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SSF Flaship  
Workshop  
4 Oct 2016

# Arctic autonomous drifting buoys

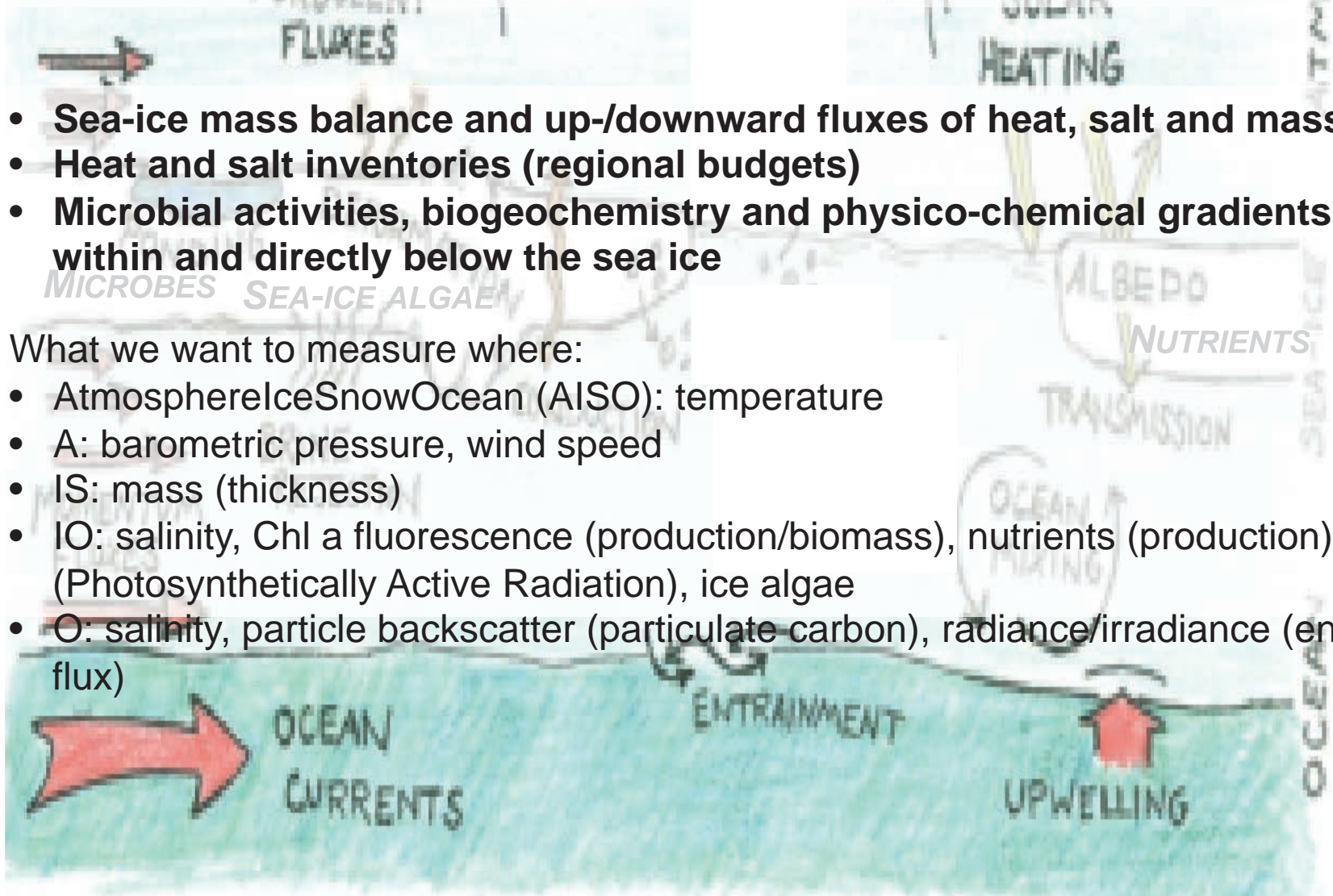
Efforts from AWI / Germany

# Atmosphere-snow-ice-ocean interface: processes and parameters

- Sea-ice mass balance and up-/downward fluxes of heat, salt and mass
- Heat and salt inventories (regional budgets)
- Microbial activities, biogeochemistry and physico-chemical gradients within and directly below the sea ice

What we want to measure where:

- Atmosphere|Ice|Snow|Ocean (AISO): temperature
- A: barometric pressure, wind speed
- IS: mass (thickness)
- IO: salinity, Chl a fluorescence (production/biomass), nutrients (production), light (Photosynthetically Active Radiation), ice algae
- O: salinity, particle backscatter (particulate carbon), radiance/irradiance (energy flux)



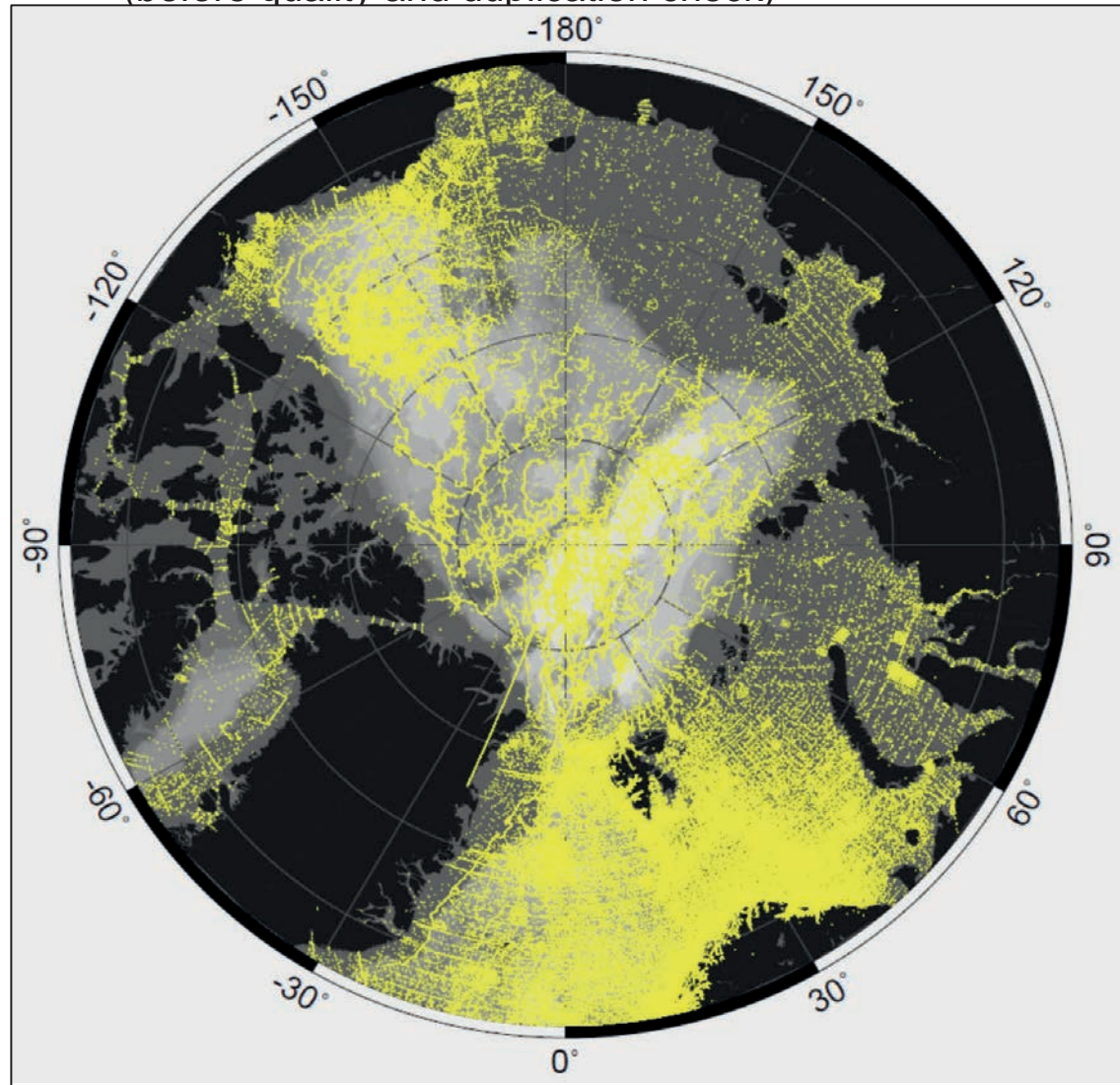
Schematic modified from M. Shupe

# Distribution of Oceanographic Profiles 1980 – 2015

(before quality and duplication check)

Before QC:  
~**500.000** T/S profiles

After QC:  
~**300.000** T/S profiles  
(estimated)



# Goals & Plans

Position

Longitude

Step 1

Step 2

collecting  
data

Cruise 4105 (1 bad stations)



