On the influence of model physics on simulations of Arctic and Antarctic sea ice

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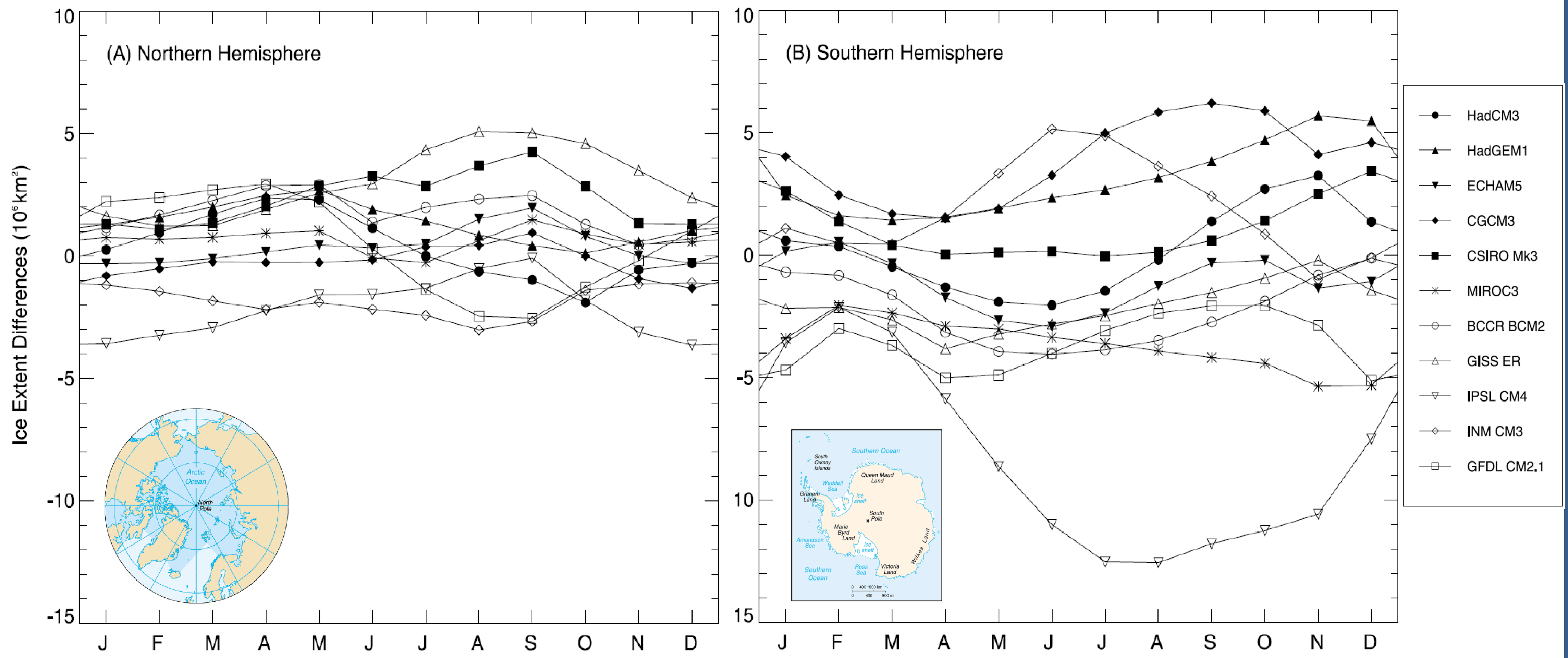
The question

Decadal simulations of sea ice with the **current General Circulation Models** (GCMs) show 3 noticeable features:

1. Large intermodel **spread**
2. Weak to strong **biases** with respect to observations
3. Remarks 1. and 2. are particularly **marked** in the **Southern Hemisphere**

This can be explained by several factors, e.g. the differences in resolution, initial conditions, and the formulation of physics in each GCM.

