Investigating the onset of the North Atlantic Bloom using a Bio-Argo float Dataset

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In collaboration with

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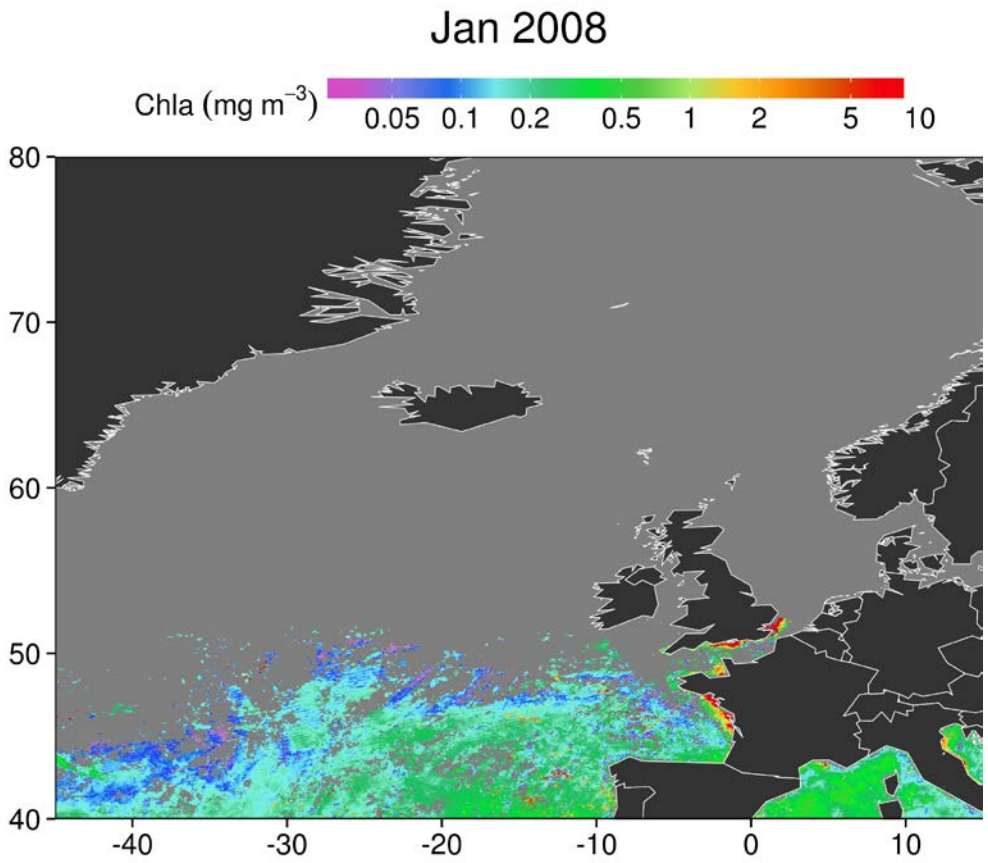
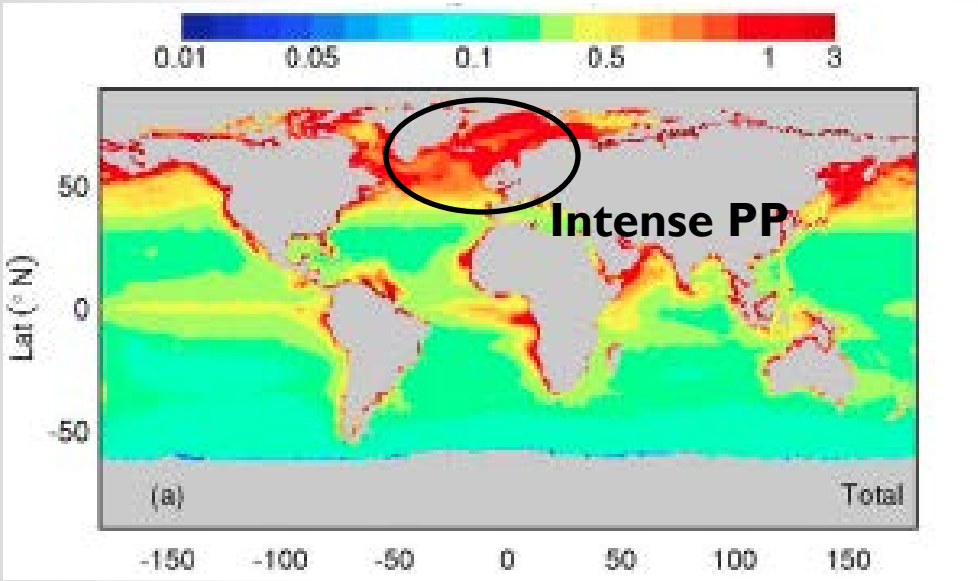
What is a Phytoplankton Bloom ?



The **bloom** is a strong increase in phytoplankton abundance (~ factor 100) that occurs in spring.

