The Slowing Gulf Stream? A science-policy breakfast discussion

A joint event of the H2020 Blue-Action and AtlantOS projects
4 September 2018, European Parliament, Brussels (BE)

BLUE ACTION

AtlantOS

Concept of the Briefing

Setting the scene

- Concepts, building blocks and the relevance of projects
- Policies and climate action

  Director Yvon Slingenberg, DG CLIMA

Scientific panel of experts

- What can Atlantic ocean observations tell us?

  Dr. Ben Moat, NOC, United Kingdom

- A view from the gateways to the Arctic

  Dr. Karin Margretha Larsen, Havstovan, Faroe Islands

- Ocean-climate linkages and promising predictions

  Dr. Marius Årthun, UiB, Norway

- What to expect from the future?

  Dr. Marilena Oltmanns, GEOMAR, Germany

Feedback Session & open discussion

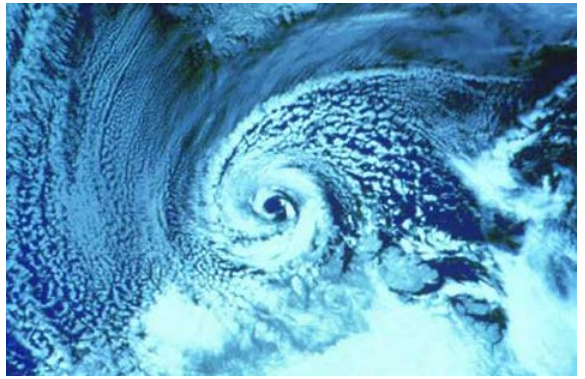
Setting the Scene

Dr. Steffen M. Olsen
Blue-Action Coordinator
Danish Meteorological Institute

&

Prof. Tor Eldevik
University of Bergen
Norway

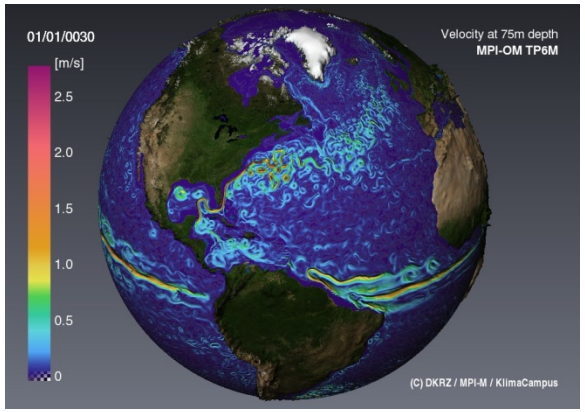
The ocean & predictions - Societal relevance



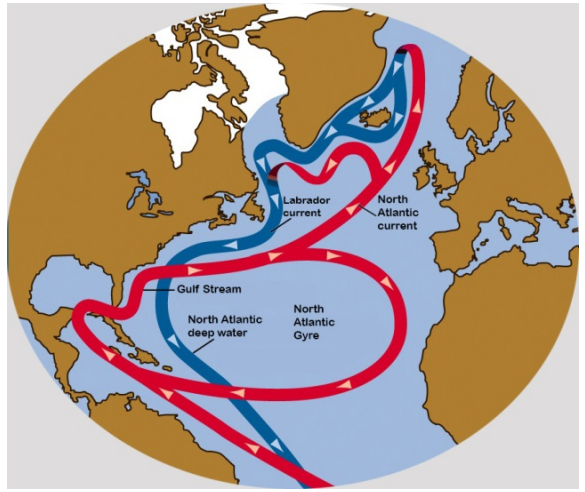
Days to a week
- Accurate weather forecasts

Long range and subseasonal
- Weather outlook
- Natural hazards preparedness

Seasonal-to-interannual
- Shifts in likelihood of weather regimes
- Resource management (e.g., water, fire, agriculture)
- New transportation patterns (e.g., Arctic shipping routes)

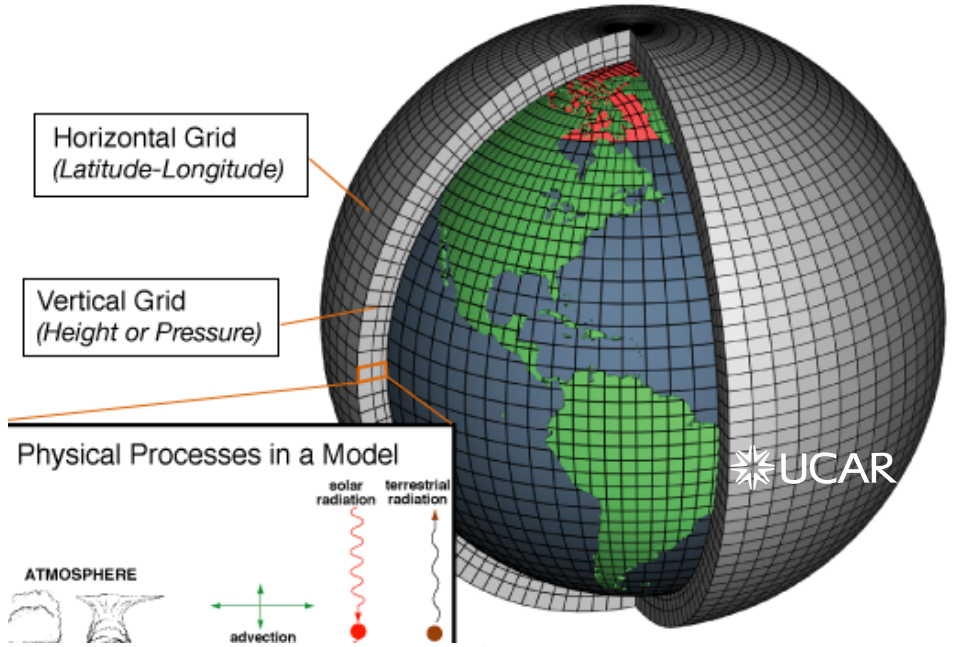


Decadal
- Long-term resource management (e.g., water, fire, agriculture, forests)
- Infrastructure investment
- Natural hazard mitigation and adaptation



Centennial
- Climate projections, tipping points, safe operation space
- Political decisions

Building Blocks of predictions



Computer Models

Advanced simulations of the Earth System run on supercomputers

Observations

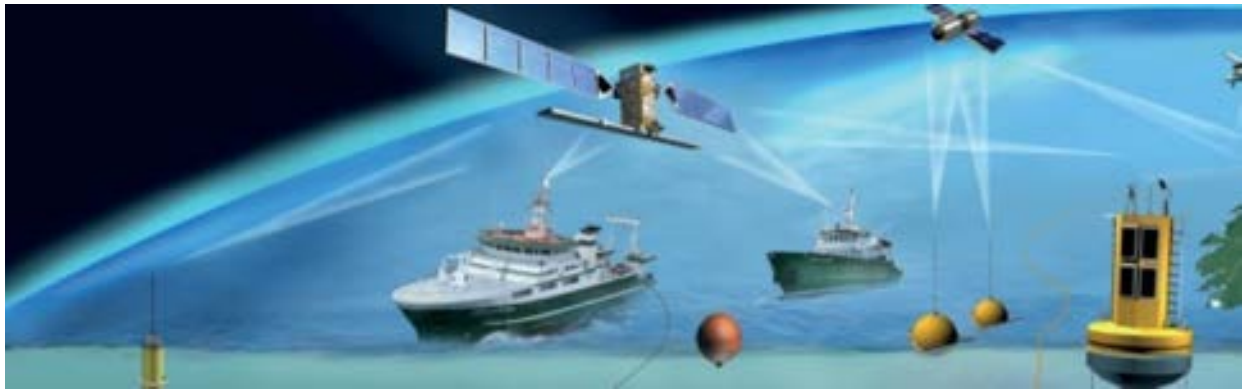
Satellite, buoys, moorings, gliders, hydrographic, etc.

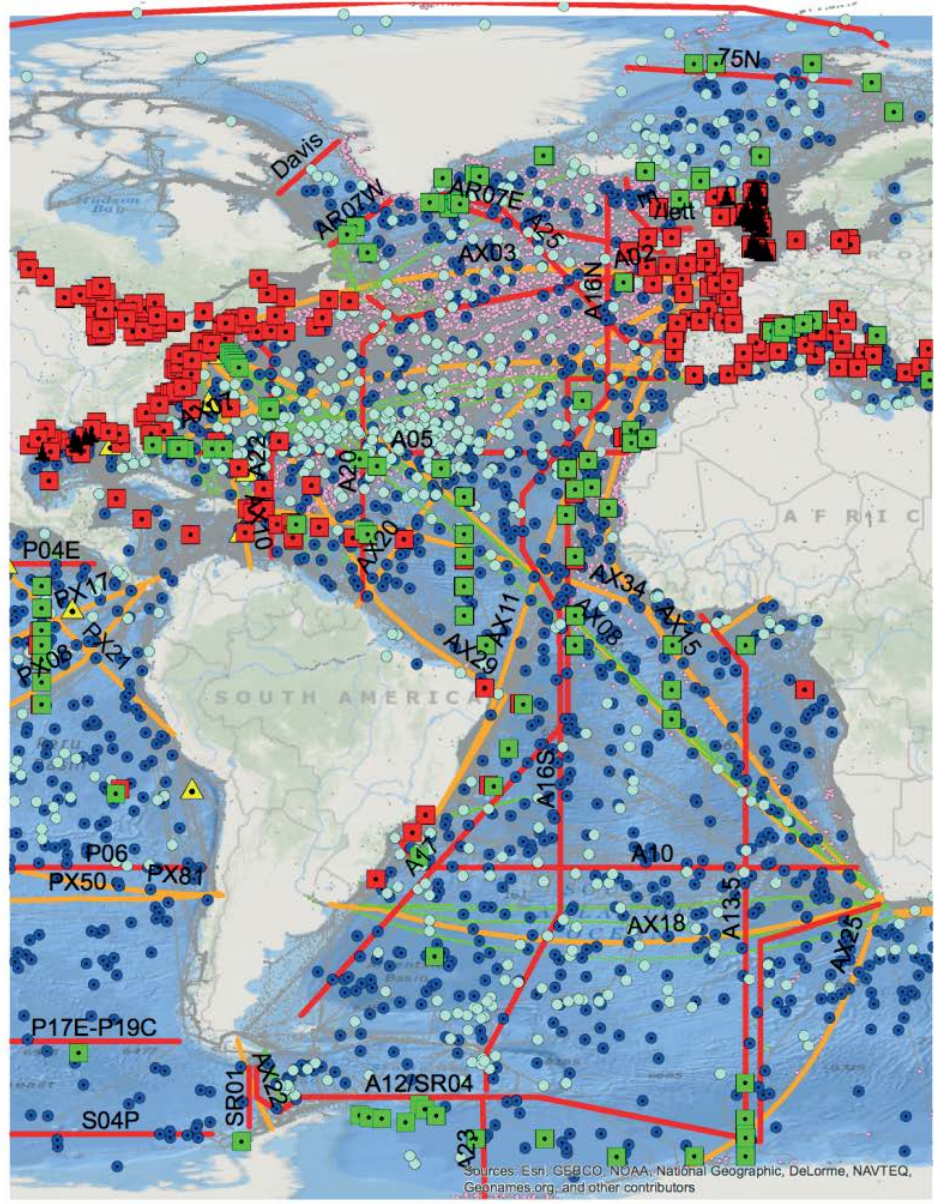
Initial Conditions

Advanced techniques to incorporate current weather / climate state into the models, i.e., a data assimilation system

AtlantOS

Integration of loosely-coordinated ocean observing activities to a more sustainable, more efficient, and fit-for-purpose Integrated Atlantic Ocean Observing System.





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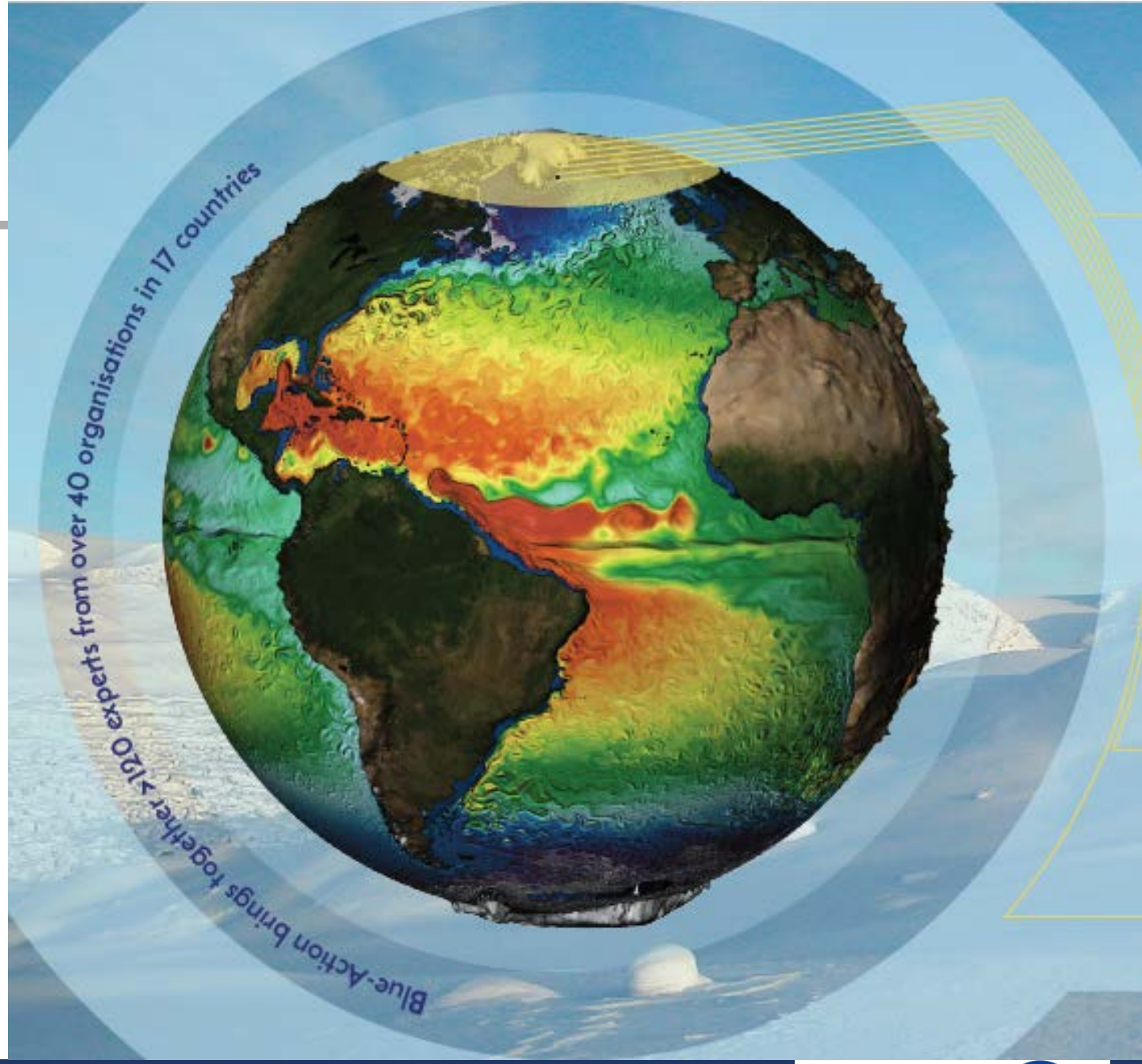
BLUE ACTION

Understanding the impact of a changing Arctic on Northern Hemisphere Weather and Climate

Apply new modelling techniques to cutting-edge climate services, co-designed with organisations and industries that rely on accurate weather and climate forecasting.



Take home messages

- The North Atlantic Ocean has a significant influence on Europe's weather and climate. This is related to the sea surface temperature and heat transported by ocean currents.
- Recent research suggests that we could use our understanding of the North Atlantic Ocean to predict winter temperatures in Europe and Arctic sea ice extent 5-10 years in advance.
- Early-warning indicators for approaching climate impacts, fit-for-purpose ocean observing systems, and development of mitigation strategies should be prioritised.

