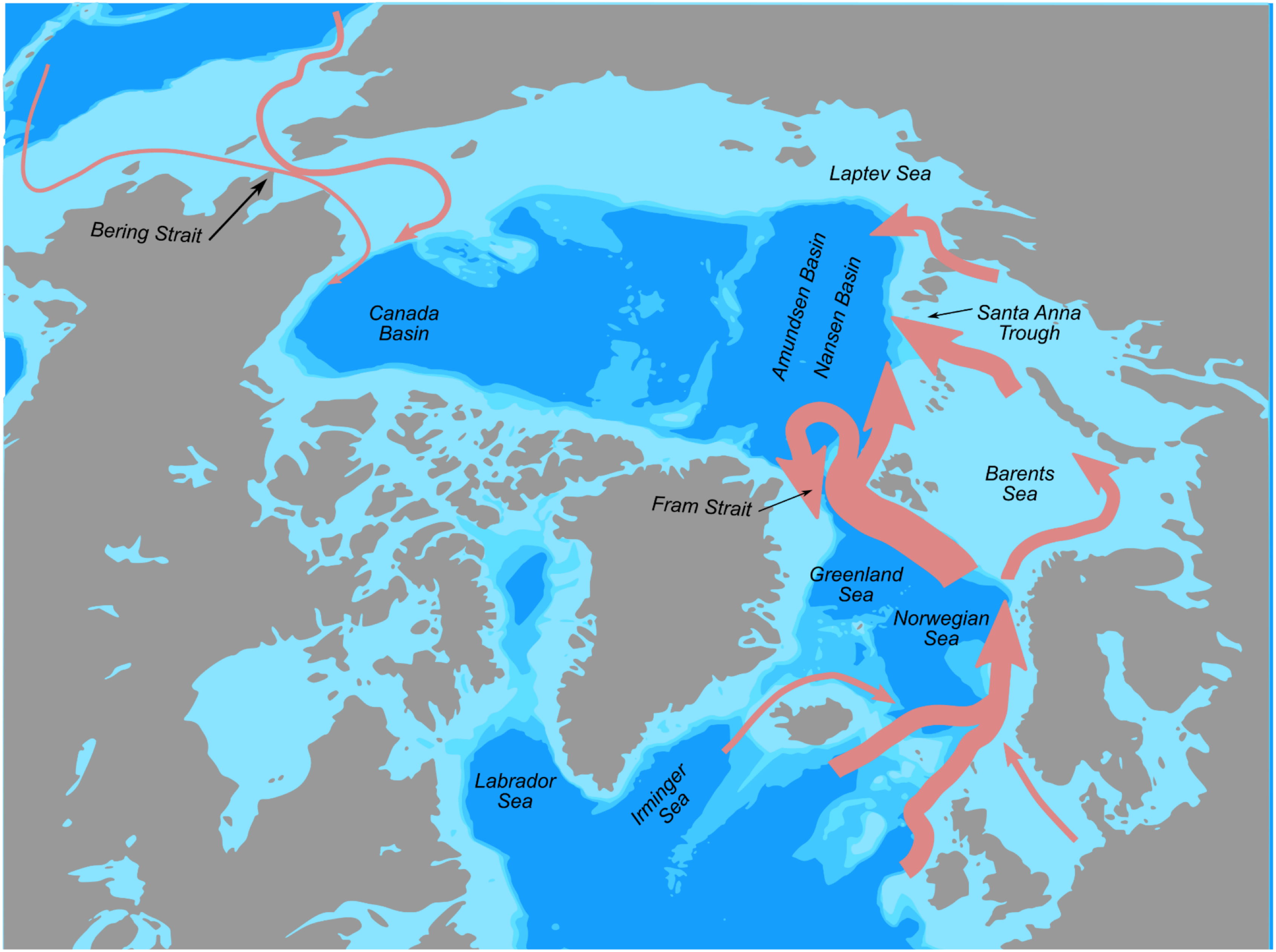
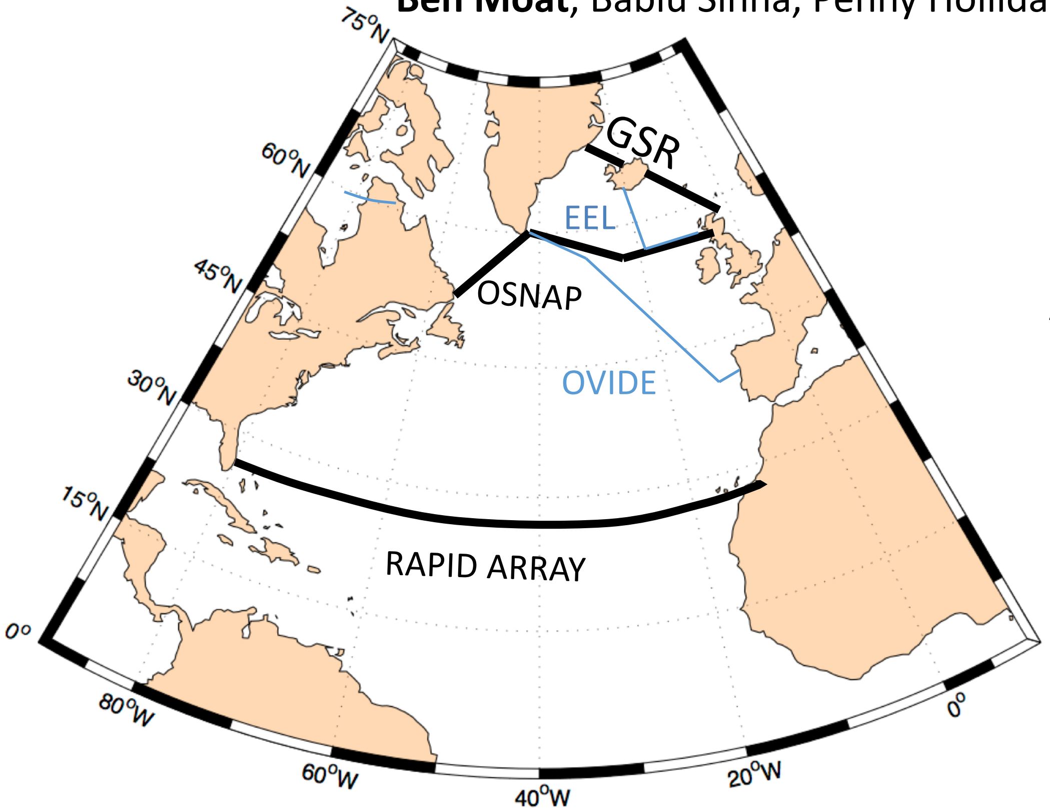
WP2: Lower latitude drivers of the Arctic



