The role of sea-ice in extended range prediction of atmosphere and ocean

Virginie Guemas

with contributions from Matthieu Chevallier, Neven Fučkar, Agathe Germe, Torben Koenigk, Steffen Tietsche

Workshop on Polar Prediction, Reading, 25 June 2013

Outline

I - Sea ice loss and impacts

II - Seasonal prediction

III - … and longer timescales

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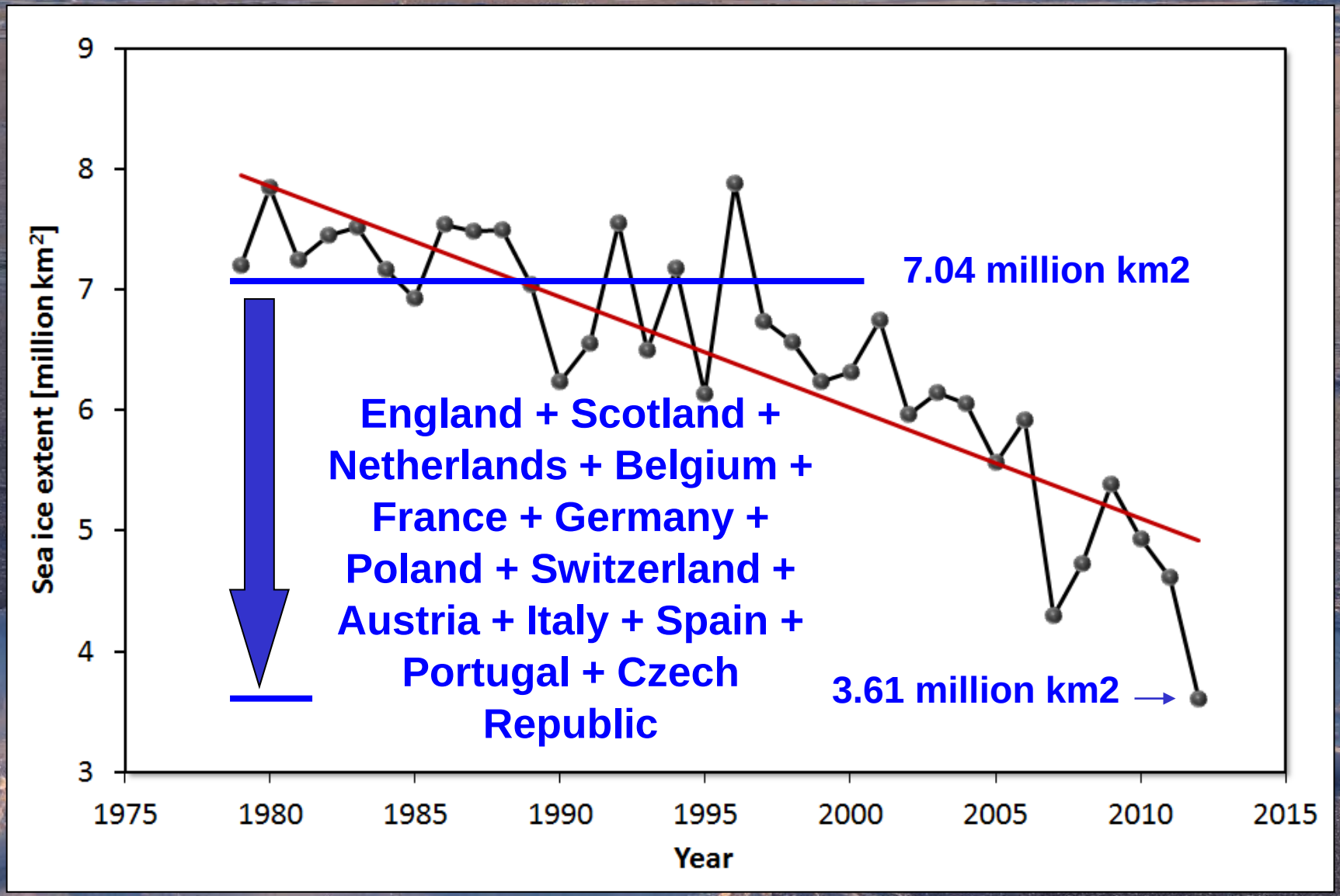
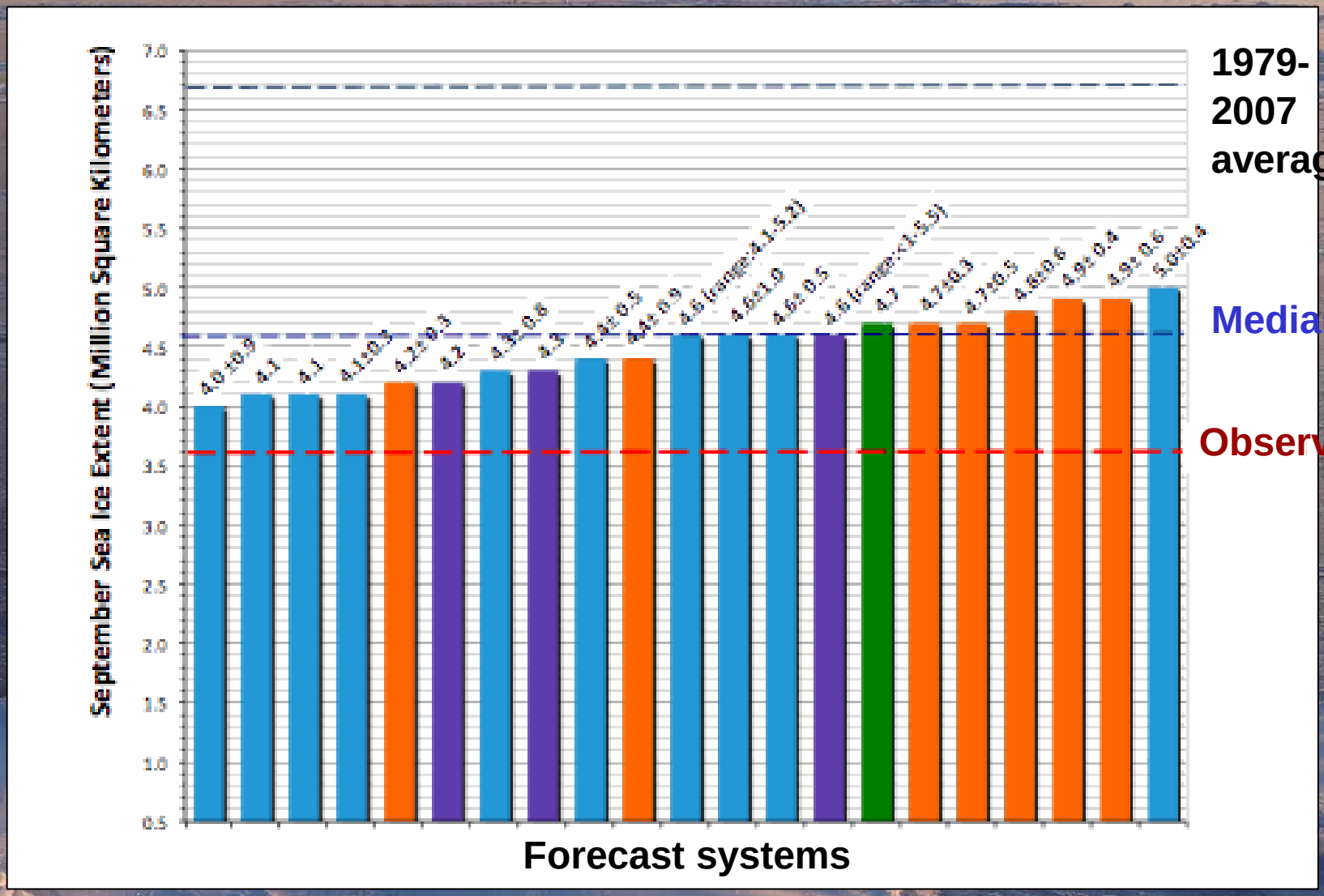
September sea ice extent from NSIDC (National Snow and Ice Data Center)

