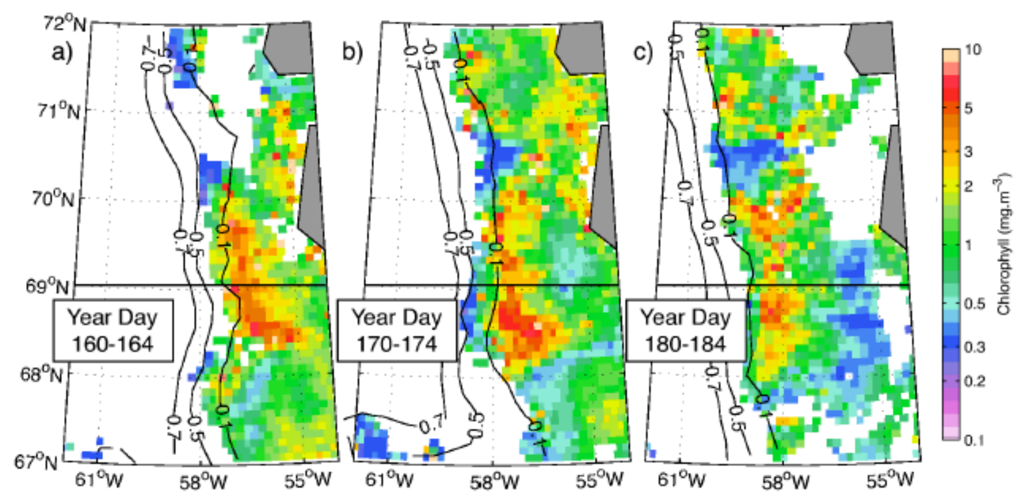
The challenge of deploying biogeochemical ARGO floats at the Arctic ice-edge:

the need for an efficient sea-ice detection system

Claudie Marec[1], Marcel Babin[1], Edouard Leymarie[2], Christophe Penkerc'h[2], José Lagunas-Morales[1], Eric Rehm[1], Emmanuel-Claude Devred[1], Guislain Bécu[1]
[1] **TAKUVIK** UMI 3376, Université Laval, Québec, Canada [2] **LOV** Laboratoire d'Oceanographie de Villefranche-sur-mer, France

Why? :

