Worrying about Snow

Ed B-W, UW, Seattle
with CC Bitz

Thanks to NCAR (Jen Kay, PCWG)

or investigating the influence that snow on sea ice has on predictability (and sea ice mean state/trends)

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with Cecilia M. Bitz

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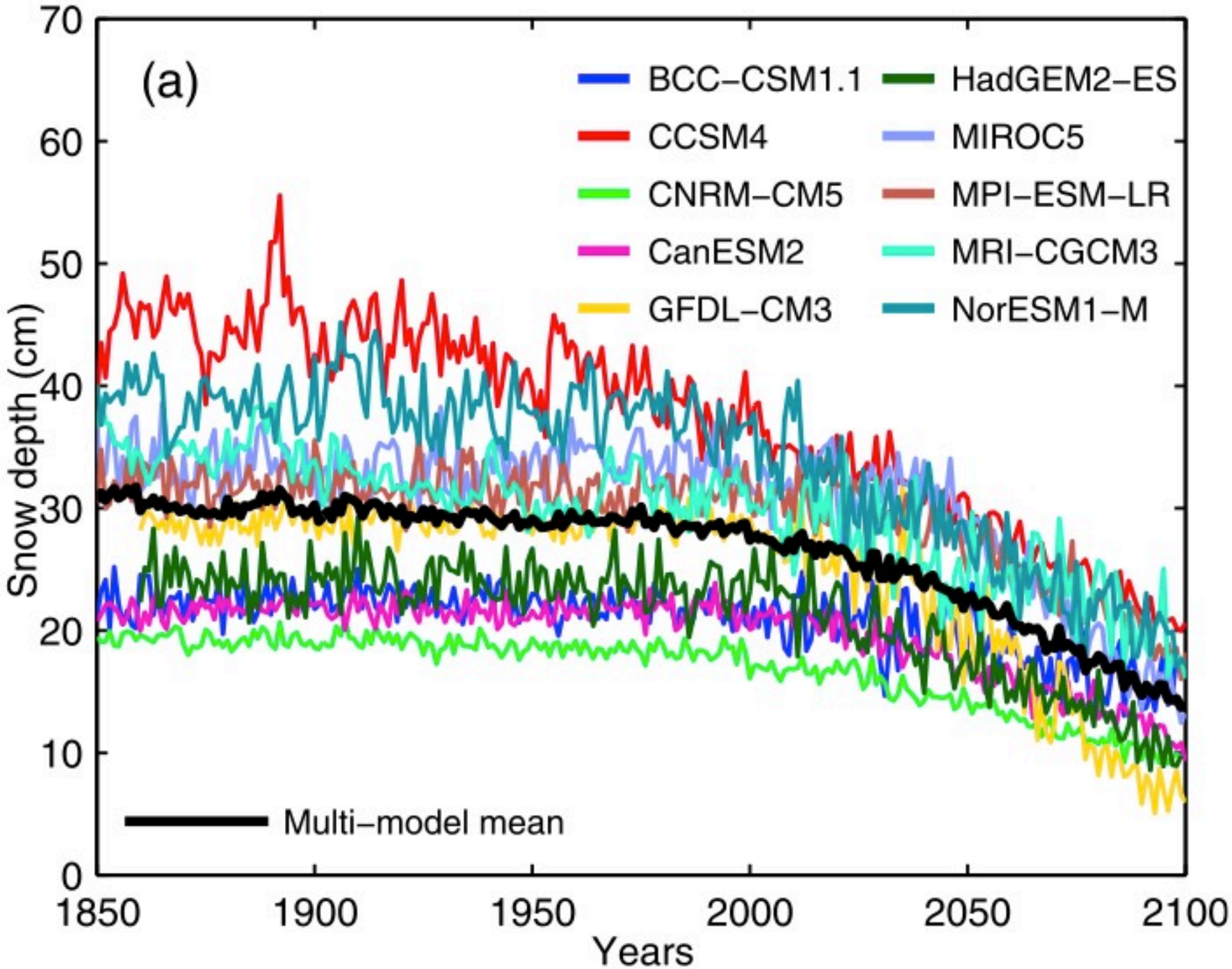
- CCSM4 has a positive bias in snow depth (both relative to CMIP5 and observations)



April Arctic snow depth from Hezel et al (2012)

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Observations:

Very limited: Russian drift stations (old), Warren climatology (old)

about ~25-30cm in spring.

Notz and Farrell 2011 (Icebridge)

33cm over MultiYear ice - 16cm over FirstYear ice in April

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Using ice age trends (e.g. Maslanik), decrease of MY from 80% to 50% in satellite era.
Could imply decrease in snow from 30cm to 24cm
without enhanced spring melt.

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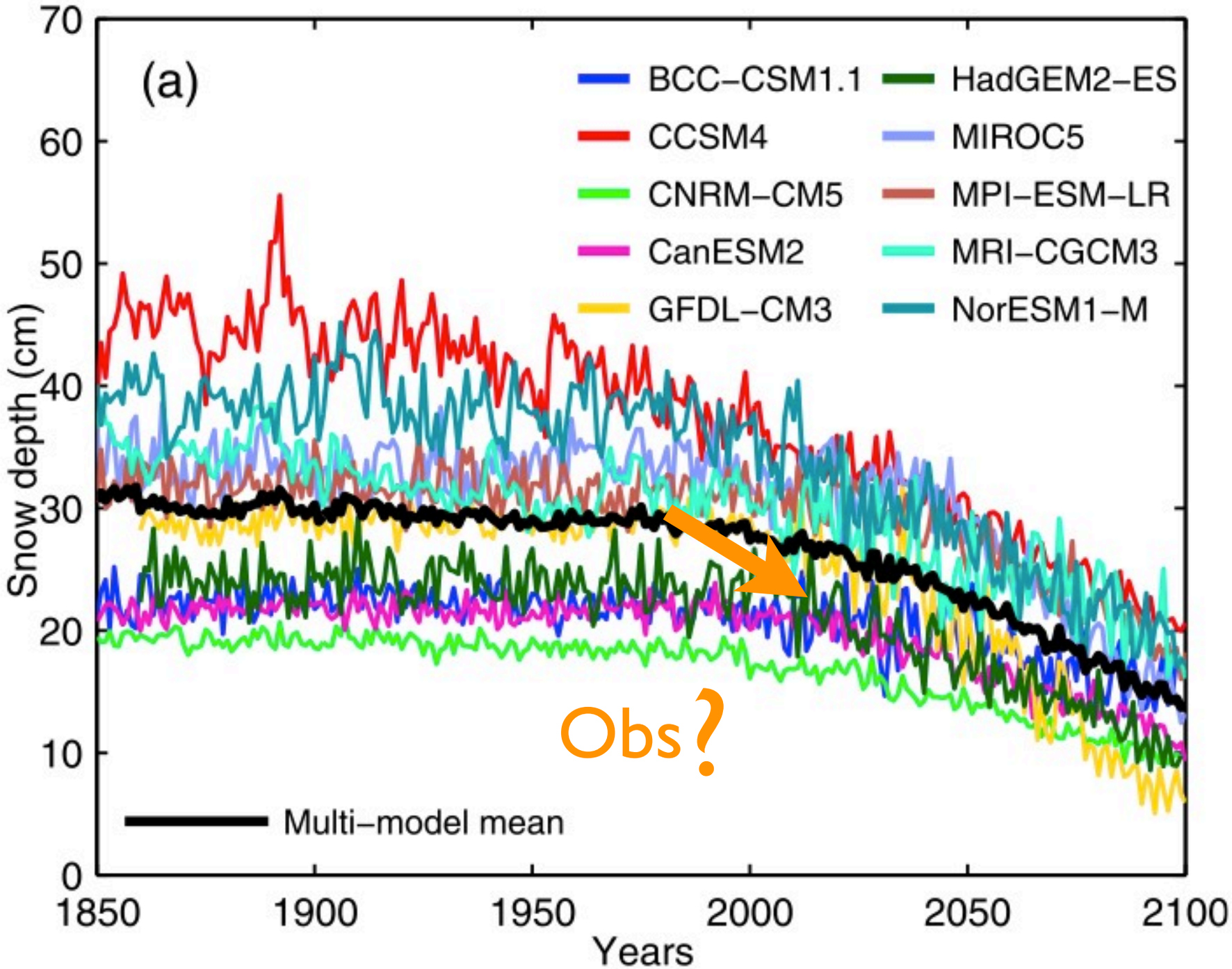

April Arctic snow depth from Hezel et al (2012)

Snow on sea ice matters.

