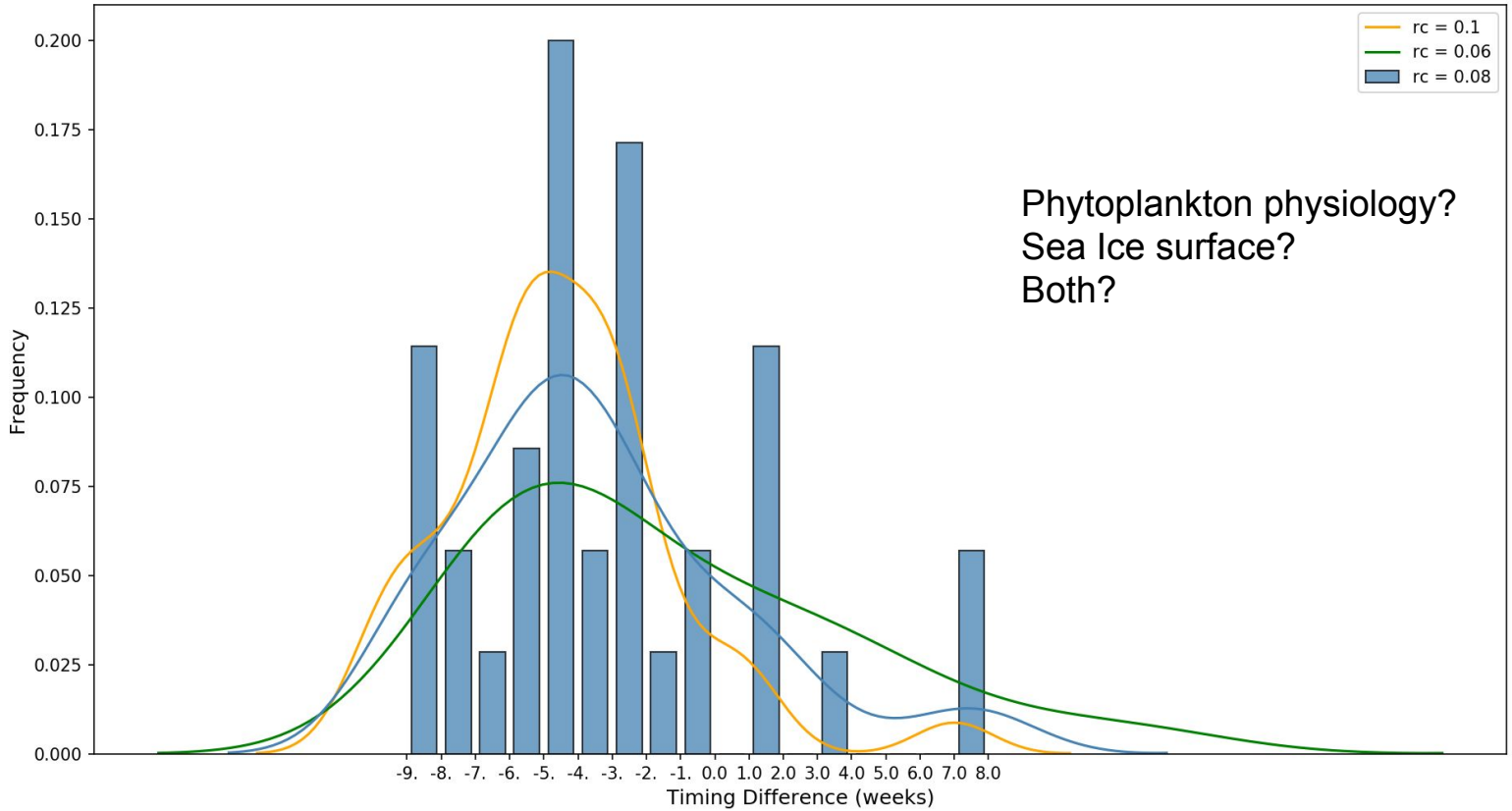
3. Example: Weddell Sea Time Series



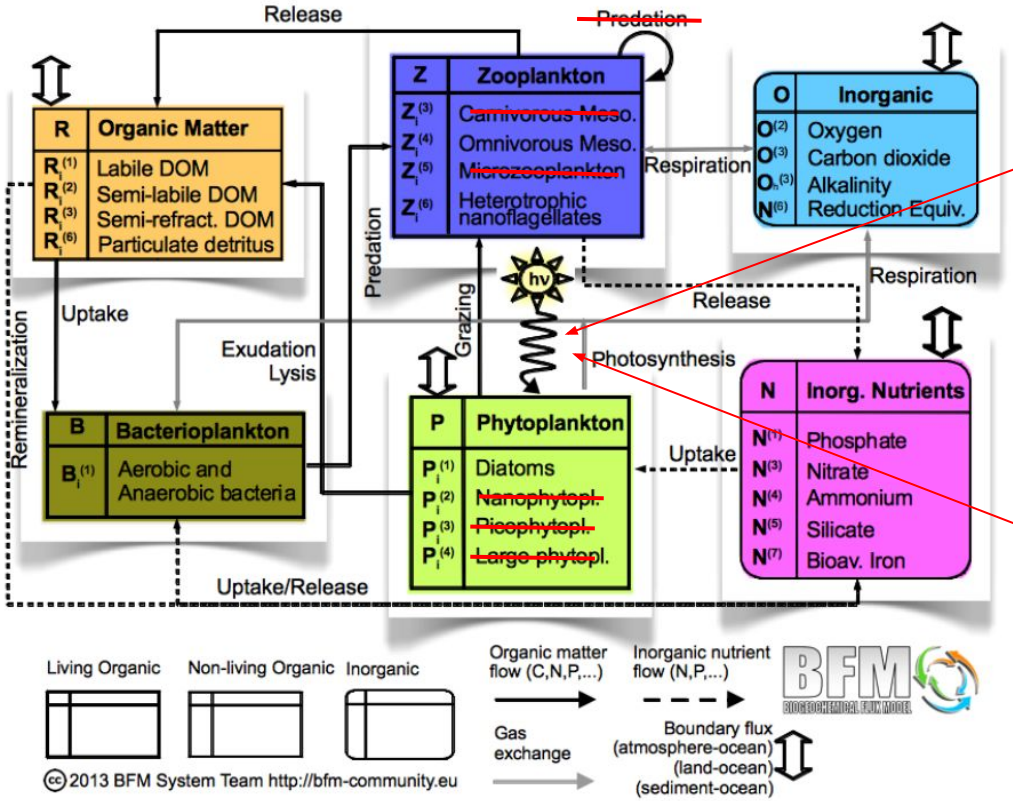
3. Testing the “melt water hypothesis”

