
EUROPEAN GEOSCIENCES UNION

T.G.I.F.

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Importance of physics in global hindcast simulations of sea ice with NEMO-LIM

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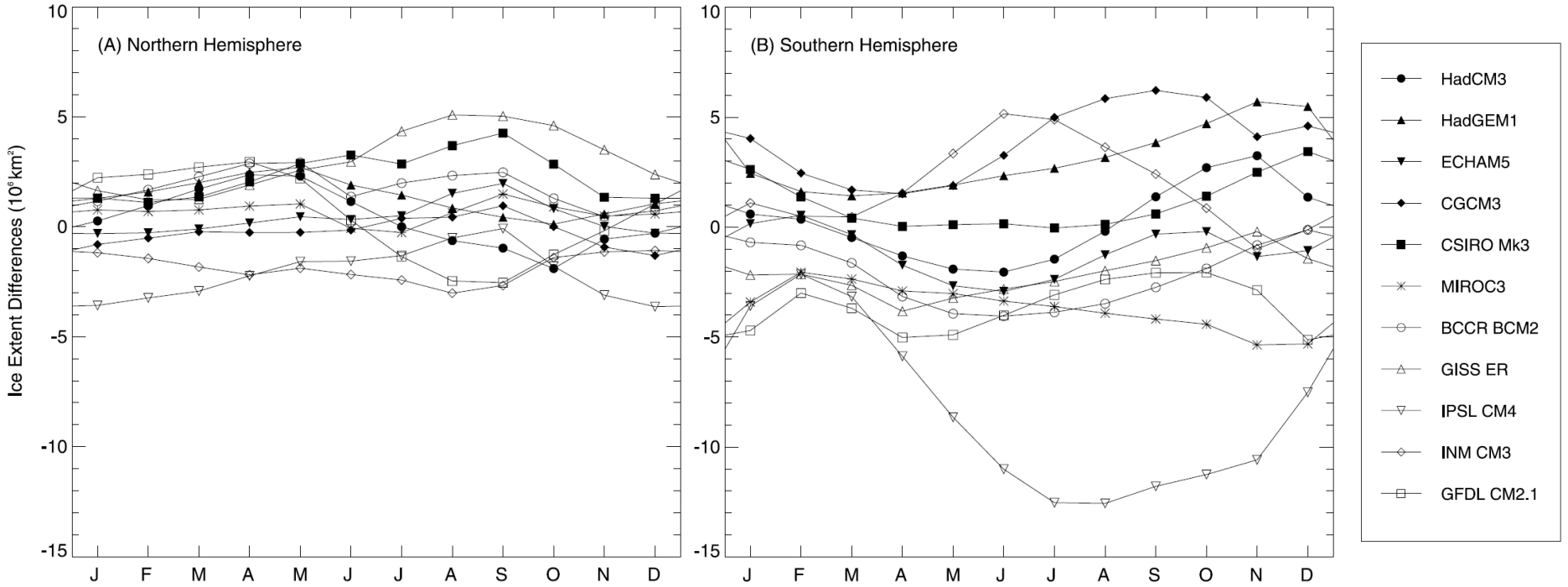
Inter-GCMs spread and simulated polar climate



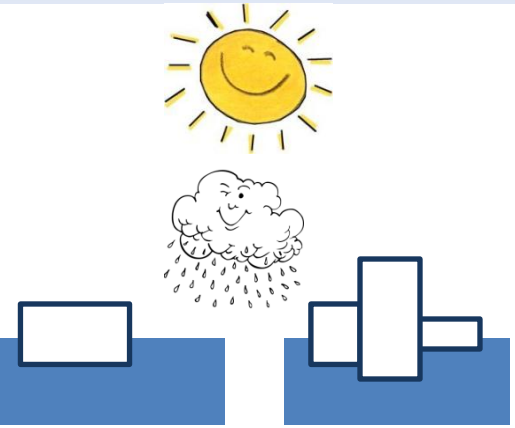
Modeled minus observed mean monthly sea ice extents (1979-2004) from 11 major General Circulation Models. (Fig. 4 of *Parkinson et al. (2006)*)