Importance of bloom

March-August Primary Production (gC m^2 day^{-1})



Uitz et al. 2010, GBC

Primary production

$CO_2 + H_2O + light \rightarrow CH_2O + O_2$

Export to the Deep ocean

Oceanic Food chain

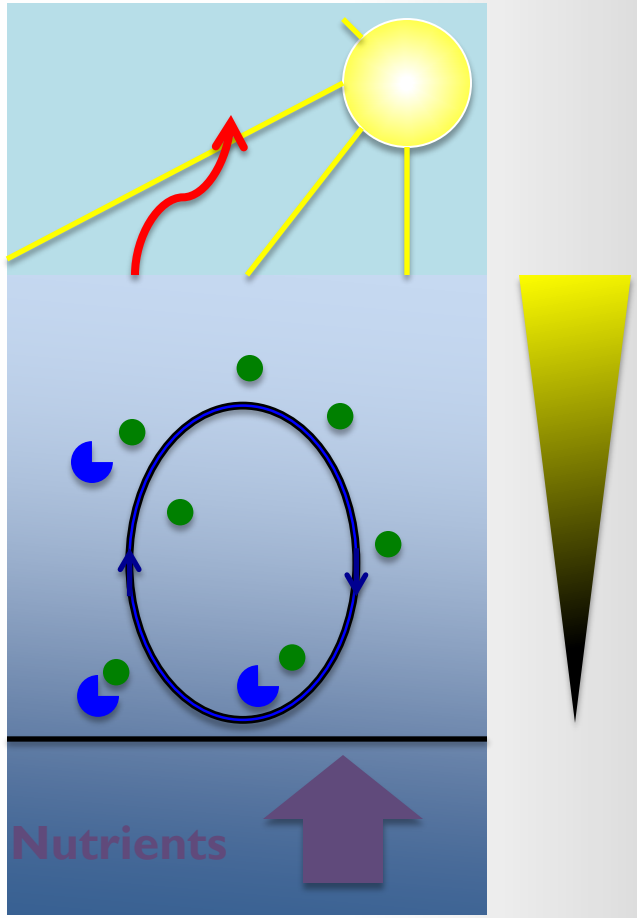
Changes in the phytoplankton growth may affect

- atmospheric CO2 concentrations
- fish production
- carbon export

Factors influencing phytoplankton

Phytoplankton is affected by

- **Surface Light** (*growth*)
- **Nutrients** (*growth*)
- **Zooplankton** (*grazing*)
- **Mixed Layer Depth** (*mixing*)
- **Air sea Heat Flux** (*mixing*)