Here we run two almost identical simulations differing only in their sea ice component to address the **importance of sea ice physics in global, decadal simulations of sea ice.**



Difference of the mean (1979-2004) seasonal sea ice extent between 11 IPCC AR4 GCMs and satellite observations. From Parkinson et al., 2006

One answer

Experimental design

Atmospheric forcing

NCEP/NCAR atmospheric reanalyses + various climatologies

1° resolution
Run 1948-2007
Focus on 1983-2007

Ocean model

NEMO 3.1
www.nemo-ocean.eu

2 sea ice models

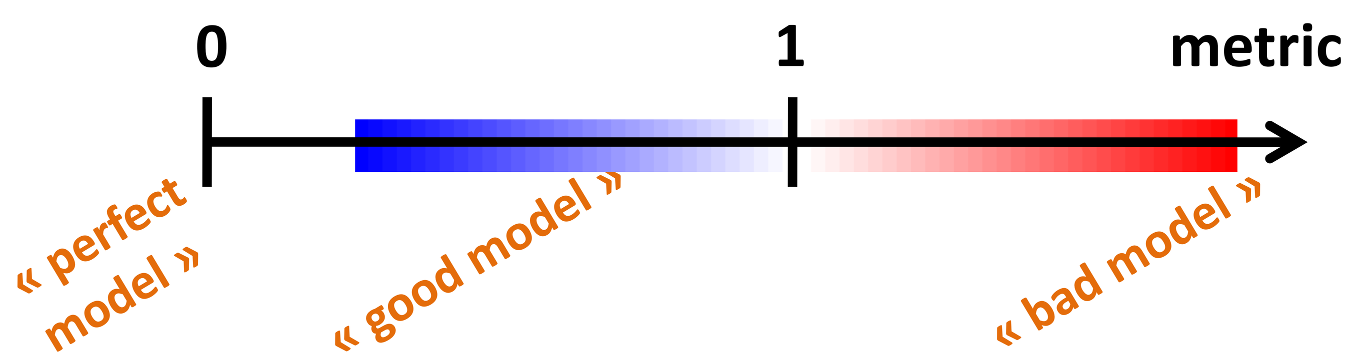
LIM2	LIM3
Fichefet and Morales Maqueda, 1997	*Vancoppenolle et al., 2009*
•Simple sea ice and snow thickness distribution	•Multicategory ice and snow thickness distribution
• 2+1 layers of ice and snow	• 5+1 layers of ice and snow
•Basic brine modelling	•Explicit brine and salinity distribution
•VP-rheology, B-grid	•EVP-rheology, C-grid