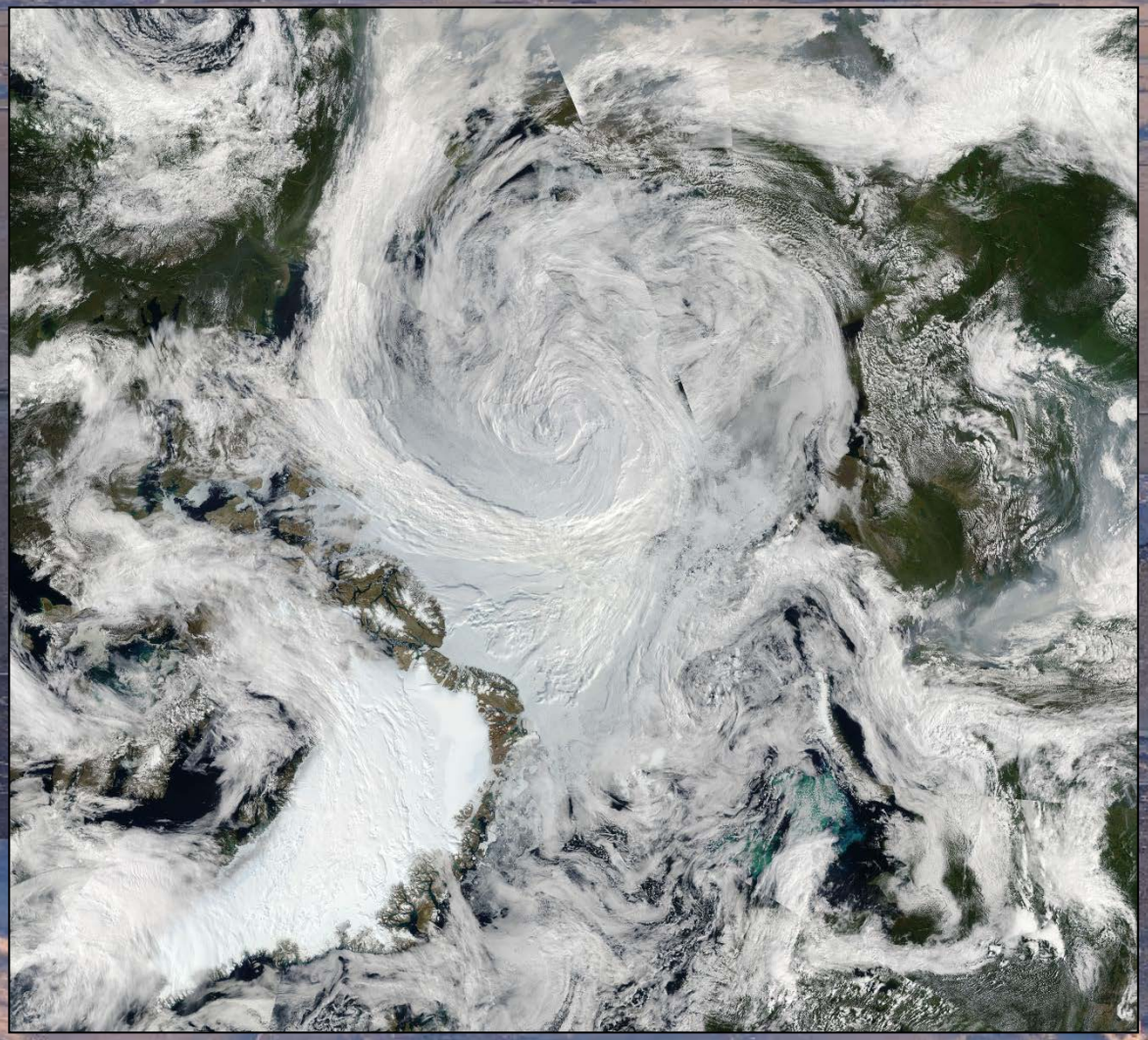


2012 Sea Ice Outlook : July report



Why 2012 record-low missed by all the forecast systems ?

Attributing the September 2012 Arctic ice minimum

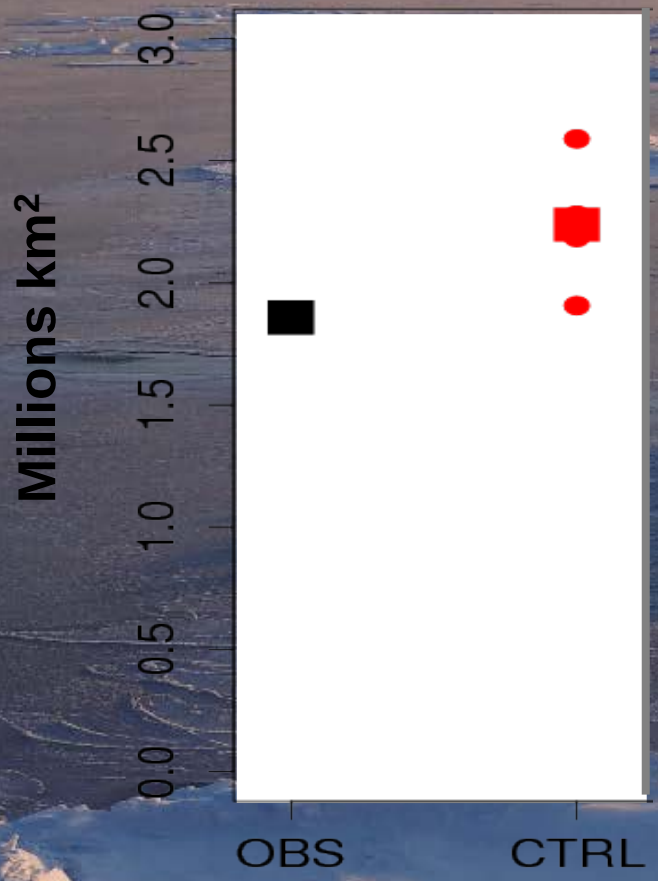


1 of the 8 most extreme summer storm over the 1979-2012 period

NASA

2012 record-low due to climate change or natural variability ?

Attributing the September 2012 Arctic ice minimum



Sea ice Loss relative to the average of the September minima over the 2000-2011 period

CTRL = NEMO3.2 ocean model + LIM2 sea ice model initialized on 1 June 2012 from a 5-member sea ice reconstruction and forced with ERAinterim.

Guemas et al, BAMS, 2013

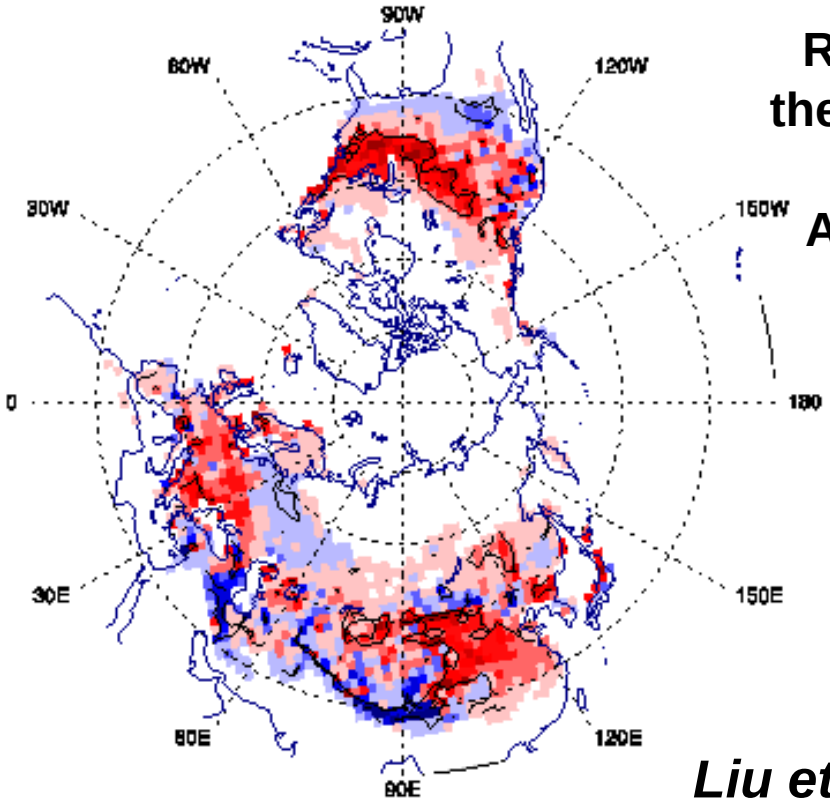
Our sea ice model overestimates the 2012 excess sea ice loss relative to the 2000-2011 average

