Arctic Climate change

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Global warming

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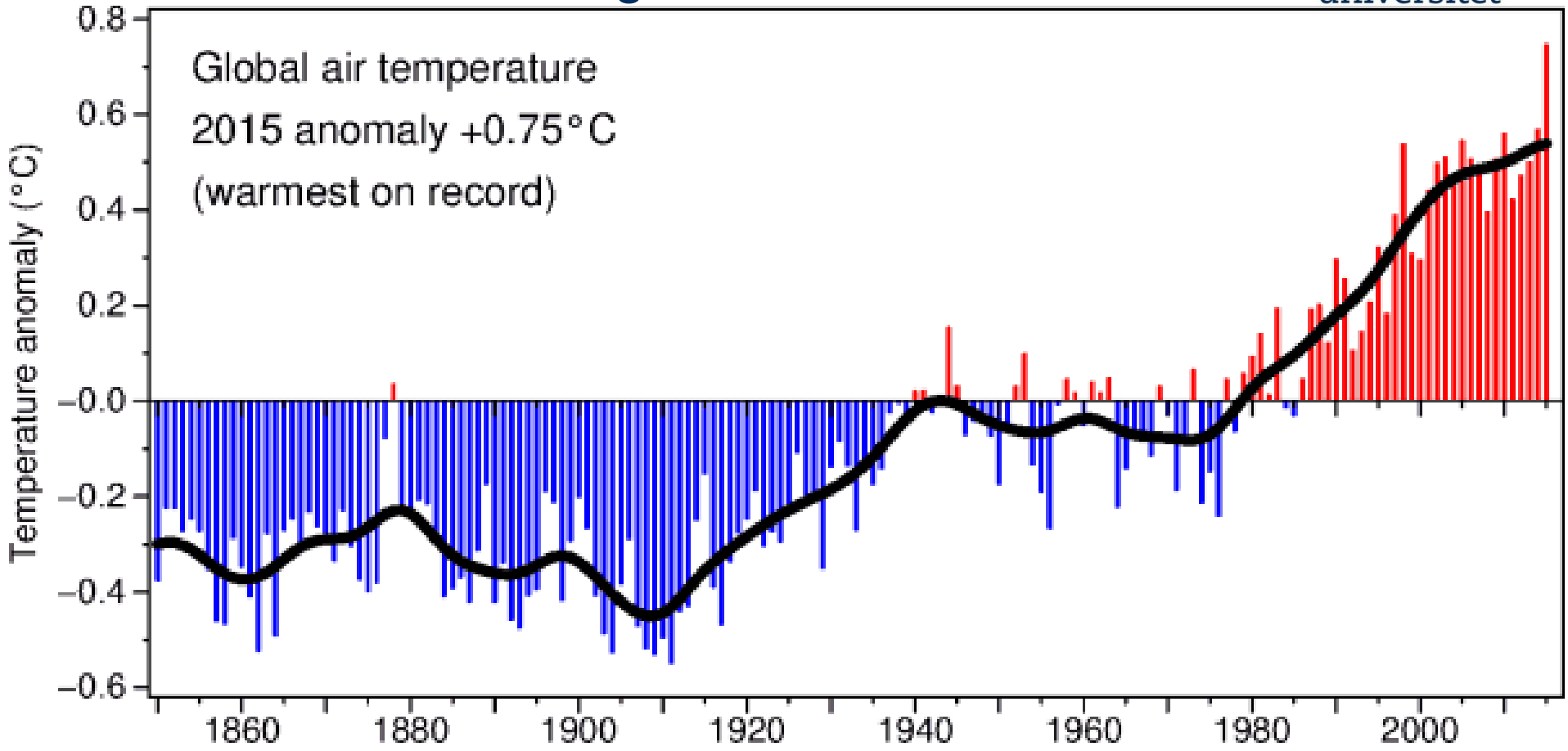

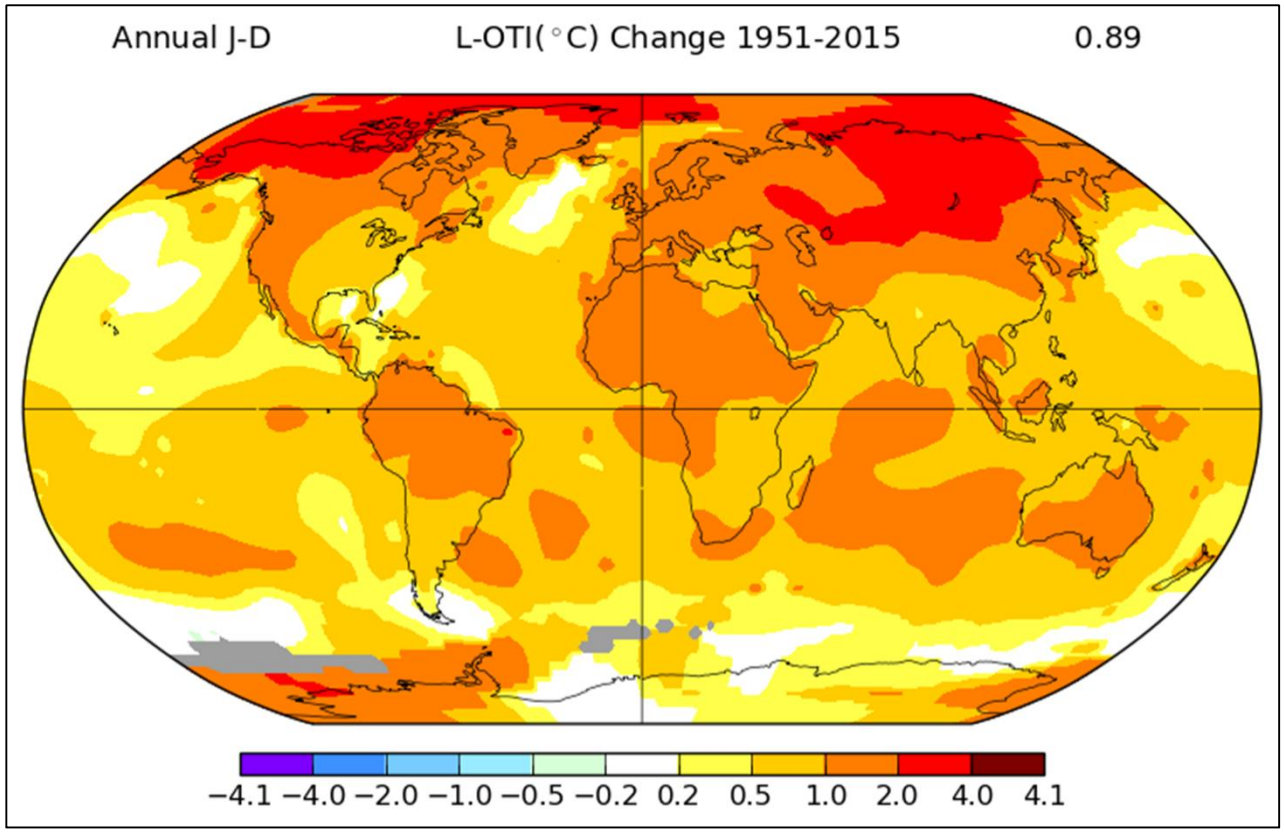

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But global warming is not globally uniform!

Global warming

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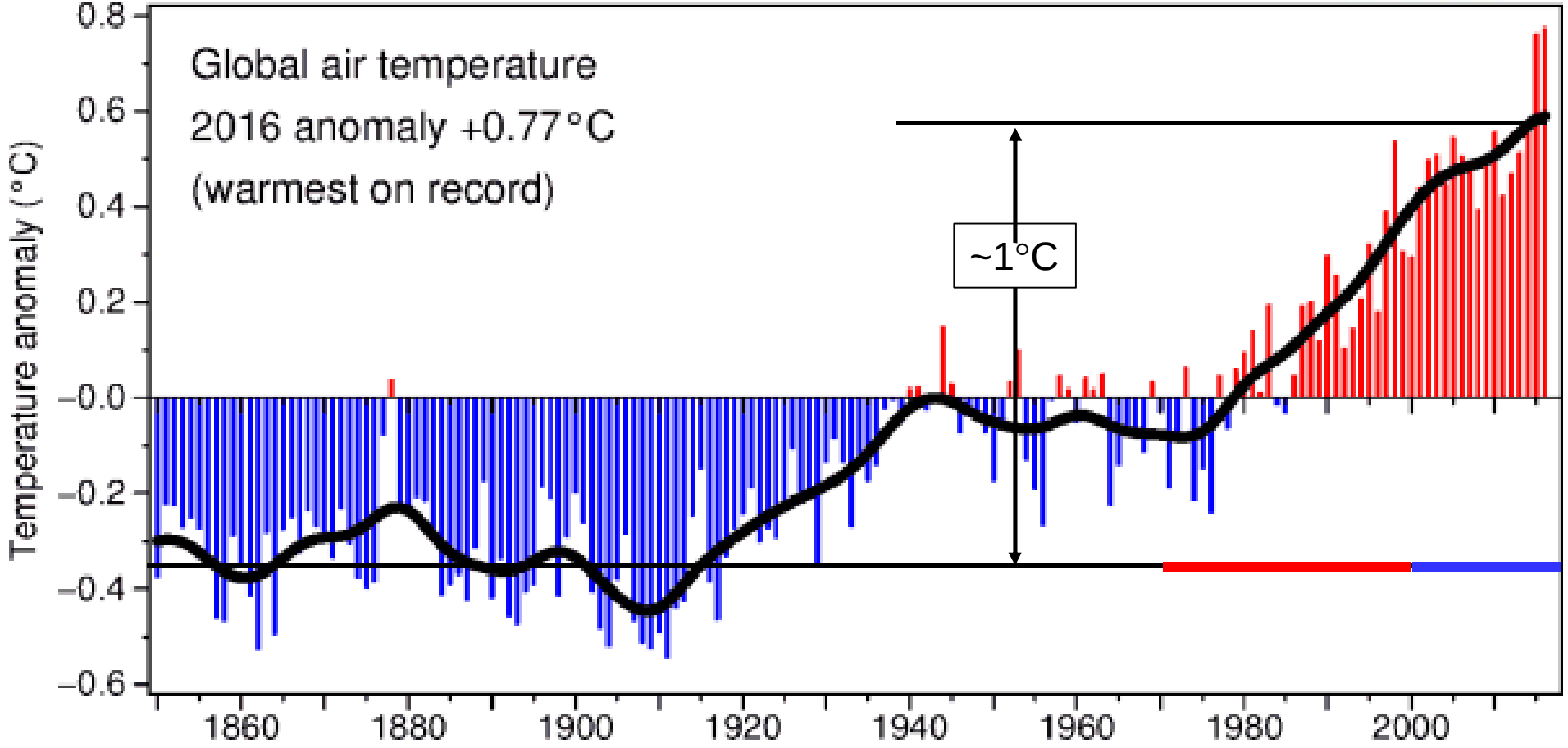