- Relevant to melt season length, albedo changes that affect end-of-summer sea ice cover
-Associated with enhanced loss of predictability in early summer

... how do biases in spring snow depth affect predictability?
Can you gain insight on snow/sea ice sensitivity?

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... how do biases in spring snow depth affect predictability?
Can you gain insight on snow/sea ice sensitivity?

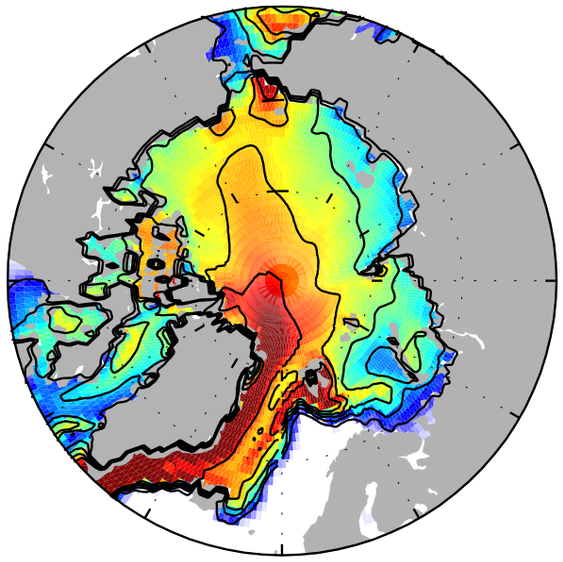
Experiment set-up:

Control: ensemble of simulations from May 1 - Oct 1 in fully coupled CCSM4, branched off from 20C historical 1deg runs (ICs picked out of period 2000-2005).

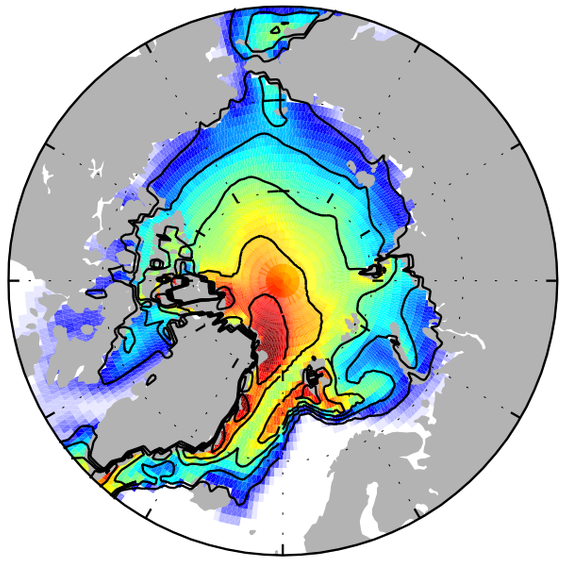
Experiment: As control, but with 1/5th of snow cover on May 1 everywhere on sea ice.

6 ensembles of each, 20 runs in each ensemble.

