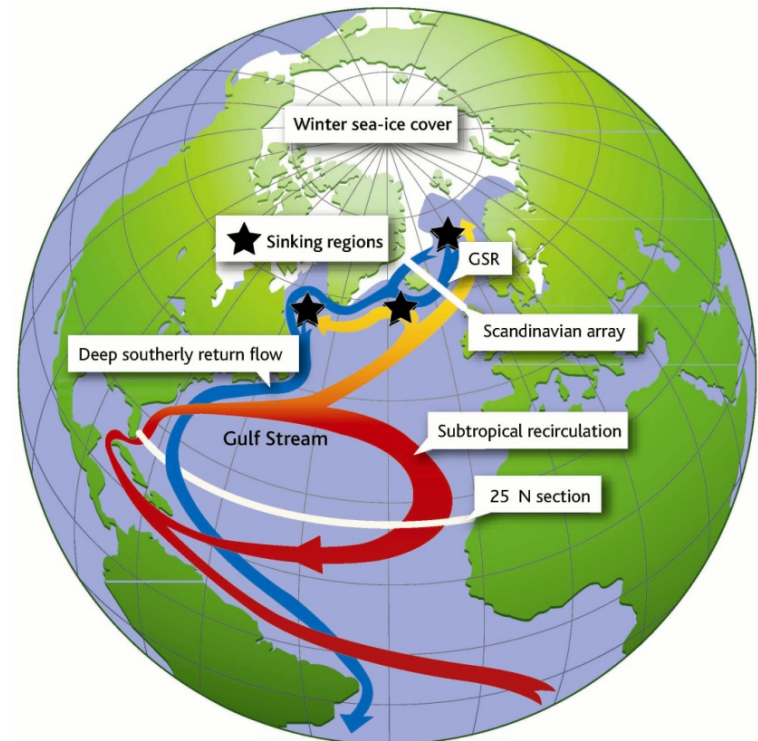


Ocean Circulation and Climate Change

Mojib Latif, GEOMAR Helmholtz Centre of Ocean Research Kiel and University of Kiel



The global carbon budget

Fate of Anthropogenic CO₂ Emissions (2003-2012 average)