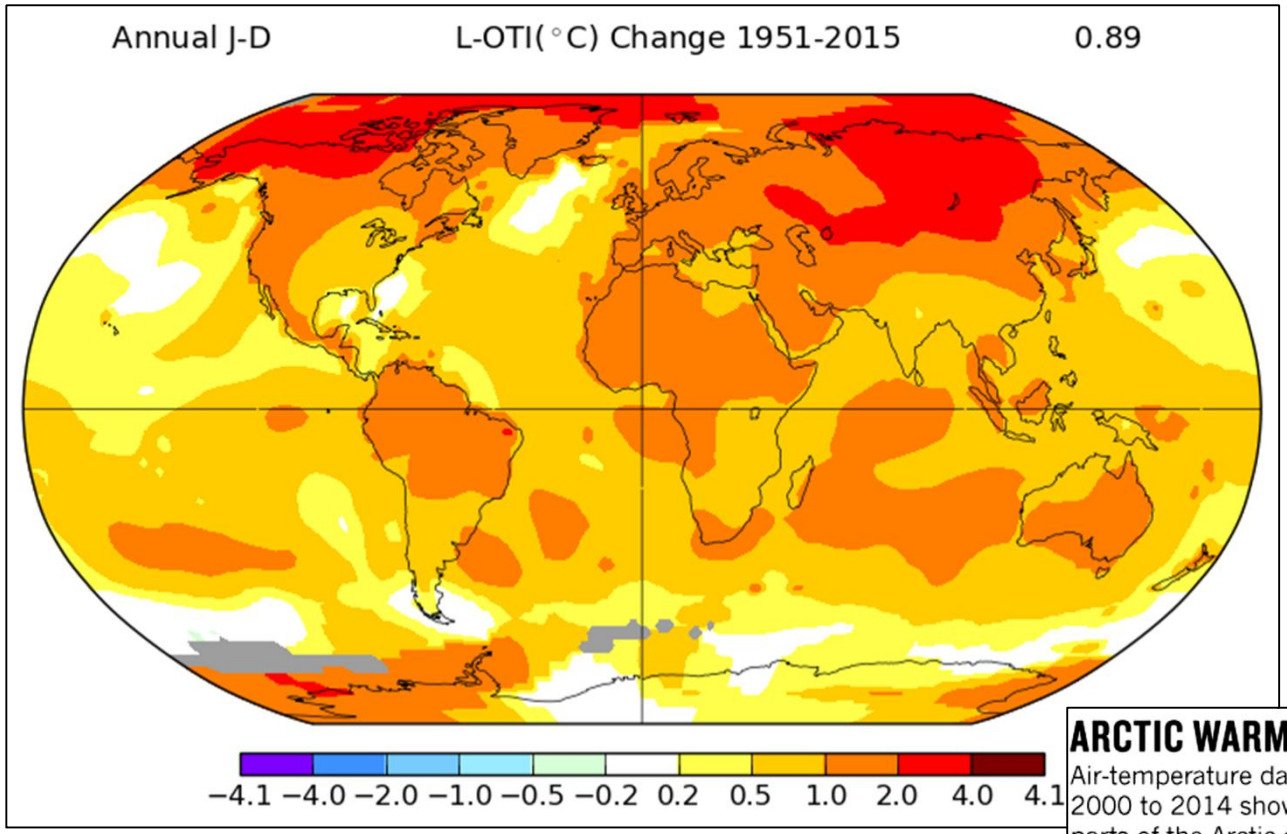

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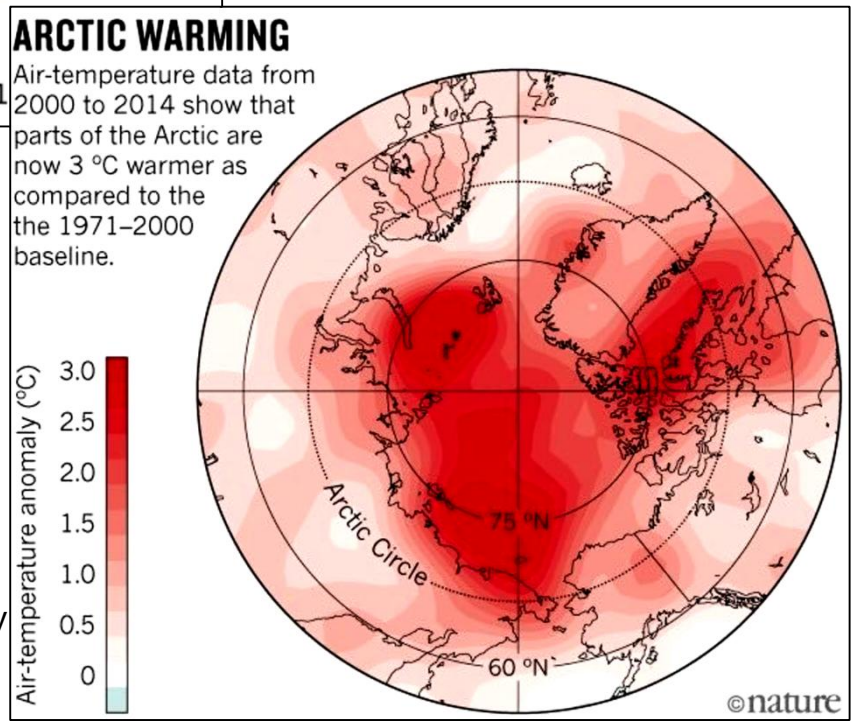
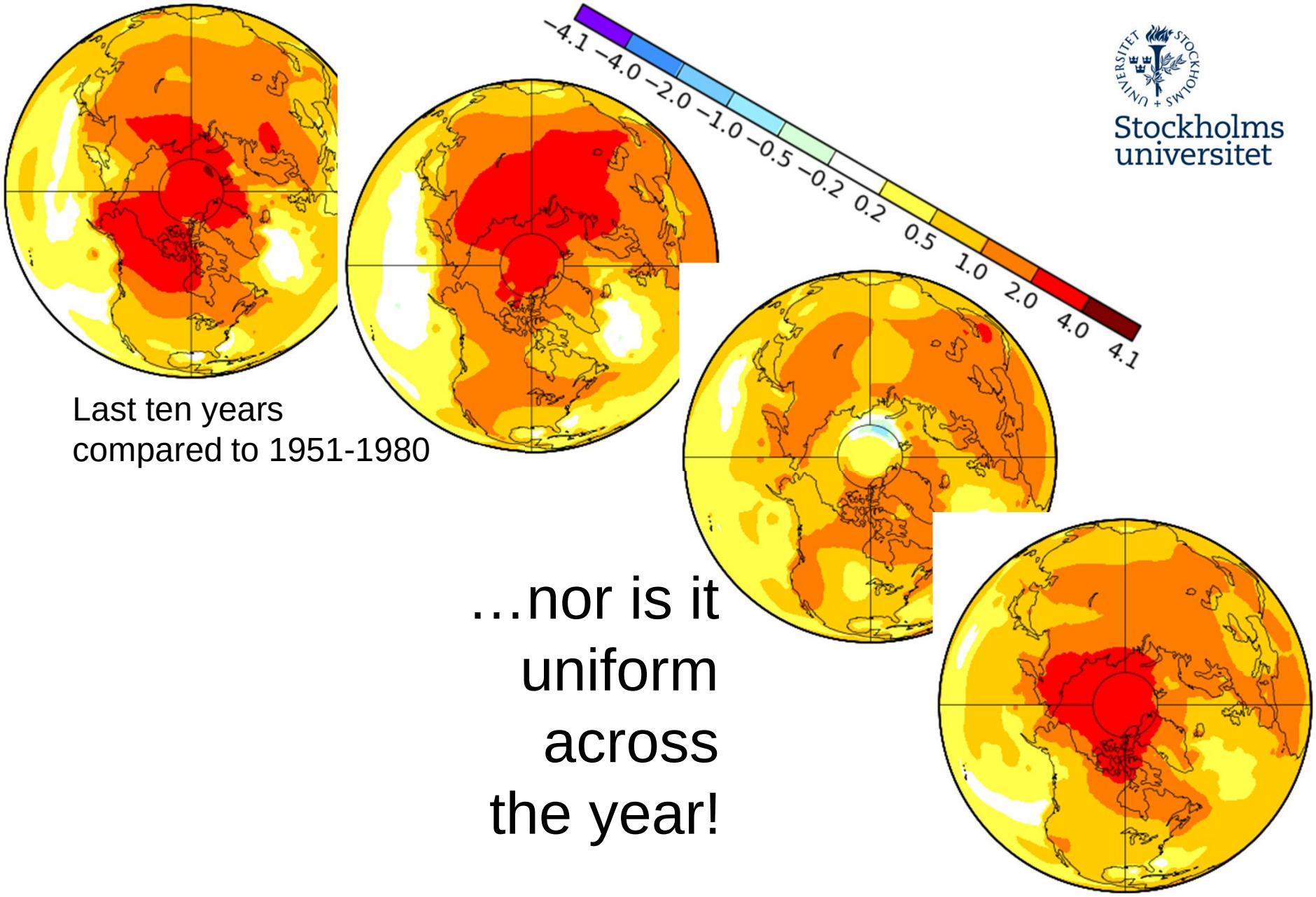
But global warming is not globally uniform!

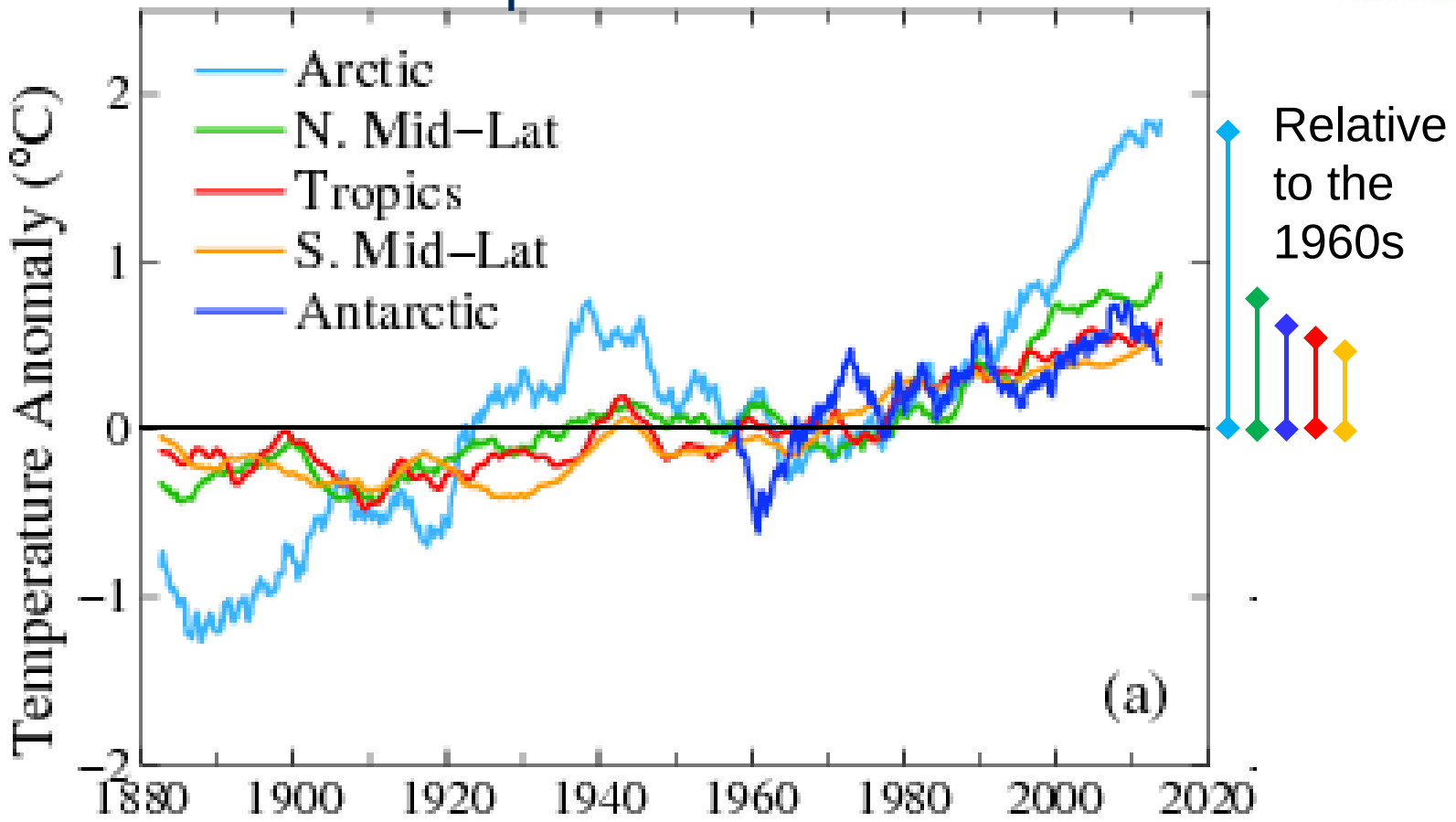




Last ten years
compared to 1951-1980

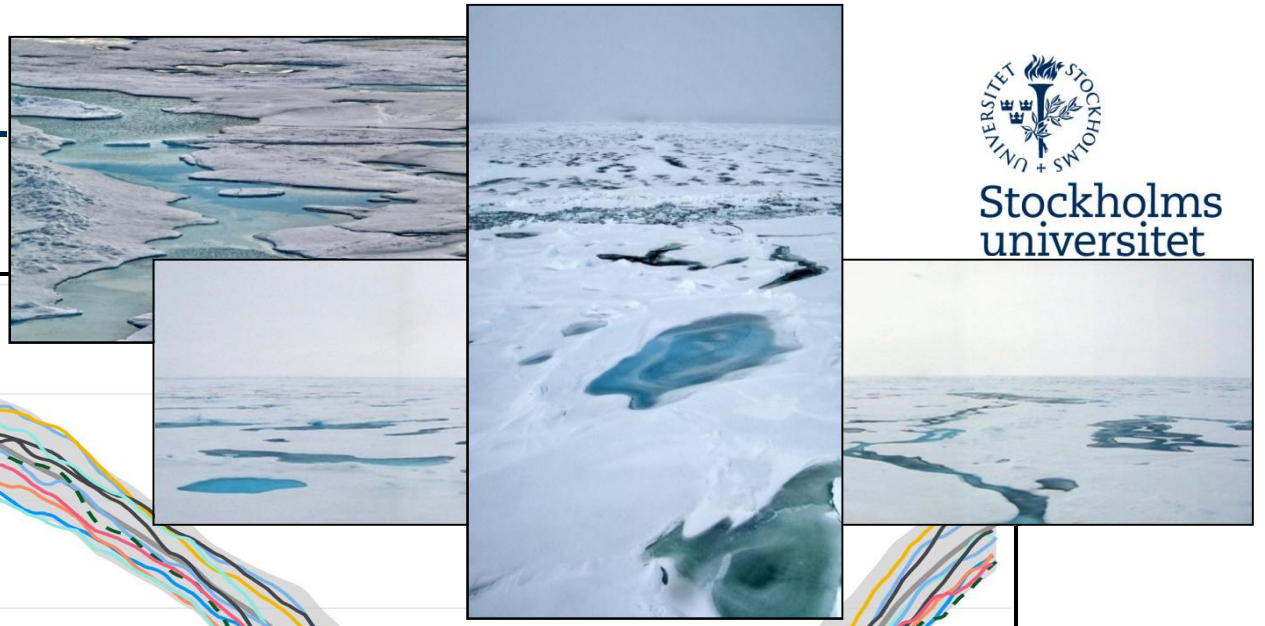
…nor is it uniform across the year!

“Arctic amplification”



Relative to the 1960s

Arctic sea-ice cover



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Sea-ice extent (million km²)

18
16
14
12
10
8
6
4
2
0

1979-1981
1999-2001

2011 & 2013

2012

2017

2007

National Snow and Ice Data Center, Boulder, CO

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

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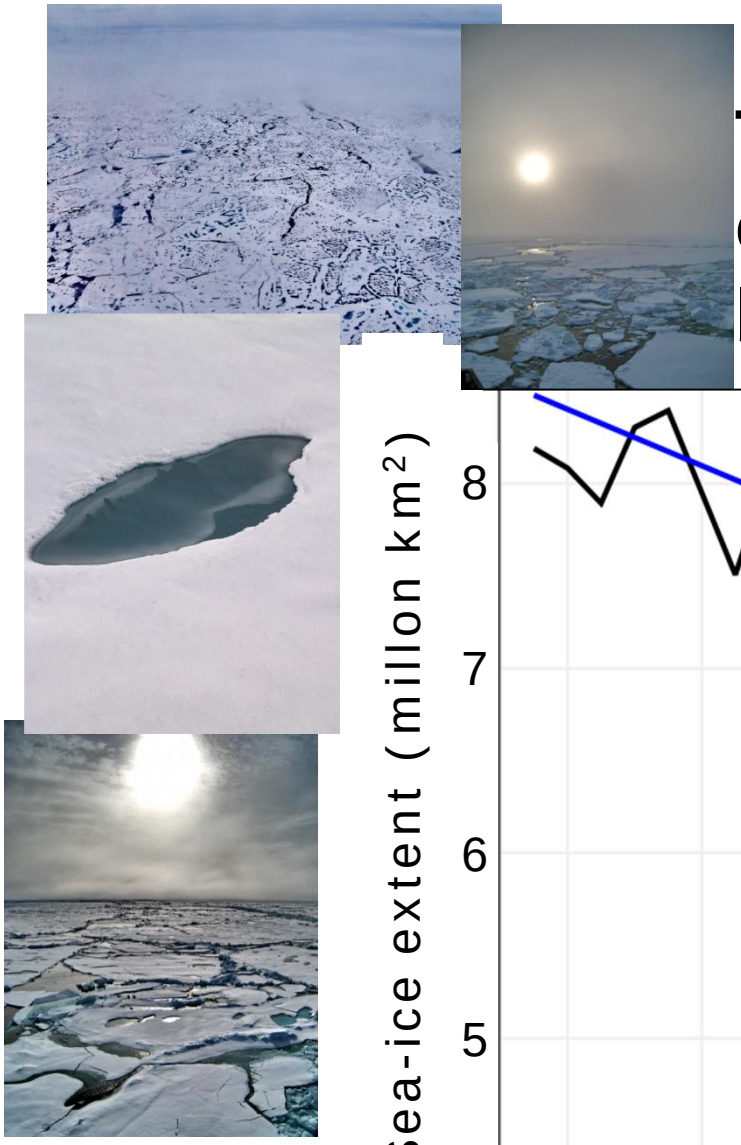

The Arctic summer ice cover has decreased by ~40% since the 1970s

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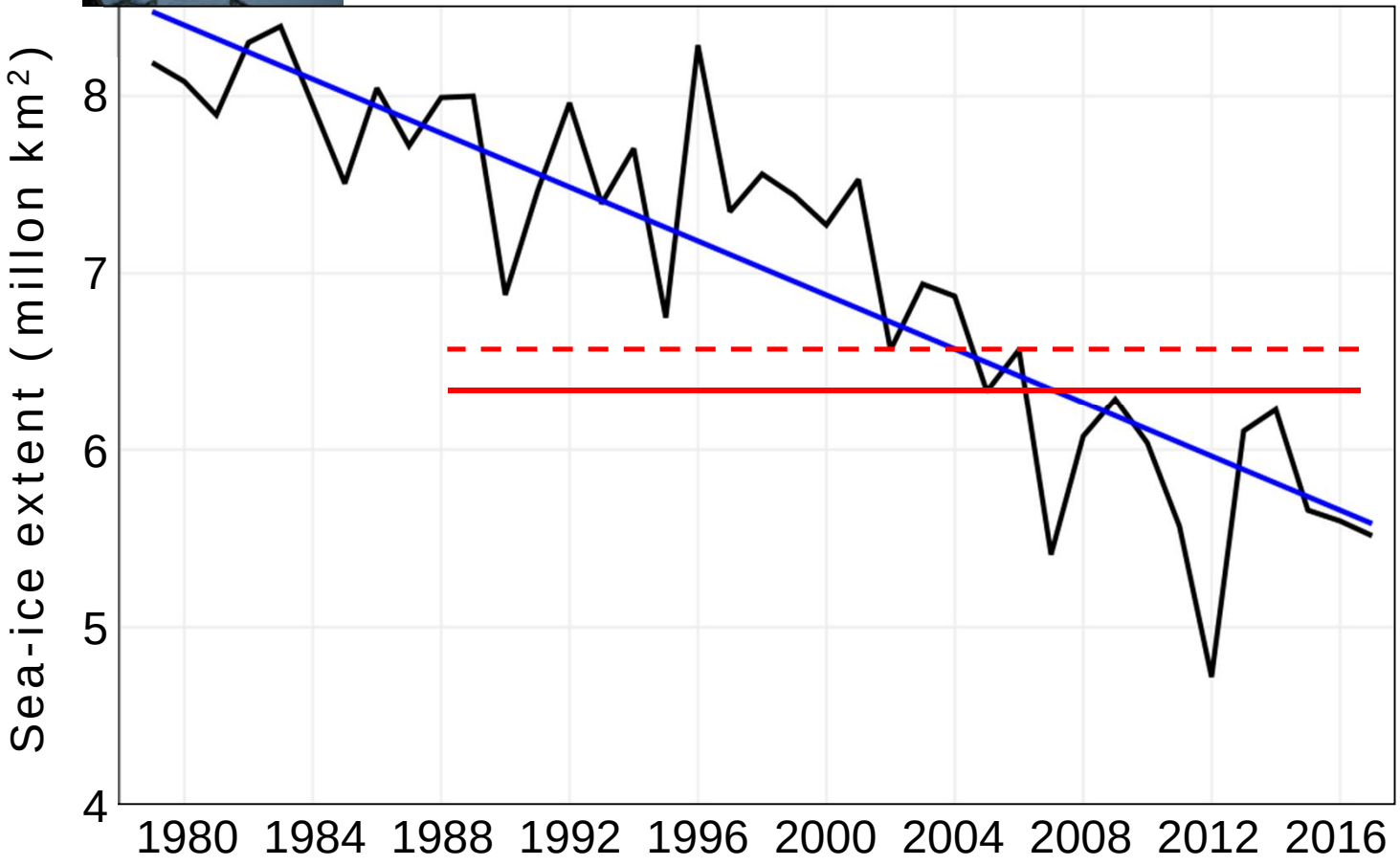

