# *The role of snow and sea ice in constraining the phytoplankton phenology in the Arctic Ocean*

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TAKUVIK

cnrs dépasser les frontières

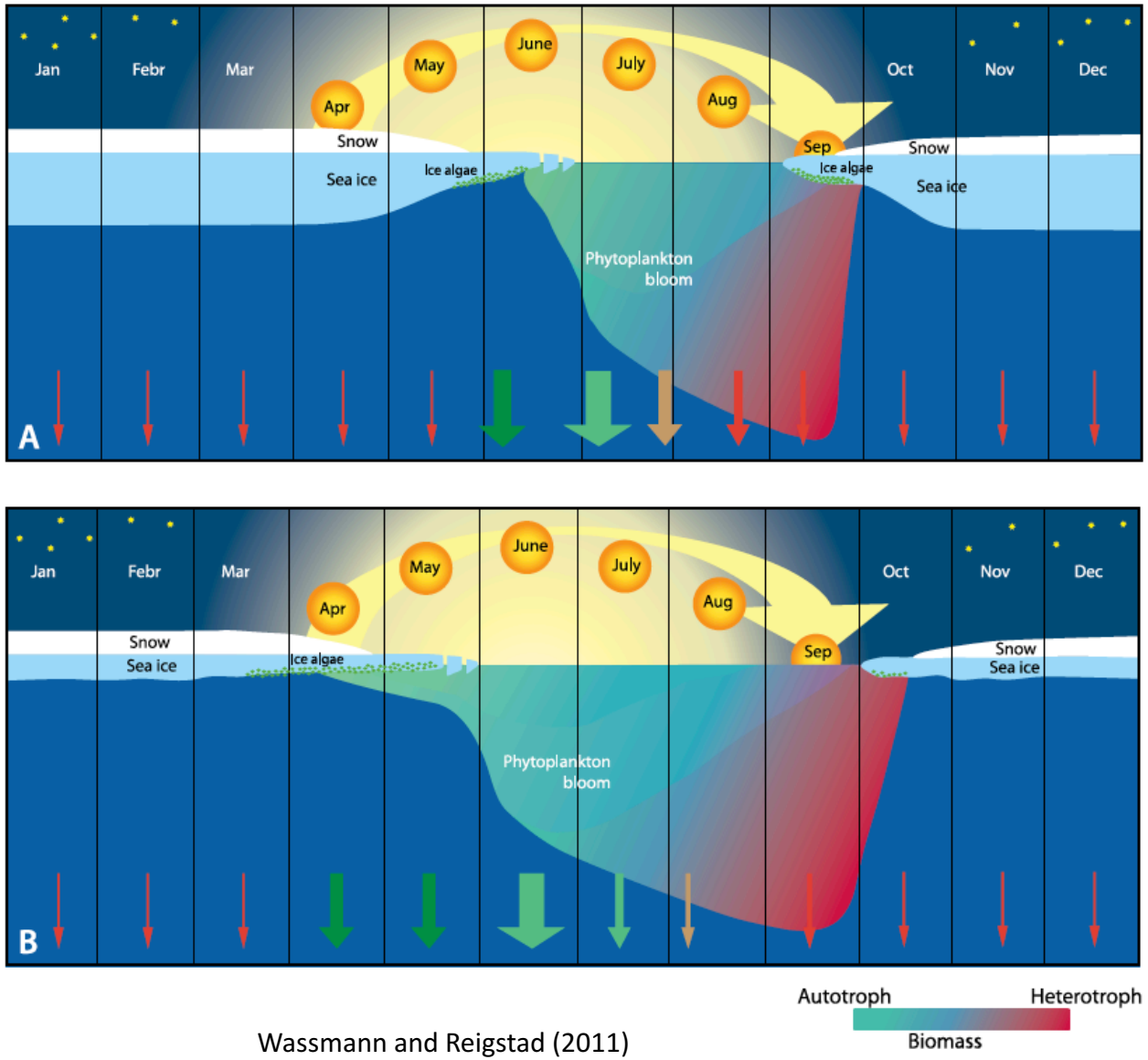
UNIVERSITÉ LAVAL
Aujourd'hui Québec, demain le monde

# Phenology of microalgae: ice algae and phytoplankton

**Biomass =** gain – losses

**Gain:** growth based mostly on photosynthesis

**Losses:** respiration, grazing, sinking, viral lysis, …




Wassmann and Reigstad (2011)

# What triggers and stops microalgae growth (focus on light)?

# In this presentation

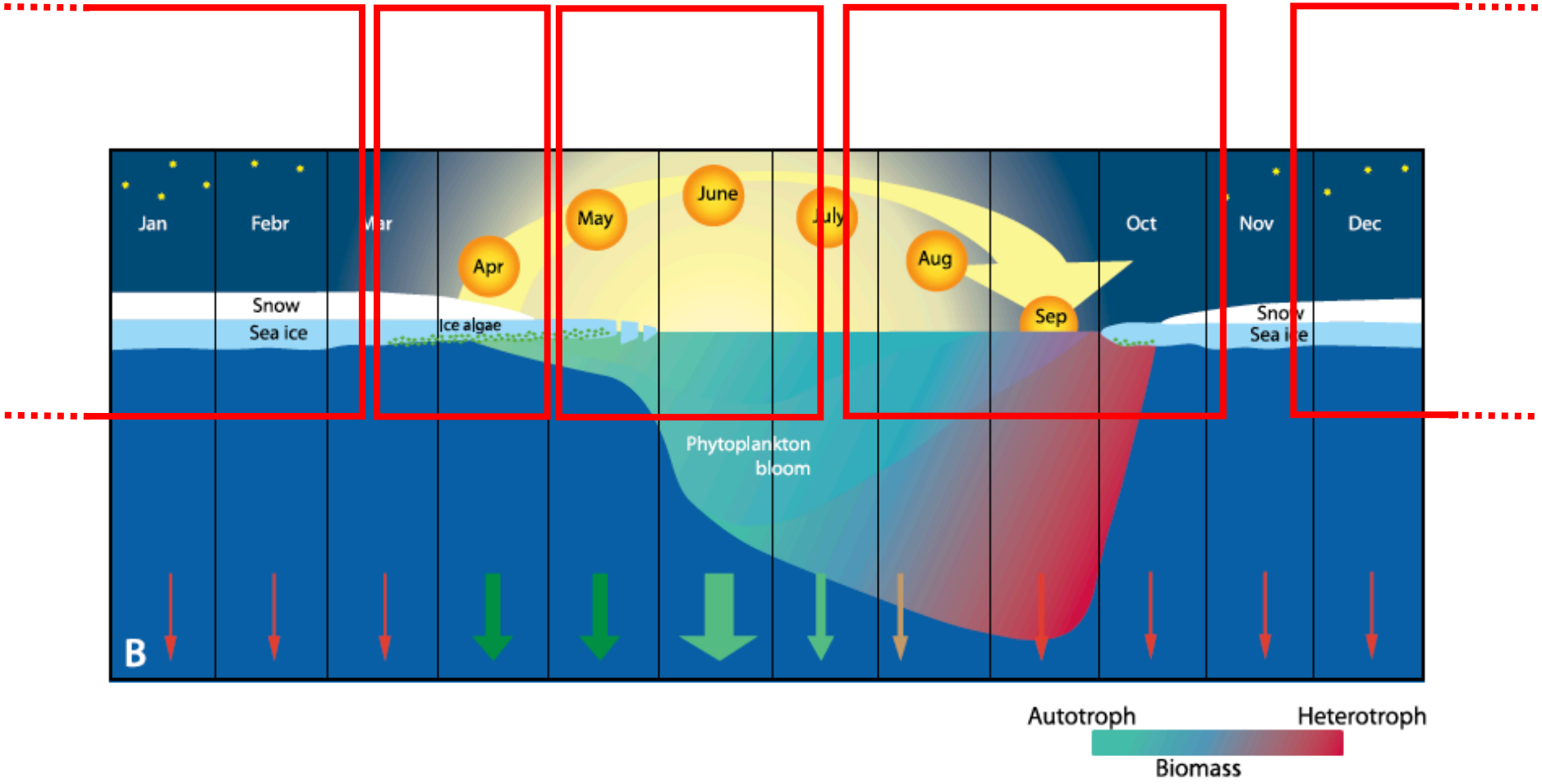
4- NAOS winter bioargo floats (2017-2018)

1- Green Edge Ice camp

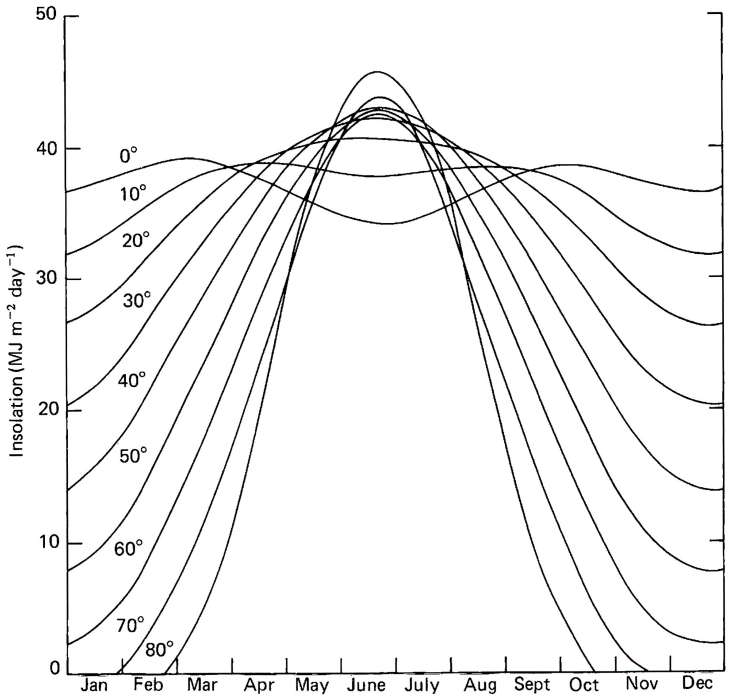
2- Green Edge cruise

3- NAOS summer bioargo Floats (2016) + lab experiment

4- NAOS winter bioargo floats (2017-2018)