8.6 ± 0.4 GtC/yr 92%



0.8 ± 0.5 GtC/yr 8%



+

4.3 ± 0.1 GtC/yr
45%



2.6 ± 0.5 GtC/yr
27%



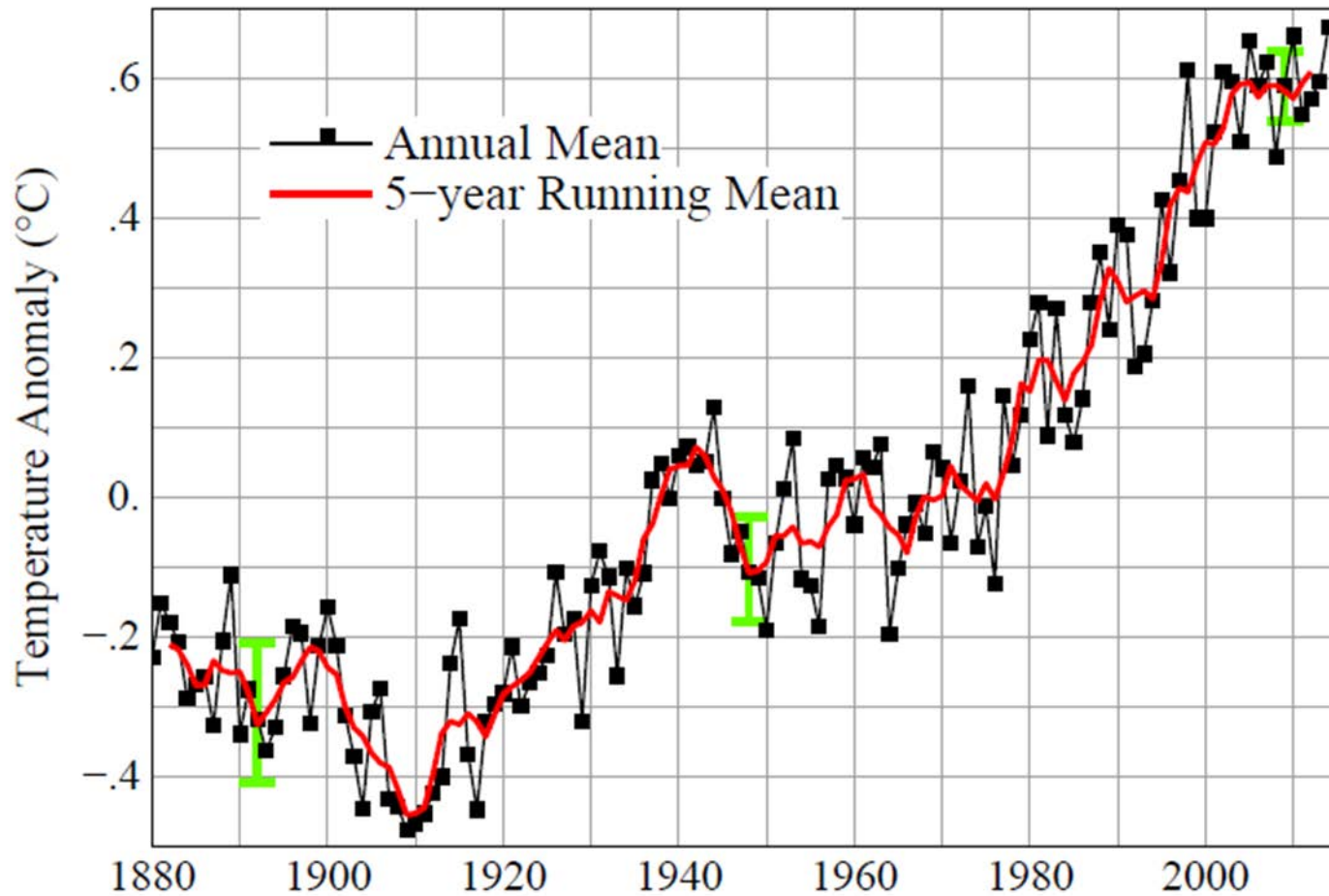
2.6 ± 0.8 GtC/yr
27%



Calculated as the residual
of all other flux components

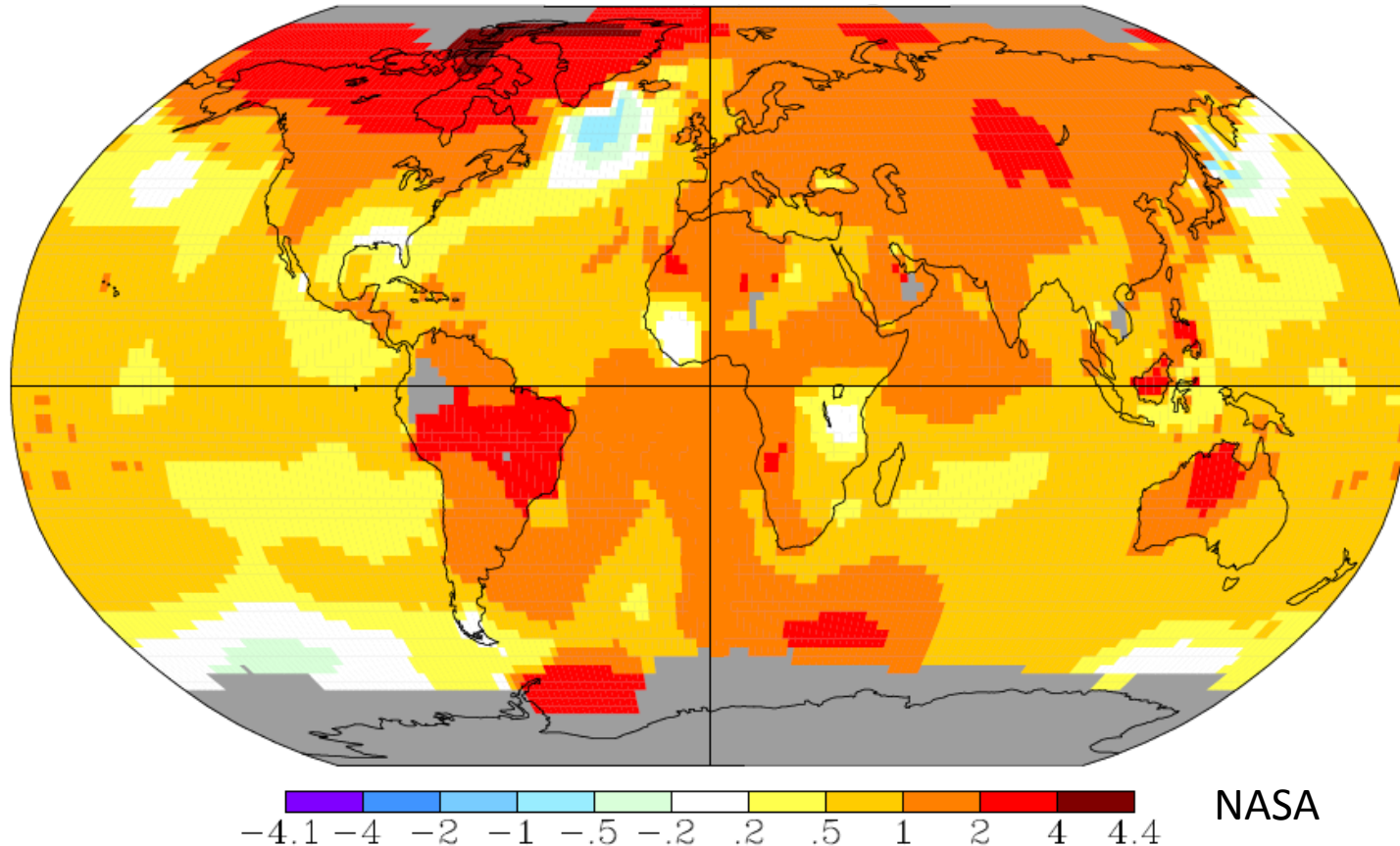
Global warming

Global Land–Ocean Temperature Index



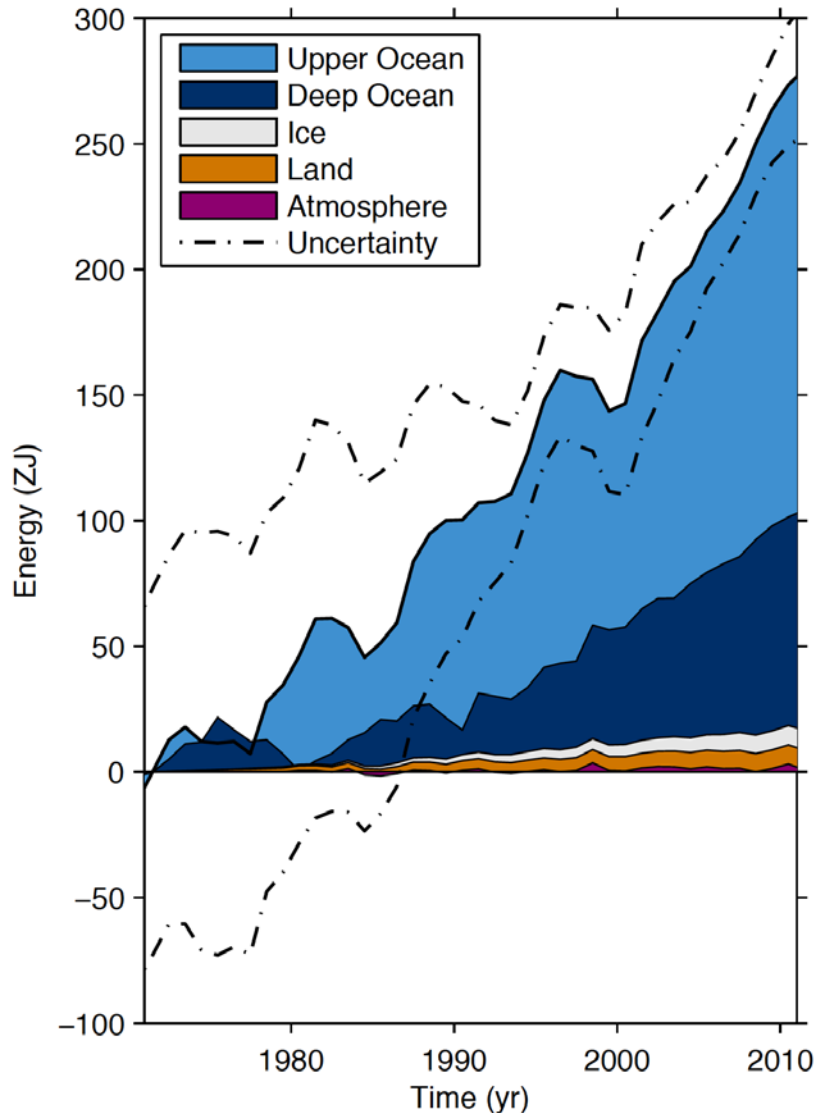
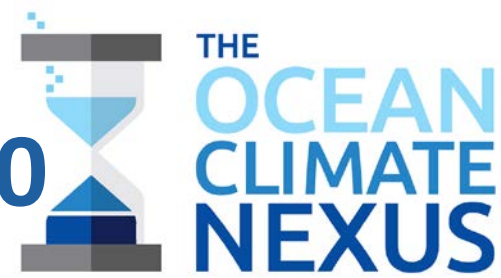
...but with regional variation

