

Sea ice ridging: impact on the Arctic climate system and (un)constrained model parameters

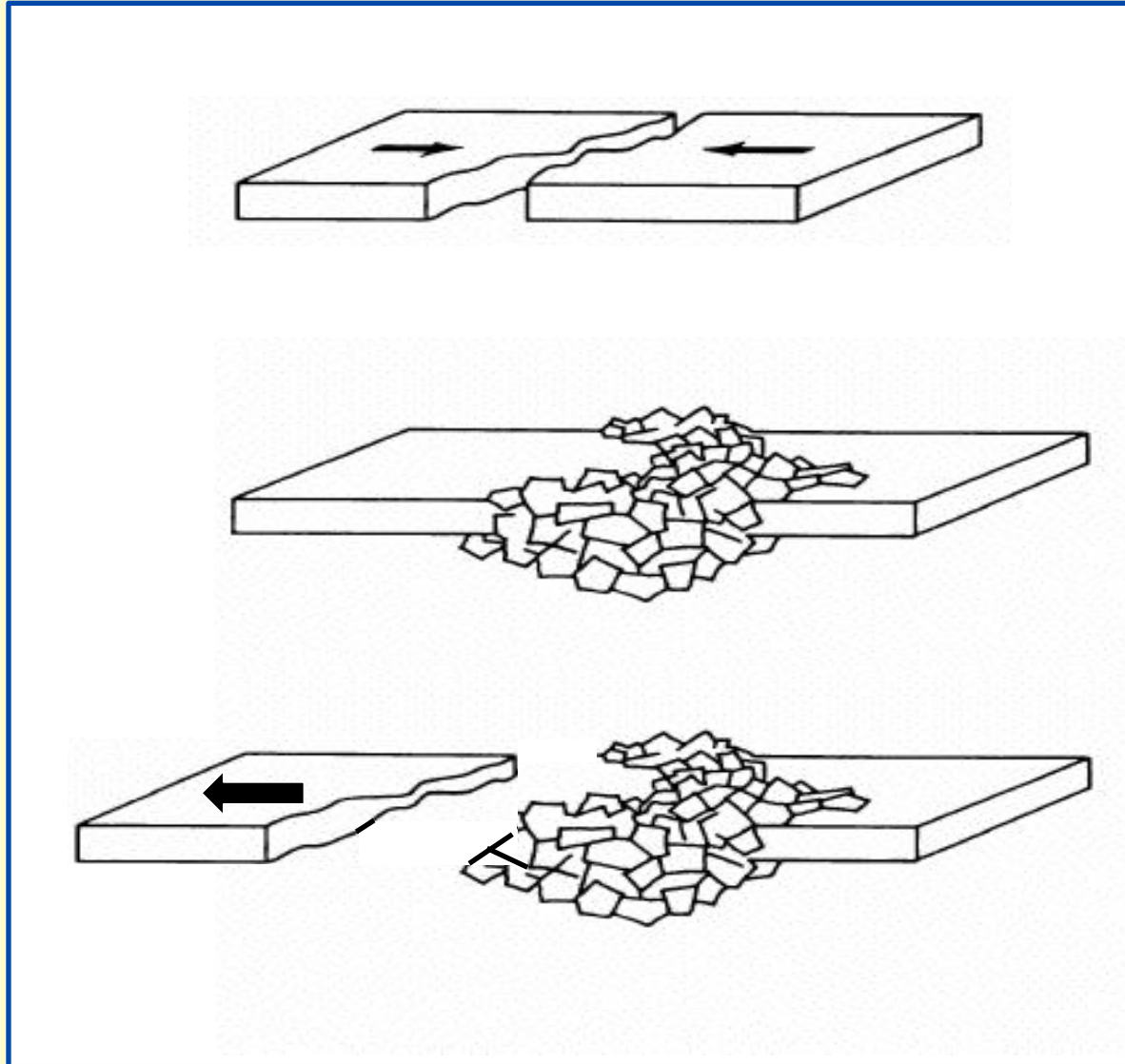
Torge Martin

Polar Science Center, APL, UW

16th AOMIP / 1st FAMOS meeting
Woods Hole, October 24, 2012

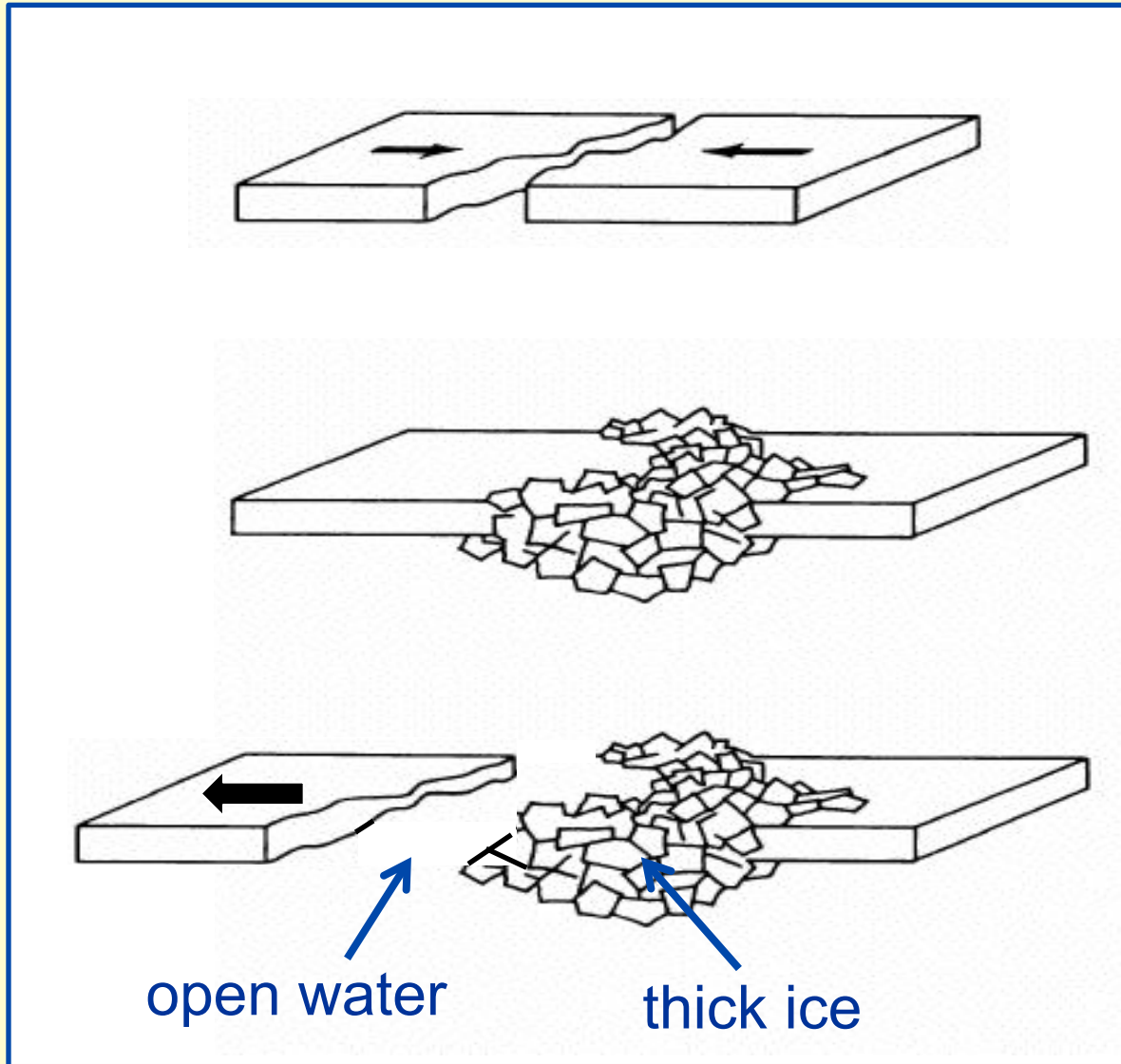
What does ridging do?

1. convergent sea ice motion
2. ridge formation
3. divergent motion; prev. level ice compacted into ridge needing less area



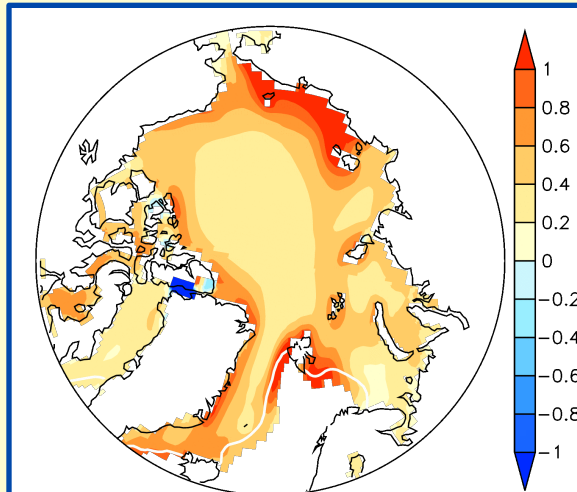
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How does that affect the Arctic sea ice/climate system?

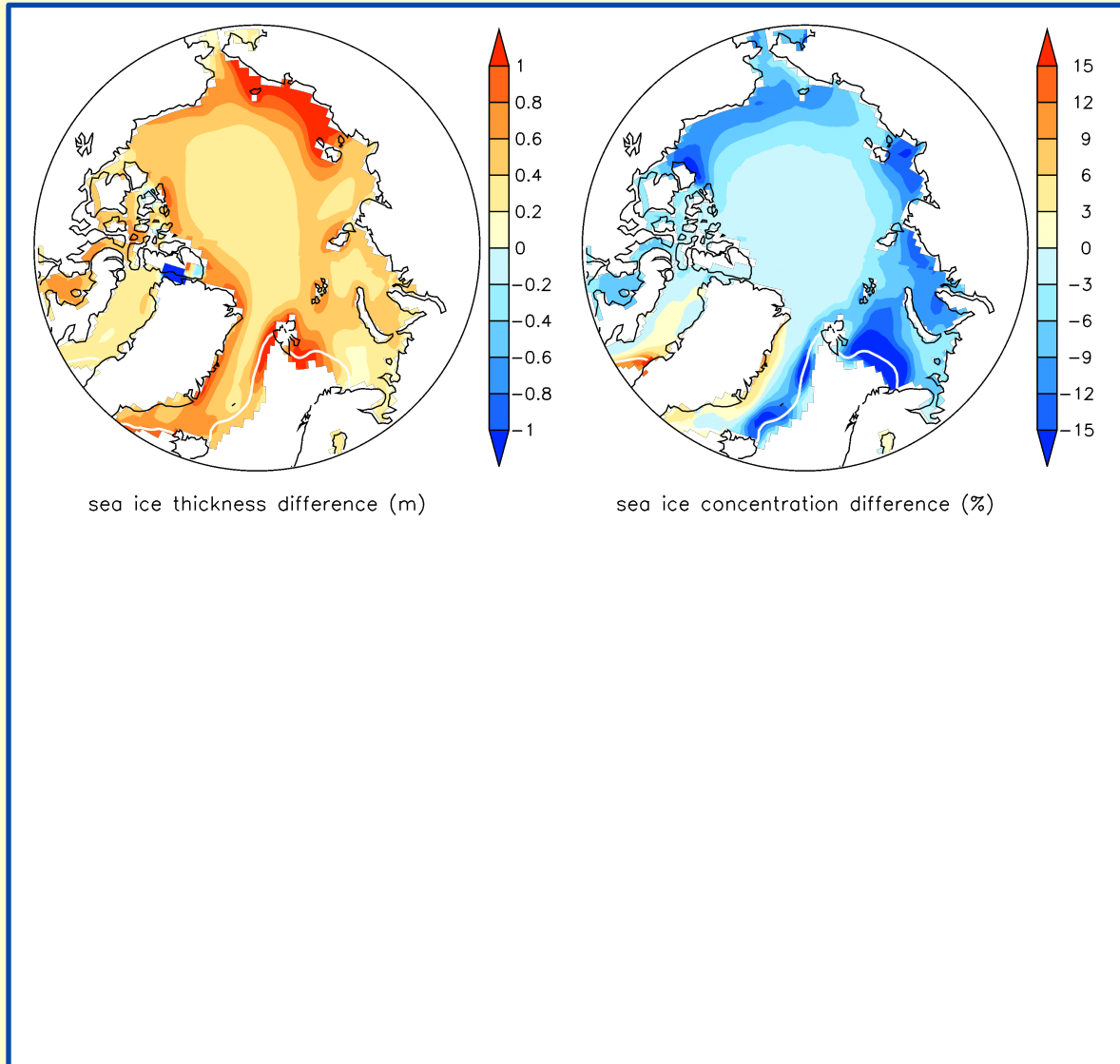
- Ridging forms thicker ice



sea ice thickness difference (m)