D2.1 Model-observation and re-analyses comparison at key locations for heat transport to the Arctic

Ben Moat, Bablu Sinha, Penny Holliday and Gerard McCarthy



1) NEMO Ocean only

1/12° 1958 to 2015

1/12° 1958 to present day (ACSIS)

2) Three (HadGEM3) - Coupled simulations

All are 1/12° Ocean with N512 Atmosphere

a) 20 year control run

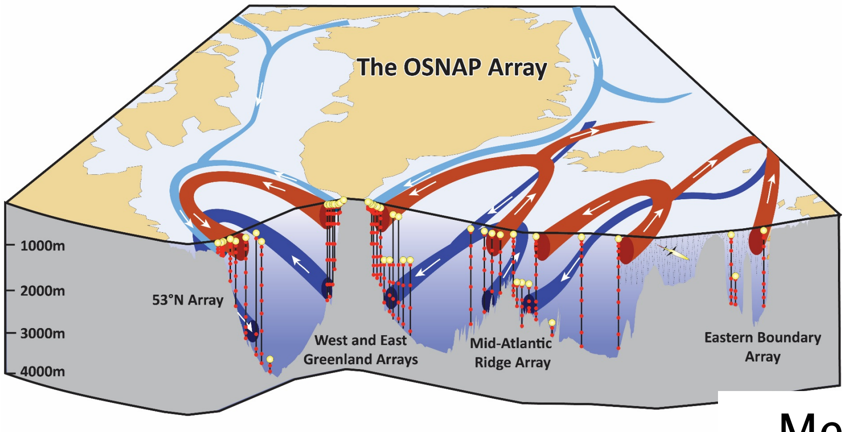
b) 100 year control run fixed present day CO_2
(RUNNING NOC, UK)

c) 100 year “all-forced” run to present day
and then a RCP scenario
1950 to 2050
(RUNNING at UK MET OFFICE)

D2.1 Ben Moat (NOC): Ben presented ongoing model-observation comparisons at key locations. Comparisons between a NEMO 1/12º hindcast with the RAPID, OSNAP and OVIDE volume, heat and freshwater transports were presented. Future plans include comparisons with GSR and EEL sections and to use high resolution coupled climate models, in concert with PRIMAVERA. Links with expertise in atmospheric heat transport was sought potentially linking with D2.4 (Wilco Hazeleger).

OSNAP: Overturning in the Subpolar North Atlantic Program (2014-2018)

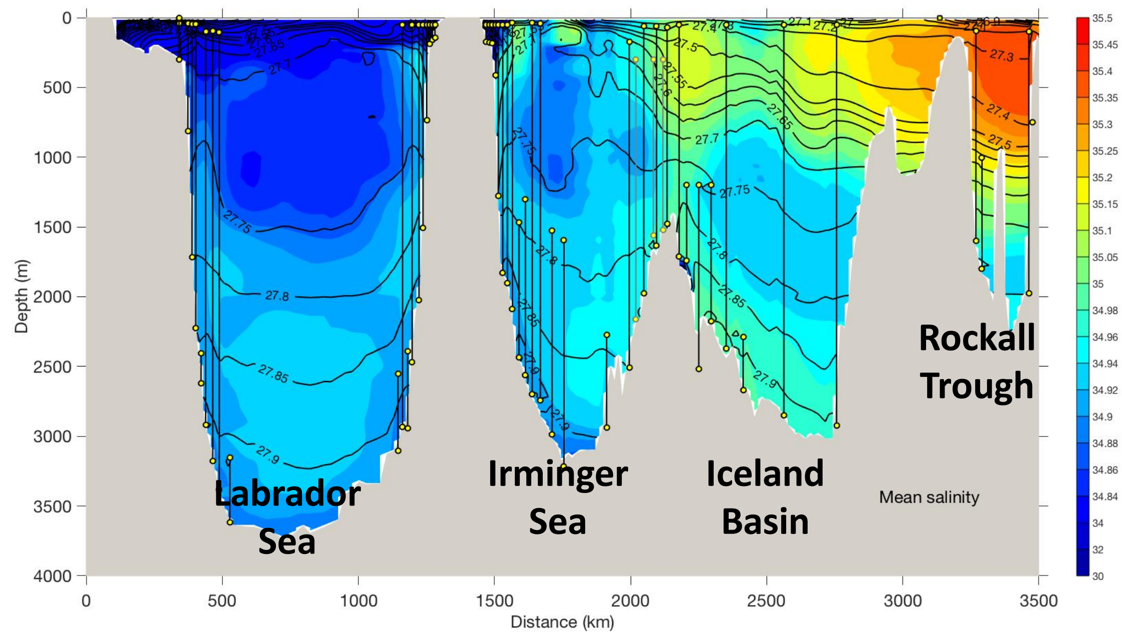
US, UK, Germany, Netherlands, Canada, France and China



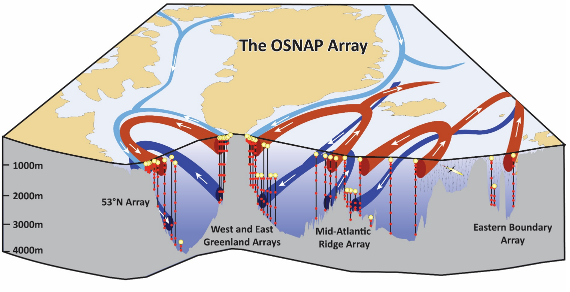
- Timeseries of Overturning, heat and fresh-water fluxes will be published in Spring 2018

Lozier, S. et al. 2016, BAMS

Mean salinity across section Aug 2014-May 2016

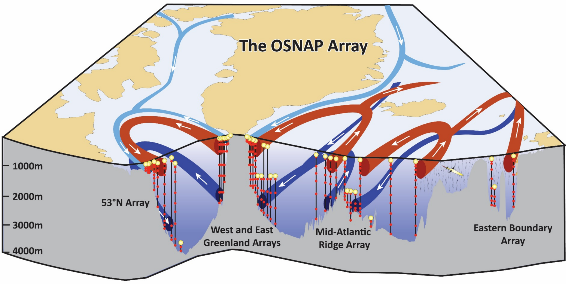


- Overall design: A transoceanic line in the subpolar North Atlantic that captures the net transport of the overflow waters from the Nordic Seas, as well as Labrador Sea export.
- Designed to test linkage between water mass variability and overturning variability.