Attributing the September 2012 Arctic ice minimum

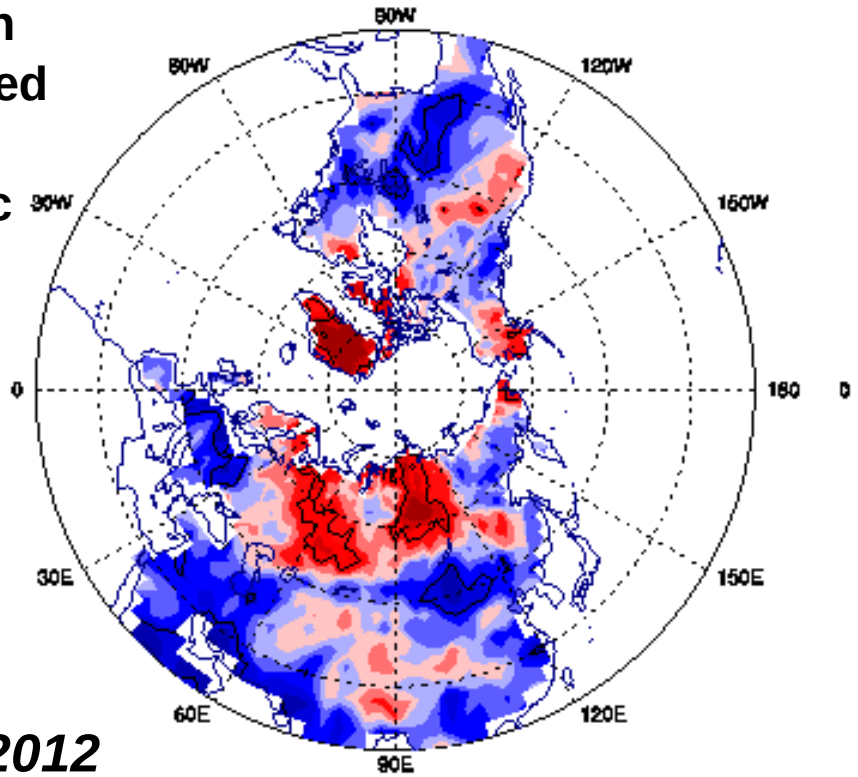
Guemas et al, BAMS, 2013

New record low seems primarily due to sea ice memory and warm conditions

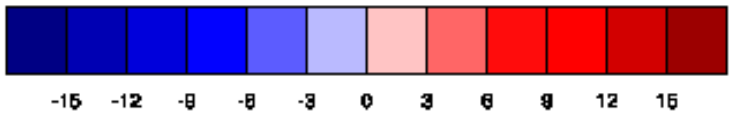
Impact of the ice decline on the adjacent continents



Regression on the sign-reversed detrended Autumn Arctic sea ice area



Liu et al, PNAS, 2012

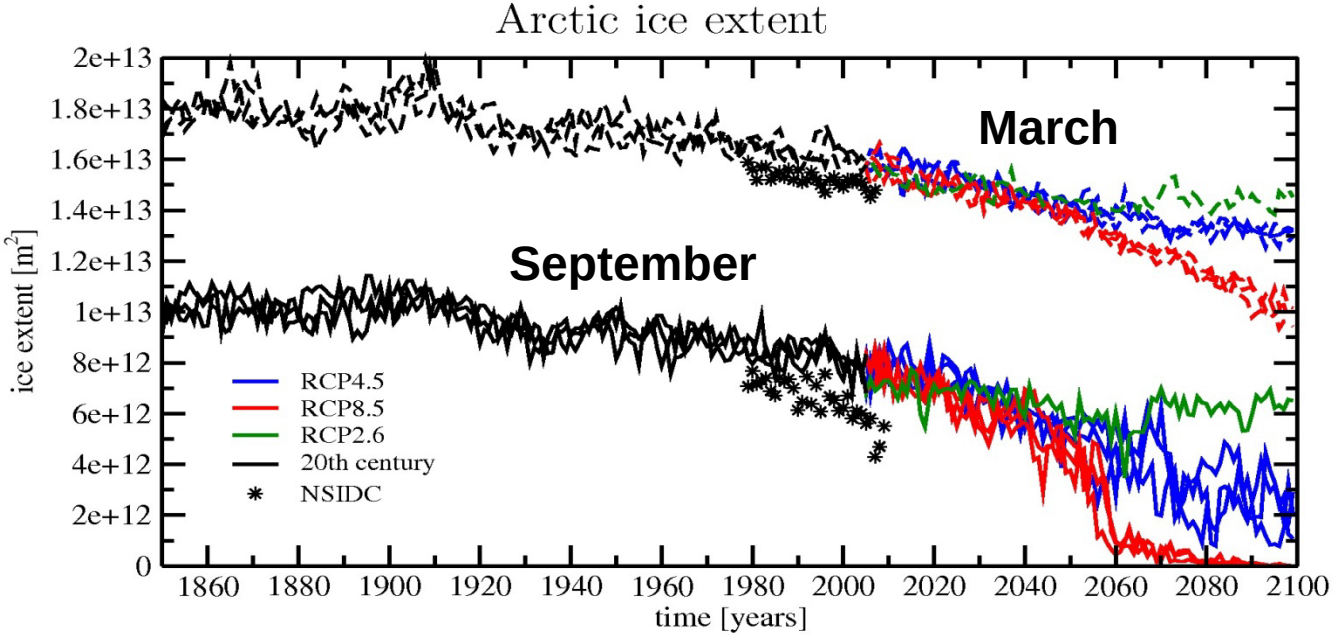


Winter snow cover anomalies (%)

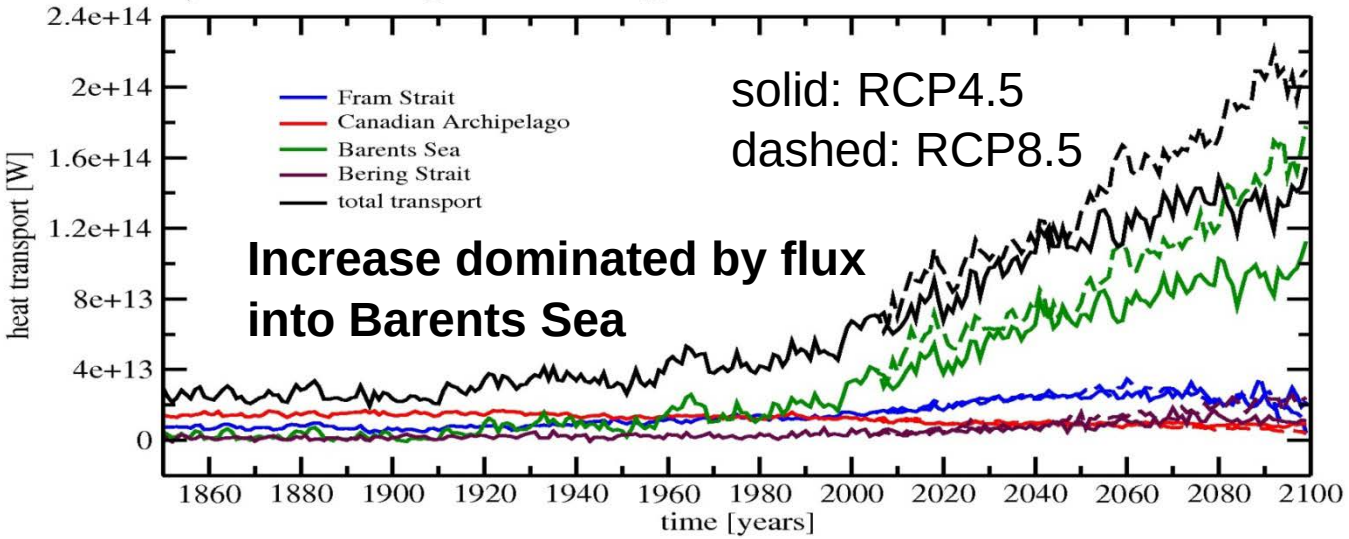
Change in winter blocking frequency (%)

Sea ice loss favours rise in snowfall and blocking frequency

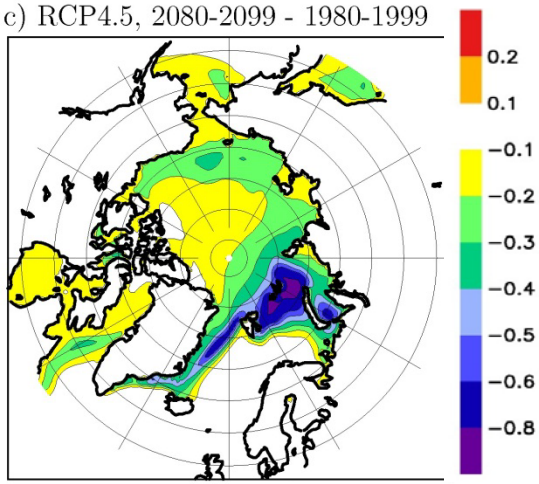
Arctic climate change in EC-Earth (Torben Koenigk)