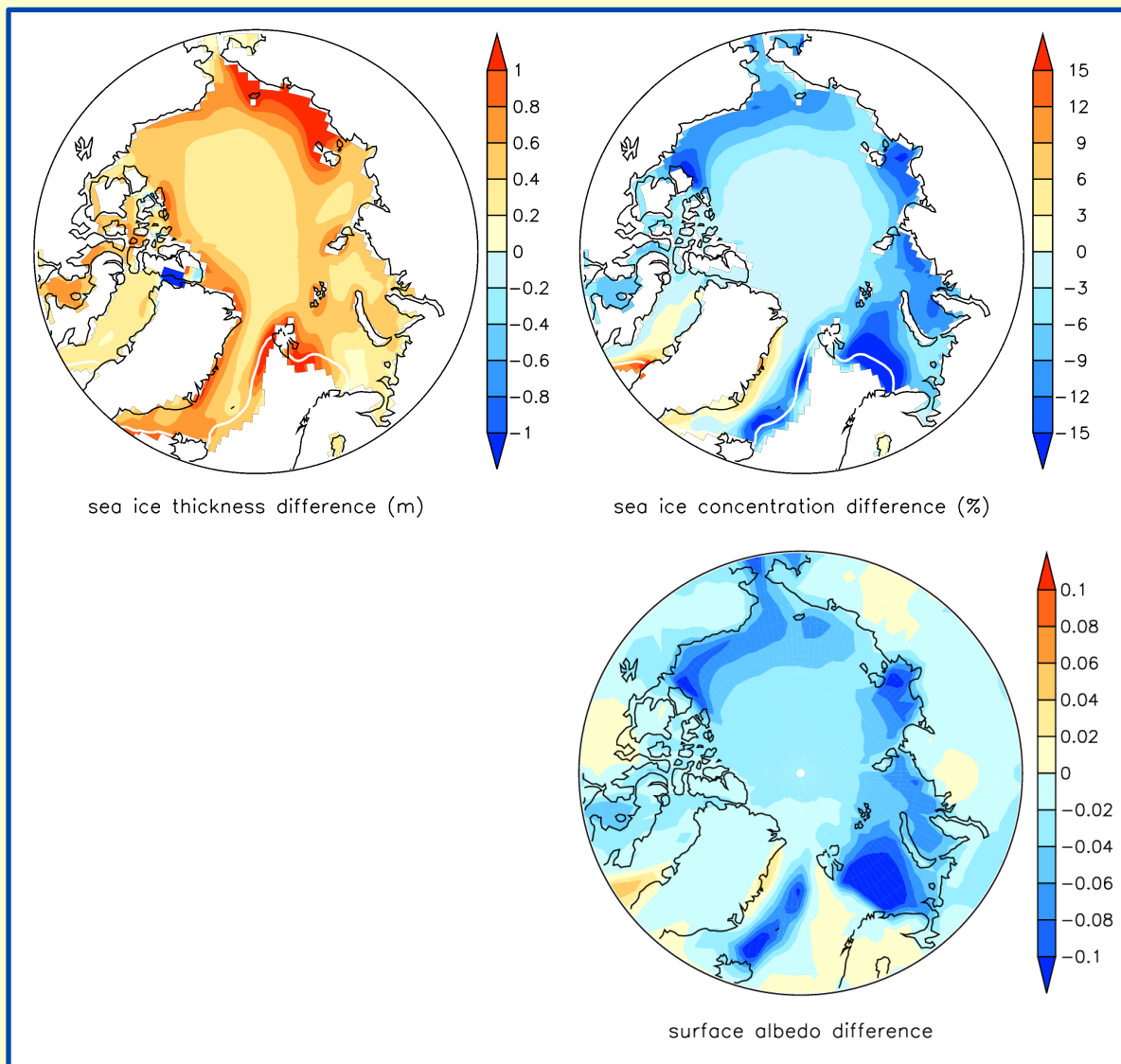
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- ... and leads



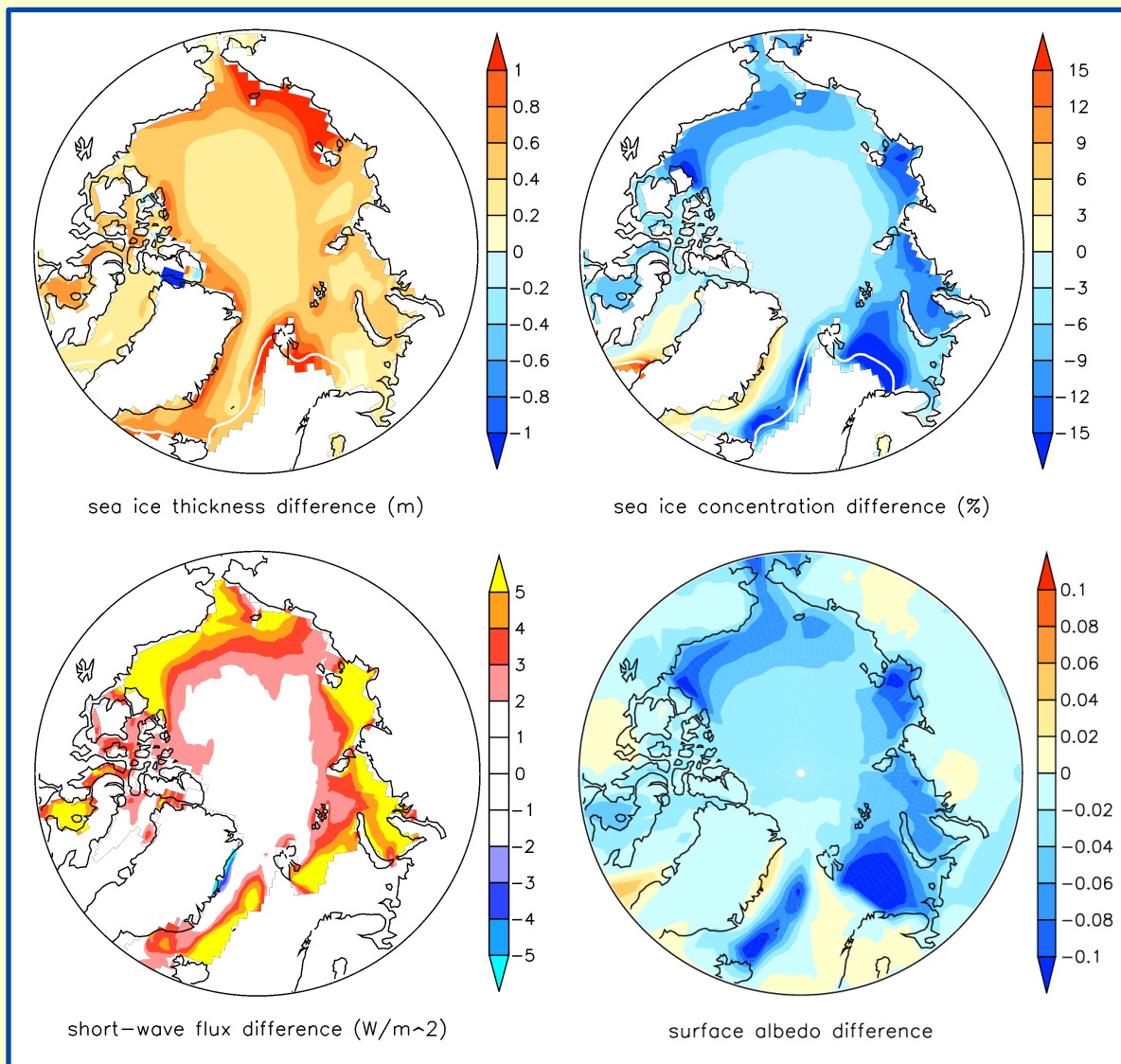
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- ... resulting in reduced surface albedo



