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

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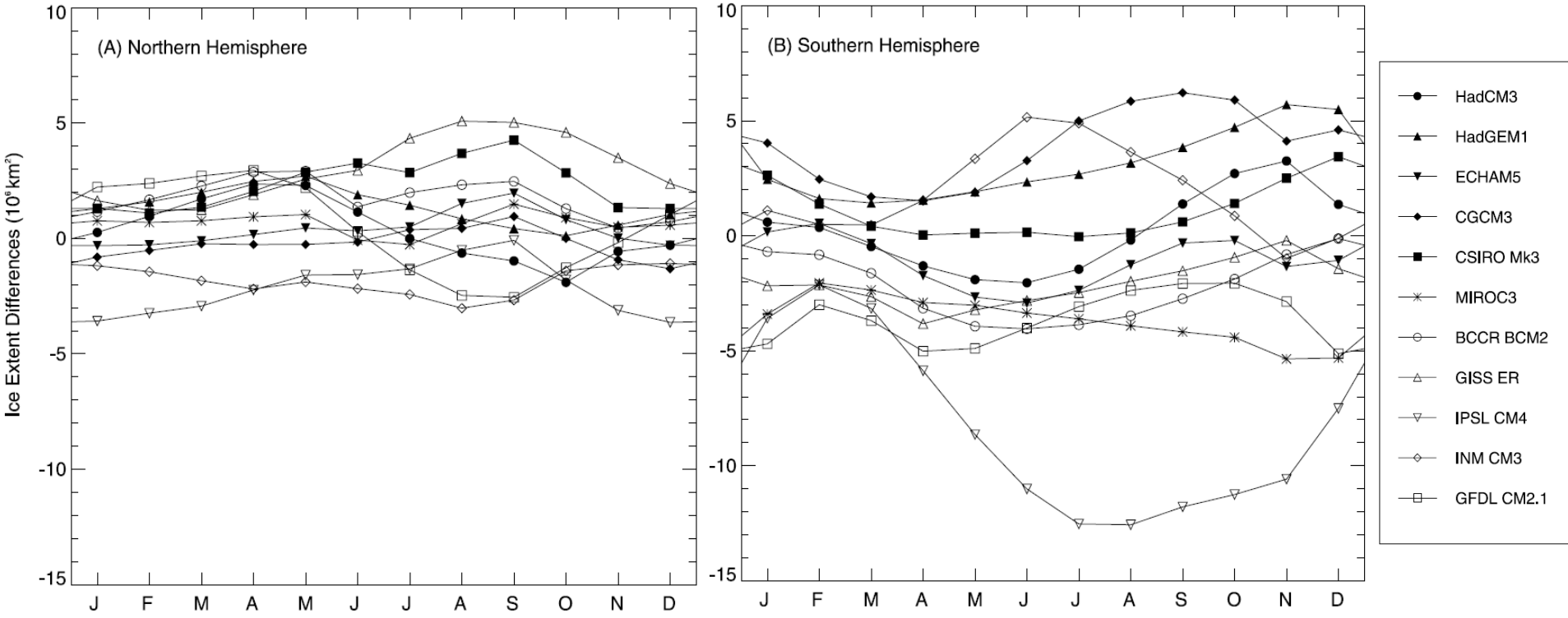
Inter-GCMs spread and unrealistic polar climate



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

- Uncertainty in atmosphere (Bitz et al., 2002 ; Walsh et al., 2002)
- Influence of initial conditions (Goosse and Rensen, 2005)
- **Representation of sea ice physics** (Holland et al., 2006 ; Bitz et al., 2001)