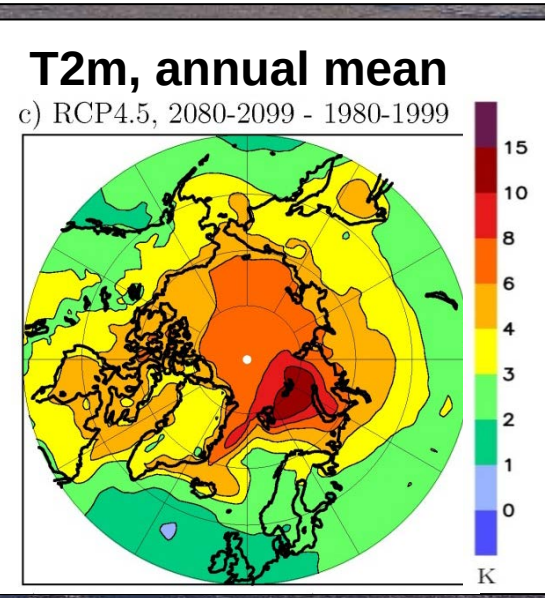
Ocean heat transport through Arctic Straits



Ice conc, annual mean



T2m, annual mean



Koenigk et al, CD, 2012

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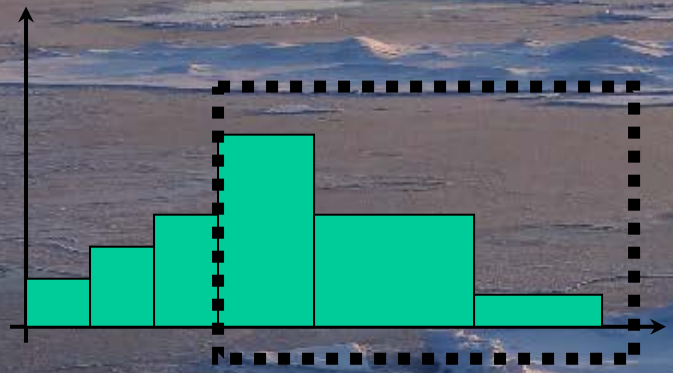
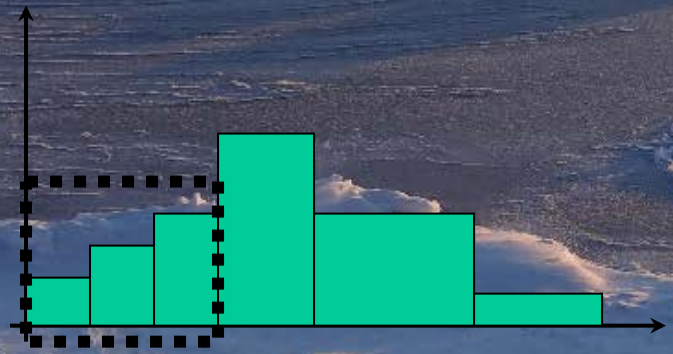
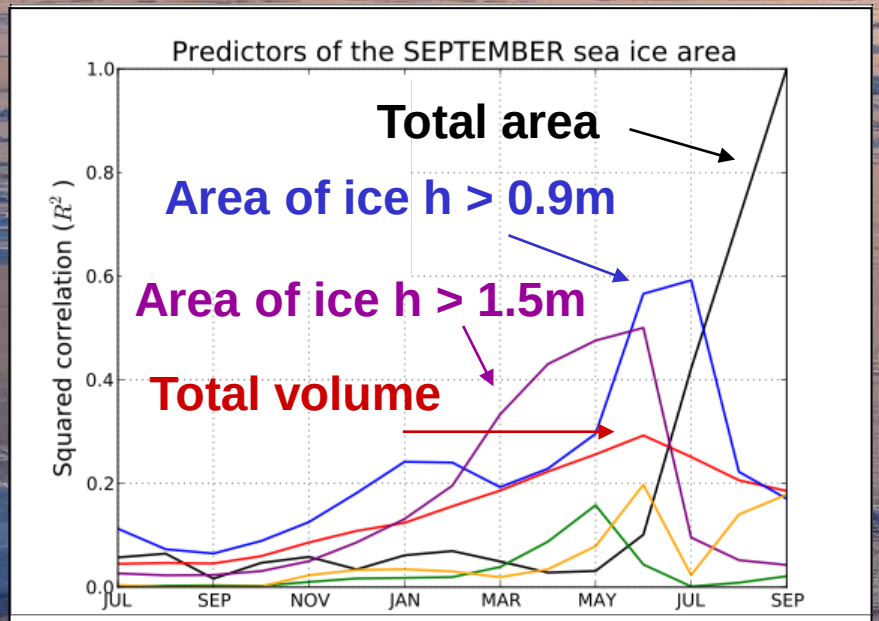
Potential predictability: ice thickness distribution (Matthieu Chevallier)

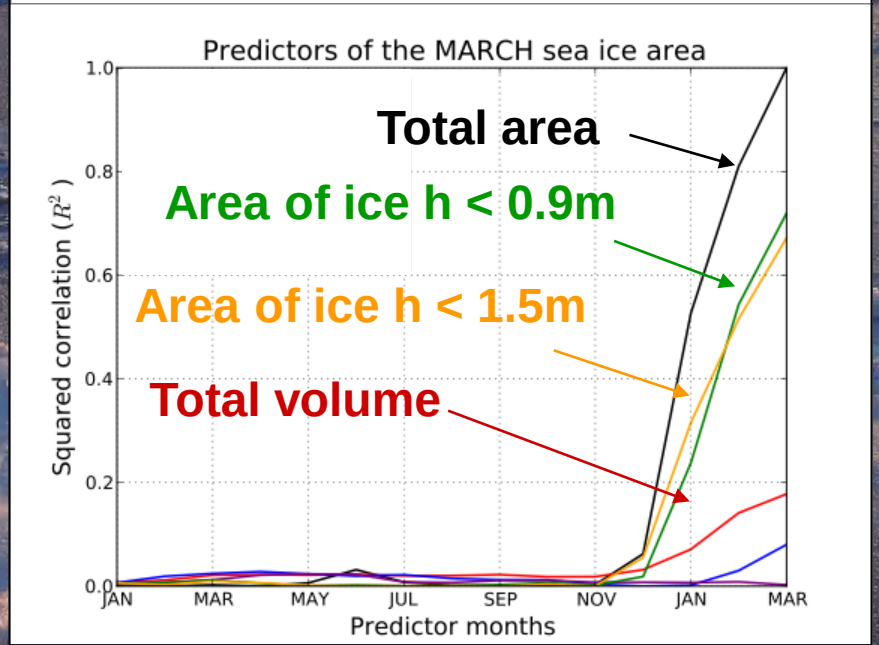


Chevallier and Salas y Mélia, JCLIM, 2012



Thick ice = best predictor of September extent, thin ice good predictor for March extent