Arctic sea-ice cover

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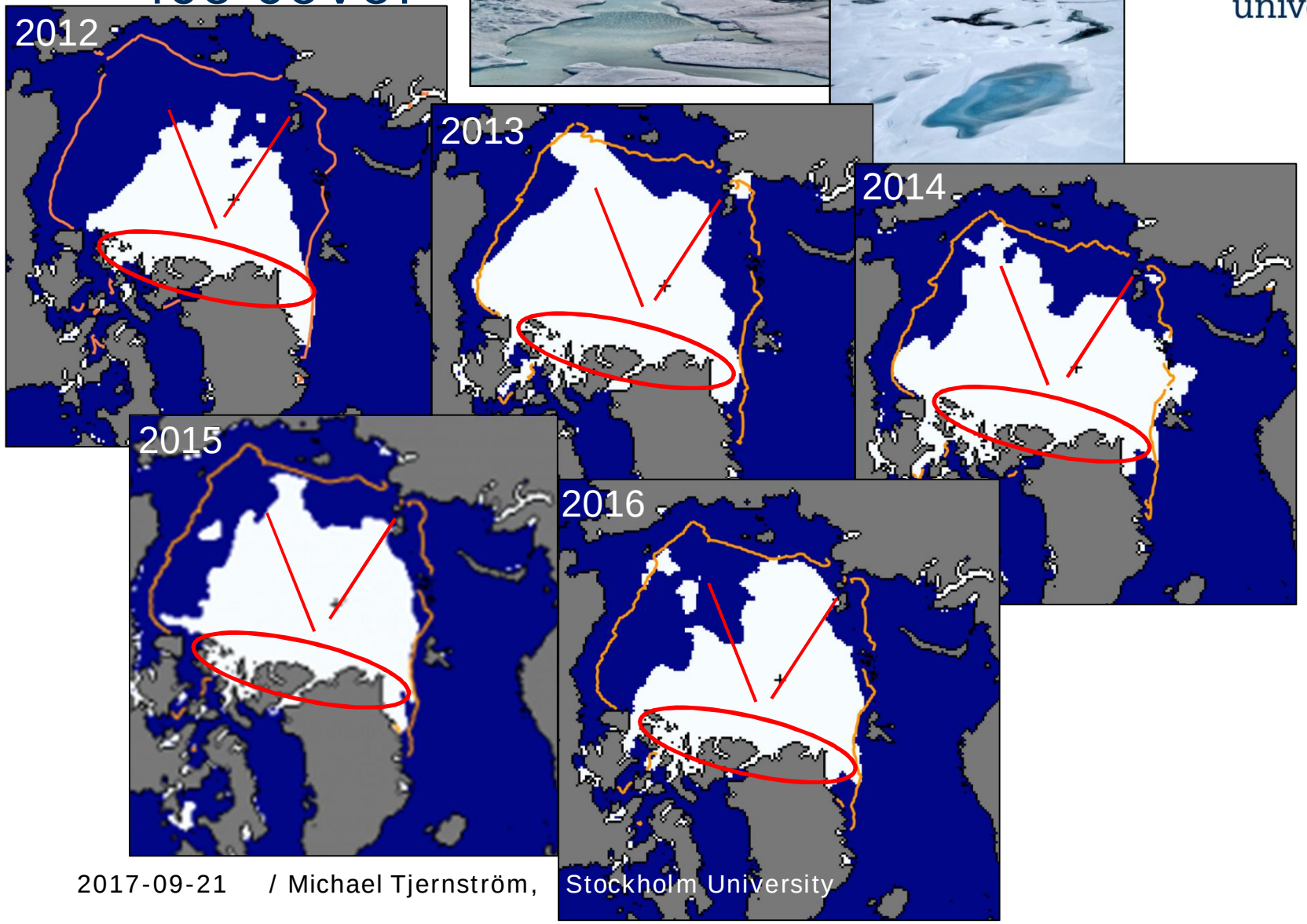

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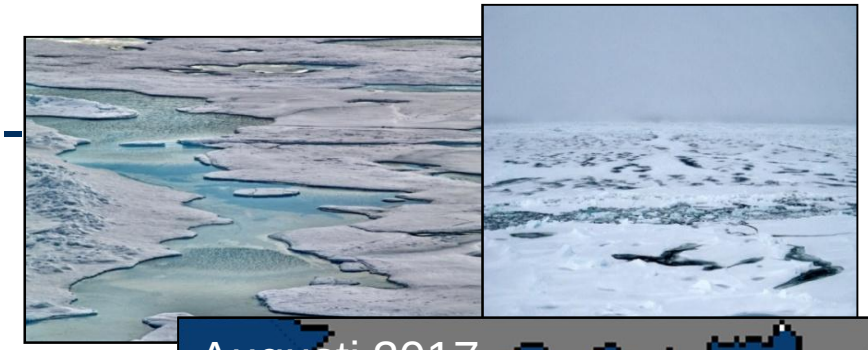
Arctic sea-ice cover



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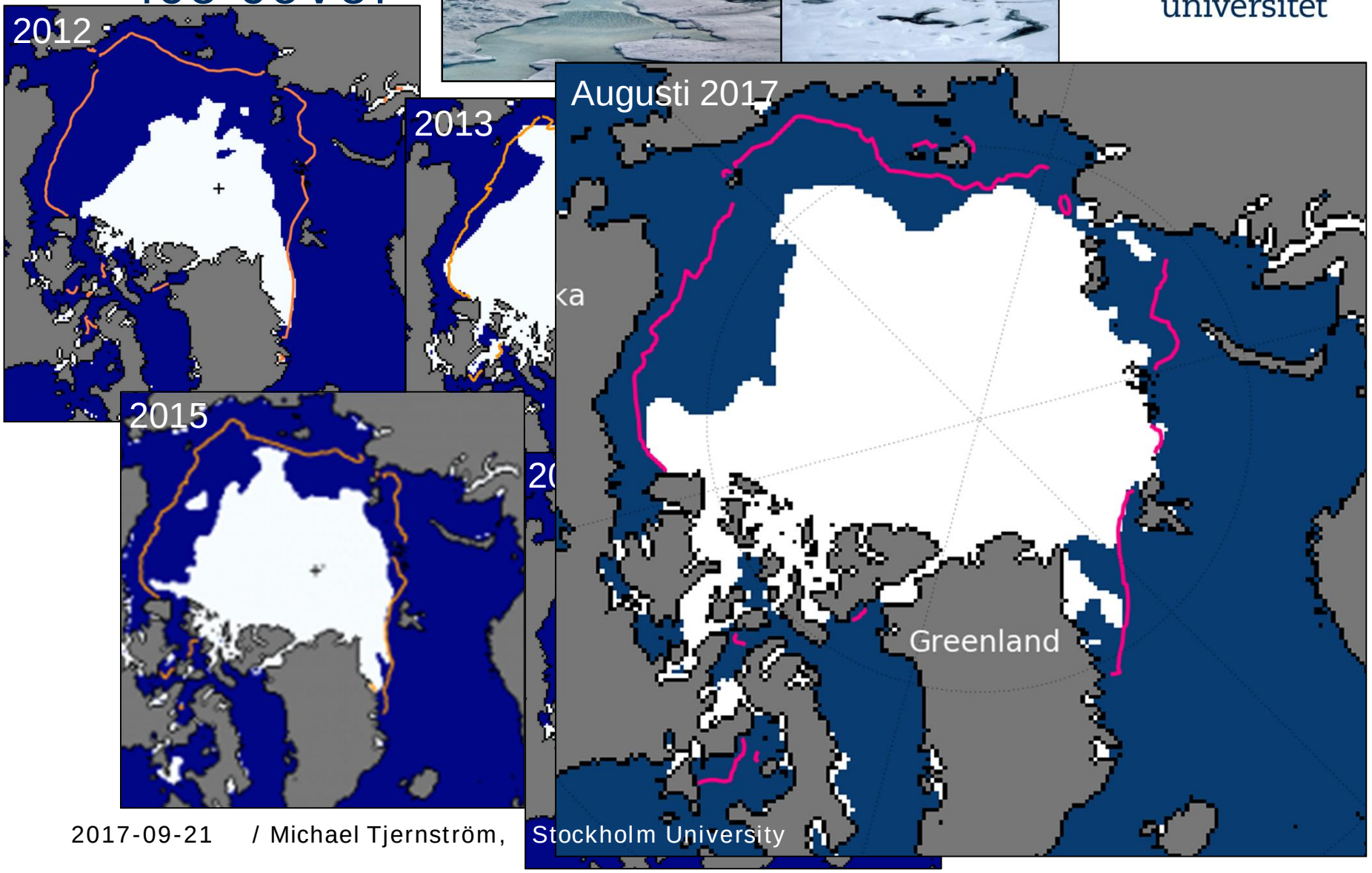

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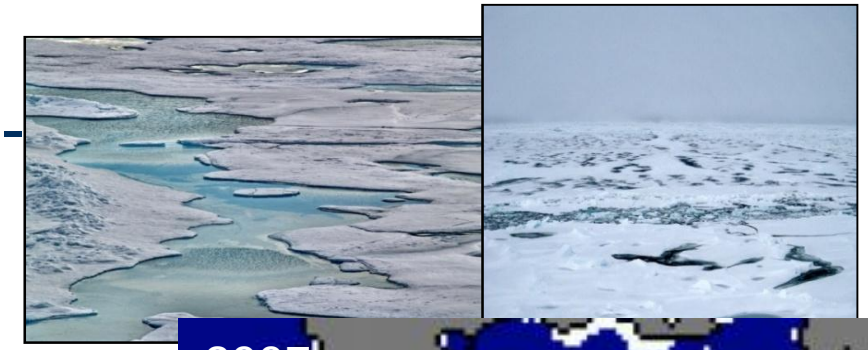
Arctic sea-ice cover



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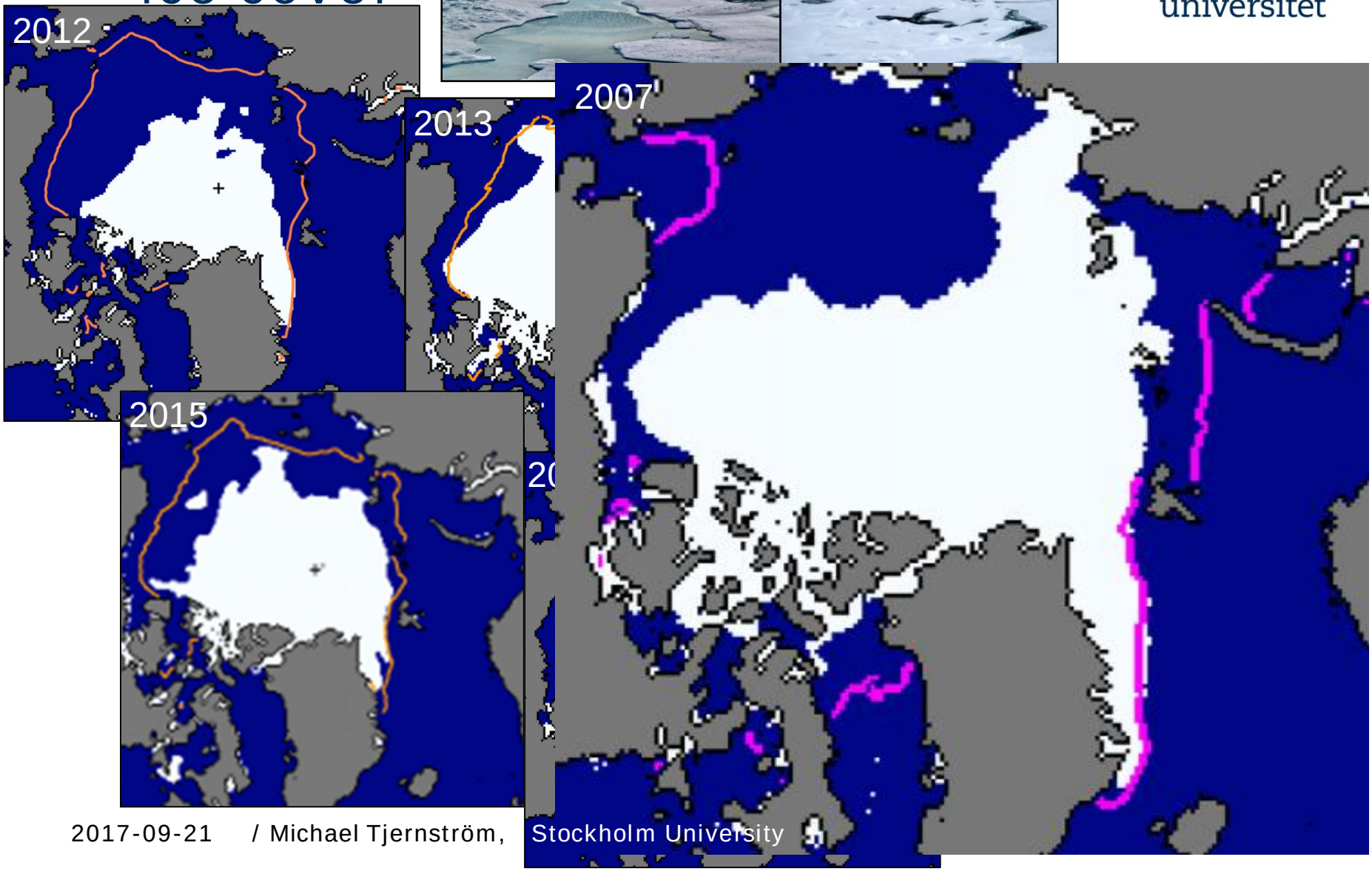

