Evaluation of atmospheric datasets in the Arctic over the period 2007-2014.

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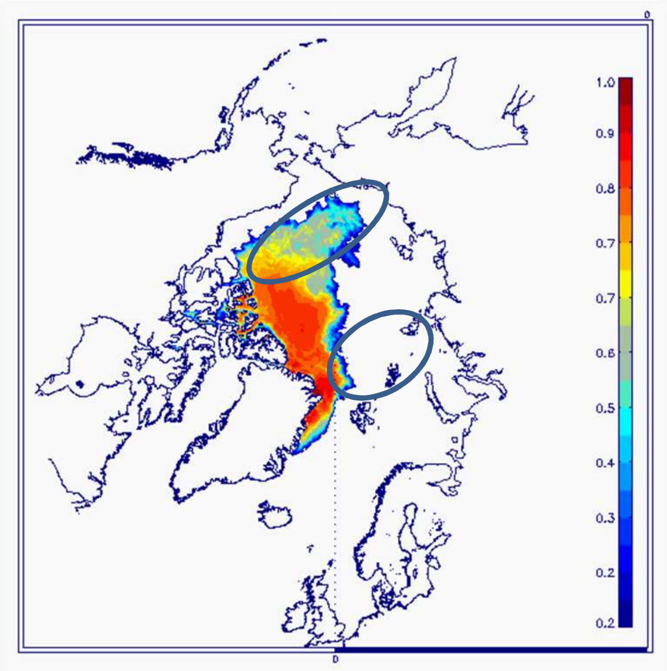
Environment Canada Environnement Canada

Evaluation of atmospheric datasets in the Arctic over the period 2007-2014.

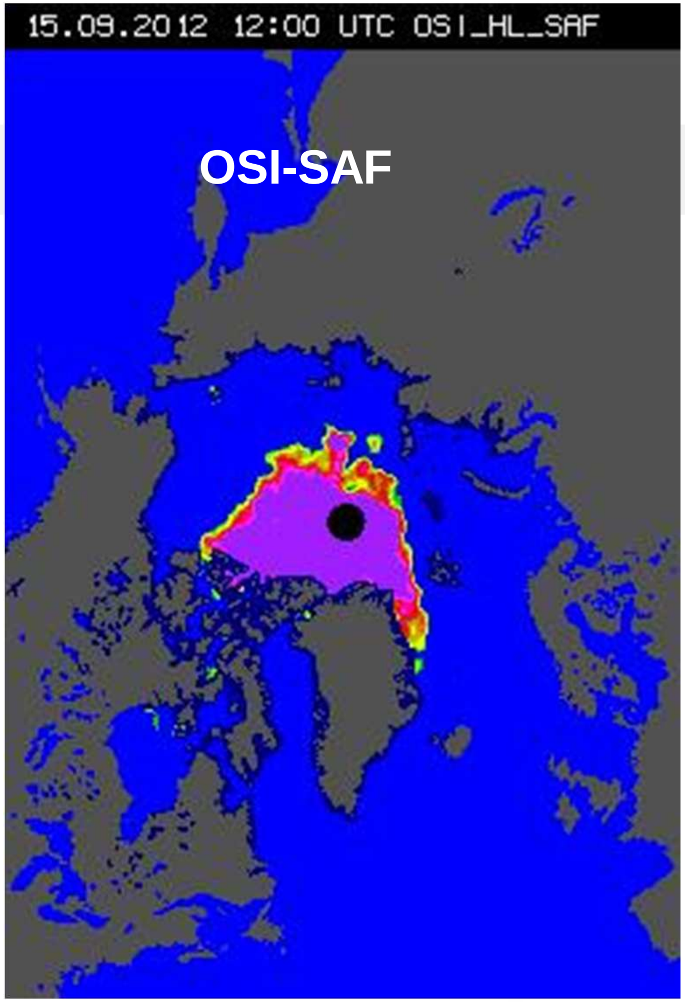
MERCATOR OCEAN

- Background - The NRT operational protocol.
- Experimental set up with the CREG configuration
- Motivation of the study : Tests with 7 different atmospheric forcing (2007 & 2012).
- Thickness validation framework.
- Tests with different initial conditions (ICESat vs GLORYS)
- Summary & Plans

Background
Copernicus Global system

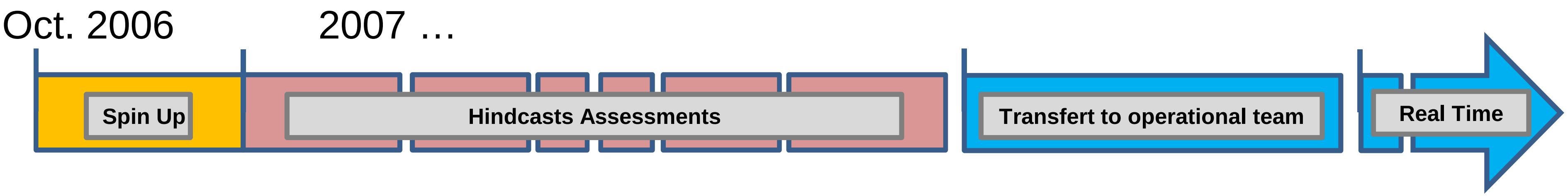


15th of September 2012



The Near Real Time Operational Protocol

- **Application of a NRT protocol to assess stability over time, data assimilation performance, error tunings→ need for long hindcasts !!**
- **Initial conditions chosen in October2006 to take benefits of : 1) the full deployment of ARGO array (3,000 floats in 2007) and IPY efforts in data deployment, 2) the 0.22° (25km) horizontal resolution from ECMWF IFS released in February 2006, 3) the « normal » year 2006 (Niño, NAO), 4) a 10 years hindcasts of assessment.**



1) **Experiments at ¼° resolution and no assimilation (model set up)**
2) **Experiment at ¼° resolution and 3D-VAR Bias Correction.**
3) **Experiment at ¼° resolution and full assimilation scheme.**
4) **Experiment at 1/12° resolution and no assimilation (model set up)**
5) **Experiment at 1/12° resolution and 3D-VAR Bias Correction.**
6) **Experiment at 1/12° resolution and full assimilation scheme**
7) **Transfert to operational team**

- **New release (fall 2016) (use CMEMS dataset (SST and sea ice), sea ice assimilation, adaptative errors, new MDT, new Initial Conditions, control of deep water masses, …) is already designed and defined (see JM Lellouche's talk).**

→ Presently, development of the next release (2017-2018) with a focus on Arctic & sea ice.

Experimental set up with the CREG Configuration

CREG = One of the tools identified in the Partnership with Canada (Env. Canada and DFO).

CREG configuration = tailored (20% of the global cost) for sea ice developments (Model, Assimilation, Observations)

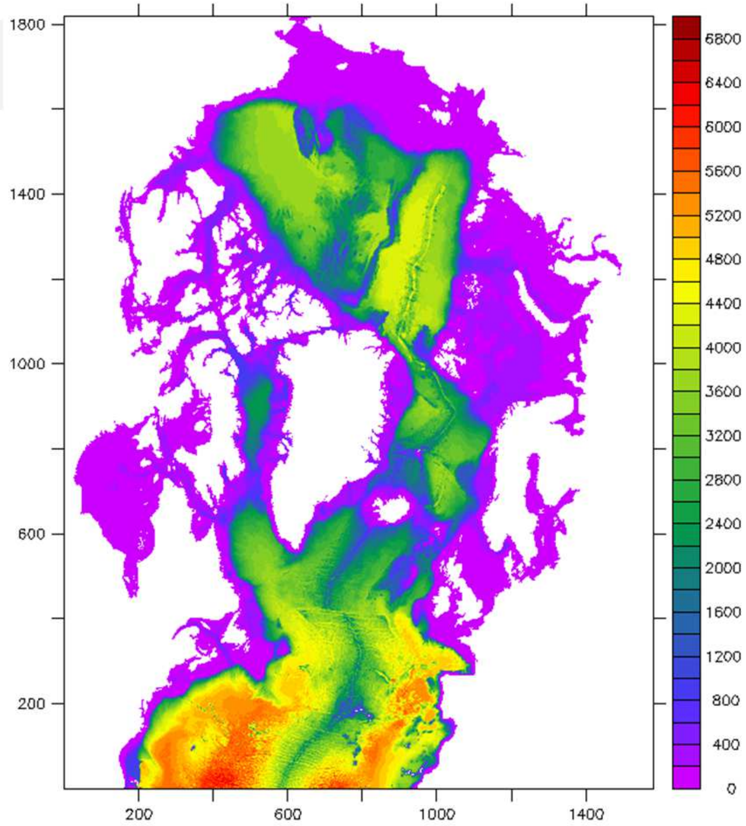
Configuration used in ICE ARC FP7 Project.