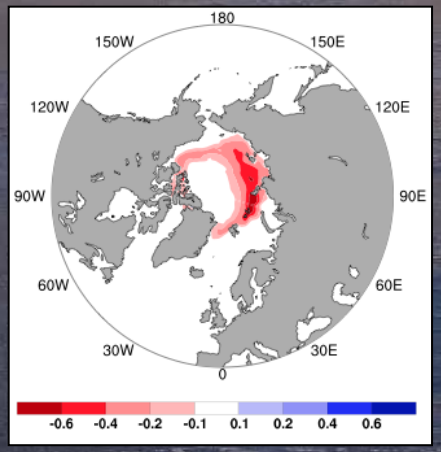


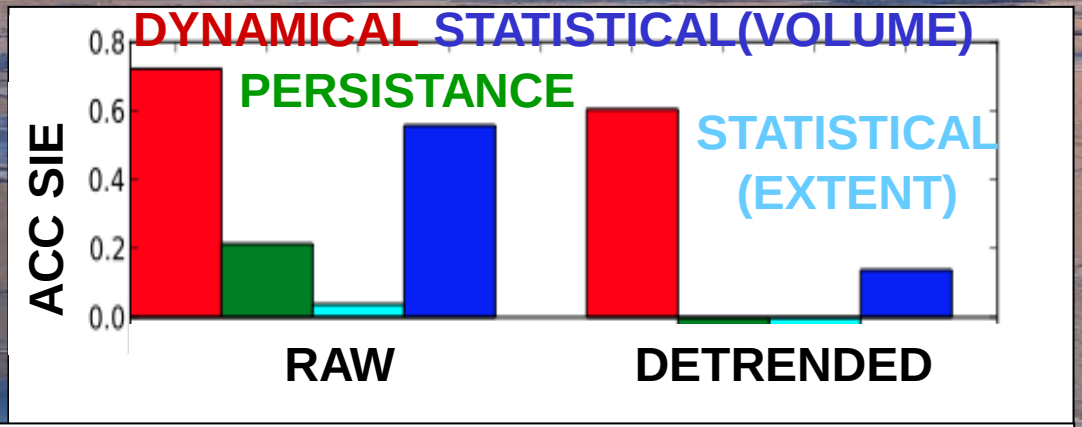


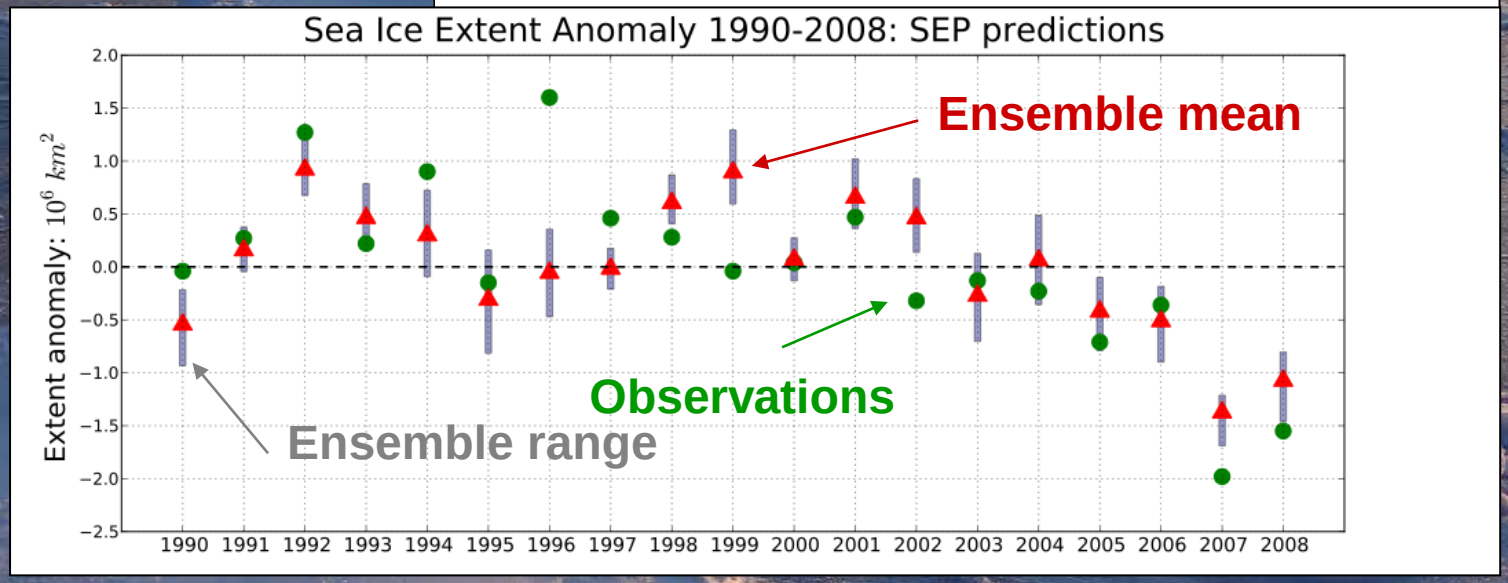
Seasonal hindcasts with CNRM-CM5.1: September (Matthieu Chevallier)

Hindcast initialized 1 May 1990-2008

Concentration: mean bias







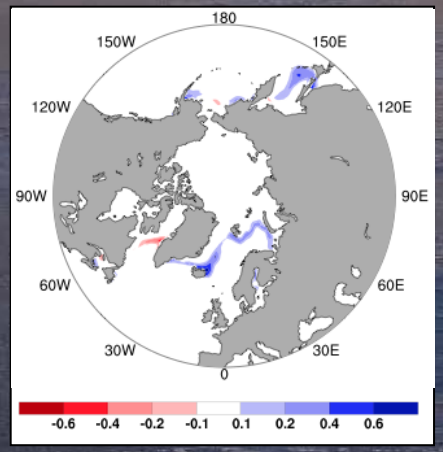
Chevallier et al, JCLIM, 2012

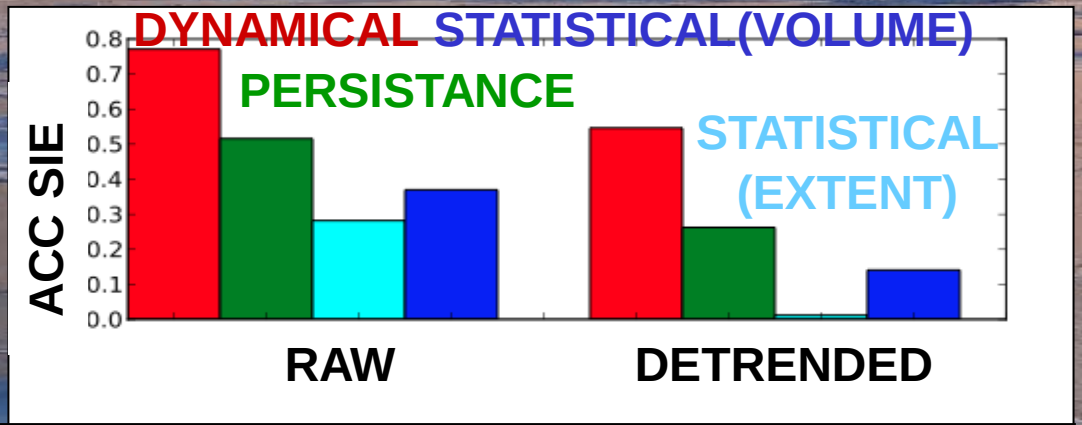
Substantial added-value of sea ice thickness initialization for September sea ice extent

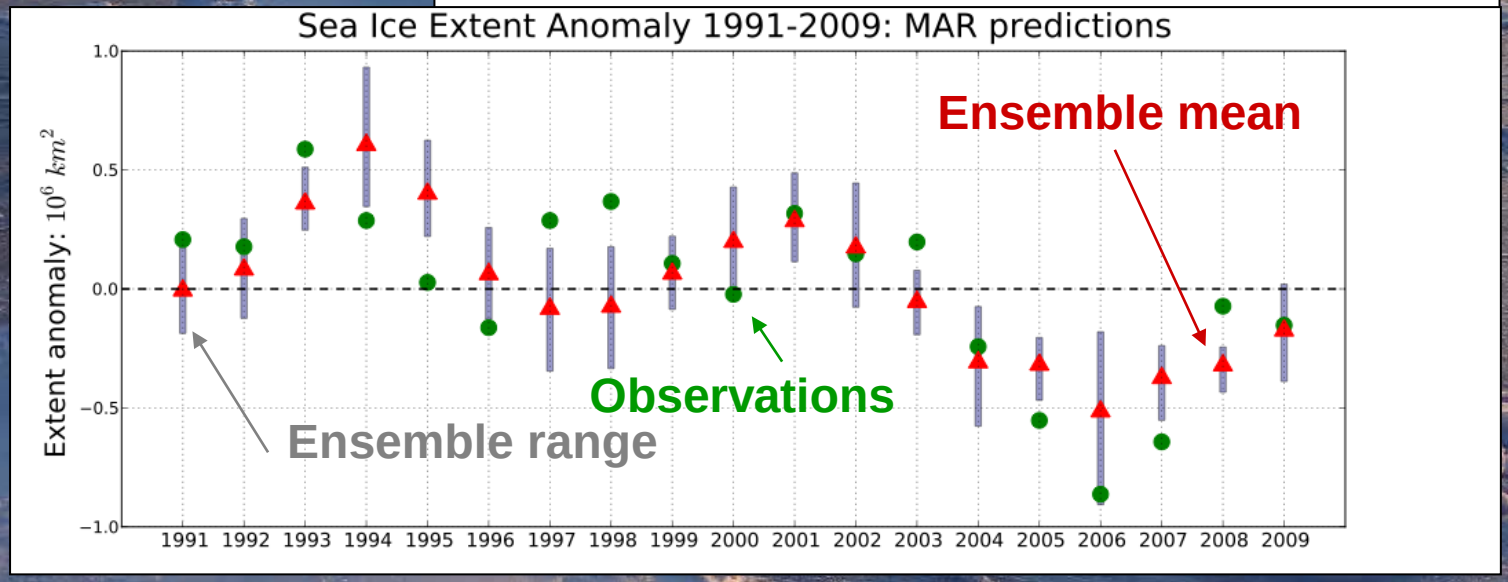
Seasonal hindcasts with CNRM-CM5.1: March (Matthieu Chevallier)

Hindcast initialized 1 November 1990-2008

Concentration: mean bias







Chevallier et al, JCLIM, 2012

Substantial added-value of ocean transport initialization for March sea ice extent