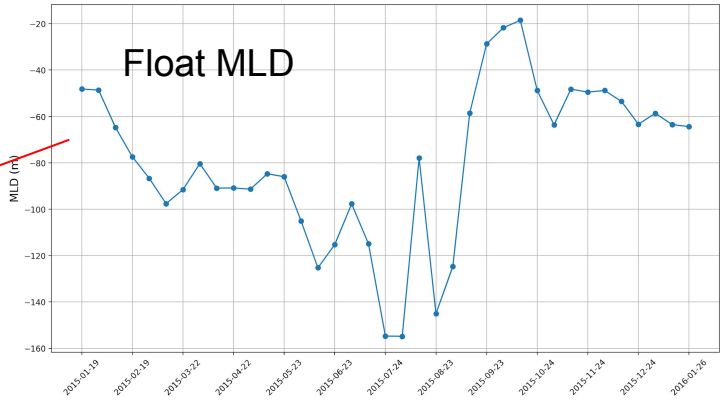


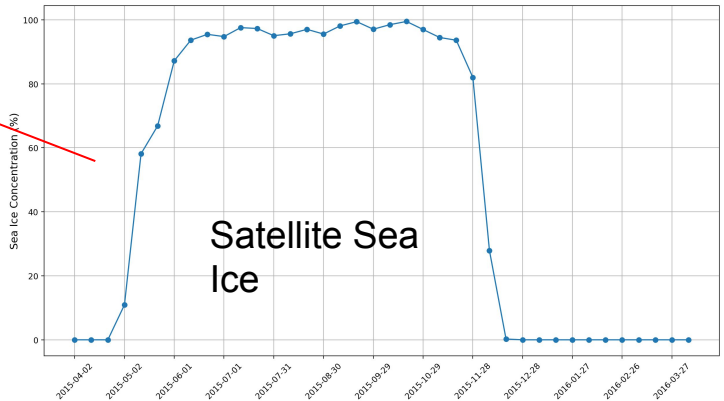
3. Testing the “melt water hypothesis”



