

# Changing Arctic Ocean

**Implications for marine biology and biogeochemistry**

Photo by Jen Freer



Dr Kirsty Crocket  
Science Coordinator  
[k.crocket@ed.ac.uk](mailto:k.crocket@ed.ac.uk)



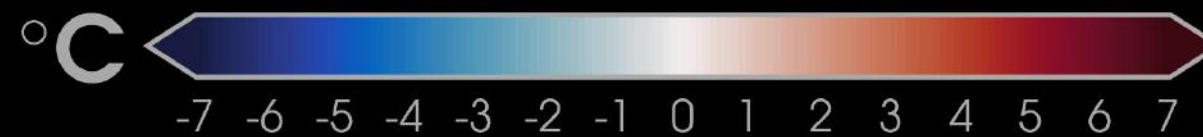
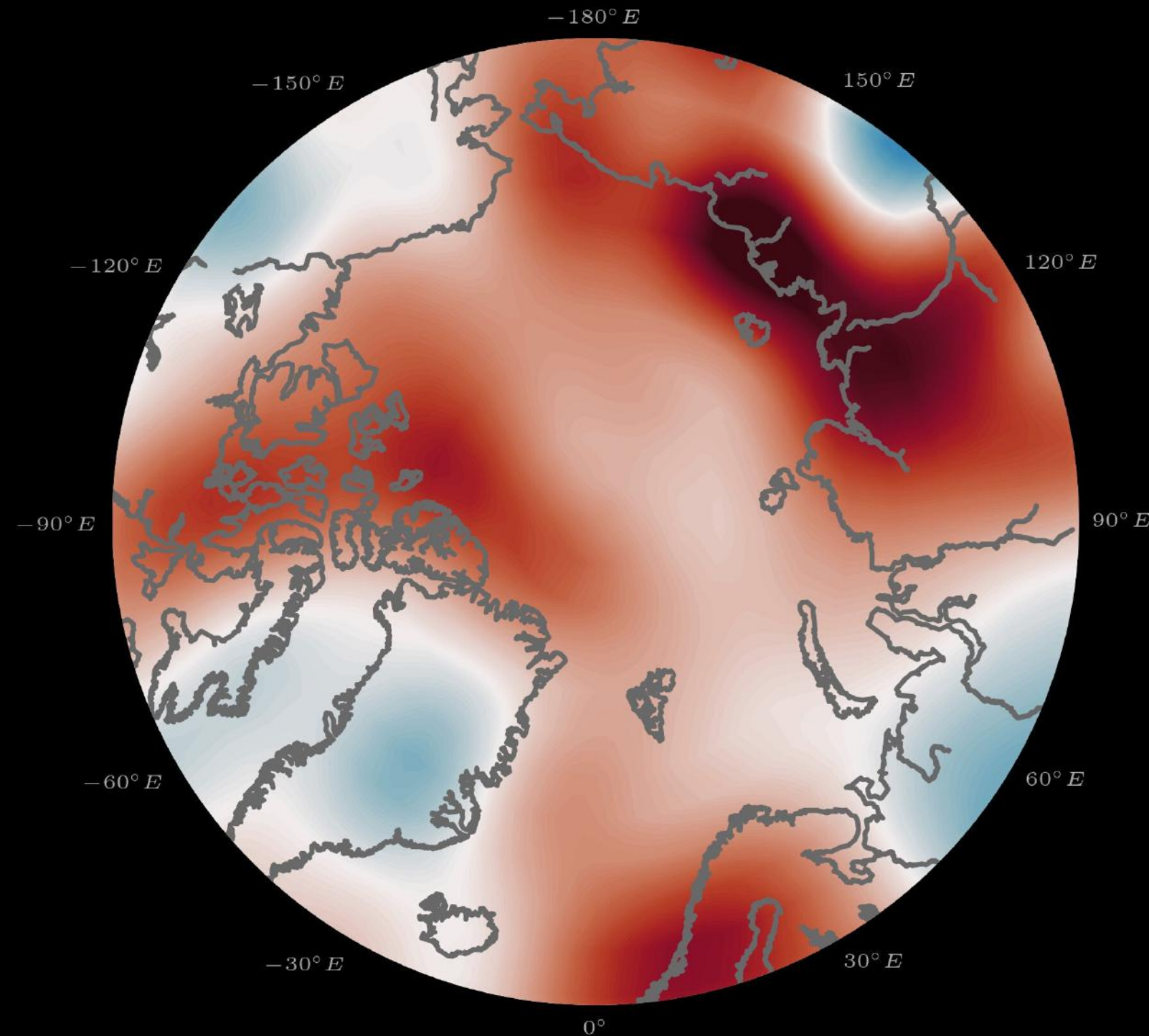
# GLOBAL WARMING RETREAT OF SEA ICE NEW PHYSICAL STATE

**Changing Arctic Ocean: Implications for marine biology and biogeochemistry**

Photo by Jen Freer

# Average air temperature anomaly in JUNE 2020

relative to 1981-2010 baseline



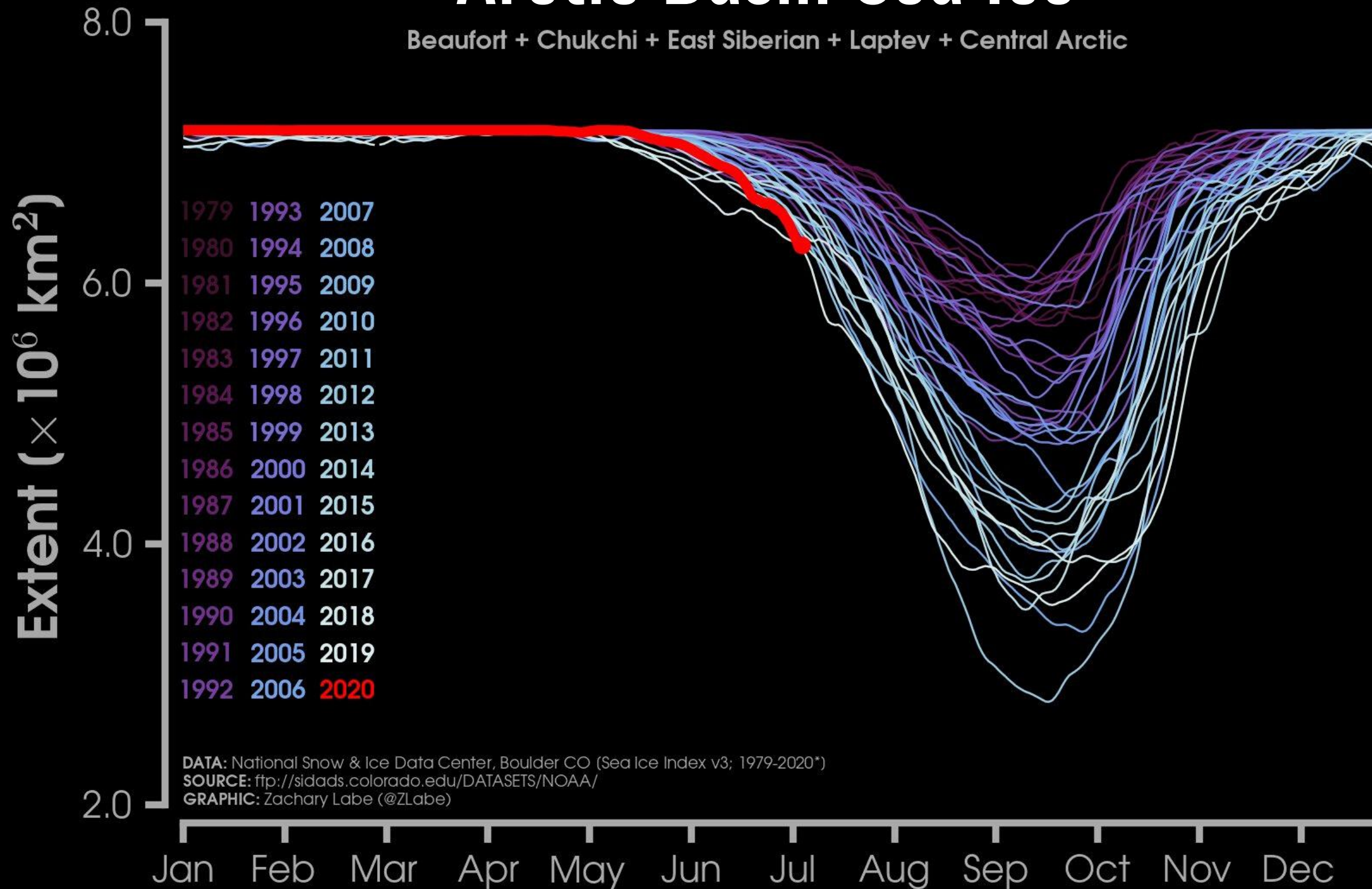
DATA: NCEP/NCAR Reanalysis (BASE: 1981-2010)  
SOURCE: <http://www.esrl.noaa.gov/psd/>  
GRAPHIC: Zachary Labe (@ZLabe)  
DATE: 6/1/2020 – 6/30/2020

Figure from Zack Labe ~ @ZLabe ~ <https://sites.uci.edu/zlabe/>

Data source: <http://www.esrl.noaa.gov/psd/>

# Arctic Basin Sea Ice

Beaufort + Chukchi + East Siberian + Laptev + Central Arctic



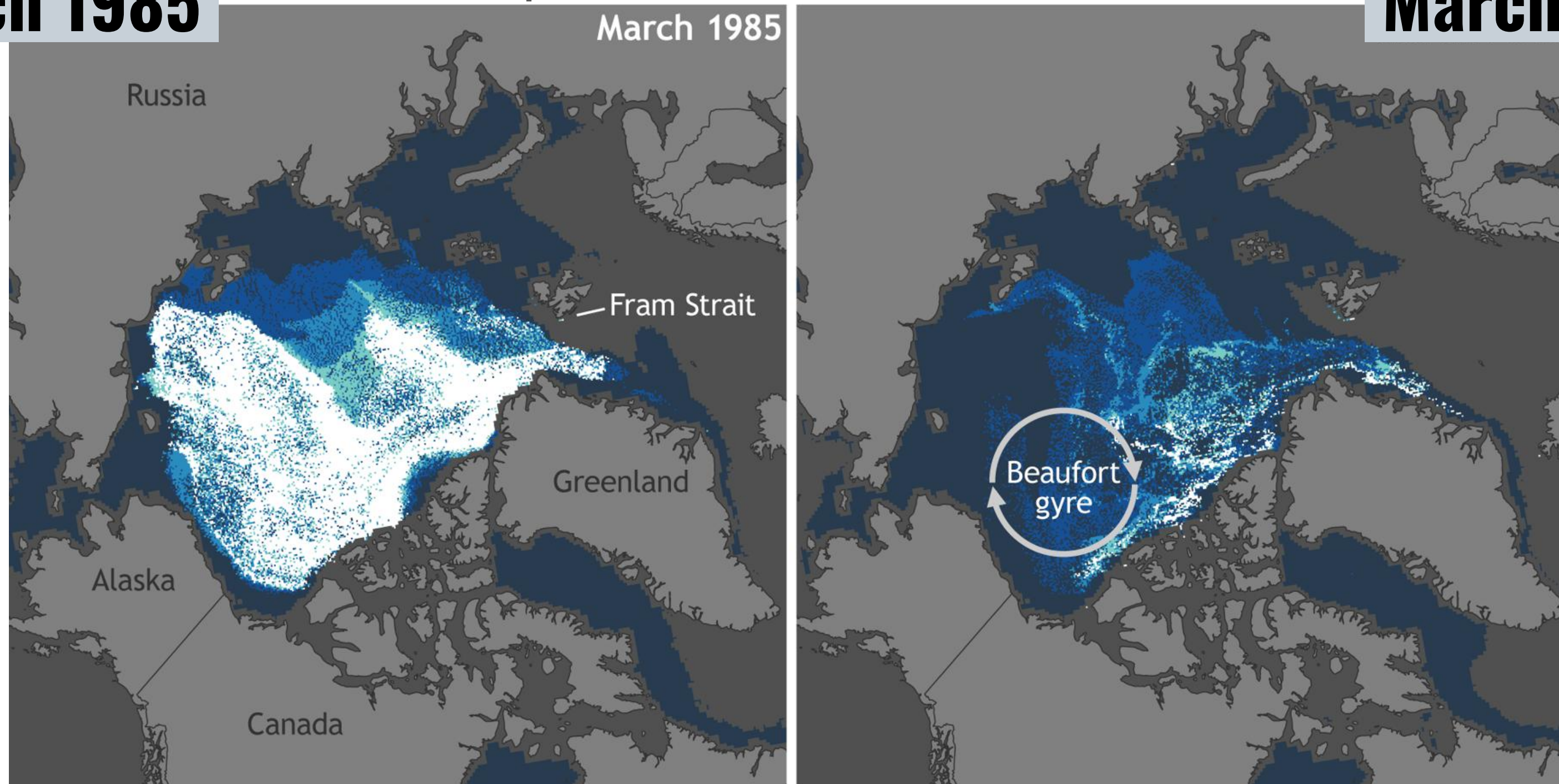
DATA: National Snow & Ice Data Center, Boulder CO (Sea Ice Index v3; 1979-2020\*)  
SOURCE: <ftp://sidads.colorado.edu/DATASETS/NOAA/>  
GRAPHIC: Zachary Labe (@ZLabe)