- Spread possibly due to differences in **resolution**, **atmospheric component**, **sea ice component**

- IPCC AR4: no outstanding model (Arzel et al., 2006)

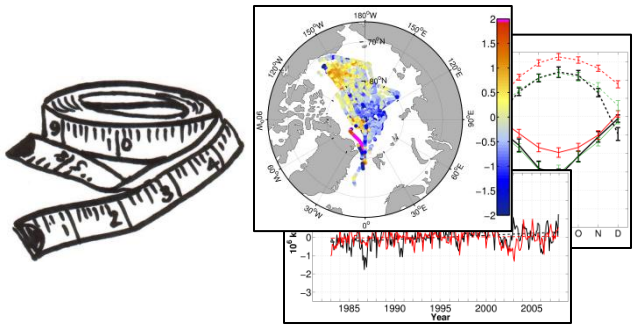
How to evaluate a sea ice model?
How does the representation of its physics component matter?

Outline



Experimental setup

1. 2 experiments differing only in their sea ice components



Models evaluation

2. Evaluate outputs from both experiments with suitable metrics

Discussion

3. Discuss physical processes possibly responsible for differences

1. Experimental setup

NCEP/NCAR daily surface temperatures and winds
Monthly climatologies of relative humidity,
cloud cover, precipitations and river runoff

~ 1° resolution (climatic-like)
1948-2007 simulation
Focus on 1983-2007

2 sea ice models

LIM2

Fichefet and Morales Maqueda, 1997

- **Simple ice thickness dist.**
- **2+1 layers ice and snow**
- **Basic brine modelling**
- **VP rheology**
- **B-grid**

LIM3

Vancoppenolle et al., 2009

- **5 ice categories**
- **5+1 layers ice and snow**
- **Explicit brine, salinity distribution**
- **EVP rheology**
- **C-grid**

