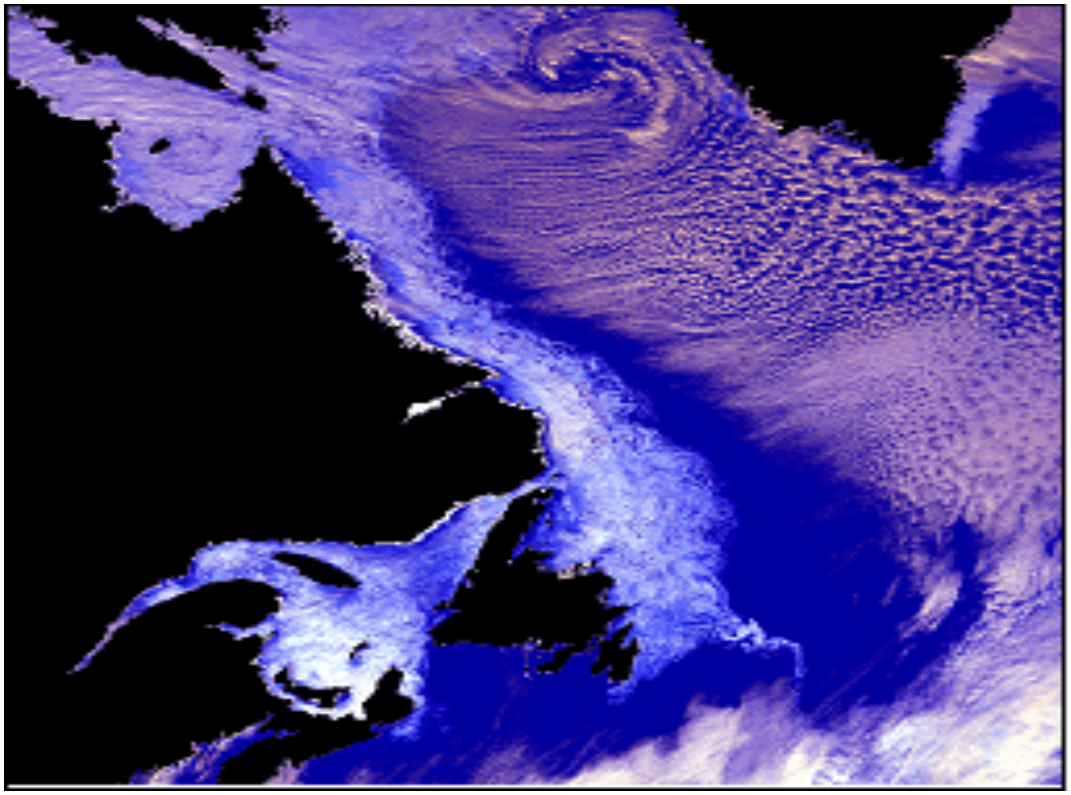
http://knossos.eas.ualberta.ca/vitals/

VITALS

Ventilation, Interactions and Transports Across the Labrador Sea



SSC: Paul Myers - Alberta
Brad deYoung - Memorial
Roberta Hamme - Victoria
Jaime Palter - McGill
Jean-Eric Tremblay - Laval
Doug Wallace - Dalhousie

NSERC CRSNG

VITALS Over-Arching Research Goal

To understand and model the functioning and vulnerability of the Labrador Sea as a key component of the Earth's climate system, including its uptake of oxygen, carbon, and heat exchange with the atmosphere.

Working Hypothesis

- Deep convection in the Labrador Sea, which allows for exchange of oxygen and natural and anthropogenic carbon to the deep ocean, is sensitive to the warming that is taking place at high latitudes.
  - Validating and quantifying this sensitivity is central to our research network and also the broader community of climate change researchers and policy makers interested in characterizing, and possibly minimizing, the effects of global climate change

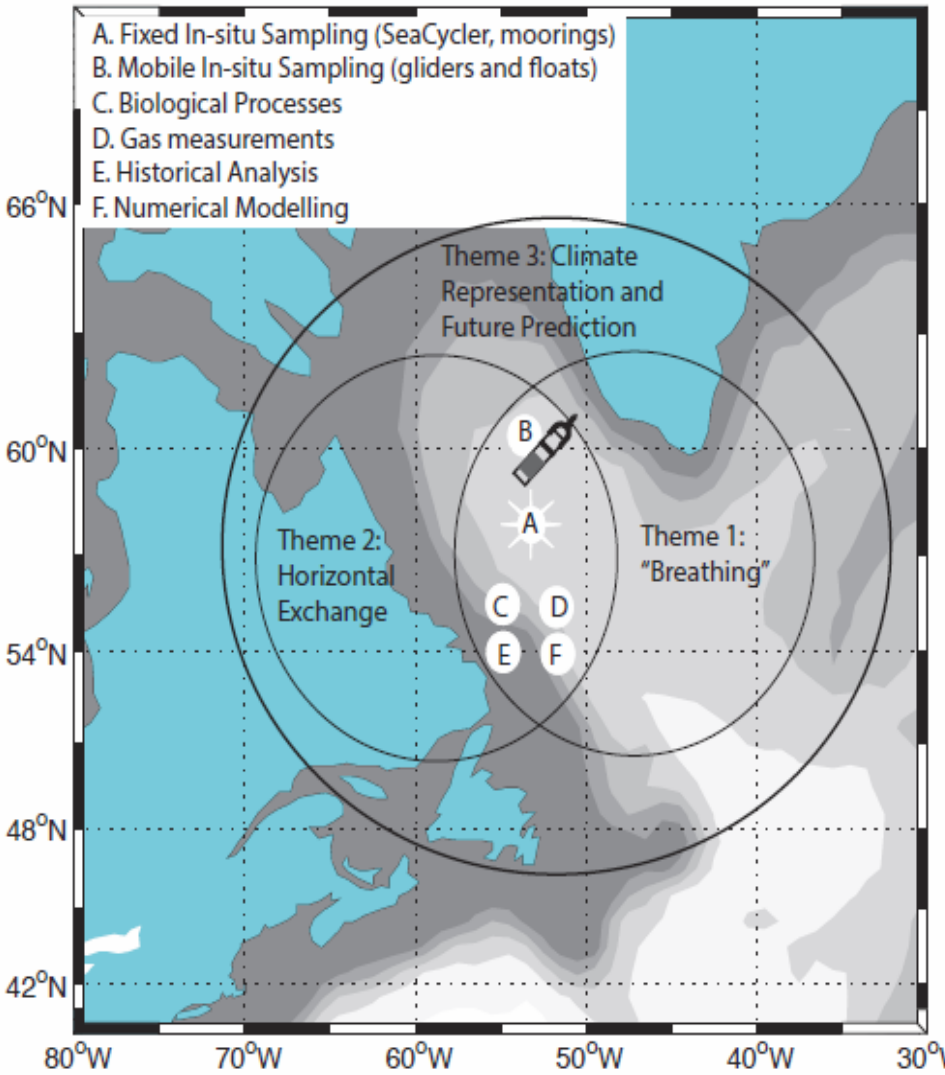
VITALS is a Pan-Canadian Initiative

Three Scientific Themes

Theme 1, "Breathing" How does the Labrador Sea take inputs from the Atlantic and a melting Arctic, modify them via atmospheric exchange and local physical and biogeochemical processes to influence the export products?

Theme 2, Horizontal Exchange: How does lateral boundary/interior exchange, especially of freshwater, control and potentially limit the exchange of gases between the atmosphere and ocean?

Theme 3, Climate Representation and Future Evolution: How can we improve the ability of high-resolution numerical models to represent these exchange processes and their sensitivity to climate change?

