Sea Ice and Polar Climate within CESM Simulations

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CESM1.5 Test Simulations

- 2 PI Control Runs (#28 and #31) with different tuning modifications (100 years in length; branched from a spinning up ocean)
- 20th century simulations branched from respective PI Runs
- Comparison to CESM-LE simulations
  - CESM-CAM5;
  - >1000 yr PI run
  - 38 ensemble members; 1920-2005

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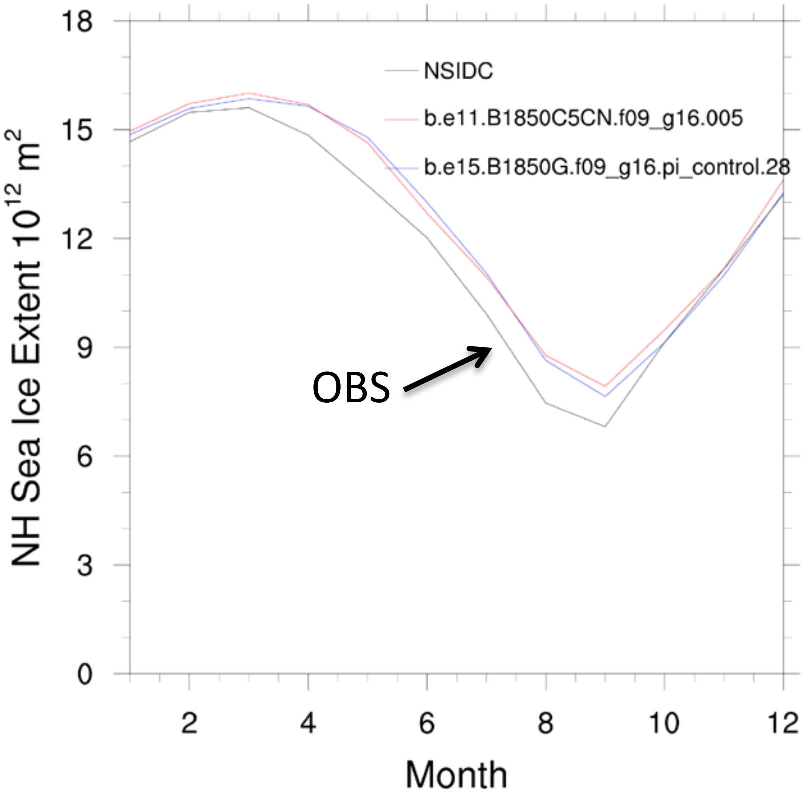
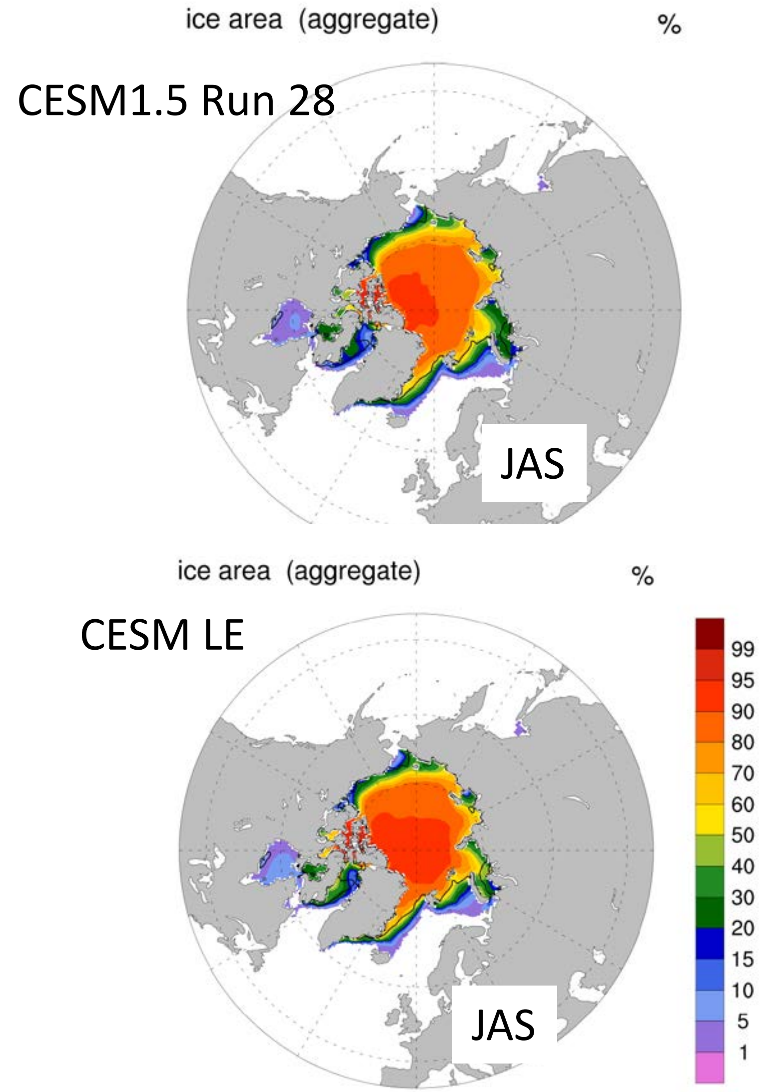
Sea ice conditions in PI runs





CESM1.5 Run 28 has very similar mean annual cycle of NH Ice Extent compared to LE Run

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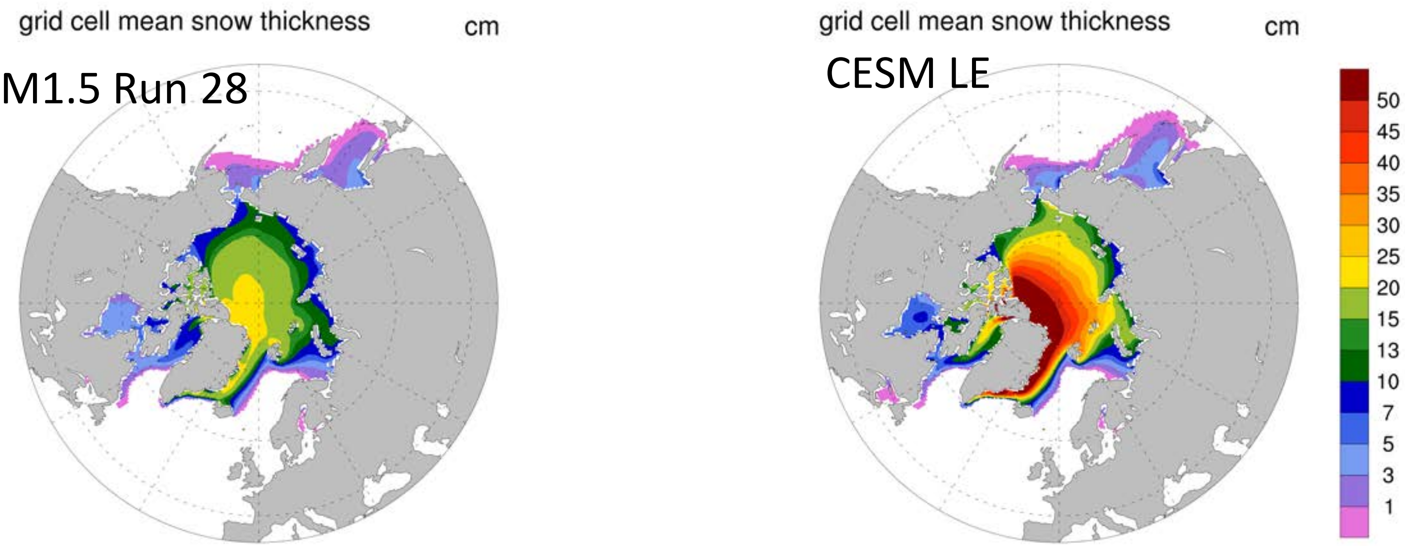
Sea ice conditions in PI runs – snow thickness



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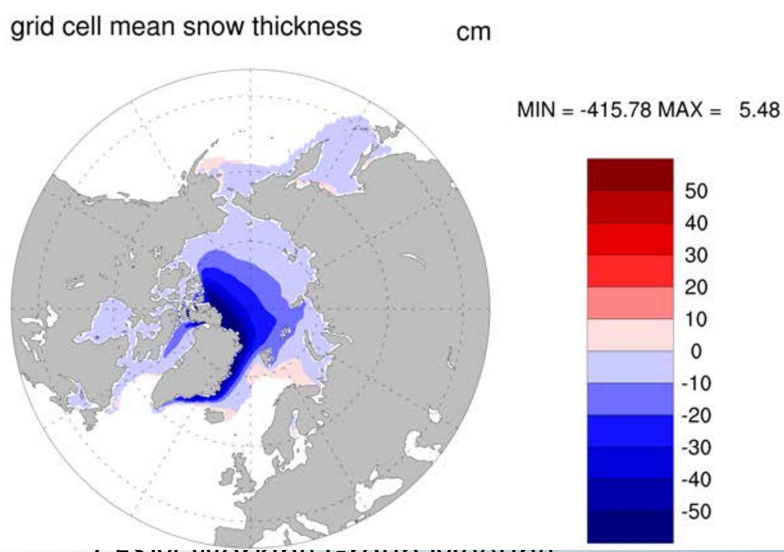