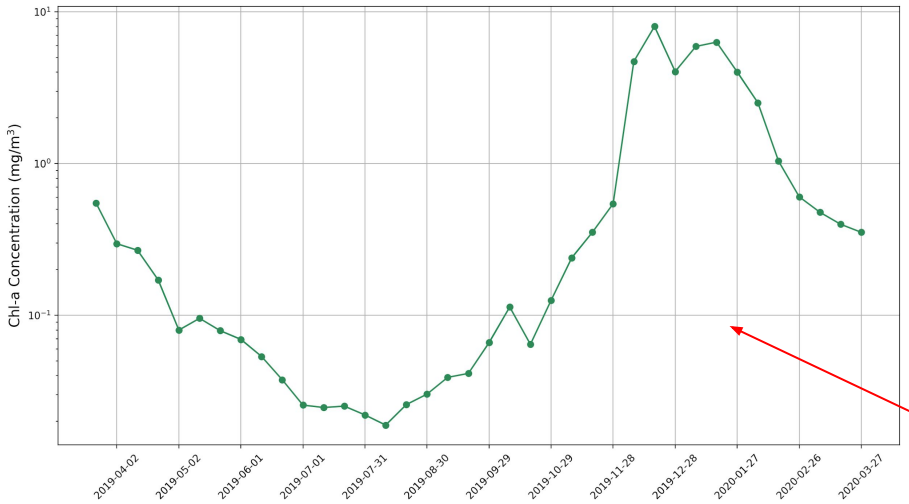
4. Modelling Sea Ice Phenology with BFM 0.5D