→ We rely on these datasets for QC of our buoy data stream!  
→ We will need similar QC on historical data of other parameters! (e.g. Chl a, nitrate...)

and corrected if necessary

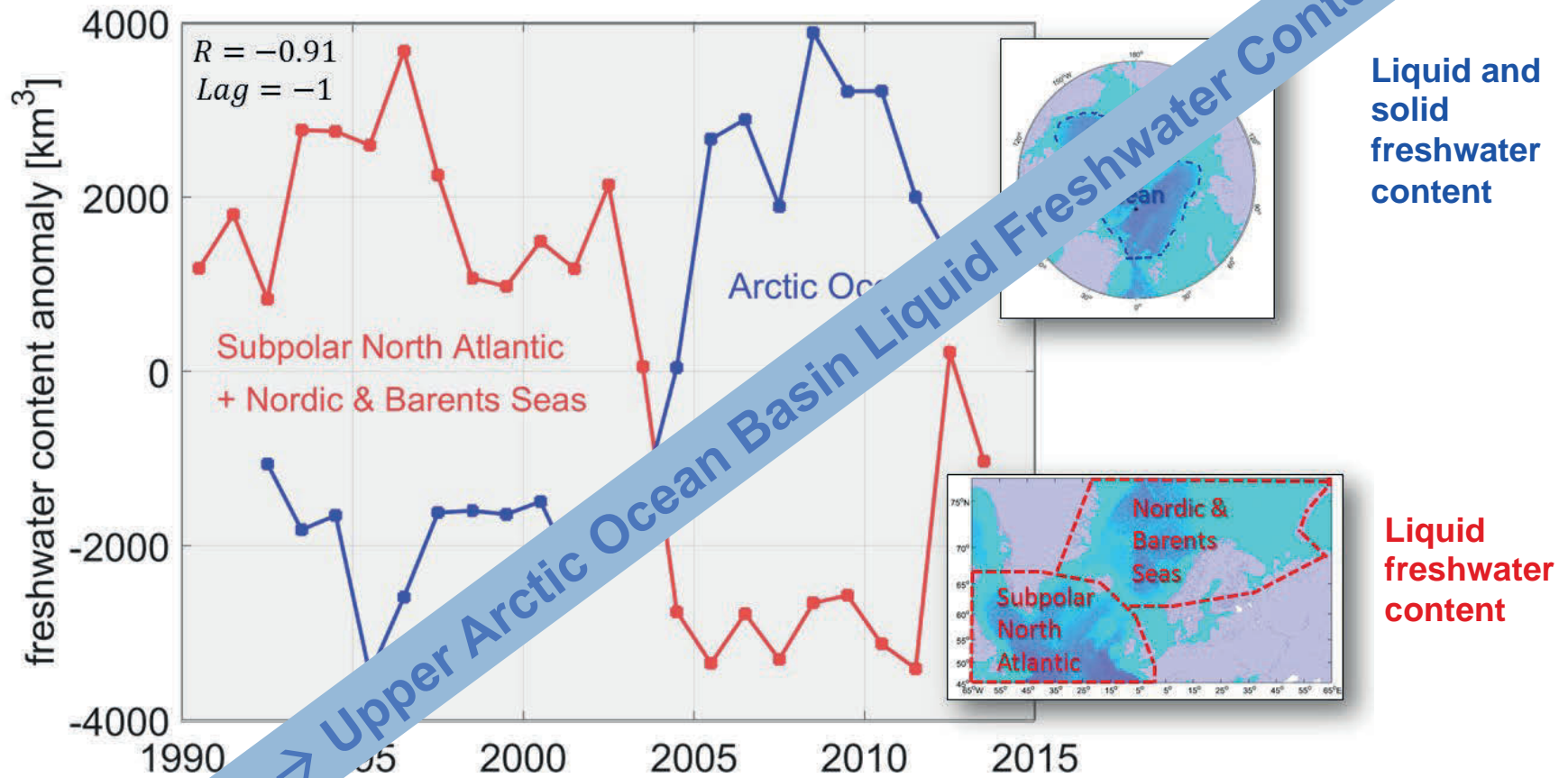
Interpolation  
Objective mapping of adjusted data to create a gridded product

Product 2 (adjusted data)

Product 3 (Arctic Ocean Atlas)

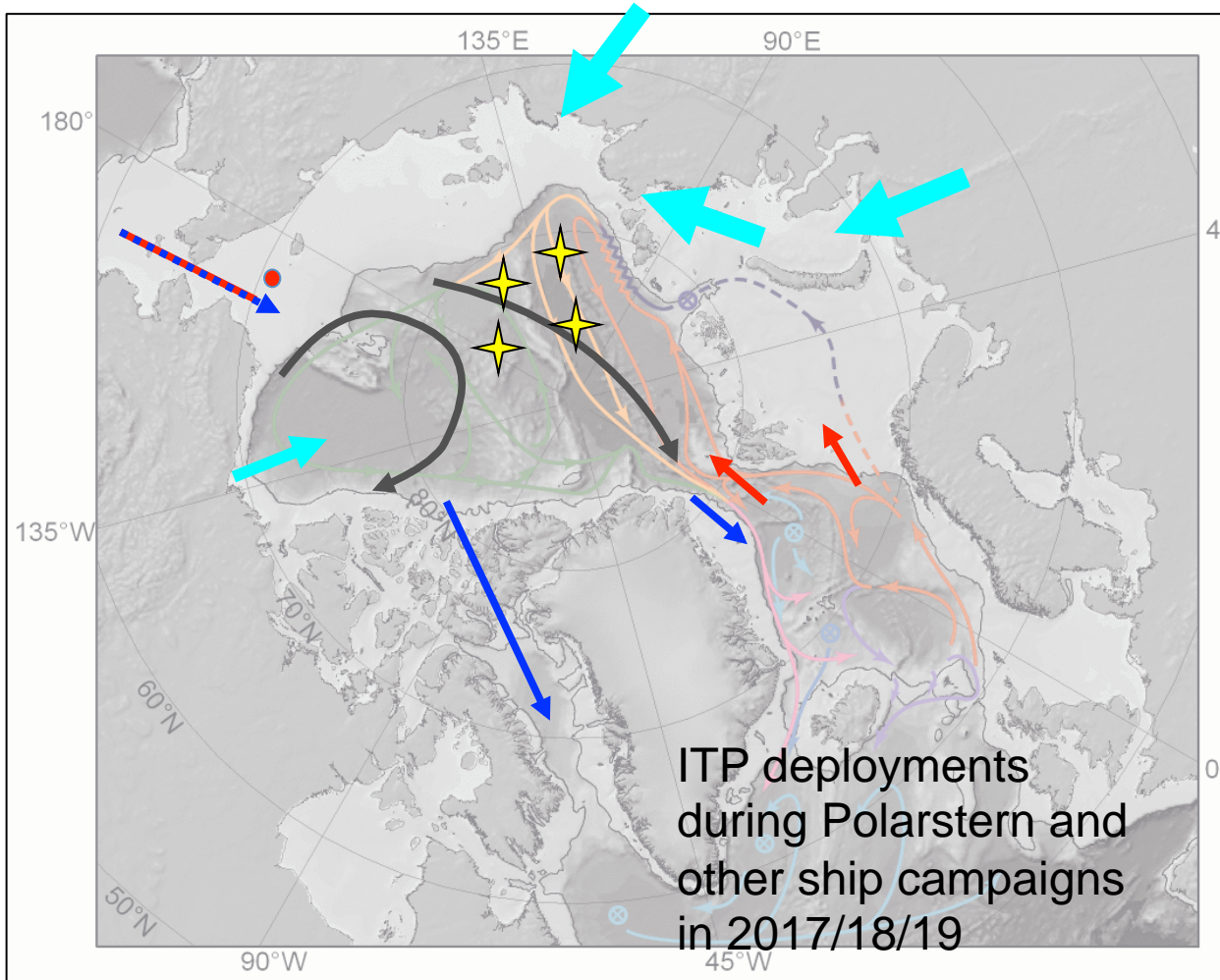
per planned by Axel Behrendt this year in *Earth System Science Data*

# Freshwater variability



- The freshwater content timeseries are **significantly anti-correlated**.
- Corresponding anomalies are of the **same size**.
- Freshwater anomalies suggest an **oscillation**.

