CLIMATE, OCEAN AND SEA ICE MODELING PROGRAM

Sensitivity of sea ice age to physical parameterizations and resolution in the CICE sea ice model

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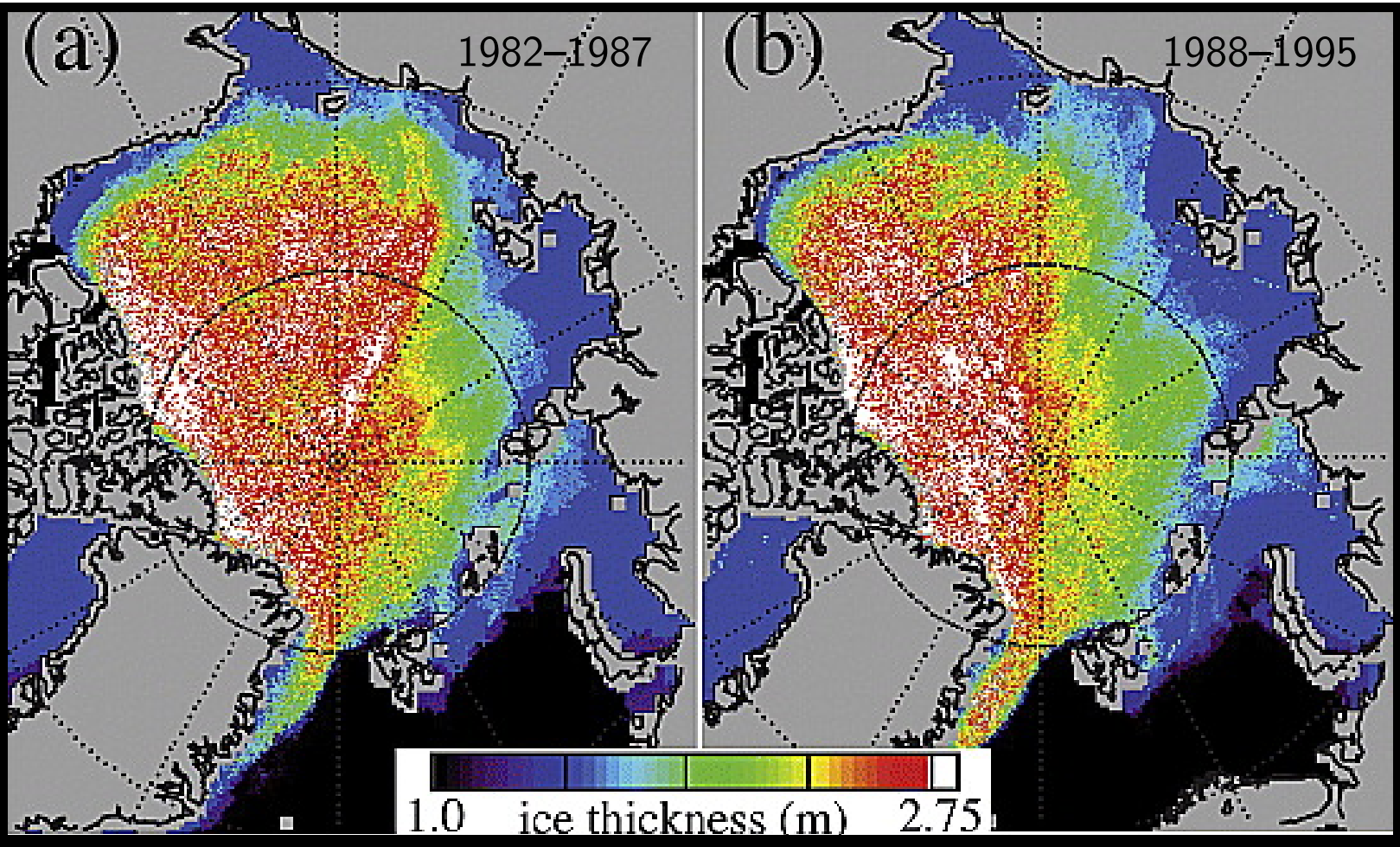
Ice age: So what?

- Can be deduced from satellite observations
- Related to ice physical properties (albedo, salinity, thickness)
- Might be useful for prediction of near-future ice pack
- Seasonal ice pack implies simpler logistics/shipping
- Ecosystem ramifications

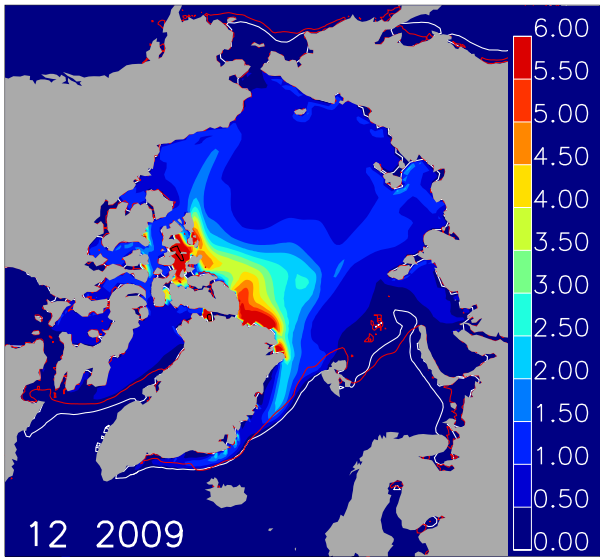
Suggested proxy for ice thickness



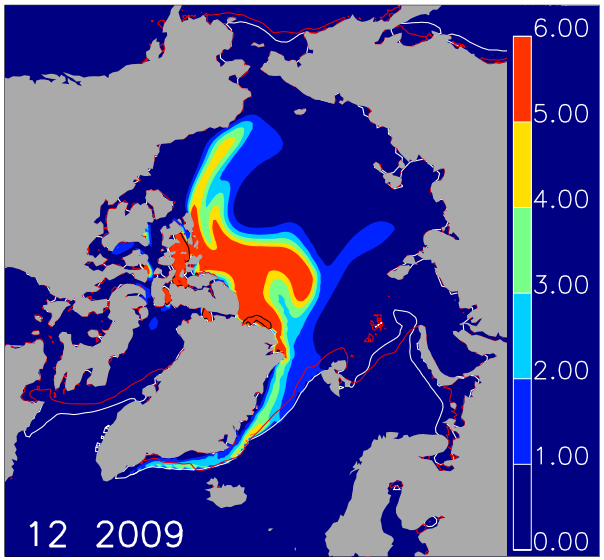
Maslanik et al., Geophys. Res. Lett. **34**, 2007

Control

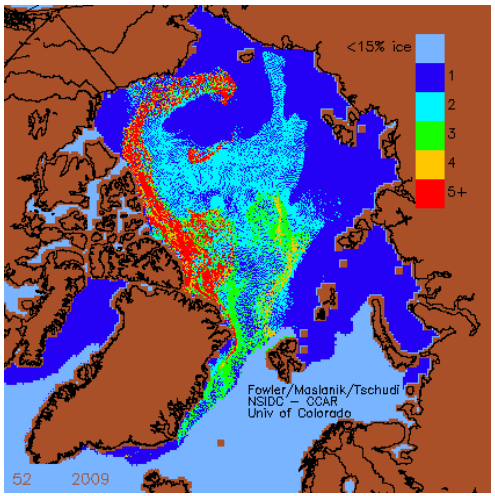
thickness (m)



age (years)