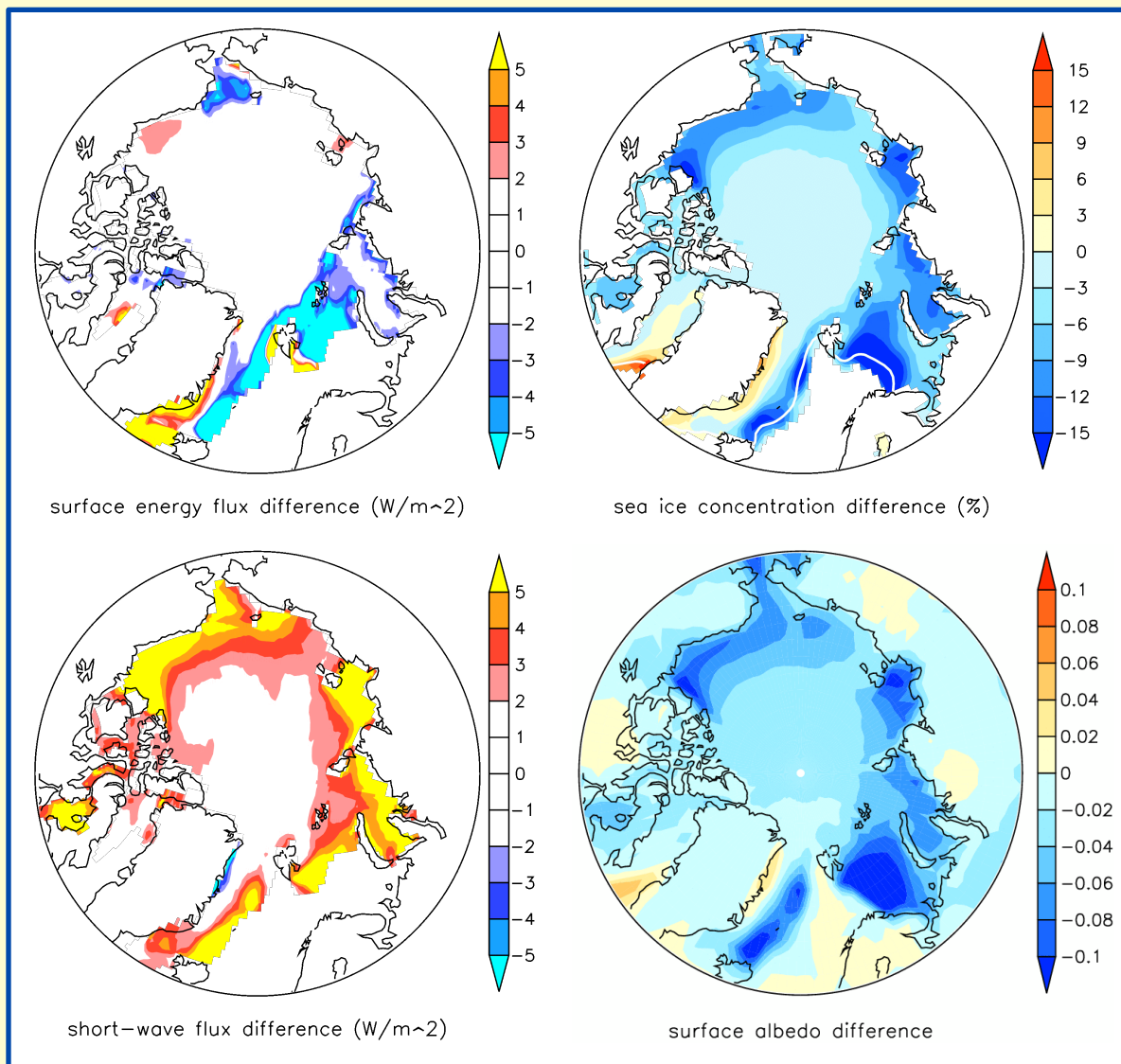
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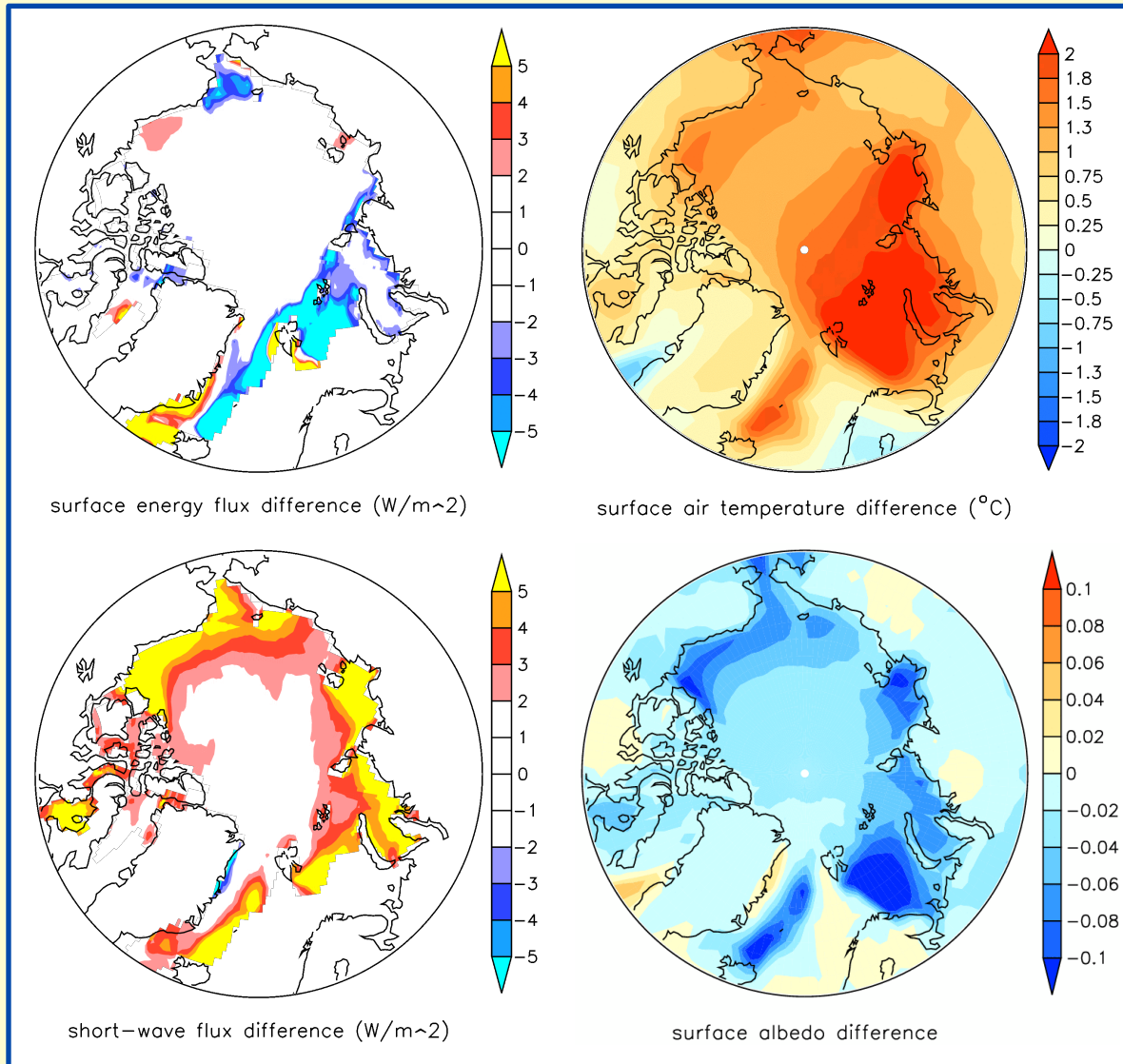
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- ... which enables increased absorption of insolation by the ocean
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How does that affect the Arctic sea ice/climate system?

- Ridging forms thicker ice
- ... and leads
- ... resulting in reduced surface albedo
- ... which enables increased absorption of insolation by the ocean
- without changing the total annual energy balance.
- This means increased turbulent heat exchange with the atmosphere year round but mostly in winter
- leading to more ice growth and warmer SAT



So, which process dominates?

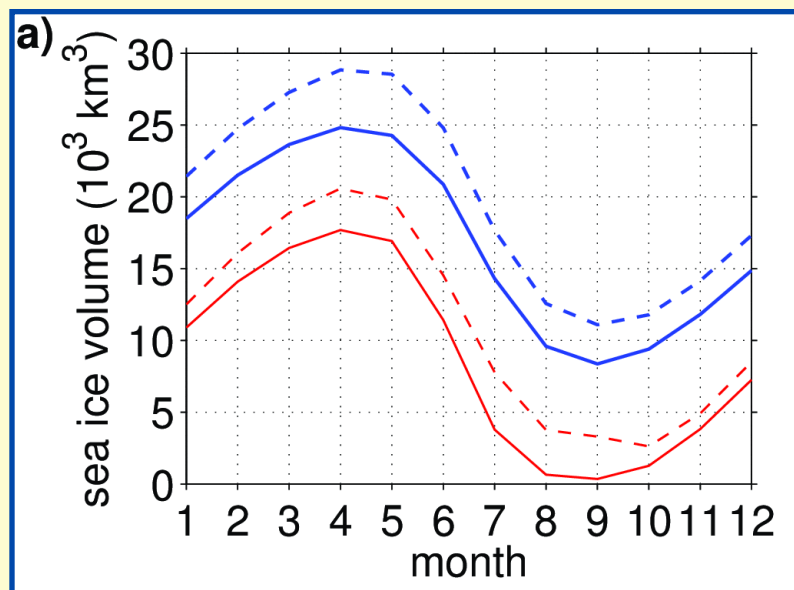
Sea ice **loss** by increased melt through increased absorption of insolation in summer?

or

Sea ice gain by increased growth associated with increased Sensible heat loss during winter?

So, which process dominates?

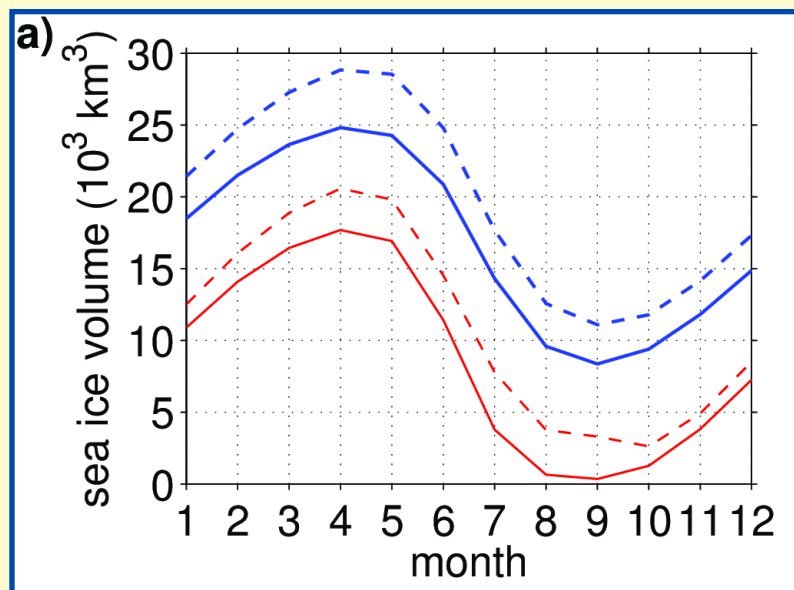
The short answer: by introducing ridging we increase the total Arctic sea ice volume



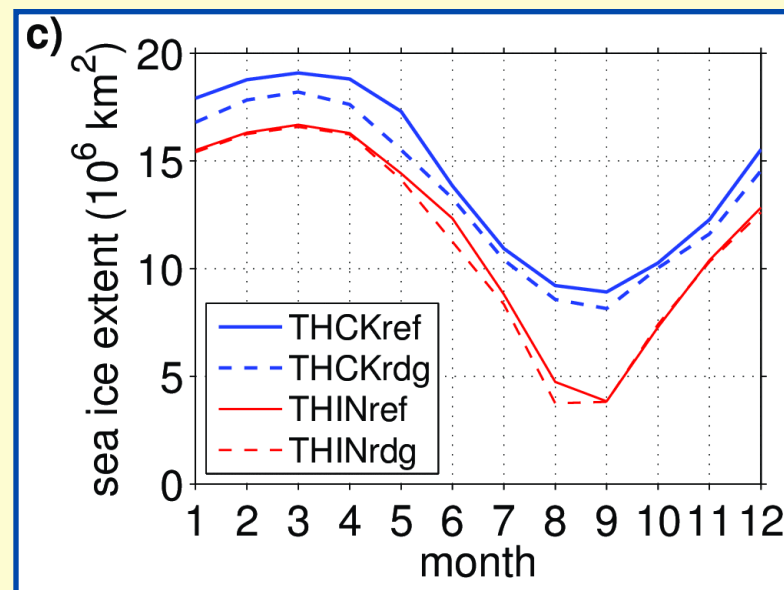
Ridging creates a greater MYI volume ...
(increased September minimum)

