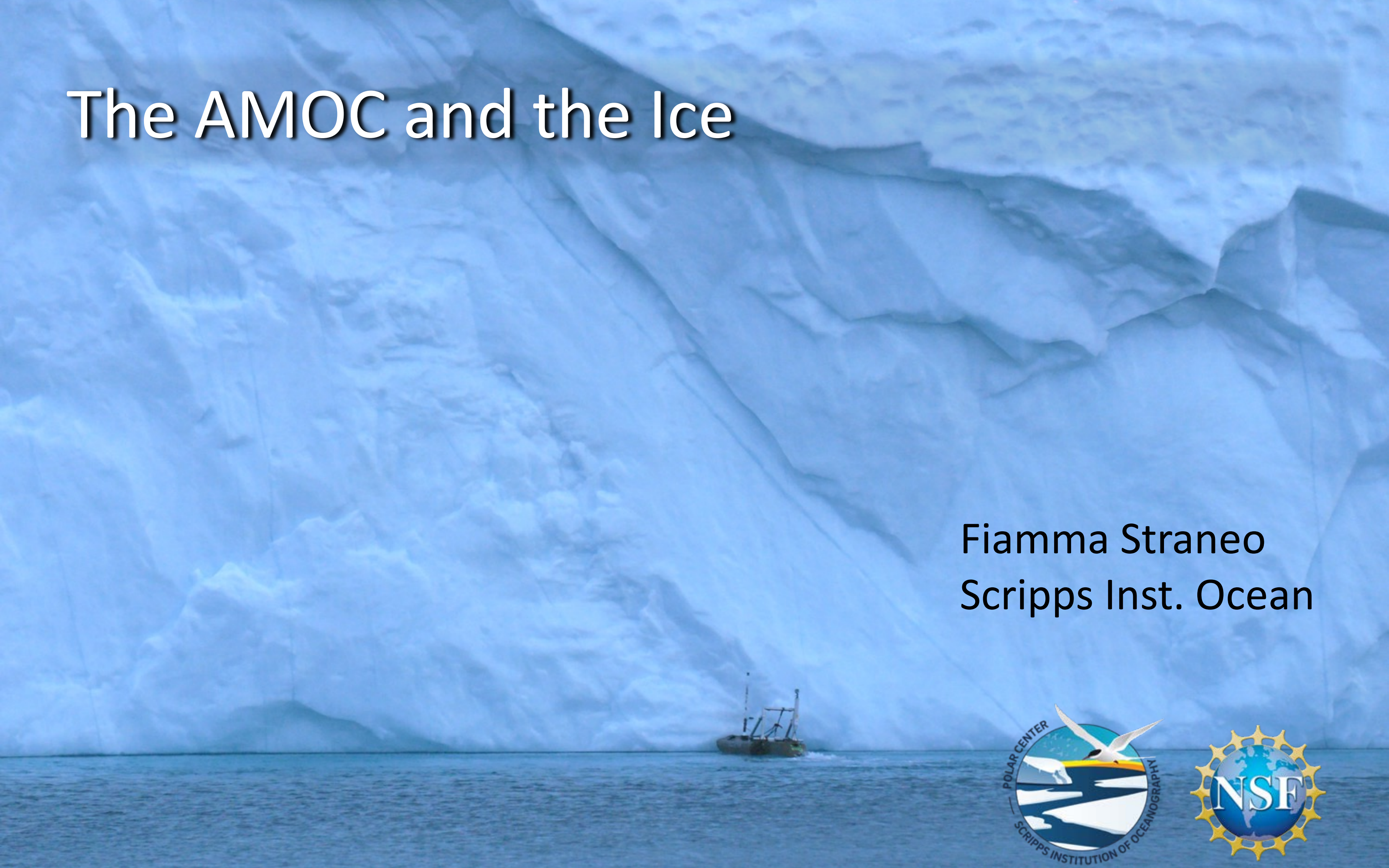
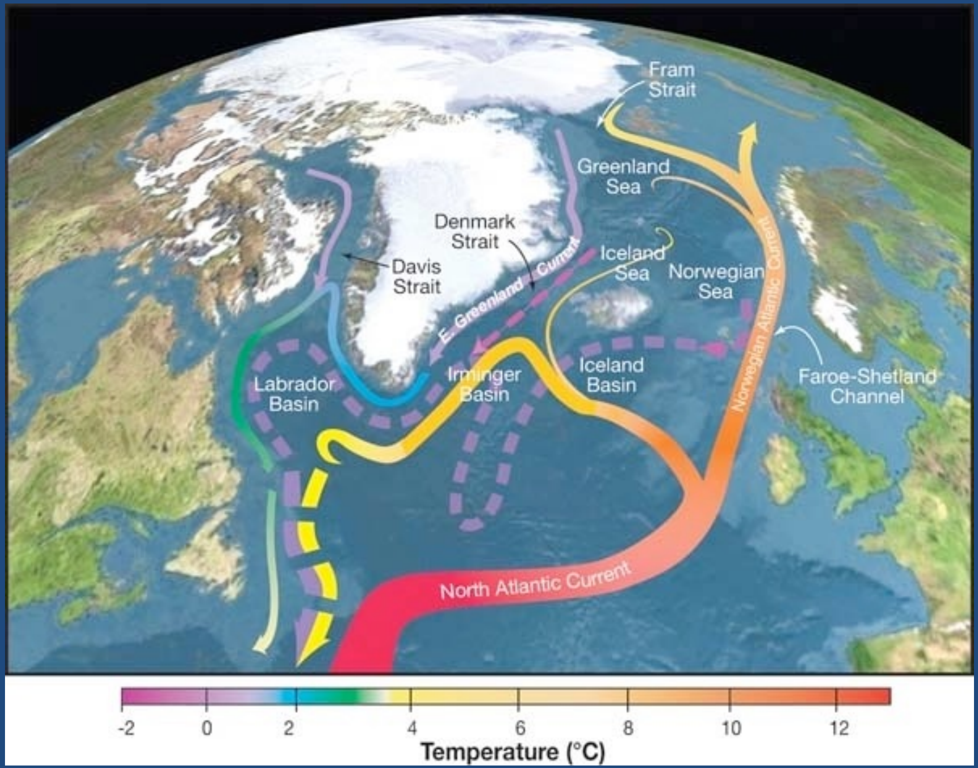
The AMOC and the Ice

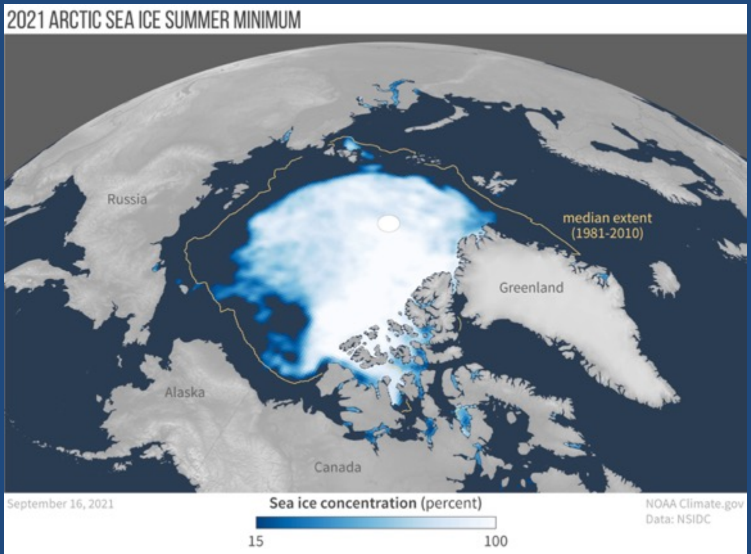


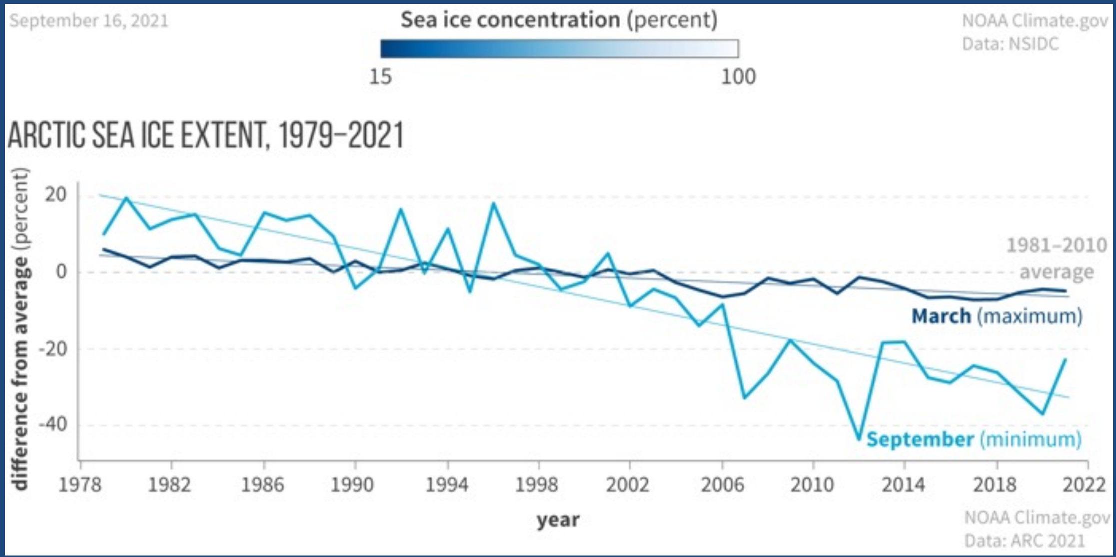
Fiamma Straneo
Scripps Inst. Ocean



Can AMOC variability drive changes in Arctic sea-ice or in the Greenland Ice Sheet?

