Operational Marine and Cryospheric Projects in Fram Strait

Paul A. Dodd, Laura de Steur, Arild Sundfjord
Norwegian Polar Institute, Tromsø

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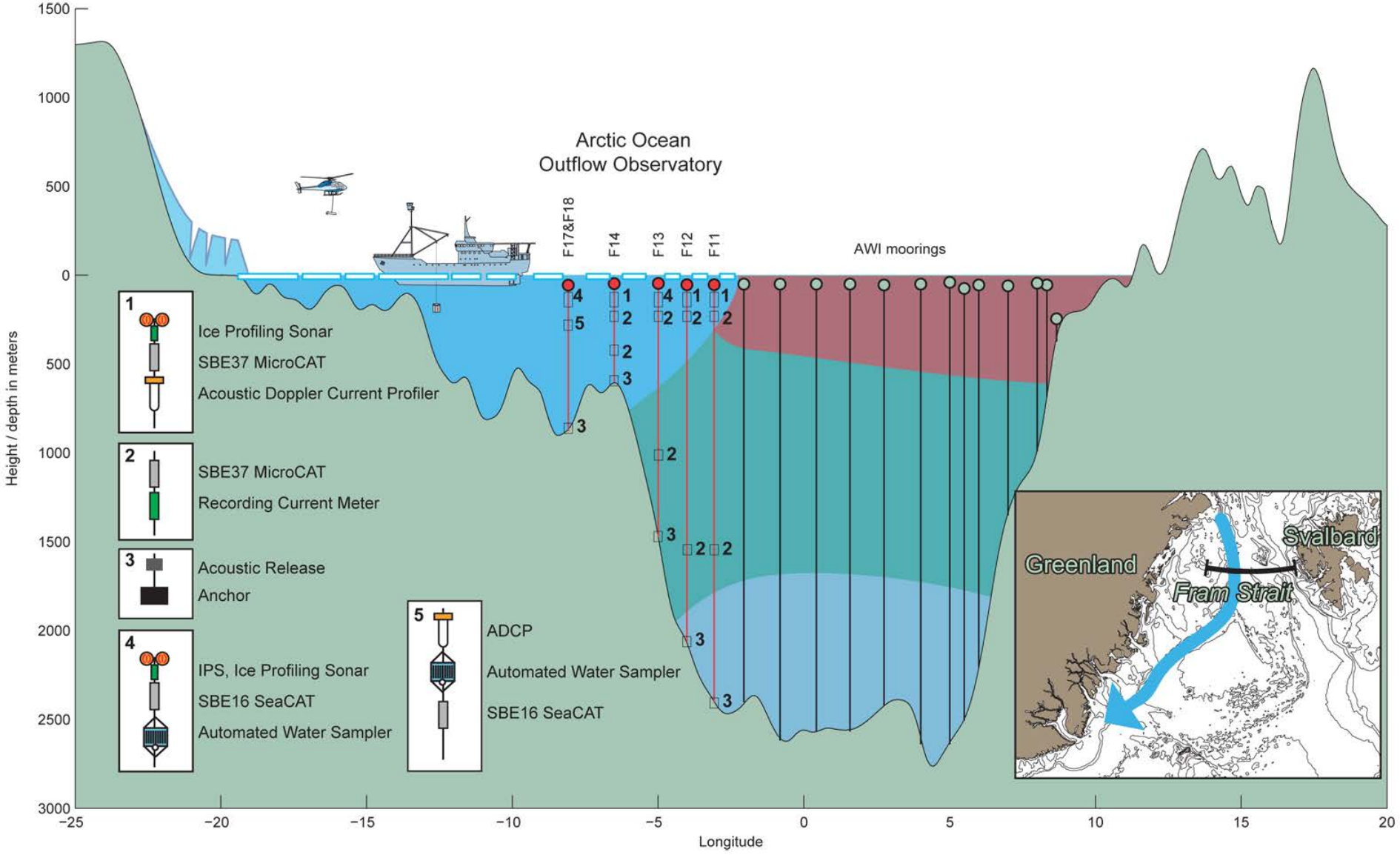
NORSK·POLARINSTITUTT

Operational Marine and Cryospheric Projects in Fram Strait

1. Moored Currents and Hydrography in Fram Strait
2. Ice Profiling Sonar measurements in Fram Strait
3. Atlantic Water Hydrography in Fram Strait and the Greenland Ice Sheet
4. TRIMODAL : Tracers, Models, Atmospheric Indices
5. MOSJ : Miljø Overvåkning Svalbard & Jan Mayen

The Fram Strait Arctic Ocean Outflow Observatory



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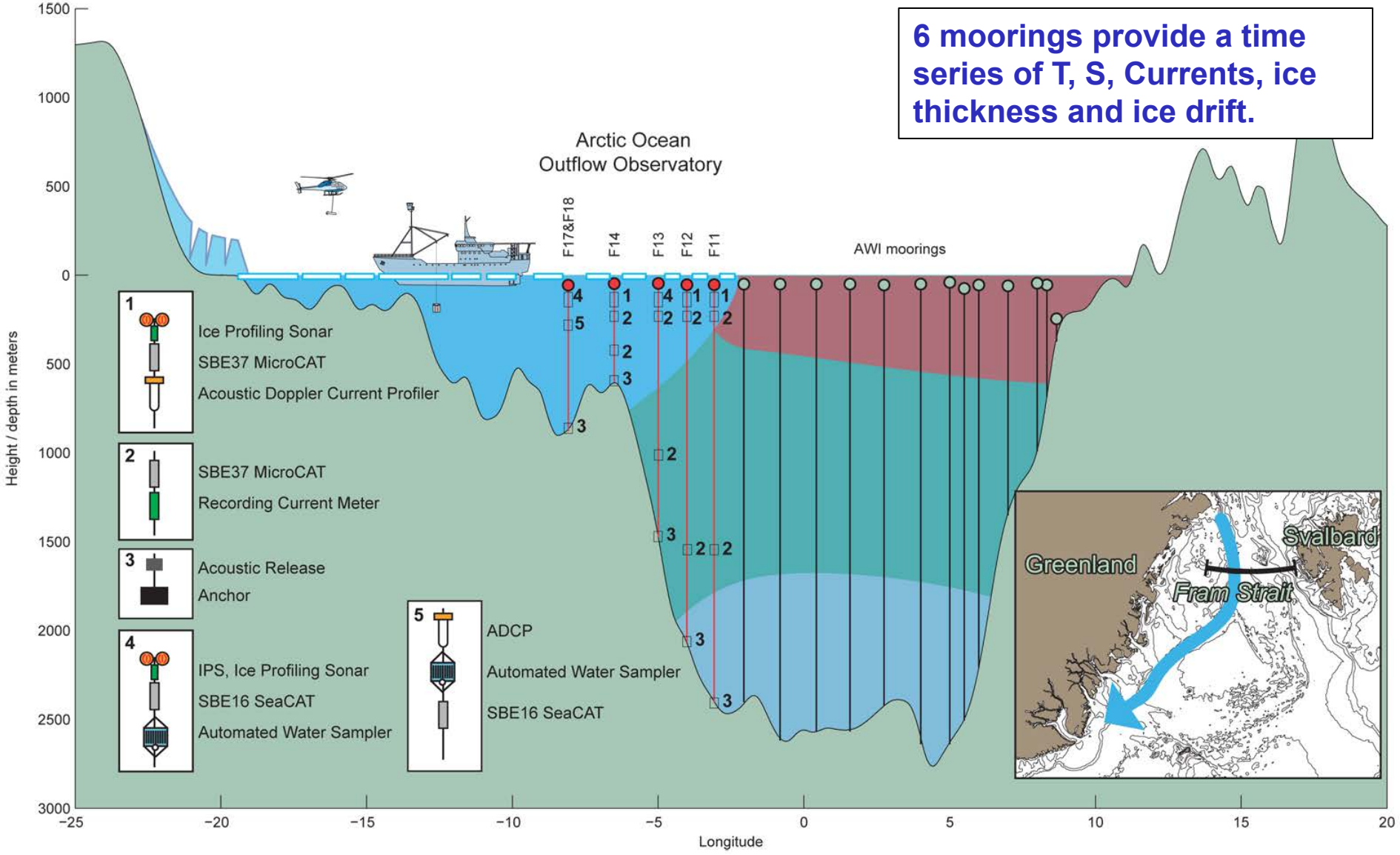

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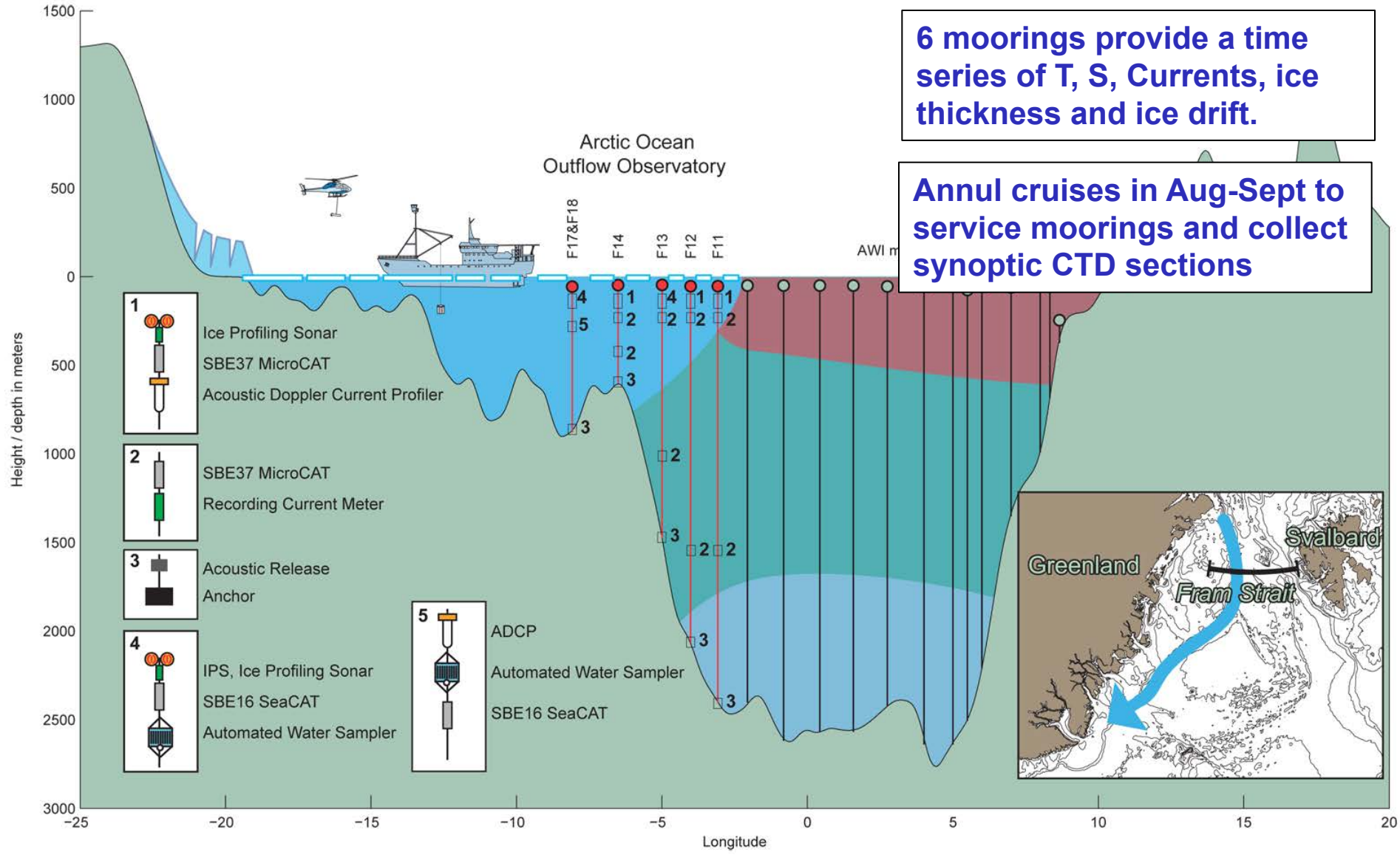

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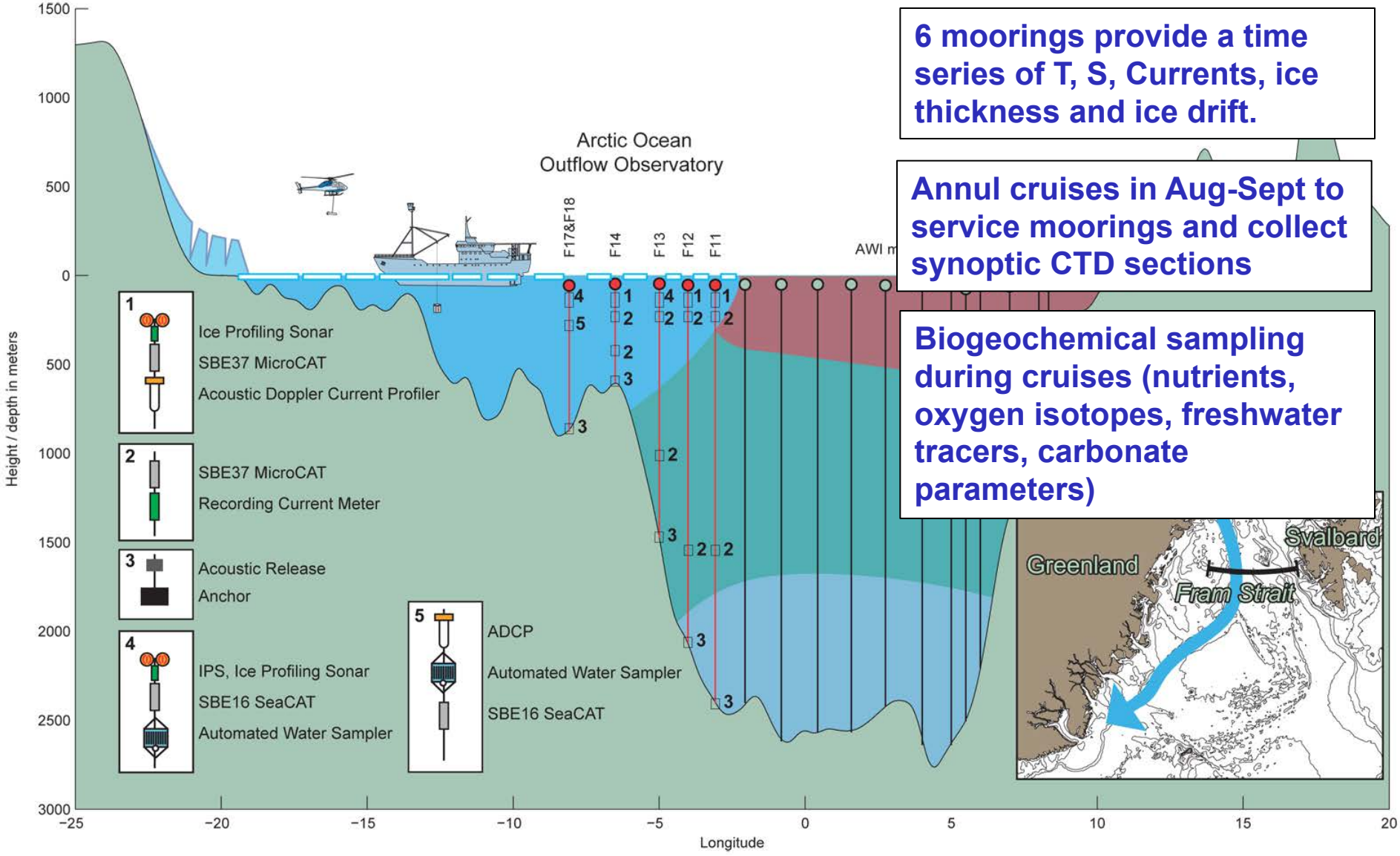

6 moorings provide a time series of T, S, Currents, ice thickness and ice drift.

