

*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



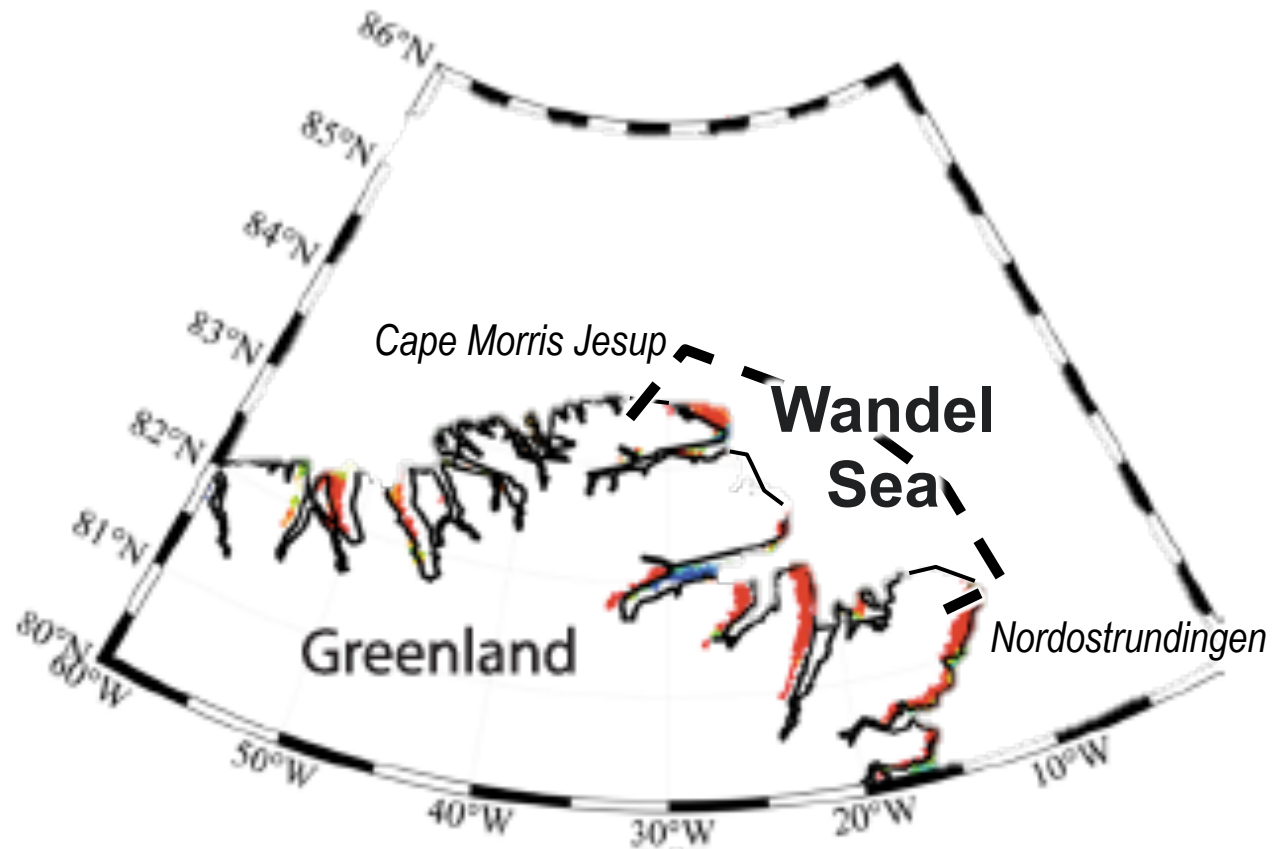
Kristin Laidre ¹
Biology

¹ Polar Science Center, APL/U of Washington, Seattle, WA, USA

² U of Toronto Mississauga, Ont., Canada

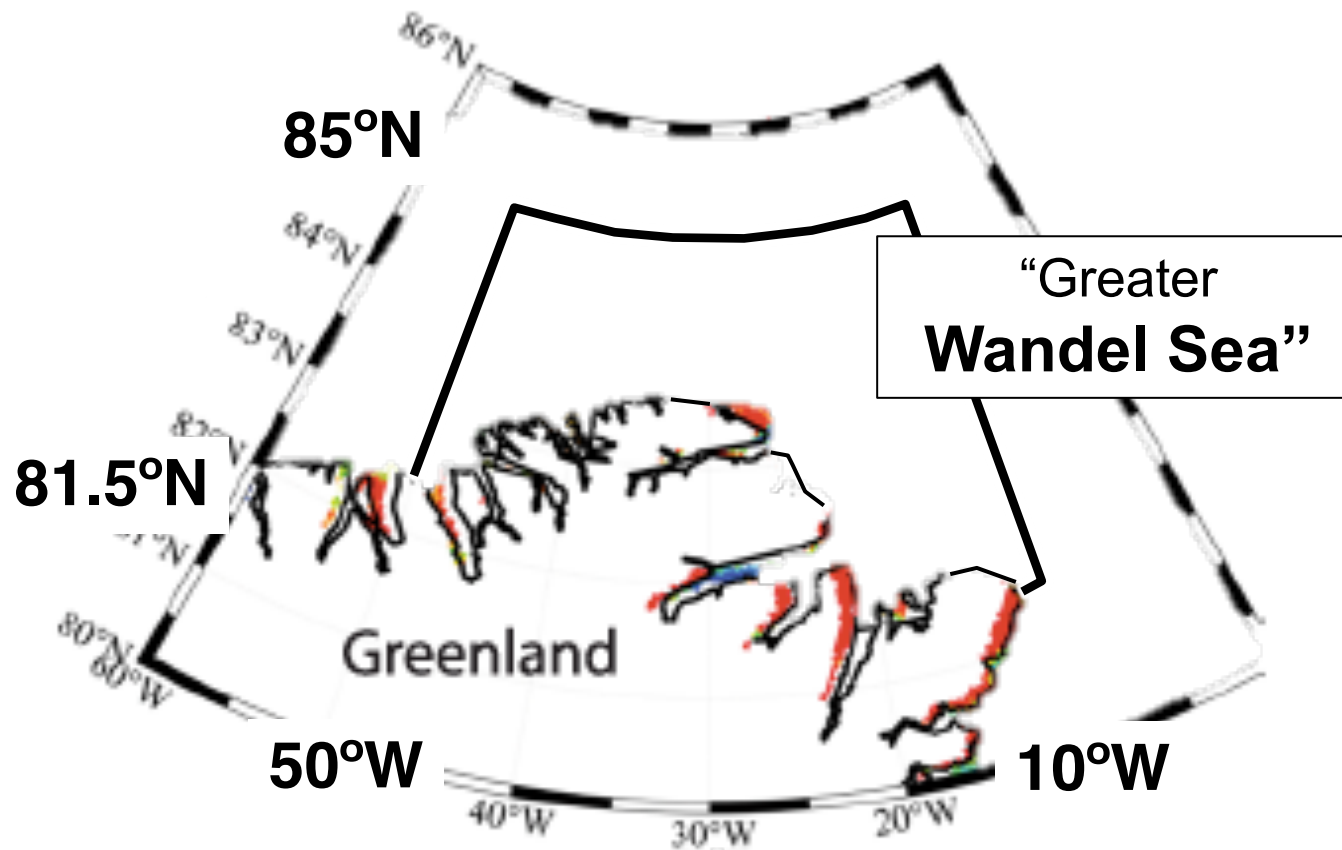
Nature Communications Earth & Environment, 2021

<https://doi.org/10.1038/s43247-021-00197-5>

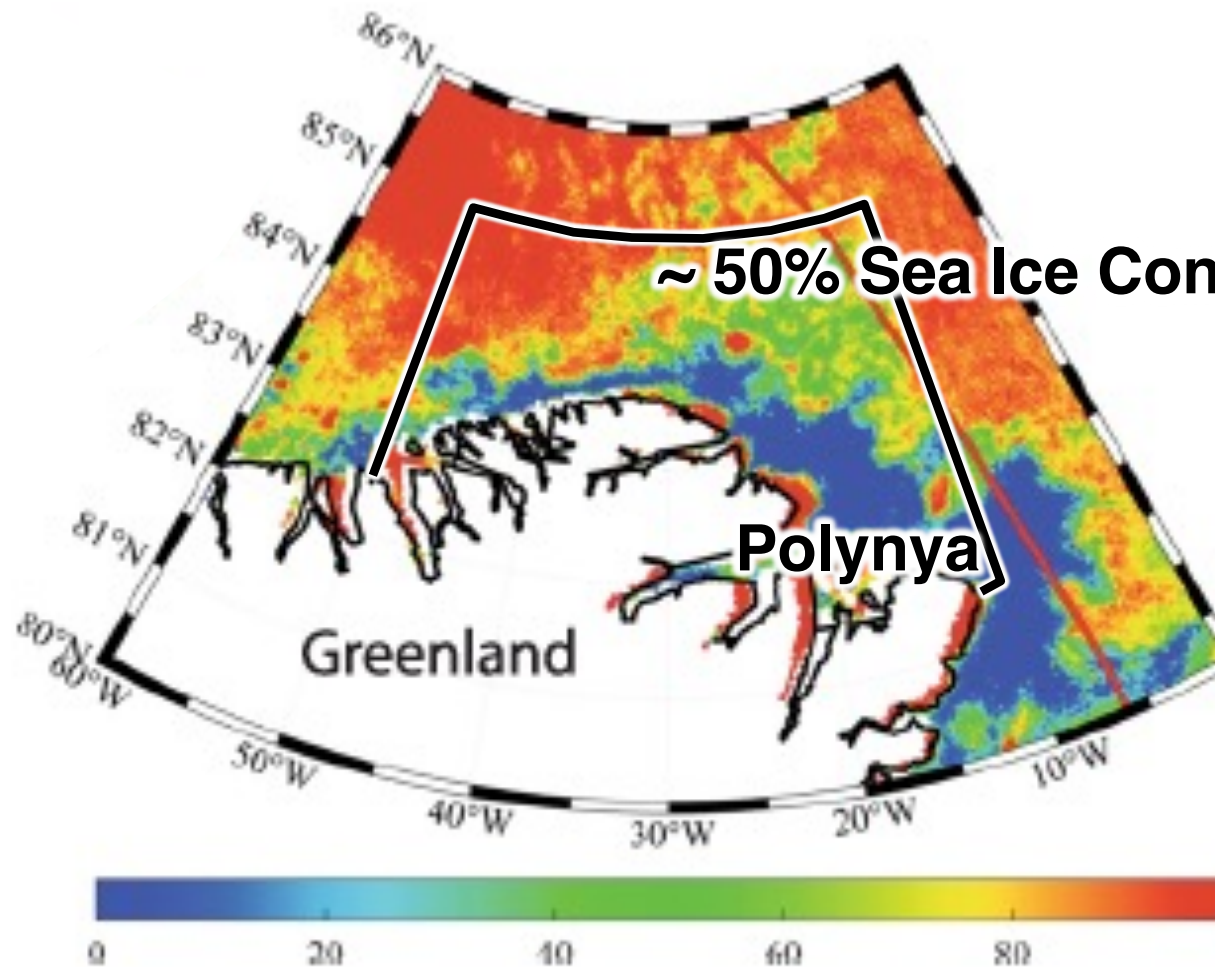


Carl Frederik Wandel
(1843 –1930)

Danish naval officer,
explorer, hydrographer



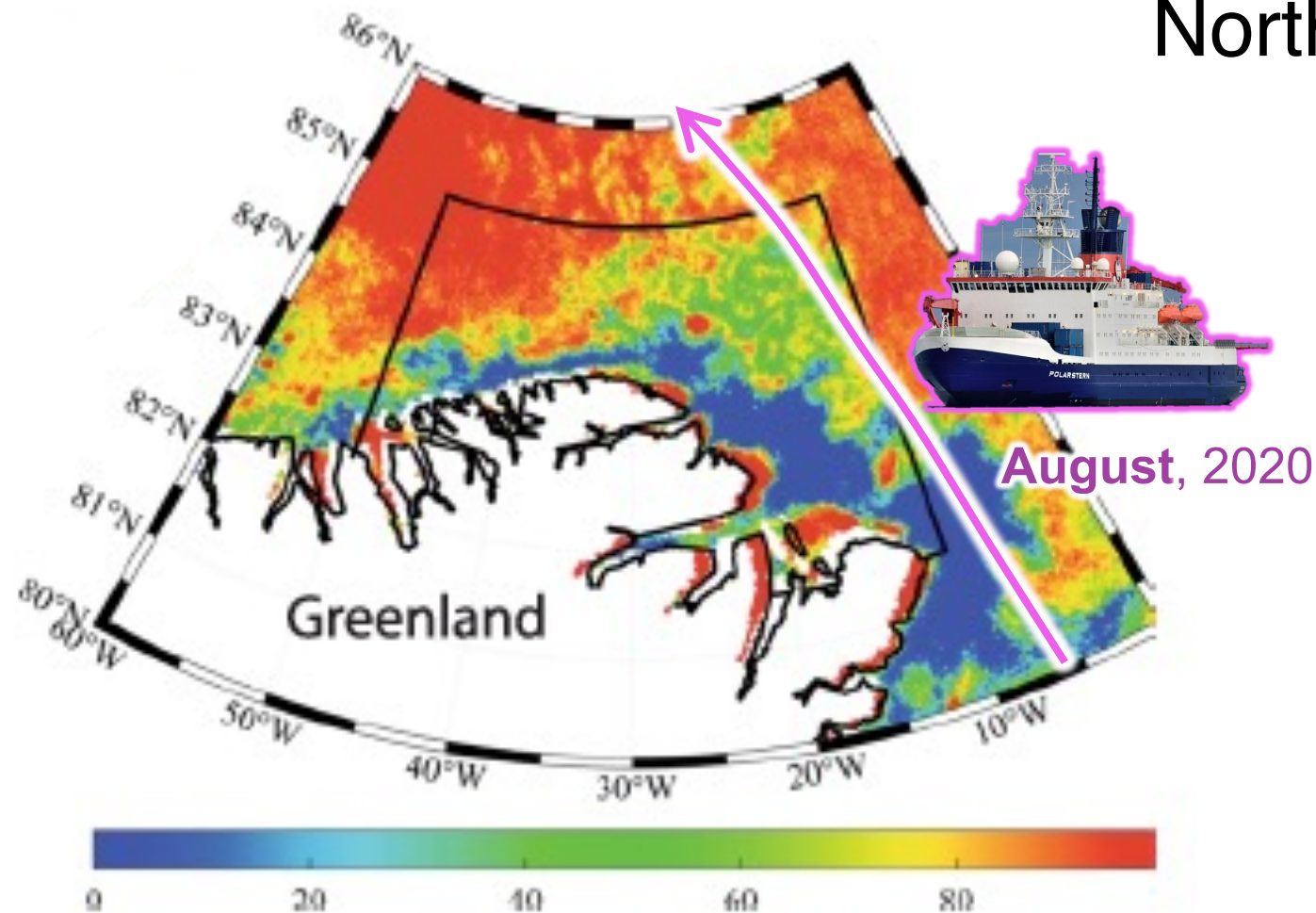
August 2020



Sea Ice Concentration [%]

