

ice **2** ice

**"Science diplomacy in the climate area:
Arctic sea ice and Greenland ice sheet sensitivity"**

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European Research Council
Established by the European Commission





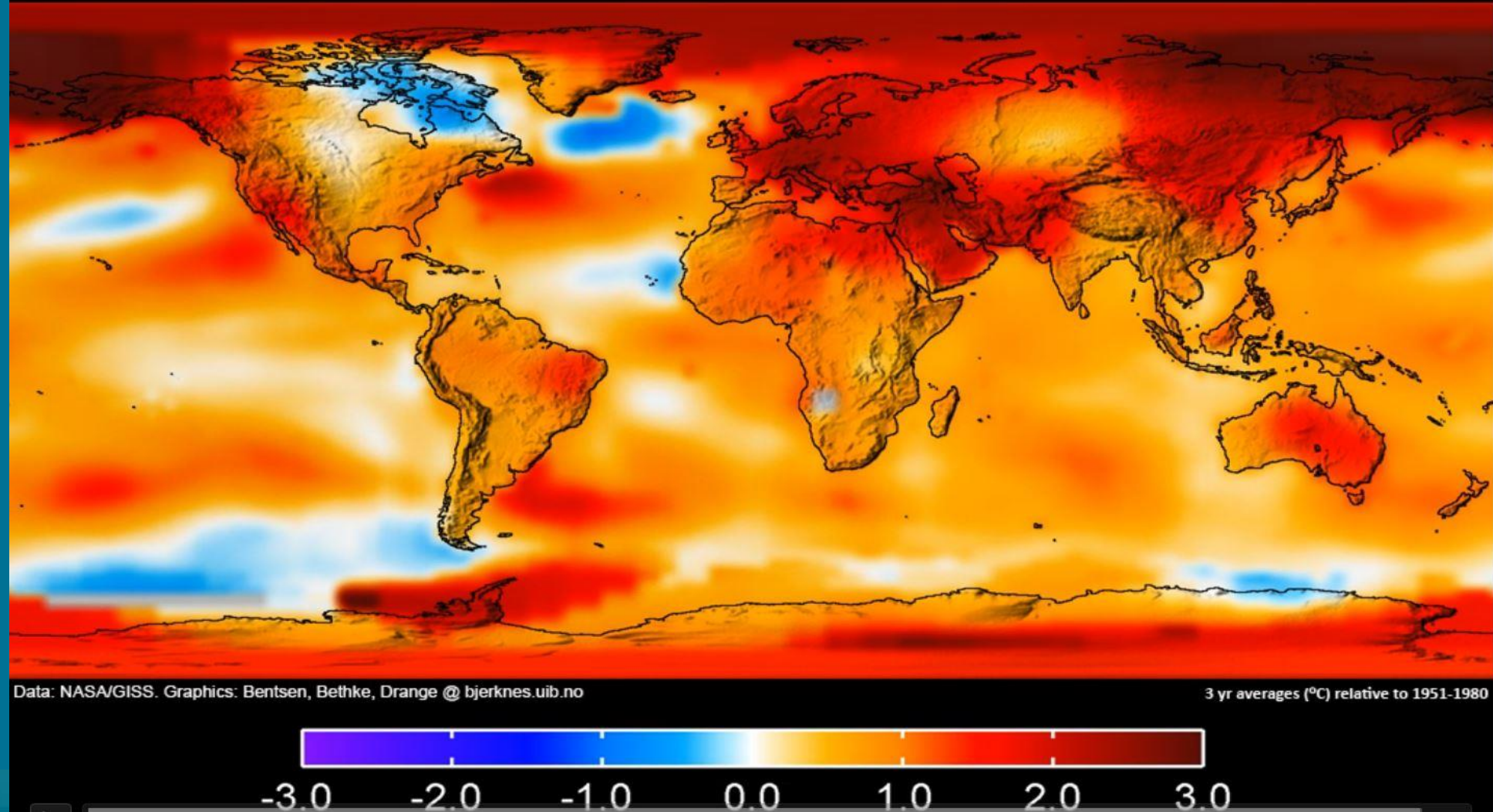
Background: The changing Arctic – The Arctic is a “hot spot” for climate change

- › Arctic temperature increase 2x global mean
- › Some areas several times larger increase
- › Sea ice dramatically diminishing in extent (-13%/decade) and thickness (90% reduction in thick multi-year ice)
- › Glaciers and ice sheets diminishing -> sea level danger
- › What happens in the Arctic does not stay in the Arctic

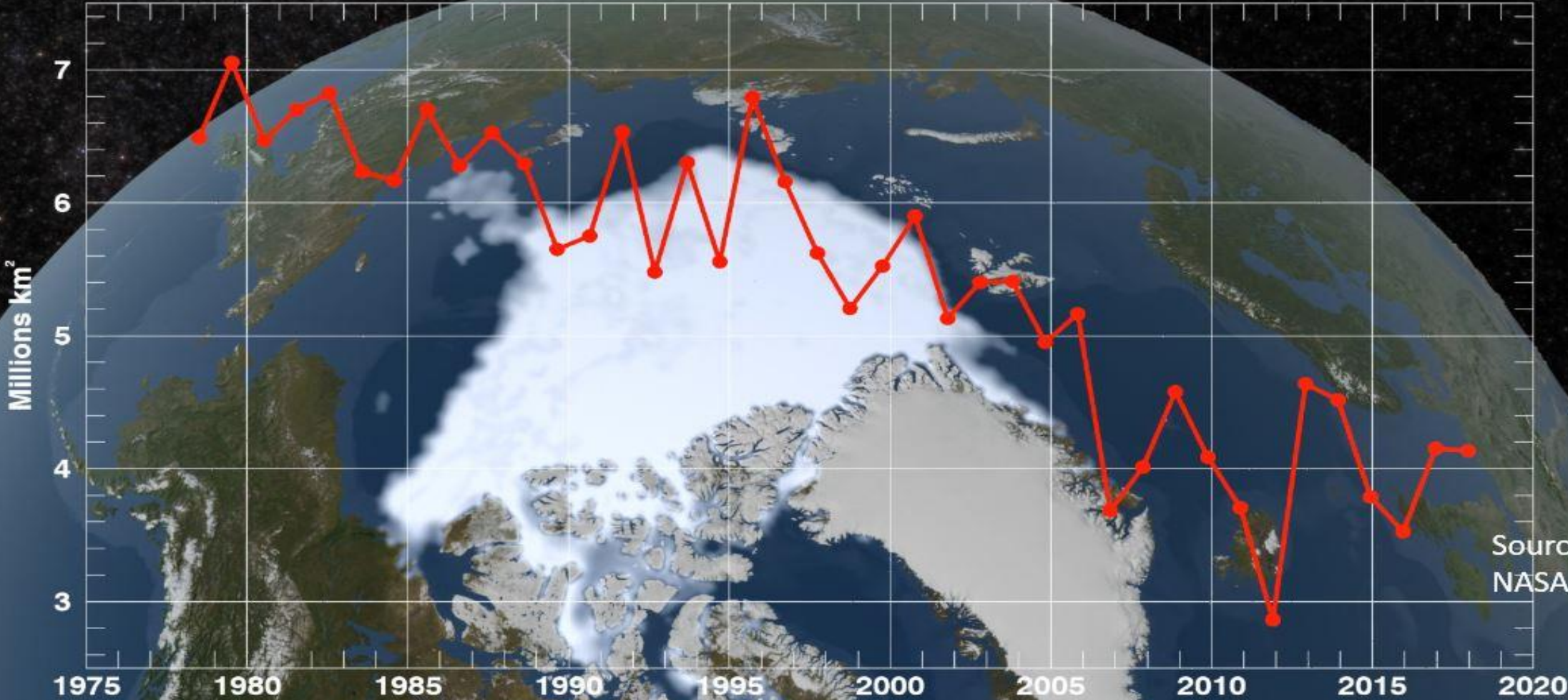
2018

IPCC 2019 SROCC:

A2.4 Arctic surface air temperature has *likely* increased by more than double the global average over the last two decades, with feedbacks from loss of sea ice and snow cover contributing to the amplified warming (*high confidence*).