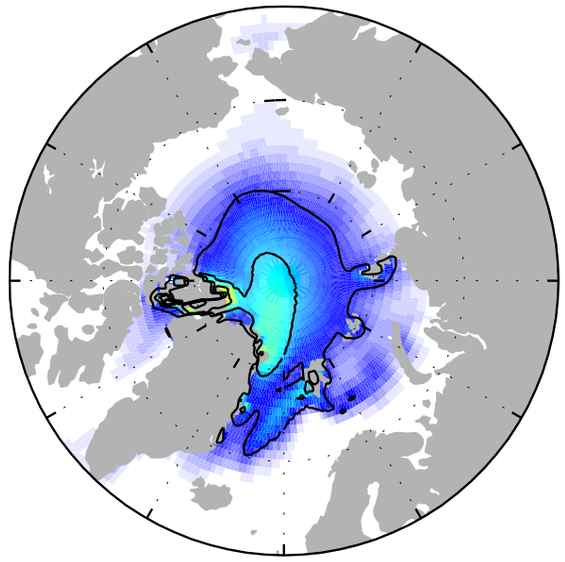
May



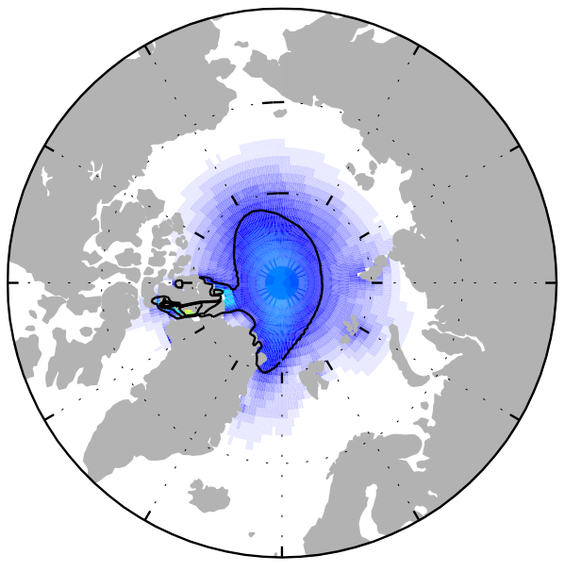
Jun



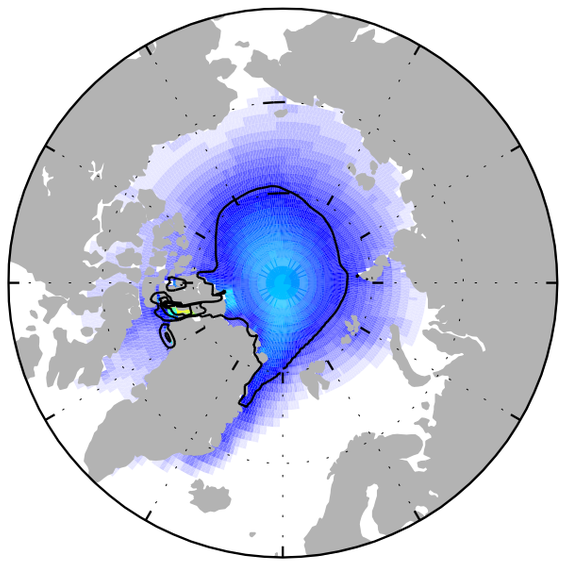
Jul



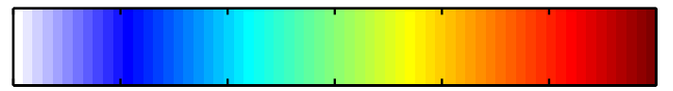
Aug



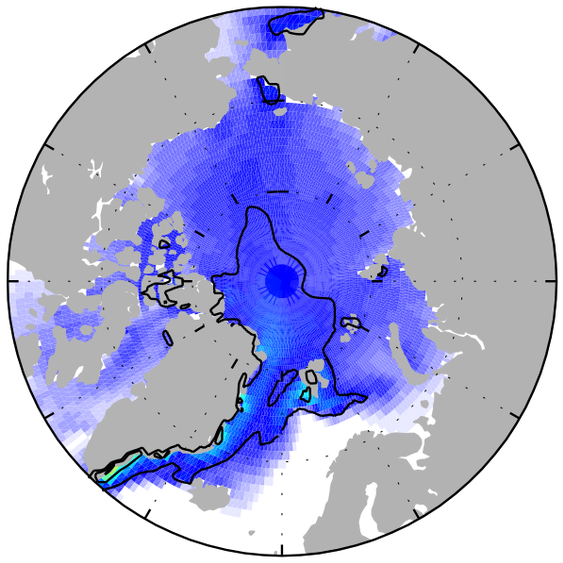
Sep



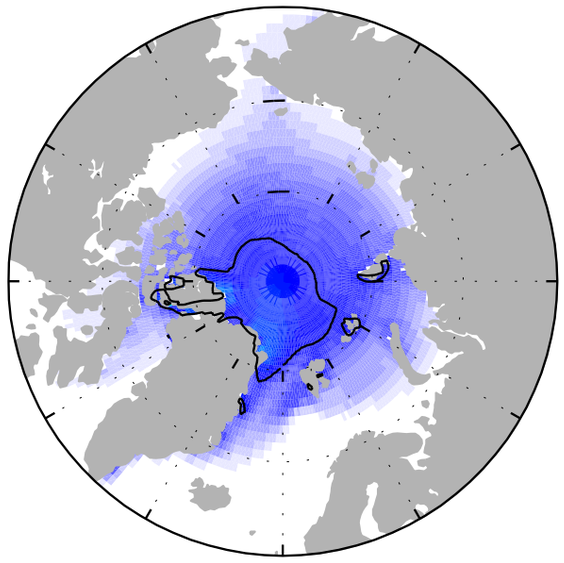
Control snow depth (cm)



May



Jun



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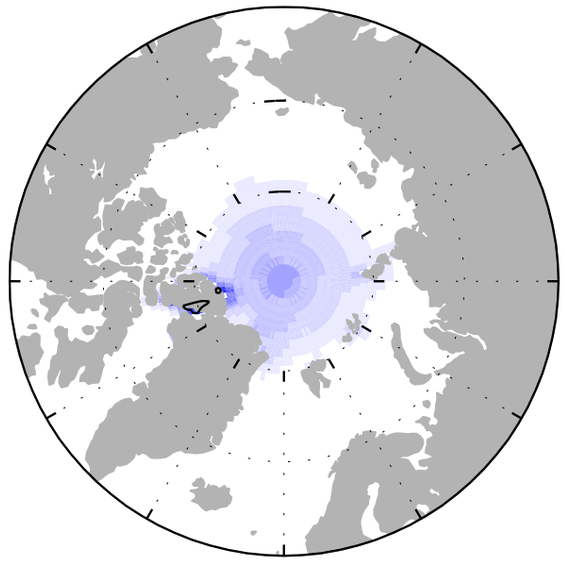

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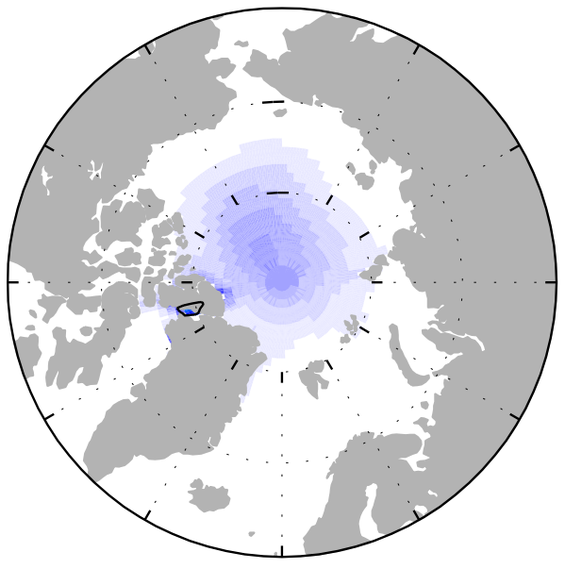
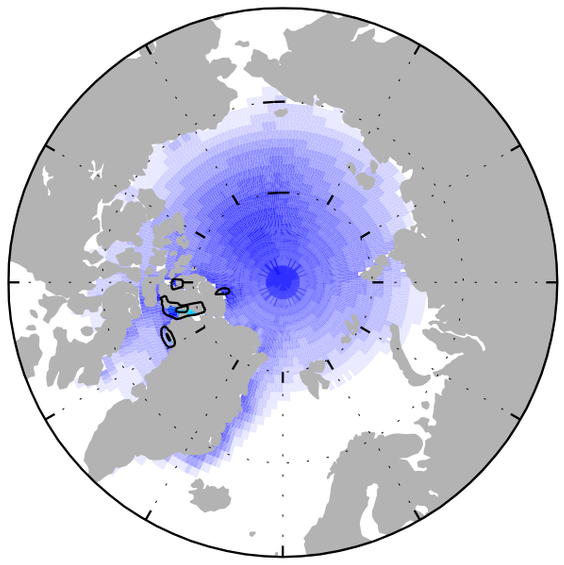
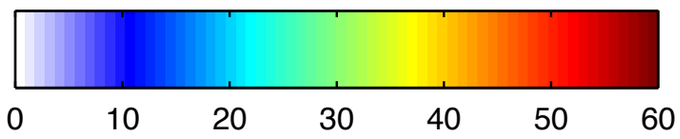