# Loss of sea ice older than 4 years

comparison March 1985 to March 2018

**March 1985**

**March 2018**



Sea ice age (years)

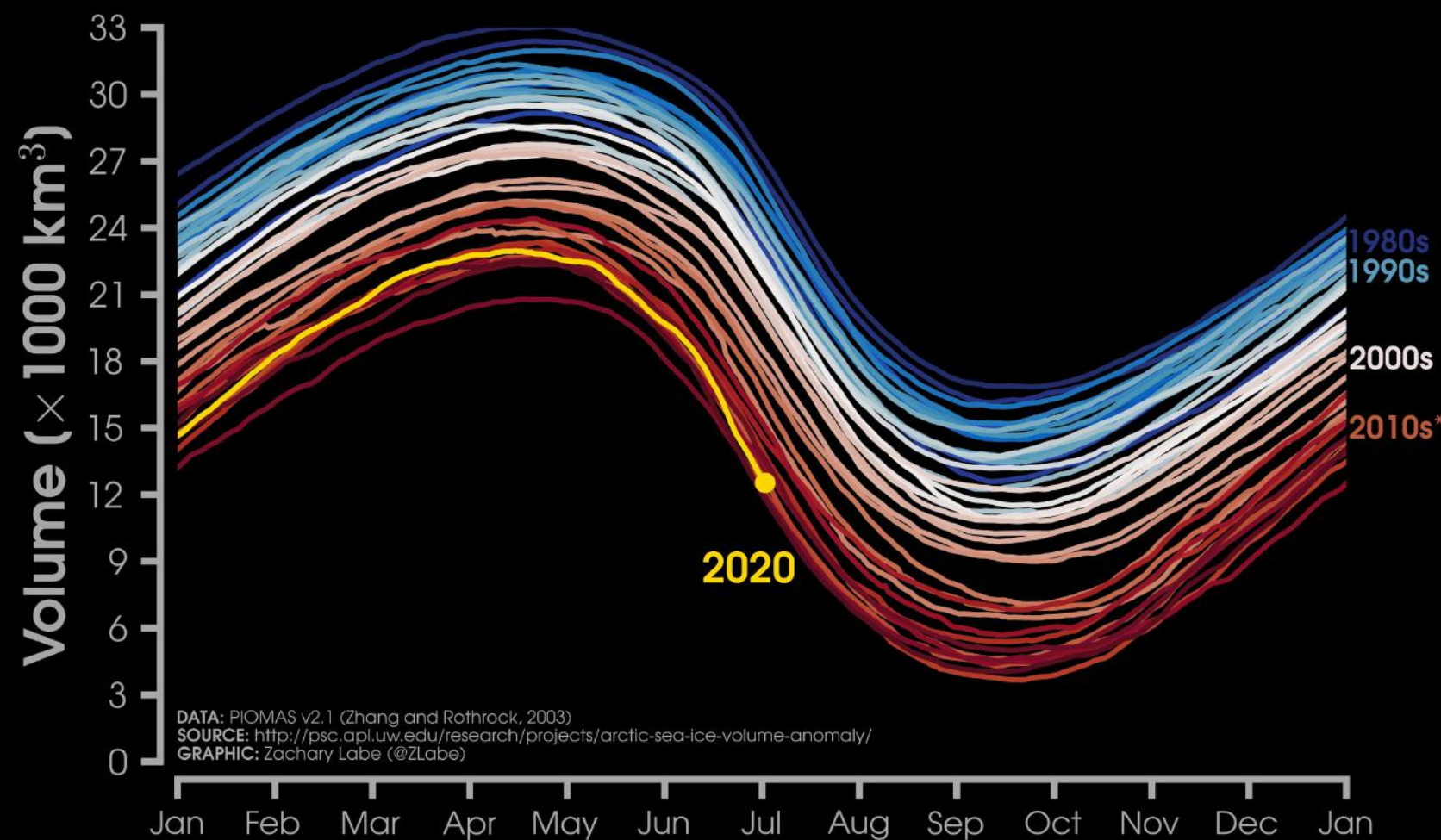


NOAA Climate.gov  
Data: ARC 2018

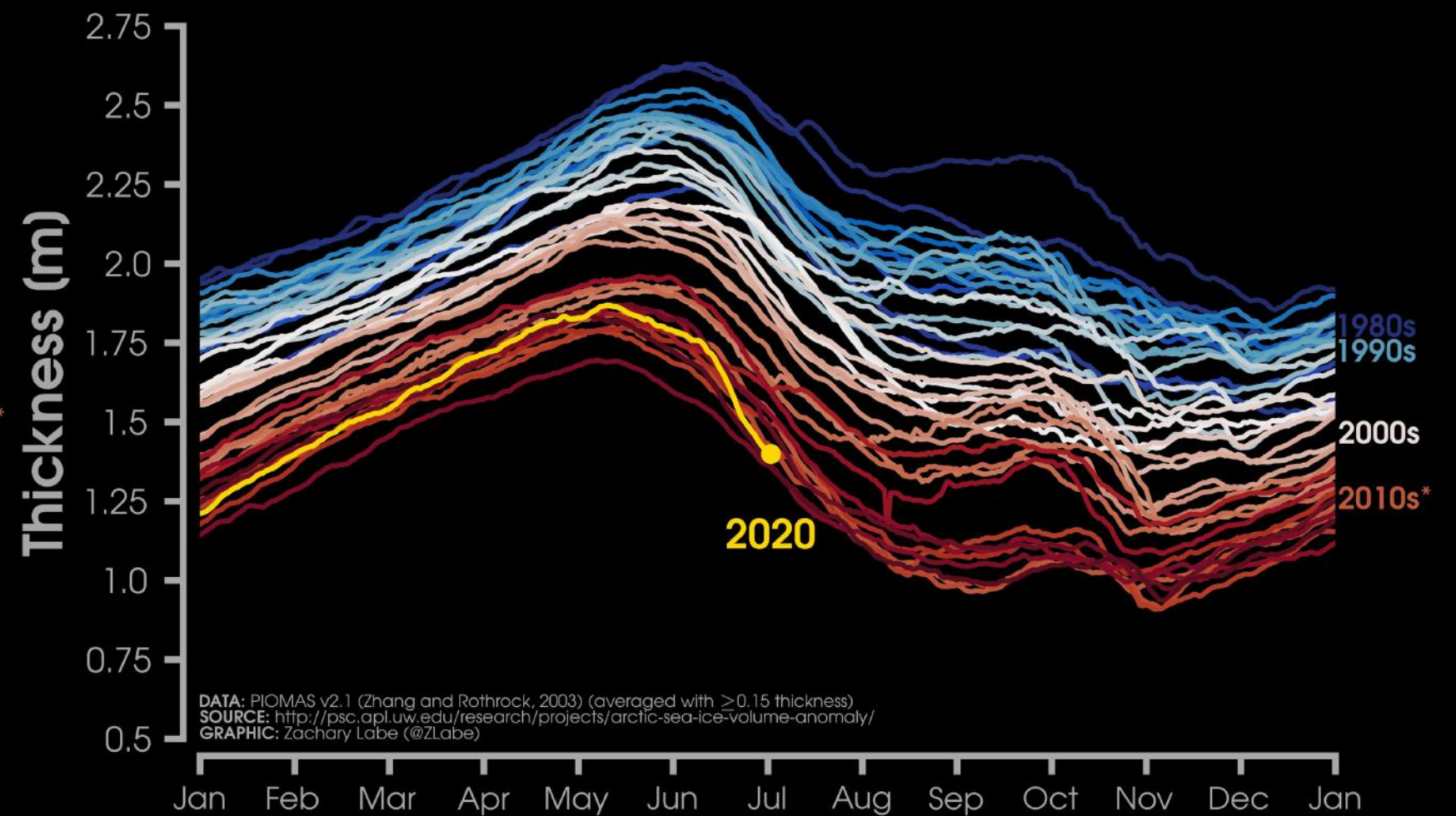
Figure from the 2018 Arctic Report Card

# Arctic Sea Ice 1979-2020

## Volume



## Thickness



# East Siberian + Laptev + Kara Seas 1979-2020

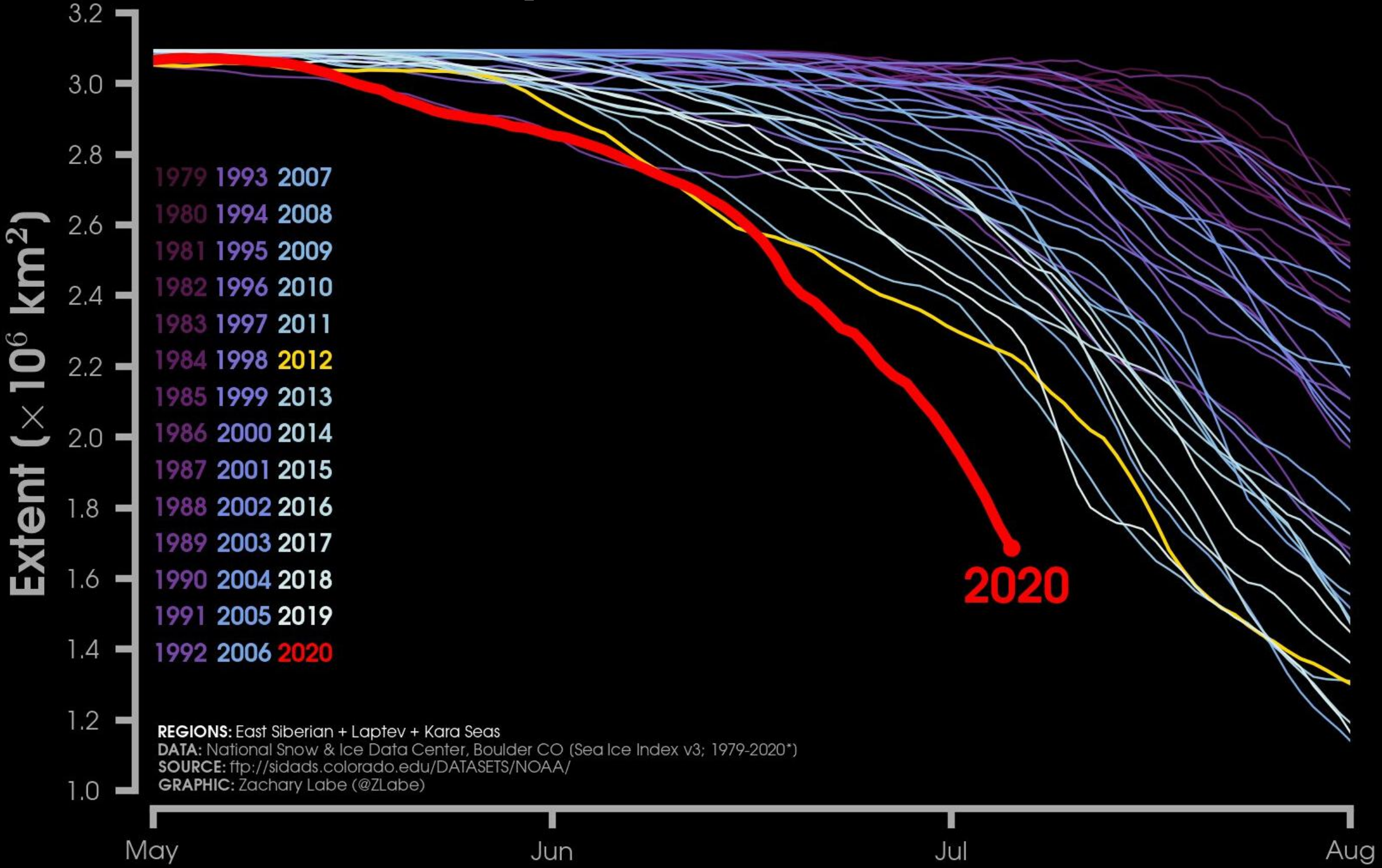
