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Recent upper Arctic Ocean warming expedited by summertime atmospheric processes

Michael Steele *& real meteorologists*
Polar Science Center, Applied Physics Lab, University of Washington
Seattle, WA USA

Zhe Li
UCSB, Santa Barbara, CA

& Q. Ding (UCSB), A. Schweiger (UW)

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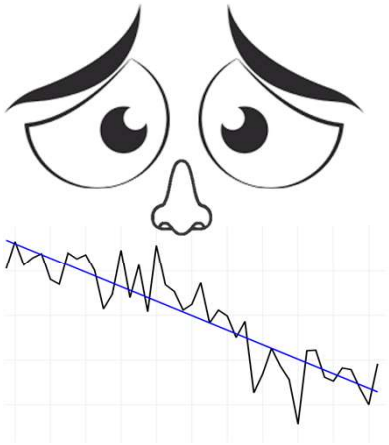
Ice Retreat



Sept. Arctic Sea Ice Extent
(1979-2021, NSIDC)

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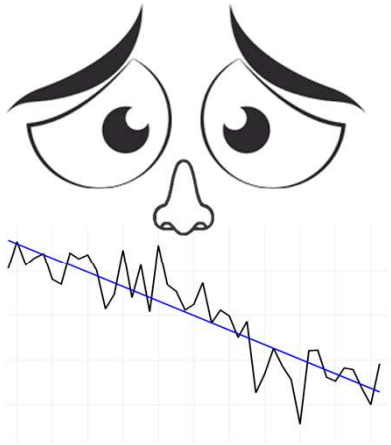

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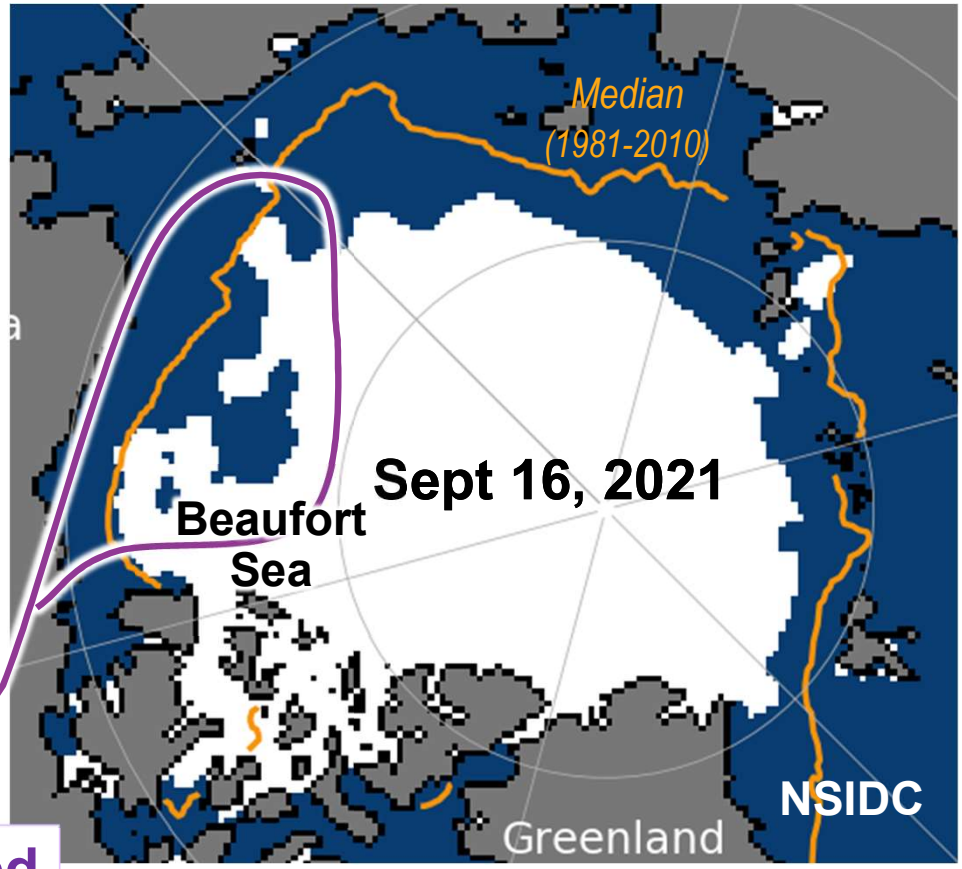

Complicated 2D geometry

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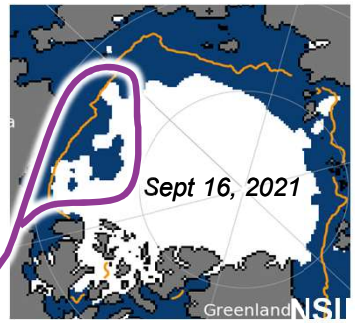
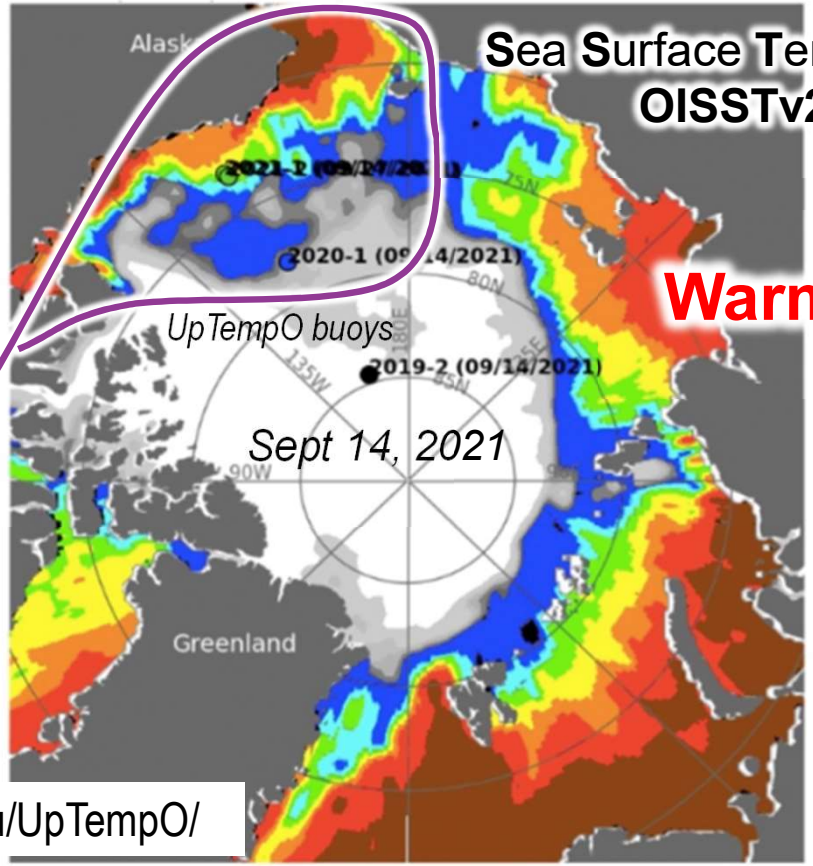
Ocean surface warming

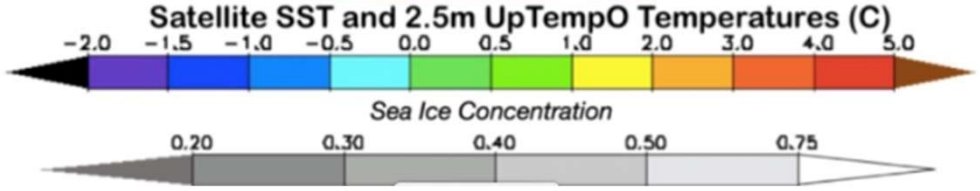


Complicated geometry

Complicated SST!



http://psc.apl.washington.edu/UpTempO/



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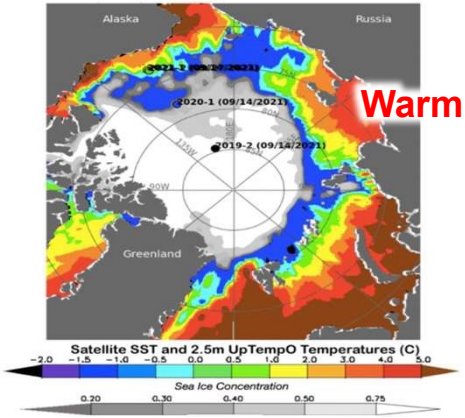

Warm

Physics?

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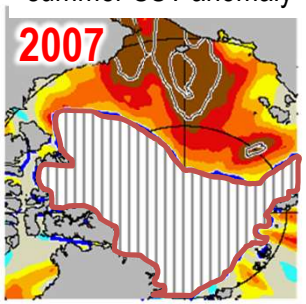
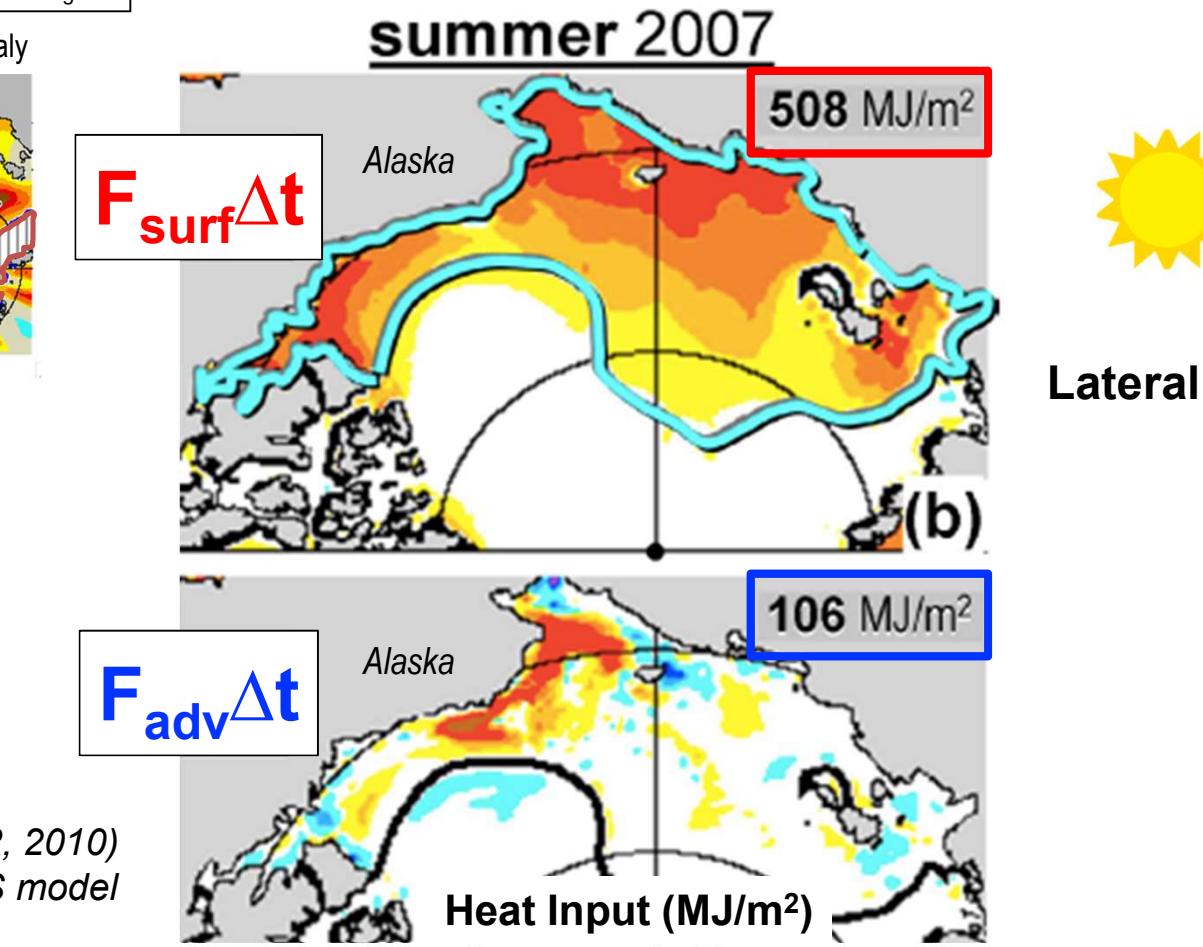
summer SST anomaly