temperature trend 1880-2014, global average change amounts to 1°C



changes in ocean circulation are an important driver of regional climate change

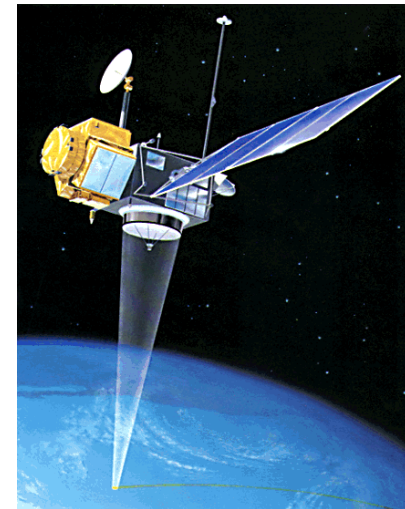
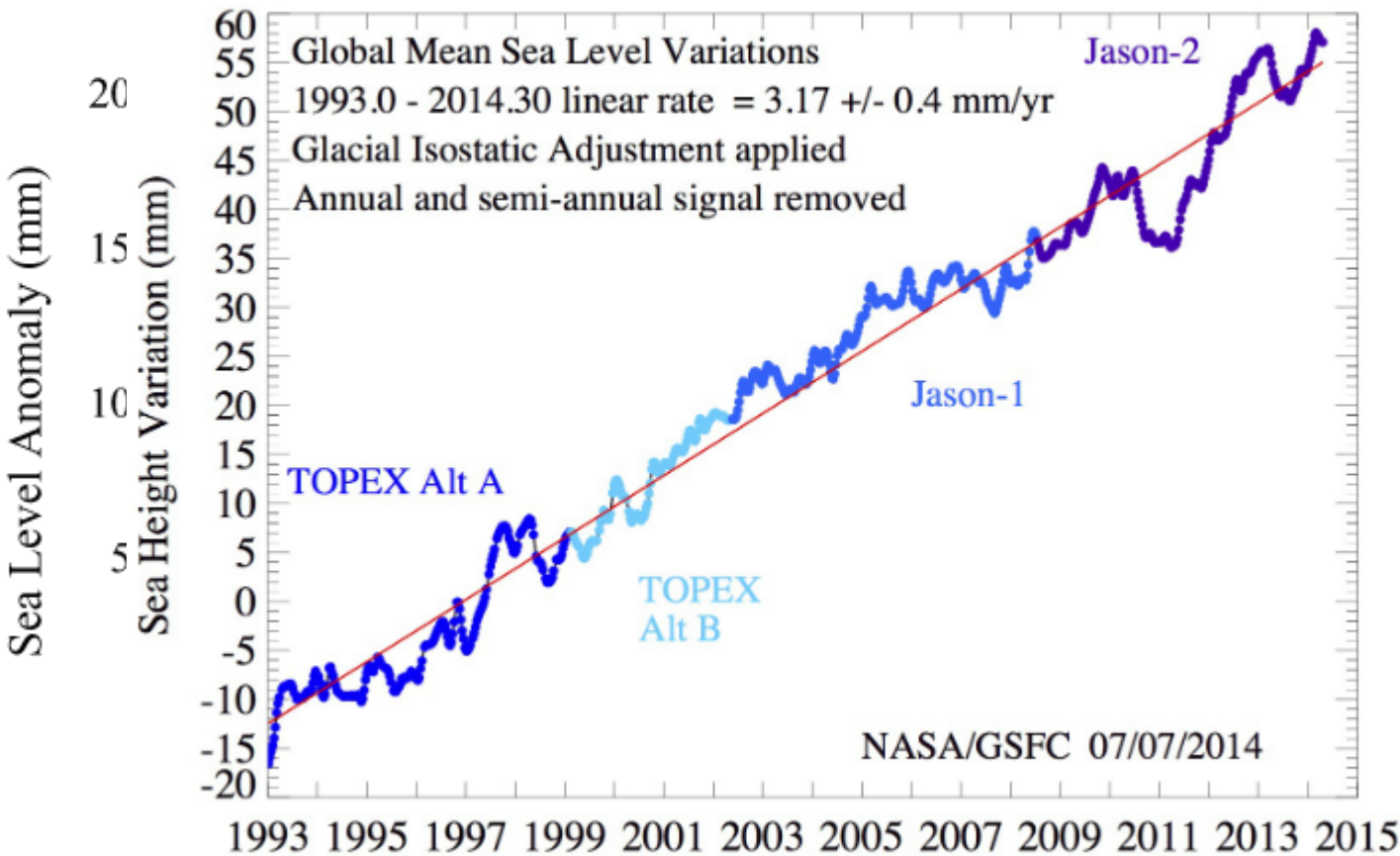
Ocean heat uptake since 1970



- ◆ Ocean warming makes up for 93% of the energy increase in the climate system
- ◆ 3% is due to warming of the land areas
- ◆ 1% is due to warming of the atmosphere
- ◆ 3% is due to ice melt (sea ice, glaciers, ice sheets)
- ◆ Prior to 1970: not enough ocean data