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

MOSAiC reposition to the North Pole

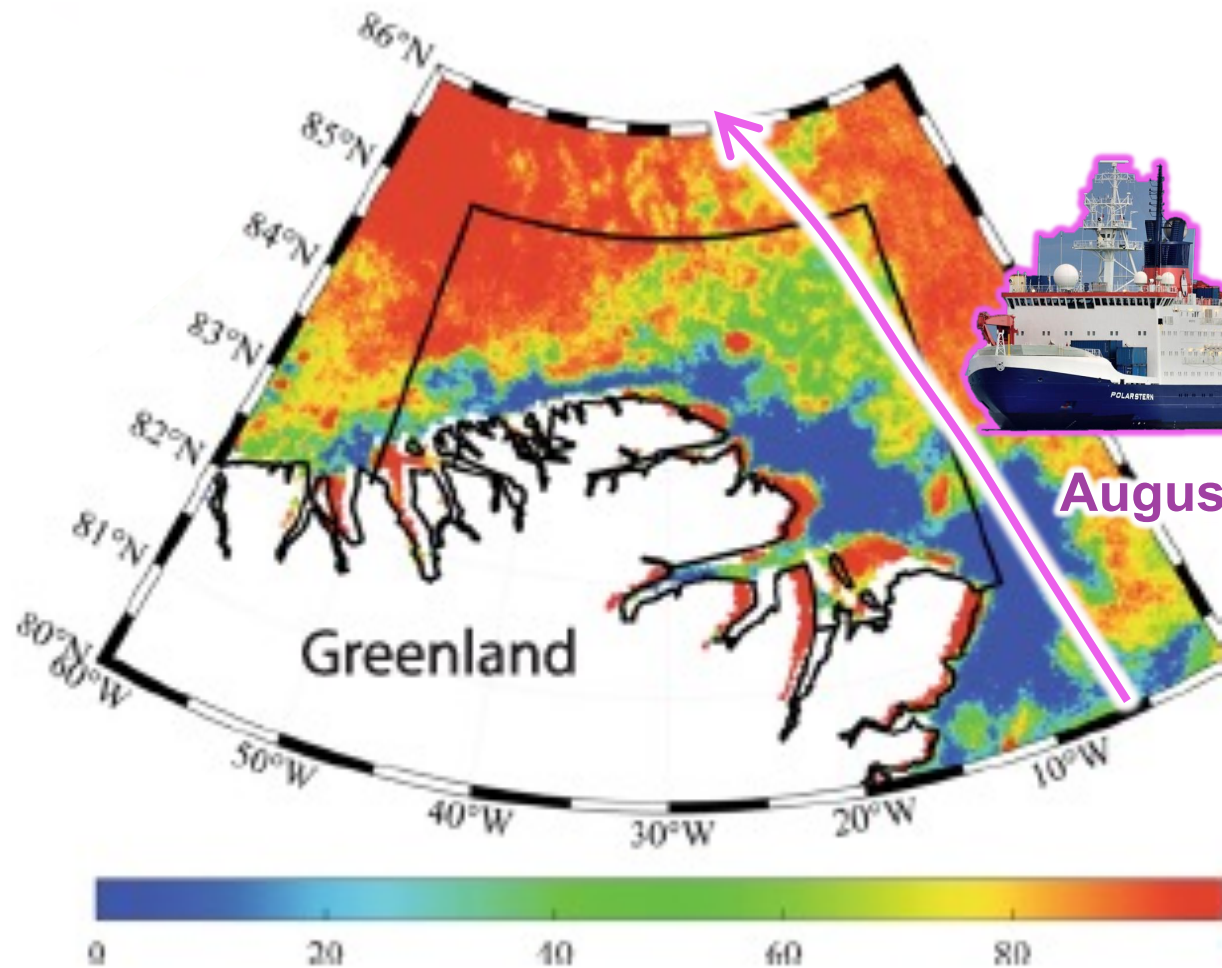


...via the Wandel Sea!

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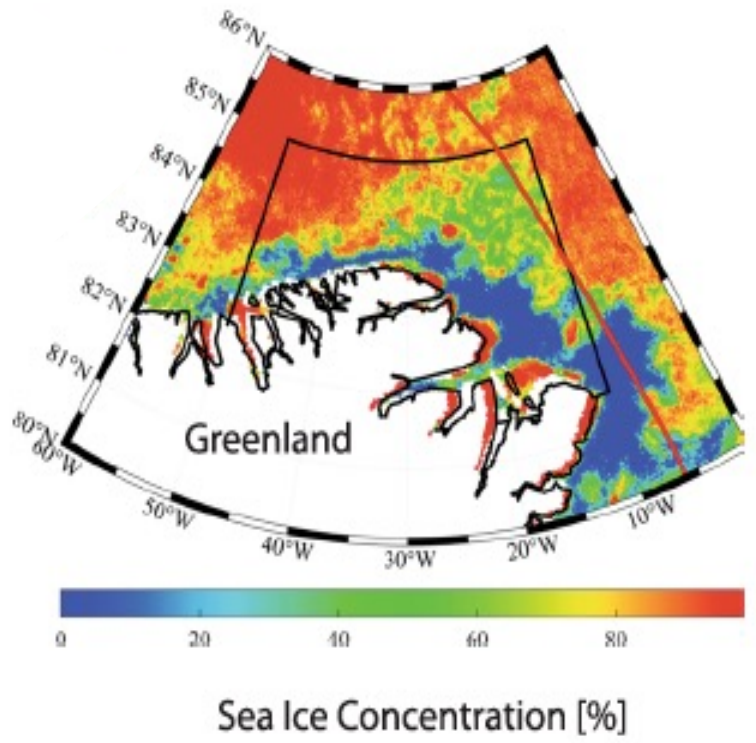


August, 2020

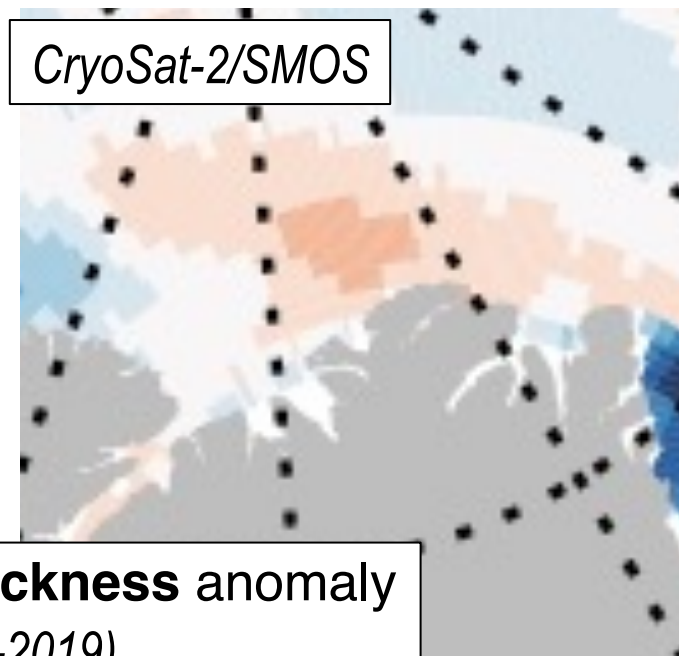
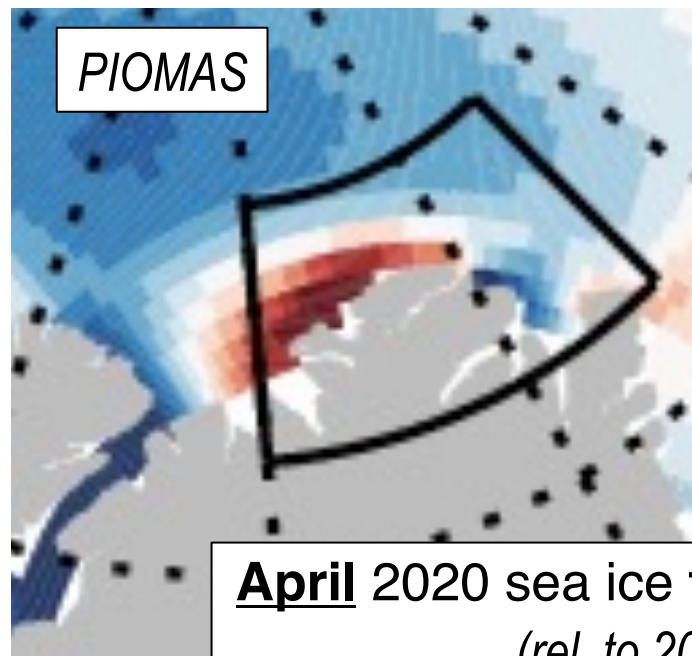
...via the Wandel Sea!

Our main question:
Why was SIC so low?

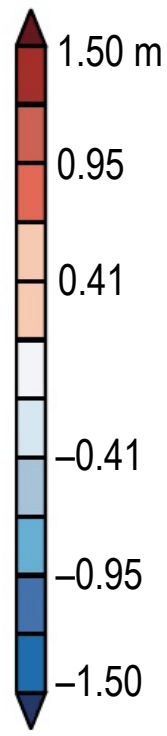
AMSR-2 (ARTIST Sea Ice, U of Bremen)



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



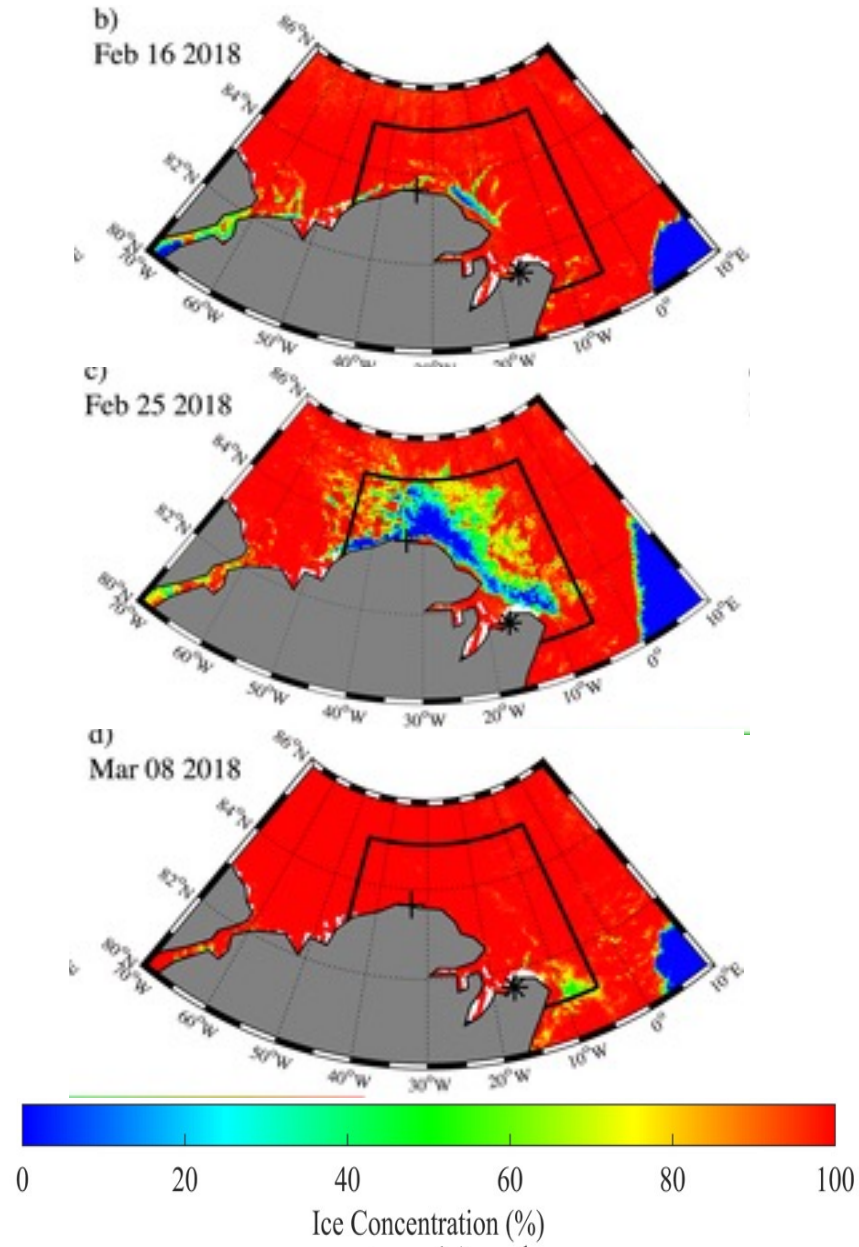
April 2020 sea ice thickness anomaly
(rel. to 2011-2019)