CESM1.5 has considerably thinner snow on sea ice

Annual Mean Snow Thickness

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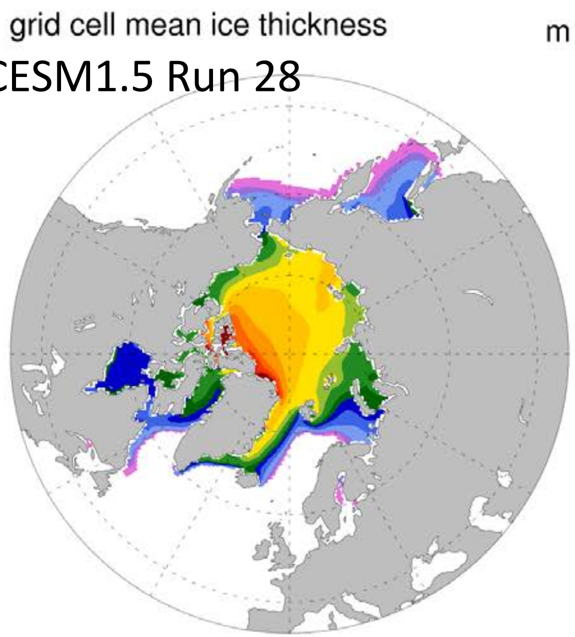
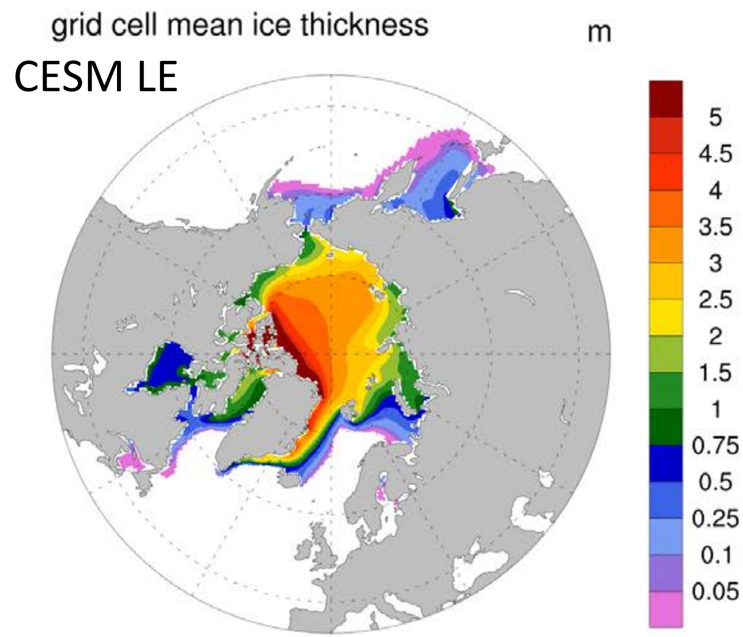
Sea ice conditions in PI runs – ice thickness





Compared to LE PI simulation, Run 28 has

- Substantially thinner sea ice
- Less snow and nearly snow-free summers
- Similar ice extent annual cycle

Annual Mean Ice Thickness

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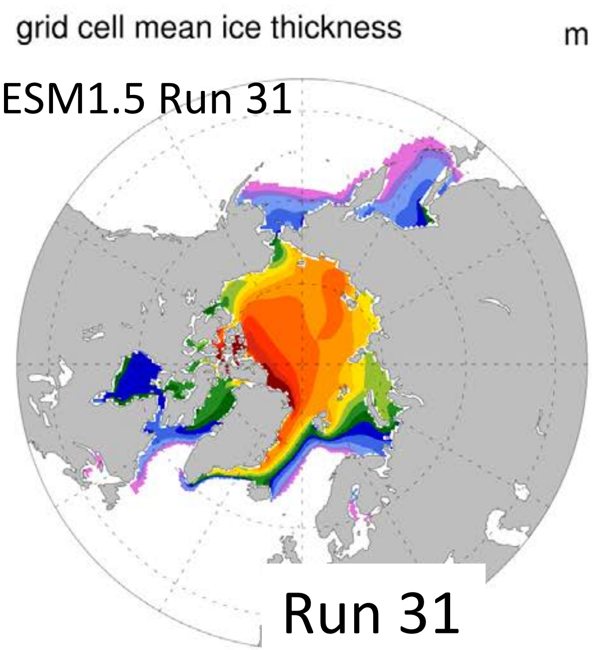
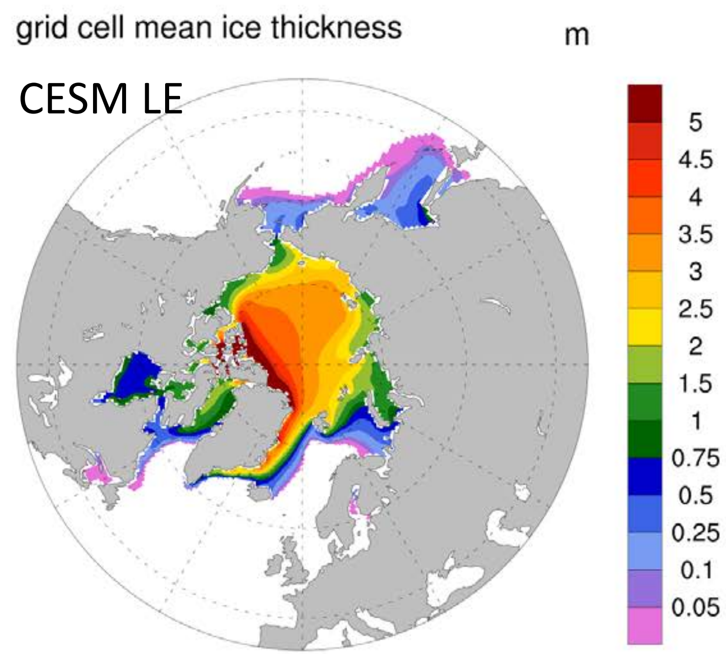
Sea ice conditions in PI runs – ice thickness





CESM1.5 Run 31 tuned to have thicker sea ice than 28
Run 31 thickness is very similar to LE Run
It has a little more extensive ice than 28
Its mean snow is similar to Run 28

Annual Mean Ice Thickness

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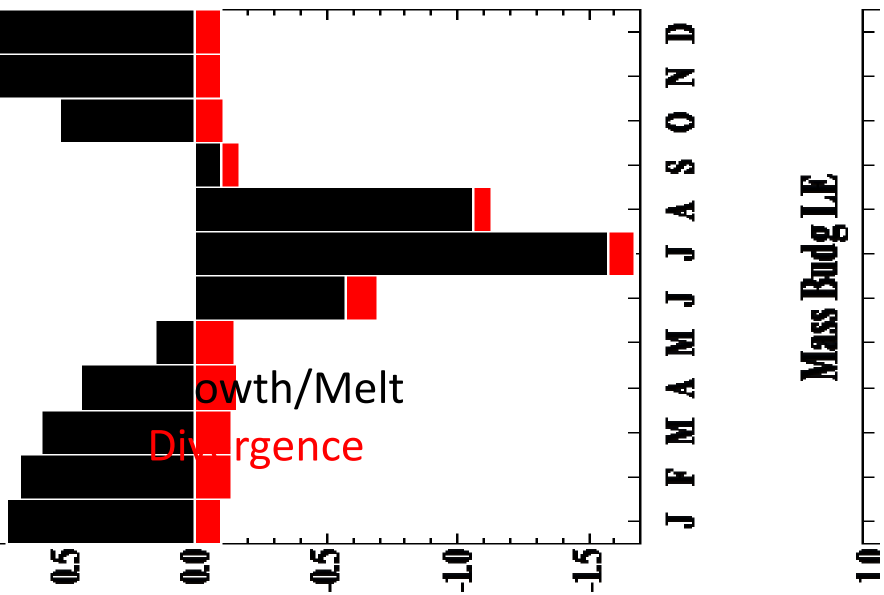
Sea ice conditions in PI runs – ice mass budgets