Atmos heating ~ 5 x

Lateral ocean heat flux convergence

Steele et al. (JGR, 2010)
- *using PIOMAS model*

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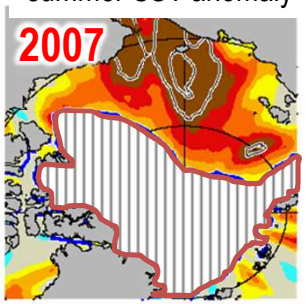
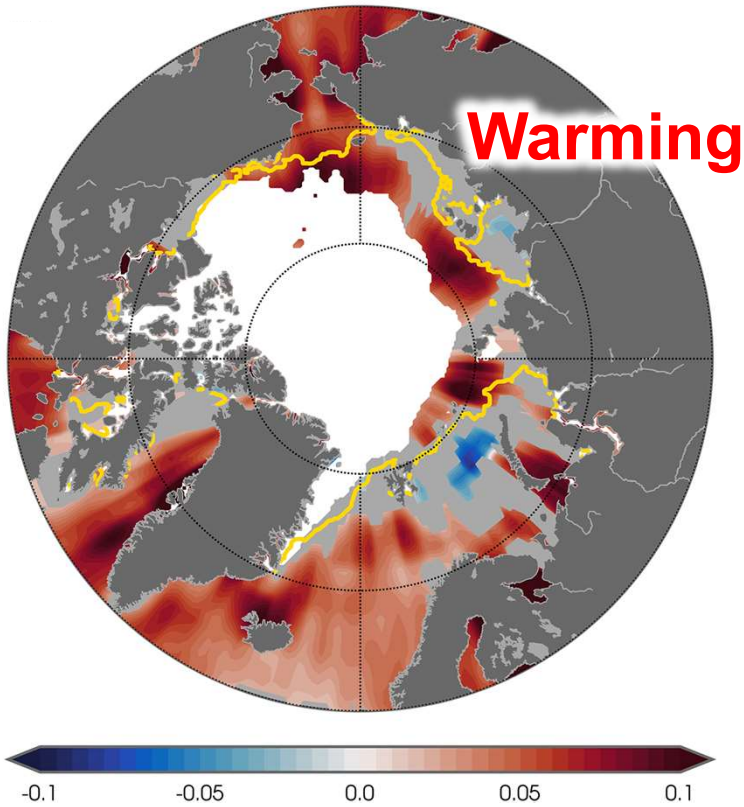
summer SST anomaly



Recently?



1982-2020 August linear OISST trend (°C/yr)

Timmermans & Labe (NOAA, 2020)

40 years x 0.05-0.1°C/yr
=
2-4°C

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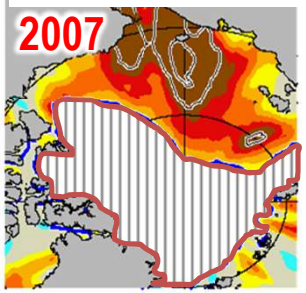
summer SST anomaly



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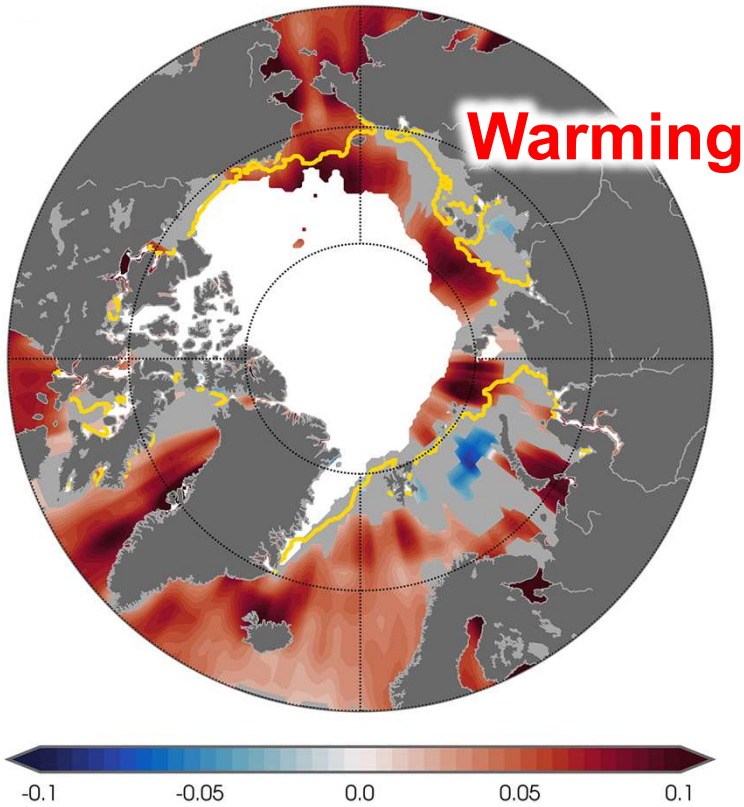

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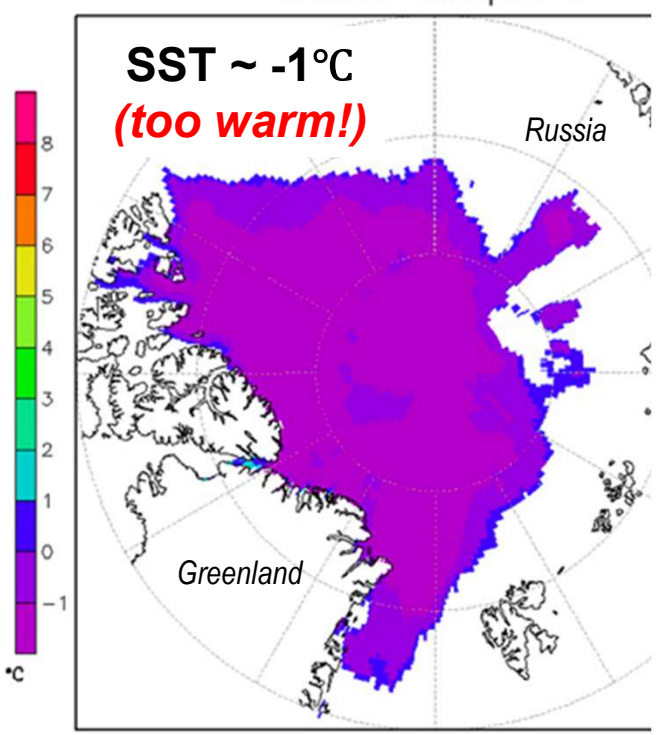
(NOAA/**OISST**)

25 km global, gridded SST 1981-present



Banzon et al. (J Tech, 2020)
Huang et al. (J Climate, 2021)

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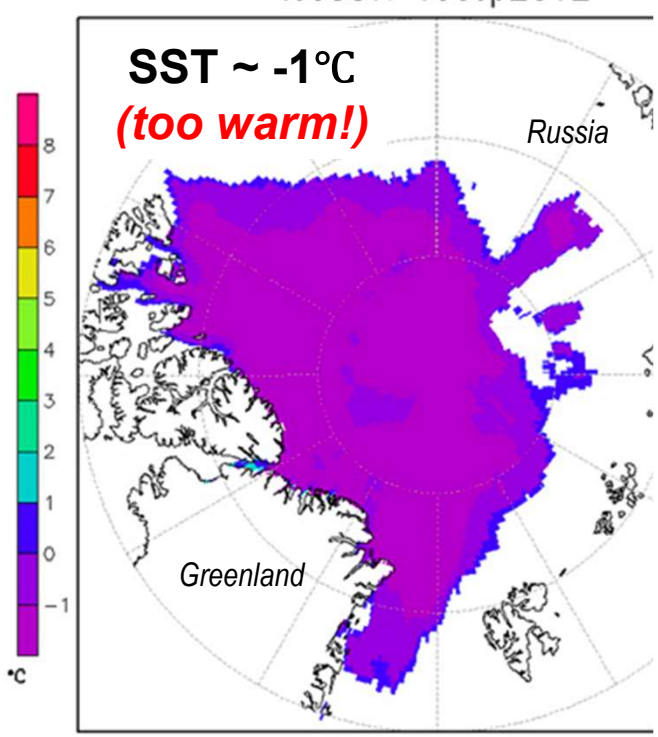