Arctic Sea Ice Change





Arctic Report Card, 2021

Modes of Arctic Sea Ice Loss

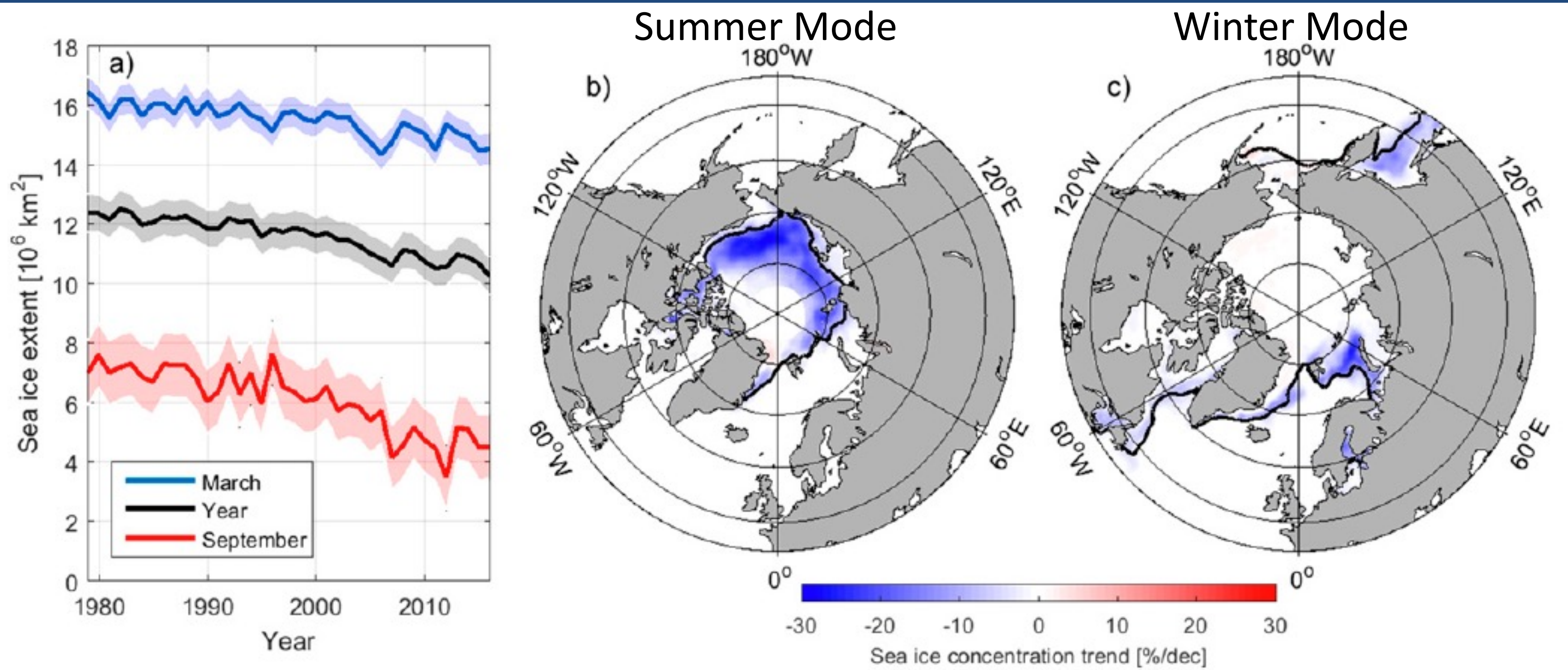
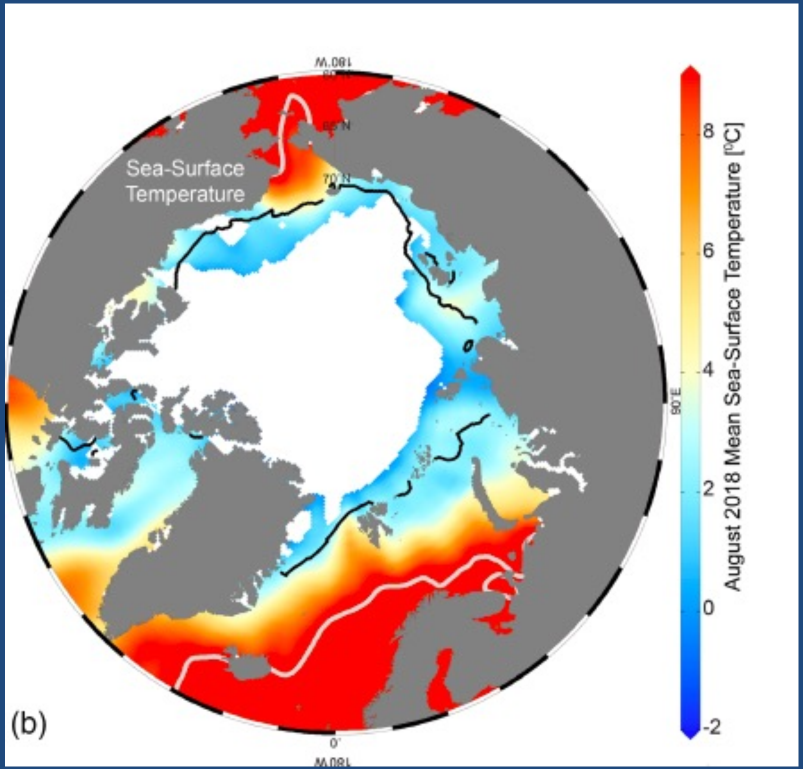


FIG. 1. (a) March (blue), September (red), and annual mean (black) Northern Hemisphere sea ice extent, 1979–2016. Shaded regions indicate plus and minus one standard deviation. Linear sea ice concentration trends (% decade^{-1}) in (b) September and (c) March, 1979–2016. Black contours show the mean sea ice edge.