Factors influencing phytoplankton at the Bloom onset

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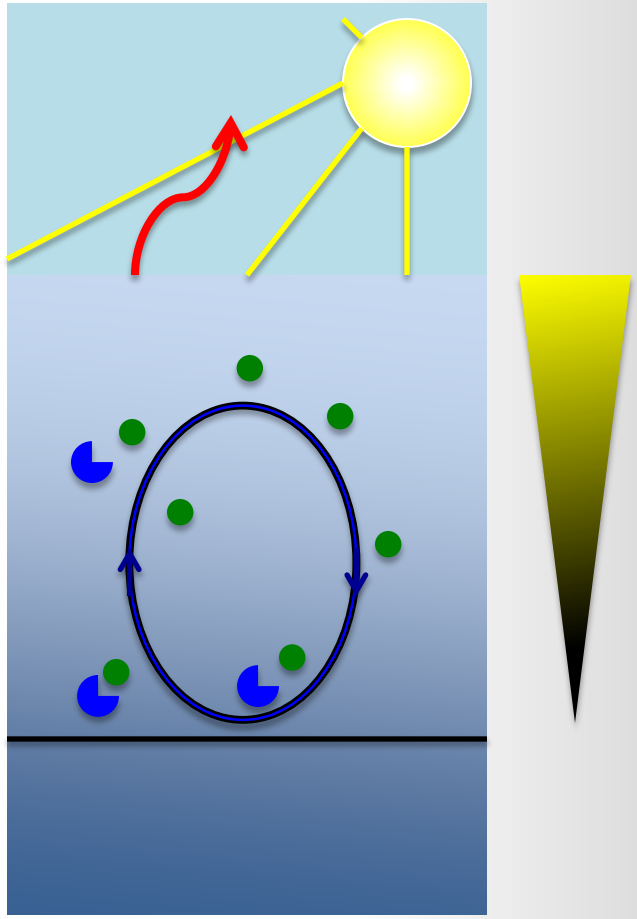
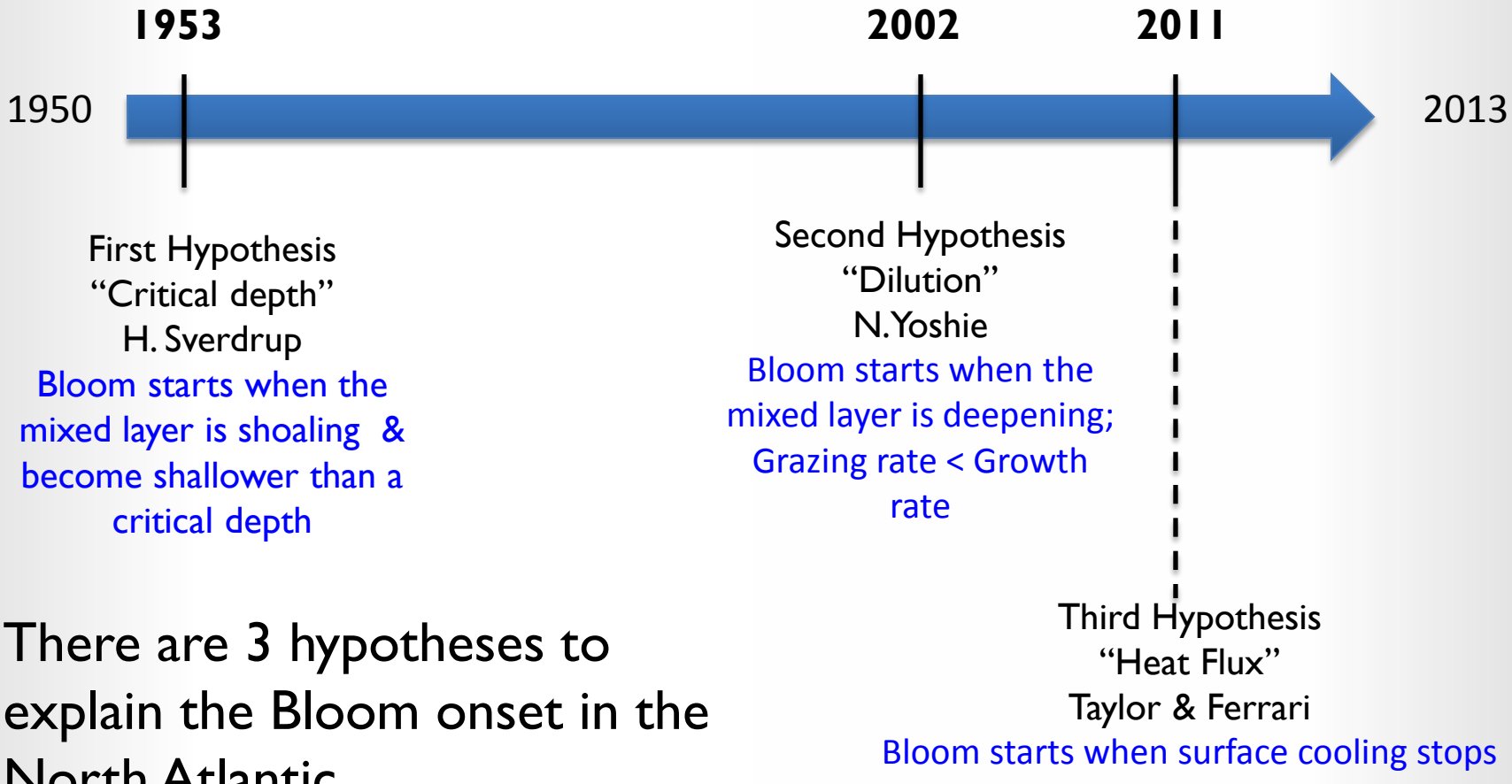
Possible mechanisms for triggering spring bloom

- Surface Light increases
- MLD shoals
- air-sea fluxes decrease
- grazing pressure decreases