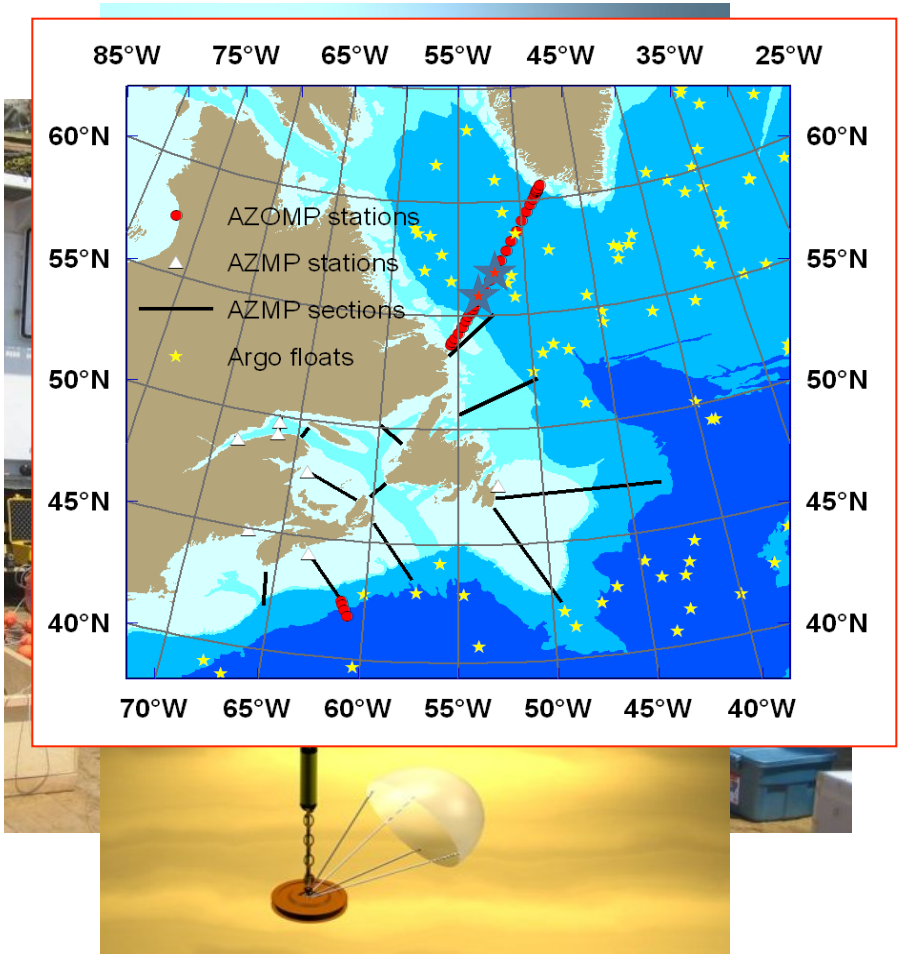


Group I: Fixed in-situ Sampling

Doug Wallace, Brad de Young, Roberta Hamme, Jody Klymak, Barry Ruddick,
Partners: Uwe Send (Scripps), Igor Yashayaev (DFO), Arne Körtzinger,
Johannes Karstensen, Martin Visbeck (GEOMAR), Rolls-Royce Canada

- Determine the annual cycle of O_2, CO_2 and relevant physical parameters in the Labrador Sea with two key mooring deployments (K1 and V1) and mobile platforms

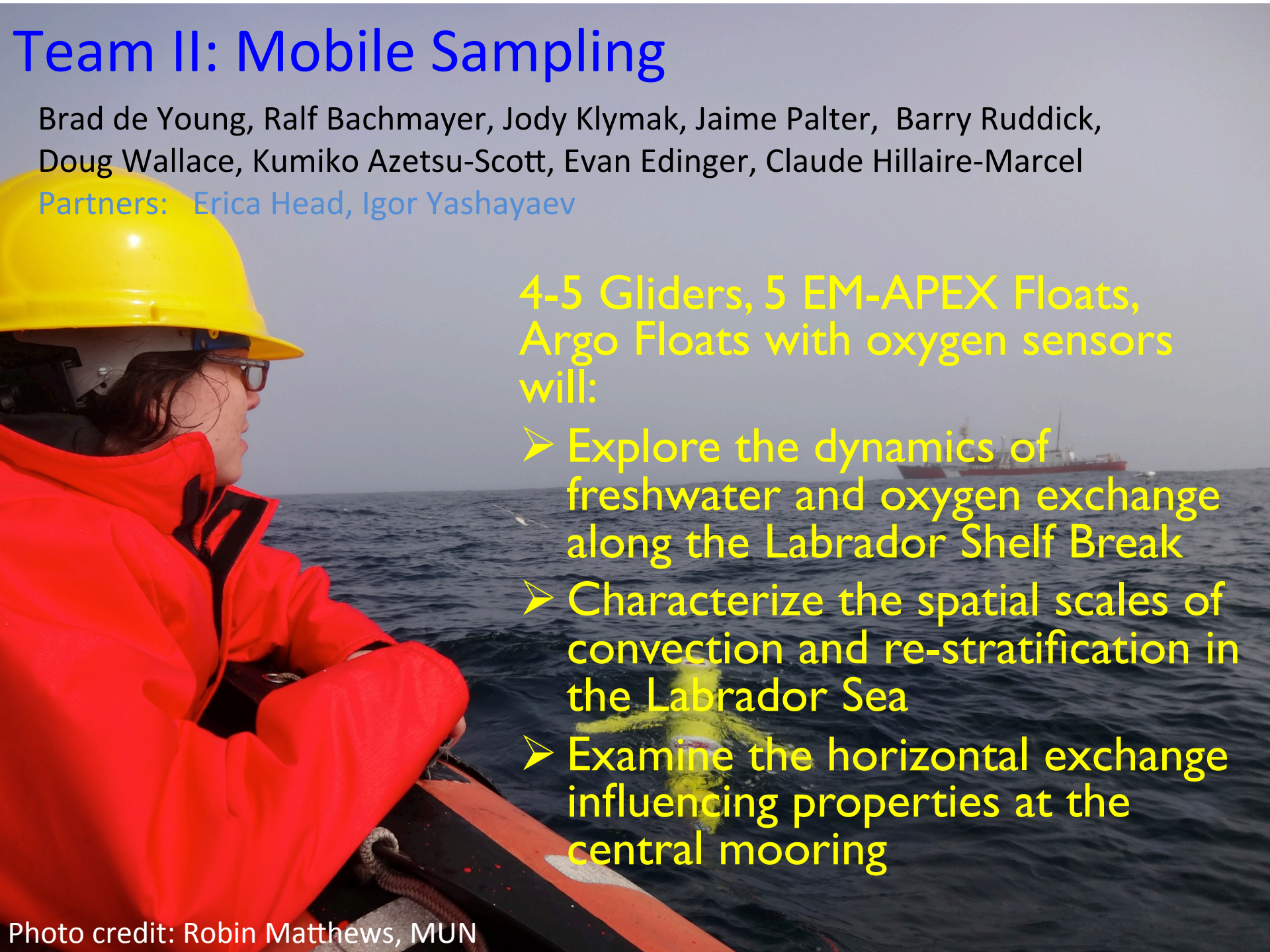
- Relate the temporal and vertical changes of O_2 and CO_2 to key controls, including air-sea gas exchange, mixing dynamics (lateral and vertical), restratification, and biological production/consumption



Team II: Mobile Sampling

Brad de Young, Ralf Bachmayer, Jody Klymak, Jaime Palter, Barry Ruddick, Doug Wallace, Kumiko Azetsu-Scott, Evan Edinger, Claude Hillaire-Marcel