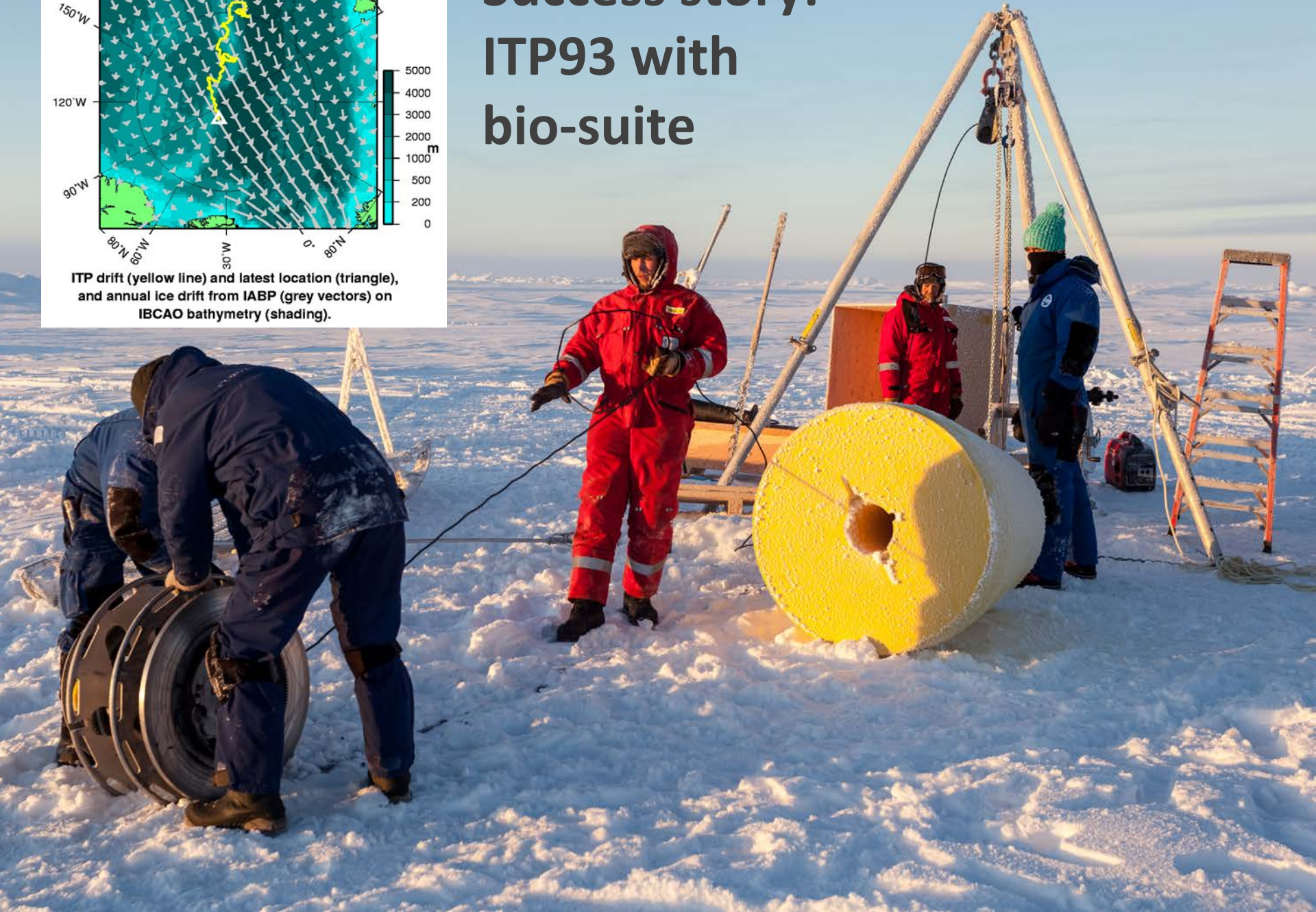
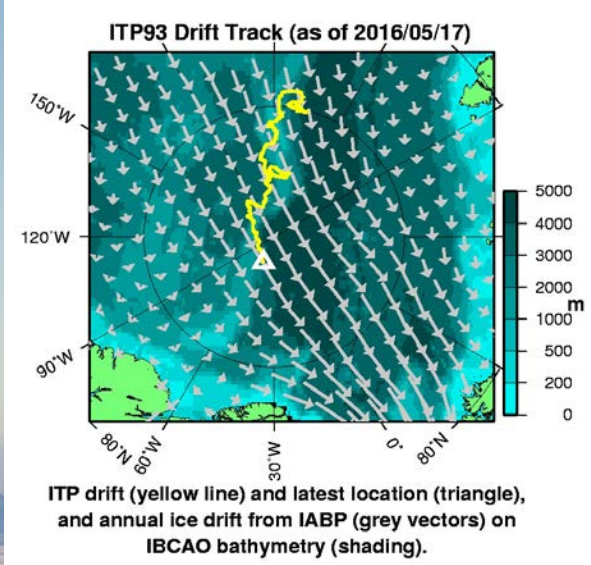
# FRAM WP 3.1 2014-2021: autonomous ice-tethered platforms



Map modified from Rudels (2005)

- Min. 4 Ice-tethered CTD profilers / year in the central Arctic / Transpolar Drift (international cooperation!)
- Within a network of buoys for ice-ocean-atmosphere observations.
- Multi-disciplinary observations (physics, biochemistry, biology), including multi-buoy arrays on single ice floes.

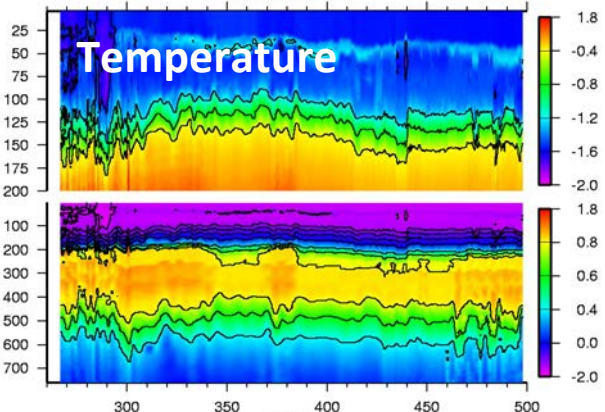
# Success story: ITP93 with bio-suite



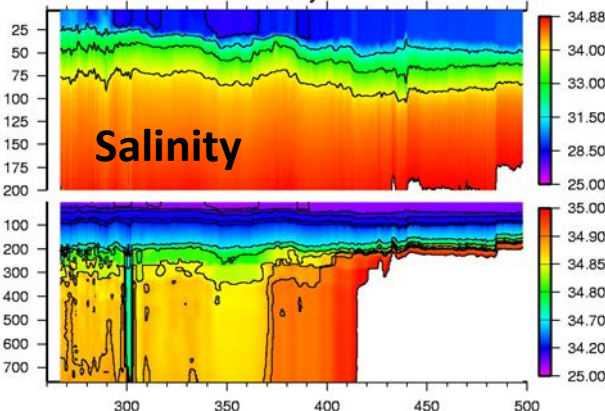
# ITP93 data



ITP93 Up Profile Contours (to profile 600)  
temperature

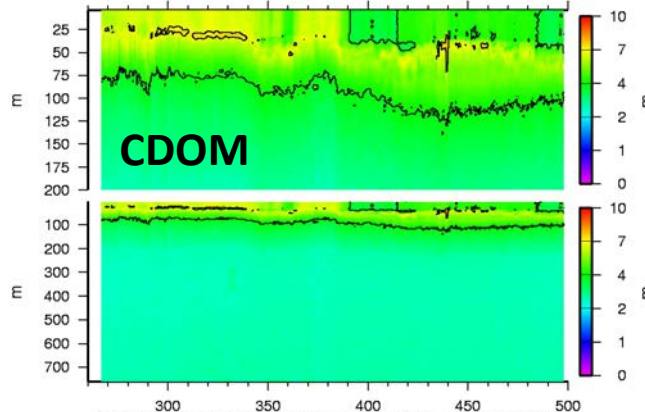


salinity



day 2015

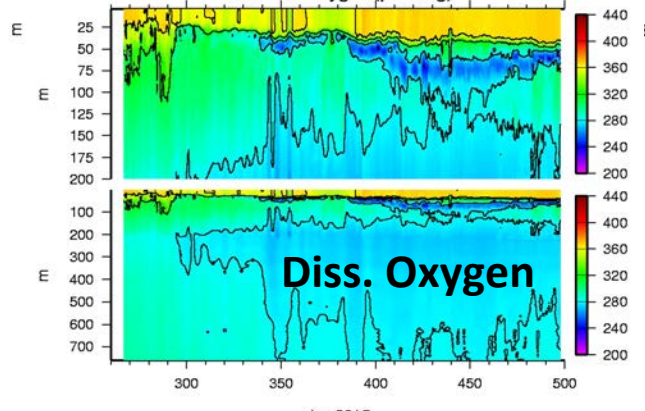
ITP93 Up Profile Contours (to profile 600)  
colored dissolved organic matter (ppb)



photosynthetically active radiation ( $\mu\text{mol photon/m}^2/\text{s}$ )