winter Wandel Polynyas

late February 2018

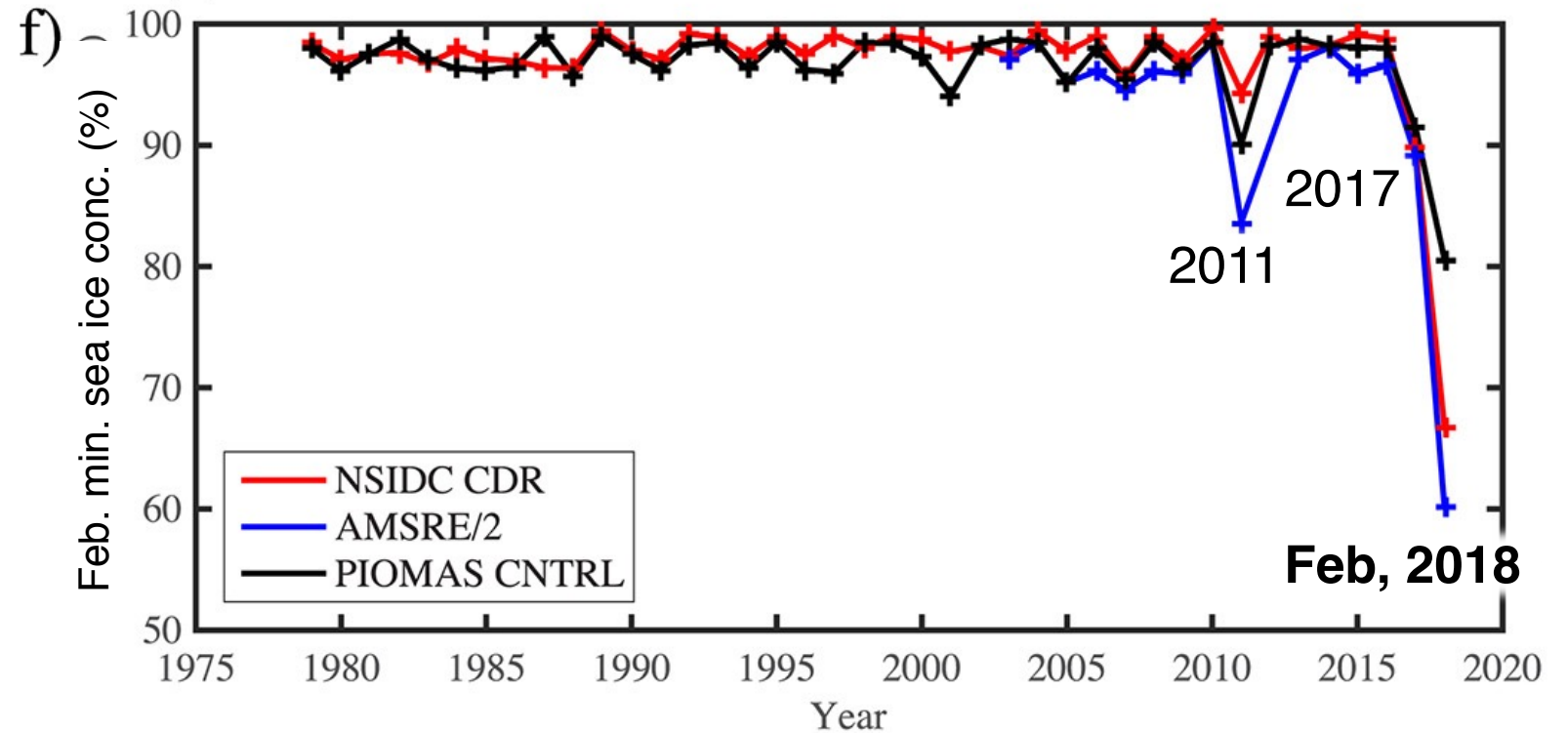
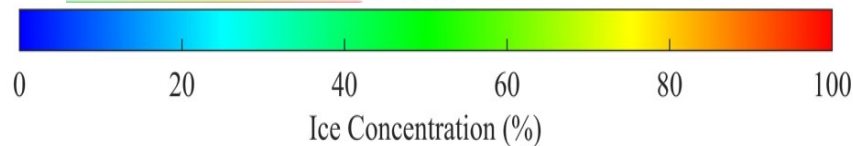
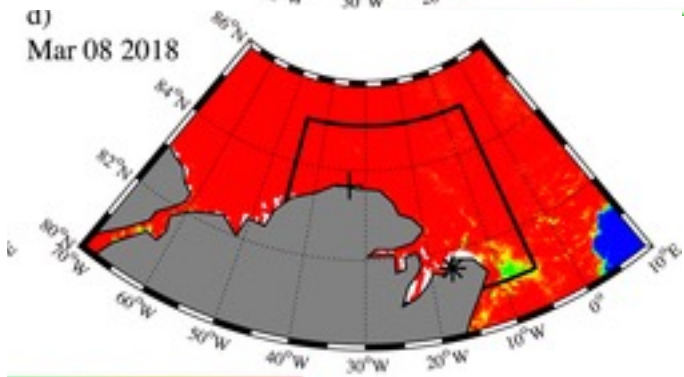
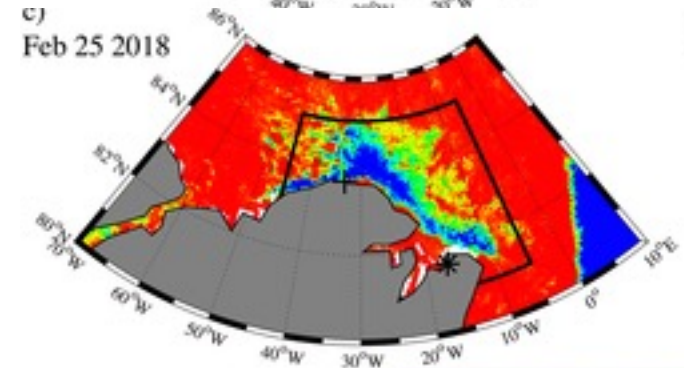
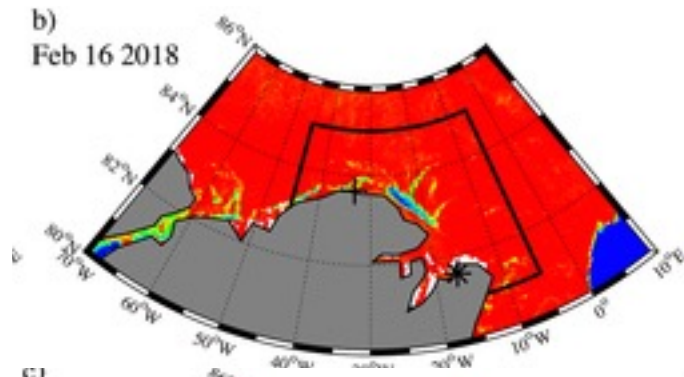
Moore et al. (GRL, 2018)



winter Wandel Polynyas

late February 2018

Moore et al. (GRL, 2018)

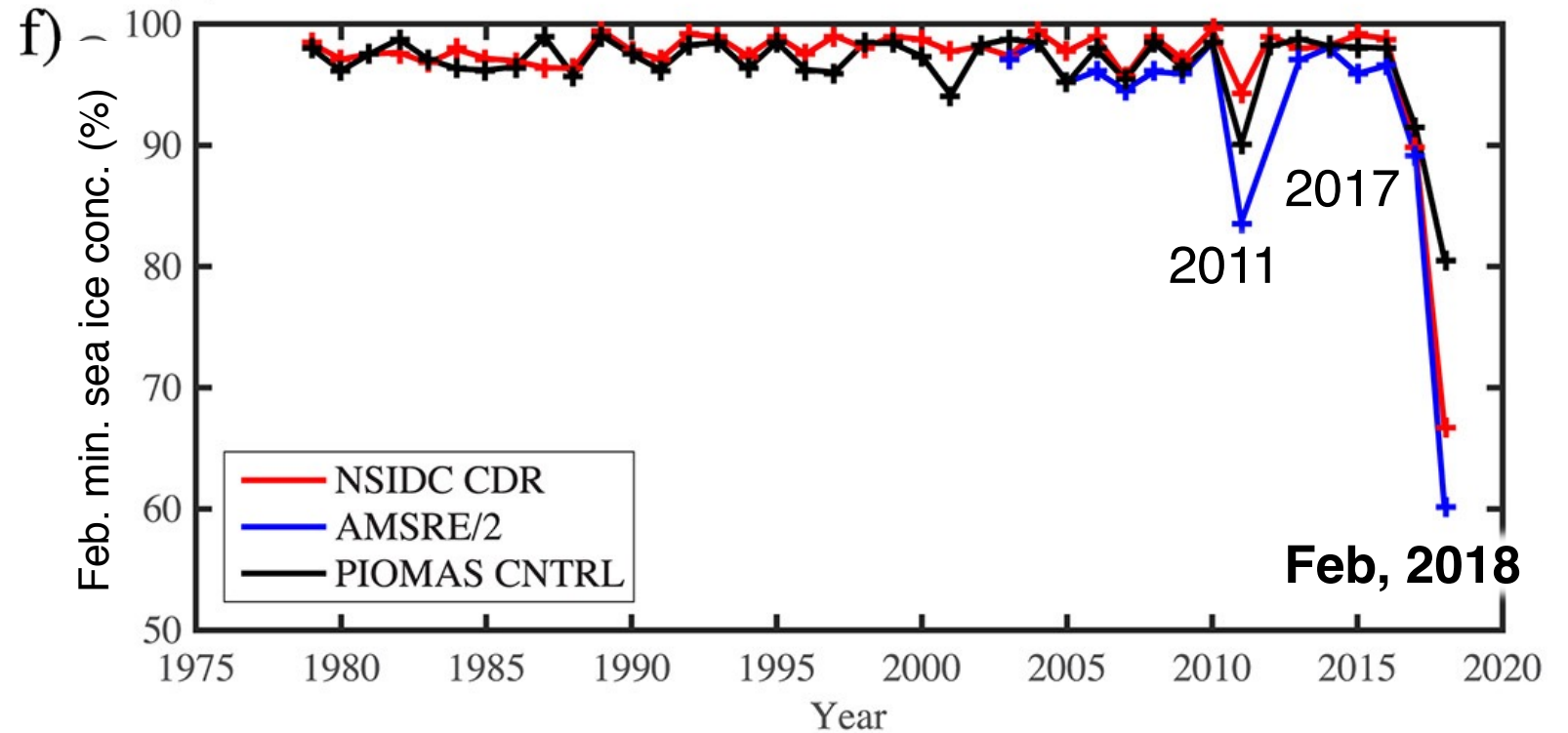
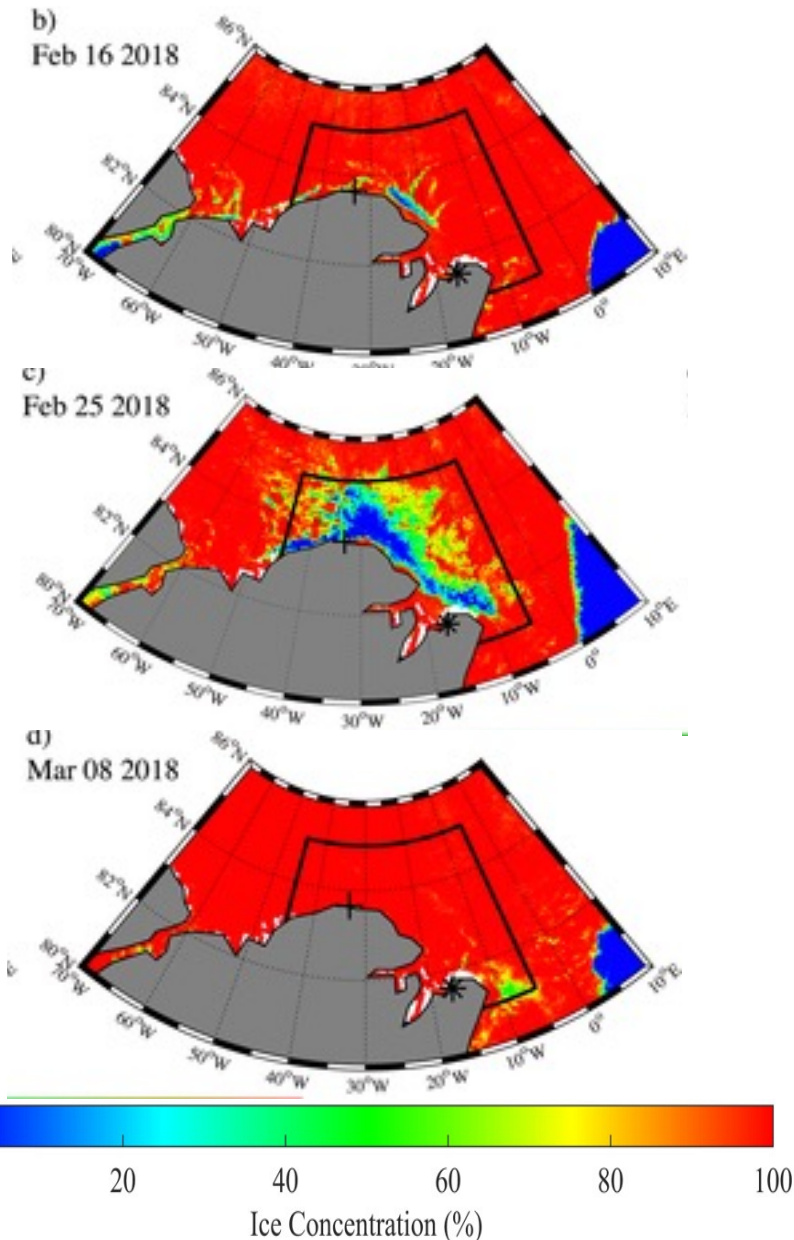


strong southerly winds

winter Wandel Polynyas

late February 2018

Moore et al. (GRL, 2018)