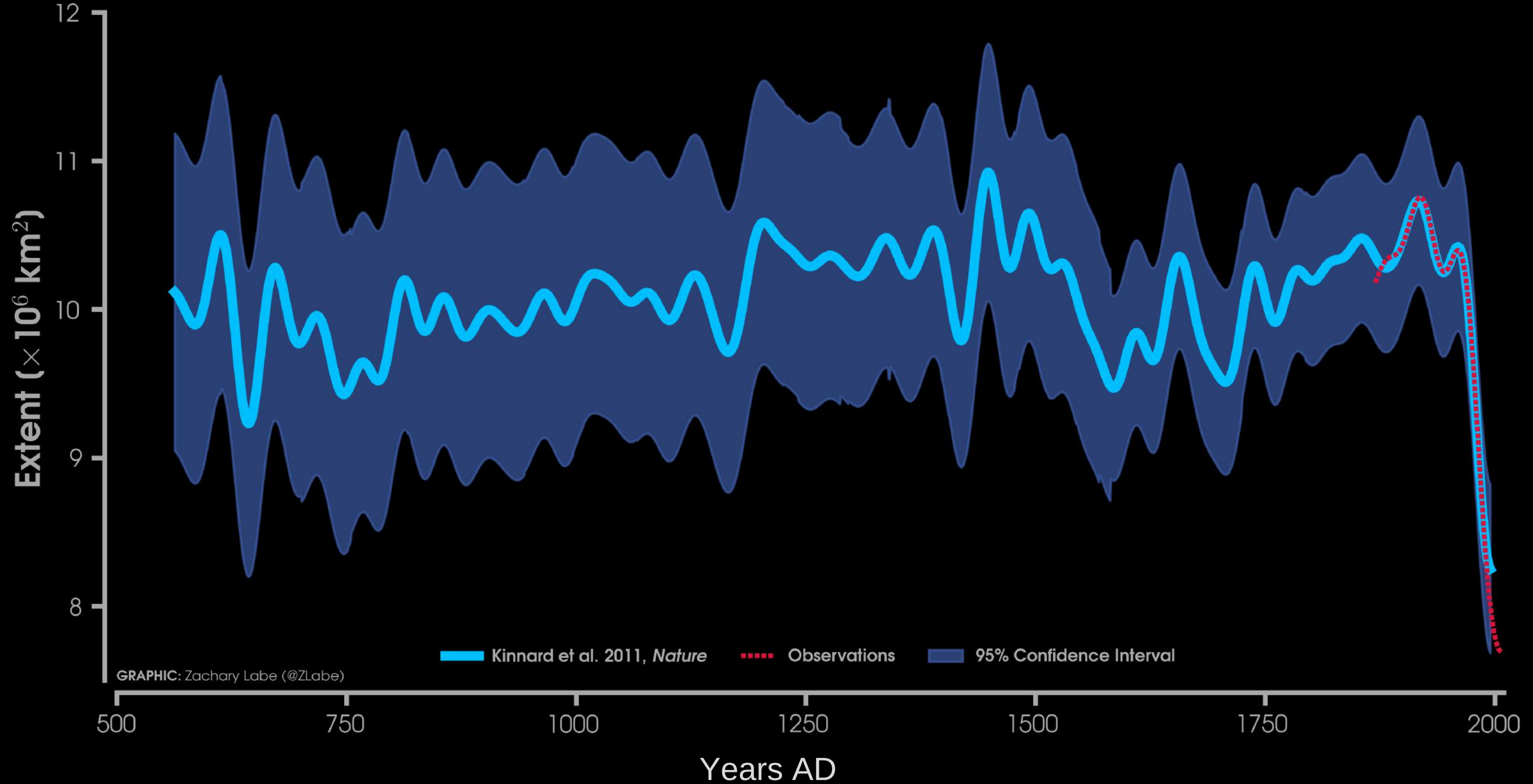


Figure from Zack Labe ~ @ZLabe ~ <https://sites.uci.edu/zlabe/>

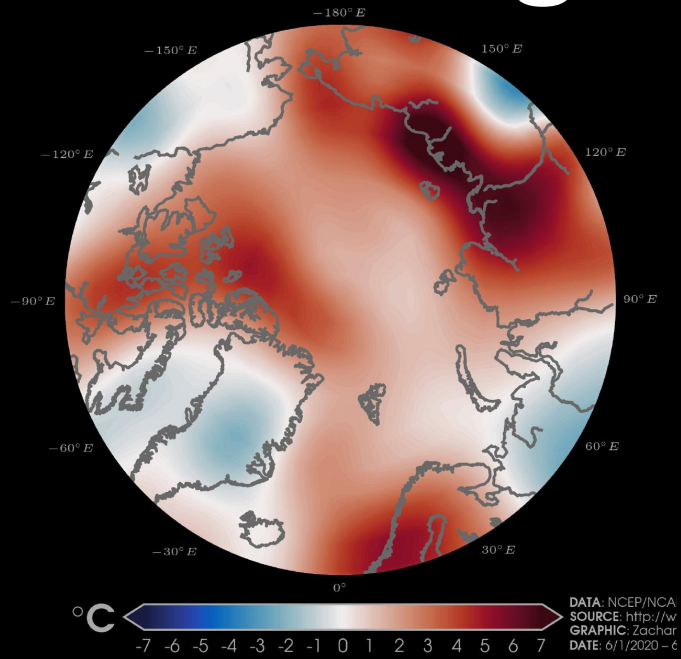
Data: National Snow & Ice Data Center, USA (Sea Ice Index v3)

# Reconstruction of Arctic sea ice extent: AD 561 to modern

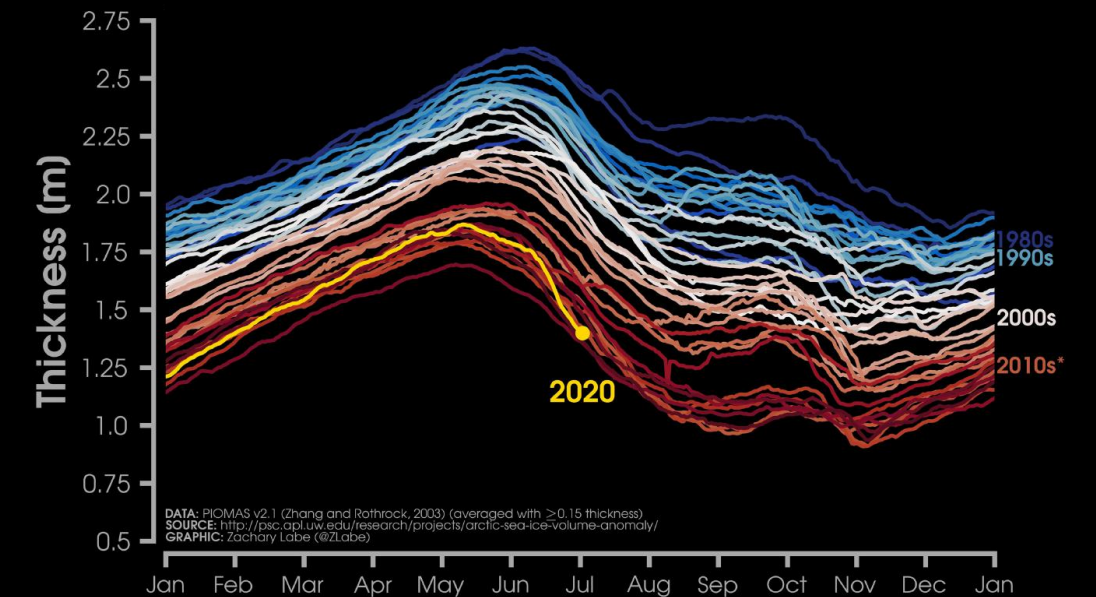
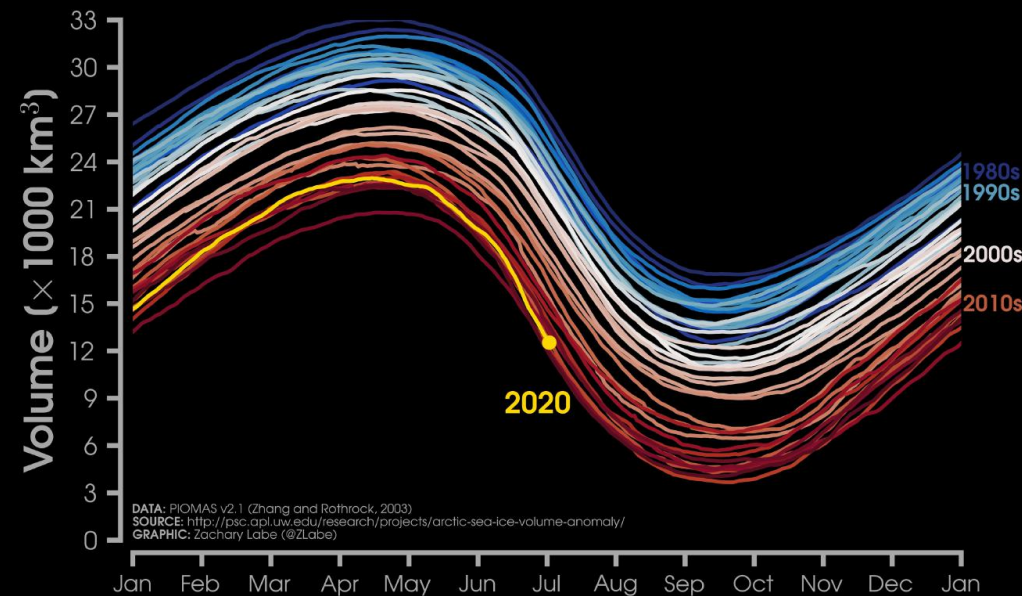
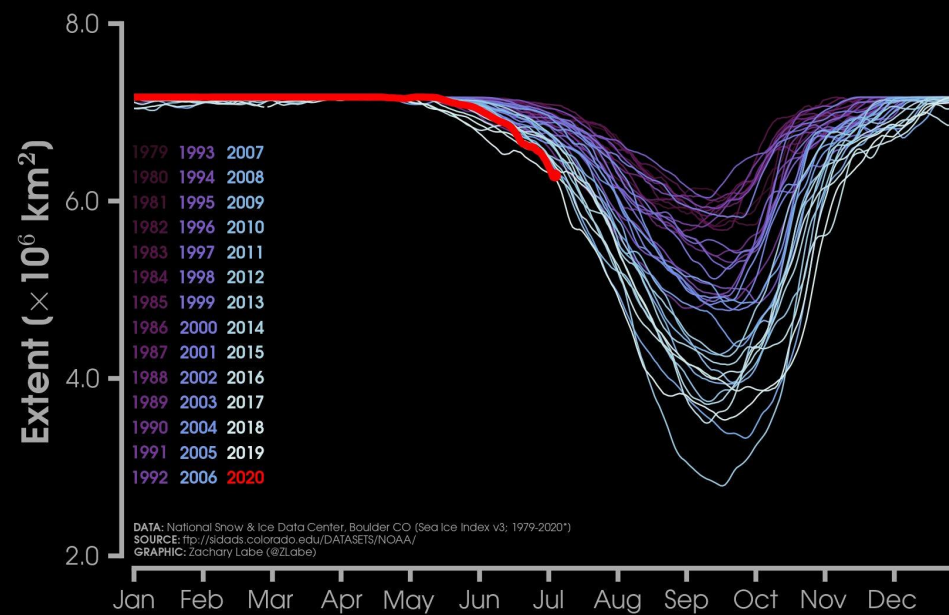