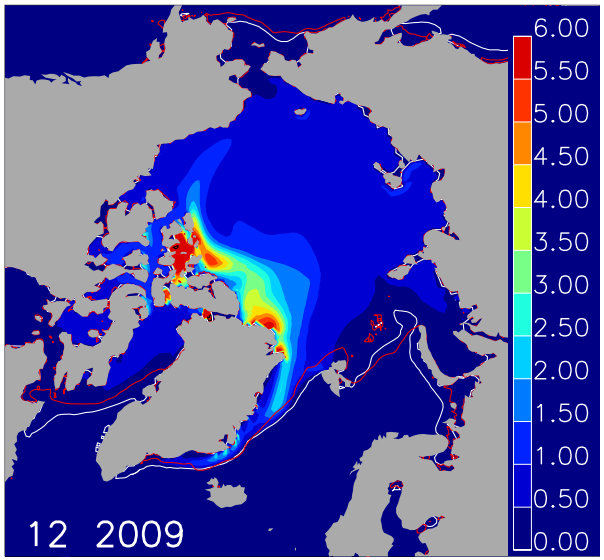
obs (years)



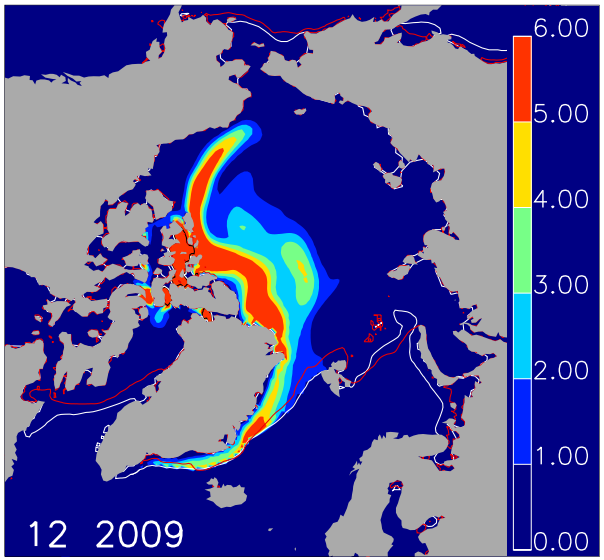
Fowler, C., Maslanik, J., Tschudi, M. Dept. of Aerospace Engr., Univ. of Colorado, Boulder, CO.

Using Form Drag Parameterization

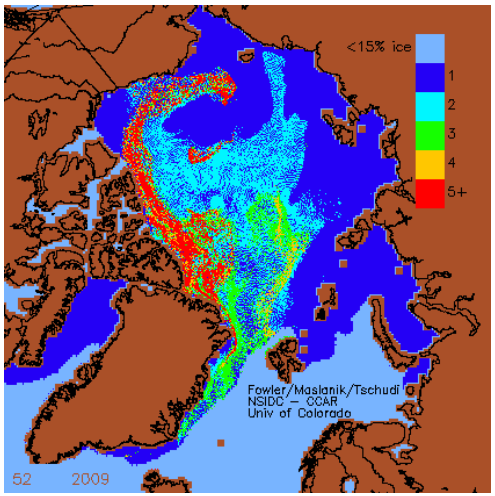
thickness (m)



age (years)



obs (years)



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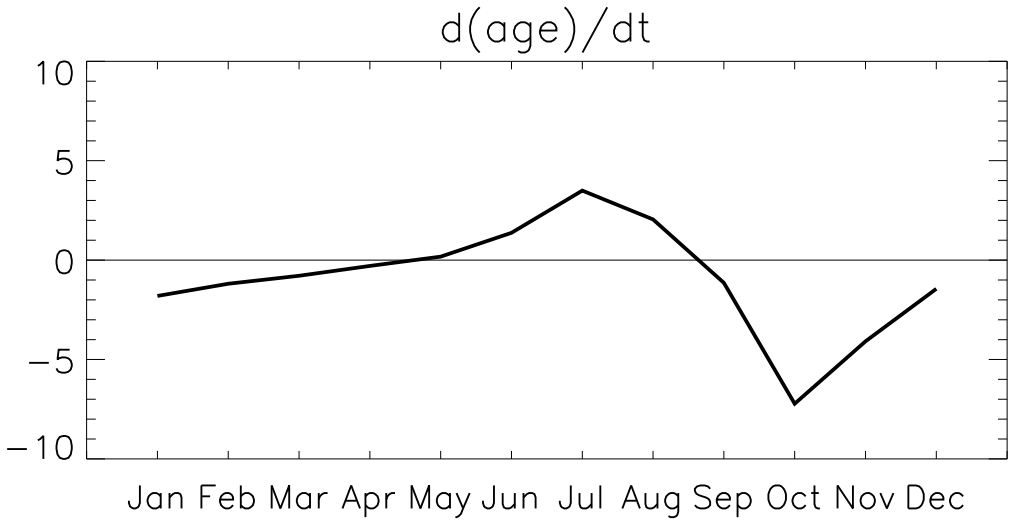
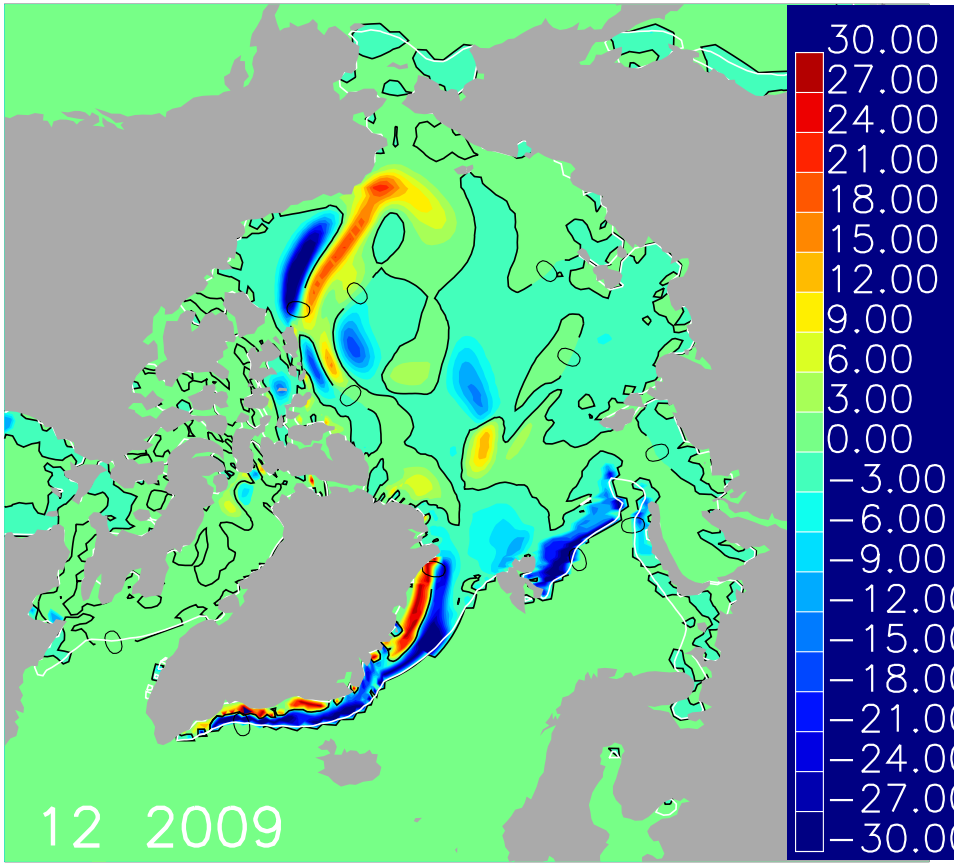
What changes sea ice age?