Outline

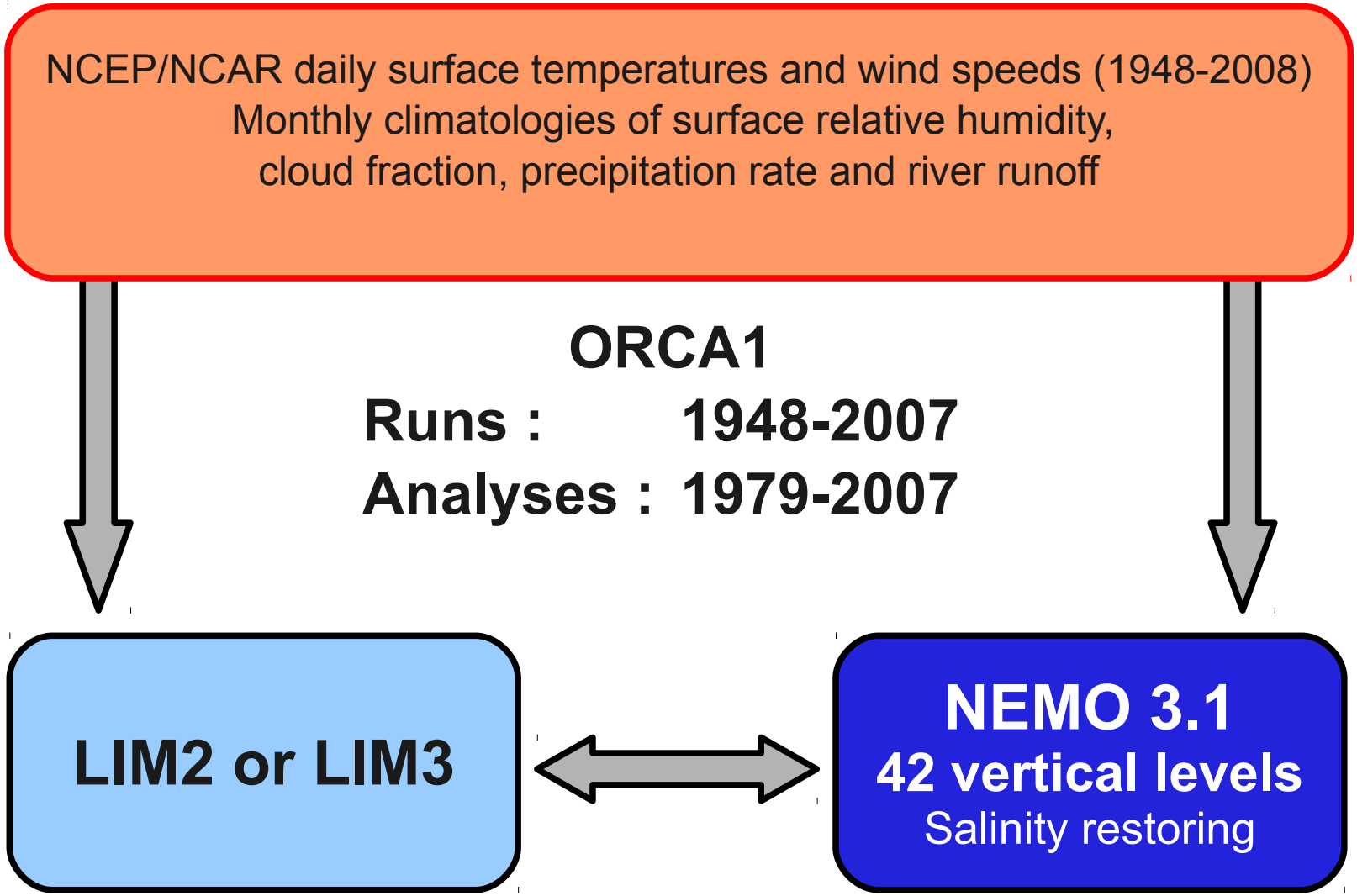
1. Experimental setup
2. Model metrics
3. Results
4. Discussion