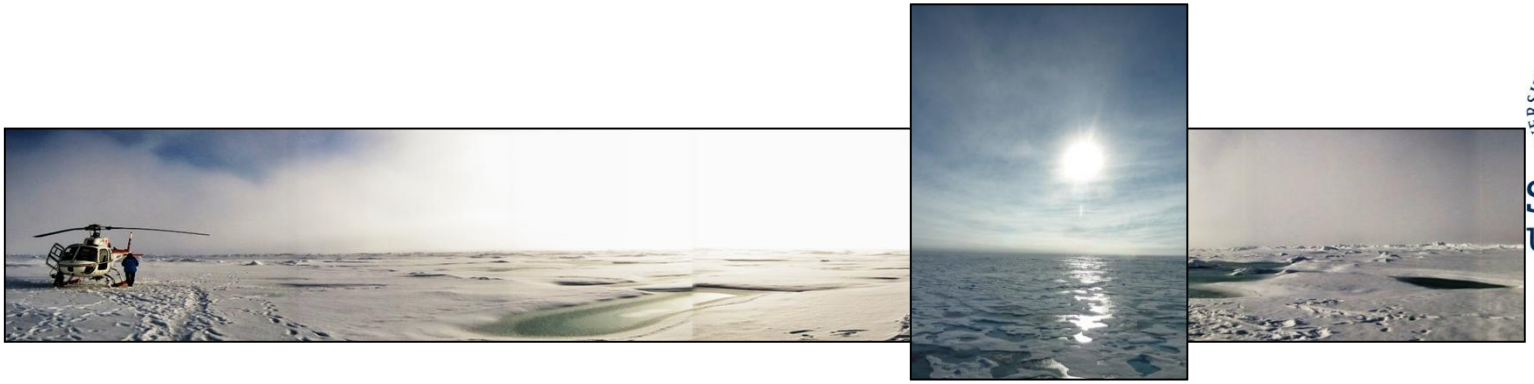

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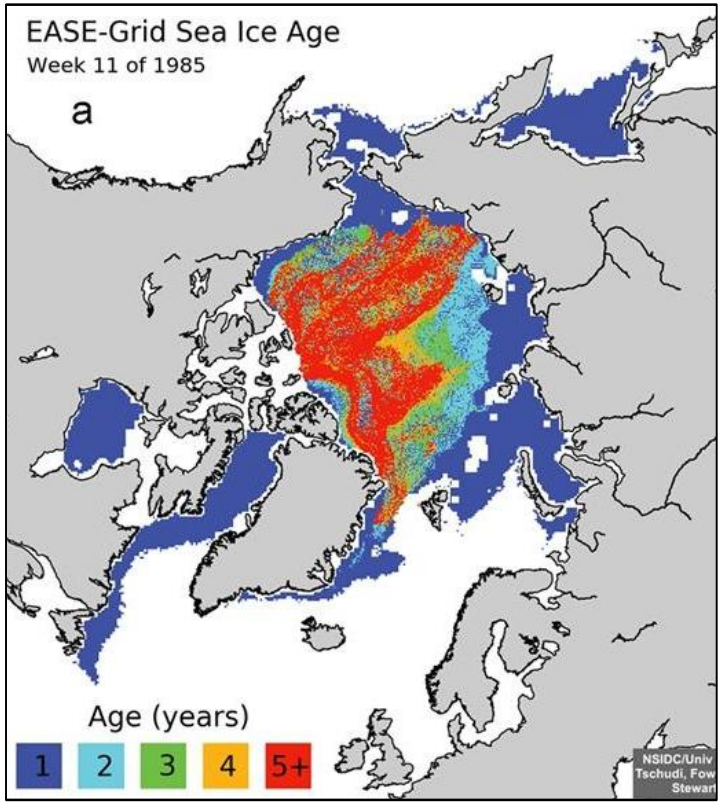
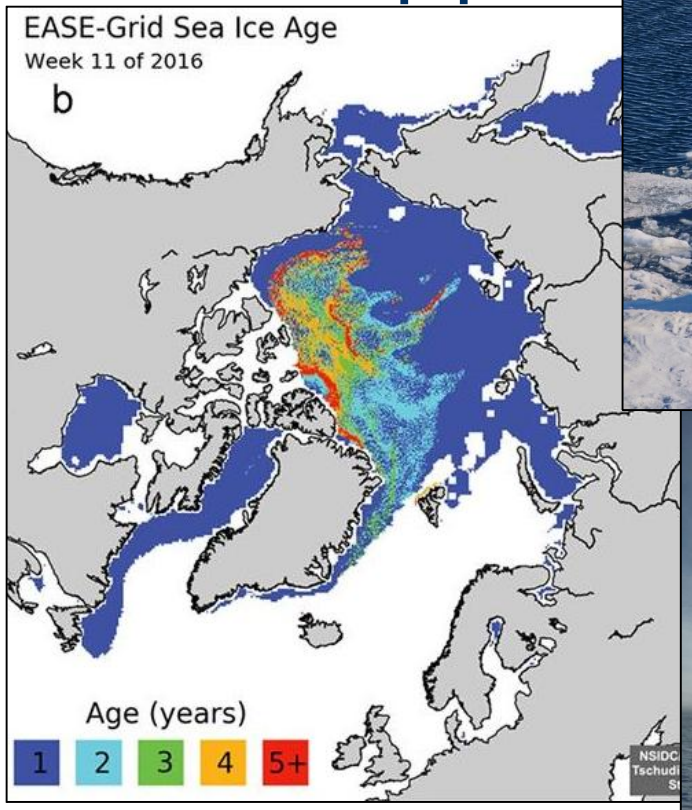
Thicker & older ice disappears fast





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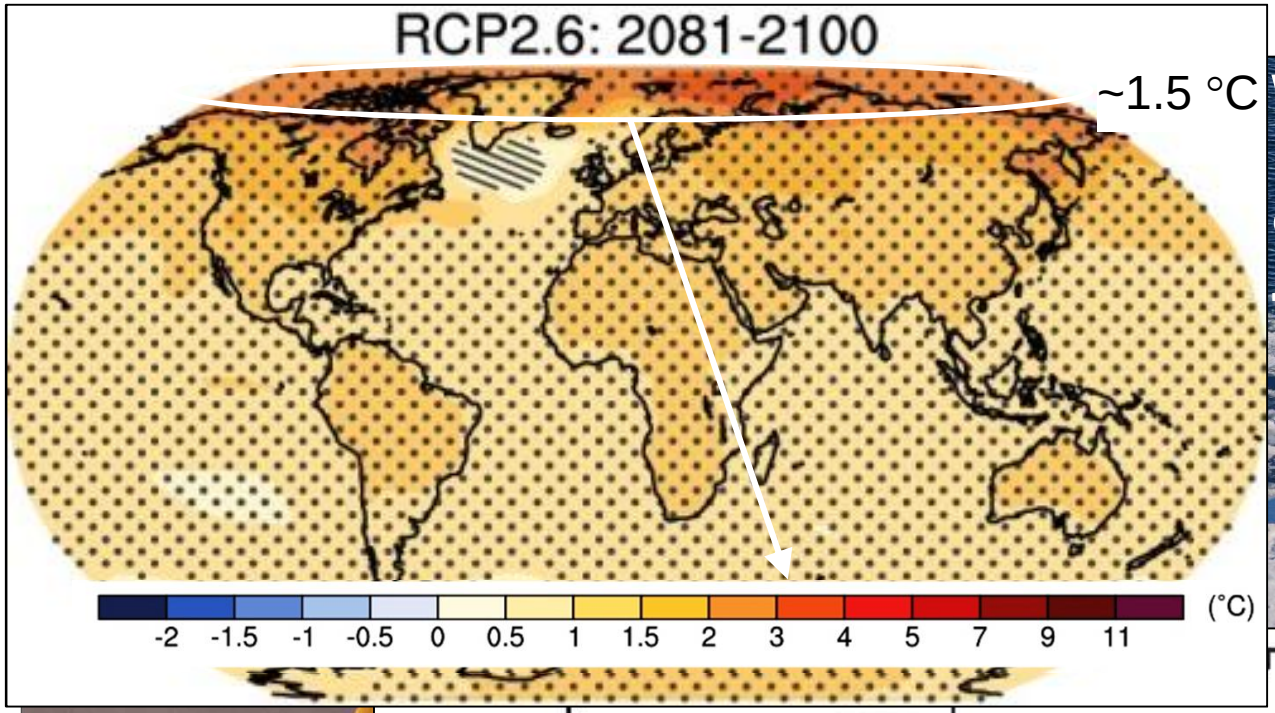

What about the future?

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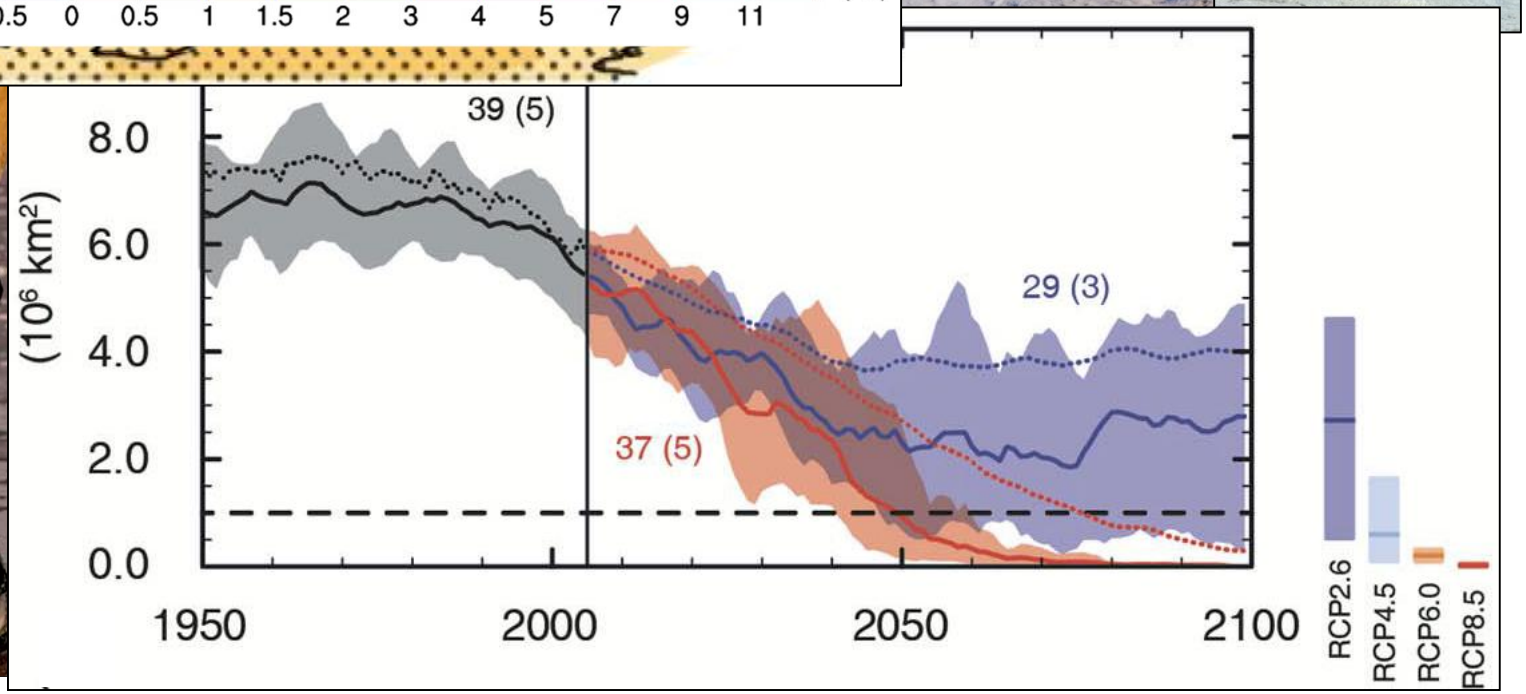

