An Overview of European Union-Funded Project **APPLICATE**

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Pablo Ortega, on behalf of APPLICATE partners

APPLICATE.eu
Advanced prediction in polar regions and beyond

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727862.

The Consortium

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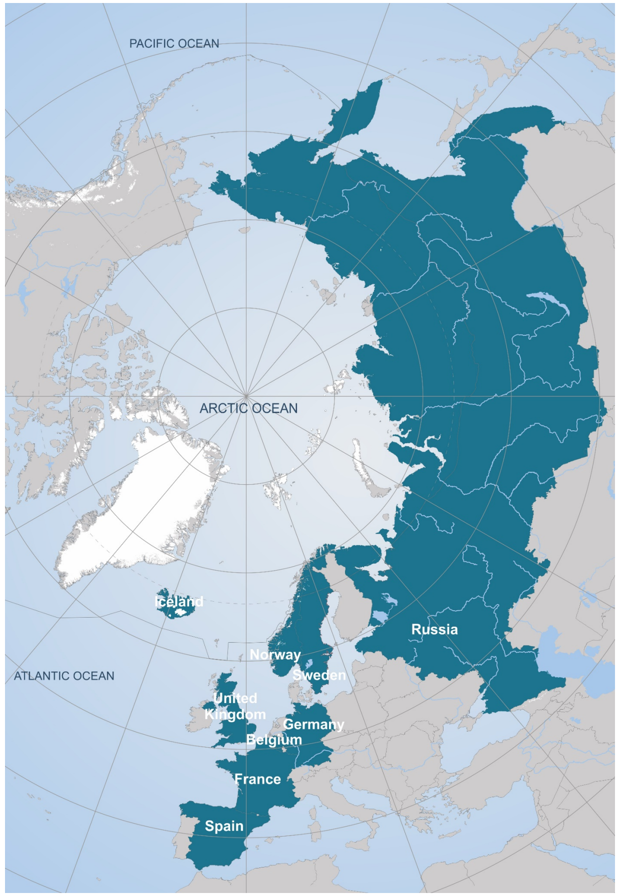
16 partners and 1 third-party from 9 countries



… and many collaborators!

Budget and duration

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- € 8 Mio + separate Russian contribution
- 1st November 2016–31st October 2020 (4-years)
- 6 month no-cost extension requested

Mission statement

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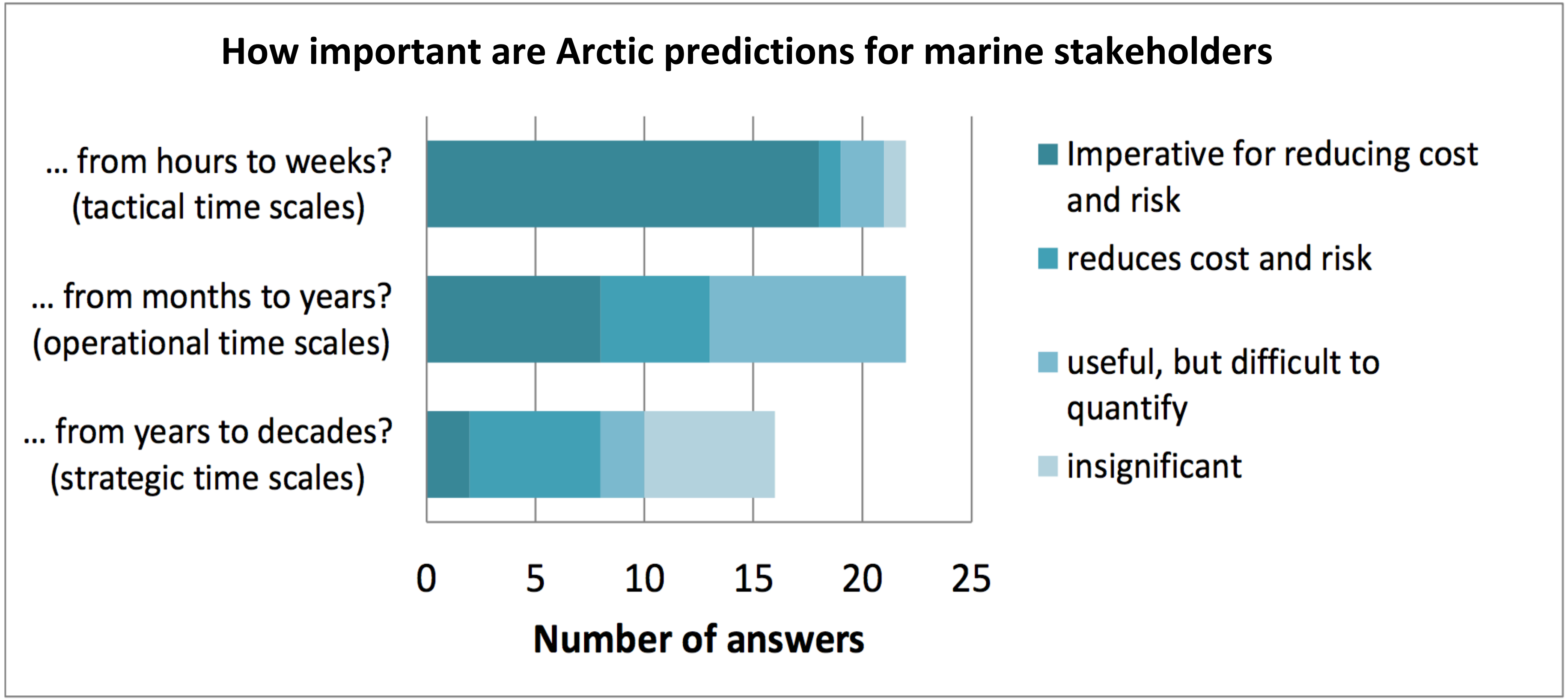
Advanced prediction in polar regions and beyond