<u>Experimental set up at ¼° with the NRT protocol …:</u>

- ✓ ECMWF IFS Forcing (3H) (Oct 2006-2014)
- ✓ Boundaries conditions from global ¼° operational systems
- ✓ Initial Conditions from WOA13 for (T,S) and GLORYS for sea ice thickness, OSI SAF for sea ice concentration
- ✓ Bathymetry ETOPO/GEBCO
- ✓ Runoff (Dai & Trenberth, 2009) + Greenland and nordic glaciers.
- ✓ No restoring.

<u>… But with different physics and parameterisation:</u>

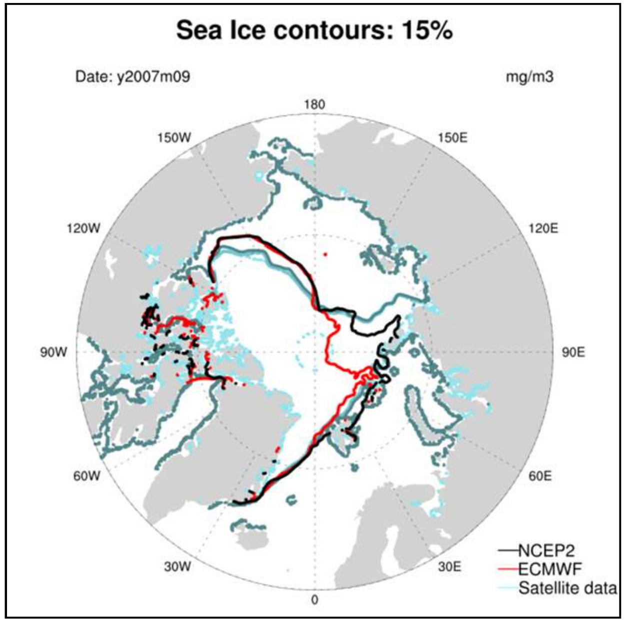
- ✓ NEMO3.6
- ✓ LIM3 (multi-category) (Drags = 1.4E-03 (ice/air), 5.10-03 (ice/ocean), P*=20000)
- ✓ Time-splitting, VVL, 75 z-levels, GLS vertical mixing, …
- ✓ Tests already made with LIM2, ocean/ice drag (Roy et al., 2015), with wave breaking cutoff, …
- ✓ … And test with NCEP-R2 forcing …



Source: G. Smith, Env. Canada, Montréal

First results

ECMWF IFS vs NCEP-R2



ECMWF IFS
NCEP-R2
Observations

September 2007

Motivation of the study

- The question : **our mean sea ice biases can be related to the atmospheric forcing?...**
- Lindsay et al. (2014)'s paper : evaluation of 7 atmospheric reanalysis dataset in the Arctic (NCEP-R1, NCEP-R2, CFSR, 20CR, MERRA, ERA-Interim & JRA-25) for the 1980-2009 period & forcing PIOMAS with four of them (NCEP-R1, CFSR, MERRA & ERA-I) & evaluation of the trend of the sea ice volume with CDR dataset. Albedo and drag coefficient bias-corrected.
- Our study : Use available reanalysis/operational atmospheric forcing over the 2007-2014 periods to drive the CREG configuration in our NRT protocol context with none assimilation and at ¼° resolution to perform numerous sensitivities tests. No bias correction. The IFS ECMWF will be our reference.
- Preliminary results with descriptive results only. Study partly achieved

Atmospheric Forcing Datasets

MERCATOR OCEAN

Selection Criteria : Period, Global domain, with assimilation, « High Resolution ».

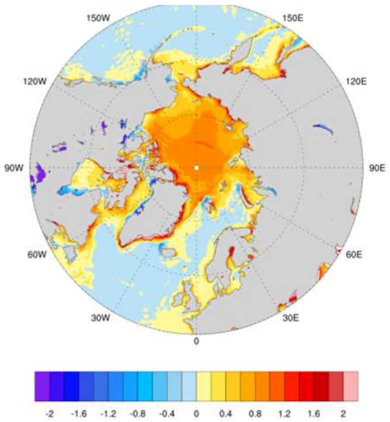
Name	Source	Domain	Period of Record	Available timestep(s)	Available resolution lonXlat	Model Resolution	Assimilation scheme & model vintage
IFS	ECMWF	Global	1985 to present	Sub-daily	…0.35°,0.22°, 0.1°… …50km,25km,16km…	…T511/L60,T799/L91,/ T1279/L91…	4DVAR|199?
ERA-Interim	ECMWF	Global	1979/01 to 2016/01	Sub-daily	0.75°x0.75°	T255, 60 levels	4DVAR | 2006
JRA-55	Japanese Meteorological Agency	Global	1958/01 to 2016/01	Sub-daily, Monthly	0.56x0.56	T319, 60 levels	4DVAR | 2009
NASA MERRA	NASA	Global	1979/01 to 2015/11	Sub-daily, Monthly	0.667° x0.5°	0.5° x 0.667°x72	GEOS IAU | 2009
NCEP Reanalysis (R2)	NCEP,DOE	Global	1979/01 to 2015/07	Sub-daily, Daily, Monthly	2.5°x2.5°	T62 28 levels	3DVAR | 2001
Climate Forecast System Reanalysis (CFSR) and Version 2 (CFSv2)	NCEP	Global	1979 to 2010 2011 to 2015/09	Sub-daily, Monthly	0.5°x0.5° & 2.5°x2.5°	T382 x 64 levels	3DVAR | 2009
CGRF	Canadian Global Deterministic Prediction System reforecasts	Global	2002-2014	Sub-daily	0.3°x0.45° (33km)	33km	4DVAR/2014

Atmospheric Forcing Datasets

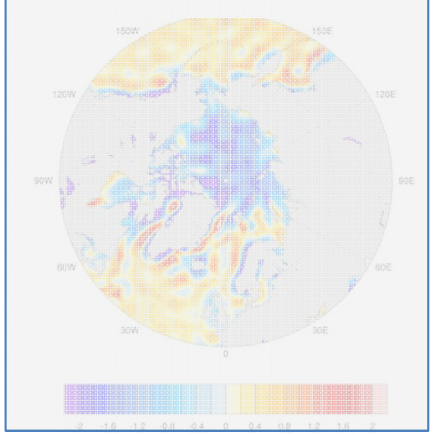
- Variables : T2m, q2m, (U10,V10), Downward SW and LW, Precipitations, snow (or Ledley (1986)).
- CGRF : Only until 2010
- Focus on 2007-2012 and historical minimums (2007 and 2012).
- IFS ECMWF is our reference.

Surface Air Temperature 2007-2012

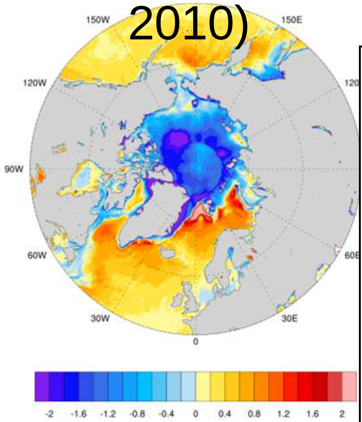
ERA-Interim



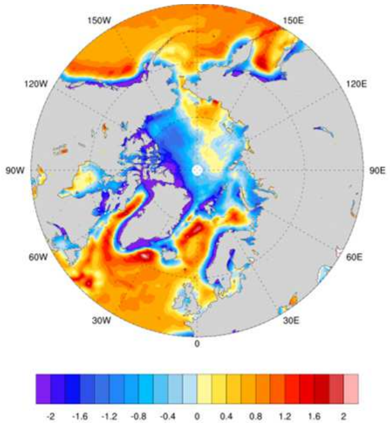
JRA55



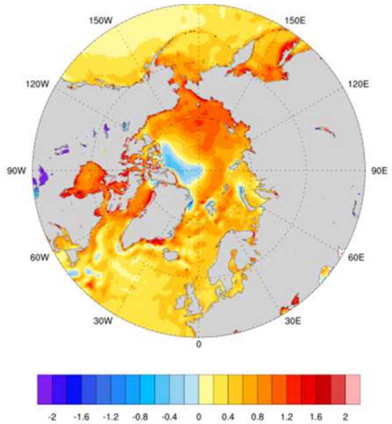
CGRF (2007-2010)



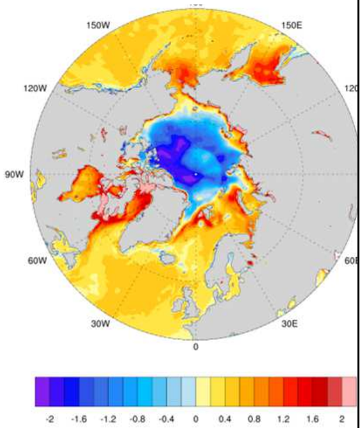
NCEP-R2



MERRA



CFSR

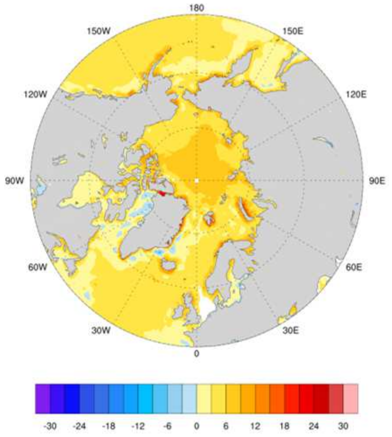


Differences with IFS.