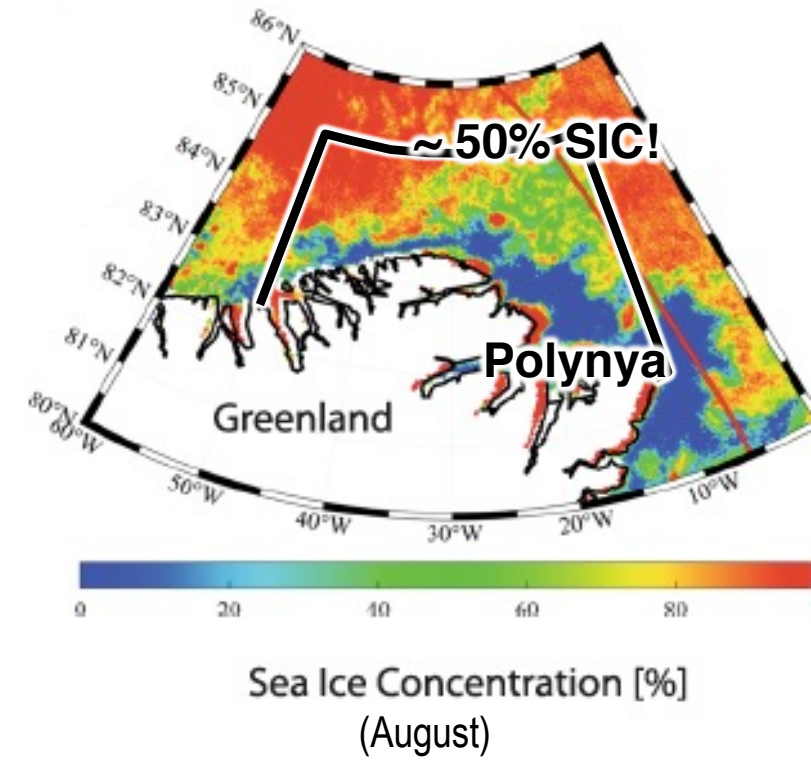
See also:

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

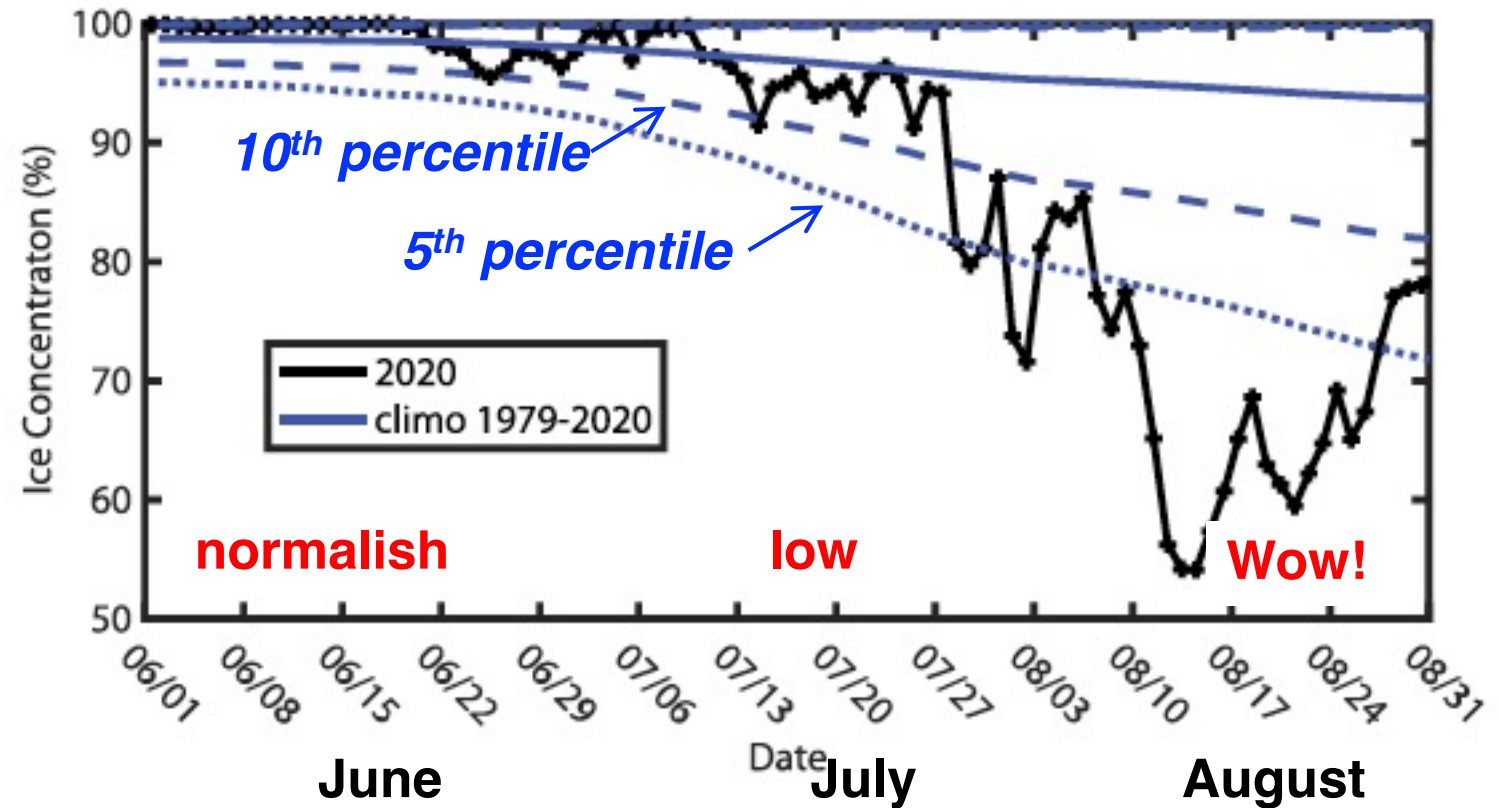
Y. **Lee** et al. (*The Cryos.*, 2021): *no polynya in 2019 or 2020*

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

Summer 2020

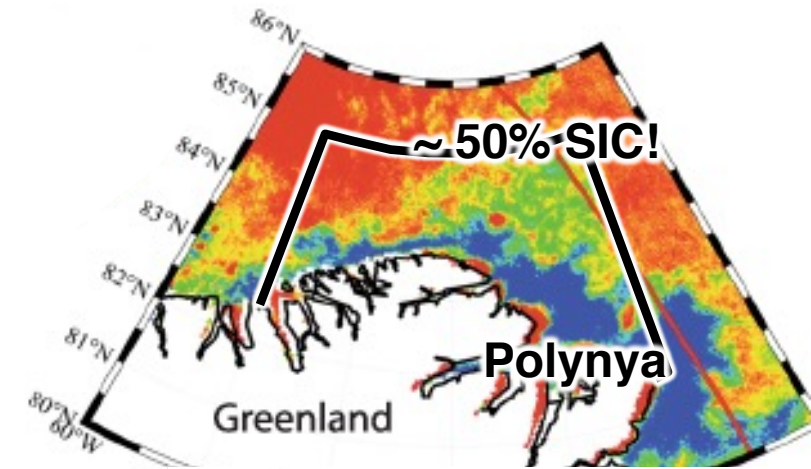


AMSR-2 (ARTIST Sea Ice, U of Bremen)

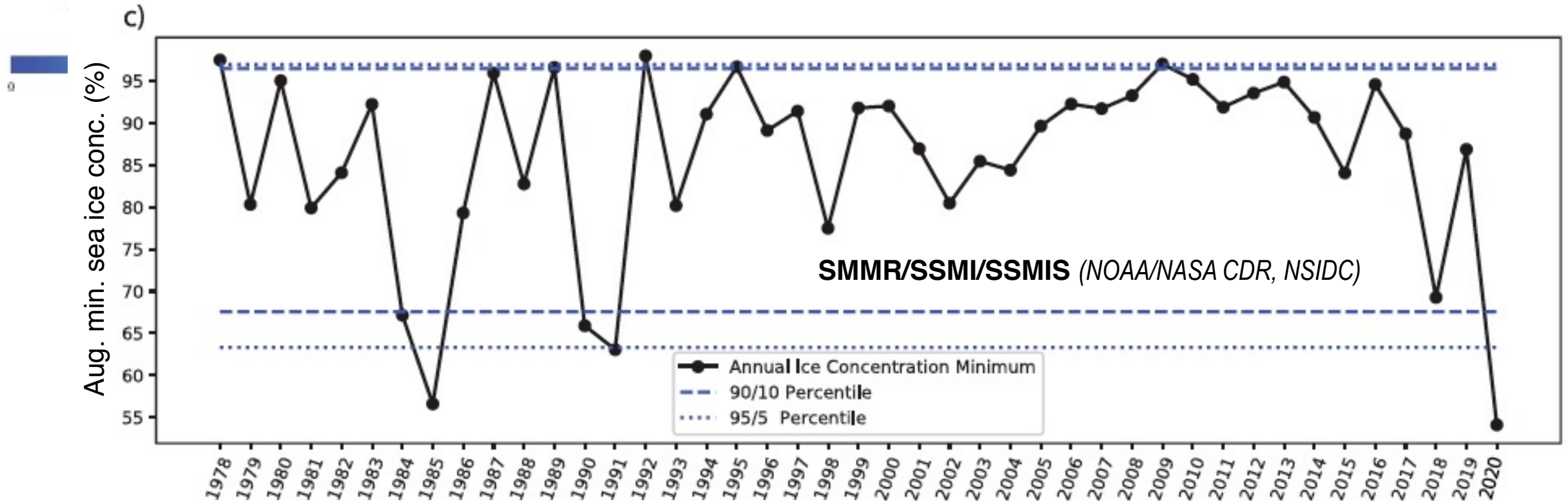


SMMR/SSM/SSMIS (NOAA/NASA CDR, NSIDC): 1979-2000

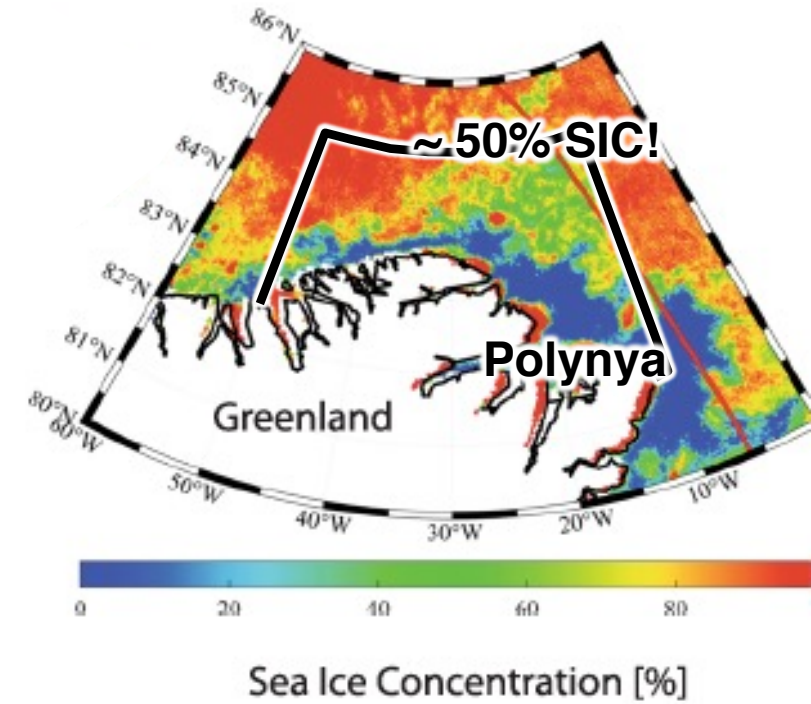
August 2020



2020 was lowest
...but other years were also low!



August 2020



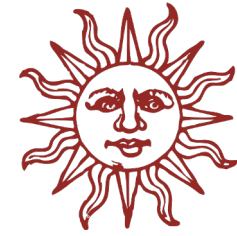
2020 was lowest
...but other years were also low!

Our main question:
Why was SIC so low?

We use:
PIOMAS: Pan-Arctic Ice-Ocean Modeling & Assimilation System



Dynamics vs Thermodynamics



Modeled
ice thickness Δ
partitioned as:

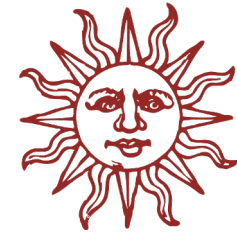
$$\Delta h_{\text{ice}} / \Delta t = F_{\text{adv}(\text{ection})} + F_{\text{prod}(\text{uction})}$$

F_{adv} = thickness flux convergence
(> 0 means thickening)





Dynamics vs Thermodynamics



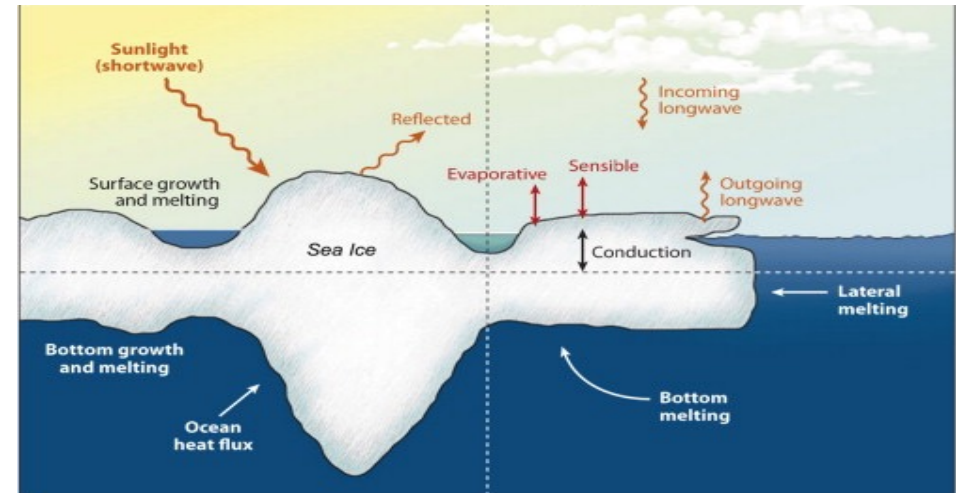
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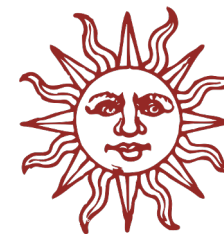


F_{prod} = net growth – melt
(> 0 means thickening)