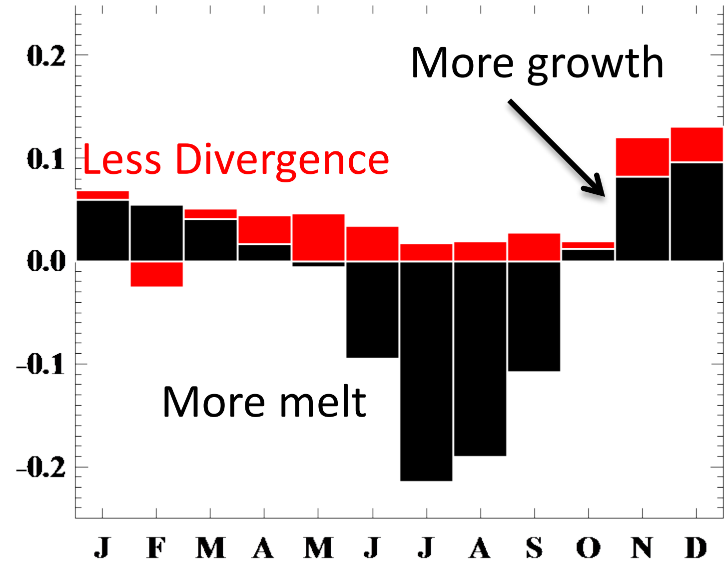
Arctic Budgets in cm/day



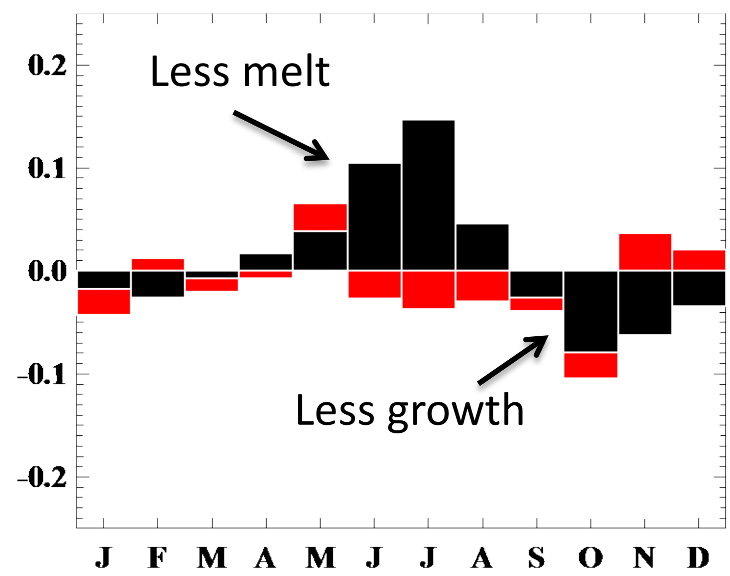
Changes consistent with thinner ice and snow

Not easy to explain changes as a consequence of ice state

Run 28 Minus CESM-LE

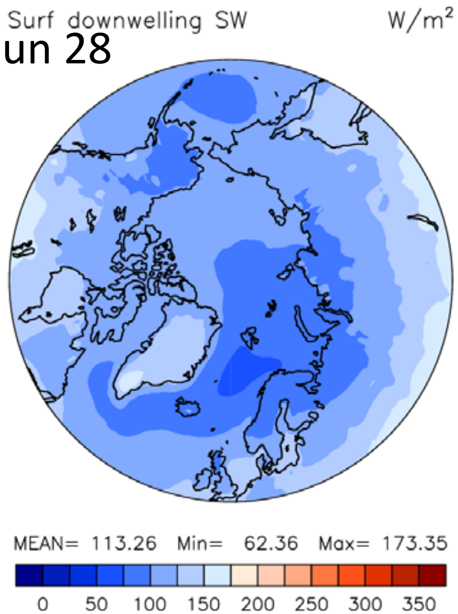


Run 31 Minus CESM-LE

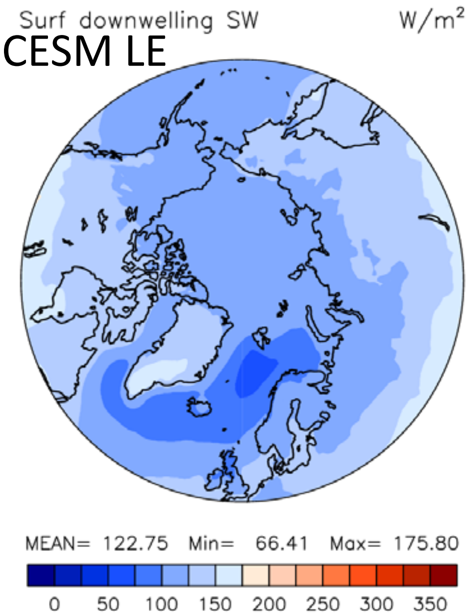


Sea ice conditions in PI runs – surface heat budgets

CESM1.5 Run 28

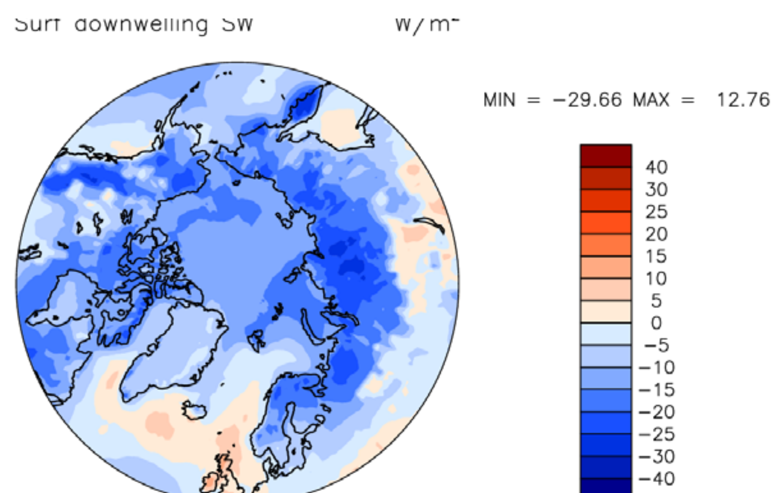


CESM LE



New runs have less incoming surface SW

CESM1.5 Run 28 Minus LE



Contributes to less summer melt in run 31

Surface Downwelling SW
Annual Mean

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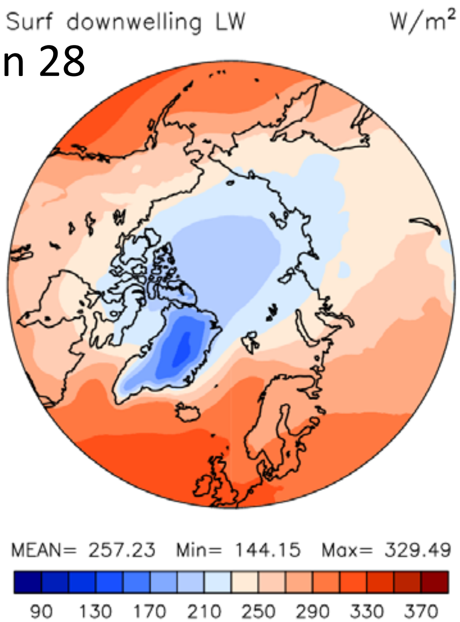
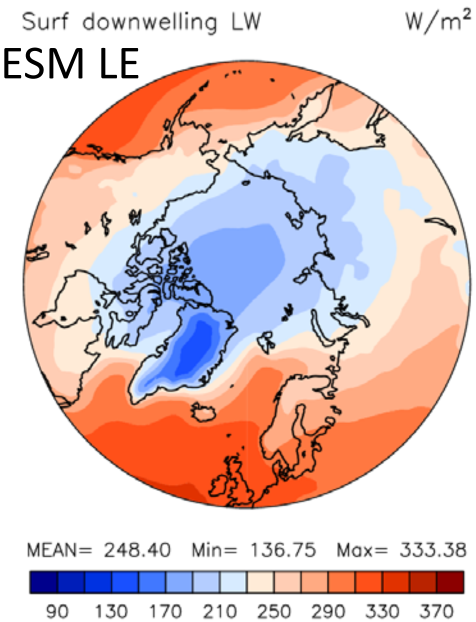
Sea ice conditions in PI runs – surface heat budgets