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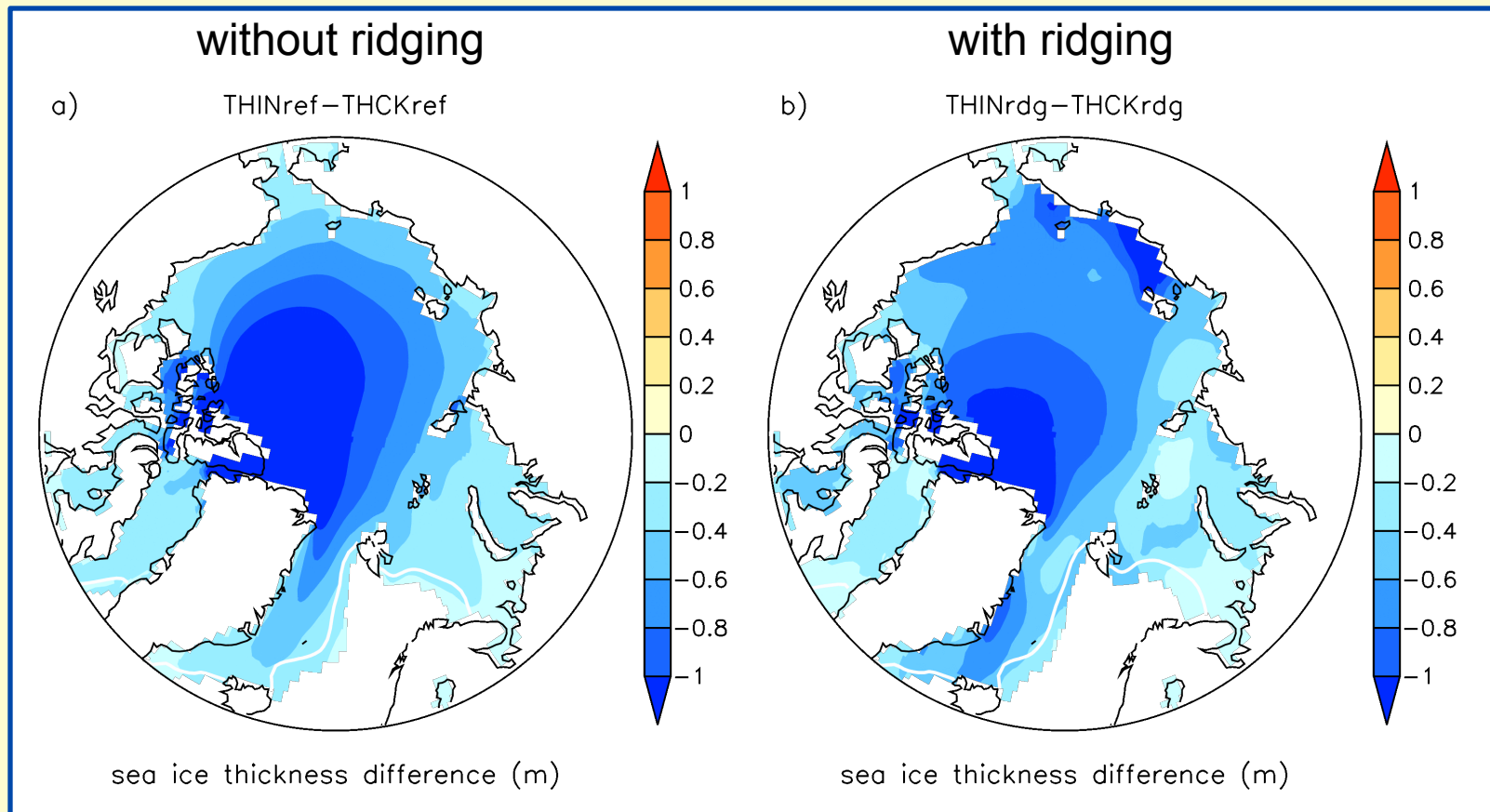
Ridging creates a greater MYI volume ...
(increased September minimum)



... but barely changes the MYI extent.
(ice cover in September)

Climate sensitivity: Can ridging bail us out?

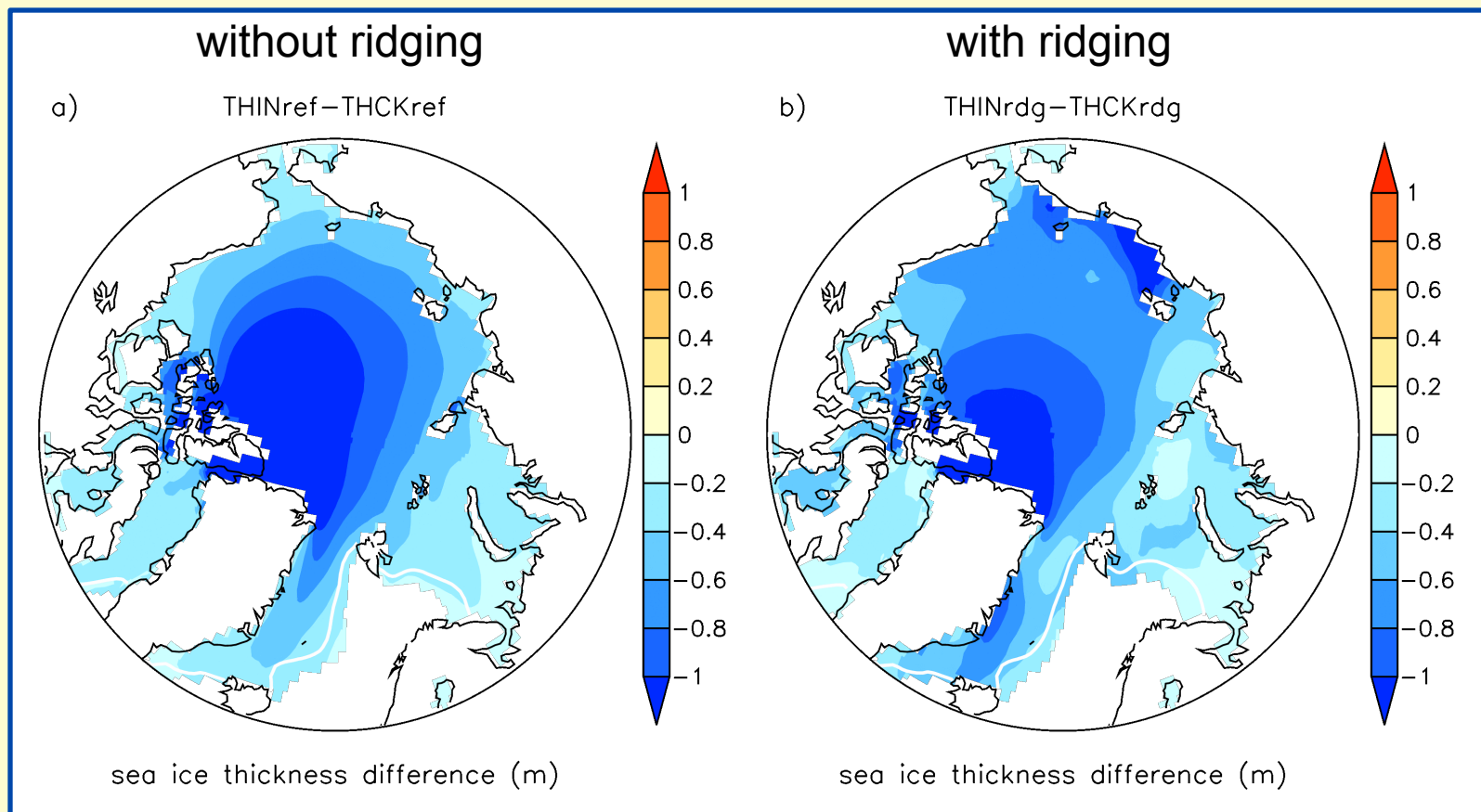
Simulating two climate states by altering snow & ice surface albedo:



Climate sensitivity: Can ridging bail us out?

In terms of the real climate trend: **maybe**

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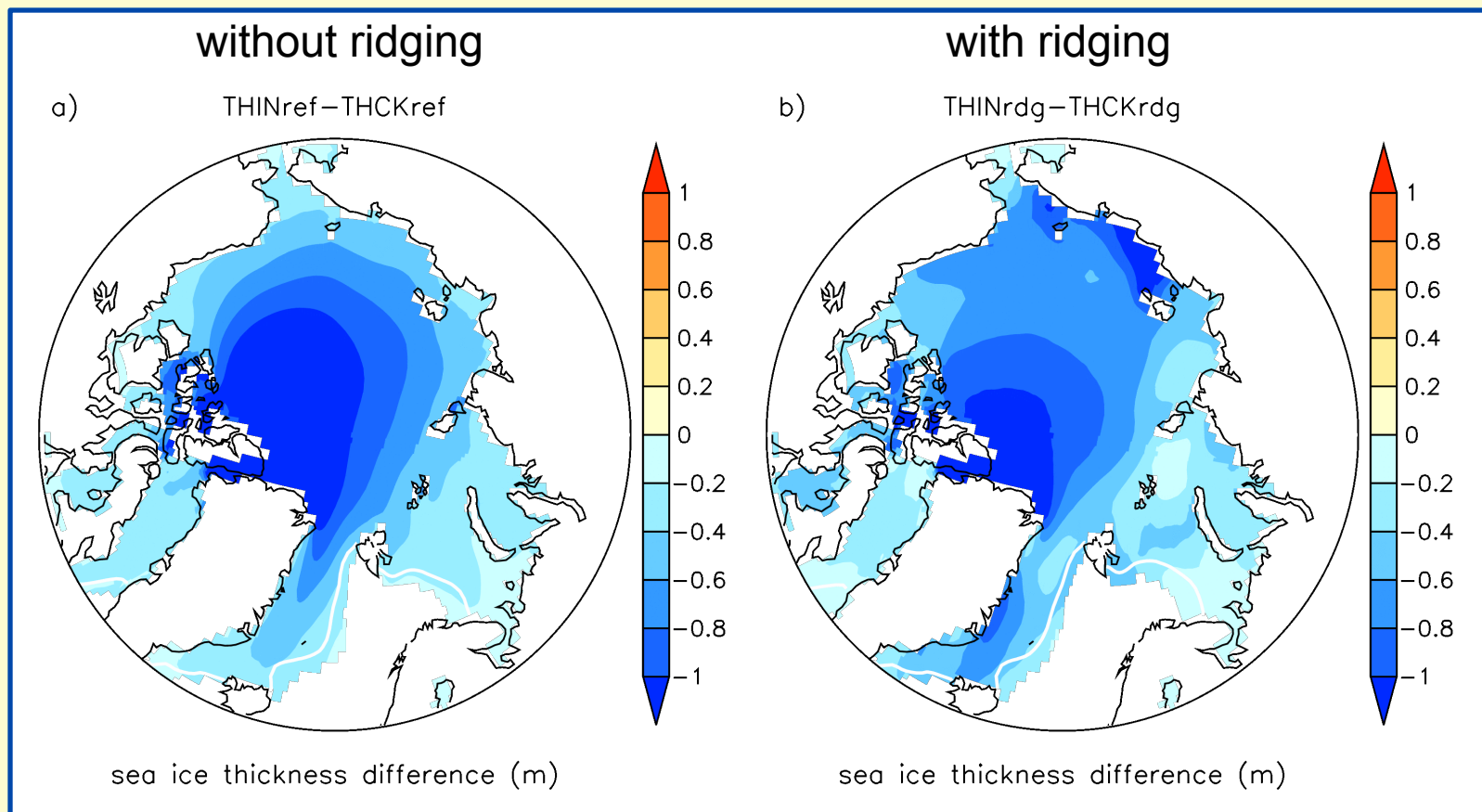