# Fews relevant facts about light and microalgae

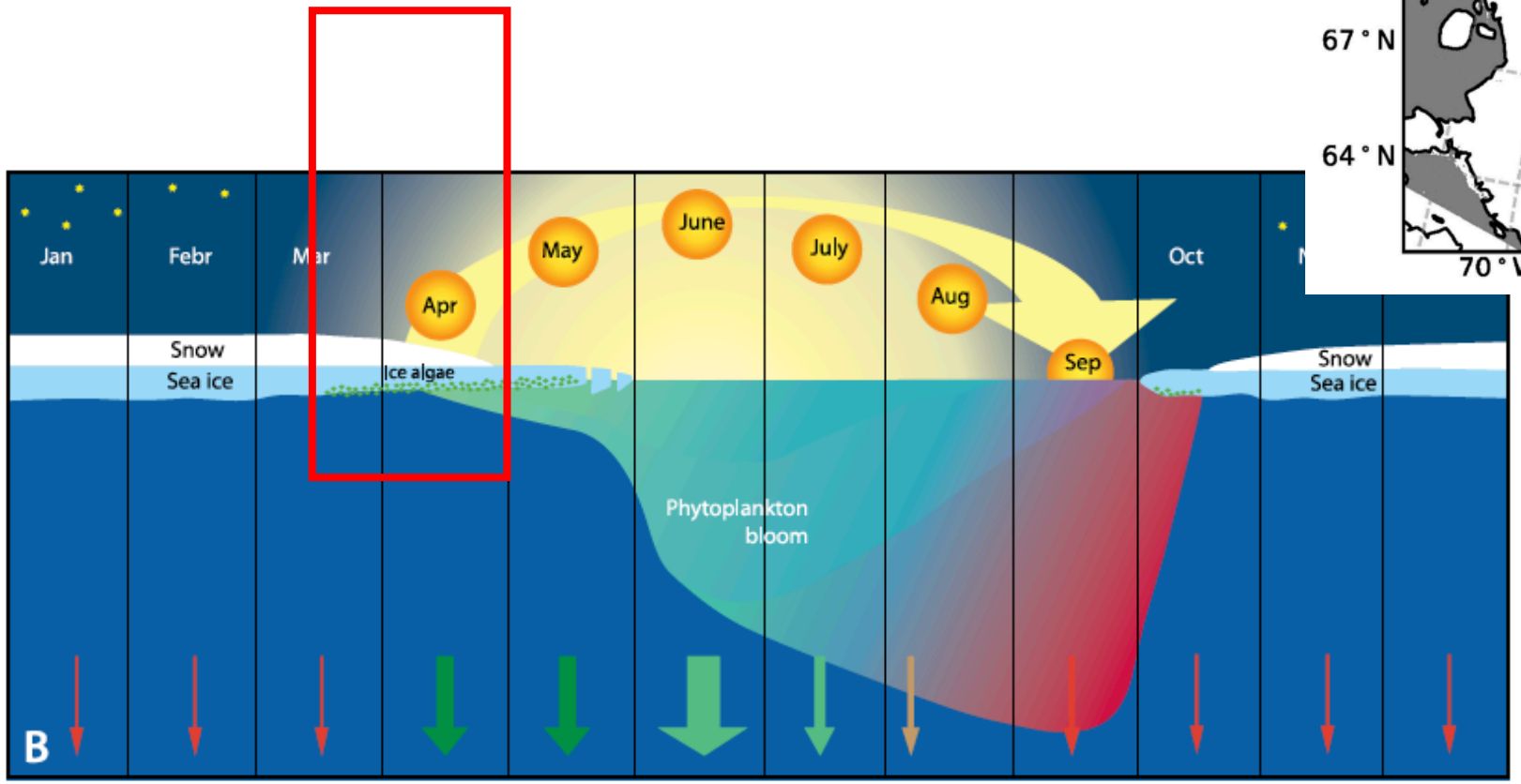


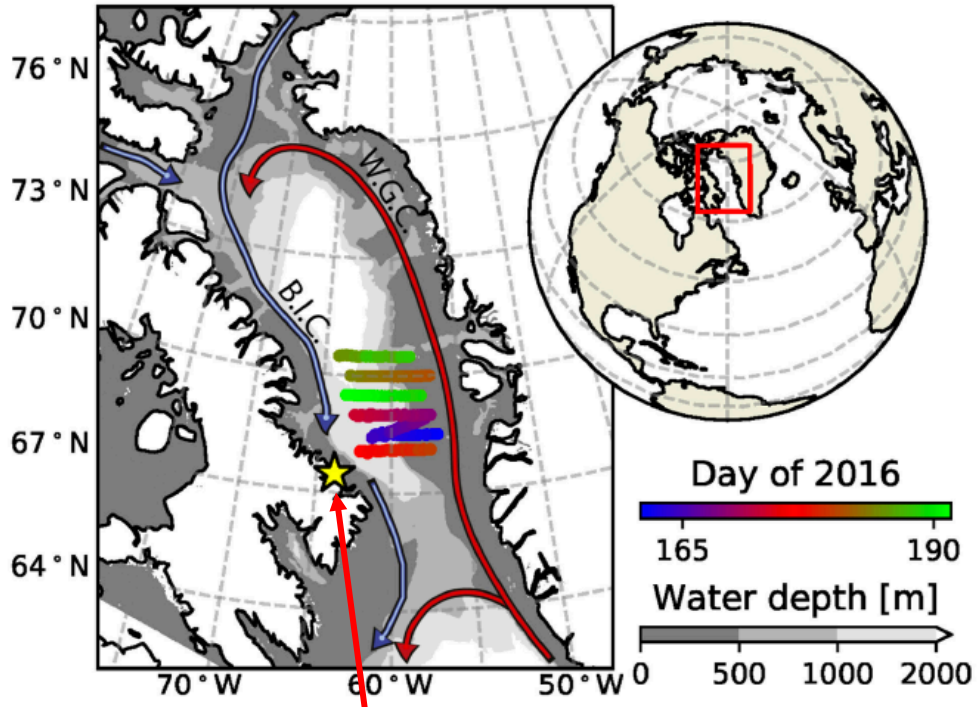

Kirk (2011)

| Incident irradiance in Arctic during summer solstice | 40-70 mol photons $m^{-2}$ $day^{-1}$ | |
|---|---|---|
| Minimum irradiance for phytoplankton accumulation – accounts for losses | 0.415 mol photons $m^{-2}$ $day^{-1}$ | Letelier et al. (2004) |
| Minimum irradiance for ice algea net growth in Arctic | ~0.01 mol photons $m^{-2}$ $day^{-1}$ | Hancke et al. (2018) |
| Theoretical irradiance for photosynthesis | ~0.001 mol photons $m^{-2}$ $day^{-1}$ | Raven et al. (2000) |

# 1- Green Edge Ice camp - **Spring**

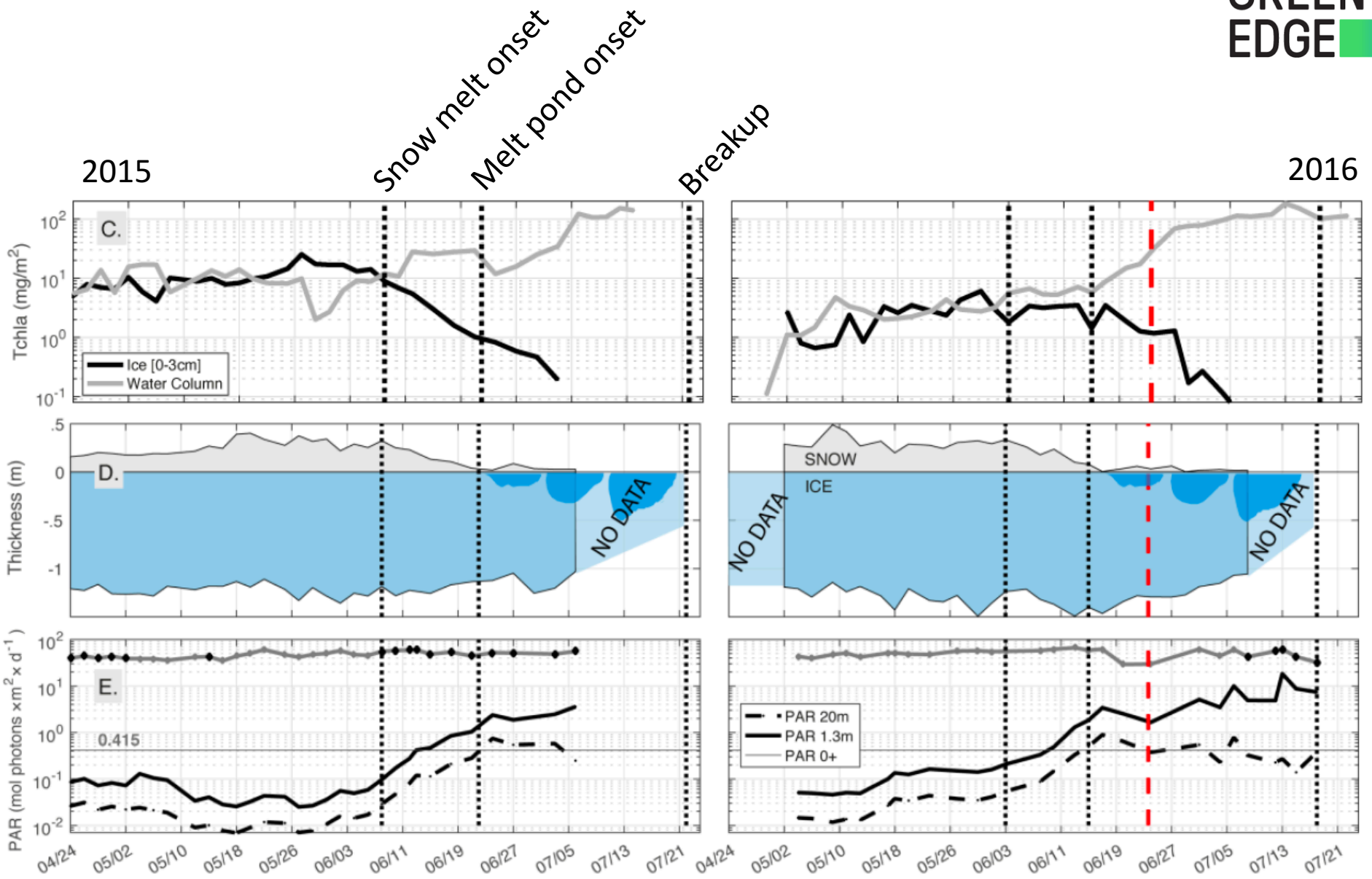
Ice-algae and phytoplankton blooms?
Triggered beyond some light threshold?