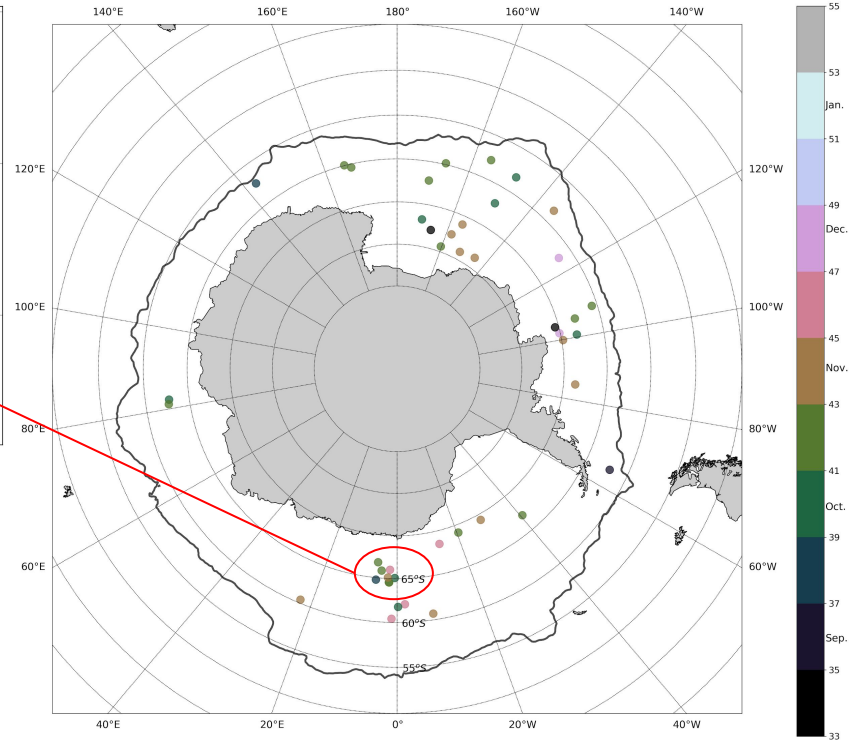






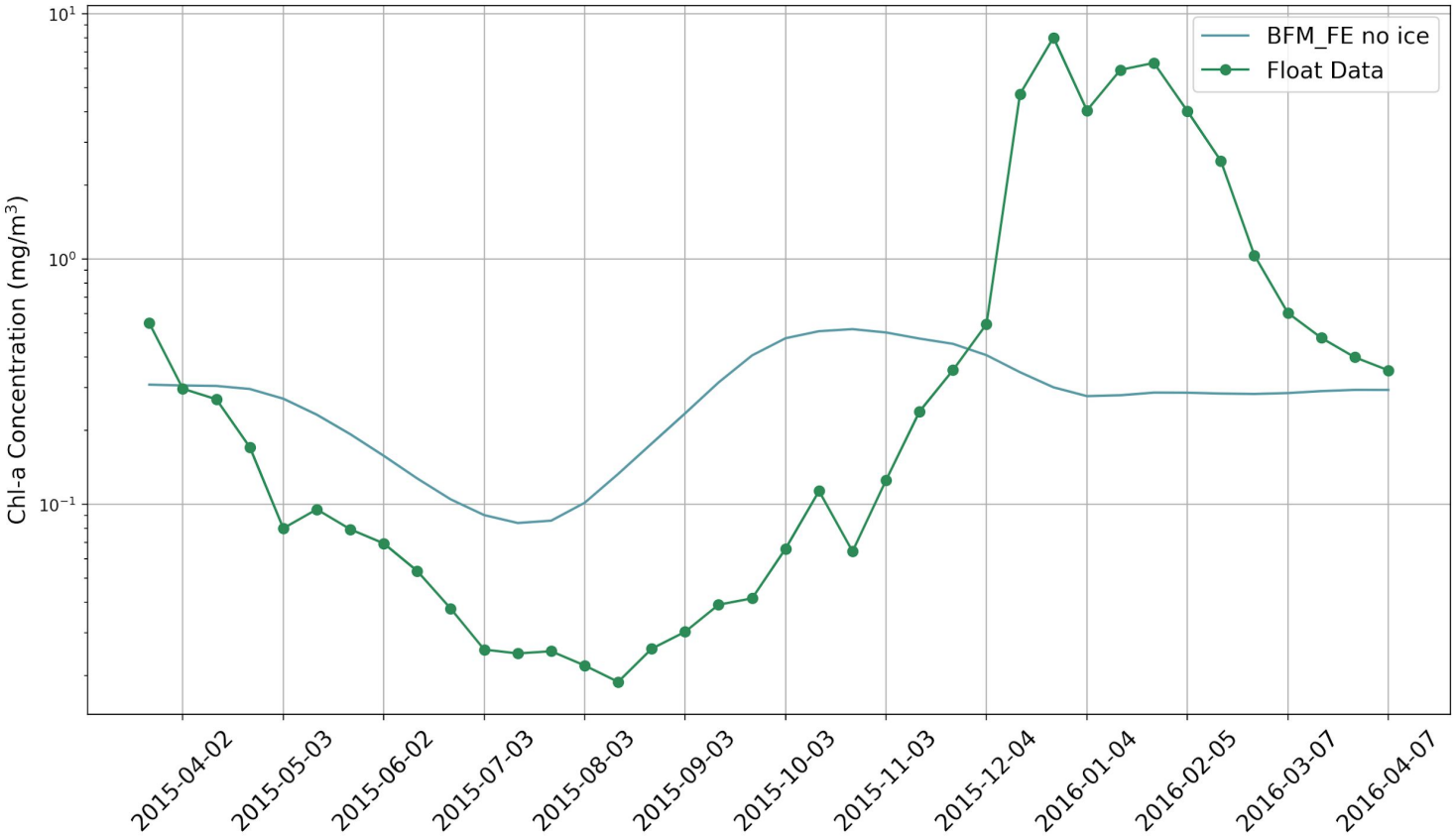
4. Reproduce Float Phenology?