Annul cruises in Aug-Sept to service moorings and collect synoptic CTD sections

Biogeochemical sampling during cruises (nutrients, oxygen isotopes, freshwater tracers, carbonate parameters)

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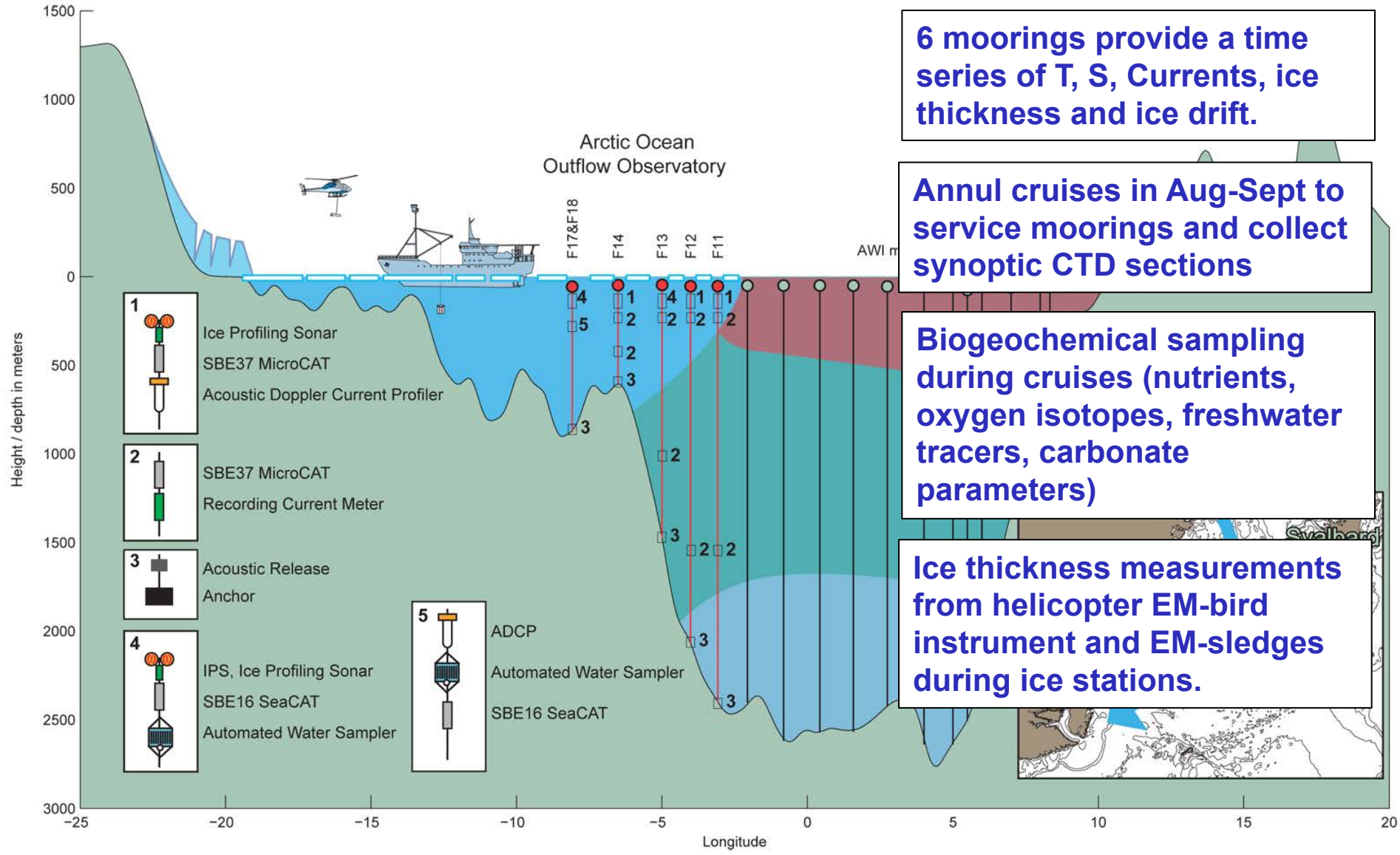

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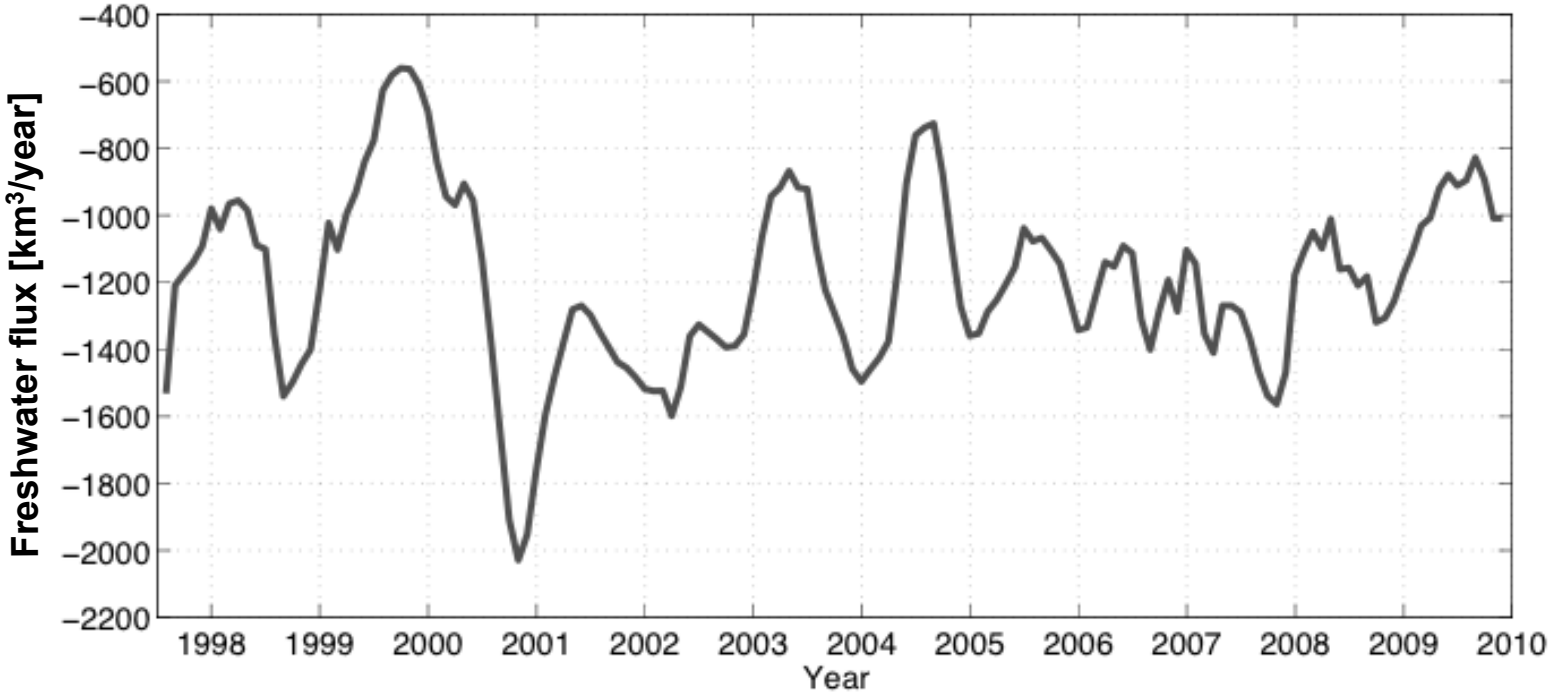
Biogeochemical sampling during cruises (nutrients, oxygen isotopes, freshwater tracers, carbonate parameters)

Ice thickness measurements from helicopter EM-bird instrument and EM-sledges during ice stations.

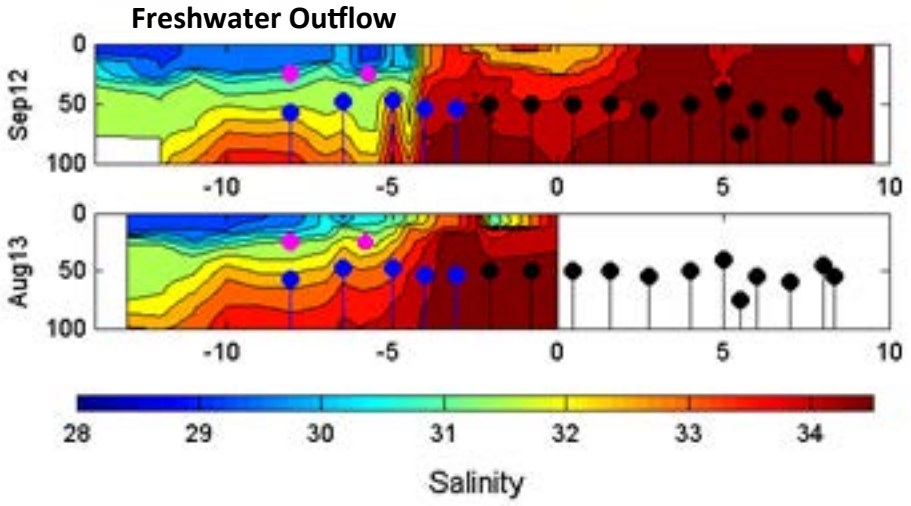
Moored Currents and Hydrography in Fram Strait: Freshwater transport



- Variability, but no significant trend from 1997 to 2010[1]
- 2010 – 2015 Update expected by the end of 2017, New mooring data processed, analysis has started,

[1] De Steur et al. (2009), Jahn et al. (2011)

Moored Currents and Hydrography in Fram Strait: Improvements in the observing system



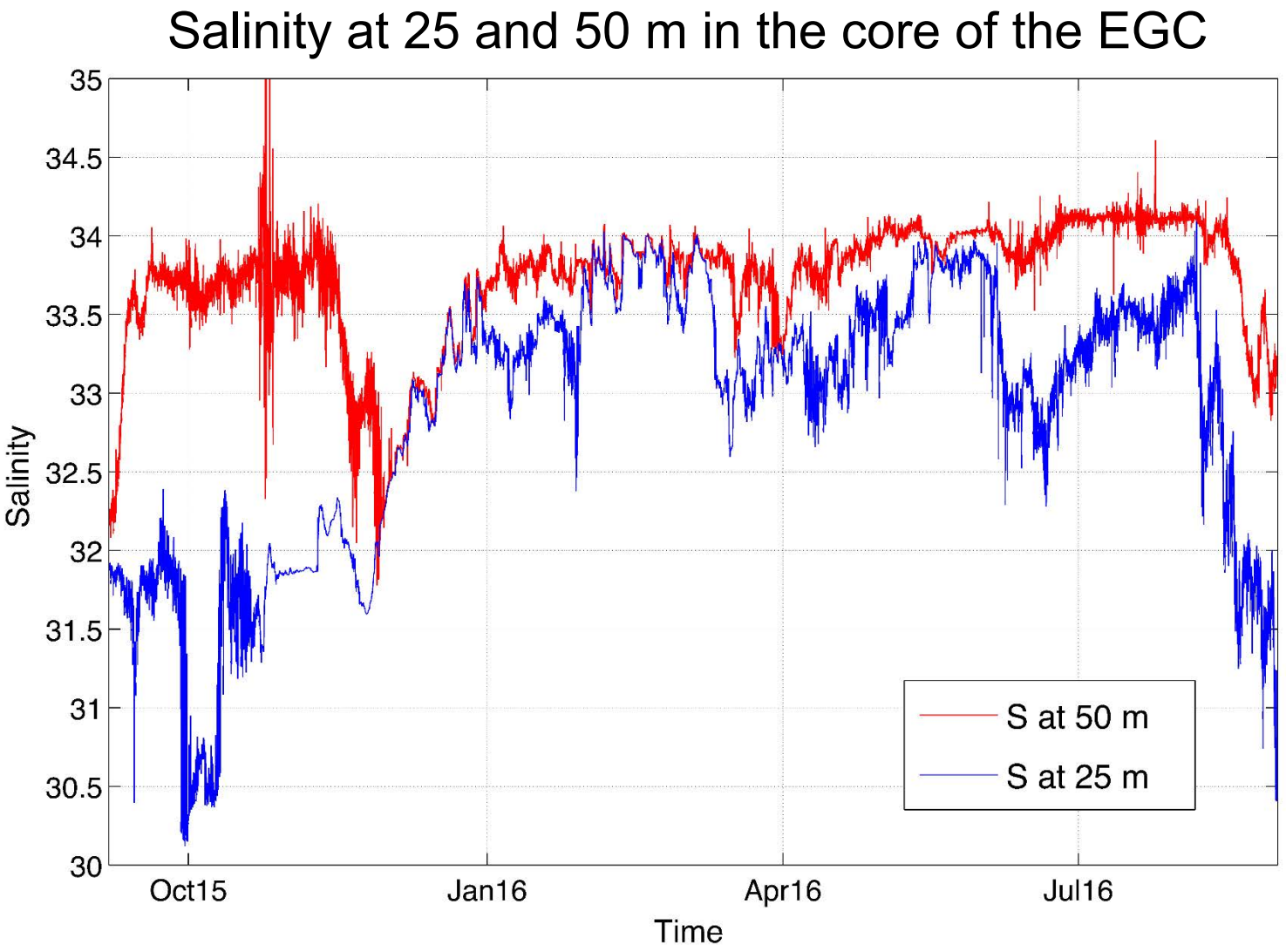
New Icecat

Existing moorings maintained by NPI

Existing moorings maintained by AWI

- The surface layer is not well observed by the moored array
- Since 2013 'Icecats' have measured temperature and salinity at 25-30 m, where conventional instruments are threatened by deep keels under sea-ice
- 'Icecats' are SBE microcats contained in a smooth float, and attached by a weak link which transmit data to a logger at a safe depth.