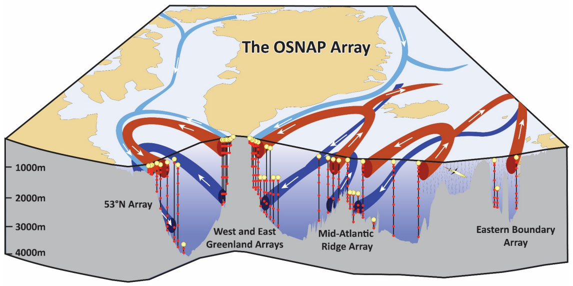
Research (Large-Scale)

1. **Timeseries of Overturning, heat and fresh-water fluxes** to be submitted in Spring 2018, Lead Author: Susan Lozier.
2. Cunningham, S. A., B. Berx, C. Johnson, L. Houpert, and S. Garry (2016), **Ocean Heat Content and Transport of Energy in the Subpolar North Atlantic**, *JGR-Oceans, in revision*.
3. Holliday, N. P., S. Bacon, S. A. Cunningham, S. F. Gary, J. Karstensen, B. A. King, F. Li, and E. McDonagh (2018), **Subpolar North Atlantic Overturning and Isopycnal Circulation and Heat and Freshwater Fluxes in the Summers of 2014 & 2016**, *JGR-Oceans, in revision*.
4. **Impacts of basin-scale forcing on the circulation and fluxes in the Faroe-Shetland Channel**, Kamila Walica, Ph.D. (to be submitted April 2018); Supervisors (Cunningham, Berx, Gary)



Research (Processes)

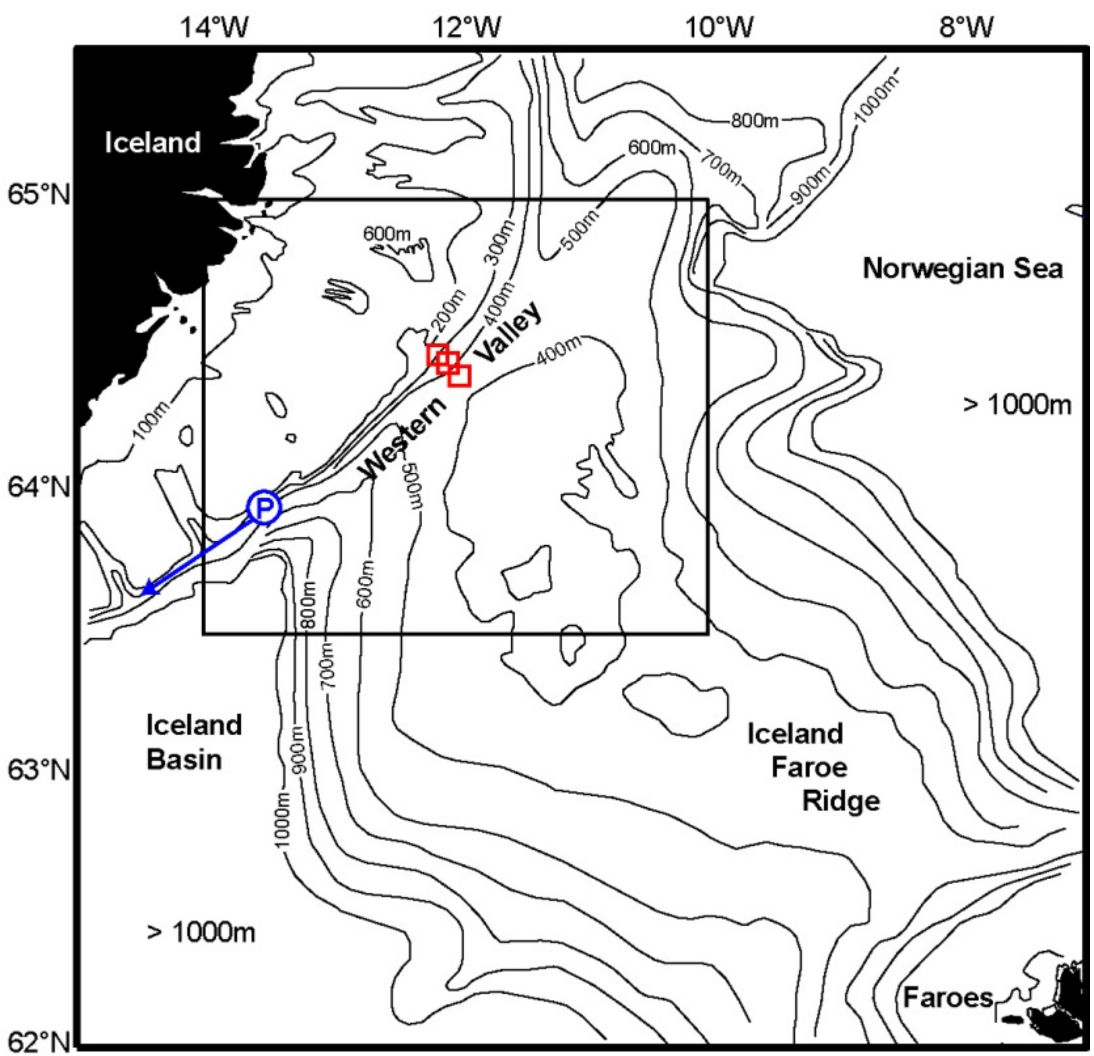
1. Gary, S. F., S. A. Cunningham, C. Johnson, L. Houpert, N. P. Holliday, E. Behrens, A. Biastoch, and C. W. Boning (2017), **Seasonal cycles of ocean fluxes in the eastern subpolar North Atlantic**, *JGR-Oceans*, *in revision*.
2. Houpert, L., S. Gary, M. Inall, and S. A. Cunningham (2017), **Transport structure and energetics of the North Atlantic Current in the eastern part of the subpolar gyre from observations**, *JGR-Oceans*, *in revision*.
3. Marsh, R., I. D. Haigh, S. A. Cunningham, M. E. Inall, M. Porter, and B. I. Moat (2017), **Large-scale forcing of the European Slope Current and associated inflows to the North Sea**, *Ocean Sci.*, *13*(2), 315-335, doi:10.5194/os-13-315-2017.
4. Johnson, C., T. Sherwin, S. Cunningham, E. Dumont, L. Houpert, and N. P. Holliday (2017), **Transports and pathways of overflow water in the Rockall Trough**, *Deep-Sea Research Part I*, *122*, 48-59,