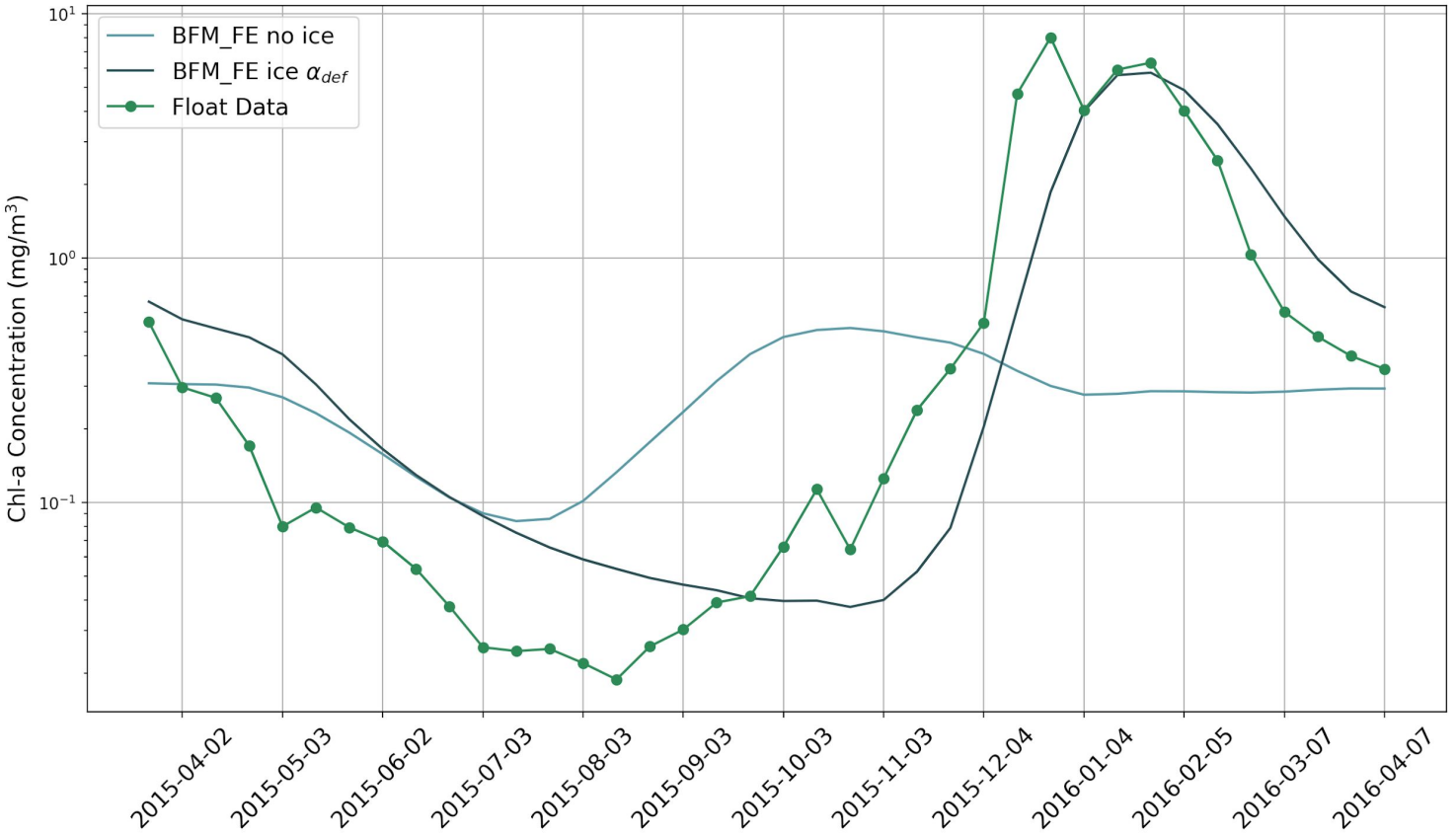


- *What does it take to reproduce this phenology?*
- 3 Experiments:
  - No Ice
  - With ice, standard physiology
  - With ice, enhanced efficiency at low light