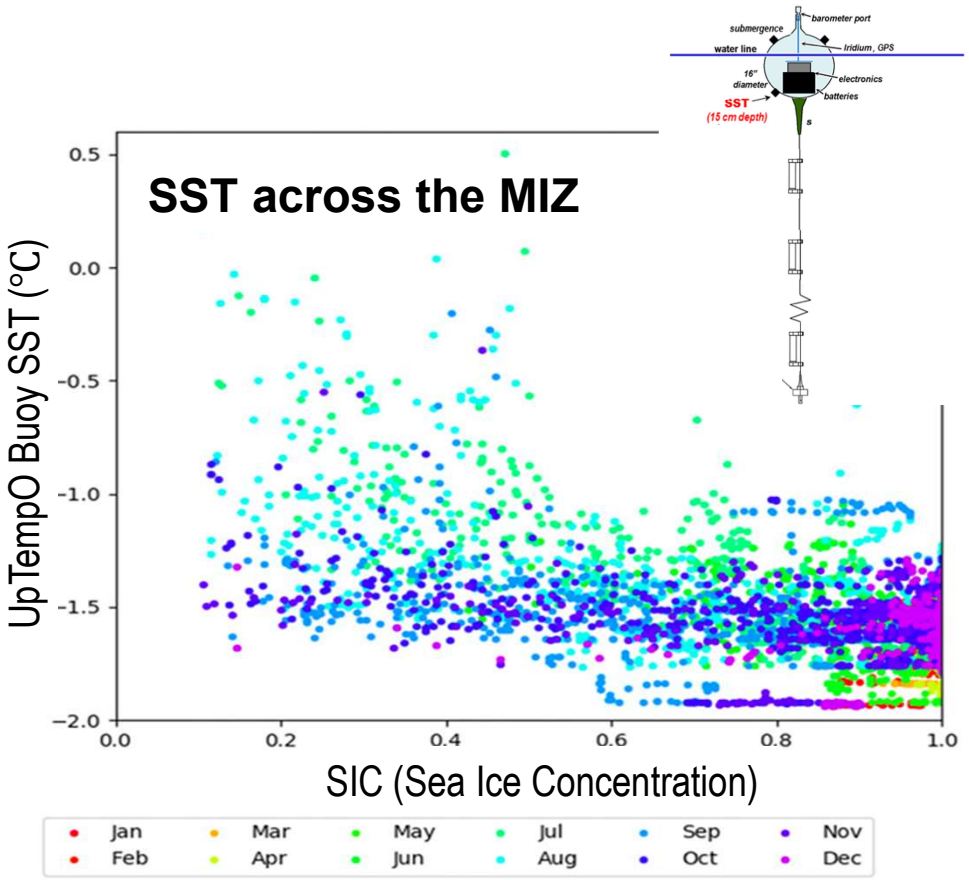

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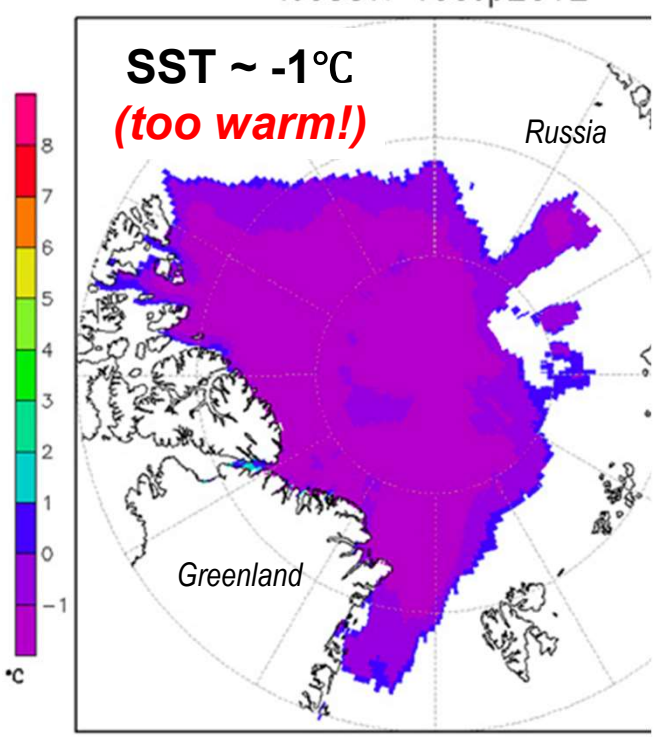

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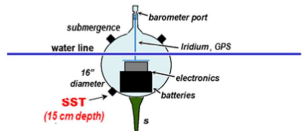

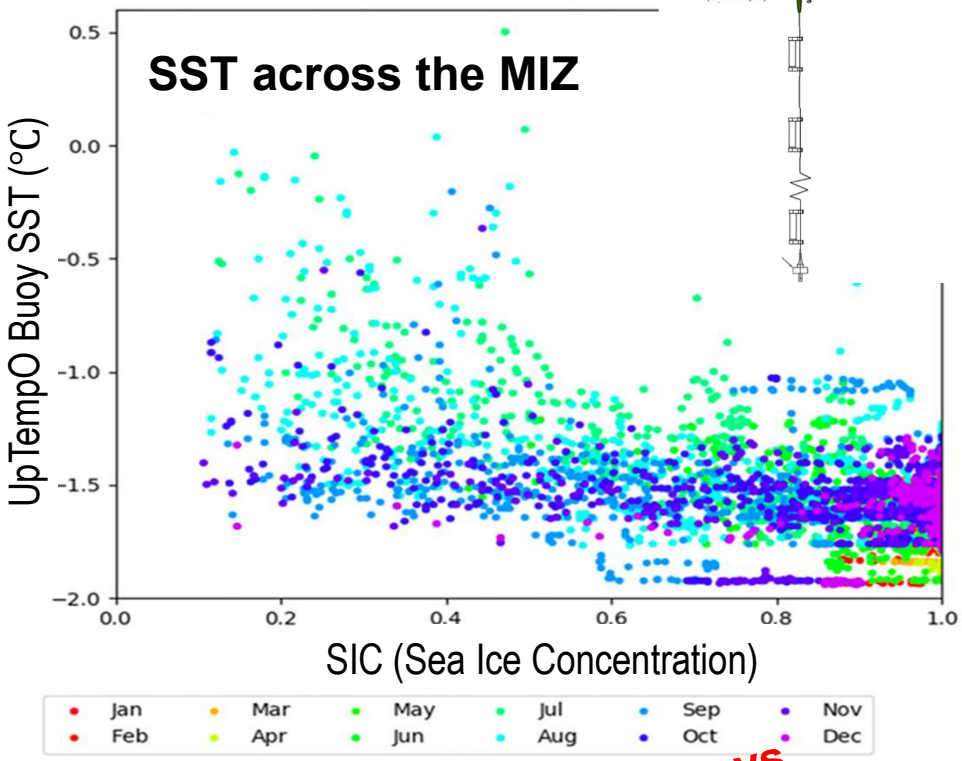

UpTempO buoys

OISST**v2.1**:

- SST = T_f + **c***SIC
- T_f (climo SSS)

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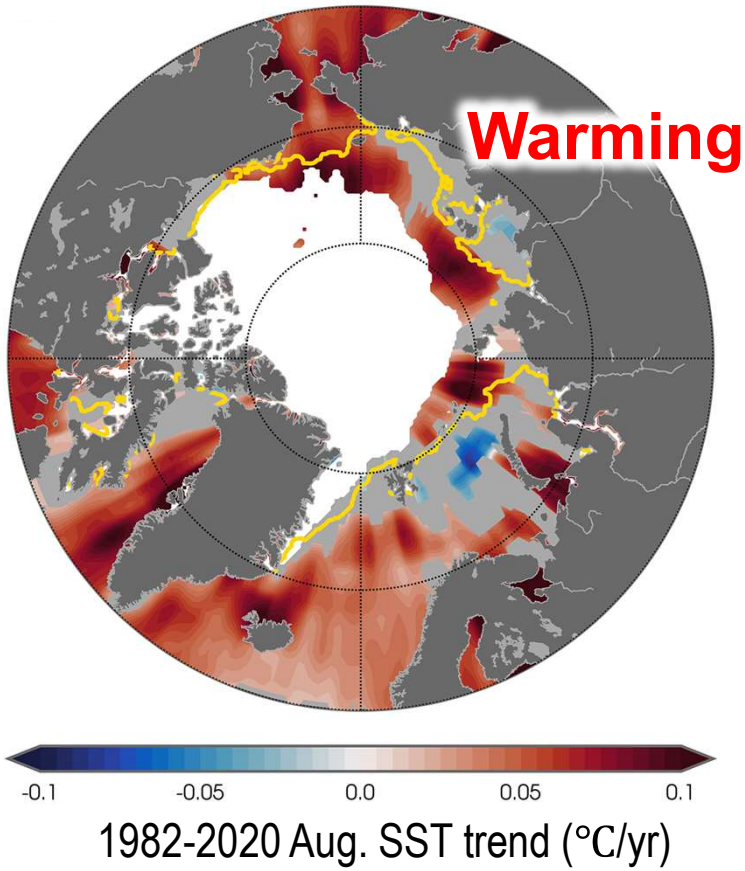
How much of this is due to:

- **Global warming vs.**
- **Internal climate variability?**



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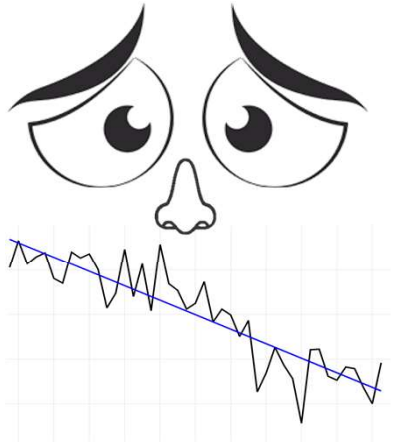
Background Question:

How much **Arctic sea ice loss** is due to:

Global warming vs. internal climate variability?



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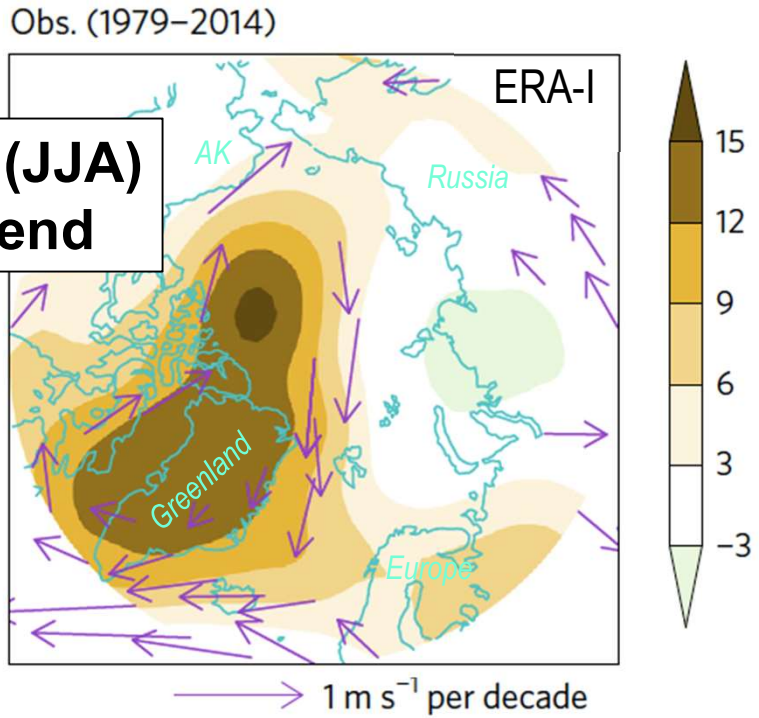
Atmos trends

Summer (JJA)
Z700 trend



☞ **Incr. high pressure & AC winds** ☜

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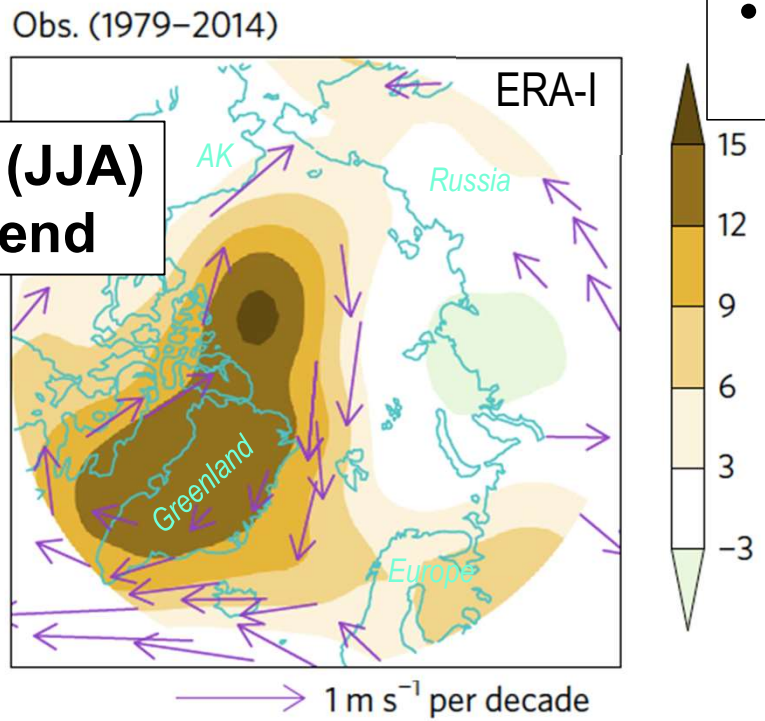