1. Experimental setup

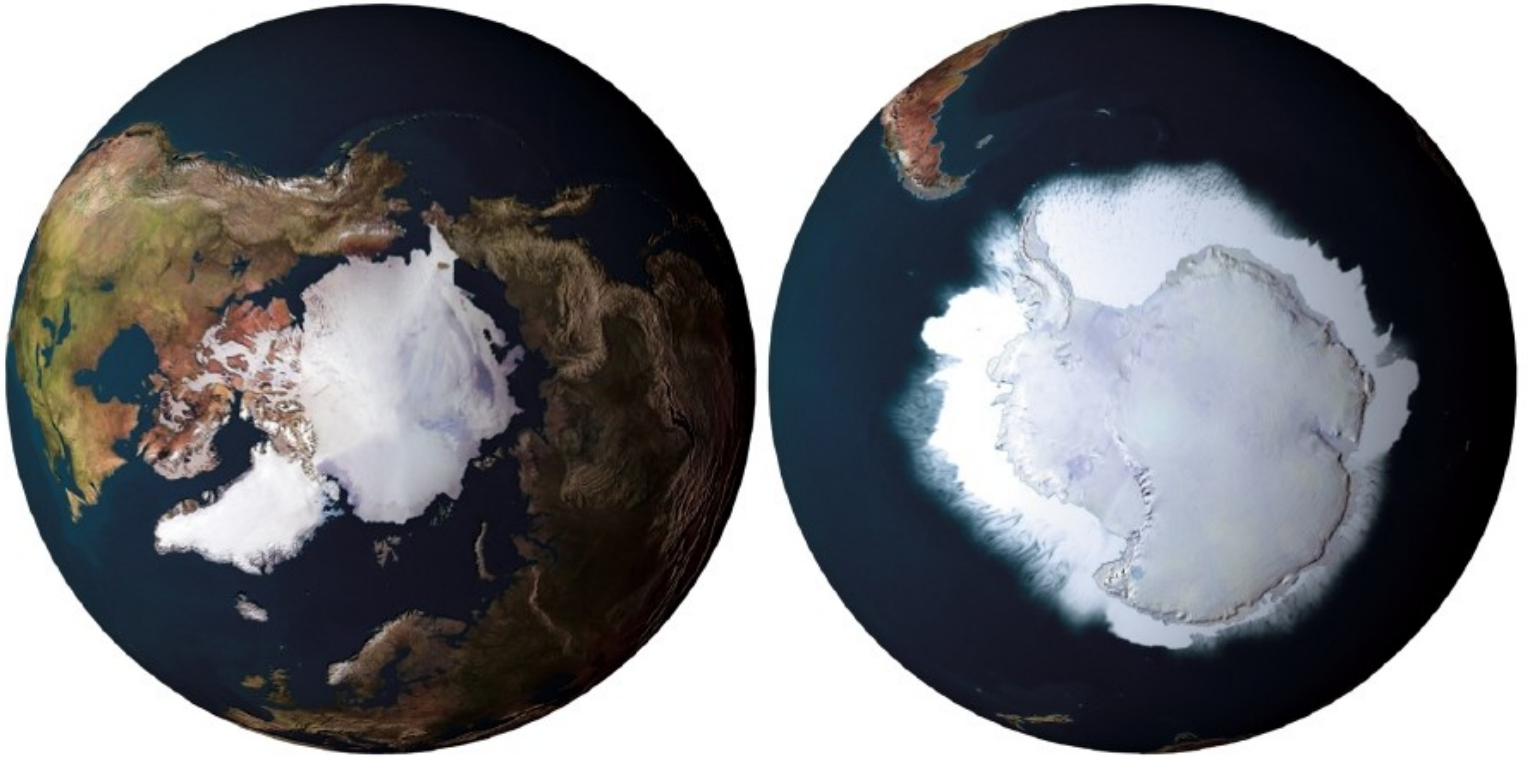
Sea ice models

	LIM2 (Fichefet and Morales Maqueda, 1997) **(in current EC-Earth)**	**LIM3** (Vancoppenolle et al., 2009) **(coupling under way)**
Thermodynamics	**1**-category Ice Thickness Distribution Basic brine modelling	**5**-category Ice Thickness Distribution Explicit brine modelling + drainage
Vertical resolution	2+1 layers (ice + snow) Effective thermal conductivity	5+1 layers (ice + snow)