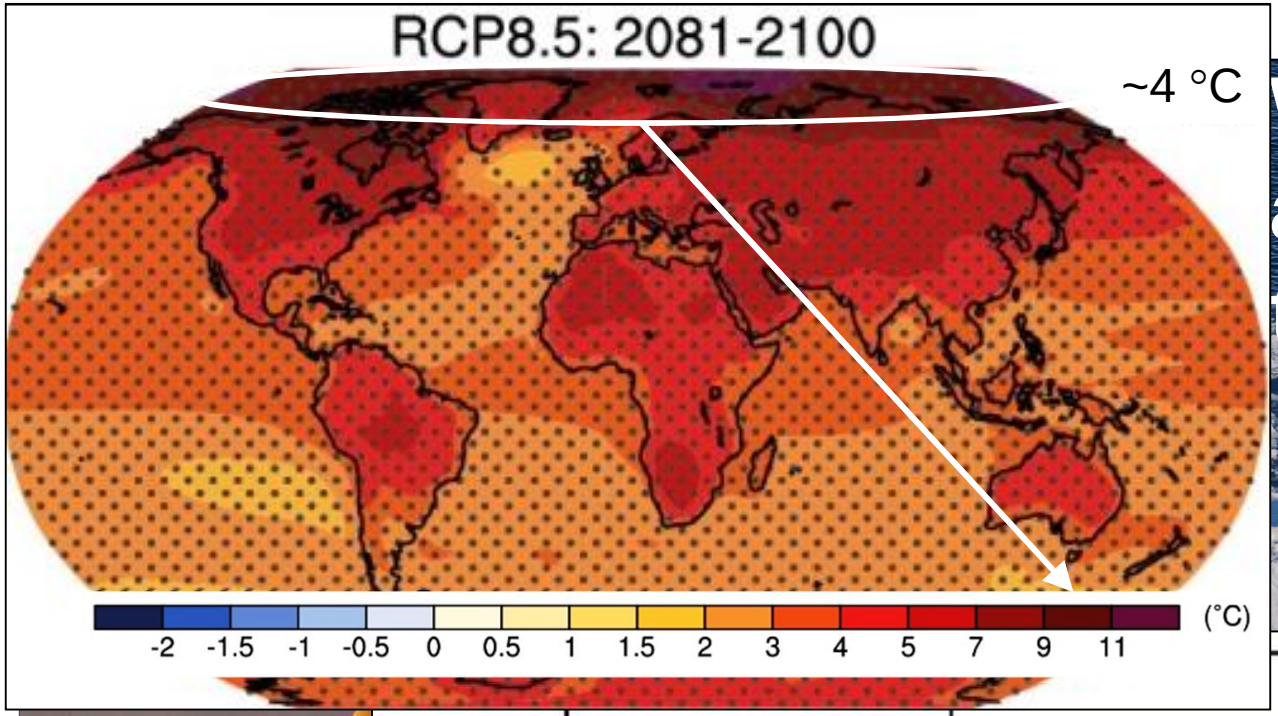

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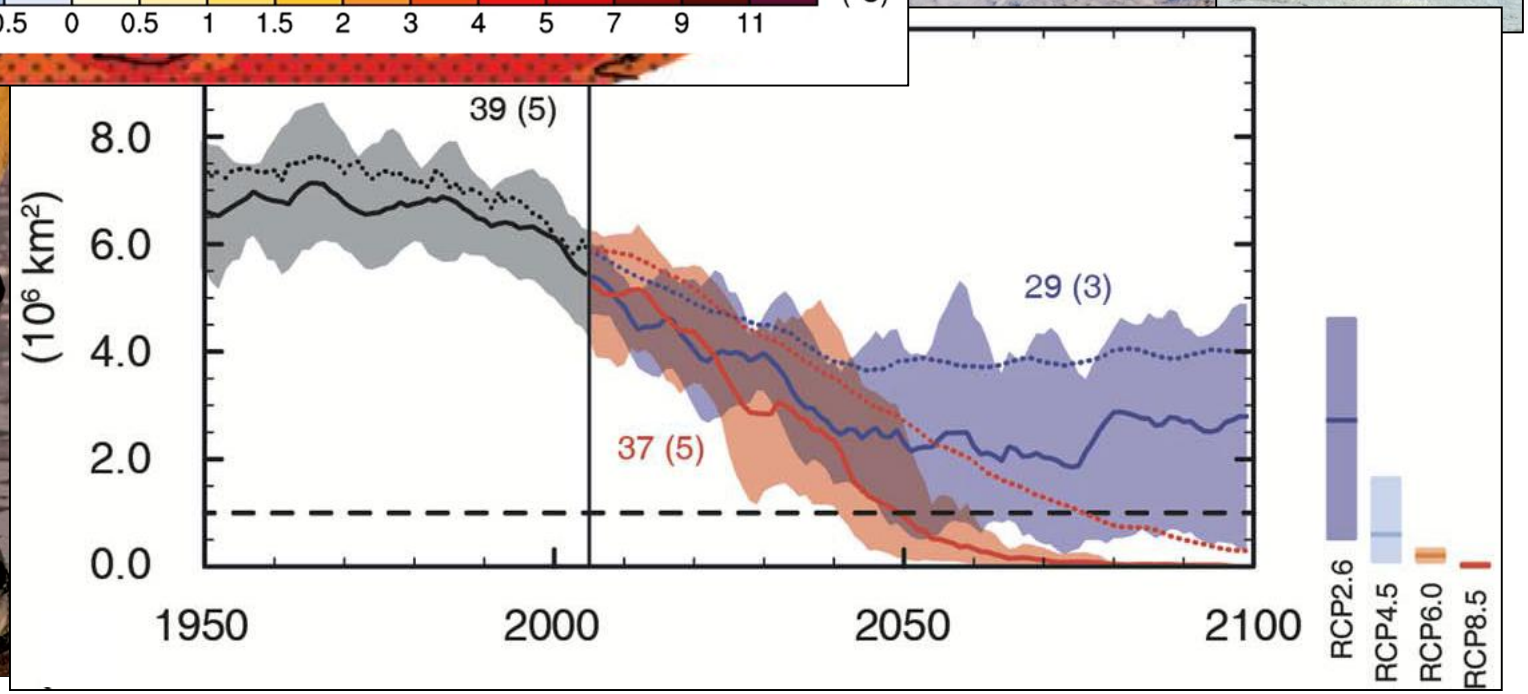
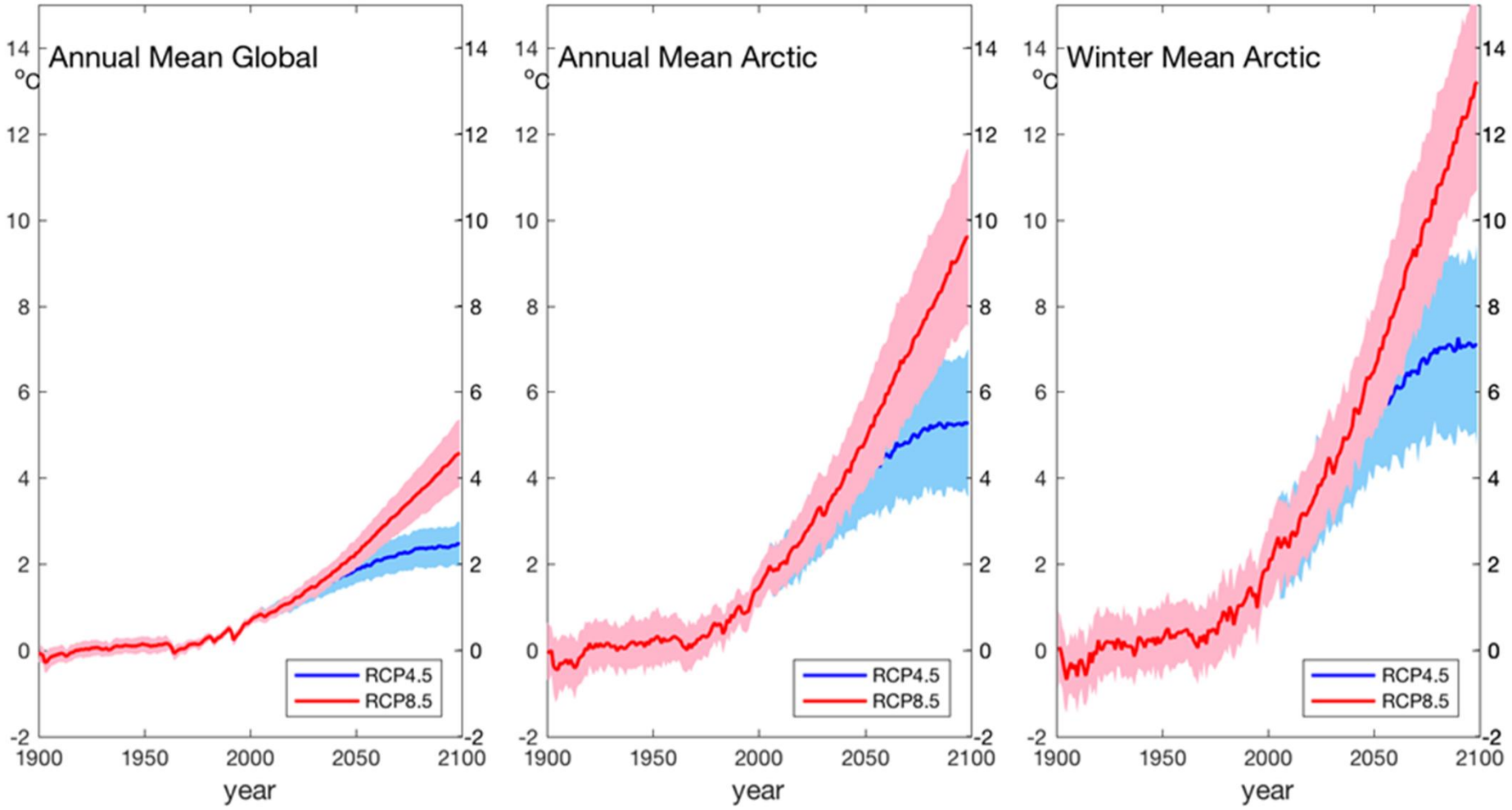
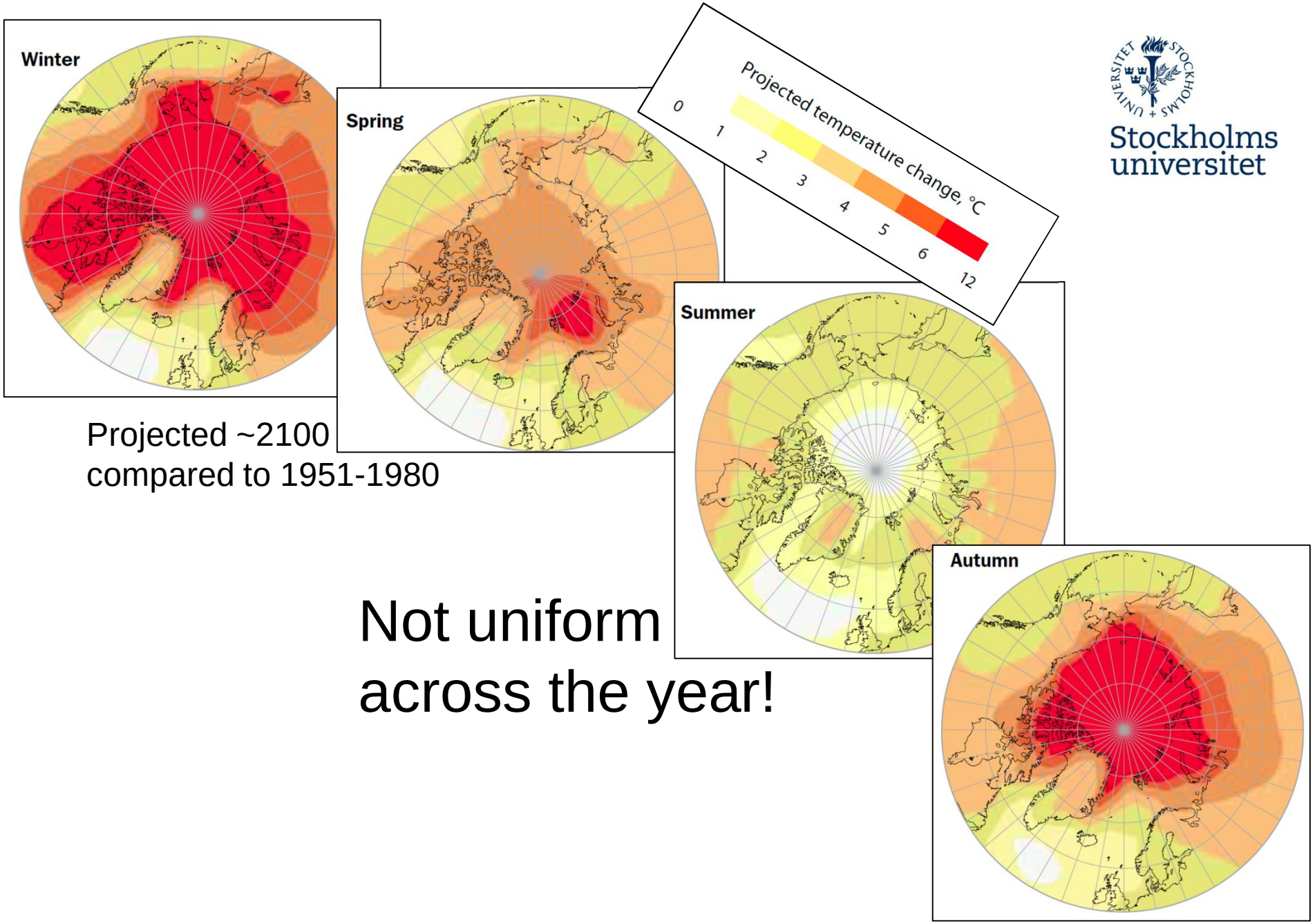


What about the future?
Temperature projections to 2100





Projected ~2100
compared to 1951-1980

Not uniform
across the year!

Uncertainty from models
Warming patterns 1957-2006

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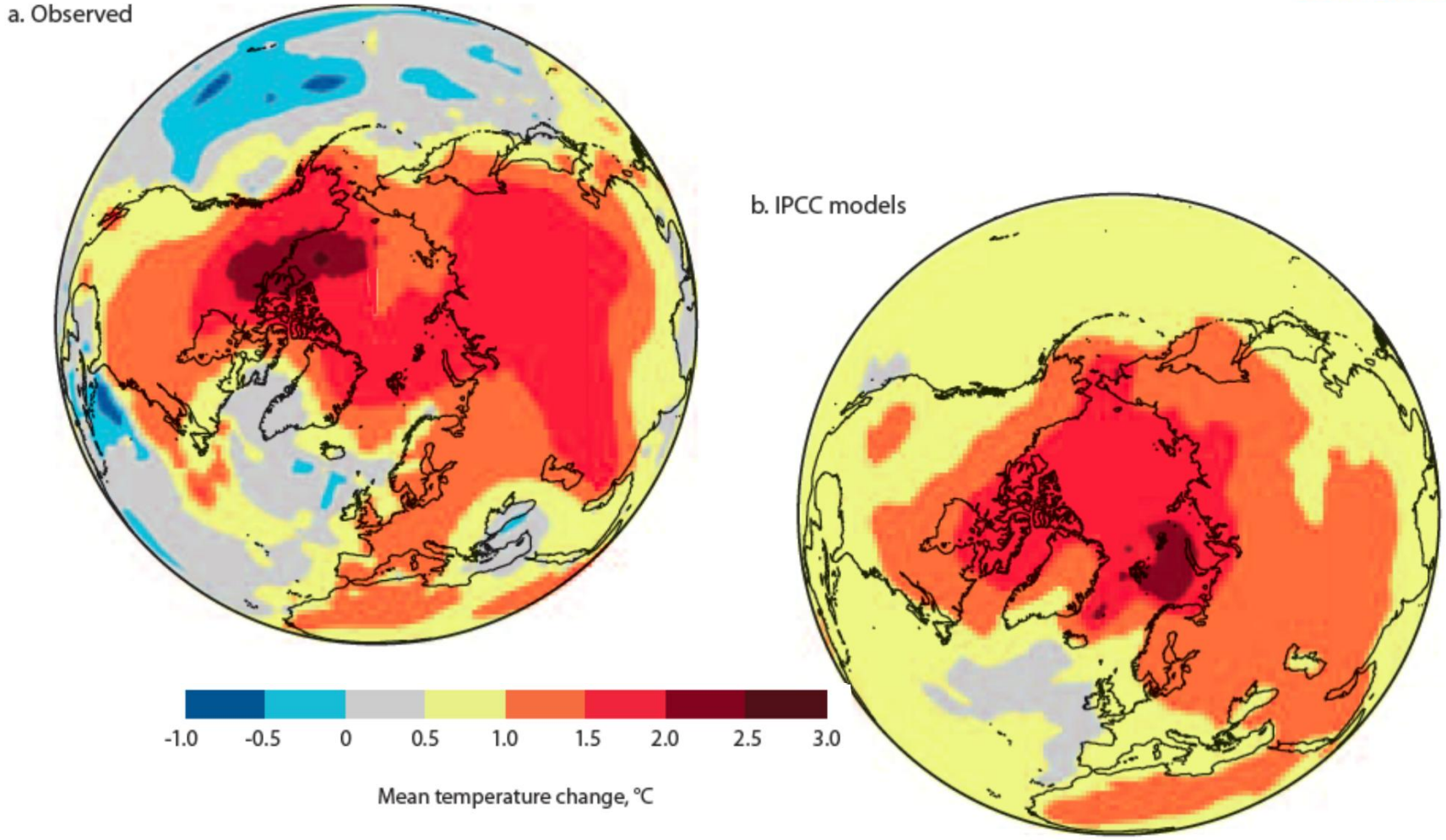
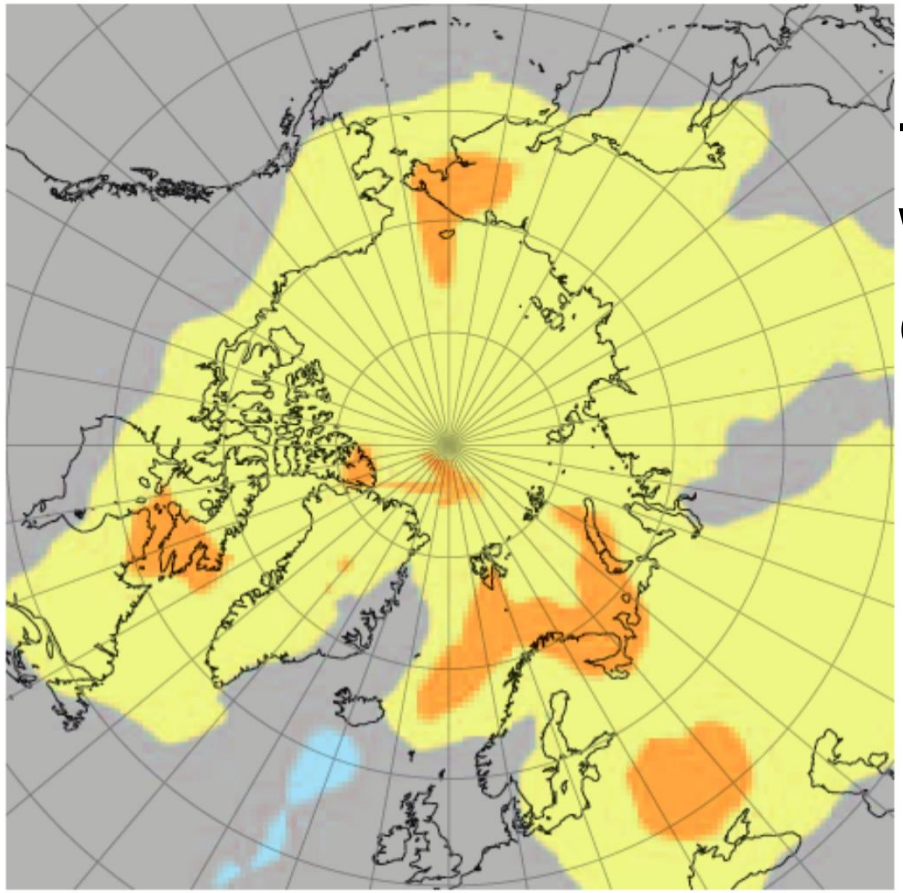