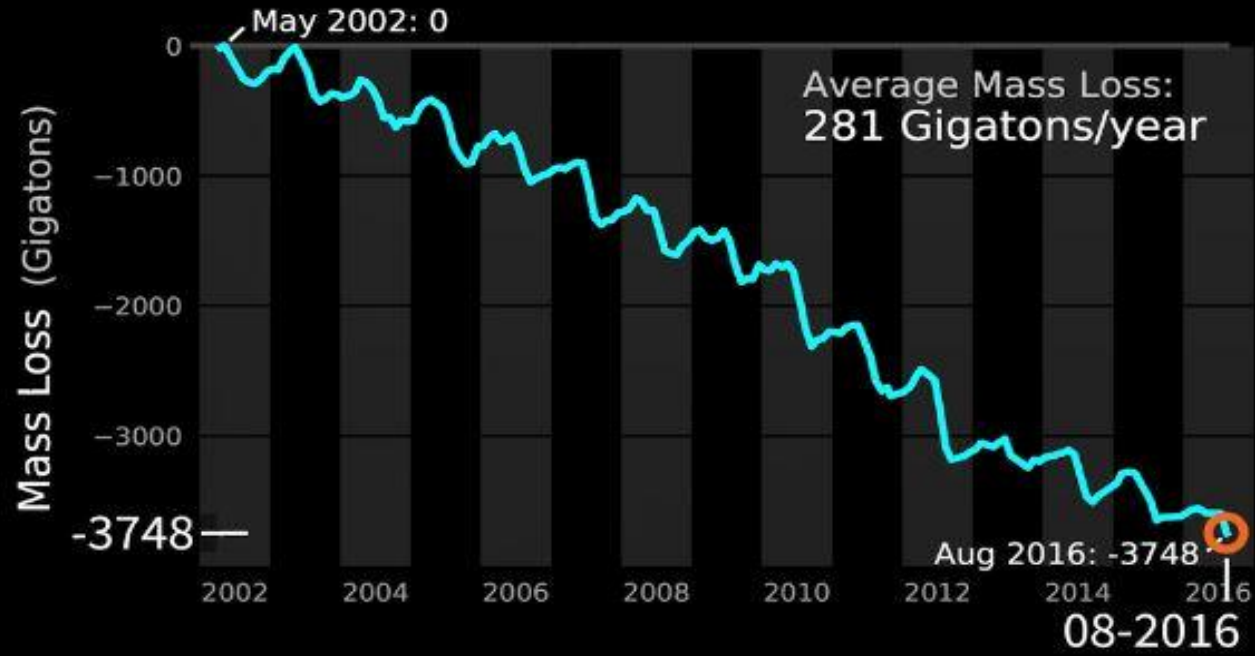
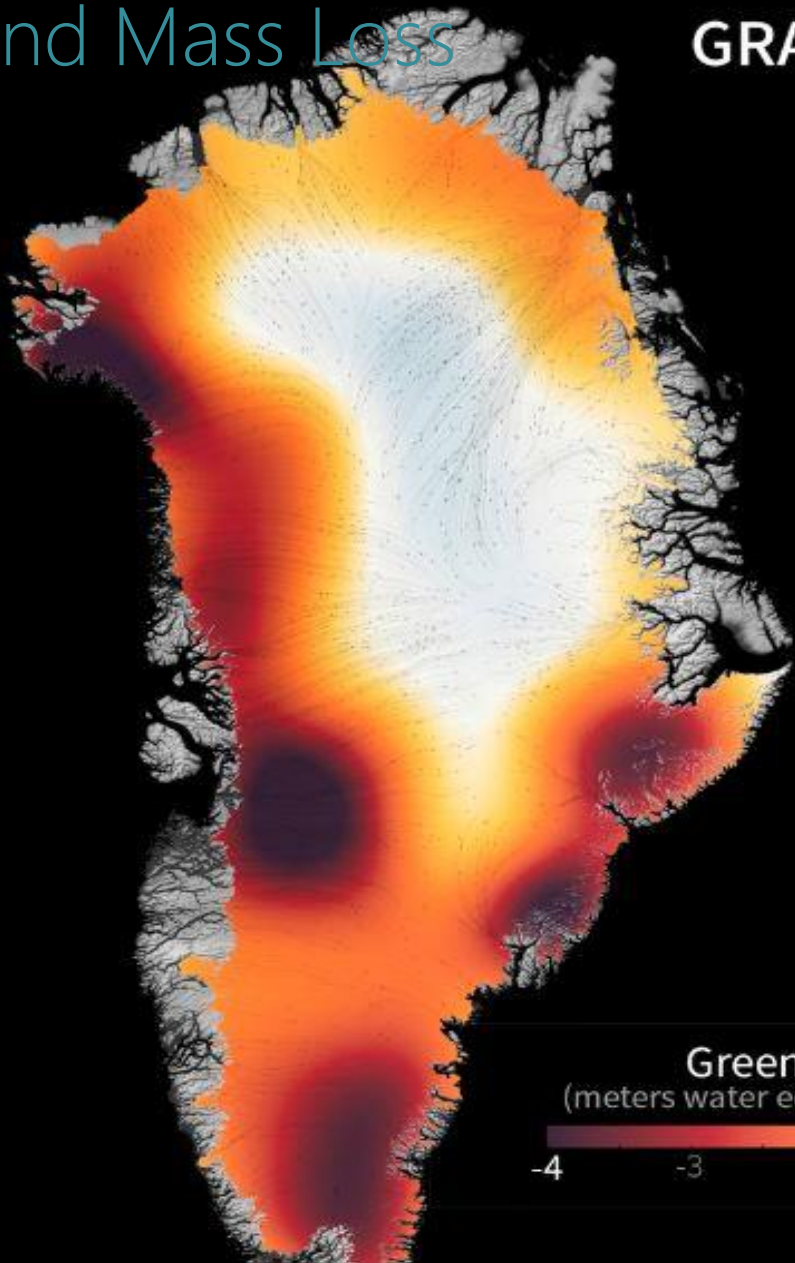
Annual Arctic Sea Ice Minimum Area



Source:
NASA

Greenland Mass Loss

GRACE Observations of Greenland Ice Mass Change



Greenland Ice Loss
(meters water equivalent relative to 2002)

-4 -3 -2 -1 0 0.5

Source:
NASA
NASA



Background: The changing Arctic – The Arctic is a “hot spot” for climate change

- › More countries are active in Arctic research (e.g. major Asian countries). More interest in the Arctic council
- › Geopolitical importance increasing due to diminished sea ice cover
- › Trans-Arctic transport routes and potential increased economic activity (fisheries, resources). Asian countries highly interested in developing infrastructure (Belt and Road).
 - Shorter transport, safer (?) transport, Developing Russian Arctic/Siberia
- › Unsolved territorial boundaries
- › Tendencies to a return to cold war tensions with a more active Russian military presence
- › High impact of Arctic climate change with global repercussions:
 - › Changing sea level from melting of Greenland ice cap
 - › Influence on lower latitude weather and climate patterns
 - › Fate of indigenous peoples



Three aspects of science diplomacy:

1. informing foreign policy objectives with scientific advice (science in diplomacy)
2. facilitating international science cooperation (diplomacy for science)
3. using science cooperation to improve international relations between countries (science for diplomacy)