Dynamics	Viscous-Plastic B-grid	Elastic-Viscous-Plastic C-grid

1. Experimental setup



2. Model metrics



http://www.cnes.fr/automne_modules_files/standard/public/p6904_7f274ac3232cb92155d818649ac2970eArtic_Antarctic.jpg

Need for **comprehensive** metrics for sea ice :

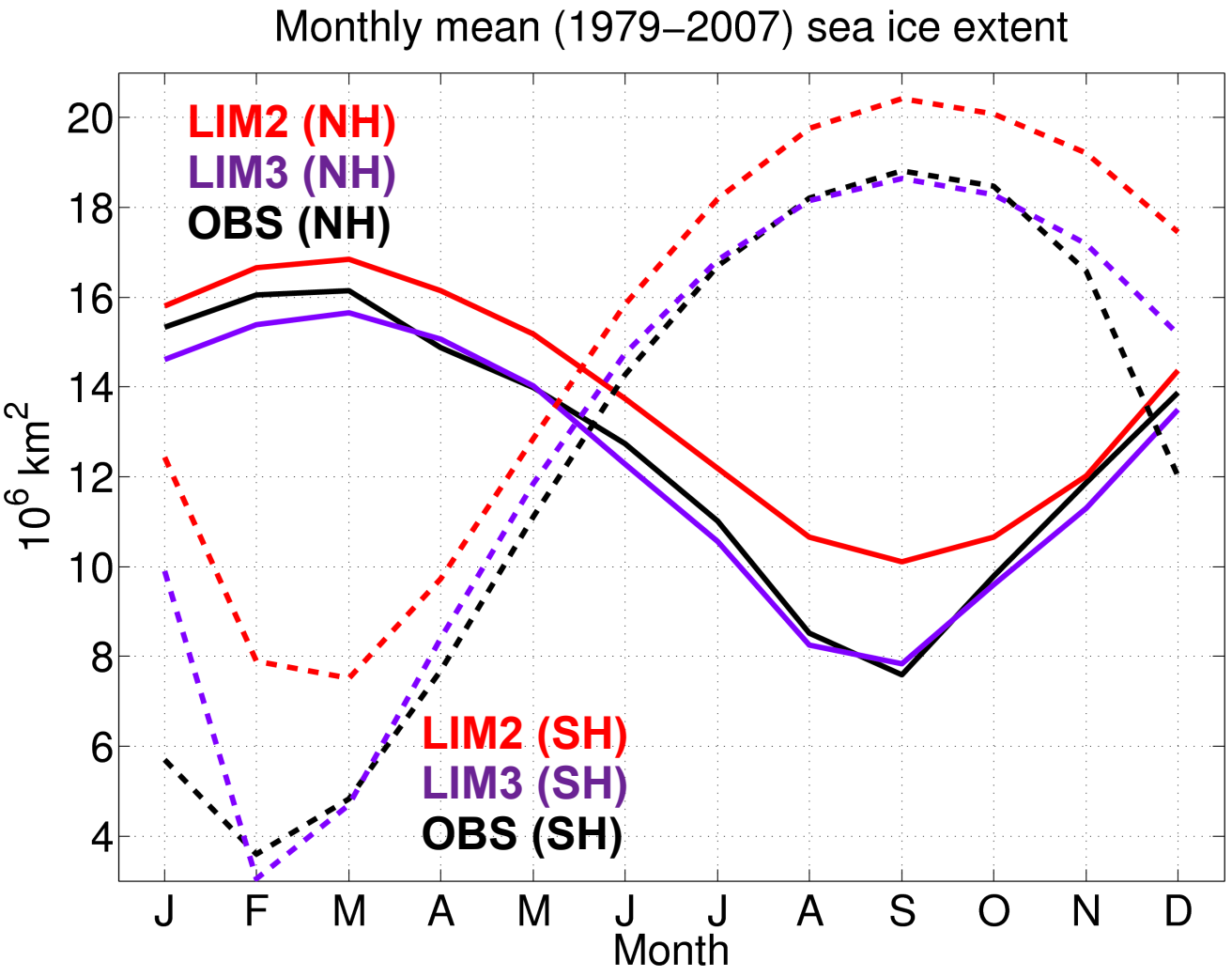
- Both hemispheres
- Regional and global
- Different variables
- Statistically robust
- Keep it simple!!