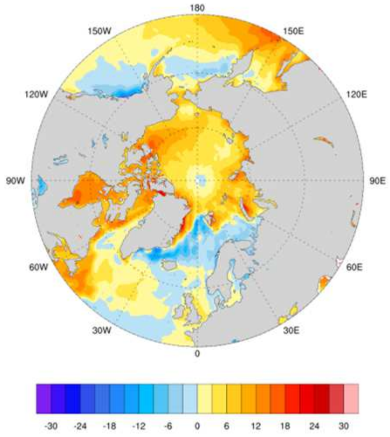
- IFS is warmer (**1° C-2° C**) than JRA55, CGRF, NCEP2 and CFSR. In accordance with Lindsay(2014)'s paper and Jakobson et al. (2012): ECMWF warmer than other reanalysis ?
- IFS is colder than MERRA and ERA-Interim (< 1° C).
- Arctic Ocean: well different from surroundings oceans.

Downward LW 2007-2012

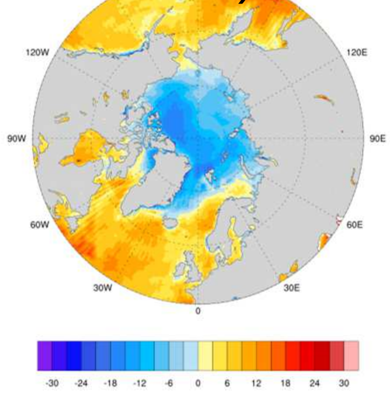
ERA-Interim



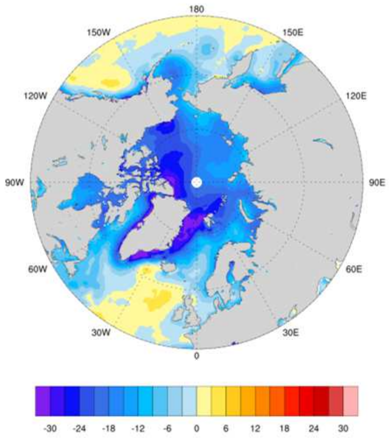
JRA55



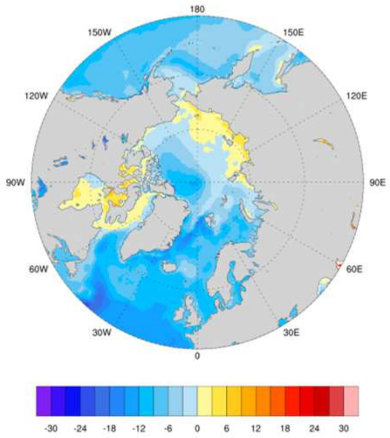
CGRF (2007-2010)



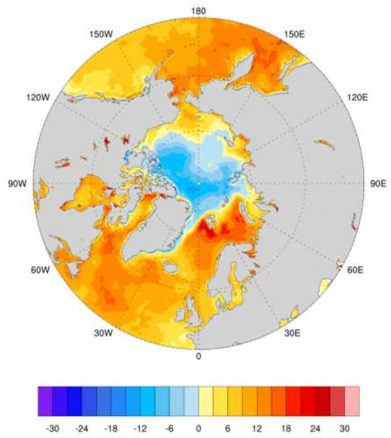
NCEP-R2



MERRA



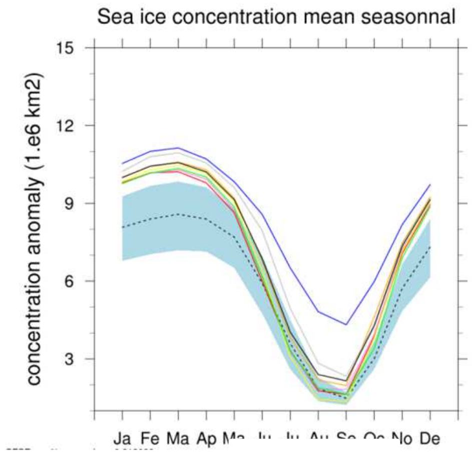
CFSR (2007-2010)

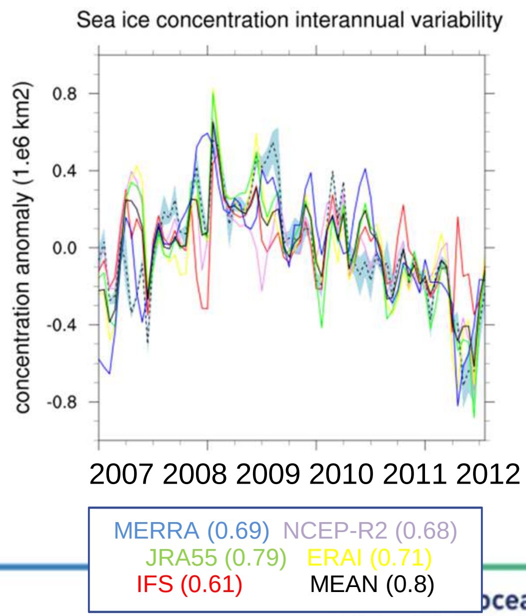


Differences with IFS

- IFS is warmer (up to **30W.M²**) than CGRF, NCEP2, MERRA and CFSR.
- IFS is colder than ERA-Interim JRA55 (> 5W.M²).
- In accordance with Lindsay(2014)'s paper.

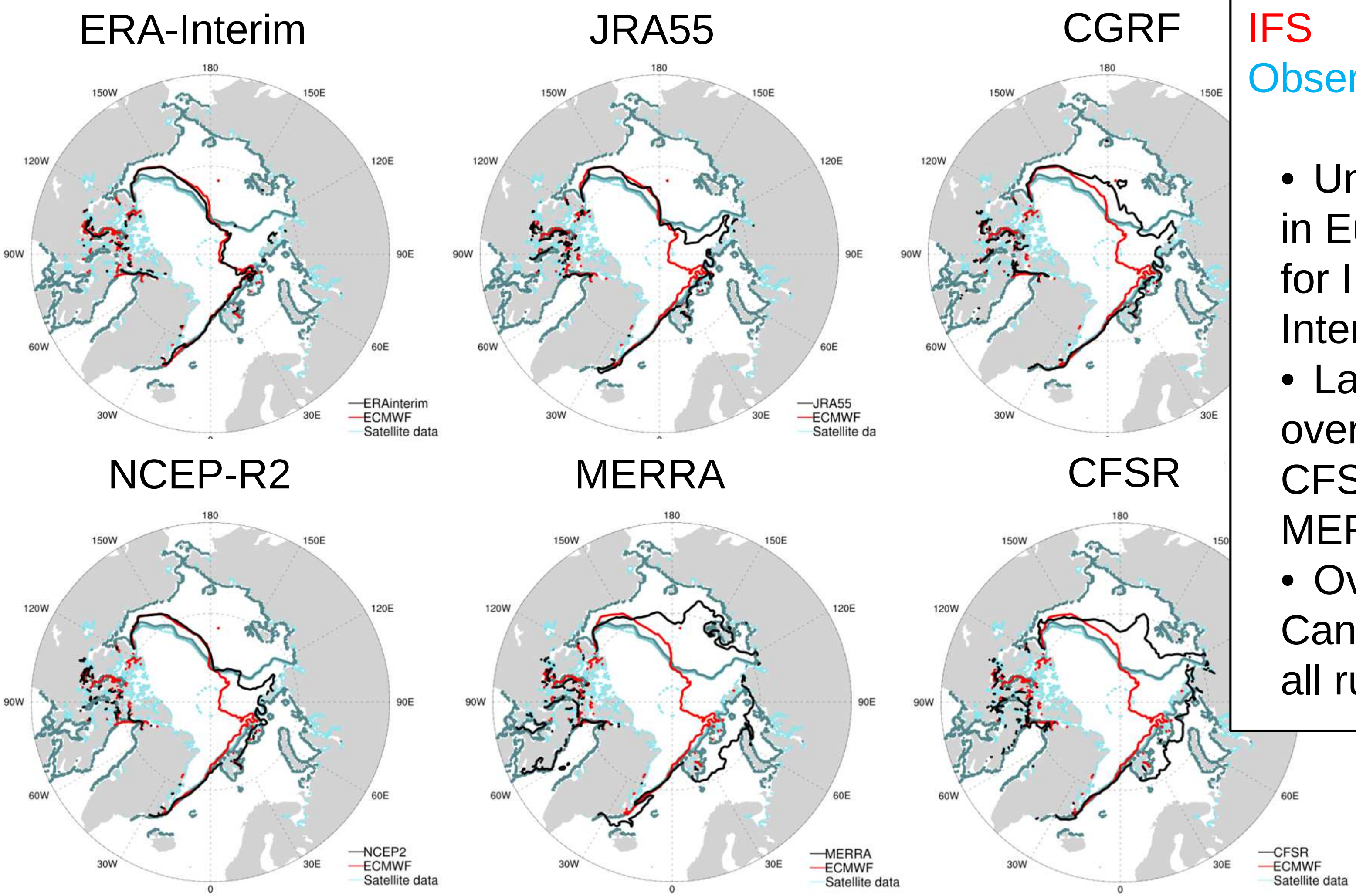
Sea Ice Concentration - Interannual and seasonal variability 2007-2012





- Seasonal cycle in phase.
- Overestimation of sea ice in winter for all runs.
- Strong overestimation (Peculiar ?) with MERRA.
- Low frequency variability well captured.
- Better correlation with the mean estimates.
- 2012 event missed by IFS.