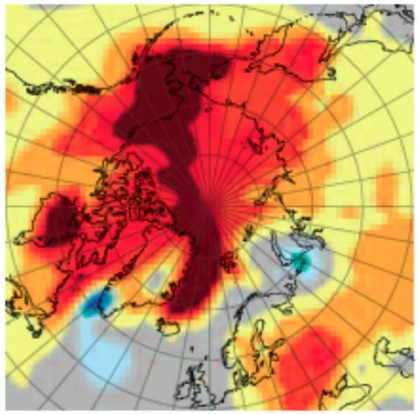
Uncertainty from models

Winter temperature change 1951-2000

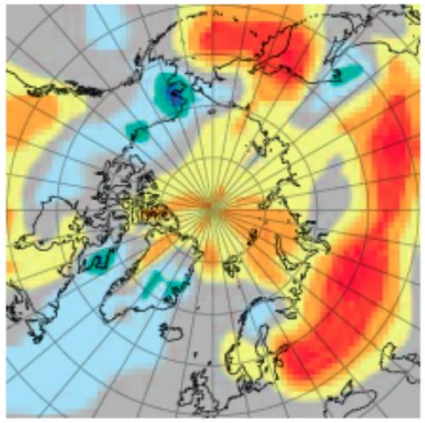
Composite, 14-GCM



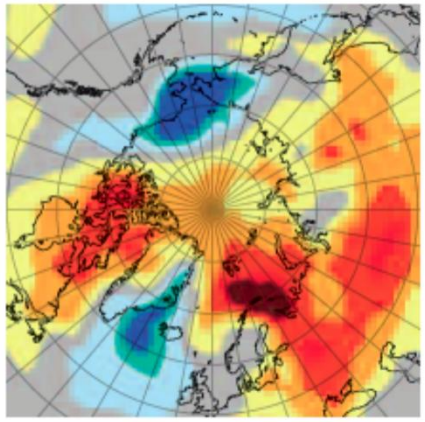
CCCMA

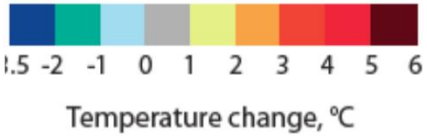


INMCM3



CNRM





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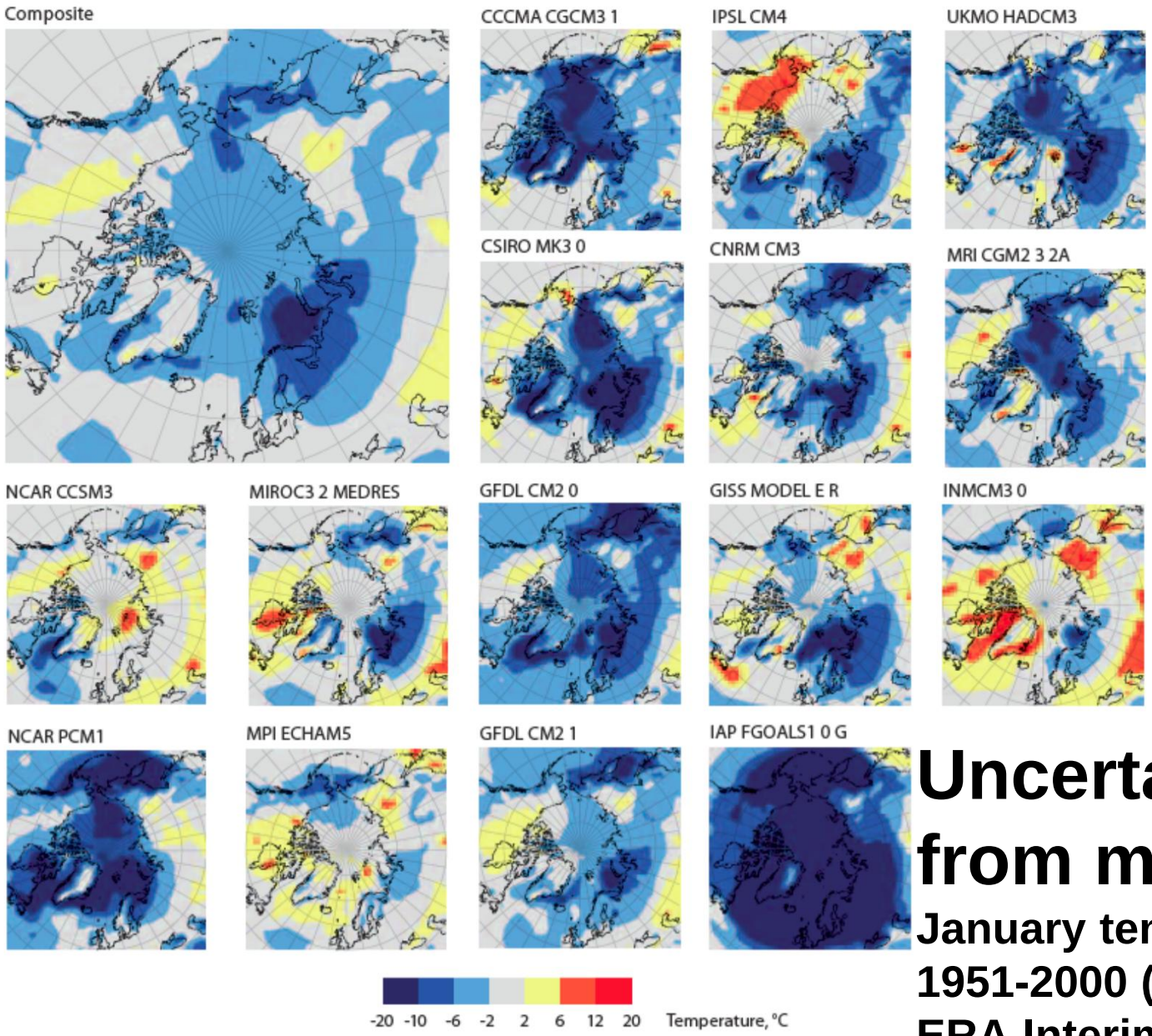

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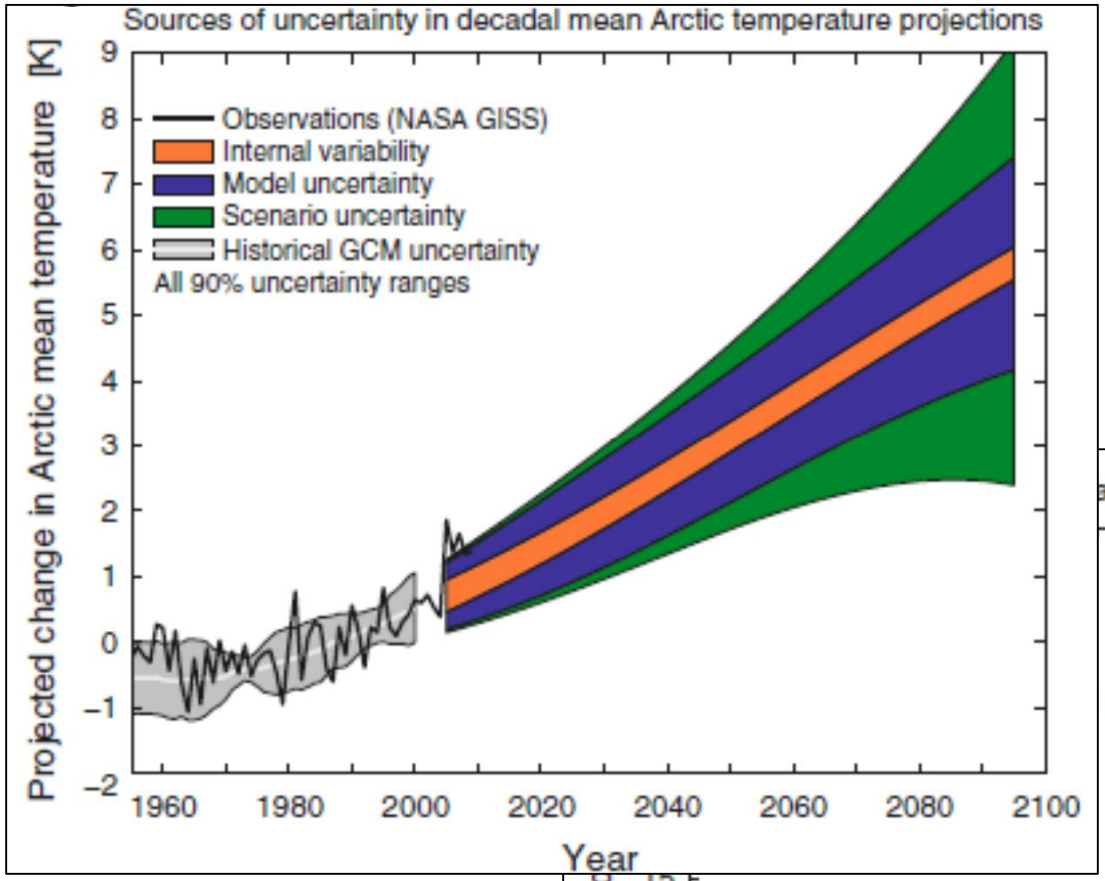
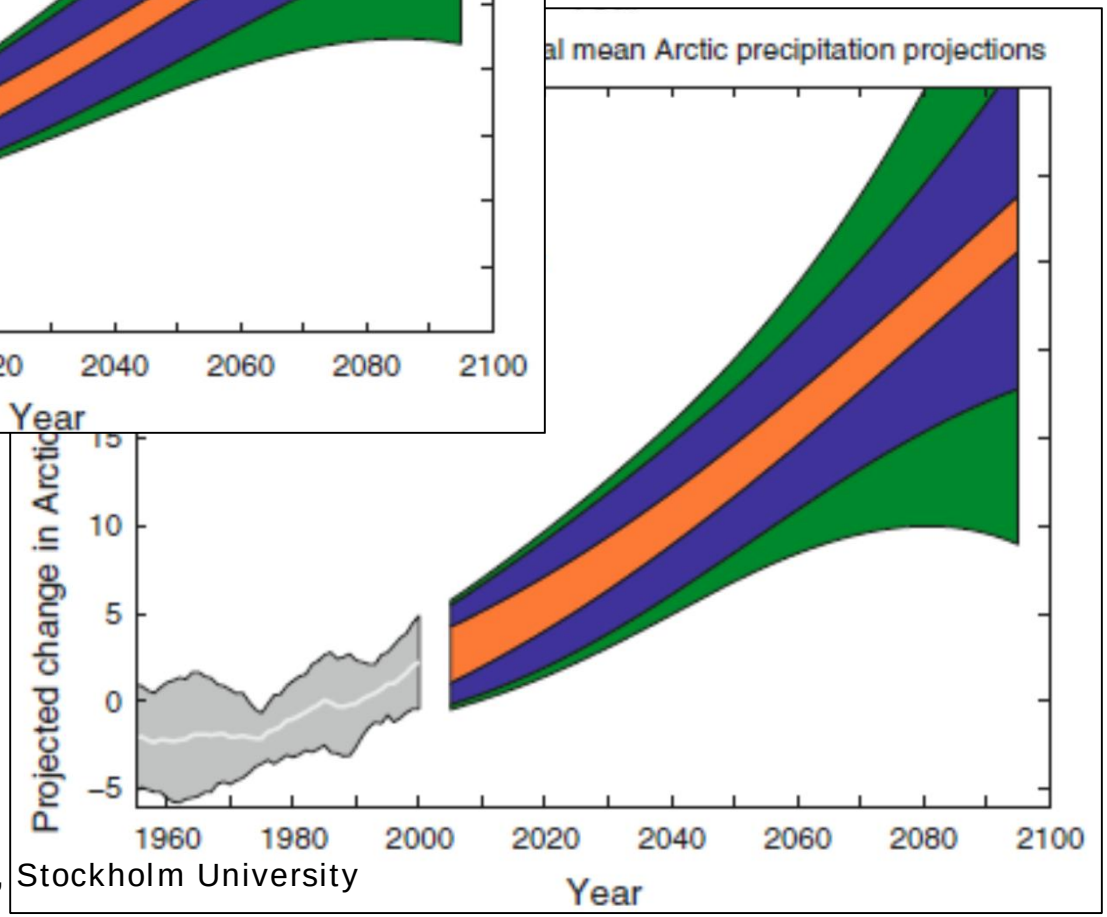
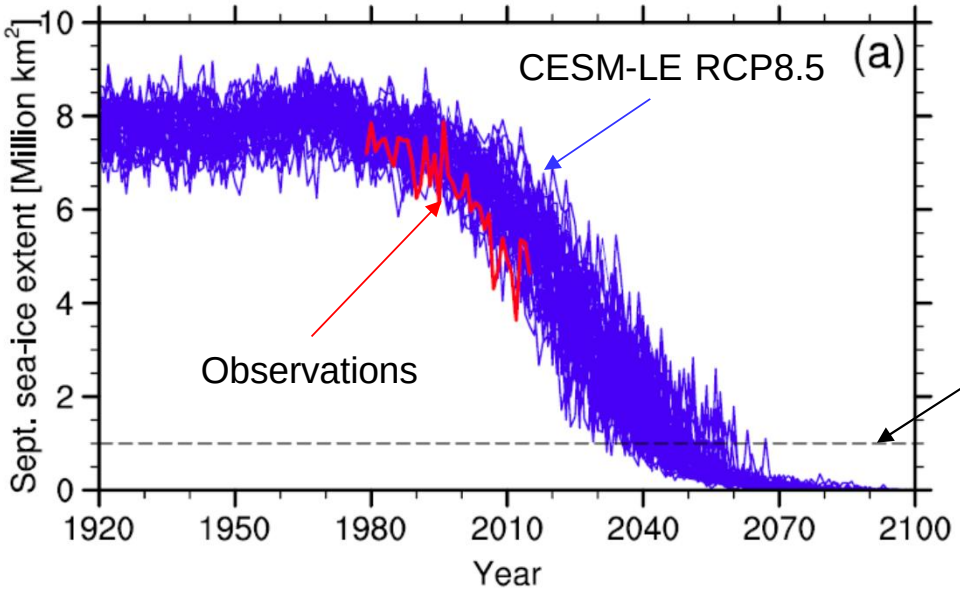
Uncertainty from models

January temperature error 1951-2000 (compared to ERA-Interim)


Sources of uncertainty in decadal mean Arctic temperature projections
Observations (NASA GISS)
Internal variability
Model uncertainty
Scenario uncertainty
Historical GCM uncertainty
All 90% uncertainty ranges
Projected change in Arctic mean temperature [K]
Year