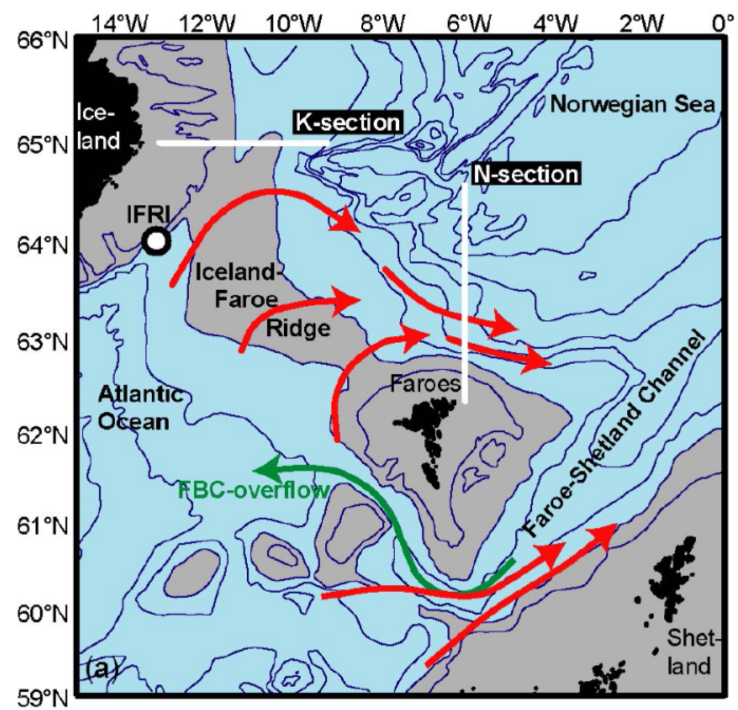


New Research (2018-)

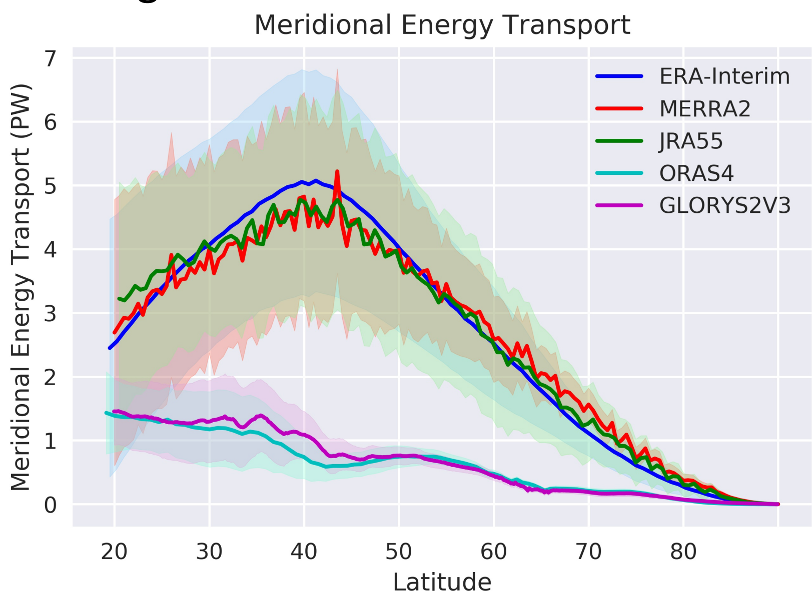
1. Circulation in the Eastern Subpolar North Atlantic Based on Three Years of Mooring Measurements.
2. A new dynamical model for the Eastern Boundary Current.
3. Lagrangian Connectivity of cold-water coral ecosystems in the North Atlantic.
4. Biogeochemical fluxes in the Rockall Trough (Combining new measurements made in the EU Atlas Programme with fluxes from the OSNAP moorings).

D2.3 Steffen Olsen (DMI): Steffen presented ongoing investigations into overflow across the Iceland-Faroe Ridge (IFR). This work links with the Danish funded WOW project which is making observations of overflow in the Western Valley of the IFR. Early conclusions indicate that this overflow is weak <0.1 Sv. Work is ongoing to understand the shortcomings of ocean climate models in representing inflow across the IFR.





D2.4 Wilco Hazeleger (NLeSC): Wilco presented analysis of atmospheric meridional energy transport (AMET) from ERA-Interim including mean and anomaly patterns, spatial and temporal variability. Future work will extend this analysis to the ORAS4 and other datasets, and relationship of AMET to climate indices such as the NAO, PDO, etc. Wilco asked for a synthesis of data available for comparison and this is included with the documents for this meeting.