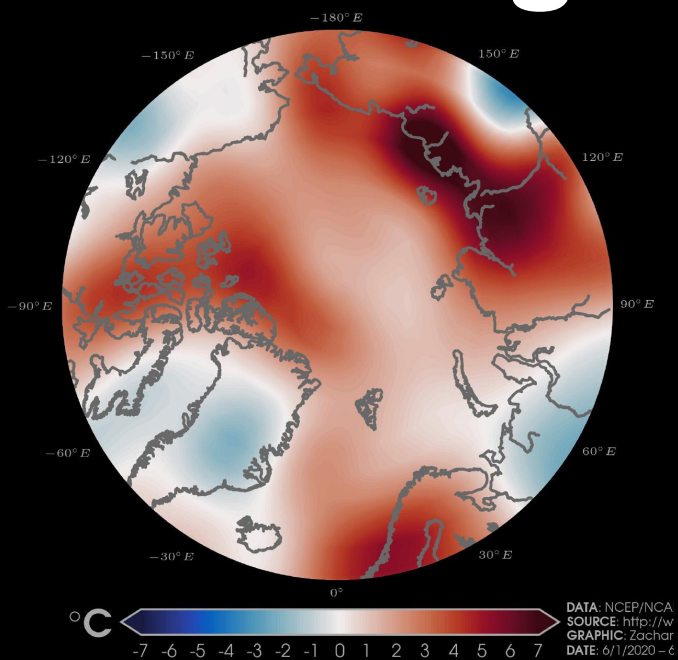
# Warming



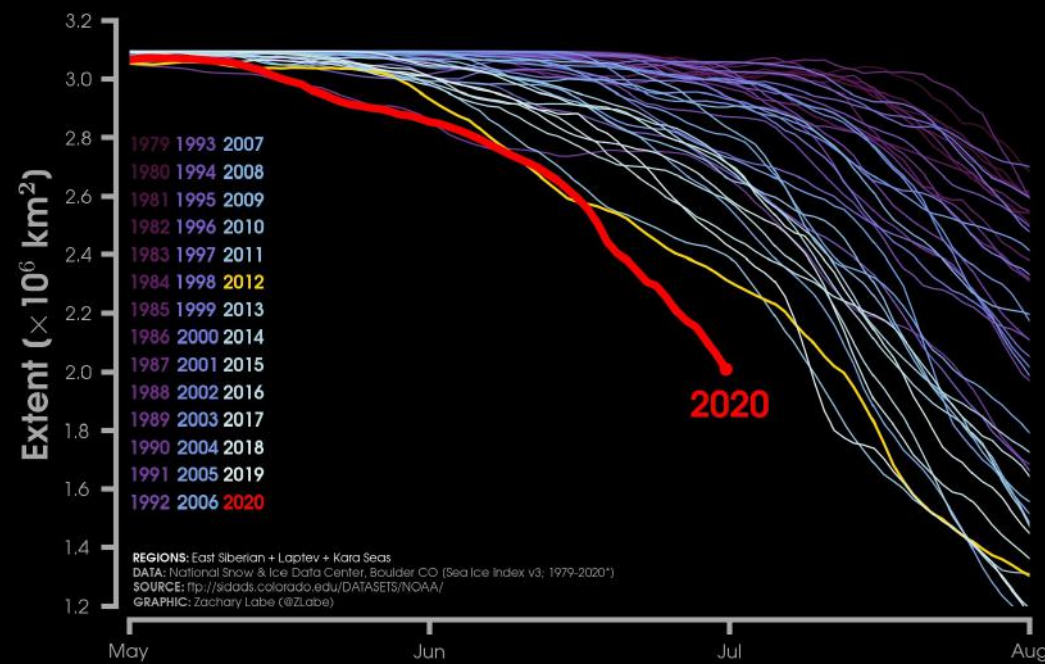
## Reduction in sea ice extent, volume and thickness