CESM1.5 Run 28

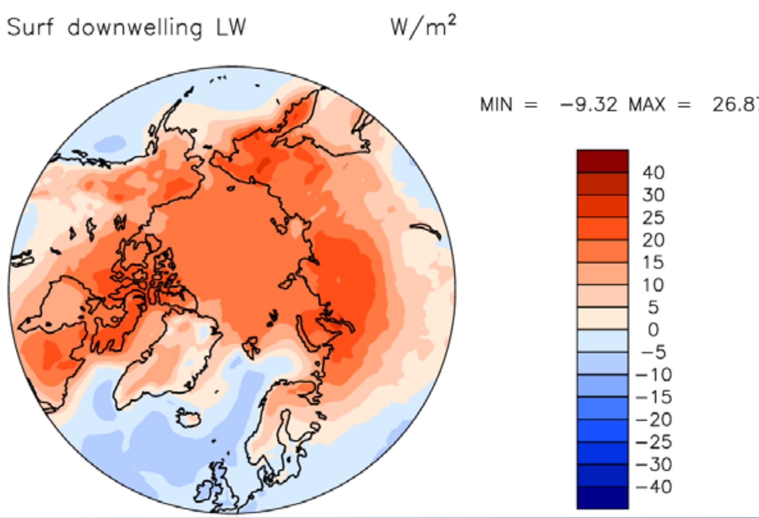


CESM LE



New runs have more incoming LW at surface

CESM1.5 Run 28 Minus LE



Contributes to less winter growth in run 31

Surface Downwelling LW
Annual Mean

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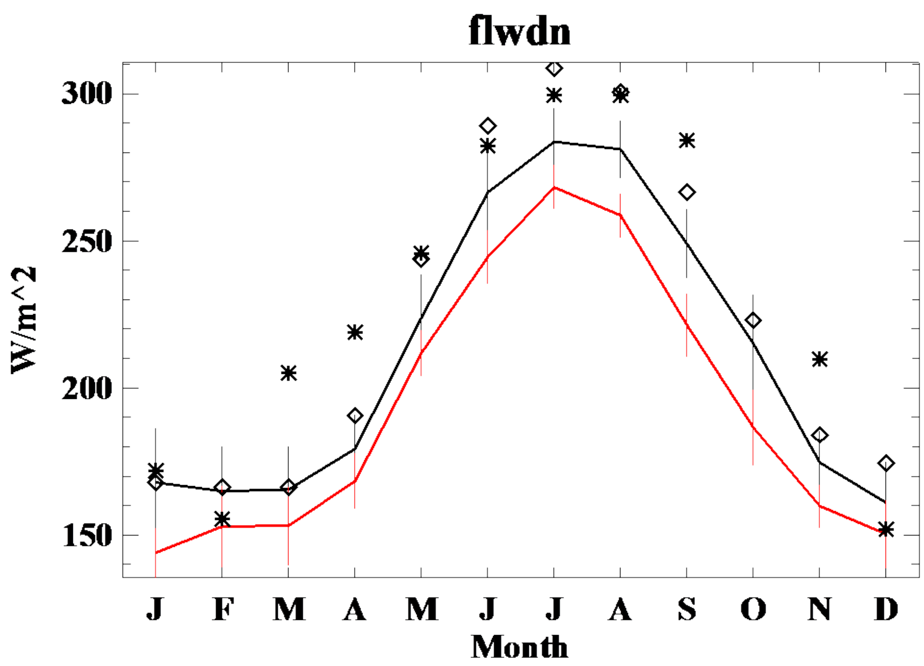
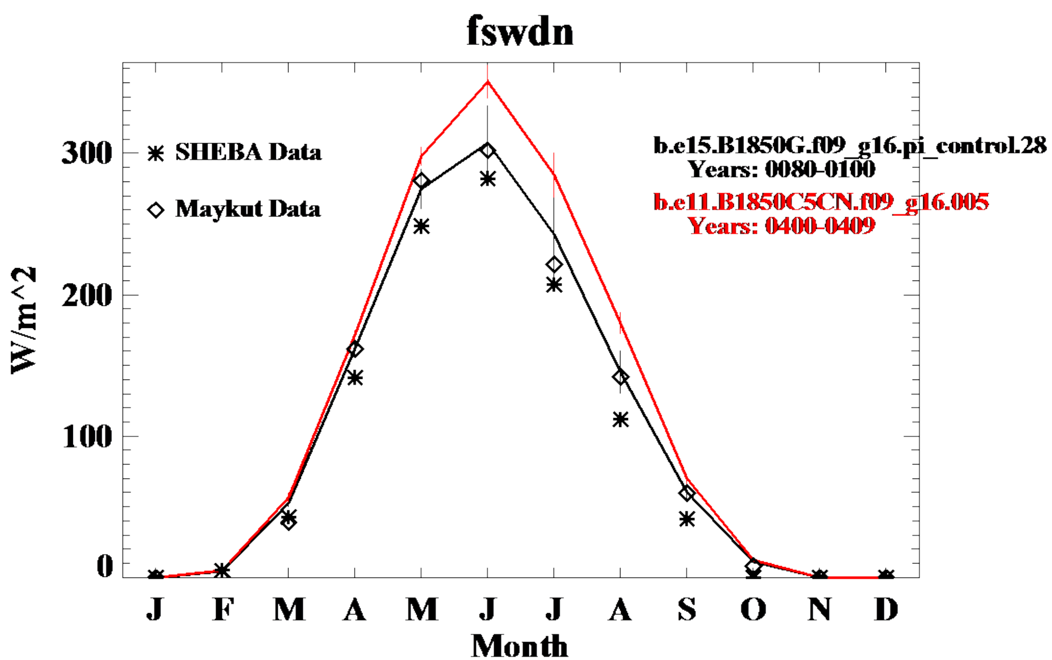
Sea ice conditions in PI runs – surface heat budgets



Increased LWDN and Decreased SWDN in CESM1.5 provide better comparison to in situ measurements

Other talks on cloud processes will discuss this in more detail



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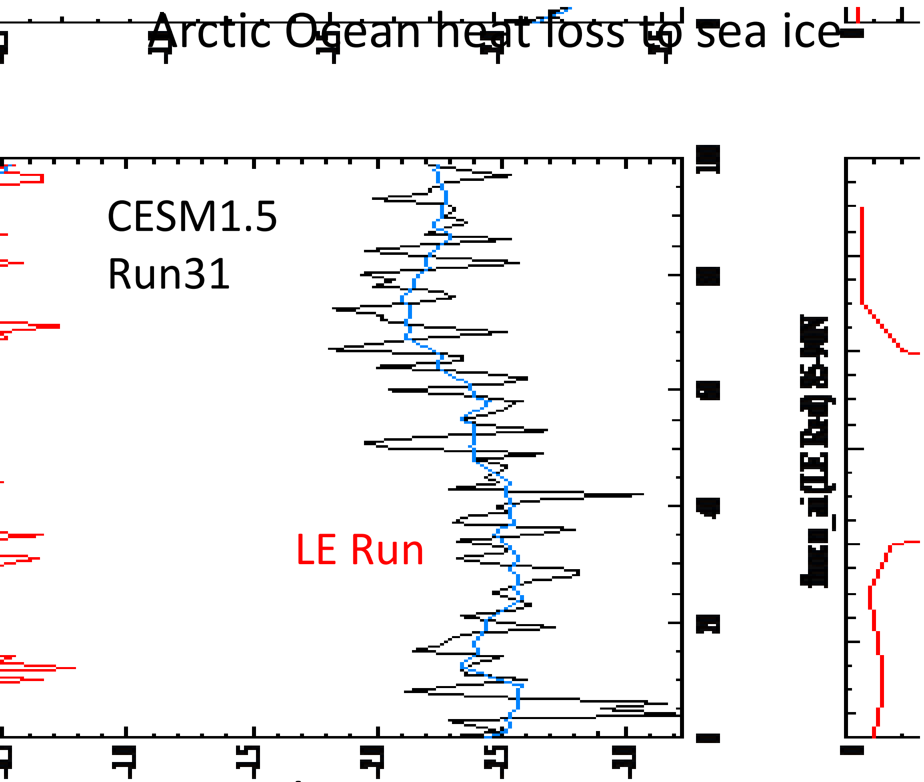
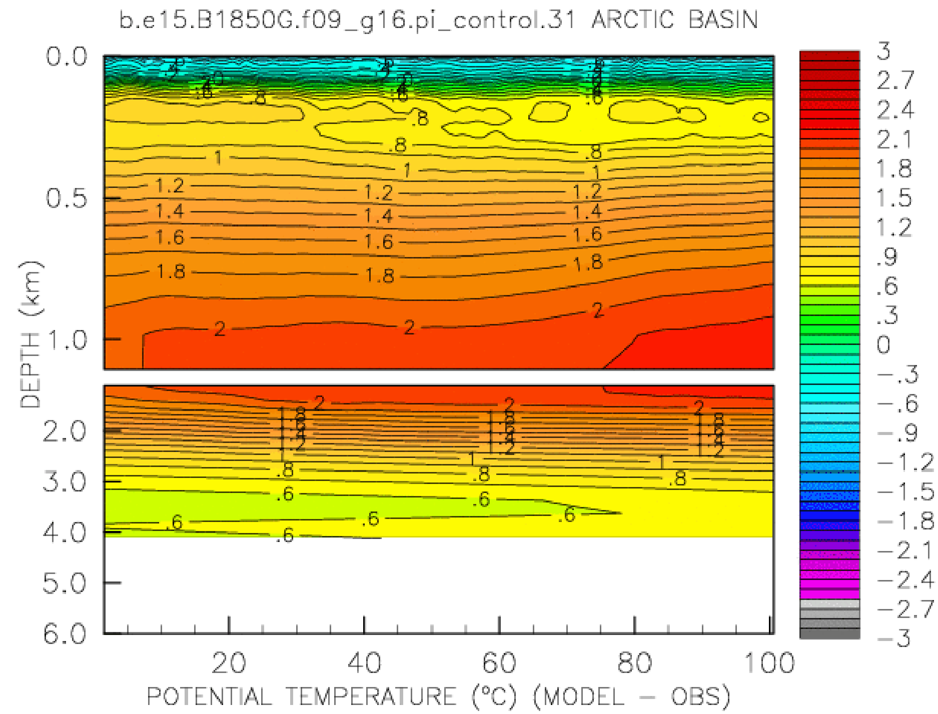
Sea ice conditions in PI runs – basal heat budgets