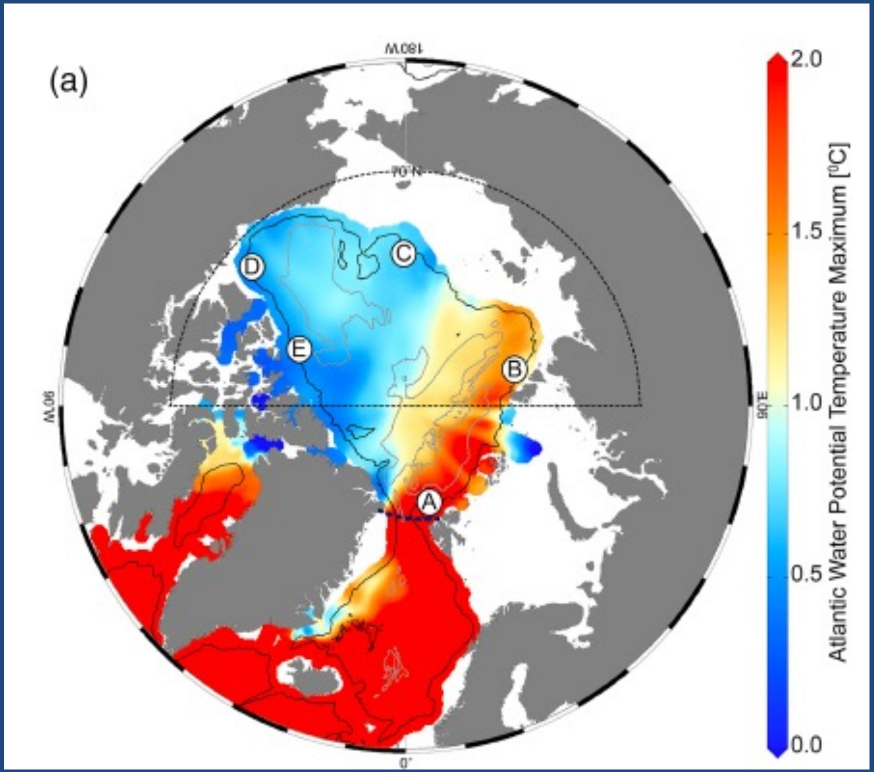
Onarheim et al. 2018

Spreading of Atlantic water in the Arctic

Atlantic Water at the surface

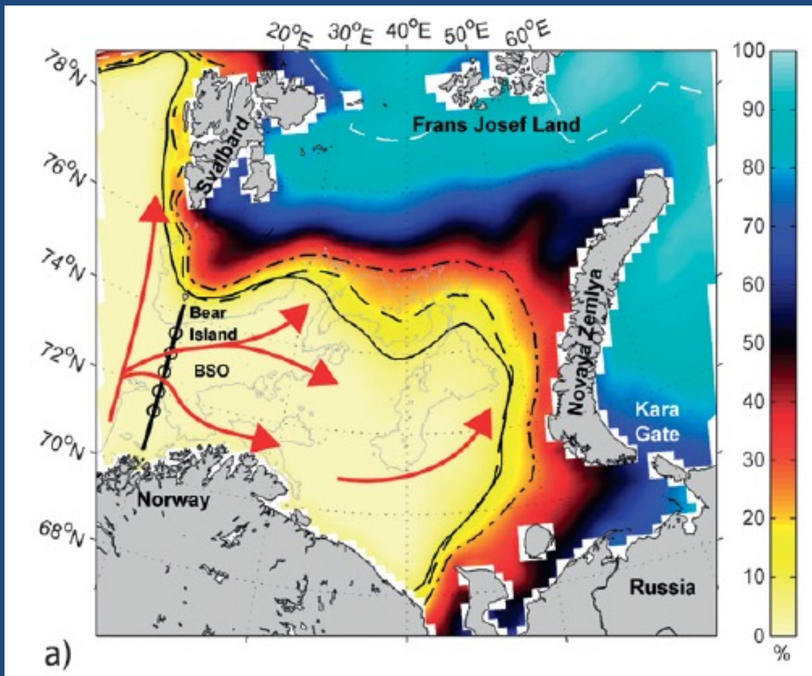


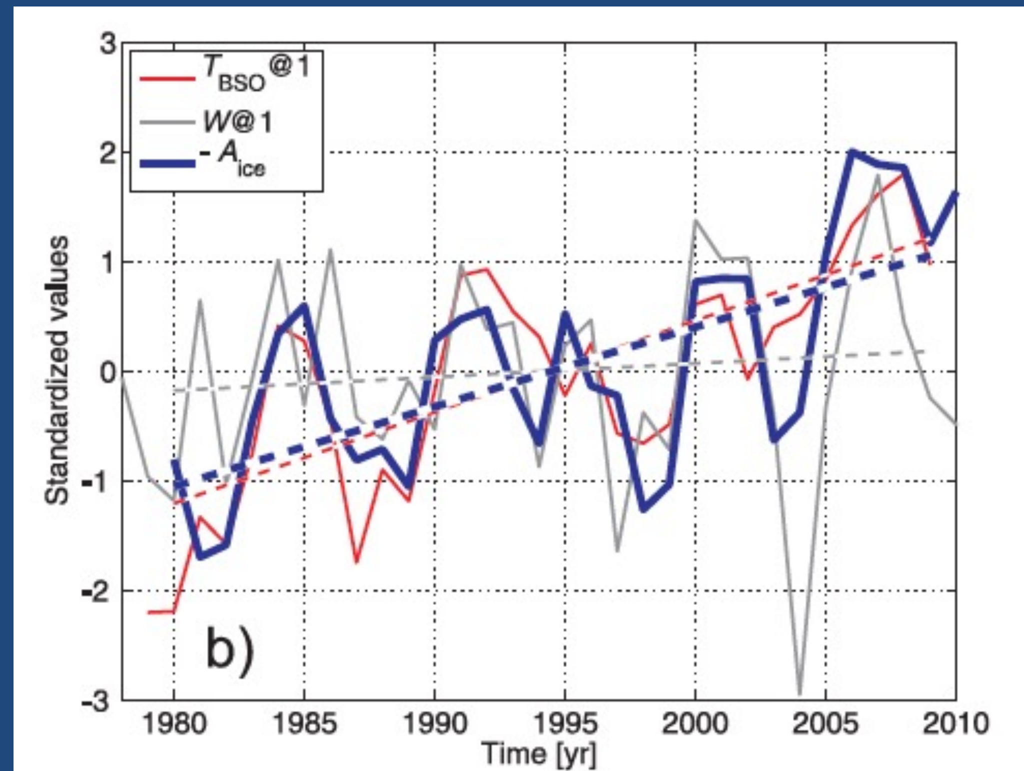
Atlantic Water



Timmermans and Marshall, 2020

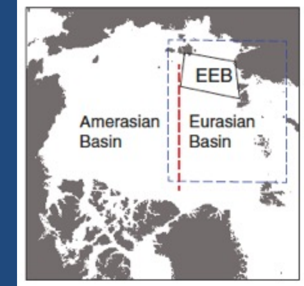
Atlantification of the Barents Sea:
Sea ice retreat with Atlantic Water (Heat) Transport increase