Royal Society 2010

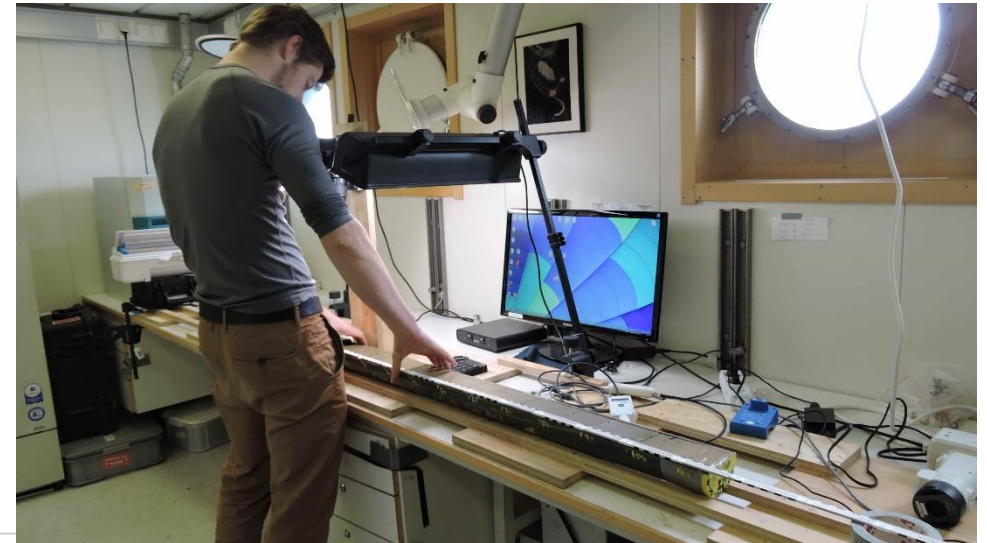


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- › ERC Synergy Grant 2014-2019
- › Univ. Bergen, Univ. Copenhagen, NORCE-Bergen, DMI-Copenhagen

Objectives

- › Did past abrupt changes (DO-events) occur due to sea ice disappearance? **YES**
- › Can we provide a comprehensive and consistent physical description of DO-events? **YES**
- › Did sea ice demise lead to changes in Greenland ice sheet (GIS) mass balance and ice sheet size? **TO SOME EXTENT**
- › **Is there a risk that the ongoing rapid diminution of Arctic sea ice cover could instigate similar abrupt changes in the future? i.e. will changes be abrupt rather than gradual? POSSIBLY**
- › What are the implications of such changes for the GIS, as well as regional Arctic and global climate? **MIXED**



Is this an abrupt climate change when compared to abrupt changes of the past?

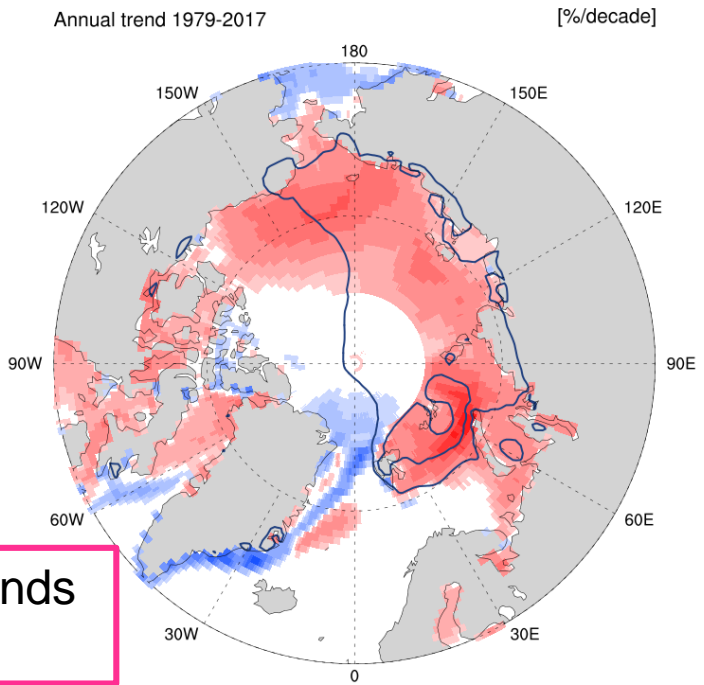
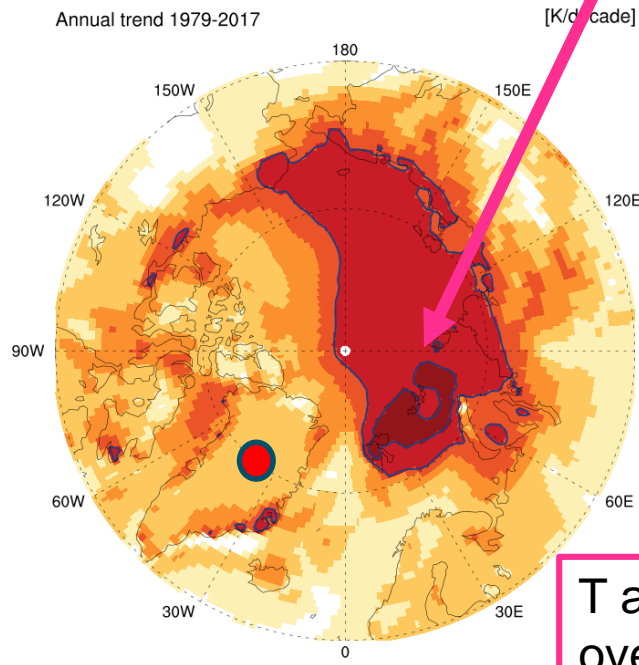
Temperature trend over the Arctic in the satellite era (1979-2017)

Trend > 1°C/decade over 40 years

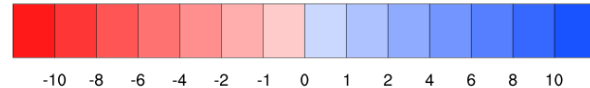
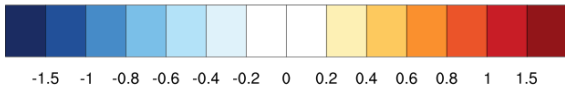
Sea ice cover trend over the Arctic in the satellite era (1979-2017)
% per decade