www.climate.be/lim

Ocean model

NEMO 3.1

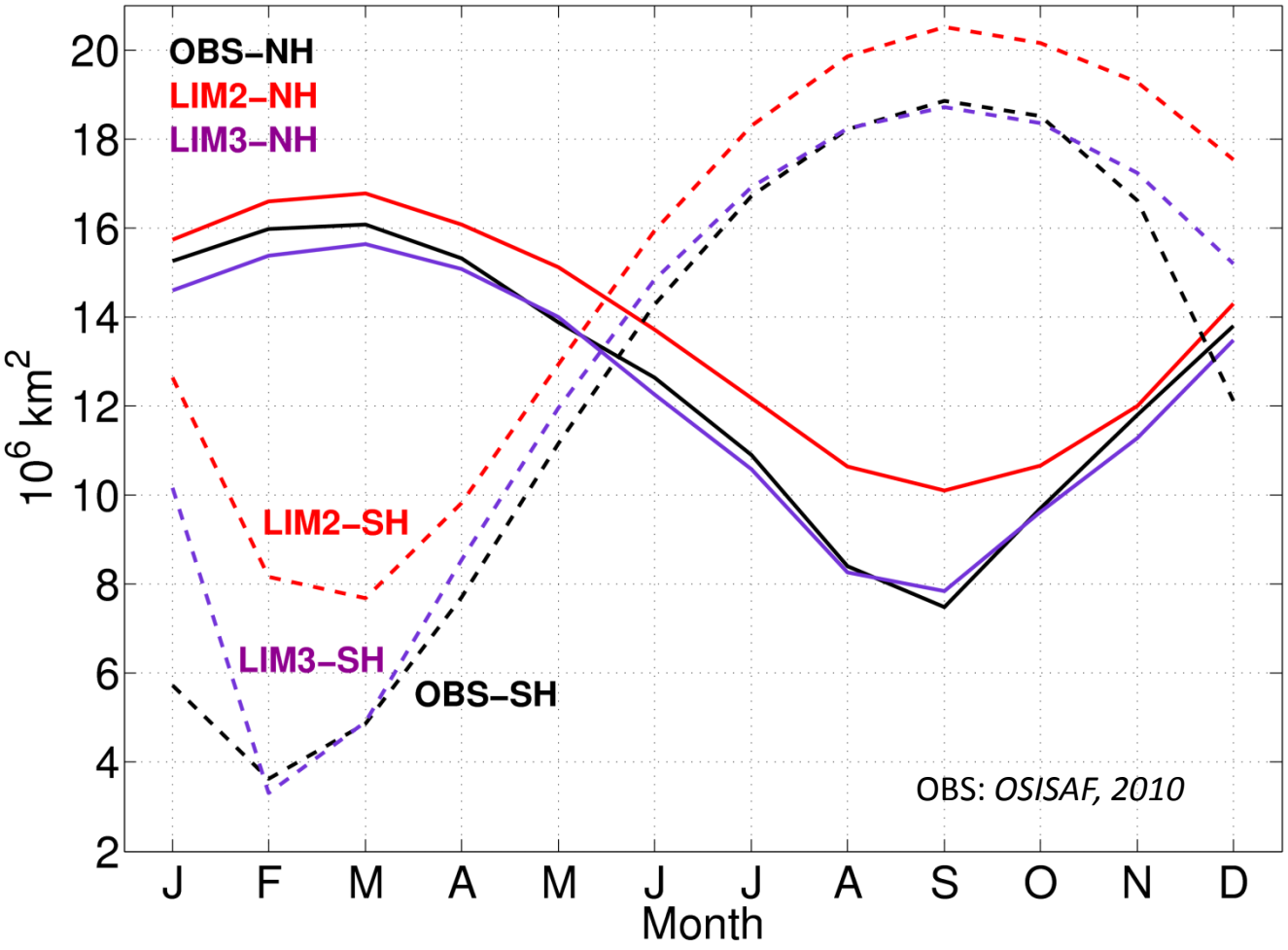
Madec, 2008

- Primitive equation free surface OGCM
- Level-1.5 turbulence closure scheme
- Isopycnal mixing + G&M param. of eddy-induced tracer advection
- 42 vertical levels
- **Salinity restoring**

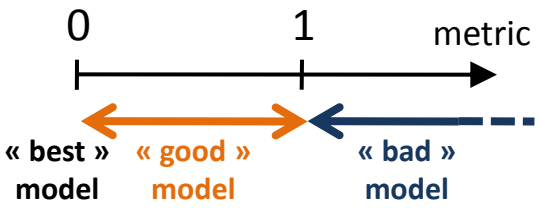
www.nemo-ocean.eu

2. Models evaluation

Monthly mean seasonal cycle of sea ice extent (1983-2007)



$$\text{Metric} \equiv \frac{\text{abs(model – obs)}}{\text{typical error}}$$



Northern Hemisphere (NH)

LIM2: 1.33

LIM3: 0.43

Southern Hemisphere (SH)

