Arctic Sea Ice Predictability and Prediction on Seasonal-to-Decadal Timescale

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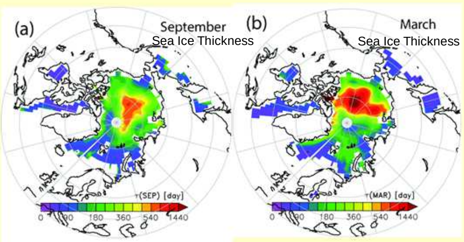
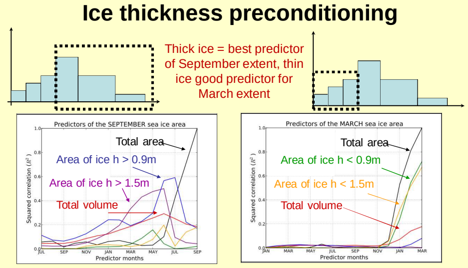
A – Dominant Arctic sea ice predictability sources

Persistence



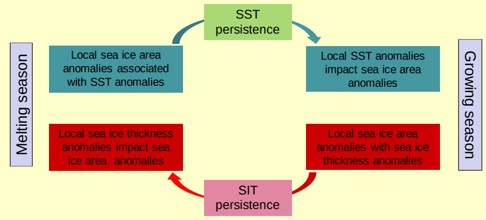
Guemas et al (2014) QJRMS

Ice thickness preconditioning



Chevallier and Salas-Melia (2012) Journal of Climate

Reemergence



Blanchard-Wrigglesworth al (2011) Journal of Climate

B – Sea ice initialization

IC3 reconstruction : methodology

- **NEMO3.2 ocean model + LIM2 sea ice model**
- **Forcings : 1958-2006 DFS4.3 or 1979-2010 ERA-interim**
- **Nudging : T and S toward ORAS4, timescales = 360 days below 800m, and 10 days above except in the mixed layer, except at the equator (1°S-1°N), SST & SSS restoring (-40W/m2, -150 mm/day/psu)**
- **Wind perturbations + 5-member ORAS4 - - - > 5 members for sea ice reconstruction**

➡ 5-member sea ice reconstruction for 1958-present consistent with ocean and atmosphere states used for initialization

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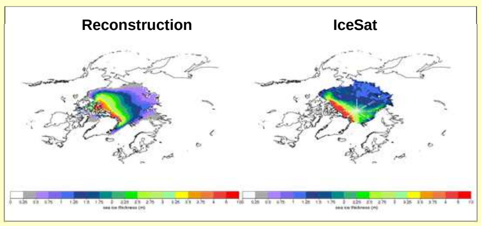
October-November Arctic sea thickness



➡ Too much ice in central Arctic, too few the Chucki and East Siberian Seas

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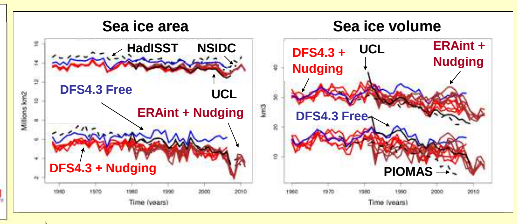
March and September Arctic sea ice



➡ Bias but reasonable agreement of interannual variability

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B – Sea ice initialization

Anomaly versus Full Field Initialization

EC-Earth2.3, 5 members, start dates every 2 years from 1960 to 2004

FFI : Full-field initialization from ORAS4 + ERA

OSI-AI : Ocean and sea ice anomaly initialization with corrections to ensure consistency

rho-OSI-wAI : Ocean and sea ice weighted anomaly initialization to account for the different model and observed amplitudes of variability + (density, temperature) instead of (temperature, salinity) anomaly initialization

NOINI : historical simulation

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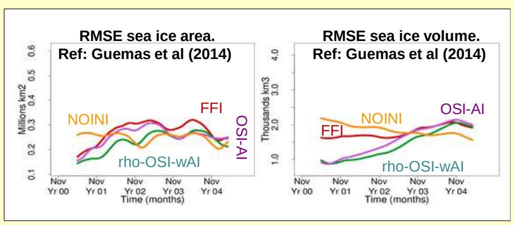