Atmos is:

- **Warmer** *(subsidence)*
- *Wetter/cloudier @ surface* **(incr. LW down)**

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Atmos trends

Internal climate variability
+
global warming

Summer (JJA)
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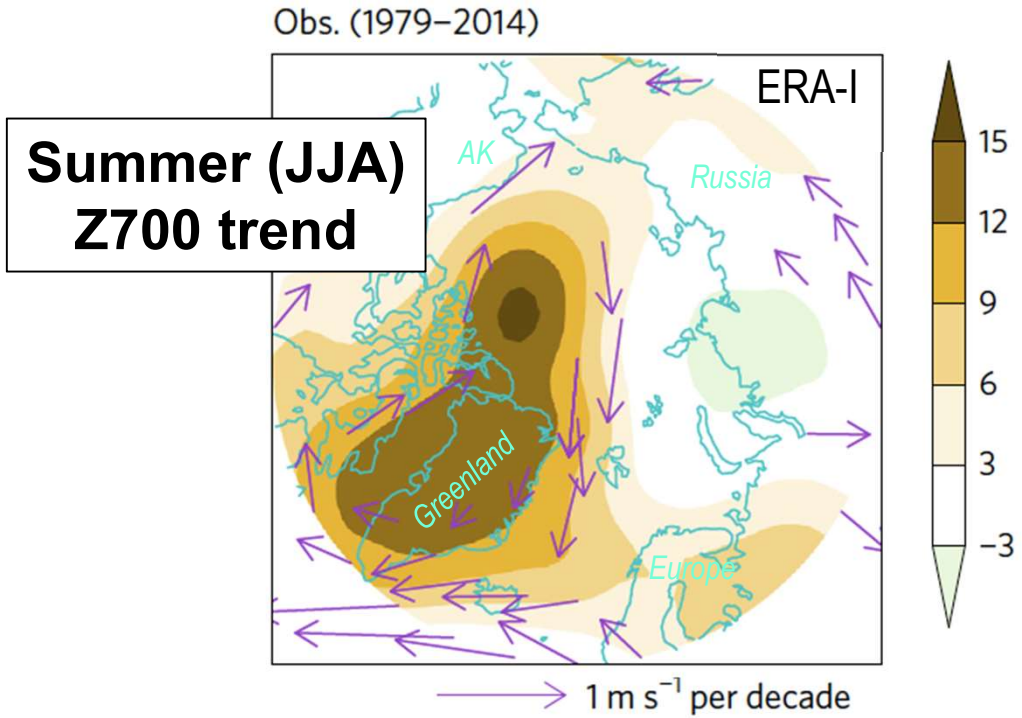

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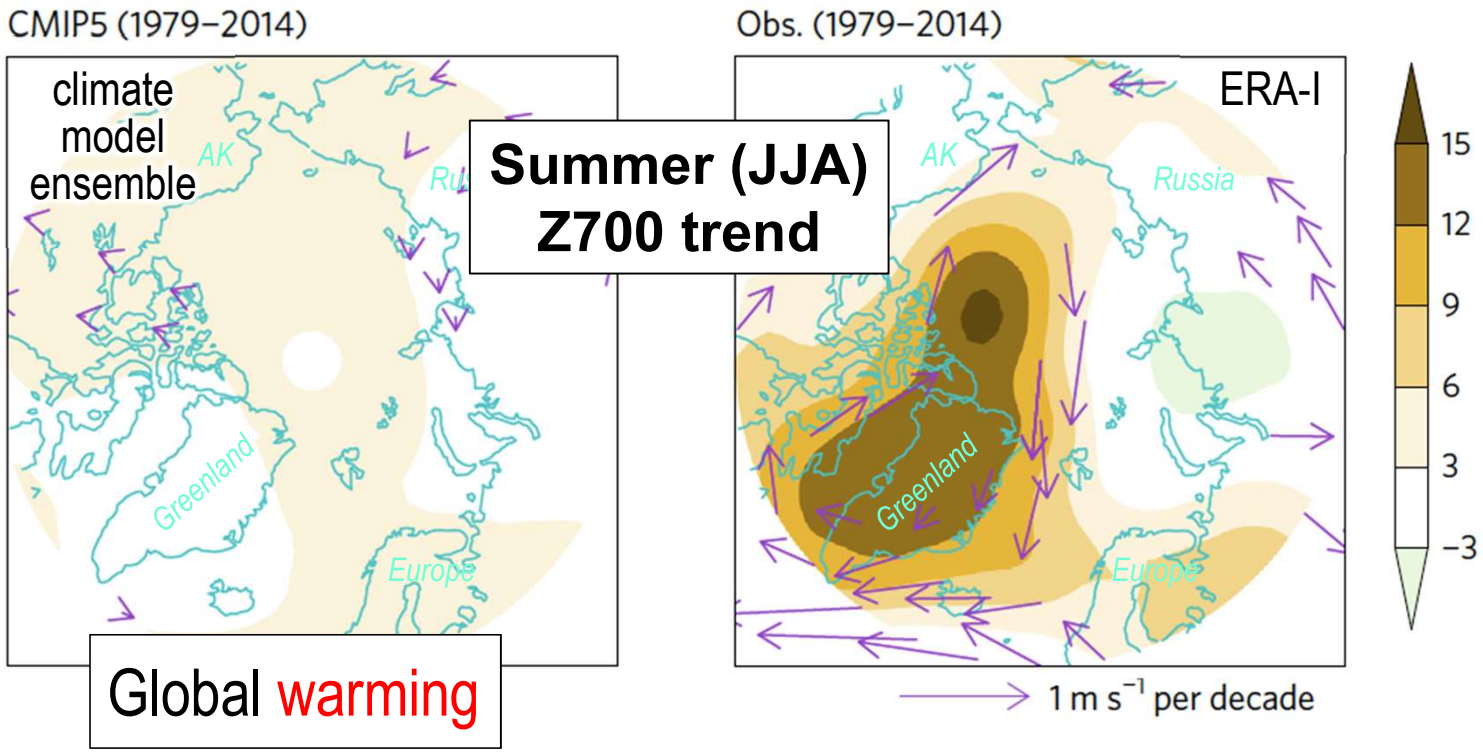

Summer (JJA) Z700 trend

Global warming

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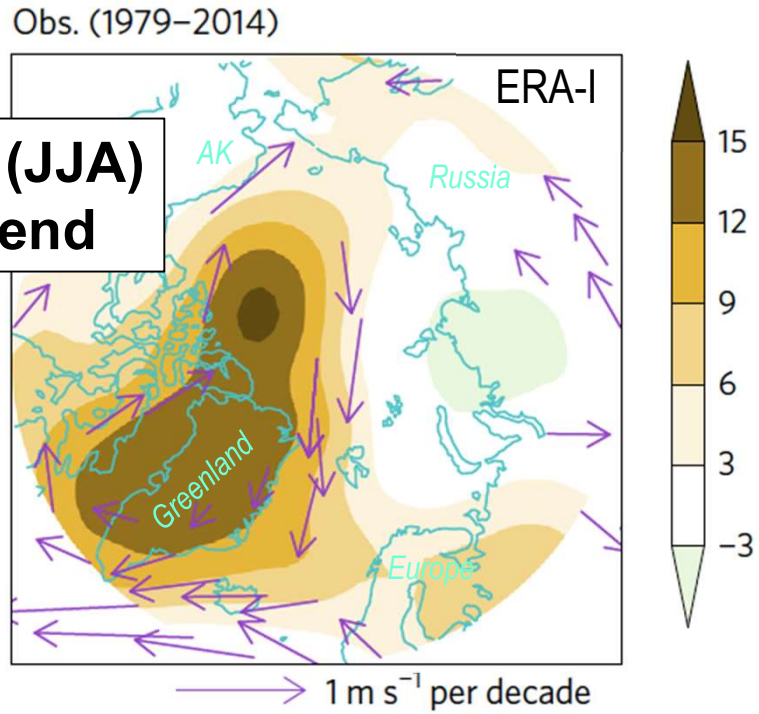

~ 40% of sea ice loss
is from internal climate variability

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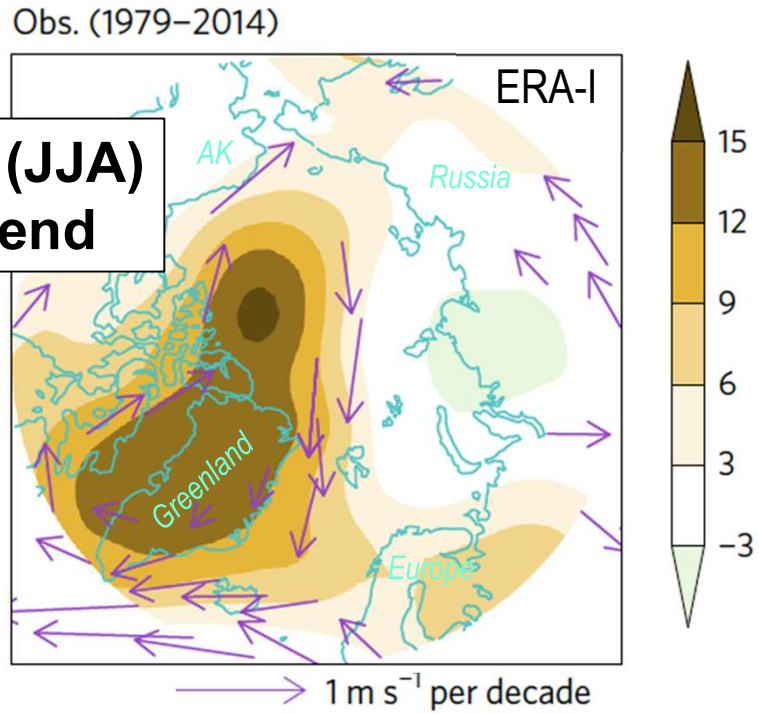
Z700 trend



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…ultimately forced by the tropical Pacific!