Compared to LE Run:

- Ice-ocean heat exchange increases in winter – likely associated with an unrealistic warming of Arctic Ocean
- Contributes to reductions in ice growth
- Summer ice-ocean heat exchange decreases, due to less SWDN

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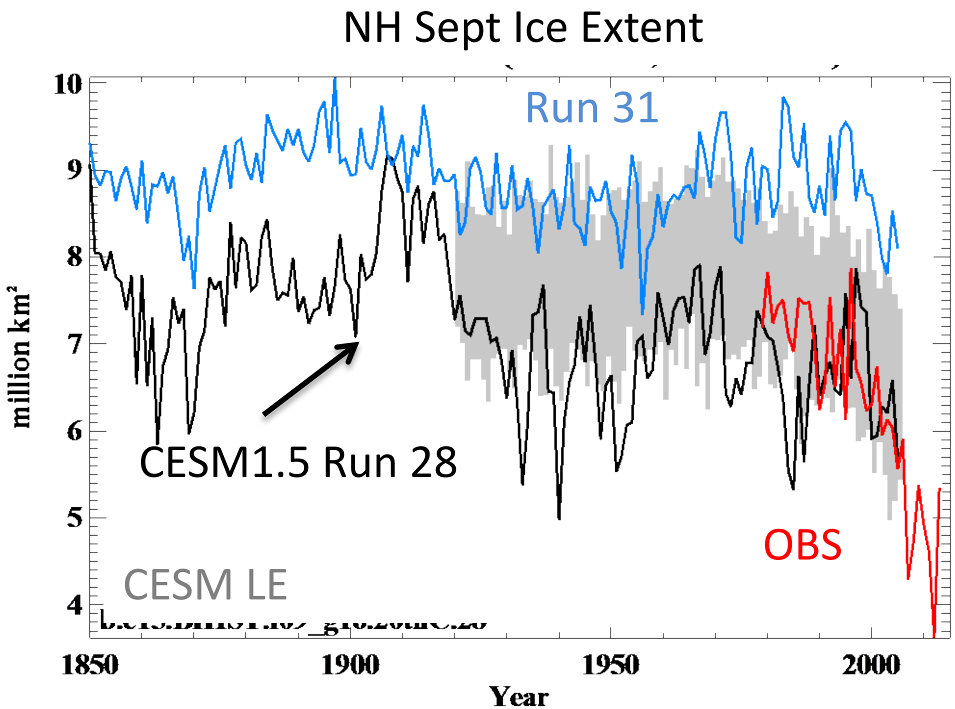
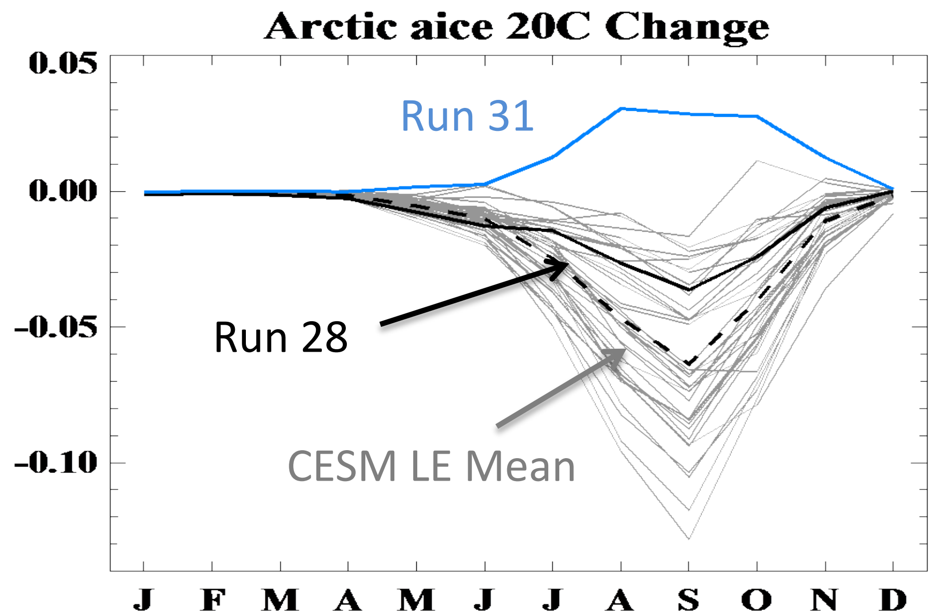
Arctic 20C Response – Ice Cover





New runs exhibit large variability

Simulate little or no (run 31) ice loss for end of 20C

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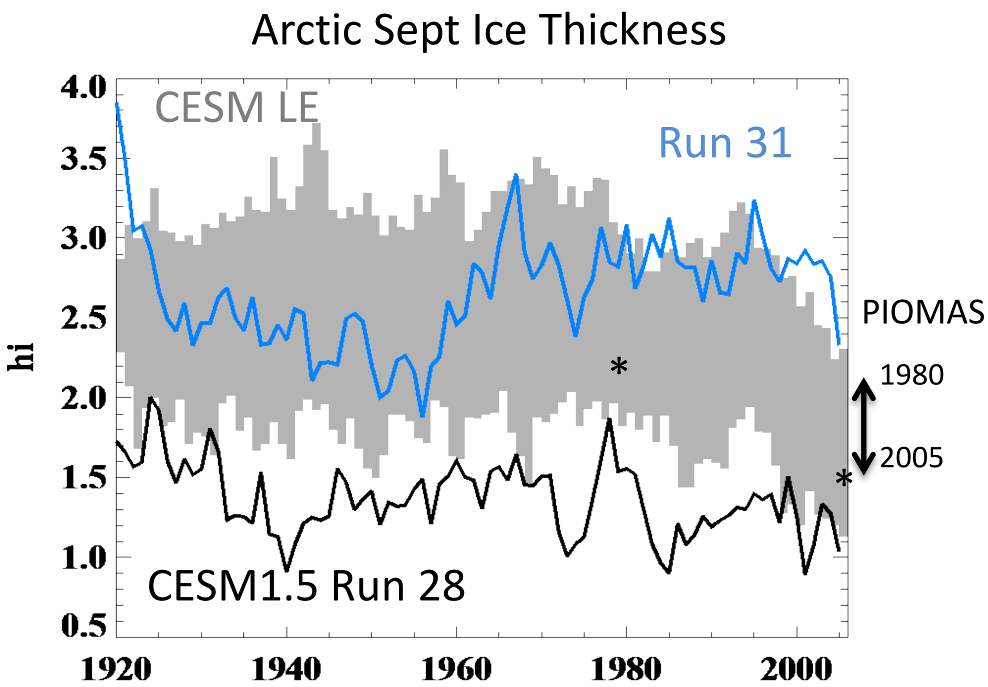
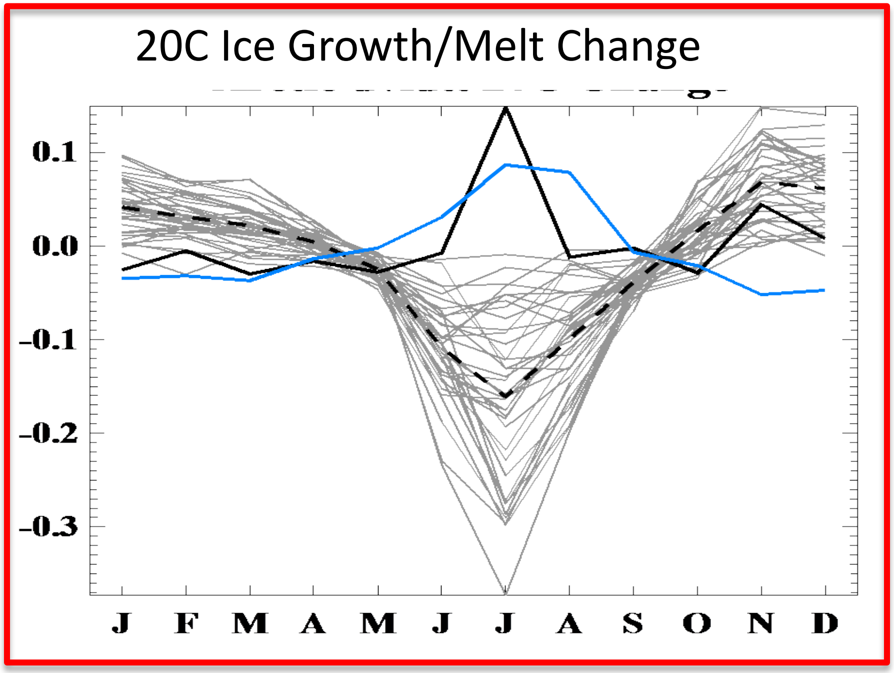
Arctic 20C Response – Ice Thickness





