Accelerated Sea Ice Loss in the Wandel Sea Points to a Change in the Arctic's Last Ice Area

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November 21, 2022

Abstract

The Arctic Ocean's Wandel Sea is the easternmost sector of the Last Ice Area, where thick, old sea ice is expected to endure longer than elsewhere. Nevertheless, in August 2020 the area experienced record-low sea ice concentration. Here we use satellite data and sea ice model experiments to determine what caused this record sea ice minimum. In our simulations there was a multi-year sea-ice thinning trend due to climate change. Natural climate variability expressed as wind-forced ice advection and subsequent melt added to this trend. In spring 2020, the Wandel Sea had a mixture of both thin and—unusual for recent years—thick ice, but this thick ice was not sufficiently widespread to prevent the summer sea ice concentration minimum. With continued thinning, more frequent low summer sea ice events are expected. We suggest that the Last Ice Area, an important refuge for ice-dependent species, is less resilient to warming than previously thought.

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Accelerated sea ice loss in the **Wandel Sea** points to a change in the Arctic's **Last Ice Area**

Axel Schweiger [1]
(lead author)
Ensemble analysis

Michael Steele [1]
Ocean

Jinlun Zhang [1]
Model

Kent Moore [2]
Satellite

Kristin Laidre [1]
Biology

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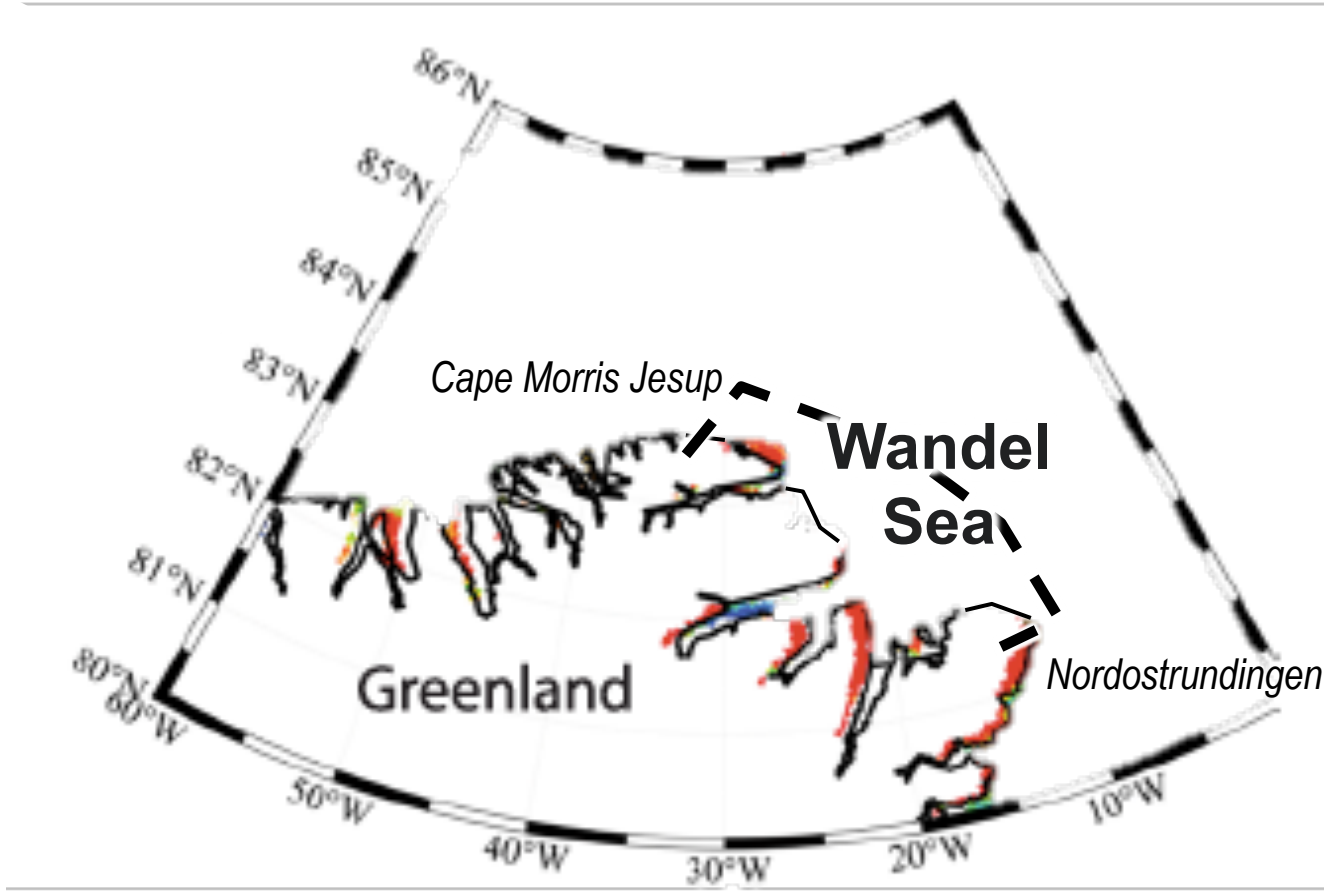

Carl Frederik Wandel
(1843 –1930)

Danish naval officer,
explorer, hydrographer

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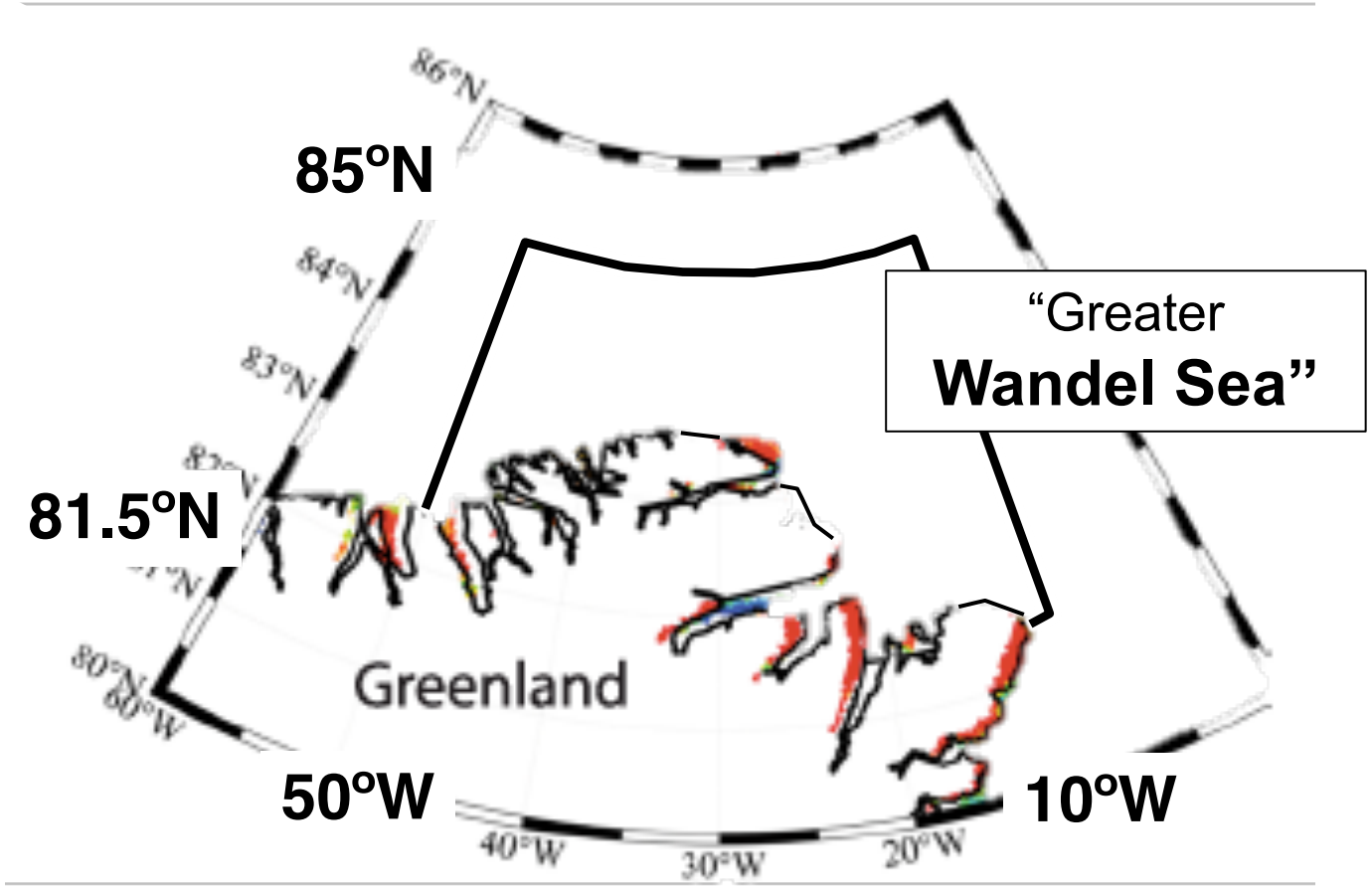

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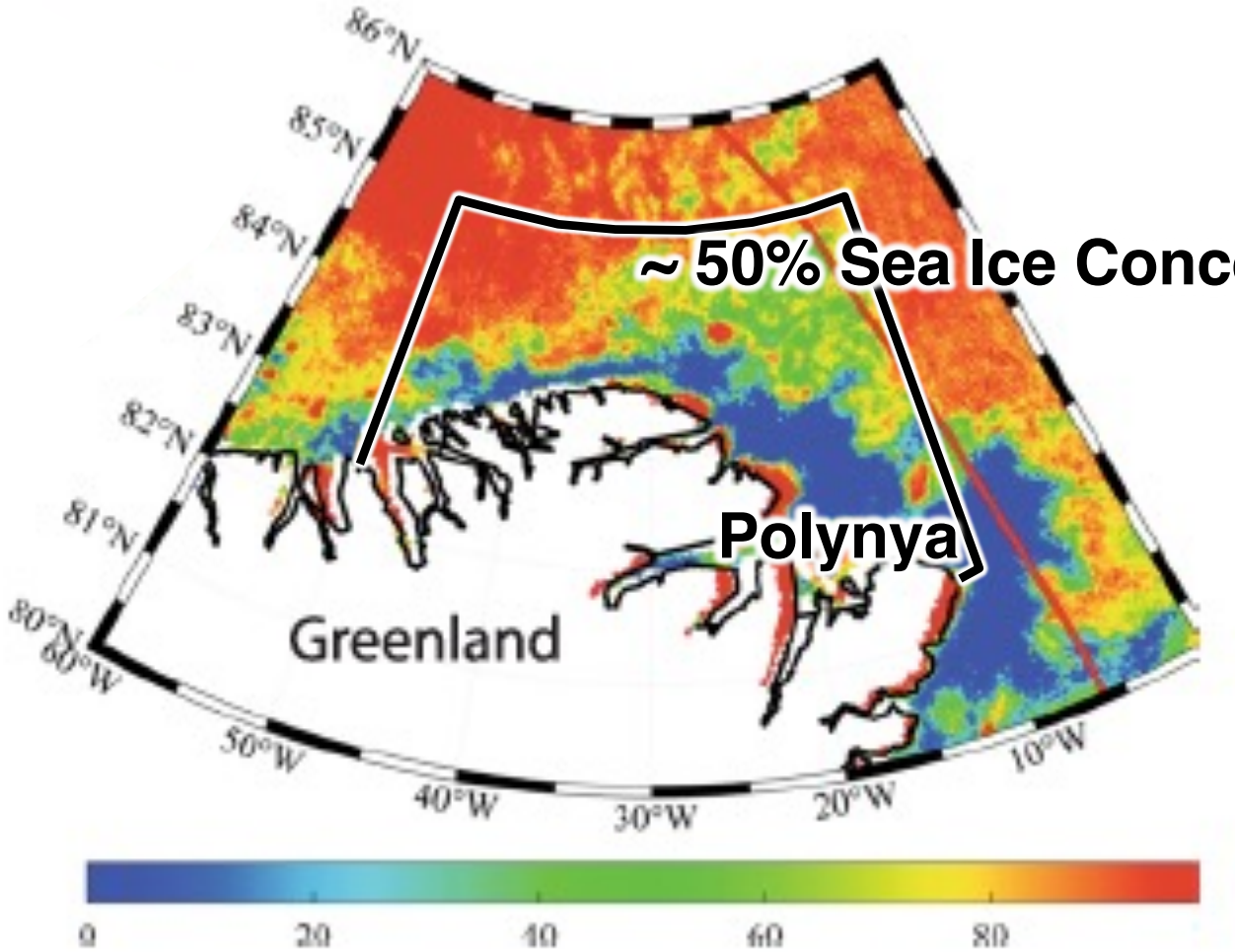
August 2020



~ 50% Sea Ice Concentration (SIC)!