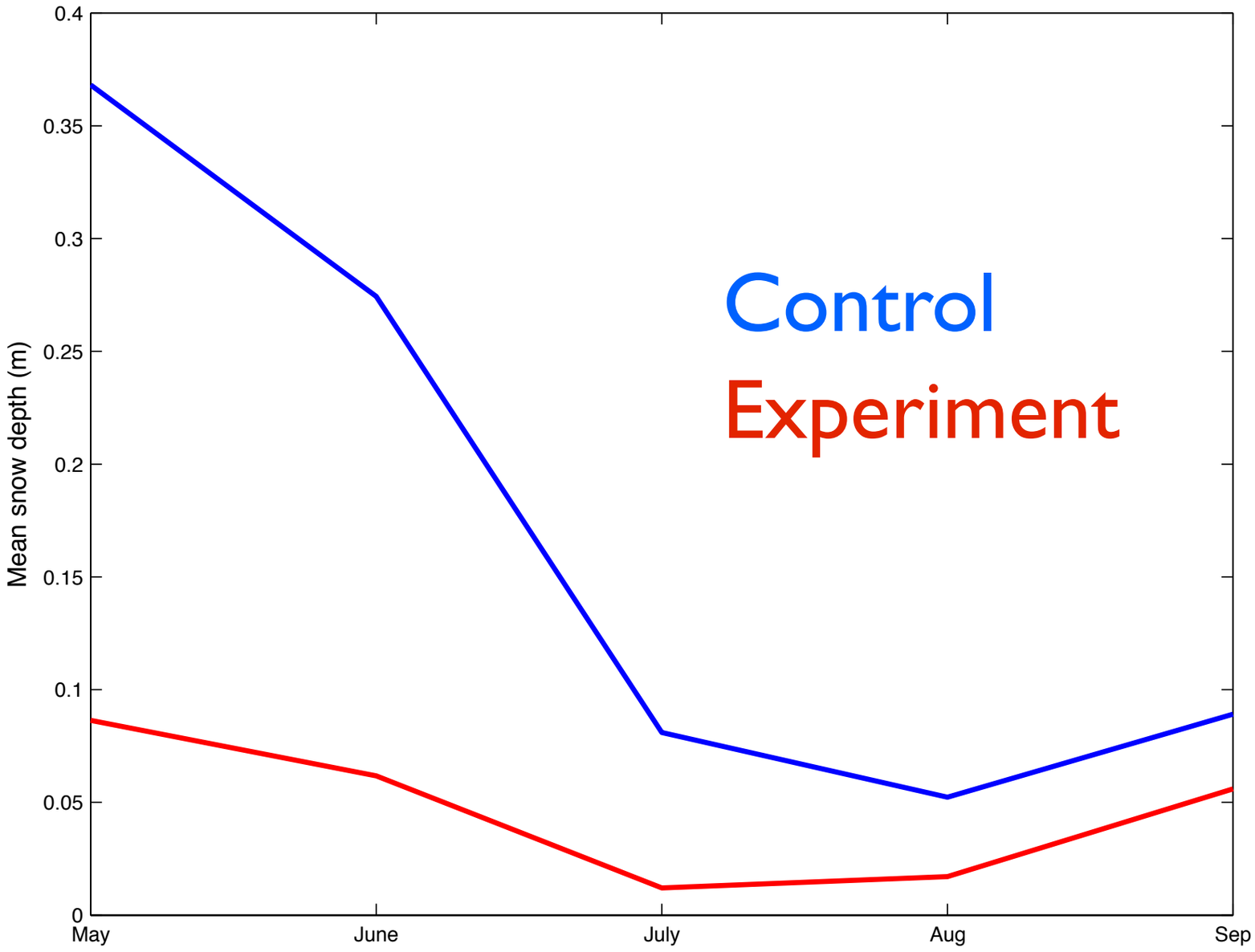
Sep



Experiment snow depth (cm)

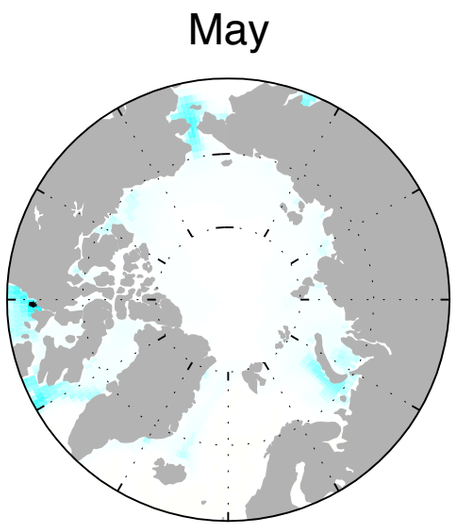


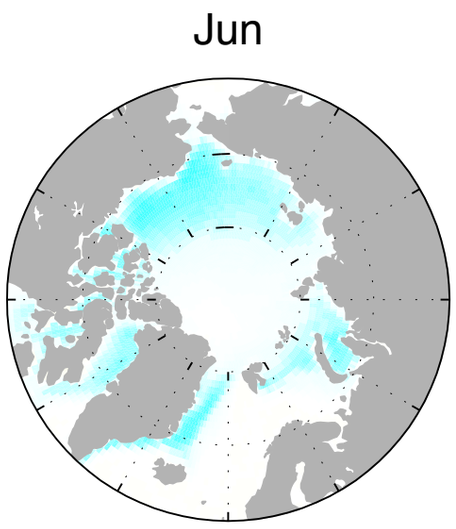
Despite shallow May 1 snow cover... still have summer snow! Modest changes in surface albedo

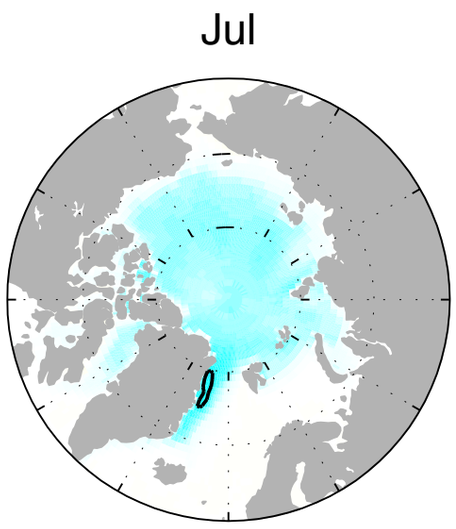


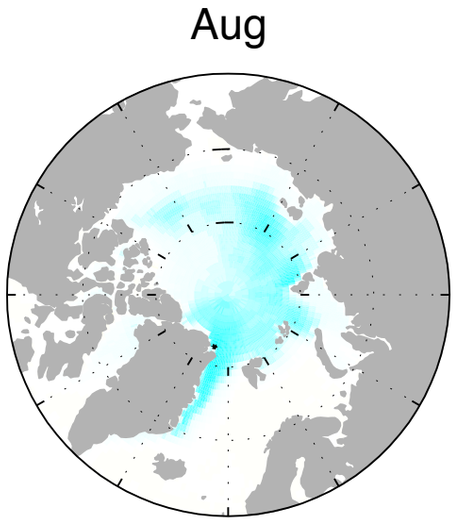
It’s not that melt rates magically reduce drastically... but summer snow storms!

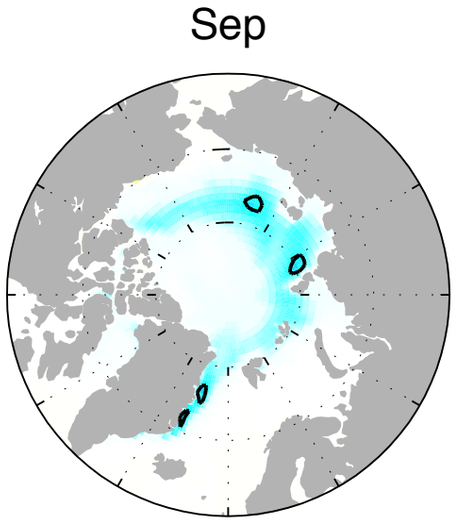
Despite shallow May 1 snow cover... still hard to melt all the snow! Modest changes in surface albedo