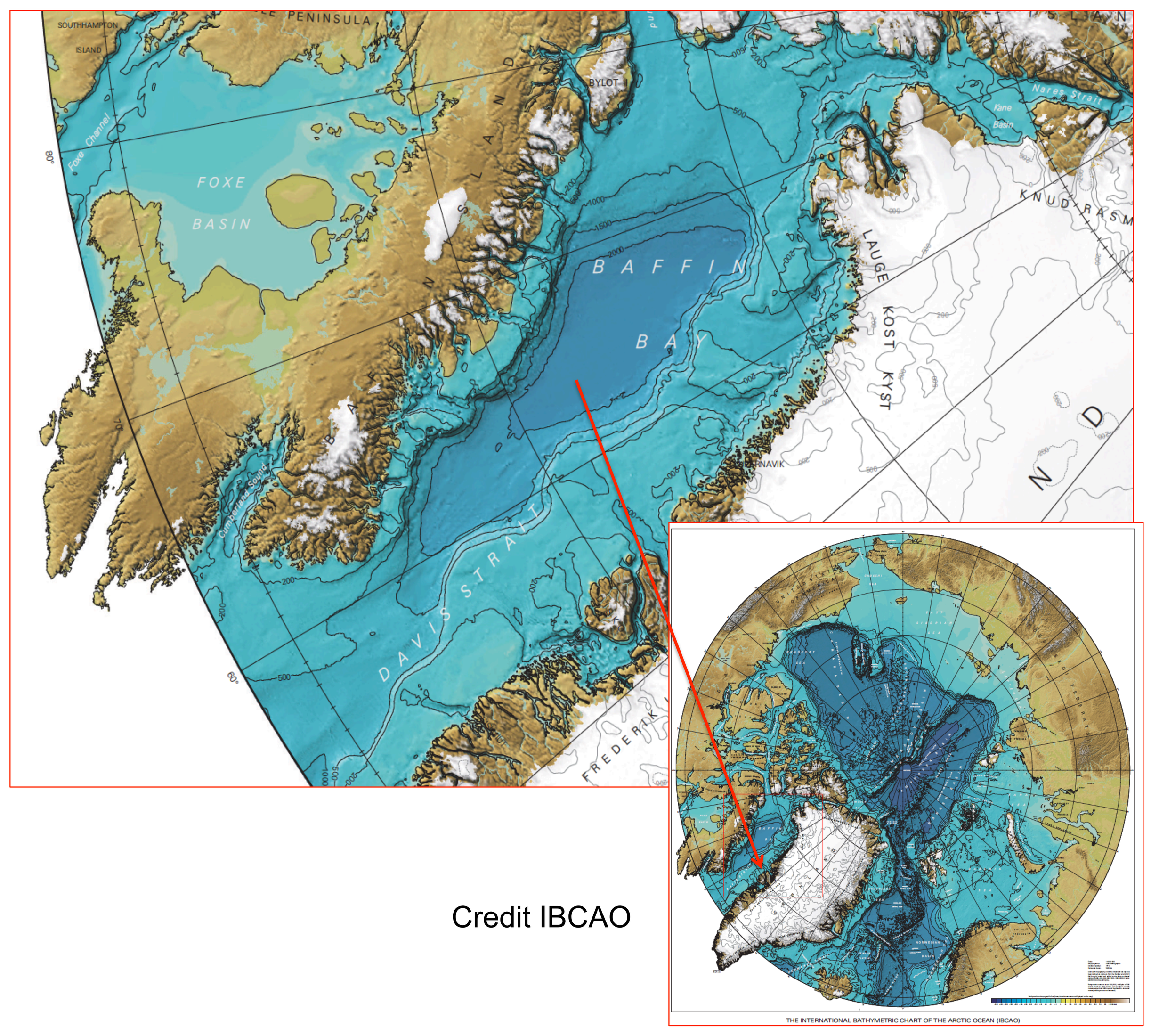
- To understand ice-edge blooms:
  - ✓ Physical mechanisms responsible for nutrient inputs
  - ✓ Propagation of sunlight (ice floe and water column)
  - ✓ Ice-edge bloom dynamics
  - ✓ Response of associated phytoplankton species



Example of the propagation of an Ice-edge phytoplankton bloom West of Greenland over a 25-day period (Images composites of chla (Seawifs) overlaid with sea-ide contours (NSIDC). Perrette et al.2011.

- Identify different nutrient sources

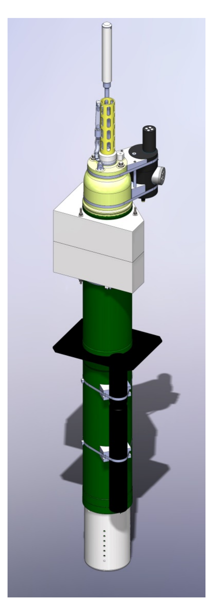
- Why Baffin Bay?: Ice edge blooms are systematically observed in the region. In addition, observations by remote sensing of ocean colour show that the spring blooms now occur 50 days earlier than in1997.



Credit IBCAO

How?

19* Argo NKE** floats equipped with additional bio-optical sensors:



- O_2 Aanderaa optode
- OCR-504 Ed 380, 410 and 490nm + PAR
- ECO FLBBCD: FL-chla, FL-CDOM , Bb
- SUNA (nitrates)

* 10 funded by Equipex NAOS (initially intention for 13)
9 funded by CFI (Canadian Foundation for Innovation) (initially intention for 10)

**NKE Electronics, France

Credit LOV

Where? Environmental conditions/tactical pattern for deployment

The strategy for float deployment in **Baffin Bay** will make provision for different environmental conditions (global circulation, climatology….)

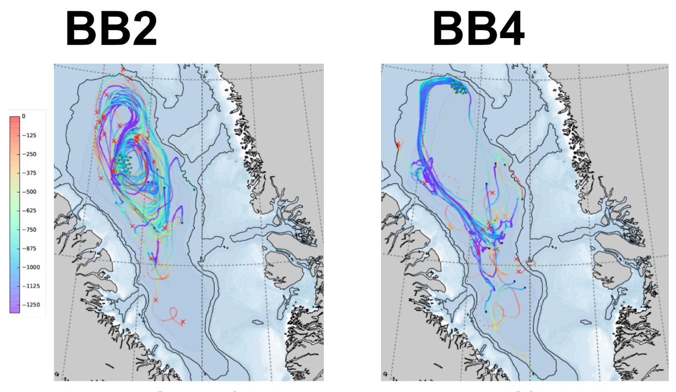
Global circulation (mainly cyclonic): the choice of location for float launch and the tactical pattern for their deployment will be optimised using **Ariane (LPO)** as a computational tool.