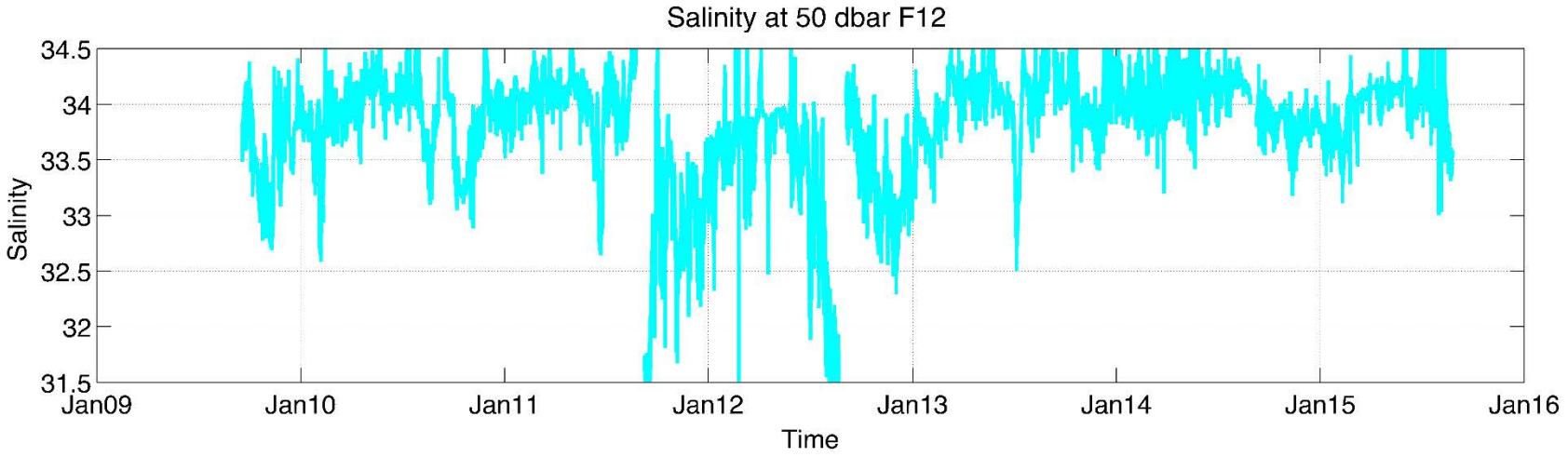
Moored Currents and Hydrography in Fram Strait: Improvements in the observing system



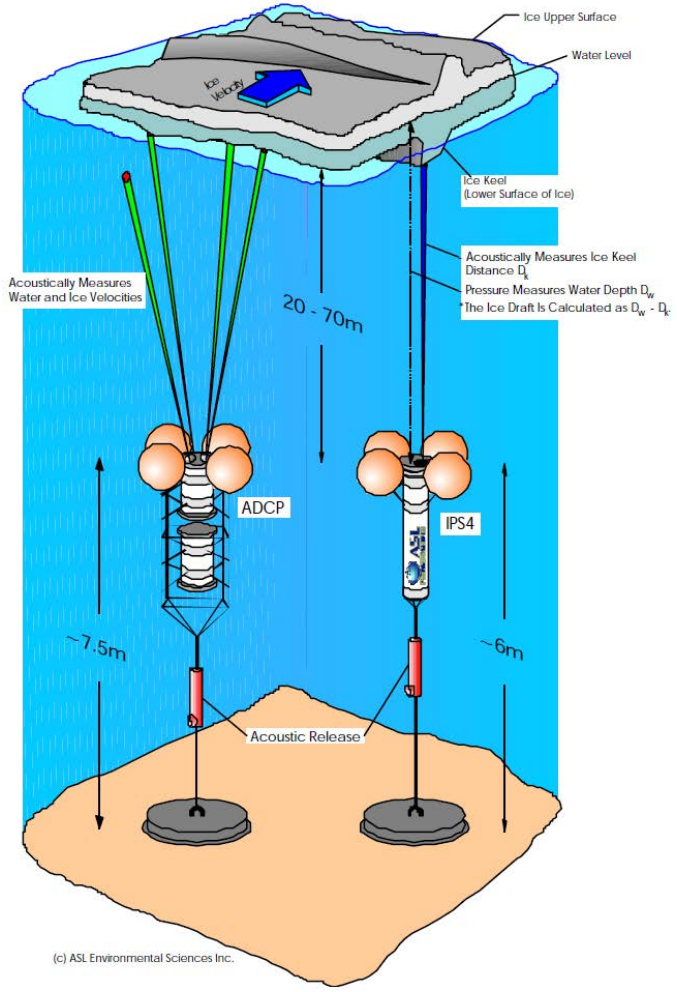
- New data from ICECats capture significantly more stratification

Moored Currents and Hydrography in Fram Strait: Improvements in the observing system

- Upward looking ADCPs at all moorings at 50 m since 2012
- More SBE Microcats provide T & S in AW, and deep layers
- New freshwater transport estimates will both extent the time series, and also be more precise then previous measurements



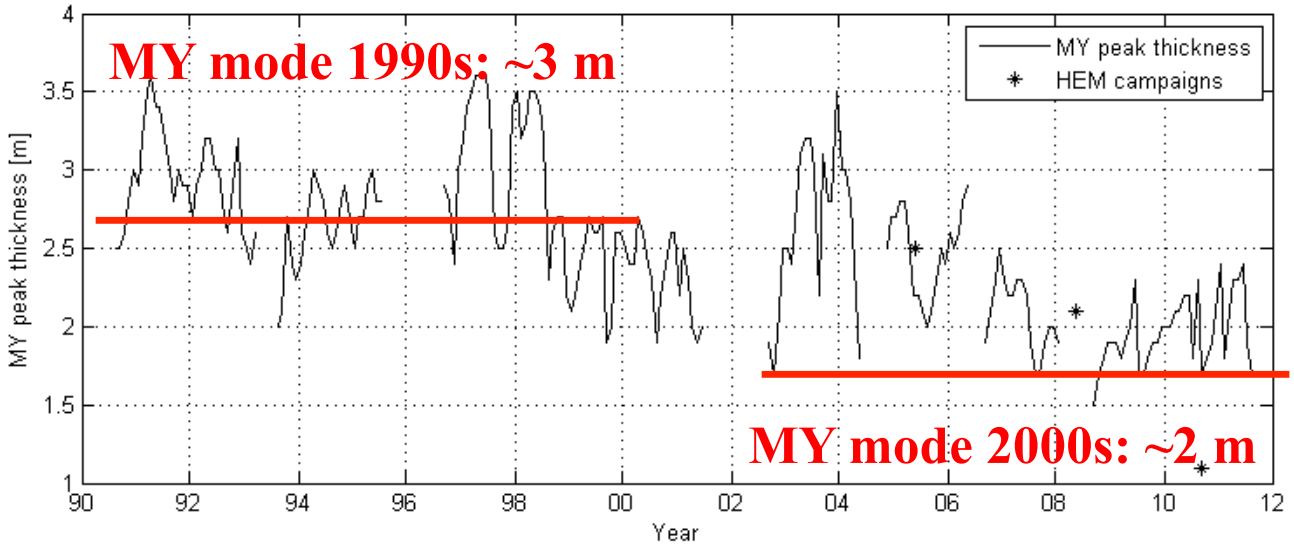
Ice Profiling Sonar Measurements in Fram Strait



- **IPS instruments** deployed at 3°,4°, 5° and 6°30’ W 1990-2016 (ongoing)

- **Helicopter-EM measurments** during Fram Strait cruises in 2008, 2010, 2011, 2012, 2014 and 2016

Ice Profiling Sonar Measurements in Fram Strait



- 2000s multi-year **modal thickness** down 30 percent compared with the 90s
- The multi-year mode is now approaching what used to be the first year modal thickness; 1.5-2 m
- **Mean** thickness at the end of winter 2010-2011 was 2 m. 50% less than the mean thickness during the 1990s

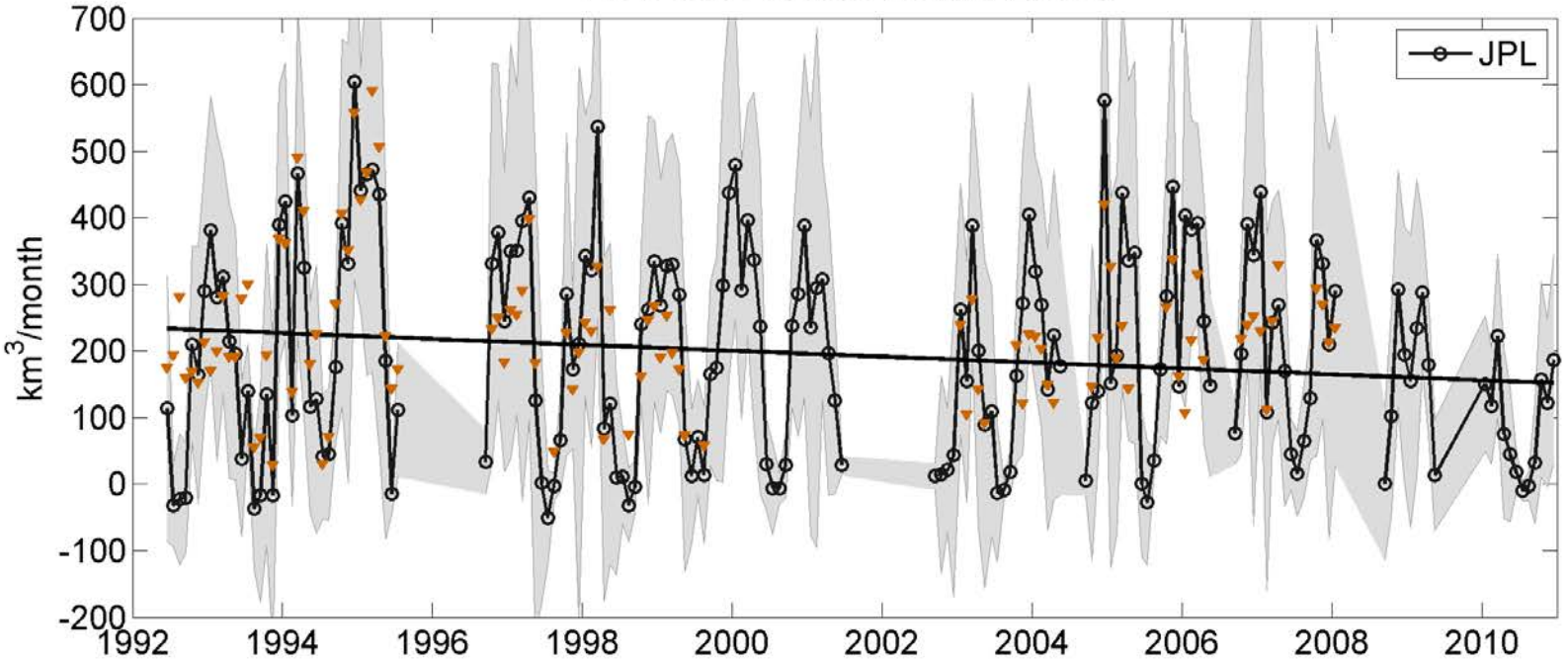
Hansen, E., O-C. Ekeberg, S. Gerland, O. Pavlova, **G. Spreen**, and M. Tschudi (**2014**) *Variability in categories of Arctic sea ice in Fram Strait*. Journal of Geophysical Research (119) 71757189. doi: 10.1002/2014JC010048

Hansen, E., S. Gerland, **M. Granskog, O. Pavlova, A. Renner**, J. Haapala, T. B. Løyning, and M. Tschudi (**2013**). *Thinning of Arctic sea ice observed in Fram Strait: 1990-2011*. Submitted to Journal of Geophysical Research, 2013-03-15, Manuscript no. 2013JC008938.

Hansen, E., S. Gerland, and G. Spreen (**2013**), *The seasonal cycle of Arctic sea ice thickness observed in Fram Strait*. Journal of Geophysical Research. (In preparation).