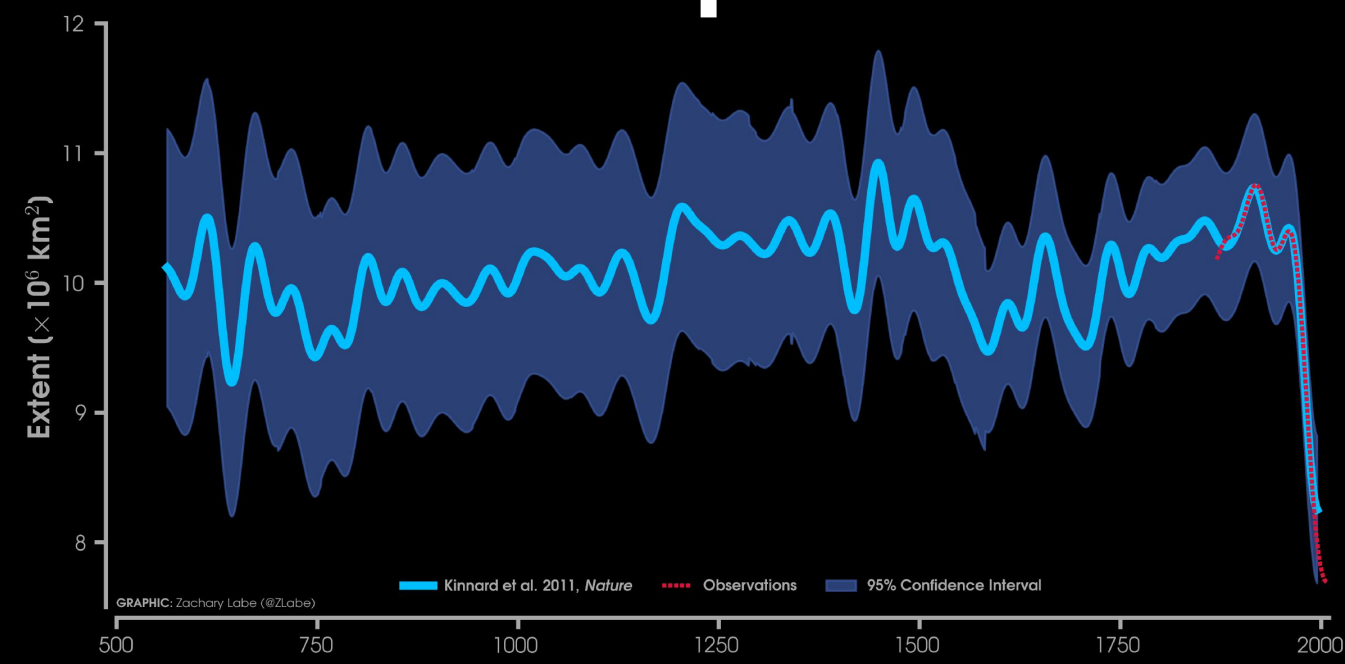
# Warming



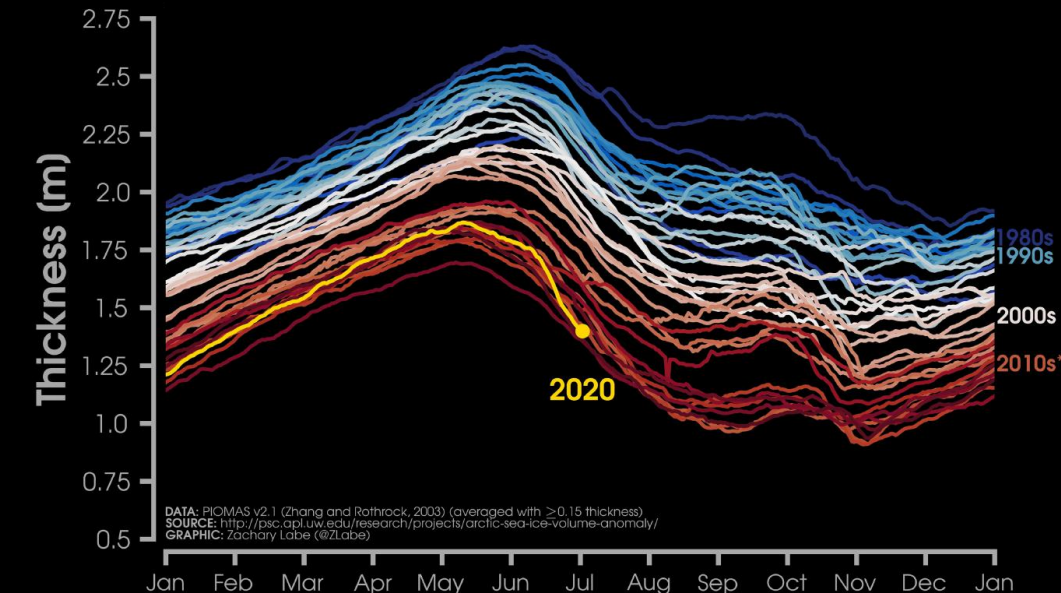
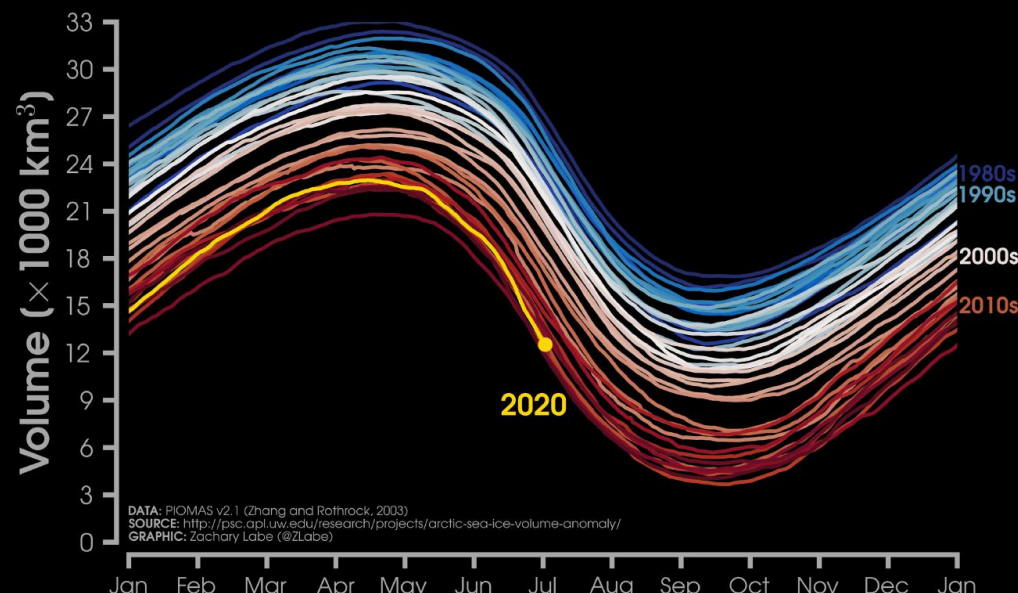
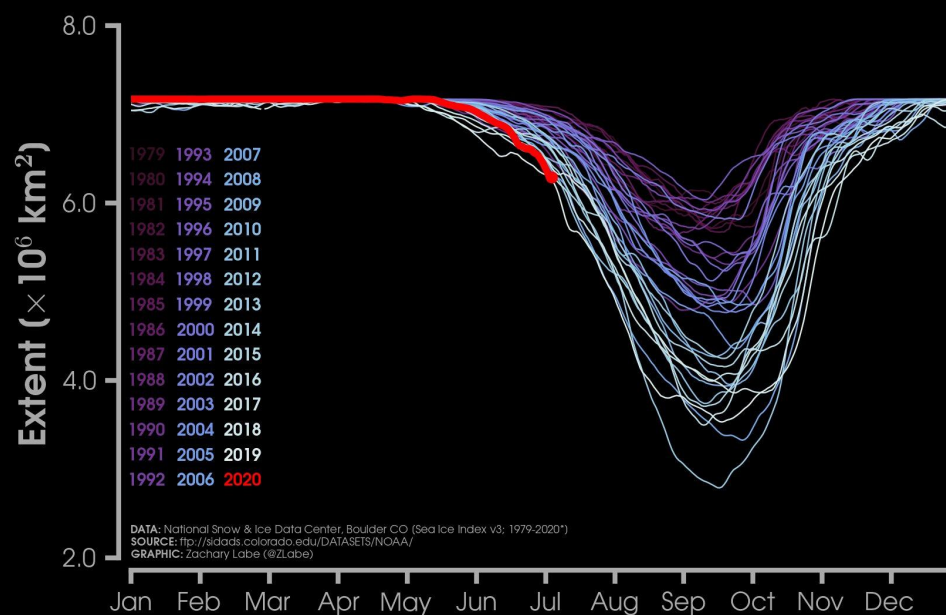
# Record anomalies



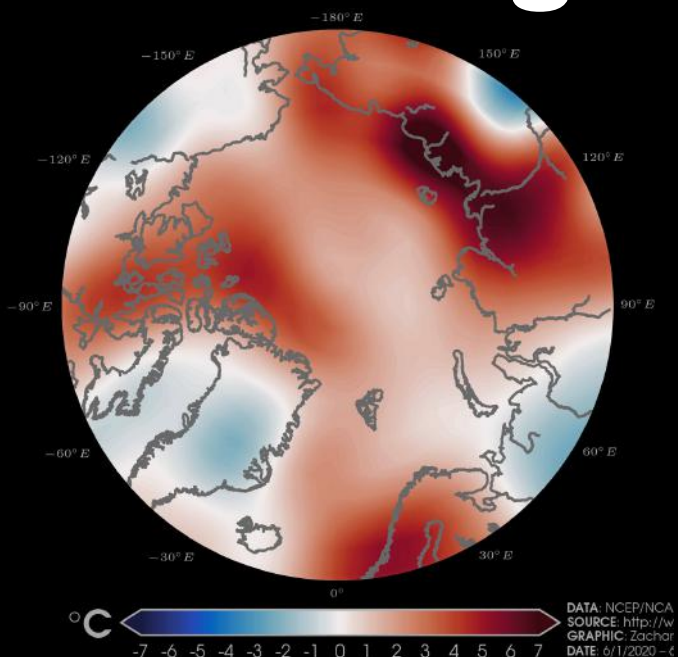
# No recent precedent



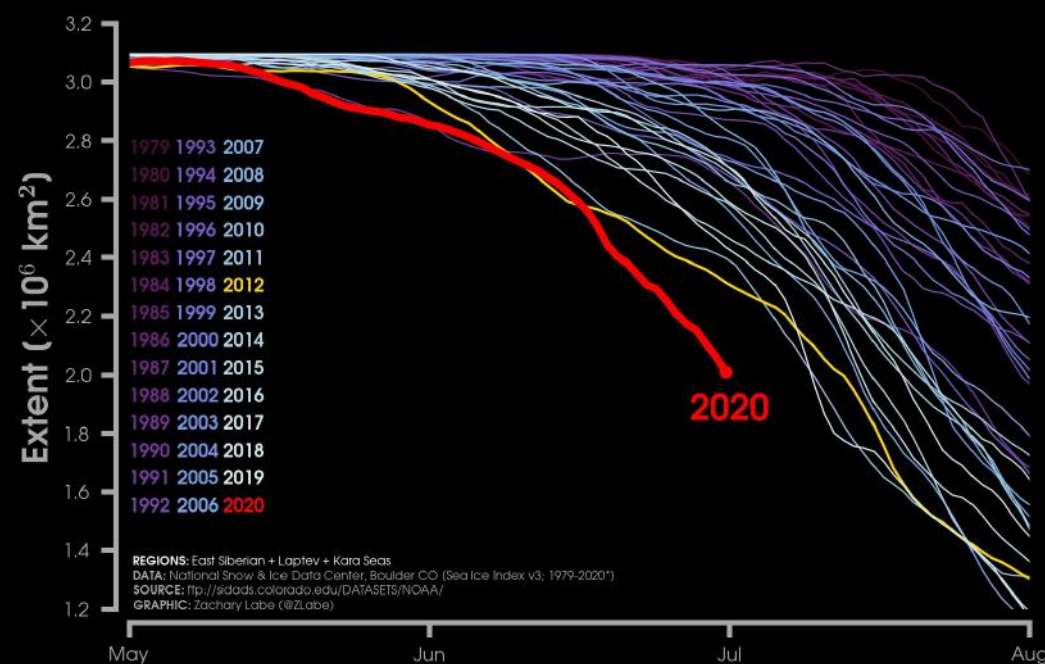
# Reduction in sea ice extent, volume and thickness