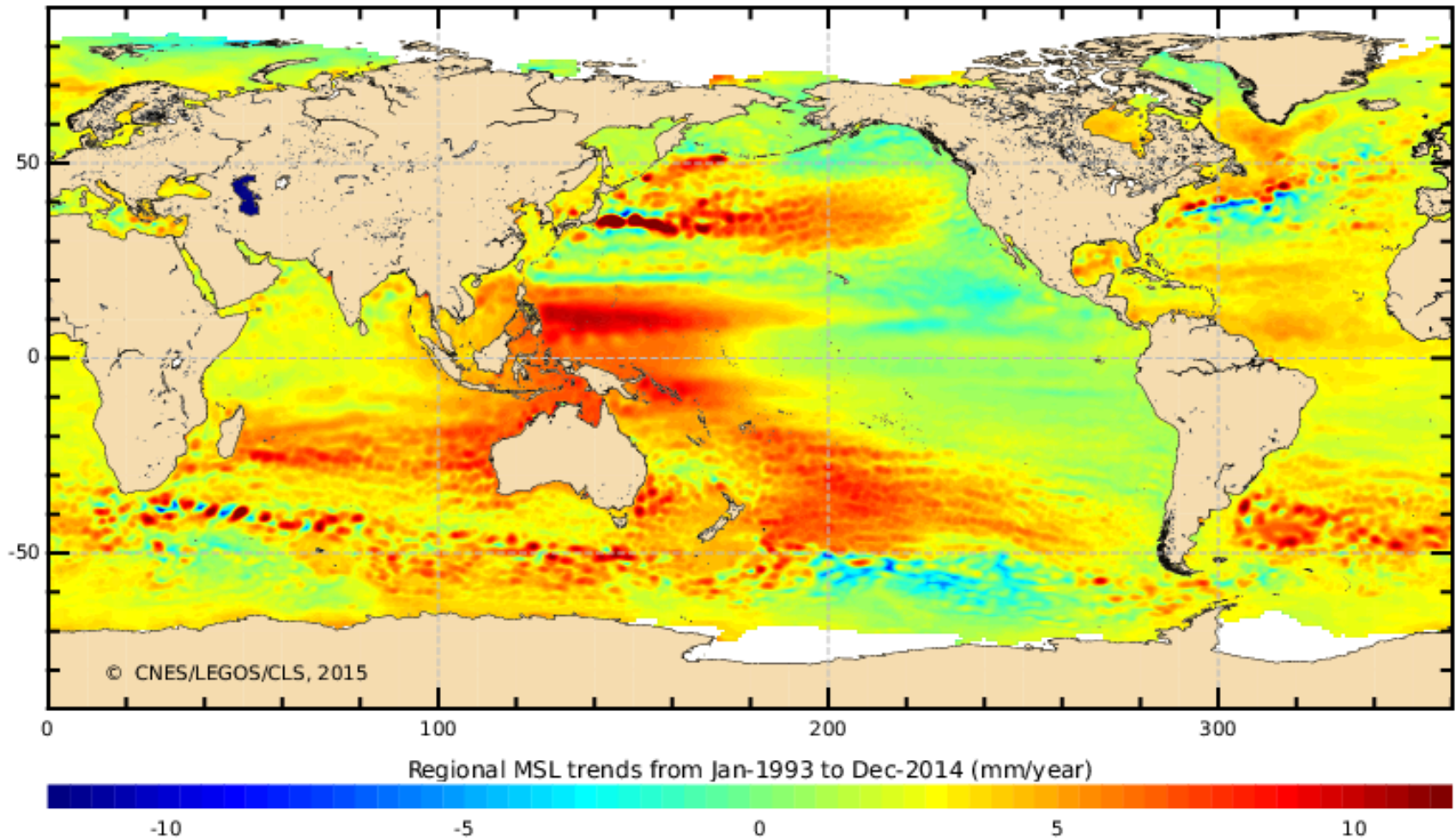
Sea level rise

Global Mean Sea Level Change

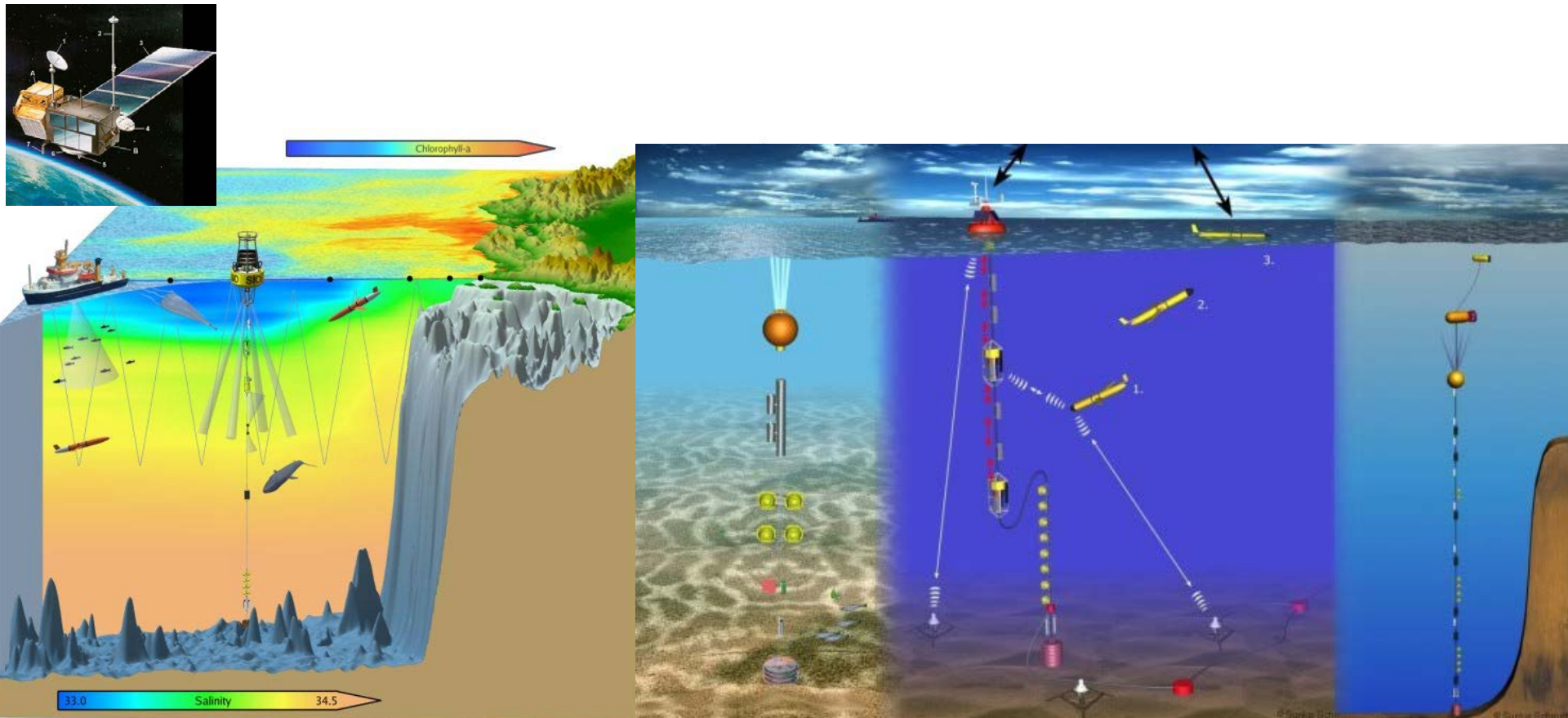


...regional variation is large

linear trend in sea level 1993-2014 from satellites



Ocean observing system

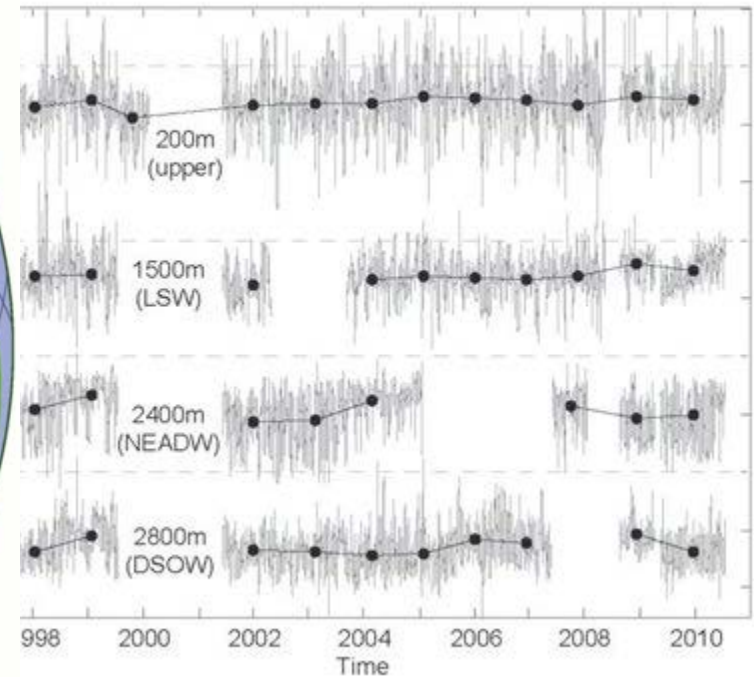