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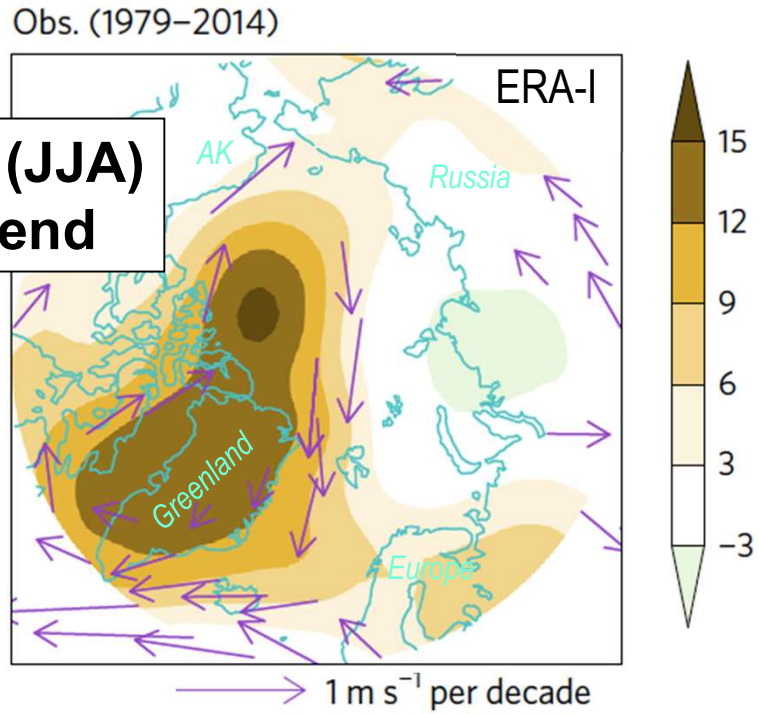

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➜ OK SO WHAT ABOUT SST?

☞ **Incr. high pressure & AC winds** ☜

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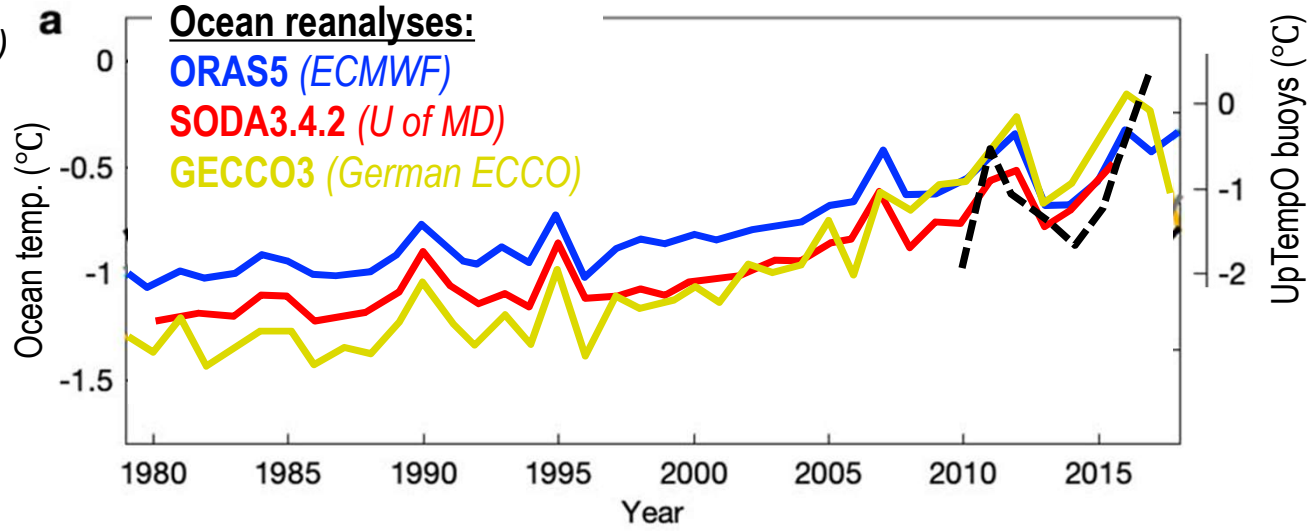
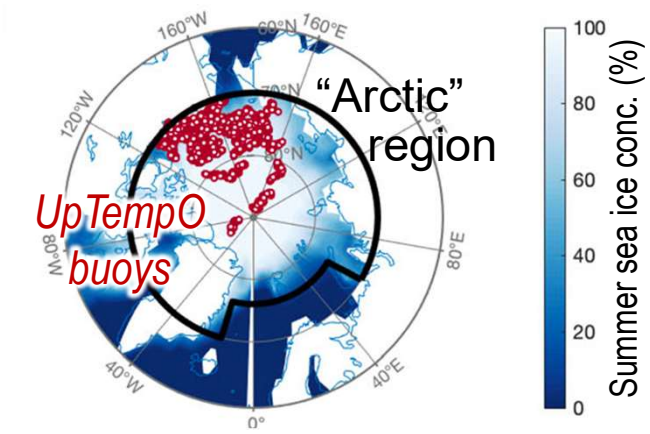
Upper Arctic Ocean warming (*0-50 m depth*)

Li et al.
(Nature Comm, 2017)





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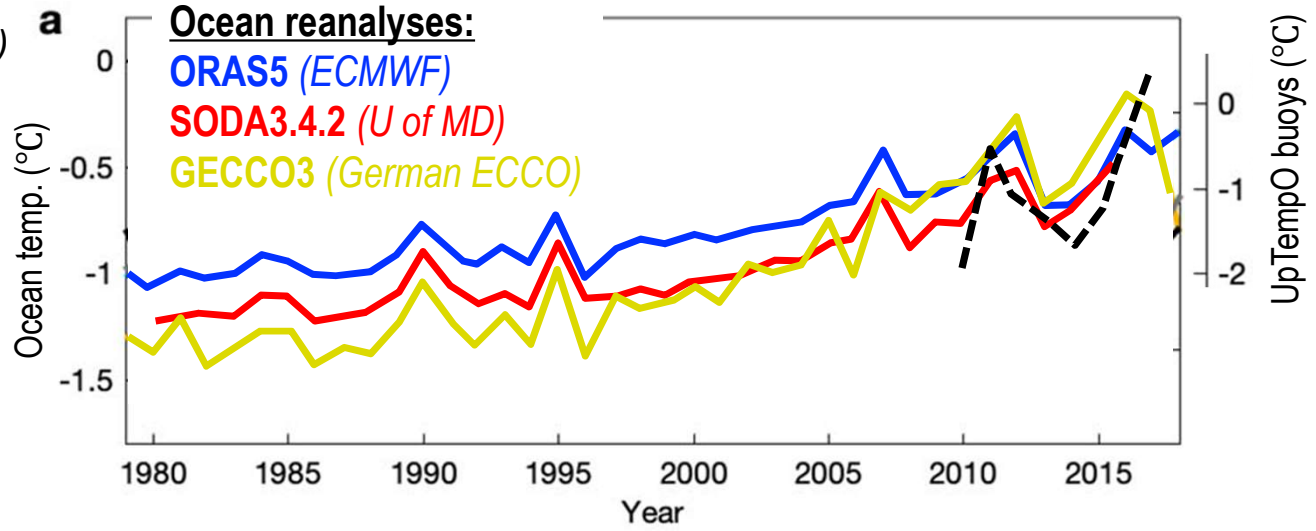

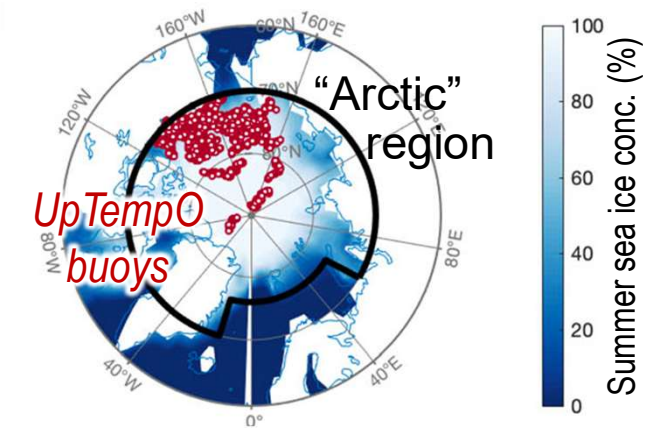

Meteorologists using **ocean reanalyses as "truth!"**

obs. oceanographer

Is this even bad?!

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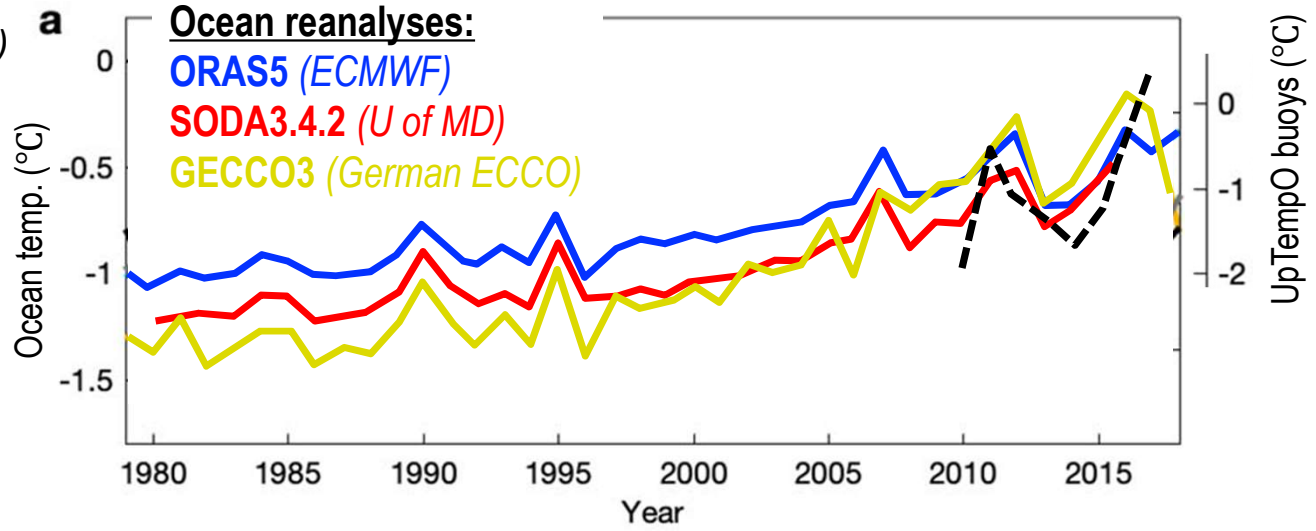

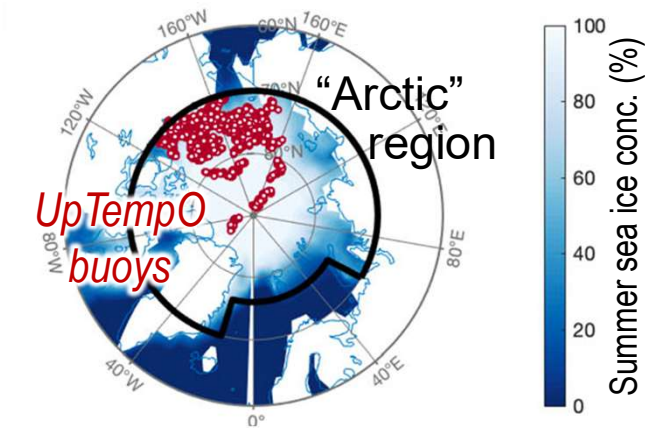

Sound familiar?!