The Gulf Stream and climate

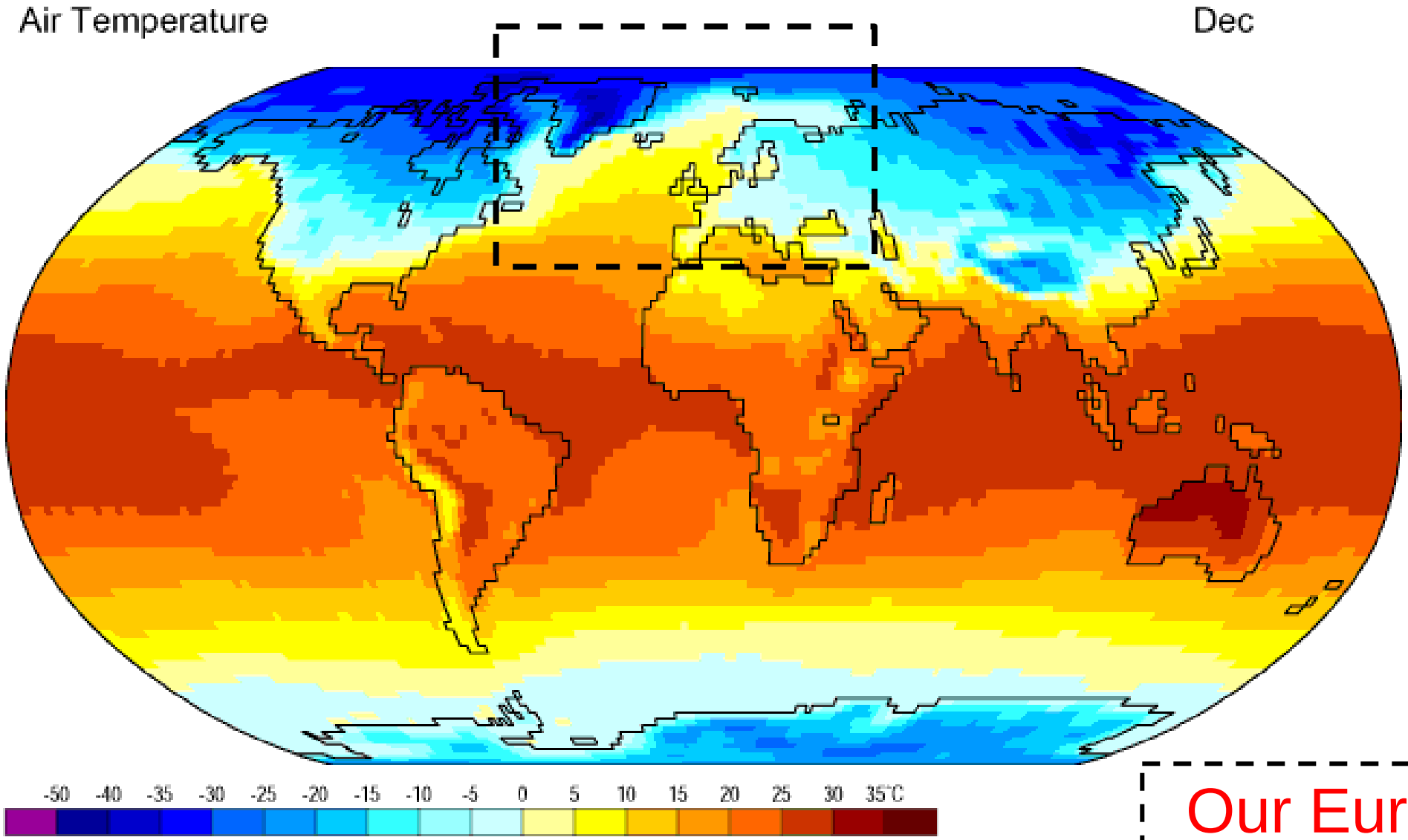
Tor Eldevik

Prof University of Bergen

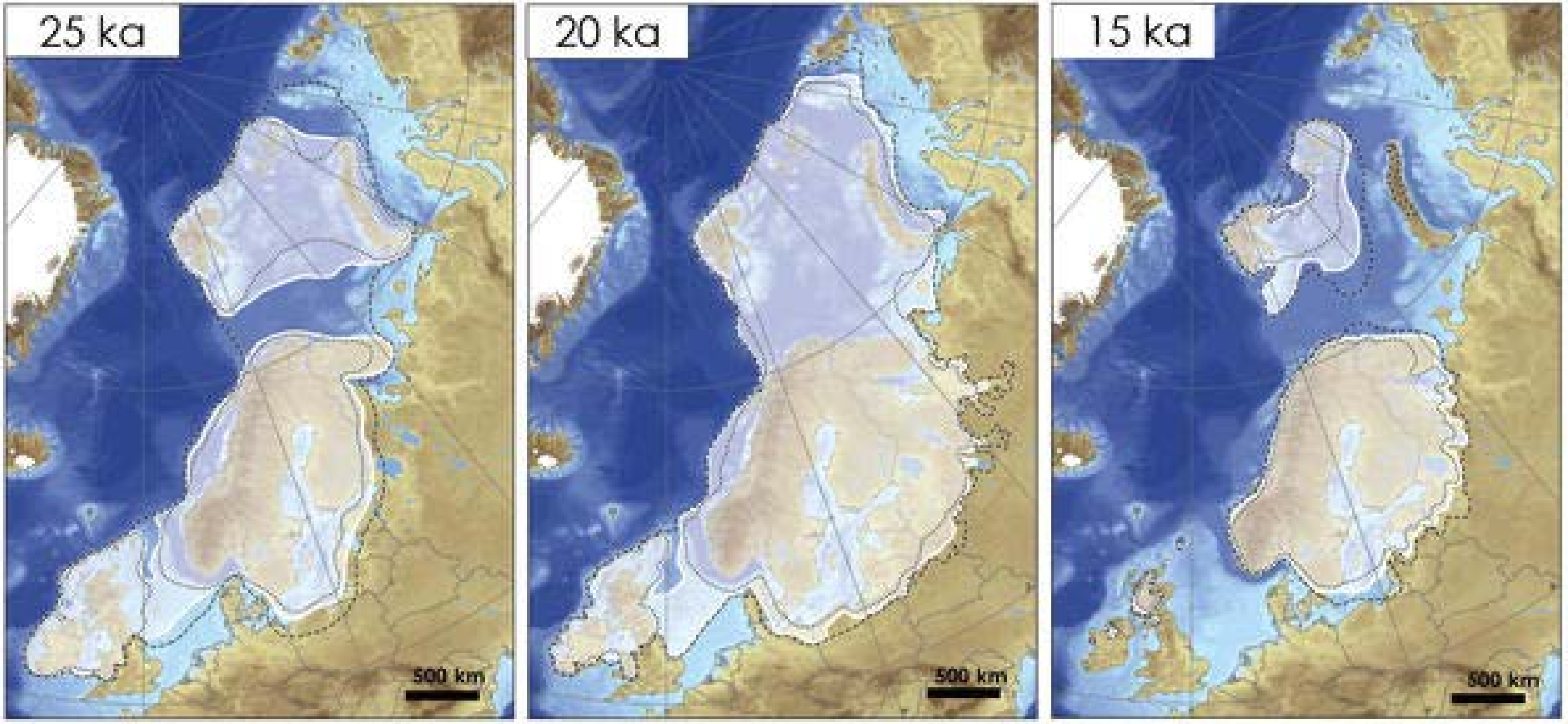
Deputy director Bjerknes Centre

BLUE ACTION

AtlantOS



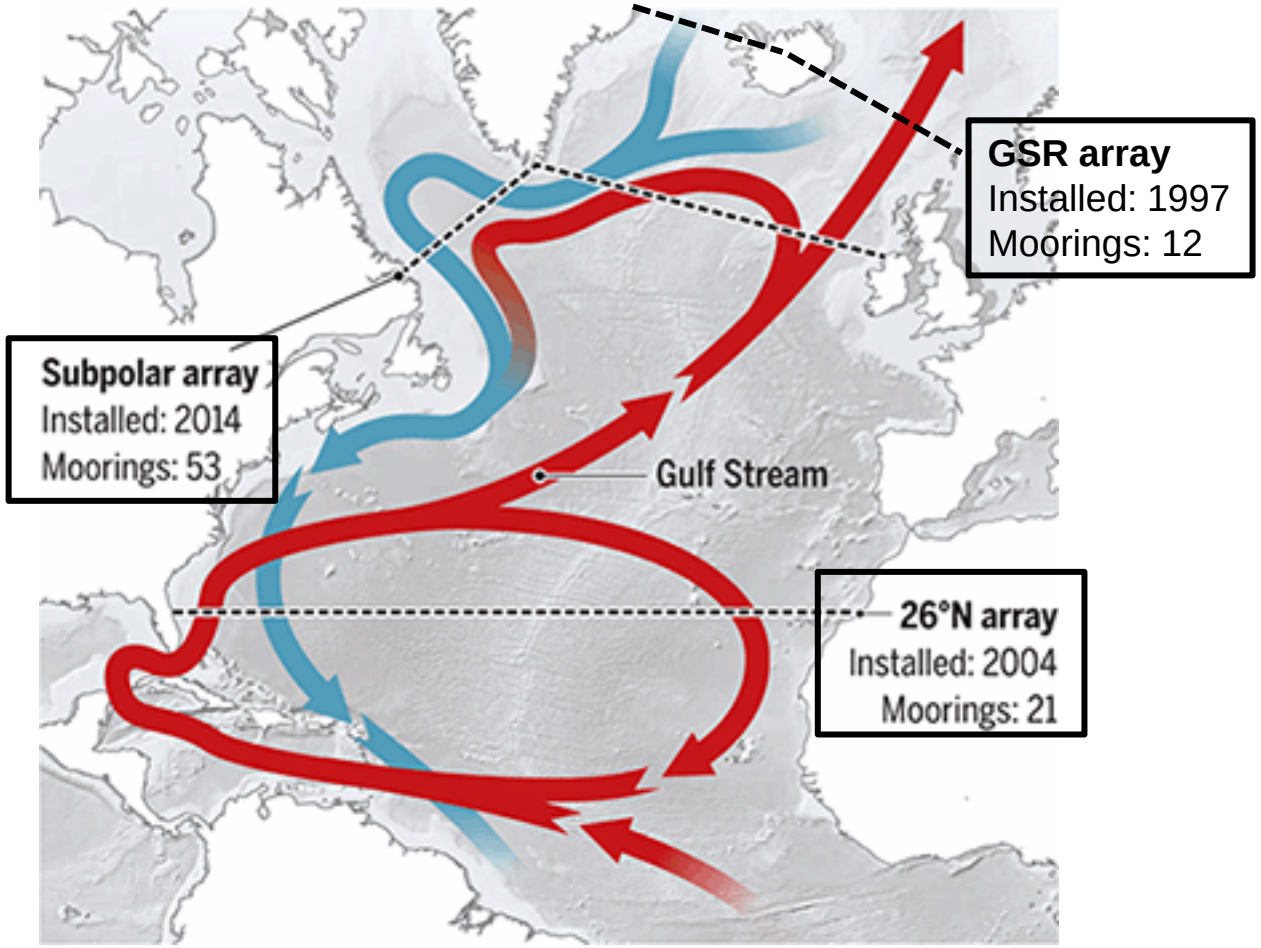
Our European
"Climate Oasis"



Hughes et al. 2016; https://www.uib.no/en/project/dated

In circulation

Arrays monitor circulating currents in the Atlantic Ocean, in which warm shallow waters move north (red), while cold deep waters move south (blue).



C. BICKEL/SCIENCE

Climate change

Gulf Stream current at its weakest in 1,600 years, studies show

Warm current that has historically caused dramatic changes in climate is experiencing an unprecedented slowdown and may be less stable than thought - with potentially severe consequences

Damian Carrington
Environment editor
@dpcarrington
Wed 11 Apr 2018 18.00 BST

20,514

This article is over 4 months old

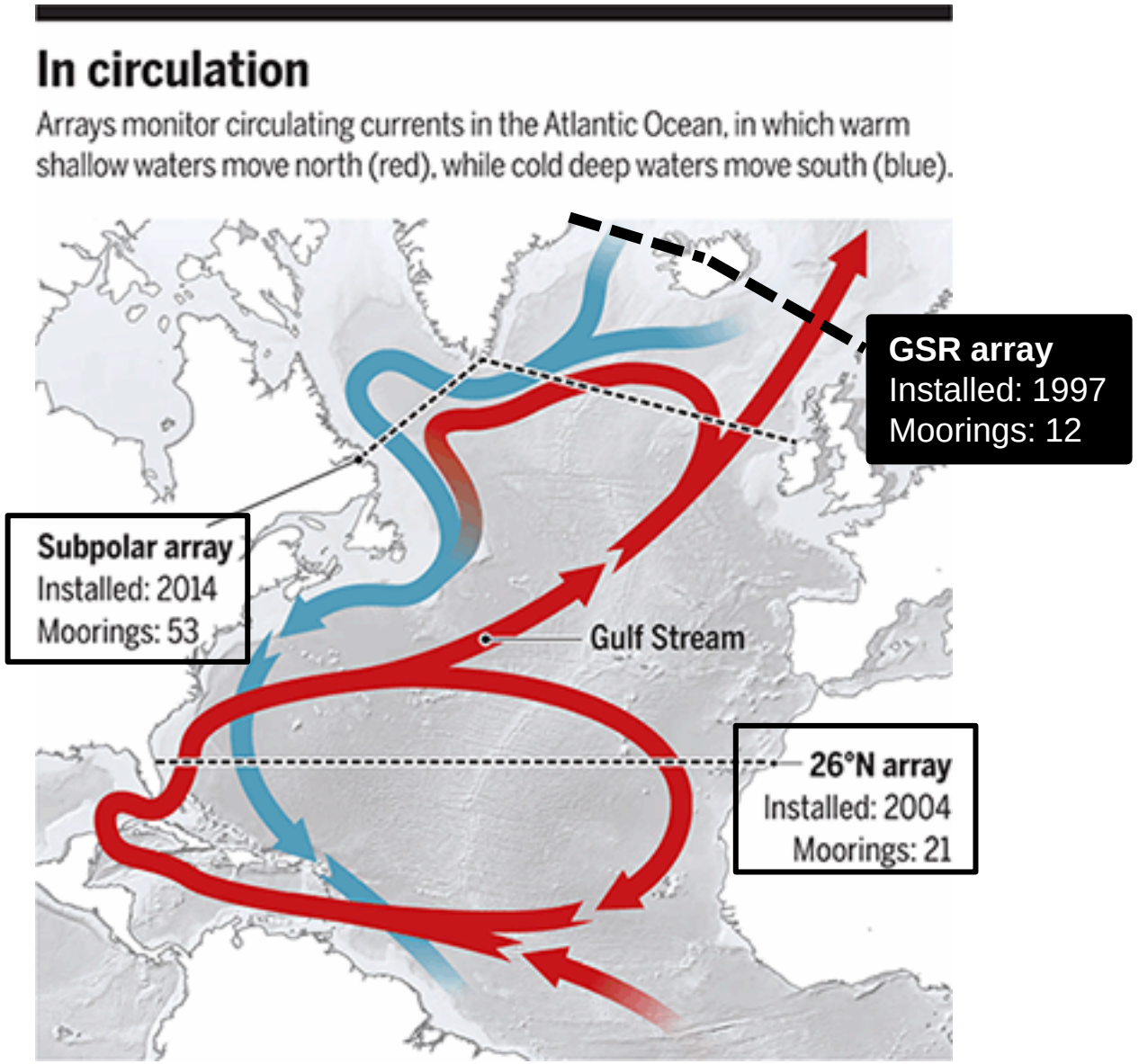
▲ Scene from The Day After Tomorrow showing the Statue of Liberty covered in ice. In the film a rapid shutdown of the Amoc current causes the temperatures to plummet overnight. In reality the change will be much slower, but still dramatic.
Photograph: 20th Century Fox/Kobal/REX/Shutterstock

The Guardian

11/4/2018

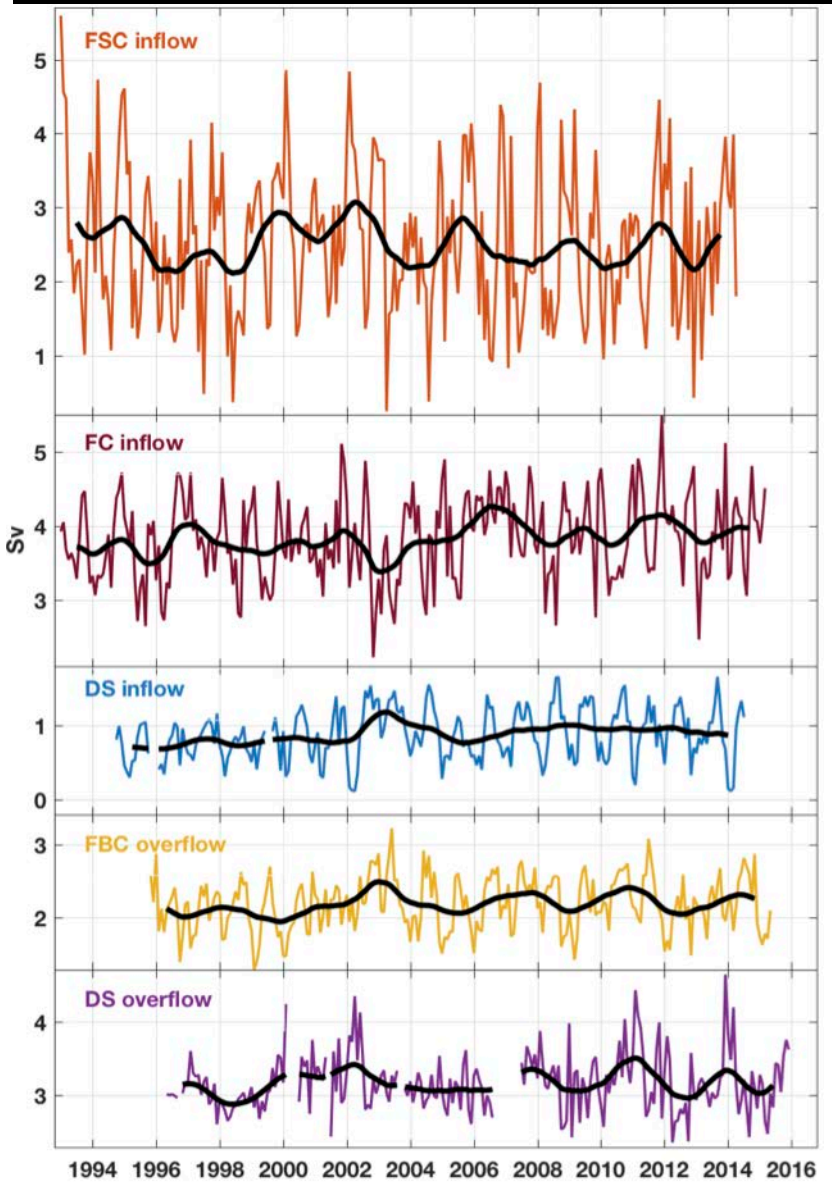
The warm Atlantic current linked to severe and abrupt changes in the climate in the past is now at its weakest in at least 1,600 years, new research shows. The findings, based on multiple lines of scientific evidence, throw into question previous predictions that a catastrophic collapse of the Gulf Stream would take centuries to occur.