Develop enhanced predictive capacity for weather and climate in the Arctic and beyond, and determine the influence of Arctic climate change on Northern Hemisphere mid-latitudes, for the benefit of policy makers, businesses and society.

General approach

➢ Bringing together the NWP and climate communities



Survey: EC-PHORS Services Task Team

General approach

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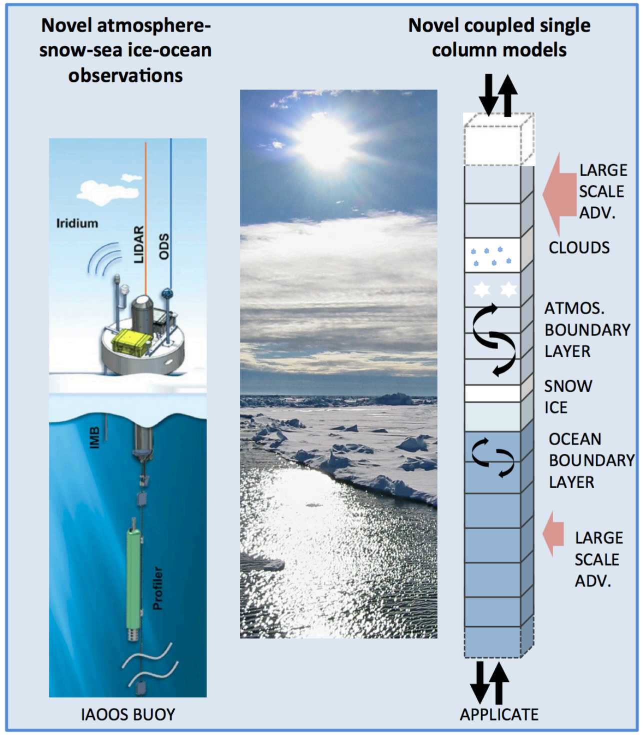
- Involving experts on the Arctic and midlatitudes
- Engaging operational centres for maximizing impact
- Effectively combining models and observations