Polynya

AMSR-2 *(ARTIST Sea Ice, U of Bremen)*

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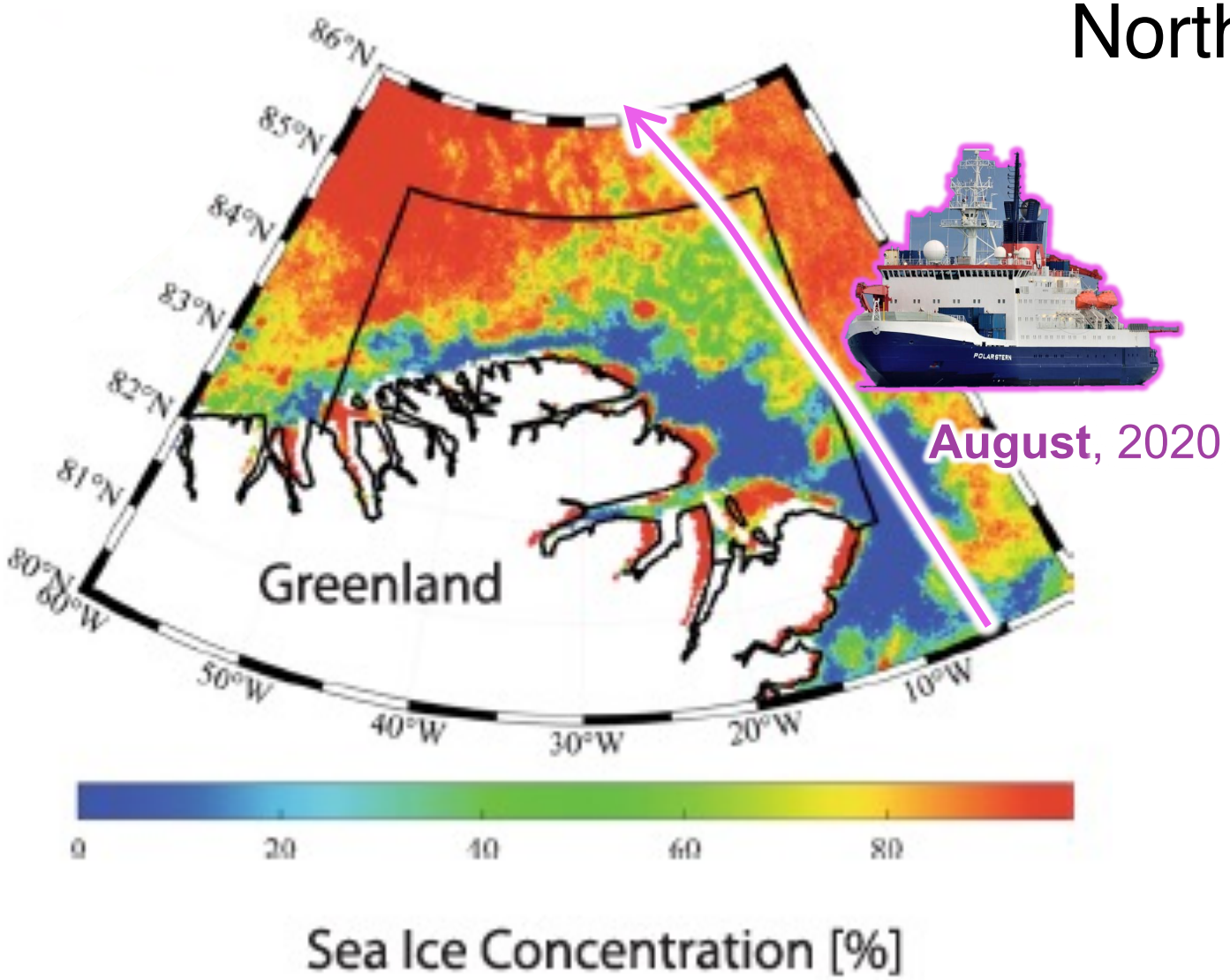
MOSAiC reposition to the North Pole



August, 2020

…via the Wandel Sea!

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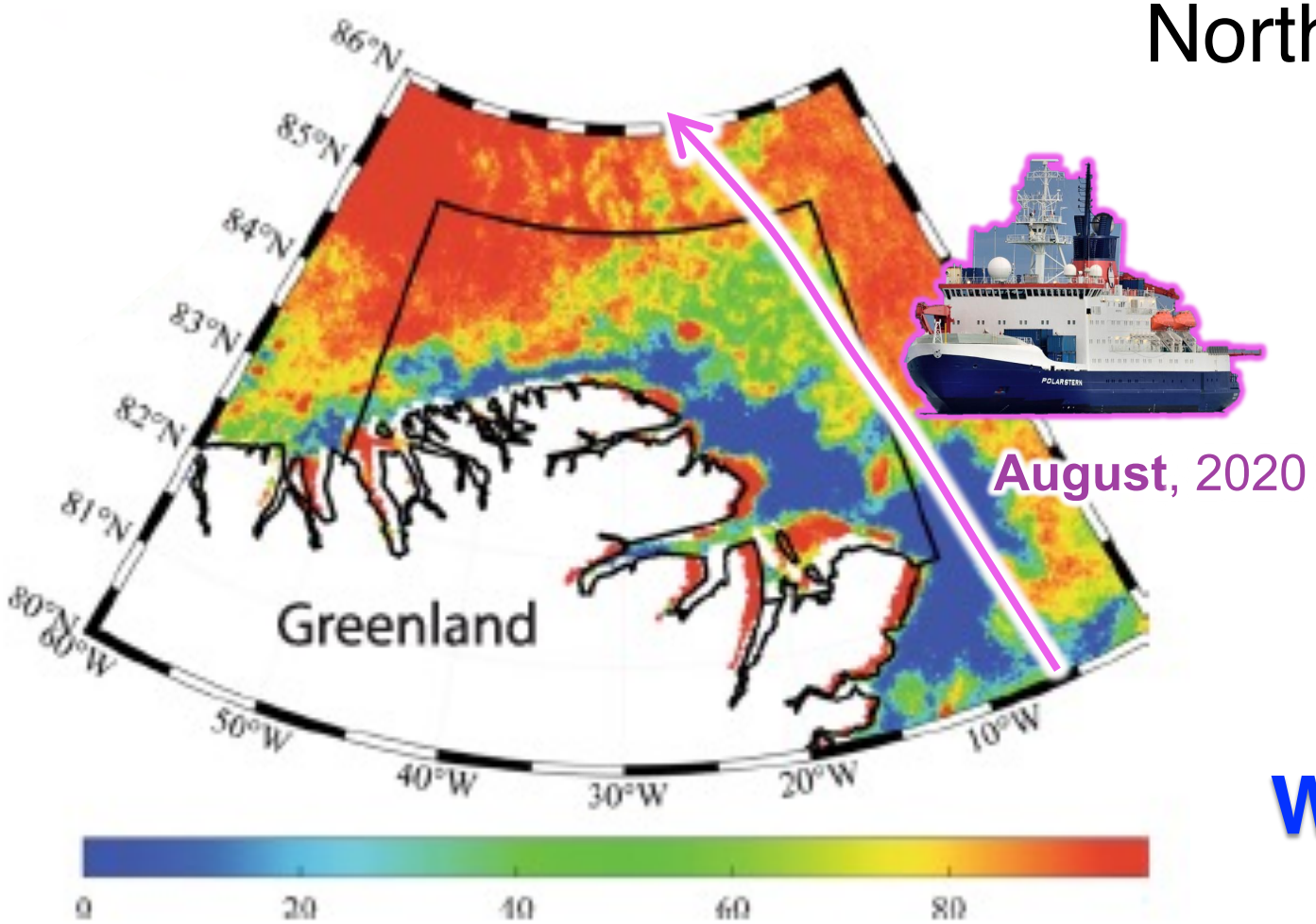

August, 2020

…via the Wandel Sea!

Our main question:

Why was SIC so low?

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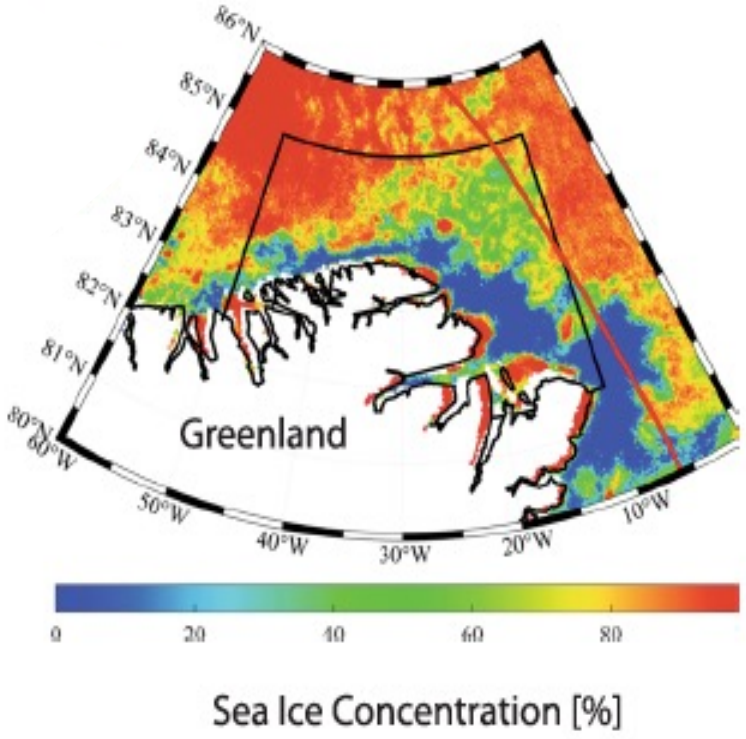
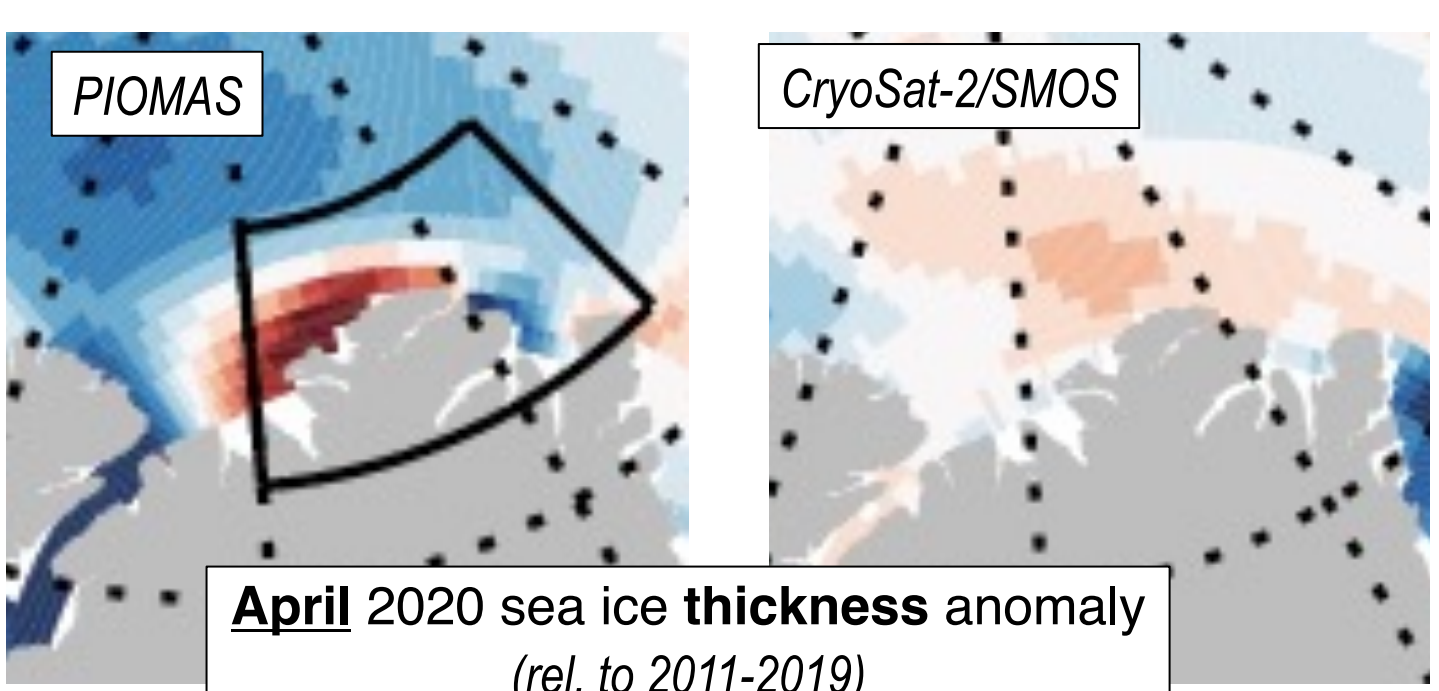


Especially puzzling, given **relatively thick** springtime ice!



April 2020 sea ice **thickness** anomaly
(rel. to 2011-2019)

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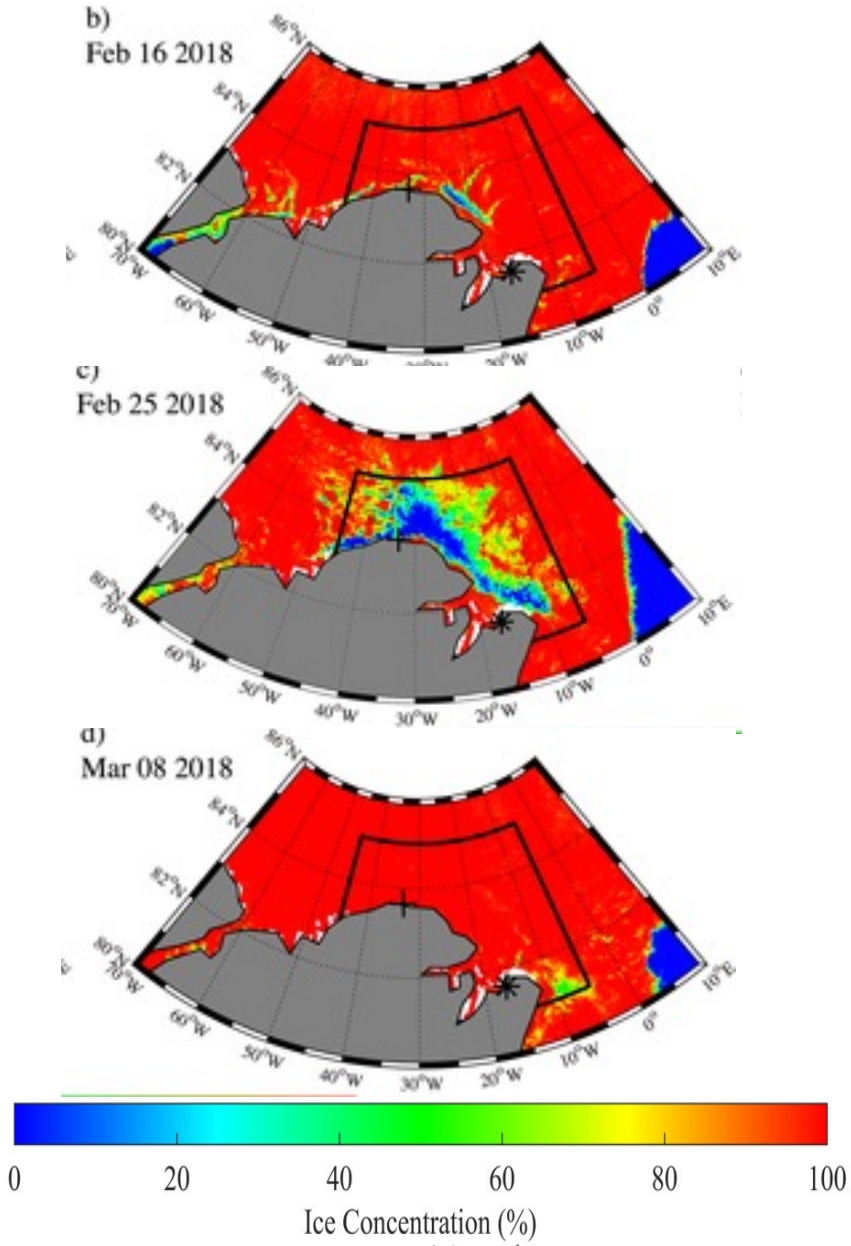
winter Wandel Polynyas