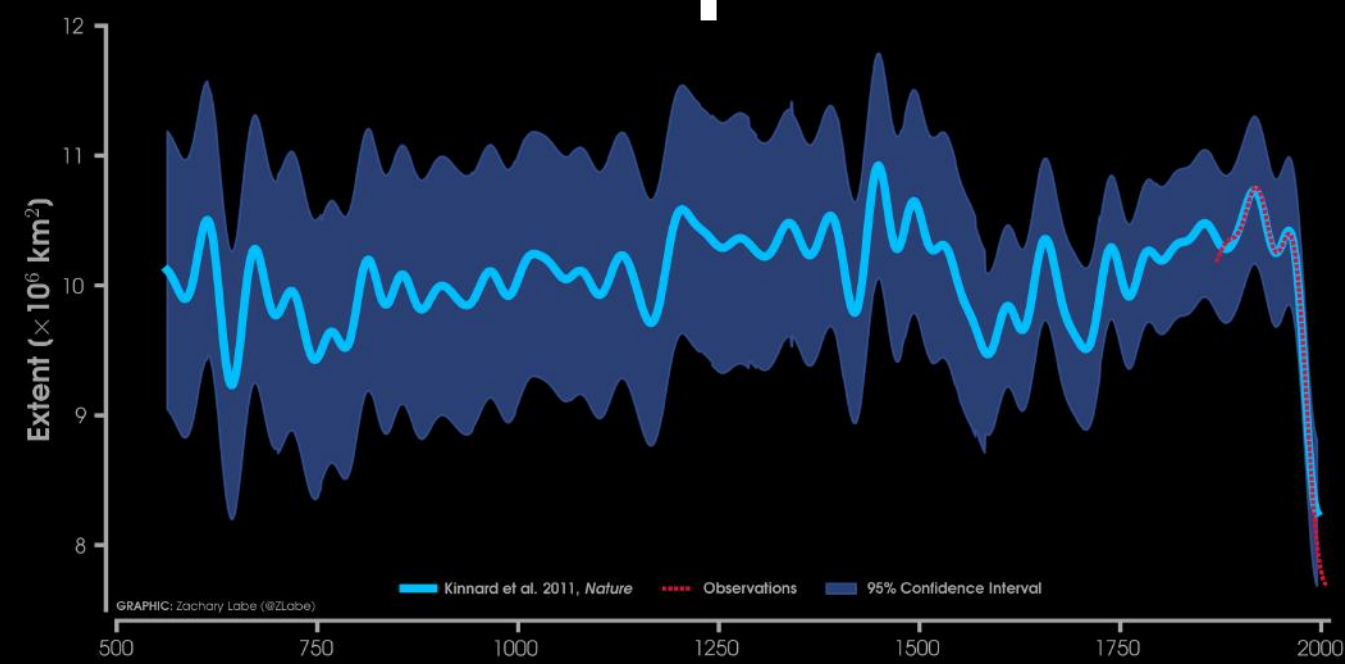
# Warming



# Record anomalies

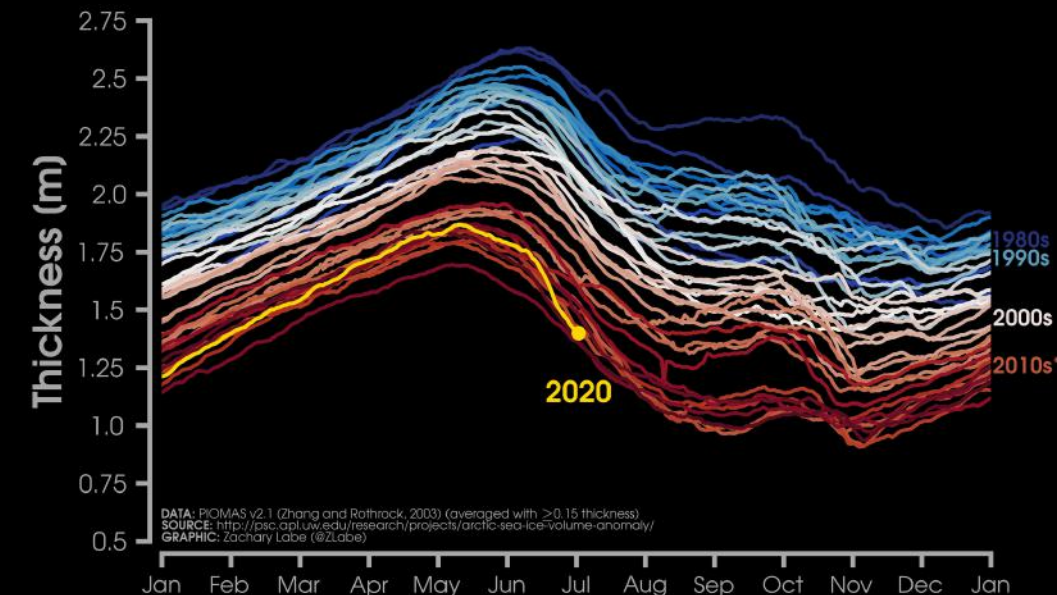
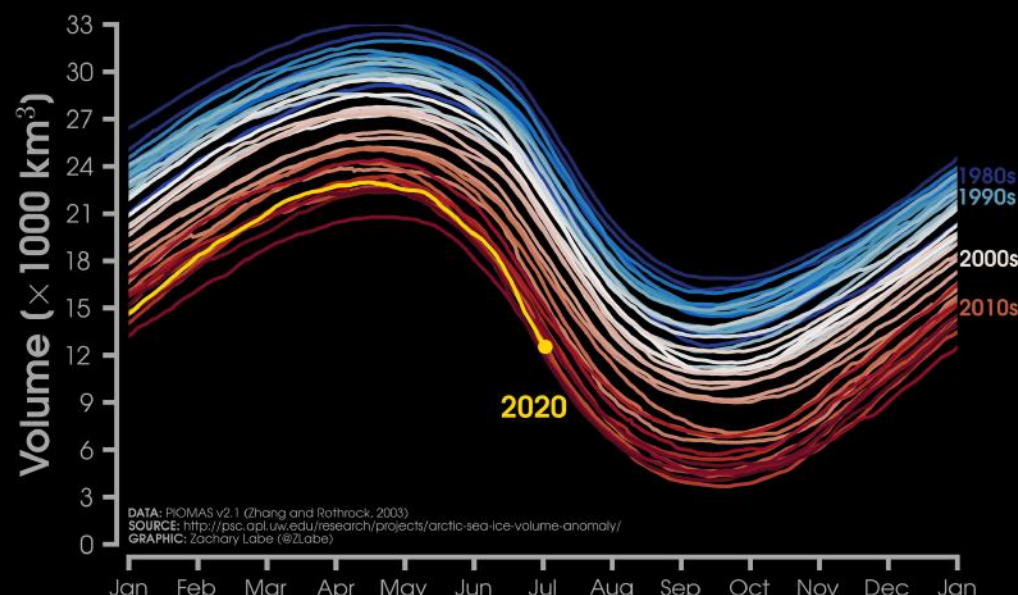
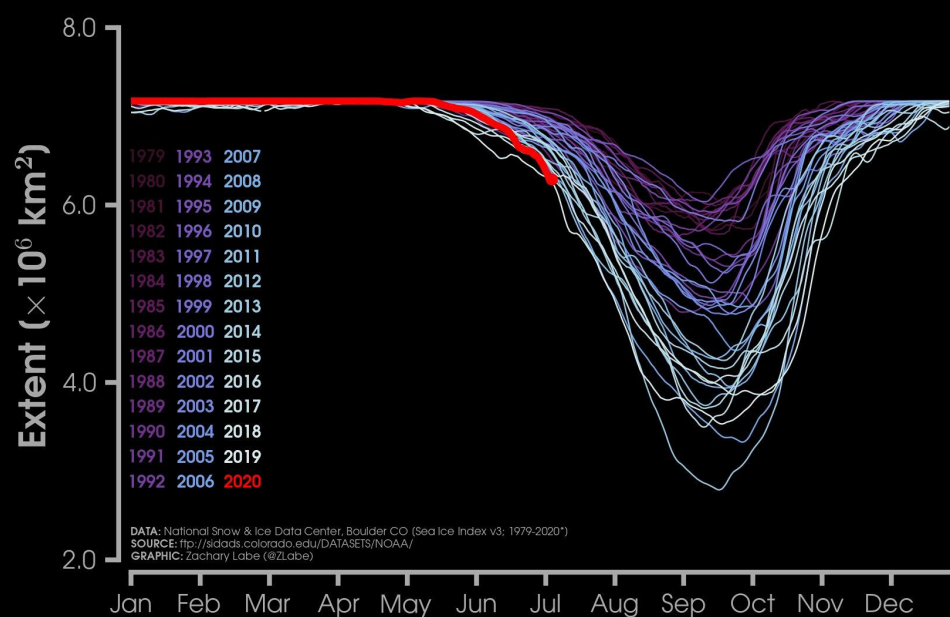


# No recent precedent



# Extreme, unprecedented, rapid change

# Reduction in sea ice extent, volume and thickness



# Why is it important to know about change in the Arctic Ocean?



Photo by Callum Whyte

# Why is it important to know about change in the Arctic Ocean?

Photo by Callum Whyte

135 - 2' 189 - 11"  
41.2M 57.9M  
← TO STEM TO STERN →

# Changing Arctic Ocean



**Changing  
Arctic  
Ocean**

**Implications for marine biology and biogeochemistry**

**Understanding and quantifying the impacts of climate change  
on Arctic ecosystems**

Photo by Jen Freer



**Changing  
Arctic  
Ocean**

# £20 million research

**5-year programme  
2017-2022**

SPONSORED BY THE



Federal Ministry  
of Education  
and Research



**Natural  
Environment  
Research Council**

**Dual national funding**  
UK and Germany

**16 projects**  
**32 research institutions**

[www.changing-arctic-ocean.ac.uk](http://www.changing-arctic-ocean.ac.uk)

 @NERC\_CAO

 @nerc\_cao

# 2 KEY RESEARCH CHALLENGES

**1.** **A quantified understanding**  
To develop a quantified understanding of the structure and functioning of Arctic Ocean ecosystems

**2.** **Sensitivity to change and future projections**  
To understand the sensitivity to multiple stressors;  
To develop projections of change

Photo by Callum Whyte

135 - 2' 41.2M  
189 - 11' 57.9M  
← TO STEM TO STERN →



# 4 LARGE PROJECTS

2017 - 2021



How does seasonal  
sea ice control  
Arctic productivity?

Prof Finlo Cottier



Can we detect  
changes in Arctic  
ecosystems?

Prof Claire Mahaffey



How do changes in the  
surface ocean affect  
seafloor processes?

Dr Christian Maerz



How does Arctic  
change affect Calanus,  
a key Arctic species?

Prof David Pond

# 12 NEW PROJECTS

2018-2021



## **Coldfish**

Key Arctic fish  
response



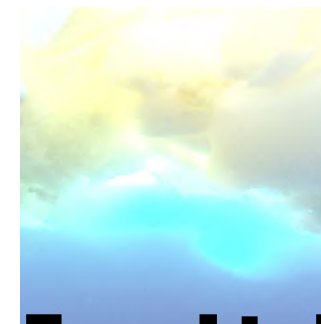
## **MiMeMo**

Fishery  
yields



## **APEAR**

Influx of Atlantic  
and Pacific waters



## **Eco-Light**

Under-ice light  
field



## **Diatom- ARCTIC**

Sea-ice  
algae



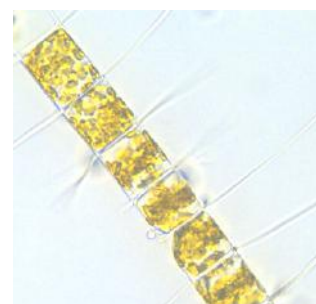
## **CHASE**

Biological  
clock



## **PEANUTS**

Ocean circulation  
and nutrients



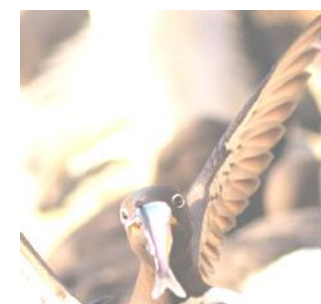
## **Micro-ARC**

Pelagic microbial  
ecosystem



## **CACOON**

Permafrost  
thaw



## **LOMVA**

Ecosystem  
competition



## **EISPAC**

Contaminant  
cycling



## **PETRA**

Climate-active  
gases

# INTERNATIONAL COLLABORATION



# INTERNATIONAL COLLABORATION



>200 investigators at 32 research organisations

# INTERNATIONAL COLLABORATION



>200 investigators at 32 research organisations

Collaboration with scientists in 15 other countries

# INTERNATIONAL COLLABORATION



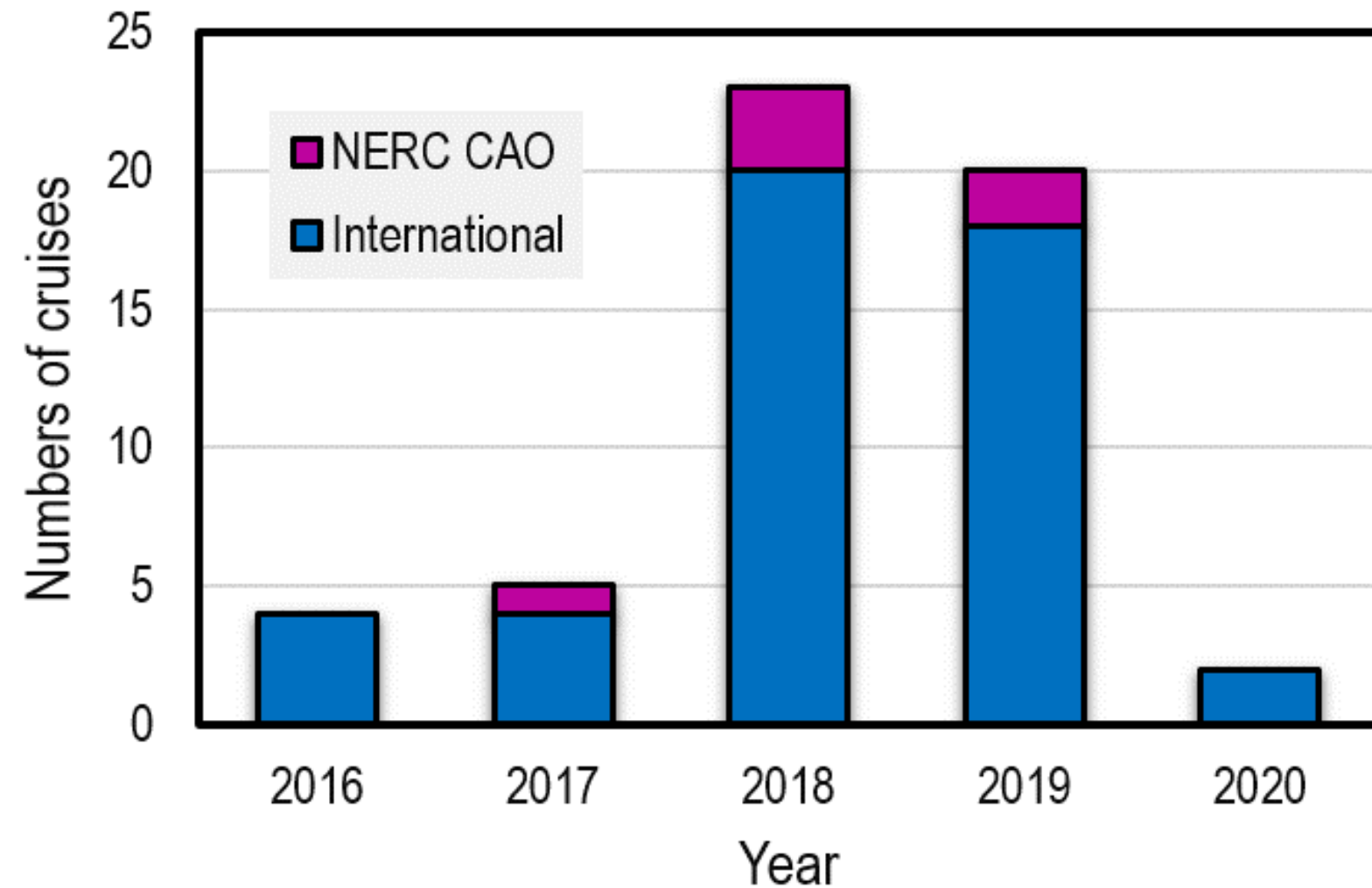
>200 investigators at 32 research organisations