Sea Ice Concentration September 2007

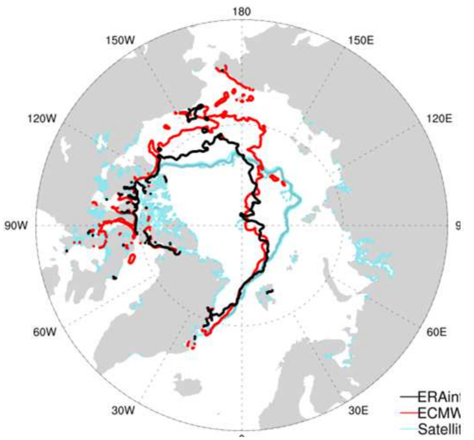


IFS
Observations

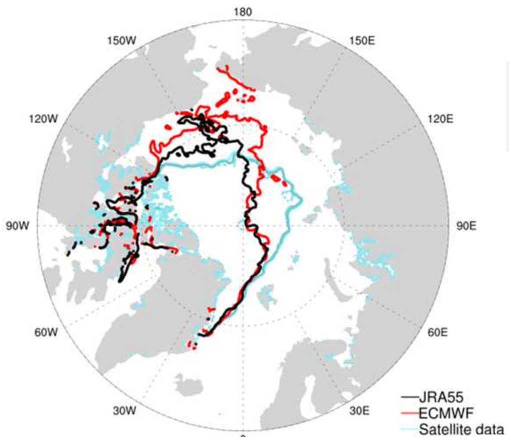
- Underestimation in Eurasian Basin for IFS and ERA Interim.
- Large overestimation with CFSR and MERRA.
- Overestimation in Canadian Basin for all runs.

Sea Ice Concentration September 2012

ERA-Interim

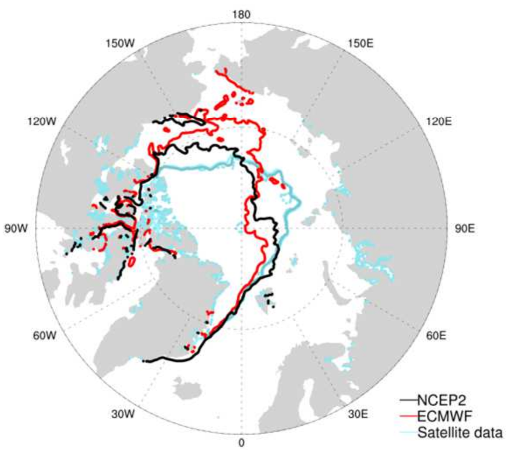


JRA55

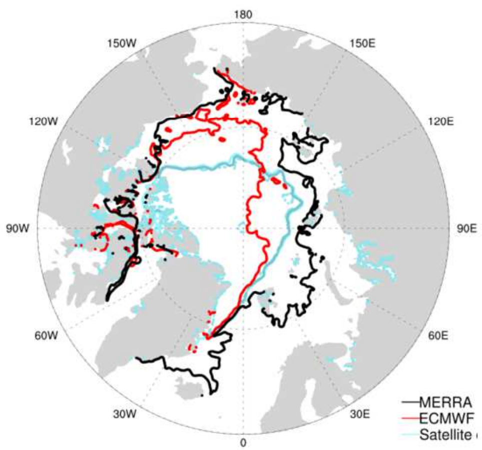


CGRF (2007-2010)

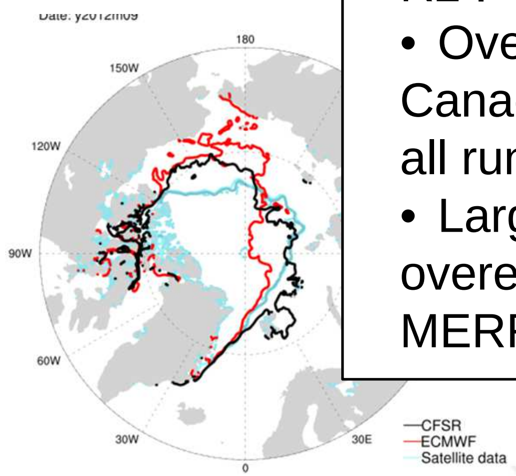
NCEP-R2



MERRA



CFSR



IFS
Observations

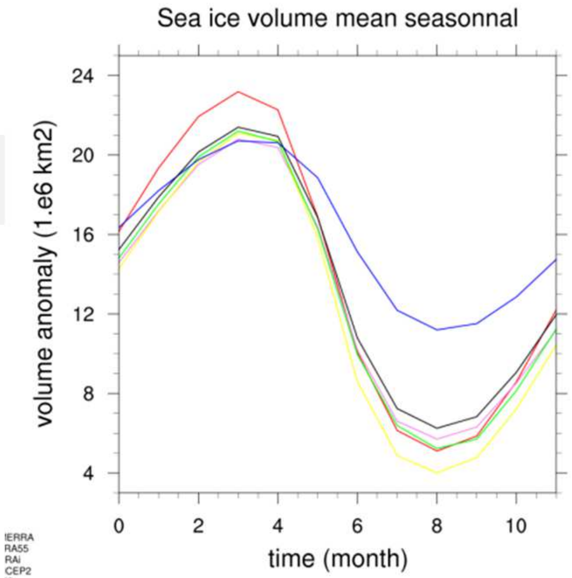
- Event missed by IFS.
- Underestimation in Eurasian Basin for ERA-Interim, JRA55 and NCEP-R2 .
- Overestimation in Canadian Basin for all runs.
- Large overestimation with MERRA.

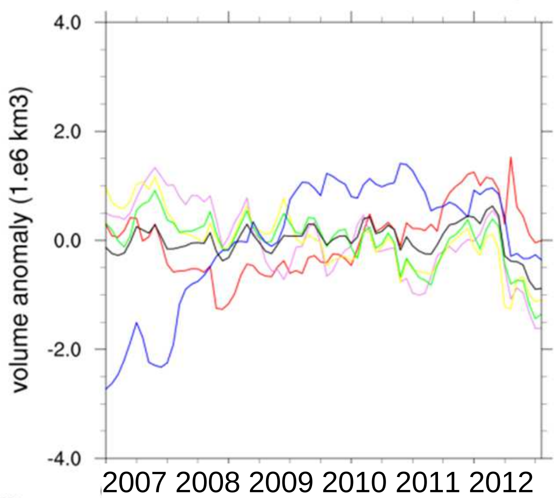
Sea Ice Thickness - Interannual and seasonal variability 2007-2012

MERRA NCEP-R2

JRA55 ERAI

IFS MEAN



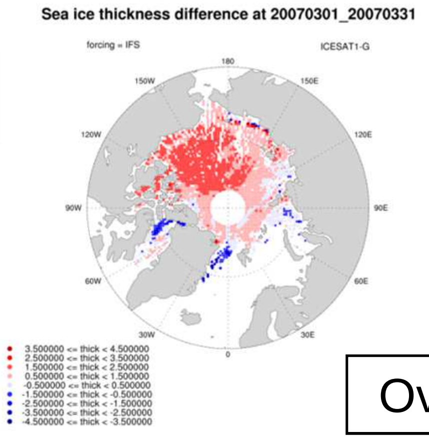


- Thicker ice with IFS in wintertime
- Stronger spread in summertime
- Weak seasonal cycle with MERRA.

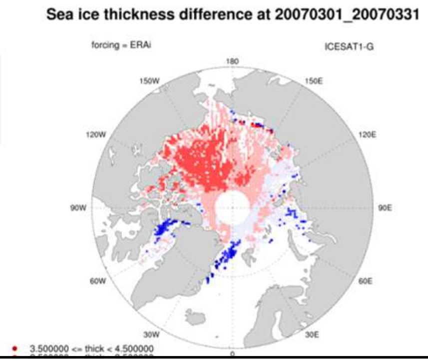
- No clear spin up.
- Apart IFS and MERRA, all experiments show their minimum in 2012 and negative « trend ».