Moore et al. (GRL, 2018)

late February 2018



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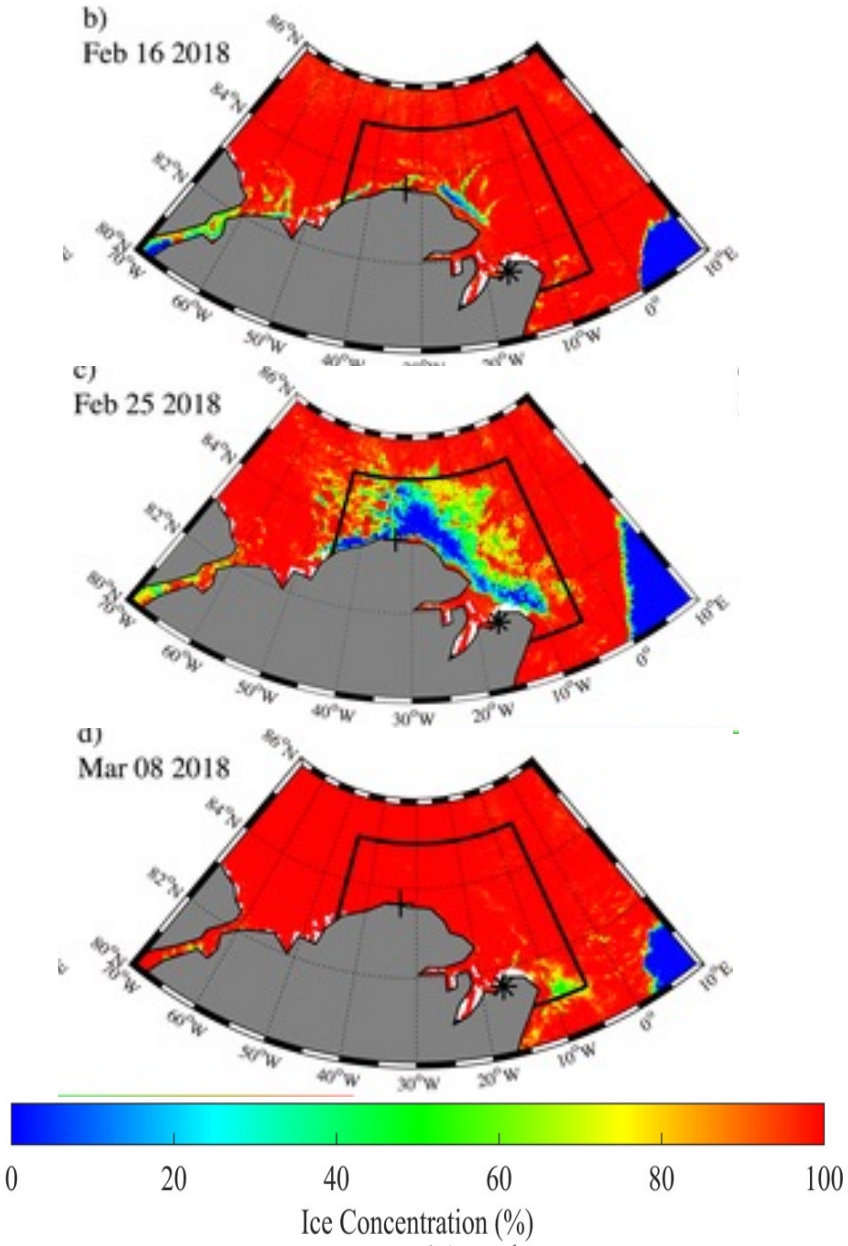
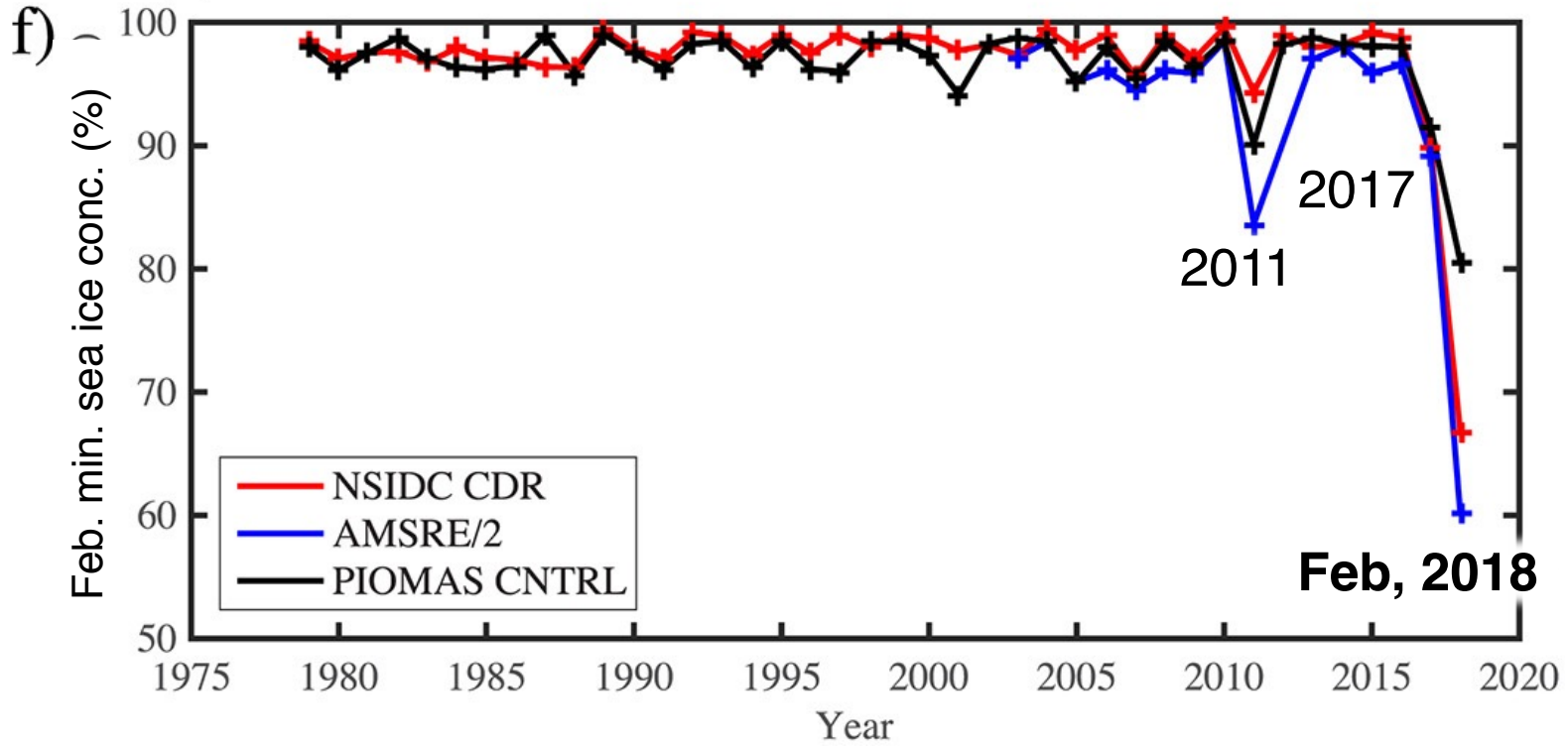
winter Wandel Polynyas

late February 2018



Moore et al. (GRL, 2018)



strong southerly winds

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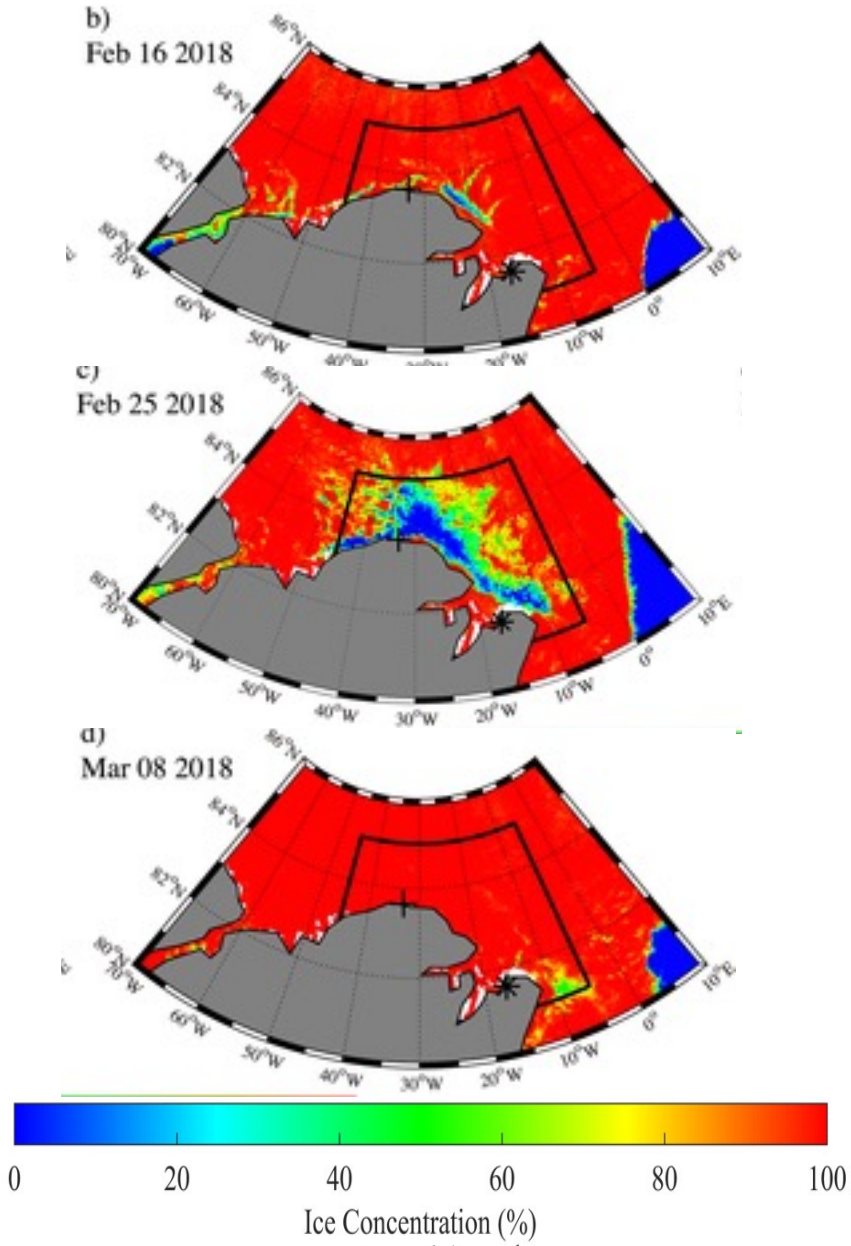
winter Wandel Polynyas

late February 2018



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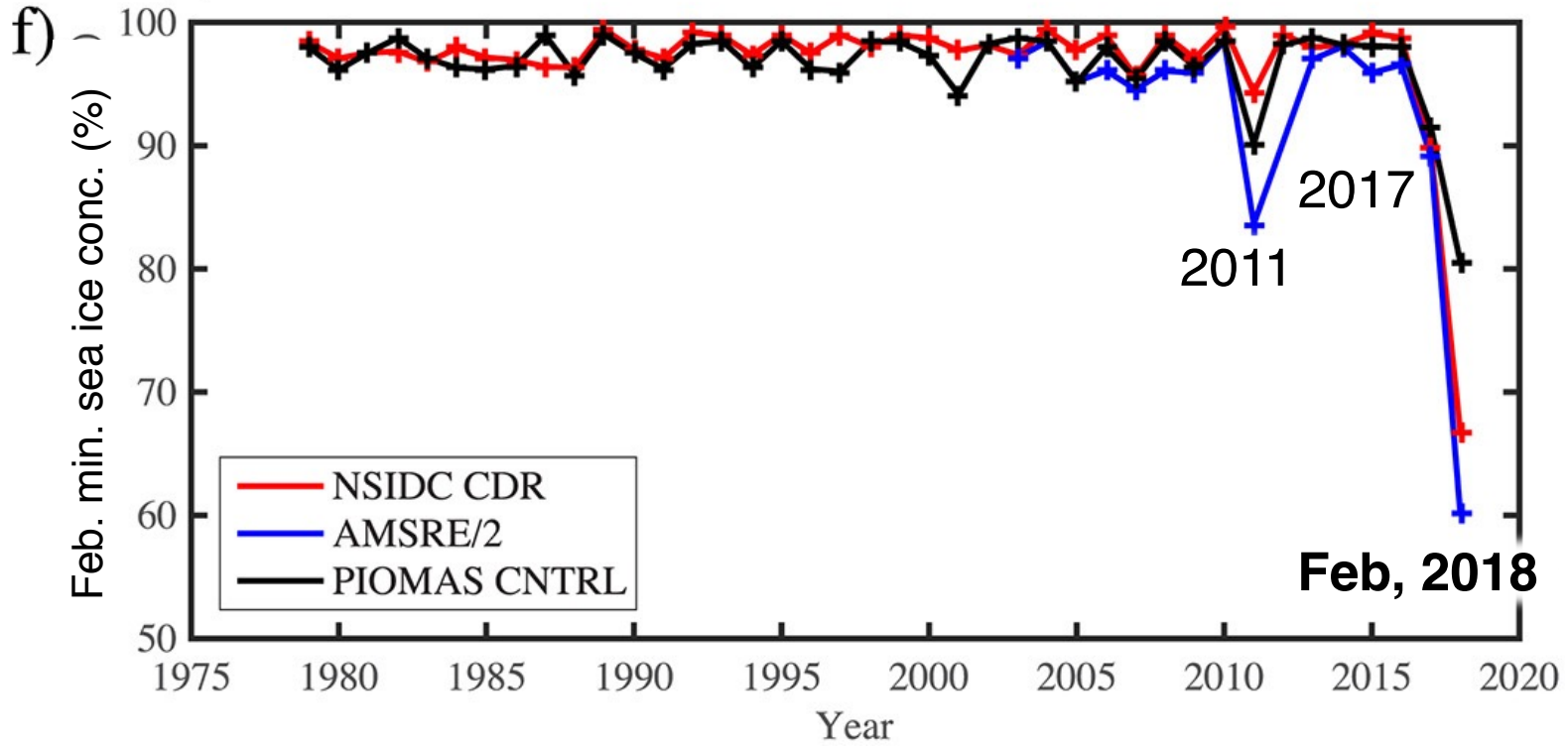