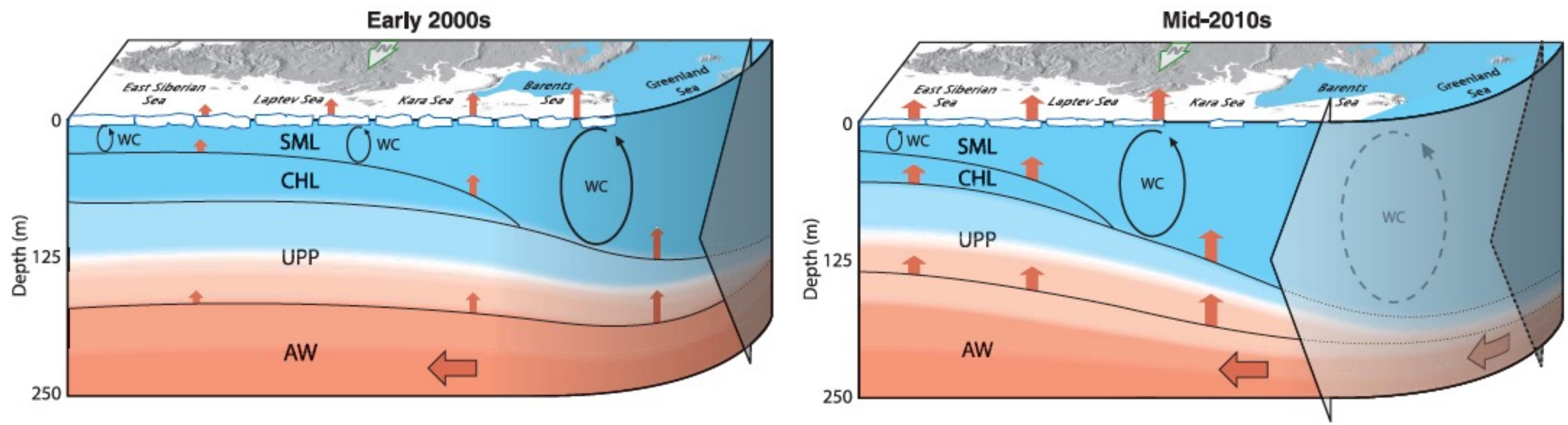




Arthun et al. 2012

Atlantification of the Eastern Eurasian Basin

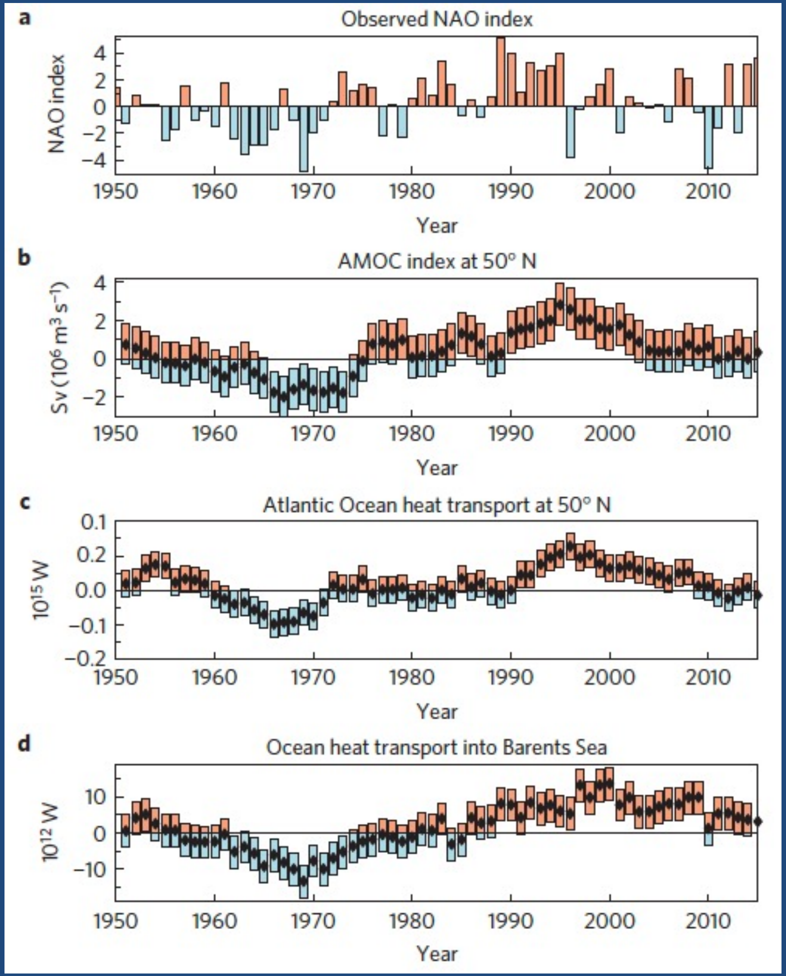




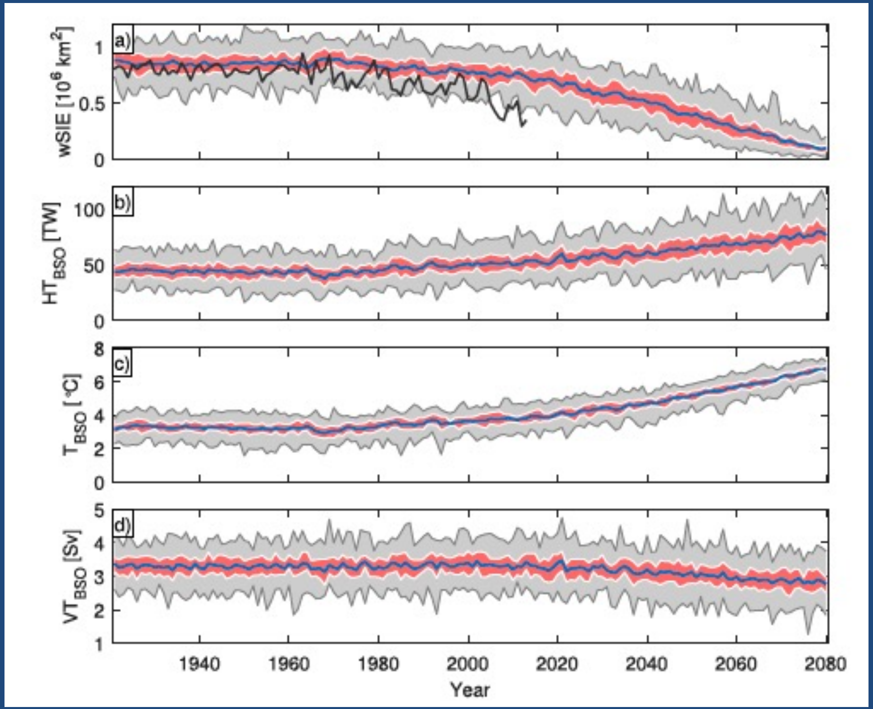
Increased penetration of Atlantic Water, reduction in sea-ice cover, greater vertical mixing, vertical heat flux from the Atlantic layer into the surface layer

Polyakov et al. 2017

Multidecadal and long-term AMOC and sea-ice



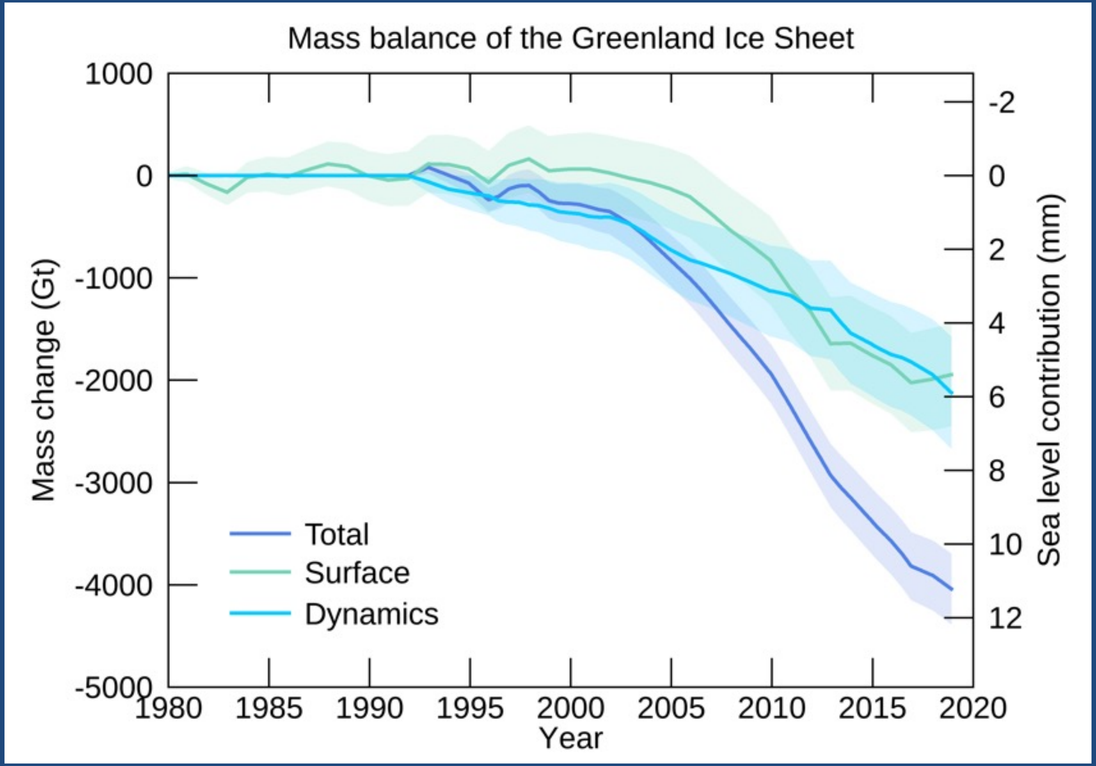
Delworth et al. 2016



Barents Sea sea-ice extent in CESM LE

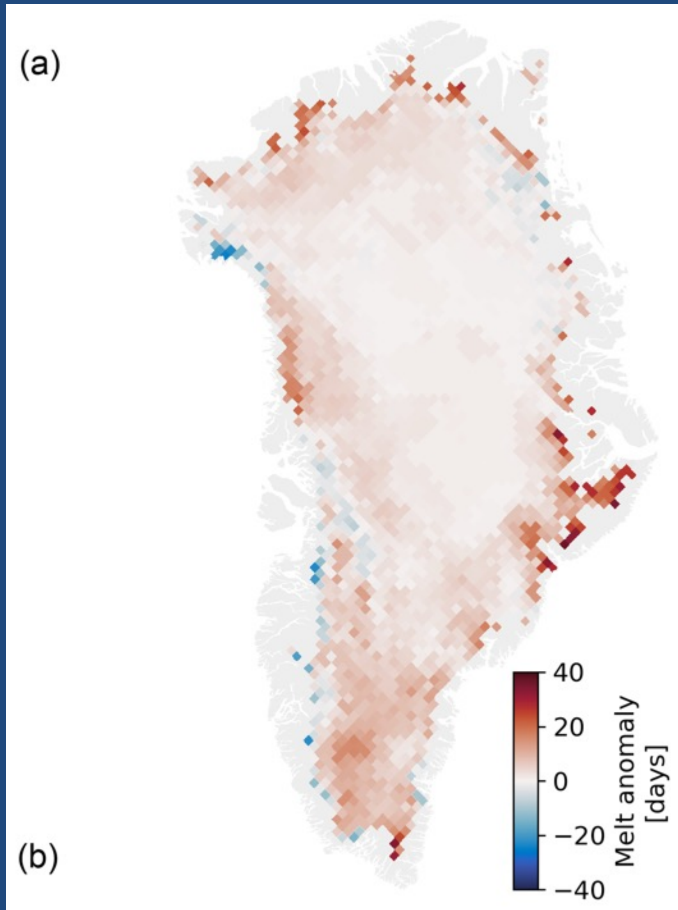
Arthun et al. 2019

Mass Loss from the Greenland Ice Sheet: surface mass balance plus dynamic changes



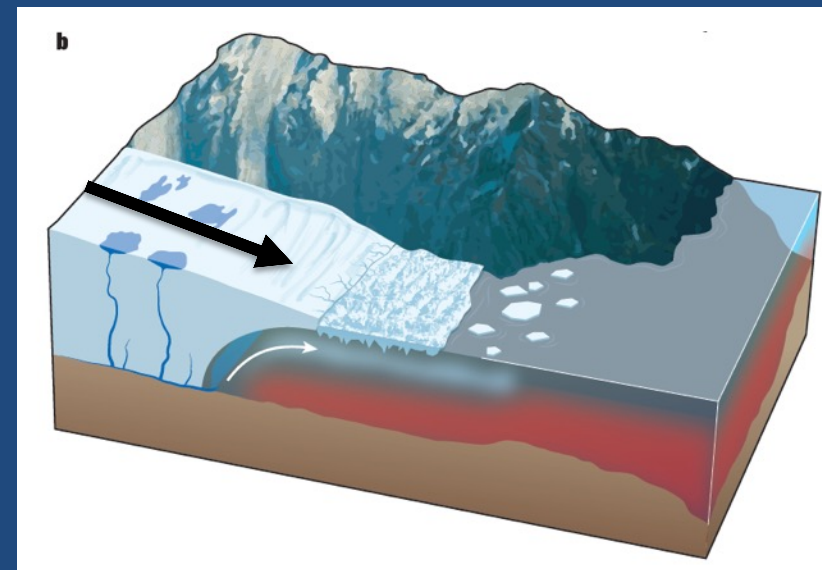
Shepherd et al. 2020, Mankoff et al. 2021