Work in collaboration with CONCEPTS : Canadian Operational Network of Coupled Environmental Prediction System / Fraser Davidson, DFO-St John's, NF).

Example for 2 deployment locations in Baffin Bay:

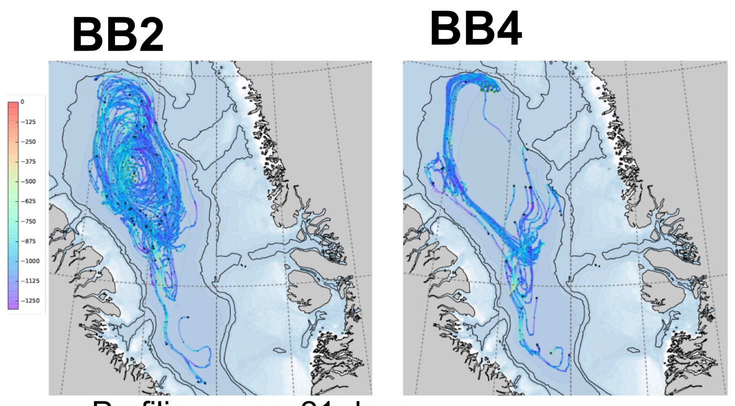
- Release ~45 particles at two CGCS Amundsen stations: BB2, BB4
- 3 drift depths: 500 m, 750m, 1000m
- 3 profiling scenarios: Thanks to Jinshan Xu, DFO, St. John's & Eric Rehm, TAKUVIK.

BB2 **BB4**



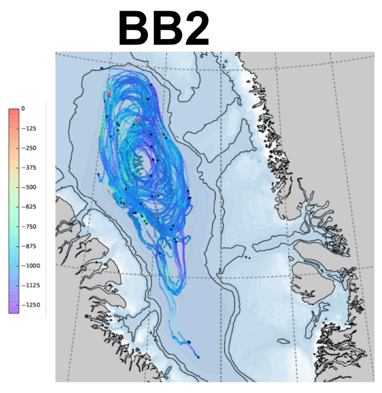
No profiling (pure Lagrangian drift), 638 day sim