See also:

*V. **Ludwig** et al. (The Cryos., 2019): higher res. satellite obs*

*Y. **Lee** et al. (The Cryos., 2021): no polynya in 2019 or 2020*

*K. **Moore** et al. (GRL, 2021): spring 2020 polynya N. of Ellesmere Island*

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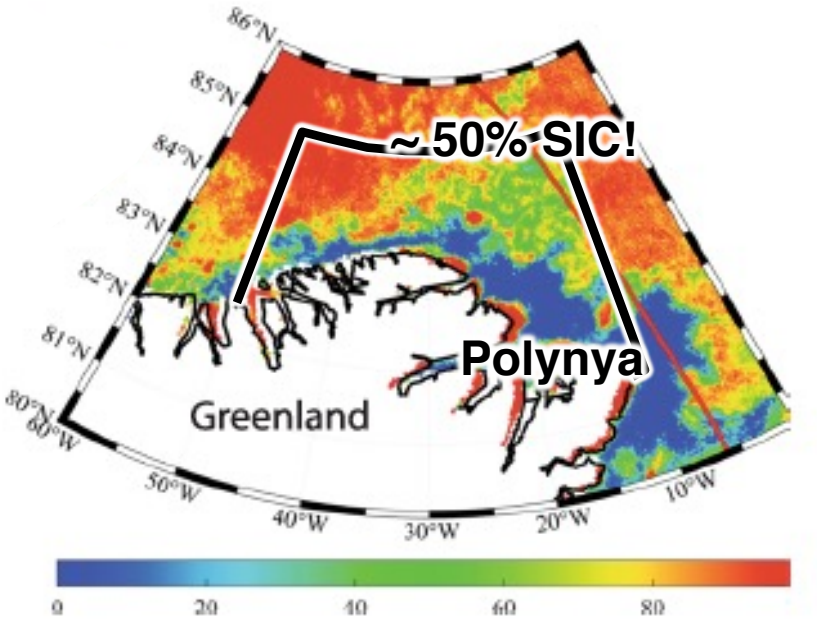
Summer 2020



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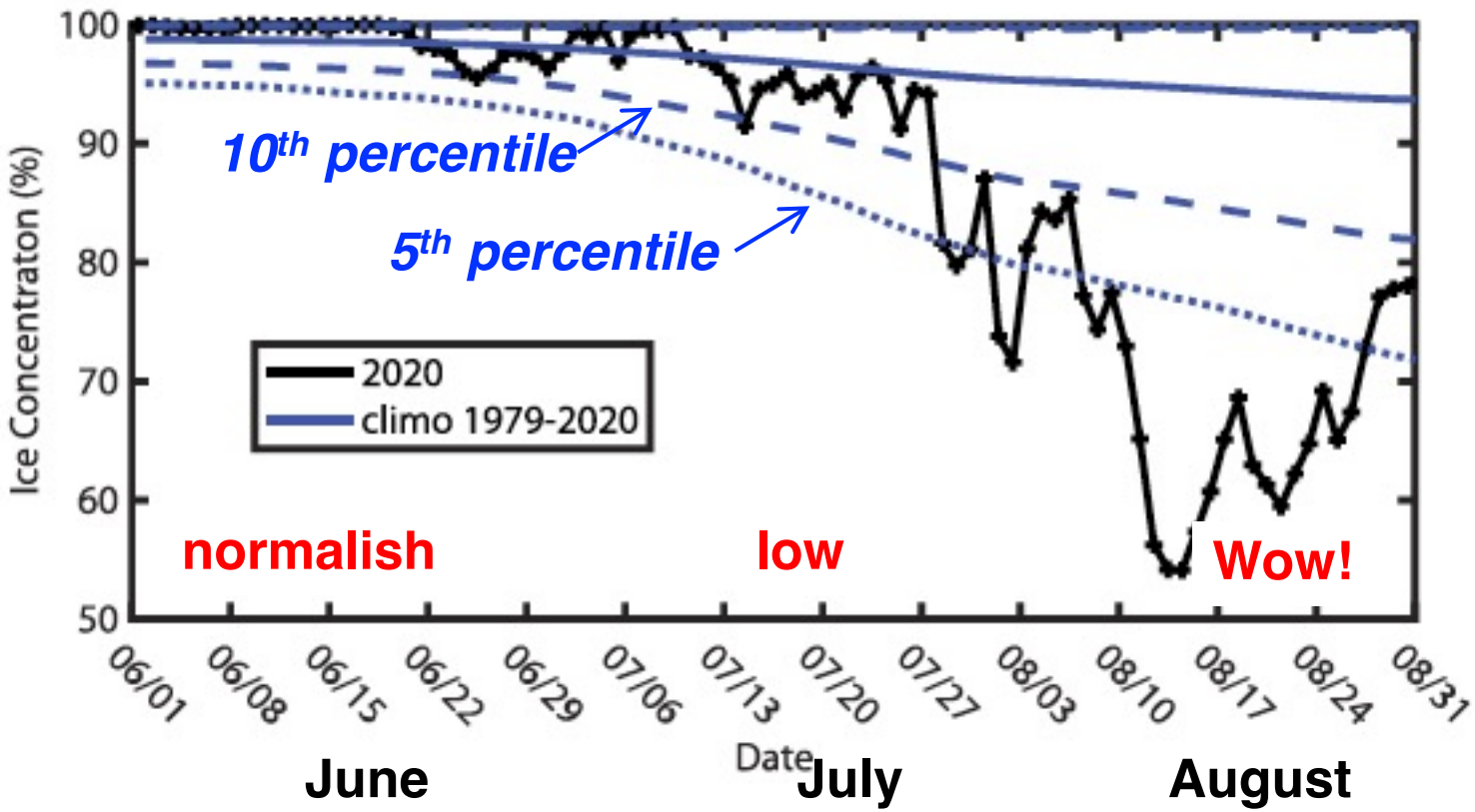

SMMR/SSMI/SSMIS *(NOAA/NASA CDR, NSIDC): 1979-2000*

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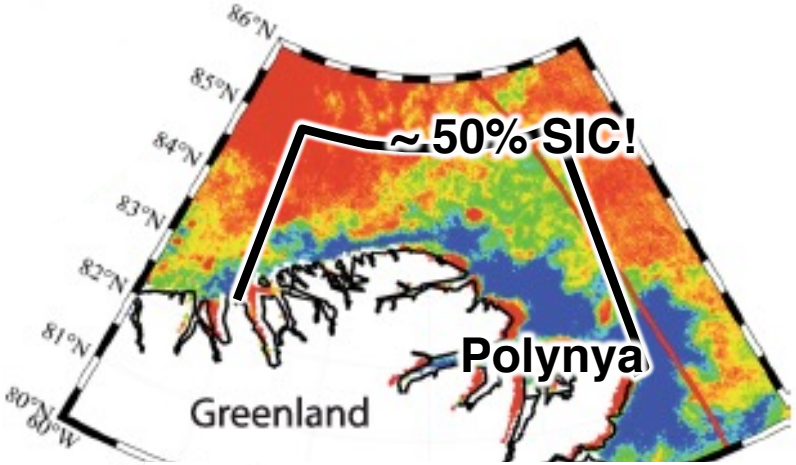
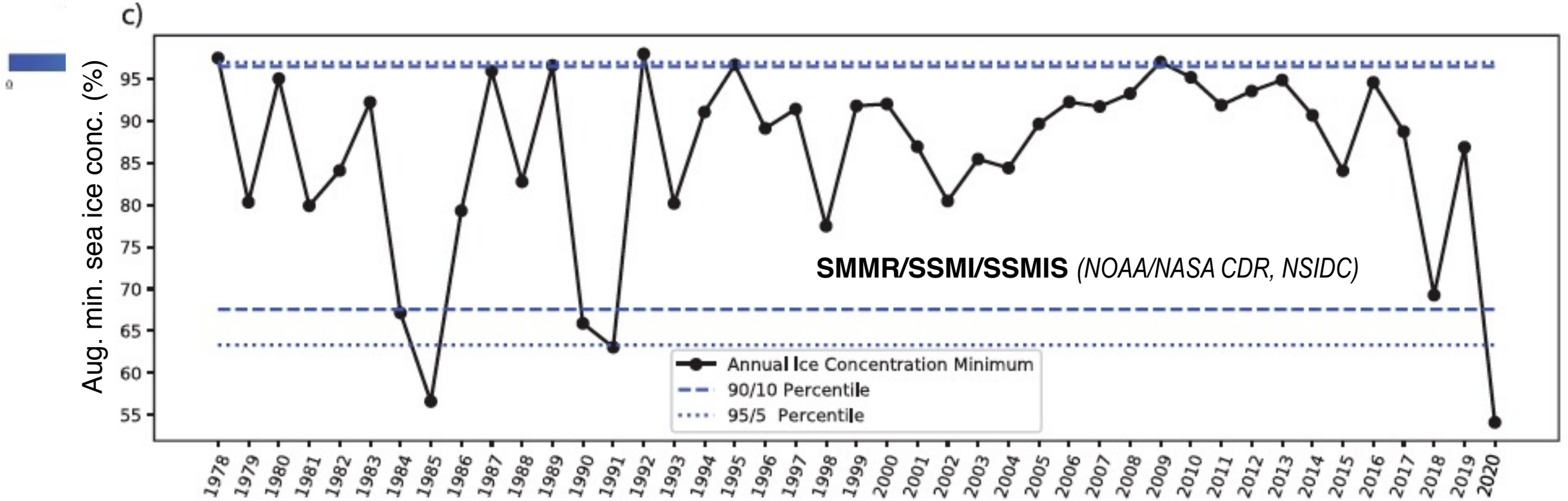
August 2020



2020 was lowest

…but other years were also low!



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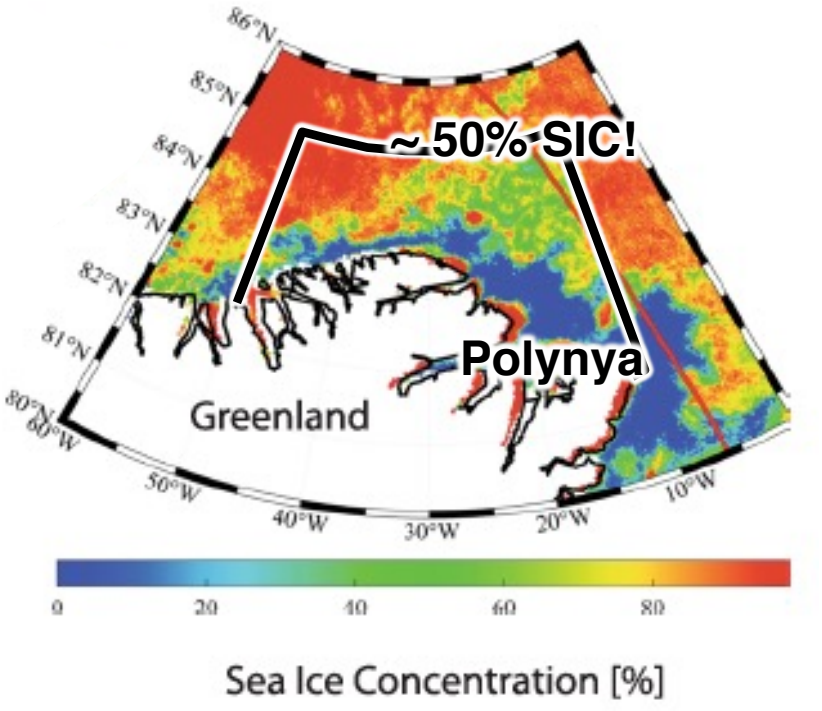
August 2020



2020 was lowest

…but other years were also low!

Our main question:

Why was SIC so low?

We use:

PIOMAS: Pan-Arctic Ice-Ocean **Modeling** & Assimilation System

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Dynamics vs Thermodynamics

Modeled ice thickness Δ partitioned as:

$$\Delta h_{ice}/\Delta t = F_{adv(ection)} + F_{prod(uction)}$$

F_{adv} = thickness flux convergence

(> 0 means thickening)

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Dynamics vs Thermodynamics

Modeled ice thickness Δ partitioned as:

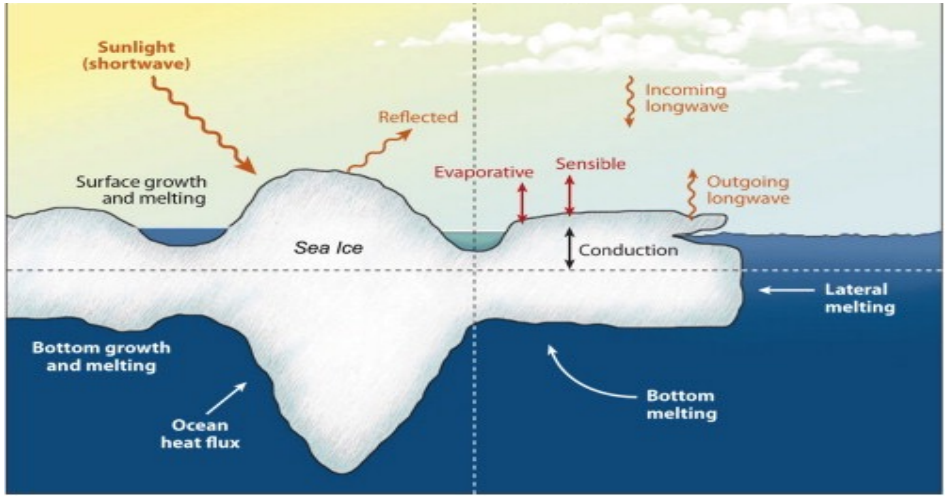
$$\Delta h_{ice}/\Delta t = F_{adv(ection)} + F_{prod(uction)}$$

F_{adv} = thickness flux convergence

(> 0 means thickening)

F_{prod} = net growth – melt

(> 0 means thickening)