Increased net surface melt, SMB



Arctic Report Card, 2021

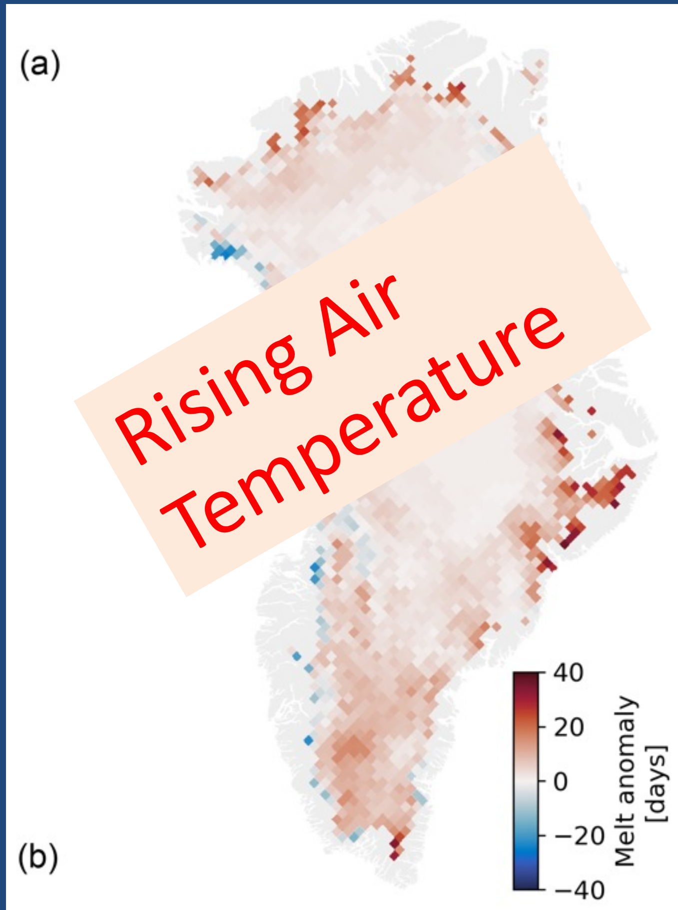
Increased ice discharge, D



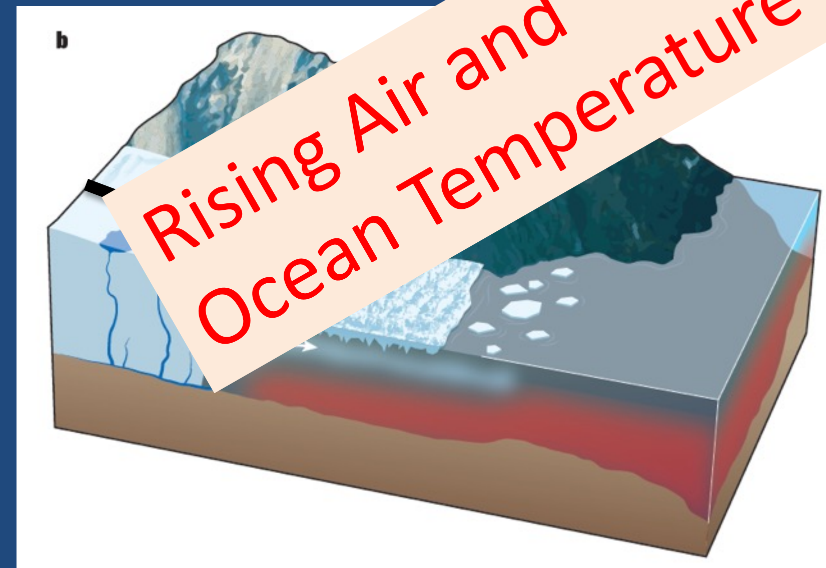
Straneo and Heimbach, 2013

Increased net surface melt, SMB

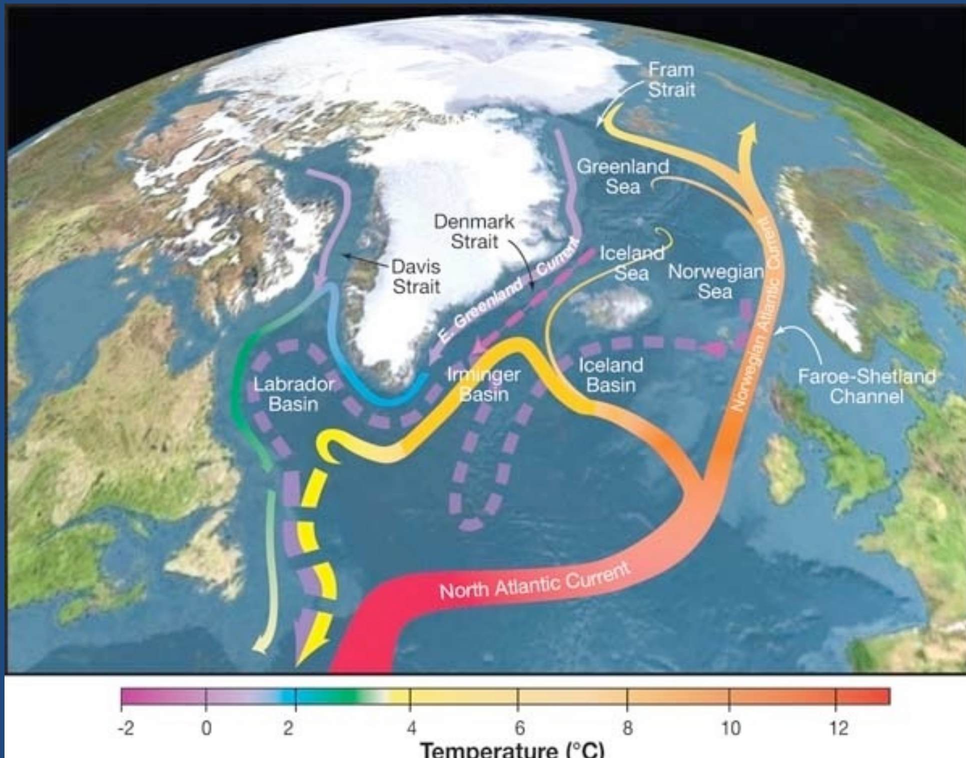
Increased ice discharge, D



Arctic Report Card, 2021



Straneo and Heimbach, 2013



Impact of AMOC on Greenland =

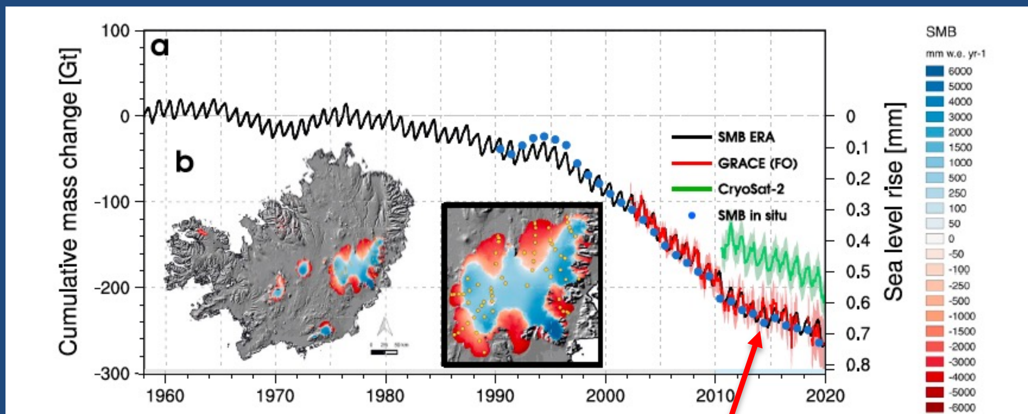
1. Air temperature over Greenland

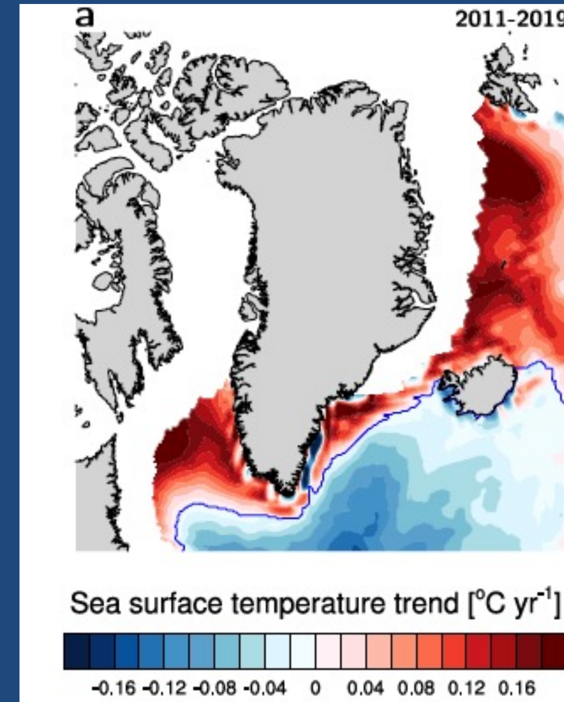
2. Heat transport to the margin of glaciers