T2m ERA-Interim

Sea ice ERA-Interim

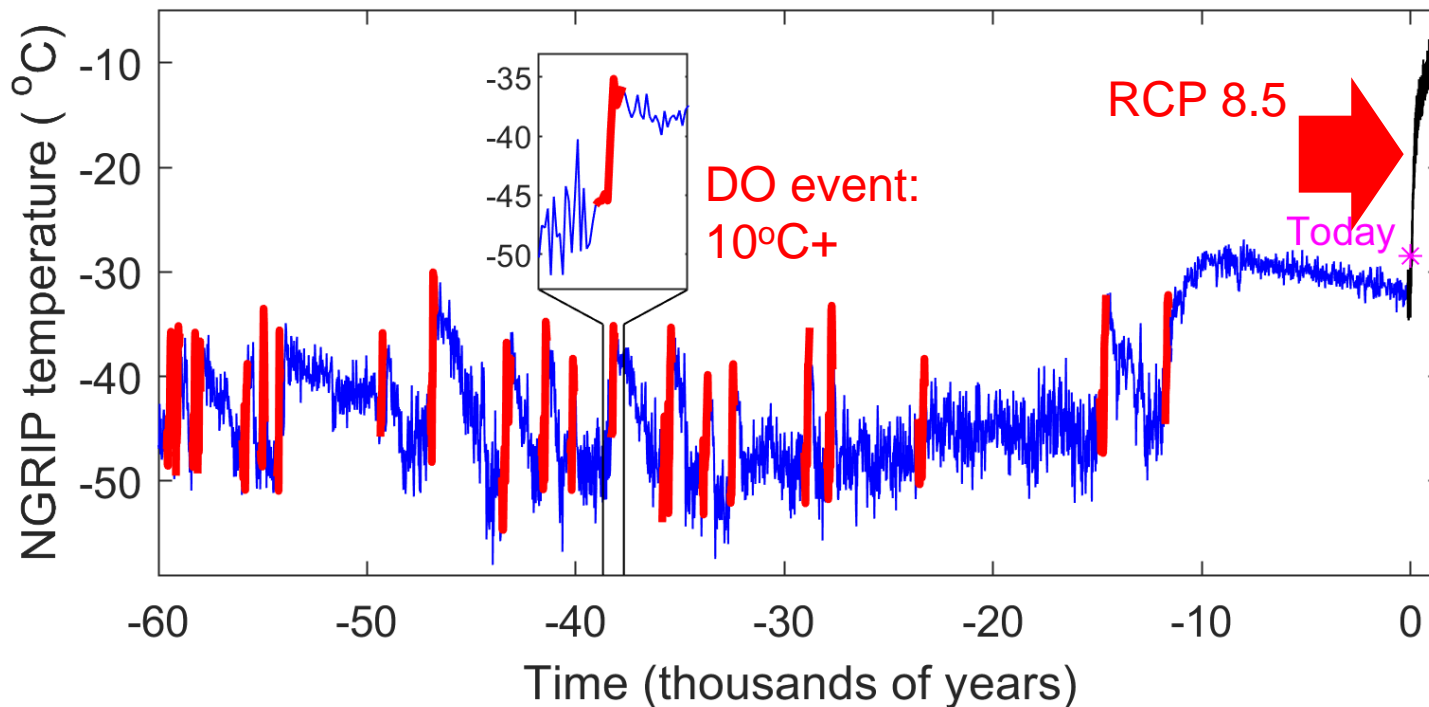


T and sea ice trends overlap



Jansen et al, in review

Is this fast when compared with the past?
($>1\text{deg/decade}$ and 4+ decades)



Analysis of the temperature record from the NGRIP ice core over the last 60ka and next 300 years with high emissions.

Red colour: Changes satisfying the $>1\text{°C/decade}$ over >40 years criterion (+ no return for 100+ years afterwards)

Conclusion: Only times rates were as high as in the Arctic today are during the past abrupt events

Changing Arctic T today is abrupt and on par with the most well known past abrupt changes

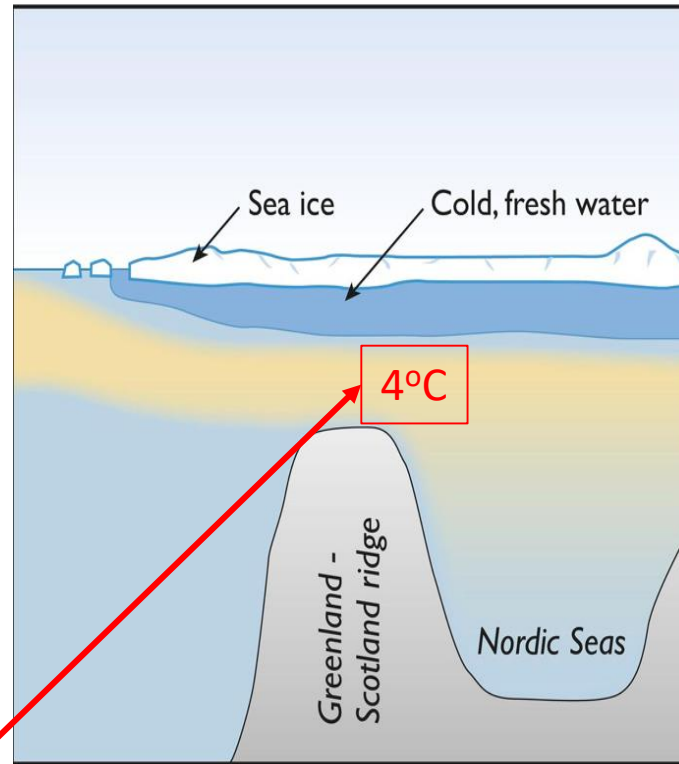
Jansen et al,
in review

Transitions then and now?

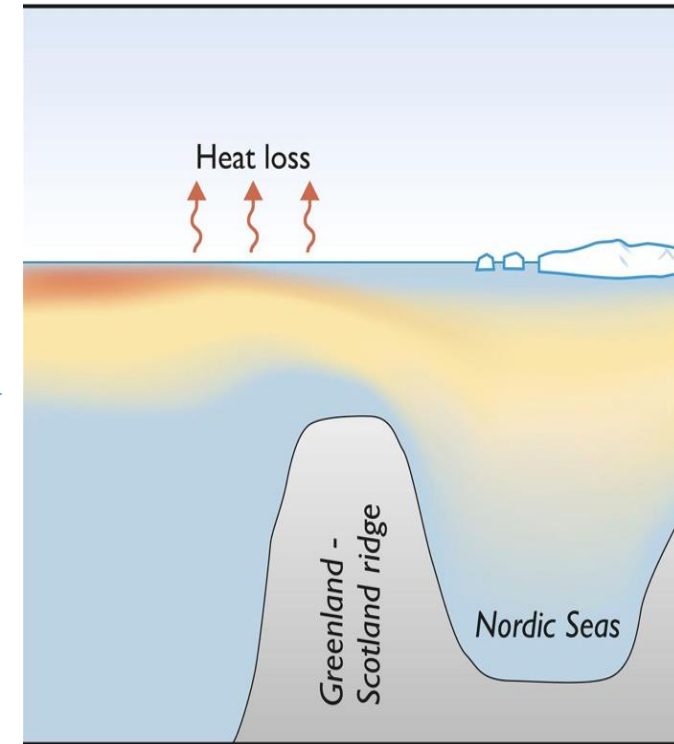
We have shown in data (Sadatzki et al. 2019 Science Adv.) and models that sea ice changes initiated the past abrupt warmings, thus releasing oceanic heat to the atmosphere. This gradual «Atlantification» made sea ice abruptly disappear in the central Nordic Seas