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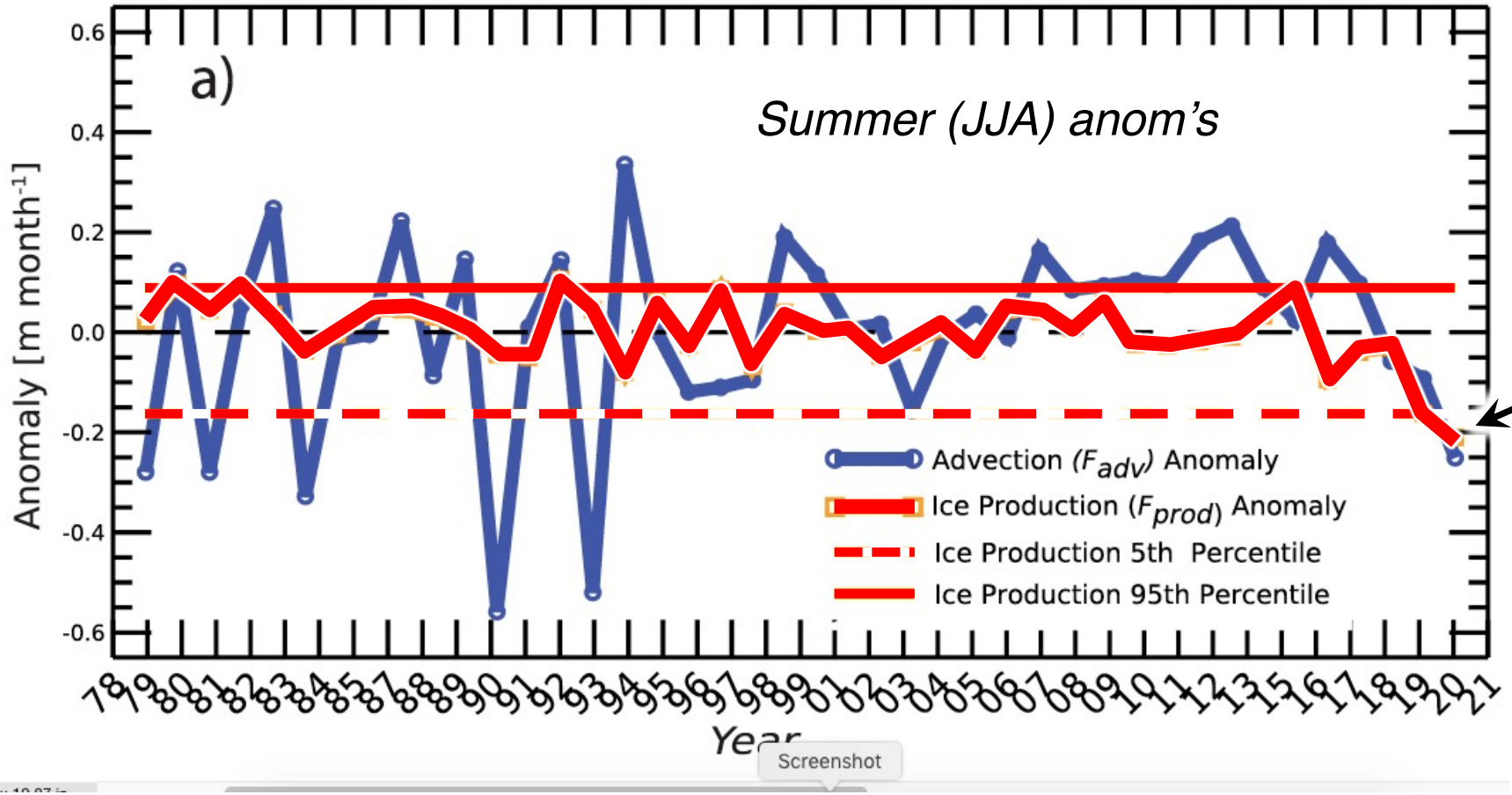
Dynamics vs Thermodynamics

$$\Delta h_{ice}/\Delta t = F_{adv} + F_{prod}$$



Summer 2020:

- Large **divergence**
- Large net **melt**

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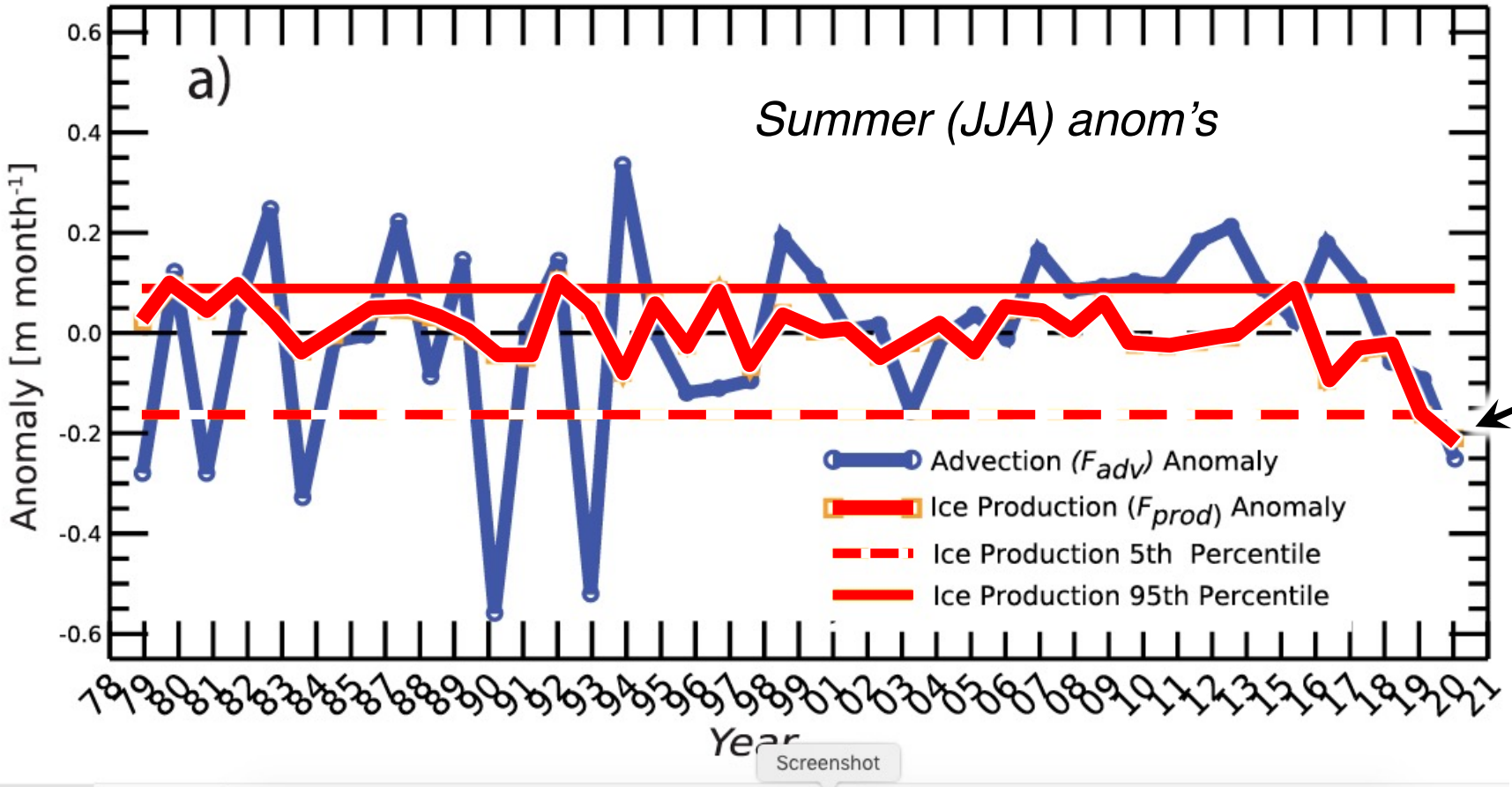
Dynamics vs Thermodynamics

$$\Delta h_{ice}/\Delta t = F_{adv} + F_{prod}$$



Summer 2020:

- Large **divergence**
- Large net **melt**

It's both!

more details…

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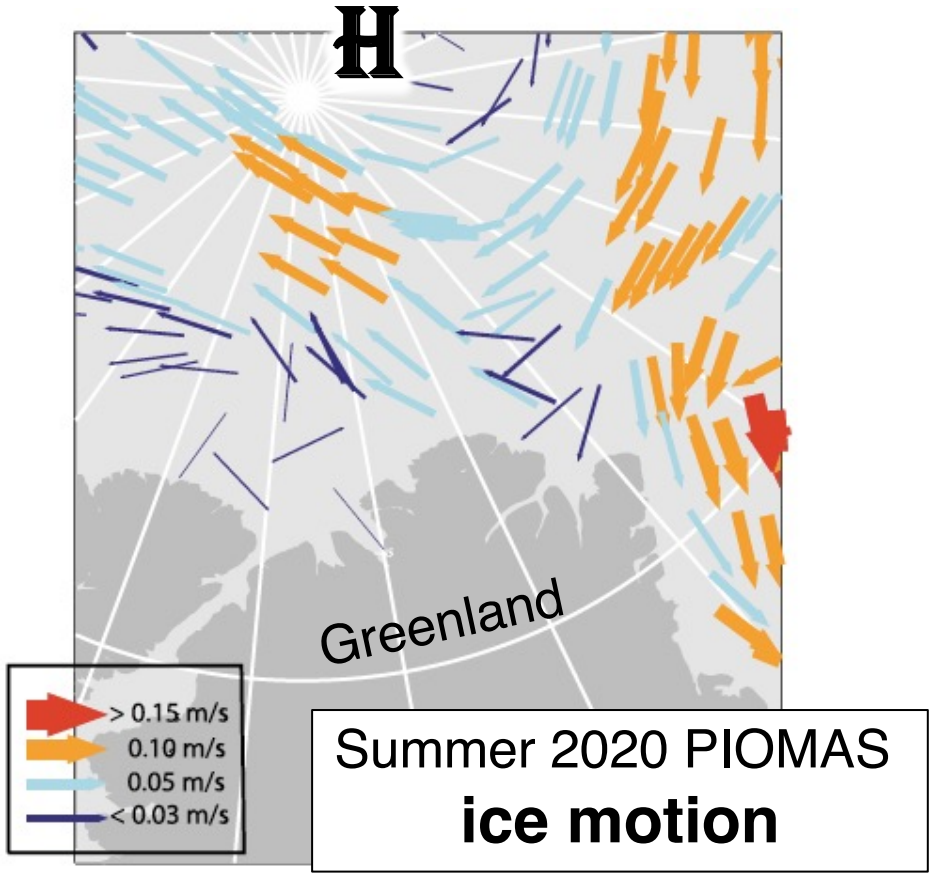
Dynamics vs Thermodynamics

$$\Delta h_{ice}/\Delta t = F_{adv} + F_{prod}$$



Summer 2020 PIOMAS
ice motion

Big, strong high pressure cell
➜ "giant Beaufort Gyre"

Mallett et al. (Nature Comm. Earth & Environ, 2021)
Moore et al. (Nature Comm. Earth & Environ., 2021)

*Lots of **divergence** out of the Wandel Sea*

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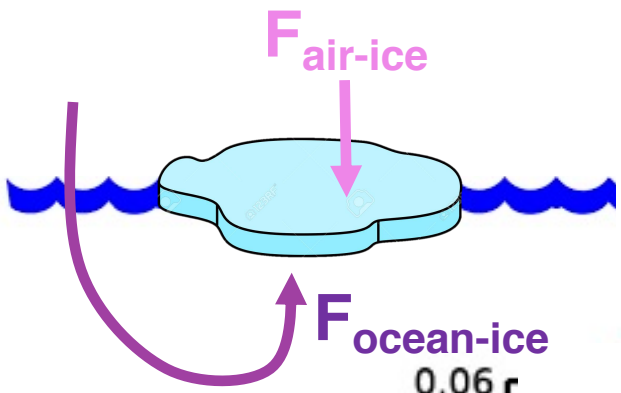
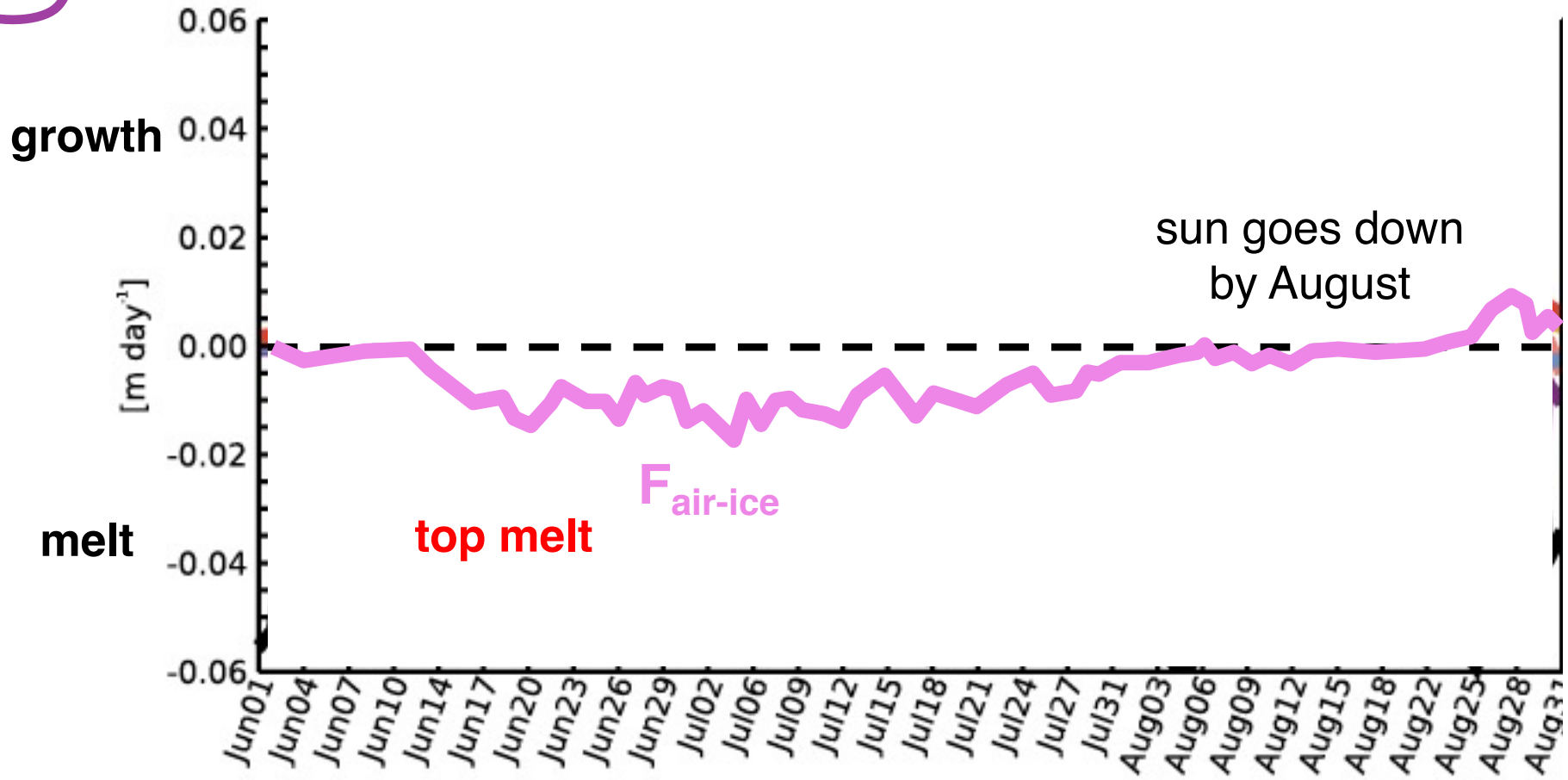
Dynamics vs Thermodynamics



$$\Delta h_{ice}/\Delta t = F_{adv} + \boxed{F_{prod}}$$



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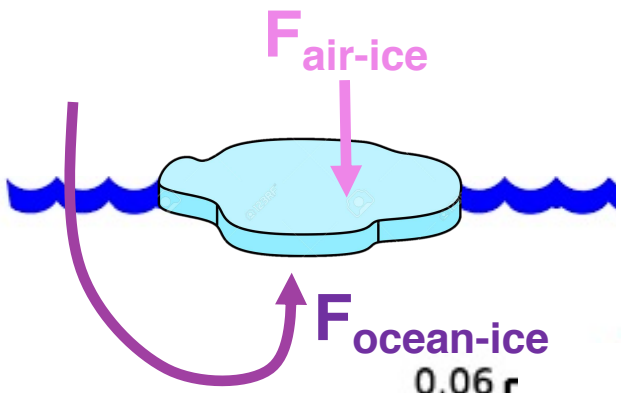
Dynamics vs Thermodynamics