Iceland’s Glaciers and North Atlantic Cooling

North Atlantic Cooling is Slowing Down Mass Loss of Icelandic Glaciers

Brice Noël[1], Guðfinna Aðalgeirsdóttir[2], Finnur Pálsson[2], Bert Wouters[1,3], Stef Lhermitte[3], Jan M. Haacker[3], and Michiel R. van den Broeke[1]





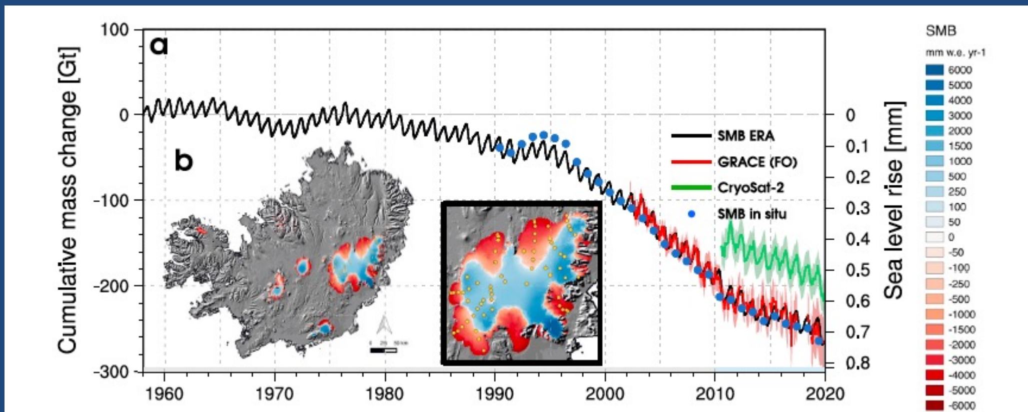
Hypothesis: Cold blob drove a reduction in ice loss from Iceland

Noel et al. 2022

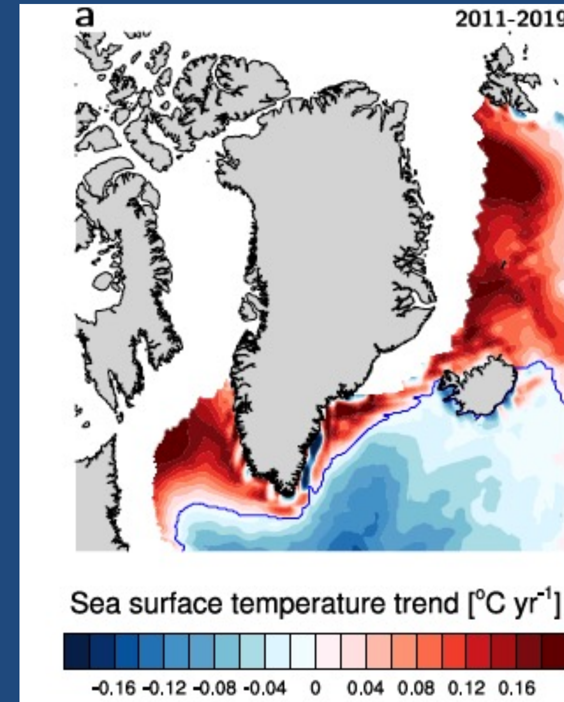
Iceland's Glaciers and North Atlantic Cooling

North Atlantic Cooling is Slowing Down Mass Loss of Icelandic Glaciers

Brice Noël[1], Guðfinna Aðalgeirsdóttir[2], Finnur Pálsson[2], Bert Wouters[1,3], Stef Lhermitte[3], Jan M. Haacker[3], and Michiel R. van den Broeke[1]



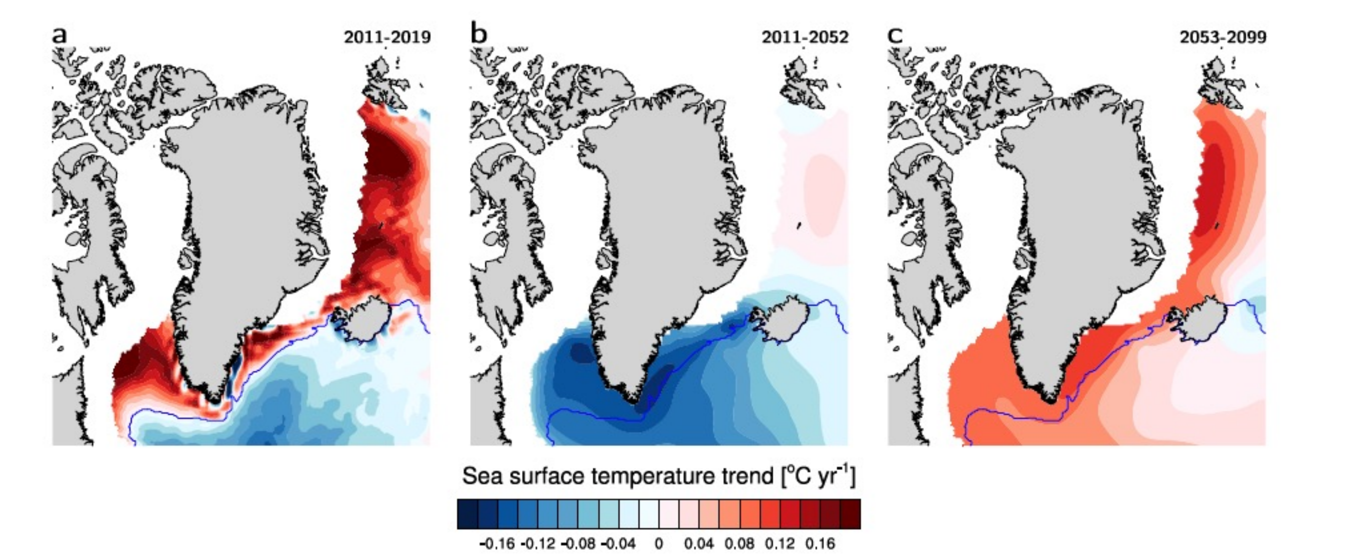
Noel et al. 2022

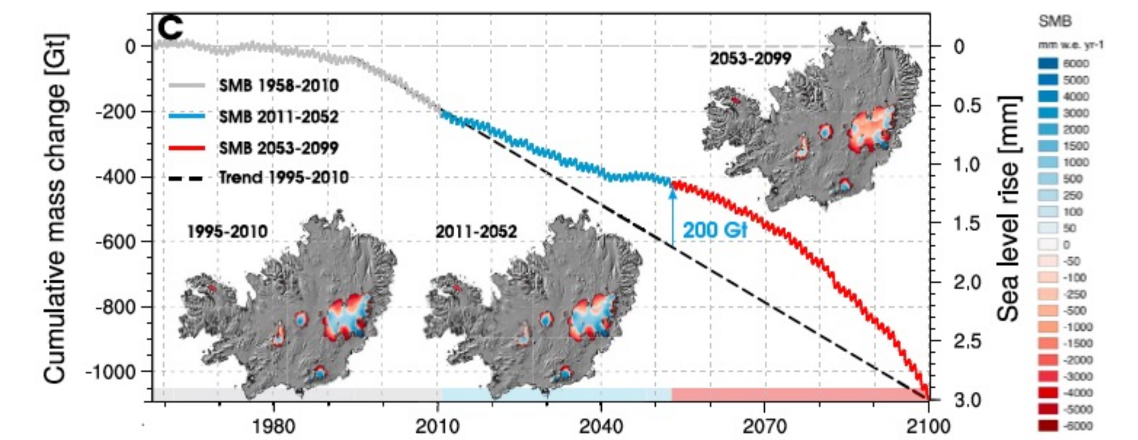


Iceland Glacier mass loss driven by increased surface melt (runoff) → Runoff/Surface Melt correlated with Iceland air temperature → Air temperature correlated with subpolar North Atlantic SST