Ice Profiling Sonar Measurements in Fram Strait: Volume transport estimates

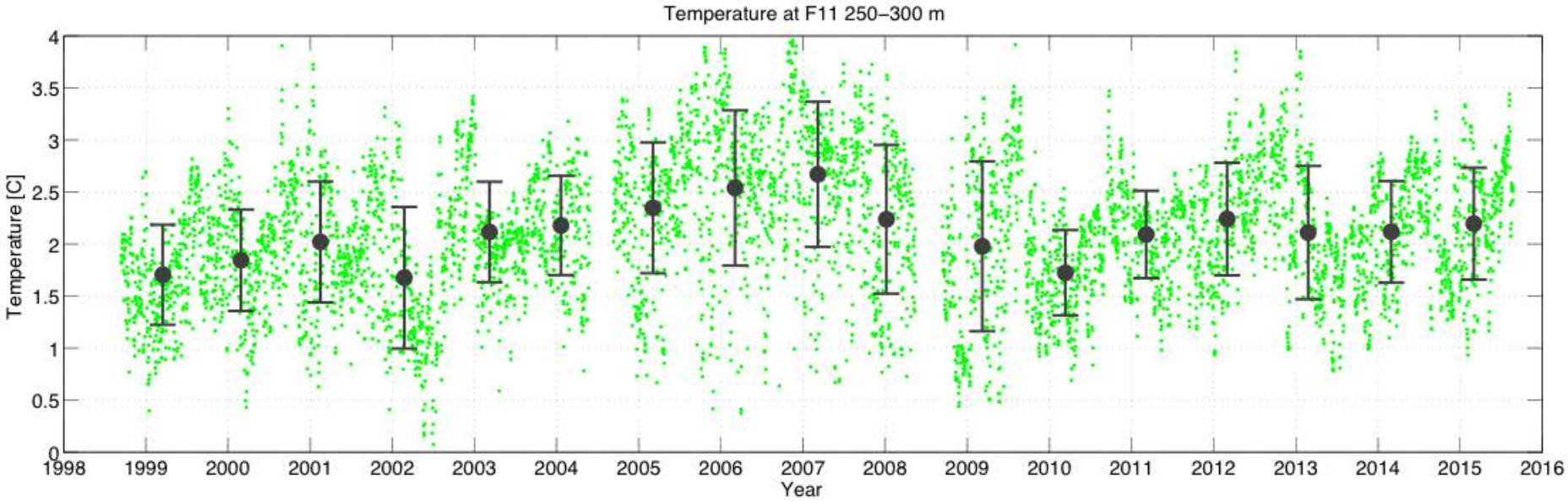
- Spreen et al., (in prep) estimate 1992-2013 volume transports combining IPS thickness measurements with SSM/I drift and area products
- Sea ice volume flux trend: –2.3±0.3%/year (p>0.99)



- NPI has a proposal in with FRINATEK to extend this in the future, lead by Laura de Steur.

Atlantic water in Fram Strait & the Greenland Ice Sheet

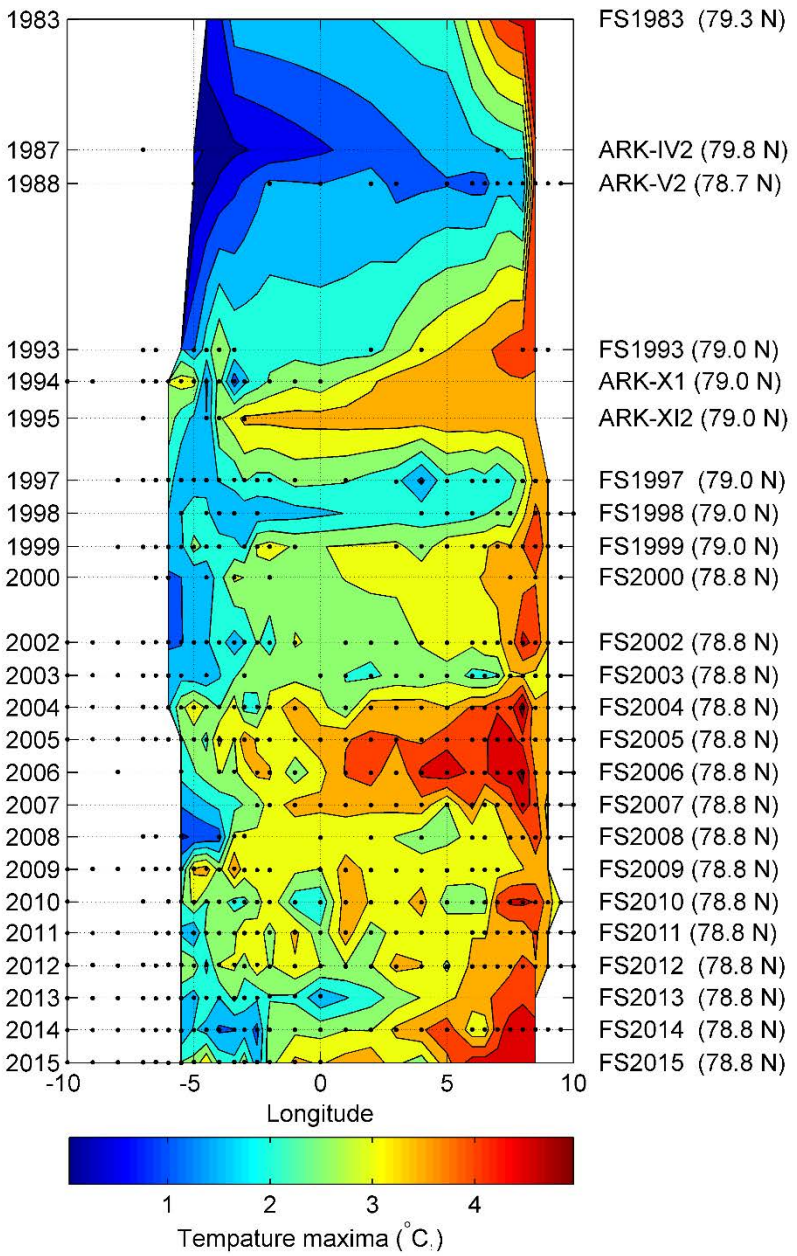
Time series of Atlantic Water temperature from mooring at 2 W



- Warm AW anomalies (e.g.2005-2007)
- Long term trend of increasing AW temperature

Atlantic water in Fram Strait & the Greenland Ice Sheet

- Repeated synoptic CTD sections by NPI and AWI from 1983-2015 show the extent of warm Atlantic Water anomalies (e.g. 2005-2007)
- Anomalies propagate right across Fram Strait and perhaps further…



Atlantic water in Fram Strait & the Greenland Ice Sheet

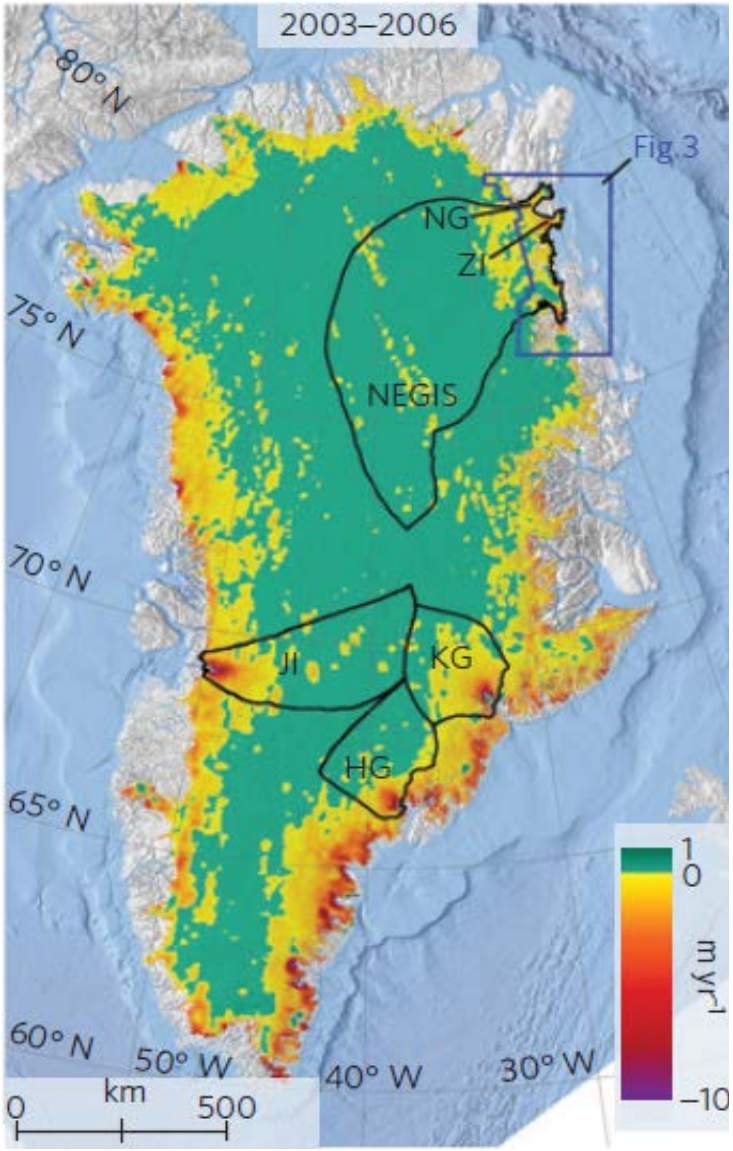
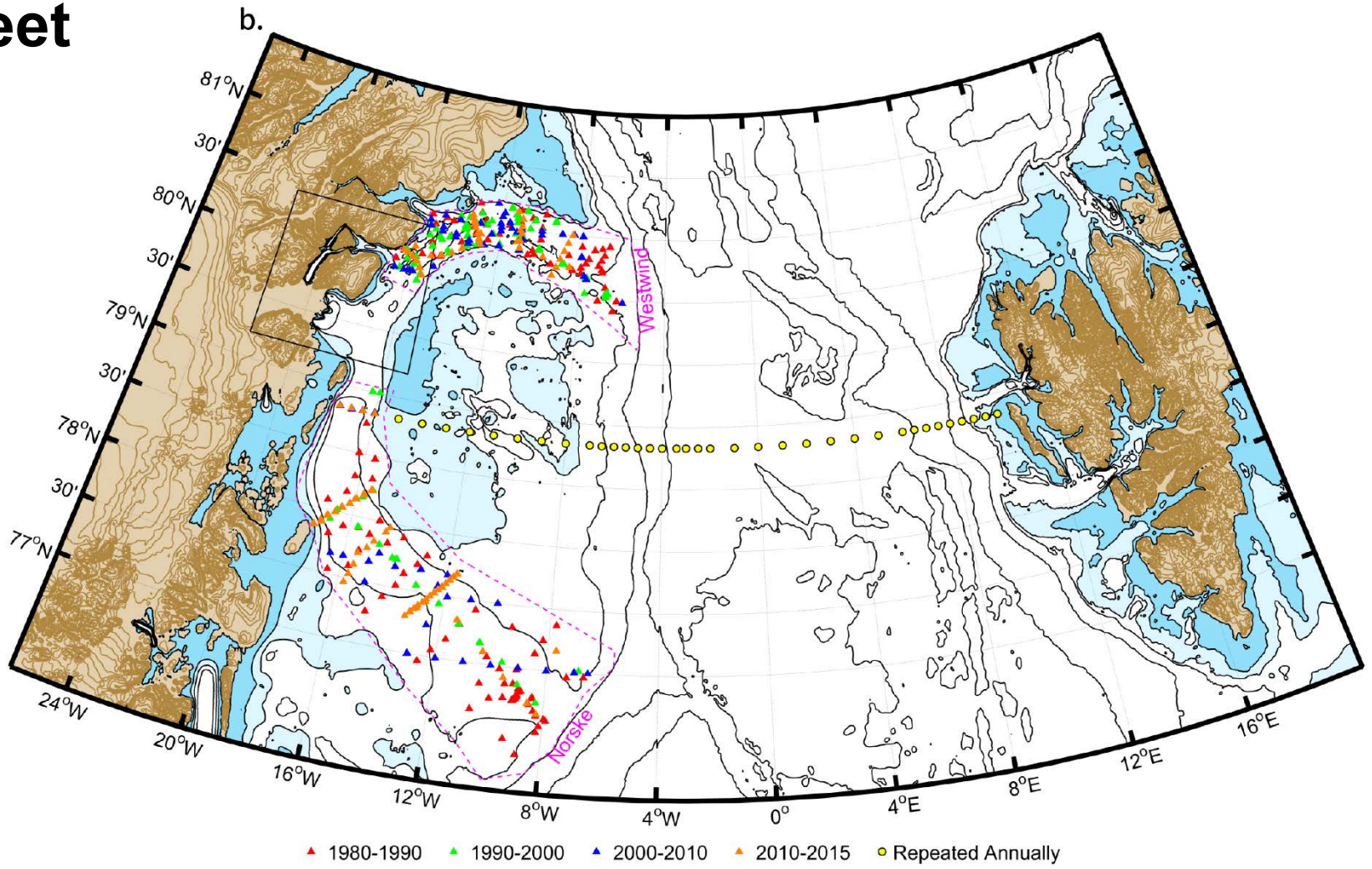


Figure from Kahn et al. (2014)