Partners: Erica Head, Igor Yashayaev

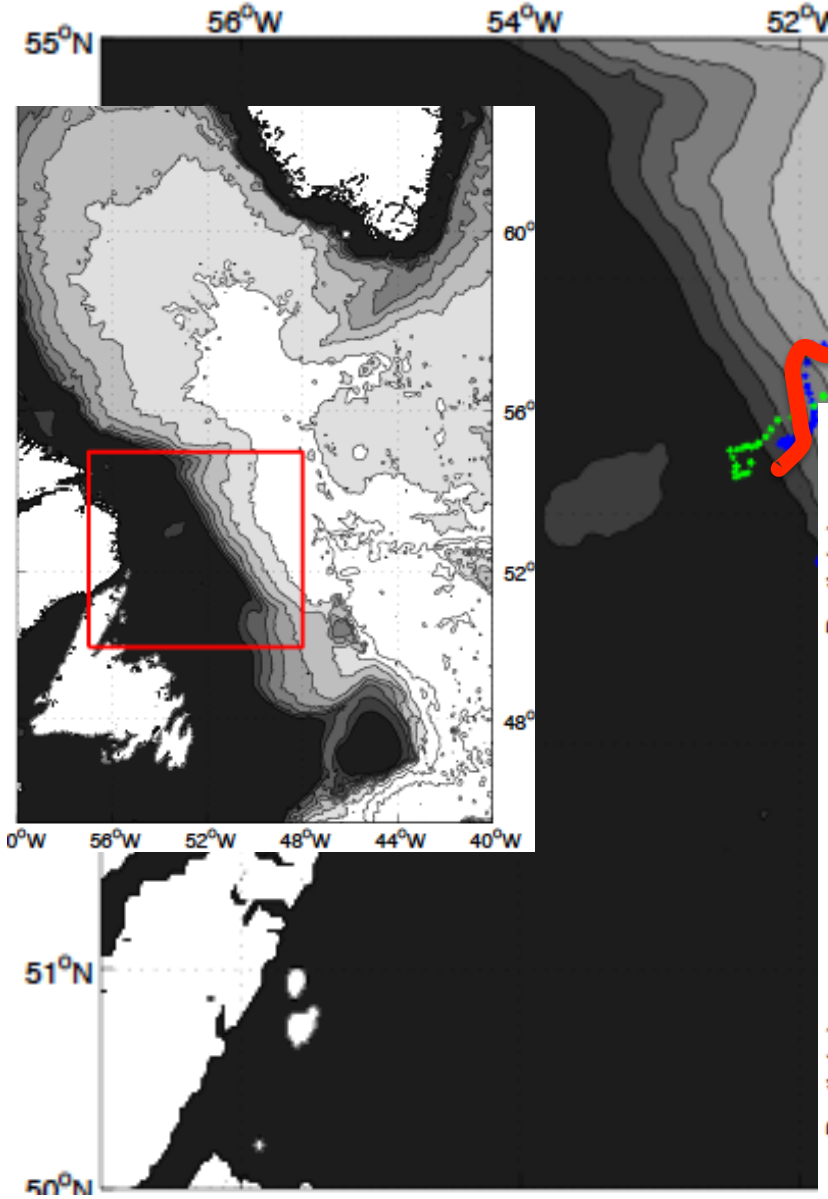


4-5 Gliders, 5 EM-APEX Floats, Argo Floats with oxygen sensors will:

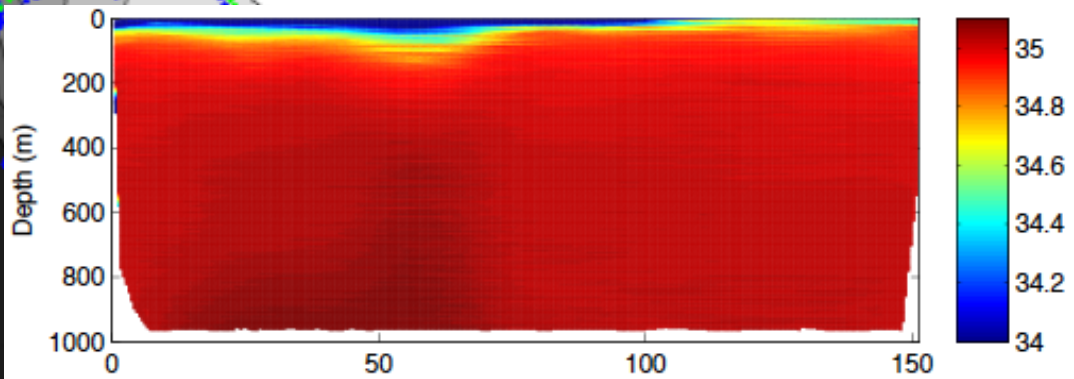
- Explore the dynamics of freshwater and oxygen exchange along the Labrador Shelf Break
- Characterize the spatial scales of convection and re-stratification in the Labrador Sea
- Examine the horizontal exchange influencing properties at the central mooring

Photo credit: Robin Matthews, MUN

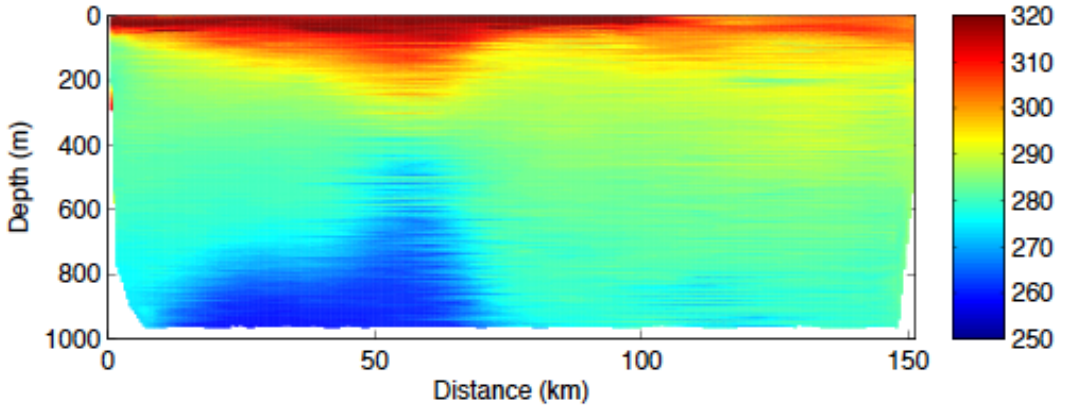
Summer 2014: Labrador Shelf Break survey



Salinity (ppt)



Oxygen (μmol kg^{-1})



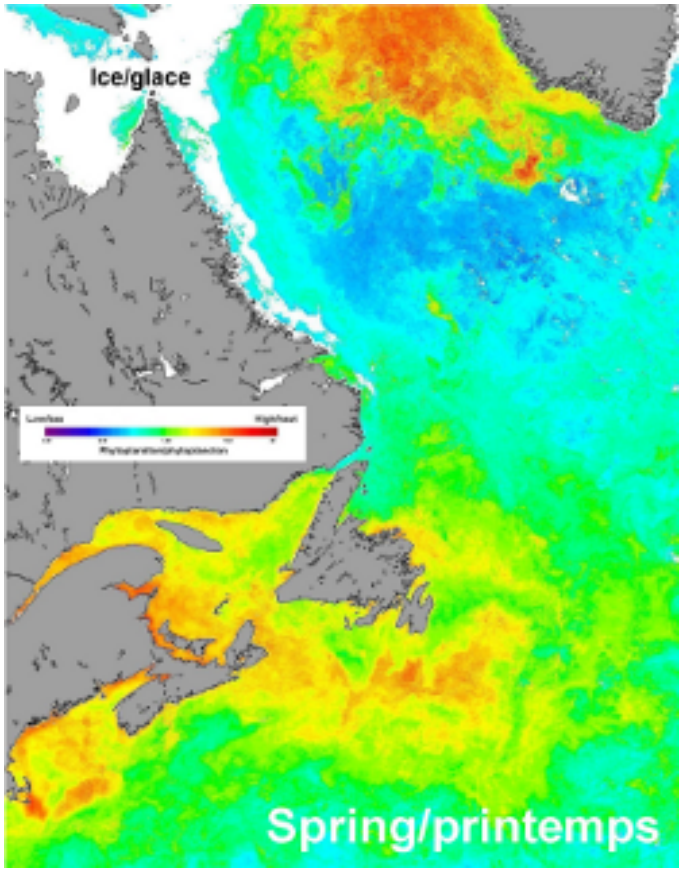
Team III: Biological Processes

Jean-Eric Tremblay, Roxane Maranger, Marcel Babin, Simon Bélanger (UQAR)
Kumiko Azetsu-Scott Partners: Nicolas Cassar (Duke), Julie Granger (U. Connecticut), Maurice Levasseur, Connie Lovejoy (Laval) Bill Li, Erica Head, Igor Yashayev, Jeff Anning (DFO)

- Determine how climate-sensitive physical processes (e.g. warming, convection and restratification) affect rates of primary production, respiration and nitrogen cycling across the Labrador Sea

- Provide direct rate measurements of major biological processes affecting O_2, CO_2, and N_2O flux in the Labrador Sea, integrating remote sensing with ship-based measurements