- the incessant march of time
- thermodynamics

	pack ice trend	
grow new ice	younger	thinner
melt older ice	younger	thinner
melt younger ice	older	thicker



What about dynamics? control

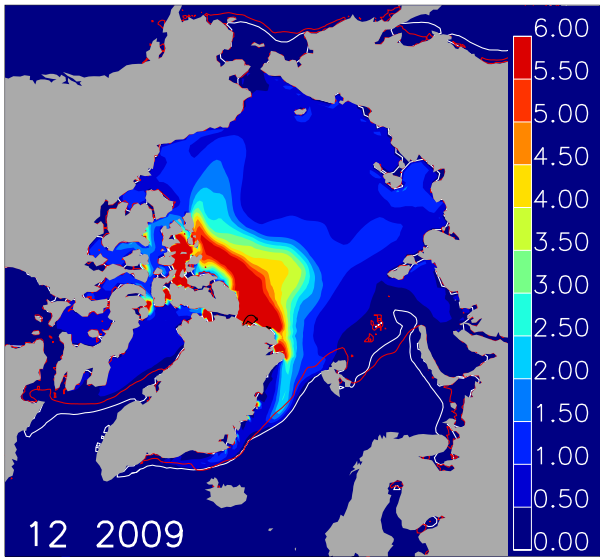


days per day

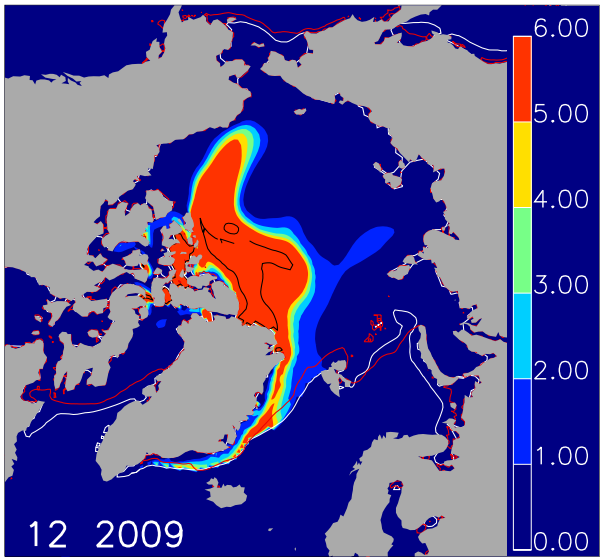
$\frac{\partial age}{\partial t}$ due to dynamics

Using Elastic-Anisotropic-Plastic Rheology

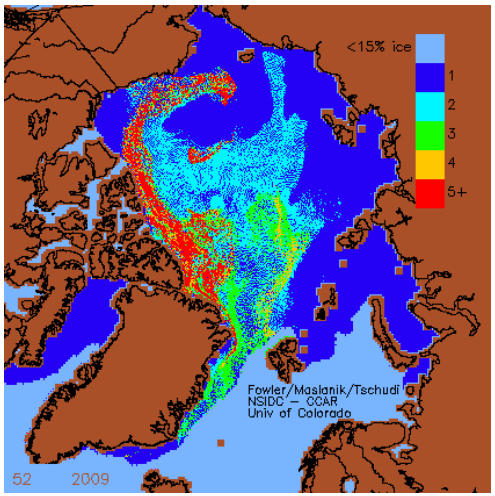
thickness (m)



age (years)



obs (years)



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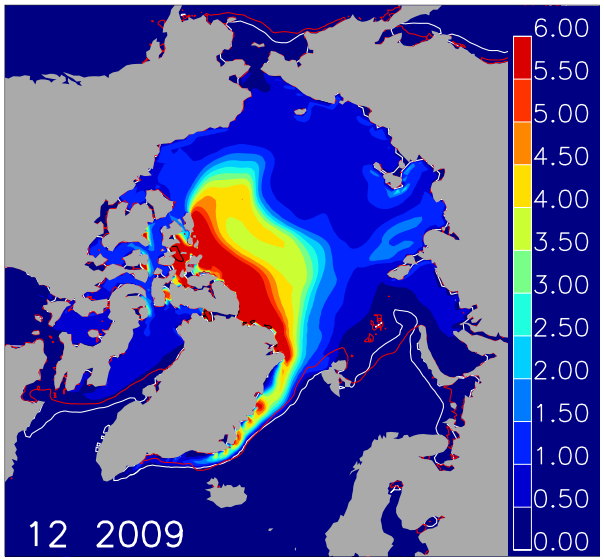
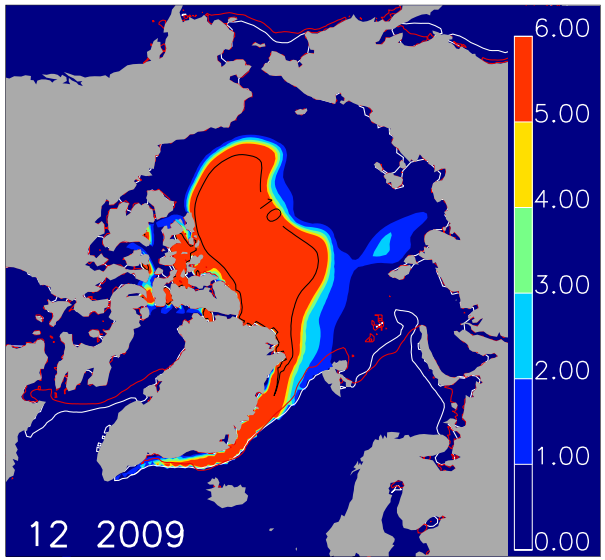
Use 0.5 * U_{ice} for advection

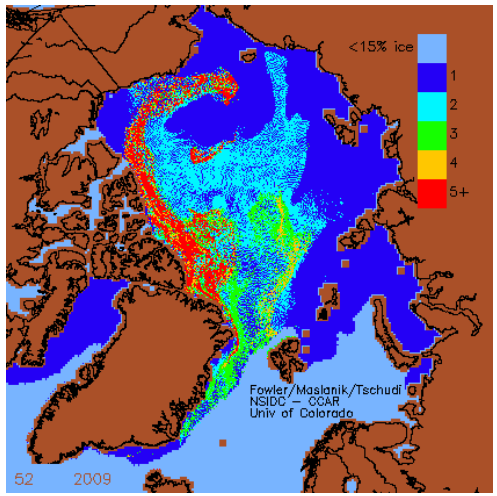
thickness (m)



age (years)



obs (years)