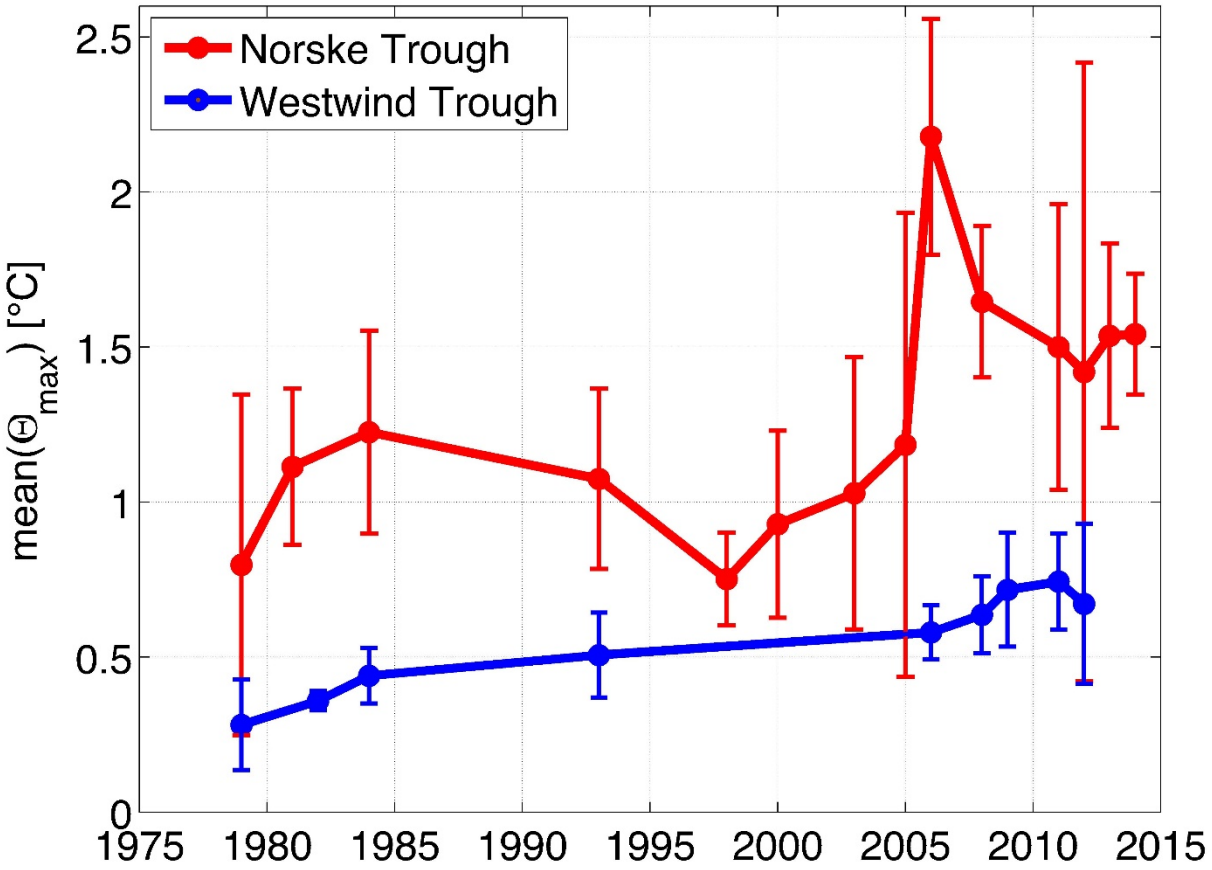
- The Northeast Greenland Ice Sheet, (about 16% of the Greenland Ice Sheet) ends in three marine terminating Glaciers: 79N, Zachariae and Storstrømmen.
- All three have fast near-terminus velocities and showed significant mass loss in the period 2003-2006
- All three glaciers draining the NEGIS are located in Western Fram Strait, where variable oceanographic conditions may affect discharge rates.
- But Atlantic water must first cross the shallow East Greenland Shelf…

Atlantic water in Fram Strait & the Greenland Ice Sheet



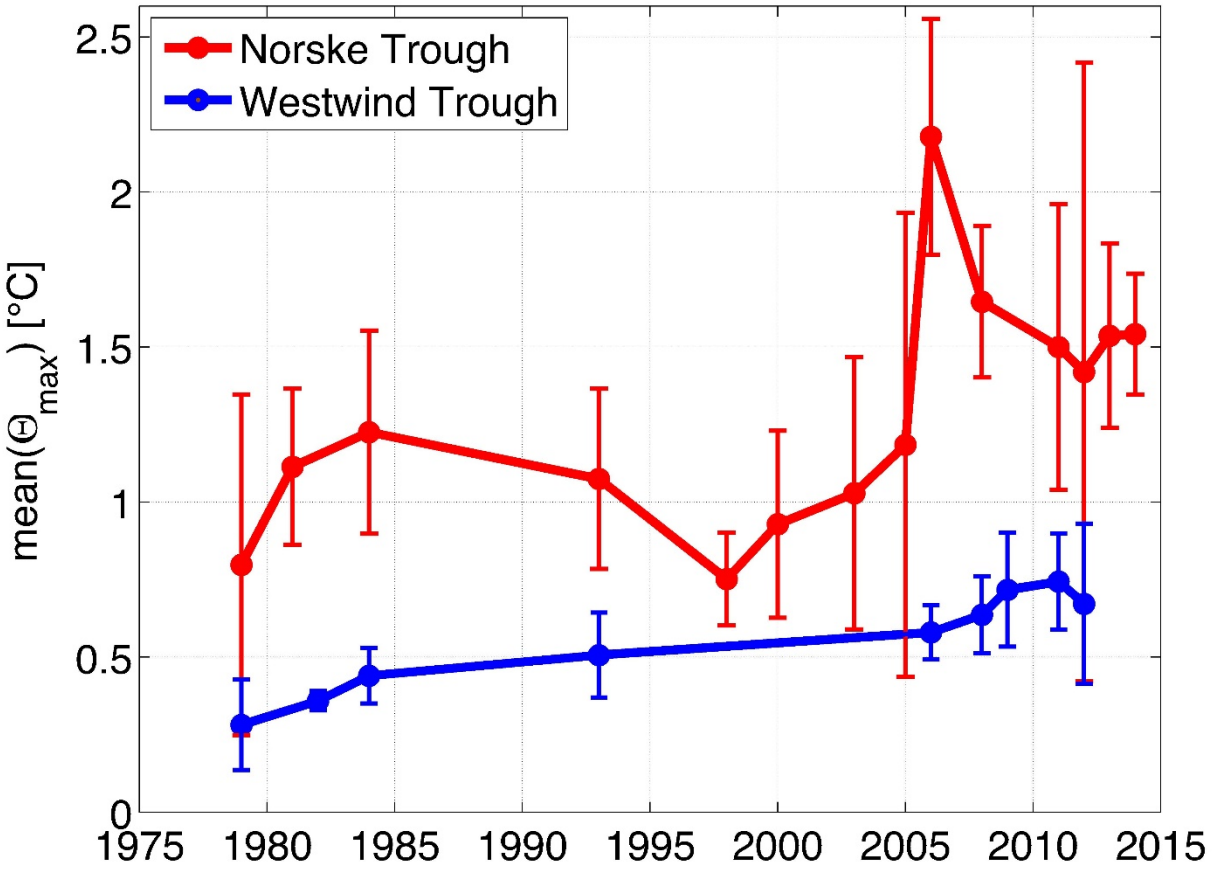
- The Norske and Belgica troughs have been quite well sampled from 1983 - 2015
- Here we investigate how the of Atlantic water temperature has changed in each part.

Atlantic water in Fram Strait & the Greenland Ice Sheet



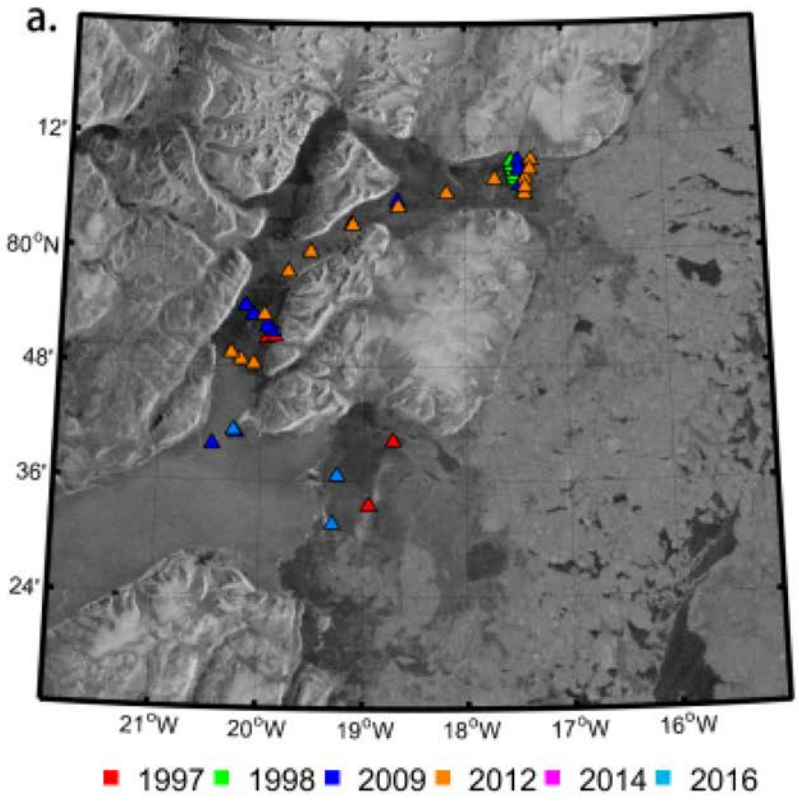
- Here we take the temperature maximum within each profile, then calculate the average of the temperature maxima in each year when data was available.
- The mean of the temperature maxima is increasing with time in both troughs, but the increase is greatest in the Norske trough.

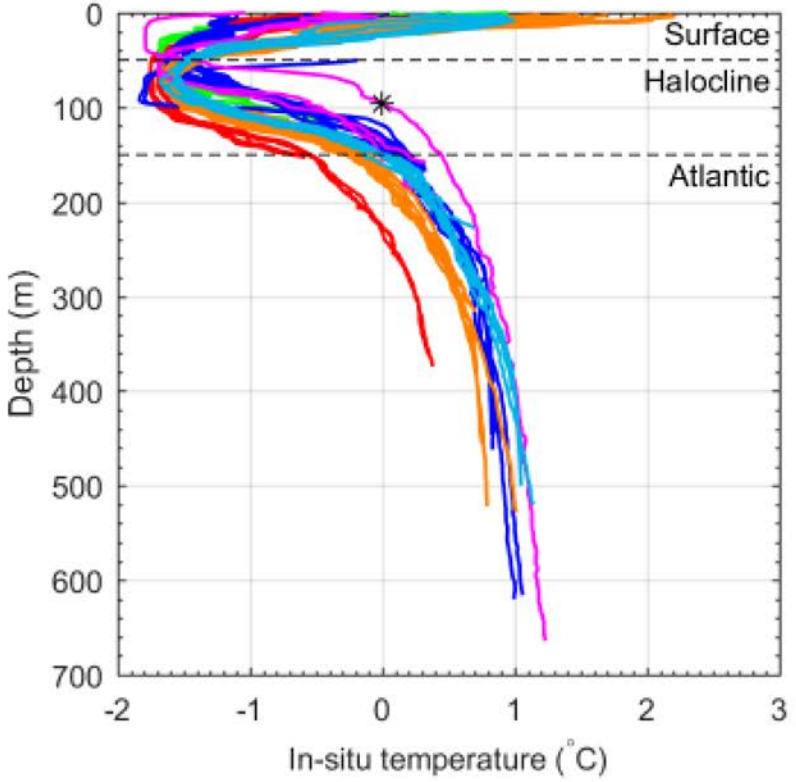
Atlantic water in Fram Strait & the Greenland Ice Sheet



- The Norske trough also shows a “spike” between 2005 and 2007”. We think the Norske trough shows more variability then the Westwind, because more re-circulating Atlantic water enters the Norske trough than the Westwind trough, due to it’s position.

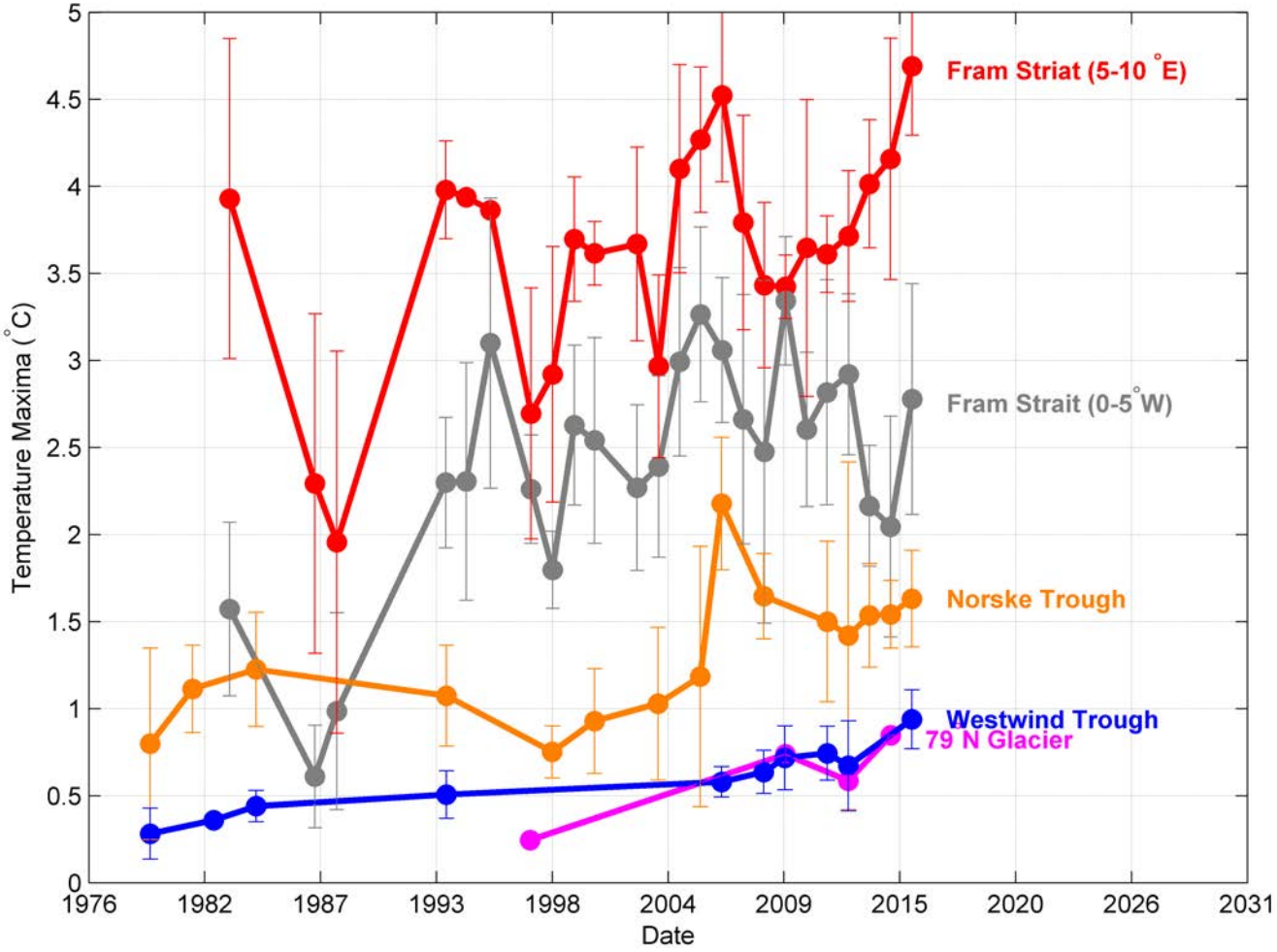
Atlantic water in Fram Strait & the Greenland Ice Sheet





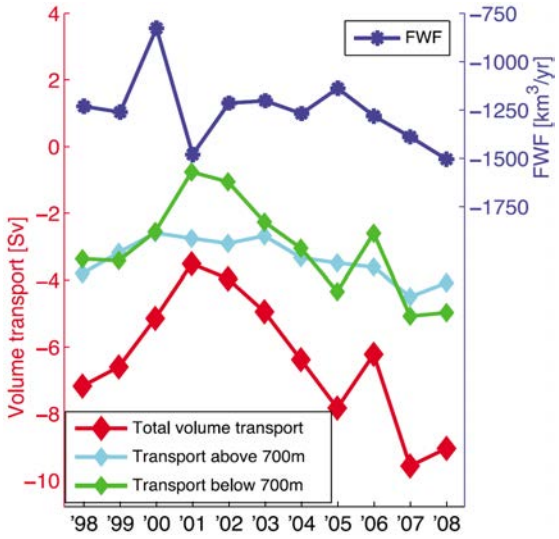
- 6 expeditions / cruises have collected CTD profiles beneth or close to the 79N Glaicer.
- Recent (2014 & 2016) profiles show Atlantic water under the ice tongue is more than 0.5C warmer than in 1997.