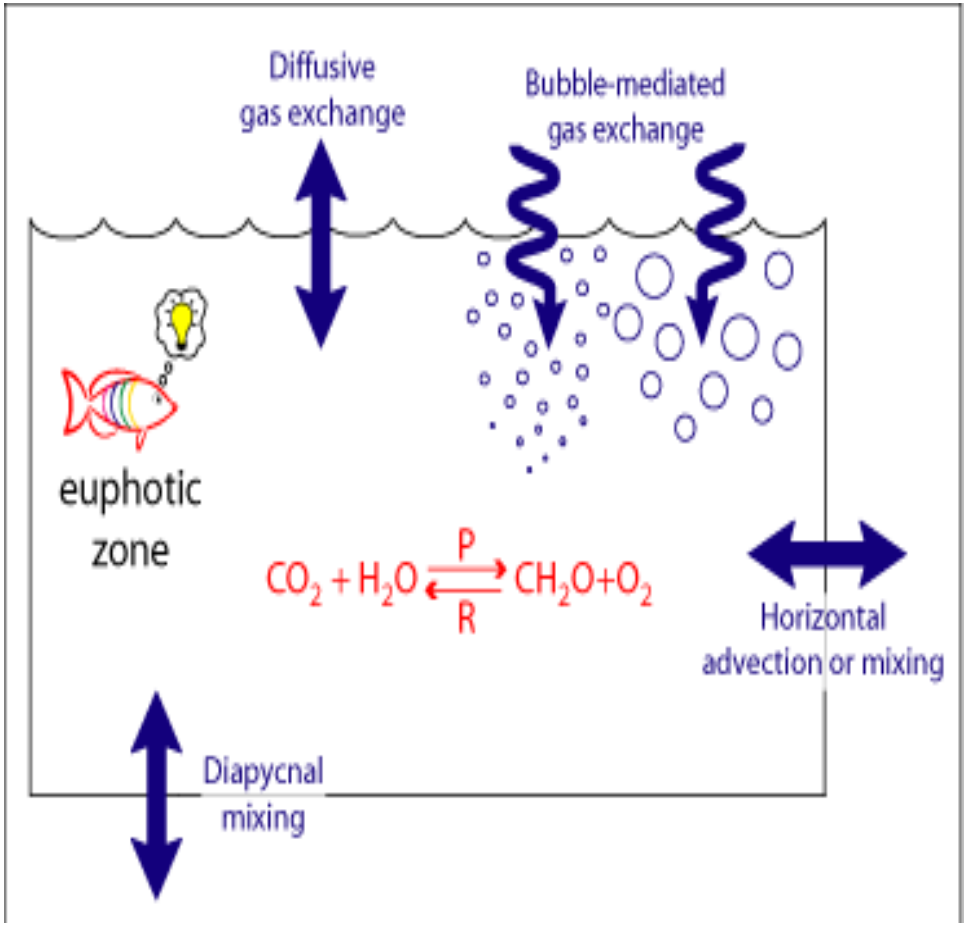
- Better understand interactions between the biological and solubility pumps



Team IV: Gases

Roberta Hamme, Doug Wallace, Kumiko Azetsu-Scott, Roxane Maranger Partner: Denis Gilbert (DFO)

- Determine how competing processes control the carbon and oxygen budgets of newly formed deep-water
- Characterize the concentrations and air-sea fluxes of key greenhouse gases
- Measure dissolved gas and calibrate autonomous sensors
- Develop process models to simulate the influence of convection and restratification on gas exchange

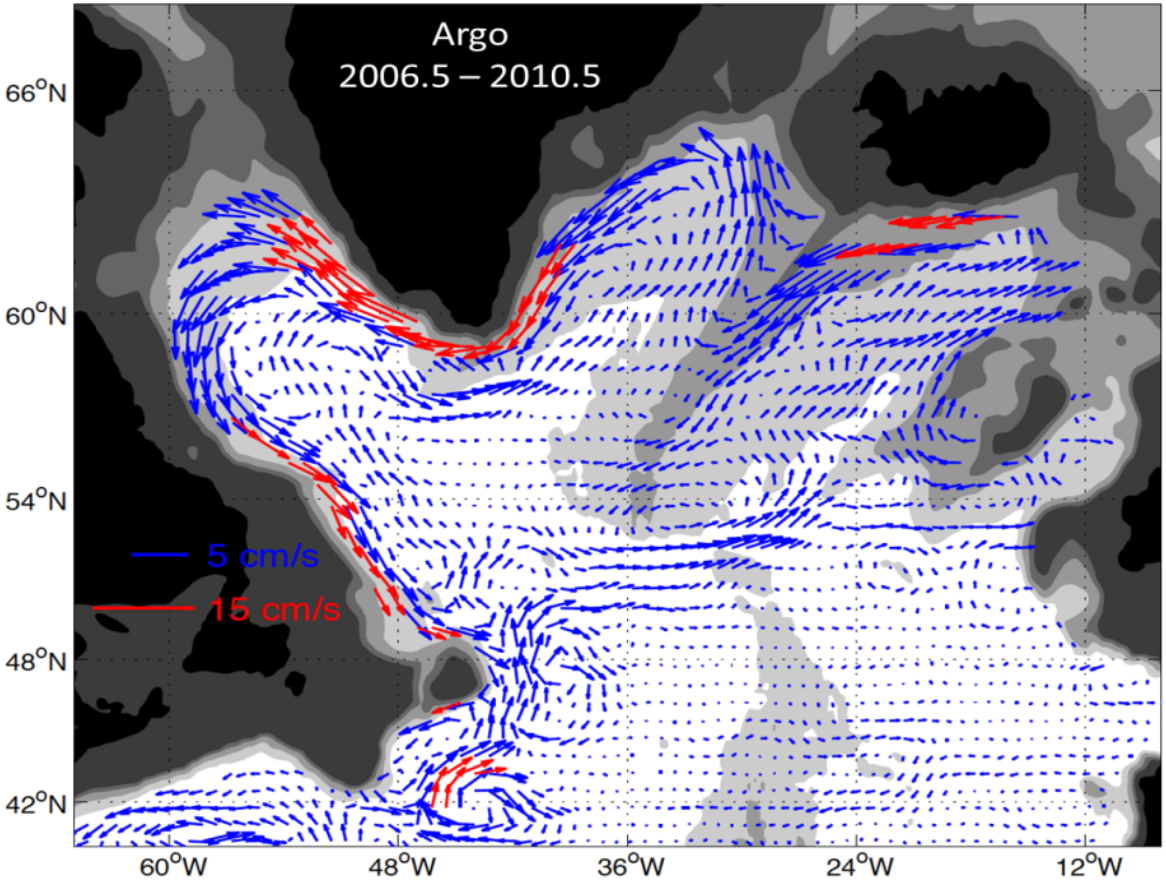


Team V: Historical Analysis

Jaime Palter, Markus Kienast, Barry Ruddick, Jean-Eric Tremblay, Anne de Vernal, Claude-Hillaire-Marcel, Evan Edinger, Roger Francois, Paul Myers

Partner: Igor Yashayaev (DFO)

- Explore existing data to understand historical trends and variability, providing a context for new observations
- Compare results with numerical simulations to validate physical and biogeochemical models
- Determine decadal to centennial variability in water mass properties (and oxygen availability) from proxy-records in corals and sediments

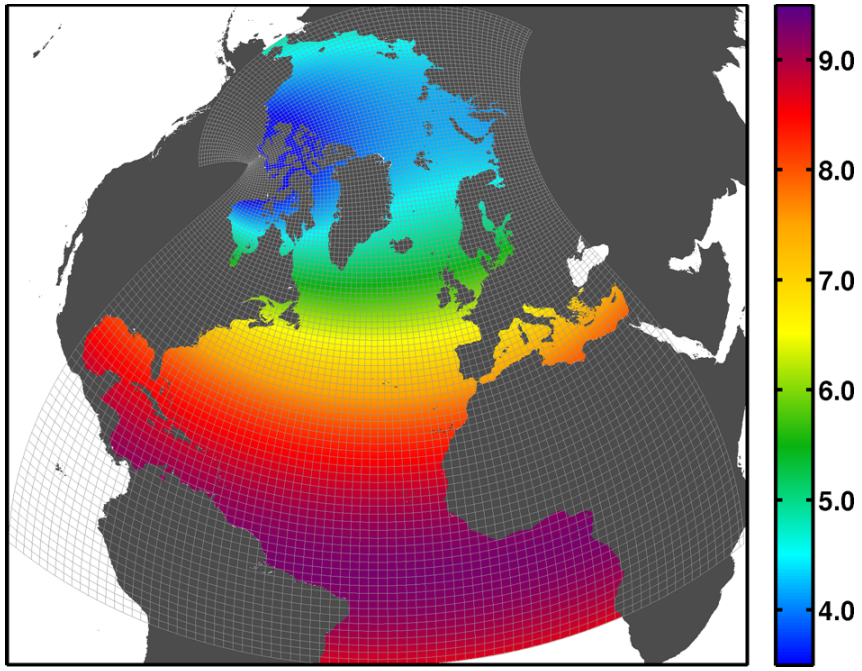


Directly observed mid-depth velocity field

Team VI: Numerical Modelling

Paul Myers, Entcho Demirov, Brad de Young, Morris Flynn, Bruce Sutherland, Eric Galbraith, Jaime Palter, Andrea Scott Partners: Fraser Davidson, Youyu Lu (DFO), Greg Smith (EC)