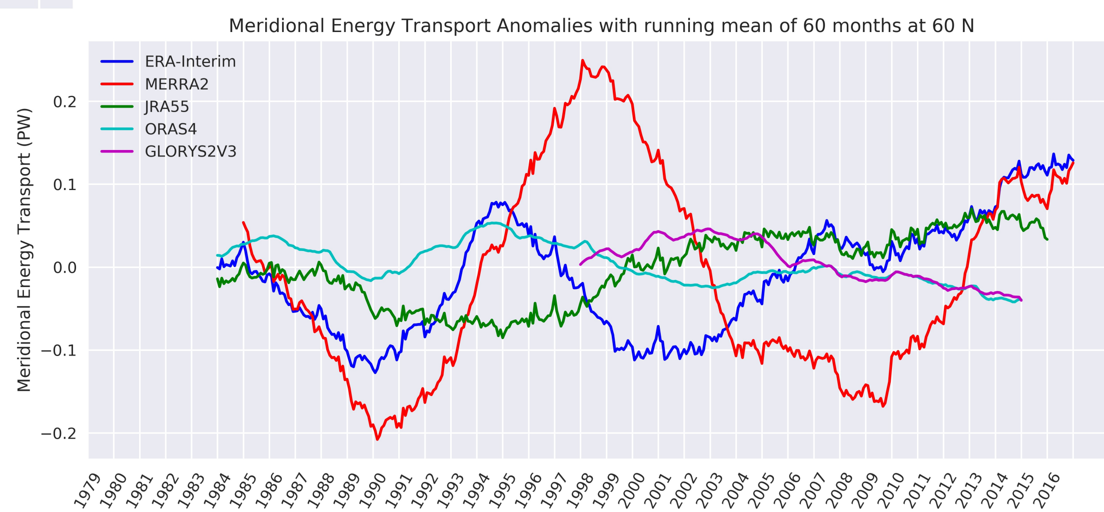


AMET & OMET

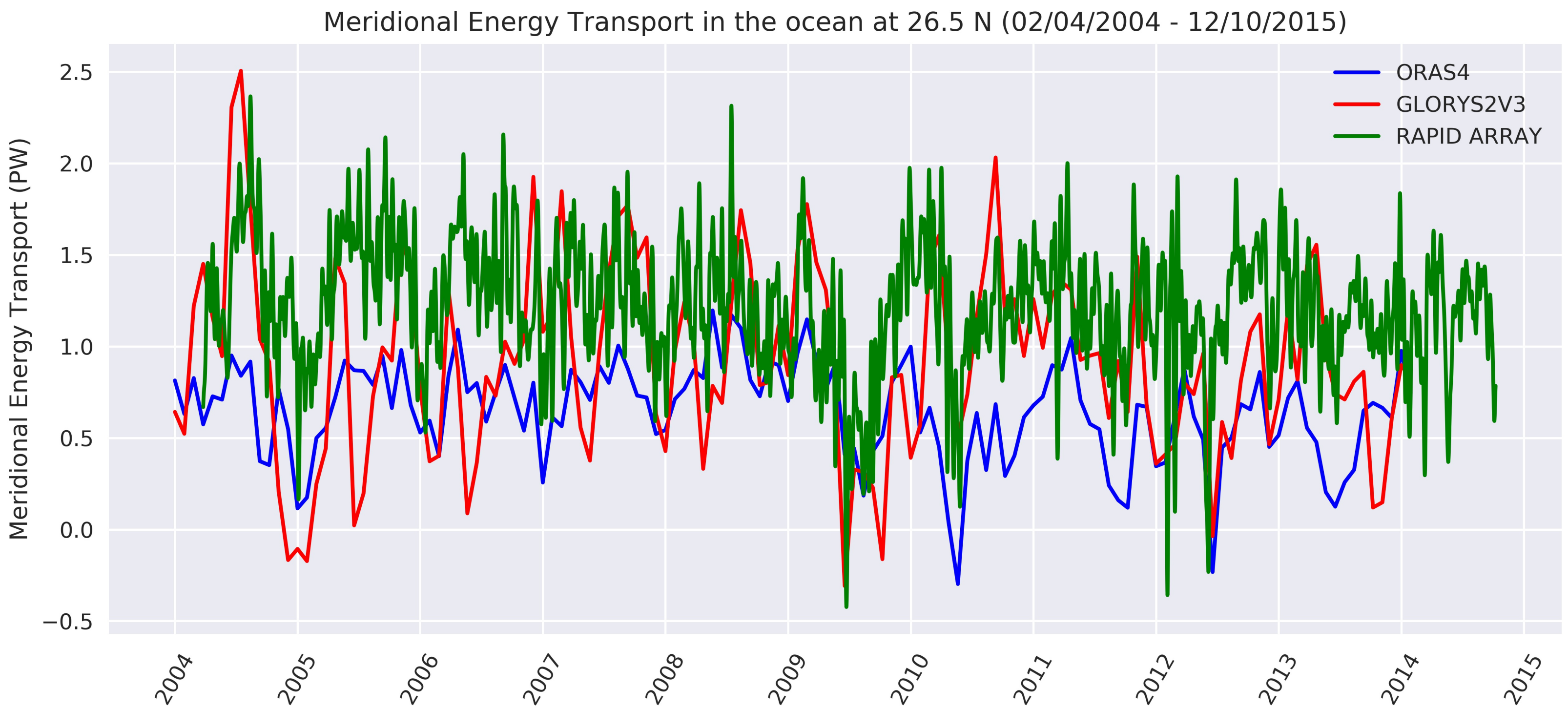
Atmospheric/ocean meridional energy transport

Mean AMET & OMET of the entire series from 20N to 90N. All the reanalysis datasets agree well.

Low pass filtered AMET & OMET anomalies at 60N. The low frequency variations of AMET & OMET deviate substantially. Except for MERRA2, the multi-annual variations of all the datasets agree well after 2008.



Reanalysis & Observation



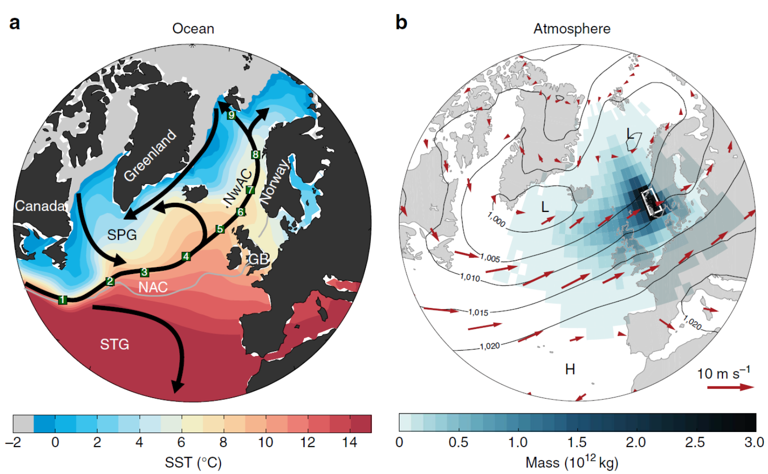
OMET from GLORYS2V3 and ORAS4 compared with RAPID ARRAY at 26.5 N GLORYS2V3 agrees well with the RAPID/MOCHA observation, while ORAS4 underestimates the OMET at 26.5N.

D2.5 Tor Eldevik (UiB): Tor presented the predictability of Norwegian temperatures derived from slow and cyclical ocean advective processes, highlighting an 8 and 14 year cycle in both. This was seen in both observations and in the NorESM model. Tor suggested a website to collate our predictions from Blue Action. Tor also presented a reconstruction of sea ice including a spatial decomposition of how sea ice is varying. Also included was an update from Juliette Mignot that the IPSL reanalysis is on track (MS9

D2.5. Marius Årthun

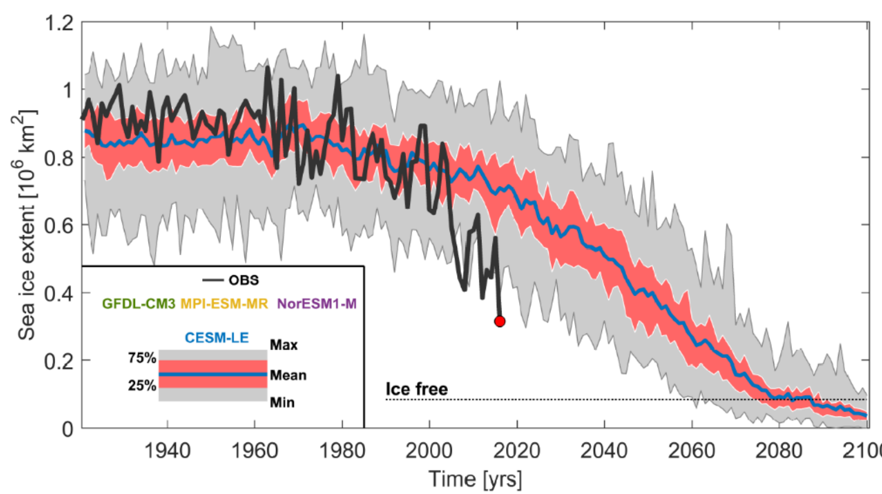
Skillful prediction of northern climate provided by the ocean (Årthun et al, 2017. *Nat. Commun.*)

- Ocean heat anomalies propagate from the subpolar NA toward the Arctic → prediction horizon.
- Ocean heat anomalies are reflected in continental climate and Arctic winter sea ice extent.
- Northern climate predicted a decade in advance based on upstream ocean conditions.