Such a collapse would see western Europe suffer far more extreme winters, sea levels rise fast on the eastern seaboard of the US and would disrupt vital tropical rains. The new research shows the current is now 15% weaker than around 400AD, an exceptionally large deviation, and that human-caused global warming is responsible for at least a significant part of the weakening.



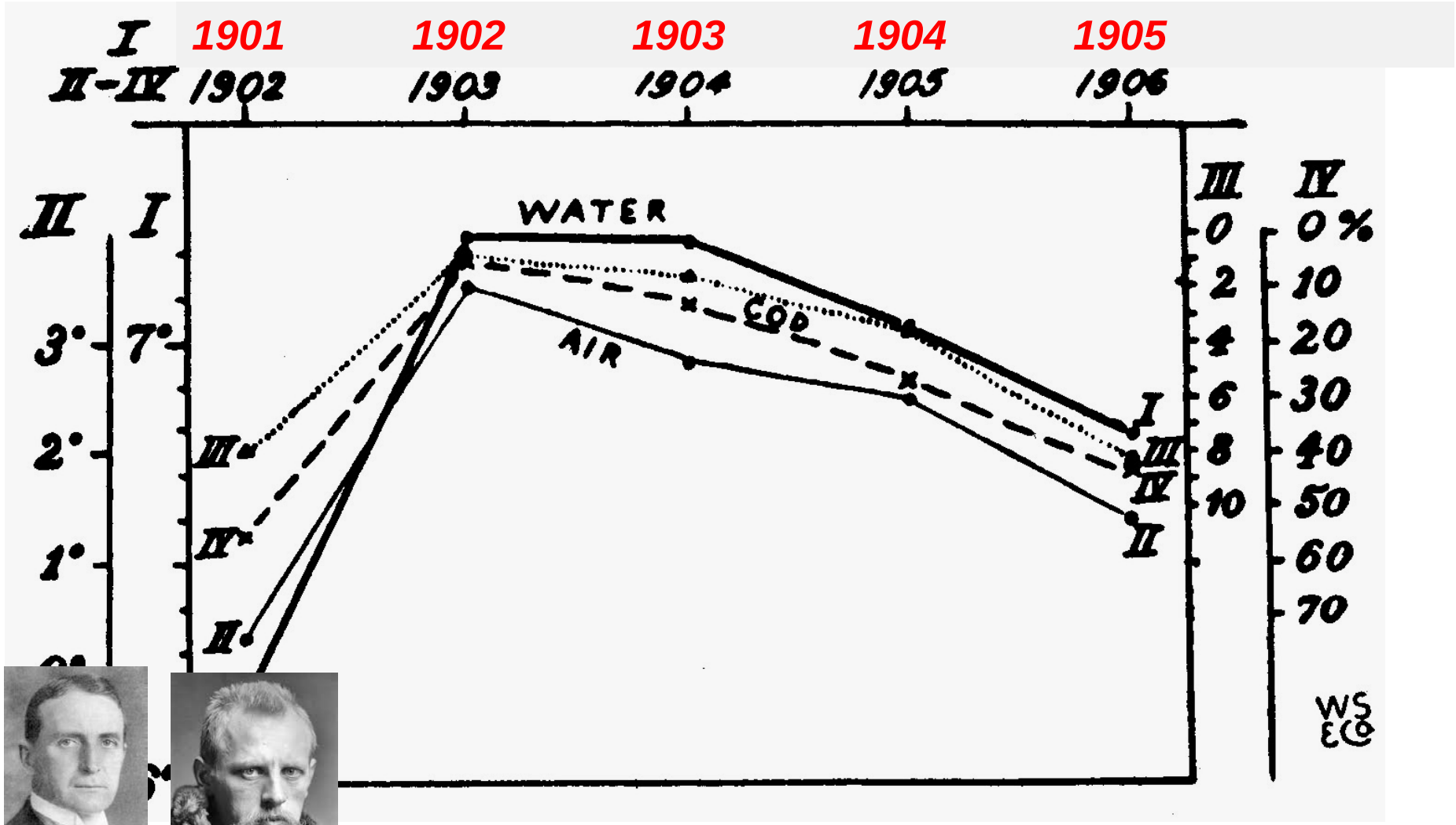
C. BICKEL/SCIENCE

Observed, Greenland-Scotland Ridge



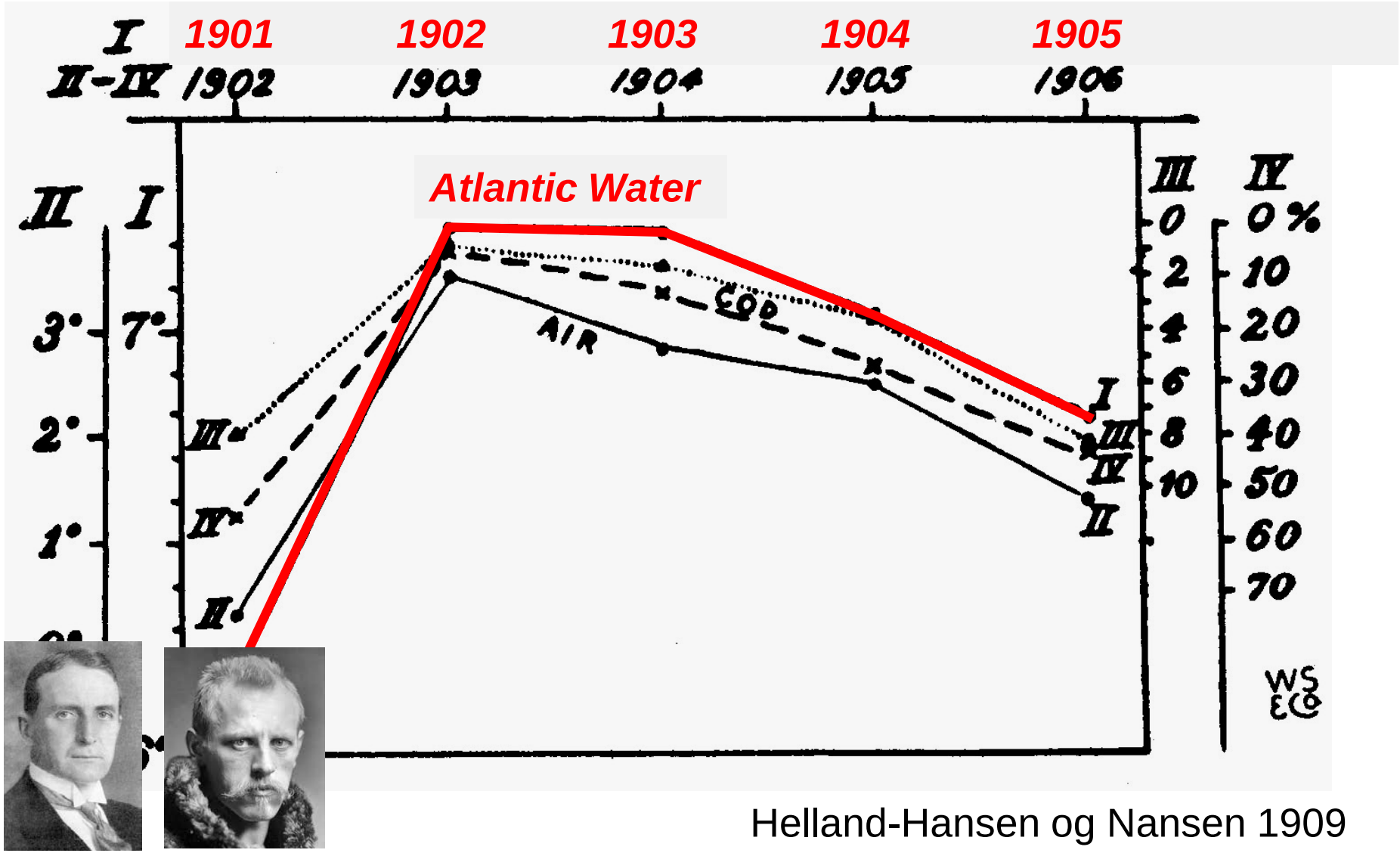
Bringedal et al., 2018, *Journal of Climate*

An early vision of a predictable climate

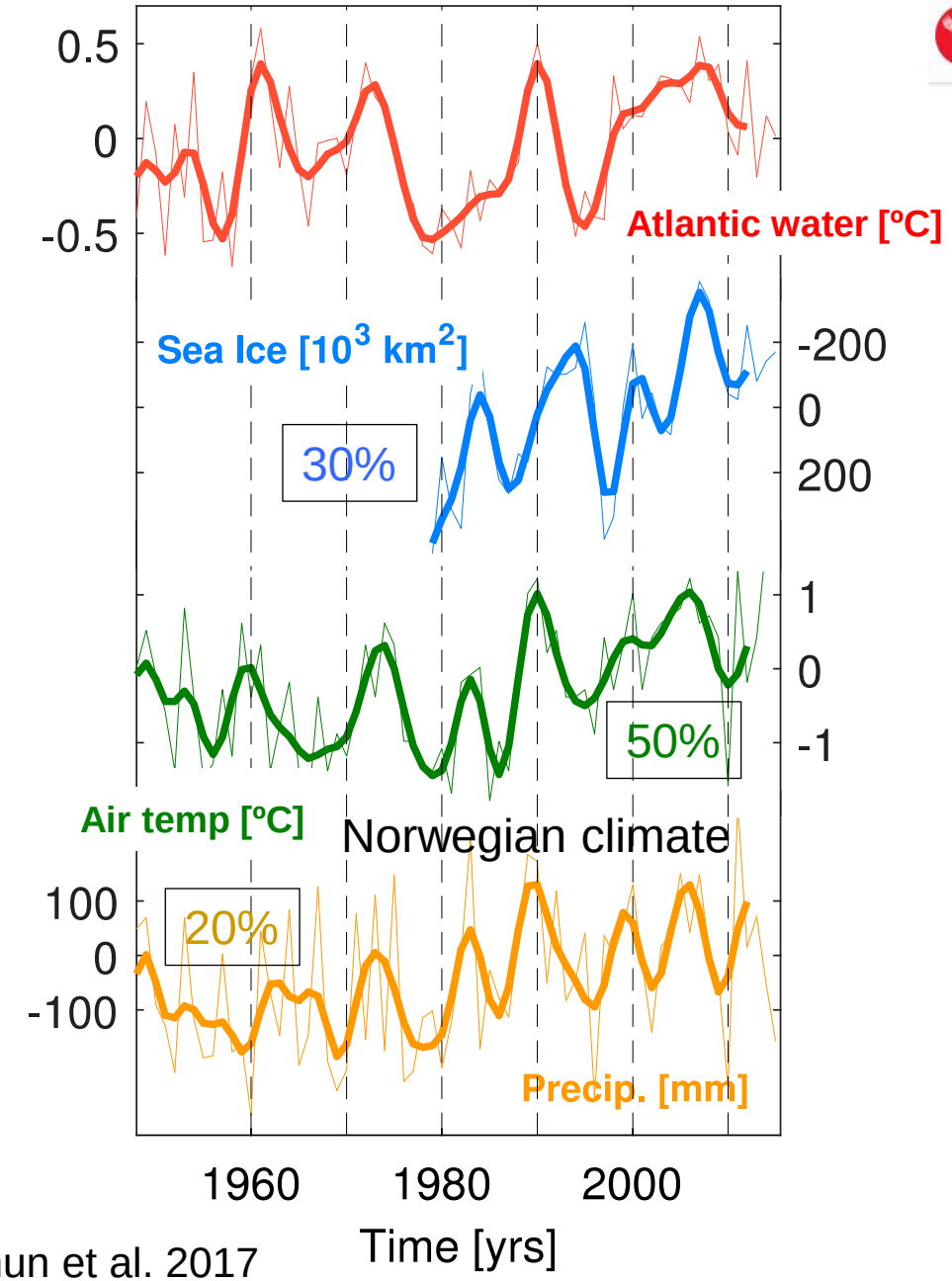


Helland-Hansen og Nansen 1909

An early vision of a predictable climate



Helland-Hansen og Nansen 1909



Årthun et al. 2017

INDEPENDENT News InFact Politics Voices Indy/Life Sport Business Video Culture

14/2/2018

Environment

First ship crosses Arctic in winter without an icebreaker as global warming causes ice sheets to melt

Crossing of polar region is becoming easier due to warming global temperatures and thinning sea ice

Josh Gabbatiss Science Correspondent | Wednesday 14 February 2018 18:00 GMT | 11 comments