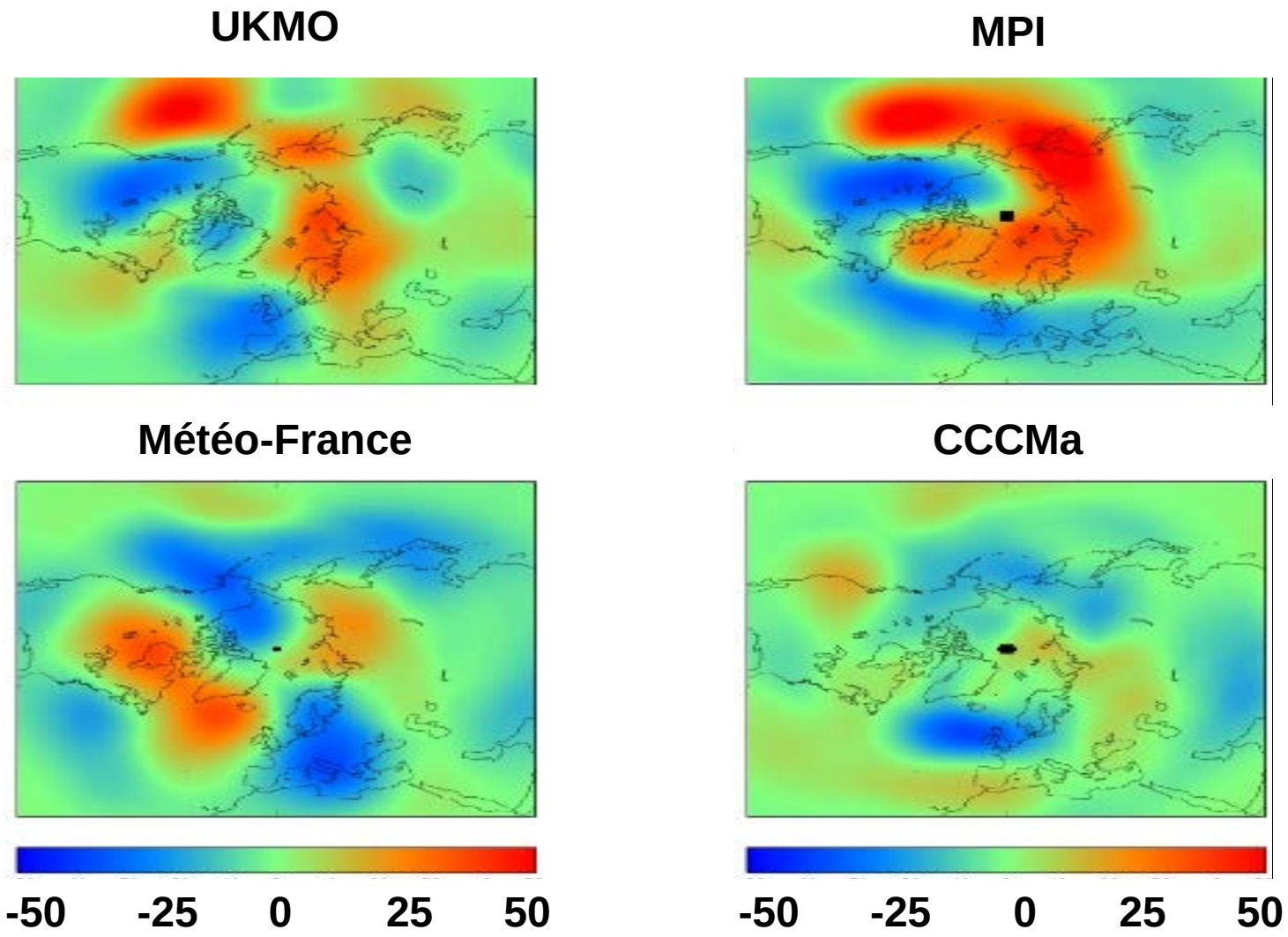
Added-value from initializing the sea ice cover (IceHFP)

Seasonal forecasts initialized on 1 Nov 2007 :

1) From realistic sea ice cover
2) From a climatology

The difference is shown for DJF Z500 (hPa)

Figure provided by Mathieu Chevallier



No robust signal on the case study of winter 2007

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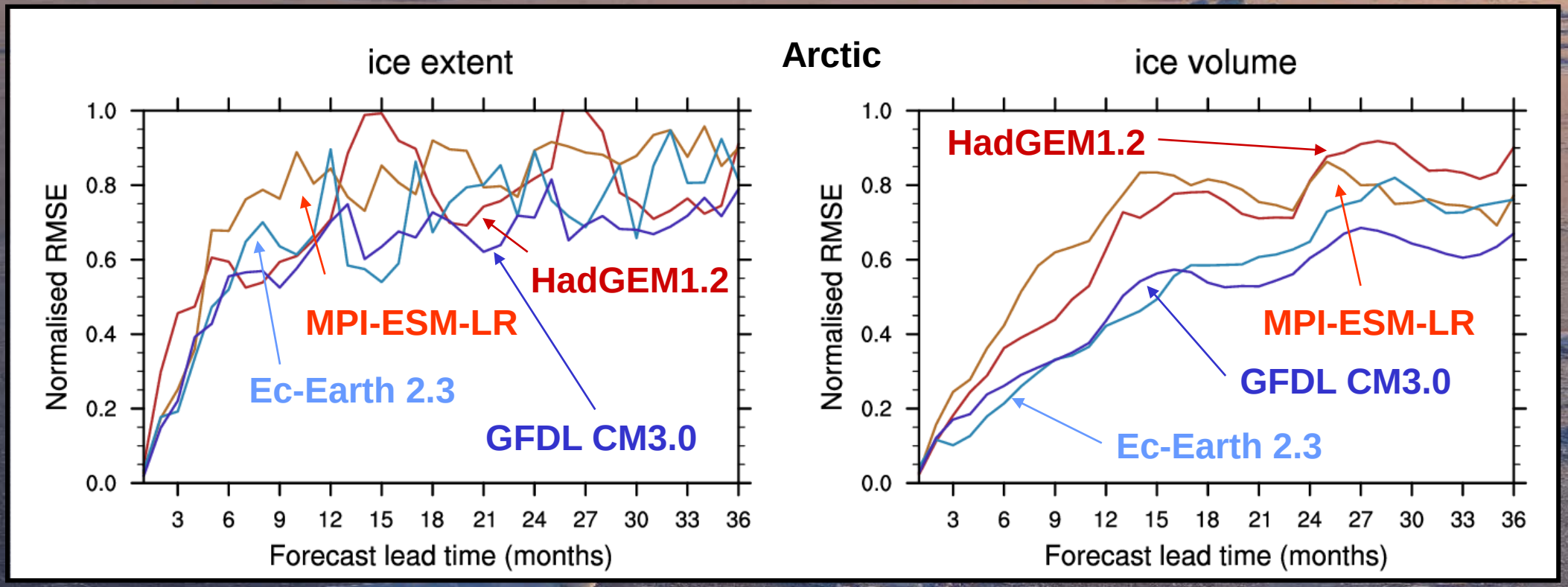
The APPOSITE Project (Steffen Tietsche)



Ensemble hindcasts initialized on 1 July from a ~200 year present-day control simulation with fixed external forcings

Potential predictability until 3 years, especially in Arctic sea ice volume, and in summer

A 5-member 1958-present sea ice reconstruction

- NEMO3.2 ocean model + LIM2 sea ice model
- Forcings : 1958-2006 DFS4.3 / 1979-2010 ERA-interim
- Nudging : T and S toward ORAS4
- Wind perturbations + 5-member ORAS4