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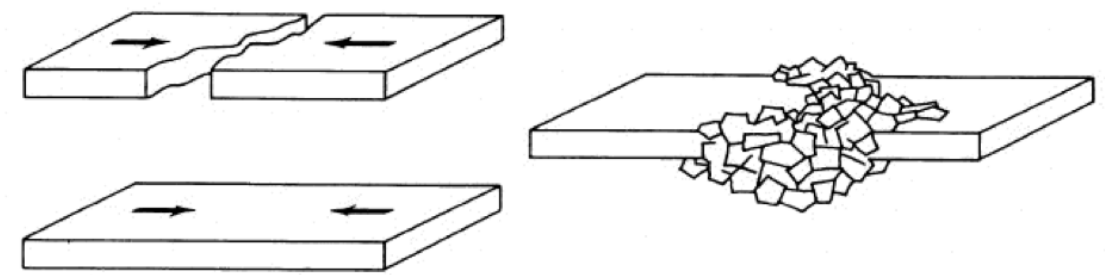
$\nabla \cdot U_{ice}$ is not altered explicitly

Mechanical Redistribution a.k.a. “Ridging”

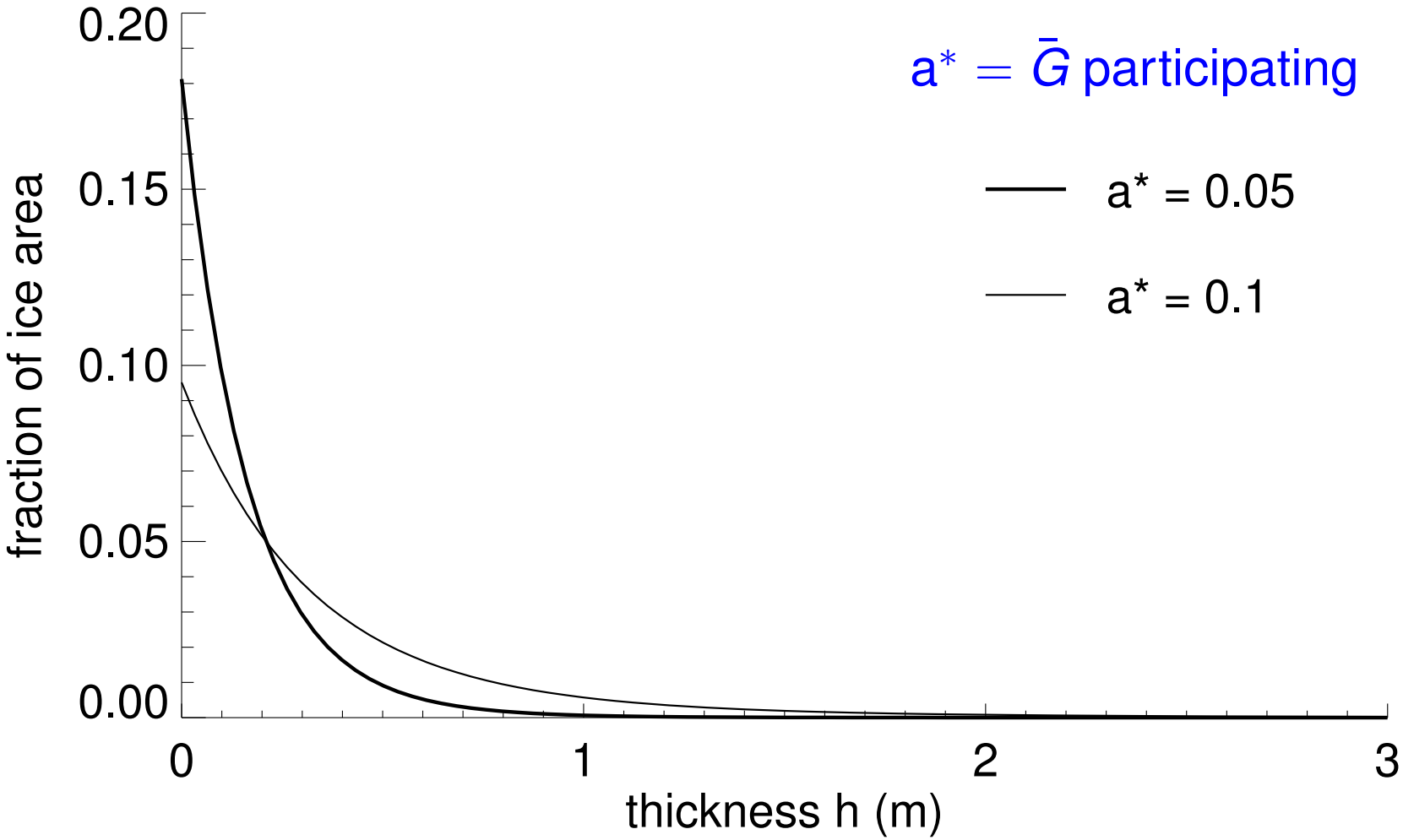
Based on gravitational work necessary to build ridges

- Participation function
  thinnest portion of ITD participates
- Redistribution function
  determines ITD of ridged ice



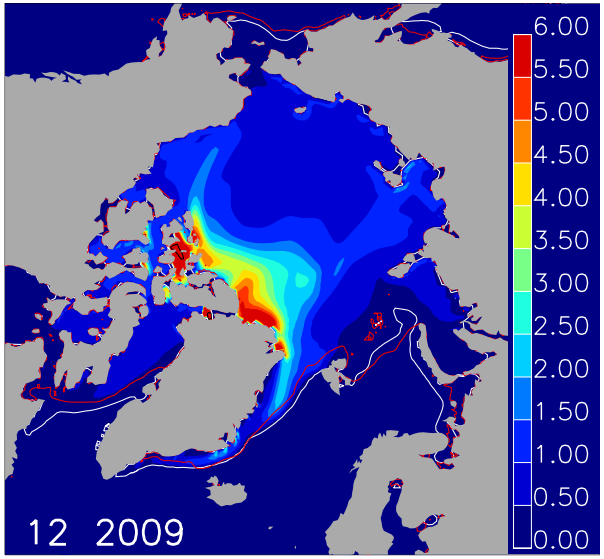
(From Sanderson, 1988)

Ridging participation function

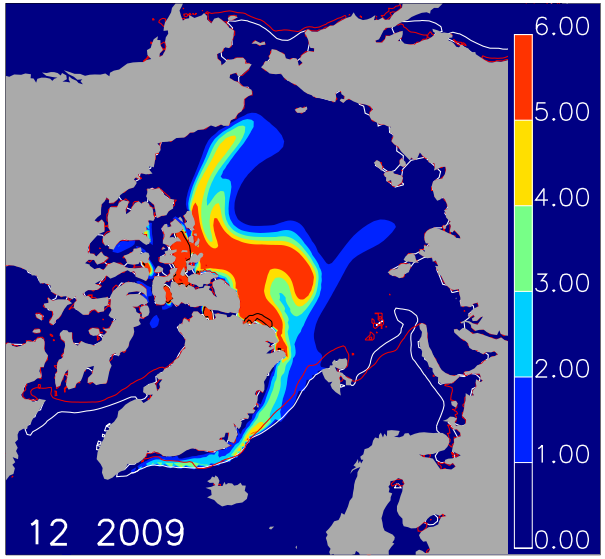


Ridging participation function

thickness (m)