Sea Ice Thickness – Comparison with ICESat - March 2007

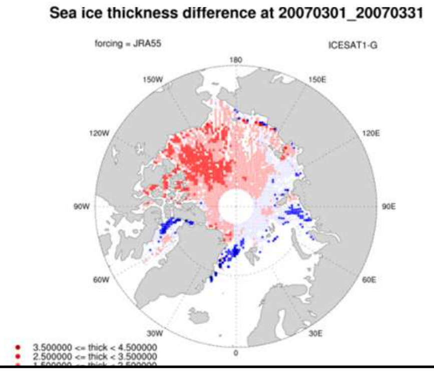
IFS



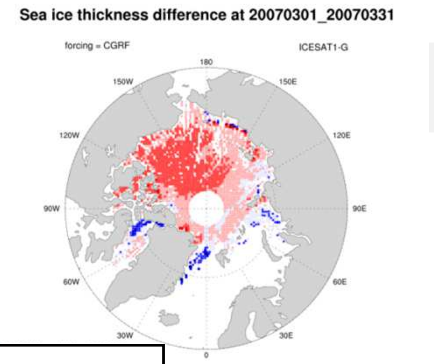
ERA-Interim



JRA55

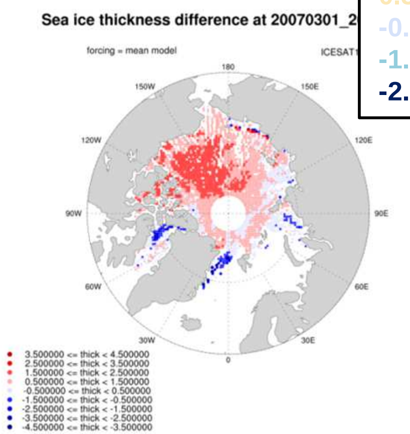


CGRF



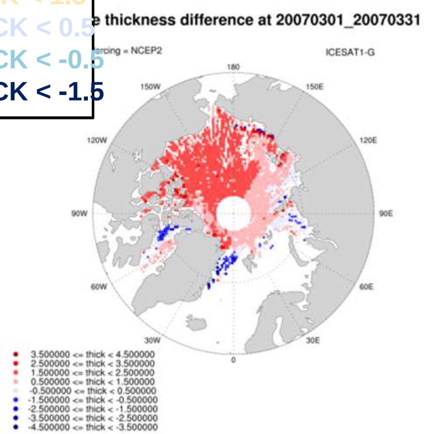
Overestimation in Canadian Basin for all experiments.

MEAN

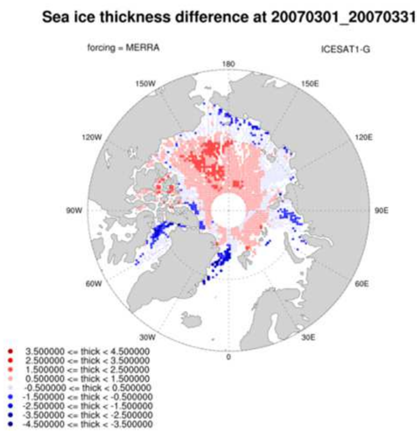


1.5 < THICK < 2.5
0.5 < THICK < 1.5
-0.5 < THICK < 0.5
-1.5 < THICK < -0.5
-2.5 < THICK < -1.5

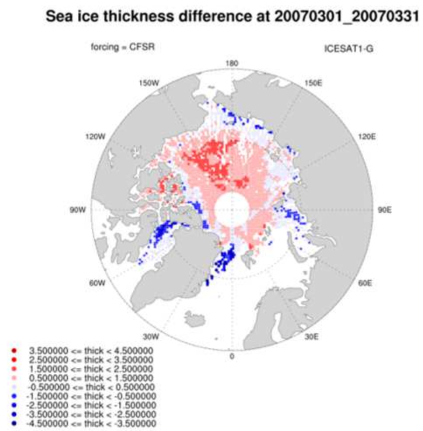
NCEP-R2



MERRA

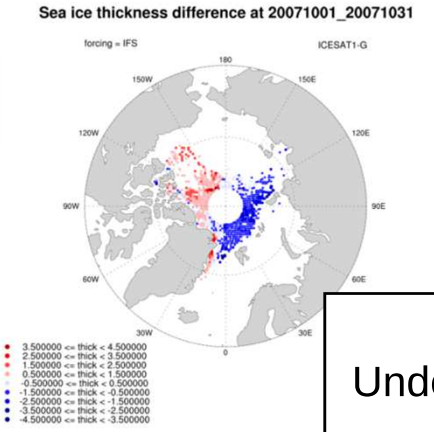


CFSR

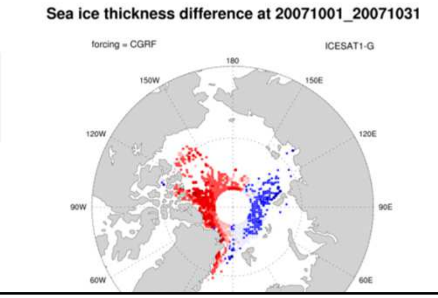


Sea Ice Thickness – Comparison with ICESat – October 2007

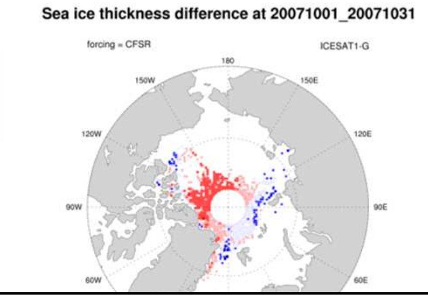
IFS



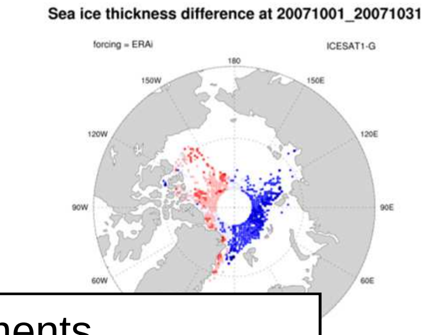
ERA-Interim



JRA55



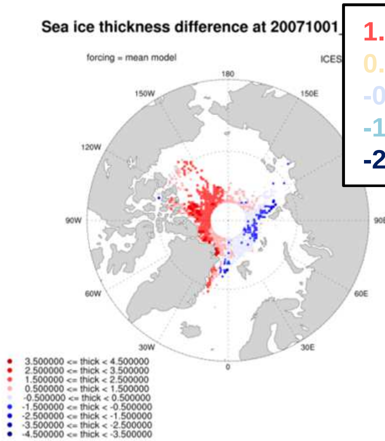
CGRF



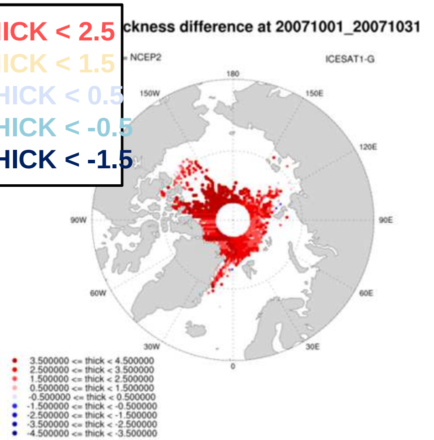
Overestimation in Western Basin for all experiments.
Underestimation in Eurasian Basin for IFS, ERA-Interim, CFSR & CGRF.
General and strong overestimation with NCEP-R2.

MEAN

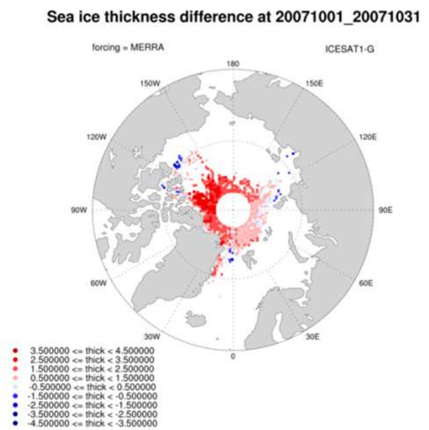
1.5 < THICK < 2.5
0.5 < THICK < 1.5
-0.5 < THICK < 0.5
-1.5 < THICK < -0.5
-2.5 < THICK < -1.5