2K shares

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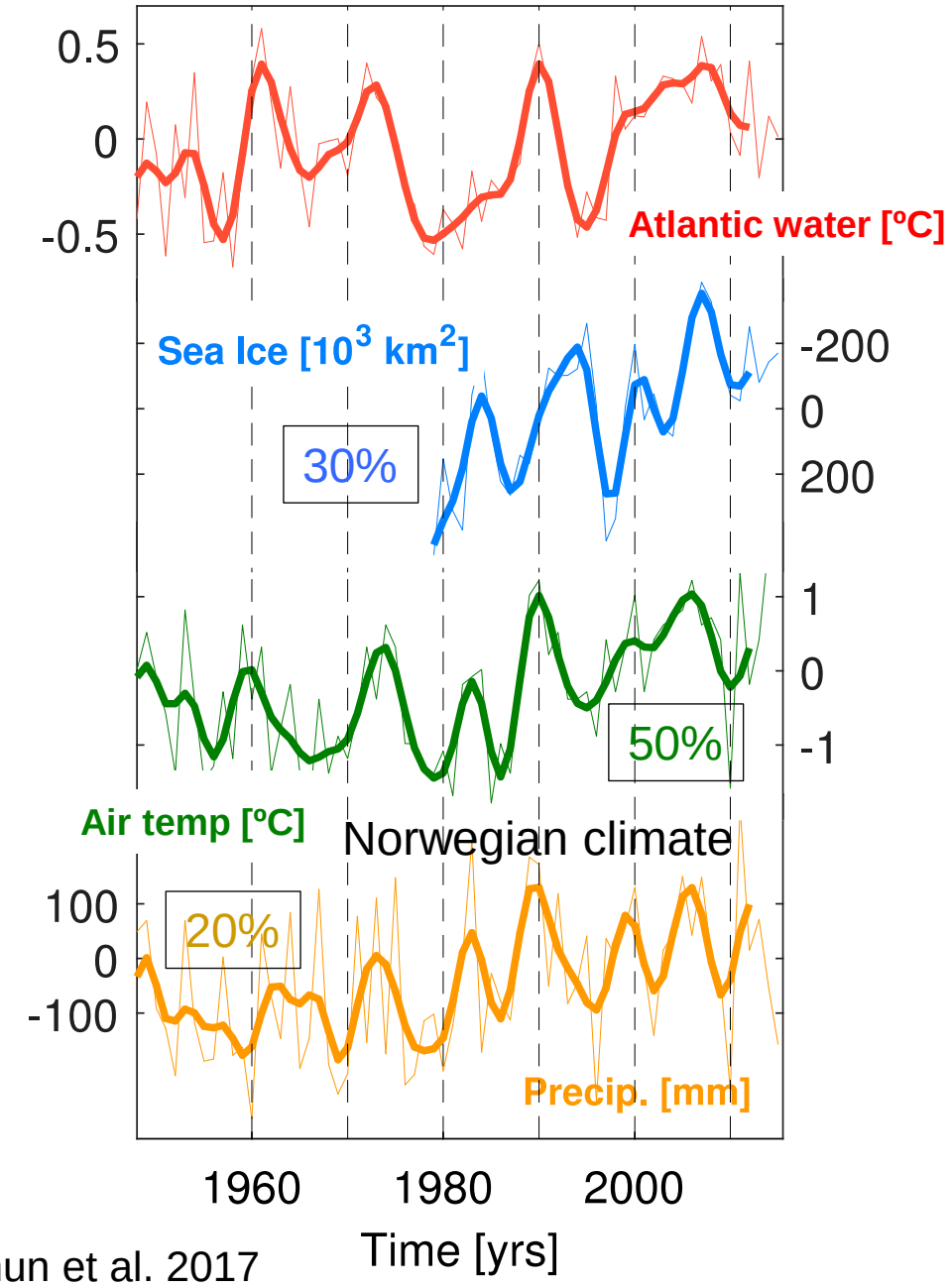
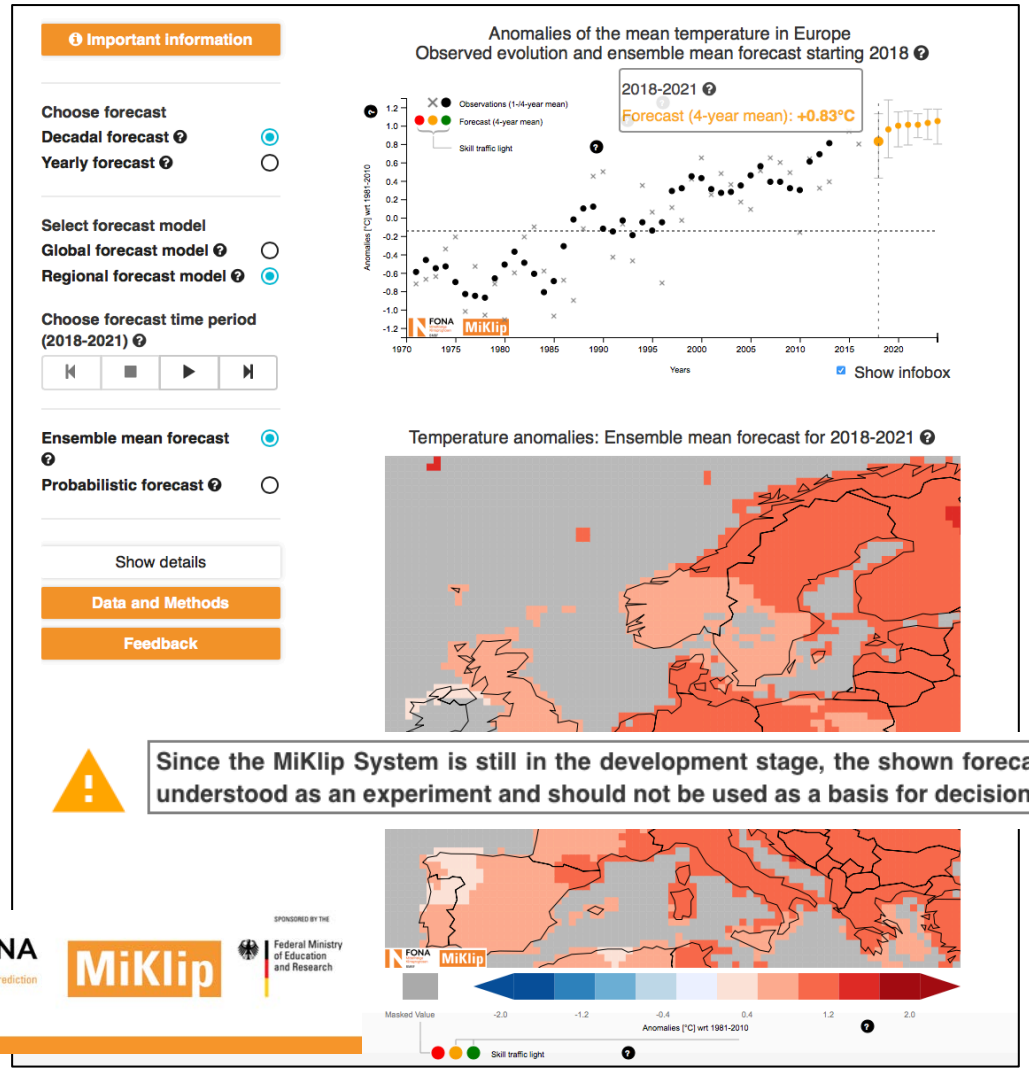


Årthun et al. 2017



The Vision

*The climate equivalent to weather forecasting, skilfully – and **usefully** – seeing seasons-to-years into the future*

Blue-Action and AtlantOS have received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727852 and No 633211.

The Slowing Gulf Stream? A science-policy breakfast discussion

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4 September 2018, European Parliament, Brussels (BE)

BLUE ACTION

AtlantOS

Panel Discussion

Dr. Ben MOAT, National Oceanography Centre, UK
Dr. Karin Margretha LARSEN, Havstovan, Faroe Islands
Dr. Marilena OLTMANNS, GEOMAR, Germany
Dr. Marius ÅRTHUN, University of Bergen, Norway

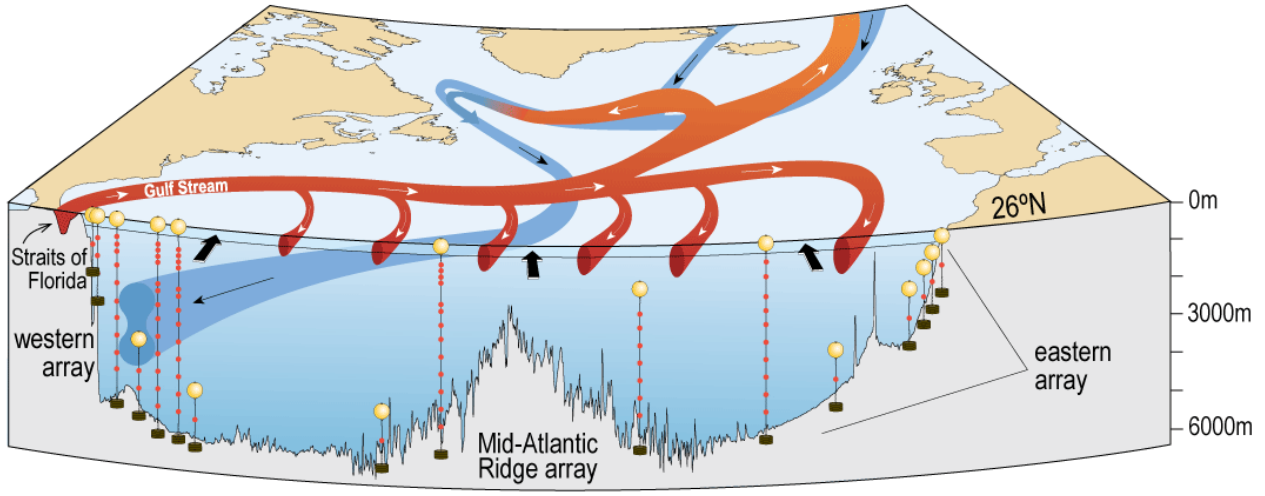
What can Atlantic ocean observations tell us?

Dr. Ben Moat

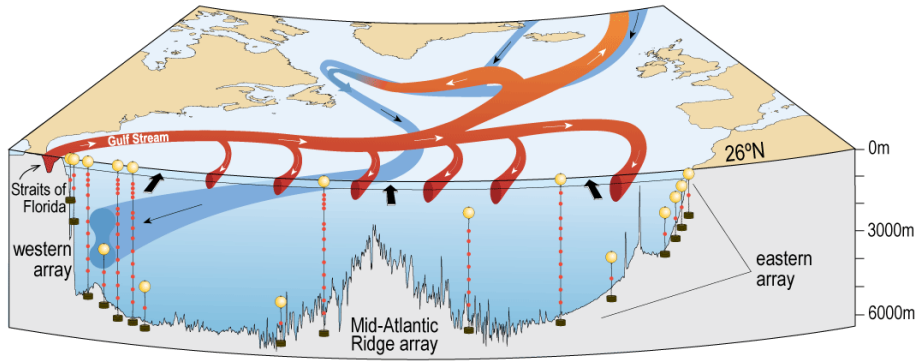
National Oceanography Centre (UK)

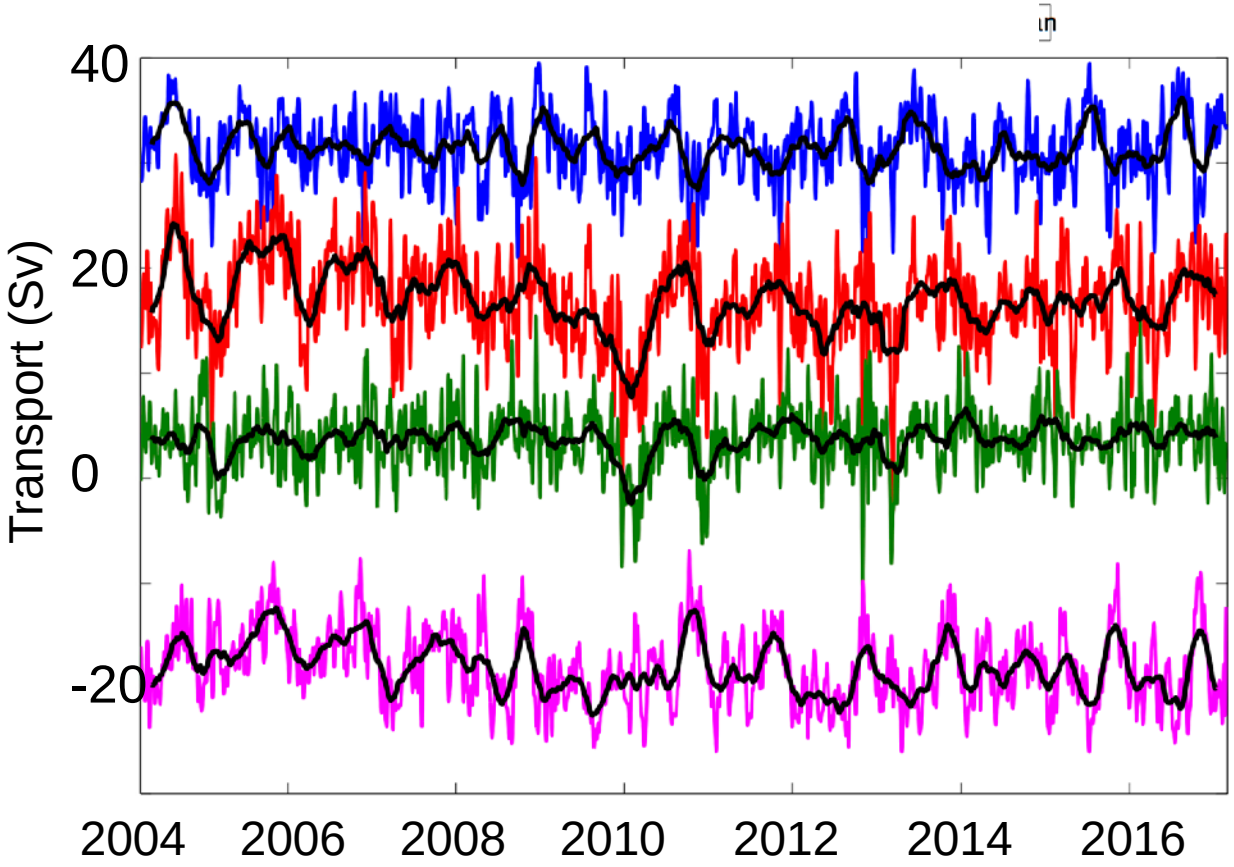
The importance of ocean observing

- Time series of the Atlantic Meridional Overturning Circulation (AMOC) at 26N from 2nd April 2004 to 28th February 2017
- The array has 29 moorings and landers and 226 instruments
- To date there have been 28 cruises and more than 600 days at sea
- Almost 300 technicians, scientists, students, officers and crew have taken part
- Next expedition Autumn 2018



The RAPID 26°N time series





Florida Straits

Atlantic Meridional Overturning circulation (AMOC)

Wind driven Surface layer

Southwards return flow

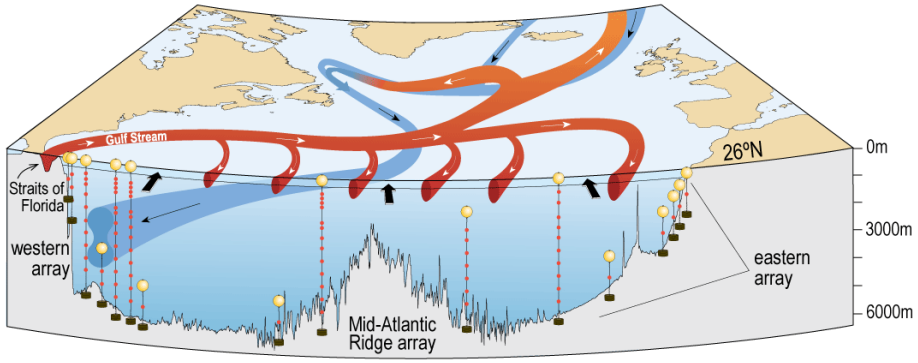
1 Sv = 1,000,000 m^3 of water per second

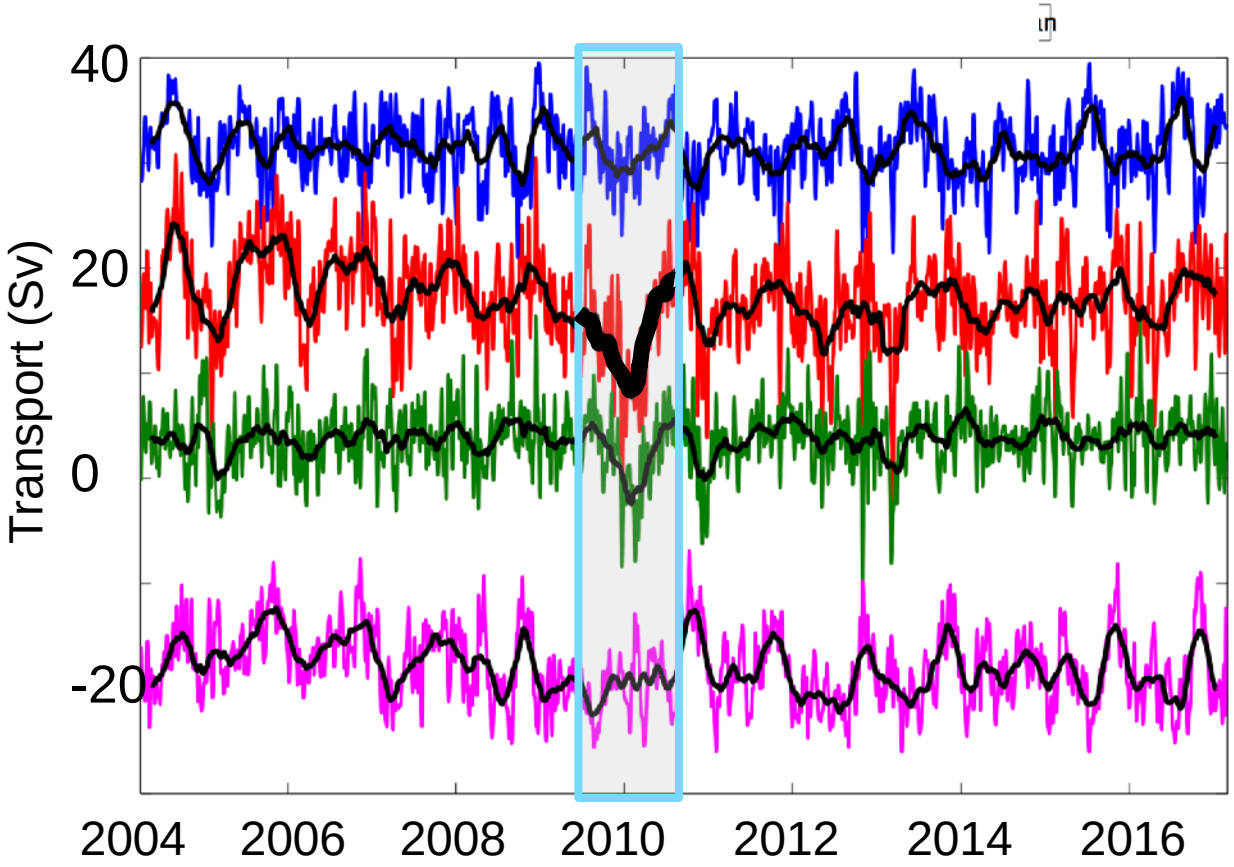
Weaker AMOC means less heat moved into Northern North Atlantic (north of 26N).