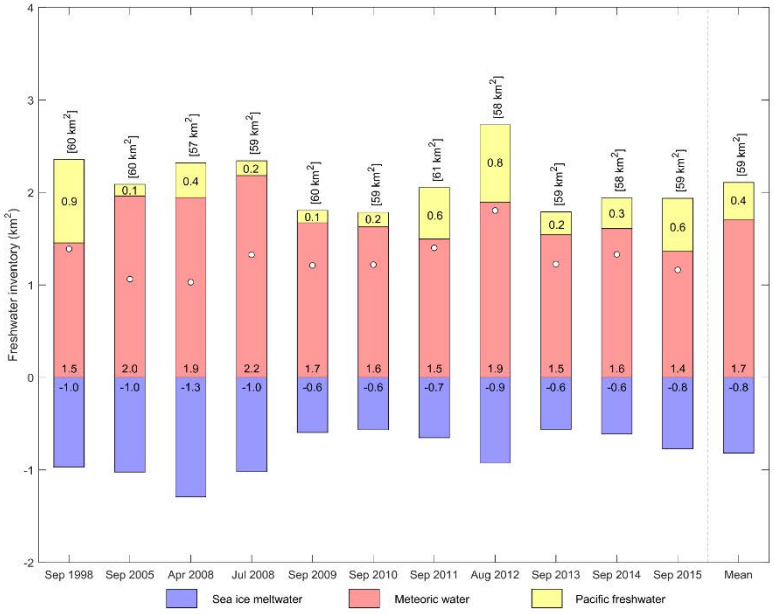
Atlantic water in Fram Strait & the Greenland Ice Sheet: Summary



- Temperature is rising beneath the 79N Glacier
- There is a pathway connecting 79N and Atlantic water in Fram Strait
- There is a correlation between temperature maxima under the glacier, in the trough system and in Fram Strait

TRIMODAL : Tracers, Models and Atmospheric Indices





- **The Fram Strait time series is dominated by inter-annual variability both in the Atlantic Inflow and Arctic Outflow.**

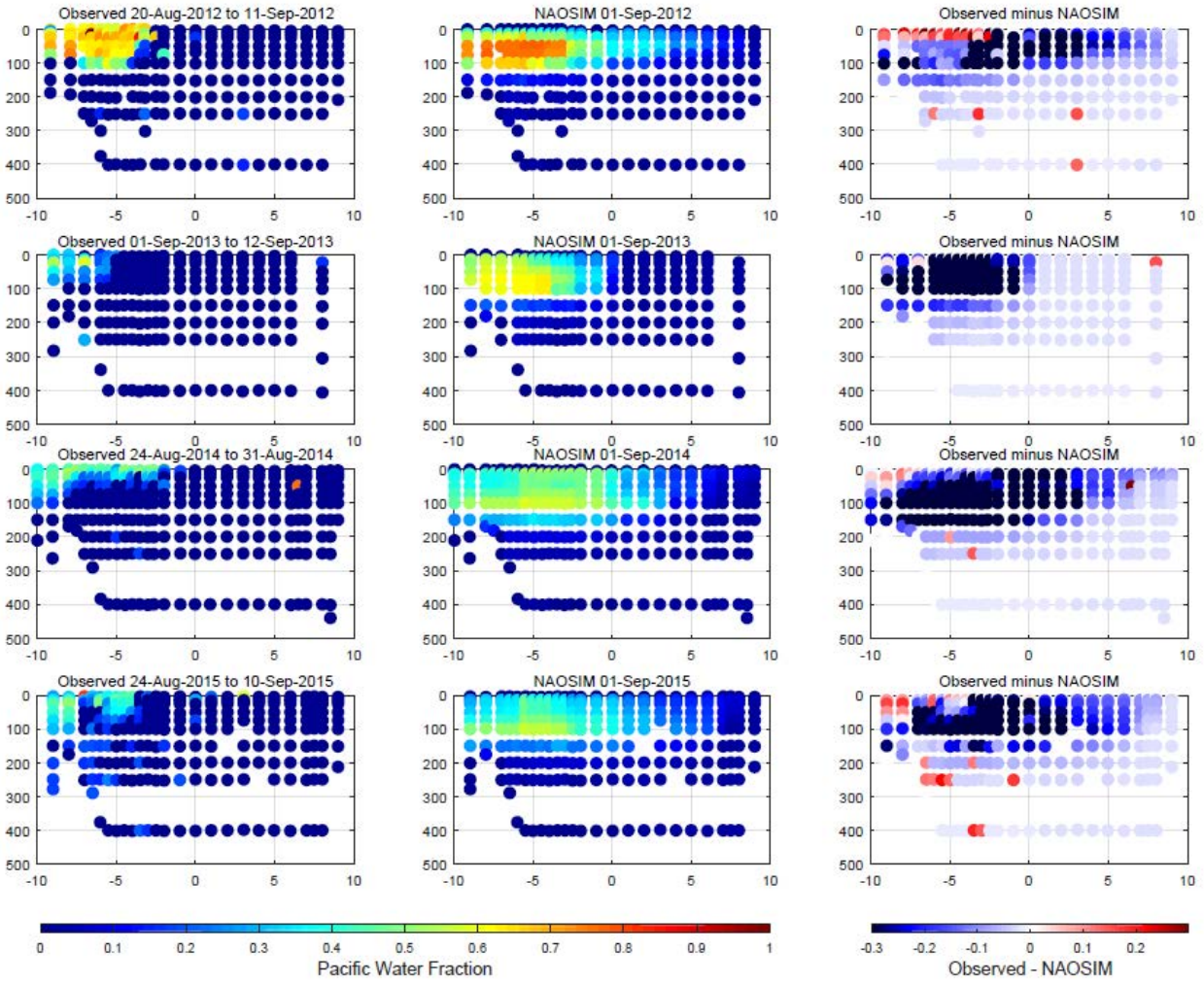
- TRIMODAL is a 2016-2019 Fram Centre project that aims to explain the drivers of variability

- Atlantic and Freshwater tracers are used to identify which freshwater masses are present in each section.

- The distribution of each watermass is compared with upstream and local atmospheric drivers (AO, AOO, wind stress curl, cross-strait pressure differences) etc.

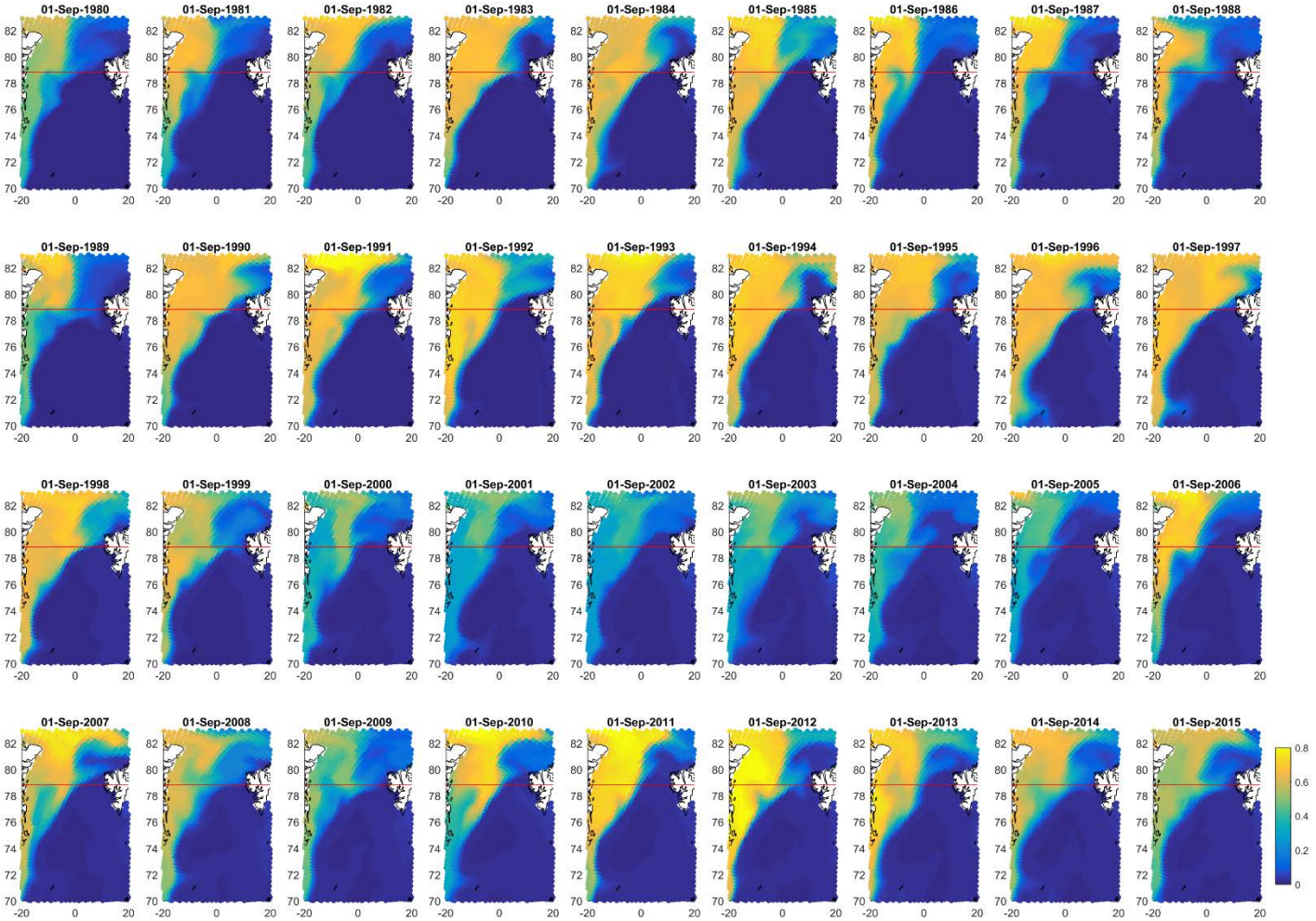
- The same investigation is done with observations and models.

TRIMODAL : Tracers, Models and Atmospheric Indices



- **Comparison of Pacific water fractions traced using nutrient ratios in observations and Pacific water fractions in the NAOSIM model estimated using a model tracer. Look promising.**

TRIMODAL : Tracers, Models and Atmospheric Indices



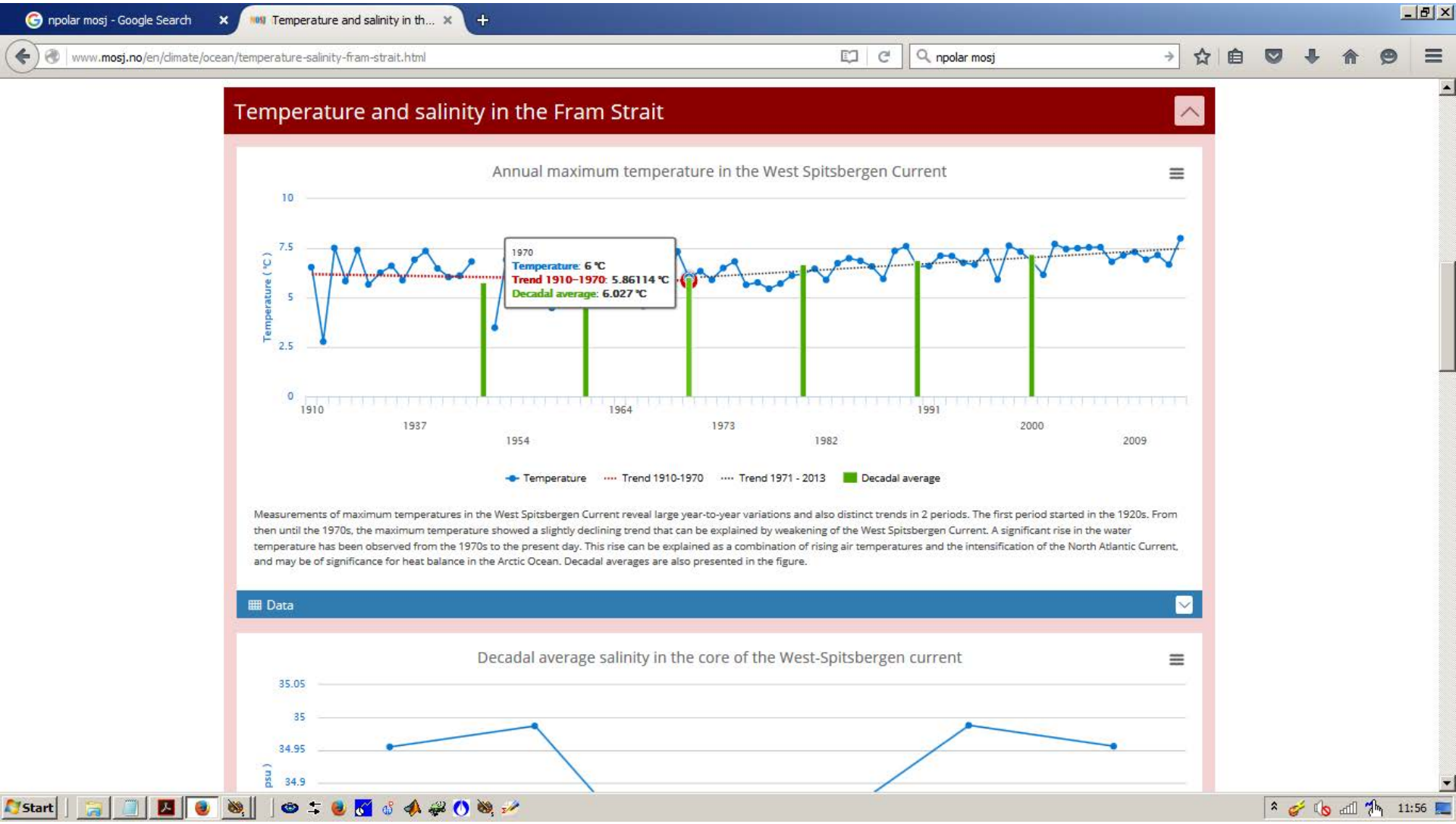
- **Model simulations of 1980 – 2015 Pacific water fractions in Fram Strait. Validated with 30+ observational sections. Next, we will investigate the route Pacific water took to reach Fram Strait in NAOSIM and compare with the atmospheric circulation.**

TRIMODAL : Tracers, Models and Atmospheric Indices

^{129}I is a radioactive isotope released from reprocessing facilities in Le Hague and Sellafield. The times when ^{129}I is released are well documented so it can be used to separate re-circulating Atlantic water in Fram Strait.