Oceanographers using **atmos reanalyses as "truth!"**

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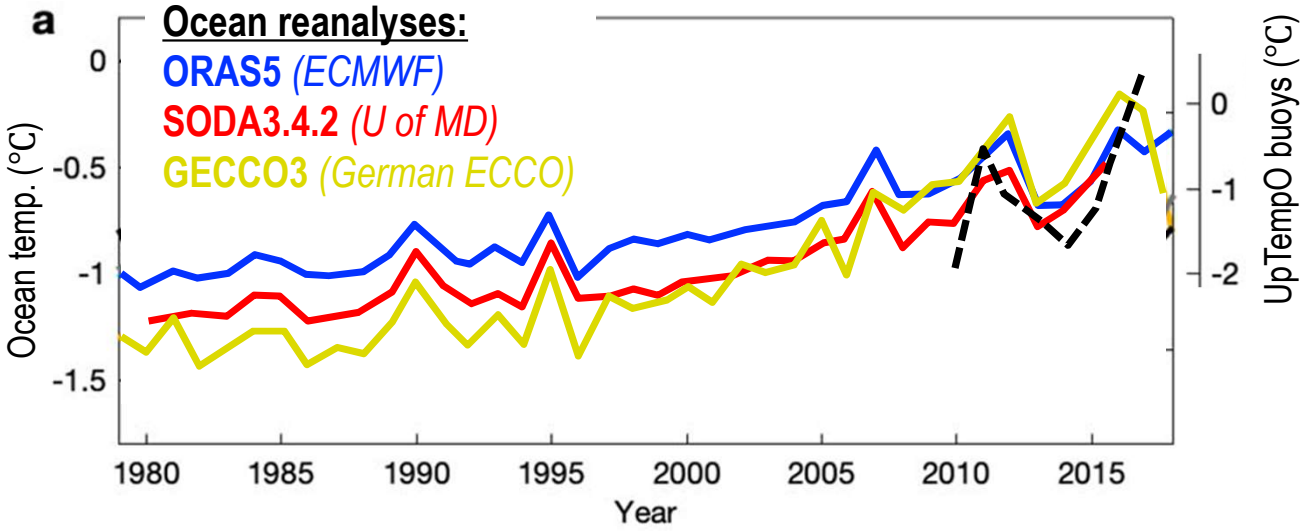
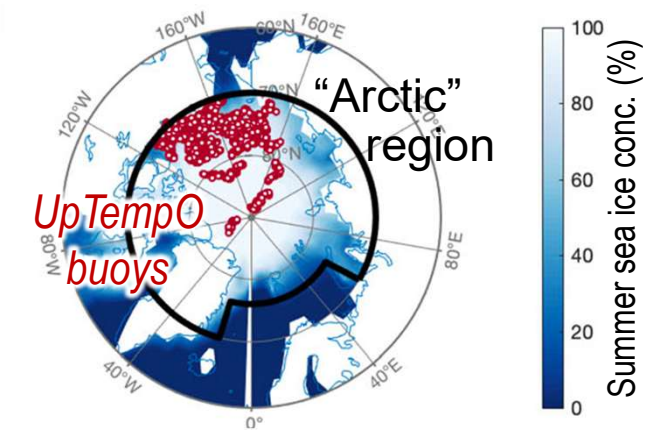
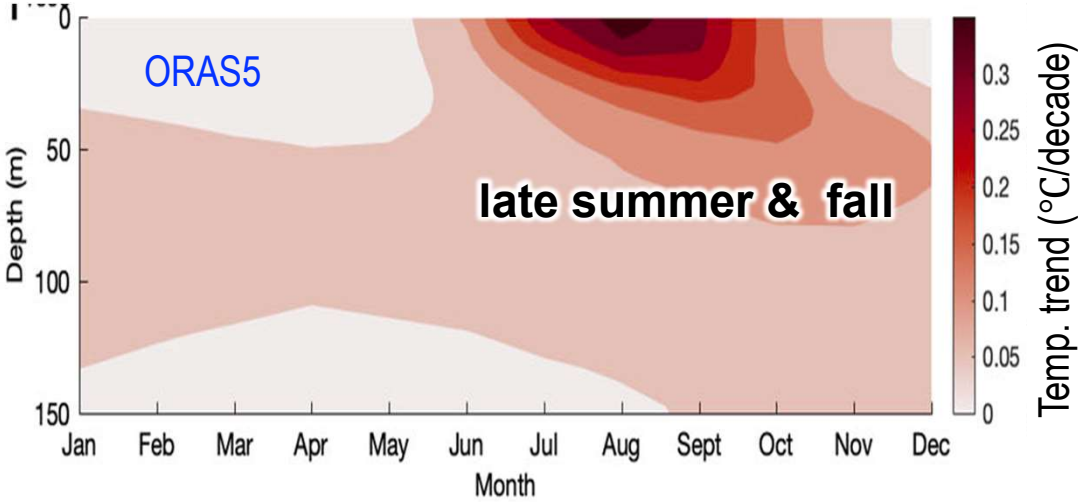


- fall (SON)





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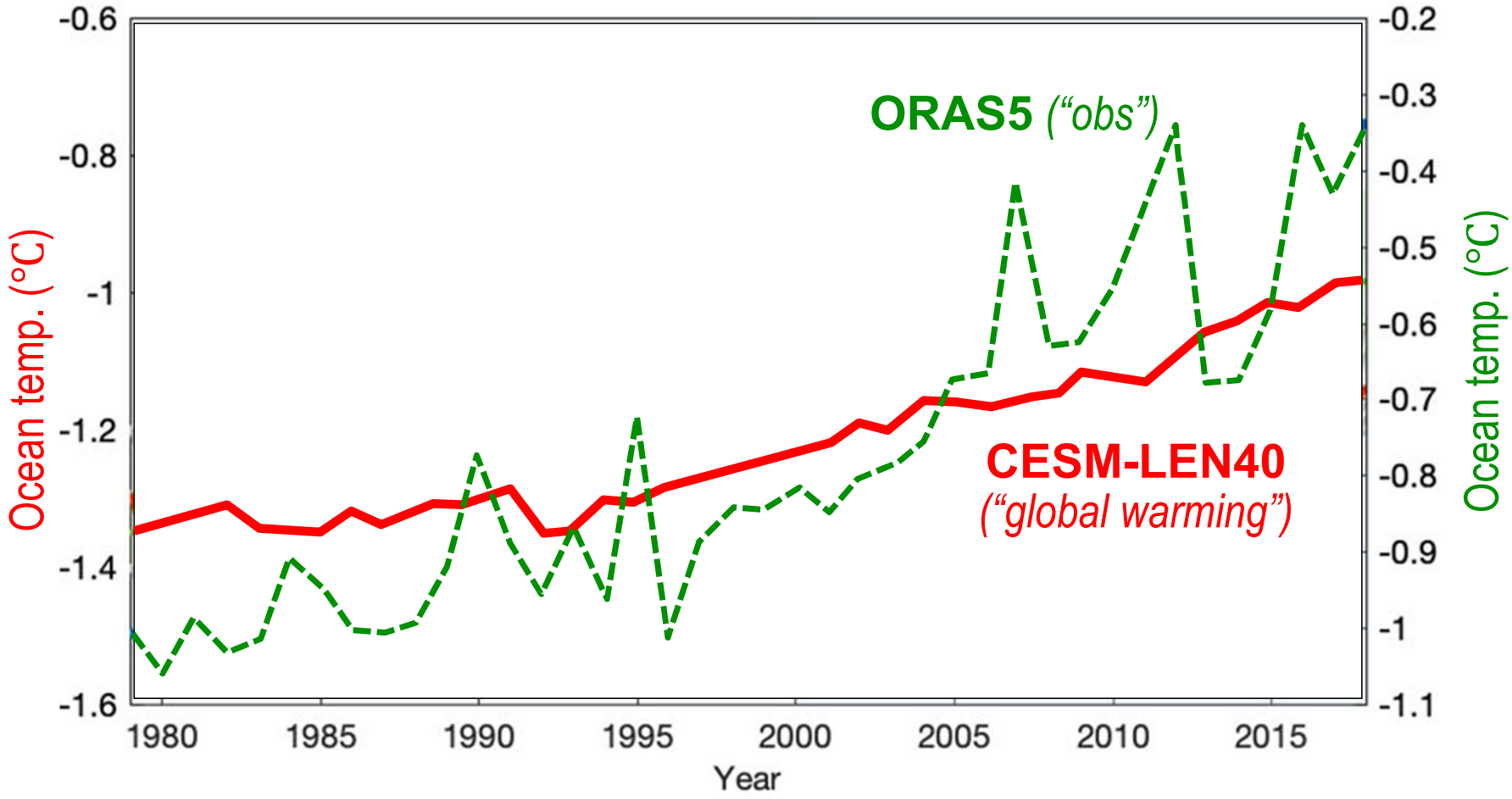
The role of global **warming** *(incr. CO_2)*

Li et al.
(Nature Comm, 2017)



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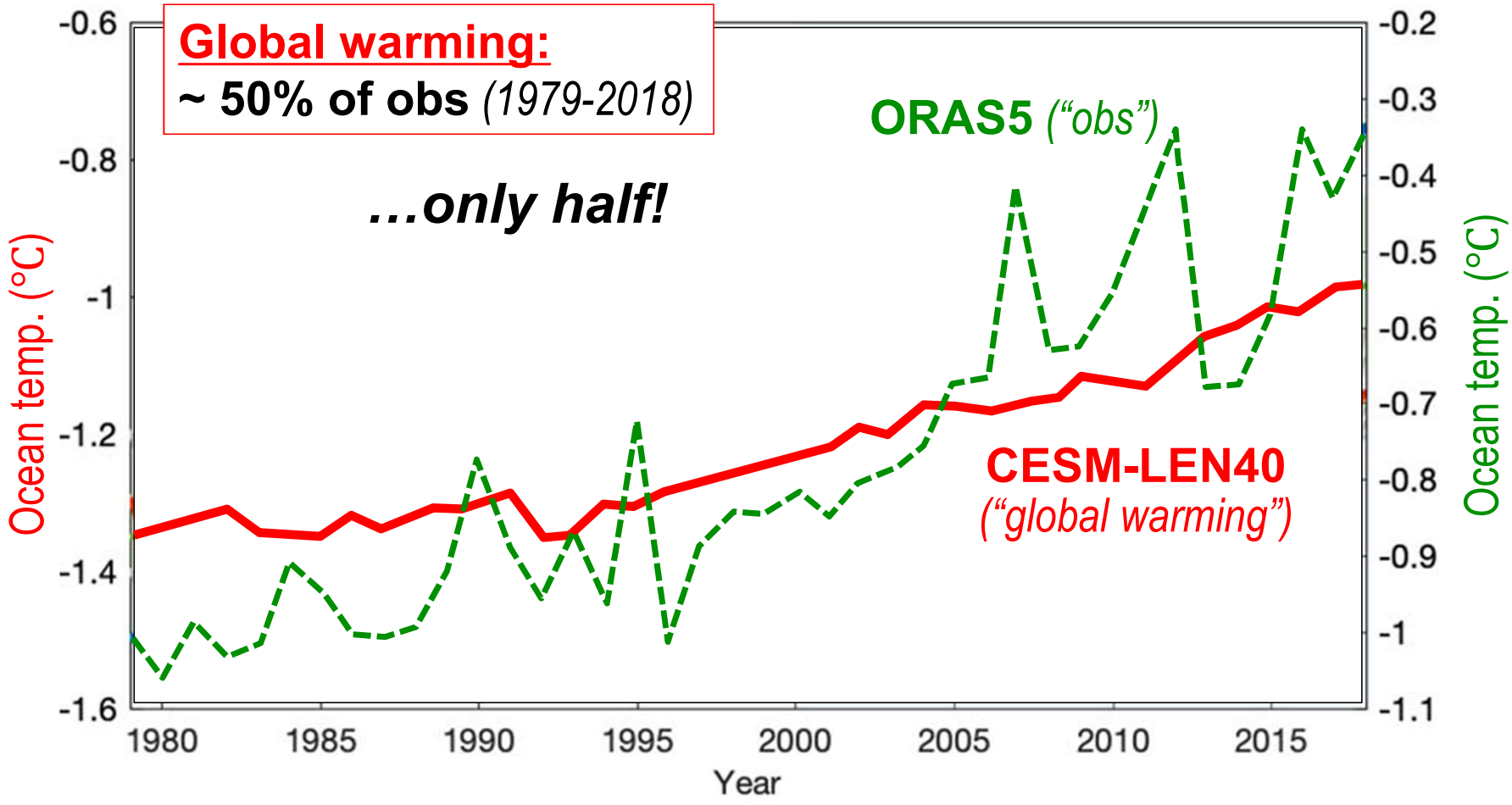