Ice-camp location on landfast ice
390 m water column depth

GREEN EDGE




Oziel et al. (in revision)

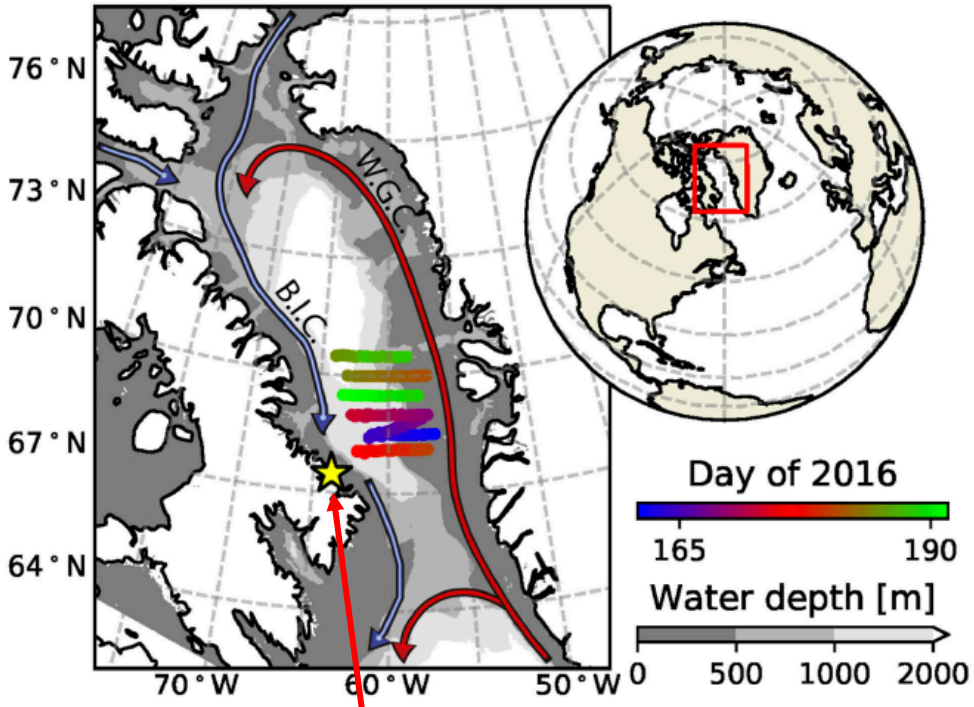
# 1- Green Edge Ice camp - **Spring**

Ice-algae and phytoplankton blooms?

→ Yes!

Triggered beyond some light threshold?