2. Model metrics

Diagnostic	Hemispheres	Observations	Period	Mean state	Variability	Local or global ?
Ice concentration	NH and SH	OSISAF (2010) (interp. to ORCA1)	1979-2007	Mean Seasonal Cycle 1979-2007	Std dev anom. + trend	Local
Ice extent	NH and SH	OSISAF (2010) (interp. to ORCA1)	1979-2007	Mean Seasonal Cycle 1979-2007	Std dev anom.+ trend	Global
Ice thickness	NH and SH	NSIDC (1998) (NH) Worby et al. (2008) (SH)	1979-2000 (NH) 1980-2000 (SH)	Mean abs. error	1980-1990 vs 1990-2000 (NH only)	Local
Ice drift	NH and SH	Fowler (2007) (interp. to ORCA1)	1979-2006	Mean Kinetic En.	Spatial only	Global
Fram Strait export (vol. and area)	NH	Kwok et al. (2004) ; Spreen et al. (2009)	1979-2007	Mean Seasonal Cycle 1979-2007	Std dev	Local

$$\text{Metrics} = \frac{\text{abs(model - obs)}}{\text{typical error}}$$

3. Results



Metrics

NH

LIM2 : 1.25

LIM3 : 0.50

SH

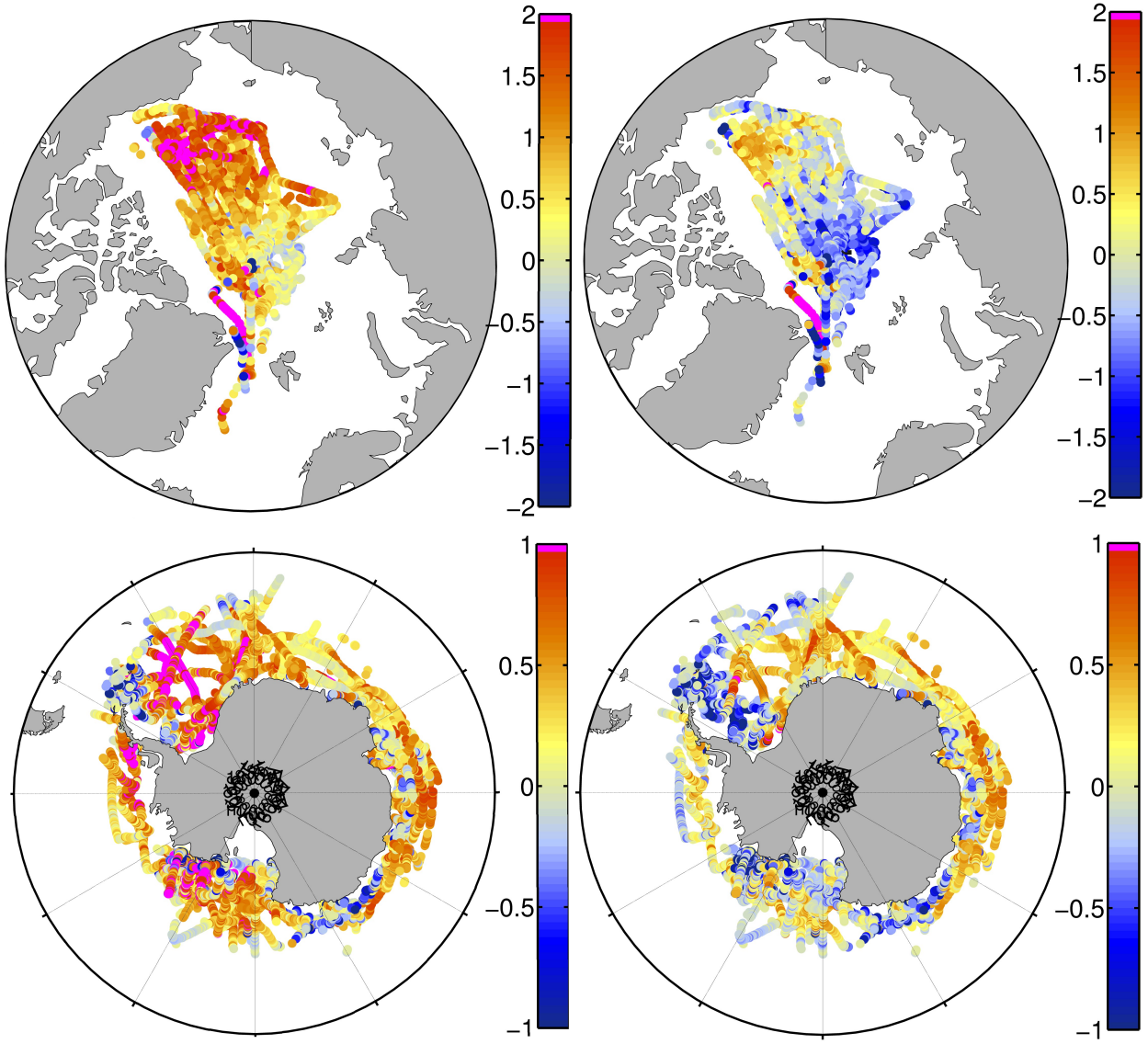
LIM2 : 3.48

LIM3 : 1.16

(the lower, the better)