Critical point when T about 4°C

Stadial conditions



Interstadial conditions

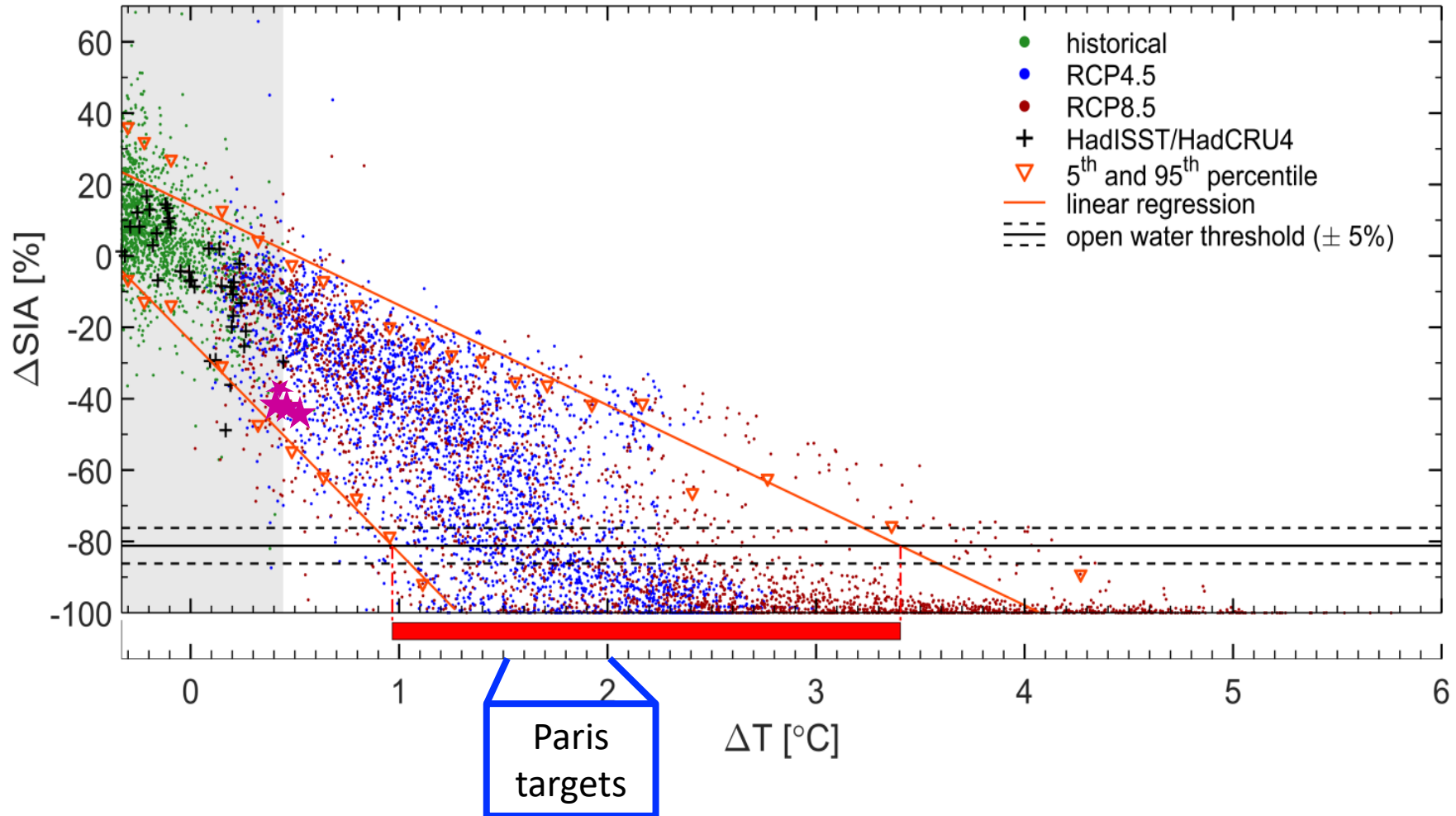


«Atlantification» and subsequent convection
 Today the Arctic is «atlantifying», a clear risk for permanent ice loss

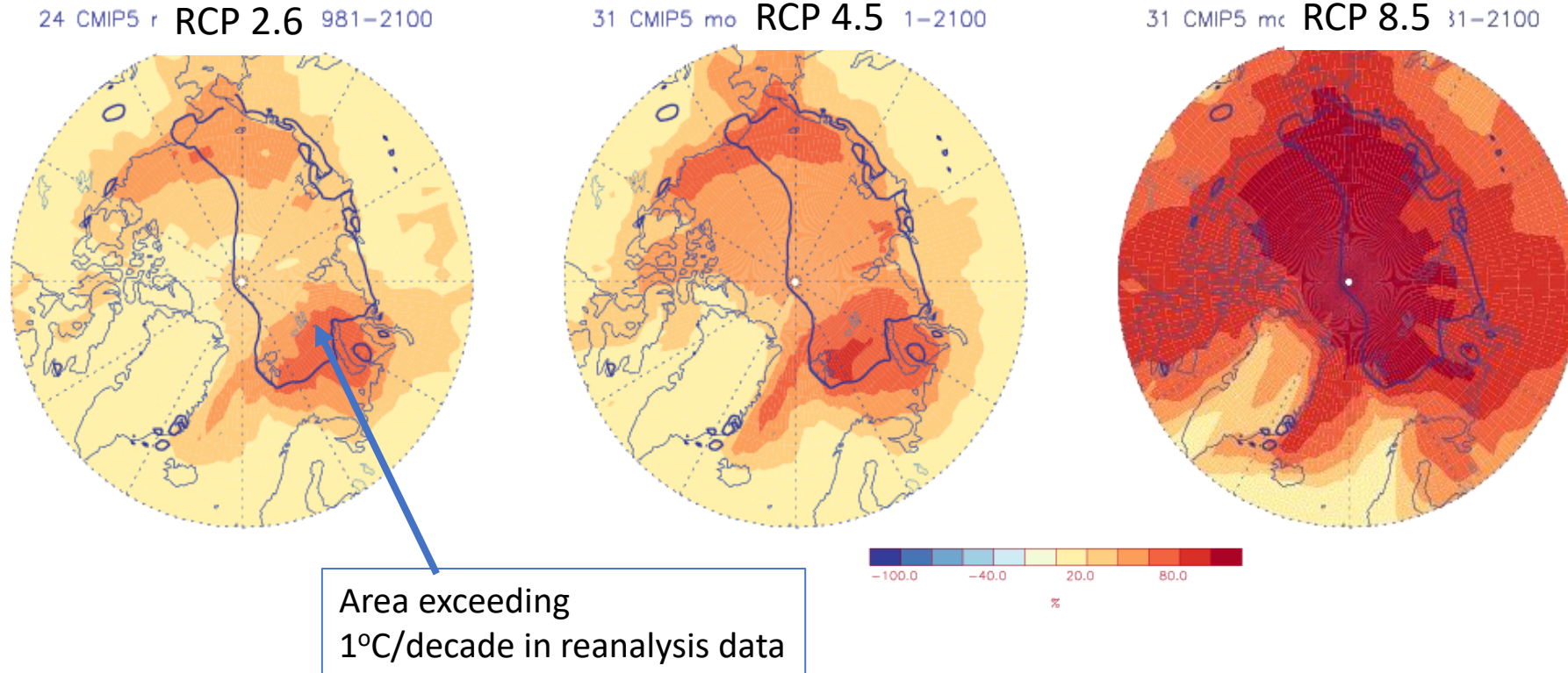
Combining all models and observations wrt. 1986-2005



2016
2017
2018
2019



Arctic T projections (% of CMIP5 models exceeding 1deg/dec threshold between 1981 and 2100)



- Less than half of models under RCP2.6 (2°C target) show abrupt change for this century
- Yet we have already observed an abrupt change in reanalysis data
- CMIP5 models underestimate modern warming rates and abruptness of warming
- Abruptness also depends on emission scenarios and possibly on model climate sensitivity

Jansen et al, in review

- Present Arctic change is abrupt, but abrupt glacial changes in Greenland were probably even faster and more widespread
- Sea ice demise is critical for the speed of changes both then and now
- Ocean processes and their impact on sea ice drove the transition and the rapidity.
- Temperature overshoot following the transition lasted approx. 150 years
- Will the ongoing Atlantification of the Arctic lead to overturning and convection as in the SE Nordic Seas in MIS3? Need better models of Arctic Ocean circulation

Three aspects of science diplomacy:

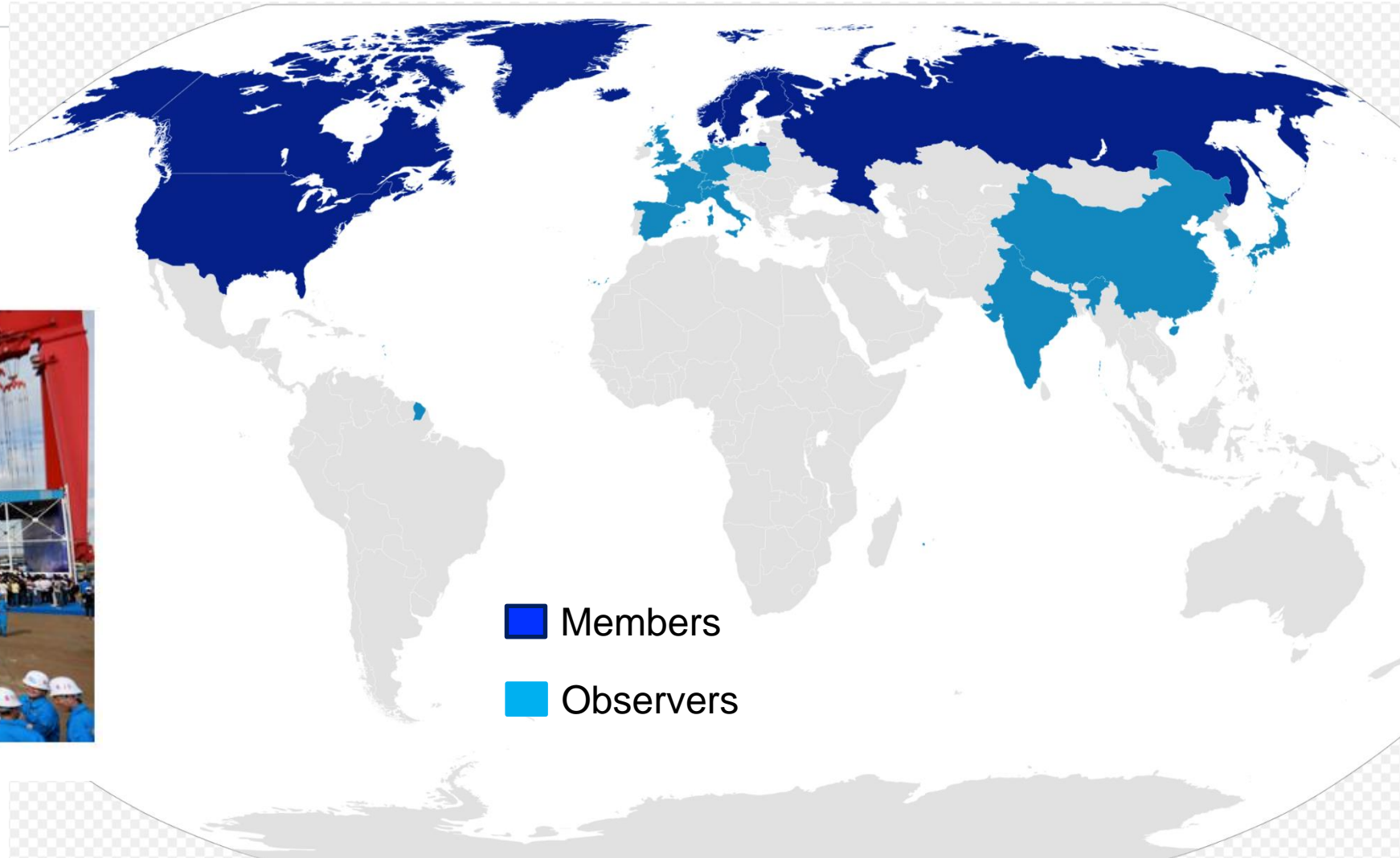
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Royal Society 2010