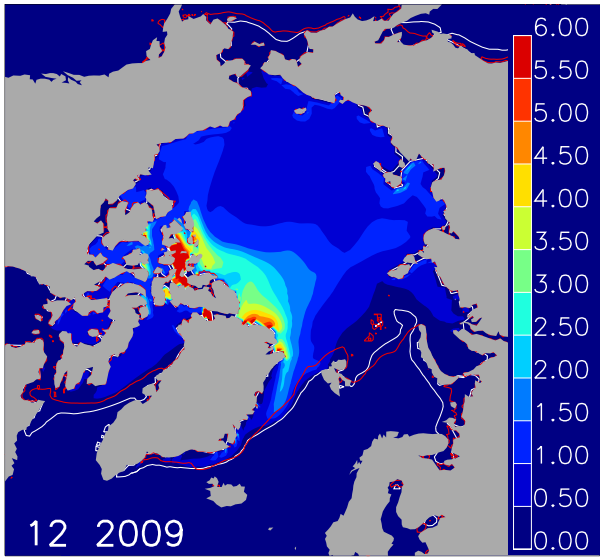


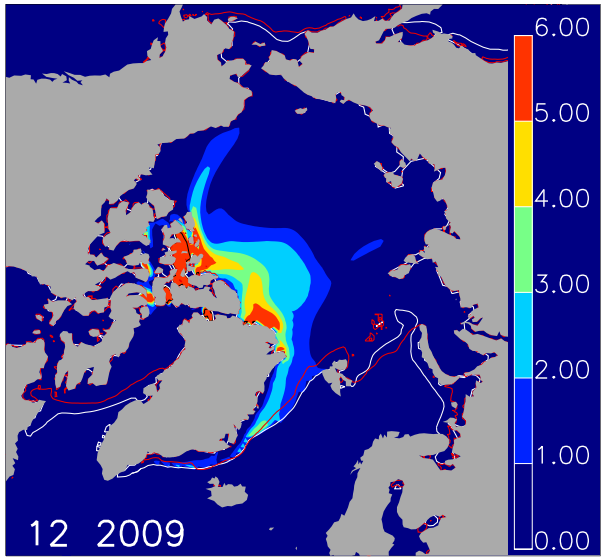
age (years)



Control

$a^* = 0.05$





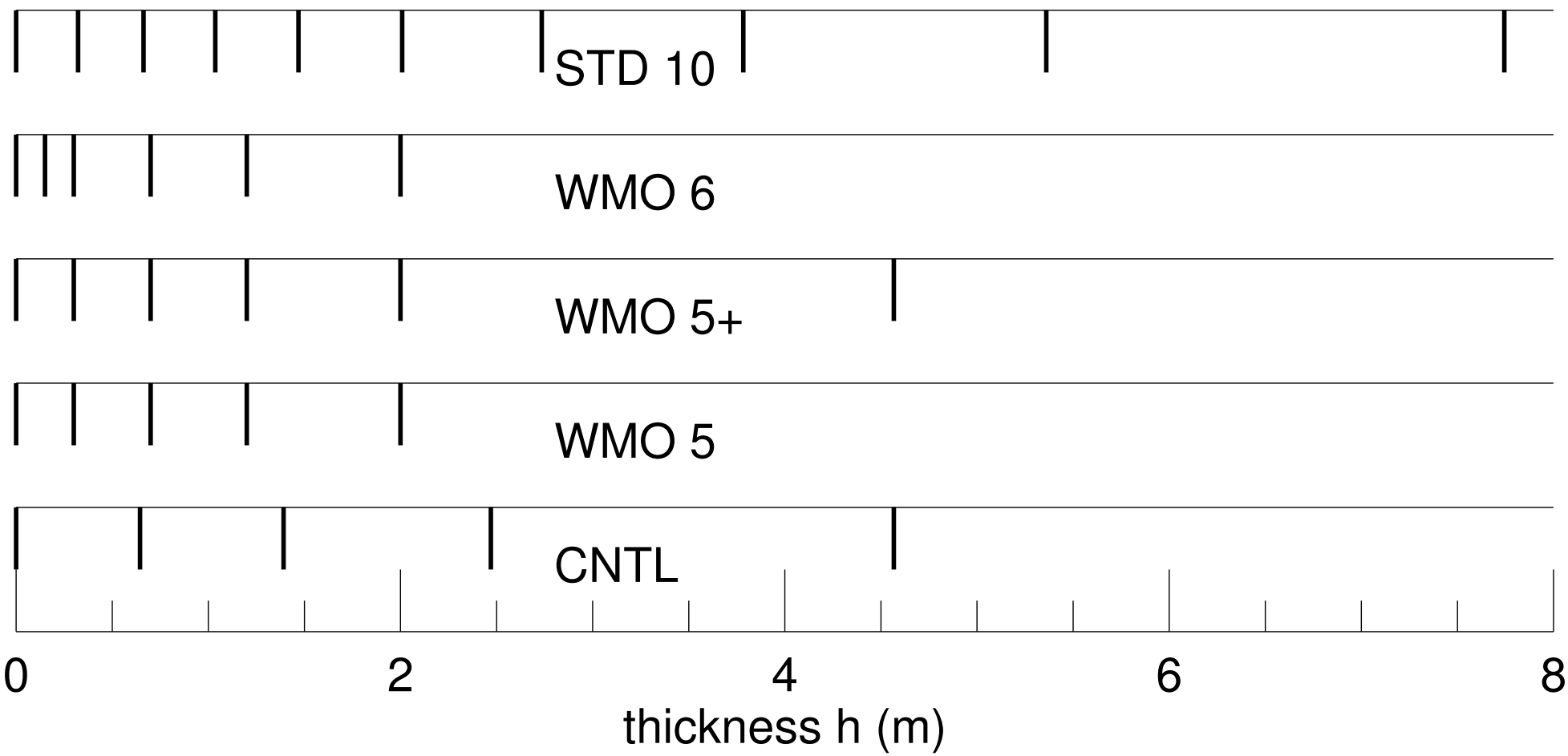
$a^* = 0.1$

Participation / redistribution negative feedback

ridge thin ice $\Rightarrow$ tall, narrow ridges + open water
more open water $\Rightarrow$ more new freezing, ridging
$\Rightarrow$ thicker ice pack