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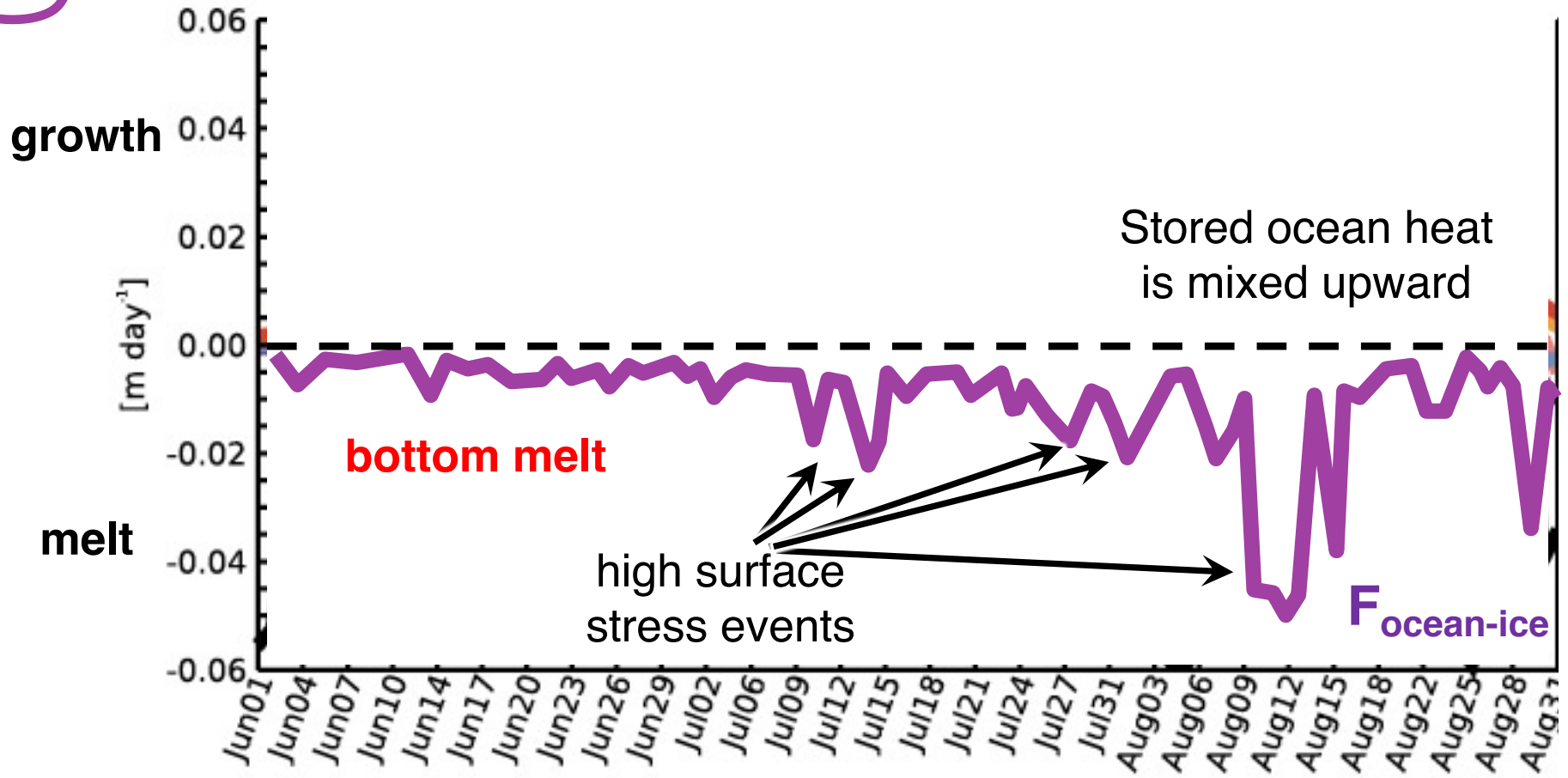

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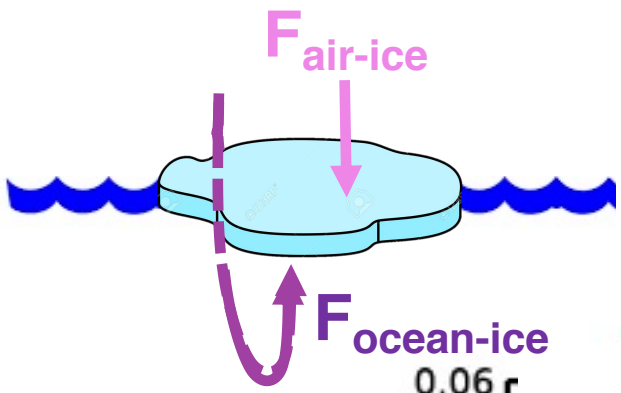
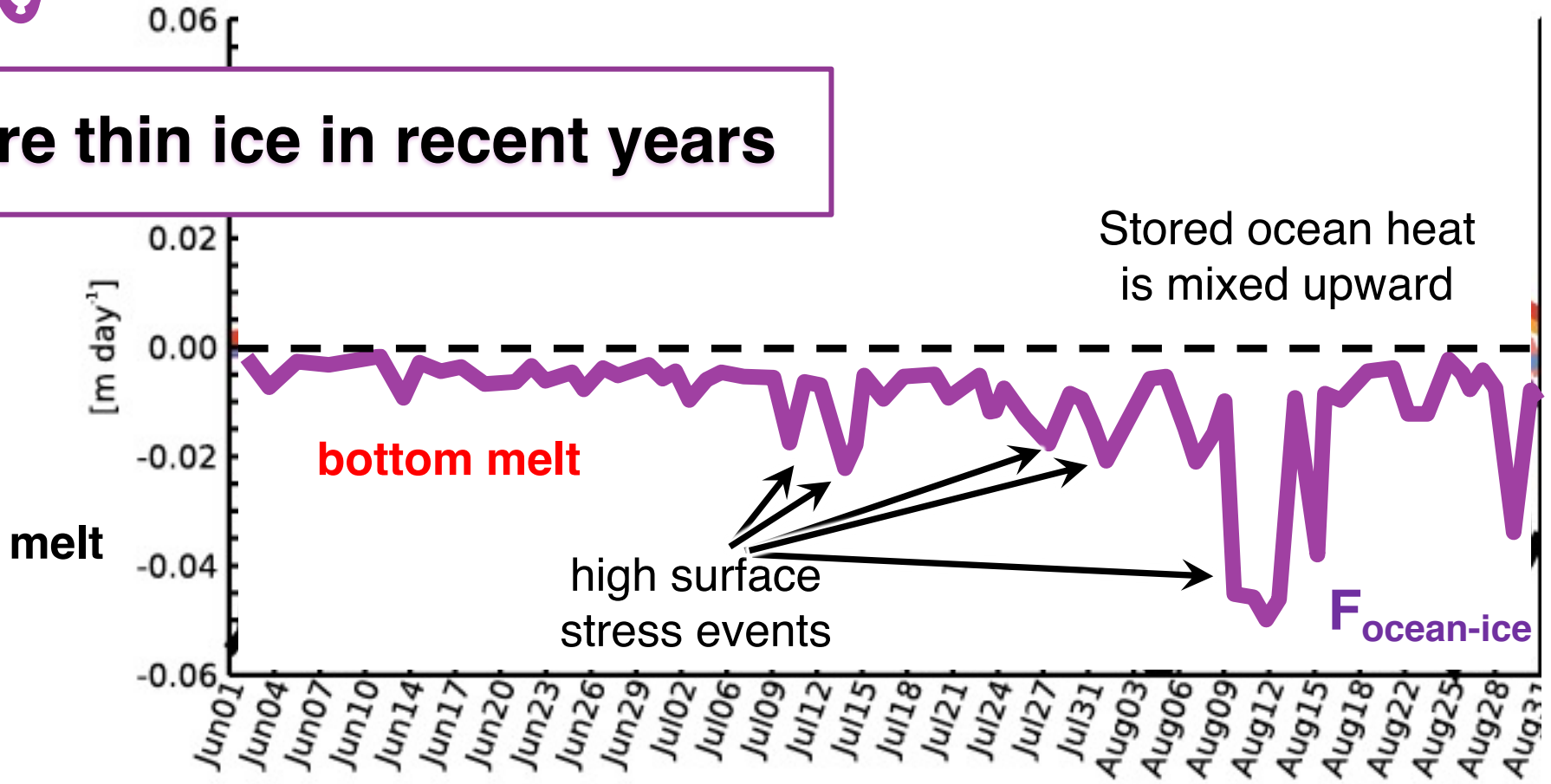
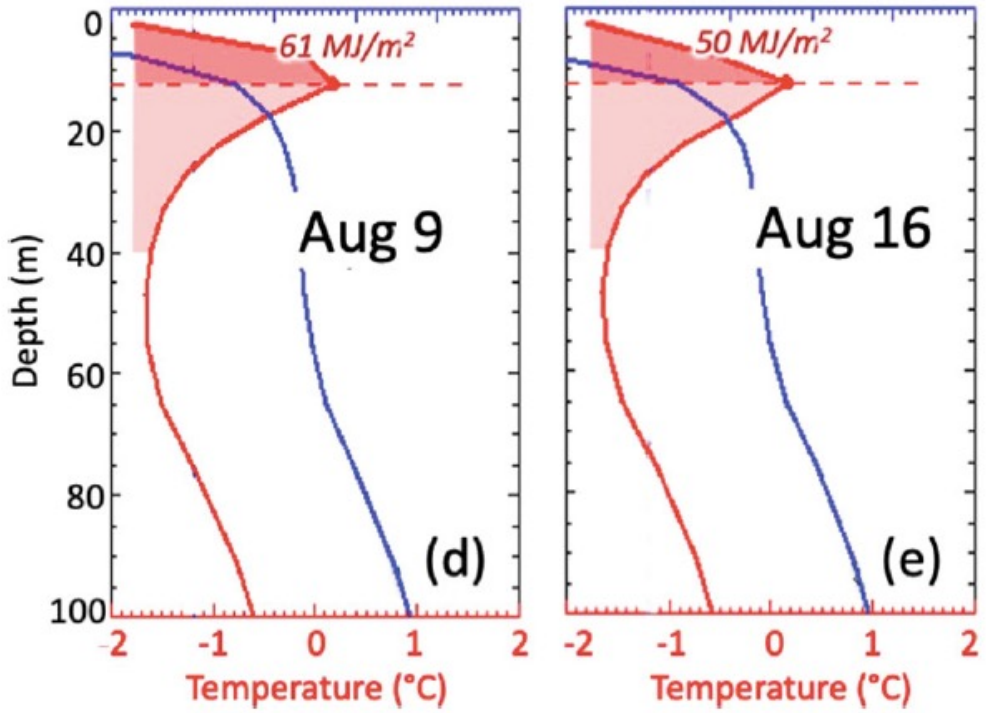
Dynamics vs Thermodynamics