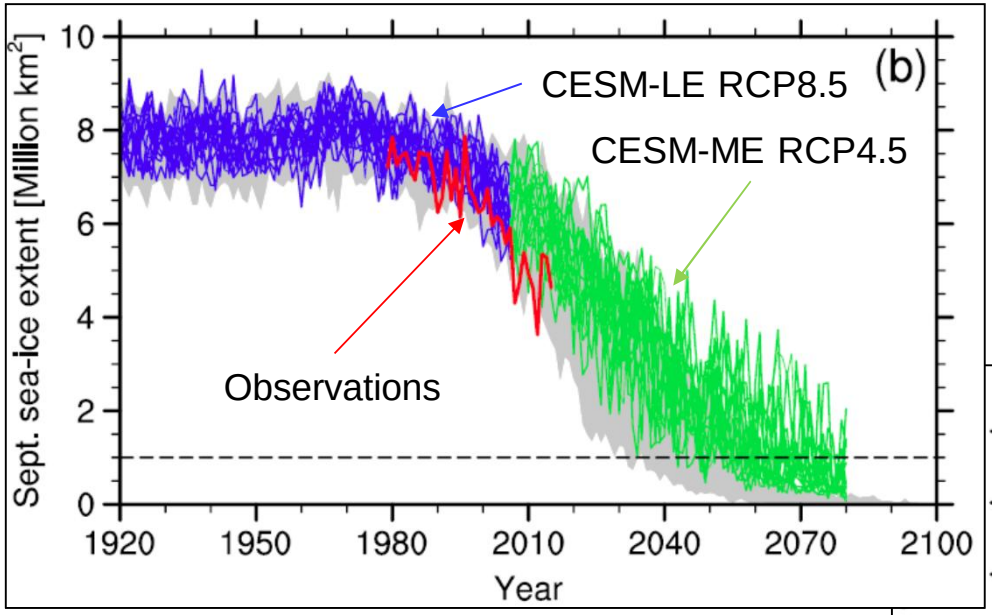

al mean Arctic precipitation projections
Projected change in Arctic
Year

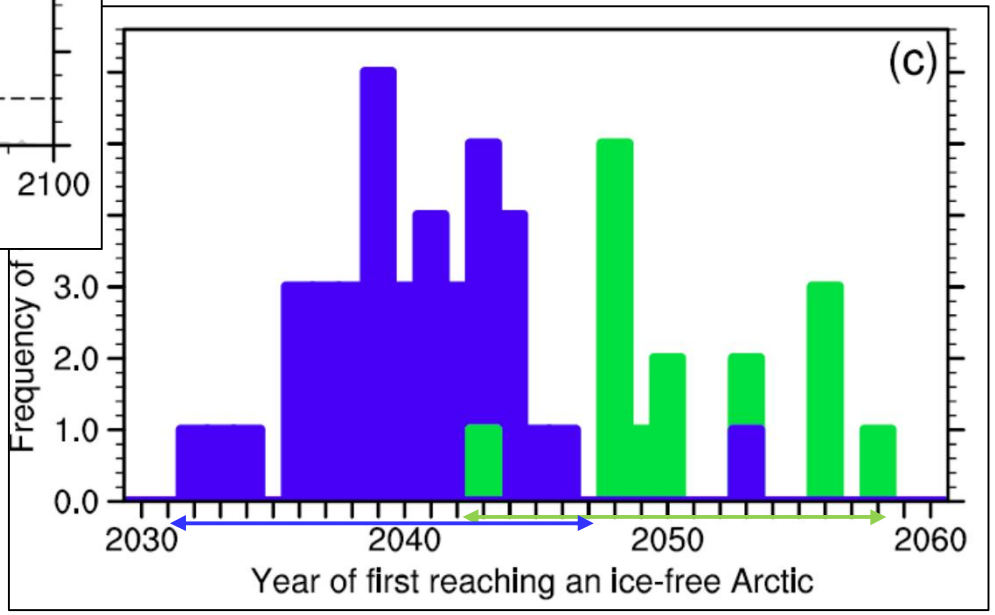
When will summer sea ice disappear?

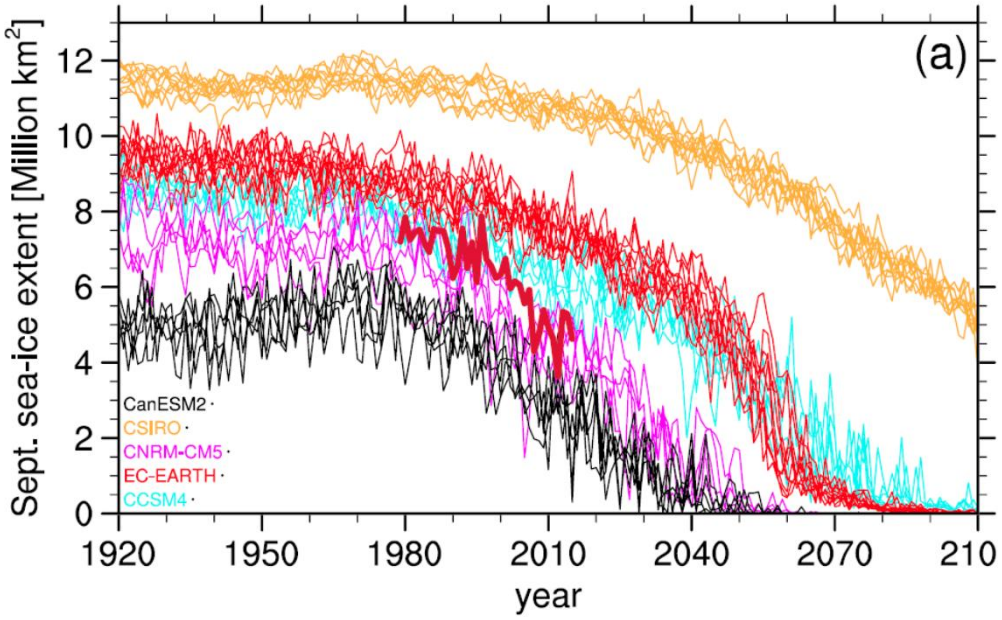


Essentially ice-free summer

When will summer sea ice disappear?







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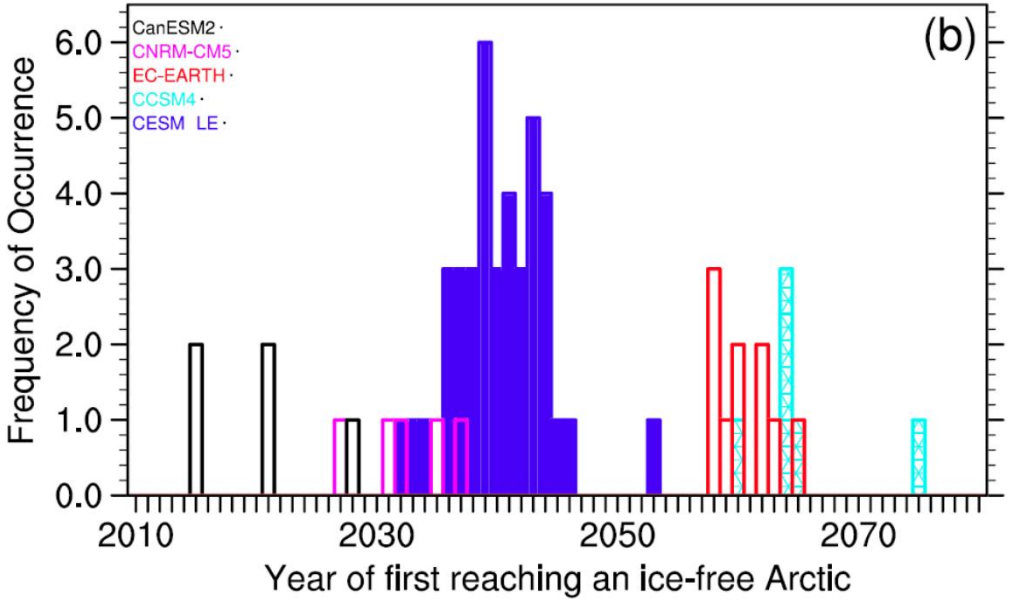
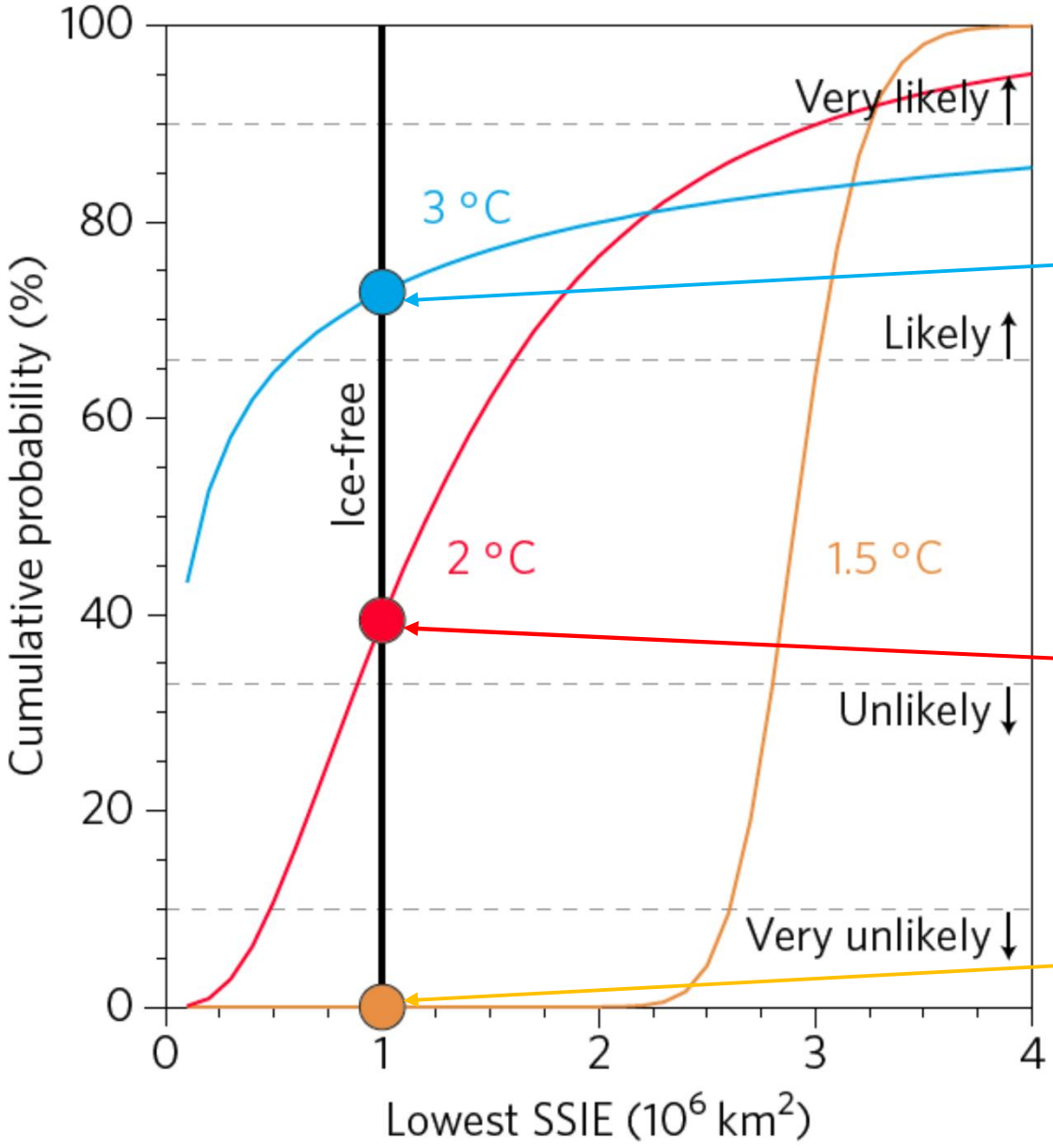


Models disagree, mostly dependent on biases in current extent…

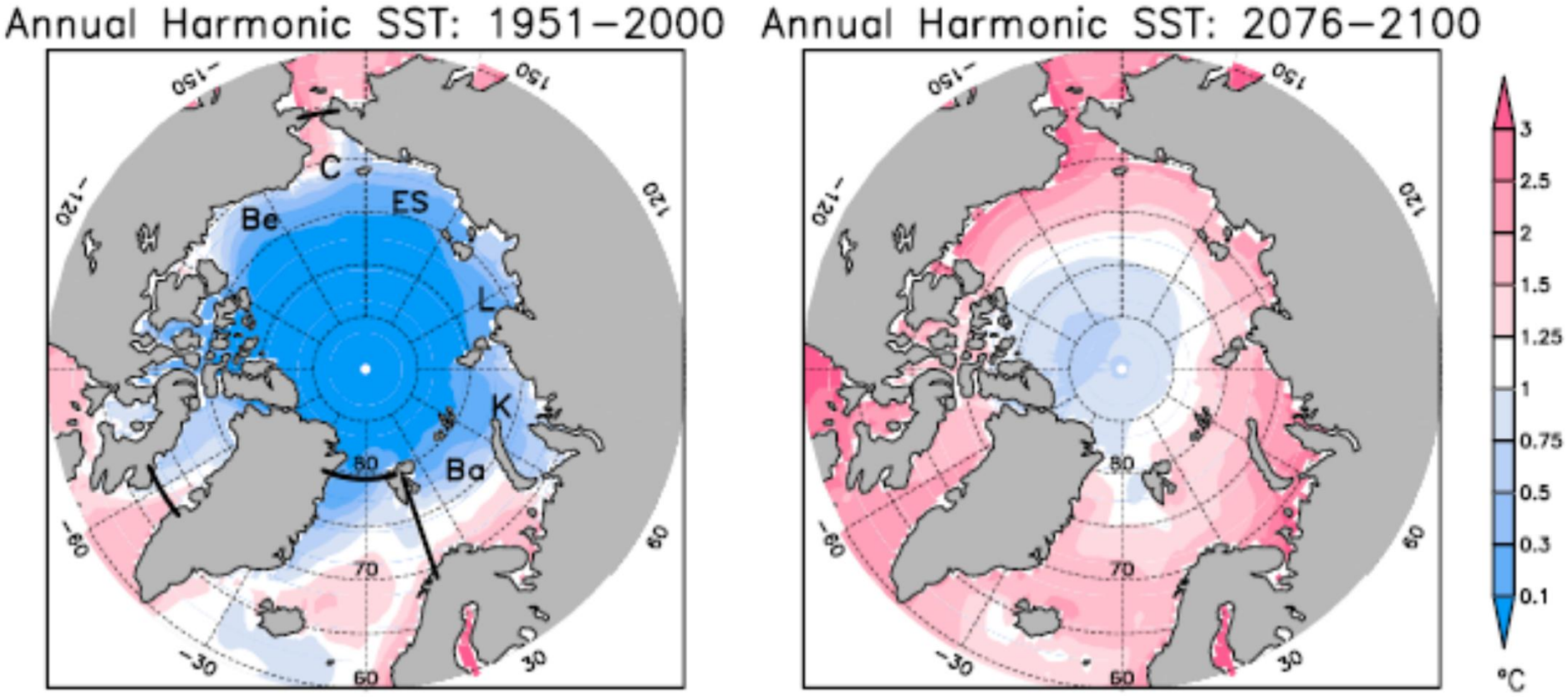


More likely than not (about 2 in 3)

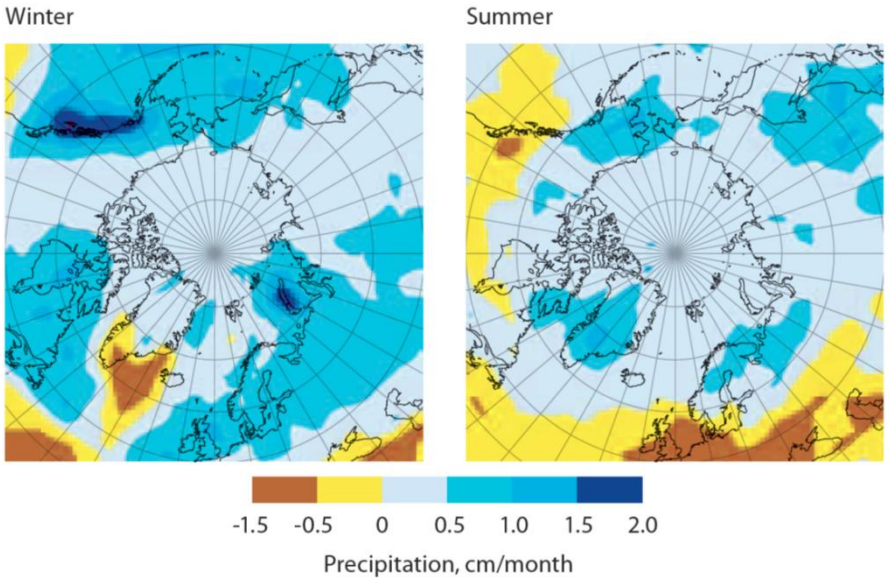
Likely (1 in 3)