Weaker AMOC means warmer subtropical North Atlantic (south of 26N).

DATA available: http://www.rapid.ac.uk/rapidmoc/

The RAPID 26°N time series





Florida Straits

Atlantic Meridional Overturning circulation (AMOC)

Wind driven Surface layer

Southwards return flow

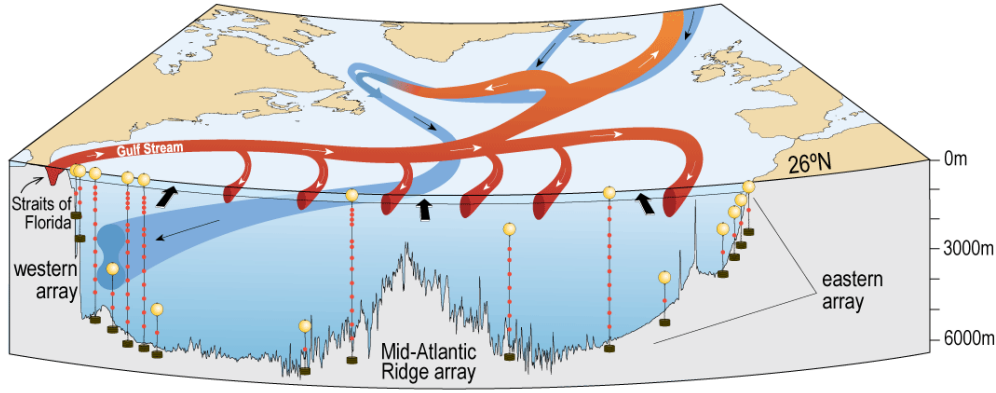
1 Sv = 1,000,000 m^3 of water per second

Large decrease in AMOC in 2010

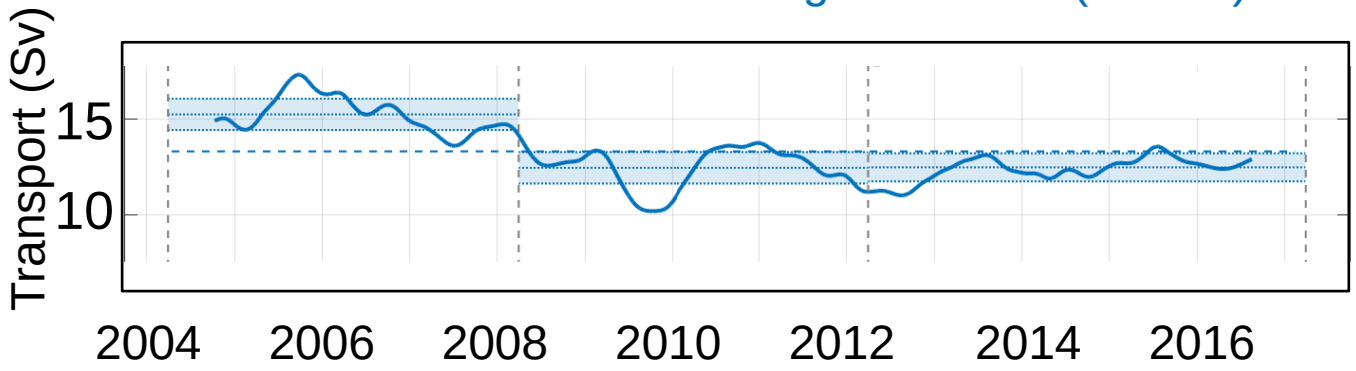
reduced heat transport --> cooler ocean temperatures and linked to a cold winter

DATA available: http://www.rapid.ac.uk/rapidmoc/

First view of decadal change



Atlantic Meridional Overturning circulation (AMOC)



1 Sv = 1,000,000 m^3 of water per second

Since 2009 the AMOC has been (16%) less than from 2004 to 2008

Climate models predict that the AMOC will continue to decline in the 21st Century

AGU PUBLICATIONS

Geophysical Research Letters

RESEARCH LETTER
10.1002/2017GL076350

The North Atlantic Ocean Is in a State of Reduced Overturning

D. A. Smeed[1], S. A. Josey[1], C. Beaulieu[2], W. E. Johns[3], B. I. Moat[1], E. Frajka-Williams[2], D. Rayner[1], C. S. Meinen[4], M. O. Baringer[4], H. L. Bryden[2], and G. D. McCarthy[1,5]

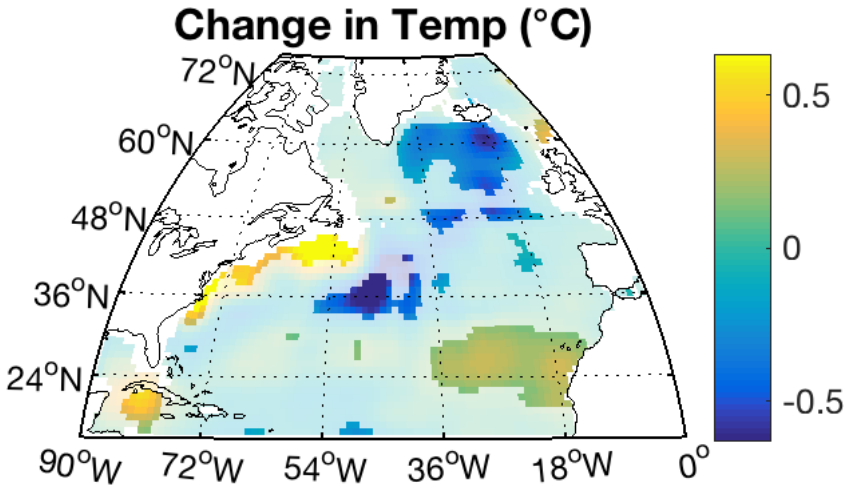
[1]National Oceanography Centre, Southampton, UK, [2]Ocean and Earth Science, University of Southampton, Southampton, UK, [3]Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL, USA, [4]Atlantic Oceanographic and Meteorological Laboratory, NOAA, Miami, FL, USA, [5]ICARUS, Department of Geography, Maynooth University, Maynooth, Ireland

Key Points:
- New data from the RAPID 26°N array show that the AMOC has been in a state of reduced overturning since mid-2008
- Observations of heat content and SSH indicate that the impact of the reduction in the AMOC is similar to that predicted by climate models
- The results indicate that changes in ocean heat transport have altered ocean-atmosphere heat exchange over the North Atlantic

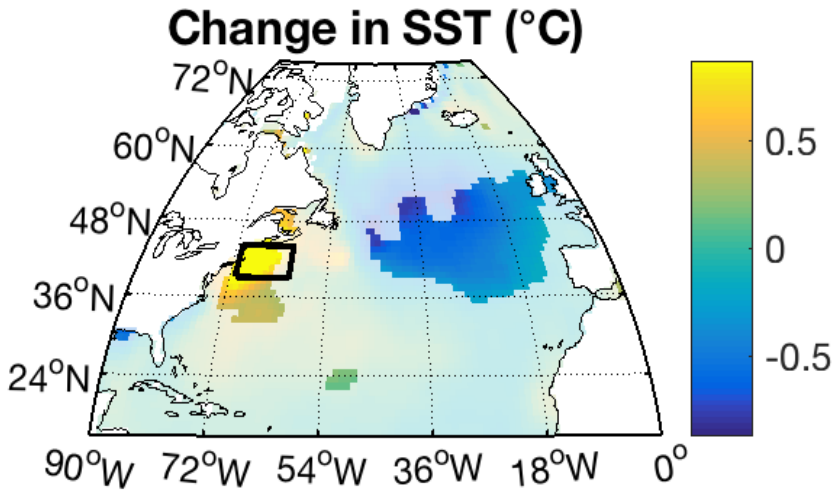
Supporting Information:
- Supporting Information S1

Correspondence to:
D. A. Smeed,
das@noc.ac.uk

Changes in the North Atlantic between (2004 to 2008) and (2009 to 1016)



surface to 1000m

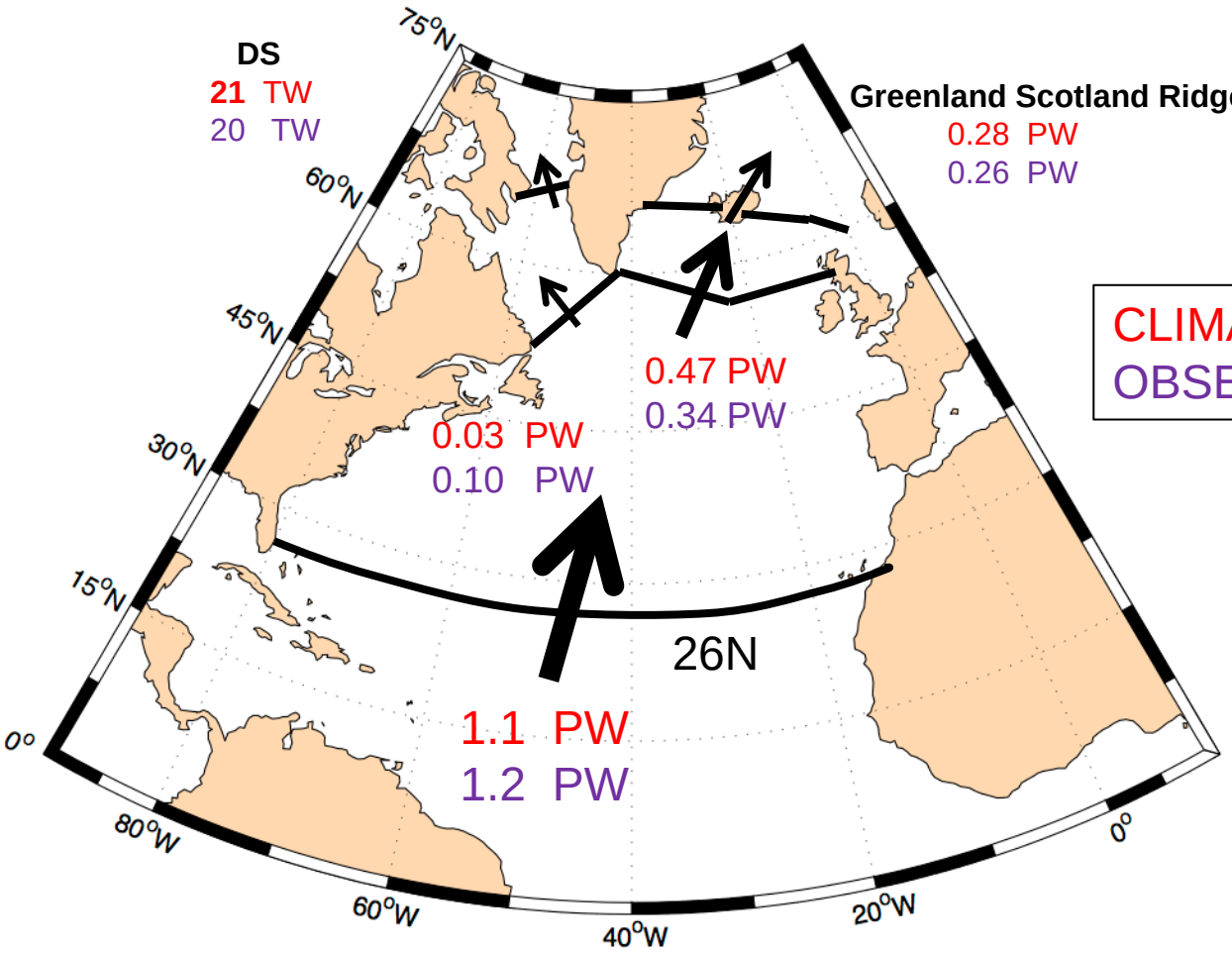


Sea surface temperature

Weak AMOC leads to **reduced** sea surface temperatures and upper ocean temperatures (blue shading)

Yellow is an increase in temperature
Blue is a decrease in temperature

Climate model evaluation



CLIMATE MODEL
OBSERVATION

Heat transported across 26N is equivalent to 1,000,000 power stations.