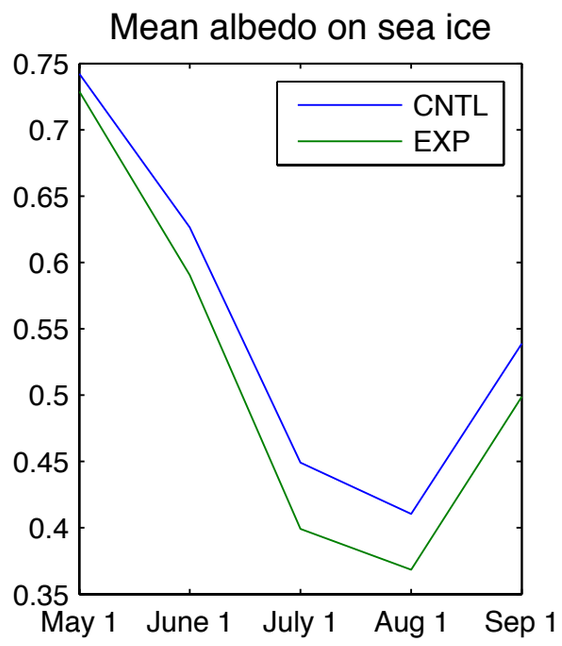


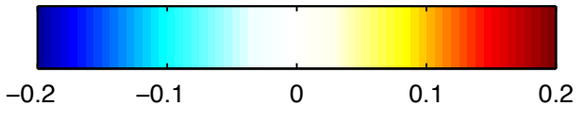






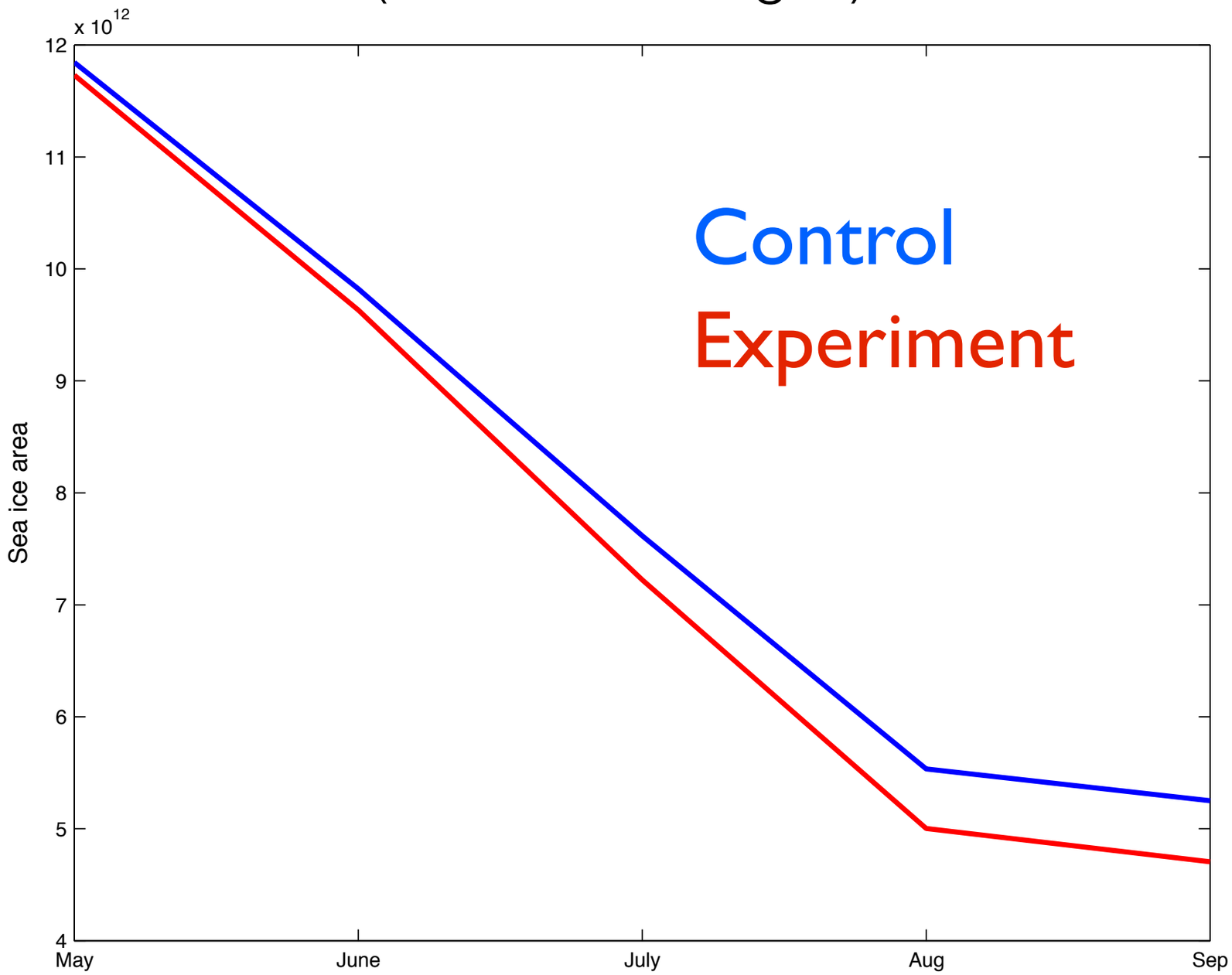






Experiment – control albedo difference

Despite shallow May 1 snow cover... still hard to melt all the snow! Modest changes in surface albedo ... but significant effect on sea ice area (transient though!!)



On predictability

Two approaches to study predictability (using numerical models):

- ‘Perfect Model’

- ‘Operational hindcast/forecast’

Perfect Model:

Upper limit of predictability in a model

‘Perfect’ initial conditions

‘Perfect’ physics

Operational:

Use model to forecast an observed outcome.

Predictability affected by imperfect initial conditions, physics.

On predictability

Two approaches to study predictability (using numerical models):

- ‘Perfect Model’

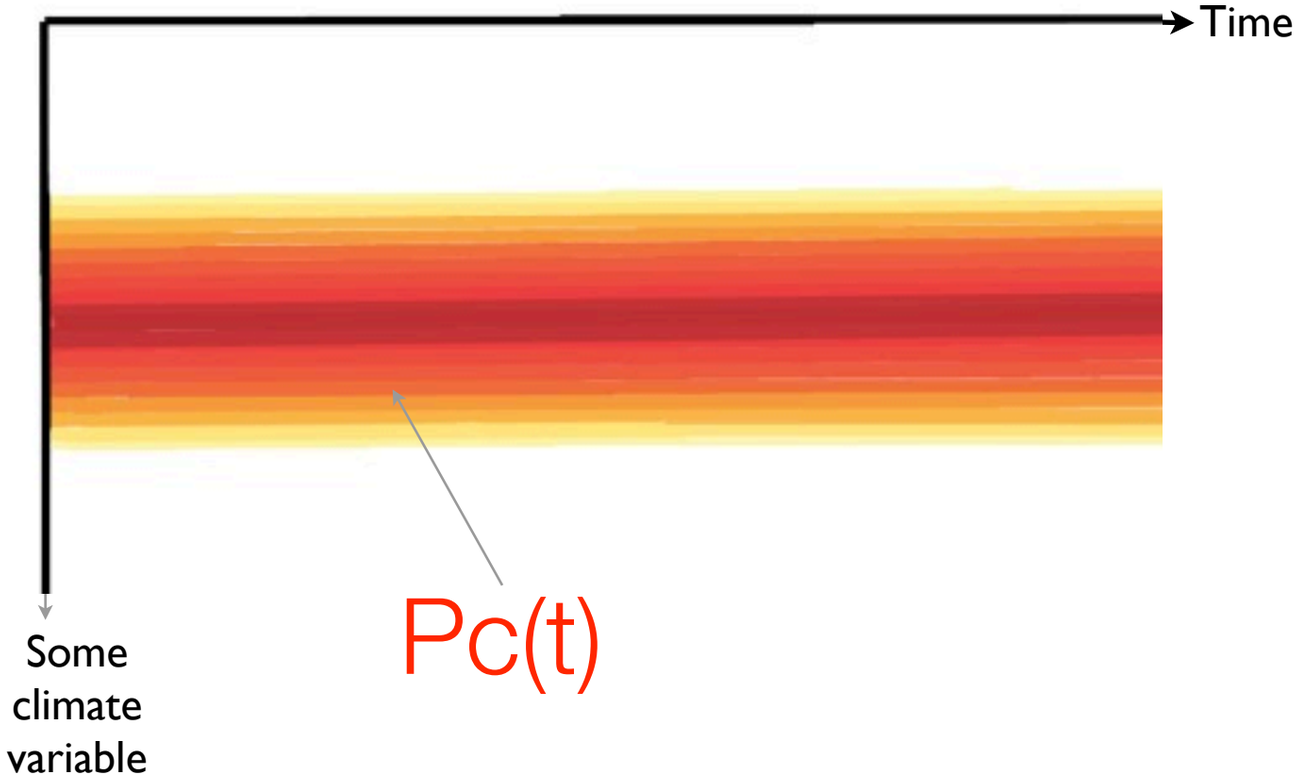
- ‘Operational hindcast/forecast’

perfect model and operational predictability can be pretty different...