Collaboration with scientists in 15 other countries

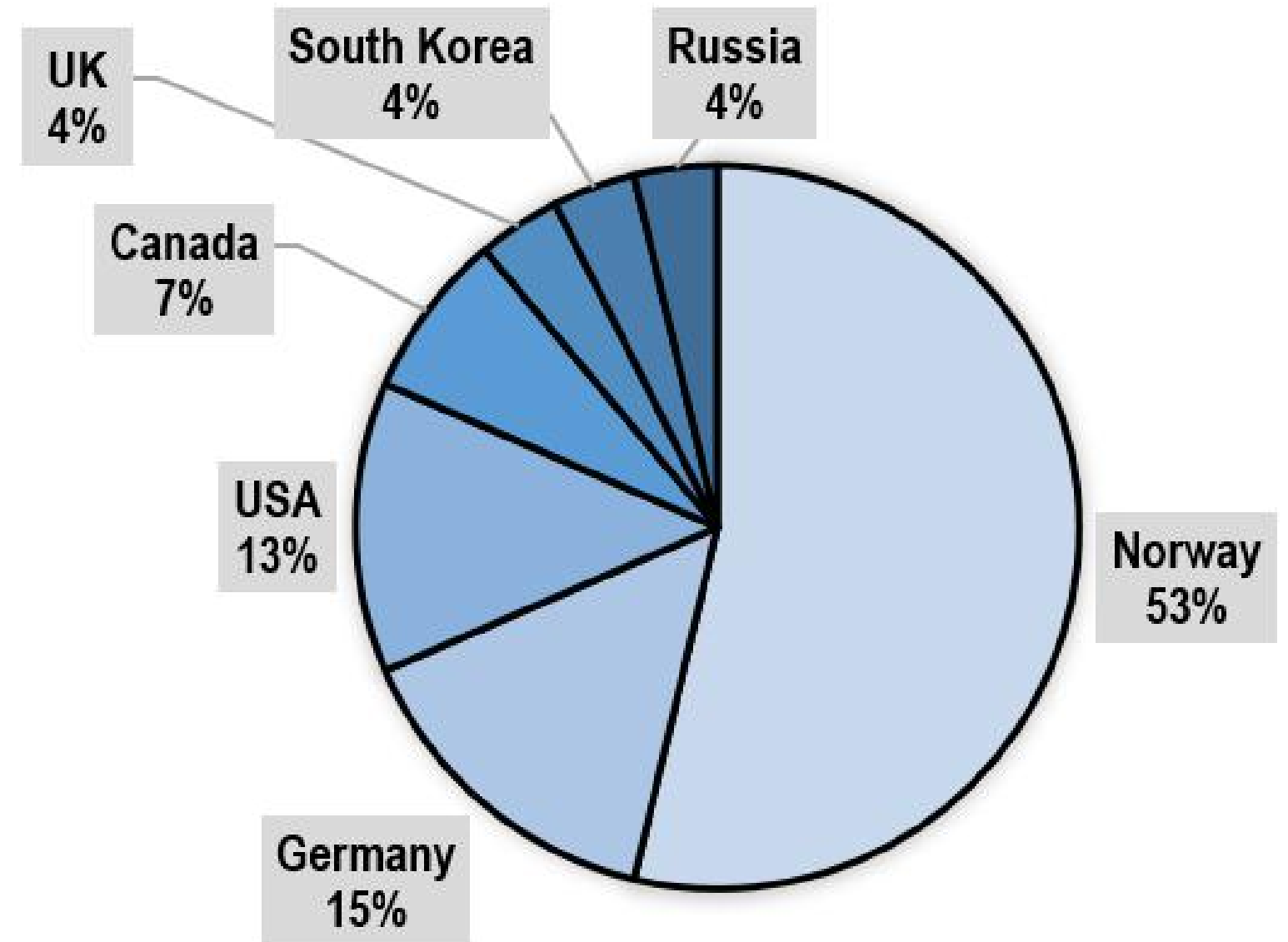
Collaboration with policy makers

# INTERNATIONAL COLLABORATION

## Participation on Arctic cruises

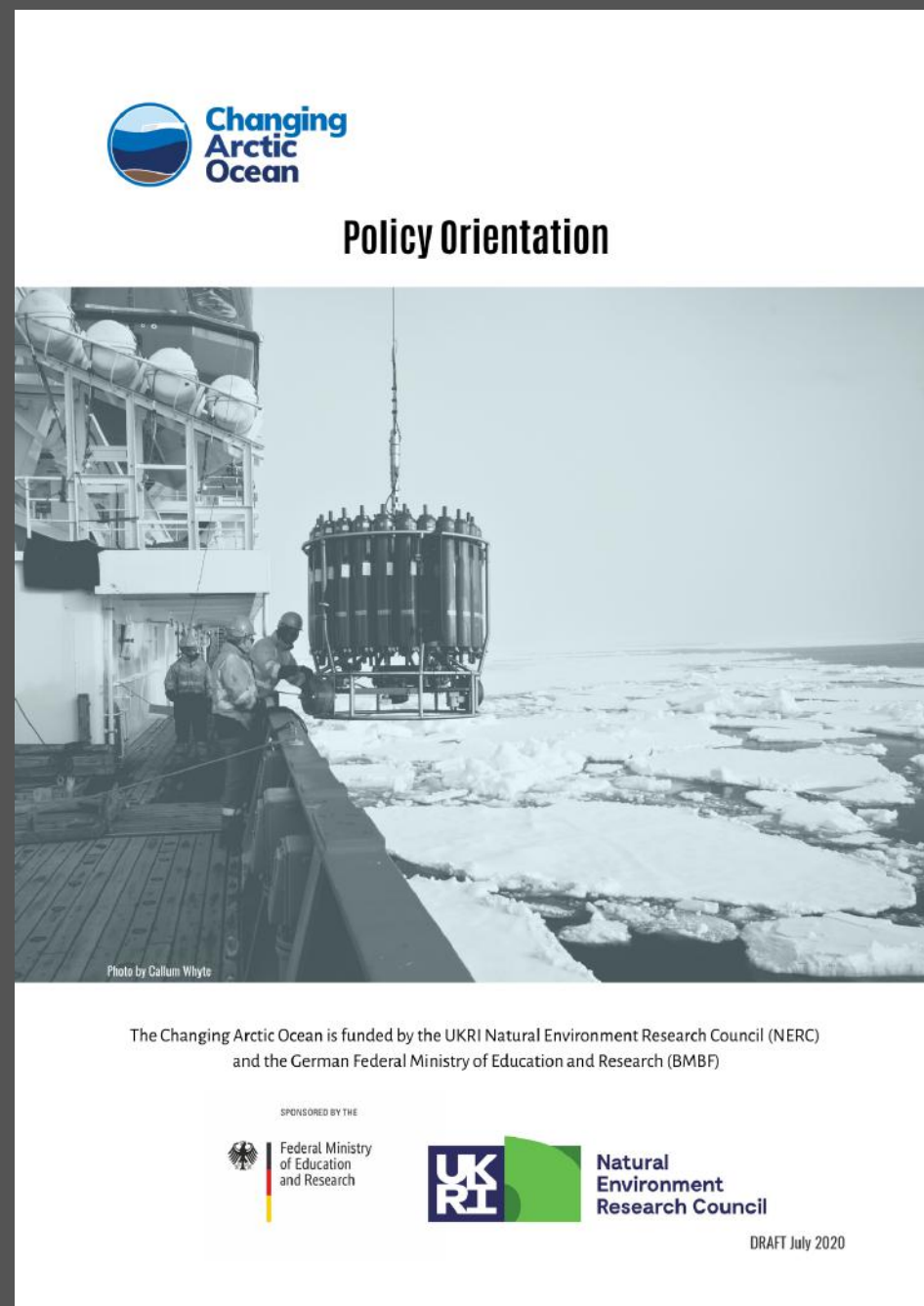


## International cruise funding source

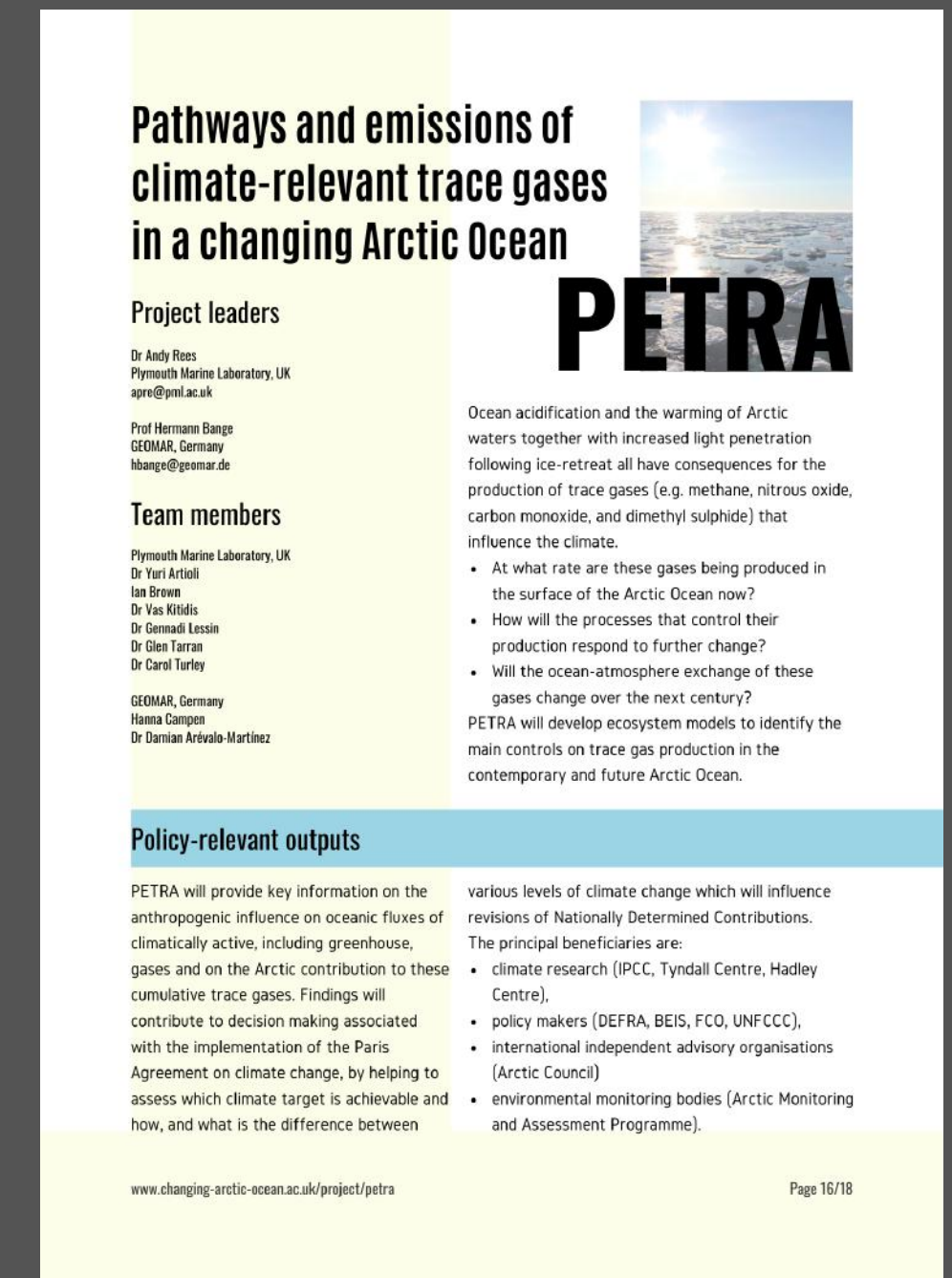


# STAKEHOLDER INTERACTION

Policy orientation document (autumn 2020)



- Overview of the programme
- Project descriptions and policy-relevant outputs
- Science areas
- International collaborators



<https://www.changing-arctic-ocean.ac.uk/science-outputs/science-in-policy/>





### Project leaders

Prof Crispin Halsall  
Lancaster University, UK  
c.halsall@lancaster.ac.uk

Dr Kirstin Dähnke  
Helmholtz-Zentrum Geesthacht, Germany  
kirstin.daehnke@hzg.de



# Science input to policy

## "Persistent Organic Pollutants (POPs) and Climate Change"

**Assessment Report** (submitted June 2020, publication imminent)

EISPAC contribution to *Chapter 2.2 Physical Environment, Levels and Trends*

- Science from sea ice chamber experiments
- Quantification of the uptake, accumulation and release of chemical contaminants in sea ice

Prof Crispin Halsall co-lead author of Chapter 2.2, along with Dr Hayley Hung

- Direct input of the Assessment Report to inform the Arctic Council
- Contributes to setting the pan-Arctic environmental strategy for the Arctic Nations
- Provides evidence for the UNEP Stockholm Convention on POPs and the UNECE Convention on long range, transboundary air pollution (LRTAP)



### Project leaders

Dr Yueng-Djern Lenn  
Bangor University, UK  
y.lenn@bangor.ac.uk

Dr Markus Janout  
Alfred Wegener Institute, Germany  
markus.janout@awi.de



# Arctic oceanographic data

Key science outputs:

- Baseline estimates of vertical mixing, stratification, turbulence, heat content and circulation
- Development of methods for satellite data interpretation to inform on water column structure and heat content
- Delivery of datasets that demonstrate turbulent mixing on the Beaufort Slope (a first) and on the Laptev slope