Iceland’s Glaciers and the AMOC

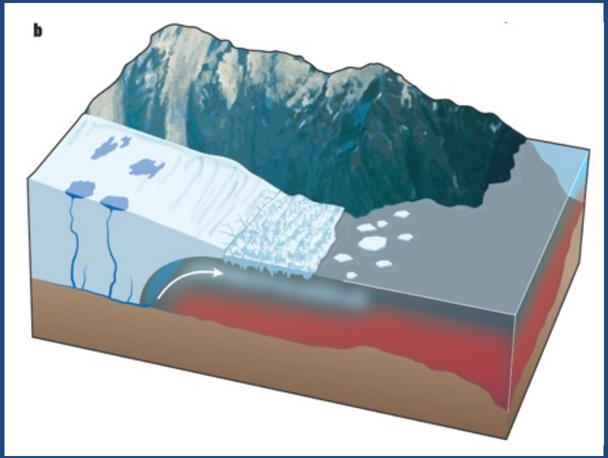
CESM-2
SSP5-8.5
(high emission scenario)





Noel et al. 2022

Increased ocean-driven melting of glaciers leads to dynamic mass loss

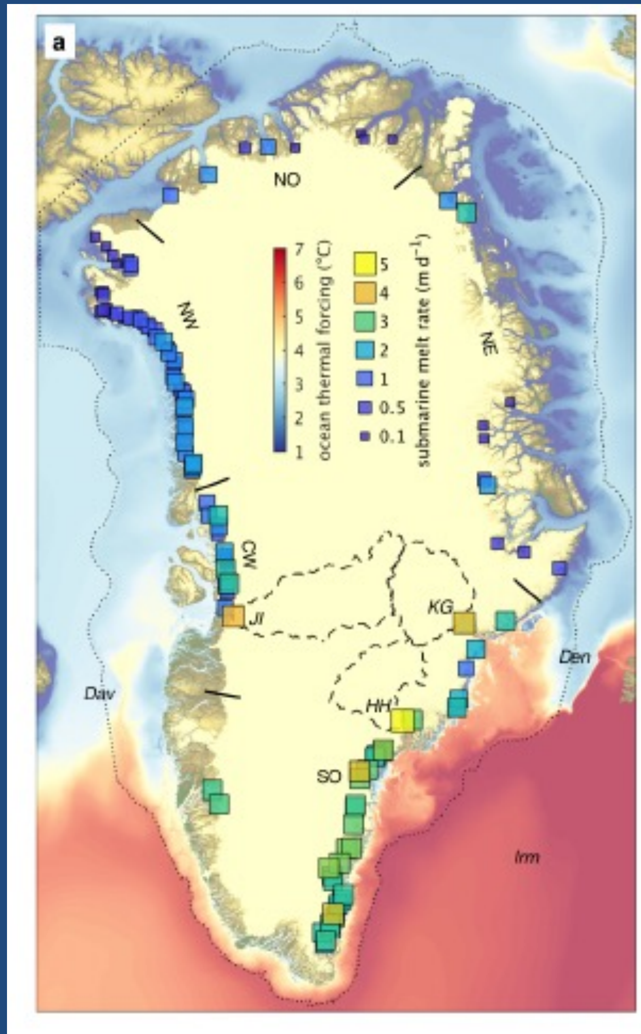


Increased ocean heat transport to a glacier

Increased surface melt

Increased submarine melting

Terminus retreat and potentially dynamic ice loss

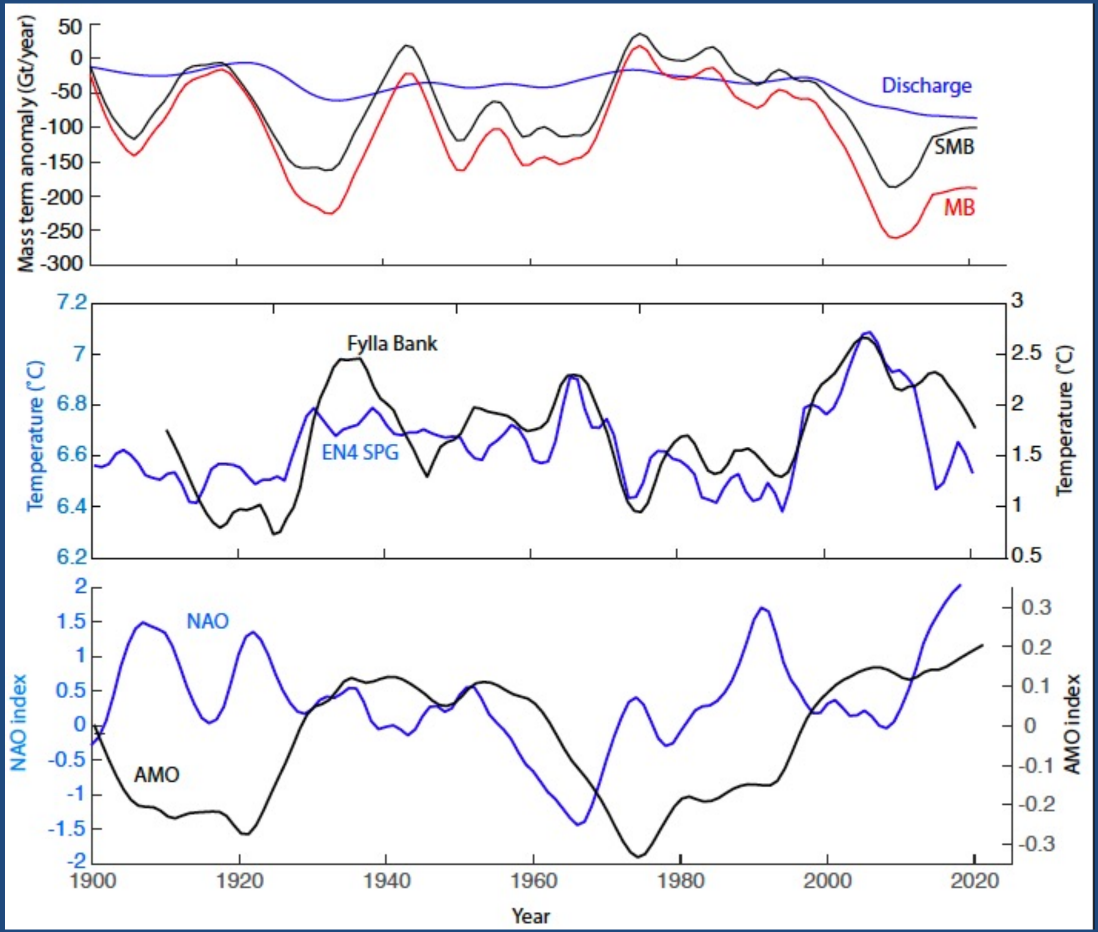


Slater and Straneo, submitted

Glacier response depends on geographic parameters, glacier dynamics as well as oceanic and atmospheric forcing

Carr et al. 2017; Porter et al. 2018; Catania et al. 2018

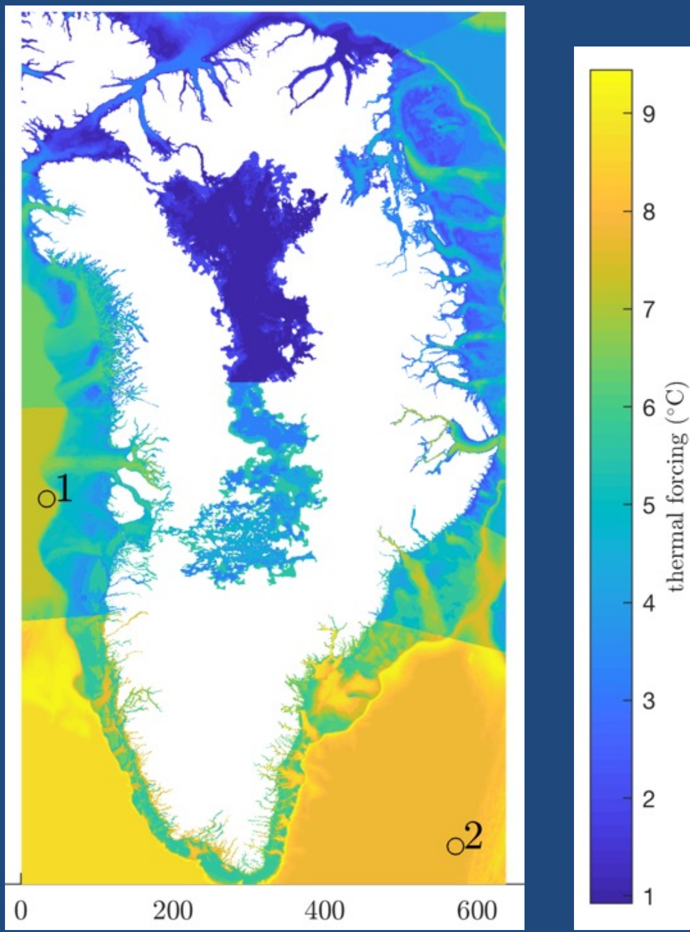
Greenland rate of loss and atmospheric/oceanic variability



Updated from Straneo and Heimbach, 2013 – Ice loss (Mankoff et al. 2021); Fylla updated from Ribergaard (2014) using annual NAFO SCR reports by J. Mortensen; SPG Heat content EN4, AMO and NAO from climate data ucar.