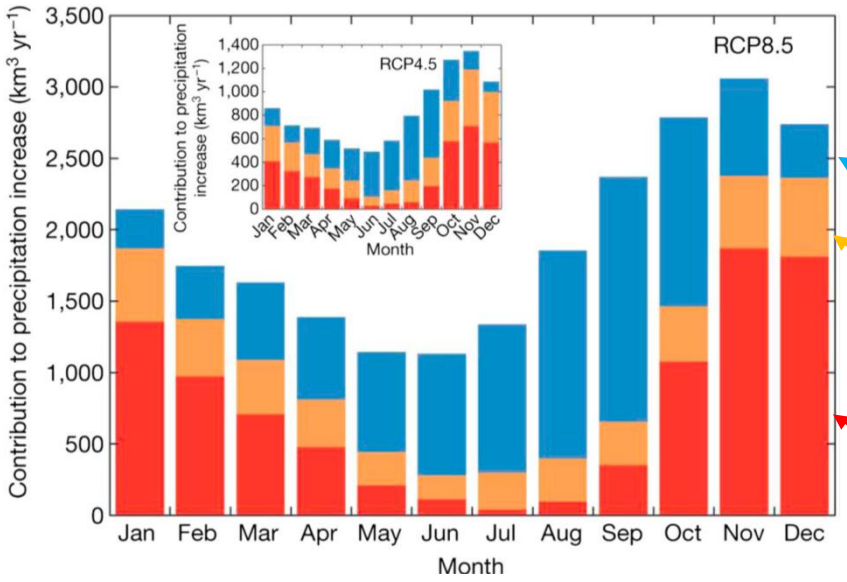
Extremely unlikely (less than 1 in 10000)

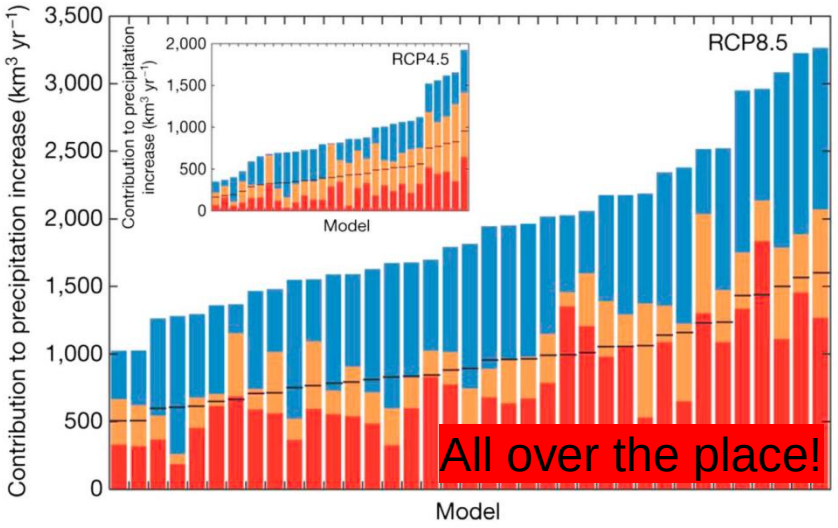
Higher summer SST in ice-free water



More precipitation







Transport in to the Arctic

Evaporation unrelated to sea-ice reduction

Evaporation from reduced sea-ice

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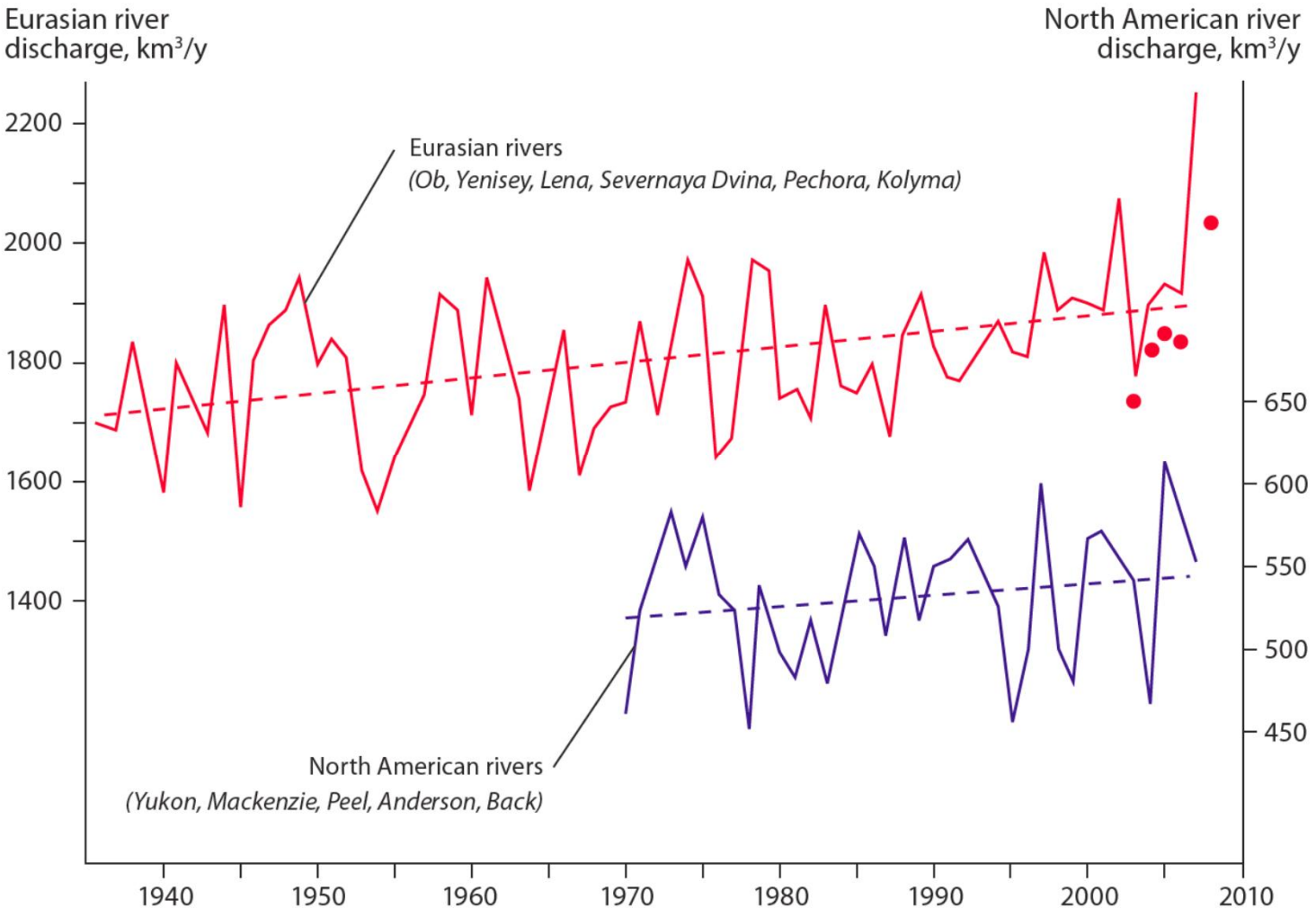
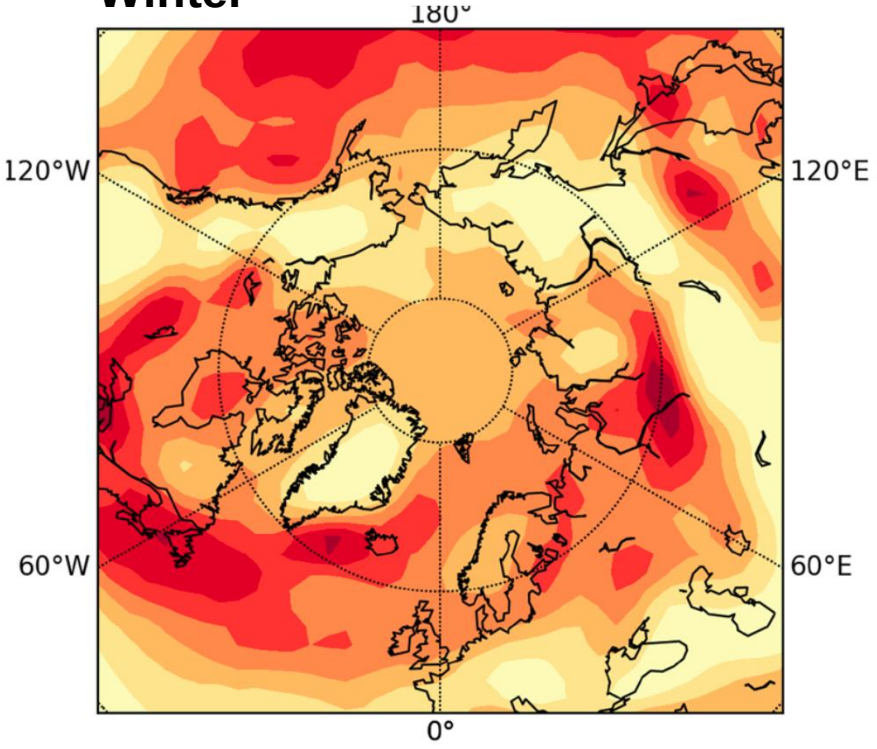


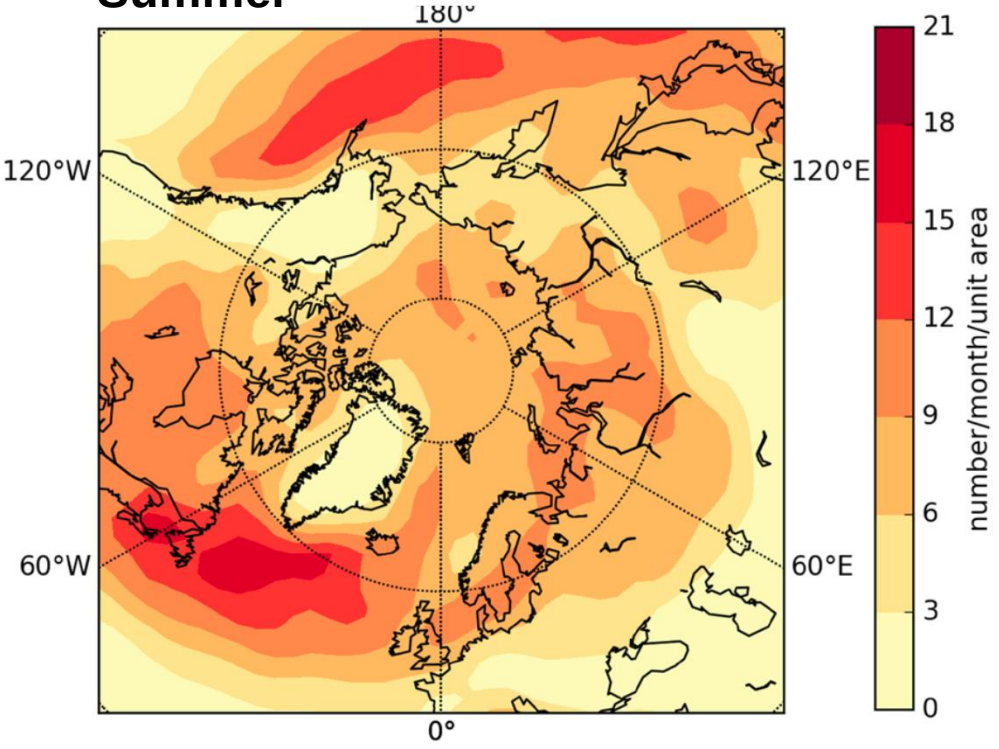
Effects on storms

Today

Winter

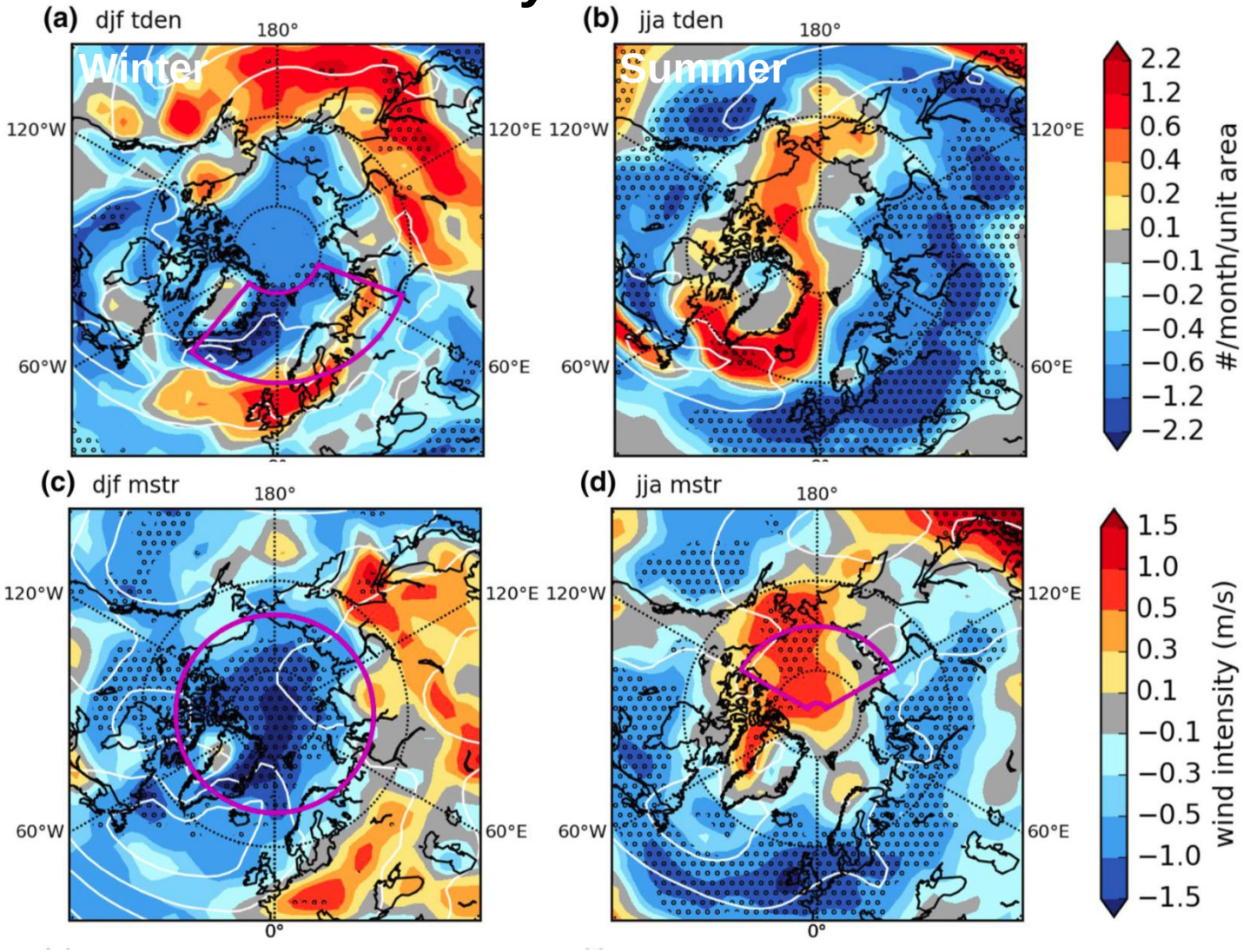


Summer



Effects on storms

End of the century



Some parting thoughs

- Climate change in the Arctic is faster and stronger than for the Earth as an average
- Temperature rises by a factor of 2-4 faster than globally
- Sea ice is disappearing in all seasons, most in summer and volume goes away faster than area

- Arctic climate change will continue to be large and fast and warming can be as large as 8-12 °C without mitigation
- Summer sea ice will at the current rate be gone by mid-century, but some may remain with mitigation keeping global warming < 2°C

- The predictive skill for Arctic climate is quite poor, mostly due to poor descriptions of processes in models
- Models agree on sign but disagree on both sensitivity of and location for change
- Only the broadest brush-strokes can be used


Thanks for the attention!