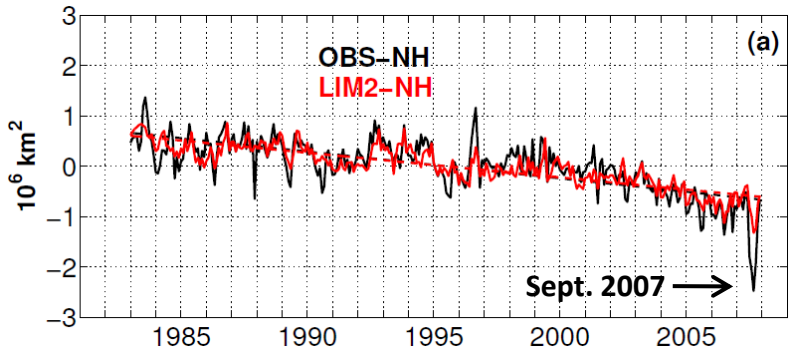
LIM2: 3.58

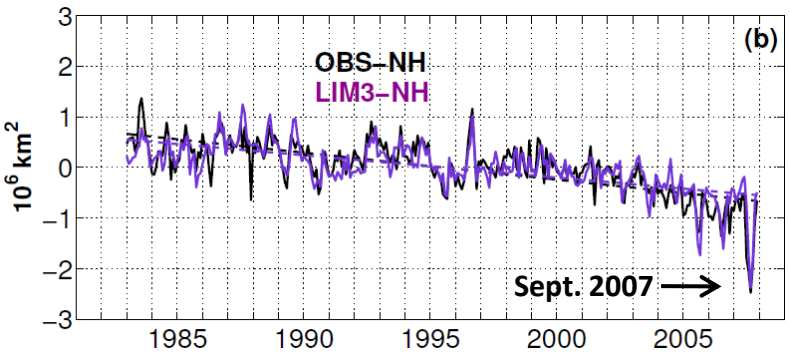
LIM3: 1.17

(the lower, the better)

2. Models evaluation

Monthly anomalies of sea ice extent (NH)

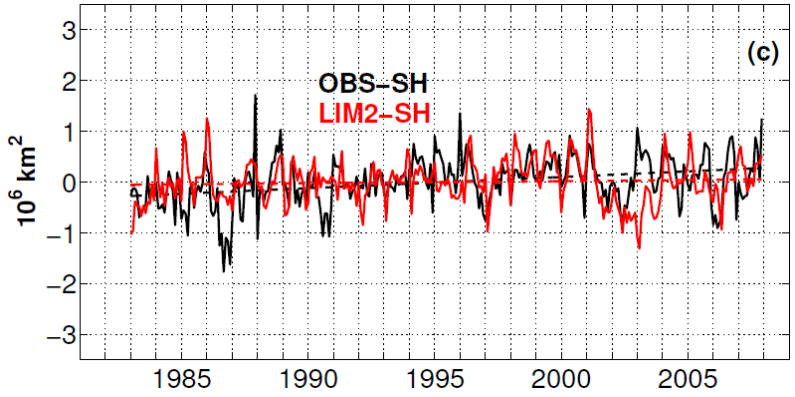


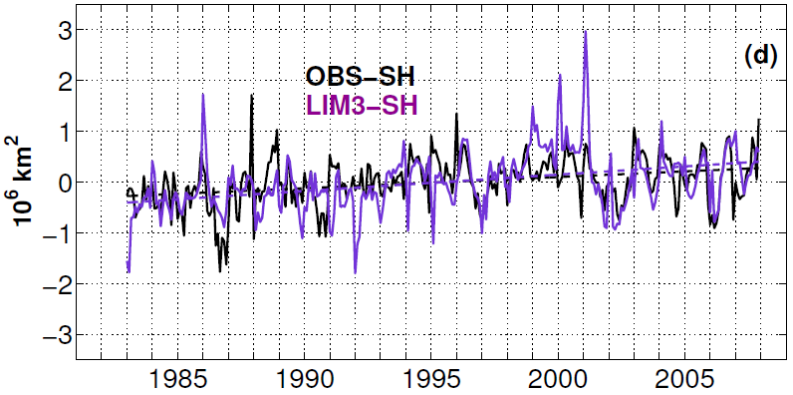


Metrics std anomalies:

LIM2: 1.22 **LIM3: 0.61** *(the lower, the better)*

Monthly anomalies of sea ice extent (SH)