In CCSM4 perfect model predictability of September sea ice area from May 1 initialization significantly greater than predictability in 1979-2012 hindcast

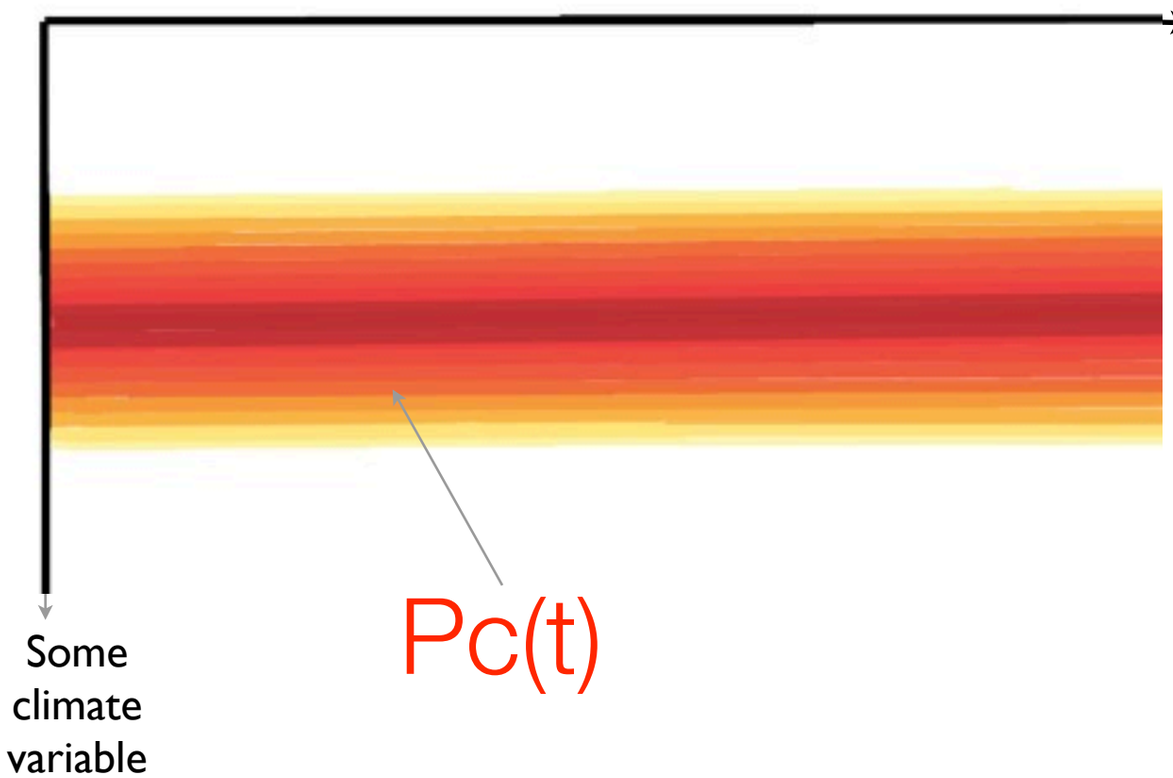
How can we bridge ‘gap’ between the two?
initial conditions? physics? both?

On predictability



- Pc(t) represents the background distribution. It is independent of any particular initial state.

On predictability



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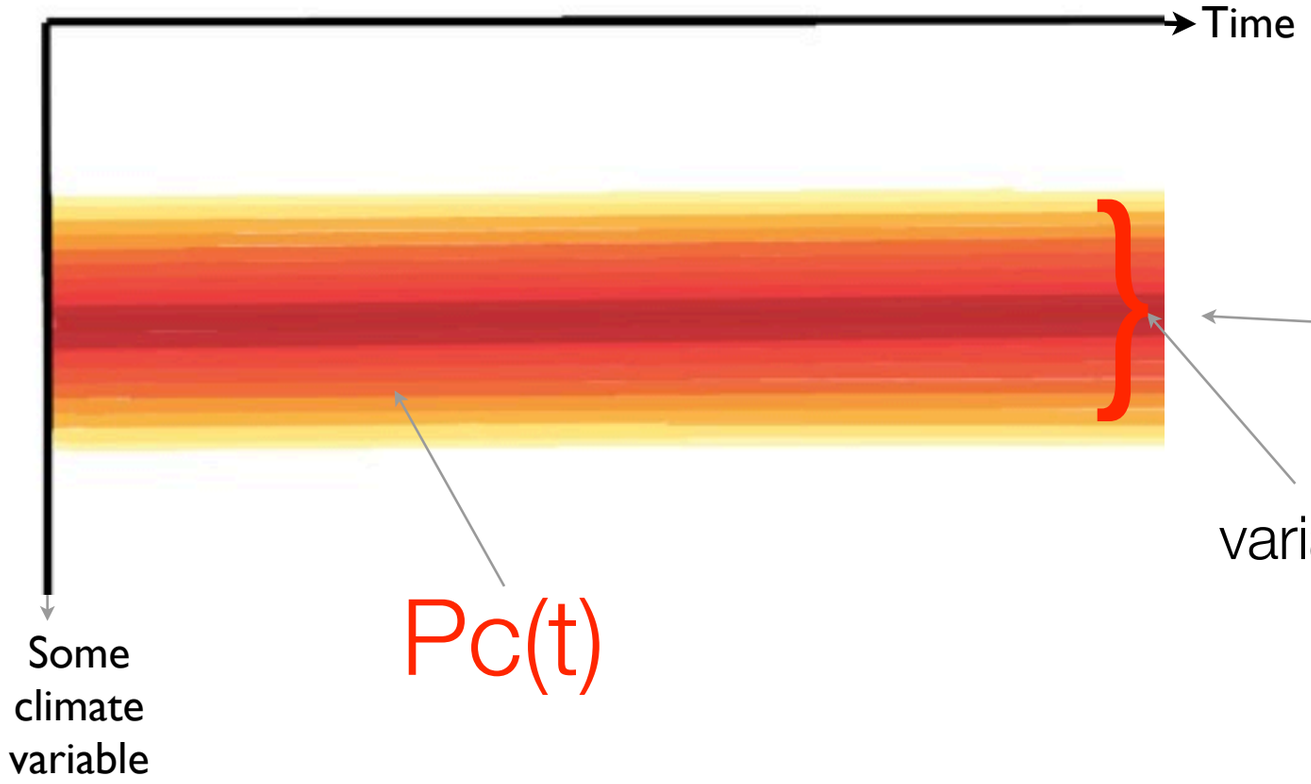
mean