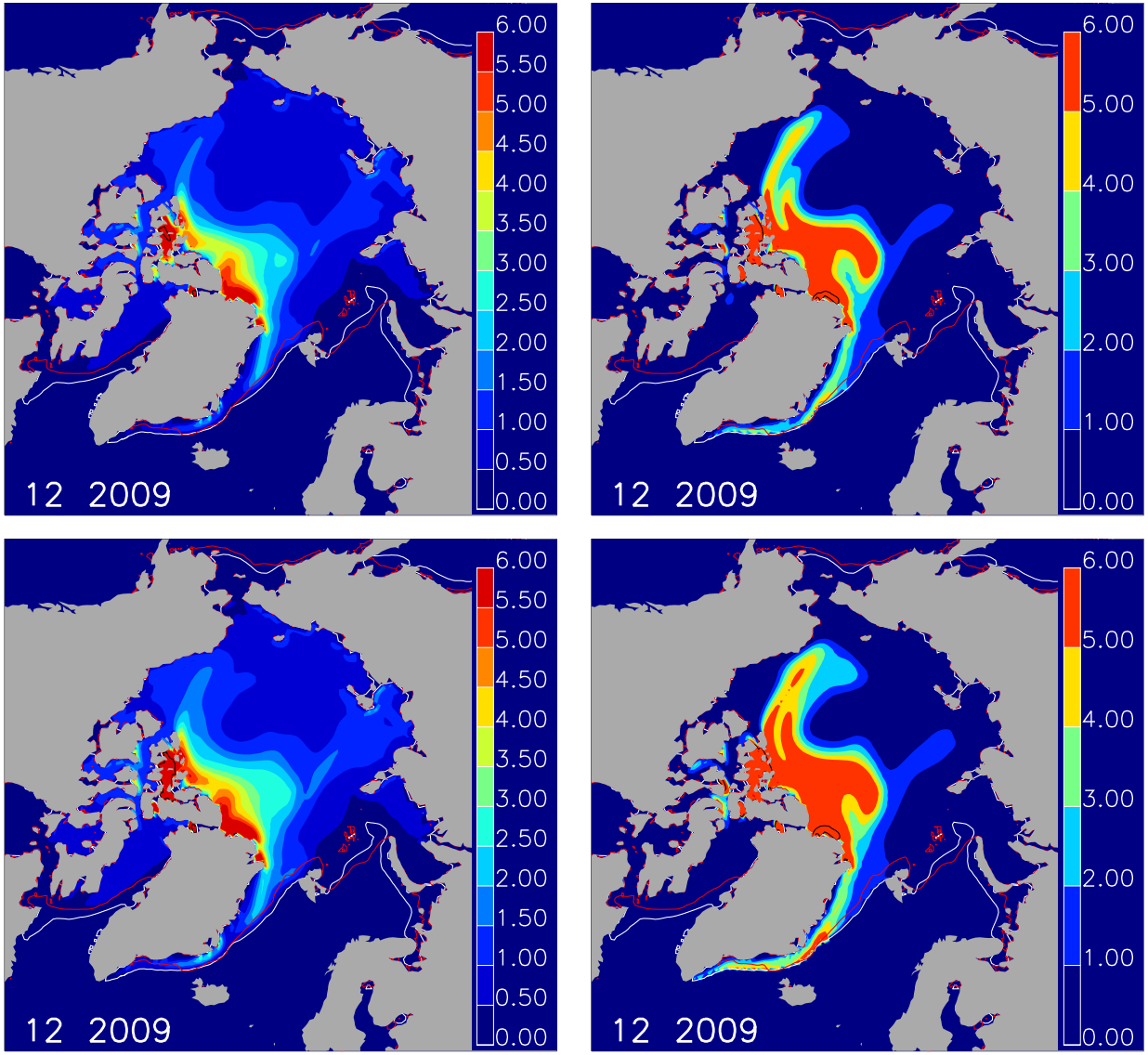
ridge thicker ice $\Rightarrow$ wider ridges, less open water
less open water $\Rightarrow$ less new freezing, ridging
$\Rightarrow$ thinner ice pack

Thickness category resolution



Thickness category resolution

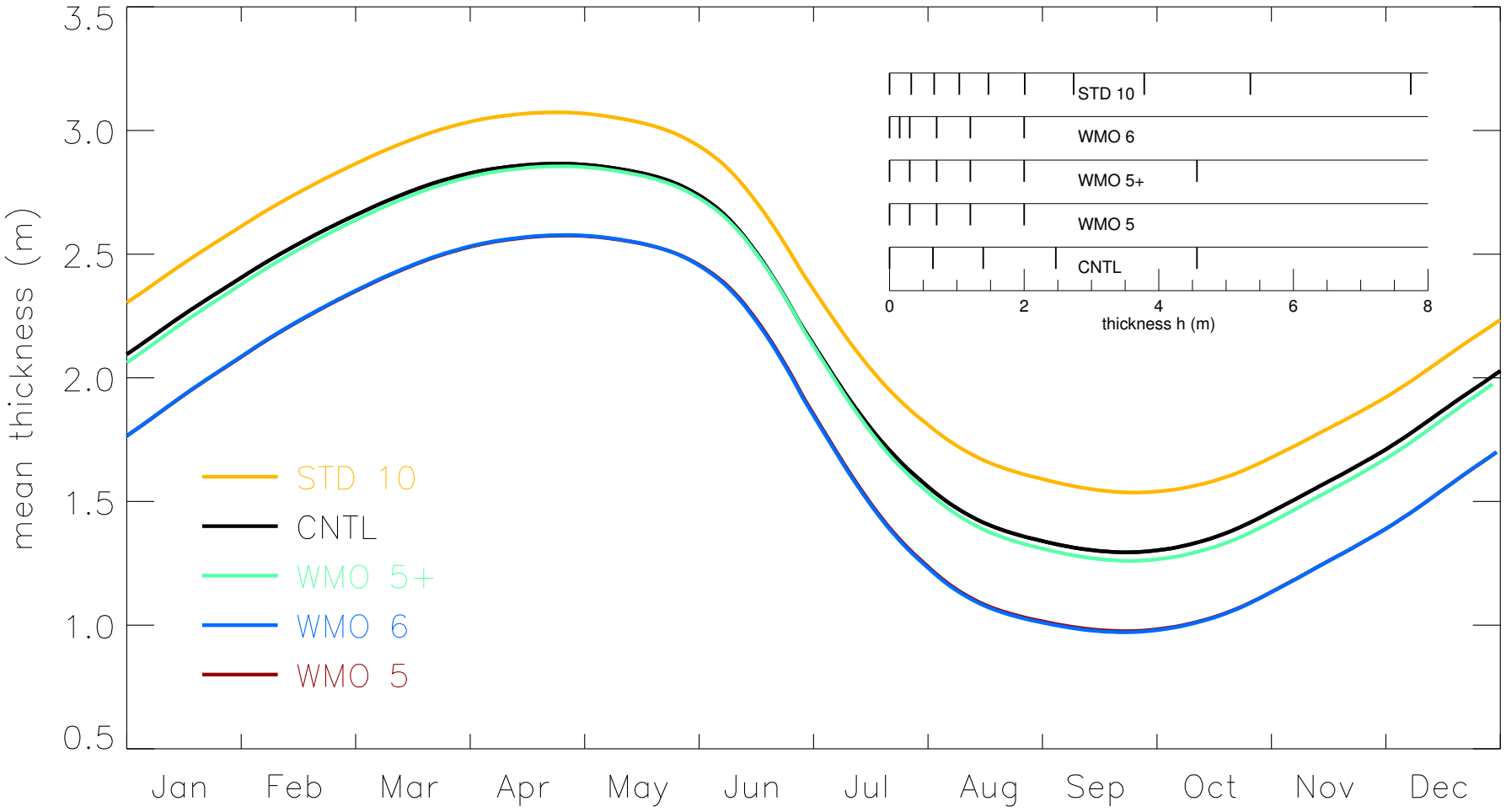
thickness (m) age (years)