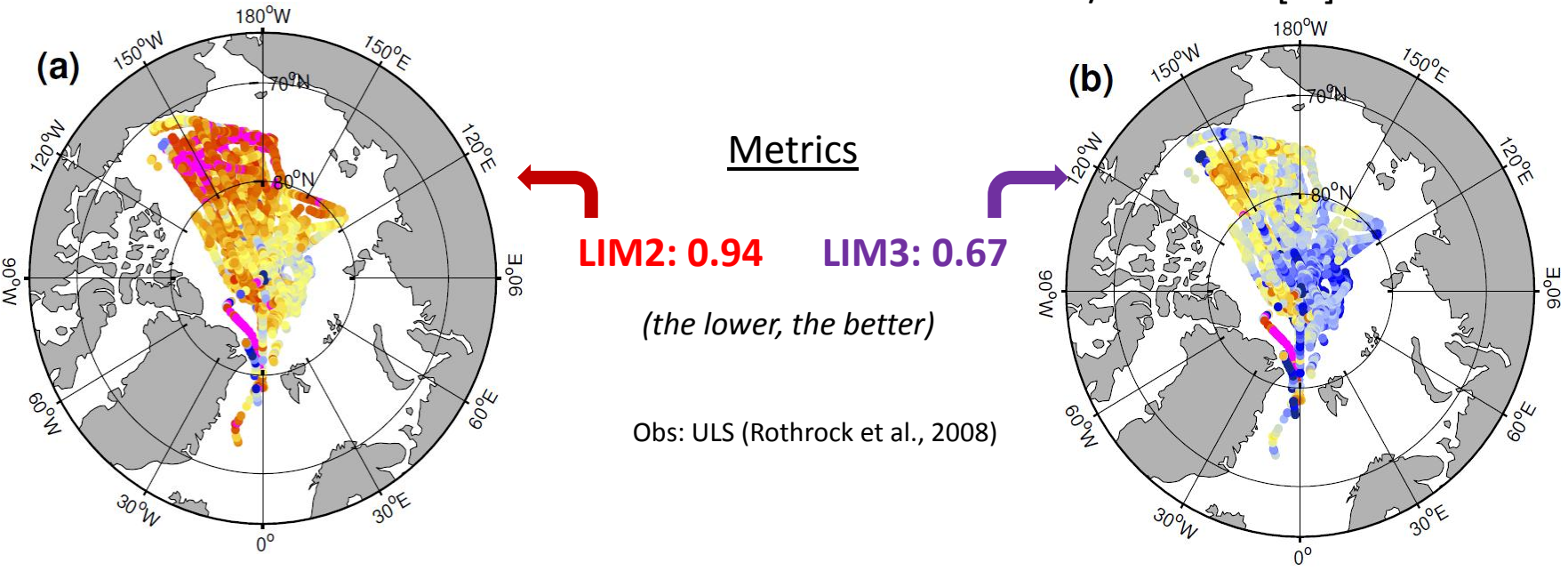


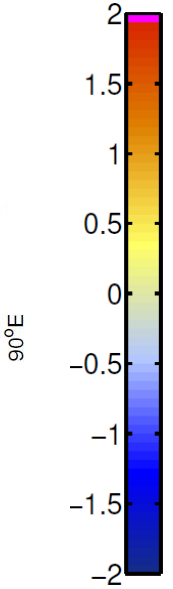
Metrics std anomalies:

LIM2: 0.48 **LIM3: 1.10** *(the lower, the better)*

2. Models evaluation

Model minus obs difference in sea ice draft/thickness [m]