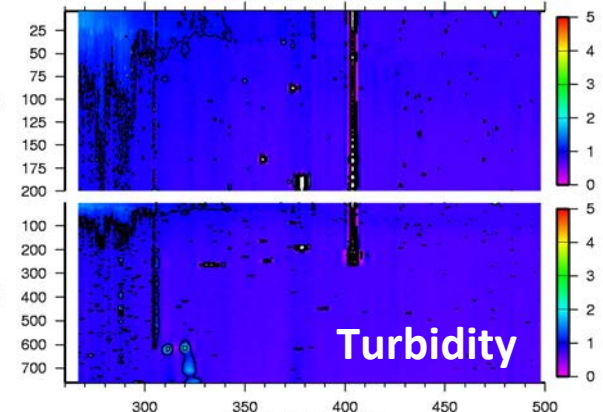


ITP93 Up Profile Contours (to profile 600)  
dissolved oxygen ( $\mu\text{mol/kg}$ )

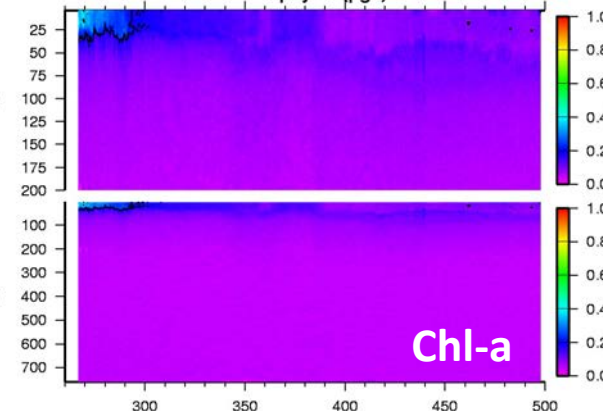


day 2015

ITP93 Up Profile Contours (to profile 600)  
turbidity ( $\text{m}^{-1}\text{sr}^{-1} \times 10^{-4}$ )



chlorophyll a ( $\mu\text{g/l}$ )

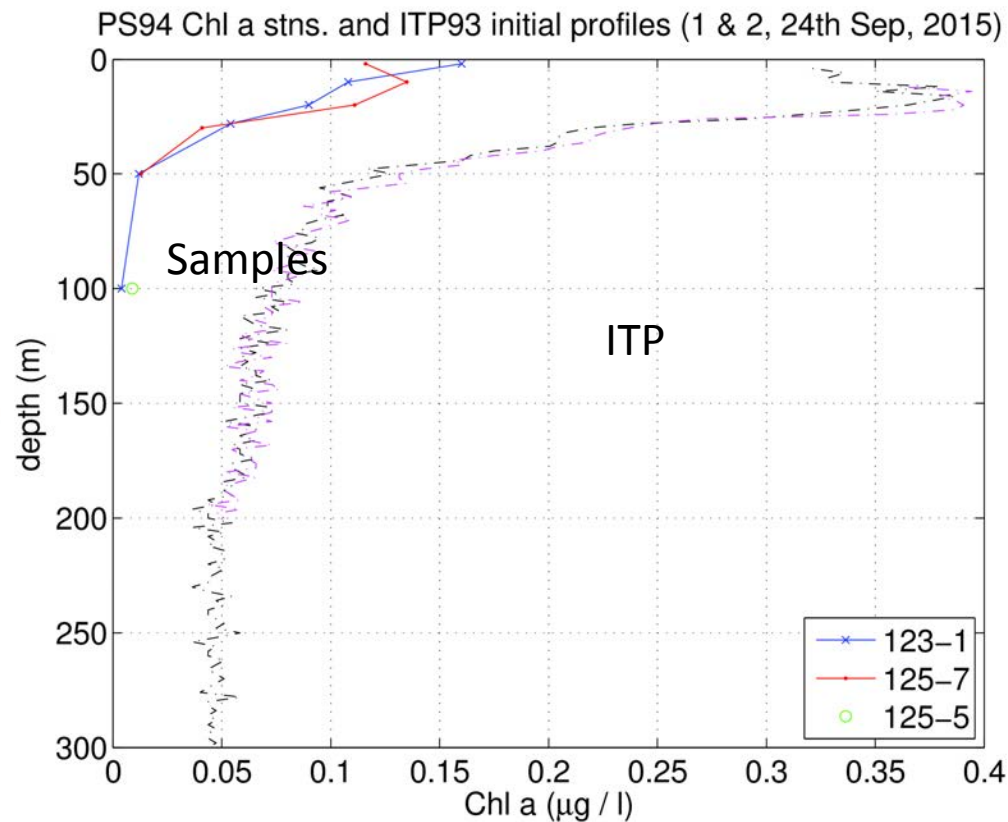
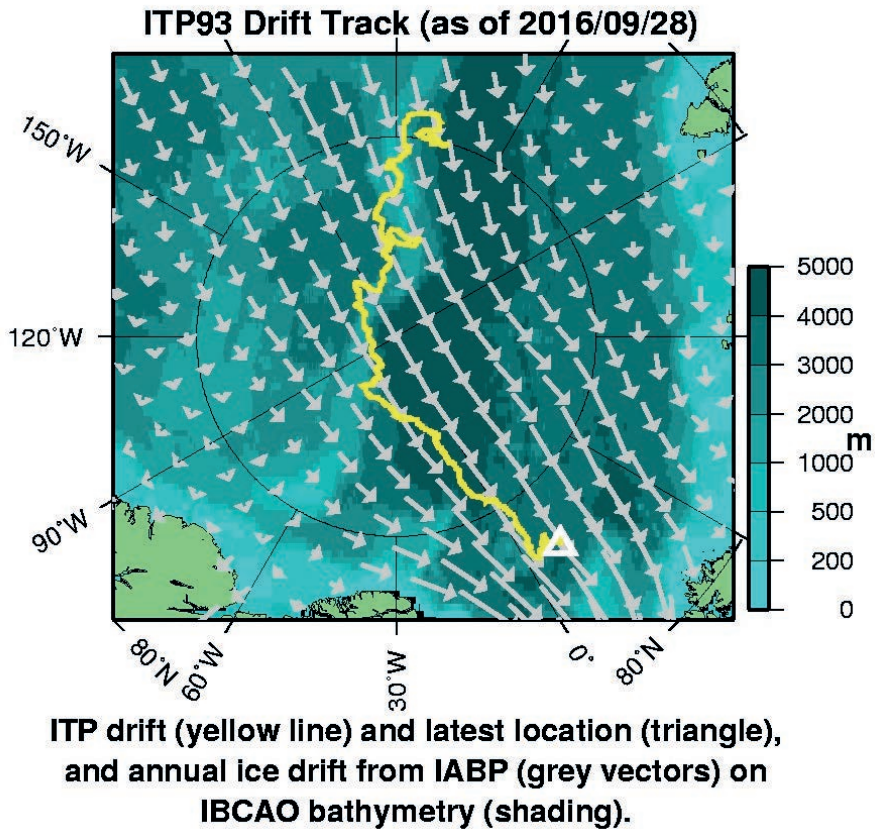


day 2015

R. Krishfield, WHOI



- Sensor challenges: calibration of bio-optical and chemical sensors
- Little historical data / small-scale decorrelation near surface
  - Use ship sample data near deployment and at selected times / locations during operation to correct sensor output



Source: <http://www.whoi.edu/itp>

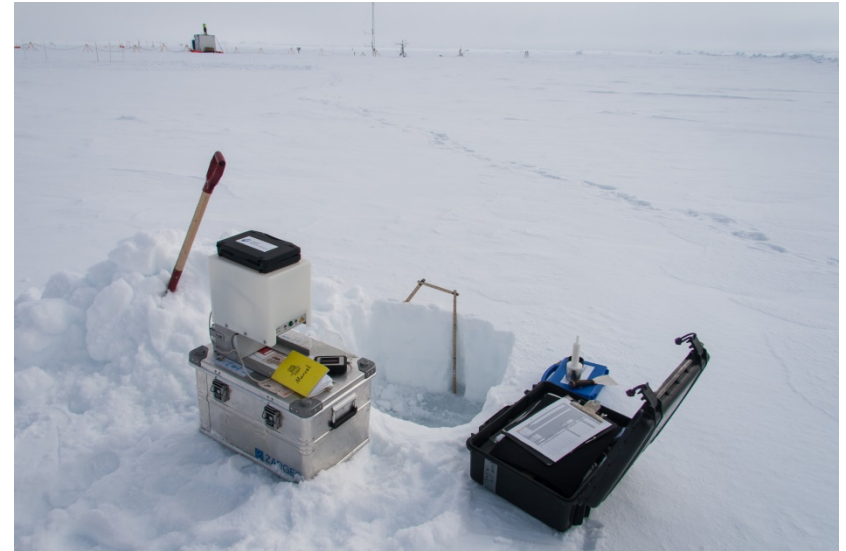
# Snow Rules !