In later years TRIMODAL will compare sections of ^{129}I measurements with the 800m resolution ROMS model to investigate processes affecting recirculation in Fram Strait.

MOSJ : Miljøovervåkning Svalbard & Jan-Mayen



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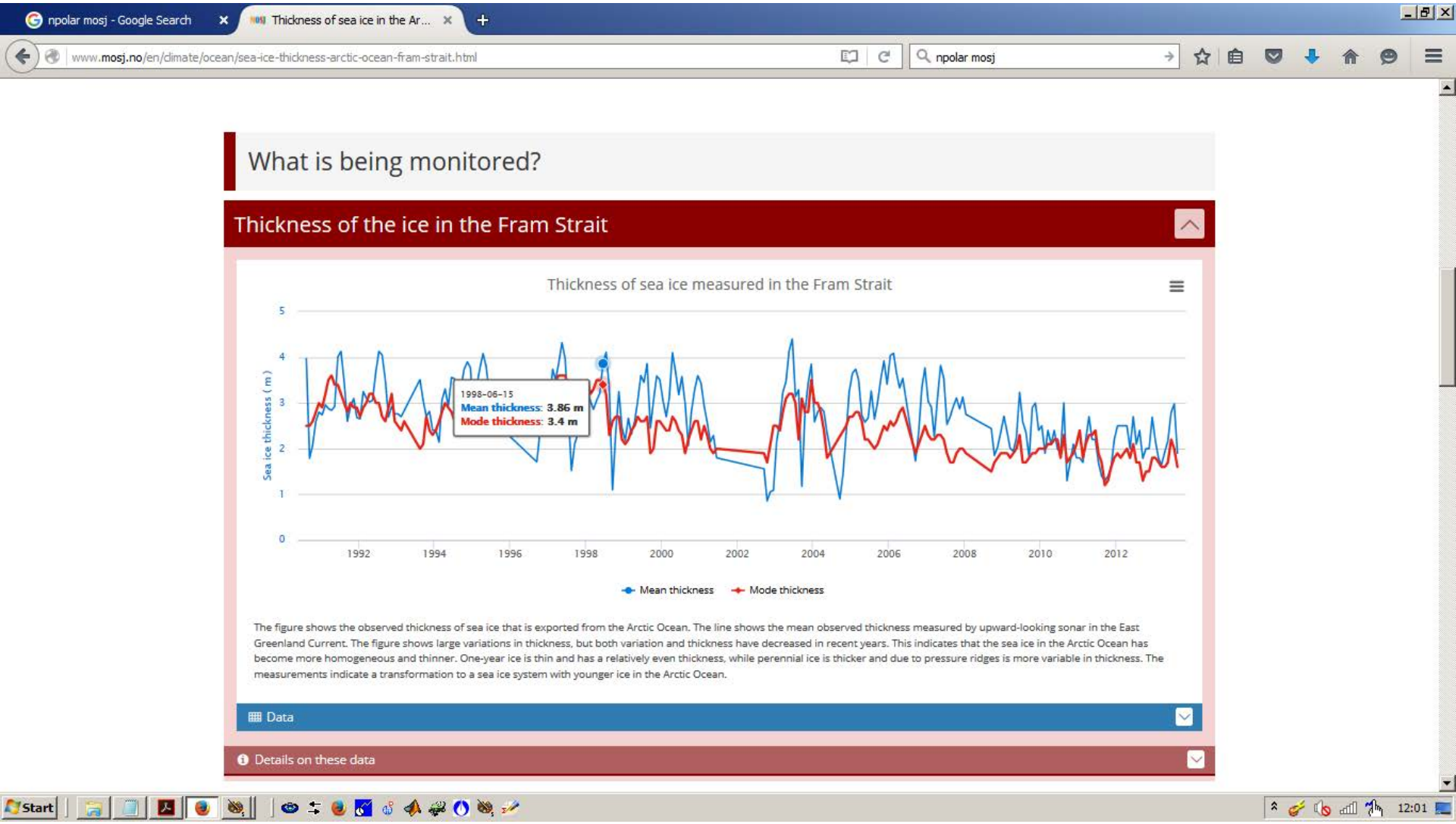

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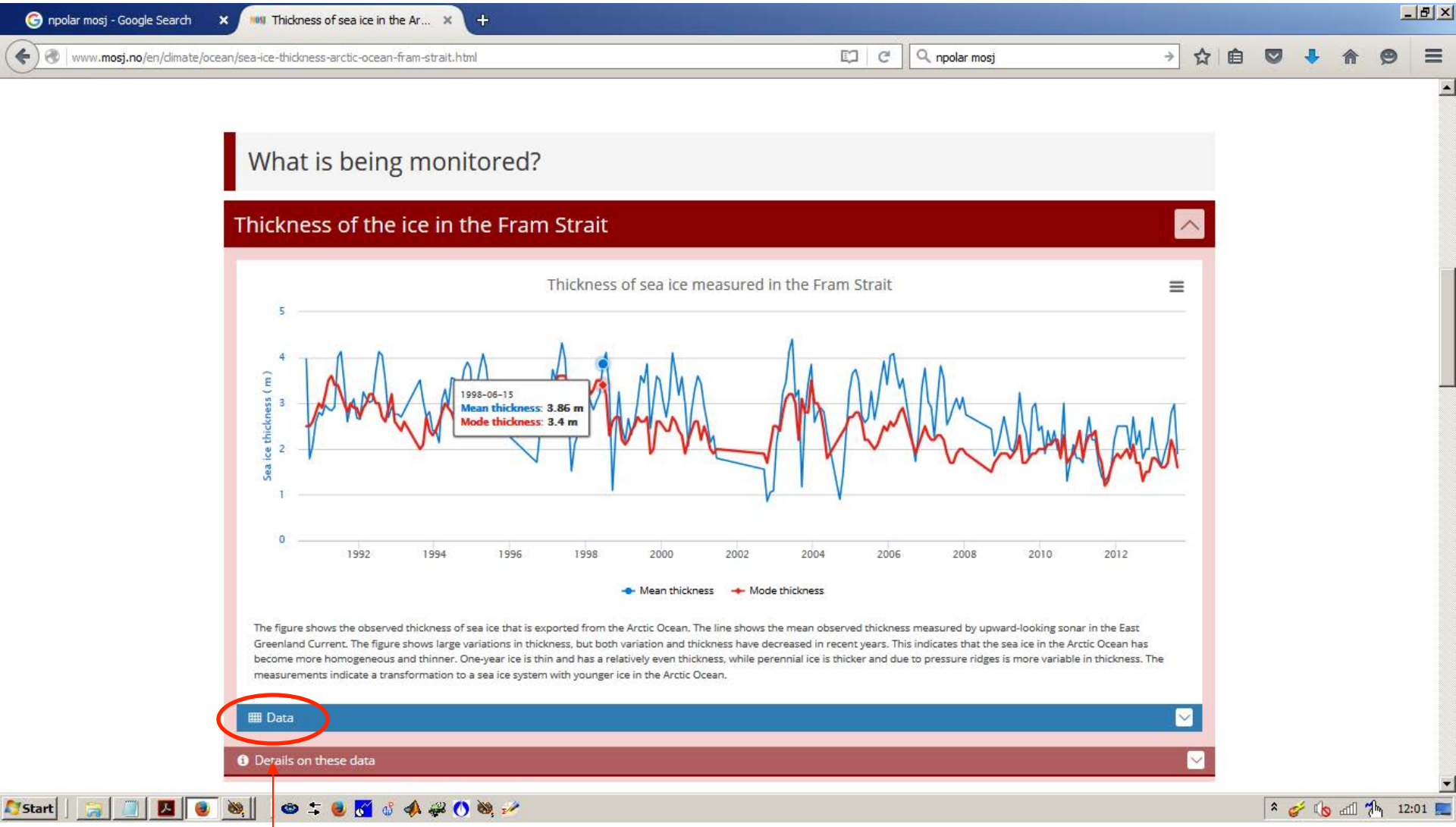

Link to Norwegian Polar Data Centre

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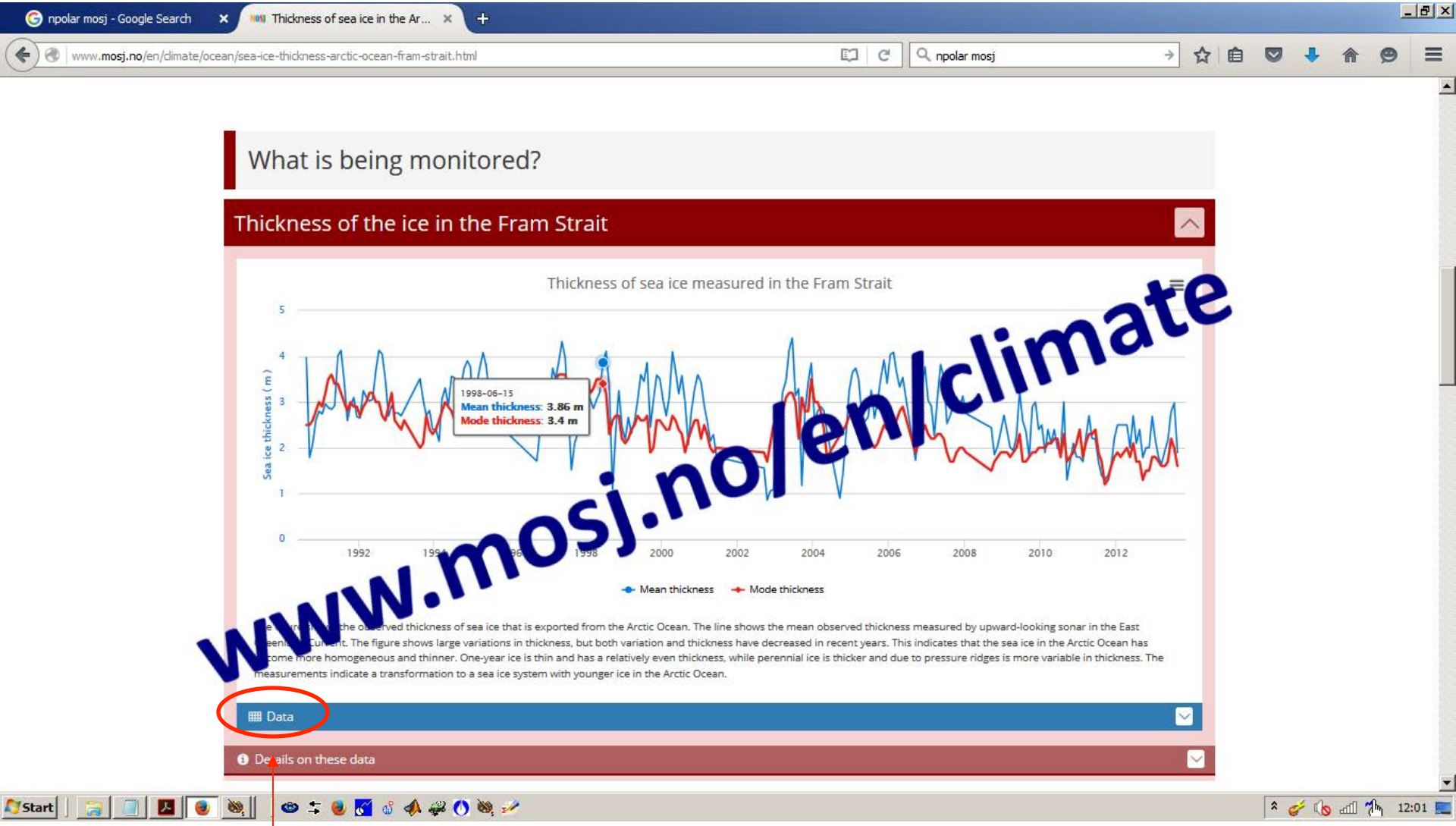


Link to Norwegian Polar Data Centre

The Fram Strait Observatory also has a web site:

The Fram Strait Arctic Outflo...

www.npolar.no/en/projects/fram-strait-arctic-outflow-observatory.html

ATWAIN npolar

Gateway to the Arctic Ocean

Fram Strait is the largest gateway to the Arctic Ocean and the only gateway allowing deep water exchange. Atlantic water flows northward in the West Spitsbergen Current while polar water and sea ice is transported southward in the East Greenland Current.