FORSKNING 00:00 - 21. juni 2019

Dragen vender blikket mot nord

Kina satser på forskningssamarbeid i Arktis, med blant andre Norge. Norske forskere strides om hva som er årsaken til den voksende interessen.



Ny giv mot nord: Xue Long 2, Kinas ferske isbryter, ble sjøsatt sent i fjor og tok sin første testtur i Østkinahavet for bare noen uker siden. Kineserne satser stort på tilstedeværelse i Arktis for tiden – for forskning, men ikke bare for forskning. Foto: VCG/Getty Images



Arctic Council a key player to reduce tensions and drive collaboration, including research collaboration



The Arctic Council is the leading intergovernmental forum promoting cooperation, coordination and interaction among the Arctic States, Arctic indigenous communities and other Arctic inhabitants on common Arctic issues, in particular on issues of sustainable development and environmental protection in the Arctic.

AGREEMENT ON ENHANCING INTERNATIONAL ARCTIC SCIENTIFIC COOPERATION

The Government of Canada, the Government of the Kingdom of Denmark, the Government of the Republic of Finland, the Government of Iceland, the Government of the Kingdom of Norway, the Government of the Russian Federation, the Government of the Kingdom of Sweden, and the Government of the United States of America (hereinafter referred to as the "Parties"),

Recognizing the importance of maintaining peace, stability, and constructive cooperation in the Arctic;

Recognizing the importance of the sustainable use of resources, economic development, human health, and environmental protection;

Reiterating the urgent need for increased actions to mitigate and adapt to climate change;

Emphasizing the importance of using the best available knowledge for decision-making;

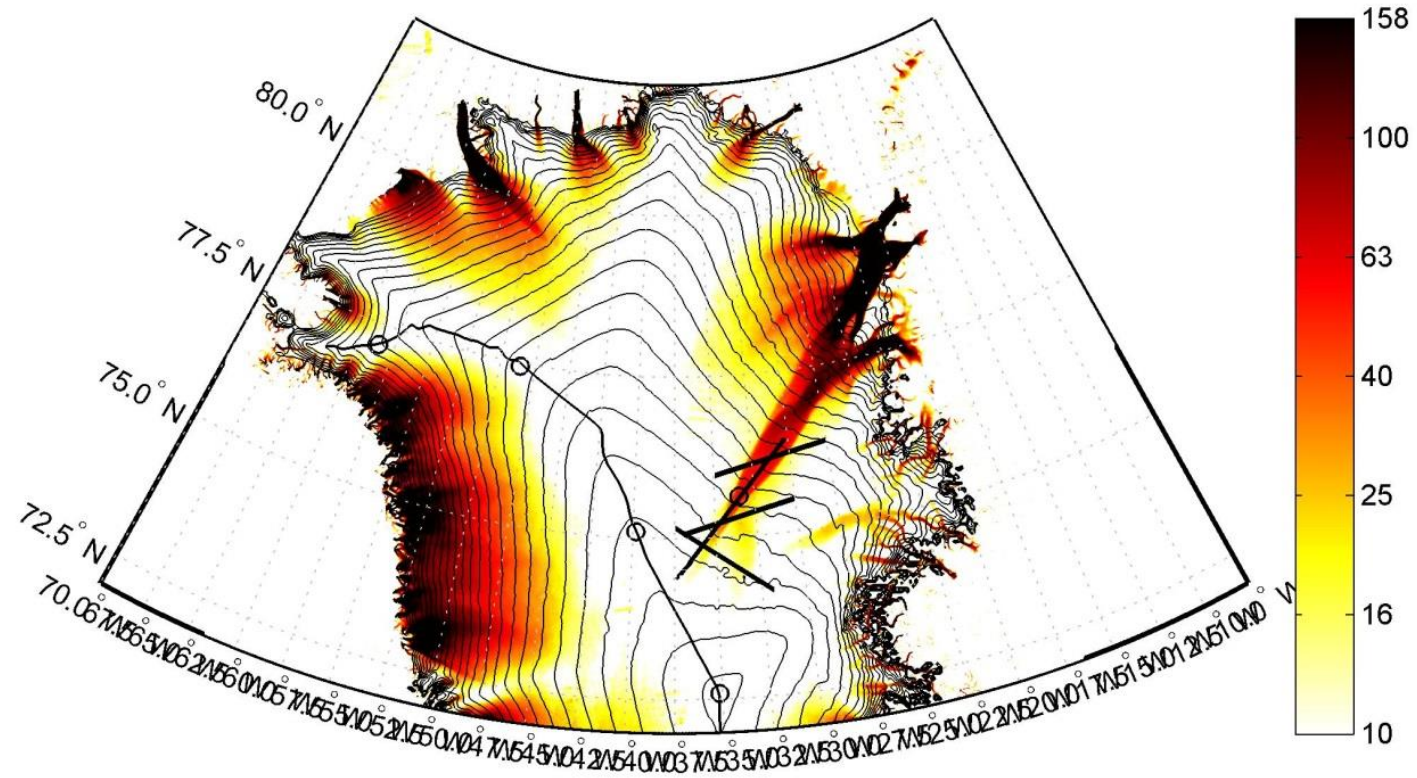
Noting the importance of international scientific cooperation in that regard;

Fully taking into account the relevant provisions of the 1982 United Nations Convention on the Law of the Sea, in particular the provisions in Part XIII on marine scientific research as they relate to promoting and facilitating the development and conduct of marine scientific research for peaceful purposes;

Recalling the Kiruna Declaration on the occasion of the Eighth Ministerial meeting of the Arctic Council held in May 2013 and the Iqaluit Declaration on the occasion of the Ninth Ministerial meeting of the Arctic Council held in April 2015;