3. Results

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



LIM2 LIM3

Metrics

NH

LIM2 : 0.92

LIM3 : 0.69

SH

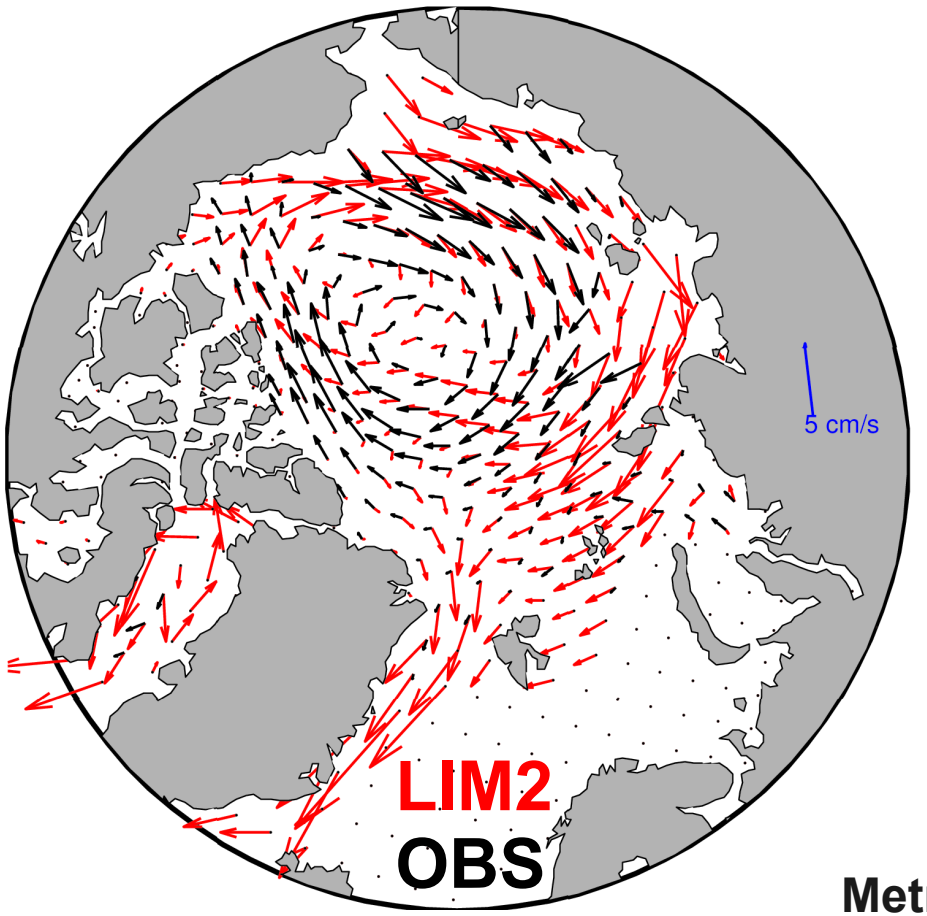
LIM2 : 3.23

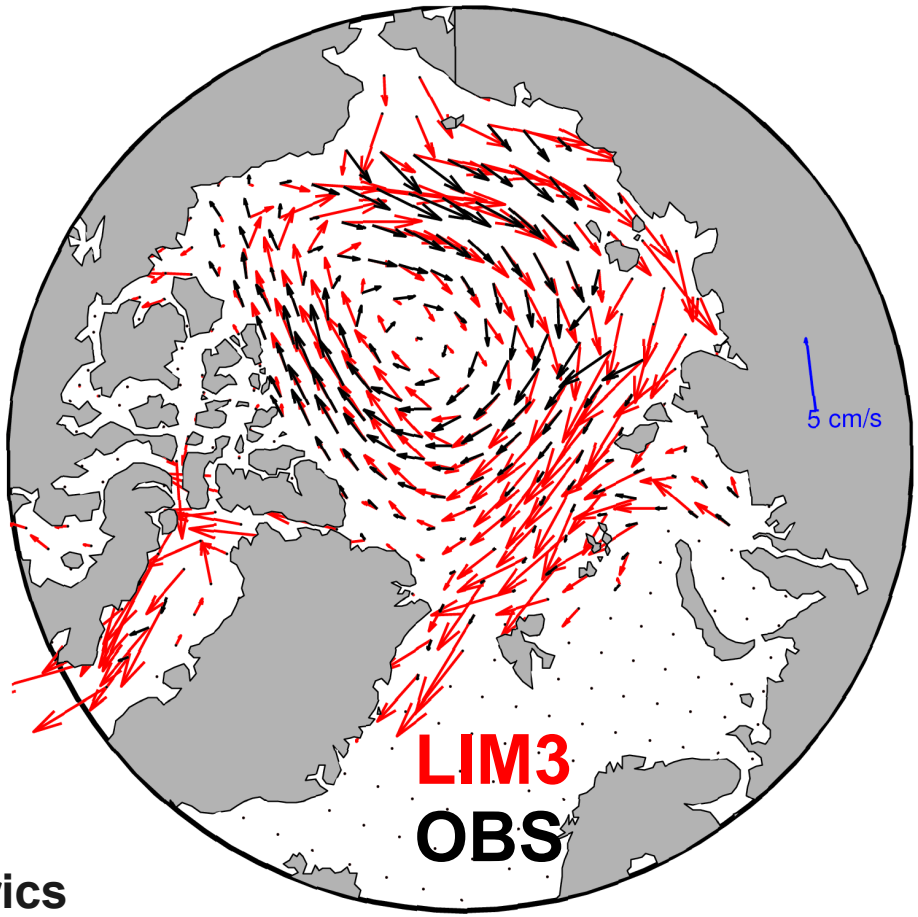
LIM3 : 2.46

(the lower, the better)

3. Results

Mean drift (example : summer 1999)