## Direct impacts

- Thermodynamics & reflection of solar irradiance
- Sea-ice mass balance
- Remote sensing signatures
- Fresh water budgets ...

## Indirect effects

- Complicates sea ice thickness retrieval from remote sensing (satellite & EM)
- Dominates surface conditions
- Influences biological processes
- Model and remote sensing validation and development

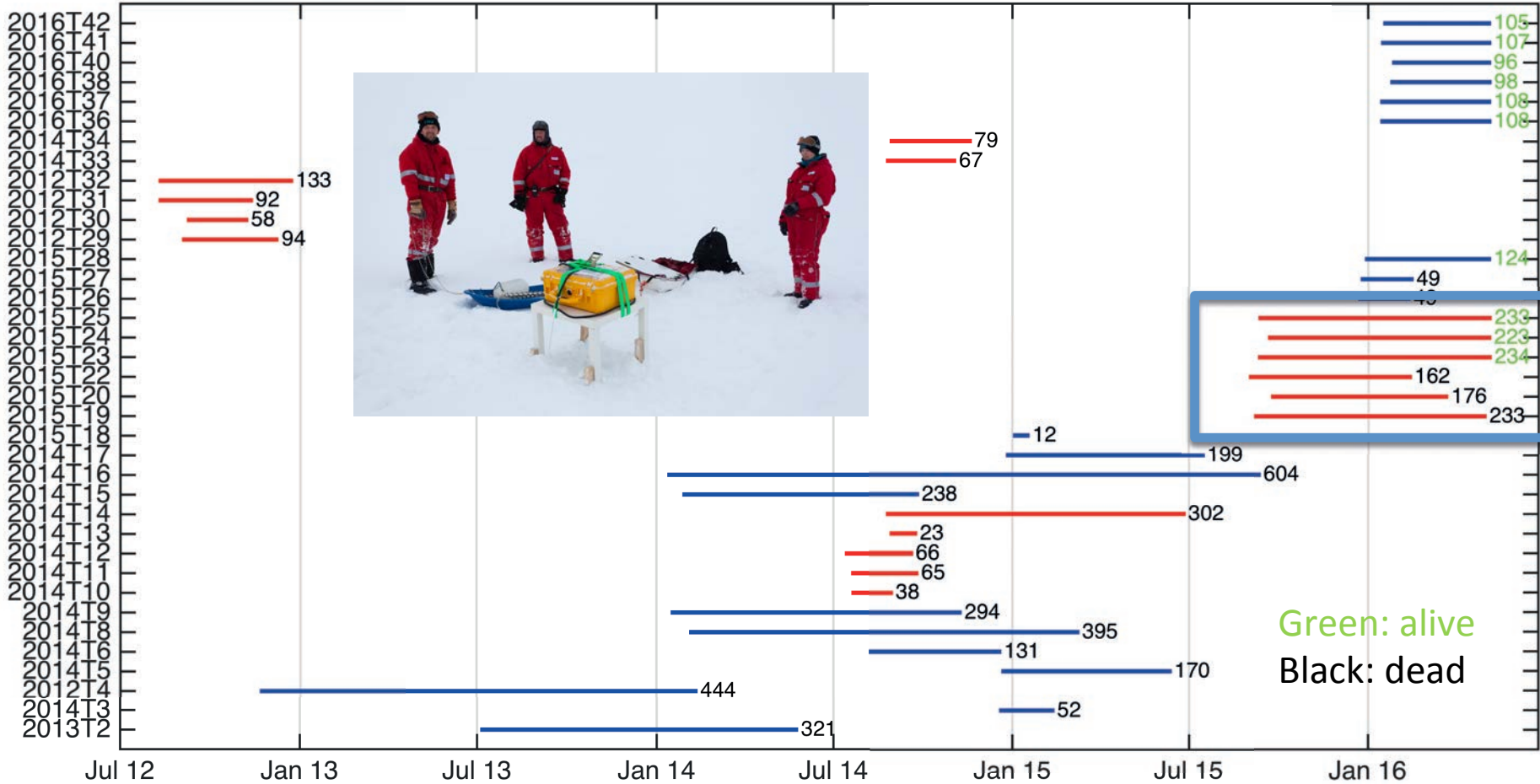


=> Need for better snow depth and properties data

# SAMS IMB lifetimes



37 deployments, 10 (4) still active



Arctic

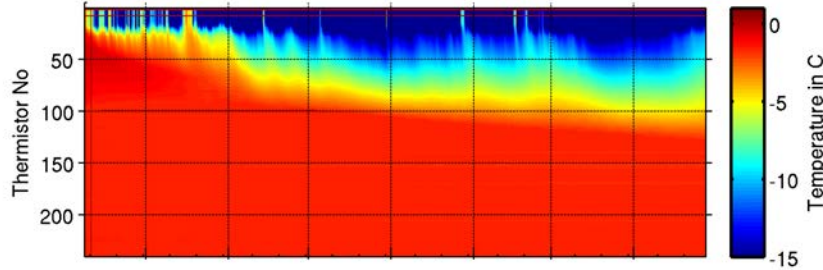
Antarctic

# IMBs: selected success stories

meereisportal.de

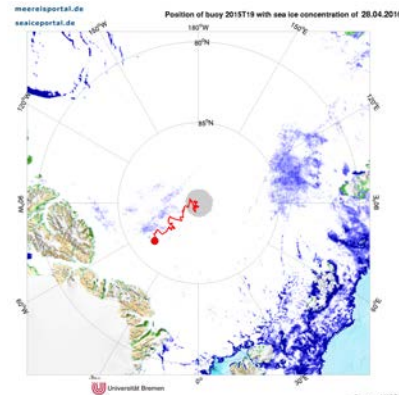
seaceportal.de

2015T19: Temperature (daily)



Sep 2015

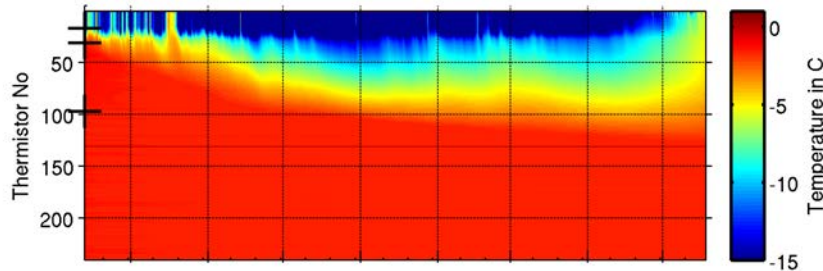
Apr 2016



meereisportal.de

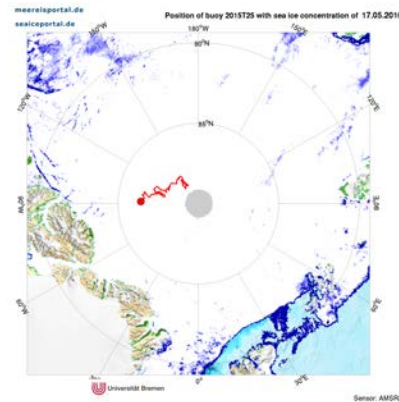
seaceportal.de

2015T25: Temperature (daily)



Sep 2015

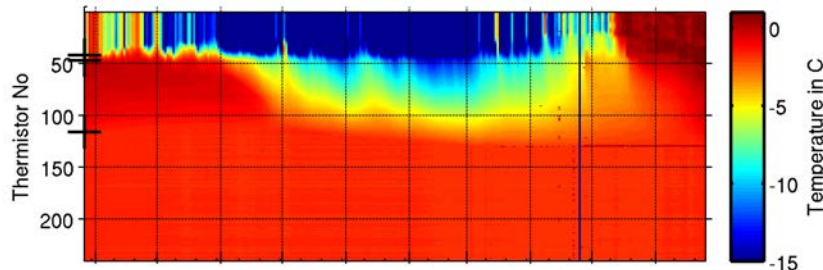
now



meereisportal.de

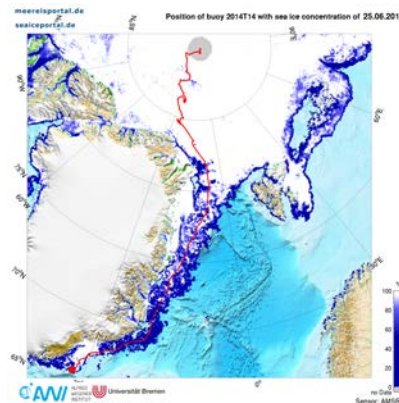
seaceportal.de

2014T14: Temperature (daily)