On predictability



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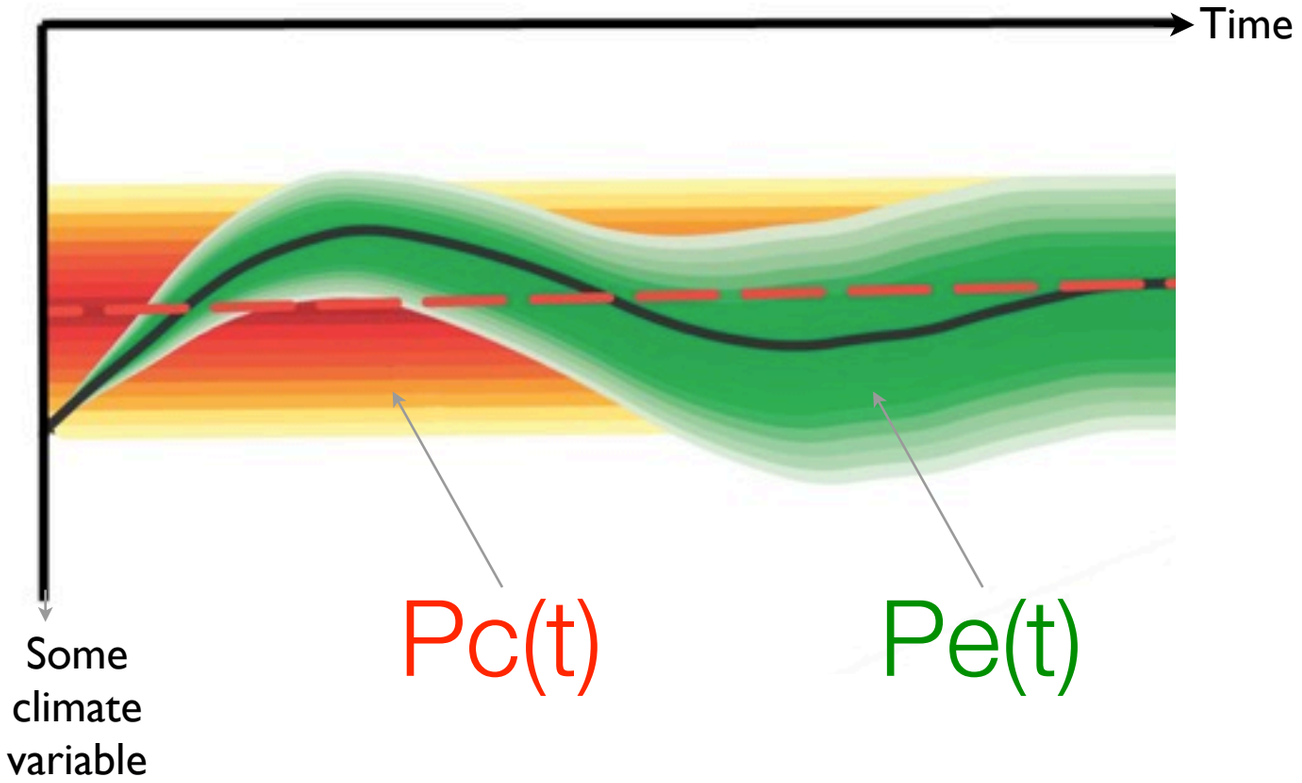

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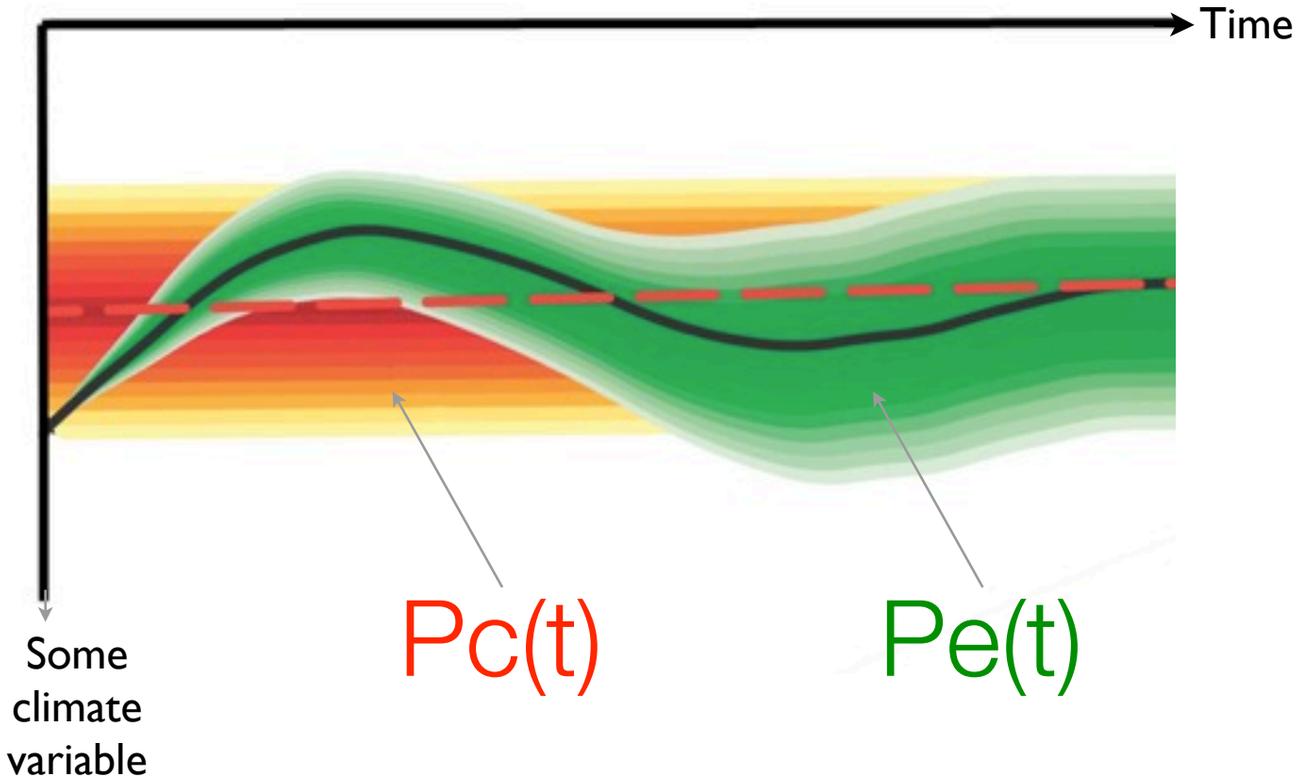
- Pe(t) is an ensemble of predicted states evolving from a specific tight cluster of initial conditions.