LE Runs thin at end of 20C, general agreement with obs

CESM1.5 Runs exhibit little late 20C thinning

20C Ice mass budget changes are quite different from LE

Radiative flux changes are similar with less SWdn and more LWdn

Surface albedo changes are smaller in CESM1.5 due to less initial snow

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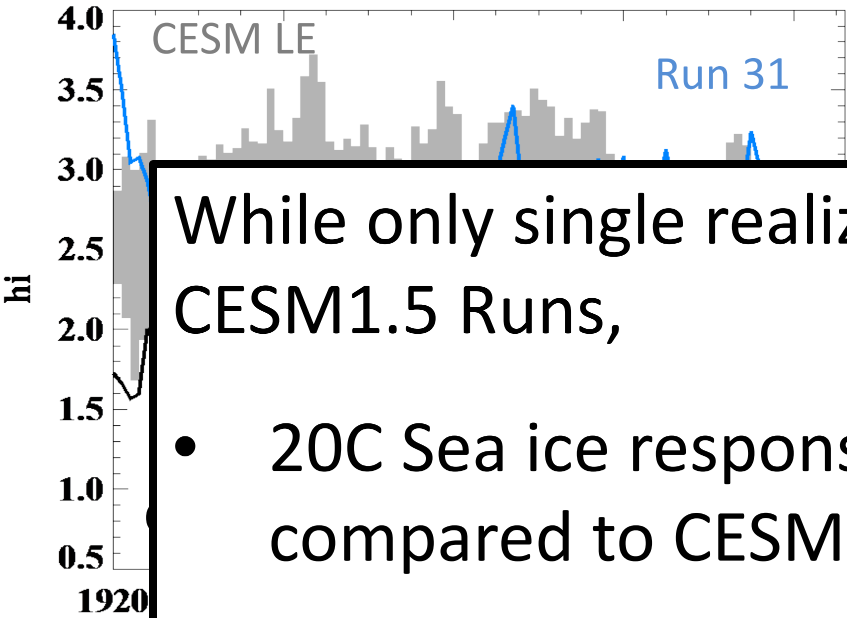
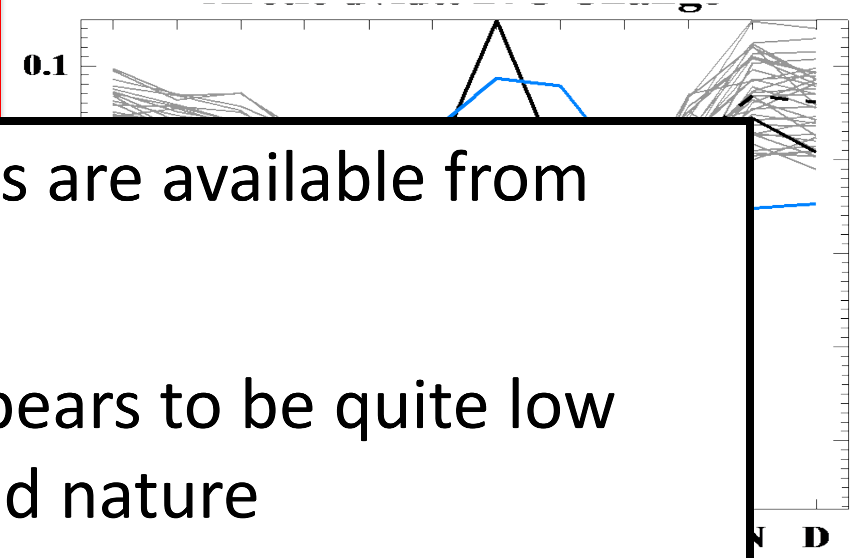
Arctic 20C Response – Ice Thickness

Arctic Sept Ice Thickness



20C Ice Growth/Melt Change



While only single realizations are available from CESM1.5 Runs,

- 20C Sea ice response appears to be quite low compared to CESM LE and nature
- Mass budget changes look quite different
- Possible changes in strength of feedbacks
- All results are preliminary and require more investigation