- - - > 5 members for sea ice reconstruction

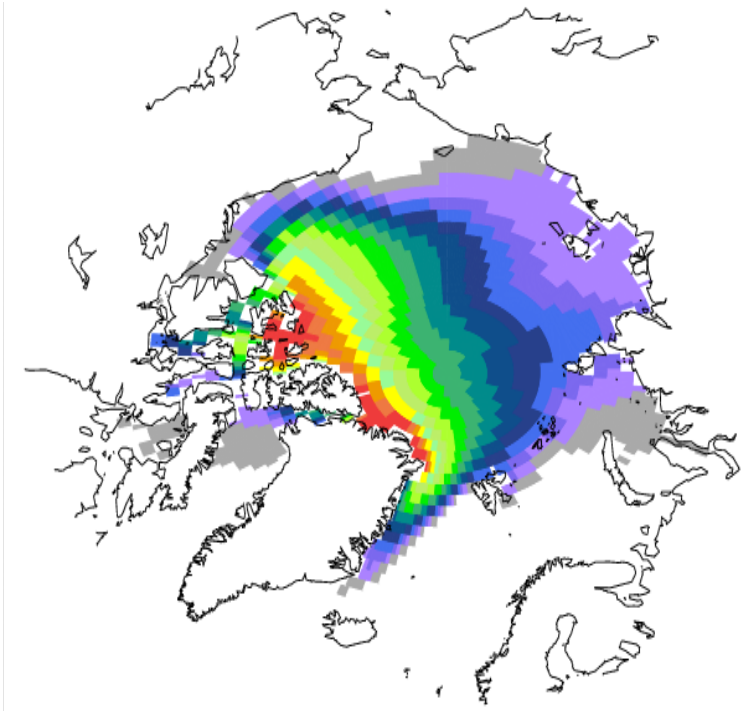
Guemas et al, CD, 2013

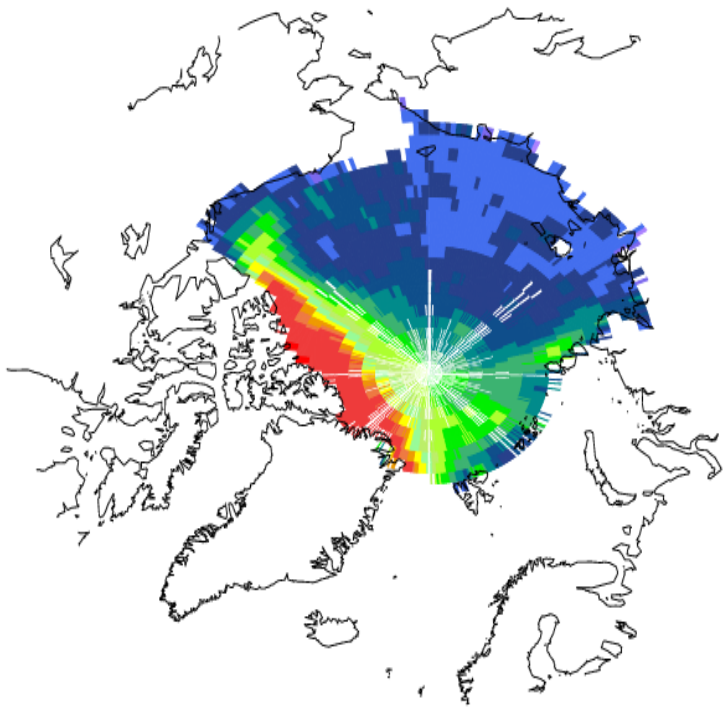
Longest available multi-member reconstruction

A 5-member 1958-present sea ice reconstruction

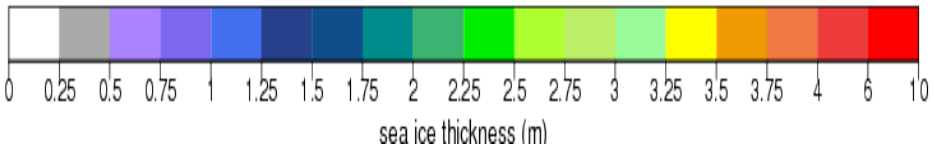
October-November Arctic sea thickness

Reconstruction





IceSat



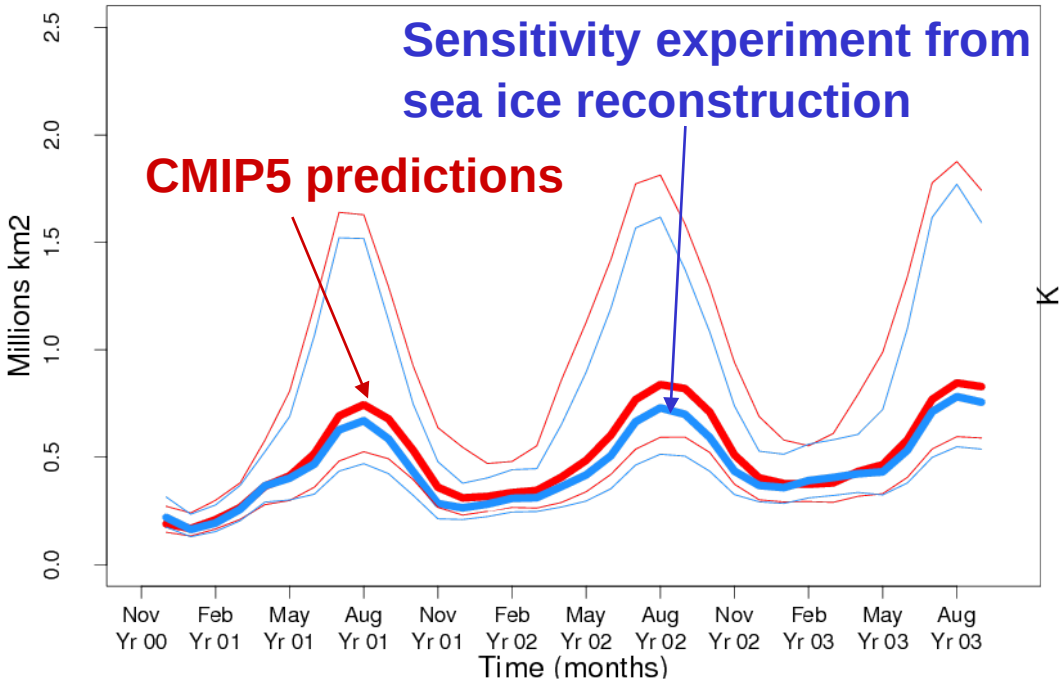
Guemas et al, CD, 2013

Too much ice in central Arctic, too few in Chucki + East Siberian Seas, ice extent biased but reasonable interannual variability