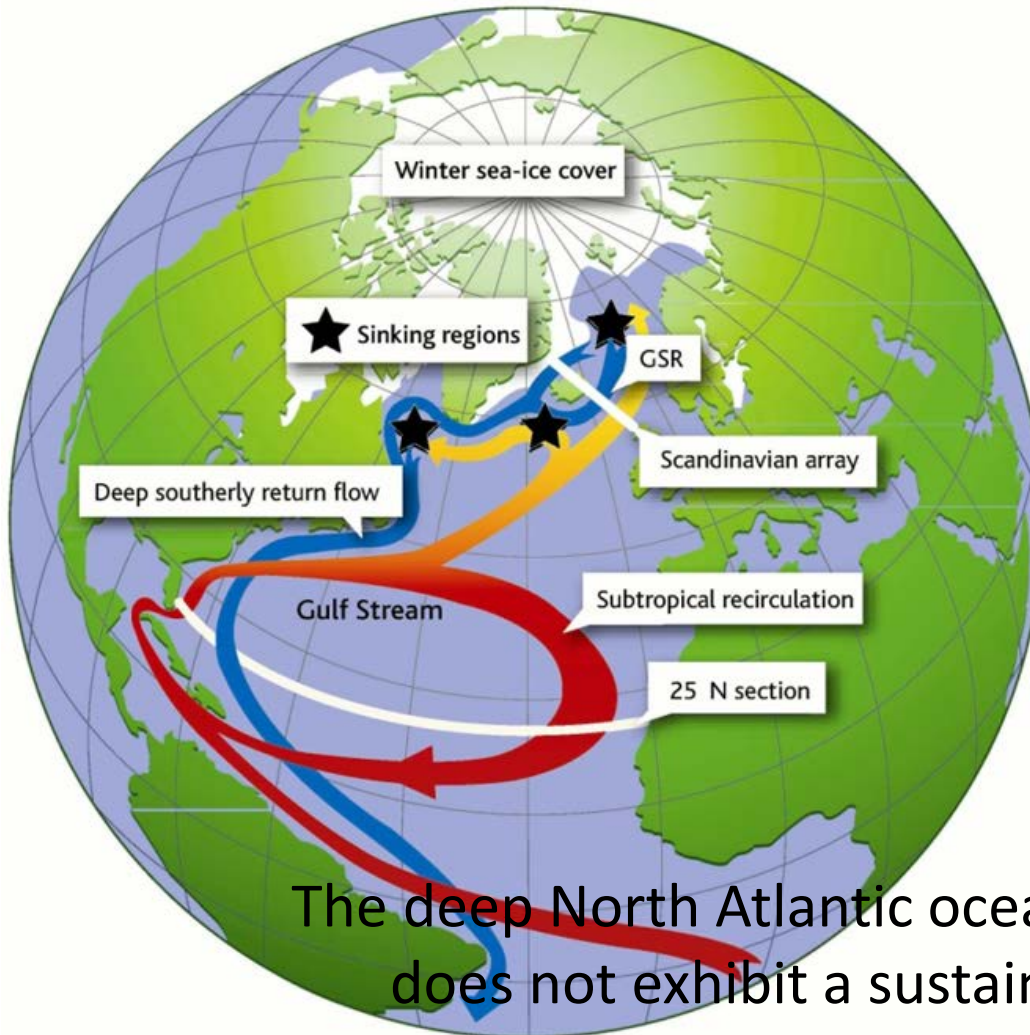


<http://mooring.ucsd.edu/>

- ship-based and autonomous technologies
- in situ and remote sensing technologies

Sustained measurements

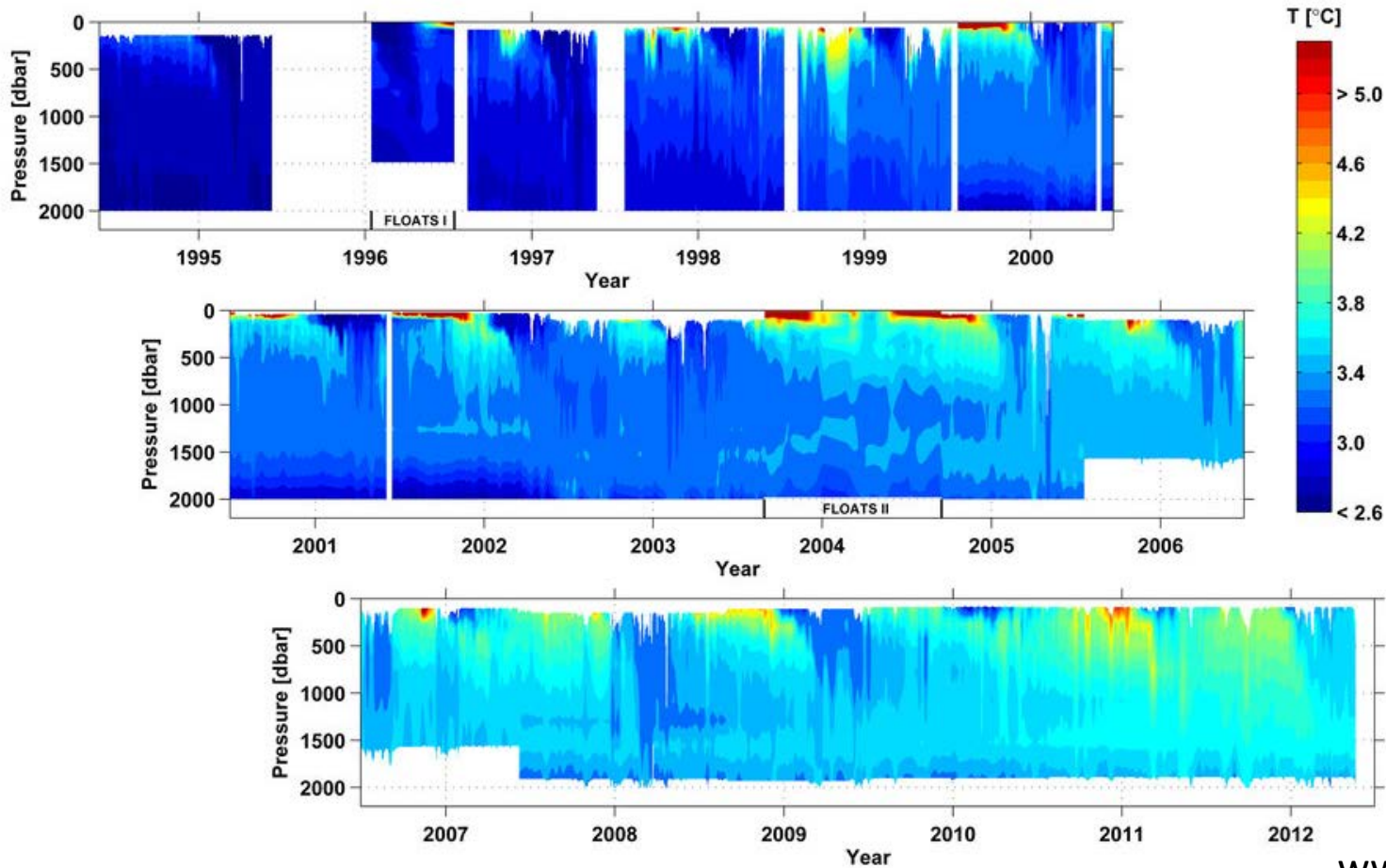
What is happening to the Gulf Stream?