Control

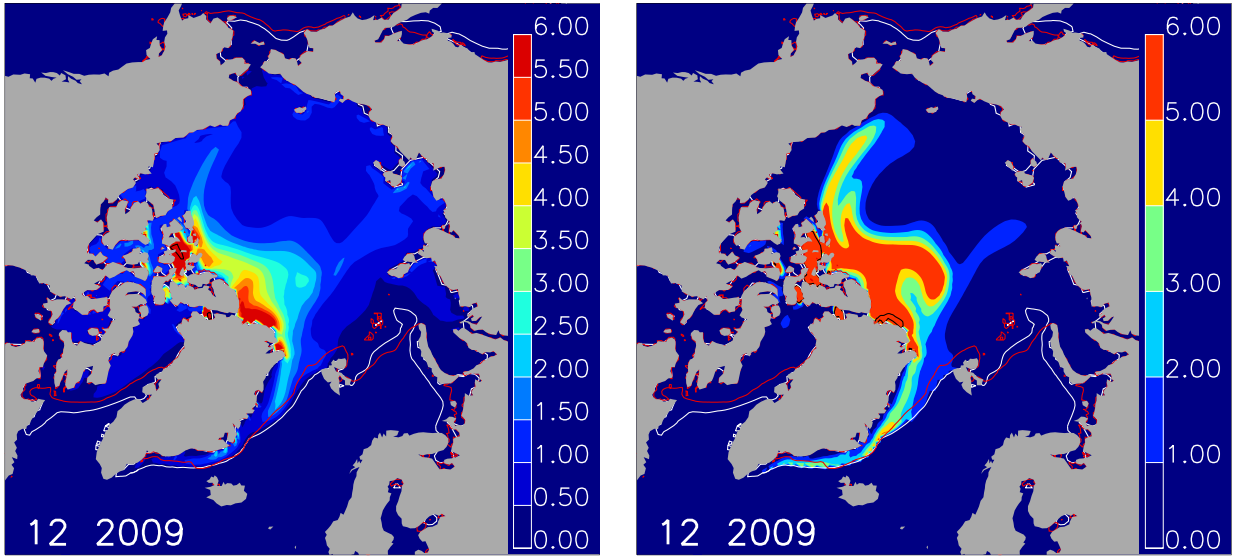
10 categories

Thickness category resolution

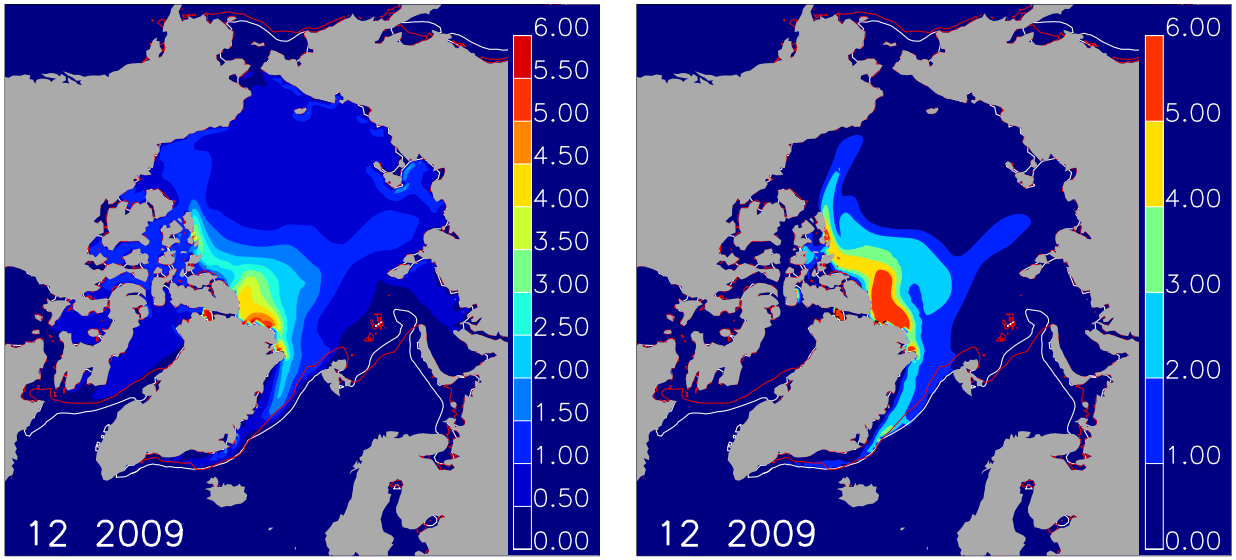


Thickness category resolution

thickness (m) age (years)