Inflowing Atlantic water is an important and variable source of heat to the Arctic Ocean; anomalies in Atlantic water temperature have been traced back far along the periphery of the Arctic Ocean and may play in important role in determining sea ice extent and thickness.

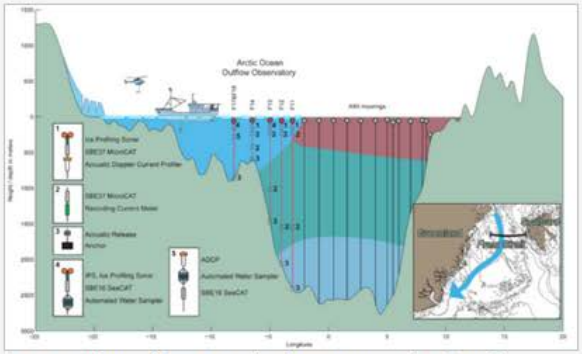
The southward flux of Arctic freshwater and sea ice is of interest as fluctuations in the volume of freshwater exported affect the density of seawater in the Nordic Seas and sub-polar North Atlantic which may modulate the Atlantic meridional overturning circulation.

Oceanography

Main contacts: Paul Dodd & Laura de Steur

An array of up to 15 moorings has been maintained in Fram Strait since the 1990s. The array is jointly operated by the Norwegian Polar Institute, which maintains moorings in the Arctic outflow in eastern Fram Strait, and the Alfred Wegener Institute, which maintains moorings in the Atlantic inflow in eastern Fram Strait.

One of the principal goals of the Norwegian Polar Institute is to monitor the freshwater flux in the East Greenland Current and over the East Greenland Shelf. Moorings in the outflow are equipped with instruments that provide a high-resolution continuous time series of temperature, salinity, velocity and sea ice thickness.



An array of up to 15 moorings has been maintained in Fram Strait since the 1990s.
Illustration: Audin Igesund / Norwegian Polar Institute

The Norwegian Polar Institute's moorings are serviced annually in August/September and at these times hydrographic and tracer measurements are collected at 30 annually repeated stations between 10° W and 10° E. Tracer measurements are used to separate

Start

11:52

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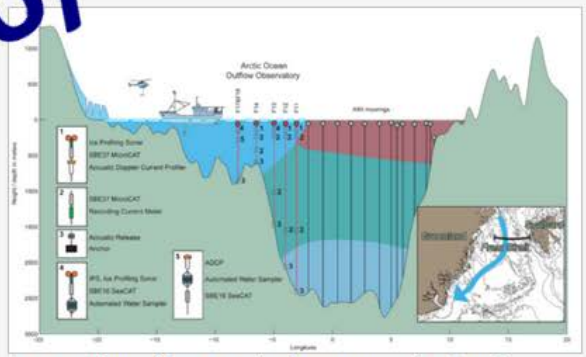

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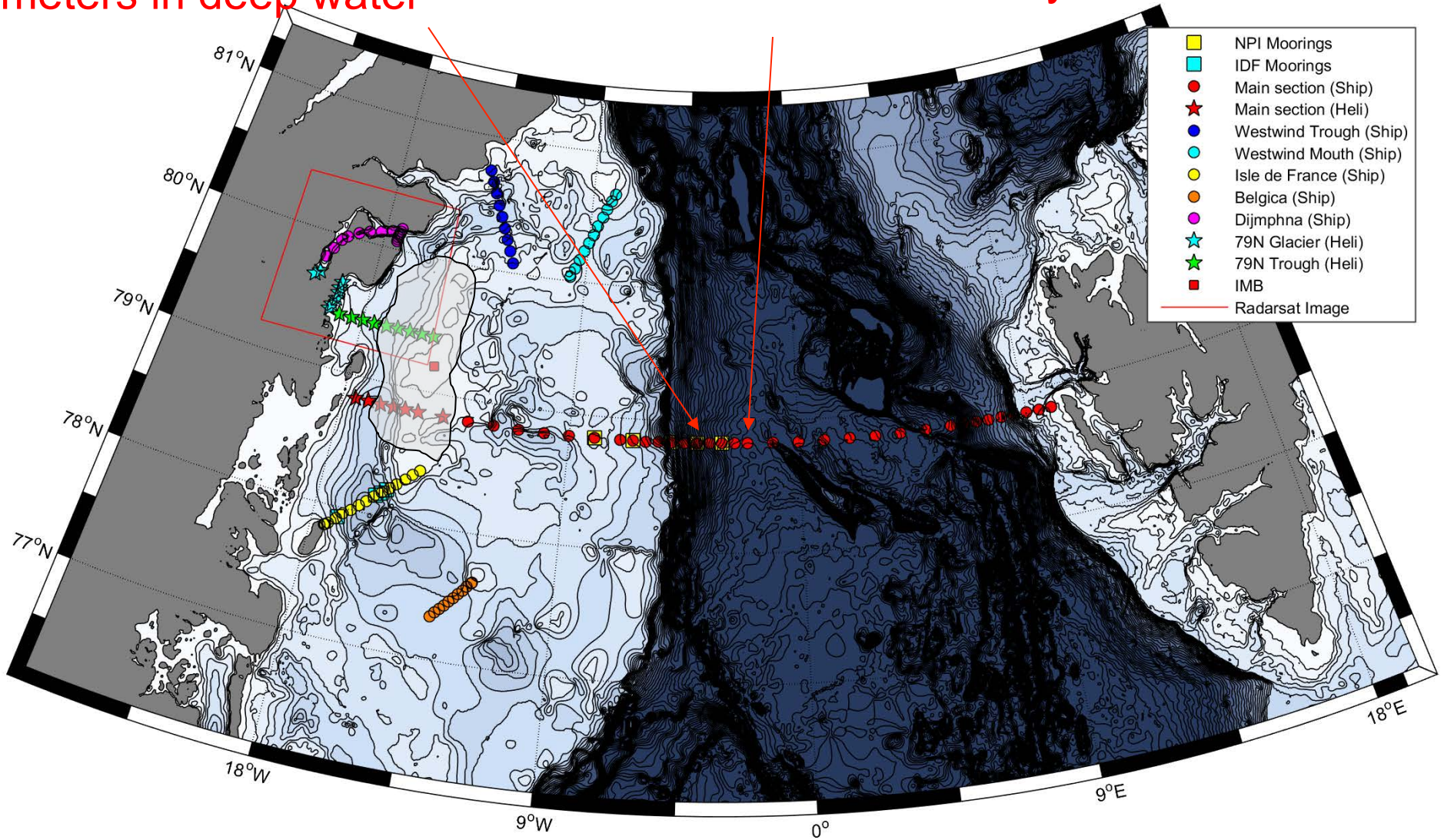
Plans for the Future?

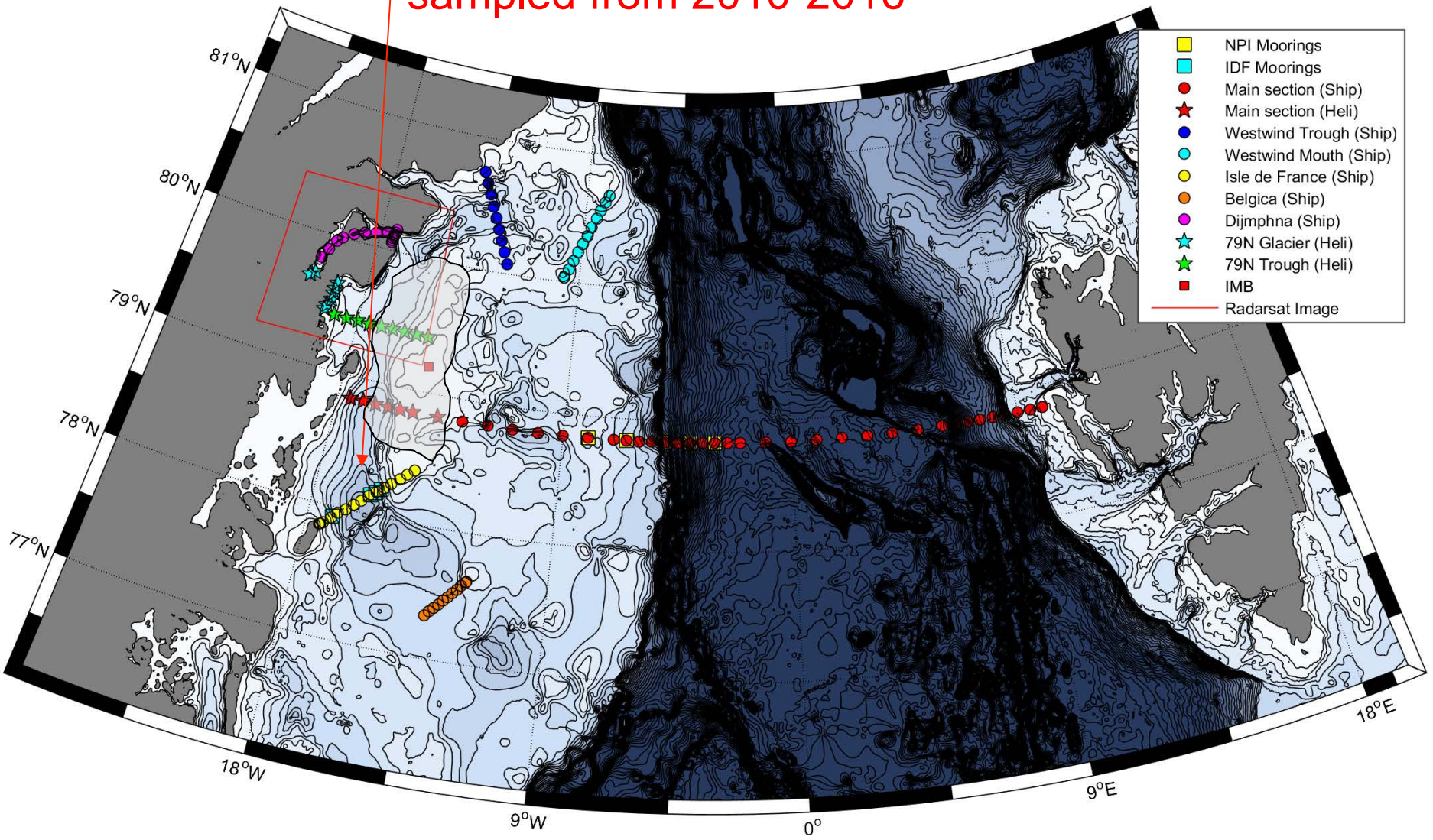
Replacement of outdated current meters in deep water

New deep water mooring at 1W as this is no longer maintained by AWI



Plans for the Future?

Continued repeats of the Isle de France section sampled from 2010-2016

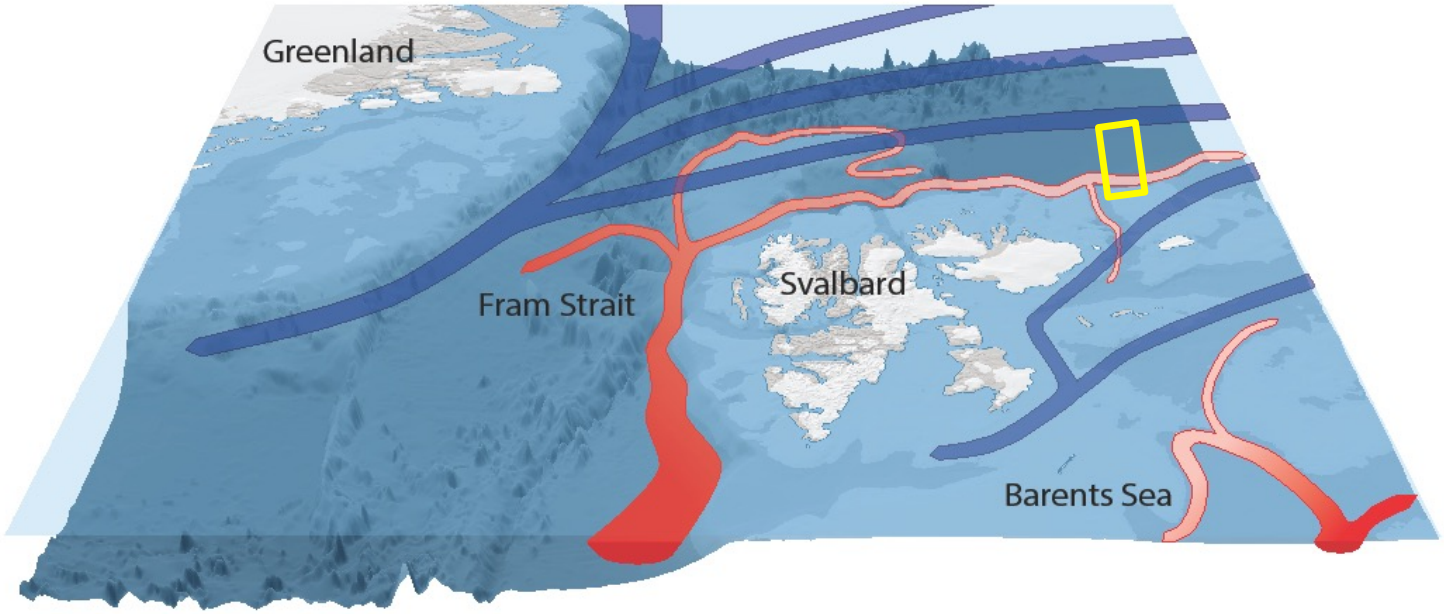


Thank you for listening!

Framsenteret

A-TWAIN

Long-term variability and trends in the Atlantic Water inflow



Partners: Norwegian Polar Institut,e Institute of Marine Res., Universty of Tromsø, UNIS, IOPAS, WHOI

Mooring deployments:
2012-2013, 2013-2015, 2015 (-2017)
Extensive cruise sampling in

New collaborations/projects:
SAMS/NERC ArcticPrize
NABOS – joint analysis, exhange of personell
AWI – joint analysis