The deep North Atlantic ocean circulation
does not exhibit a sustained trend

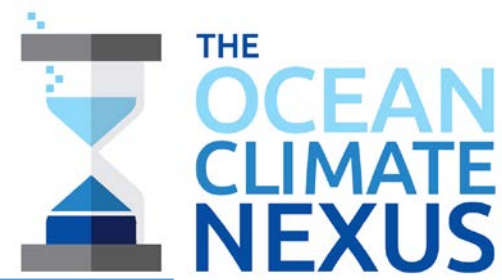
Sustained measurements

K1 Mooring – Central Labrador Sea – Temperature

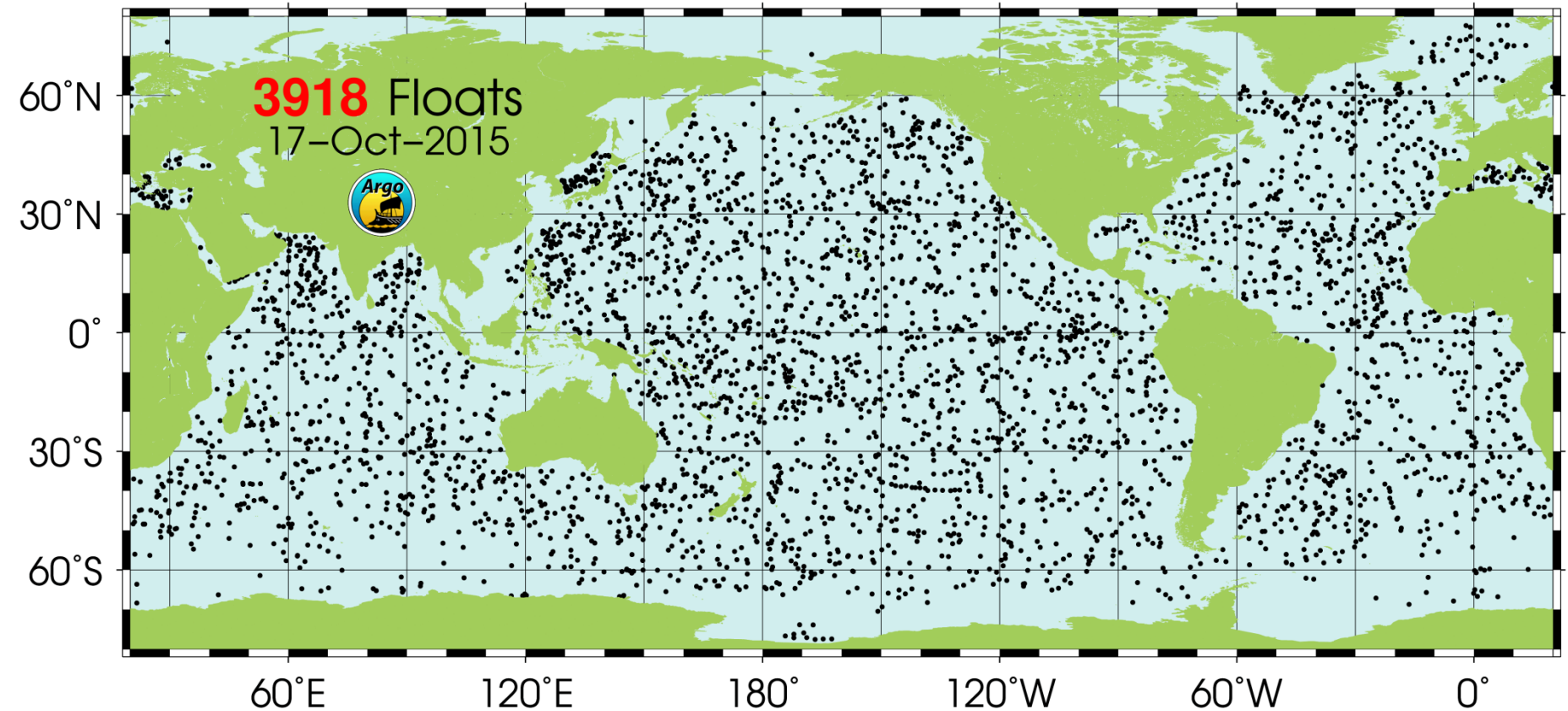


...but decadal-scale warming is evident

The international ARGO program

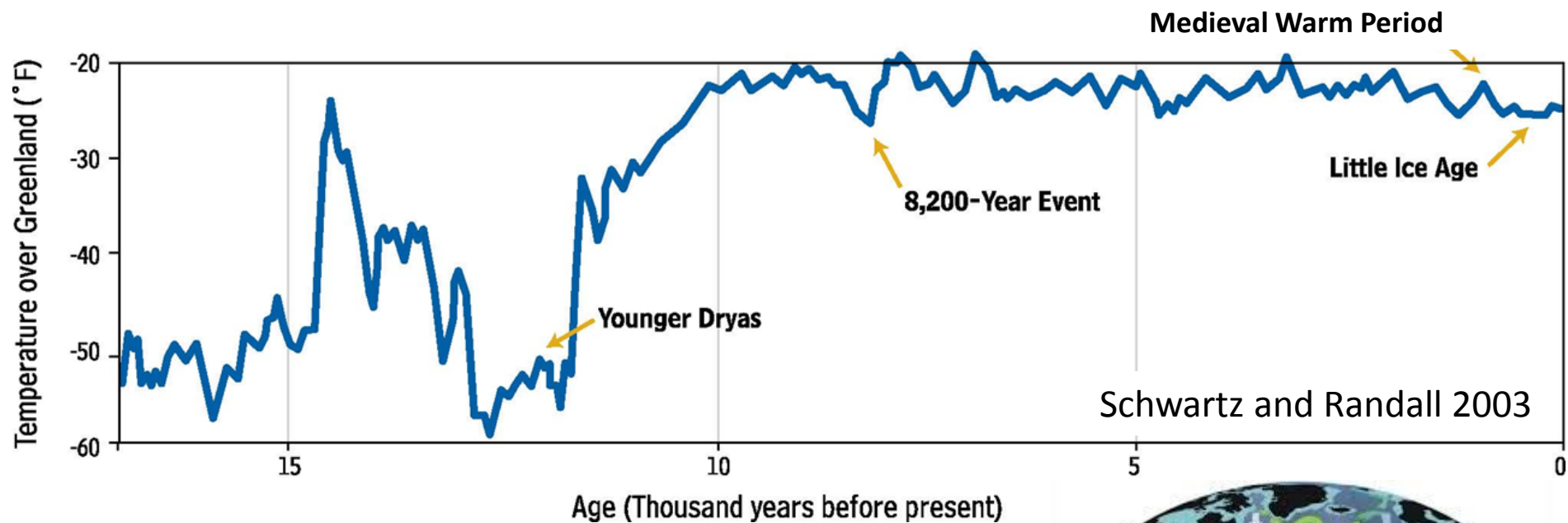