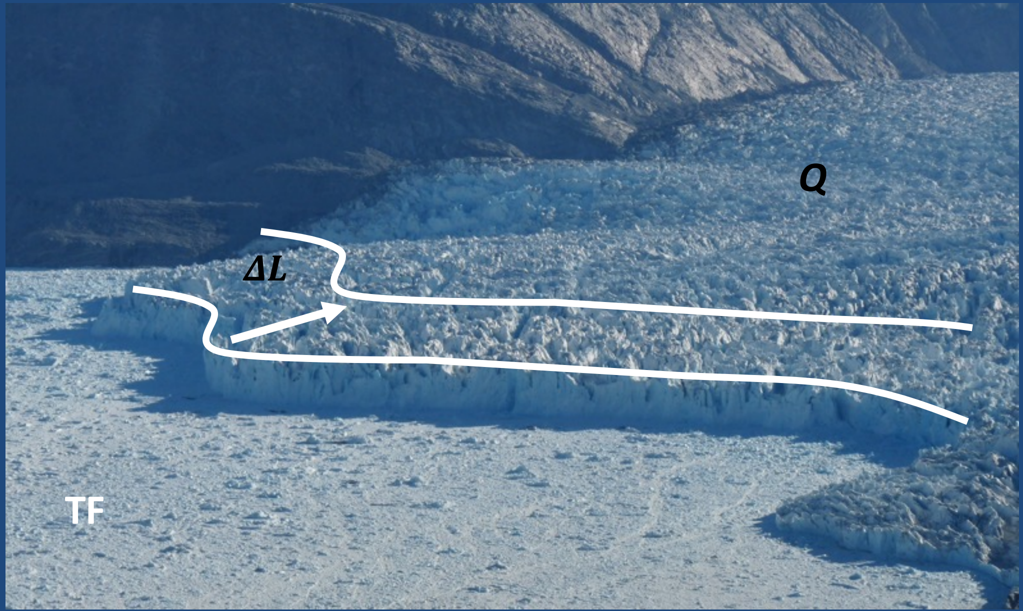
Investigating Ice Sheet Response to Atmospheric and Oceanic Forcing

Extrapolation of properties in fjords



Retreat function of ocean and atmosphere

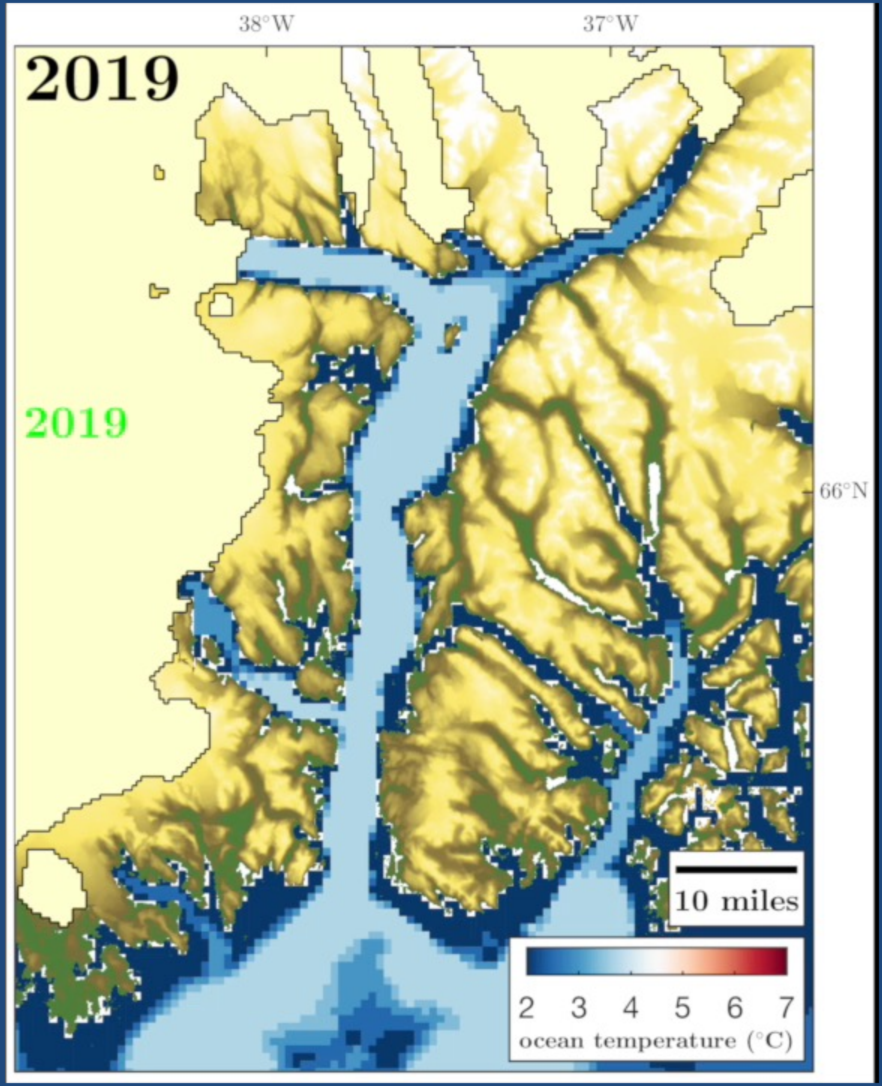
$$\Delta L = K \times \Delta\left(Q^{0.4}\mathrm{TF}\right)$$



Slater et al., 2019,2020

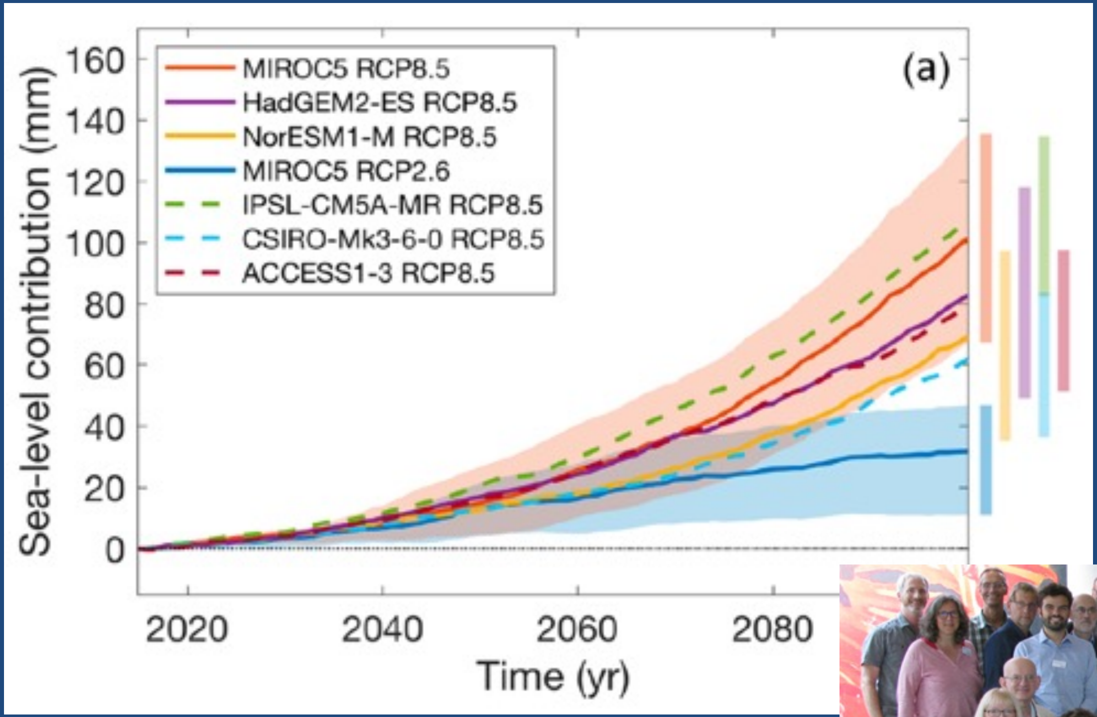
Ocean Forcing of Helheim Glacier (SE Greenland)

Assumption: Properties in fjord = Properties on shelf above sill depth



Slater et al. 2019
Nowicki et al. 2019

Greenland Ice Sheet Model Projections in AR6



Goelzer et al. 2020

Greenland:
21 simulations
14 modeling groups
9 countries

Papers: Ocean Forcing Greenland: Slater et al. 2020; Model Selection Bartel et al. 2020; Protocol: Nowicki et al. 2020; see The Cryosphere Special Issue ISMIP6

Summary AMOC, Sea-ice and Land-Ice

Increased AW transport into Barents Sea and Arctic (eastern) leads to decreased wintertime sea-ice

Not a simple relation between AMOC and AW transport into the Barents Sea and Arctic

Surface mass balance of Arctic/Greenland glaciers affected by air temperatures over ice (potential indirect influence by the ocean)

Dynamic glacier retreat influence by atmosphere and fjord properties which are partly tied to shelf properties and hence AMOC?