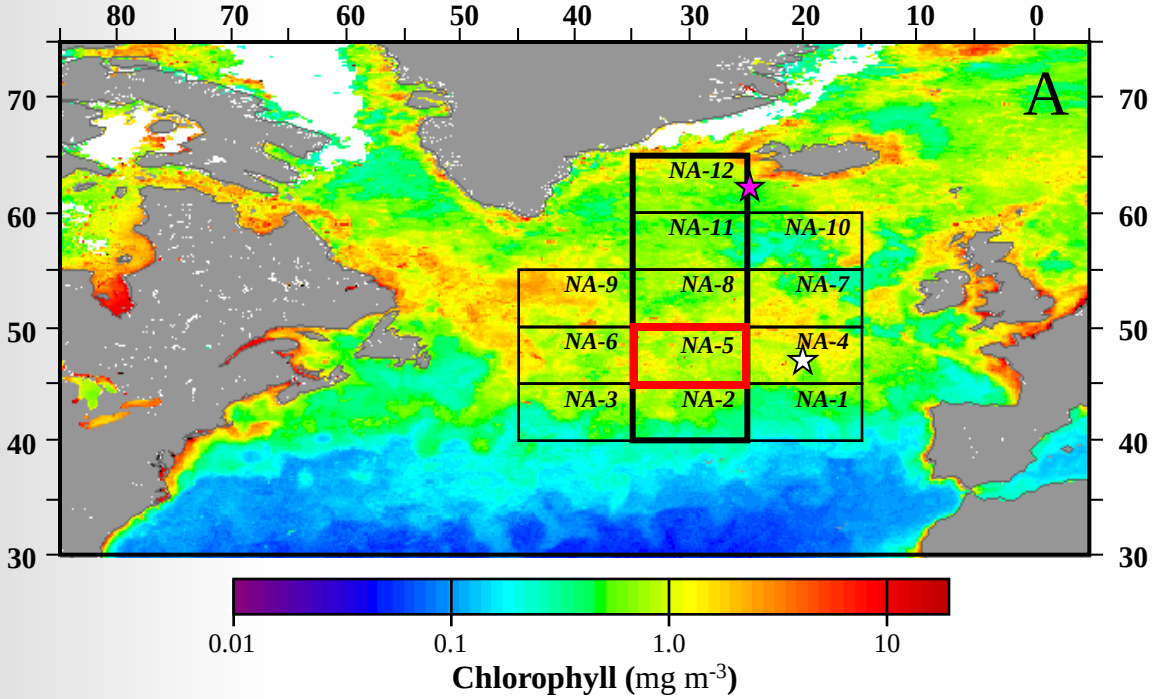
The Bloom onset: an ongoing debate



There are 3 hypotheses to explain the Bloom onset in the North Atlantic

The Bloom onset: an ongoing debate

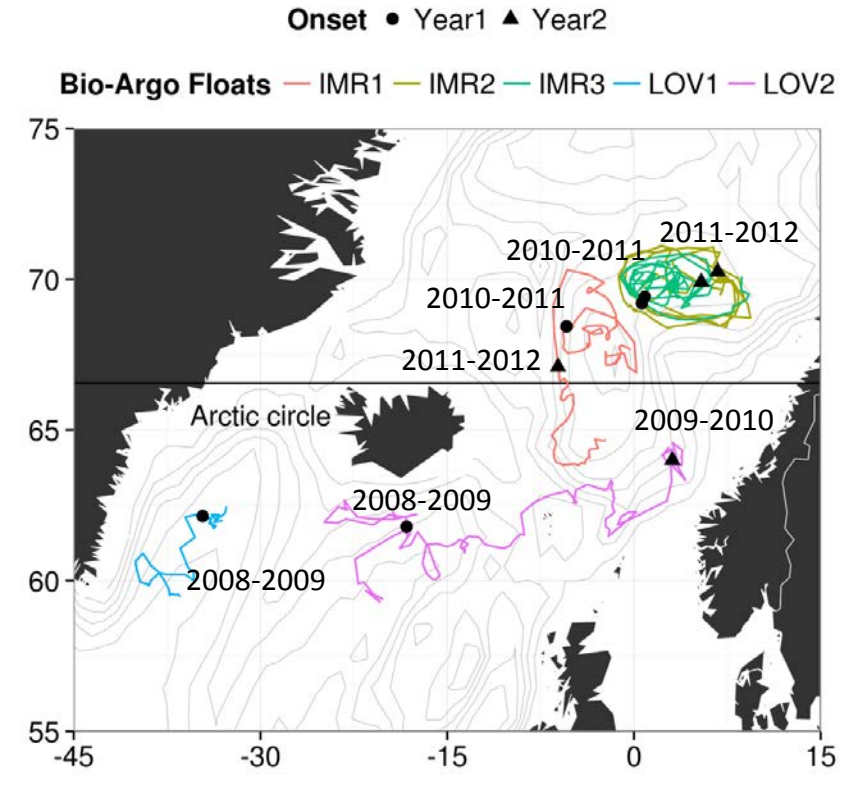
In the last decade, Ocean color data have been used to test the 3 hypotheses (siegel et al. 2002, Behrenfeld et al., 2010, Ferrari et al., 2013,…)



Behrenfeld et al., 2010

But there is still an ongoing debate as to what trigger the onset of the Bloom

Bio-Argo floats dataset



- In situ data from 0 to 1000 m
  - [Chla]
  - T-S
- Every 10 days
- 9 winters at different locations

We use the Bio-Argo floats dataset to investigate the Bloom onset.

Testing Hypothesis

1) Critical depth hypothesis:
Bloom starts when the mixed layer is shoaling & become shallower than a critical depth

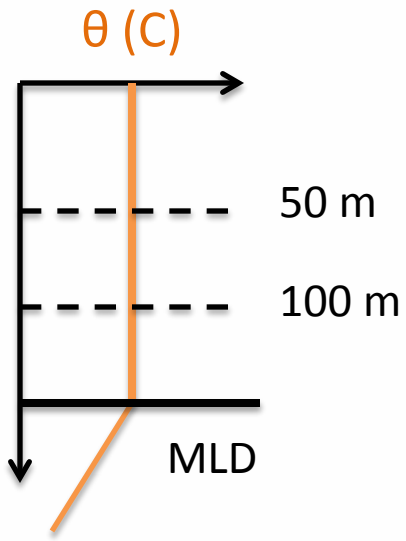
2) Dilution Hypothesis
Bloom starts when the mixed layer is deepening & Grazing rate < Growth rate

3) Heat flux Hypothesis
Bloom starts when surface cooling stops

What do we test

- The shoaling of the mixed layer,
- stratification index:

$$\Delta\theta = \bar{\theta}_{0-50} - \bar{\theta}_{50-100}$$



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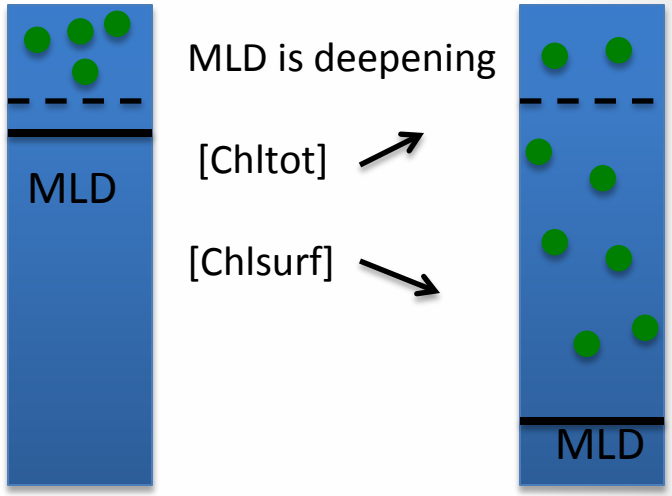
What do we test