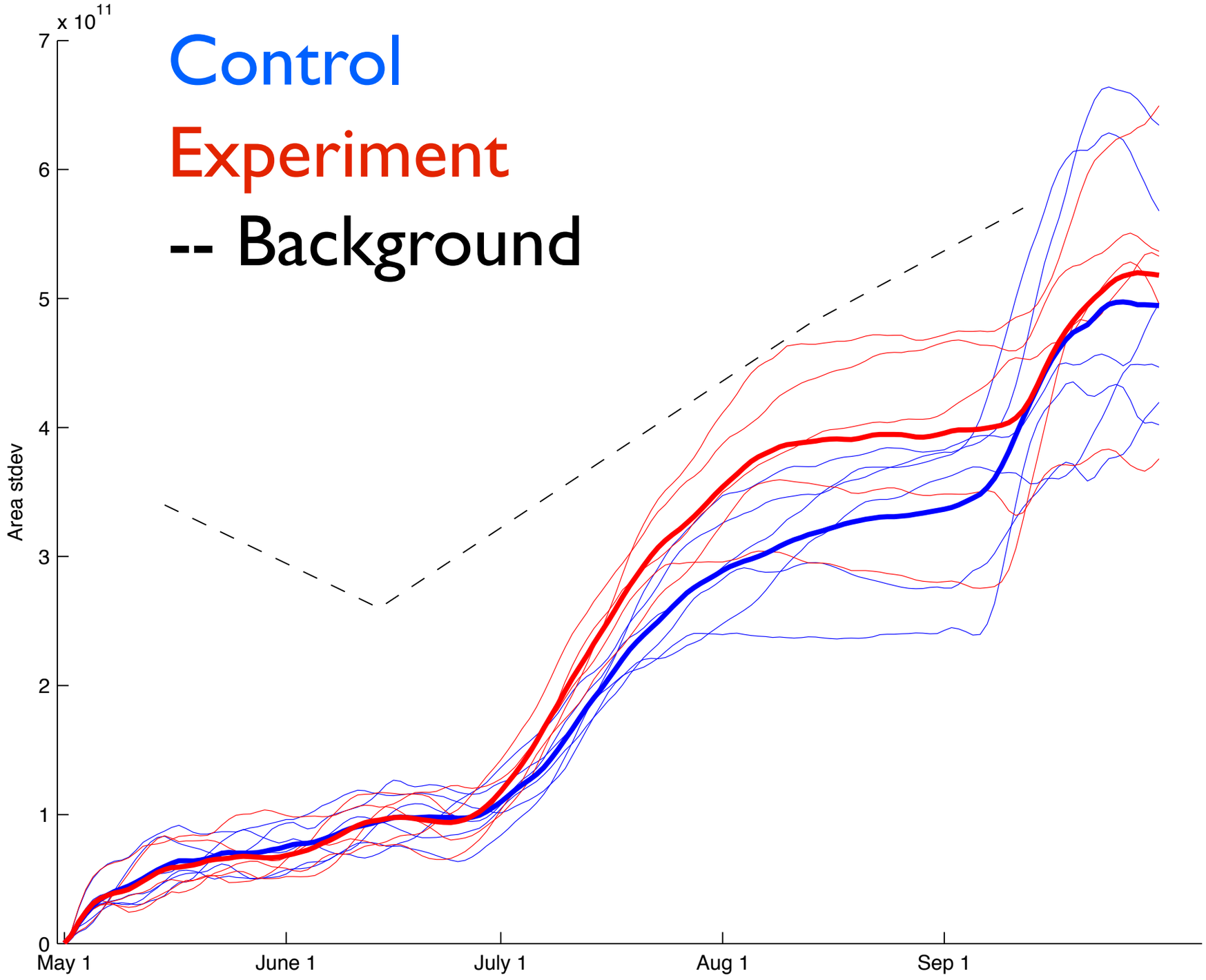
On predictability



- Pc(t) represents the background distribution. It is independent of any particular initial state.

- Pe(t) is an ensemble of predicted states evolving from a specific tight cluster of initial conditions.
- A comparison of Pe(t) to Pc(t) represents "initial-value predictability" (Lorenz 1975). This is what a weather (or seasonal sea ice) forecast is.

Predictability of total sea ice area



Summary

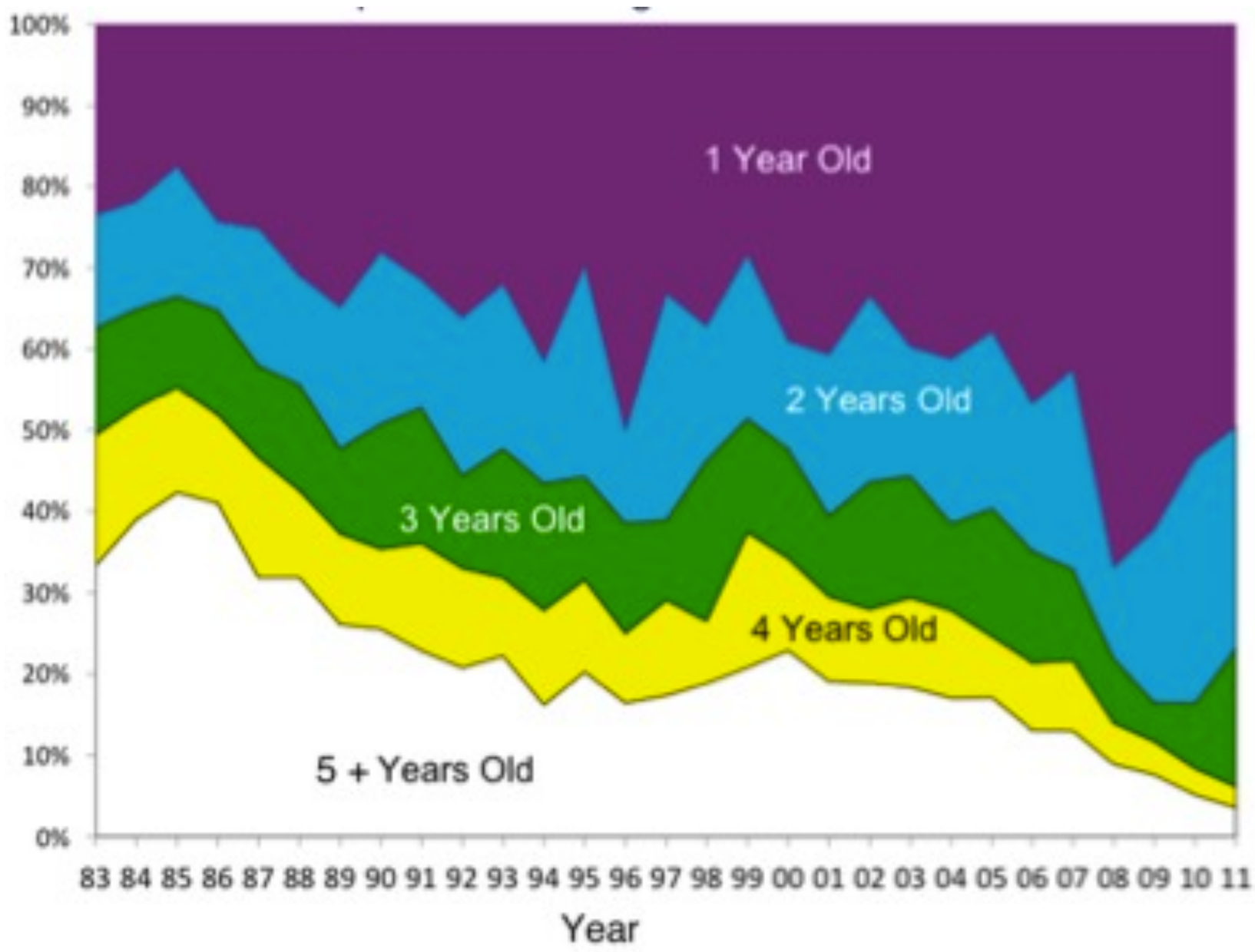
- Gap in knowledge of observed snow on sea ice, but it's quite possible that spring snow cover has decreased (and more than CMIP5 suggests, just like snow-on-land).

- Sensitivity of summer sea ice cover to snow -> spring snow trends responsible for part of the ice trend?

- A reduced spring snow cover leads to reduced predictability in July/August, but by the end of melt and freeze start up (mid September), predictability is unaffected. I don't know why.

Extra worriness

Ice age


100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 Year Old
2 Years Old
3 Years Old
4 Years Old
5 + Years Old
83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11
Year