MOSAiC
International Arctic Drift Expedition

General approach

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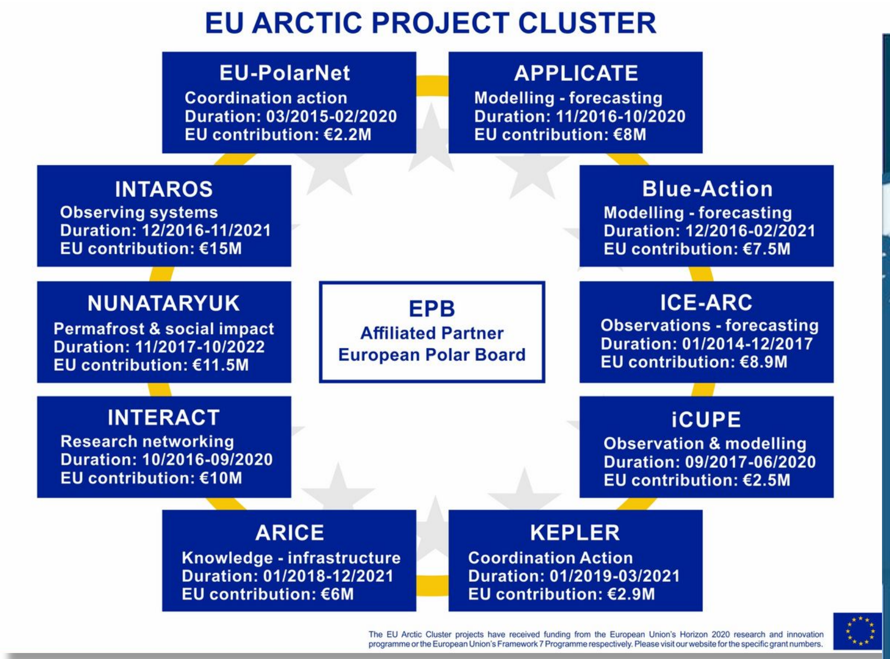
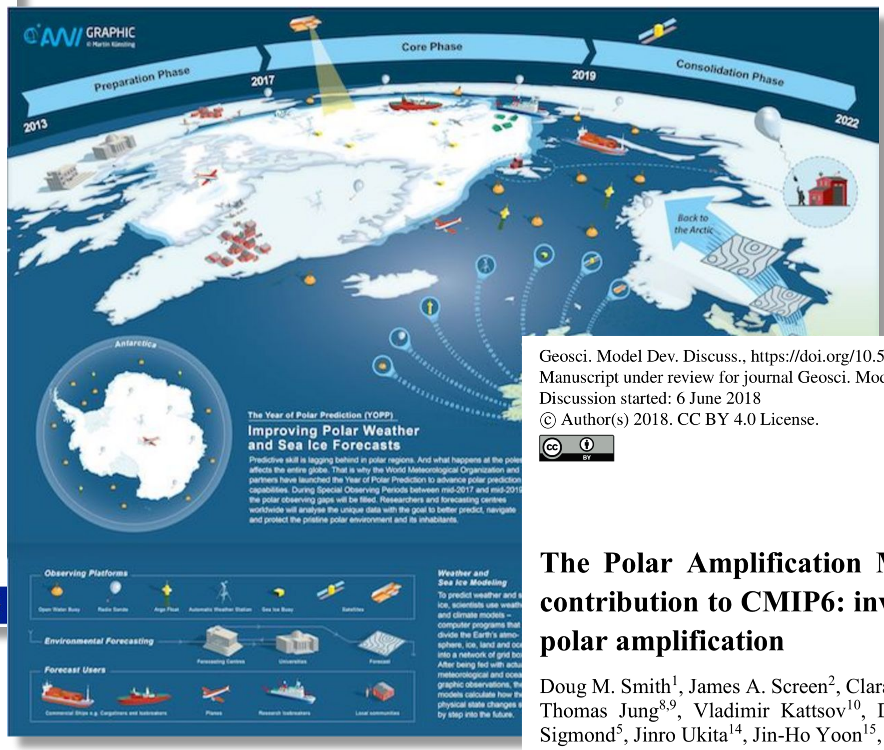
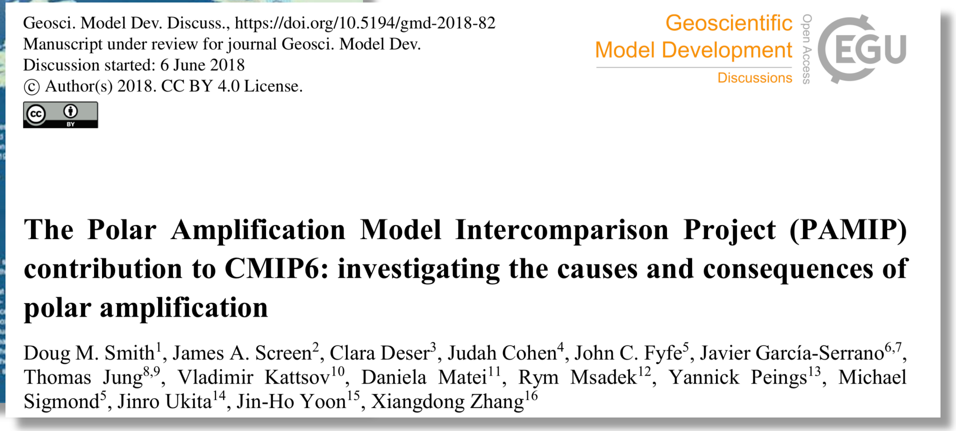
- Exploiting European and international collaboration (e.g. Arctic Cluster, YOPP and PAMIP)







Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2018-82
Manuscript under review for journal Geosci. Model Dev.
Discussion started: 6 June 2018

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Geoscientific Model Development Discussions
Open Access
EGU

The Polar Amplification Model Intercomparison Project (PAMIP) contribution to CMIP6: investigating the causes and consequences of polar amplification

Doug M. Smith[1], James A. Screen[2], Clara Deser[3], Judah Cohen[4], John C. Fyfe[5], Javier García-Serrano[6,7], Thomas Jung[8,9], Vladimir Kattsov[10], Daniela Matei[11], Rym Msadek[12], Yannick Peings[13], Michael Sigmond[5], Jinro Ukita[14], Jin-Ho Yoon[15], Xiangdong Zhang[16]

Strategy

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Delivering enhanced predictions

Establish Baseline

- New metrics and diagnostics
- NWP
- Subseasonal to seasonal prediction
- CMIP5/6

Develop Enhancements

- Enhanced models
- Optimized Arctic observing systems
- Improved initial and boundary conditions

Test Enhancements

- Enhanced NWP
- Enhanced Subseasonal to Seasonal Prediction
- Enhanced CMIP6

Recommen-dations

- Presentations
- Reports
- Publications
- Contribution to assessment reports

Enhanced Predictions

- CMIP6-Interim and CMIP7
- Enhanced operational:
  - NWP
  - Subseasonal to Seasonal Prediction
  - Interannual to Decadal Prediction