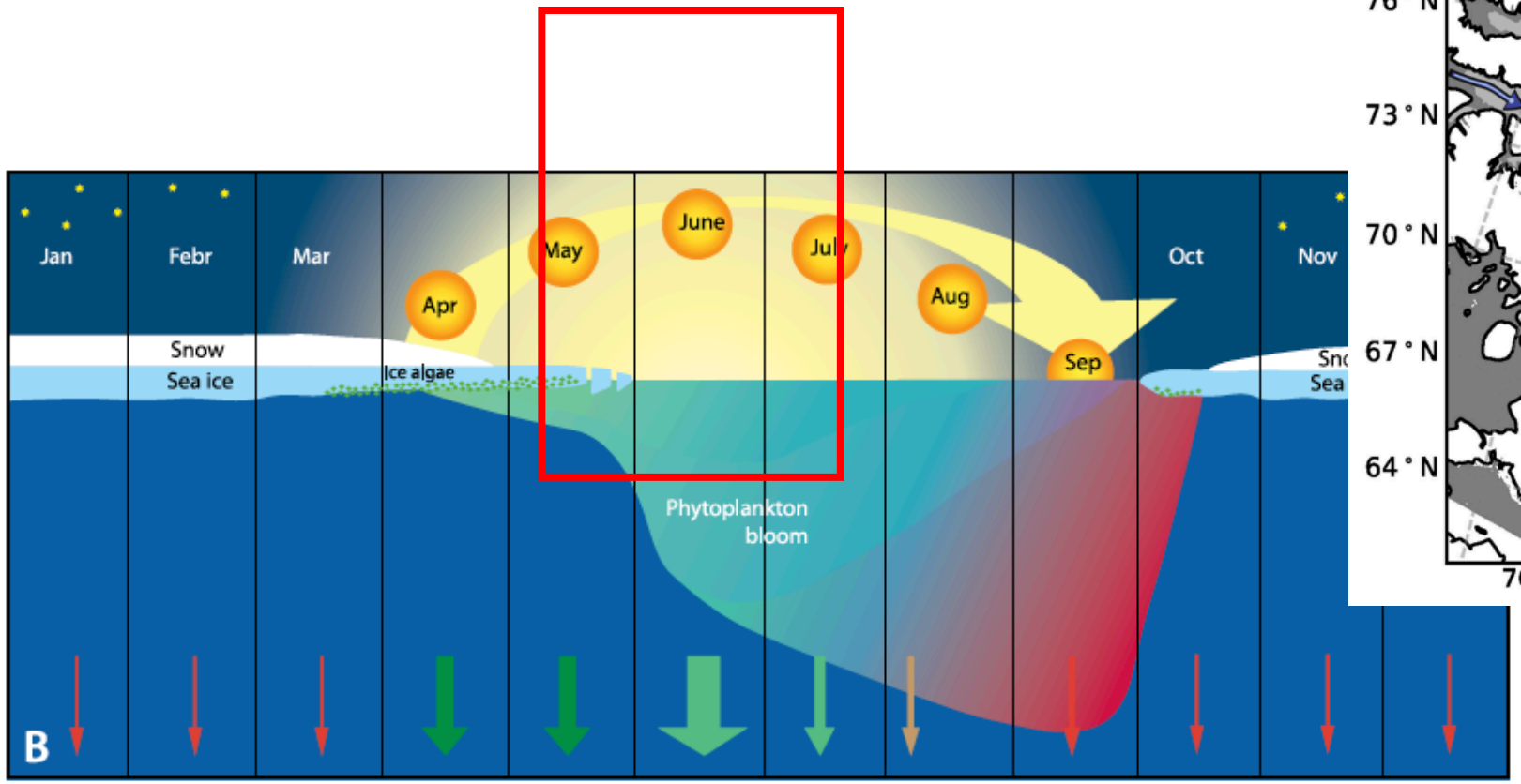
→ Not so clear … not so simple

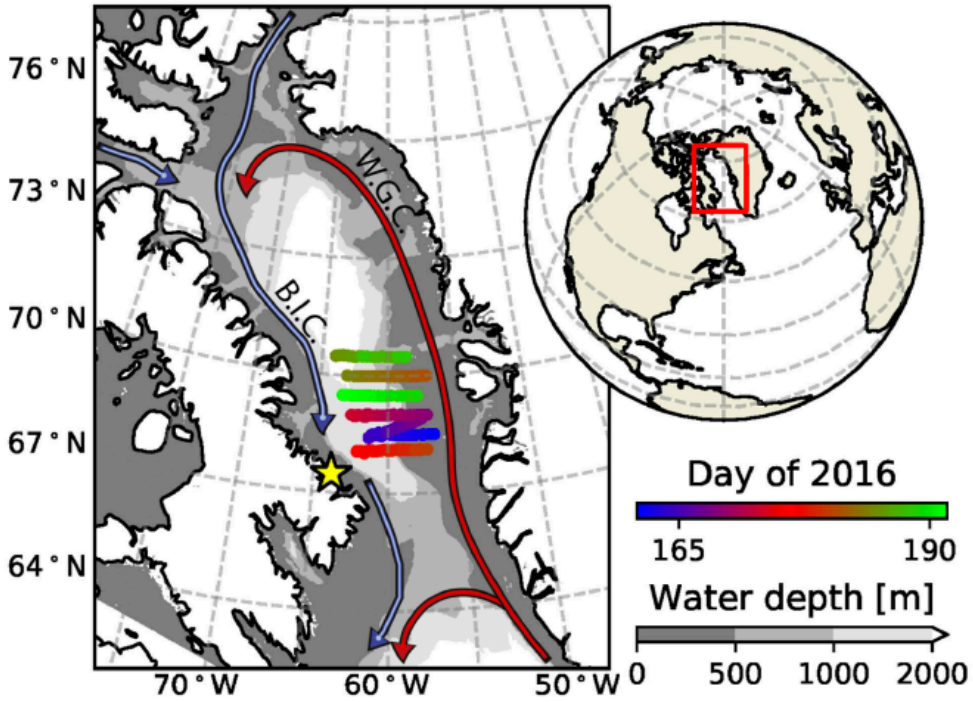


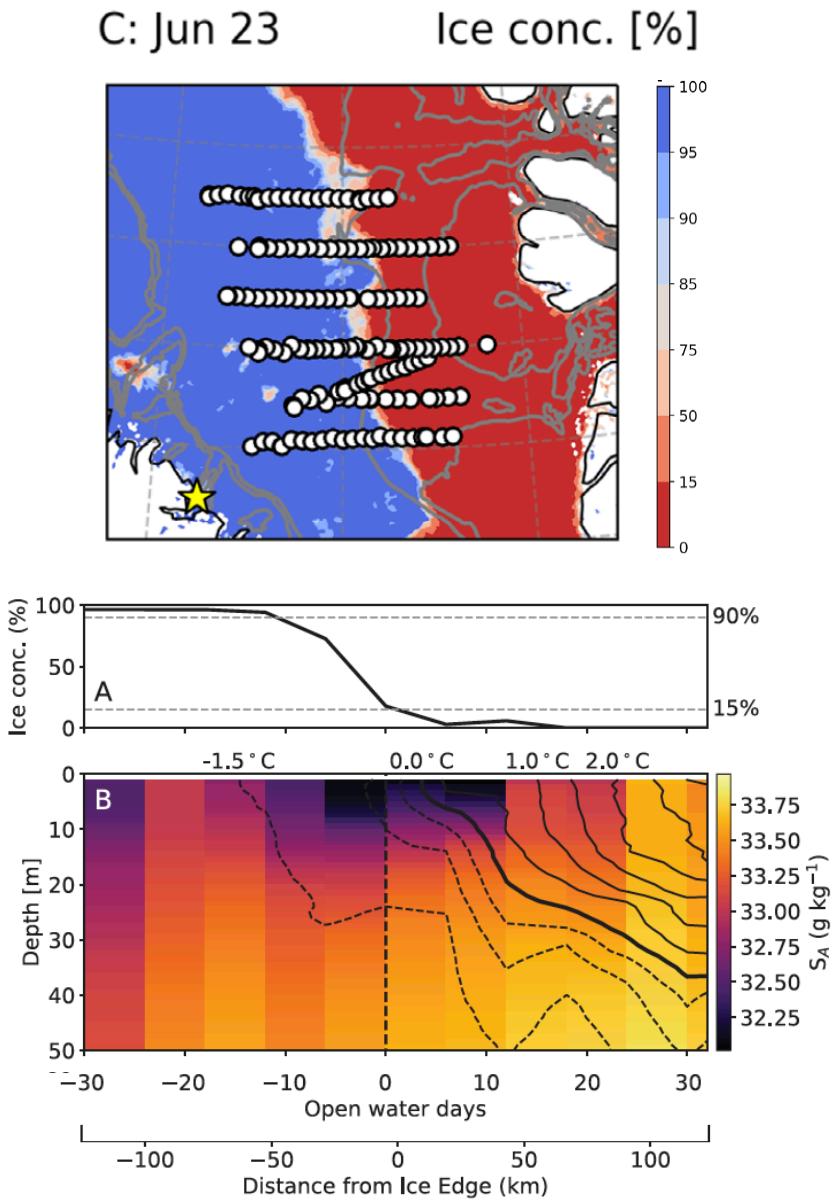

Ice-camp location on landfast ice
390 m water column depth

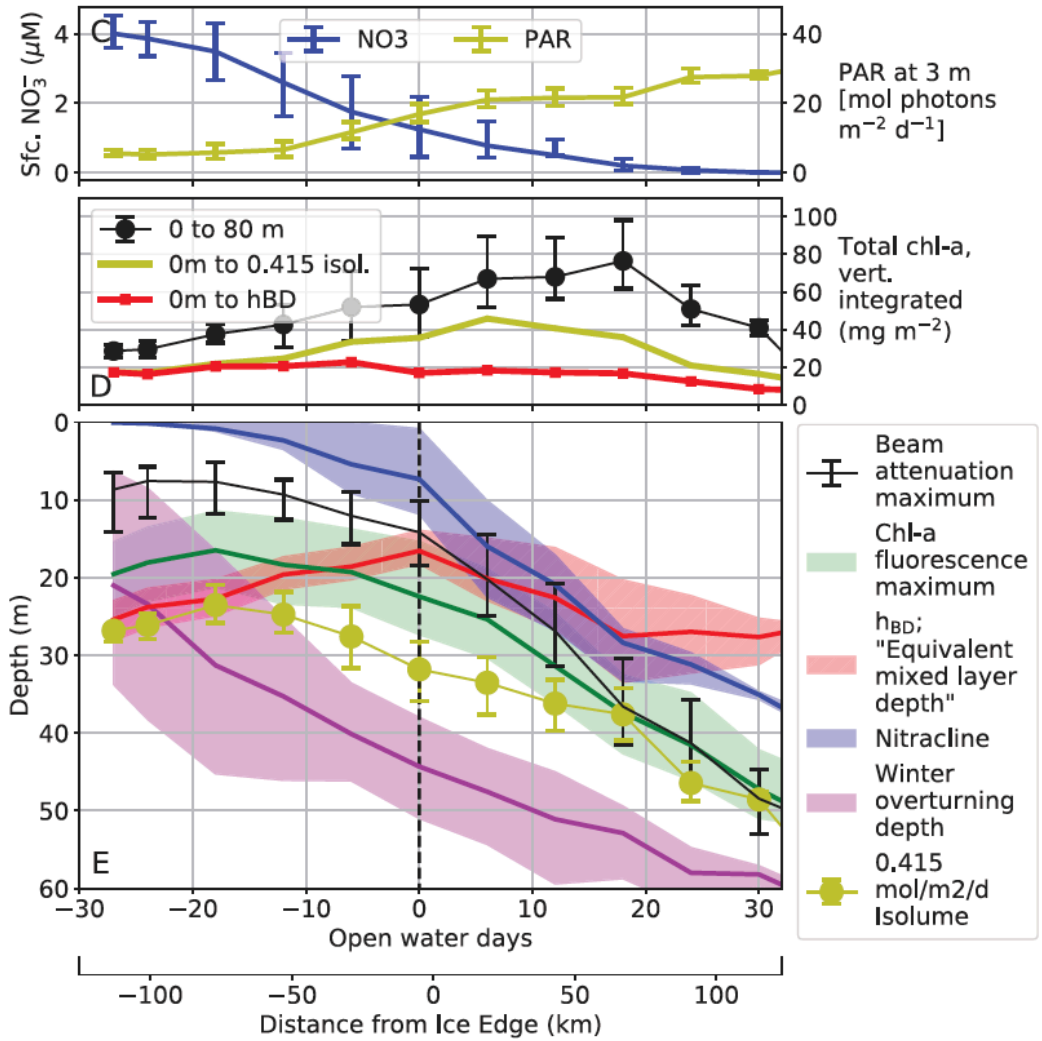
# 2- Green Edge cruise - Spring-Summer transition

Under-ice vs. Ice-edge bloom, how do they compare?
Triggered beyond some light threshold?






GREEN EDGE

< surface irradiance under ice

Irradiance > 0.415 everywhere

Nutrient low in open water

More biomass in open water despite deep

Randelhoff et al. (2019)

# 2- Green Edge cruise - Spring-Summer transition

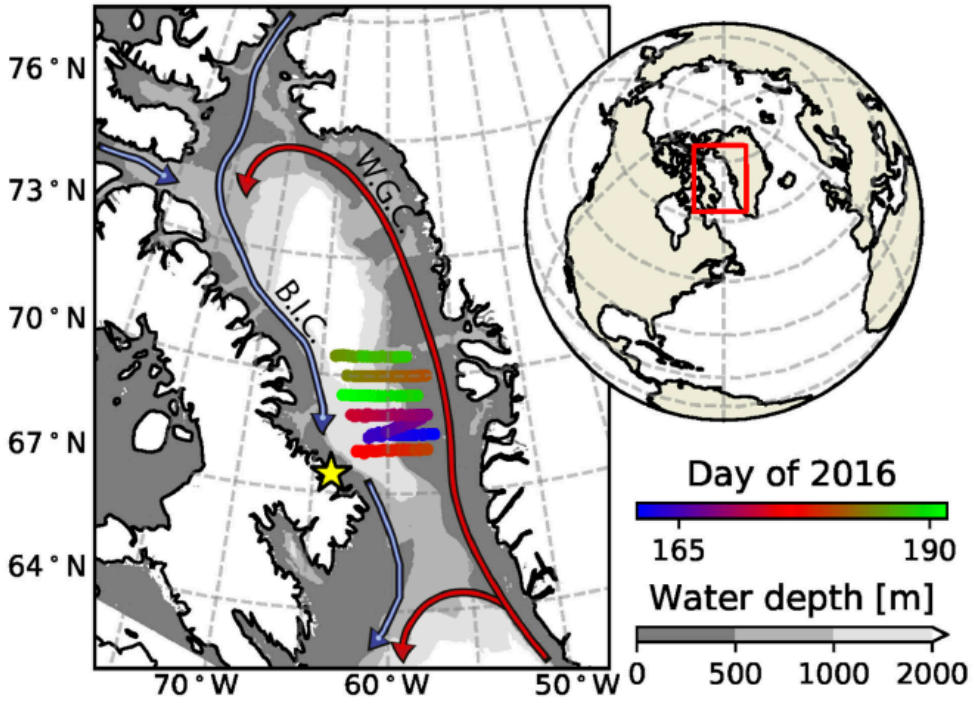
Under-ice vs. Ice-edge bloom, how do they compare?
Triggered beyond some light threshold?

Under-ice vs. Ice-edge bloom, how do they compare?

→ The ice-edge bloom is more intance.

Triggered beyond some light thresold?