BB2 **BB4**



Profiling every 21 days

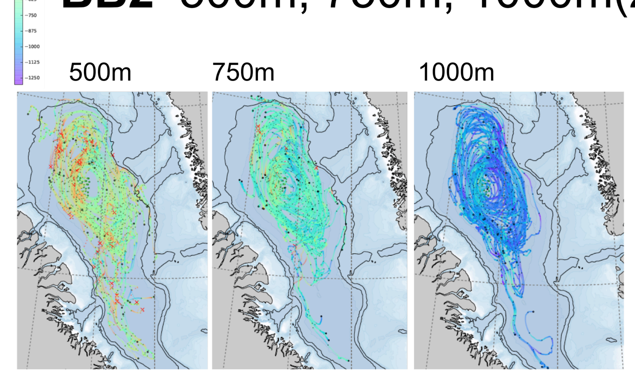
BB2



Profiling according to a typical (LOV) biogeochemical pattern

green circle = release,
black circle = end,
black dot = profile

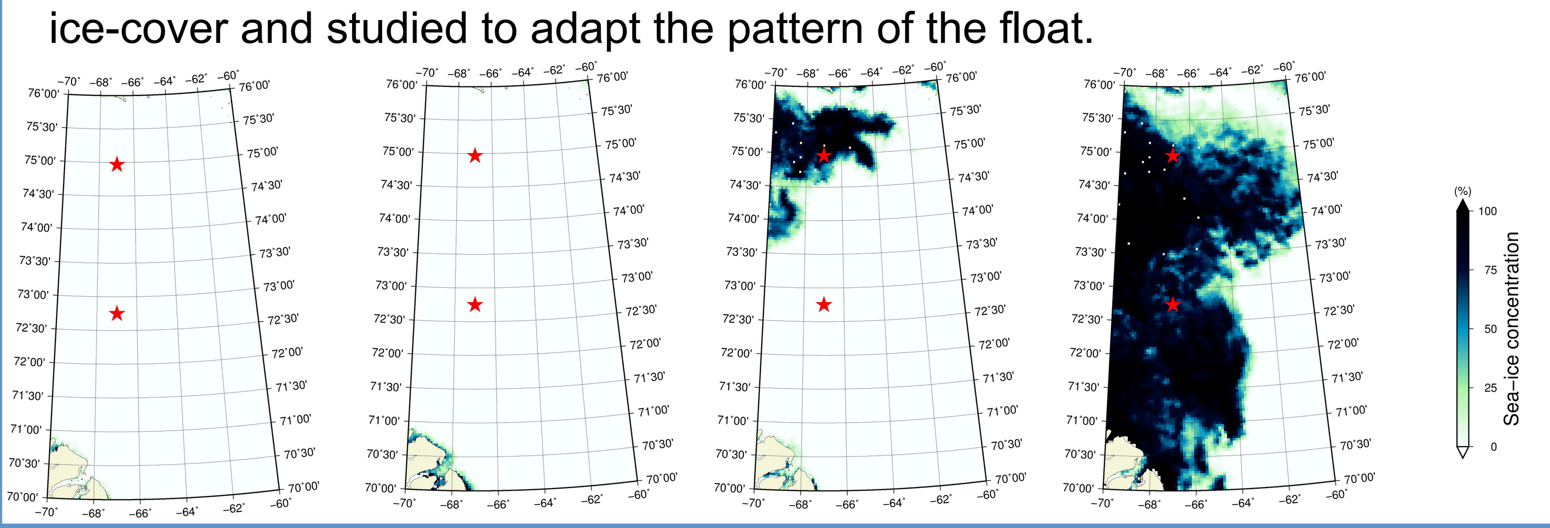
BB2 500m, 750m, 1000m(21d)



Probability of ejection to Labrador Sea via southern trajectories is reduced with increasing drift/profiling depth.

Sea-ice cover in Baffin Bay:

Taking into account typical sea-ice cover maps in Baffin Bay, floats are programmed to park at a safe depth during the period of ice cover period and to start profiling again in spring. Thanks to Emmanuel Devred, TAKUVIK. Real time are also generated for ice-cover and studied to adapt the pattern of the float.



Sea-ice cover (1st october to 15 november 2014, area of BB2 and BB4.Maps generated from daily data AMRS2-resolution 3.125km

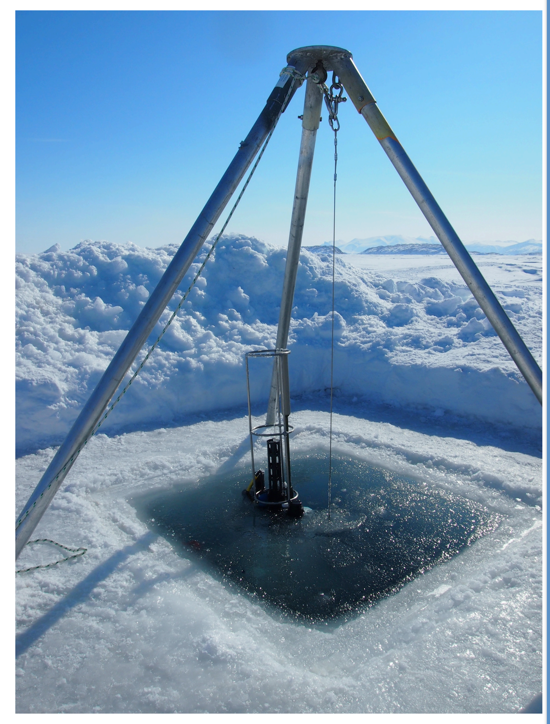
Trials in cold conditions

Tests of the behaviour of the float and sensors in cold conditions during 2 Takuvik experiments:

- In wintertime **(feb 2015**) in a lake of fresh water close to Québec-city (captive mode – profiling to and from 8m)

All sensors were active during ascension and performed correctly.
Tests helped to debug issues with delayed transmission (of data stored when no surfacing is possible)

- **April 2015**, on GreenEdge2015 ice camp(Qikiktarjuaq,Nu)