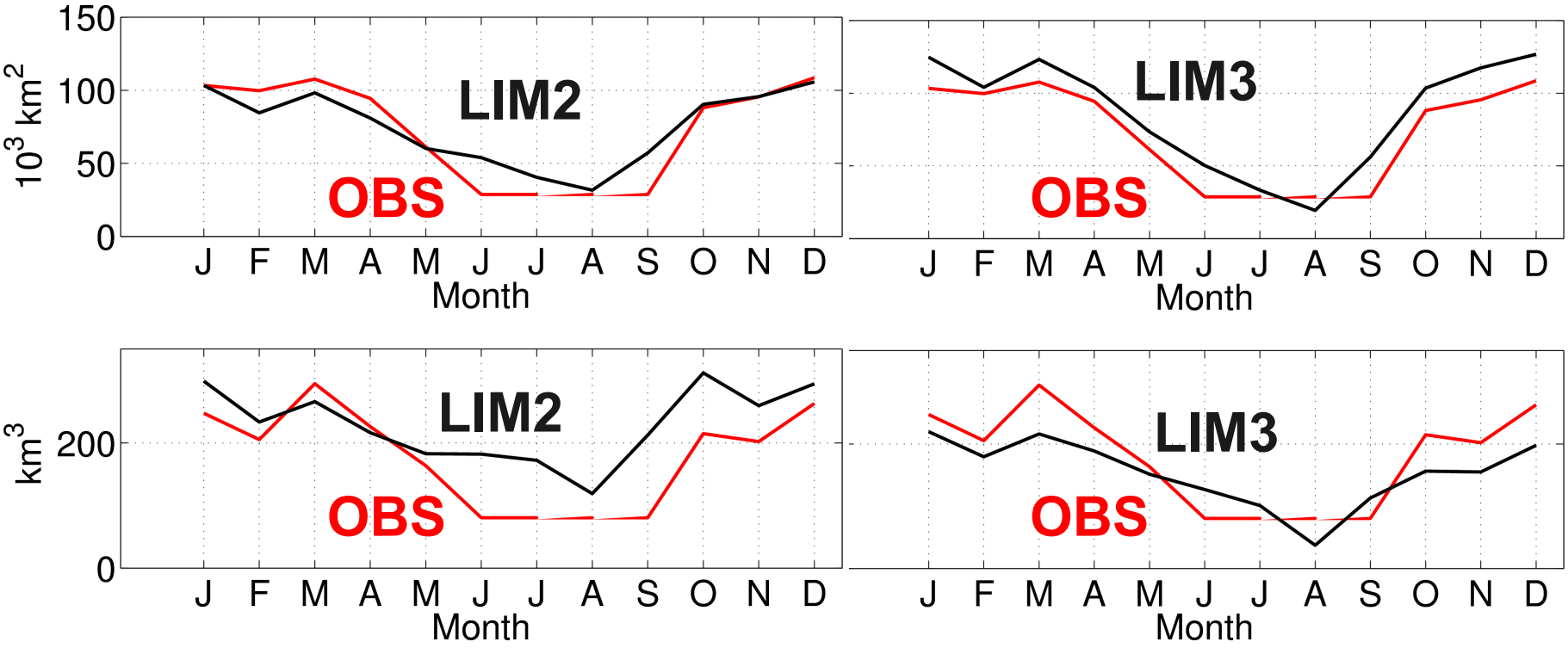
Metrics

On kinetic energy :	0.30	On kinetic energy :	1.40
On circulation. :	0.98	On circulation :	0.70

(the lower, the better)

3. Results

Areal (upper) and Volume (lower) export through Fram Strait



Metrics

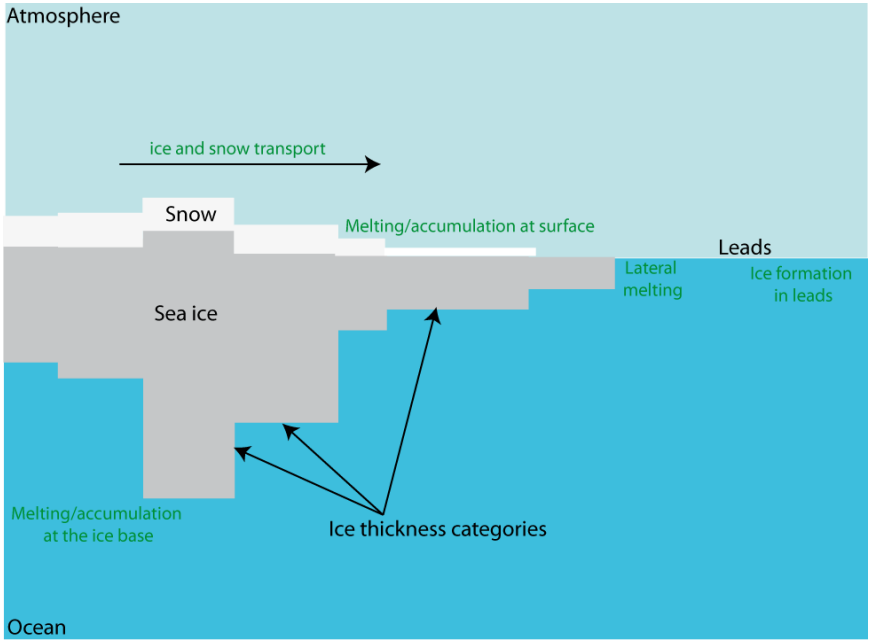
	LIM2	LIM3
Area	0.47	0.76
Volume	1.14	0.82

(the lower, the better)