Example 1: EastGRIP a new deep drill site on the North Greenland Ice Stream

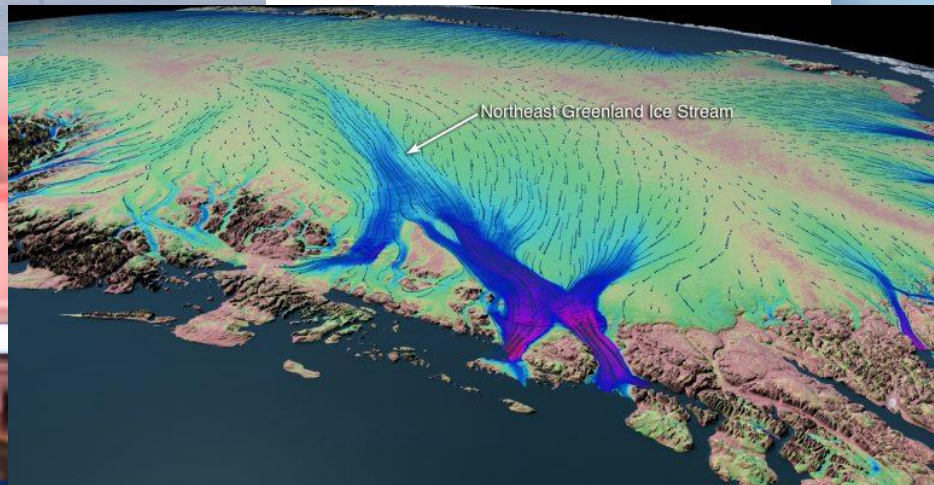
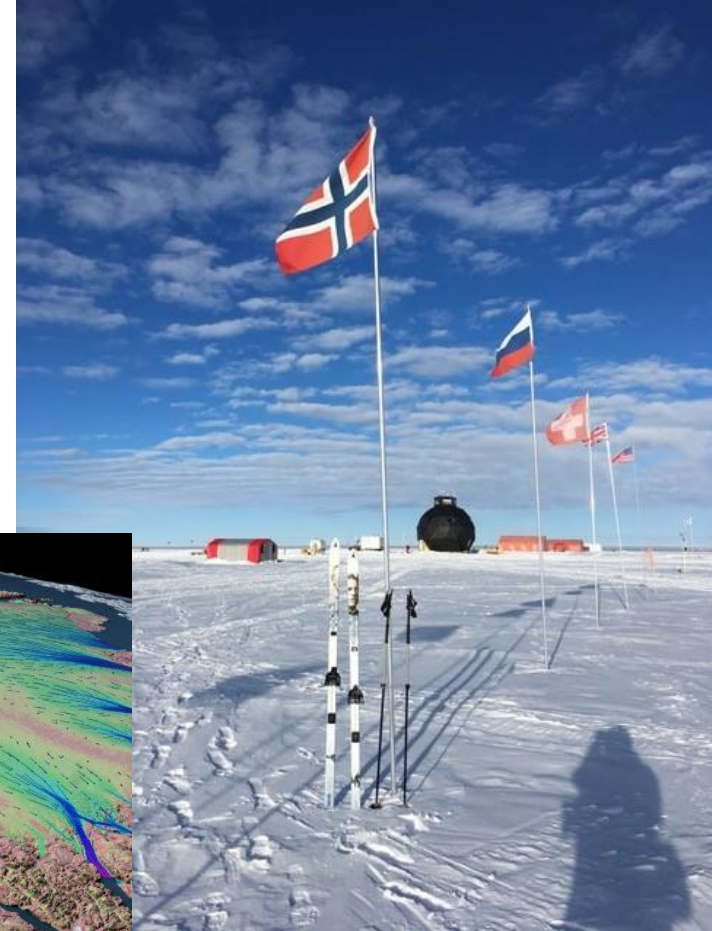
The North Greenland Ice Stream (NEGIS):





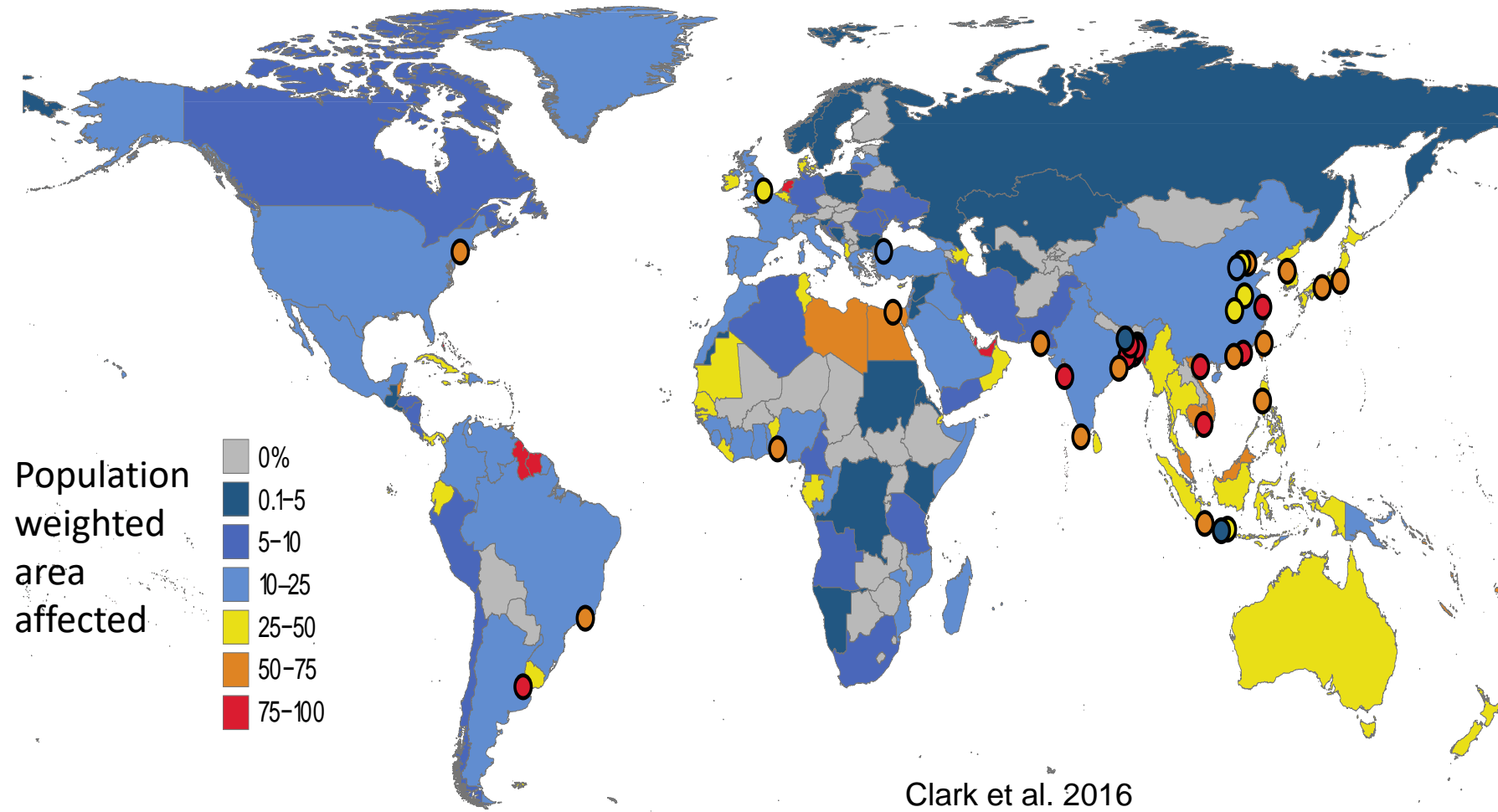
Example 1: EastGRIP a new deep drill site on the North Greenland Ice Stream

Includes the permanent members of UN Security Council



The Guardian

Long-term sea level effects (from Greenland+Antarctic) of not acting now



Clark et al. 2016
Nature geoscience

Example 2: MOSAiC Expedition

MOSAiC is the first year-round expedition into the central Arctic exploring the Arctic climate system. The project with a total budget exceeding 140 Million € has been designed by an international consortium of leading polar research institutions, led by the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI).