Water temp: -1.7deg C
Surface Temp: -20 to -30 deg C
Snow layer:40cm
Ice thickness: 110cm
All sensors active during ascension and performed well(0-80m).
Strong tidal currents:
We assumed that these currents prevented the float to slide correctly along the line –>safety mechanism->end of life.
The issue seems to be related, not only to currents, but also to ballast problems.
This is under check but it looks like a combination of:

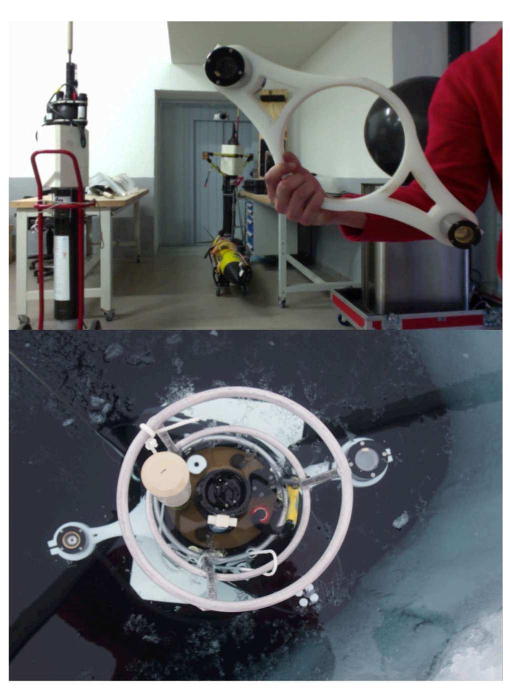
- an output fllow of the valve reducted under low temperatures
- a wide range of local seawater density (1008-1038) leading to a restricted room to maneuver
- a soft configuration limiting the usefull volume to 2.3Liters.

Progress in sea-ice detection:

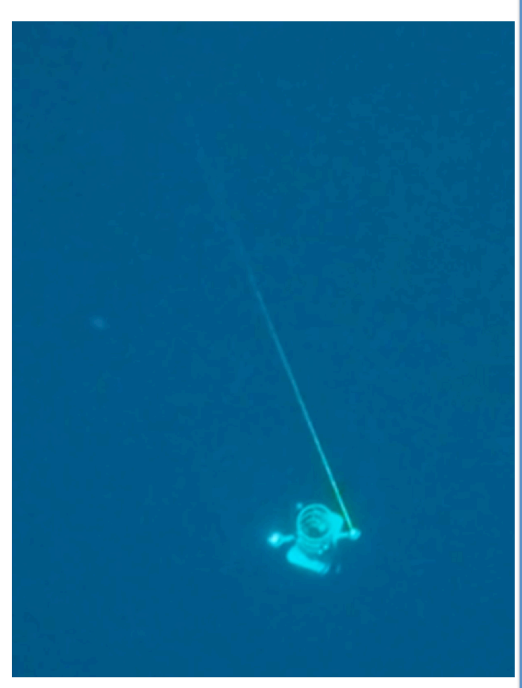
The main issue, when deploying floats in icy waters, is the capability to detect ice and, when it is present, to postpone surfacing of the floats. The floats need to surface to transmit data, geo-localize and, if required, receive instructions for a new mission

An ice layer as thin as 2 cm. (0.81 in.) can prevent the float from surfacing. The floats have only a 500-600 g pull when ascending

- ✓ **ISA** (Ice Sensing Algorithm) for progress, see Poster from E.Leymarie , LOV
- ✓ **Active acoustique technique** (upward looking altimeter range 100m)
- ✓ **Optical technique :** a new system is developped by J.Lagunas (Takuvik) and collaborators . Based on the depolarizing effect of sea-ice, this new system will estimate ice presence for a close range environmental characterization).



- Sea ice depolarizes light.
- Ice detection system :Linearly polarized source (500 mW @ 532 nm) + Optical detector (polarizing beamsplitter)
- Optical detector :Two amplified photo diodes are used to receive the vertical (Ep) and horizontal (Es) components separated by the polarizing beamsplitter.
- The ratio Es/Ep indicates the presence or absence of sea ice in the surface.
- Funding Takuvik and CNRS « défi Instrumentation aux limites ».



Sea-ice detector in operation on CTS5