→ Not so clear … not so simple



# How is the ice-edge bloom currently evolving?

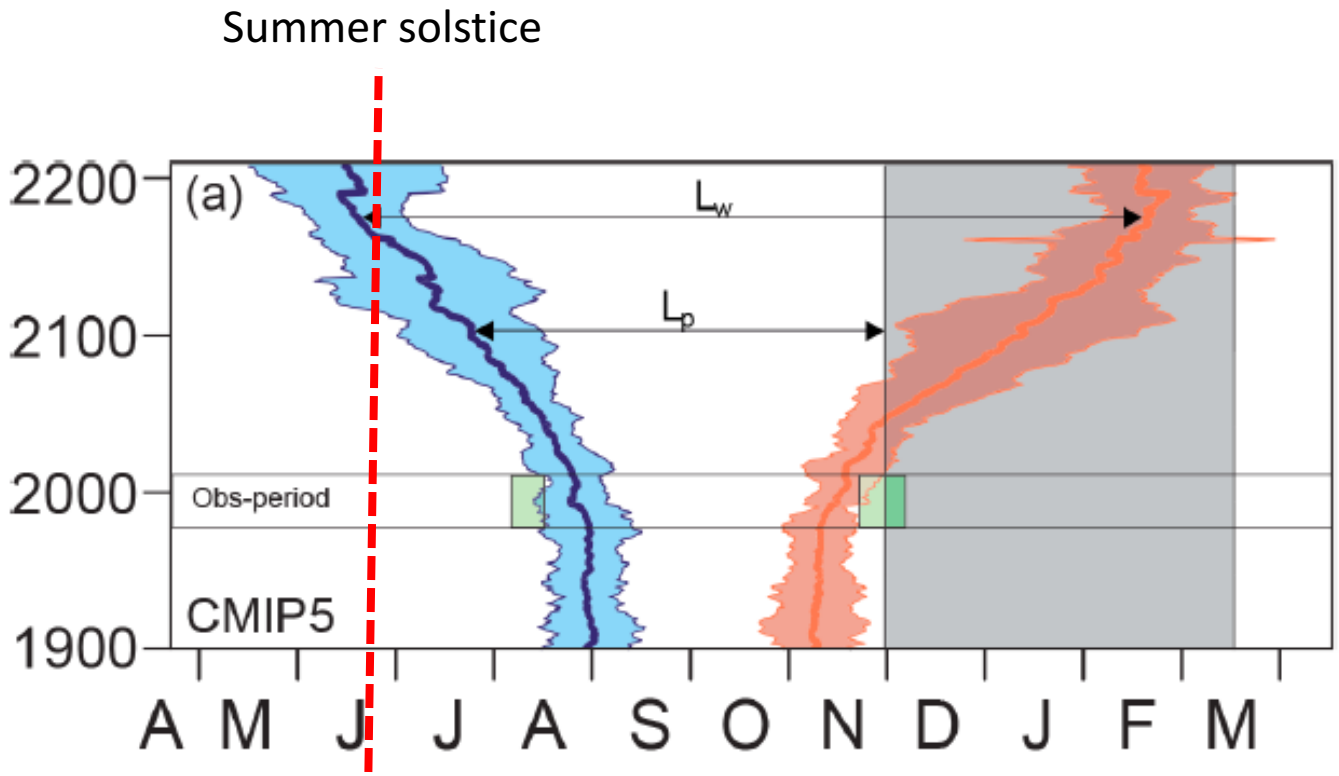
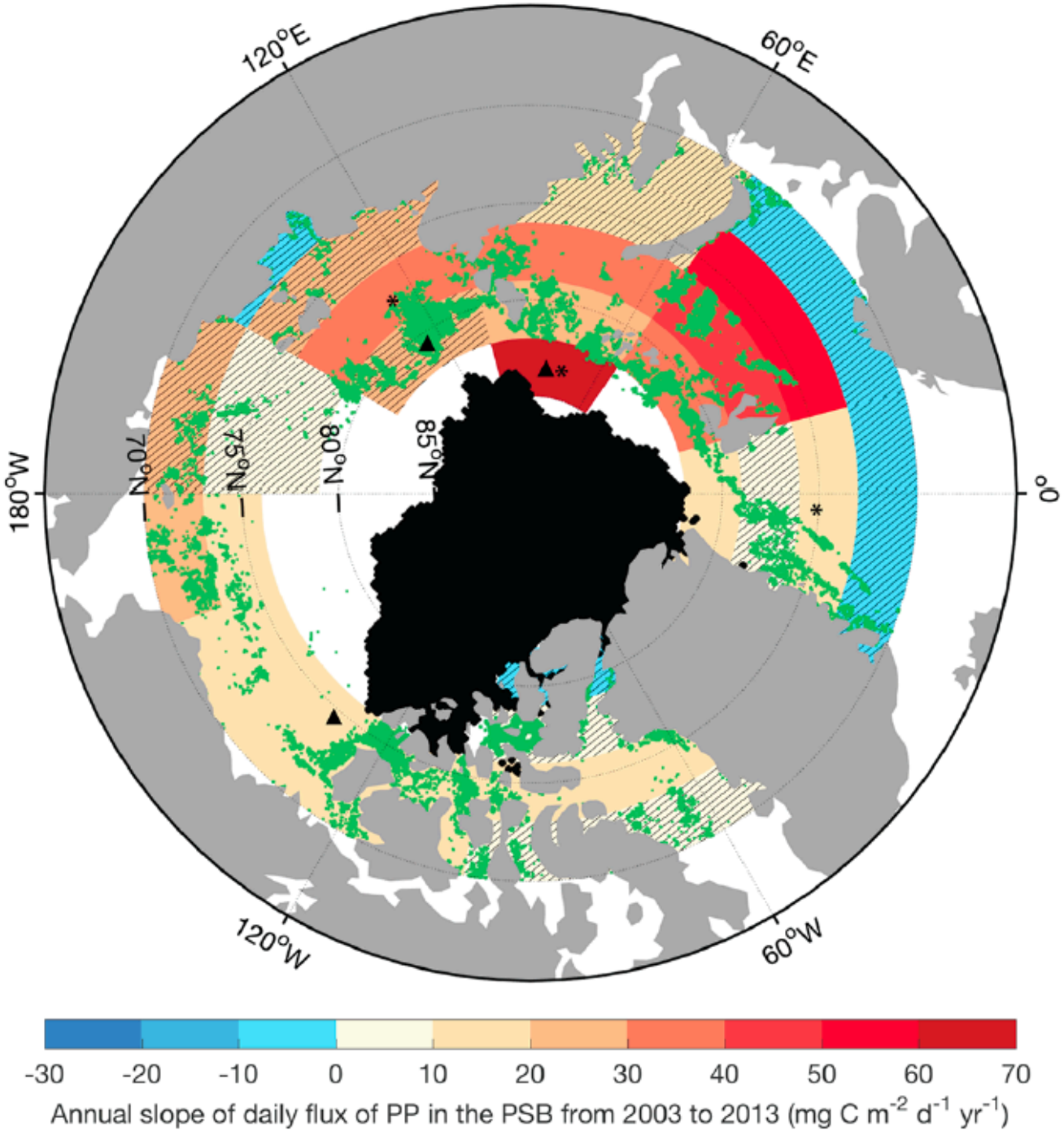



**Figure 1.** Evolution of the ice seasonality diagnostics (ice retreat date, blue; ice advance date, orange): **(a)** CMIP5 median and interquartile range, with corresponding range of satellite-derived values (green rectangles 1980–2015) over the 70–80° N latitude band;

Lebrun et al. (2019)

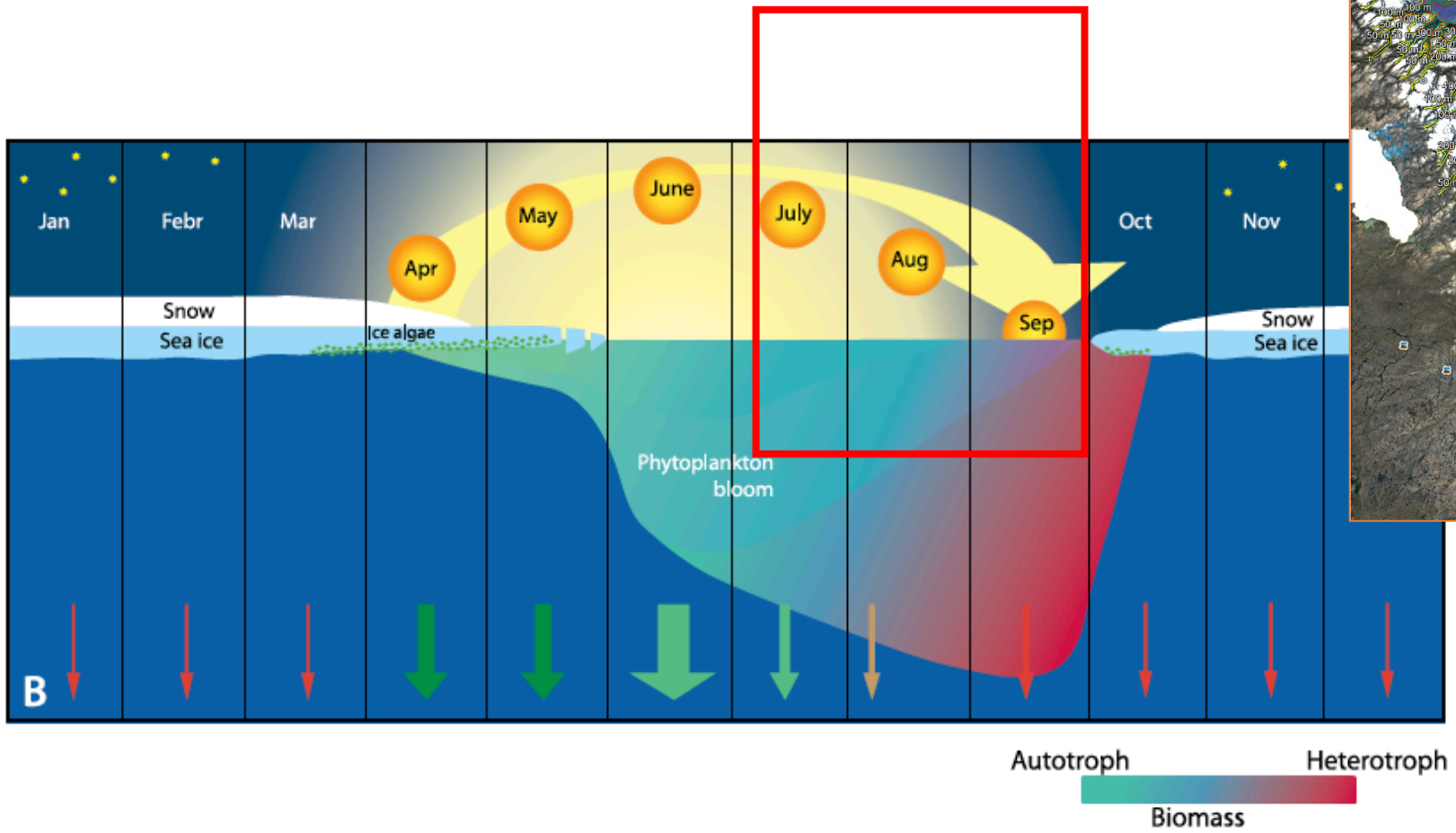
GREEN EDGE

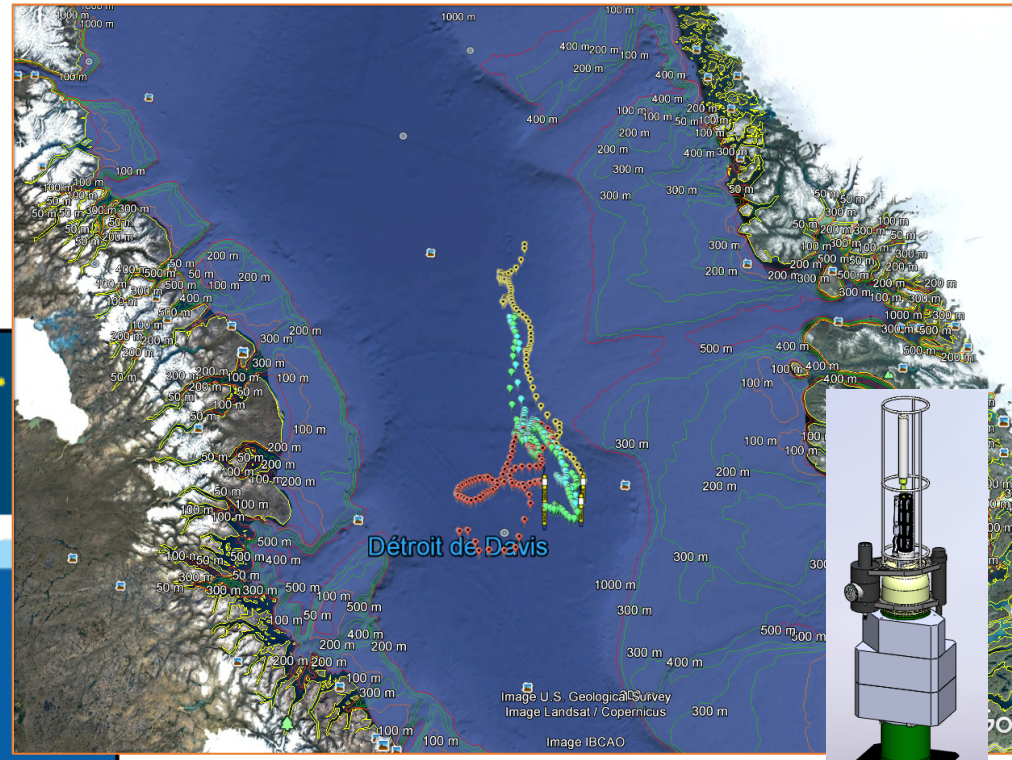



Renaut et al. (2018)

# 3- NAOS summer bioargo floats (2016) + lab experiment

When does phytoplankton « growth » stop?
Controlled by some light threshold?