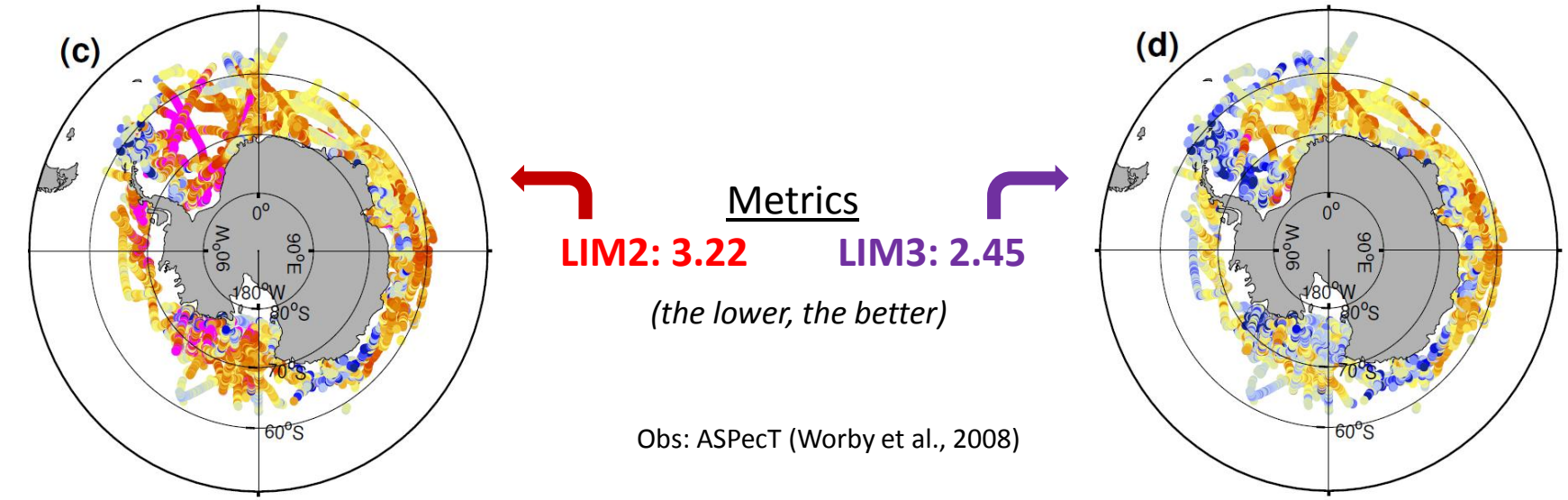


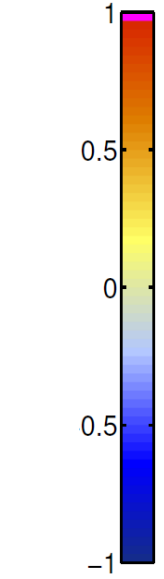
Metrics

LIM2: 0.94 **LIM3: 0.67**

(the lower, the better)

Obs: ULS (Rothrock et al., 2008)





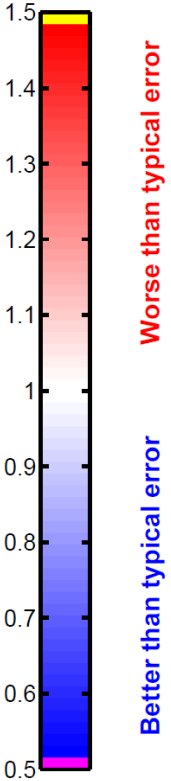
Metrics

LIM2: 3.22 **LIM3: 2.45**

(the lower, the better)

Obs: ASPecT (Worby et al., 2008)

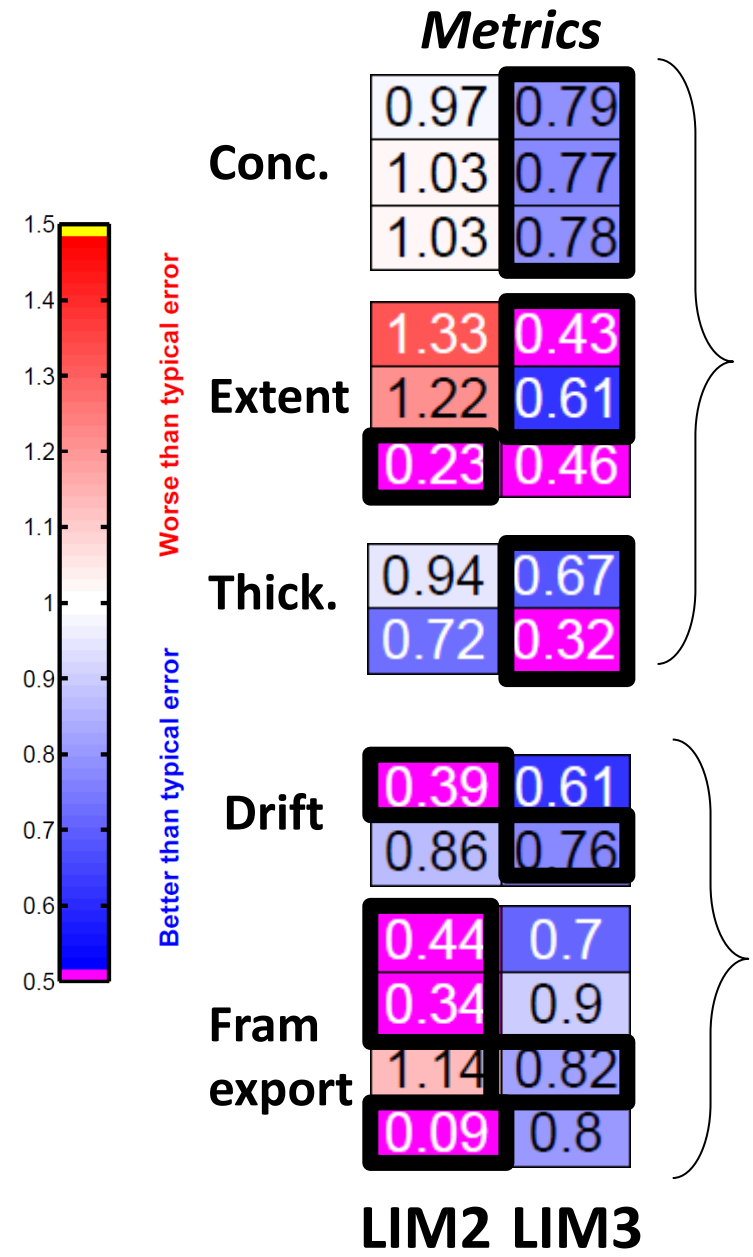
3. Discussion (NH)