Toward an ice-free ('blue') Barents Sea (Onarheim & Årthun, 2017. *GRL*)

- Arctic wintertime sea ice changes largely result from a retreating Barents Sea ice cover.
- The current observed trend appears as an uncommon feature in observations and climate models.
- Large spread in model projections of ice-free conditions due to large internal variability.



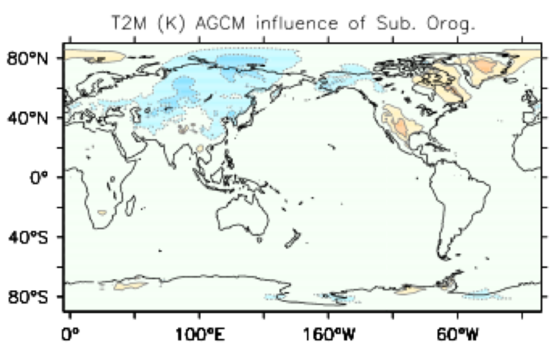
D2.6 Christophe Herbaut and Guillaume Gastineau (CNRS): Christophe presented work highlighting the impact of subgrid orography on ocean and atmosphere energy transport to the Arctic. Comparison and validation of these results with those from D2.4 was discussed.

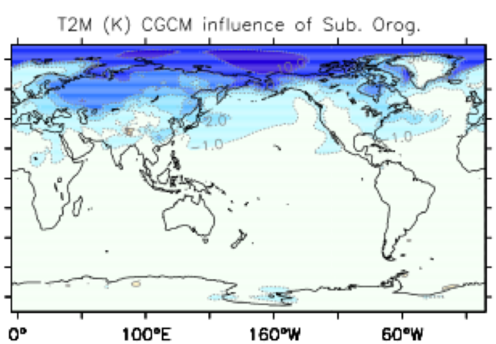
In the AGCM LMDZOR the influence of subgrid orography is parameterized following Lott and Miller (1997). Two effects on stationnary wave :

- Drag
- Lift

We did :

- AGCM experiment (20-yr) increasing the drag, and decreasing the lift, with climatological SST/SIC conditions,
- Same experiment, but with an AOGCM, 200-yr.

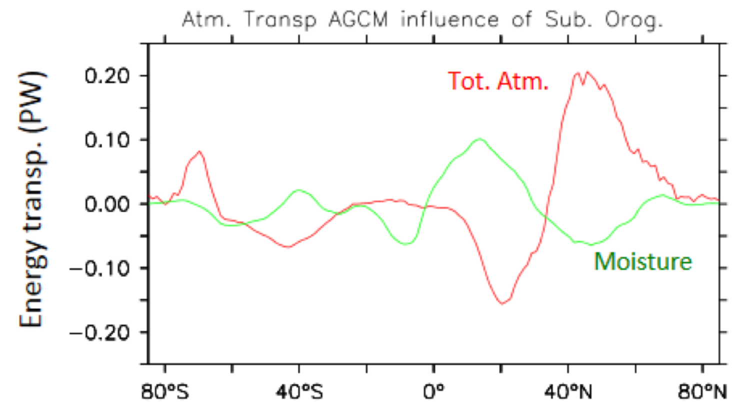


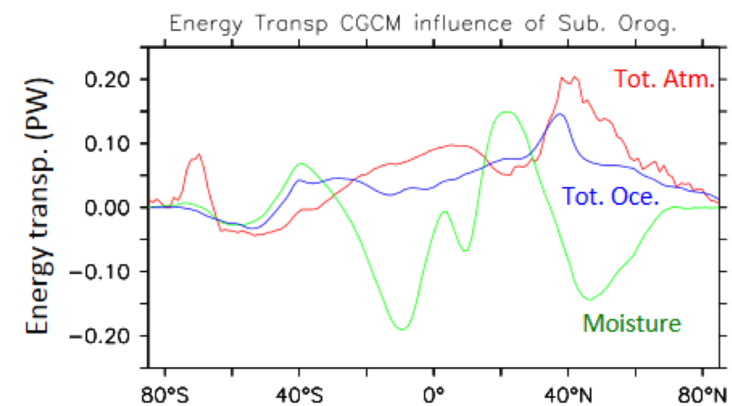


In AOGCM, large influence on sea-ice and on winter climate:

Weaker *vq* → Weaker *LW down* → Sea Ice growth

Change in atmospheric and oceanic transport :





Existence of coupled feedback leading to global changes.

Christophe also presented analysis closely linked with the INTAROS project of Arctic heat content with a high resolution regional model (NEMO 3.6, LIM3, resolution ~2.5 km near Svalbard, 8 tidal components) with promising initial results.

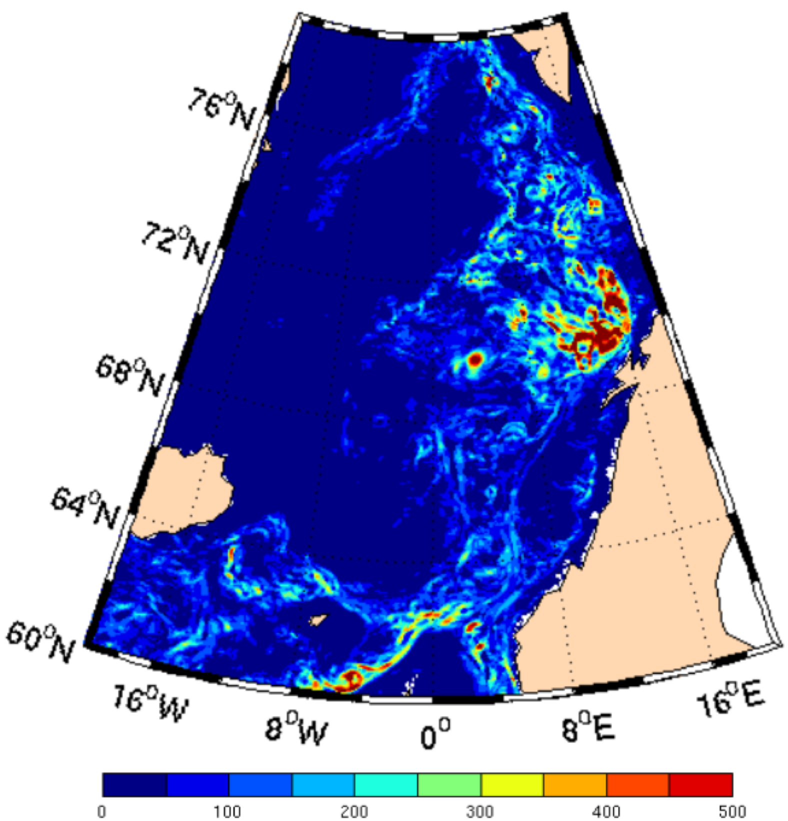
High resolution simulation: Spin-up phase : year 3