NAOS
Novel Argo Ocean observing System

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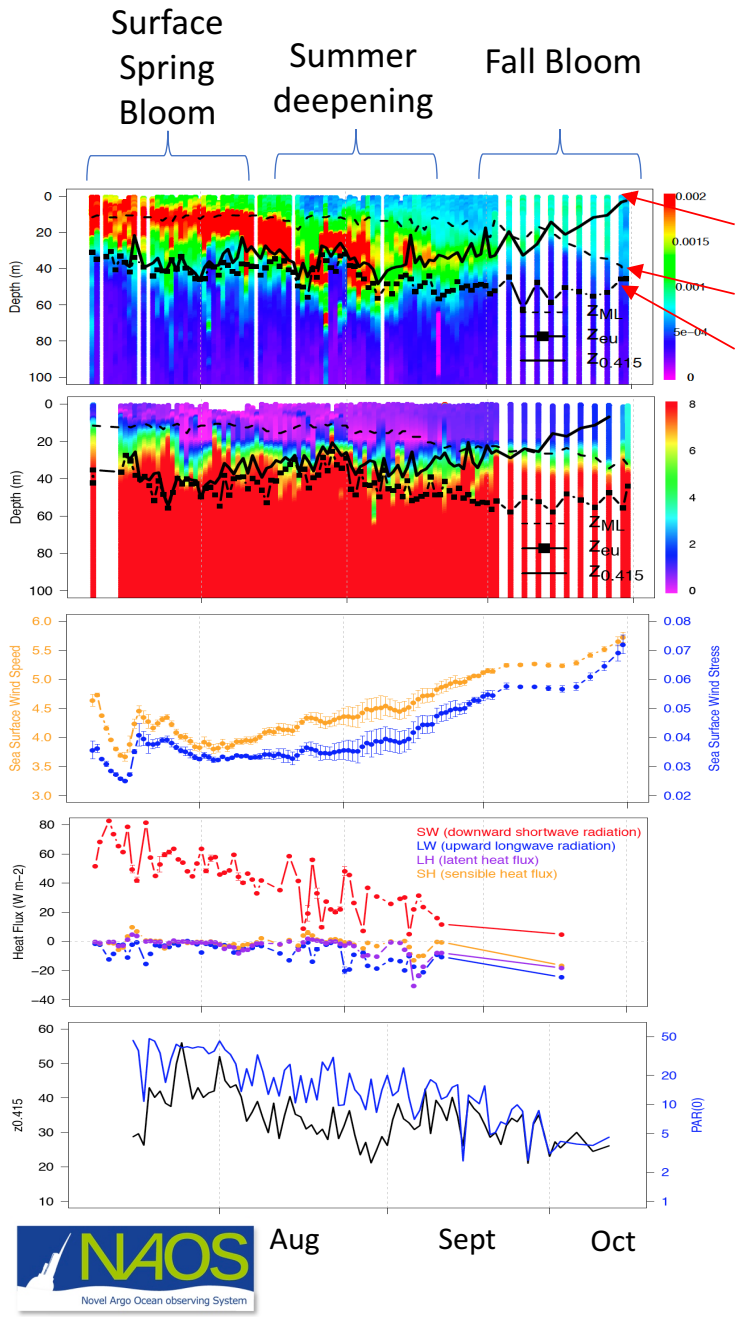
Biomass

Nitrate

Wind stress

Heat flux

Incident irradiance (blue)




1- Surface deplenishment of nitrate leads to a deepening of biomass in July, above $Z_{0,415}$

2- A mixing event leads to an increase in surface nitrate and a fall bloom at surface

3- The fall bloom is possible until $Z_{0,415}$ reaches the surface because incident irradiance decreases before winter

4- Vertical mixing is driven by wind and/or thermal convection

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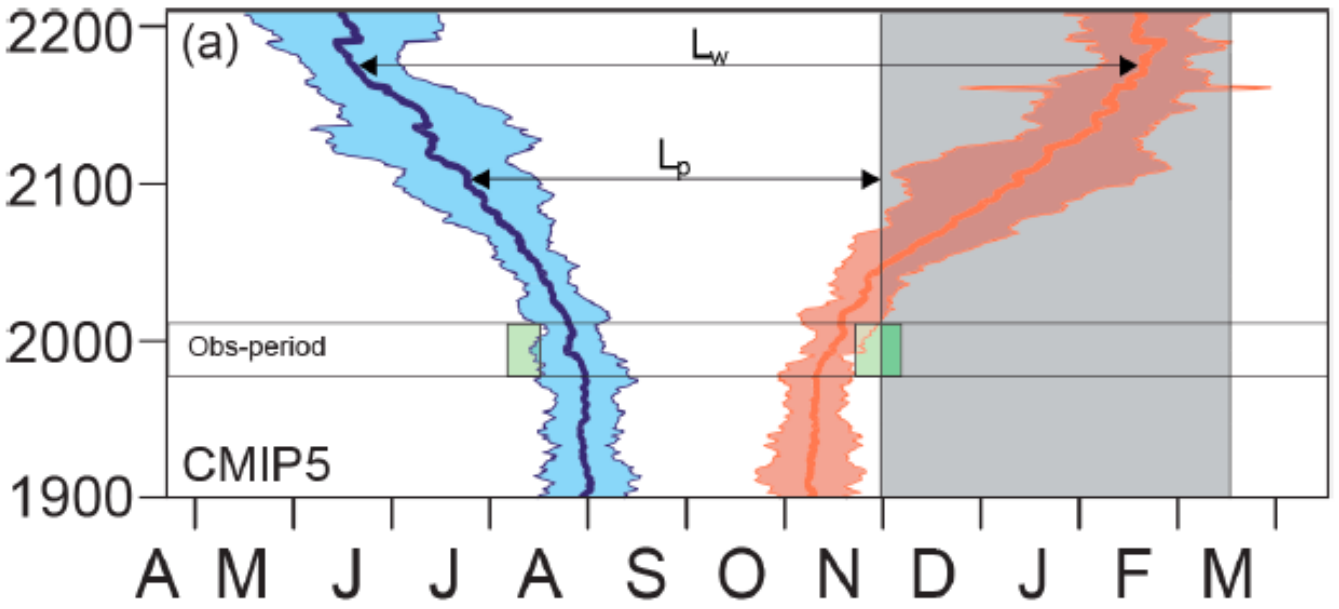
Babin et al. (in progress)

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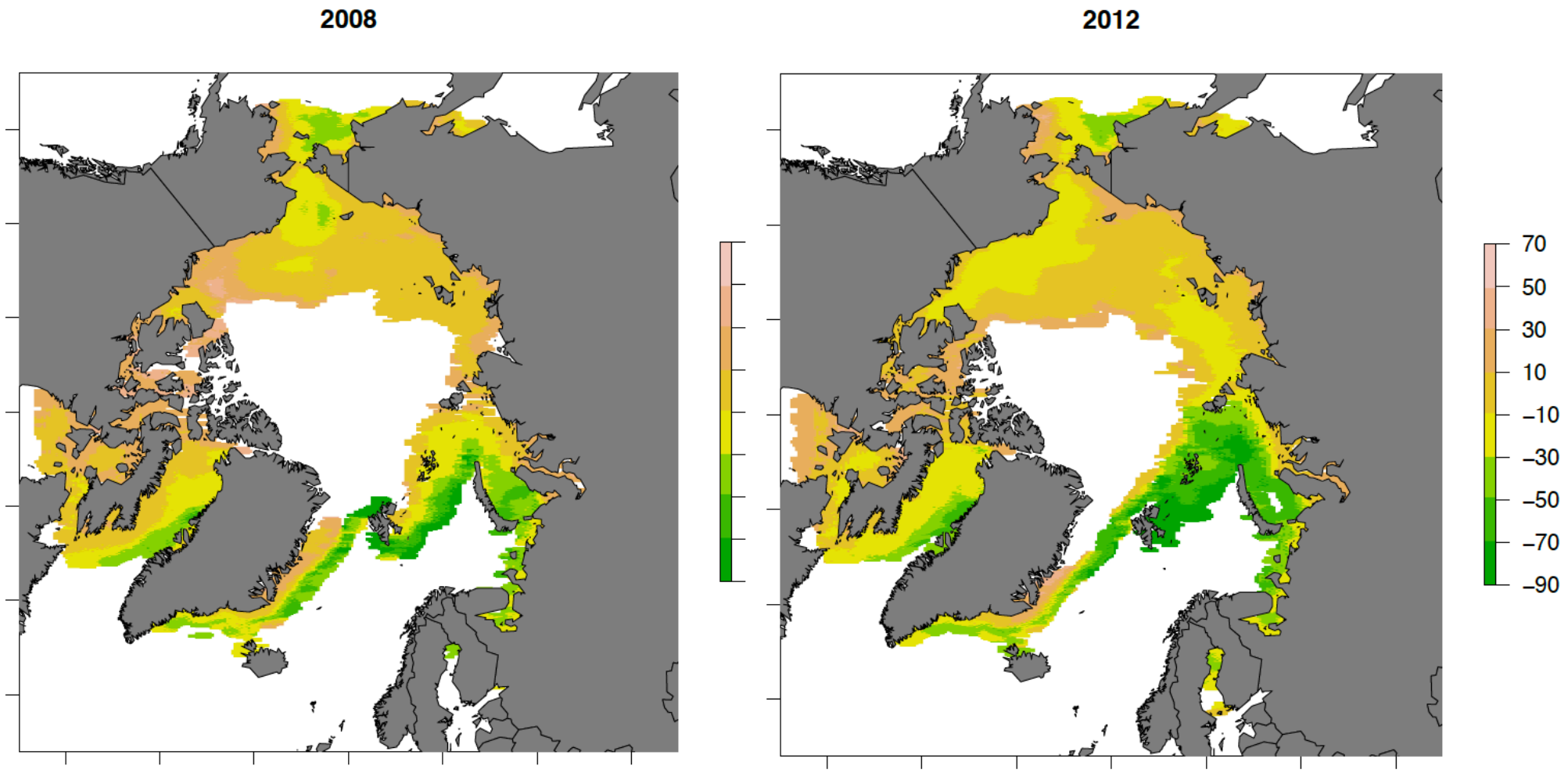



Data: Comiso, J. C. 2017. *Bootstrap Sea Ice Concentrations from Nimbus-7 SMMR and DMSP SSM/I-SSMIS, Version 3*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. doi: https://doi.org/10.5067/7Q8HCCWS4I0R.