Ocean gives up heat to the atmosphere

AMOC is largely responsible for the relatively mild climate of Western Europe

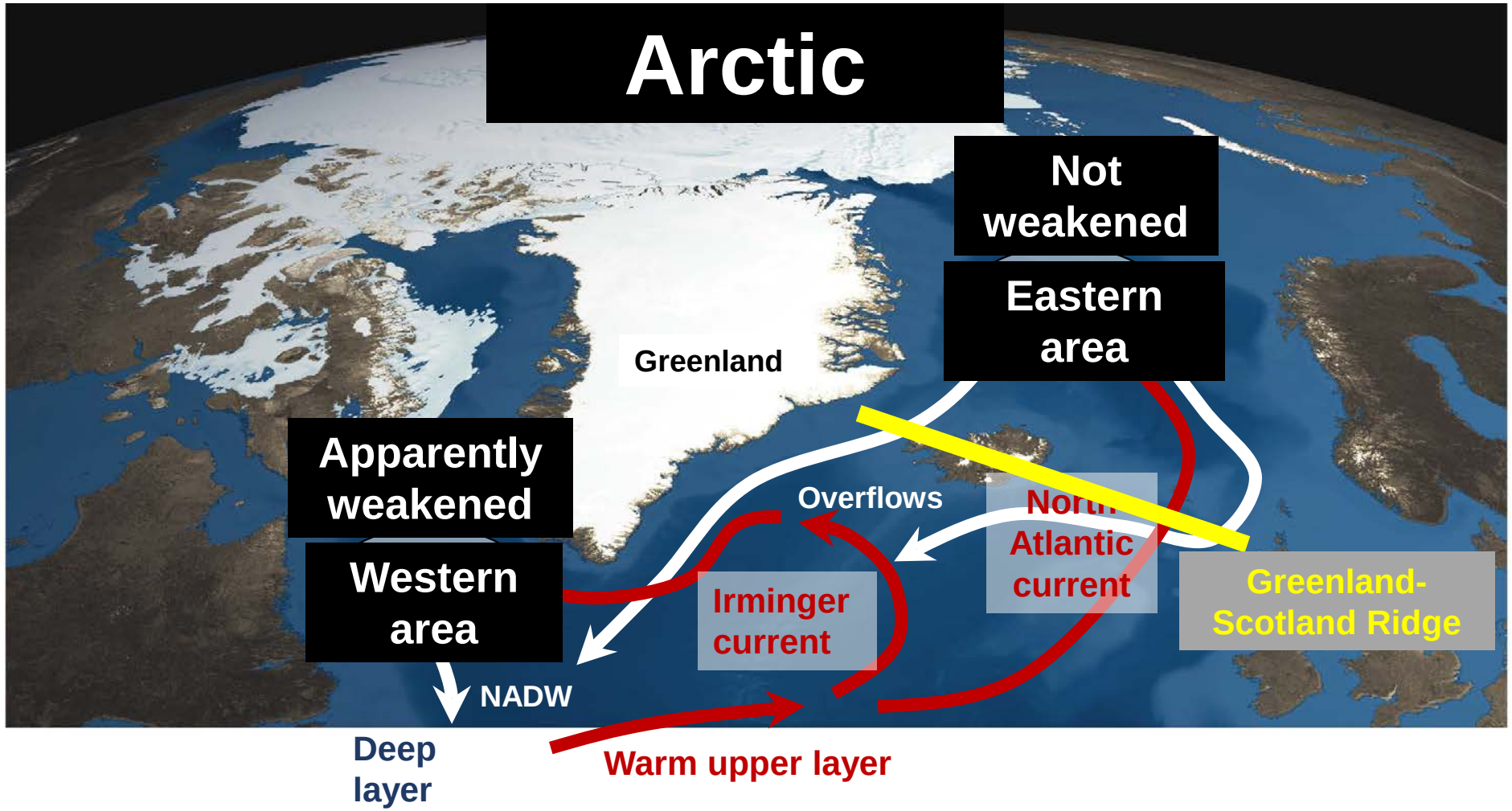
A view from the gateways to the Arctic

- an example from the Greenland-Scotland Ridge

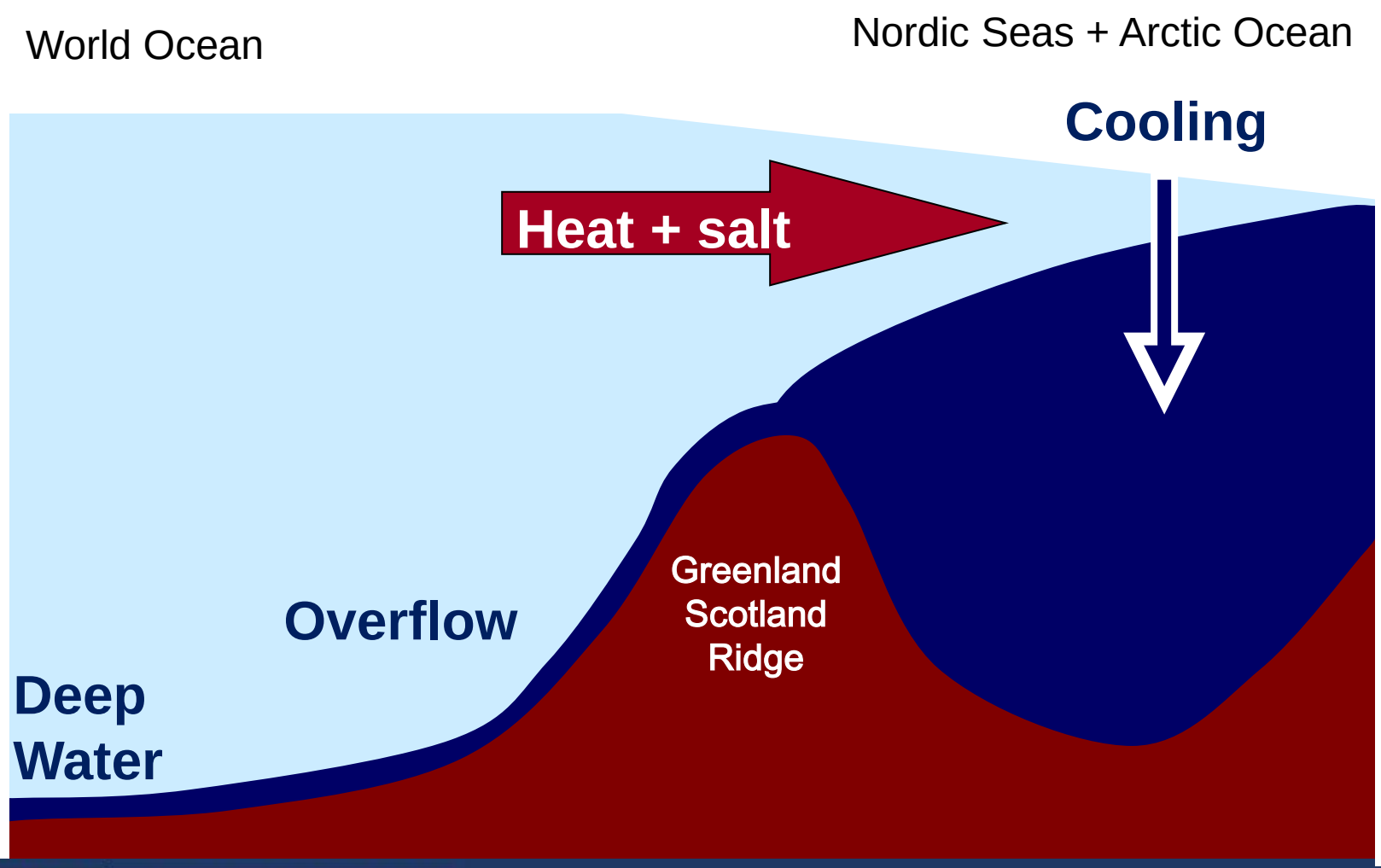
Dr. Karin Margretha H. Larsen

Faroe Marine Research Institute

Two ventilation areas



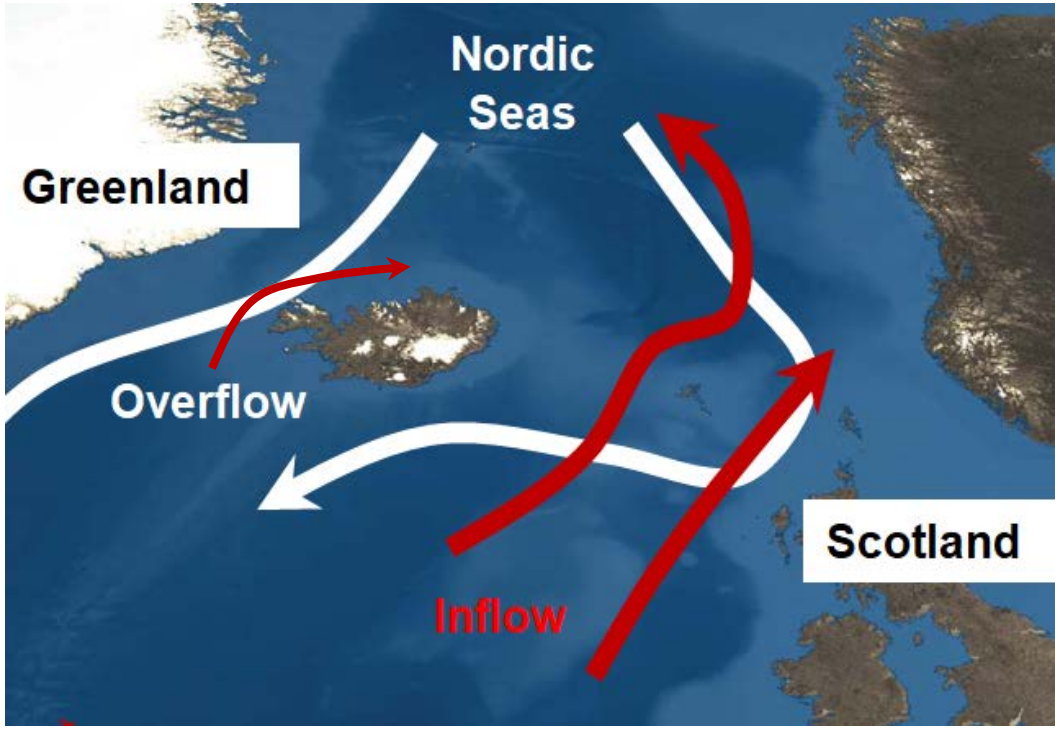
Positive feedback loop



Present state:
Rising temperature accompanied by rising salinity

If freshening would occour:
Turn loop into a vicious circle?

Greenland-Scotland Ridge - Exchanges



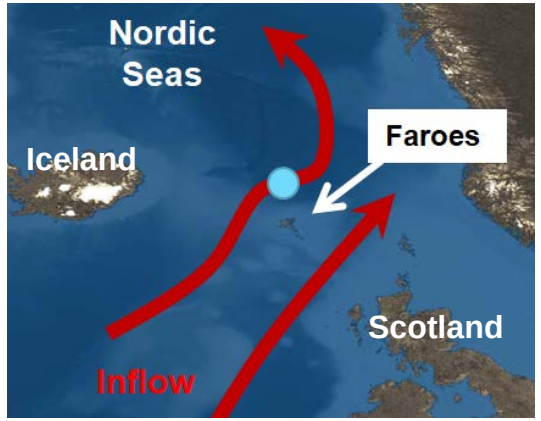
Stable flow:
No trend in transports

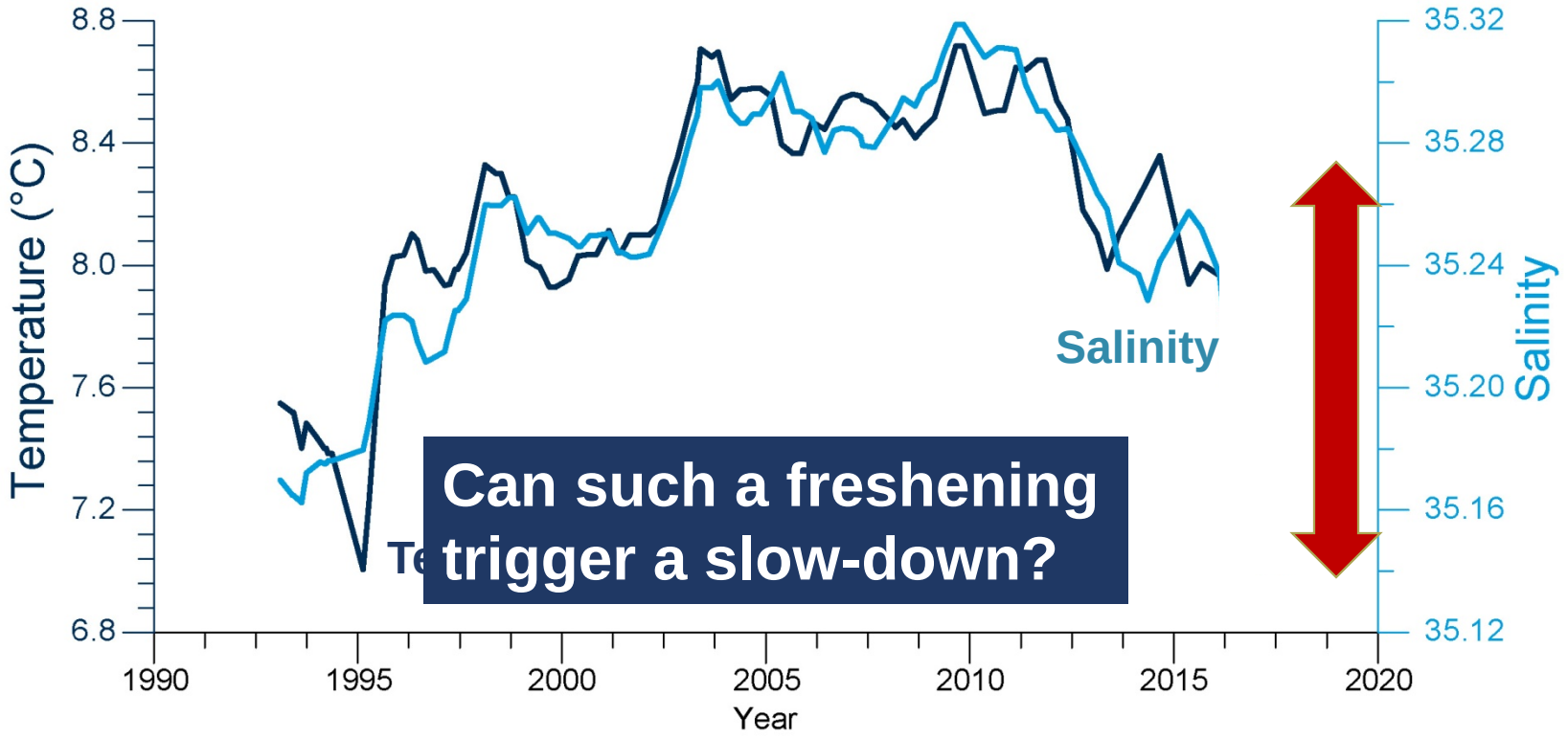
Keeps northwestern Europe warm...

...and melts the Arctic sea-ice

Østerhus et al, in prep

Example from the Faroe Current



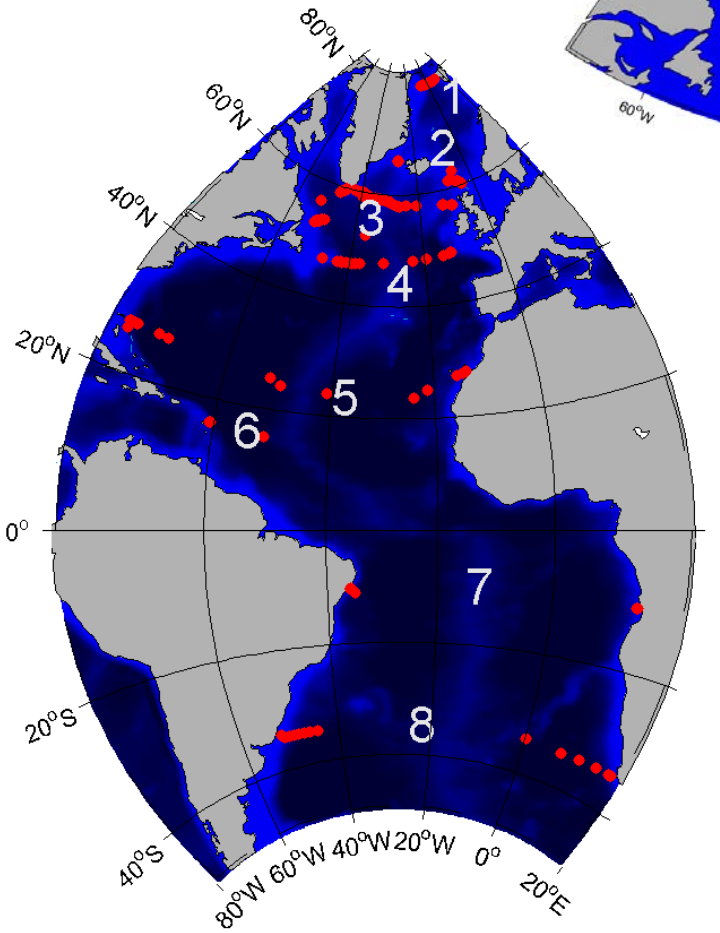


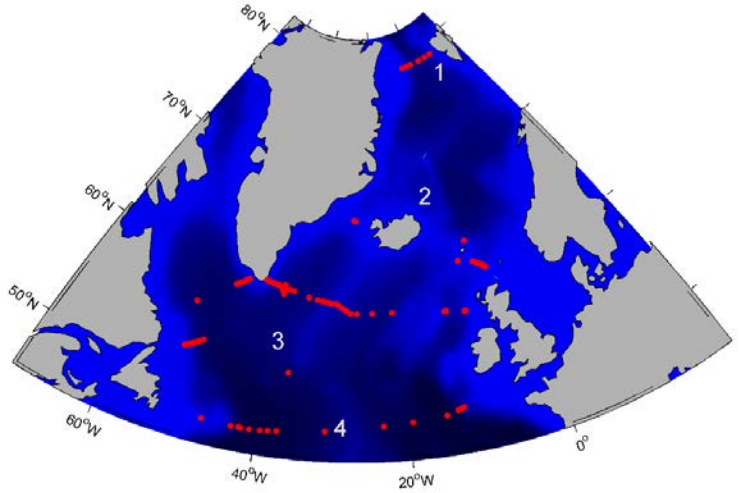
Can such a freshening trigger a slow-down?

Are we approaching a tipping point?