Aug 2014

Jun 2015



**IMB 2015T19**  
**233 days**

**IMB 2015T25**  
**249 days**  
**still active**

**IMB 2014T14**  
**303 days**

# The future: „advanced IMBs“



- **Change company/partner: from SRSL to** **uncin**
- Prototypes developed/deployed with **EU project**
- Very flexible platform (Fox, Linux)
- Short product cycles
- Close collaboration, feedback
- Better chain, camera, other **loads possible**
- Radiation package (in **with NPI**)
- Bio-optics for PS<sup>1</sup>
- **All existing knowledge & future**  
**development to be freely available**

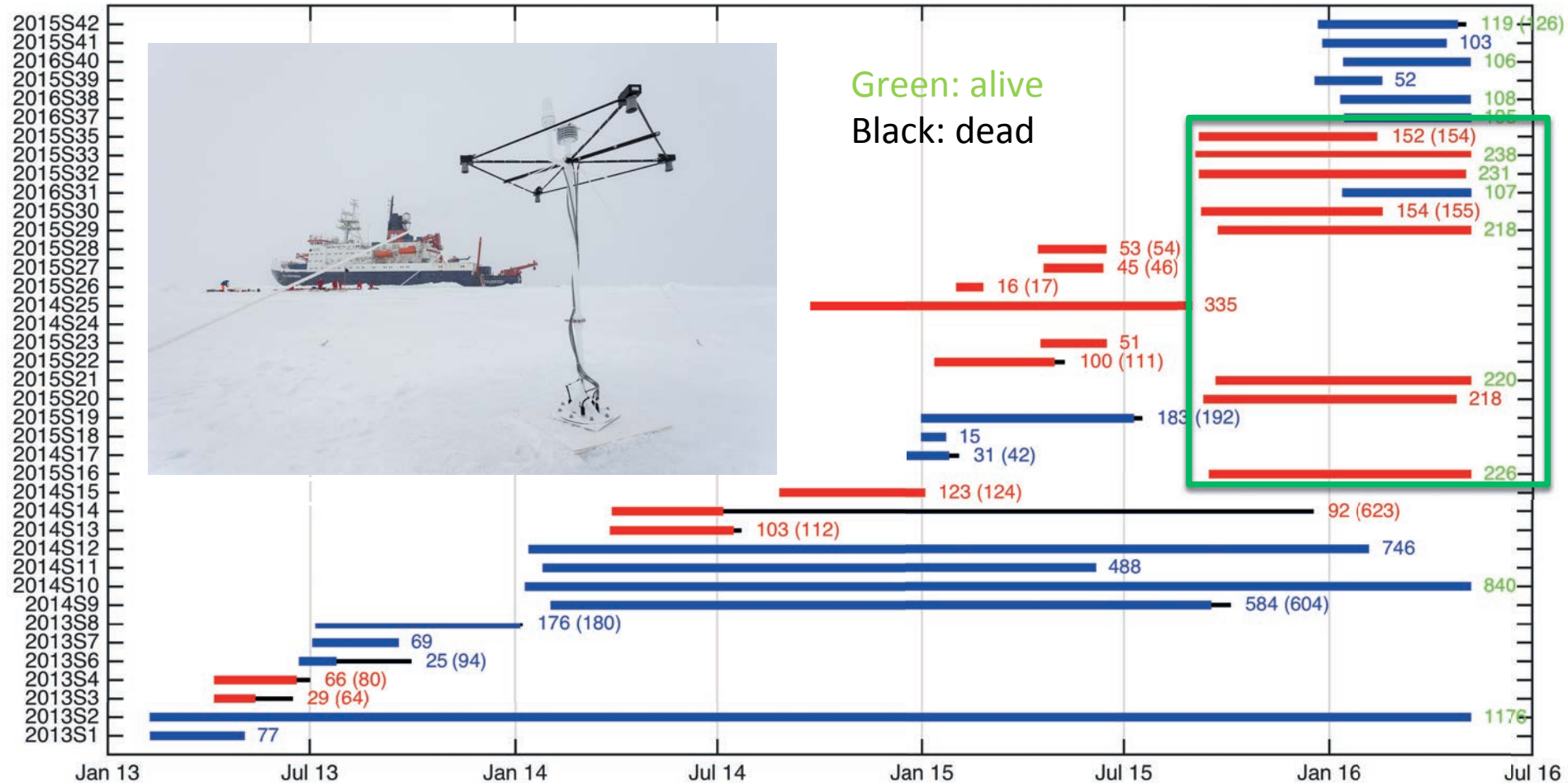
**Long-term community driven,**  
**entirely open source platform**

**Improved communication within the community:  
IMB workshop @AWI: 14-15 June 2016**



# Snow Buoy lifetimes

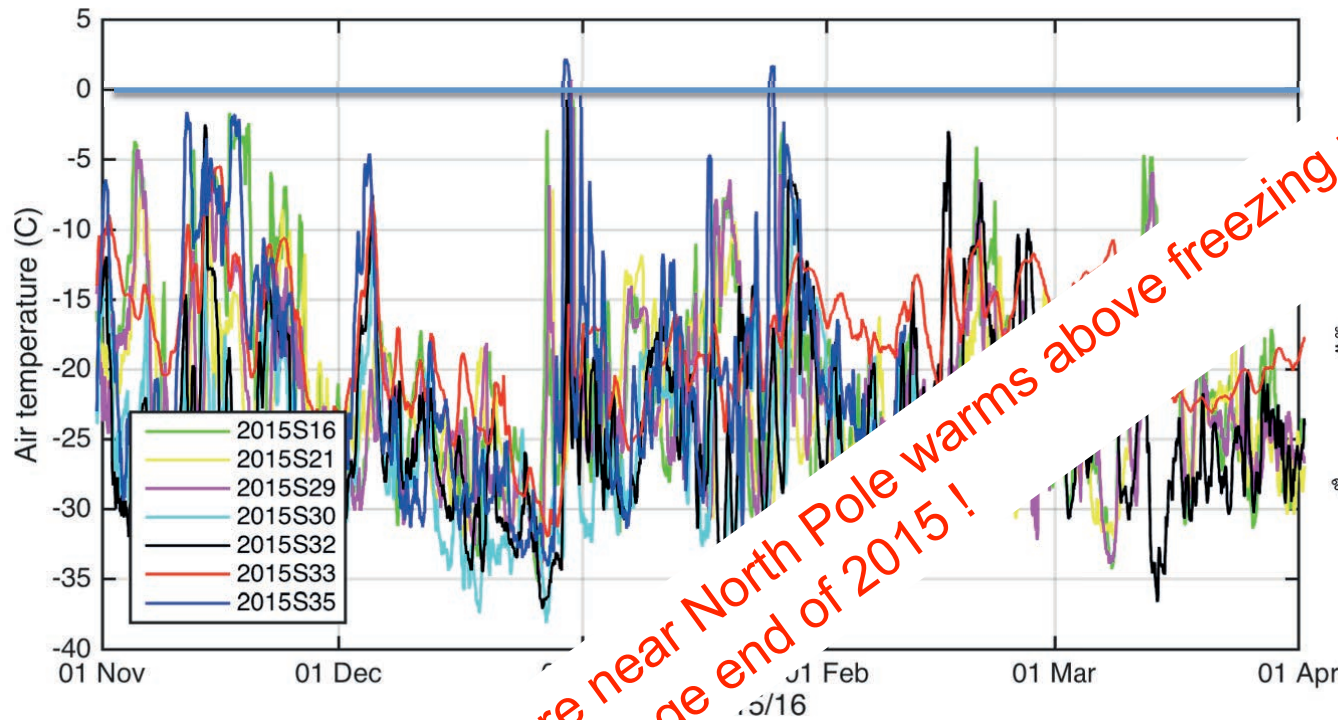
39 deployments, 13 still active, longest record ~ 1177 days, 6 ordered for 2016



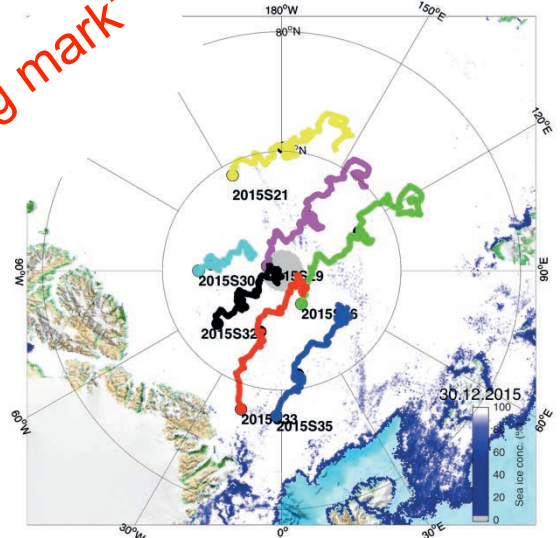
Arctic

Antarctic

# Warm Winter 2015/16



Temperature near North Pole warms above freezing mark  
 → news coverage end of 2015!