Babin et al. (in progress)

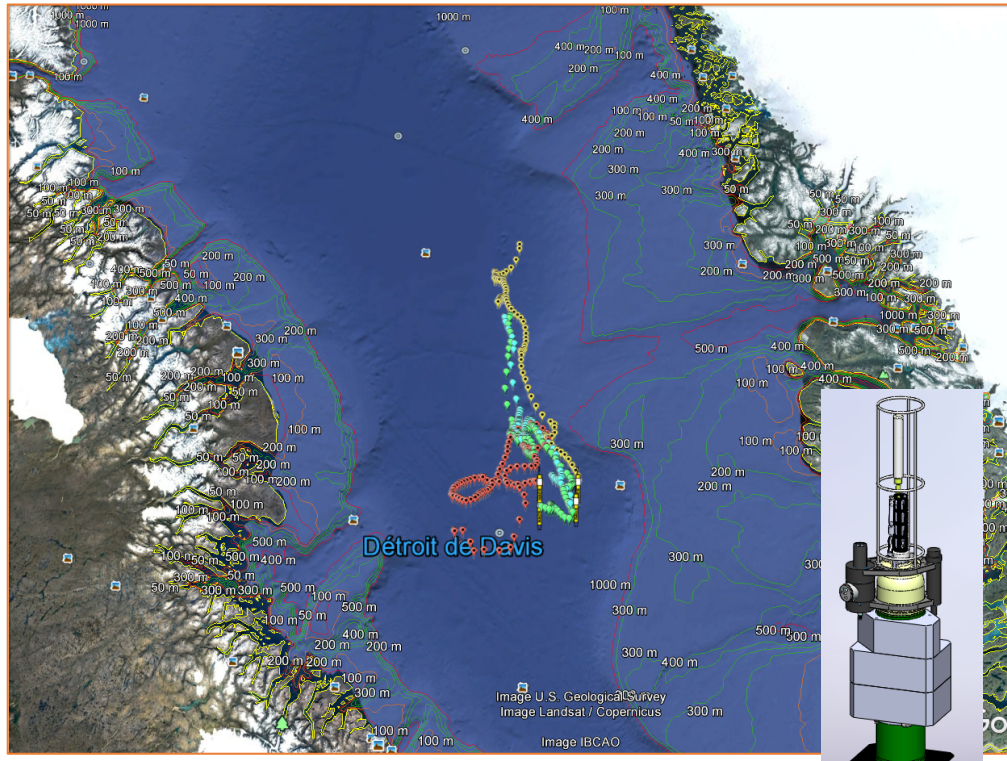
# 3- NAOS summer bioargo floats (2016) + lab experiment

When does phytoplankton « growth » stop?

→ depends: when the sun set or ice forms

Controlled by some light threshold?

→ ~ 0.415 mol photons $m^{-2}$ $day^{-1}$



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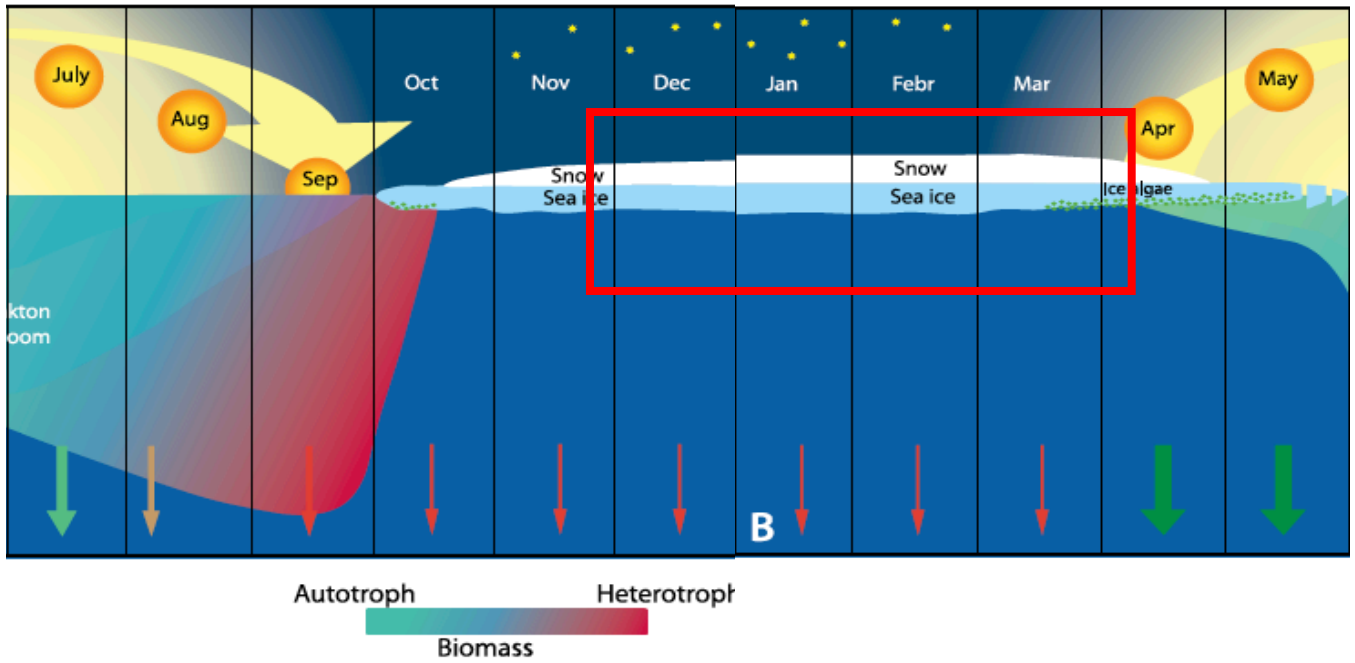
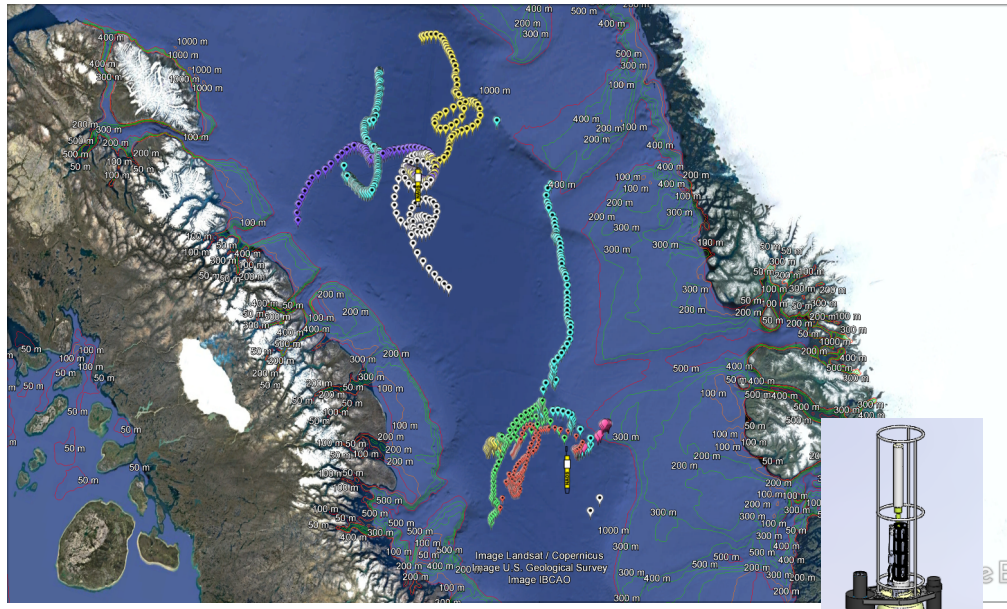
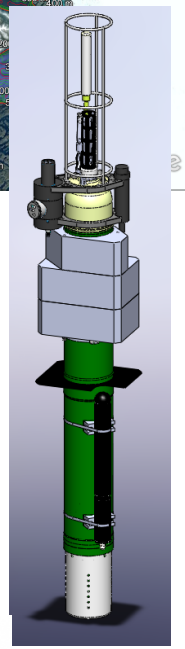
# 4- NAOS winter bioargo floats (2017-2018)

When does microalgae growth actually starts growing during spring?
Controlled by some light threshold?



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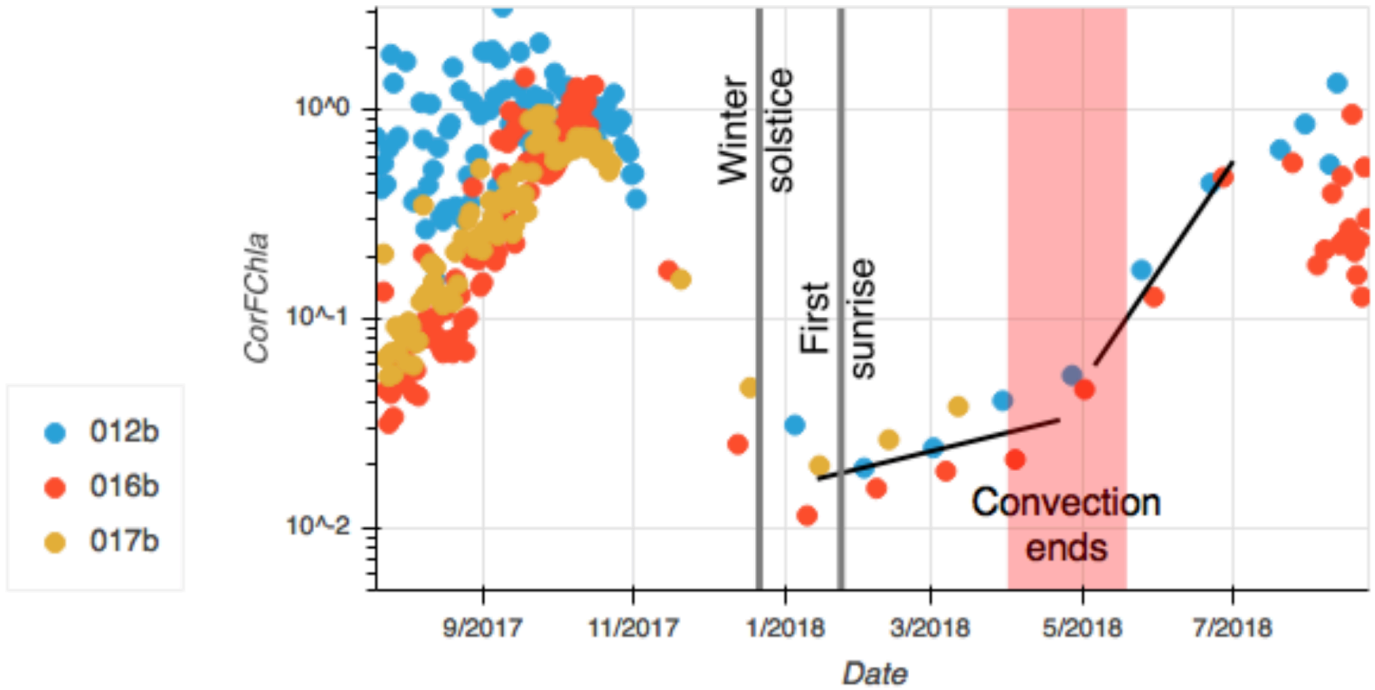