Project structure

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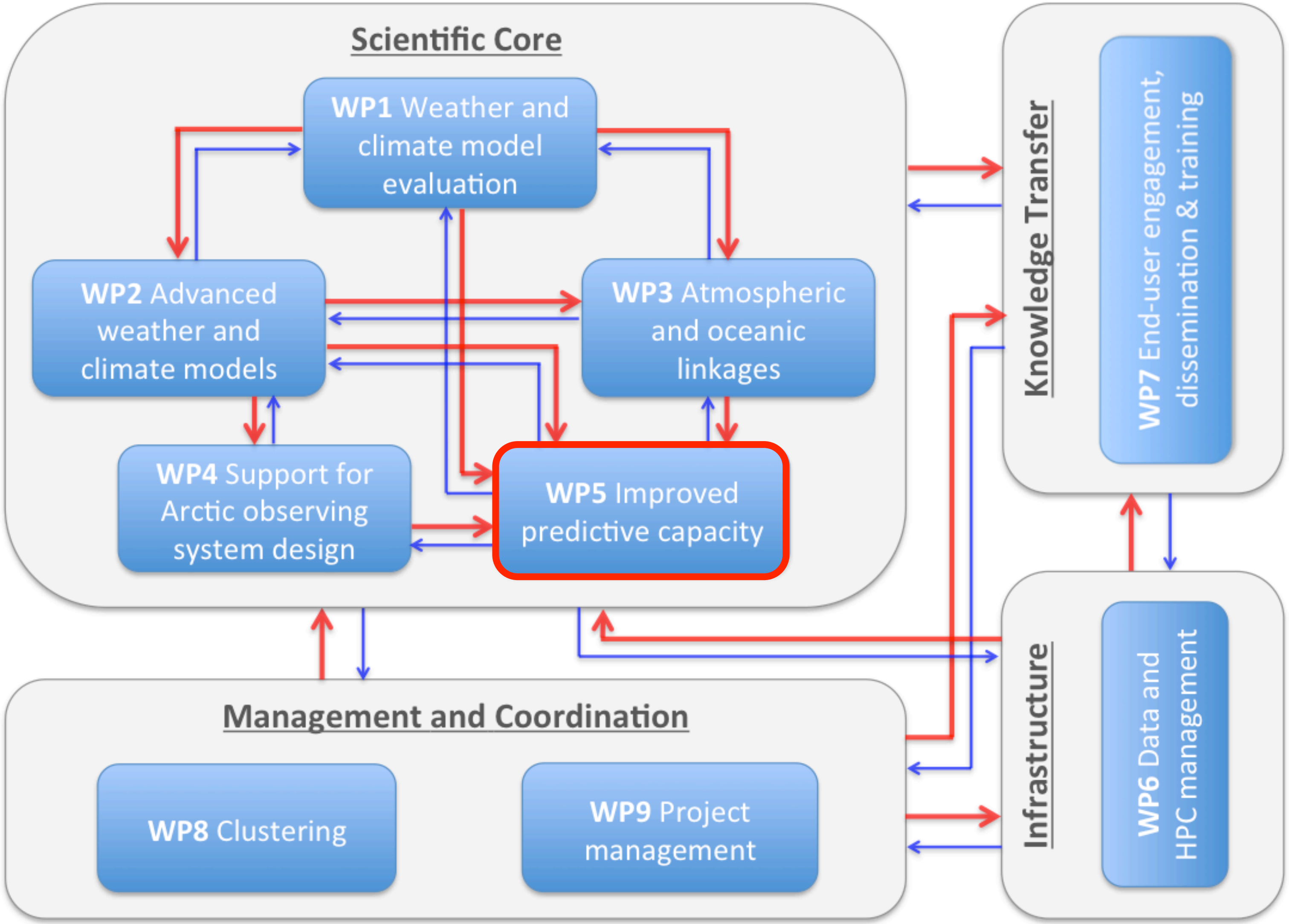

WP5: Main goals

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1. Advance our understanding of **predictability mechanisms** operating at 3 different timescales:

NWP	–	**Seasonal Prediction**	–	**Climate Projections**
CRNS (CNRM)		*CRNS (CNRM)*		*AWI*
Met Norway		*Met Office*		*BSC*
ECMWF		*BSC*		
		UCLouvain		

deterministic/ensemble	10 members	**HiResMIP:**
global/limited area models	1993-2014 period	1950 fixed forcing control
focus on YOPP period	May/November ICs	1950-2050 transient

WP5: Main goals

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1. Advance our understanding of **predictability mechanisms** operating at 3 different timescales:

   NWP – Seasonal Prediction – Climate Projections

2. Investigate whether and how **linkages between the Arctic and mid-latitudes contribute to prediction skill**

3. Assess the **added-value of APPLICATE developments on prediction skill** in the Arctic and beyond

WP5: Main goals

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APPLICATE TIMELINE

NWP – Seasonal Prediction – Climate Projections

STREAM 1
Baseline skill of APPLICATE prediction systems

STREAM 2
Skill after including APPLICATE developments

3. Assess the **added-value of APPLICATE skill** in the Arctic and beyond

Improved **Initialization** (WP4, WP5)

Improved **Models**/Components (WP2,WP5)

Better **ensemble generation** (WP5)

New **diagnostics** (WP1)

WP5: Main tasks

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Task 5.1: Production of Stream 1 experiments ✔

Task 5.2: State-of-the-art of weather/climate prediction and projections ✔
(sources of predictability, links with mid-latitudes, forecasts of extremes,...)