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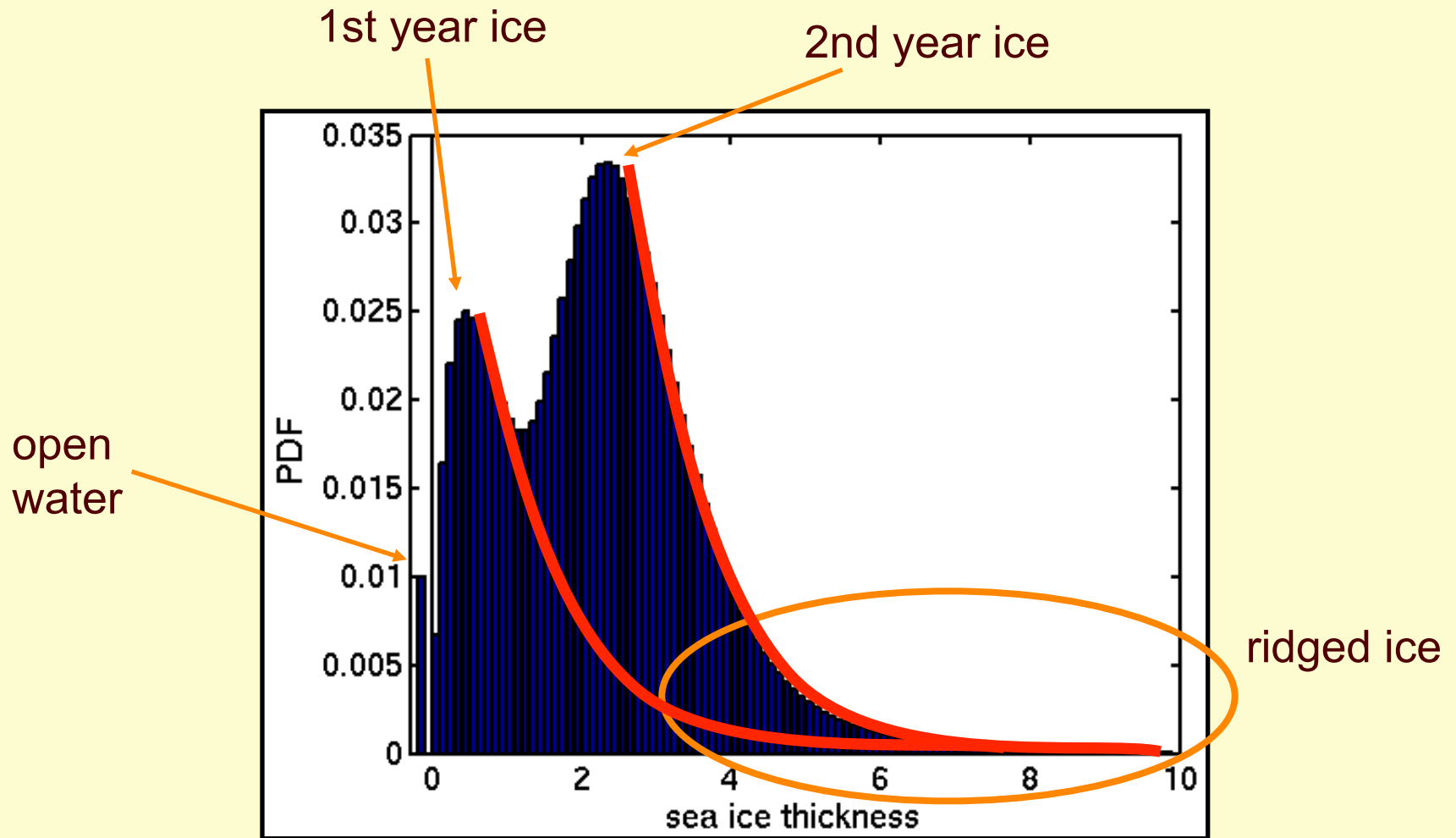
Regarding CGCMs underestimating current trends: **no**

Simulating two climate states by altering snow & ice surface albedo:



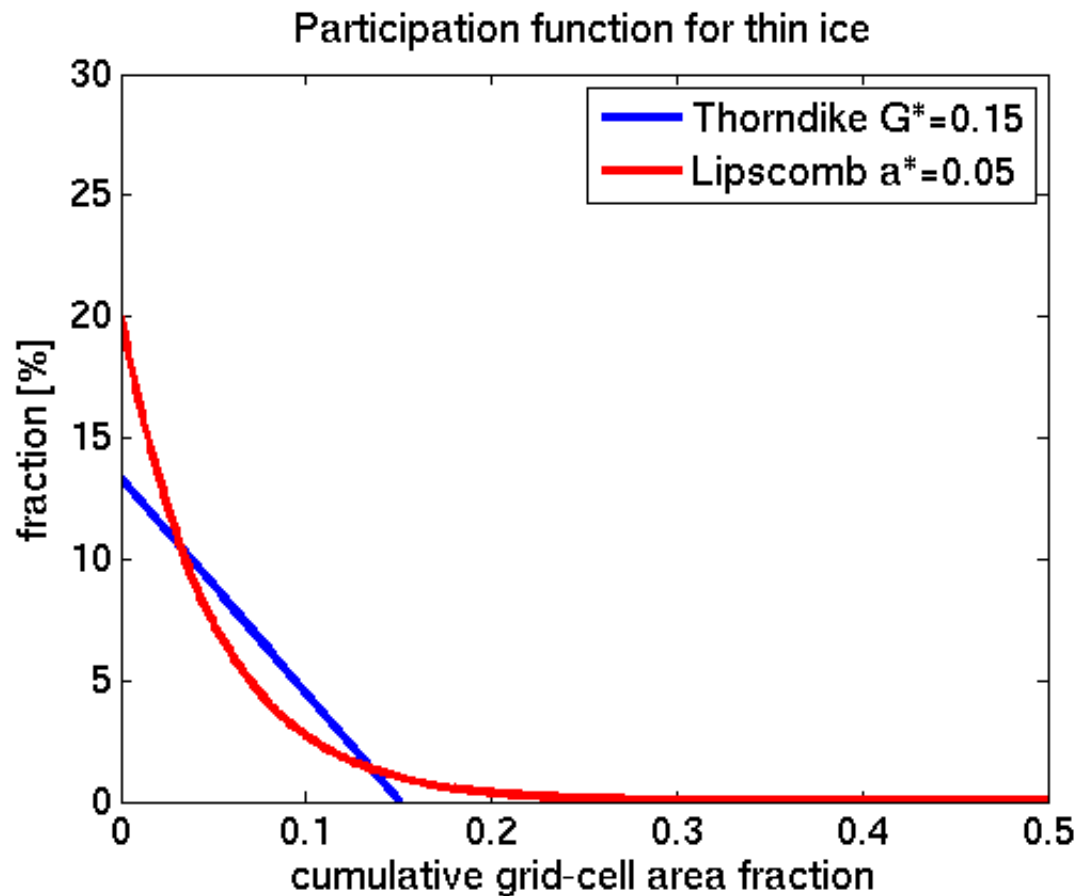
Sea-ice thickness distribution

an idealized example from the Beaufort Sea



Which ice is being ridged?

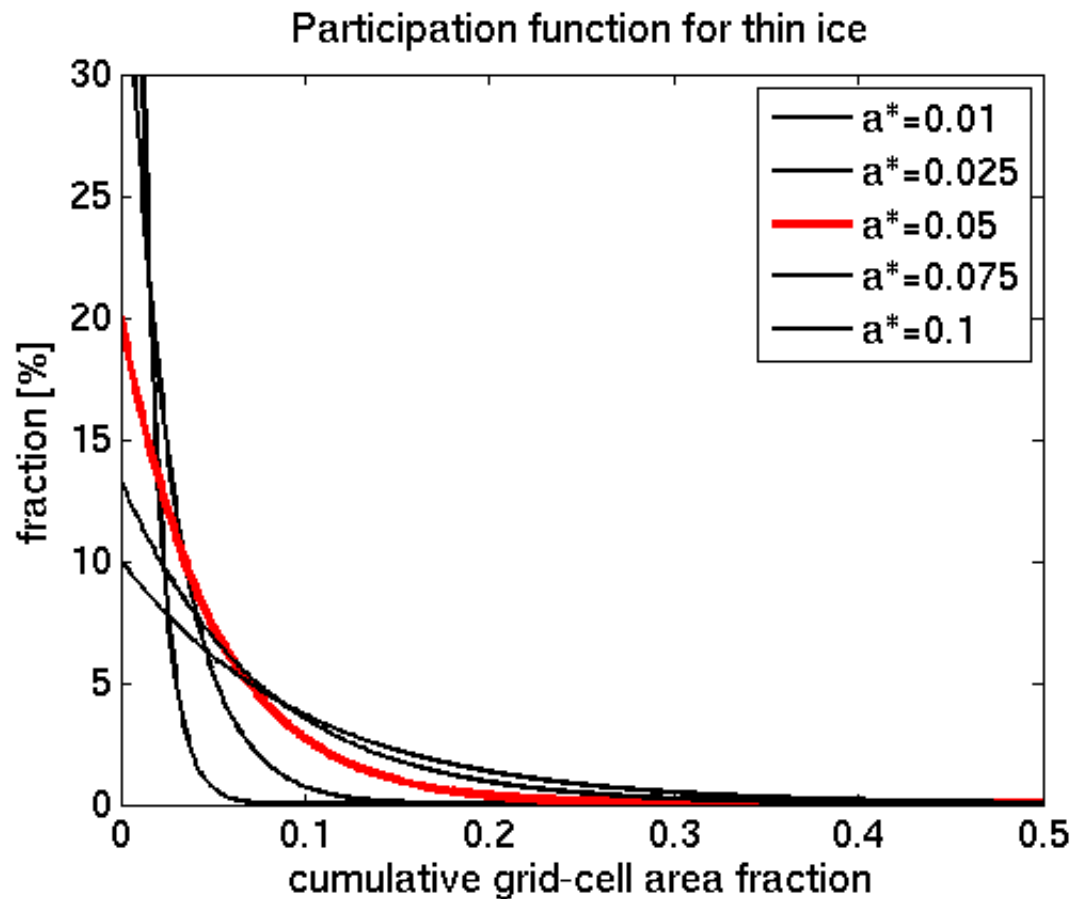
after Lipscomb et al. (2007), based on Thorndike (1975) and Hibler (1980)