www.climate.be/lim

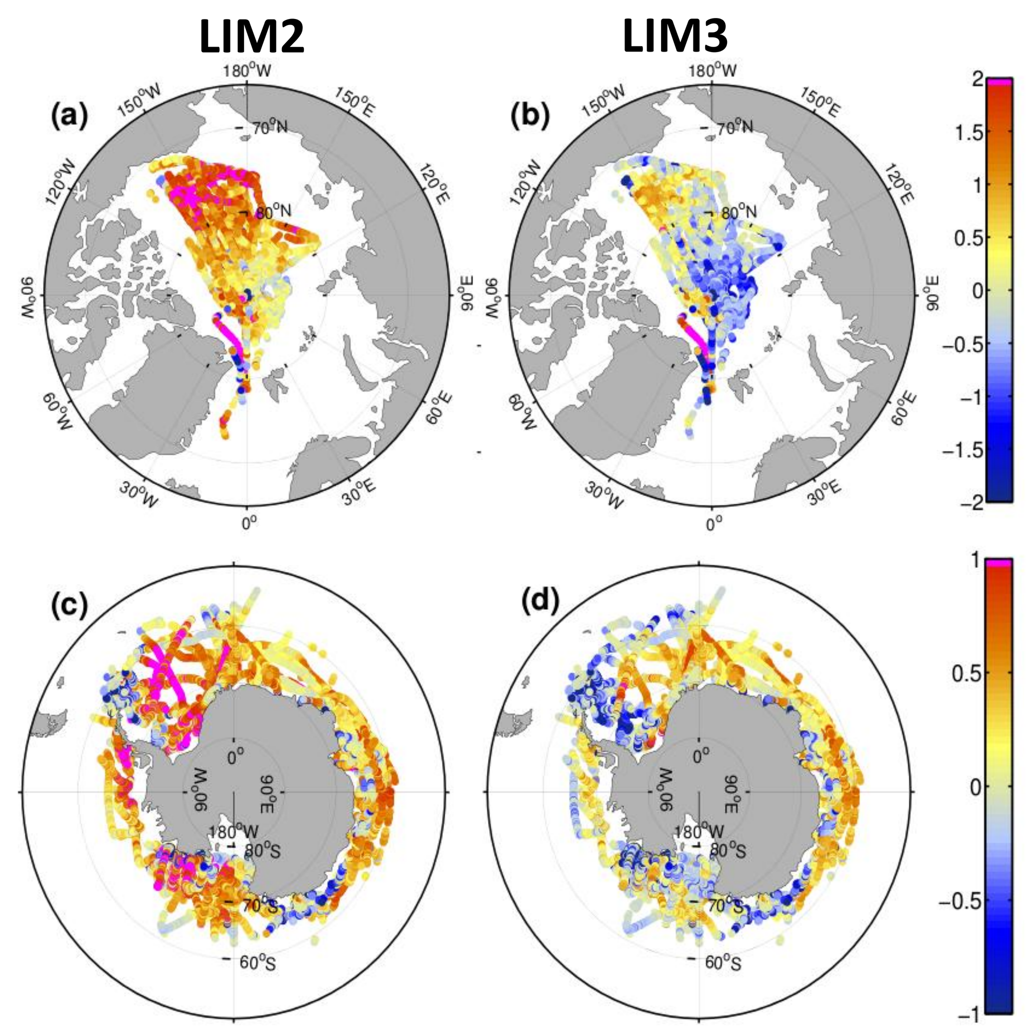
Performance metrics for sea ice models

$$\text{metric} \overset{\text{DEF}}{=} \frac{|\,\text{model} - \text{obs}\,|}{\text{typical error}}$$

Arbitrary (e.g. obs. error)

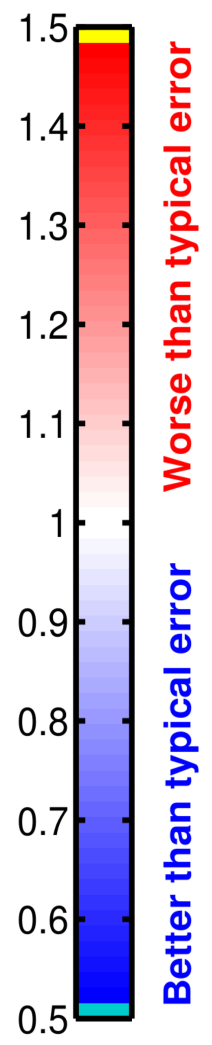


Results and discussion



Difference of Arctic sea ice draft* (**a**,**b**) and Antarctic sea ice thickness (**c**,**d**) between the two models and observations (NSIDC, 1998; Worby et al., 2008)

* draft: thickness of the part of sea ice that is submerged, i.e under the sea.



Metrics Arctic

	LIM2	LIM3	
conc.	0.97	0.79	mean
	1.03	0.77	std ano
	1.03	0.78	trend
extent	1.33	0.43	mean
	1.22	0.61	std ano
	0.23	0.46	trend
draft	0.94	0.67	mean
	0.72	0.32	trend
drift	0.39	0.61	kin. energy
	0.86	0.76	circulation
Fram export	0.44	0.7	mean area
	0.34	0.9	std ano area
	1.14	0.82	mean vol
	0.09	0.8	std ano vol

Higher skill for LIM3 (concentration, extent, thickness)
• Effect of subgrid scale ice thickness distribution
• Importance of salinity variations

Metrics Antarctic

	LIM2	LIM3	
conc.	1.07	1.12	mean
	0.8	0.71	std ano
	0.92	0.94	trend
extent	3.58	1.17	mean
	0.48	1.1	std ano
	0.9	0.52	trend
thick.	3.22	2.45	mean
drift	1.3	1.4	kin. energy
	1.26	1.26	circulation

Lower, similar skill for both models
• Resolution as limiting factor
• Atmospheric forcing
• Thinner ice

References

- Parkinson et al., JGR 2006, doi:10.1029/2005JC003408
-Fichefet and Morales Maqueda, JGR 1997, 97JC00480
-Vancoppenolle et al., doi:10.1016/j.ocemod.2008.10.005
- NSIDC, 1998, http://nsidc.org/data/docs/noaa/g01360_upward_looking_sonar/index.html#format
- Worby et al., JGR 2008, doi:10.1029/2007JC004254