$$\Delta h_{ice}/\Delta t = F_{adv} + \boxed{F_{prod}}$$

More thin ice in recent years

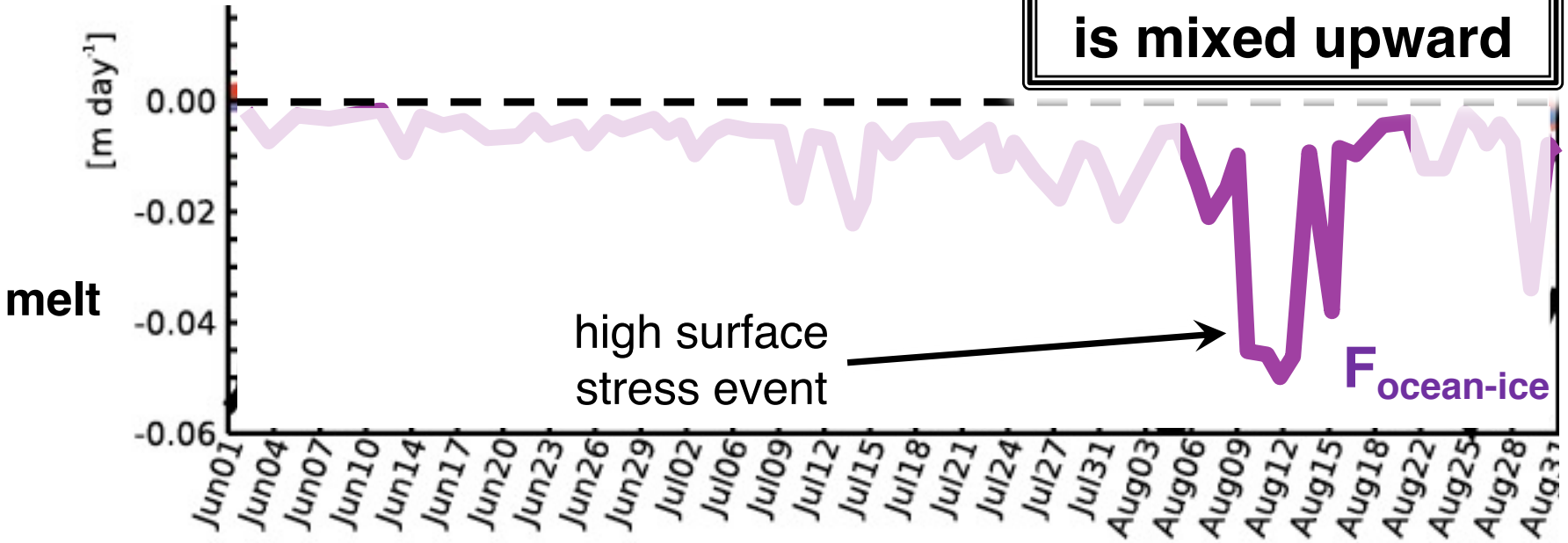


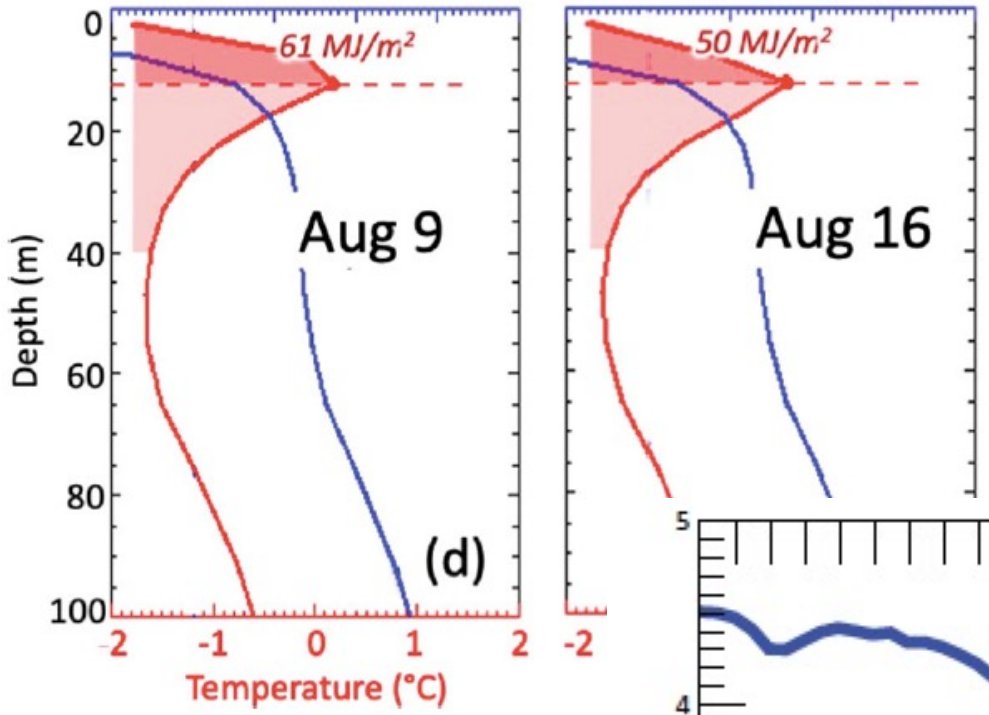


Decrease in subsurface ocean heat

(NSTM = Near-Surface Temp. Max.)

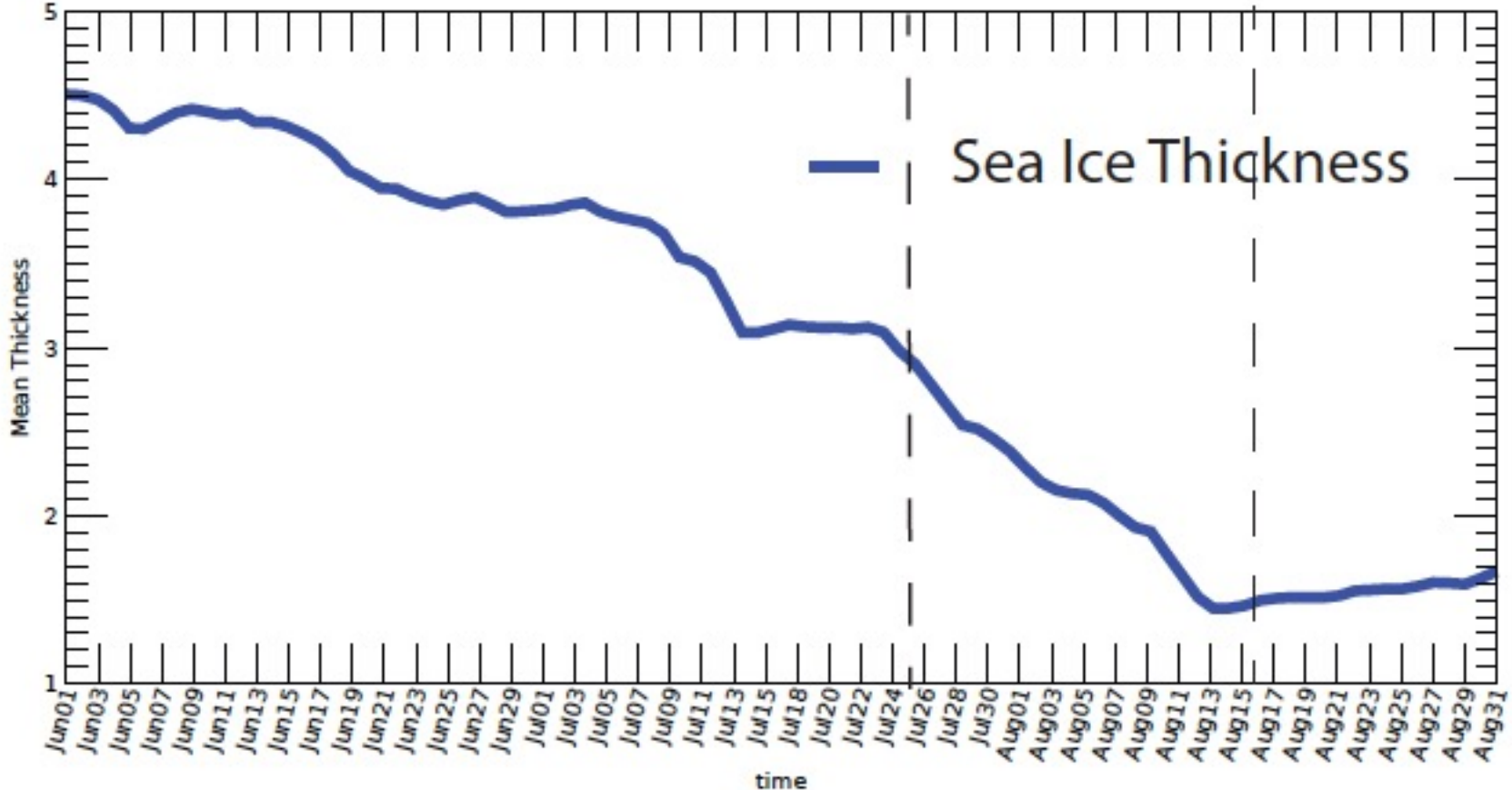
Stored ocean heat is mixed upward





Subsurface ocean heat

➜ ice melt



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Let's play with the model!

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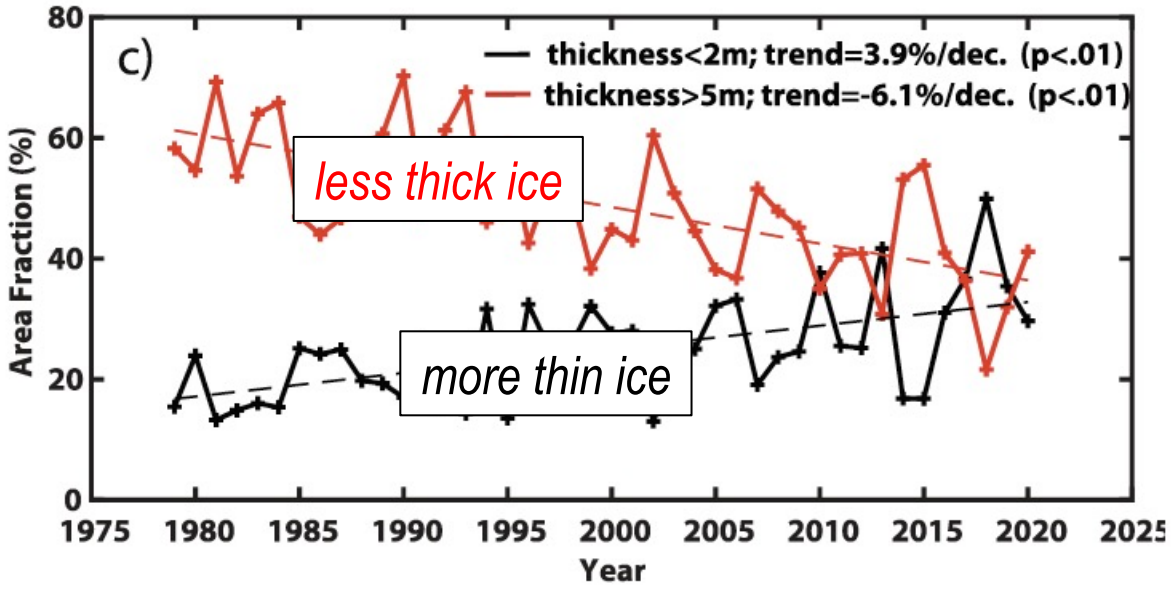
What would have happened if…

Summer 2020 started with

ice-ocean conditions

from another year?



"The role of long-term ice thinning"

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What would have happened if…

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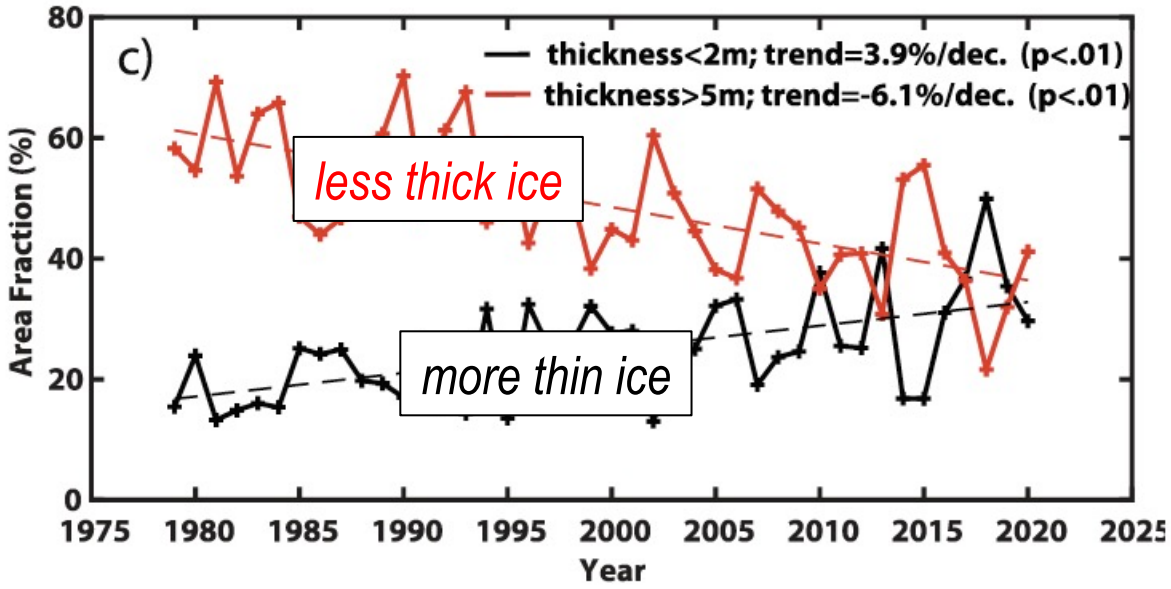

Run the model
starting with ice-ocean conditions
from June 1, 1979, 1980, … 2019
(using 2020 atmos. forcing)

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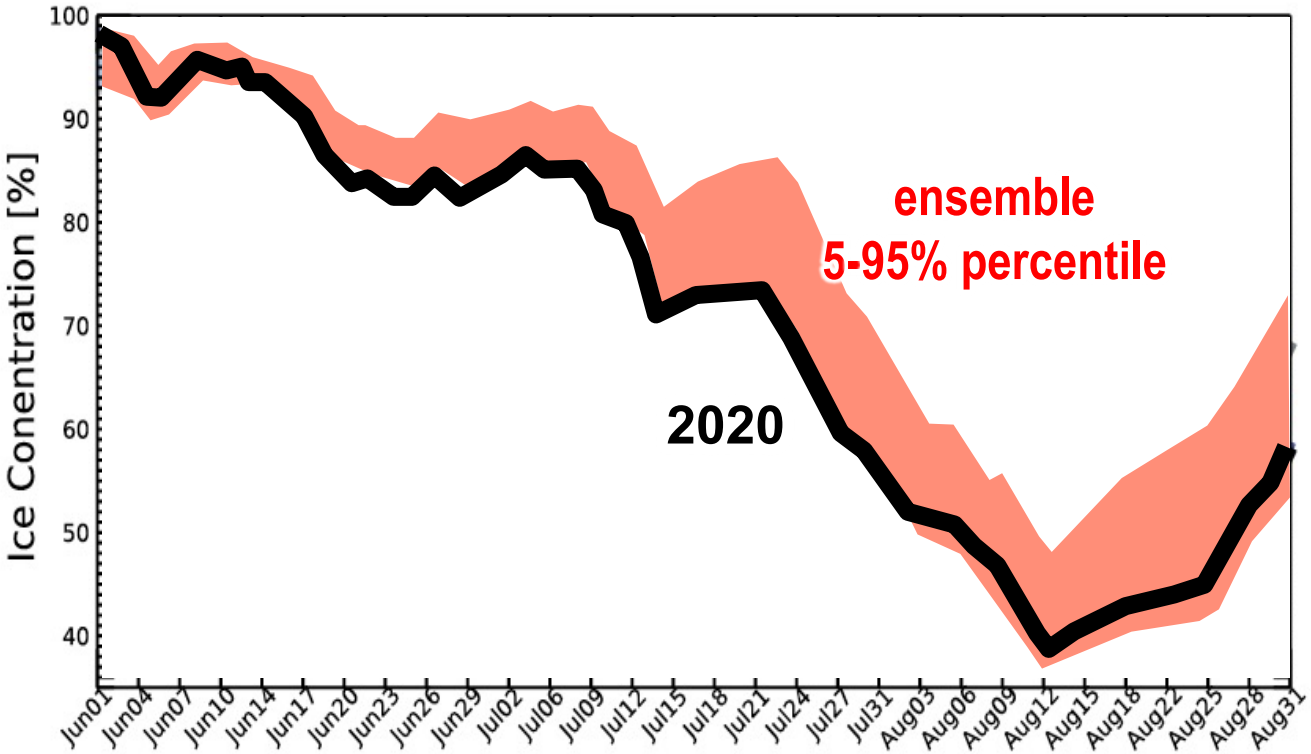
The role of June 1, 2020 ice-ocean conditions