exponential solution found to be numerically more stable

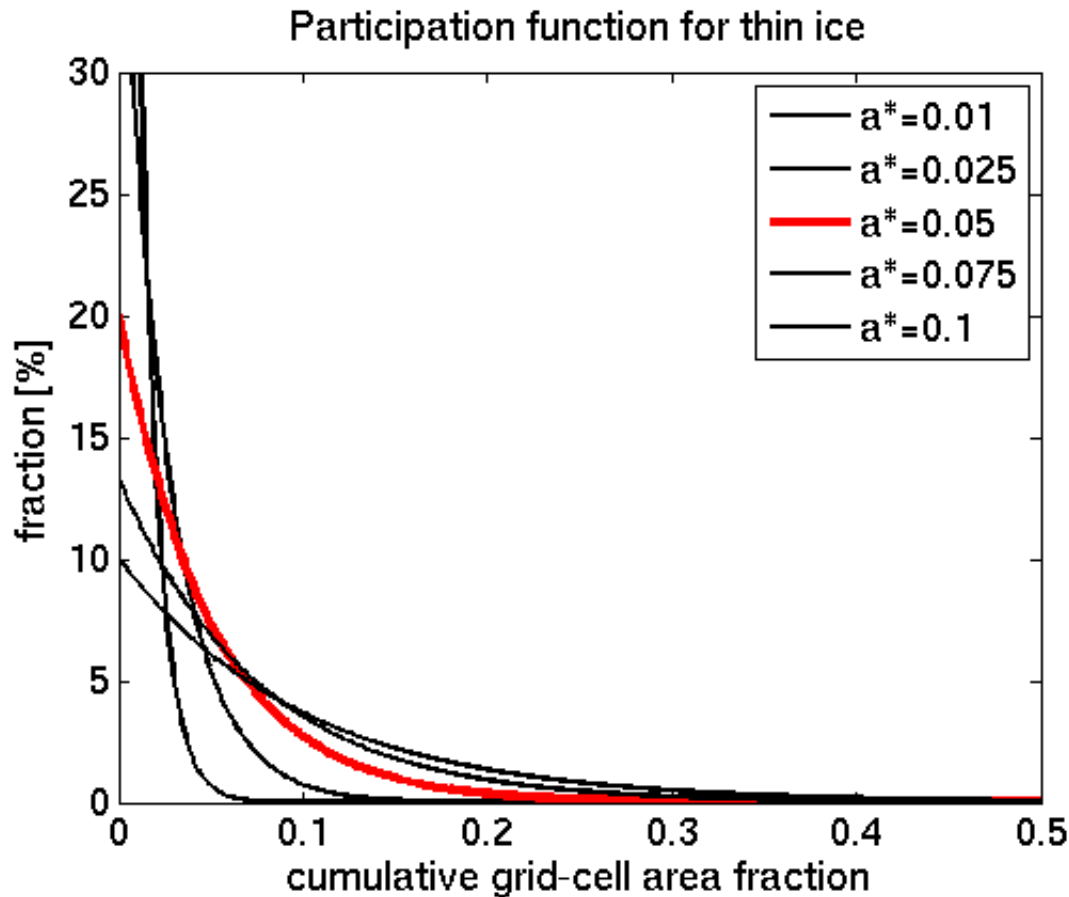
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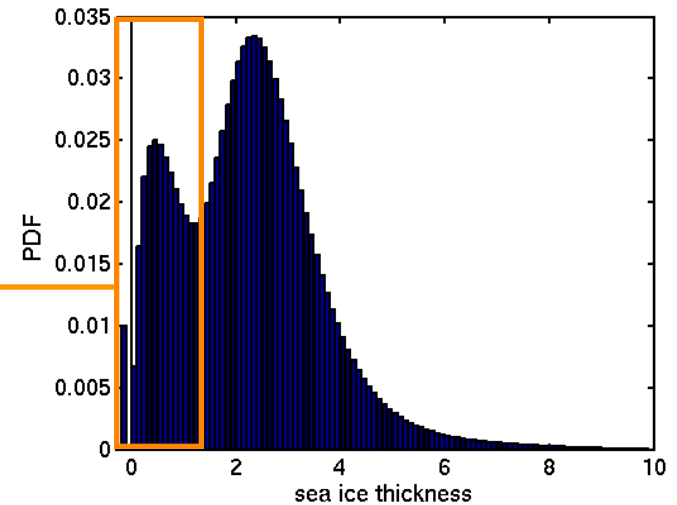
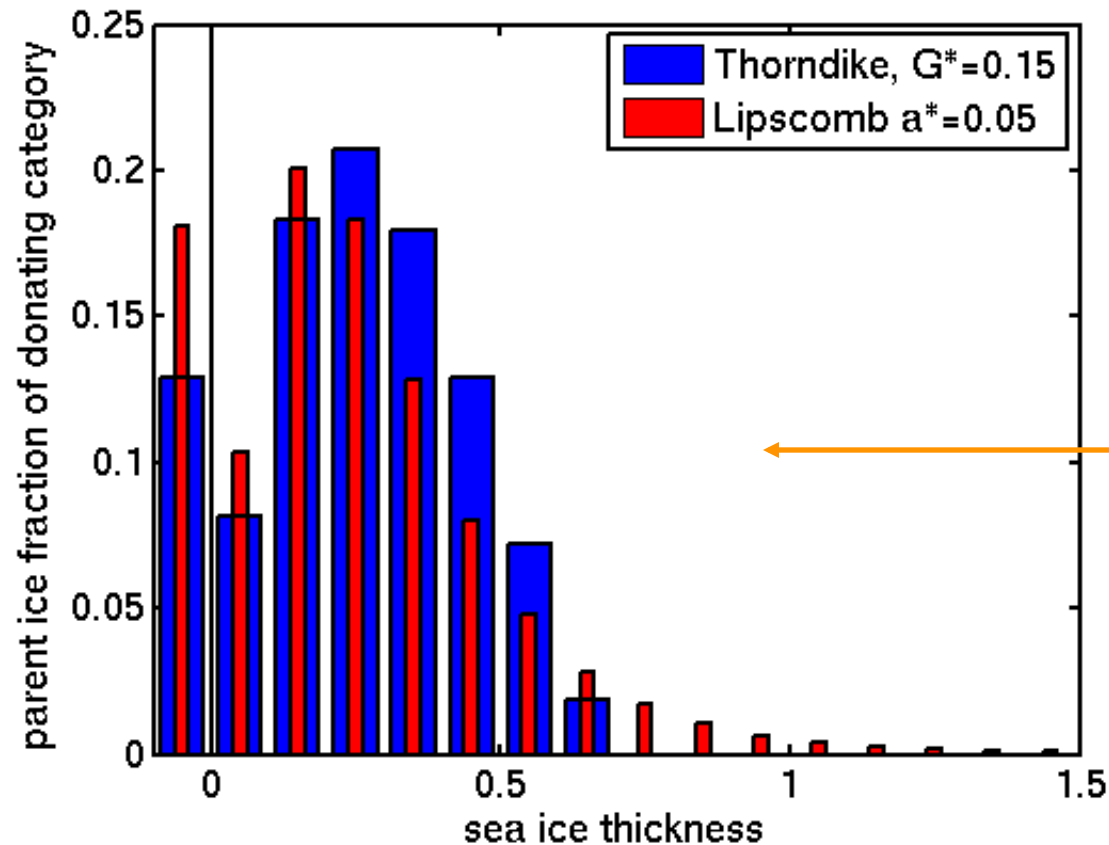
heat flux increase of
2 orders of magnitude

1% decrease in
ice concentration
can cause SAT
Increase of 3.5°C

(Lüpkes et al., 2004,2008)

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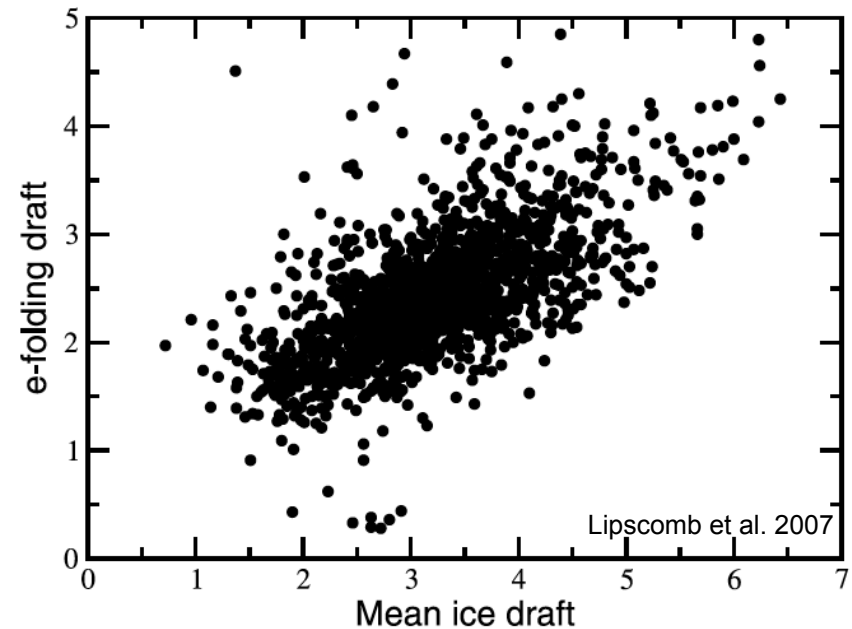
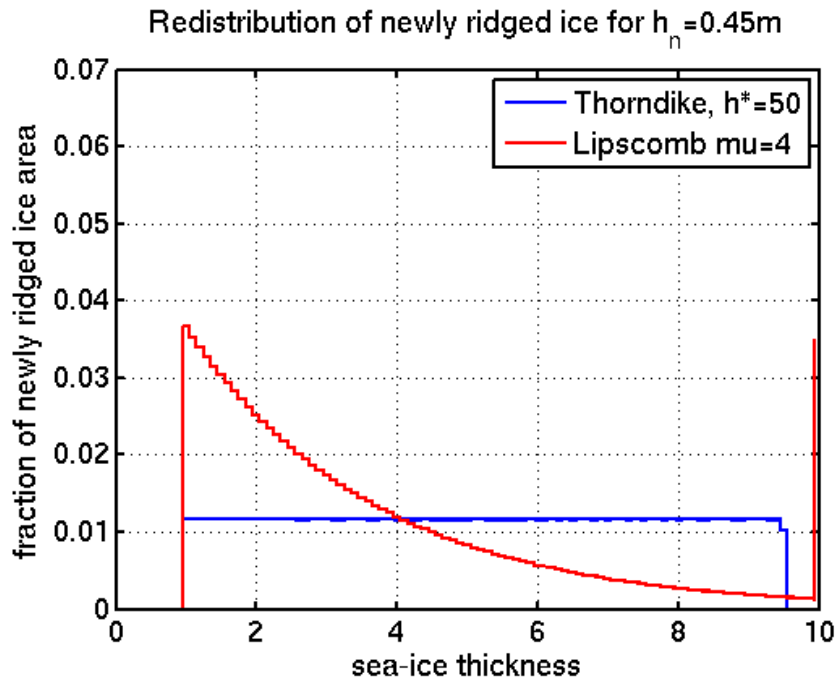
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Where to put the newly ridged ice?