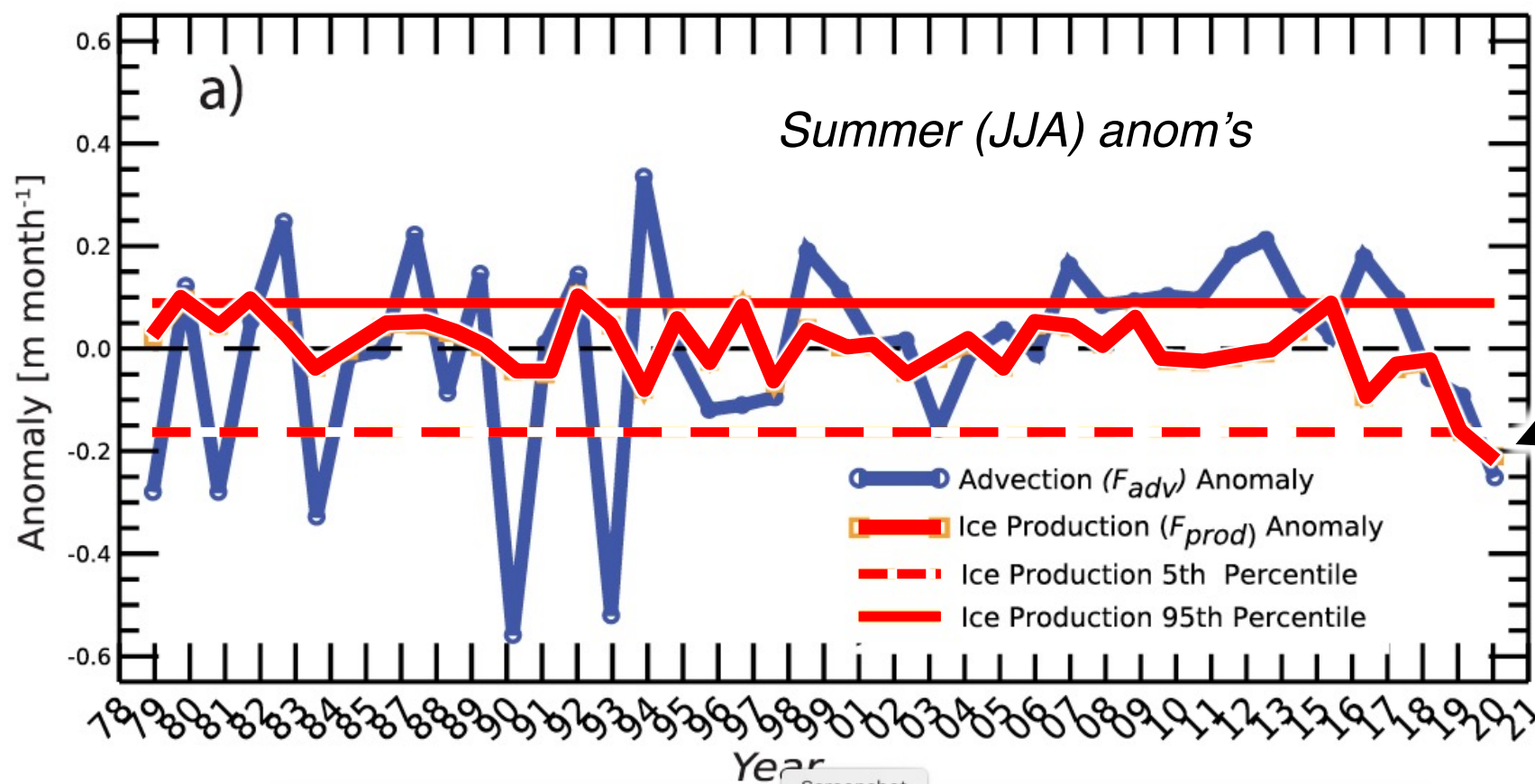




Dynamics vs Thermodynamics



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

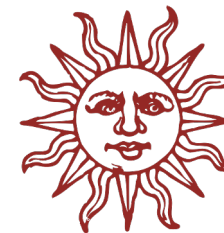


Summer 2020:

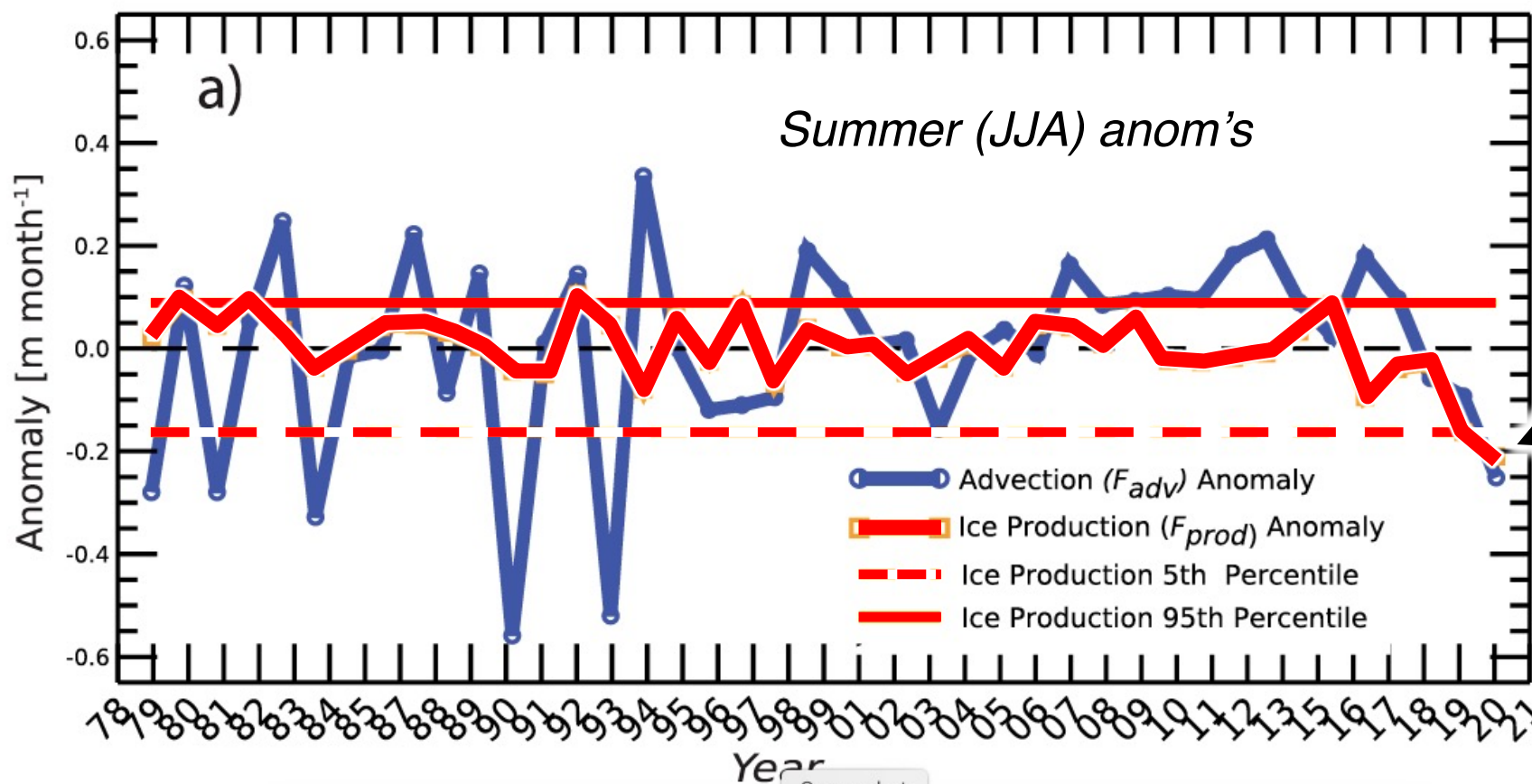
- Large **divergence**
- Large net **melt**



Dynamics vs Thermodynamics



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



Summer 2020:

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

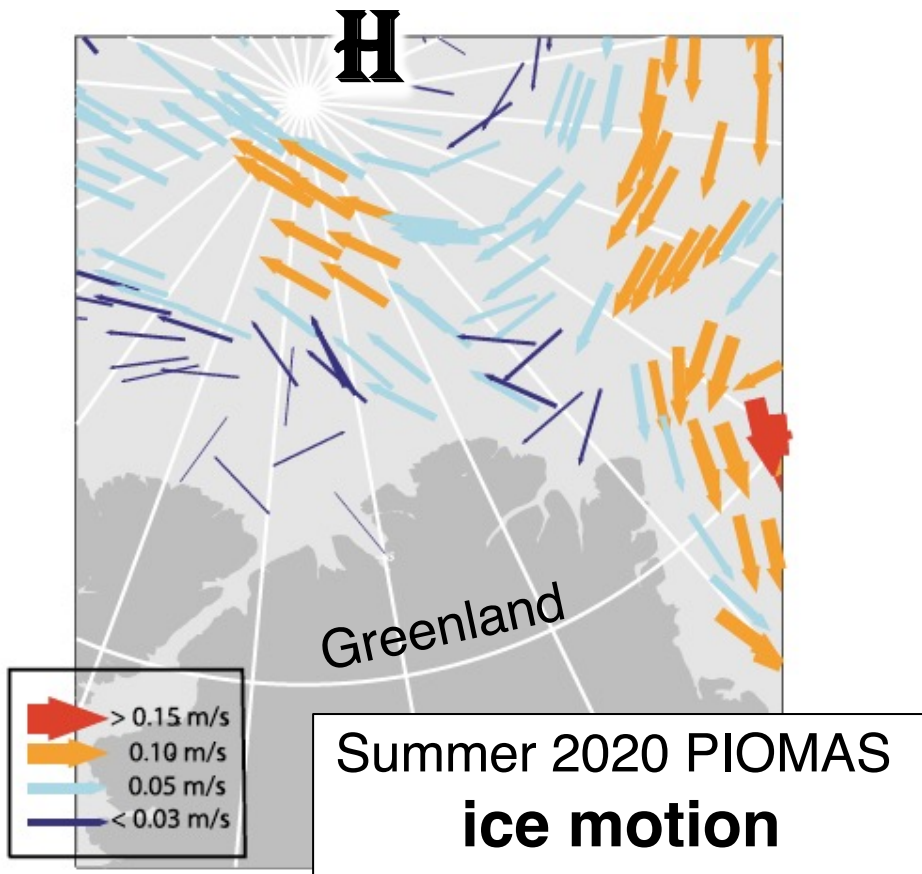
It's both!

more details...



Dynamics vs Thermodynamics

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



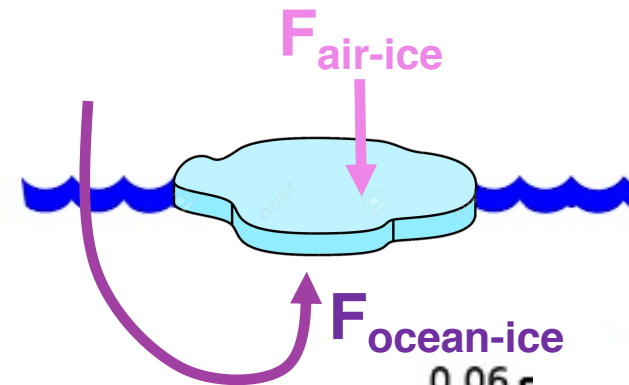
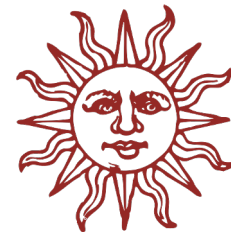
Summer 2020 PIOMAS
ice motion

Big, strong high pressure cell
→ “giant Beaufort Gyre”

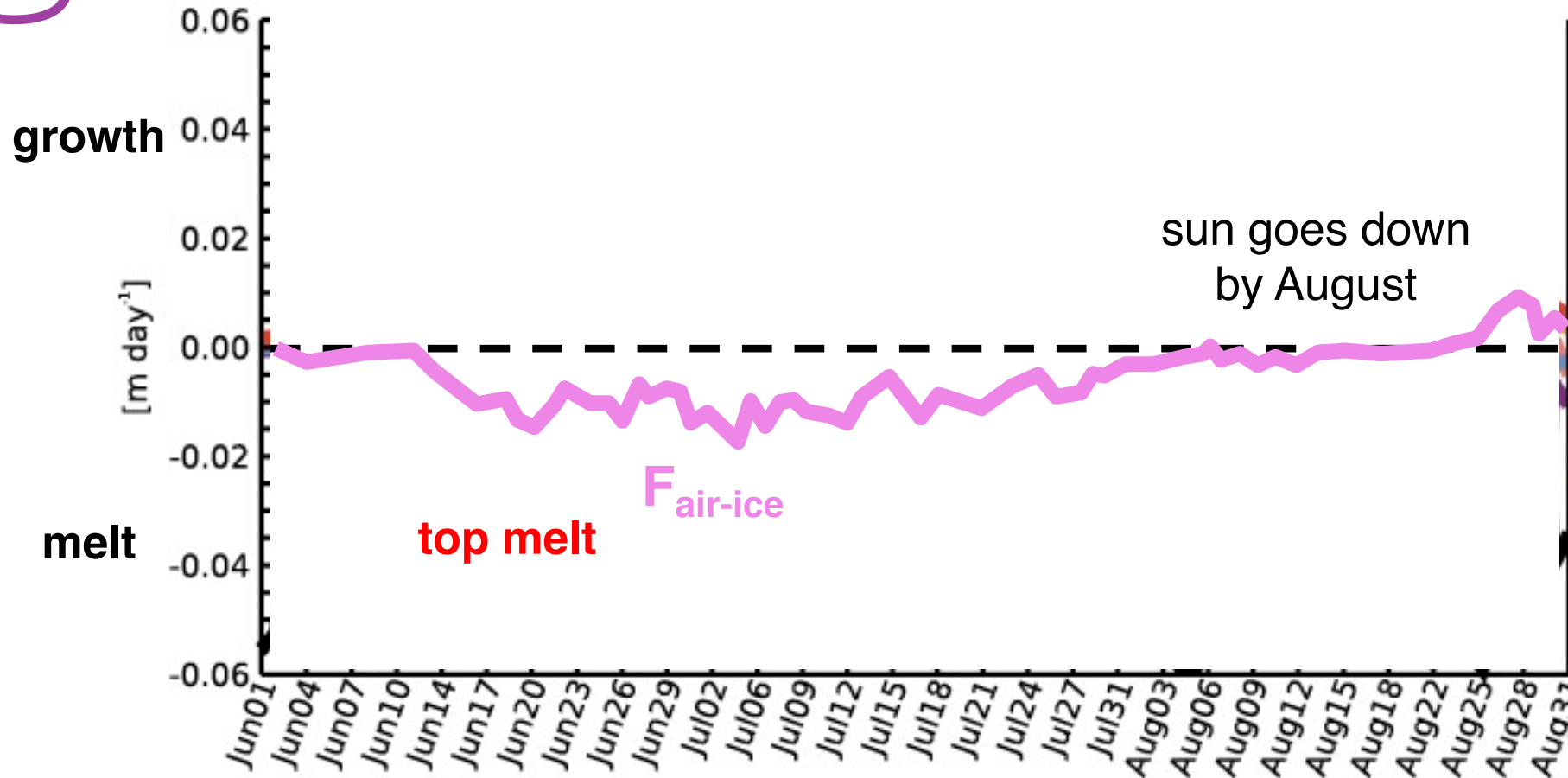
Mallett et al. (Nature Comm. Earth & Environ, 2021)
Moore et al. (Nature Comm. Earth & Environ., 2021)