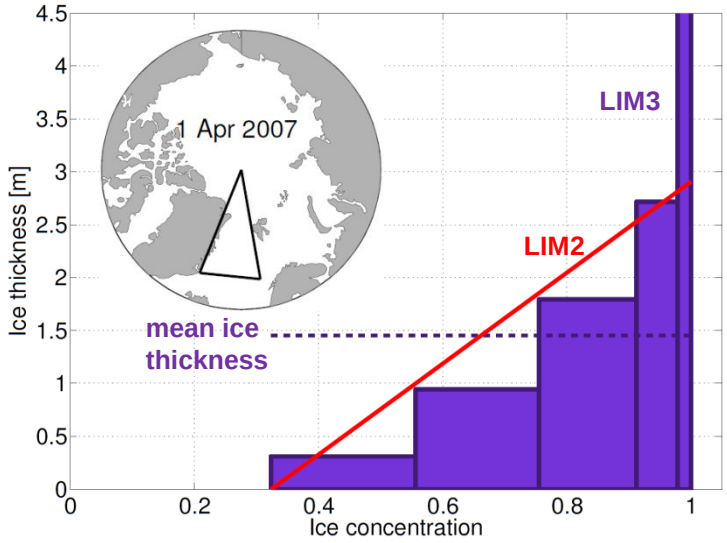
Metrics

	LIM2	LIM3	
Conc.	0.97	0.79	Mean
	1.03	0.77	Std of anomalies
	1.03	0.78	Trend
Extent	1.33	0.43	Mean
	1.22	0.61	Std of anomalies
	0.23	0.46	Trend
Thick.	0.94	0.67	Mean
	0.72	0.32	Trend
Drift	0.39	0.61	Mean kinetic energy
	0.86	0.76	Circulation pattern
Fram export	0.44	0.7	Mean area
	0.34	0.9	Std anomalies area
	1.14	0.82	Mean volume
	0.09	0.8	Std anomalies volume

3. Discussion (NH)

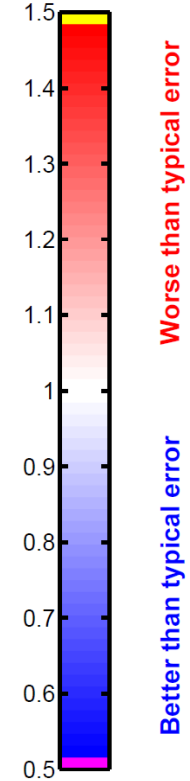


- Ice thickness distribution: Metrics confirm earlier results of Bitz et al. (2001) and Holland et al. (2006) with GCMs.
- **Importance of salinity variations in LIM3 (*Vancoppenolle et al., 2009*)**