- The deepening of mixed layer
- The dilution effect

Dilution effect



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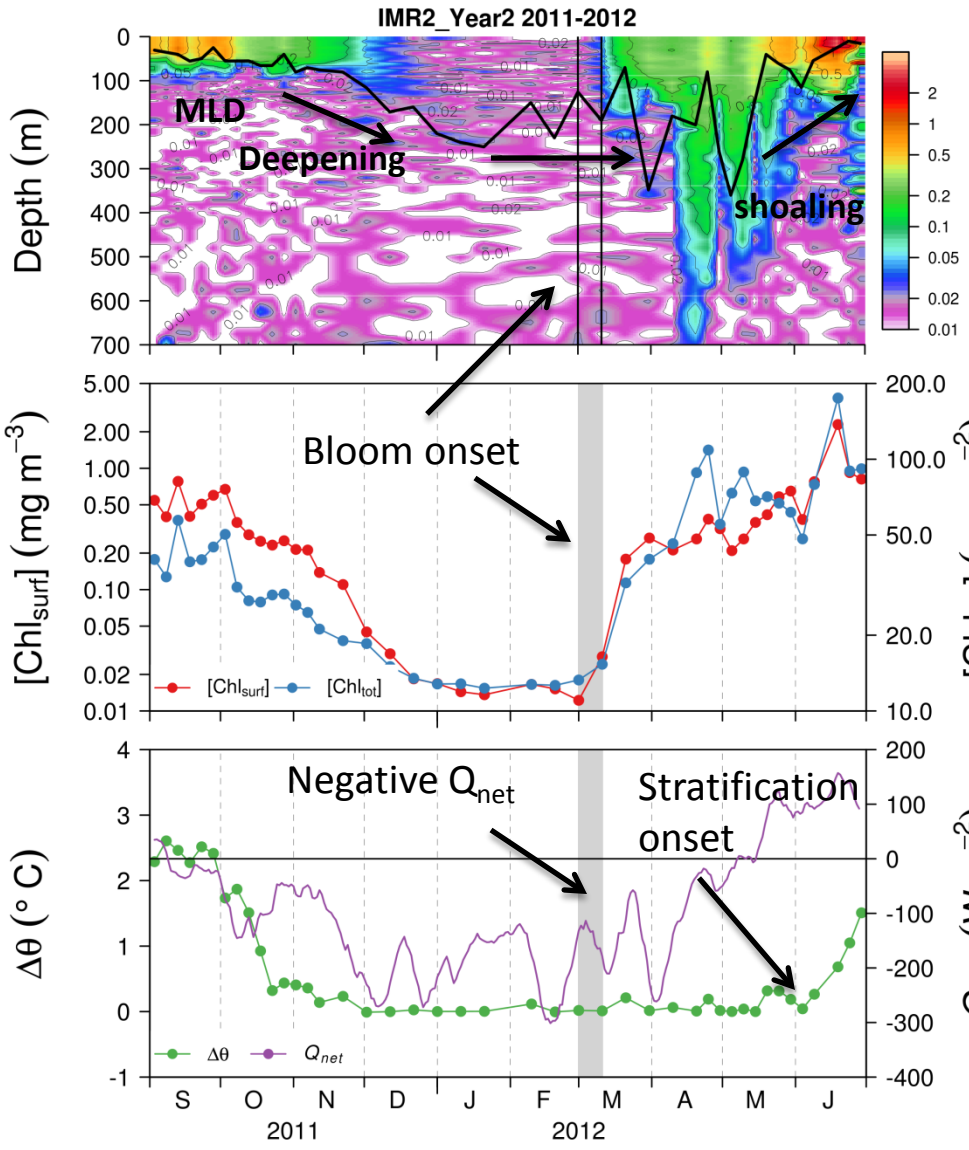
What do we test

- Are the Heat Fluxes Q_{net} negative of positive ?