Improvement in forecast quality in the Arctic region

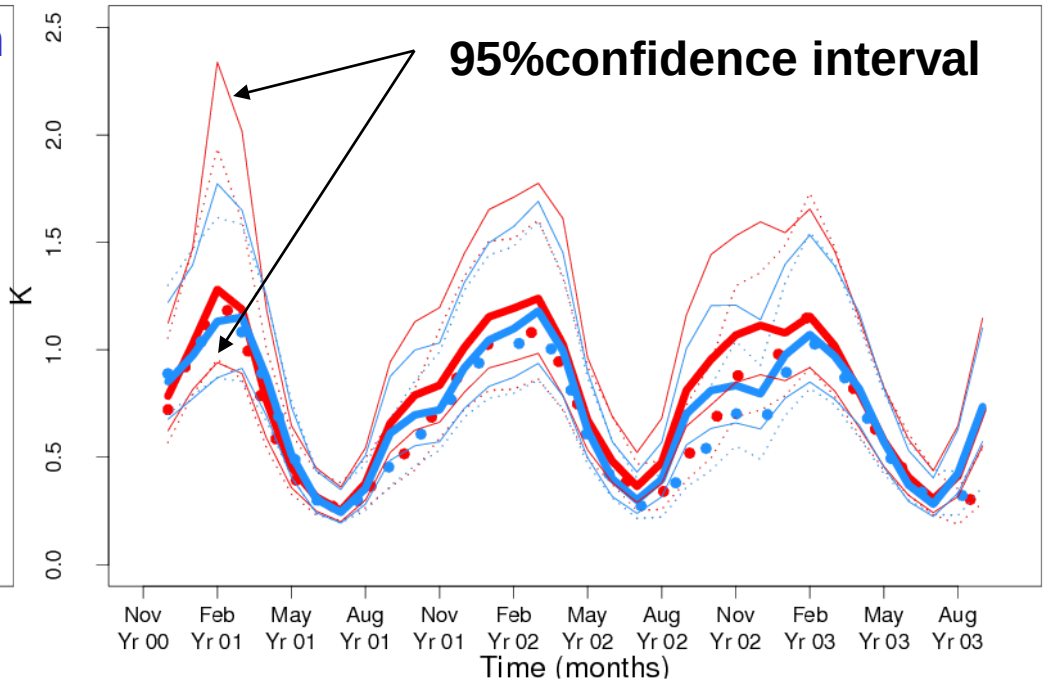
Root Mean Square Error

Arctic Sea Ice Area



Versus HadISST

Arctic 2m temperature

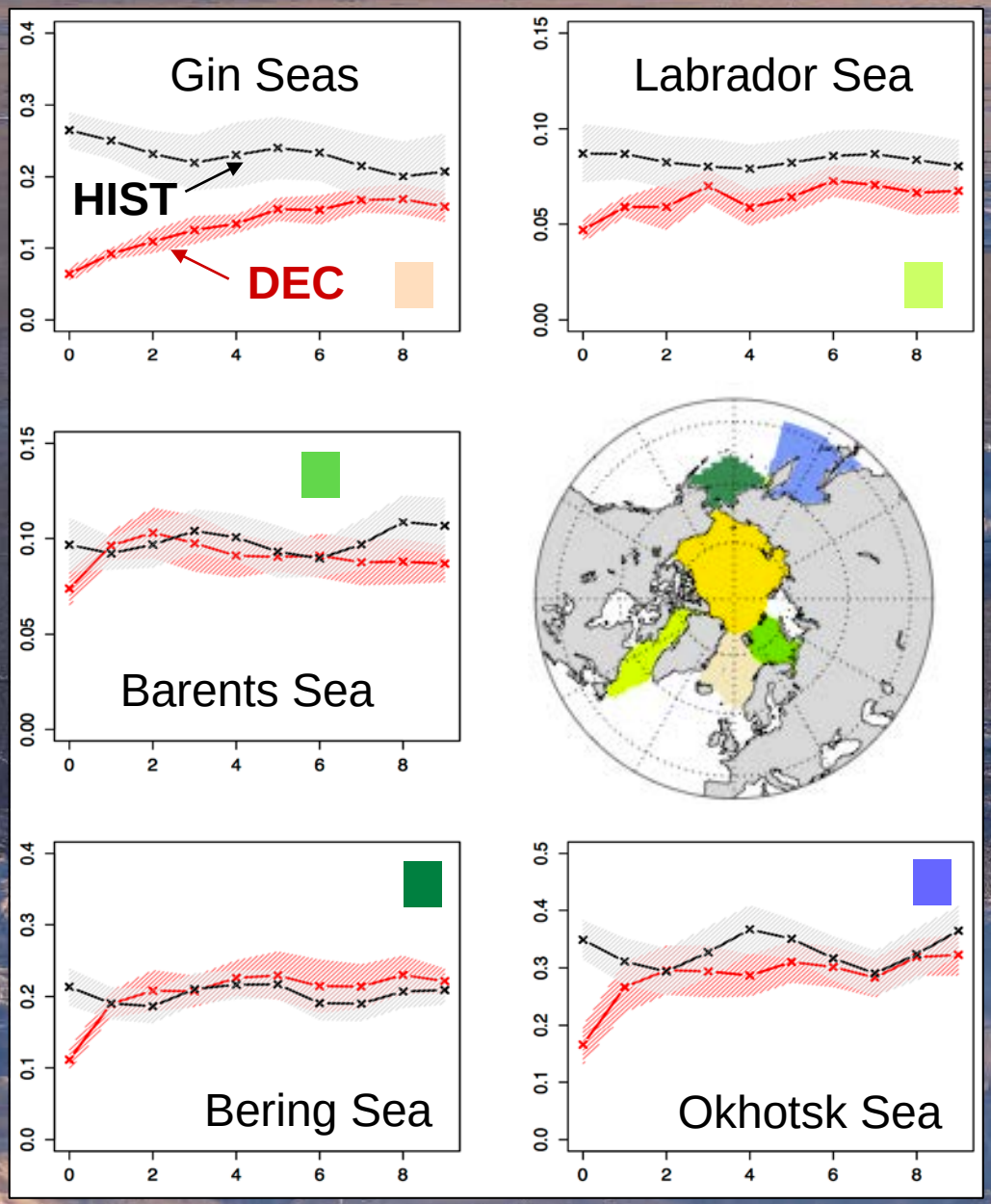


Versus NCEP (continuous) and ERA40 (dots)

Guemas et al, CD, 2013

Better forecast skill in the Arctic region all along the prediction

Regionaly contrasted sea ice predictability: Winter extent (Agathe Germe)



- CNRM-CM5.1
- 16 Decadal hindcasts (DEC)

. 1960-1996

. 10 member ensemble

Initialized 1st january

- CMIP5 Historical simulation (HIST)

. 1850-2012

.10 member ensemble

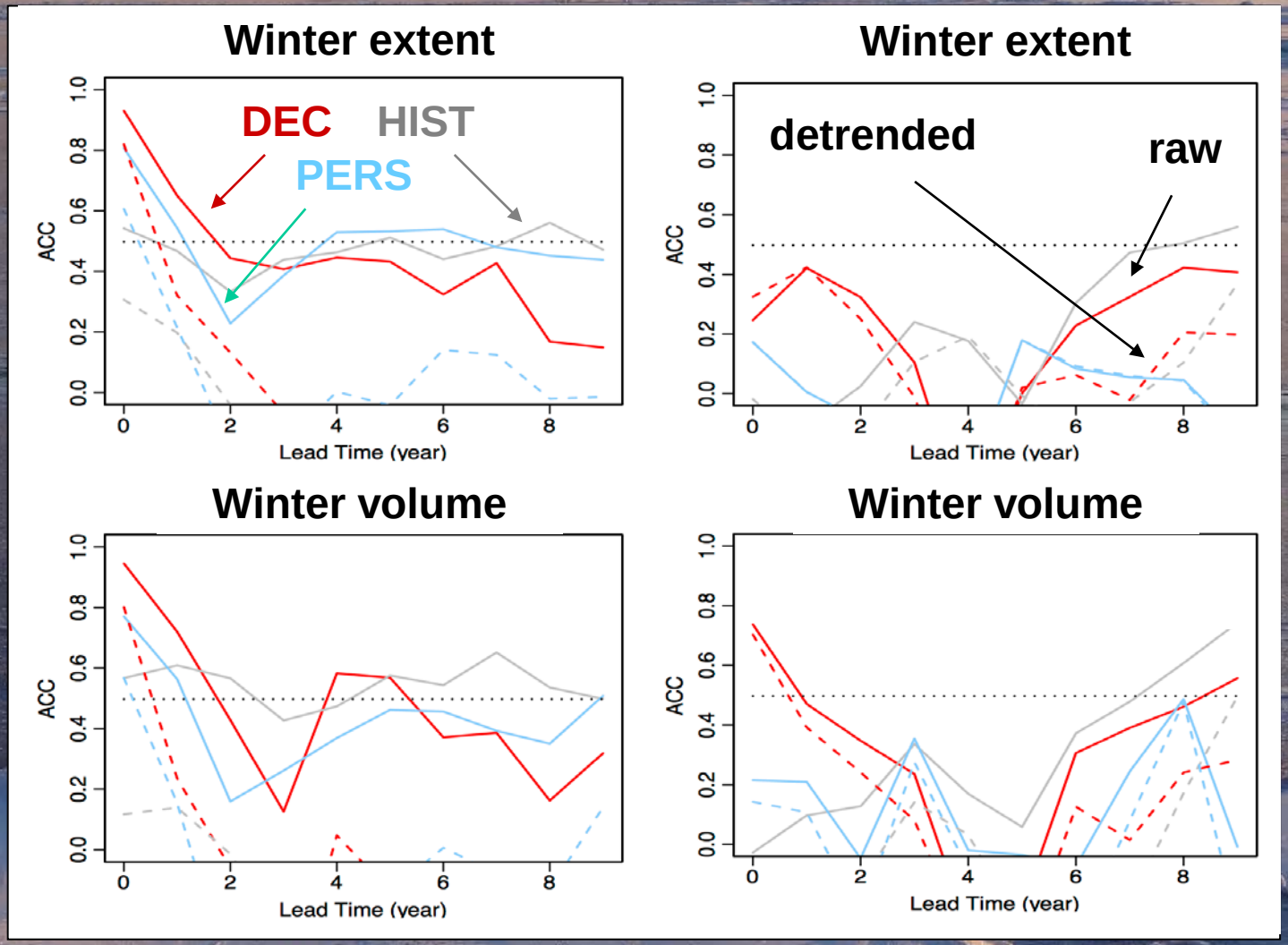
. Initialized from PICTL

Germe et al. CD, 2013

Higher Potential Predicta-bility in the Atlantic Sector

Winter Anomaly Correlation Coefficient (Agathe Germe)

Gin Seas



Labrador Sea

Germe et al. CD, 2013

Added-value of initialization for the first 2 years, reemergence of predictability due to exernal radiative forcing

Conclusion

1) - Half of the sea ice extent lost in a few decades, climate sensitivity underestimated by climate models

- Impact of sea ice loss on the winter snow cover and winter blocking frequency

2) - Predictability of the September sea ice extent from the spring distribution of sea ice thickness

- No robust impact of sea ice initialization on the atmosphere on seasonal timescales

3) - Forecast skill improvement in the Arctic region up to 3 years ahead in EC-Earth when refining the sea ice initialization

- Potential predictability on decadal timescales larger in the Atlantic Sector in CNRM-CM

Climate Forecasting Unit

SPECS
Seasonal-to-decadal climate Prediction for the improvement of European Climate Services

SEVENTH FRAMEWORK PROGRAMME

Thank you very much for your attention

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MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

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