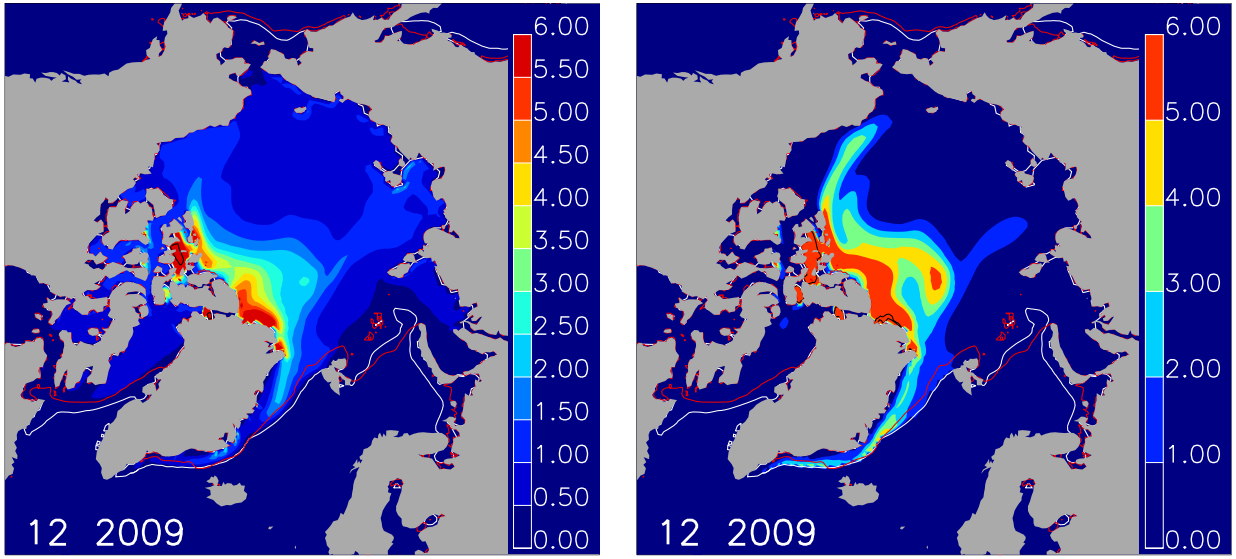
Control



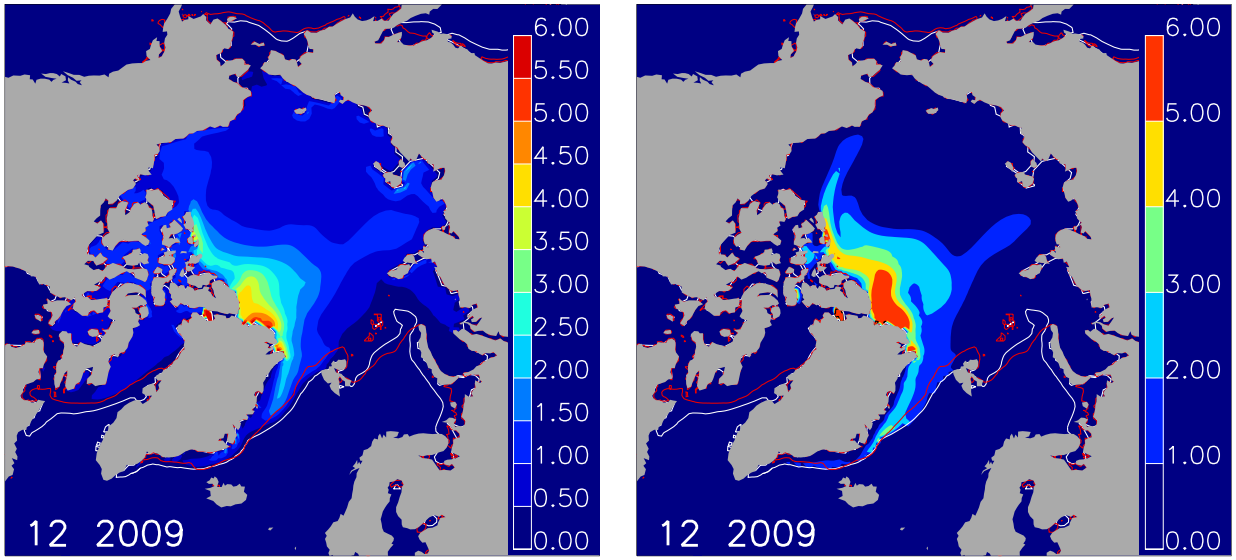
WMO 5

Thickness category resolution

thickness (m) age (years)

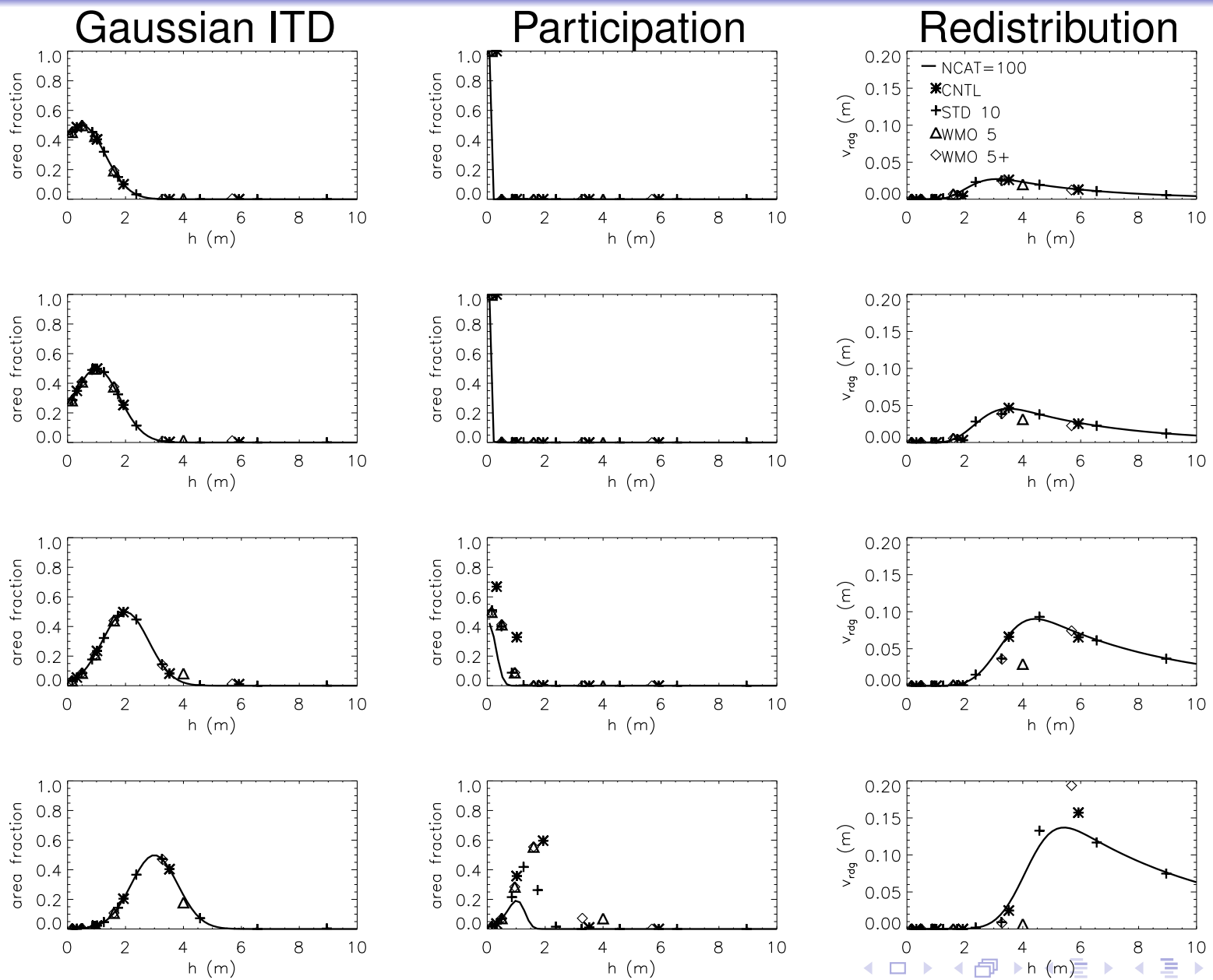


WMO5+



WMO 5

Thickness category resolution



Summary

Ice age may be useful for model tuning, validation.

Parameterizations:

- form drag looks very promising
- anisotropic rheology needs to be tuned
- need to constrain participation, redistribution functions

Resolution:

- need more!
- are 10 categories enough?

CICE v5 options/tests for consideration by PCWG

Physical parameterizations:
- mushy thermodynamics (prognostic salinity)
- explicit melt pond parameterizations (topo, level-ice)
- form drag
- anisotropic rheology
- other parameters?

Biogeochemistry (still in development):
- Aerosols
- Skeletal layer vs vertical BGC

Resolution:
- number of thickness categories
- vertical layers