Run the model
starting with ice-ocean conditions from June 1, 1979, 1980, … 2019
(using 2020 atmos. forcing)

- **low SIC** from the start
- **not much change** over the summer

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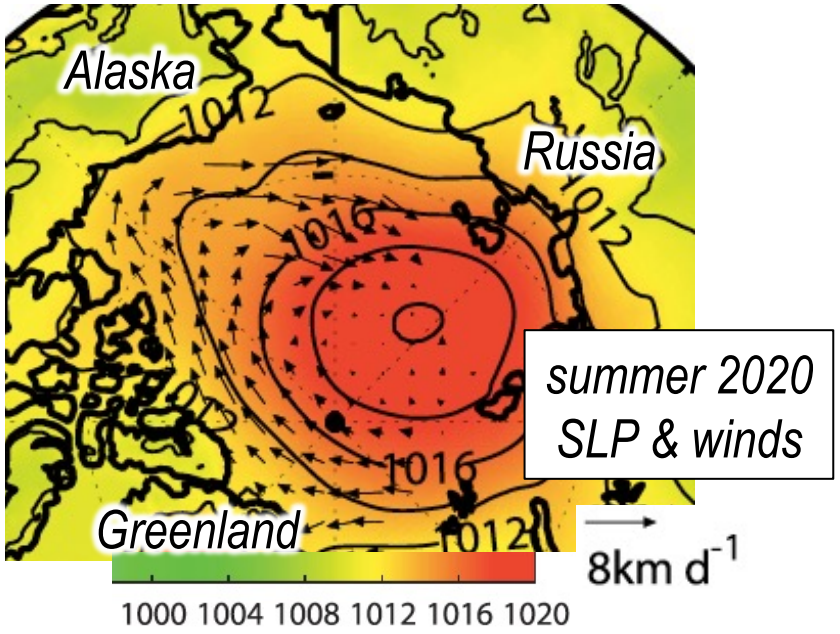
What would have happened if…

Summer 2020 had
atmospheric forcing
from another year?



"The role of atmos. forcing in 2020"

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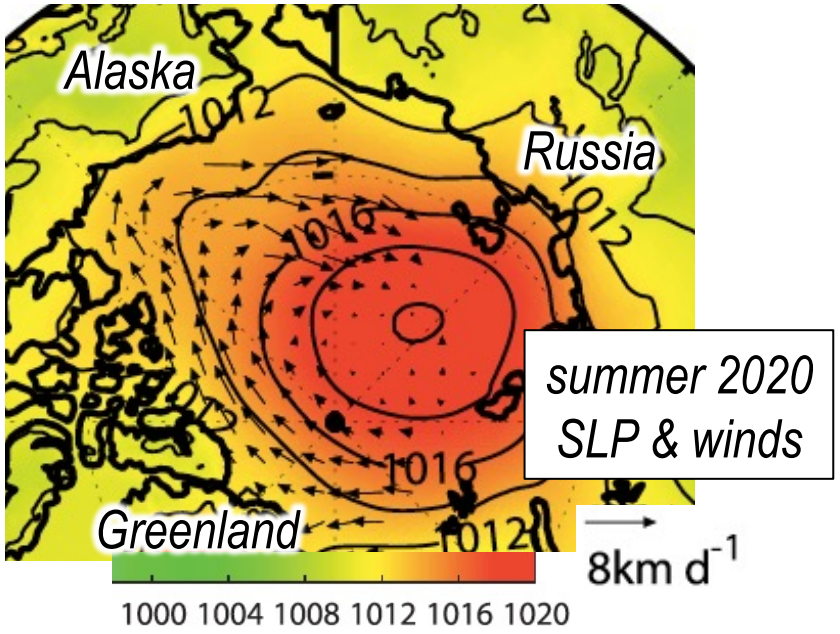
What would have happened if…

Run the model
using **atmos. forcing from summer 1979, 1980, etc.**
(starting with June 1, 2020 ice-ocean conditions)

Summer 2020 had
atmospheric forcing
from another year?



"The role of atmos. forcing in 2020"

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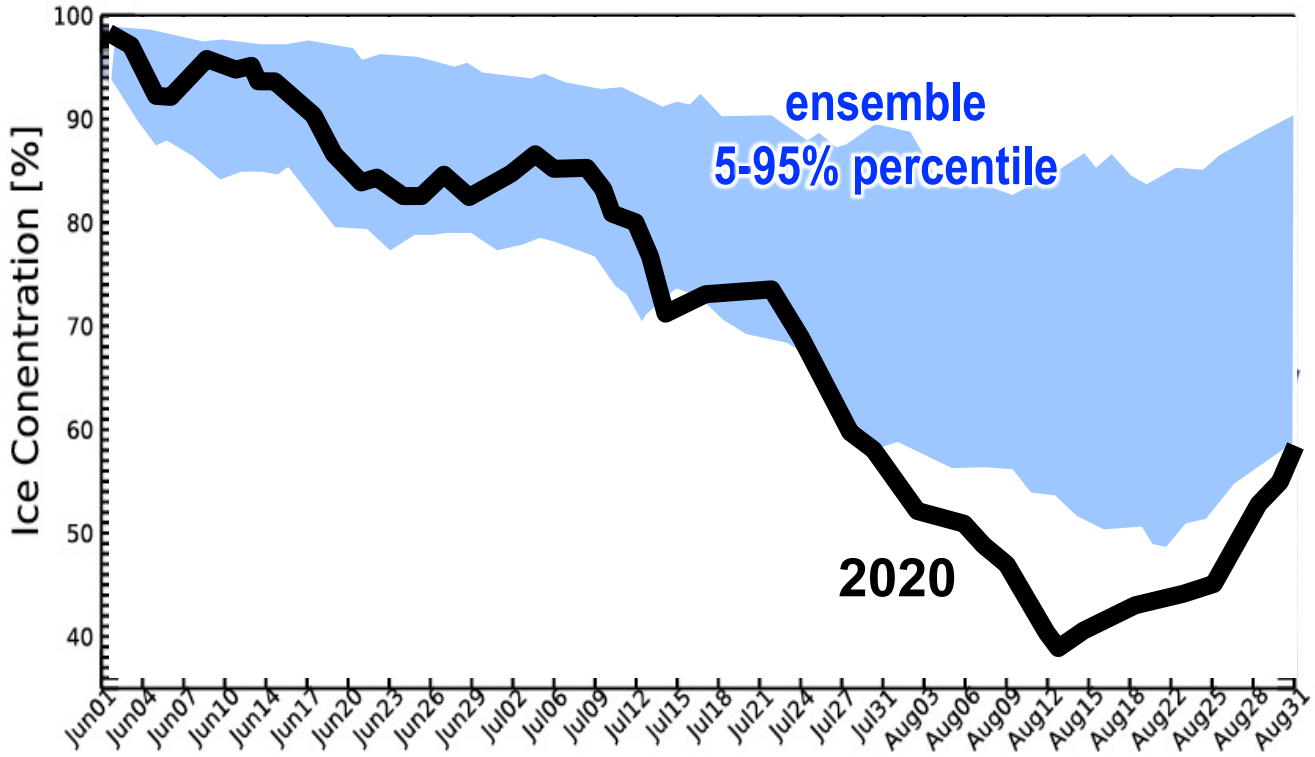
The role of summer 2020 atmos. forcing

Run the model
using **atmos. forcing from summer 1979, 1980, etc.**
(starting with June 1, 2020 ice-ocean conditions)



- **SIC decrease mostly in late summer**

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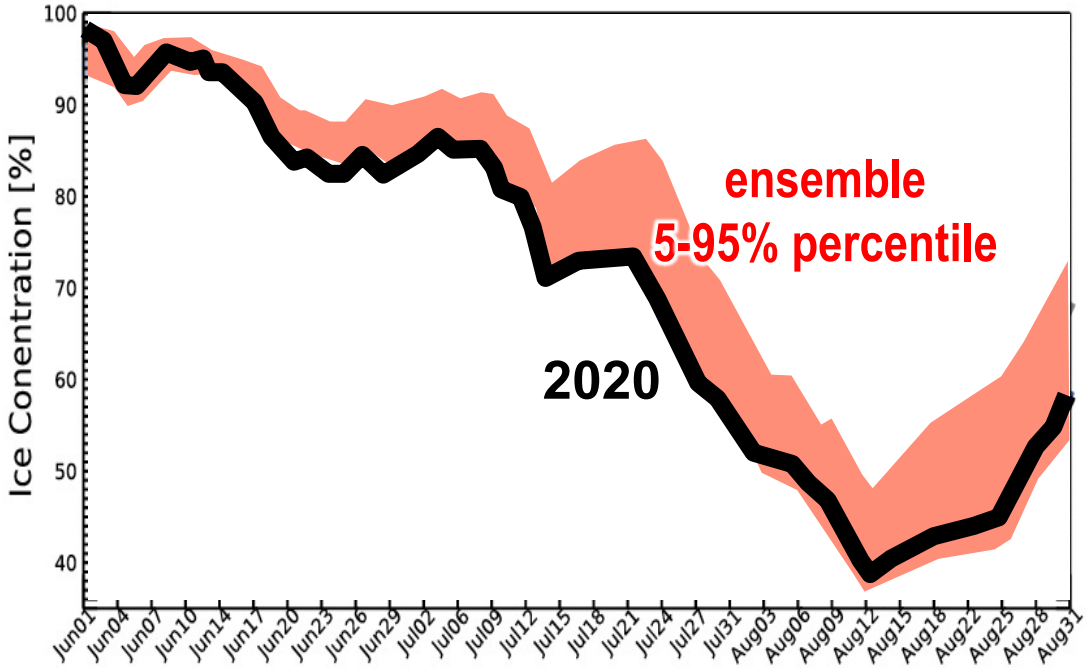
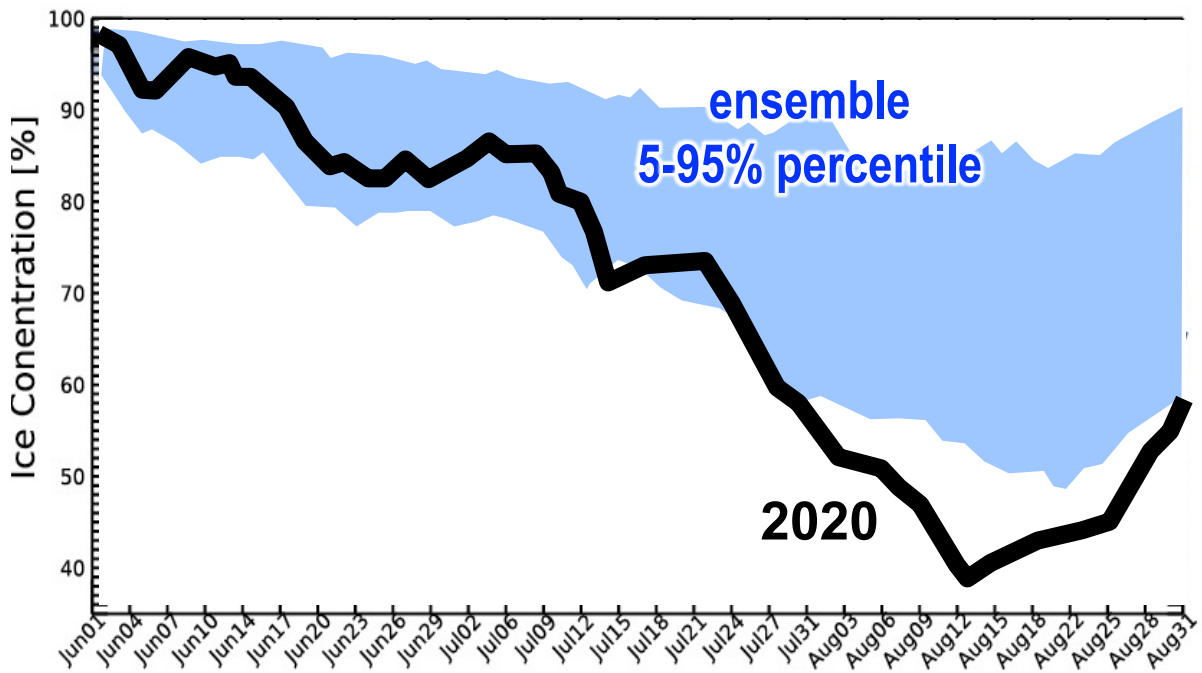
June 1 conditions vs. summer atmos. forcing





Early summer SIC decrease

Late summer SIC decrease

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June 1 conditions vs. summer atmos. forcing

20% June 1 vs. **80% atmos.** ➜ **2020** SIC min.
(mid-August)

climate change signal *(i.e., ice thinning)*

~ NYC flooding from

Swain et al. (One Earth, 2020)

Superstorm Sandy
October, 2012

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Other stuff

- Low SIC **likely to happen again** under strong wind forcing throughout the "**Last Ice Area**"

World Wildlife Fund

- Why aren't **models** reproducing low SIC here?

- *Transient* benefit to **marine mammals**?

  (thick, compact ice ➜ more productive thinner, looser ice ➜ no summer ice)

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Other stuff

- Low SIC likely to happen again under strong wind forcing thro
- Why
- *Transient benefit to marine mammals?*

Thank you

Wildlife Fund

(thick, compact ice ➜ more productive thinner, looser ice ➜ no summer ice)