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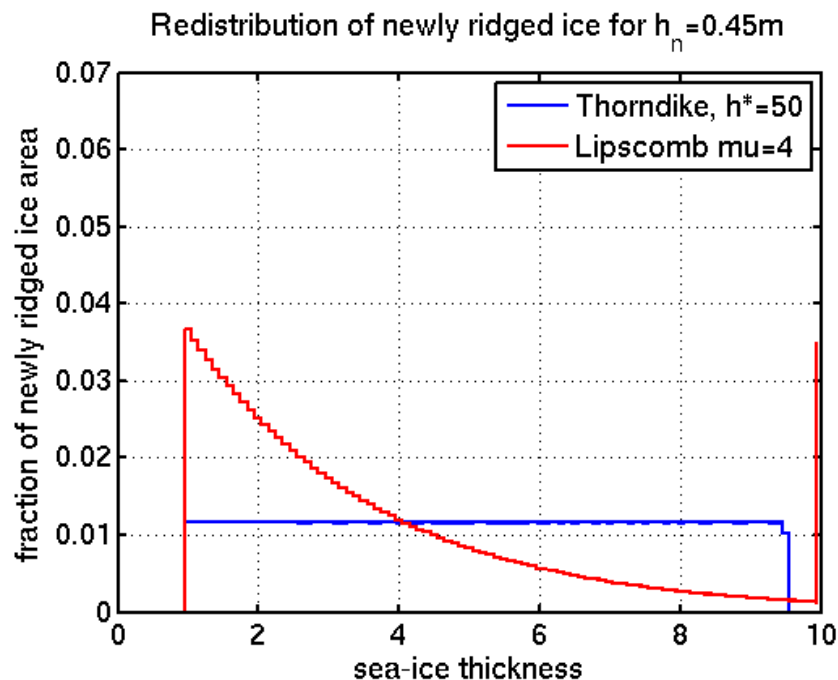
ice area



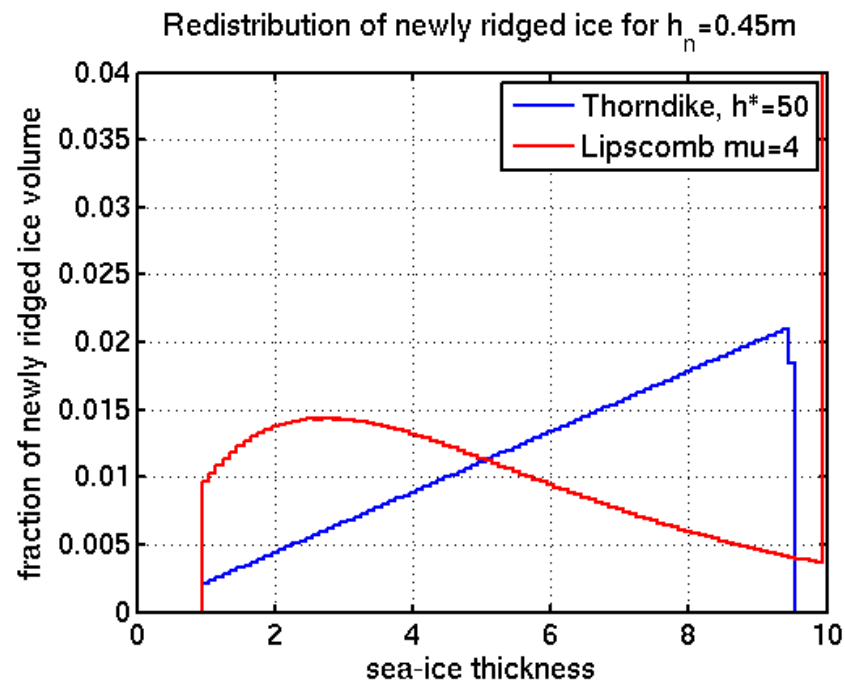
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ice volume

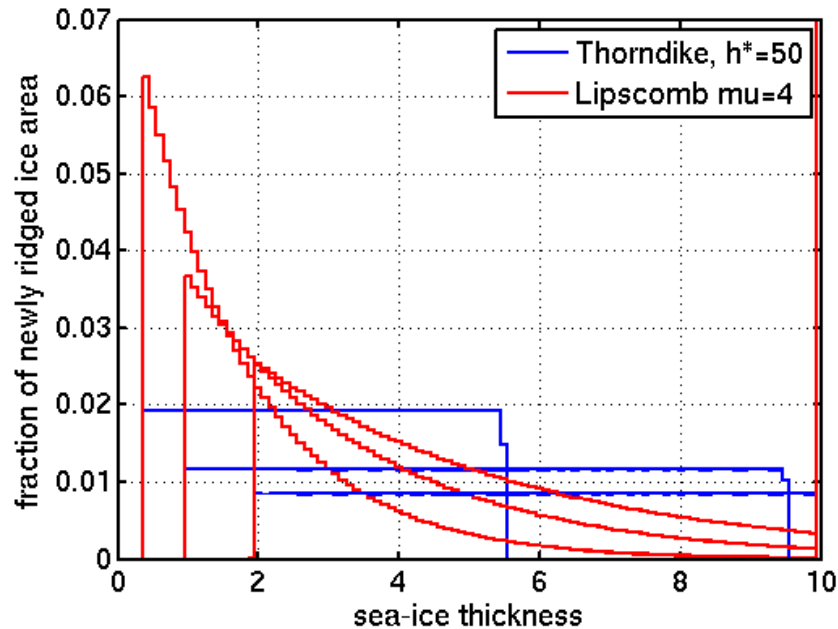


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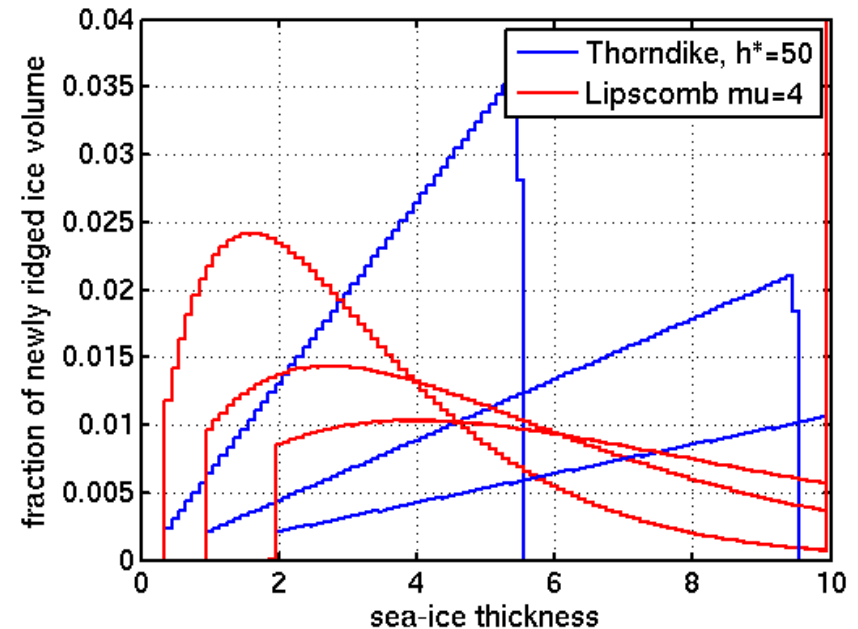
ice area

Redistribution of newly ridged ice for various $h_n = [0.15 \ 0.45 \ 0.95]m$



ice volume

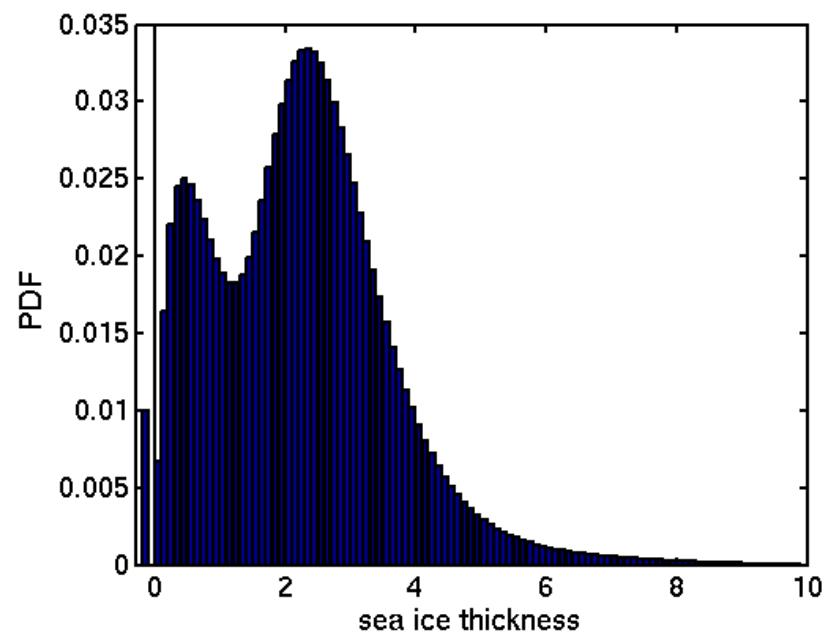
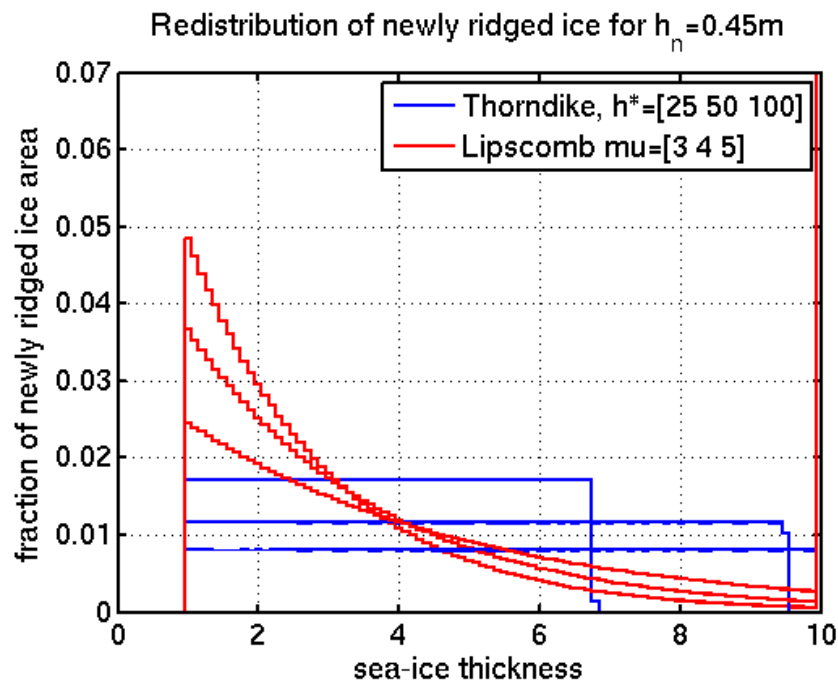
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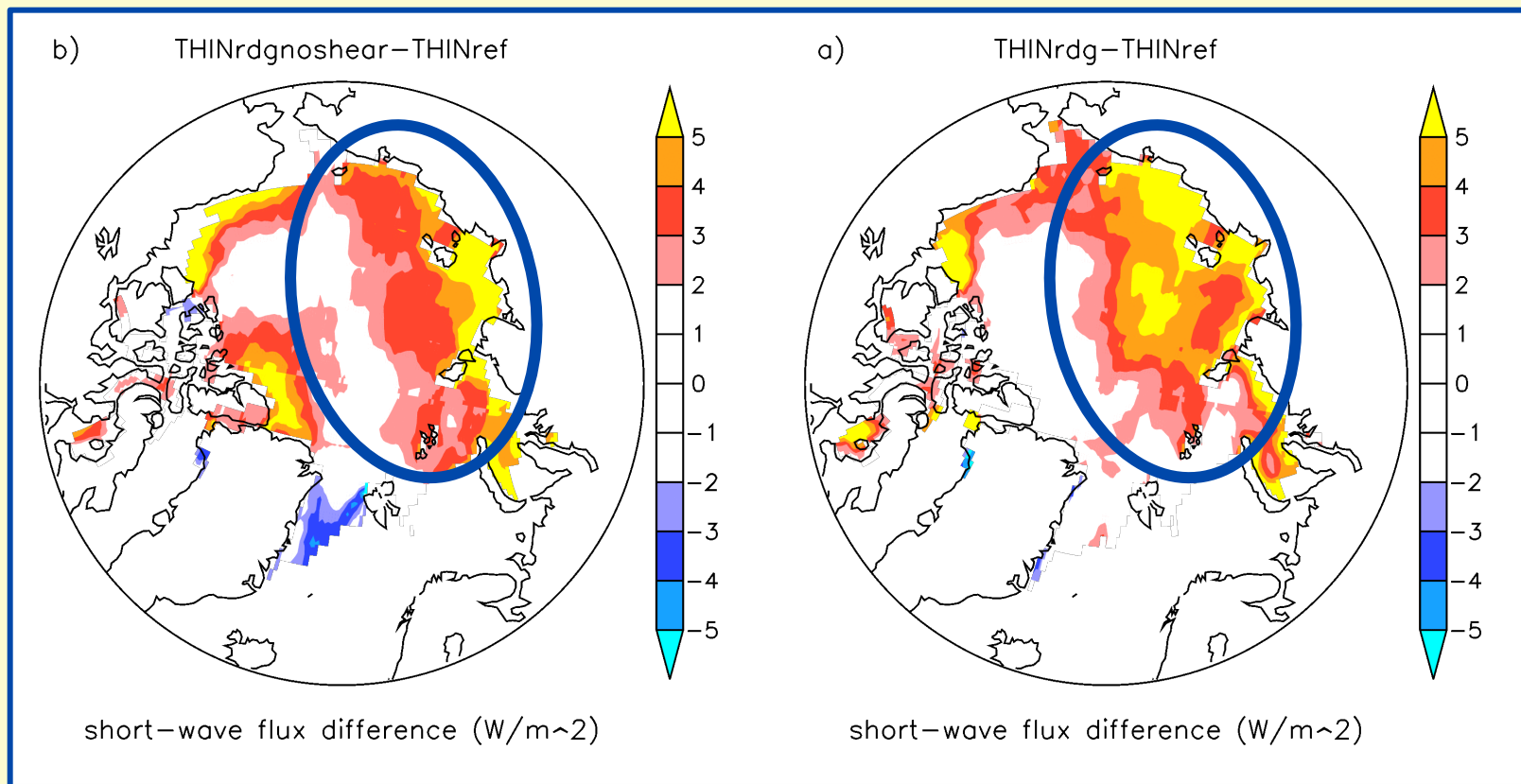
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ice area