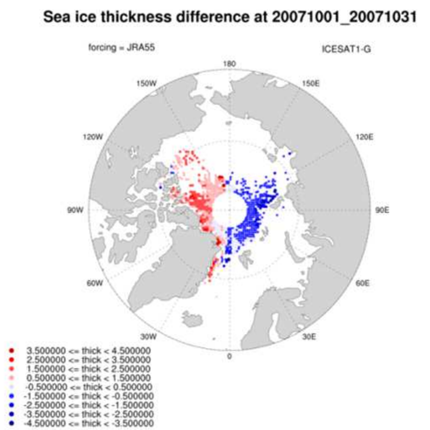
NCEP-R2



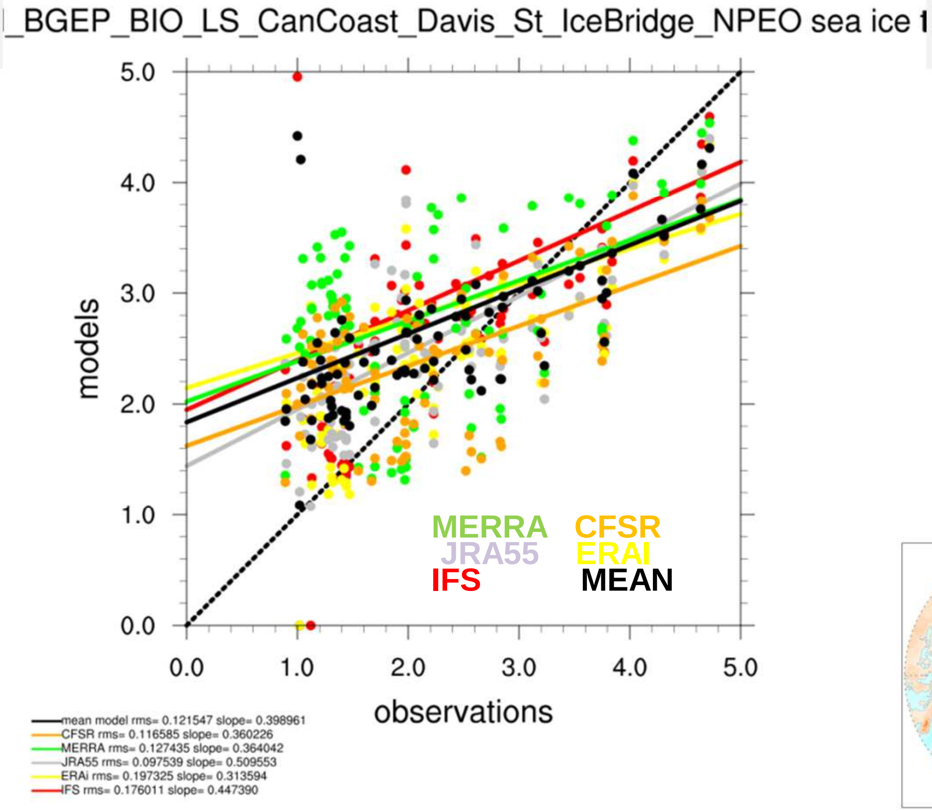
MERRA



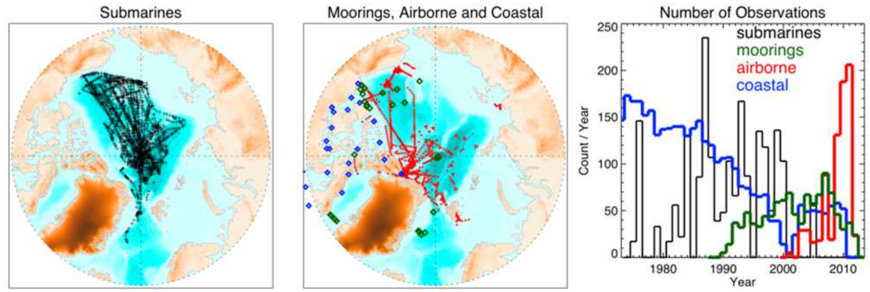
CFSR



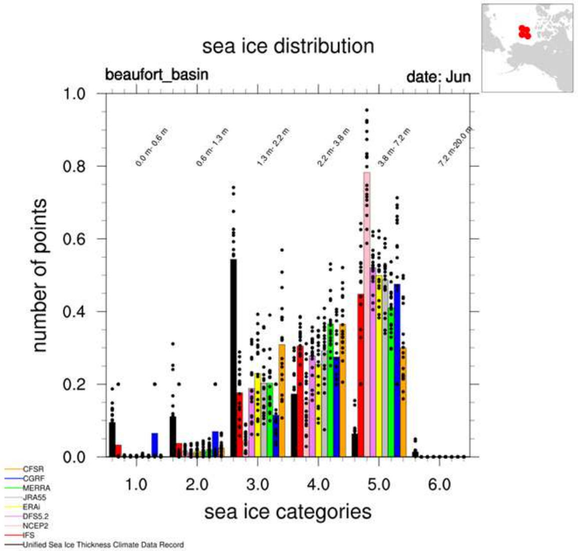
Sea Ice Thickness
Comparison with Unified Sea Ice Thickness Climate Data Record (2007-2012)

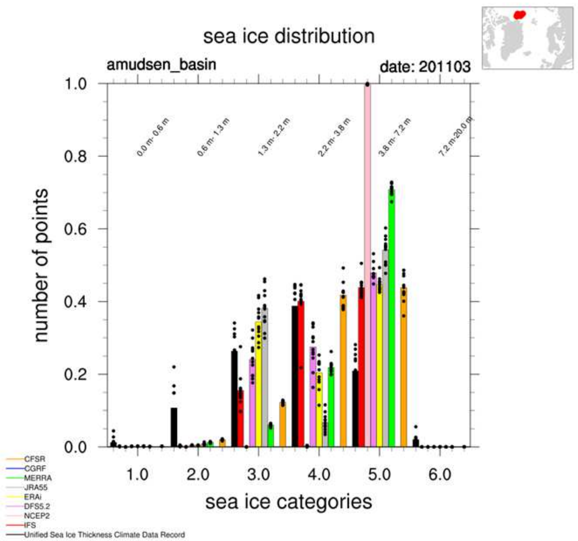


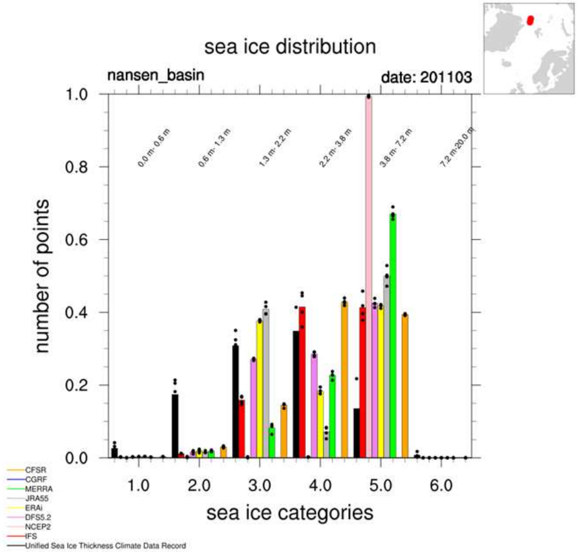
- General overestimation
- Underestimation for thicker ice.
- Few data in Eurasian Basin



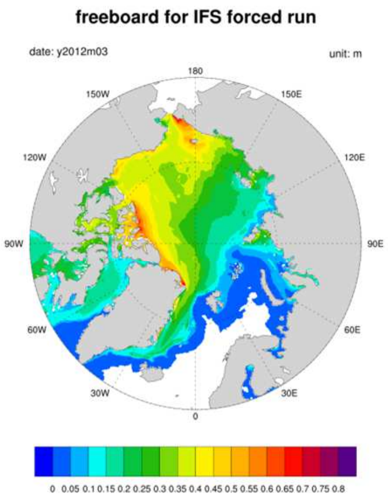
Sea Ice Thickness Distribution
Comparison with Unified Sea Ice Thickness Climate Data Record (2007-2012)

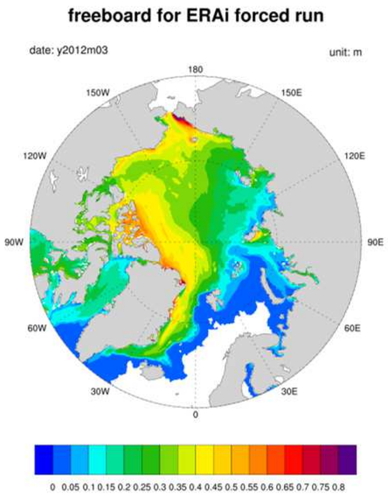


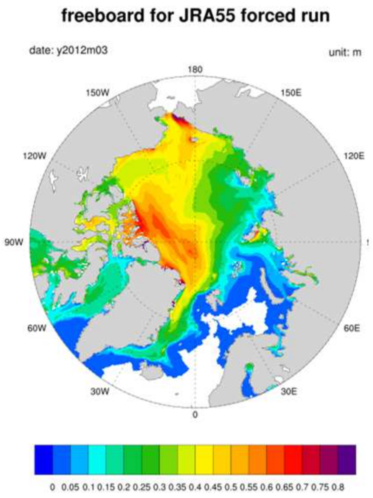


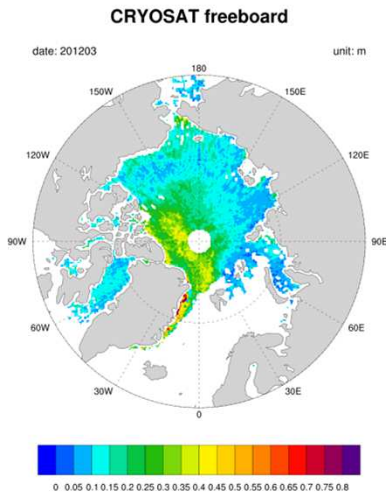


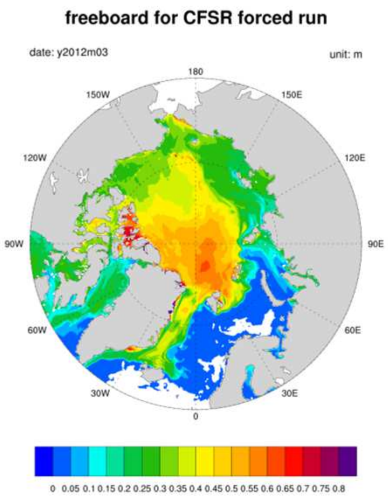
Sea Ice Freeboard
Comparison with CRYOSAT2