collaborative partnership of more than 30 nations from all continents



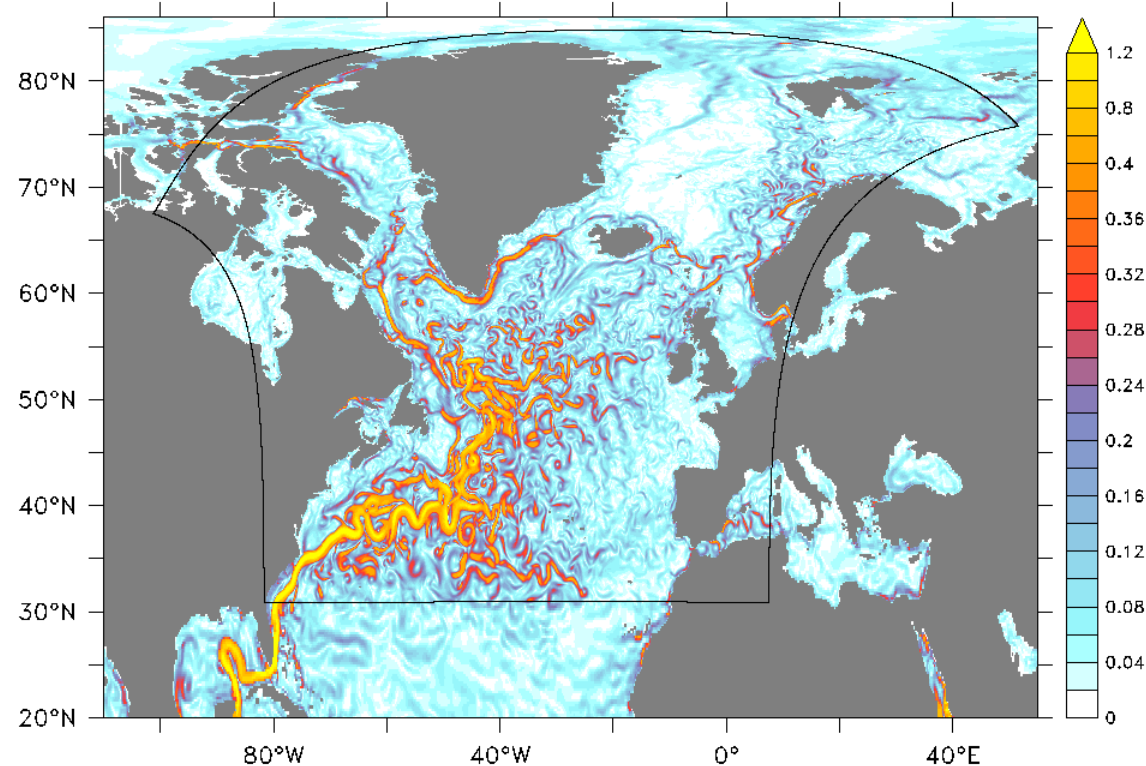
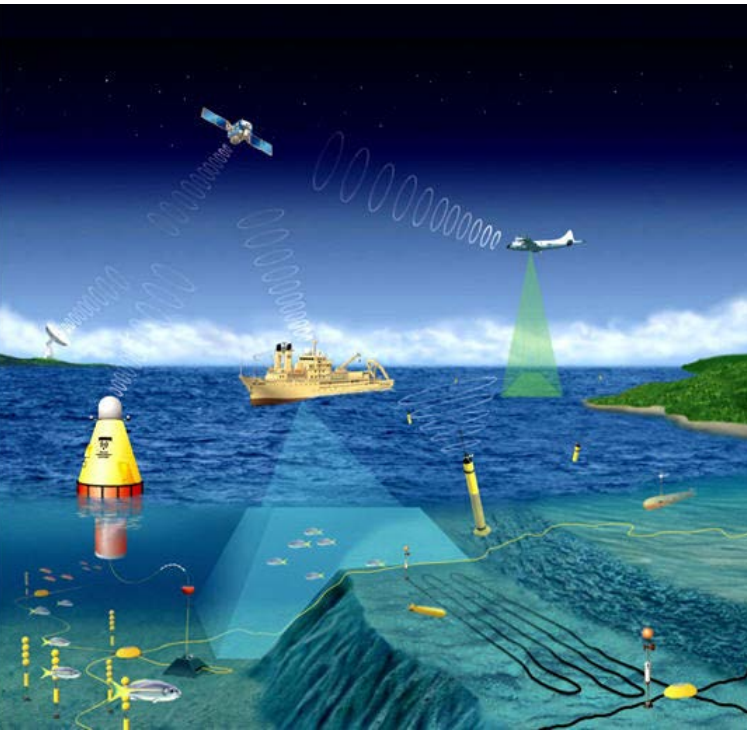
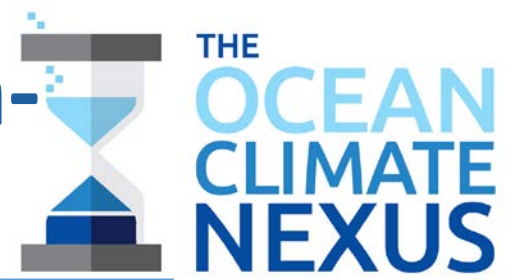
no floats below 2000 m, but that ocean variability is important to global and regional ocean and climate change