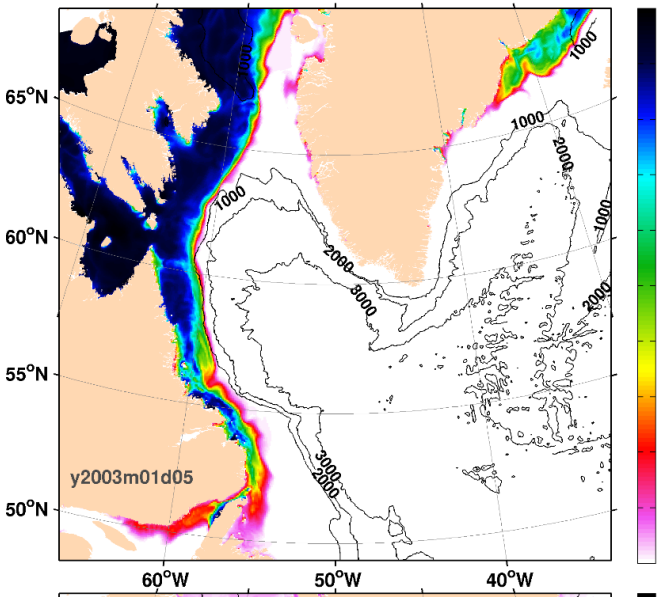
- Use high-resolution numerical models to represent gas cycles sensitive to climate change
- Determine the climate sensitivity of gas exchange, convection, re-stratification, and biogeochemical processes studied through the observational program
- Explore parameterizing key results so that they can be represented in coarser resolution coupled climate models.

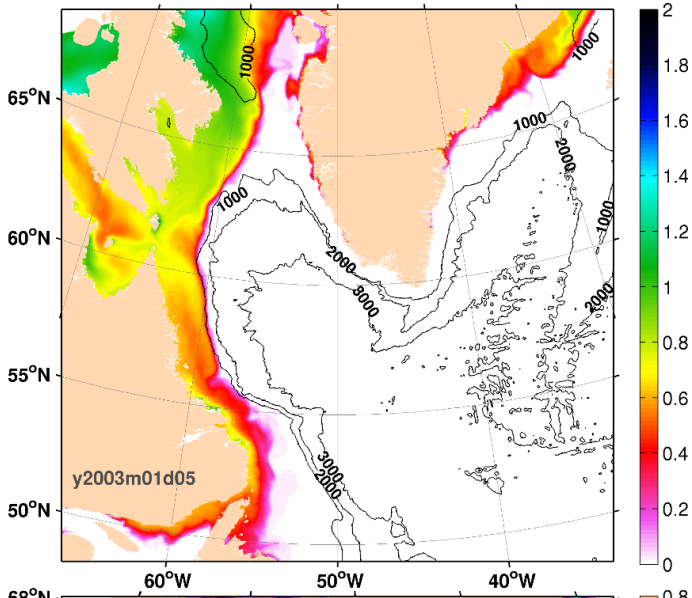


Strongly eddying: 1/12 degree NEMO
Weakly eddying: ¼ degree NEMO
Observing System Simulation Experiment(s) and Data Assimilation
Biogeochemical: BLING
Filling Box Models:
NS alpha-model:

Labrador Sea in ANHA12

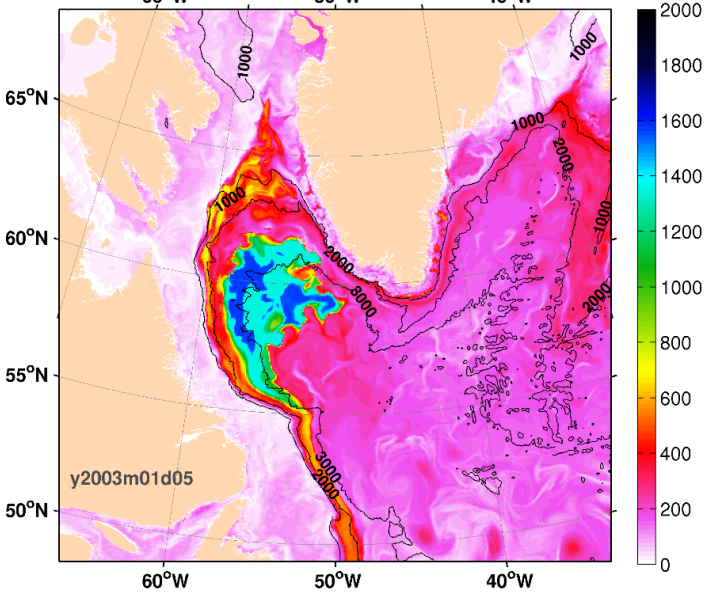
Sea Ice Concen-tration

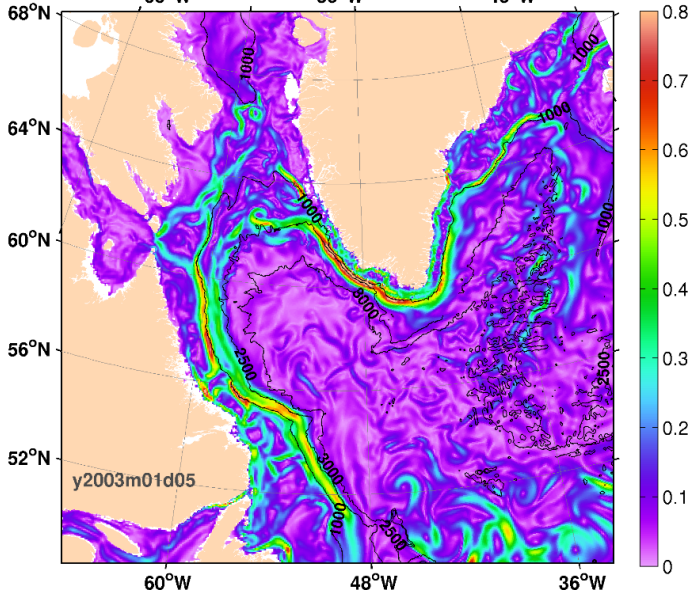




Sea Ice Thickness

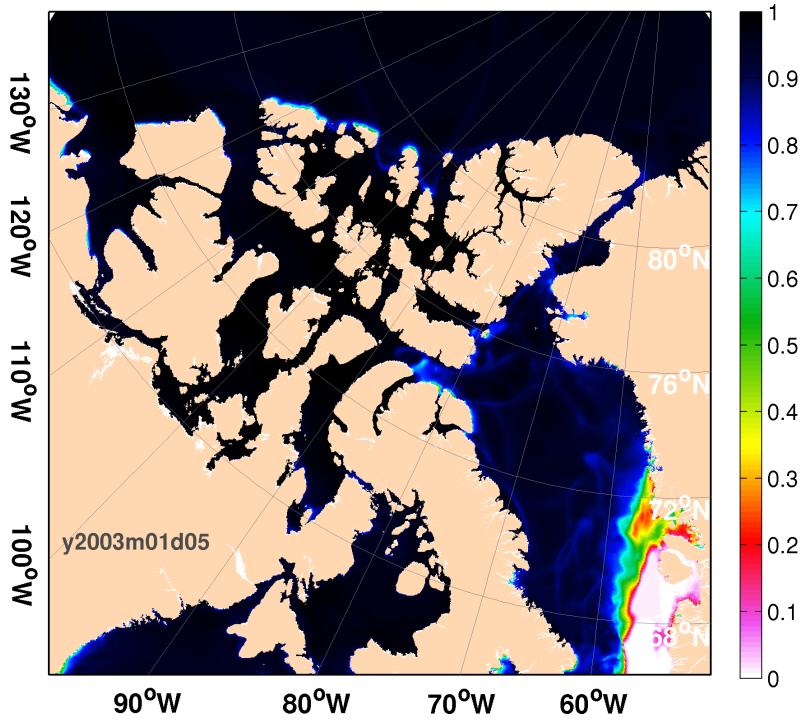
Mixed Layer Depth



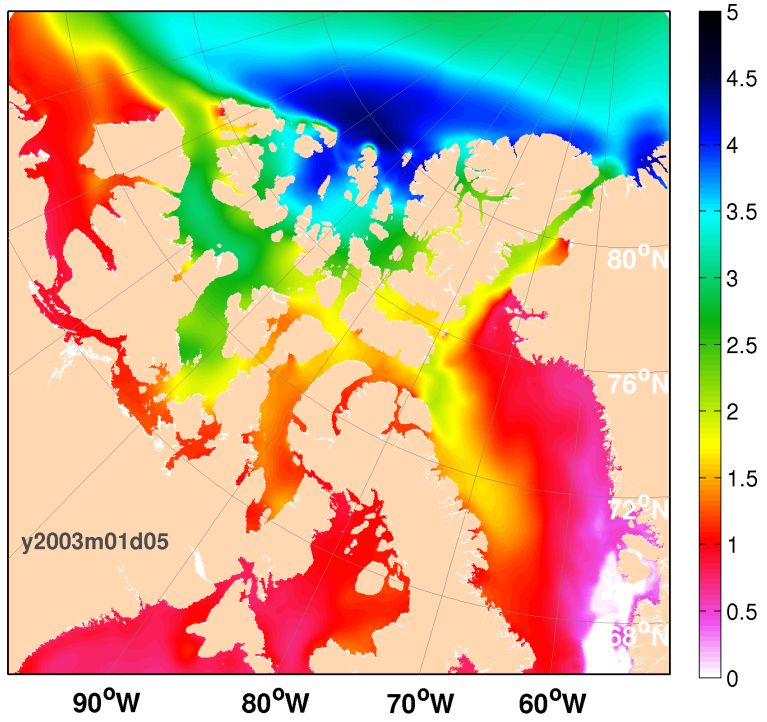


Velocity magnitude averaged over top 55 m

CAA in ANHA12



Sea Ice
Concentration

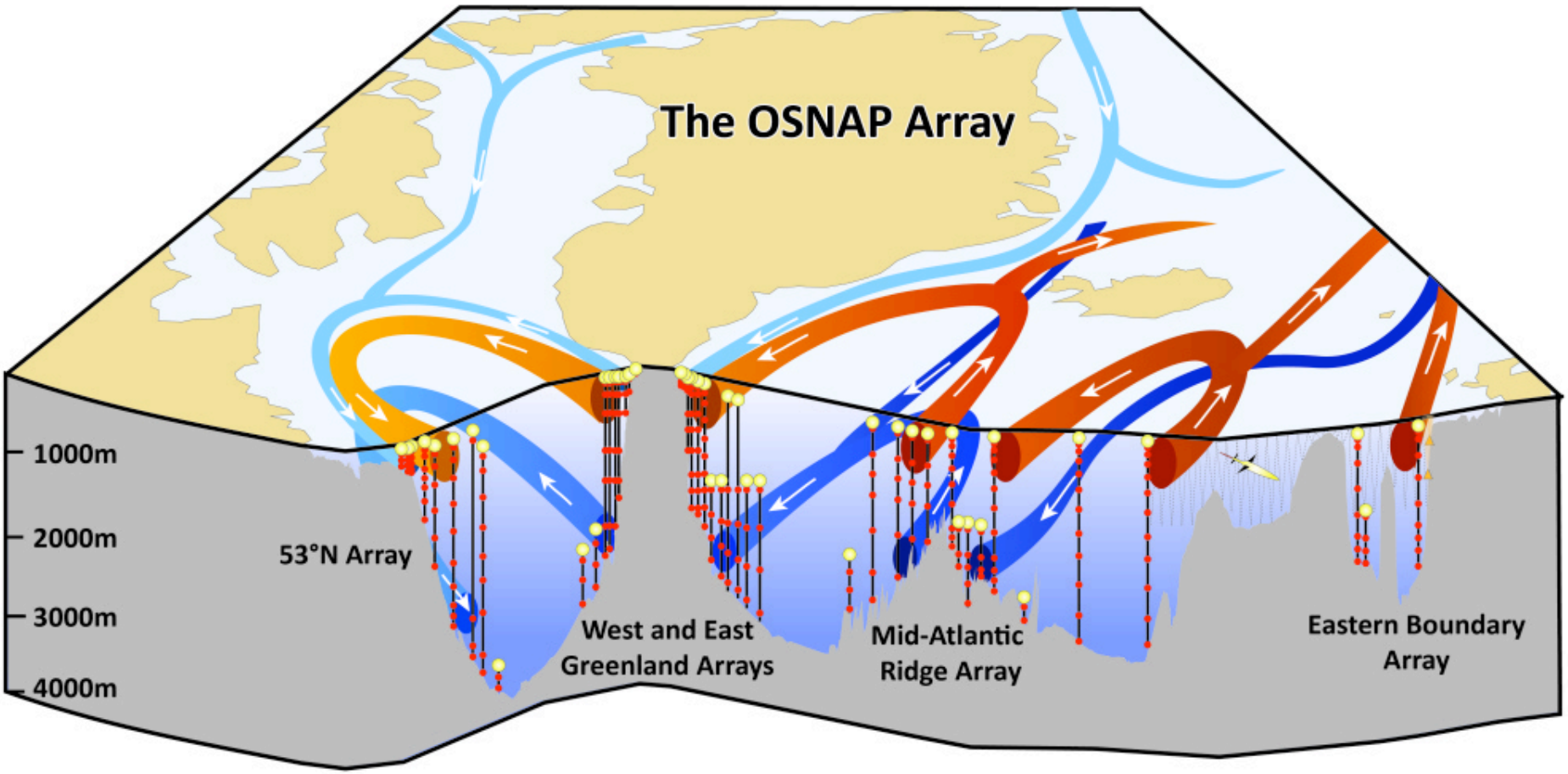


Sea Ice
Thickness

Summary

- VITALS seeks a mechanistic understanding of carbon & oxygen cycles in a region of global importance on Canada's doorstep
- Our hierarchy of modelling approaches will significantly improve our understanding of the Labrador Sea and its role in climate
- New observations will shed light on the evolution of the physical and biogeochemical properties for two annual cycles
- Novel observational strategies, including data mining of three decades of historical and proxy data, will lead to a greater understanding of processes that are highly variable in space and time.
- VITALS synergistically partners with and builds upon existing long-term DFO Labrador Sea programs to provide a detailed understanding of processes for use by DFO in management decisions
- The central mooring uses unique Canadian technology and Canadian physical/biogeochemical sensors to provide a high-visibility showcase of advanced ocean technology and allow for technology transfer to Canadian companies

OSNAP

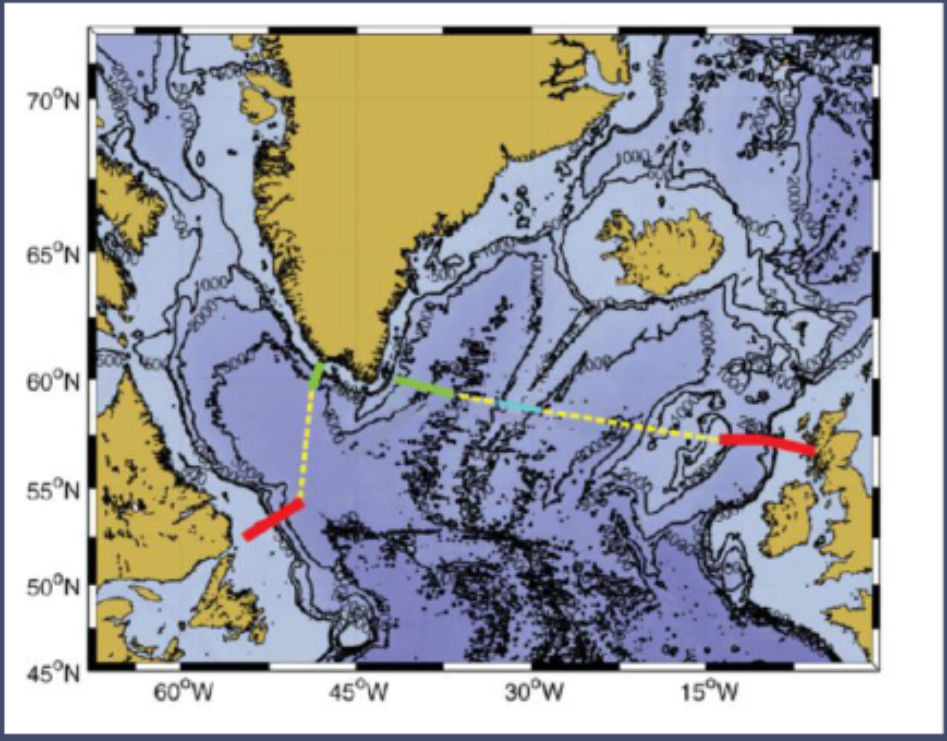

The OSNAP Array
1000m
2000m
3000m
4000m
53°N Array
West and East
Greenland Arrays
Mid-Atlantic
Ridge Array
Eastern Boundary
Array