➡ Lower forecast error when using ocean and sea ice anomaly initialization, even lower with weighted anomalies

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C – Multi-model sea ice prediction

The hindcasts

- **CNRM-CM5.1 and EC-Earth2.3**
- **Seasonal forecasts initialized every 1st November and every 1st May from 1990 to 2008**
- **5 month long**
- **Initialized from ERA-interim for the atmosphere + in-home sea ice reconstructions + ORAS4 (EC-Earth2.3) or ocean reconstruction (CNRM-CM5.1) for the ocean**
- **5 members using initial perturbations applied to all components for EC-Earth2.3, only the atmosphere for CNRM-CM5**

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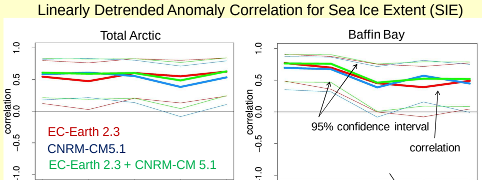
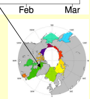
C – Multi-model sea ice prediction

Linearly Detrended Anomaly Correlation for Sea Ice Extent (SIE)





➡ Predictability until March
Similar performance between CNRM-CM5.1 and EC-Earth 2.3

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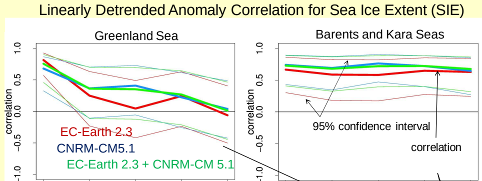
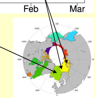
Linearly Detrended Anomaly Correlation for Sea Ice Extent (SIE)





➡ Predictability for the first month only in Greenland, until March in Barents and Kara
Better performance from CNRM-CM5.1

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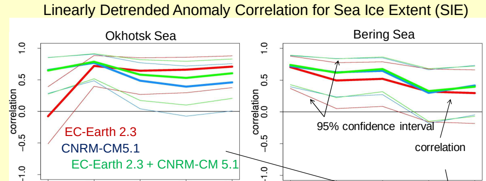
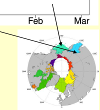
Linearly Detrended Anomaly Correlation for Sea Ice Extent (SIE)





➡ Better initialisation in Okhotsk Sea with CNRM-CM5: ocean ? Multi-model allows to make the most of individual performance

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Conclusions

- **Sources of sea ice predictability: persistence, ice thickness preconditioning, advection, ocean heat transport, reemergence**
- **Initialization:1. Need to make the most of the growing sea ice observations (thickness, melt pond, ice drift)**
  2. Need for ensembles consistent with the atmospheric and oceanic state
  3. Need for further investigation of anomaly initialization benefits
- **Prediction: winter predictability until March in the Baffin Bay, Kara, Barents and Okhotsk seas**

References :

Blanchard-Wrigglesworth E., Armour K.C., Bitz C.M., DeWeaver E., 2011, Persistence and Inherent Predictability of Arctic Sea Ice in a GCM Ensemble and Observations. J Clim 24:231–250.

Chevallier M., Salas-Mélia D., 2012, The role of sea ice thickness distribution in the arctic sea ice potential predictability: a diagnostic approach with a coupled GCM. J Clim 25:3025–3038, DOI 10.1175/JCLI-D-11-00209.1.

Guemas V, Blanchard-Wrigglesworth E, Chevallier M, Day J J, Déqué M, Doblas-Reyes F J, Fučkar N, Germe A, Hawkins E, Keeley S, Koenigk T, Salas y Mélia D, Tietsche S, 2014, A review on Arctic sea ice predictability and prediction on seasonal-to-decadal timescales, doi:10.1002/qj.2401

Guemas V, Doblas-Reyes F J, Mogensen K, Keeley S. , Tang Y., 2014, Ensemble of sea ice initial conditions for interannual climate predictions. Climate Dynamics, in press, doi:10.1007/s00382-014-2095-7.