The project is communicating key science outputs to Dstl



# Eco-Light

## Project leaders

Dr Jeremy Wilkinson  
British Antarctic Survey, UK  
jpw28@bas.ac.uk

Dr Giulia Castellani  
Alfred Wegener Institute, Germany  
giulia.castellani@awi.de



- 2012 Marginal Ice Zone (MIZ)
- 2016 Stratified Ocean Dynamics in the Arctic (SODA)
- **2017 Changing Arctic Ocean**
- 2019 Arctic Mobile Observing System (AMOS)

# Robotics and artificial intelligence

To better understand the Arctic marine system, year-round measurements of key parameters are essential

Eco-Light have developed and deployed innovative robotic technology that provides a year-round presence in the Arctic Ocean.

These robots constantly monitor the marine environment and transmit physical and biological data, via satellites, to the UK in near real time.



- **Ocean properties:** Salinity, temperature, oxygen...
- **Atmospheric properties:** Wind speed & direction, air pressure, humidity...
- **Sea ice and snow properties:** Thickness and temperature
- **Biological properties:** Zooplankton (animals) and phytoplankton (plants) concentrations
- **Sunlight properties:** Above and below sea ice
- **Time-lapse images:** Above and below sea ice

This technology has applications beyond the polar regions.



## COP26

November 2021

Key conclusions

## Final programme event

Late 2021

- Programme highlights
- UK-based
- In-person & on-line participation

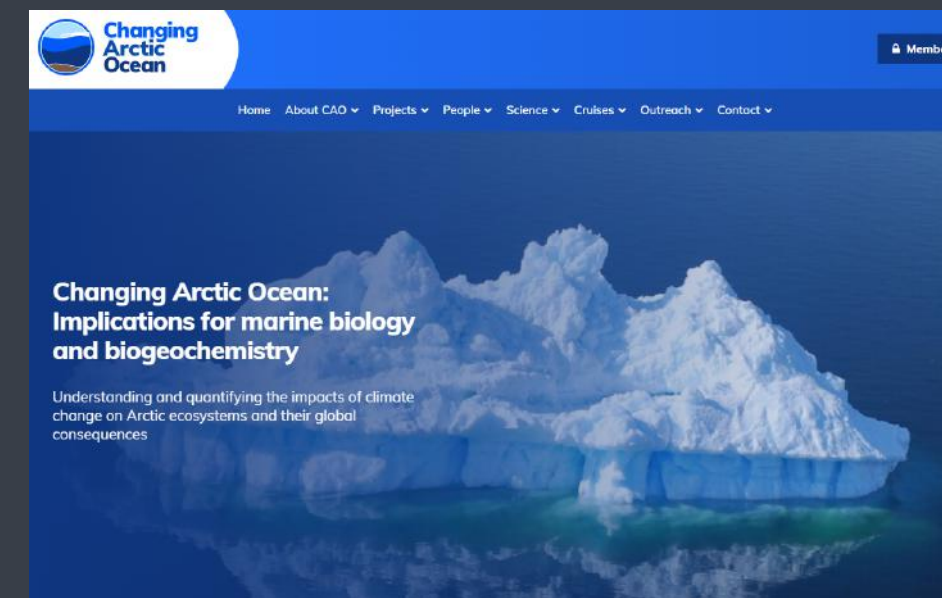
## "Ambio" special issue

Publication in February 2022

- Summary articles of key scientific outputs
- Aimed at stakeholder audience



## Stay updated...



[www.changing-arctic-ocean.ac.uk](http://www.changing-arctic-ocean.ac.uk)



@NERC\_CAO



# Changing Arctic Ocean

**Dr Kirsty Crocket**  
**Science Coordinator**  
**University of Edinburgh**

**k.crocket@ed.ac.uk**

**www.changing-arctic-ocean.ac.uk**

 **@NERC\_CAO**

 **@nerc\_cao**

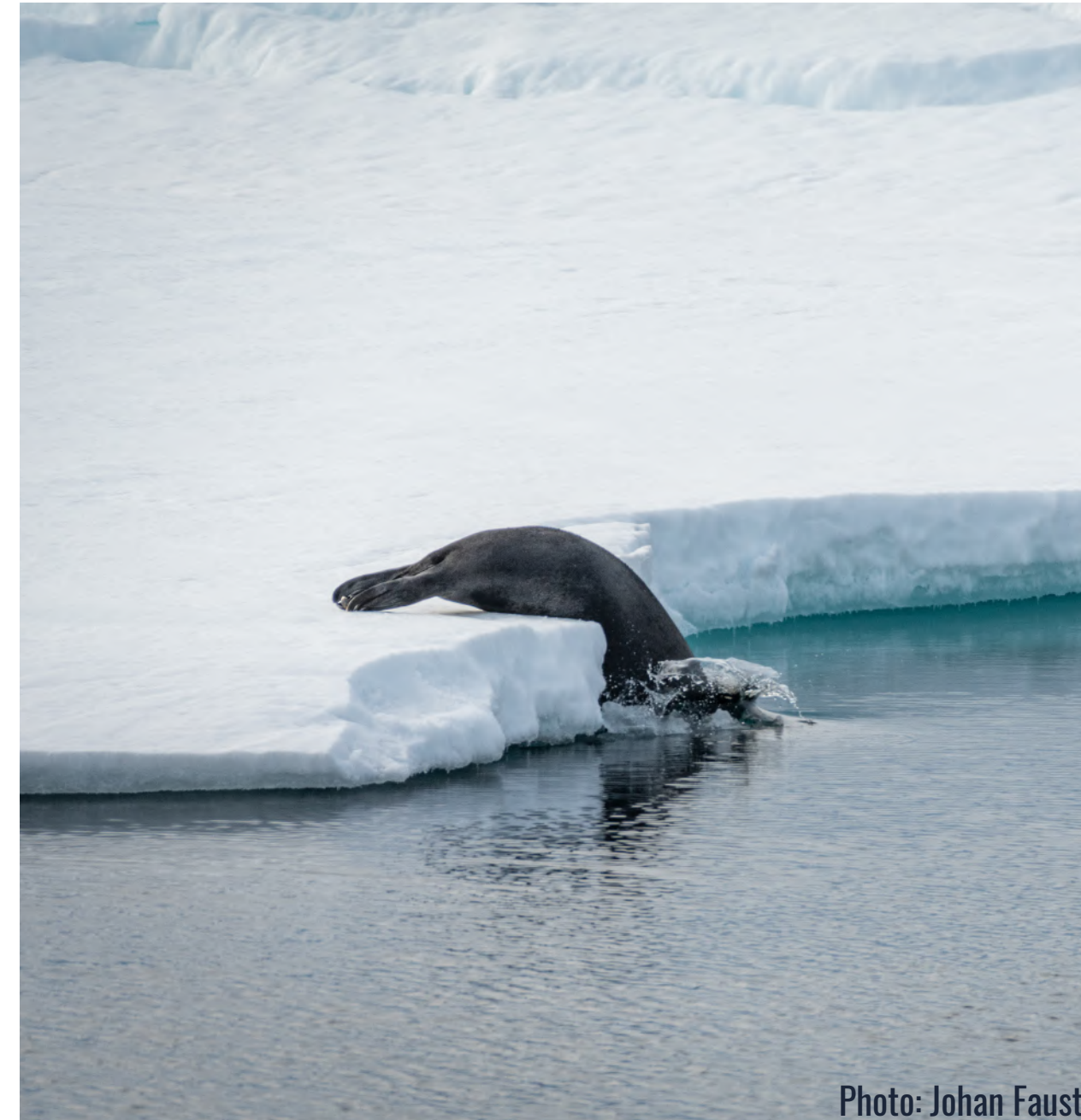
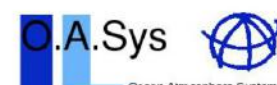


Photo: Johan Faust



With thanks to Zack Labe for permission to use his figures ~ @ZLabe ~ <https://sites.uci.edu/zlabe/>