- *The daily net air-sea heat fluxes, Q_{net} ($W\ m^{-2}$) was obtained from the ECWMF ERA-interim reanalysis.*

Typical situation (7/9 winters)



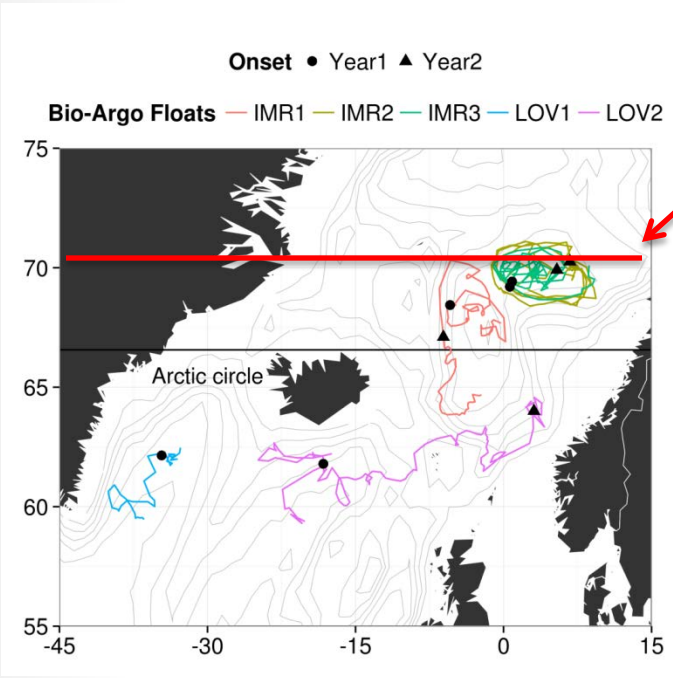
At the Bloom onset,

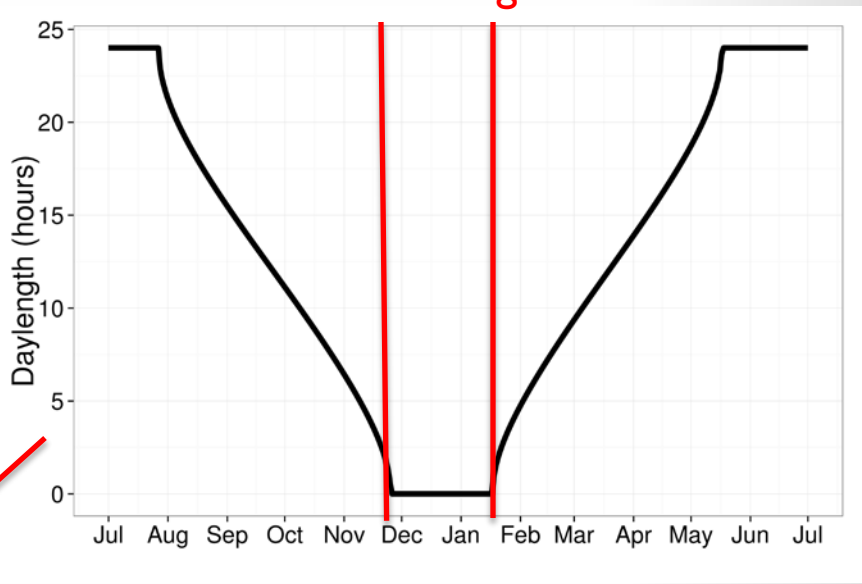
- The MLD remains at the same depth
- There is no dilution effect
- Heat fluxes are negative
- There is no stratification

For 7 winters, the 3 hypotheses fail to explain the Bloom onset

Polar Night

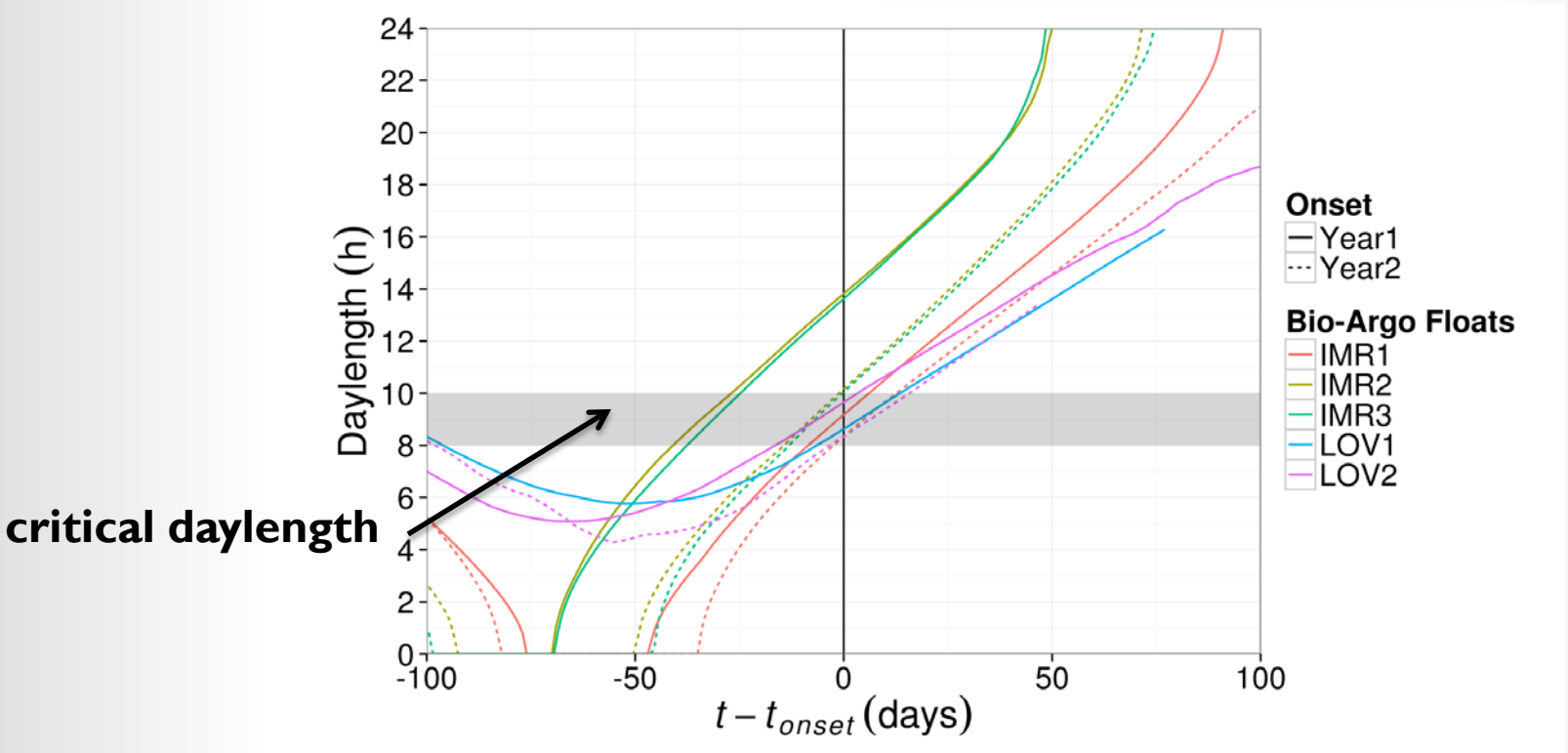
The Bio-Argo floats have sampled area where polar night last for several weeks in winter (*inside the Arctic circle*).