4. Discussion

4.1 Northern Hemisphere

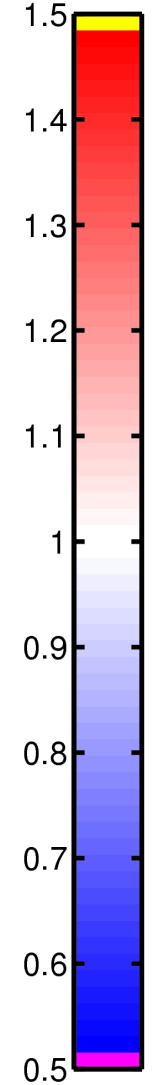
- Ice Thickness Distribution



http://stratus.astr.ucl.ac.be/textbook/chapter3_node12.xml

- Grid formulation

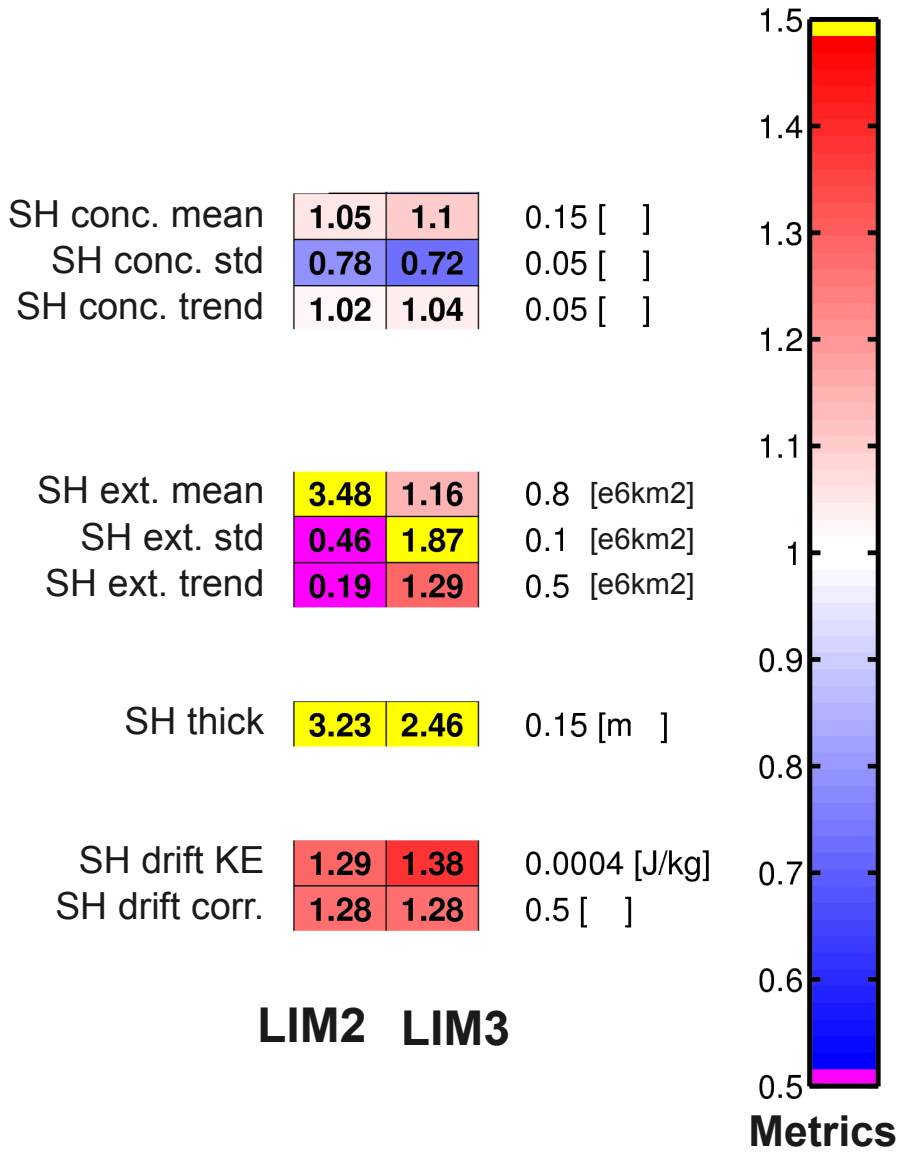
	LIM2	LIM3	Typical error
NH conc. mean	0.96	0.78	0.15 [ ]
NH conc. std	1.02	0.76	0.05 [ ]
NH conc. trend	1.09	0.78	0.05 [ ]
NH ext. mean	1.25	0.5	0.8 [e6km2]
NH ext. std	1.44	0.96	0.1 [e6km2]
NH ext. trend	0.79	1.28	0.5 [e6km2]
NH thick	0.92	0.69	1 [m]
NH thick trend	0.88	0.66	0.1 [ ]
NH drift KE	0.39	0.63	0.0004 [J/kg]
NH drift corr.	0.88	0.78	0.5 [ ]
Fram are mean	0.47	0.76	20 [e3km2]
Fram are std.	0.36	0.84	10 [e3km2]
Fram vol mean	1.14	0.82	50 [km3]
Fram vol std.	0.09	0.8	20 [km3]



4. Discussion

4.2 Southern Hemisphere

- Thinner ice
- Quality of atmospheric forcing
  (Timmerman et al., 2004)
- Role of the ocean



5. Conclusion

- Metrics help quantify qualitative findings
- Model performance more sensitive in NH
- In NH : LIM3 better for ice concentration and thickness (ITD)
- In SH : LIM2 and LIM3 worse than NH, no clear improvement

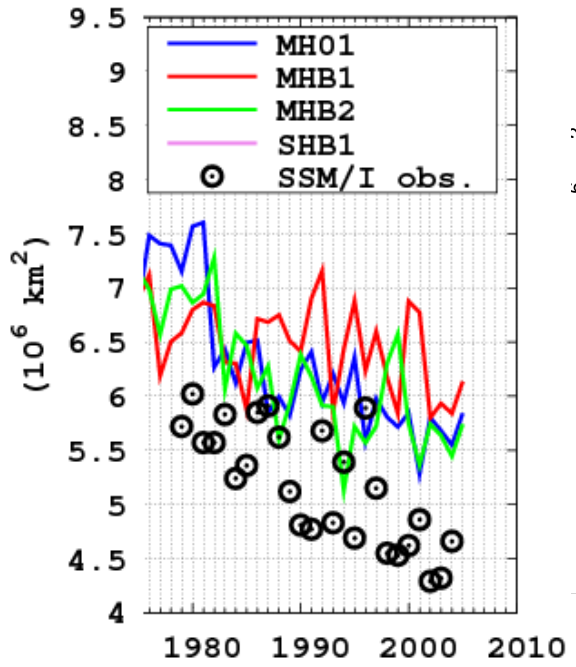
What can we expect from EC-Earth-LIM3?

- Caution : EC-Earth is a GCM
- More seasonal to decadal variability than LIM2
- Reduced mean ice thickness

Current EC-Earth sea ice

EC-Earth-LIM2

NH sea ice extent in September



K. Wyser, pers. comm.

Forced NEMO-LIM

NH sea ice extent in September