Task 5.3: Added-value of improved process representation on predictive skill ✔
(enhanced sea ice models, increased resolution, improved ensemble generation)

Task 5.4: Production and evaluation of Stream 2 Experiments

Task 5.5: Recommendations for future forecasting system development

WP5: Stream 1 baseline skill

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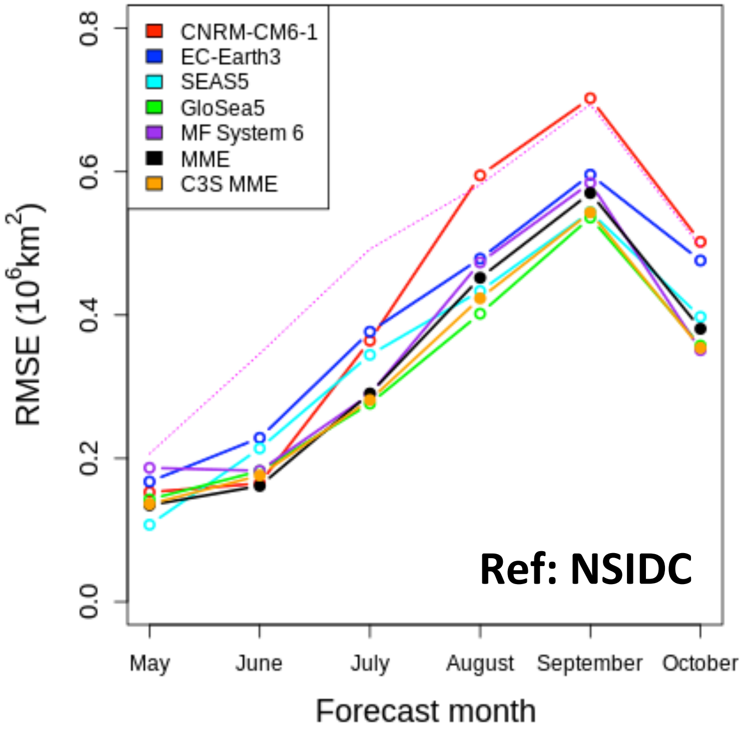
Lauriane Batté

STREAM 1 + C3S systems

RMSE of total Arctic SIE



Integrated Ice Edge Error

Goessling et al. 2016

1st May Initialized Forecasts (1993-2014)