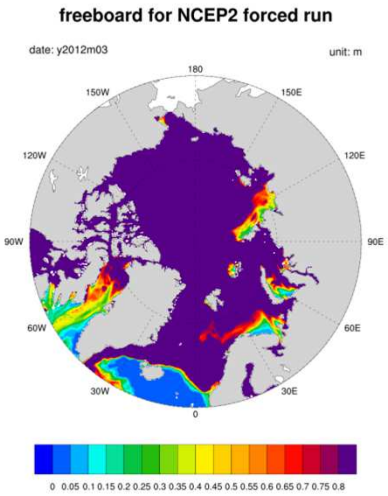


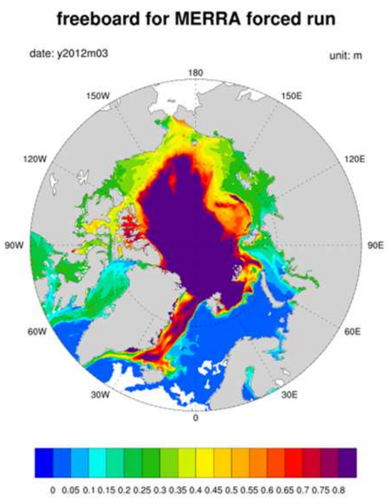








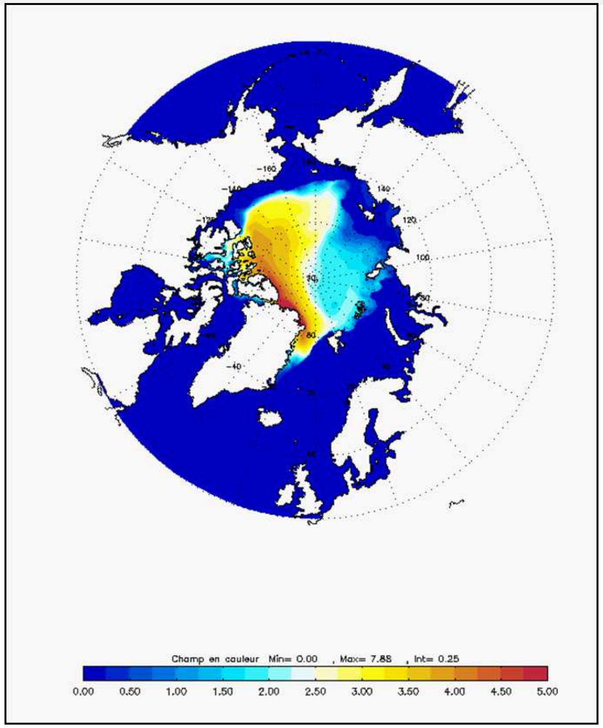




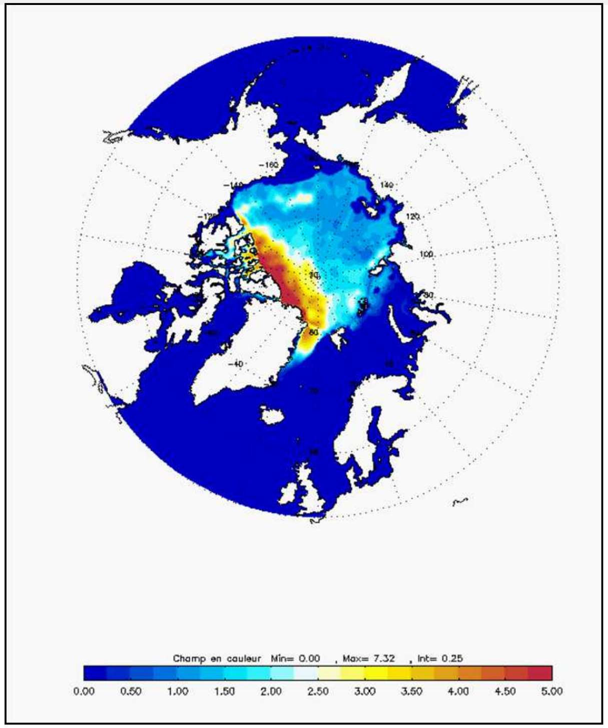
Initial conditions of ice thickness from ICESat

October 2006

GLORYS



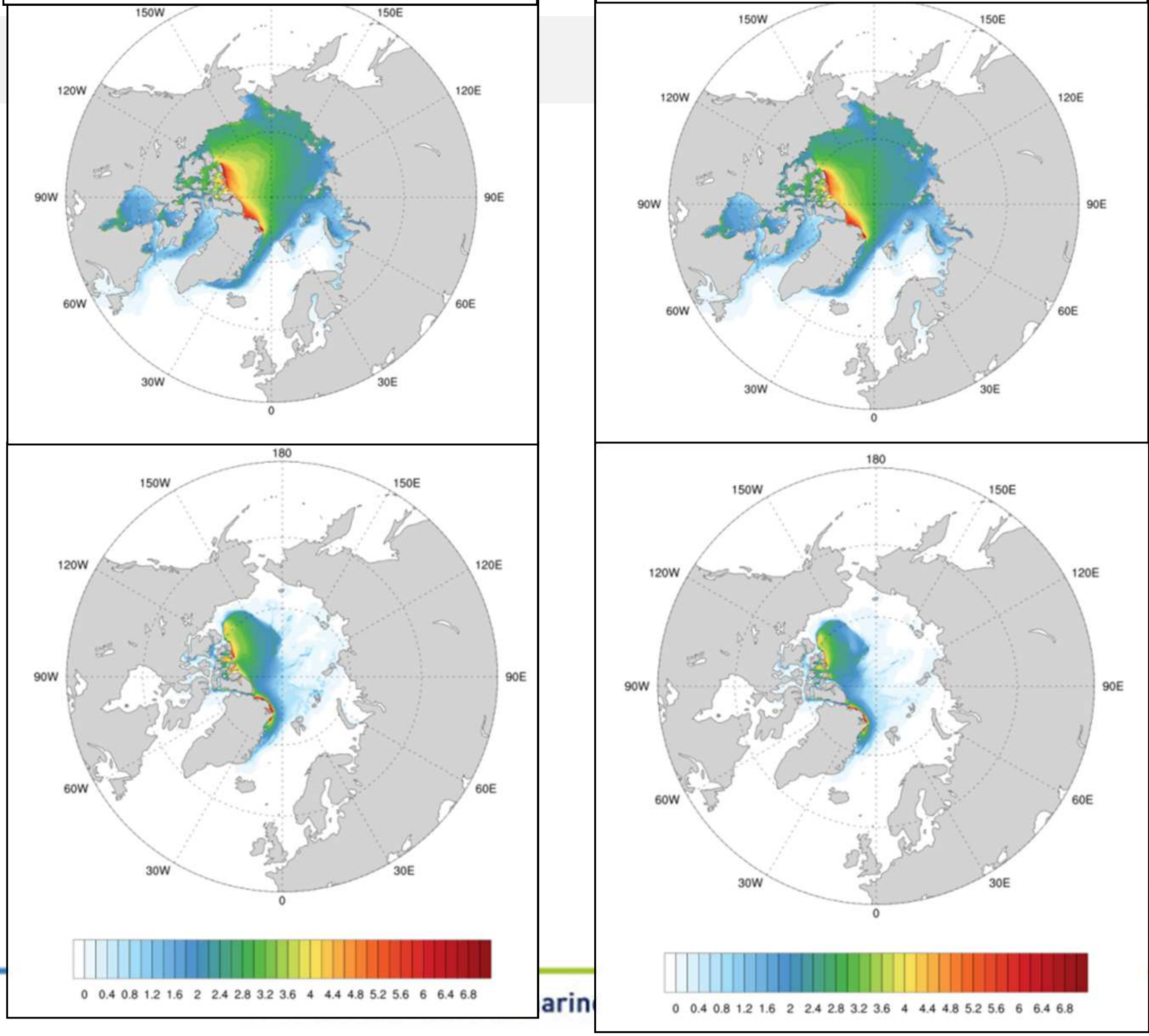
ICESAT



Initial conditions of ice thickness from ICESat

Initialisation with :

	GLORYS	ICESat
March 2007		
Sept 2007		



Summary

✓ IFS : Warmer (1°C-2°C) (and dryer and higher wind speed) than any other reanalysis. → In accordance with results found for ERA-Interim in previous studies.