Lots of divergence out of the Wandel Sea

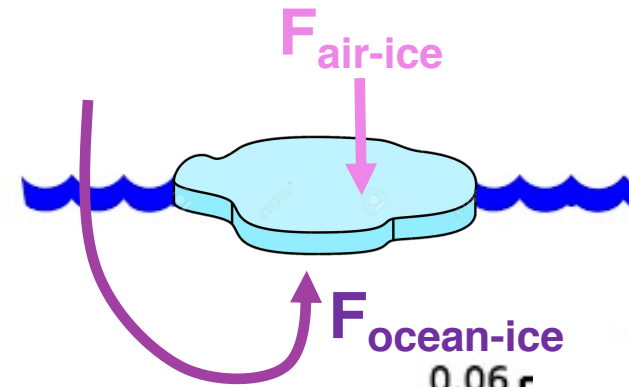
Dynamics vs Thermodynamics



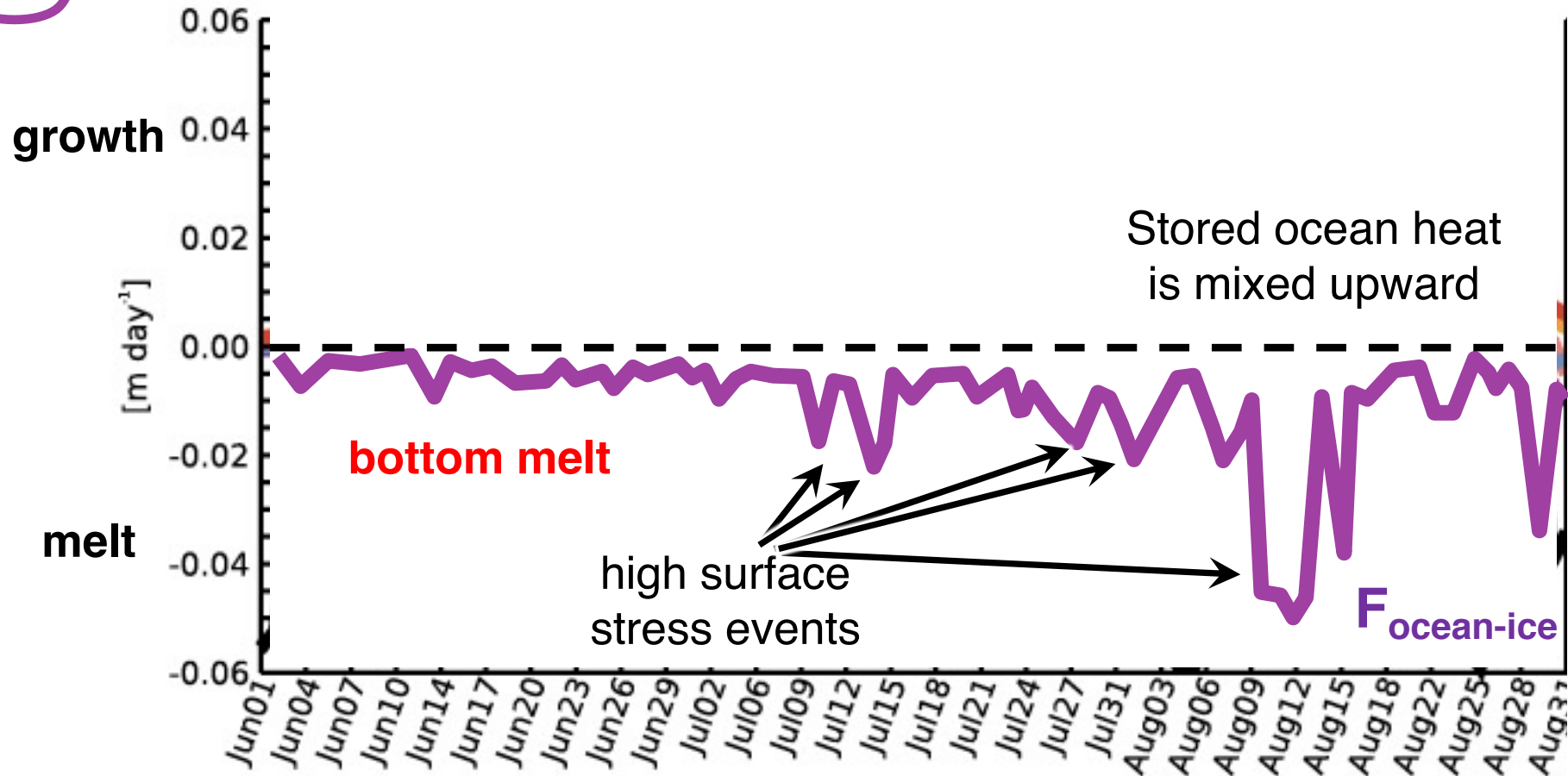
$$\Delta h_{\text{ice}} / \Delta t = F_{\text{adv}} + F_{\text{prod}}$$



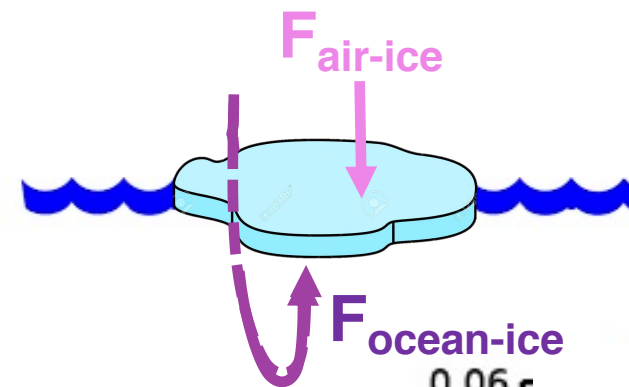
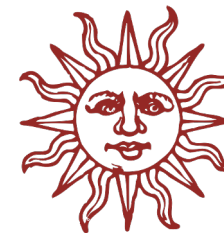
Dynamics vs Thermodynamics



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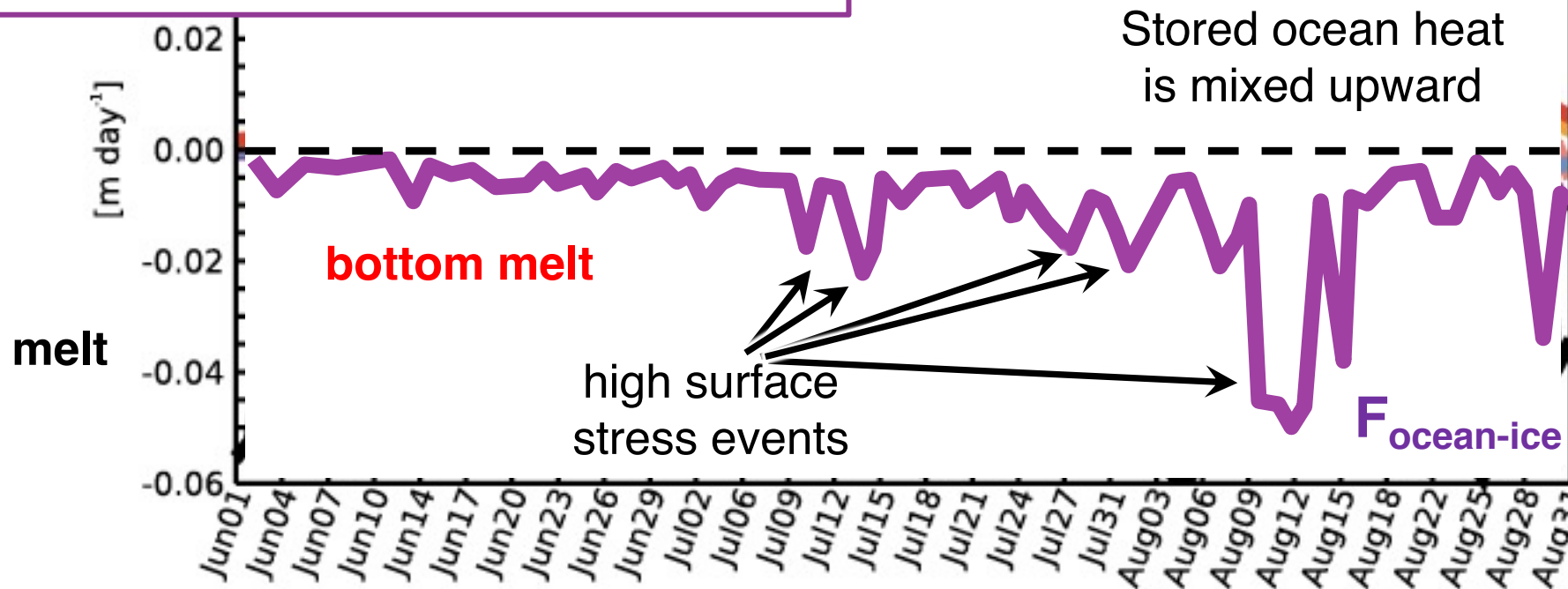


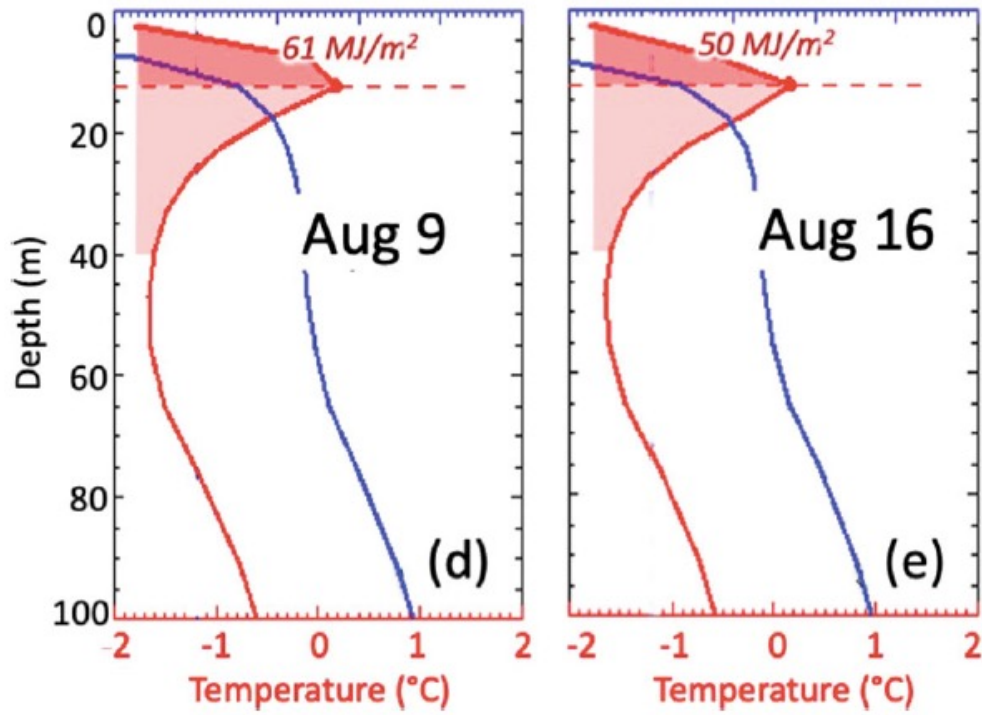
Dynamics vs Thermodynamics



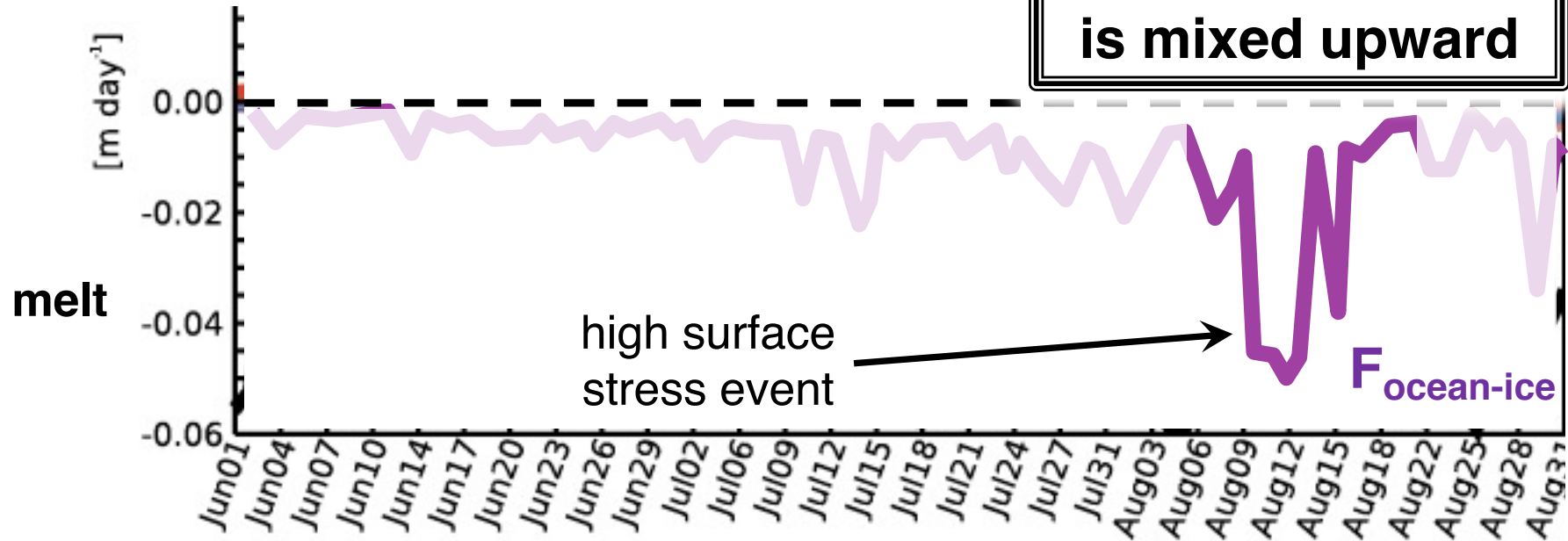
$$\Delta h_{\text{ice}} / \Delta t = F_{\text{adv}} + F_{\text{prod}}$$