Observations of the circulation

- AtlantOS observational arrays span the Atlantic Ocean
- Each array provides important information on circulation and processes
- Help us understand the role of the ocean in the climate system





http://www.oceansites.org/tma/index.html

Summary

- The Eastern deep water formation area seems stable
  - Based on more than 20 years of observations from the Greenland-Scotland Ridge
- Recent freshening raises concern
  - Is it an Early Warning signal?
- Underlines the importance of continued observations
  - Also in apparent “no-change” conditions

How the North Atlantic Ocean is linked to European climate

Dr. Marius Årthun

Geophysical Institute, University of Bergen, Norway

Bjerknes Centre for Climate Research

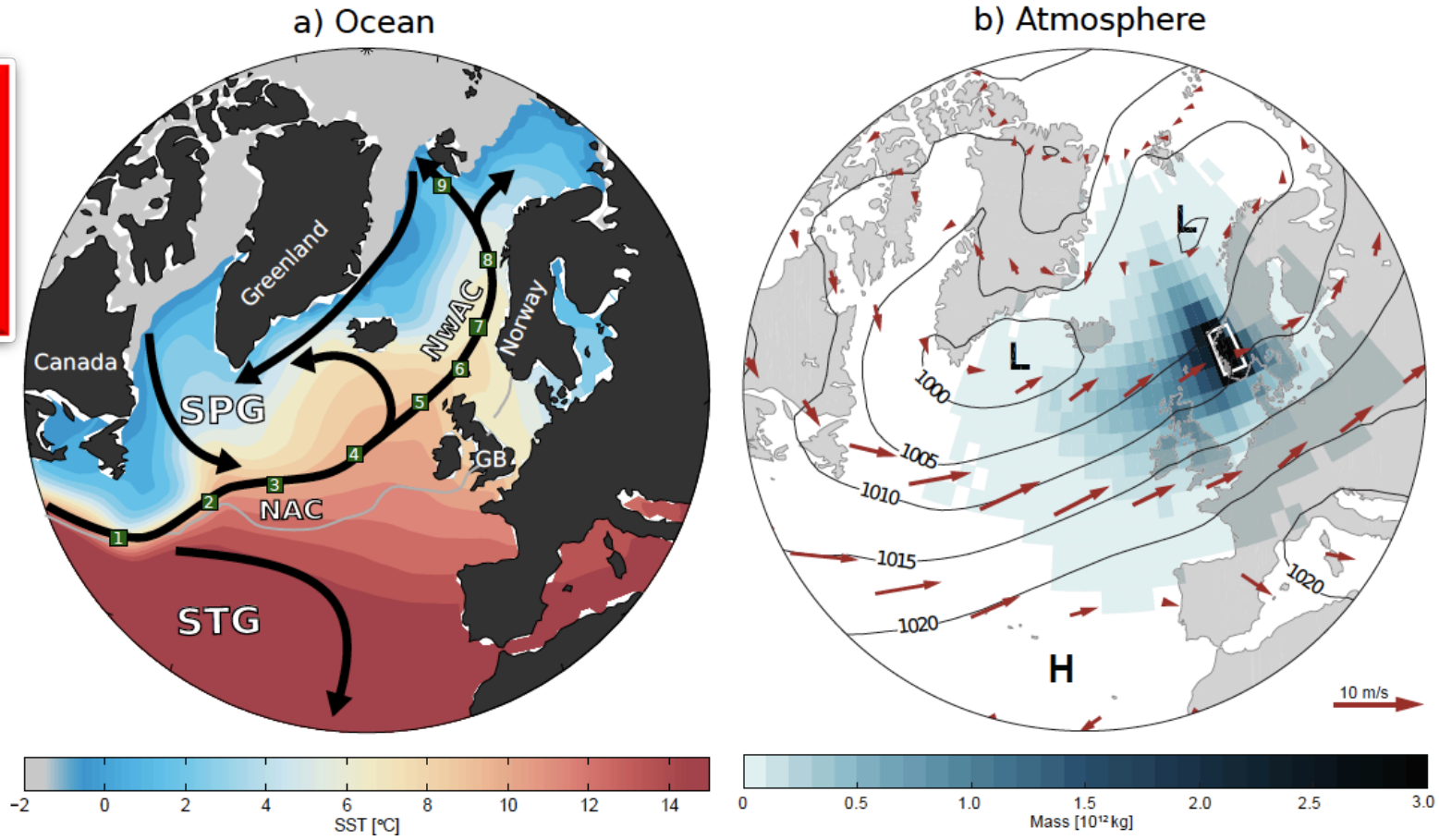
BLUE ACTION

AtlantOS

European climate: The Gulfstream and the westerly winds

Ocean
Provides the memory in the climate system

Predictable several years ahead

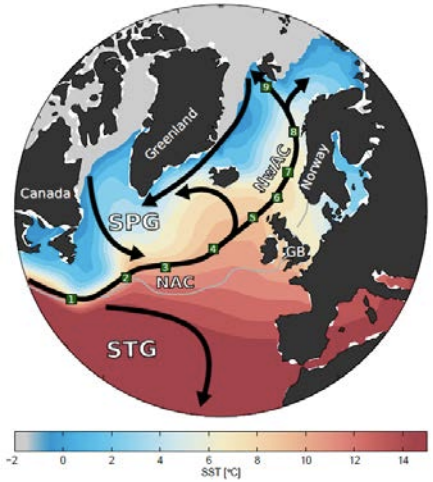


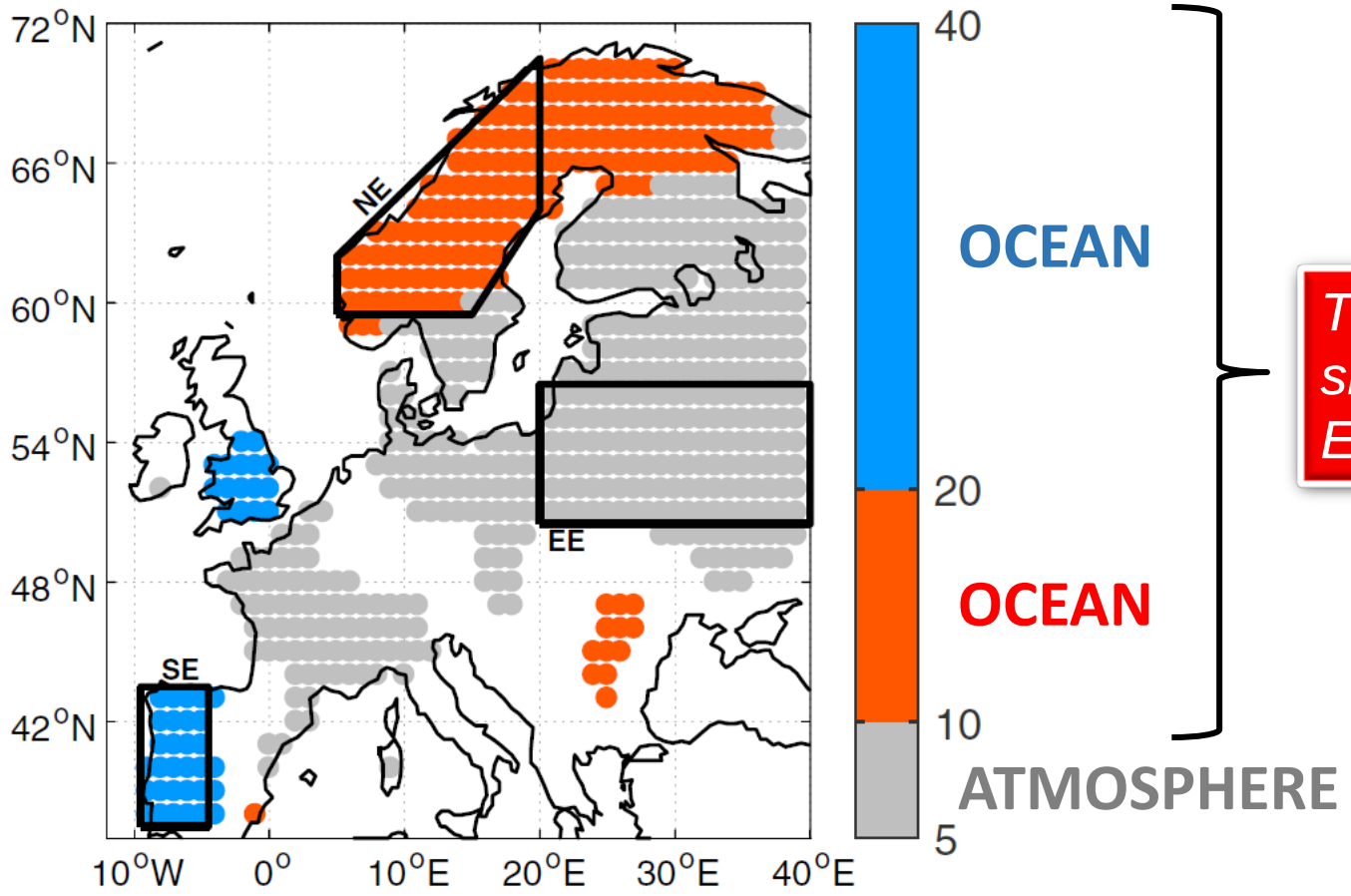
Atmosphere
Short memory

Generally not predictable beyond seasonal time scales

Årthun et al. (2017)

How the North Atlantic Ocean is linked to European climate



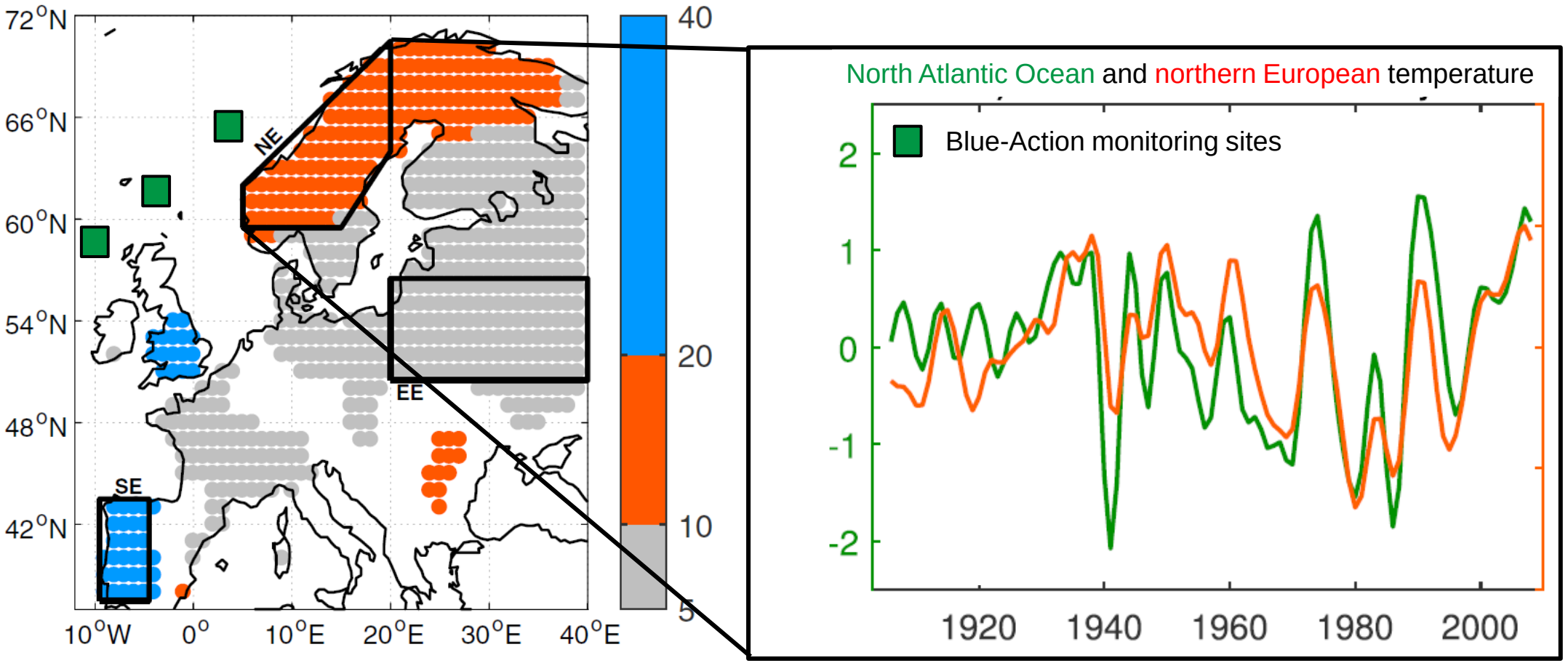


The ocean controls slow variations in European temperature.

Colours: The leading time scale (in years) of air temperature variability

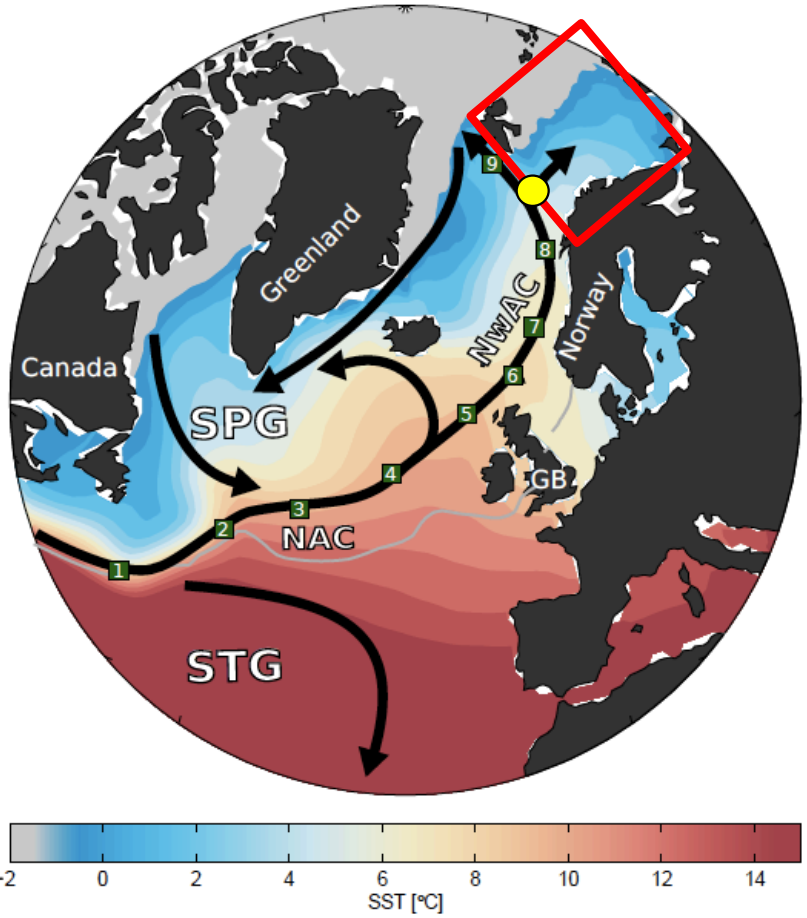
Årthun et al. (2018)

How the North Atlantic Ocean is linked to European climate



Årthun et al. (2018)