✓ Sea Ice concentration and thickness:

- Overestimation in Canadian Basin for all experiments
- Underestimation (thickness) in Eurasian Basin in IFS, better reproduction with other forcing
- Results in accordance with Chevallier et al. (2016).
- No clear negative trend in ice volume for IFS.
- Peculiar results with MERRA.
- (Test with DFS5.2 : similar results with IFS/ERA_Interim)

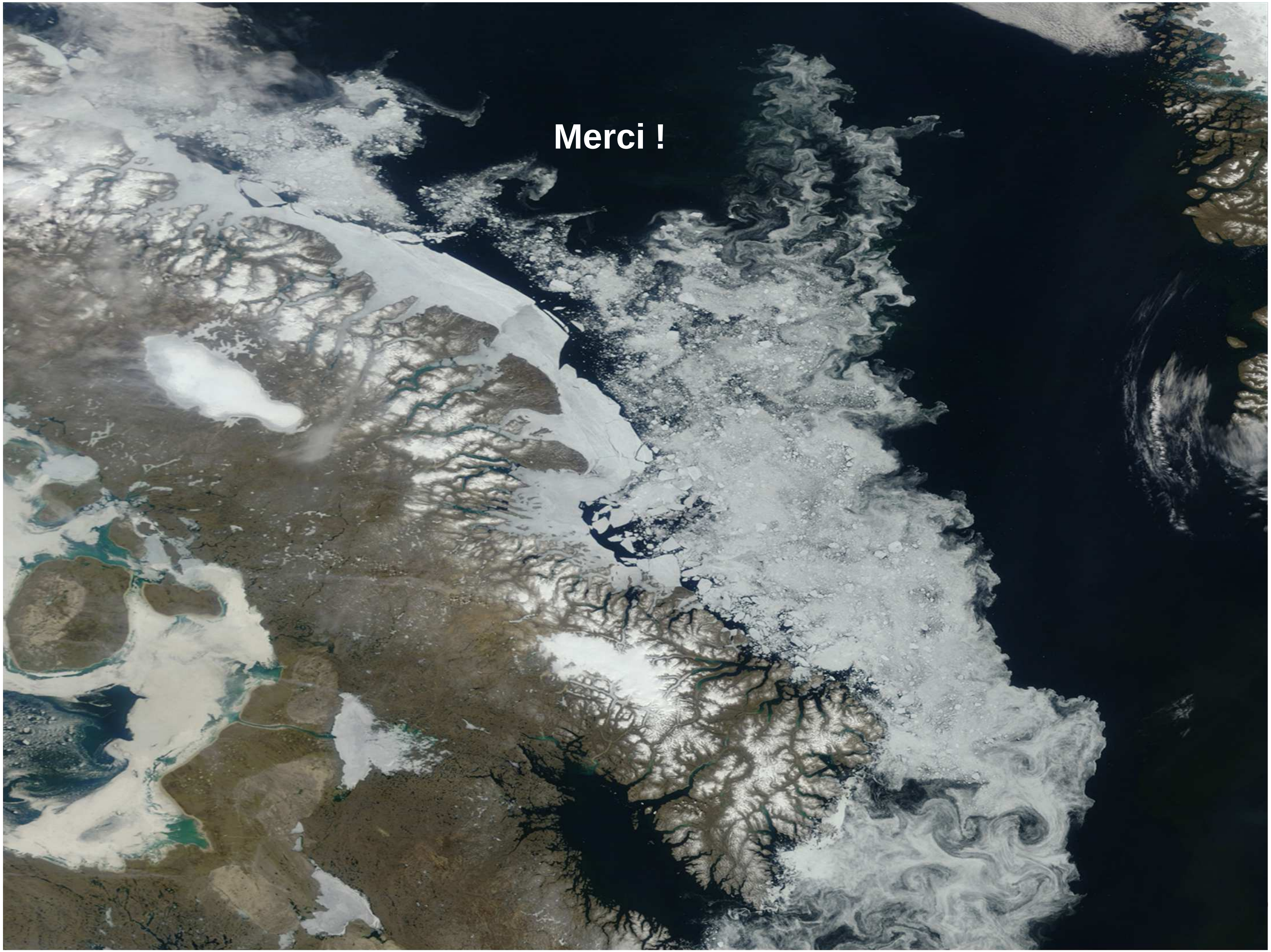
✓ No real impact with more realistic thickness initial conditions.

✓ Validation of concentration with different sources of passive microwave data.

✓ Thickness validation framework with altimetry and in situ.

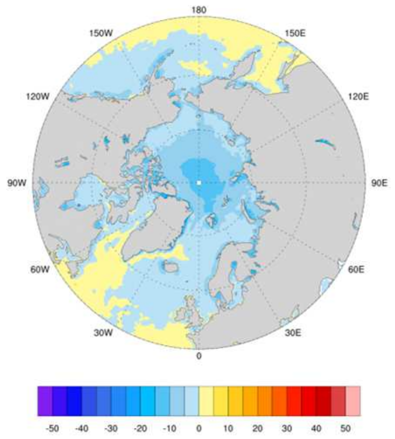
Plans

- ✓ Test the **ERA5** atmospheric forcing.
- ✓ Implementation of the **ice/ocean drag** from Env. Canada and new **air/ice form drag** from Lupkes (see poster G. Samson).
- ✓ Reference run with **CREG12**
- ✓ Data to be implemented in the ice thickness validation framework : IMB (Ice Mass Balance), ESA-CCI (SMOSice); Cryosat2 in real time.
- ✓ Other metrics : Validation of dynamics & **surface temperature** with CMEMS satellite dataset and snow depth.
- ✓ **Assimilation** of sea ice concentration with **LIM3**.
- ✓ Bias correction with in situ (T,S) (ITP,...).

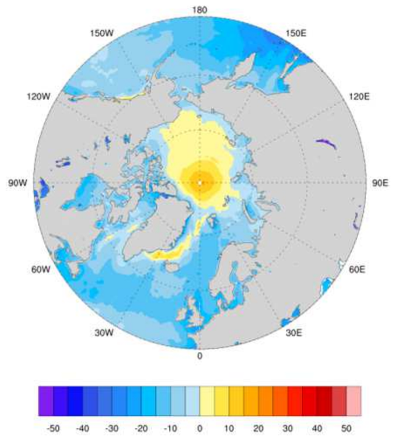

Merci !

Downward SW 2007-2012

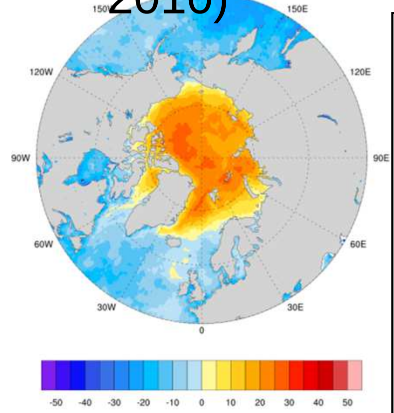
ERA-Interim



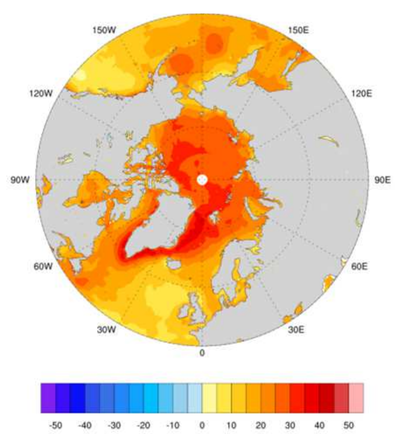
JRA55



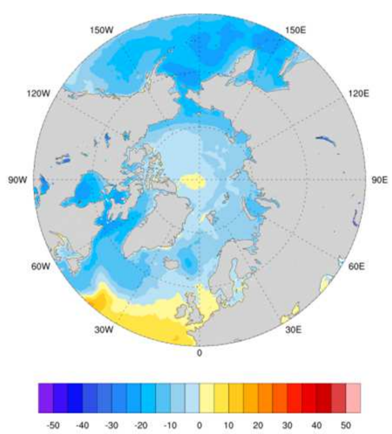
CGRF (2007-2010)



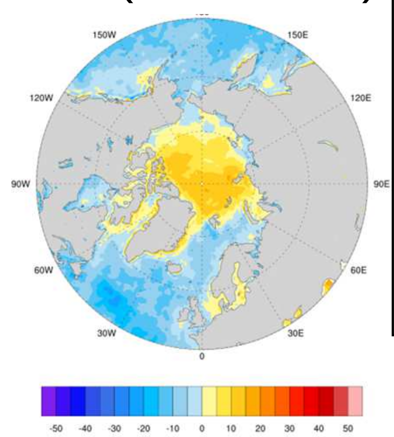
NCEP-R2



MERRA



CFSR (2007-2010)



Differences with IFS

- **IFS is colder (up to 30W.M²) than JRA55, CGRF, NCEP2 and CFSR.**
- **IFS is warmer than ERA-Interim (> 5W.M²) and MERRA.**
- **In accordance with Lindsay(2014)'s paper.**