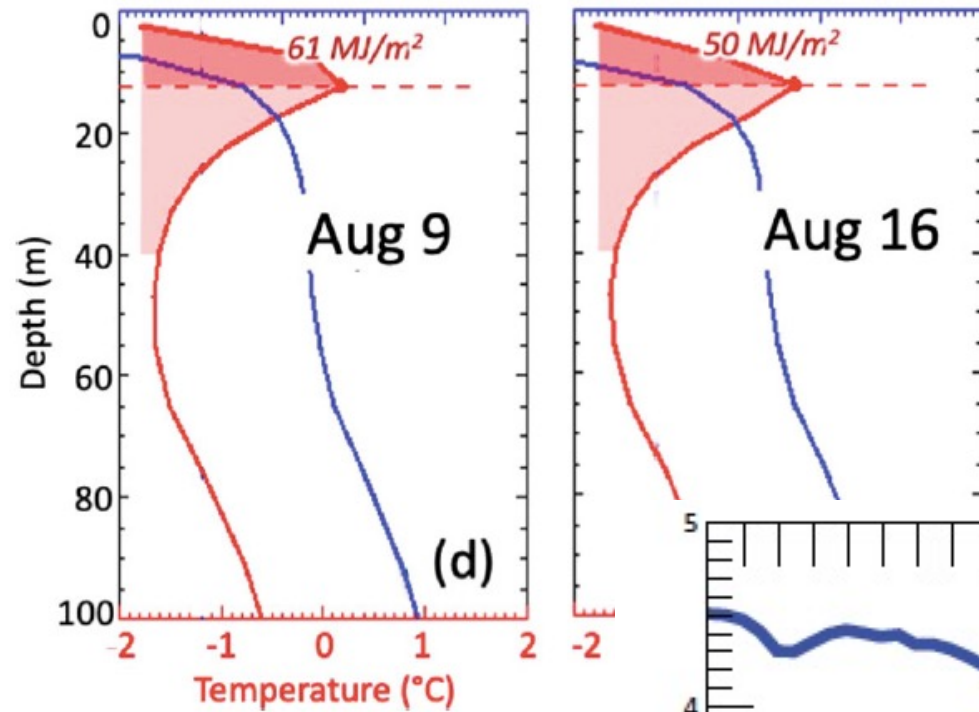
More thin ice in recent years



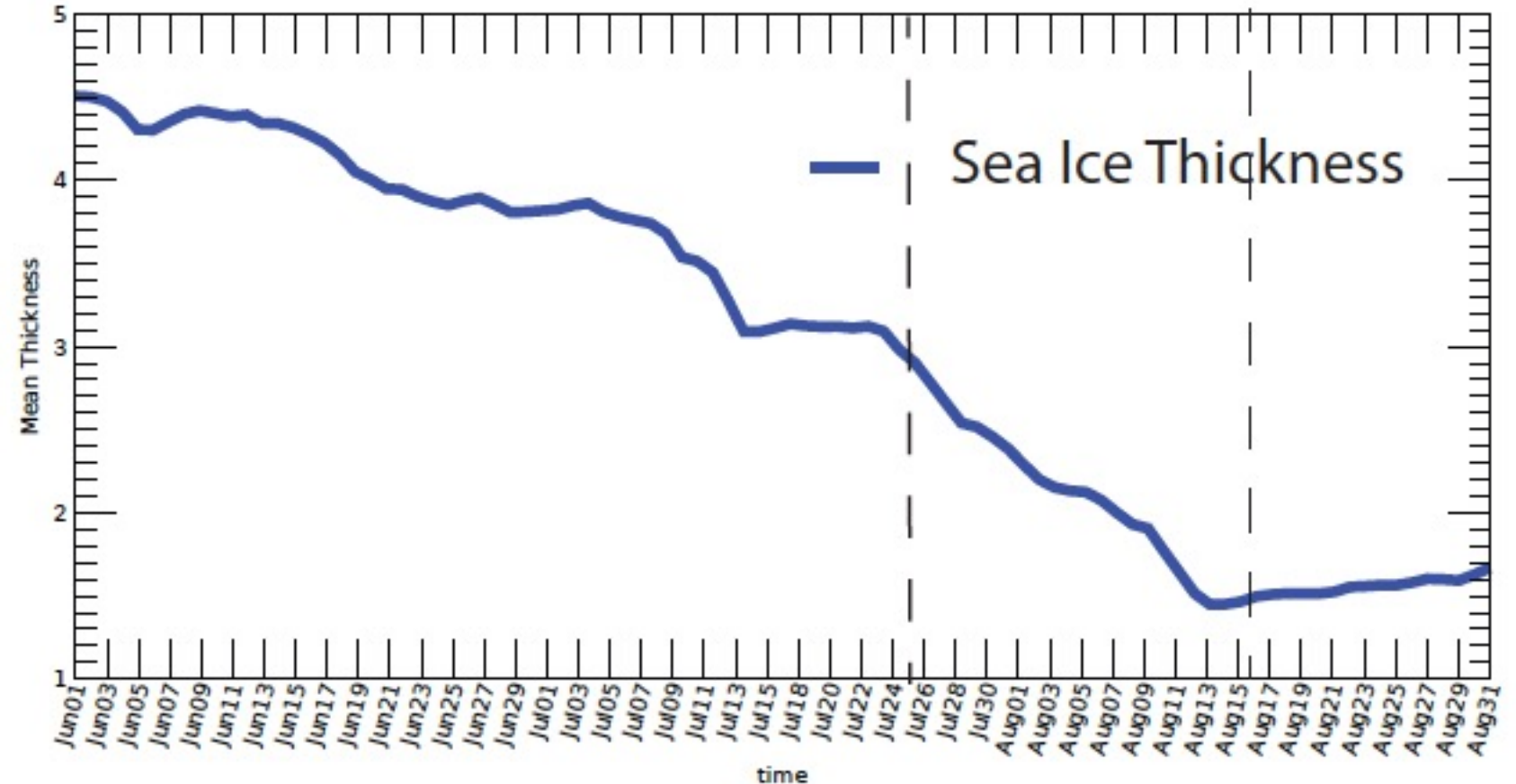


Decrease in subsurface ocean heat
(NSTM = Near-Surface Temp. Max.)





Subsurface ocean heat
→ ice melt

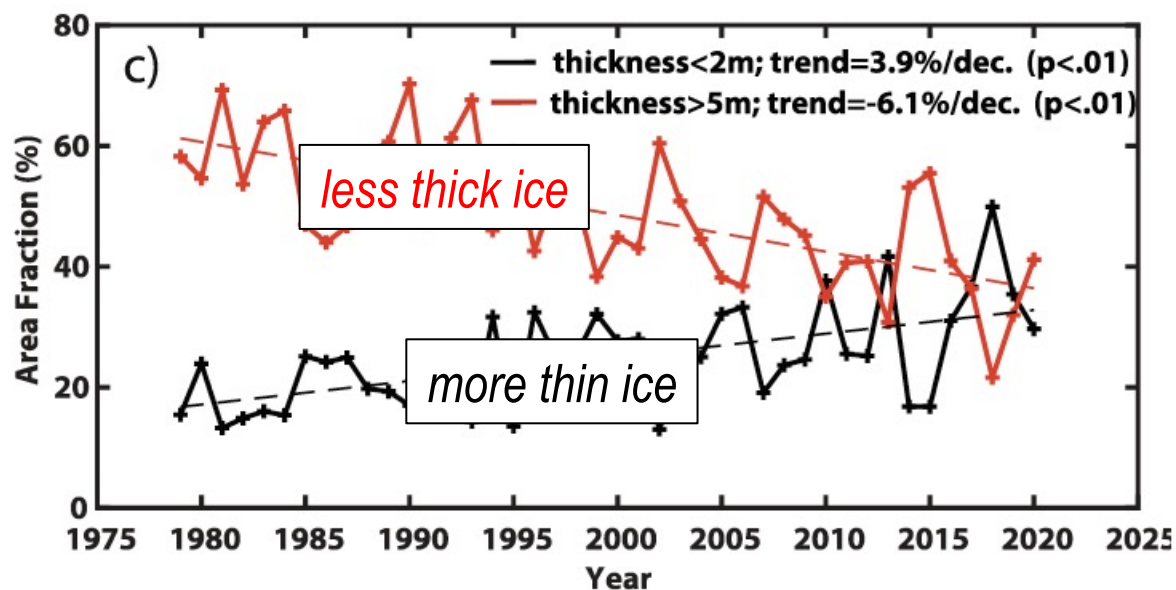


Let's play with the model!



What would have happened if...

Summer 2020 started with
ice-ocean conditions
from another year?

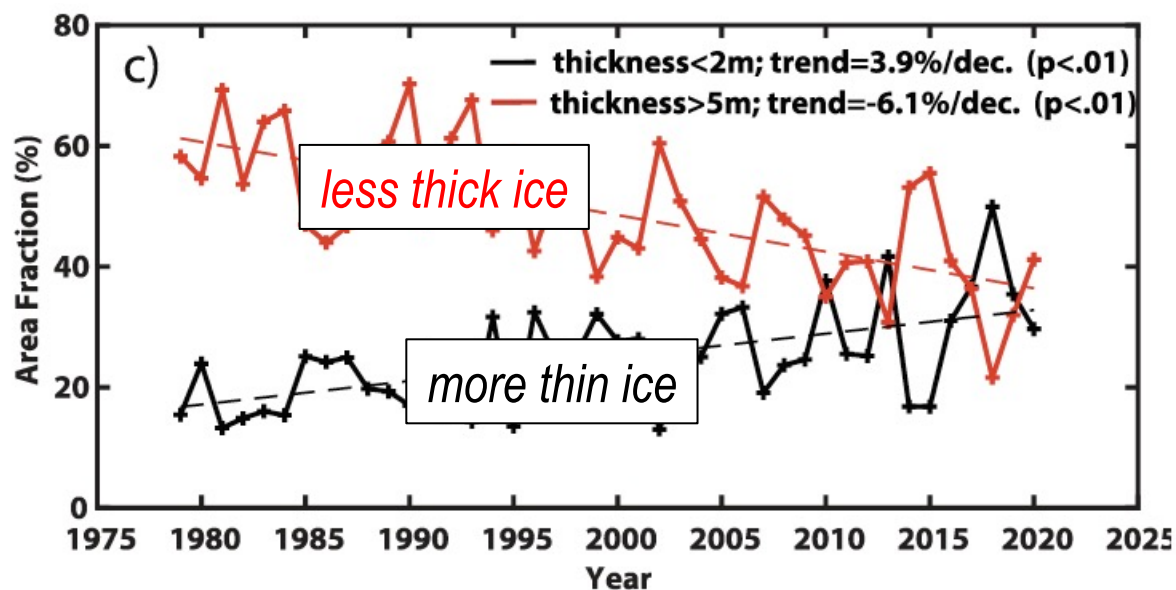


“The role of **long-term ice thinning**”

What would have happened if...

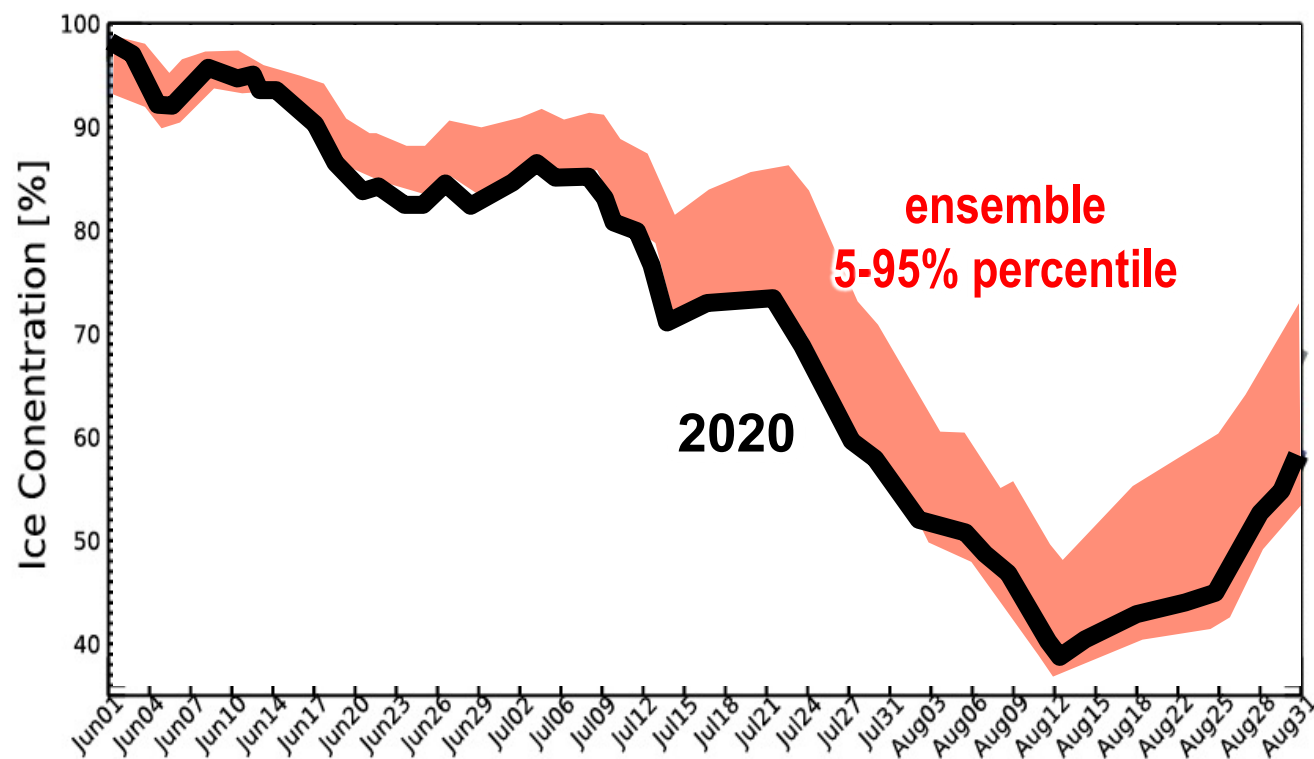
Summer 2020 started with
ice-ocean conditions
from another year?