OSNAP goals:

1. Relate AMOC variability to deep water mass variability and basin-scale wind forcing.
2. Assess overturning sensitivity to variations in Arctic freshwater input and continued warming
3. Determine the pathways and transports of overflow waters in the NASPG to investigate the connectivity of the deep boundary current system.
4. Determine the nature and degree of the overflow-subpolar-subtropical AMOC connectivity.
5. Determine from new OSNAP measurements the configuration of an optimally efficient long-term AMOC monitoring system in the NASPG.

OSNAP: Overturning in the Subpolar North Atlantic Program

A US-led program with UK, Germany, Netherlands, France, Canada and China



U.S. : Susan Lozier (Duke); Bill Johns (U. Miami); Amy Bower, Bob Pickart and Fiamma Straneo (WHOI)

UK: Sheldon Bacon, Penny Holliday and Chris Wilson (NOC); Stuart Cunningham and Mark Inall (SAMS); David Marshall and Helen Johnson (Oxford) and Ric Williams (Liverpool)

Netherlands: Laura de Steur (NIOZ)

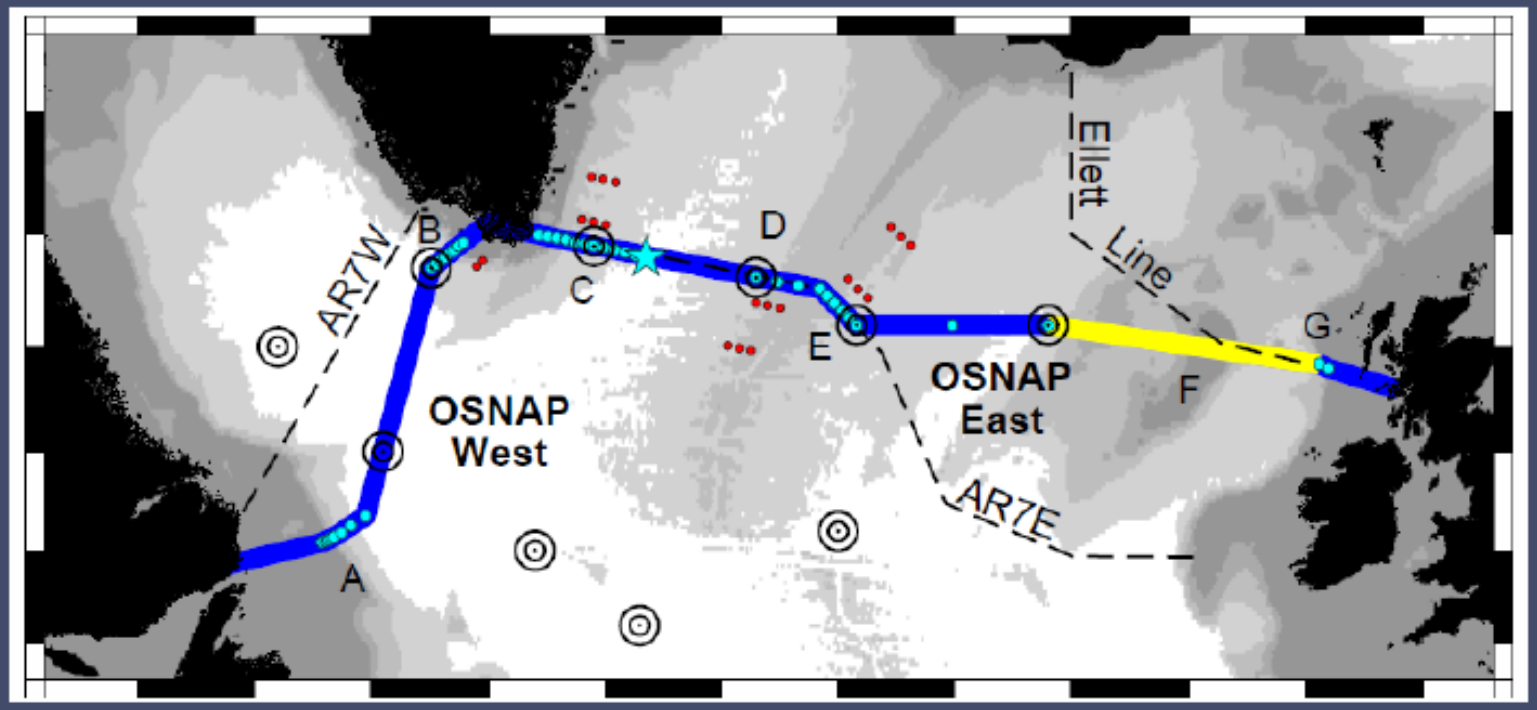
Germany: Johannes Karstensen and Jürgen Fischer (GEOMAR)

Canada: Blair Greenan (BIO); Brad de Young (Memorial U.)

France: Herlé Mercier, Virginie Thierry and the OVIDE group (IFREMER)

Overall design: A transoceanic line in the subpolar North Atlantic that can capture the net transport of the overflow waters from the Nordic Seas, as well as that from the Labrador Sea. Designed to complement the RAPID array and EU NACLIM observations, thereby providing measurements to evaluate intergyre connectivity within the North Atlantic.

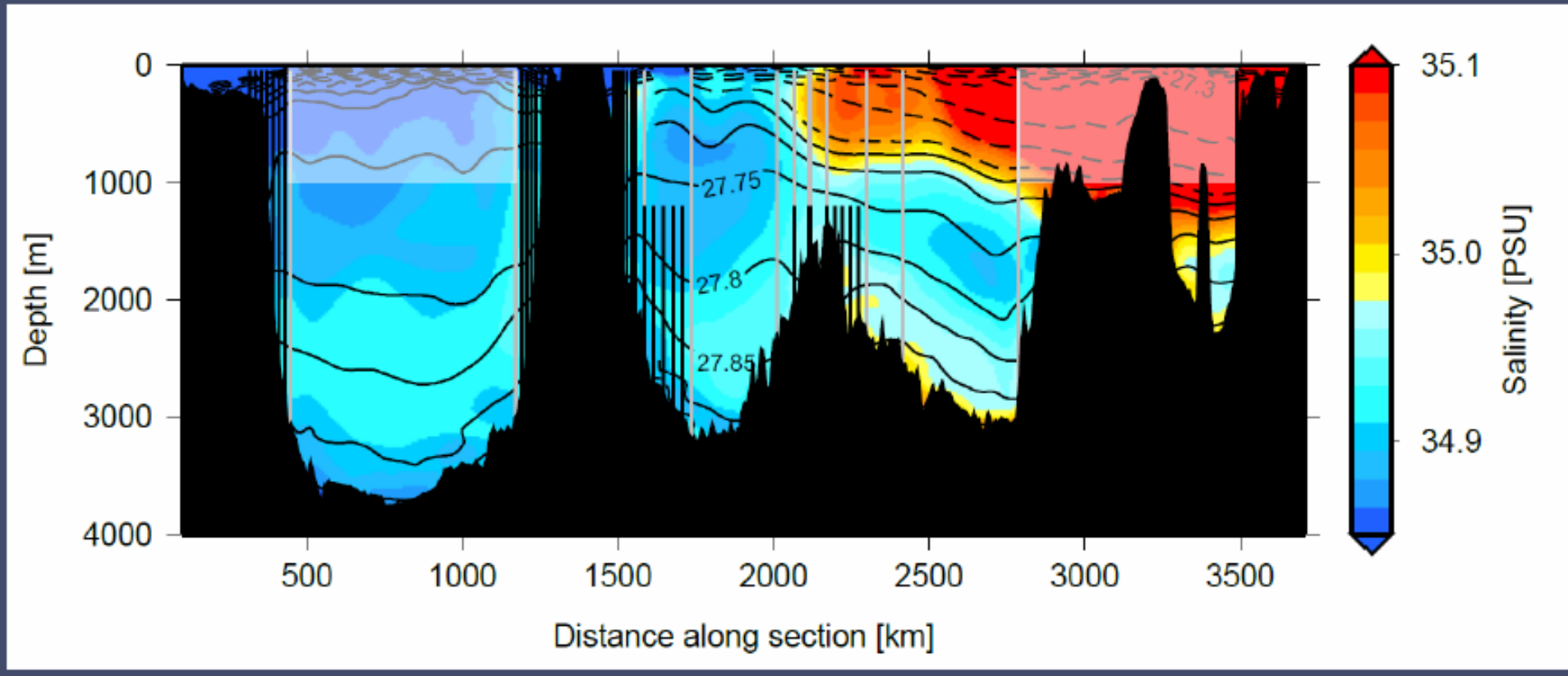
OSNAP overall goal: To quantify the large-scale, low-frequency, full water-column net fluxes of mass, heat and fresh water associated with the meridional overturning circulation in the subpolar North Atlantic.