## Snow Buoy

- Multiple spells during winter all the way to North Pole
- Exceeding 0°C end of Dec 2015

Svalbard Results (AWIPEV-Station): 8°C warmer than long term average (February)

# Frosting on some units



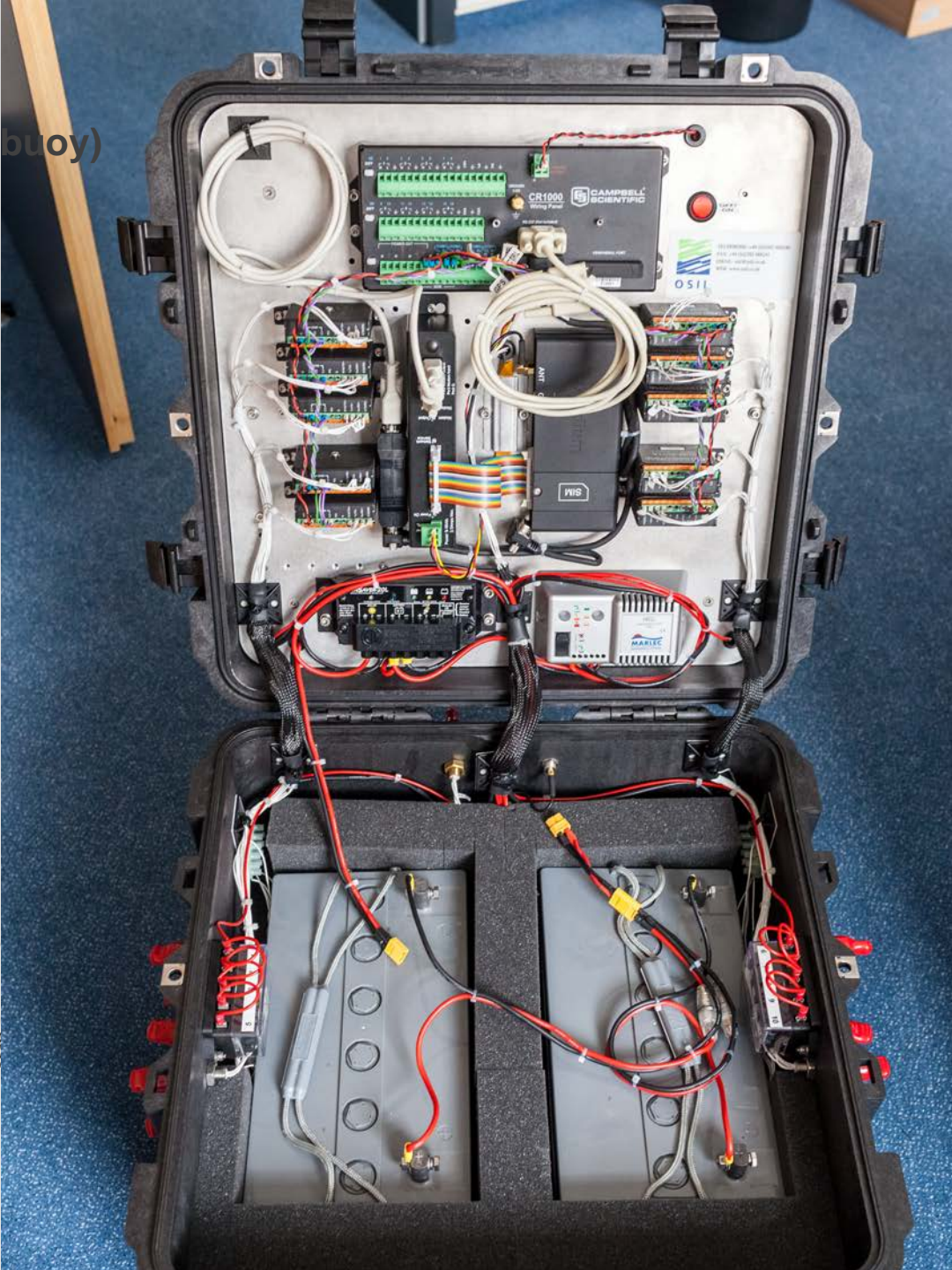
Snow depth (sensor 1 2 3 4)

Air pressure  
Air / Body  
temperature





# IBOB (Ice-tethered bio-optical buoy)



**Meteorological  
observations:  
e.g. snow & weather beacon**



# Arctic deployer

# PS101 ongoing (Karasik seamount)



- 8 (3) Snow Buoys

- 6 (1) SAM

- 8 (3) SVP

- 1 (1) PAV

- 1 (0) Rad

- 1 (1) Bio-

- 4 (?) IAOS (incl. 4 IMBs)

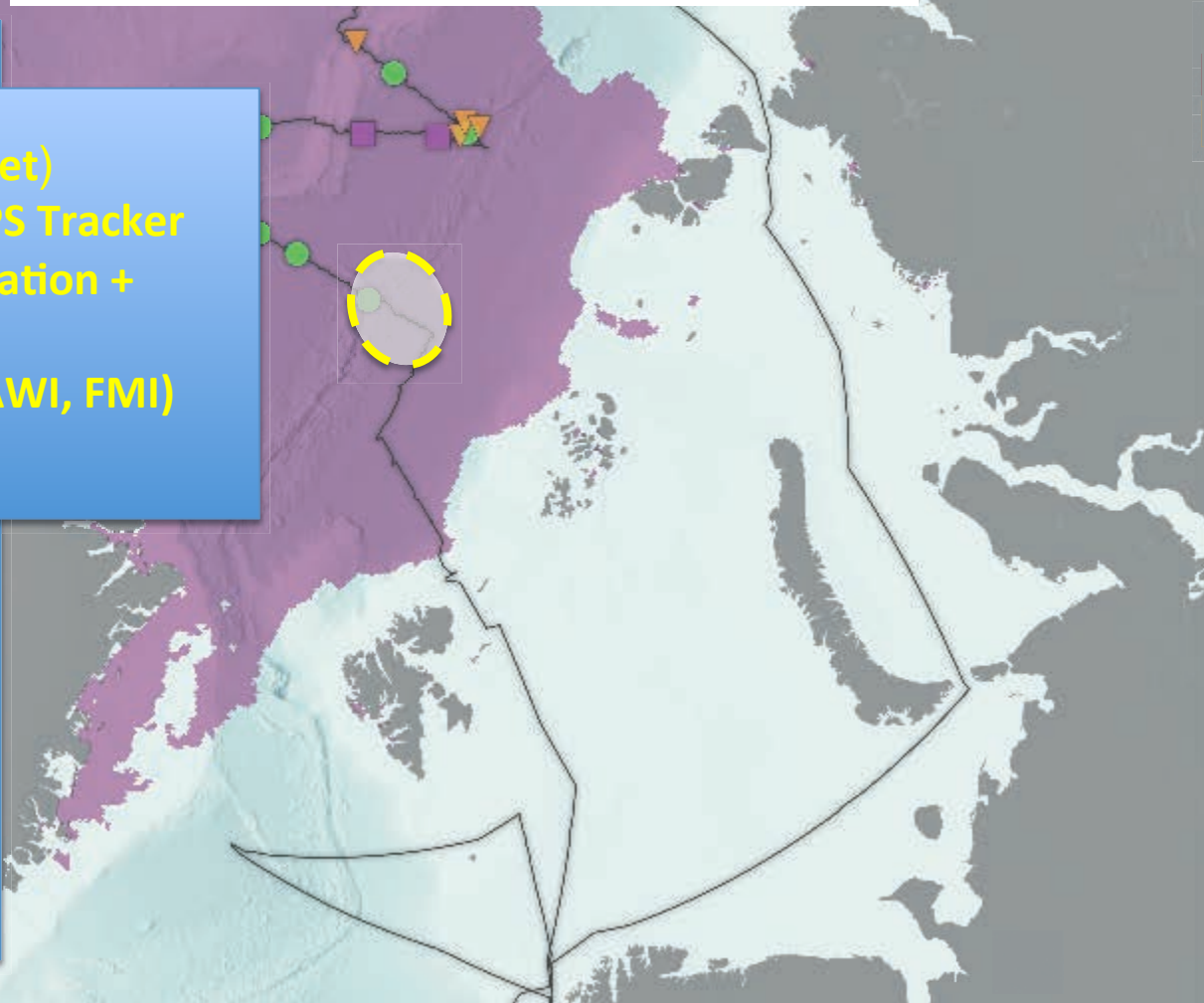
- 1 (?) SATICE

- 2 (0) BAS IMBs

Total: 32 buoys,

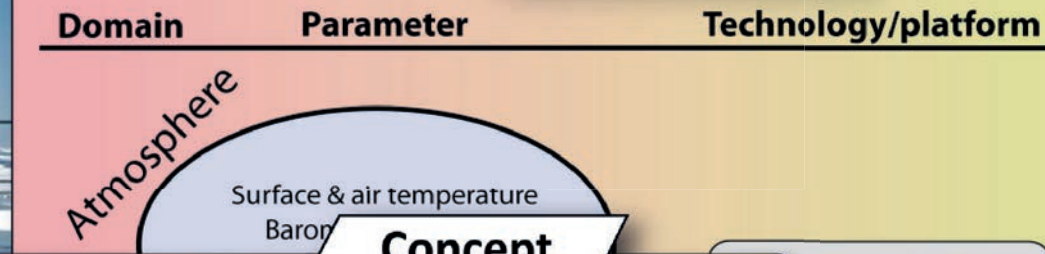
11-16 units still reporting

- 8 SVPs (Eumetnet)
- 11 Novatech GPS Tracker
- 2 BAS IMB (radiation + bio-optics)
- 4 SAMS IMBs (AWI, FMI)
- 4 Snow Buoys