Daylength at 70 N from the theoretical model of Forsythe et al., Ecological Modeling 80:87-95.

Bloom onset around the arctic circle



Around the arctic circle, the Bloom onset is triggered by a critical daylength (8-10 Hrs).

Bloom onset in high latitudes shelf areas

Vol. 116: 303–307, 1995 | MARINE ECOLOGY PROGRESS SERIES Mar. Ecol. Prog. Ser. | Published January 12

NOTE

Photoperiodic control of diatom spore growth: a theory to explain the onset of phytoplankton blooms

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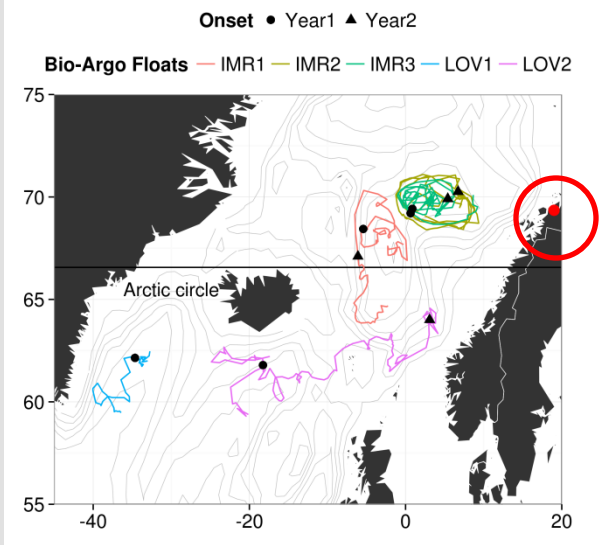
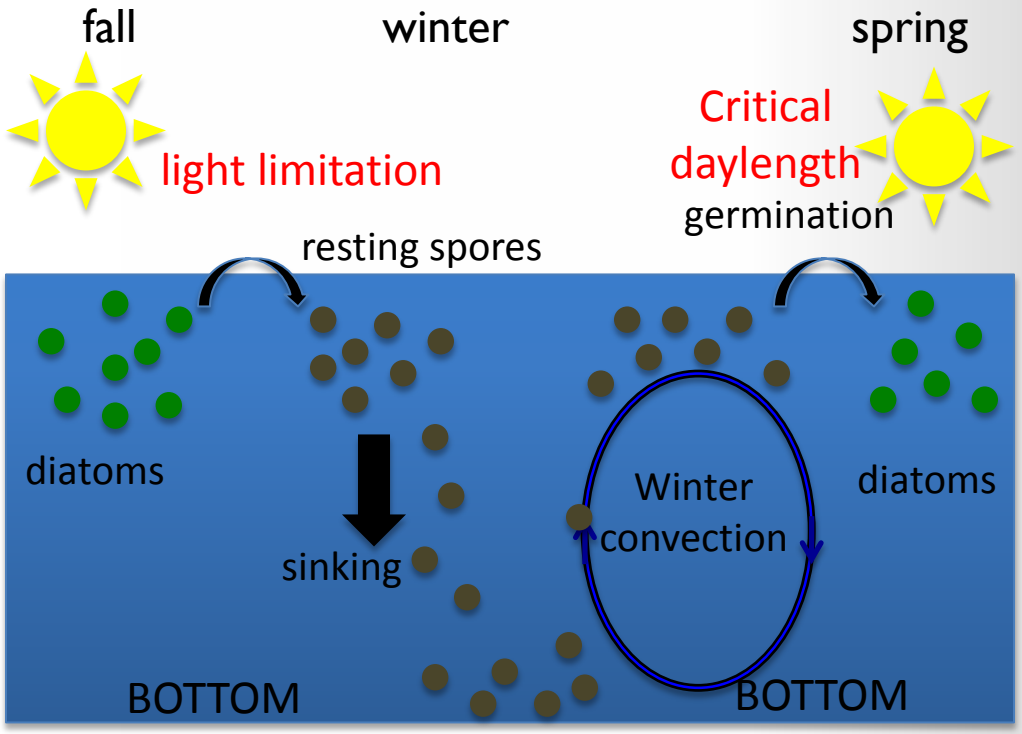