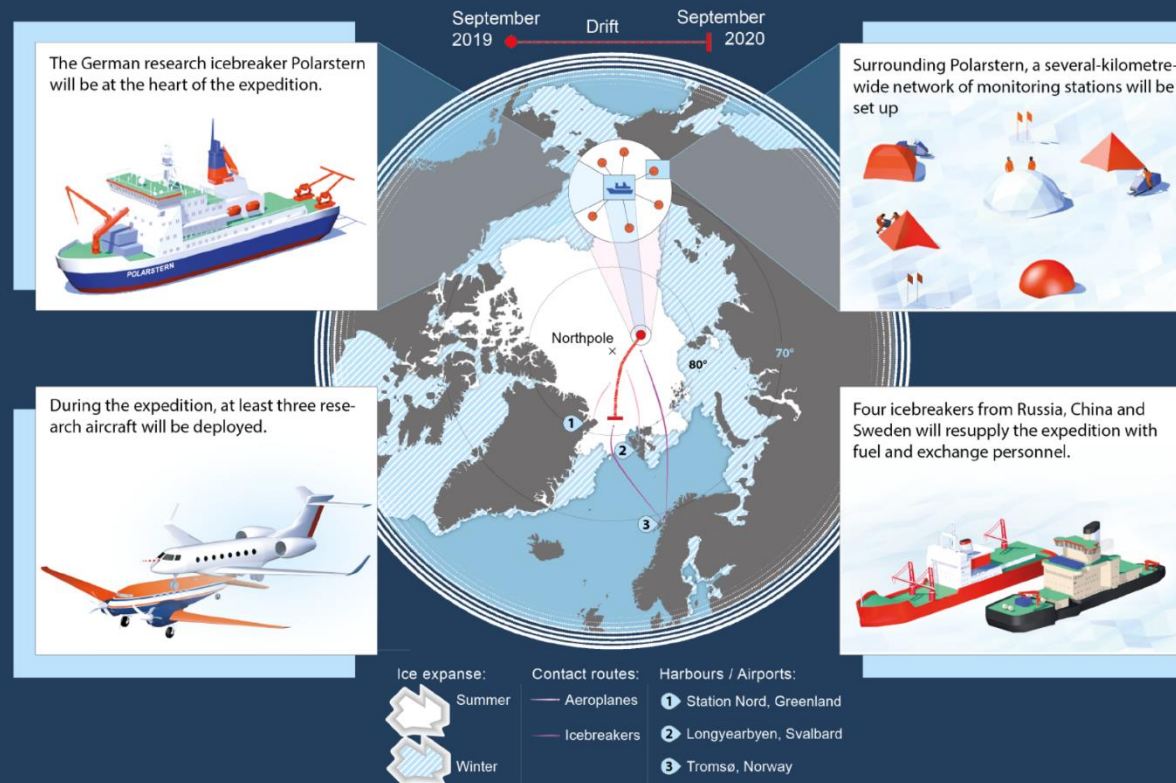


Figure 1: Not only the science behind MOSAiC is a huge endeavour that needs the expertise of multiple nations and scientific disciplines, but also the logistics face unparalleled

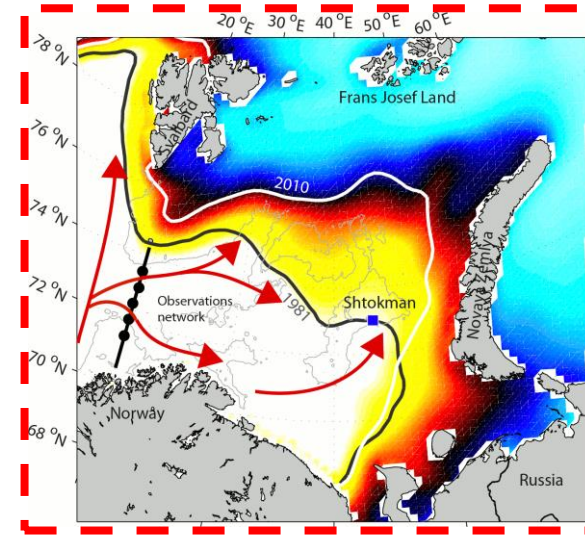
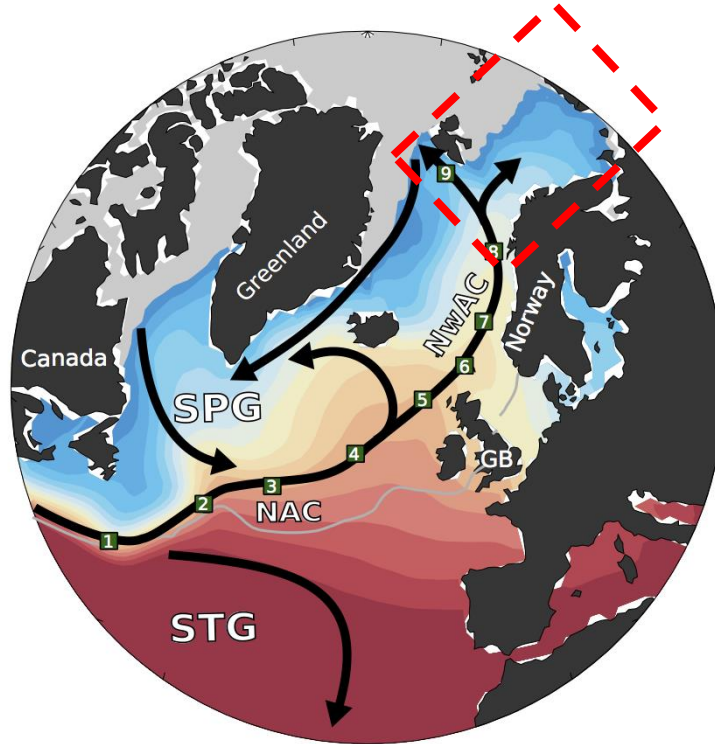


Example 2: MOSAiC Expedition

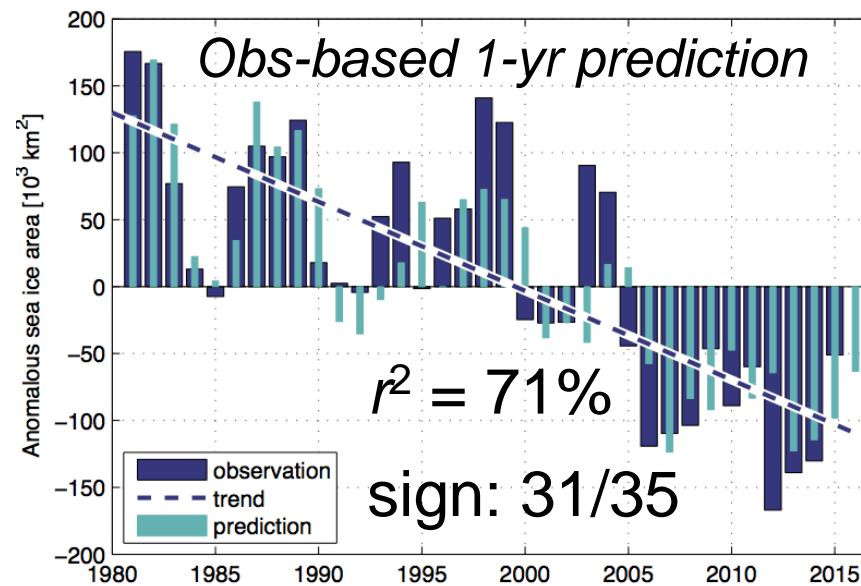
Partner nations



Observed Barents Sea ice predictability



Onarheim et al. 2015:
Skillful prediction of
Barents Sea ice cover.
GRL



Onarheim et al. 2015: GRL; Årthun et al. 2012: JCLim



Summary

- › Research on fundamental, complex and unsolved issues critical for assessing our climate future, climate impacts and the risks and thresholds involved when implementing the Paris Agreement
- › Management and regulations need much better predictability of the system:
 - Longer-term
 - Decadal
 - Seasonal
 - Abrupt surprises
- › Increased importance of the Arctic – Arctic Research is multinational and can help ease tensions, and give all stakeholders open information