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Li et al.
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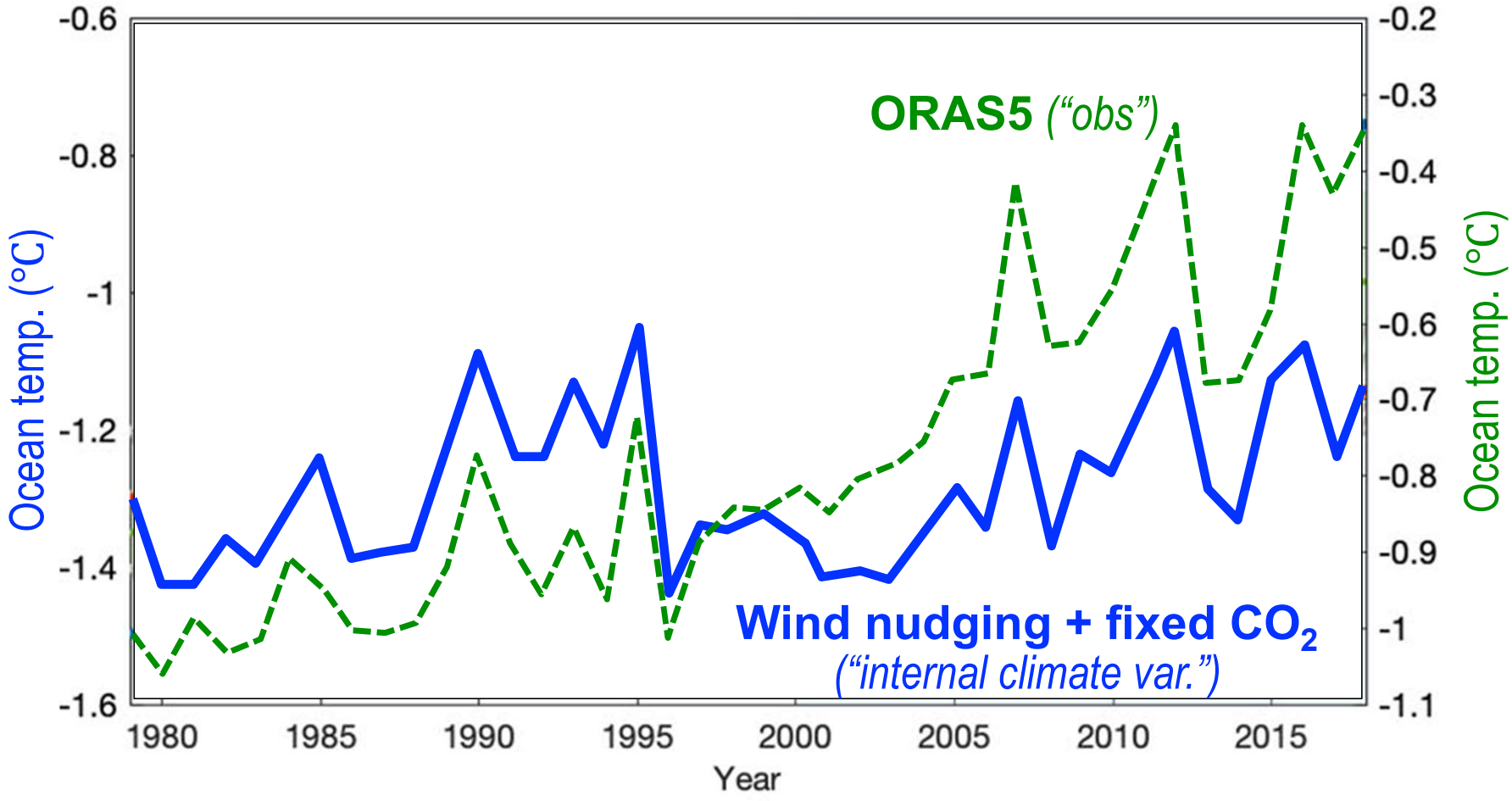

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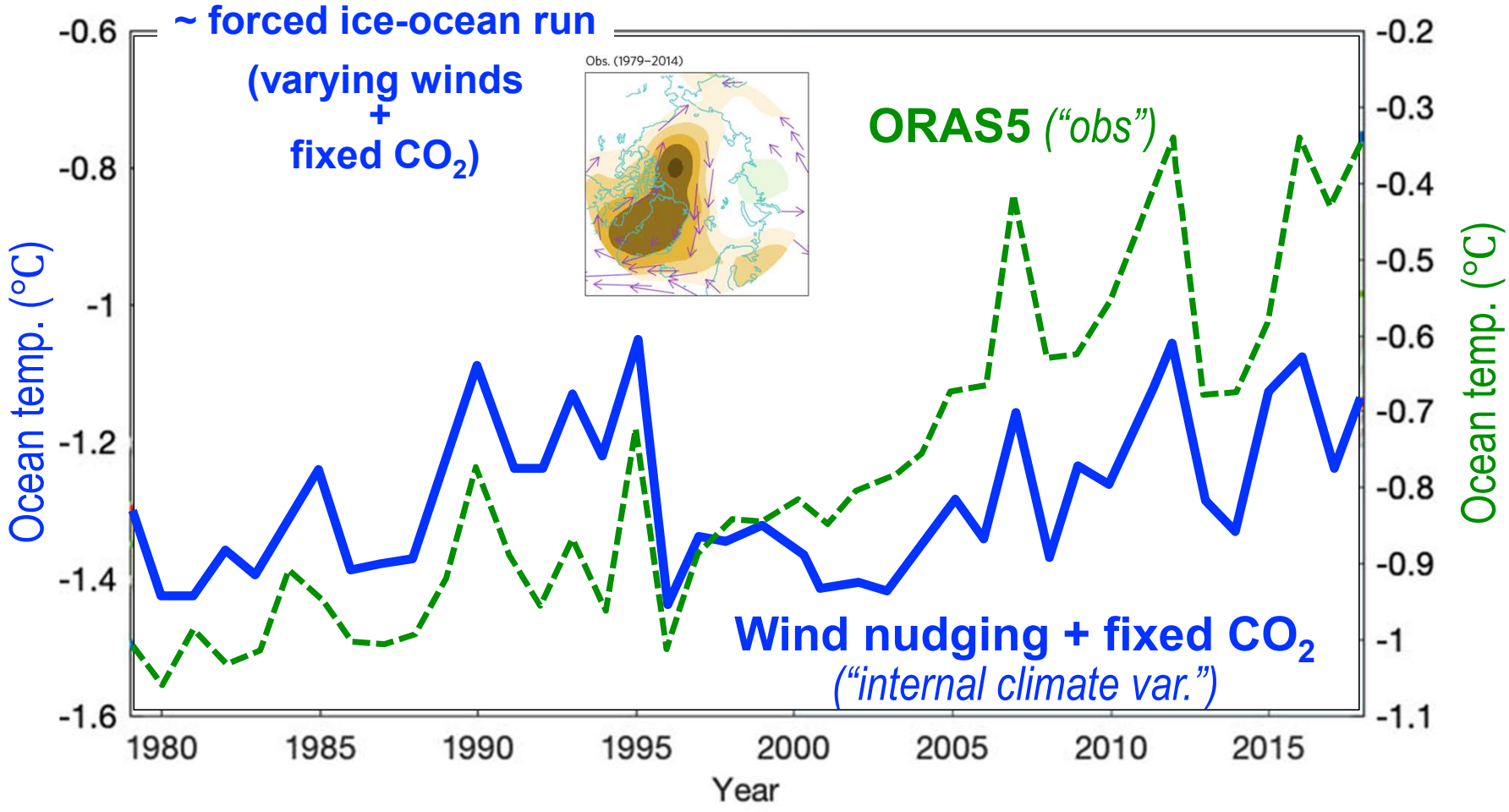

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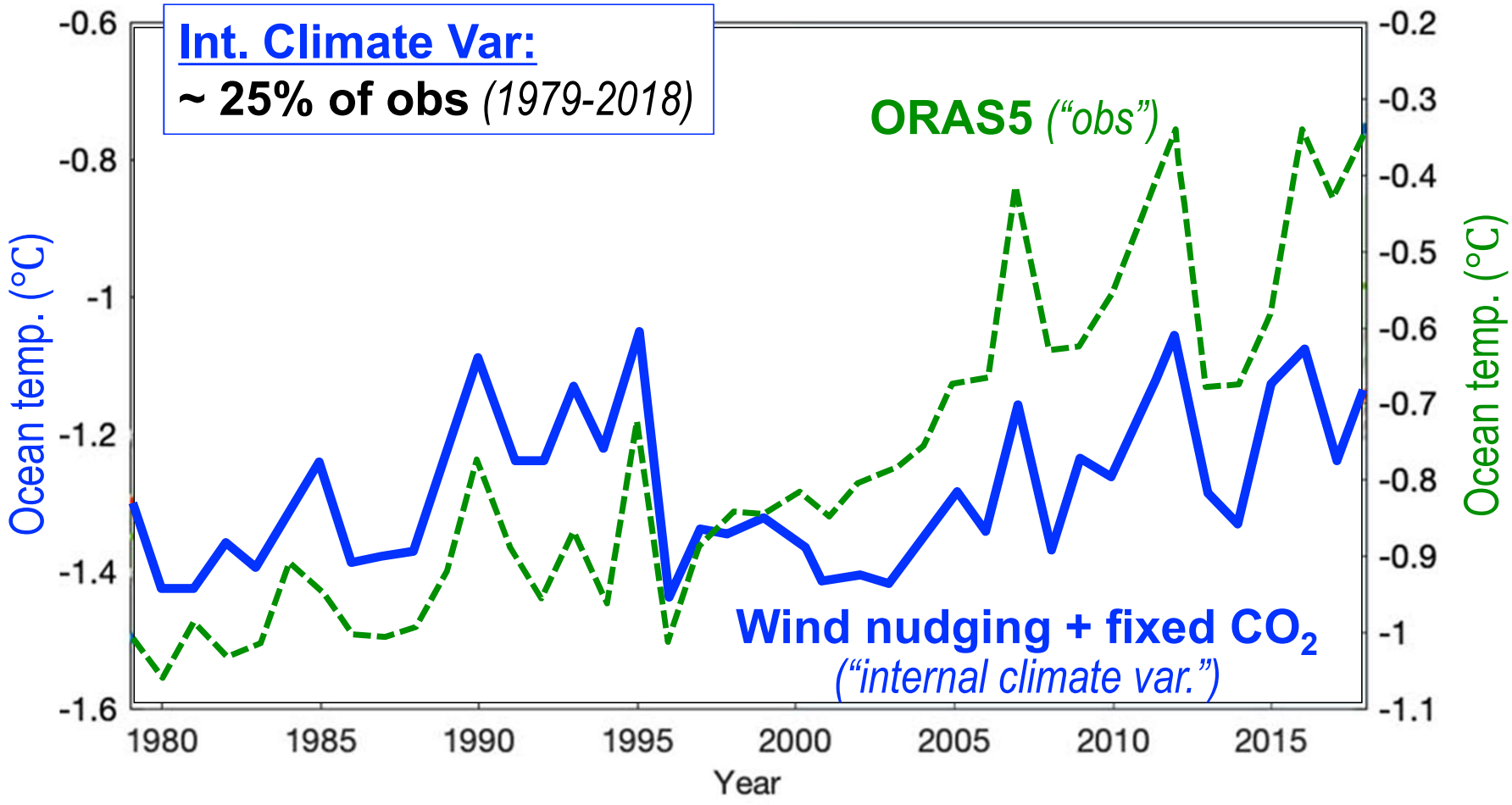