LE

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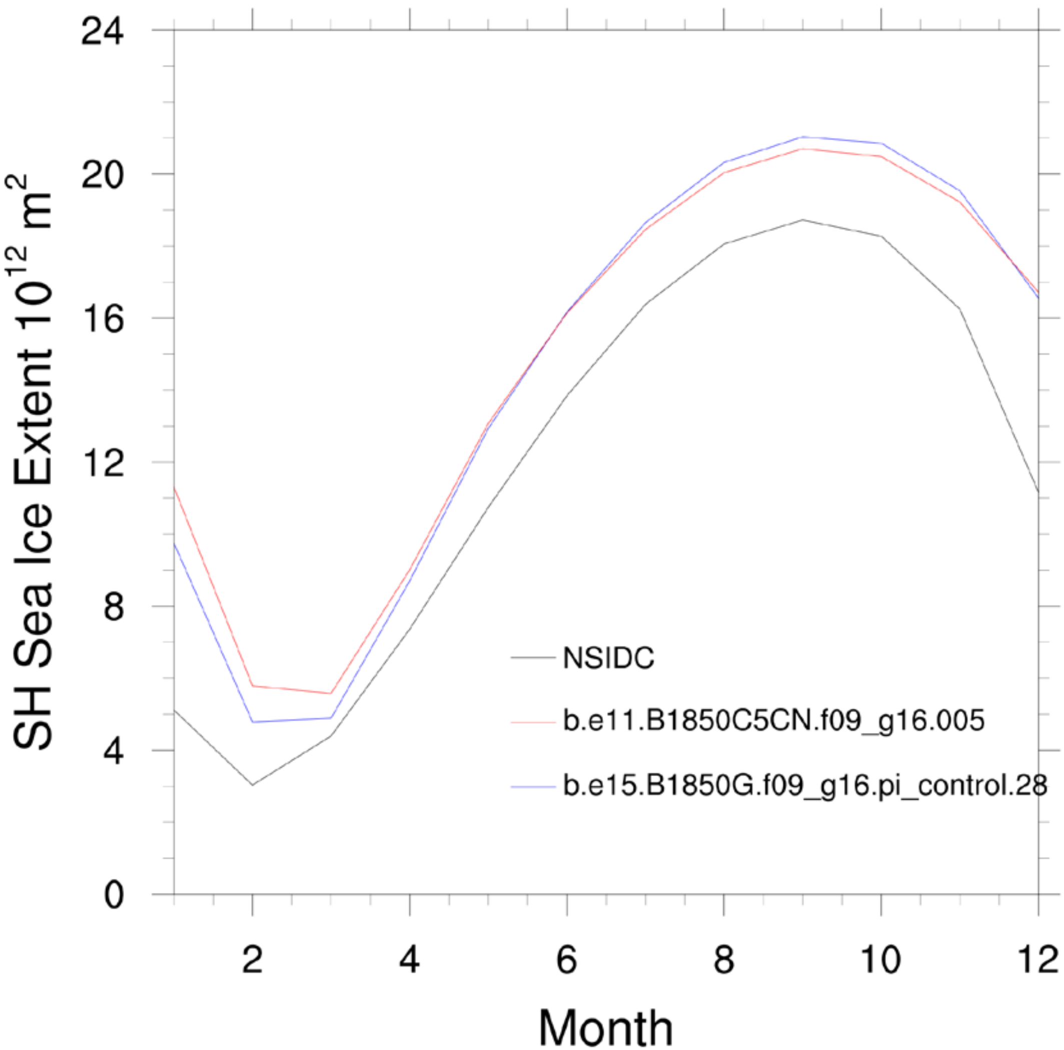
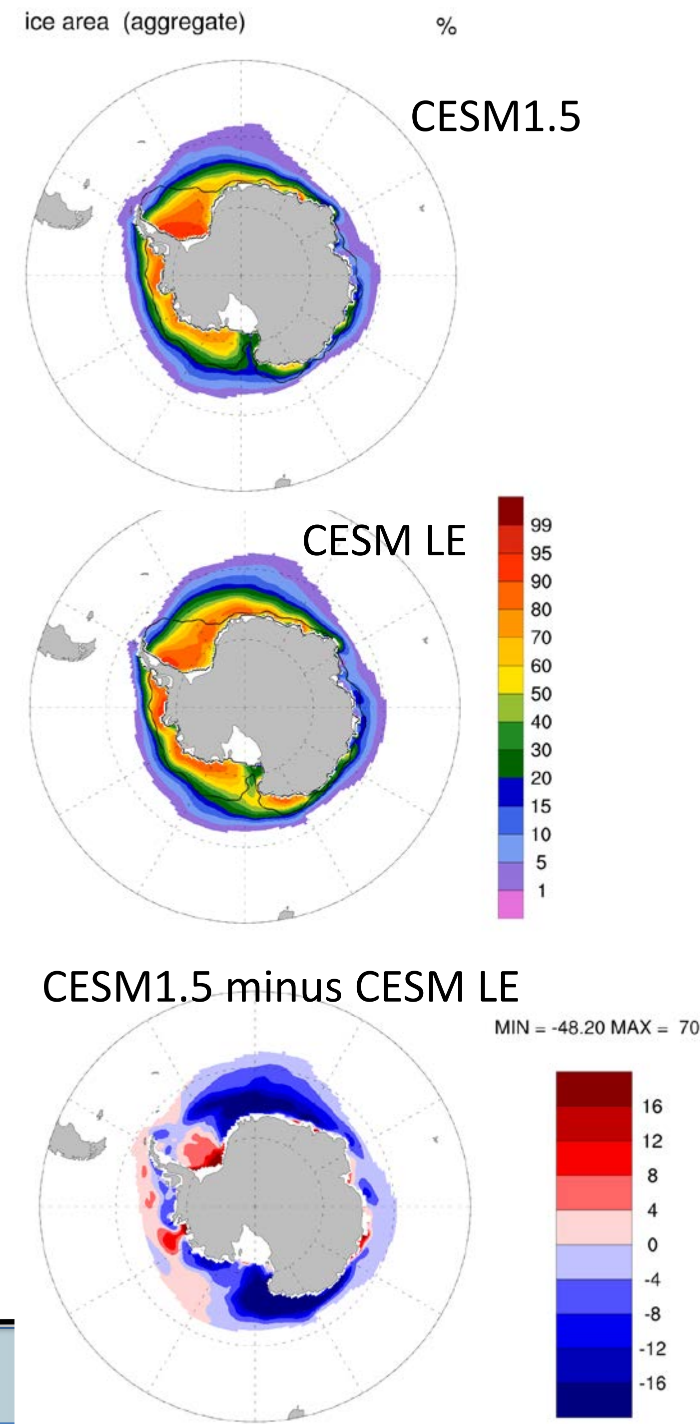
Ice r

Radi

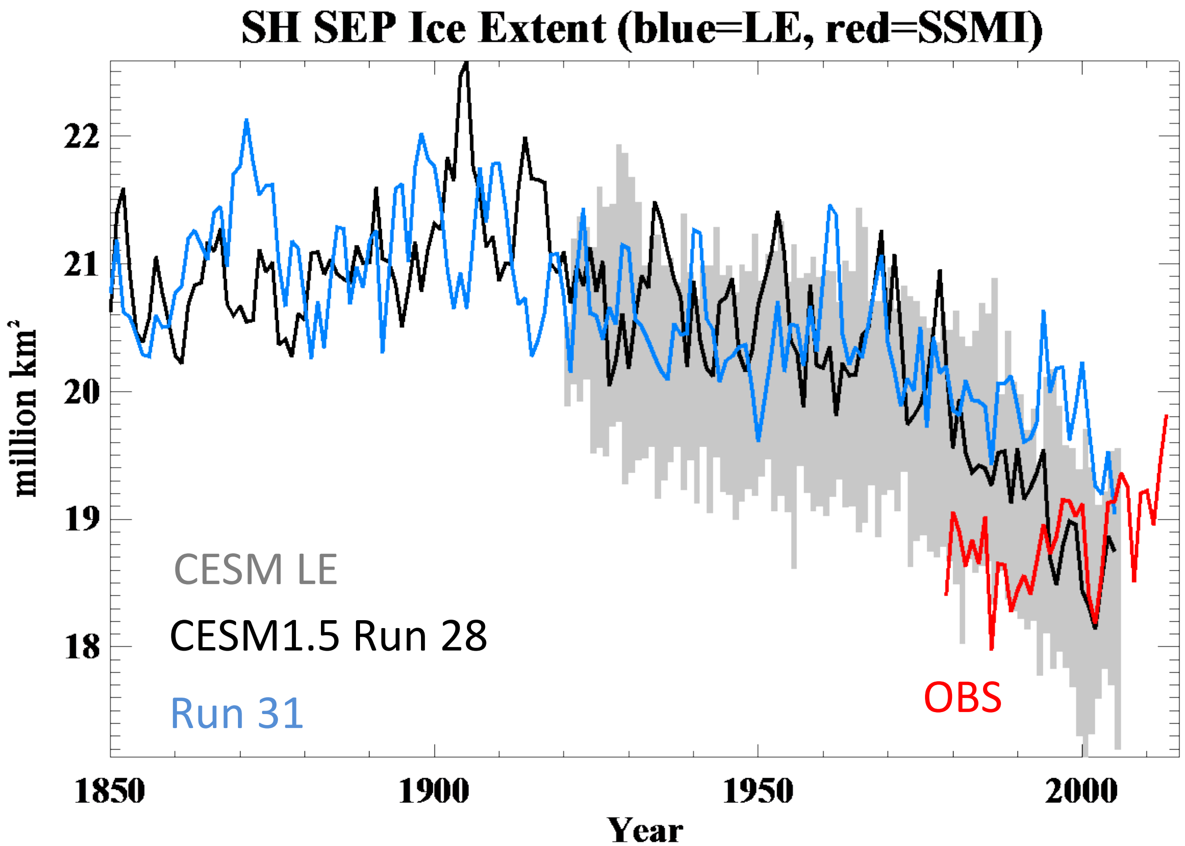
Surface albedo changes are smaller in CESM1.5 due to less initial snow

SH Sea ice conditions in PI runs





SH 20th Century Ice



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Summary

- CESM1.5 exhibits some improvements in Arctic surface radiation fluxes, degradation in Arctic ocean temperatures
- These changes modify sea ice heat and mass budgets
- The 20C ice response looks quite small in CESM1.5 runs – reasons for this need to be further investigated
- SH sea ice looks quite similar to CESM1-CAM5 LE simulation with perhaps modest improvement in summer ice cover