- Models parameters not tuned for optimizing drift
- LIM2 (VP) versus LIM3 (EVP); EVP more responsive to wind forcing (*Hunke and Dukowicz, 1997*)

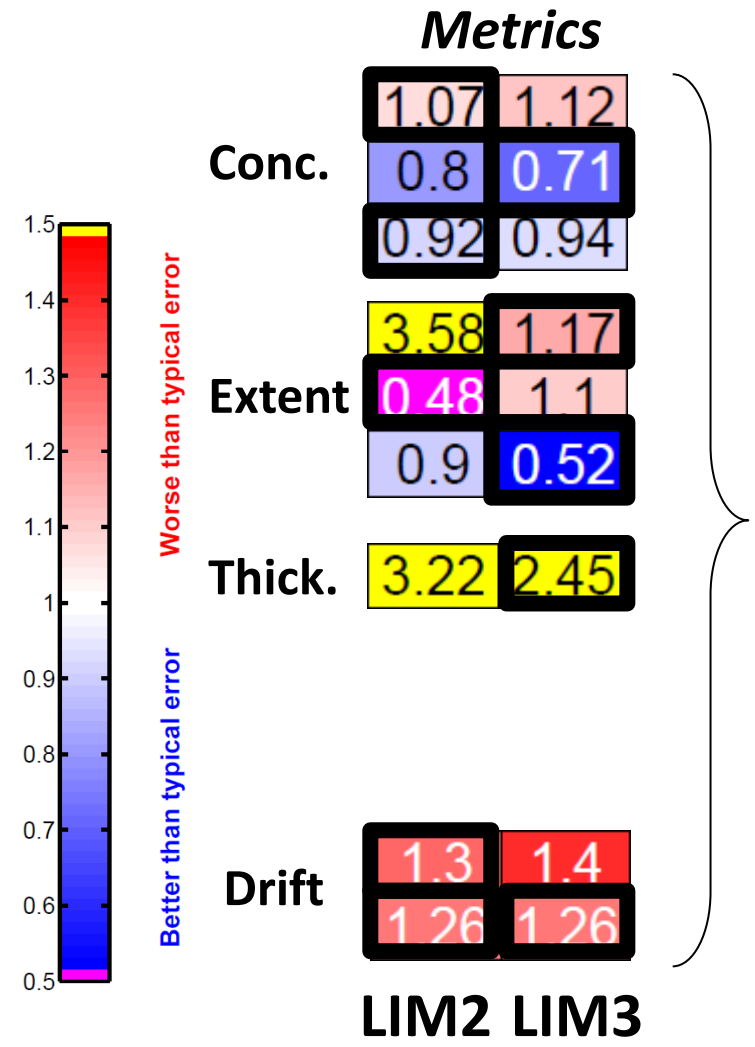
3. Discussion (SH)



Metrics

Conc.	1.07	1.12	Mean
	0.8	0.71	Std of anomalies
	0.92	0.94	Trend
Extent	3.58	1.17	Mean
	0.48	1.1	Std of anomalies
	0.9	0.52	Trend
Thick.	3.22	2.45	Mean
Drift	1.3	1.4	Mean kinetic energy
	1.26	1.26	Circulation pattern
	LIM2	**LIM3**	

3. Discussion (SH)



- No outstanding model!
- SH is different from NH in many respects:
  - Dynamics of the Southern Ocean and unresolved small-scale processes (Rintoul et al., 2001)
  - Quality of the reanalyses (Vancoppenolle et al., 2010; Vihma et al., 2002; Timmerman et al., 2004)
  - Thinner ice than NH

T.G.I.F. - Take home message

2 hindcast (1983-2007) **experiments** with the OGCM NEMO-LIM at climatic resolution, **differing only in their sea ice component**

Set of comprehensive metrics evaluating main sea ice variables, for both hemispheres

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- Skill is model-dependent in NH
- Limitations of skill in SH are not due to model physics

Conclusions could be sensitive to experimental setup

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