Learning from the past



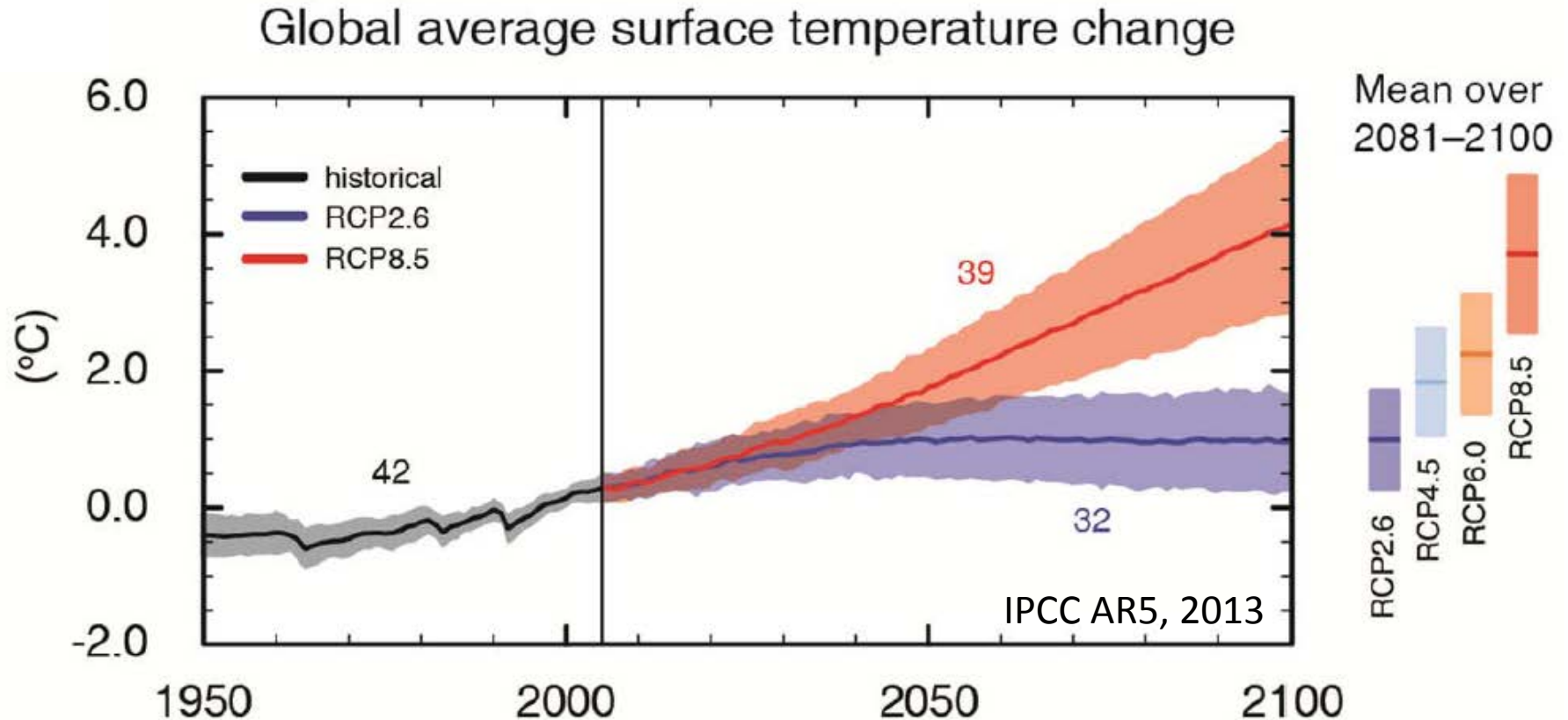
Abrupt climate change: should we be worried?

Ocean observations and high-end numerical modeling



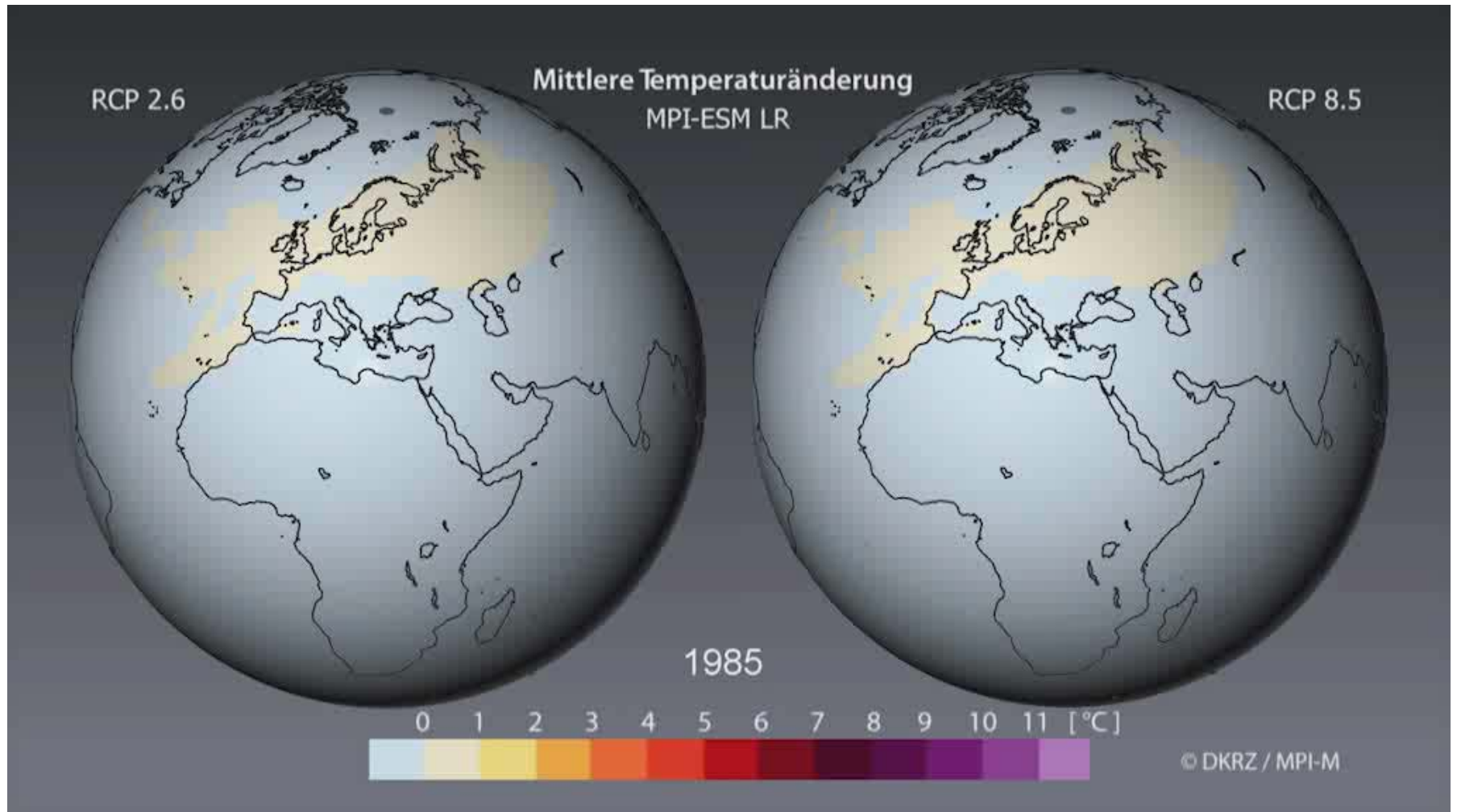
- they go hand in hand,
- both are needed for prediction

The latest IPCC projections



How will climate change regionally?

Ocean circulation shapes the future



Understanding the ocean's role in climate change



The research combines

- cutting-edge instrumental observations
- innovative proxy development
- high-end numerical modelling