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Extra slides

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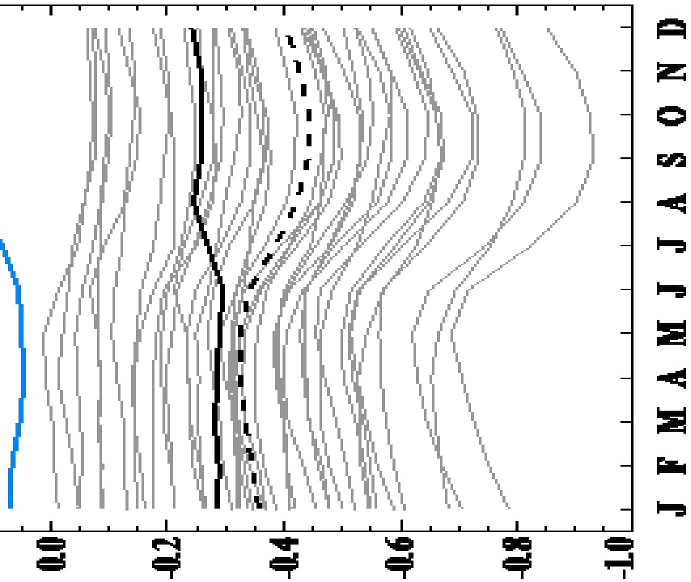
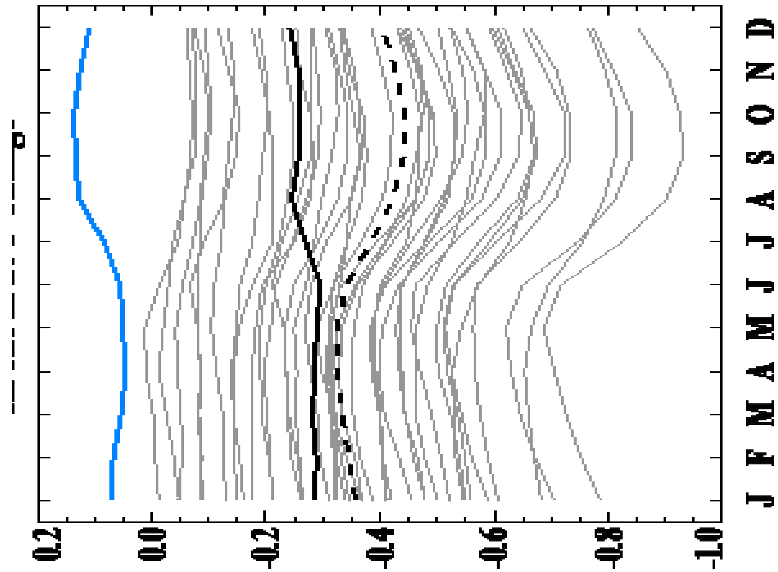
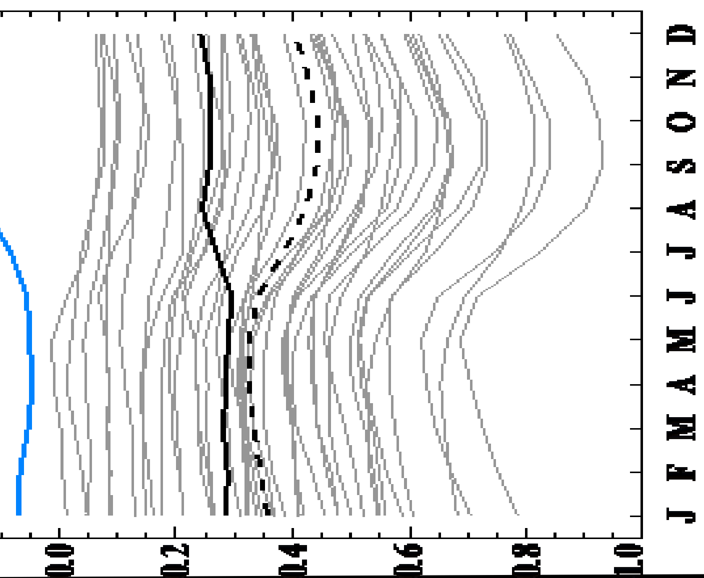




Over 20C,

- Incoming SW decreases and incoming LW increases
- In LE run, large albedo reduction lead to an increase in absorbed SW
- In CESM1.5, albedo changes are smaller, and a reduction in net SW results



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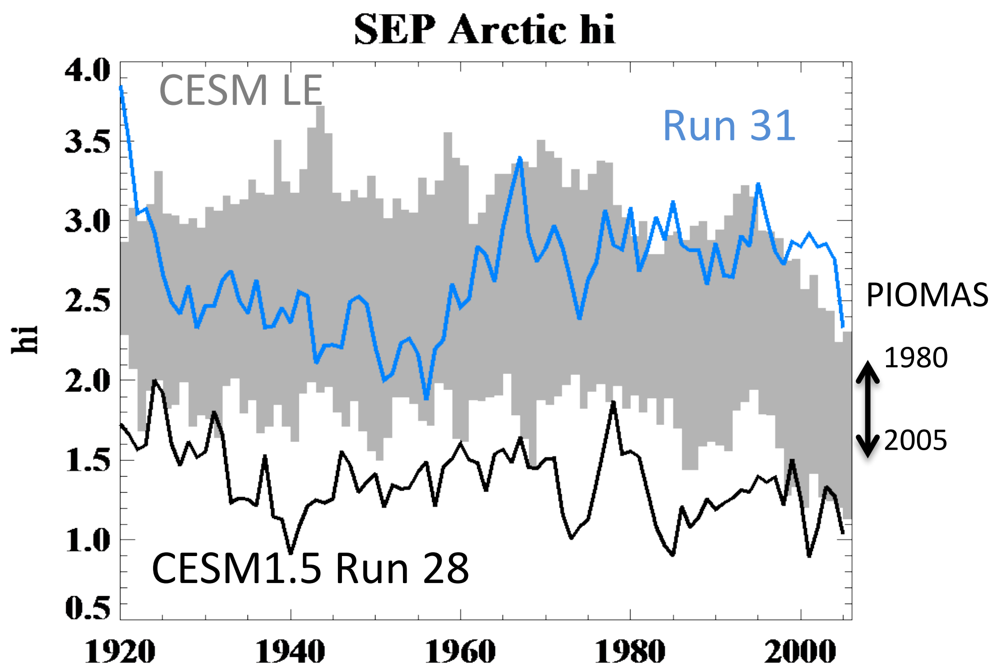
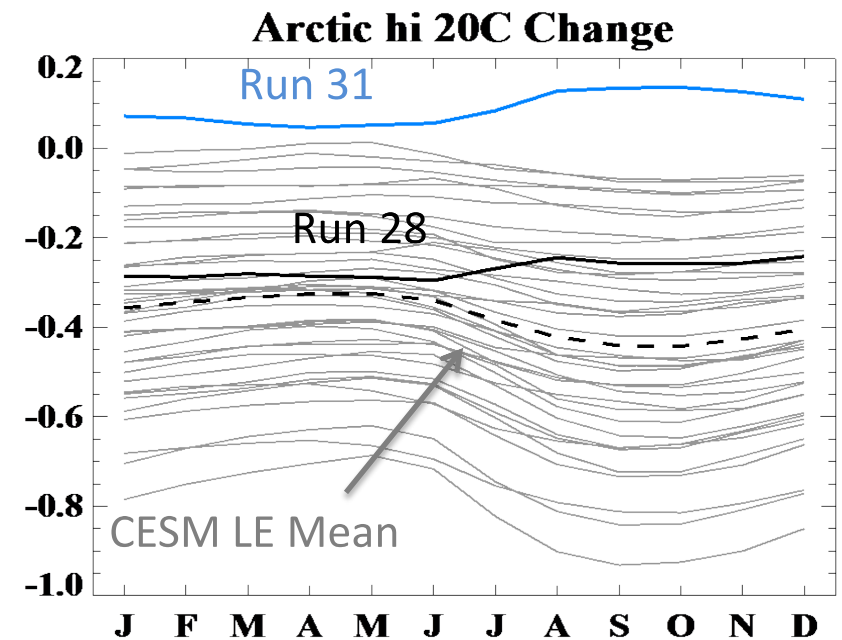
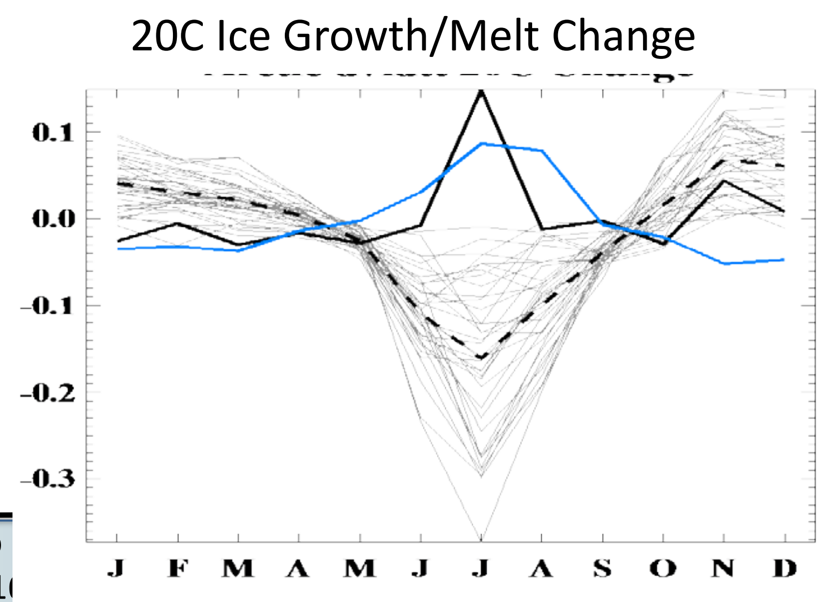
Arctic 20C Response – Ice Thickness







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CESM1.5 Runs exhibit little late 20C thinning