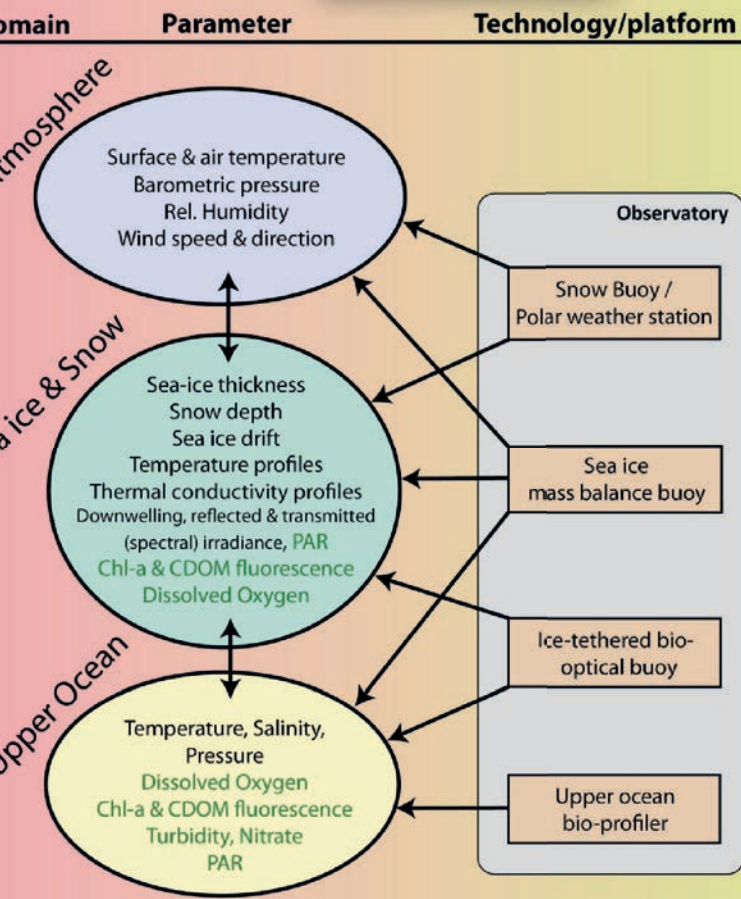


# Multidisciplinary Ice-based Distributed Observatory (MIDO)

## Concept



## Concept



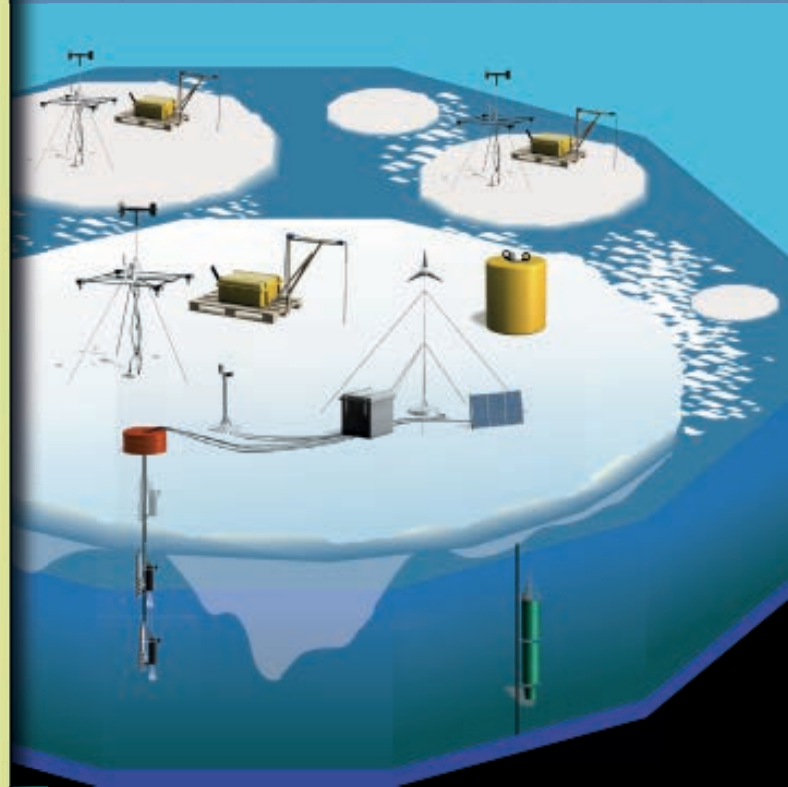
## Observatory

Snow Buoy / Polar weather station

Sea ice mass balance buoy

Ice-tethered bio-optical buoy

Upper ocean bio-profiler

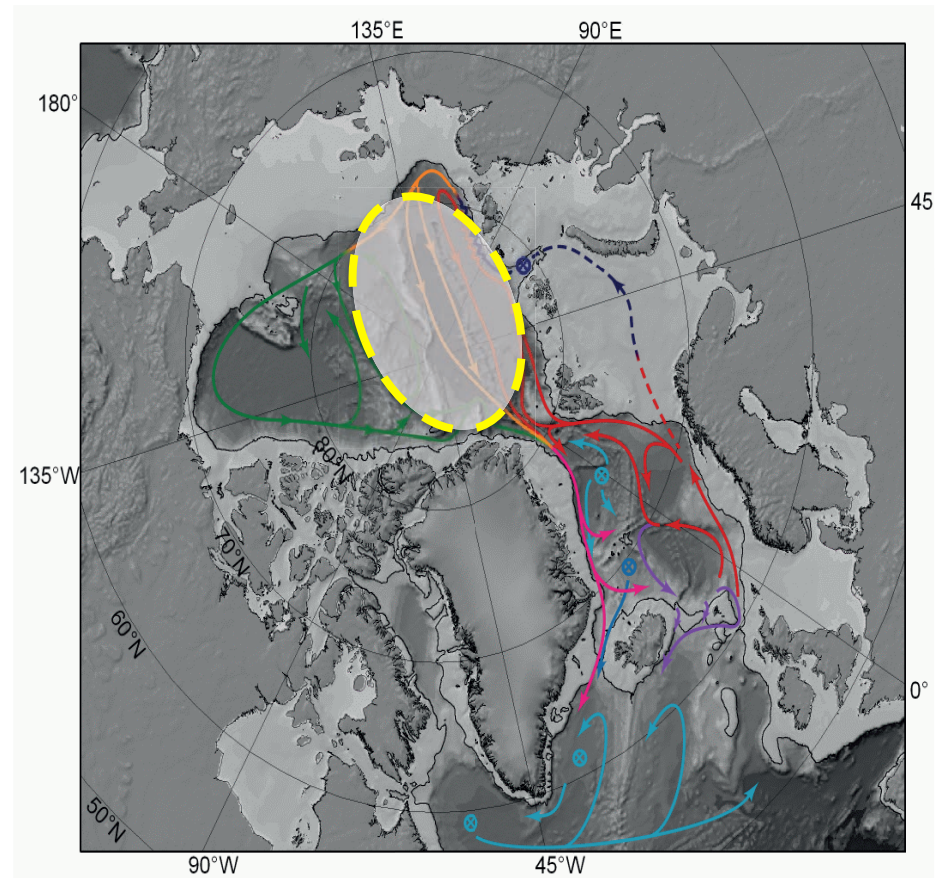


proposal within AWI infrastructure fund  
 2 buoy "array systems" / year and hemisphere  
 Array: instruments on central floe + within  
 100 km  
 multidisciplinary observations  
 Data feed into GTS

# Preliminary time plan until 2021

## Expeditions with AWI (FRAM / MIDO) participation:

- PS101 (Sep 2016)
- NABOS (2017)
- **2018 still pending**
- TransARC III (2019)
- MOSAiC (2019/20)



Map modified from Rudels (2005)

# MOSAiC 2019/20

Multidisciplinary drifting Observatory  
for the Study of Arctic Climate





Thanks – questions?