(A) German 53°N western boundary array and Canadian shelfbreak array;
(B) US West Greenland boundary array;
(C) US/UK East Greenland boundary array;
(D) Netherlands western Mid-Atlantic Ridge array;
(E) US eastern Mid-Atlantic Ridge array;
(F) UK glider survey over the Hatton-Rockall Bank and Rockall Trough;
(G) UK Rockall Trough current array.
Red dots: US float launch sites.
Blue star: US OOI Irminger Sea global node.
Black concentric circles: US sound sources.

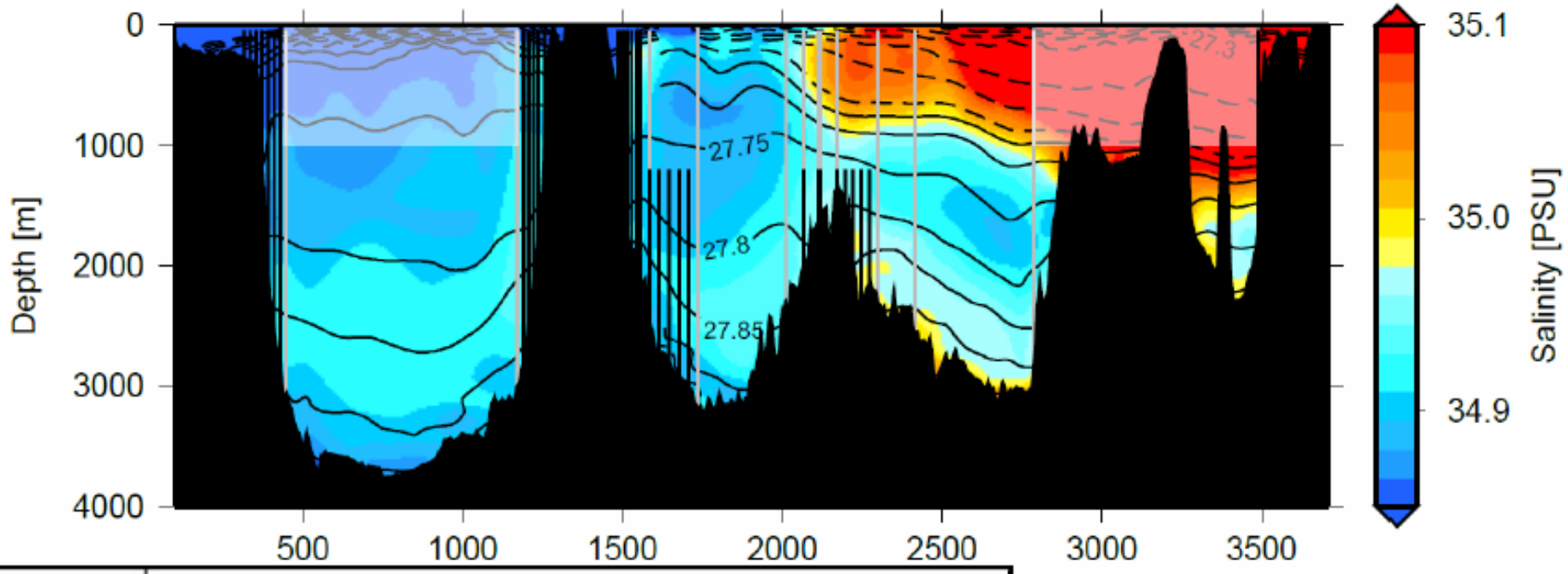
*To be added in 2015: Glider survey across the Iceland basin by OUC (China)

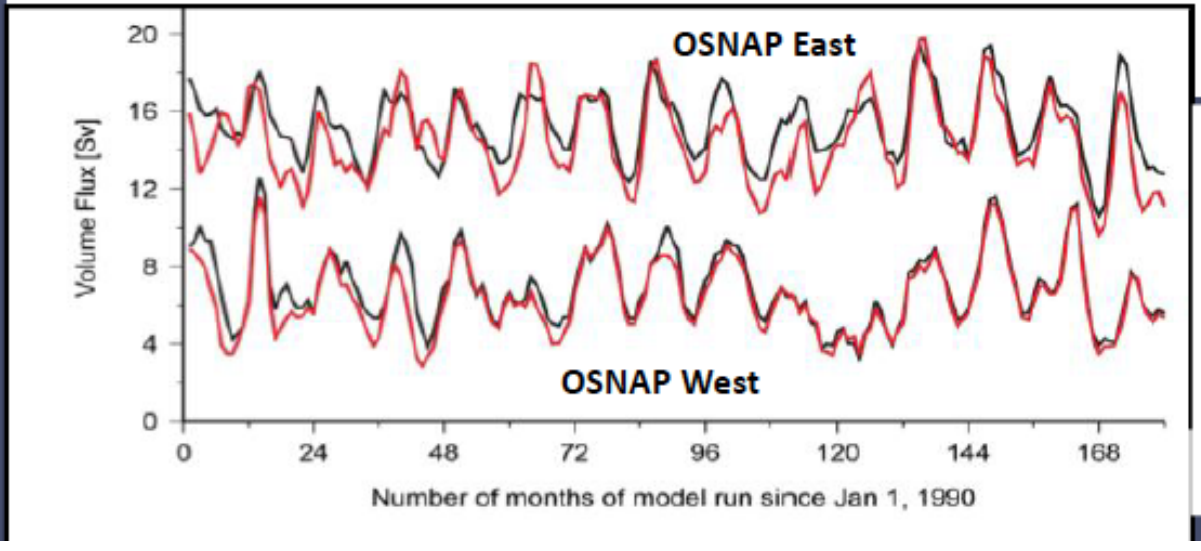
OSNAP array superposed on climatological salinity along the OSNAP West (leftmost basin) and East lines.



Mooring locations (vertical lines) and glider domains (shaded boxes) are indicated. To reconstruct the velocity field, we are directly measuring the currents at the boundaries and the flanks of the Reykjanes Ridge and using T/S sensors and gliders to estimate the interior geostrophic velocities. Black moorings indicate where the velocity field is directly sampled. Gray moorings double as direct velocity measures and endpoints for the geostrophic regions.

OSNAP array superposed on climatological salinity along the OSNAP West (leftmost basin) and East lines.





OSSE Simulations

Overturning in density coordinates:

Red = model truth

Black = OSE

Summary

- Given the breadth of expected impacts from AMOC variability, the international community has launched a new observational program, OSNAP, in the summer of 2014 to measure the overturning in the subpolar North Atlantic.

- Motivation for OSNAP stems in large measure from success of RAPID.

- OSNAP is an international program, with 7 participating countries.

- Together, OSNAP, NACLIM and the RAPID 26^{o}N observational systems will provide a means to evaluate intergyre connectivity and to establish a long-term comprehensive observing system in the North Atlantic.

- For more information on OSNAP, see: www.o-snap.org (cruise plans, cruise reports and blogs, news and events, etc.)