How sensitive is the ridging scheme?

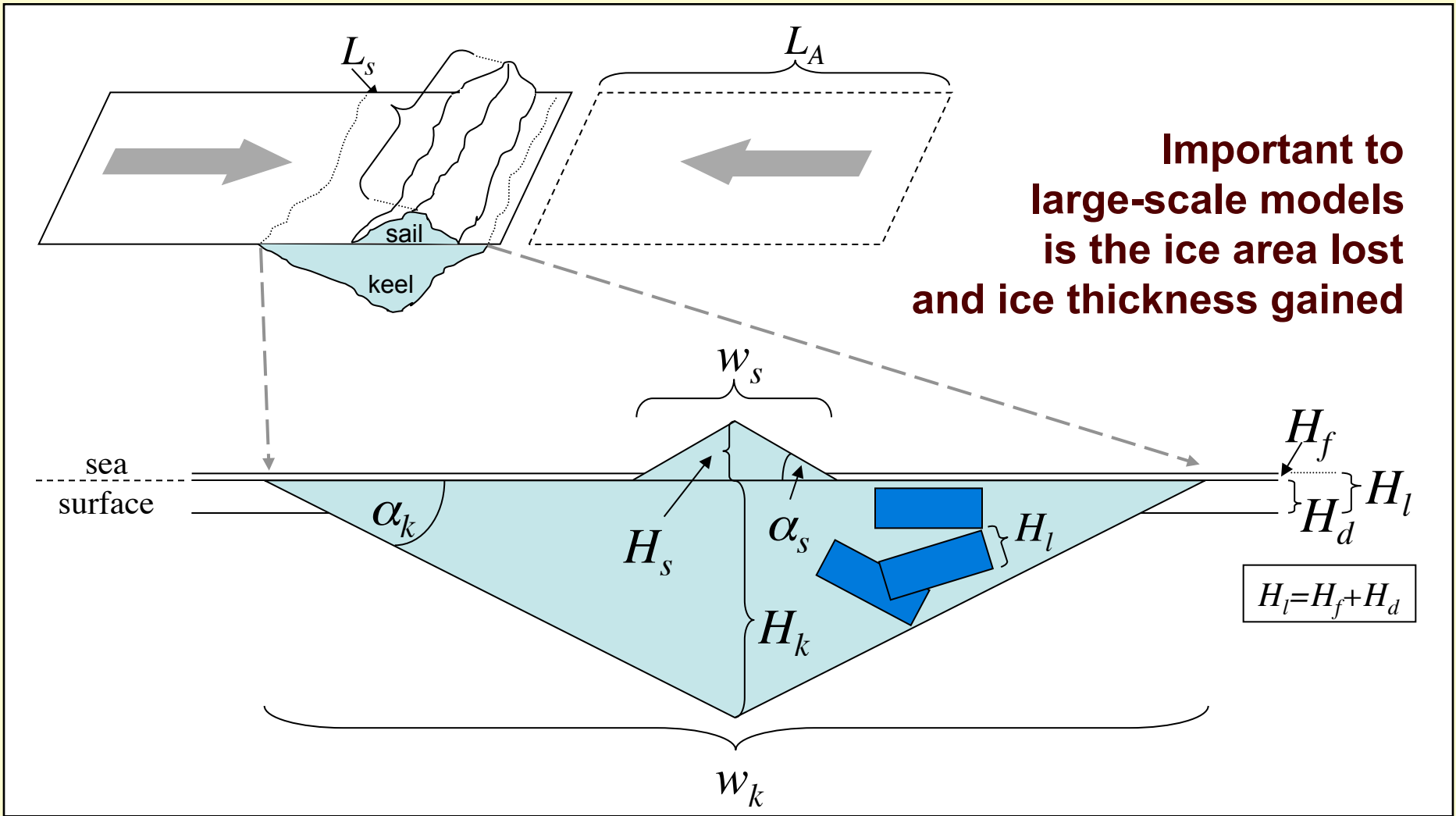
difference in shortwave heat flux going into ice/ocean



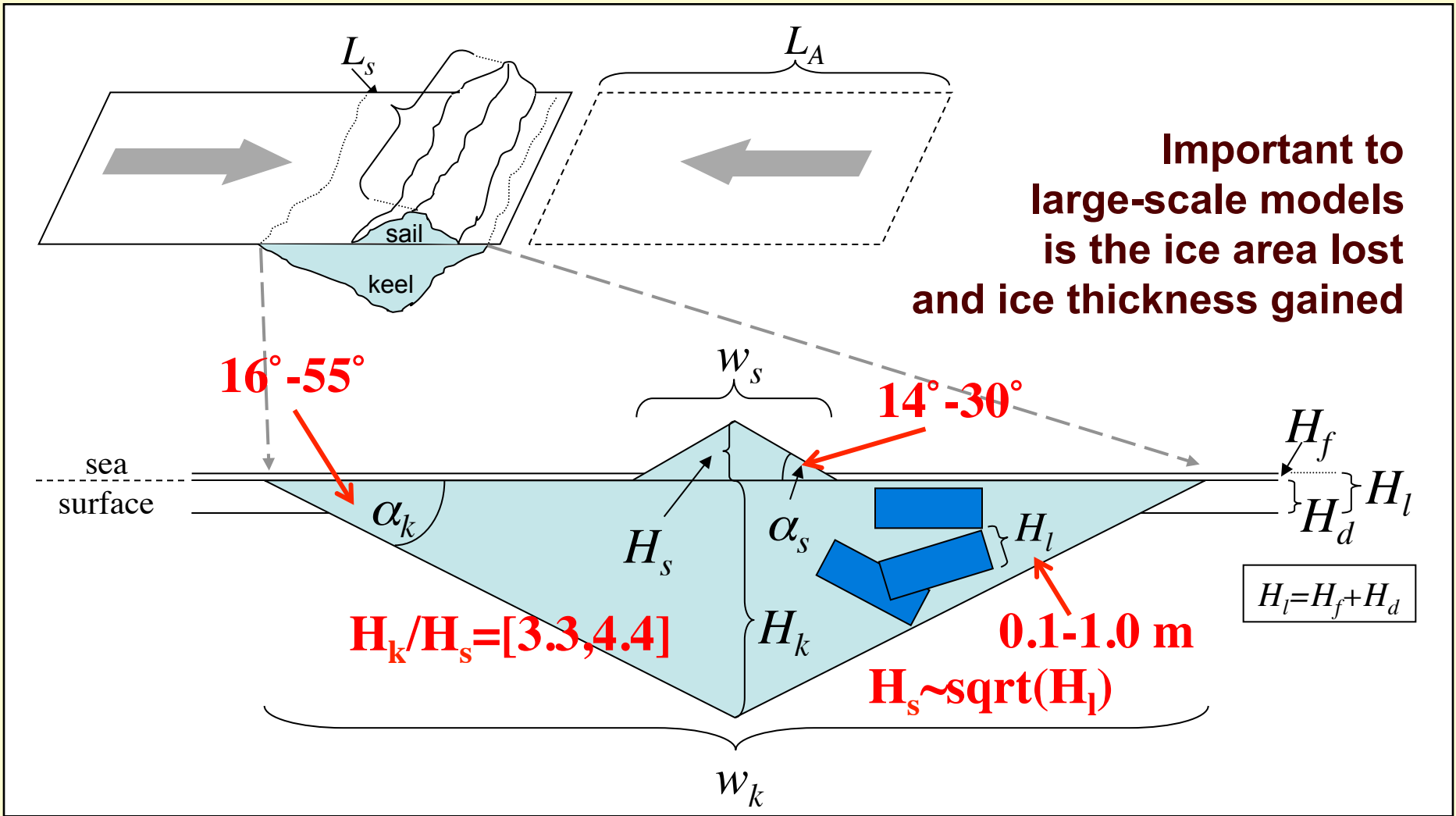
ridging w/o shear ...

and w/shear contribution

Ridge geometry: parameterizing a complex structure



Ridge geometry: parameterizing a complex structure



Conclusions: Ridging ...

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- causes a warmer sea surface and surface air temperatures
- increases the volume of multi-year ice
- rather reduces the loss of sea ice due to external forcing
- parameterizations depend on a whole lot of variables, which statistics are still not well observed



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