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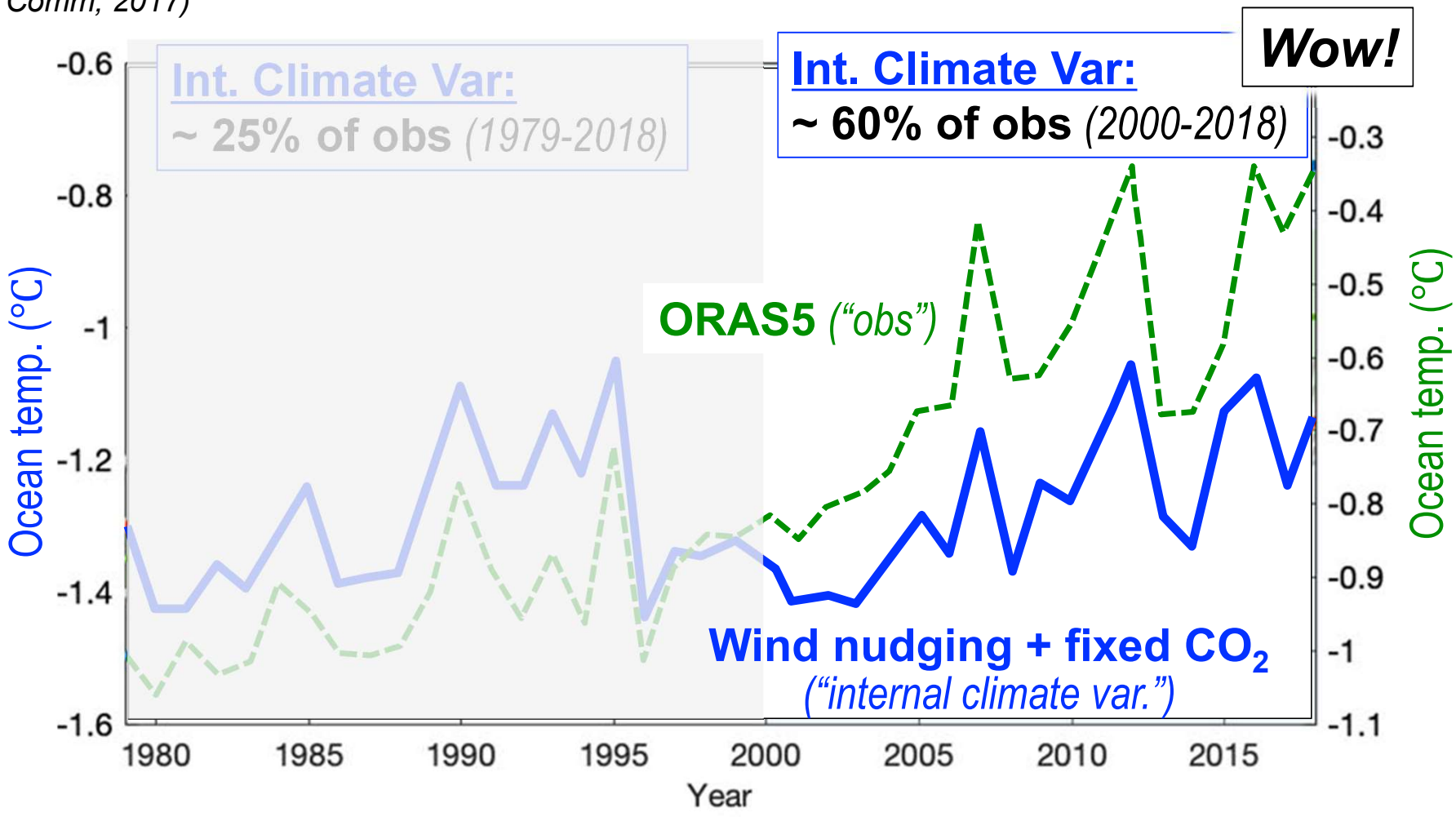

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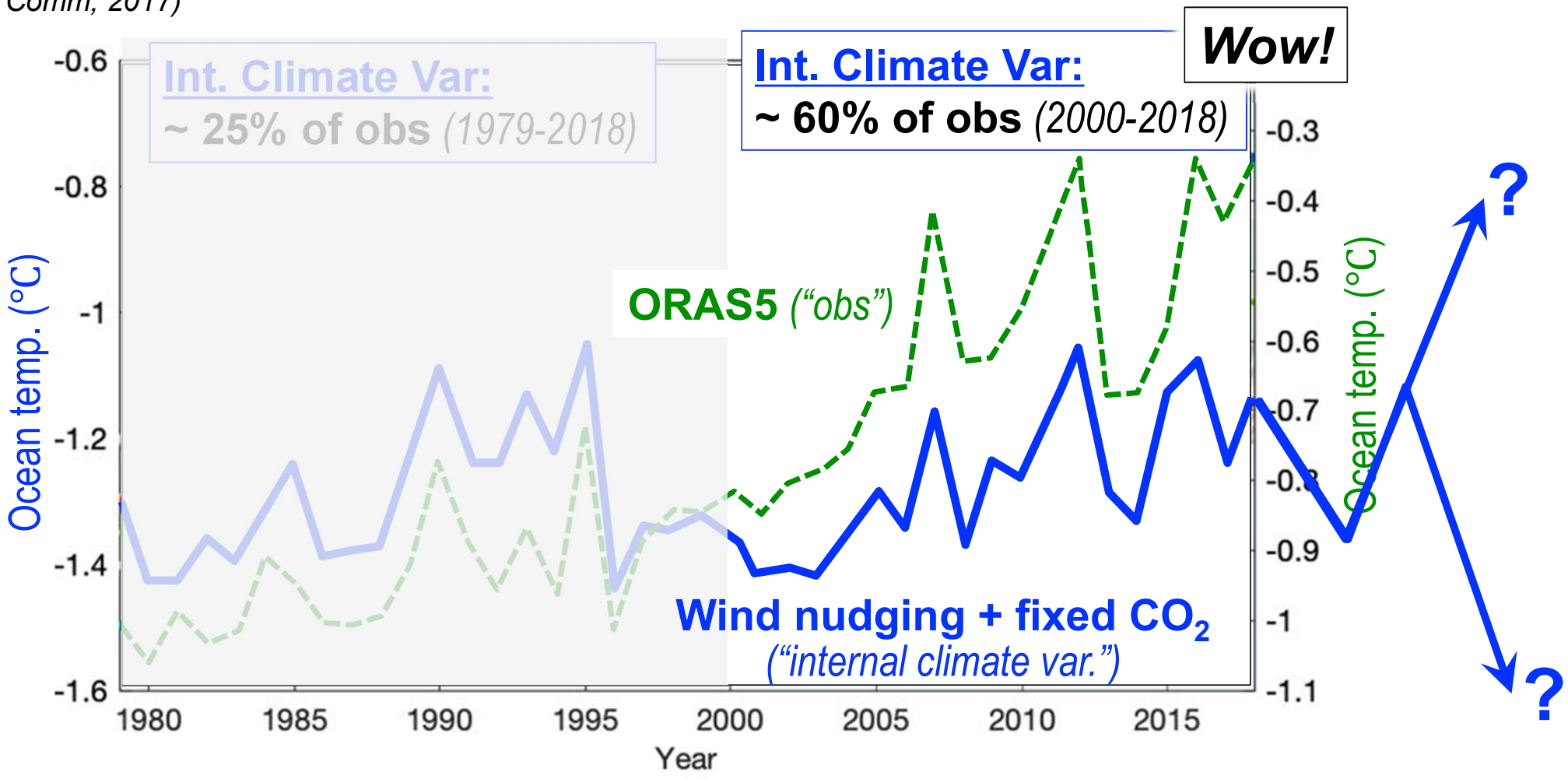

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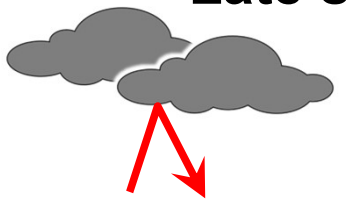
Summary: **Clouds** & Arctic **SST**

Late summer / fall: warming



incr LW down

Now: Arctic SST strongly influenced by the tropical Pacific!

Michael Steele
Polar Science Center / APL
University of Washington

GRHSST 2022
Barcelona, Spain

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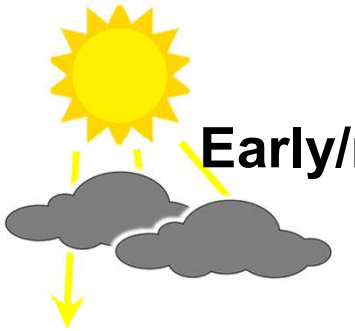
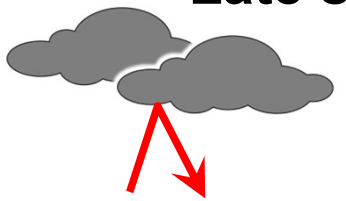


Early/mid summer: cooling

decr SW down



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The future: Early sea ice retreat
➜ a boring, "regular" ocean!

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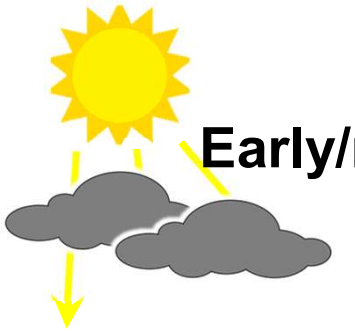

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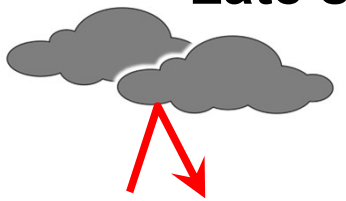

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Thank you