Randelhoff et al. (in progress)

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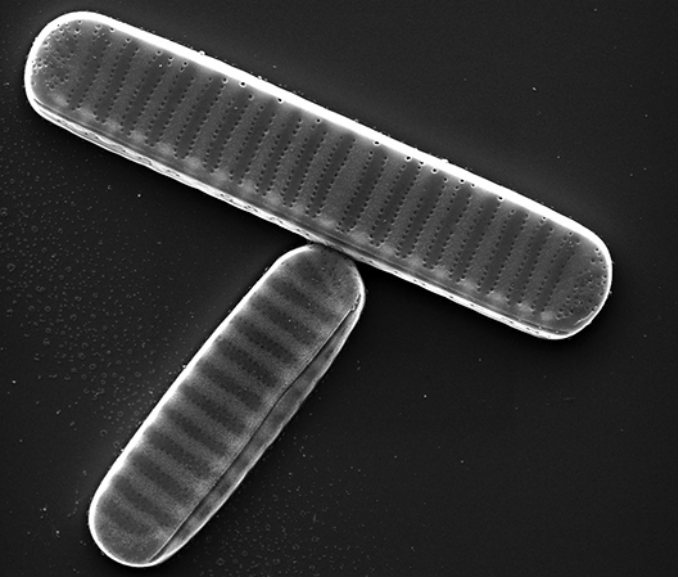
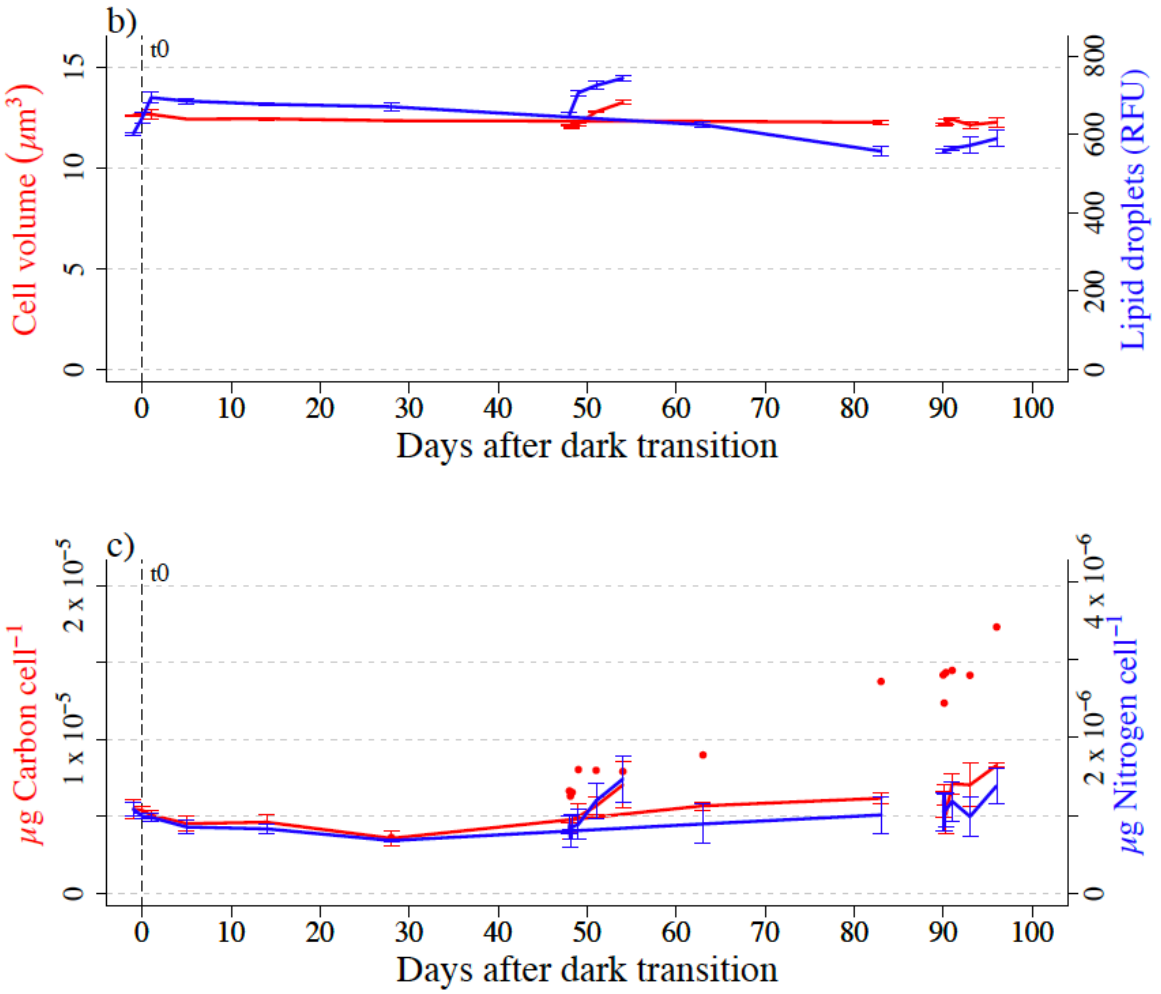
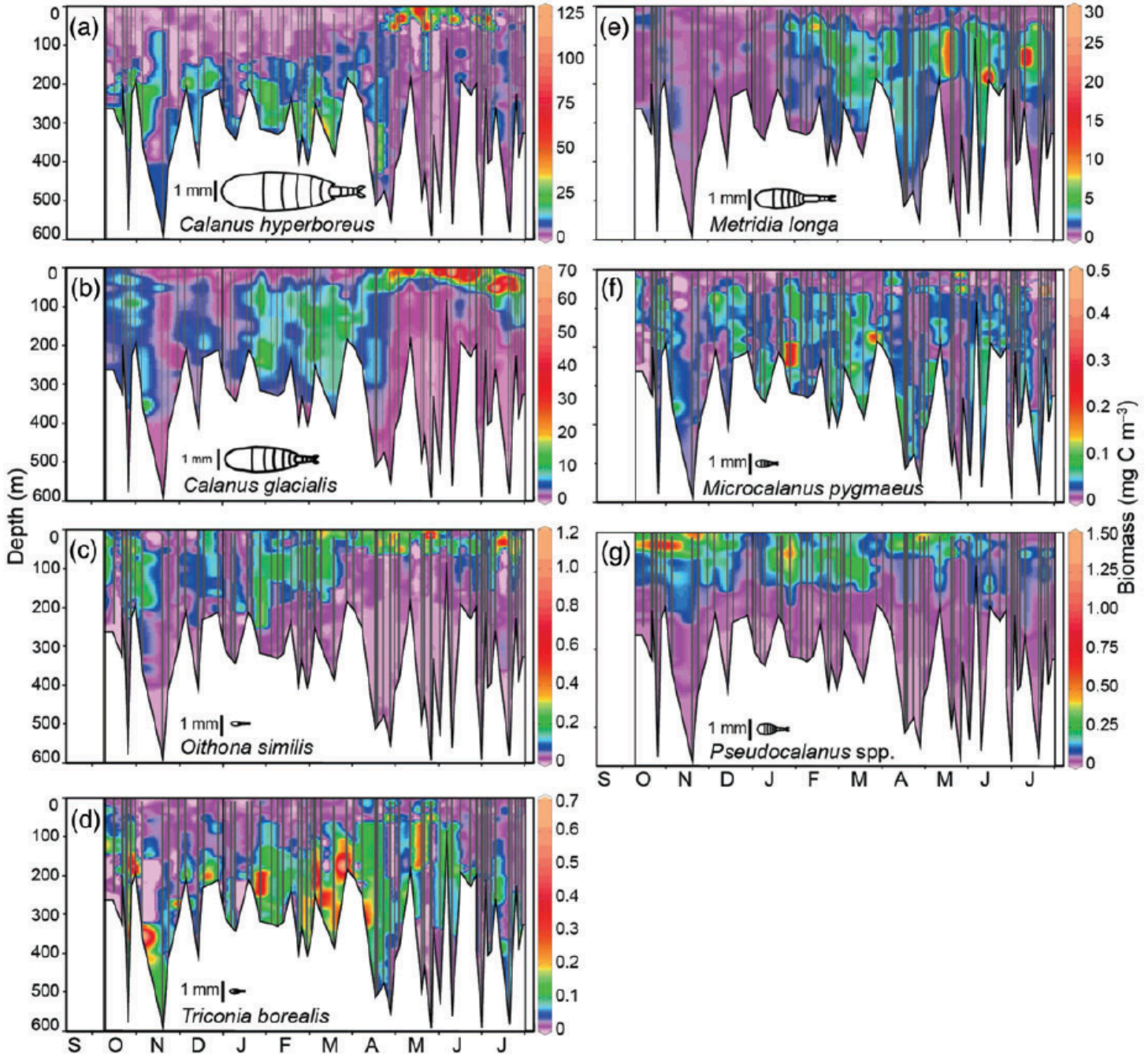


*Fragilariopsis cylindricus*

Preparation and SEM microscopy: Dr Gerhard Dieckmann, Alfred Wegener Institute for Polar and Marine Research, Germany




Morin et al. (in revision)




Darnis & Fortier (2014)

# Few general conclusions

- It can be tricky to use simple light thresholds microalgae growth in models
- Light dynamics is at least as important
- Top-down control is terribly important here