Preliminary validation of EKE:

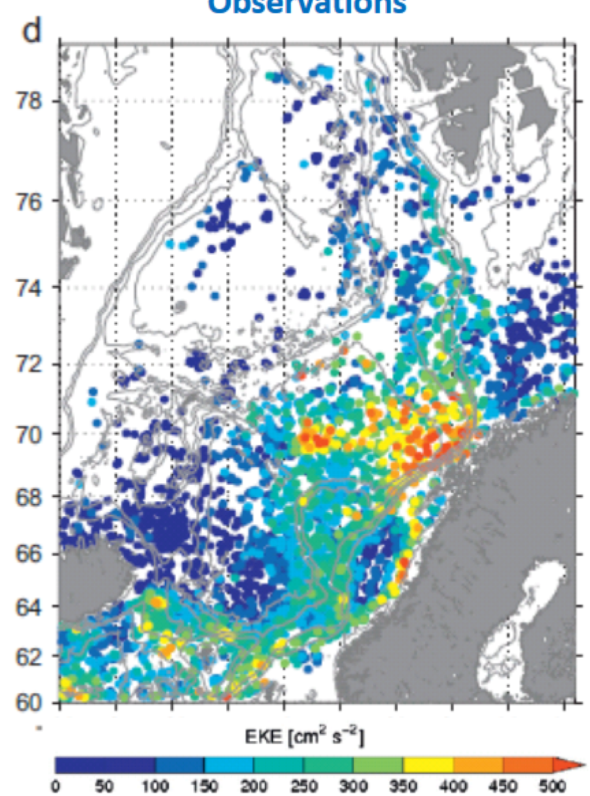
Comparison of model EKE with EKE deduced from drifters in the Nordic Seas:

- High EKE values in Lofoten Basin and NwAC.
- Reasonable agreement between model and observations

Model



Observations



Kosalzka et al. ,2011

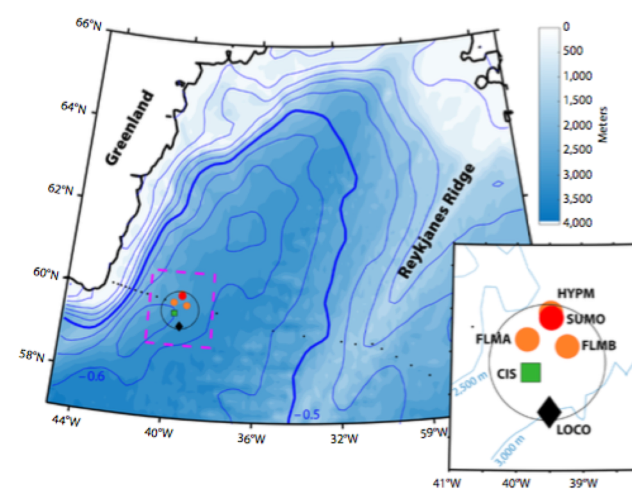
D2.7 Johannes Karstensen (GEOMAR): Johannes presented on cost-benefit analysis of mooring arrays, emphasizing the importance of deep, basinwide measurements for estimating long term AMOC variability. Johannes also reported on the status of real-time data availability from the moorings. Developments are ongoing on a pop-up and glider based system at NOC. Real time data from the OOI moorings in the Irminger Sea is available.

Deep Convection in the Irminger Sea Observed with a Dense Mooring Array
de Jong, et al. 2018. Oceanography, doi.org/10.5670/oceanog.2018.1xx.

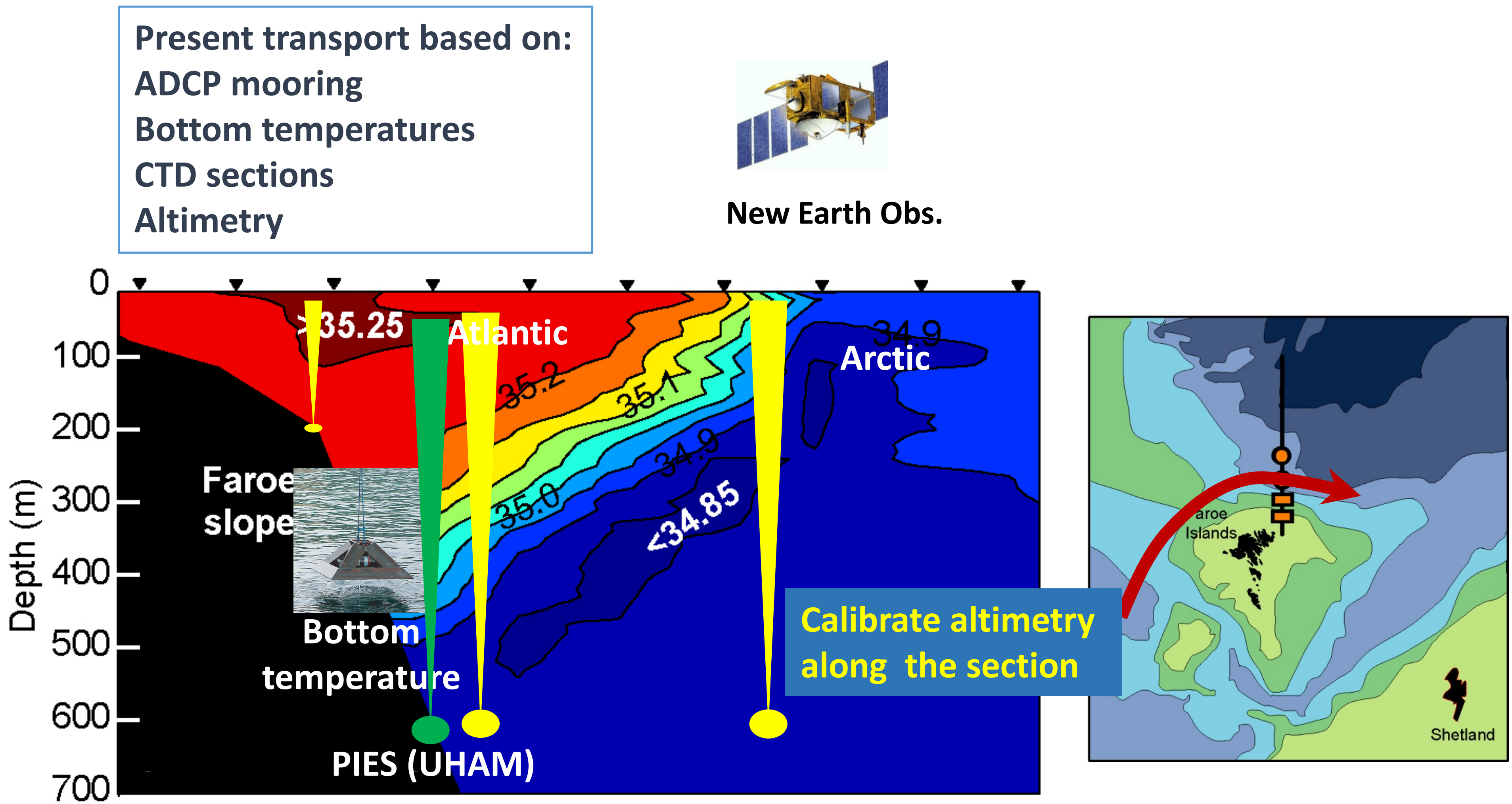
- The temporal evolution and the coherence of the mixed layer evolution in the Irminger Sea deep convection area was investigated using an array of six moorings during the deep convection period 2014/15 and 2015/16
- Winter heat loss was significant less in 2015/16 but deep mixed layers (about 1600m) are observed in both winters
- Properties of the mixed patch converge across moorings
- Northern most moorings are more frequent affected by