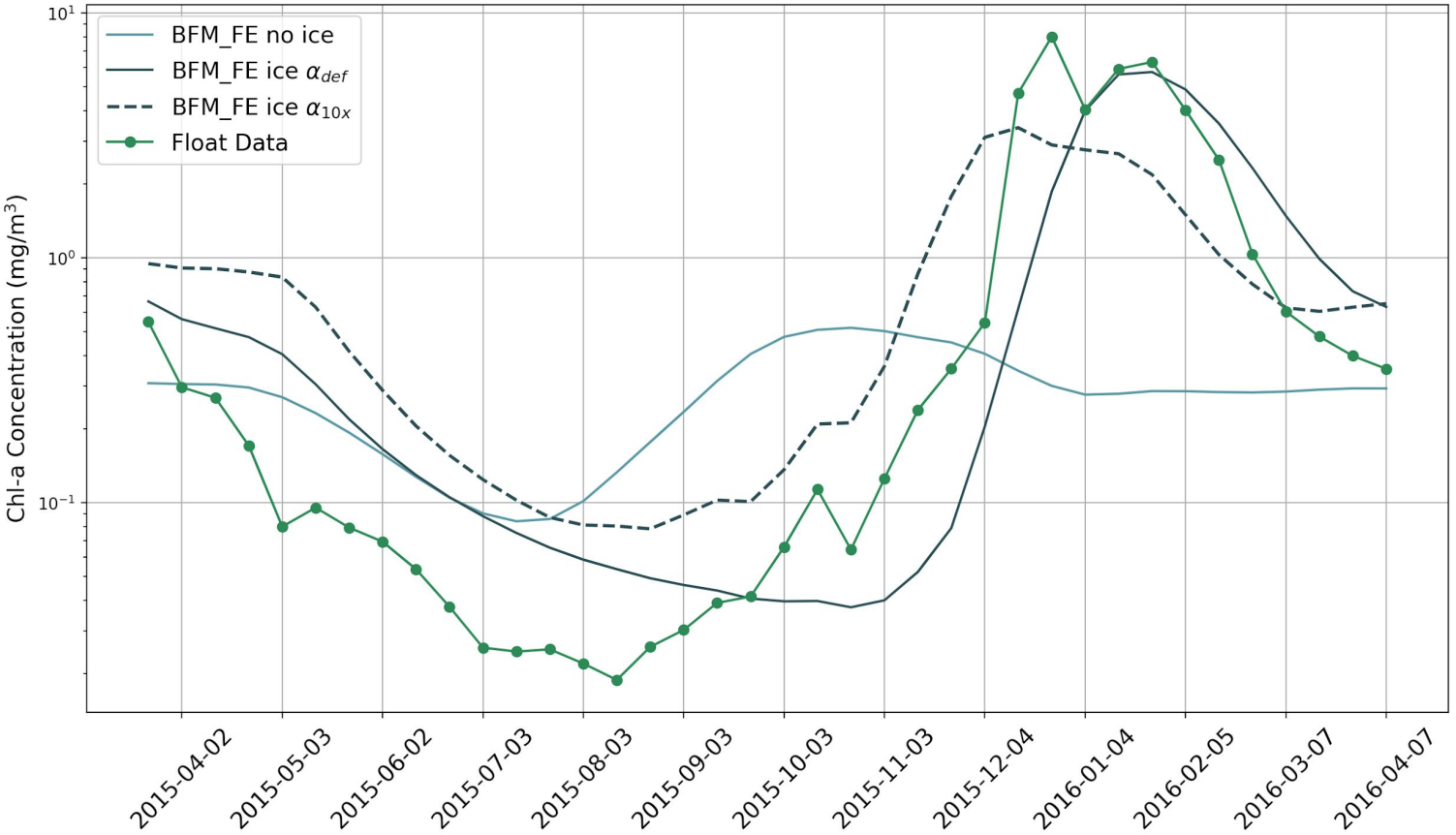
4. Results


BFM_FE no ice
Float Data
Chl-a Concentration (mg/m^3)
10^1
10^0
10^{-1}
2015-04-02
2015-05-03
2015-06-02
2015-07-03
2015-08-03
2015-09-03
2015-10-03
2015-11-03
2015-12-04
2016-01-04
2016-02-05
2016-03-07
2016-04-07

4. Results


BFM_FE no ice
BFM_FE ice α_{def}
Float Data
Chl-a Concentration (mg/m^3)
10^1
10^0
10^{-1}
2015-04-02
2015-05-03
2015-06-02
2015-07-03
2015-08-03
2015-09-03
2015-10-03
2015-11-03
2015-12-04
2016-01-04
2016-02-05
2016-03-07
2016-04-07

4. Results


BFM_FE no ice
BFM_FE ice α_{def}
BFM_FE ice α_{10x}
Float Data
Chl-a Concentration (mg/m^3)
10^1
10^0
10^{-1}
2015-04-02
2015-05-03
2015-06-02
2015-07-03
2015-08-03
2015-09-03
2015-10-03
2015-11-03
2015-12-04
2016-01-04
2016-02-05
2016-03-07
2016-04-07

Summary

- Earth System Models struggle to represent southern ocean phenology, with sea ice playing an important role.
- Relying on satellite observations to study phenology in the SSIZ can be misleading, however, a growing Bio-ARGO dataset can help.
- This dataset reveals substantial, ubiquitous under ice growth, often during mixed layer deepening with poor light conditions.
- A simplified 0.5D biogeochemical model is able to reproduce an observed under ice seasonal cycle by assuming a tenfold increase in low light efficiency.
    - This suggests that pelagic phytoplankton are much more adapted to extremely low light than previously thought.
- With possible earlier sea ice retreat in the future we can expect even earlier growth, with cascading effects on the Southern Ocean ecosystem and biological pump.