What we know from **shelf areas**



Final Comments

- Bio-Argo floats provide crucial in situ data to explore bloom dynamics in high latitudes.

- High latitudes bloom onset in open ocean seems to be triggered by a critical daylength.

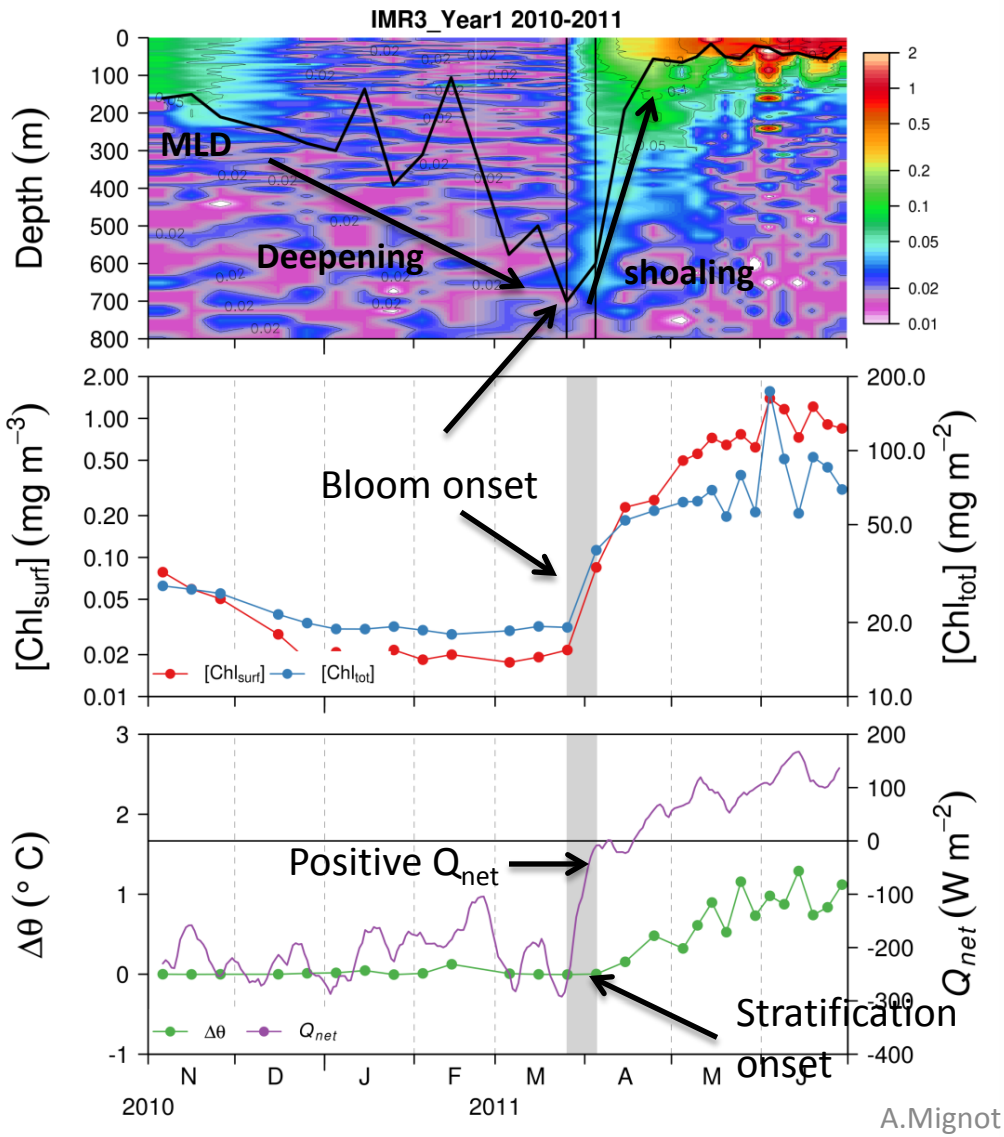
- Future works
  - How spores can detect daylength in an "active" mixed layer ? (**numerical modeling**)
  - Extension of the concept North and South ? (**more Bio-Argo floats**)

Acknowledgements

Kjell Arne Mork (IMR, Norway), OAO team (LOV), Coriolis Data Center.

Thanks for your attention.

(2/9 winters)



At the Bloom onset,

- The MLD is at its maximum
- There is no dilution effect
- Heat fluxes are turning positive
- Stratification onset

For 2 winters, the Heat flux hypothesis explain the Bloom onset