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



“The role of **long-term ice thinning**”

The role of June 1, 2020 ice-ocean conditions

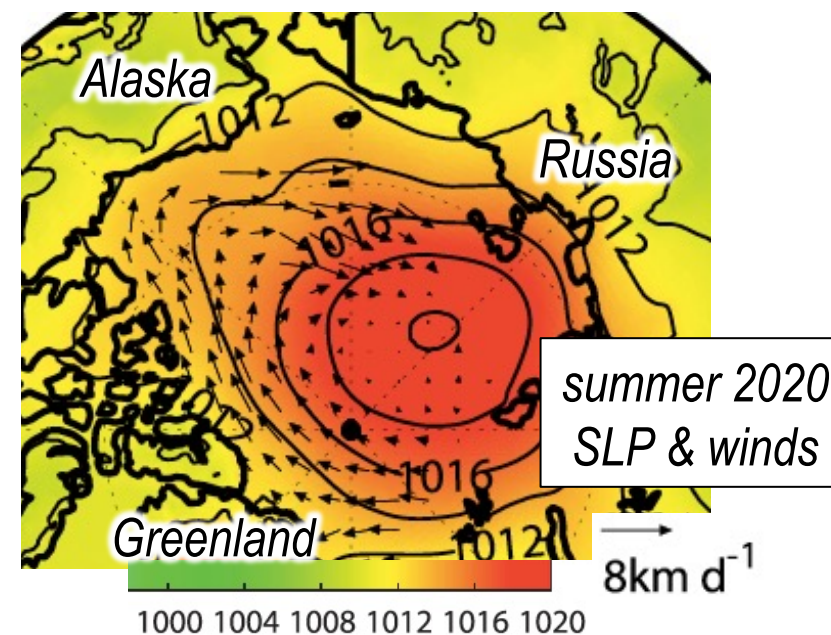


Run the model
starting with ice-ocean conditions
from June 1, 1979, 1980, ... 2019
(using 2020 atmos. forcing)

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

What would have happened if...

Summer 2020 had
atmospheric forcing
from another year?

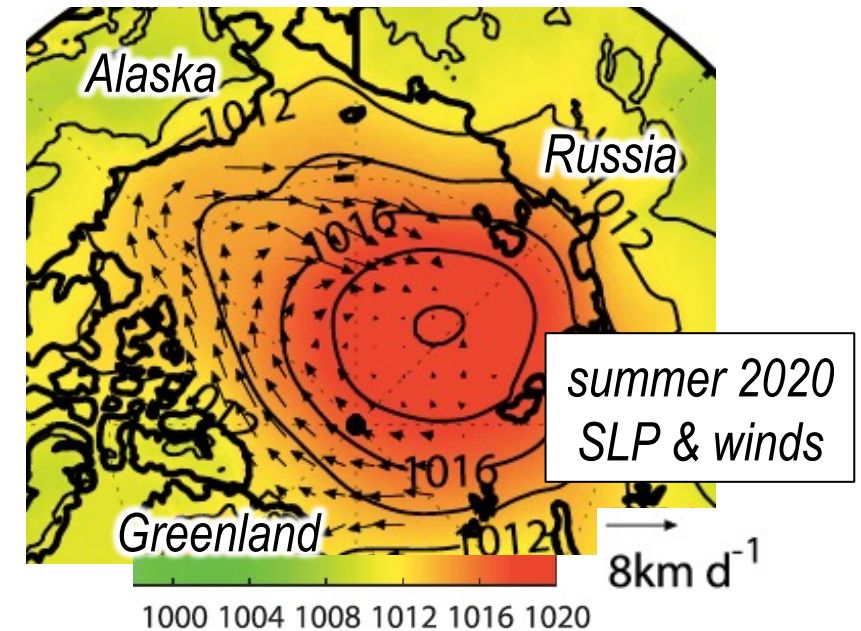


“The role of **atmos. forcing** in 2020”

What would have happened if...

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

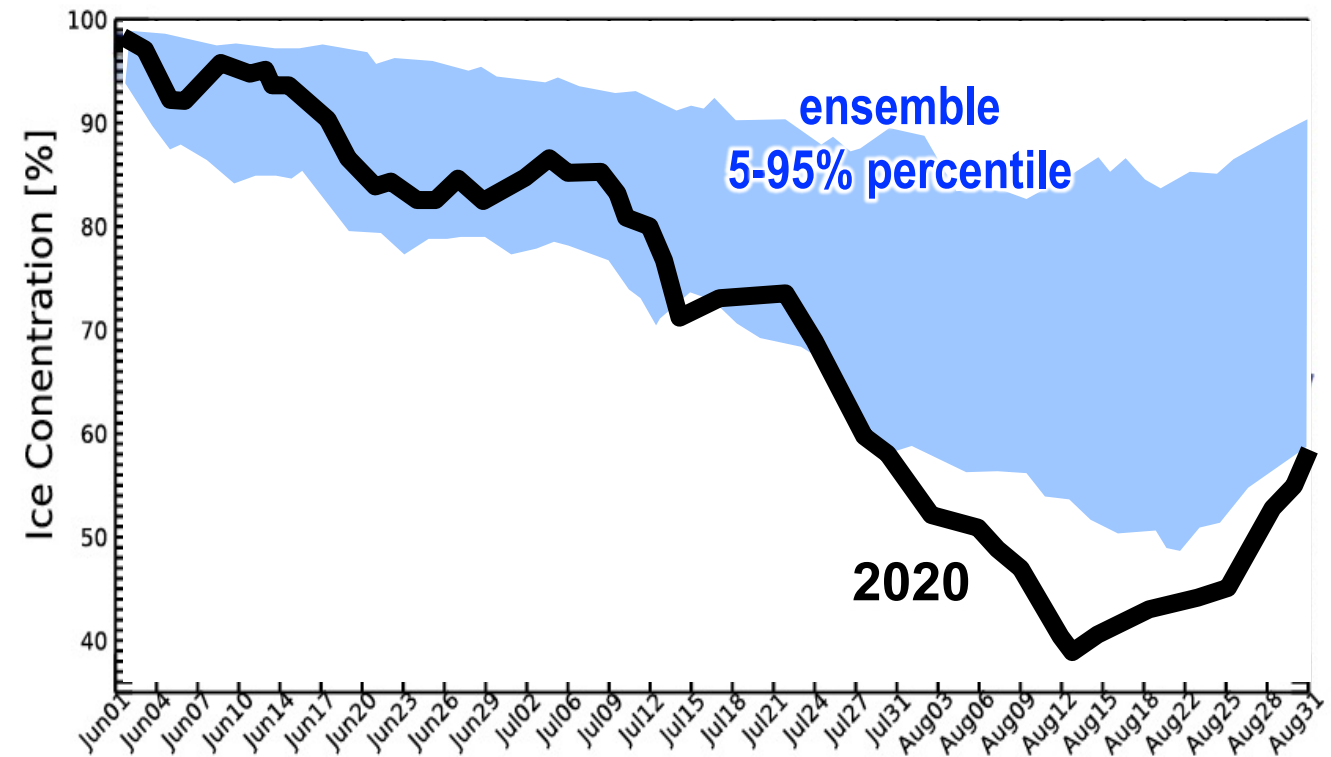
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“The role of **atmos. forcing** in 2020”

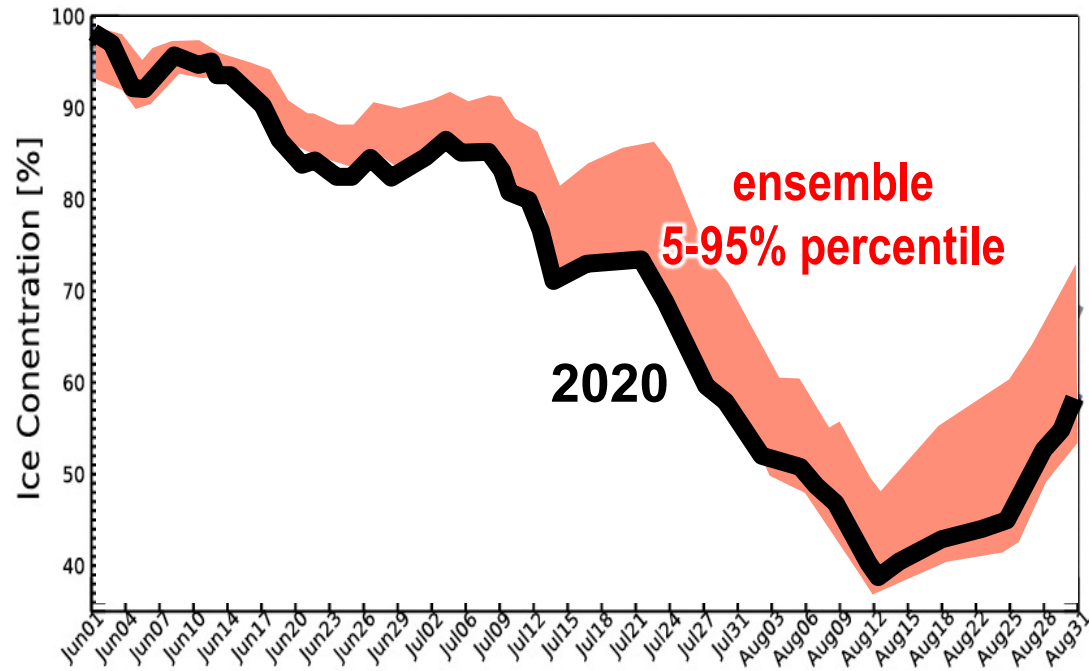
The role of summer 2020 atmos. forcing

Run the model
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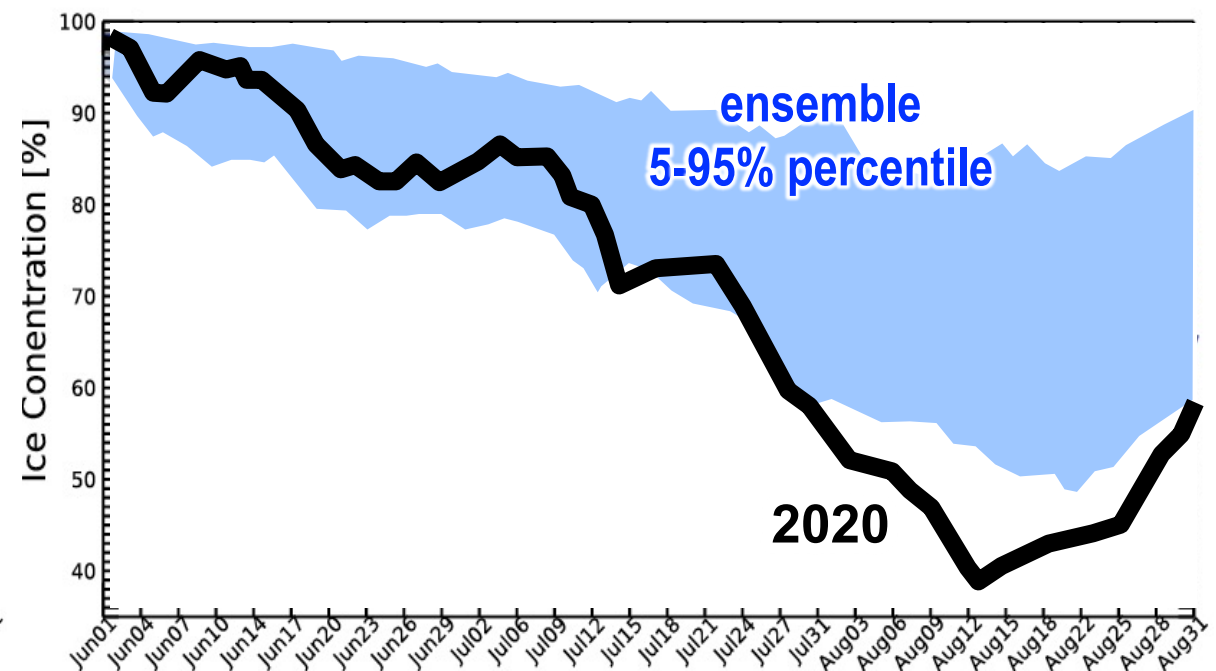


- **SIC decrease mostly in late summer**

June 1 conditions vs. summer atmos. forcing



Early summer SIC decrease



Late summer SIC decrease

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

Other stuff

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

- Why aren't models reproducing low SIC here?

- *Transient* benefit to marine mammals?

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



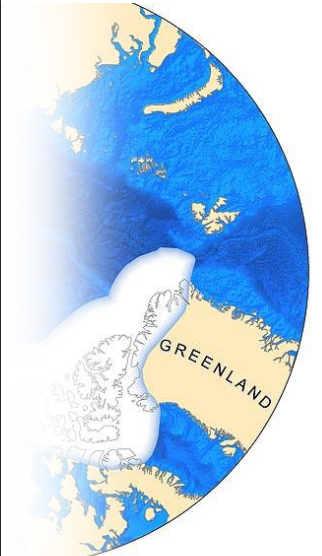
World Wildlife Fund



Other stuff

- Low SIC likely to happen again under strong wind forcing through

Thank you



- Why
- *Transient benefit to marine mammals? (thick, compact ice → more productive thinner, looser ice → no summer ice)* Wildlife Fund