“warm events” most likely mesoscale eddies

- This is a shared observing effort between the US (Ocean Leadership) and Europe (NIOZ & GEOMAR)



D2.8 Karin Margretha Larsen (HAV): Karin Margretha presented a synthesis of observations across the GSR. The Faroe branch monitoring is currently being optimized with the utilization of satellite altimetry and bottom temperature loggers to reduce cost. Similar analysis is ongoing at the Iceland branch. A website for TMAs will be produced in conjunction with the AtlantOS project



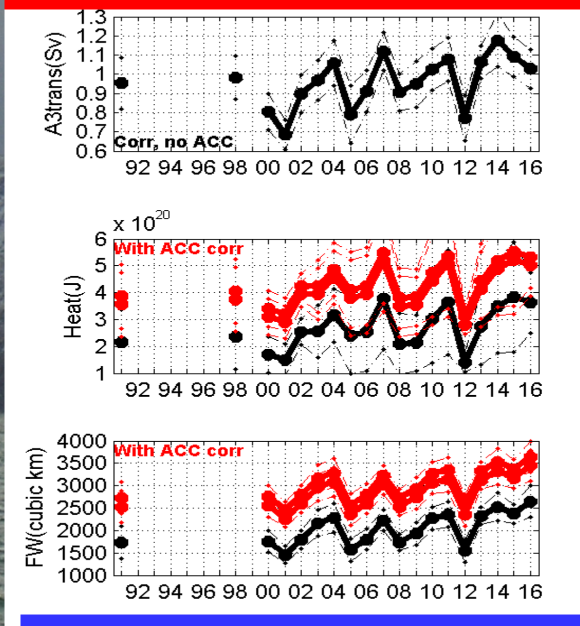
Recent Bering Strait Change: *Rebecca Woodgate, Univ. of Washington, Seattle (woodgate@uw.edu)*

Recent warming, freshening and flux increases from observations, and the long-sought structure of the "pressure-head" forcing, from GRACE ocean bottom pressure data

Woodgate, R.A., 2018 in press, Progress in Oceanography

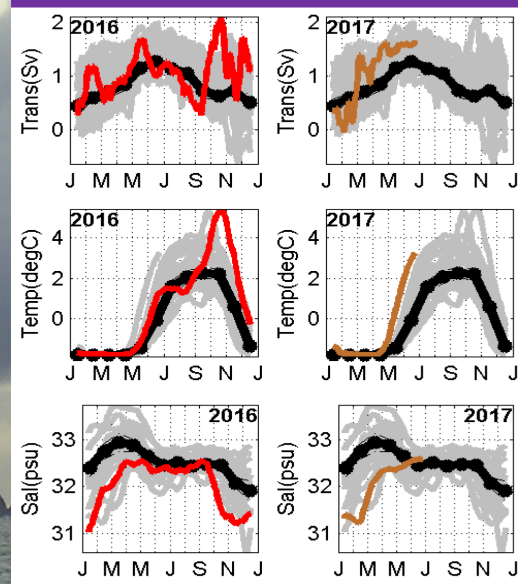
Continued ..

Increasing annual mean fluxes



2016/2017 Remarkably warm & fresh

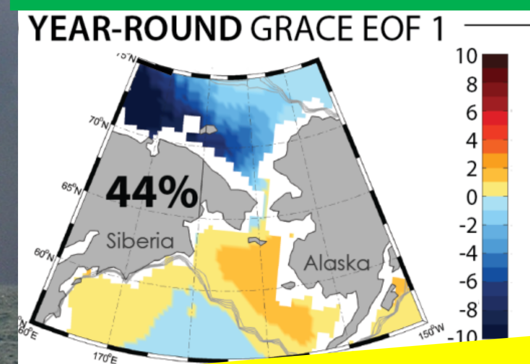
in prep



June 2017 3°C warmer than climatology

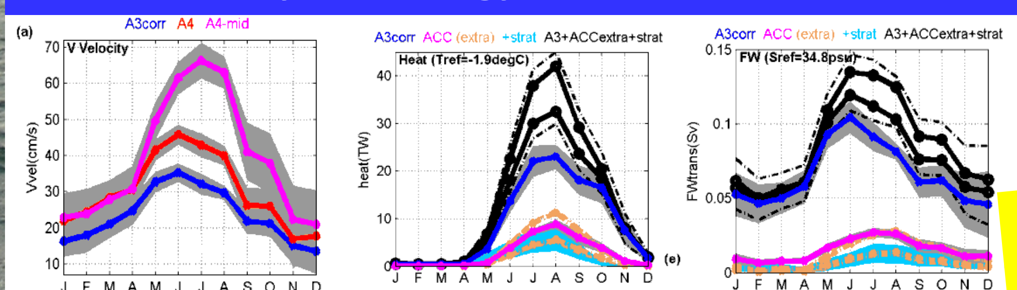
Peralta-Ferriz, C., & R.A.Woodgate, 2017, Geophysical Research Letters

The patterns of the Pressure-Head forcing of the Bering Strait flow



70% of summer variability is related to the East Siberian Sea
- Is the Bering Strait throughflow driven from the ARCTIC?

A new Monthly Climatology – incl Heat and Freshwater



New 2000s climatology of 1Sv

Diomede Islands, Bering Strait, Photo by Woodgate

The Blue-Action project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727852