Example of prediction: Arctic sea ice



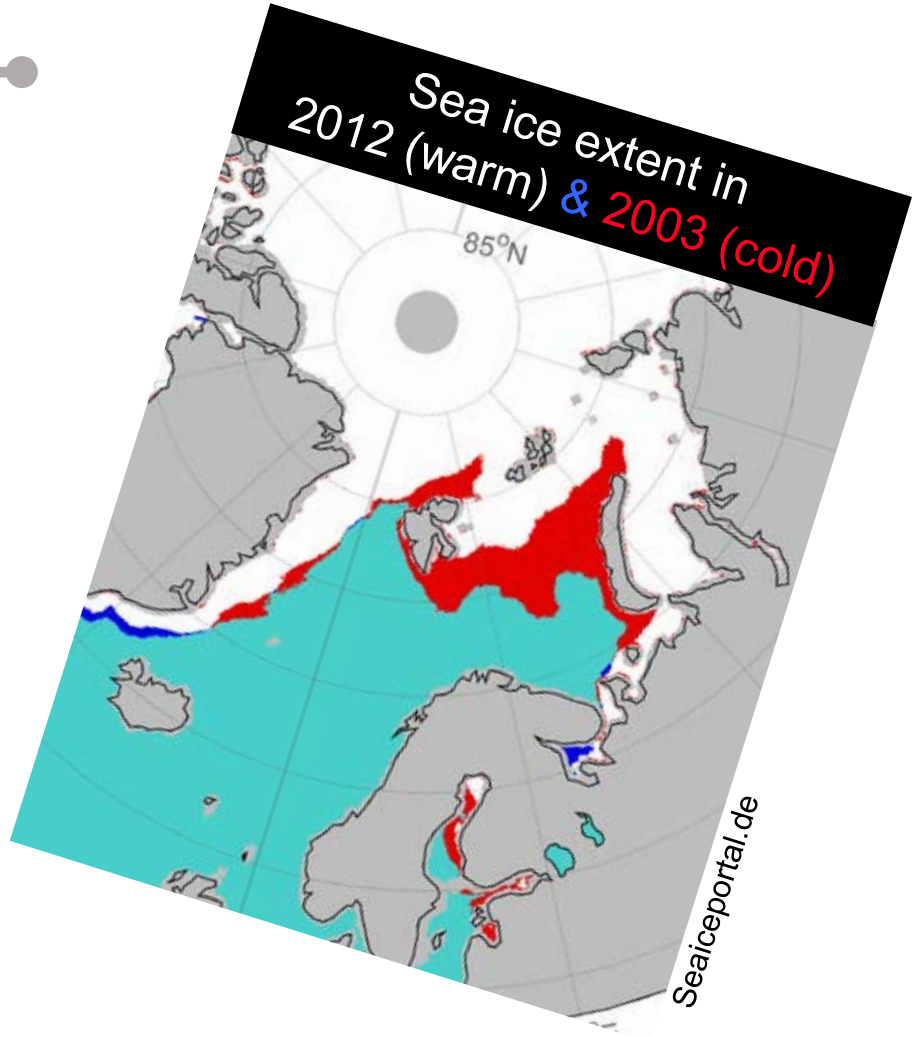
Warm ocean

↓

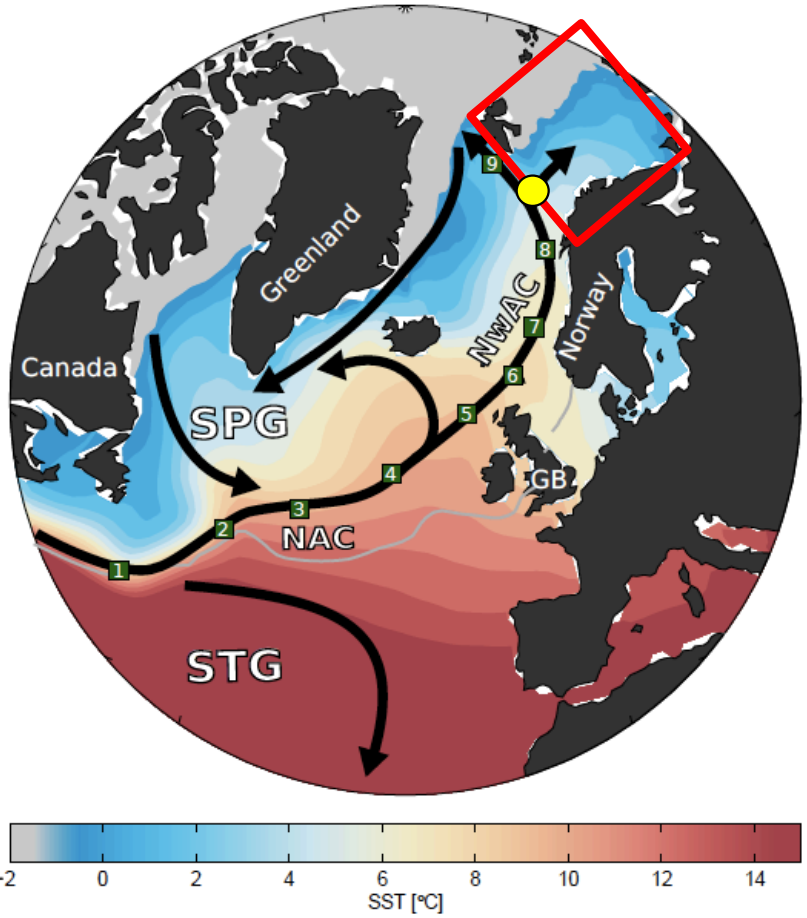
Less sea ice

↓

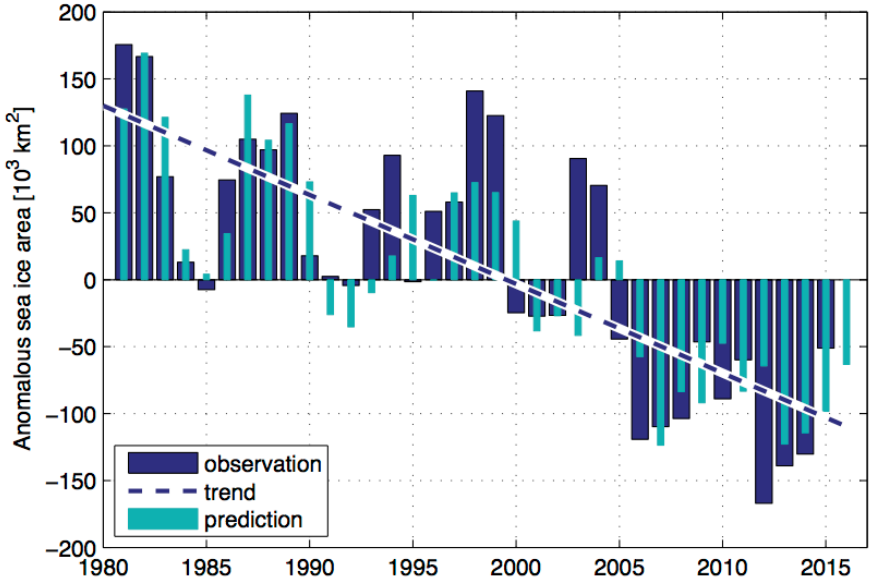
Implications for fisheries, shipping, offshore industry



Example of prediction: Arctic sea ice



Winter sea ice in the Barents Sea can be predicted from **observed** ocean temperature 1-2 years before.



Correct prediction: 31/35

Onarheim et al. (2015)

How the North Atlantic Ocean is linked to European climate

Climate forecasts – benefit for society

Climate forecasts – soon a reality?

How will the snow conditions be next year?

Where will the ice edge be in 2020?

Are the next few summers going to be wet?

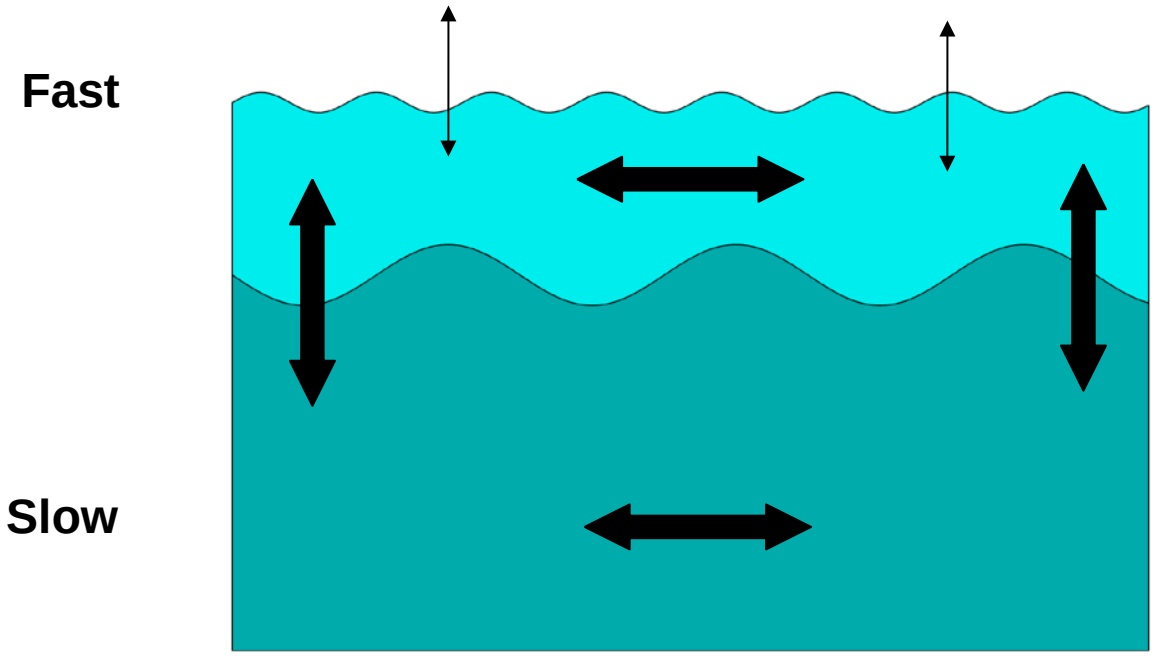
Courtesy of H.R. Langehaug

What to expect from the future?

Dr. Marilena Oltmanns

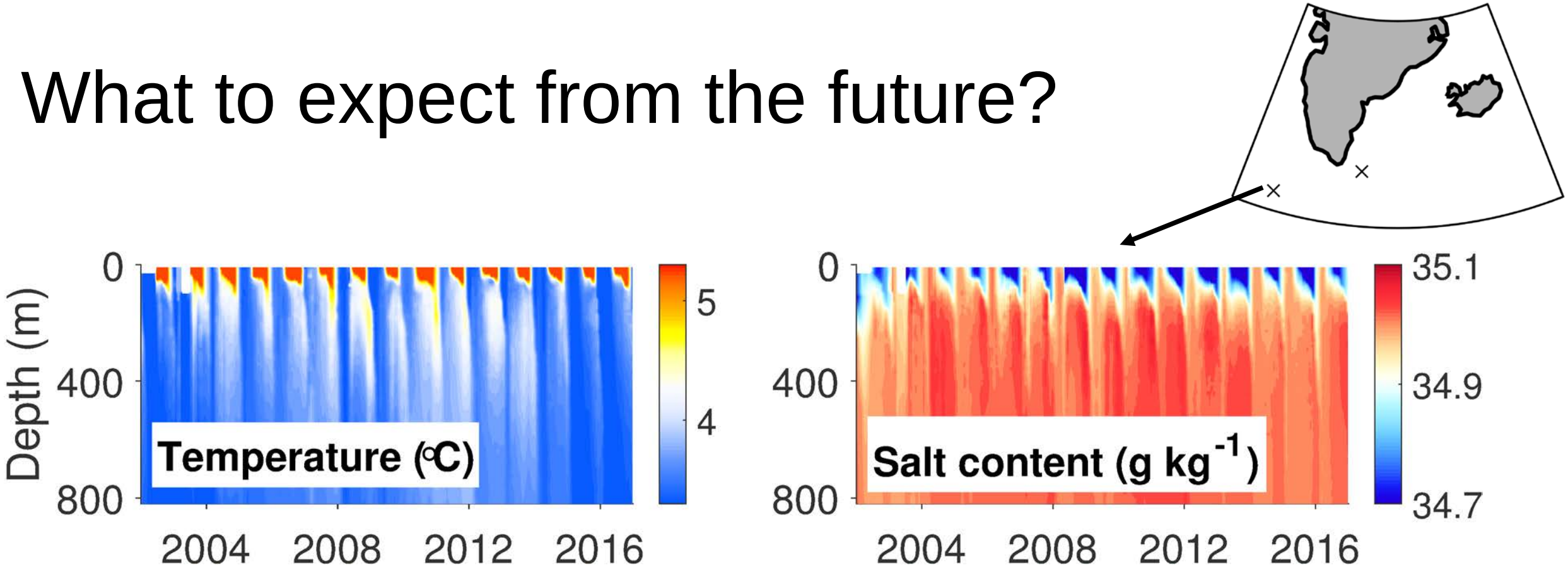
GEOMAR - Helmholtz Centre for Ocean Research Kiel (DE)

What to expect from the future?



- Complex interactions between ice, ocean and atmosphere on a range of timescales make predictions challening.
- Important question: Are there critical thresholds?

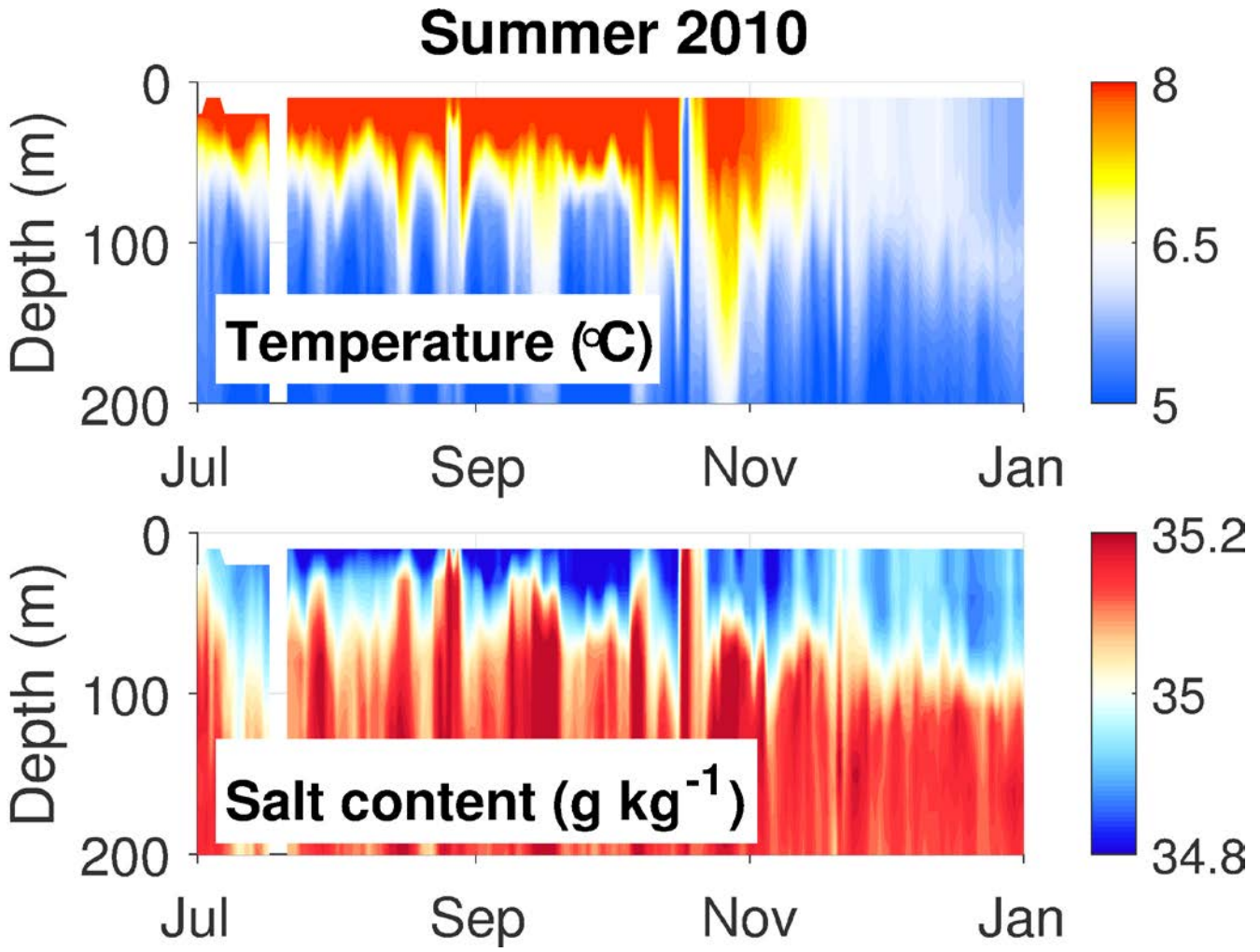
What to expect from the future?



- Each summer, the North Atlantic warms and freshens and each winter, the freshwater is mixed down.
- A potential threshold is reached, if freshwater from two or more summers combine, making it harder to return to the previous state.

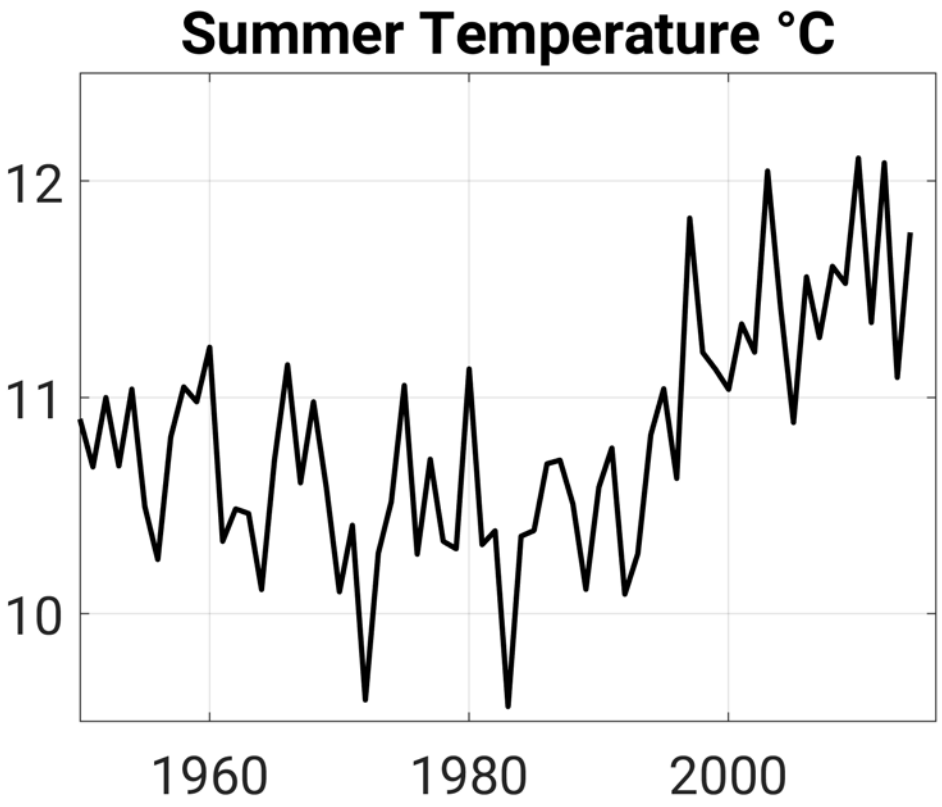
What to expect from the future?

- Warmer summers are associated with more freshwater.
- In the following winters, the time to remove freshwater is shortened.
- After the summer 2010, some freshwater remained at the surface throughout winter.



Oltmanns et al. 2018

What to expect from the future?



- Summers will become warmer and fresher, thus delaying ventilation of the deep sea.
- The annual cycle imposes a threshold to the duration of the ventilation.
- Crossing this treshold is expected to trigger far-reaching climatic responses.
- Due to the complex interactions between ice, ocean and atmosphere, predicting these responses remains challenging.

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