WP5: Stream 1 baseline skill

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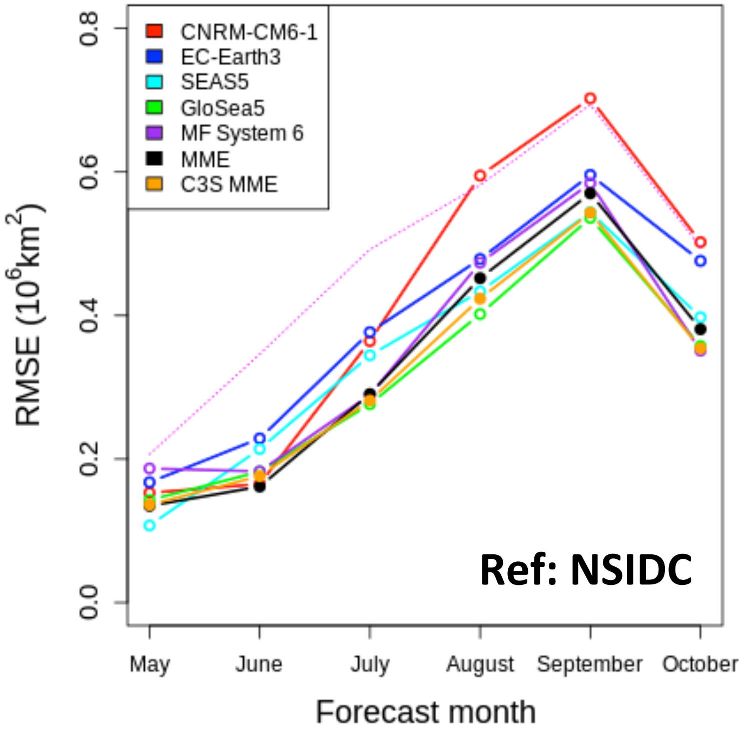
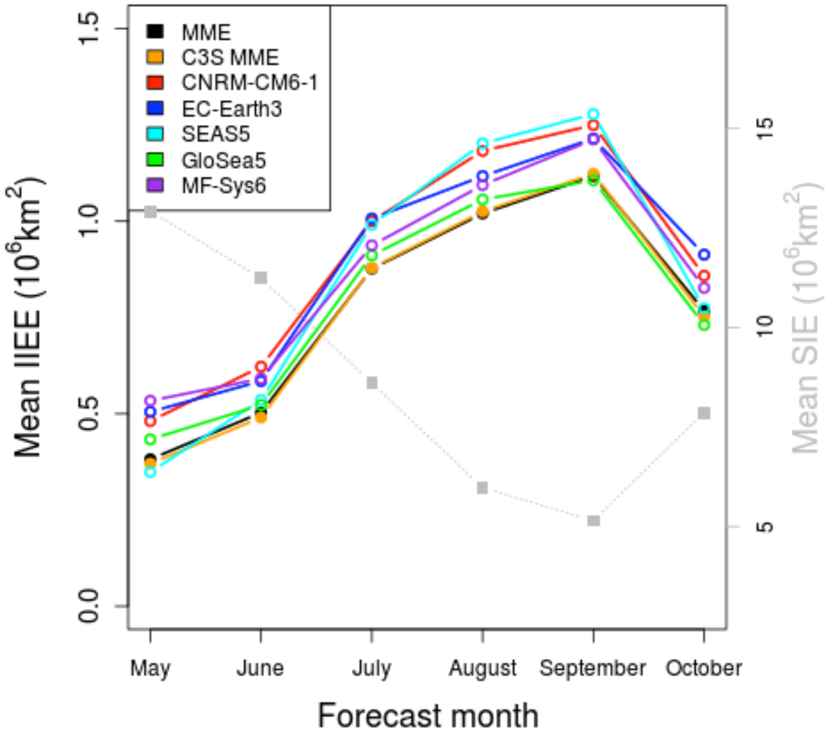
STREAM 1 + C3S systems

RMSE of total Arctic SIE



Pan-Arctic IIEE



Inter-model **differences** are **smaller in IIEE**

Multi-models are **better** than individual models

1st May Initialized Forecasts (1993-2014)

WP5: Stream 1 baseline skill

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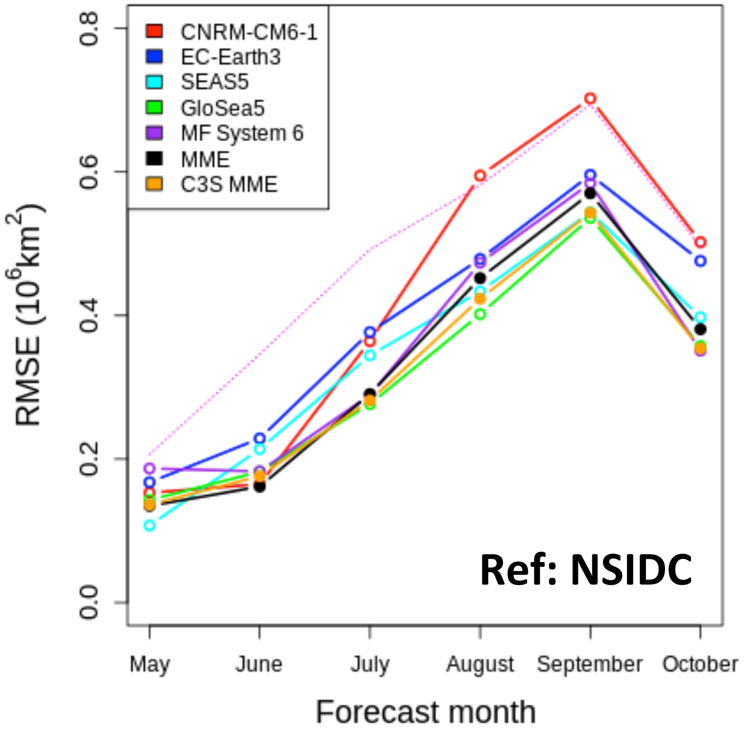
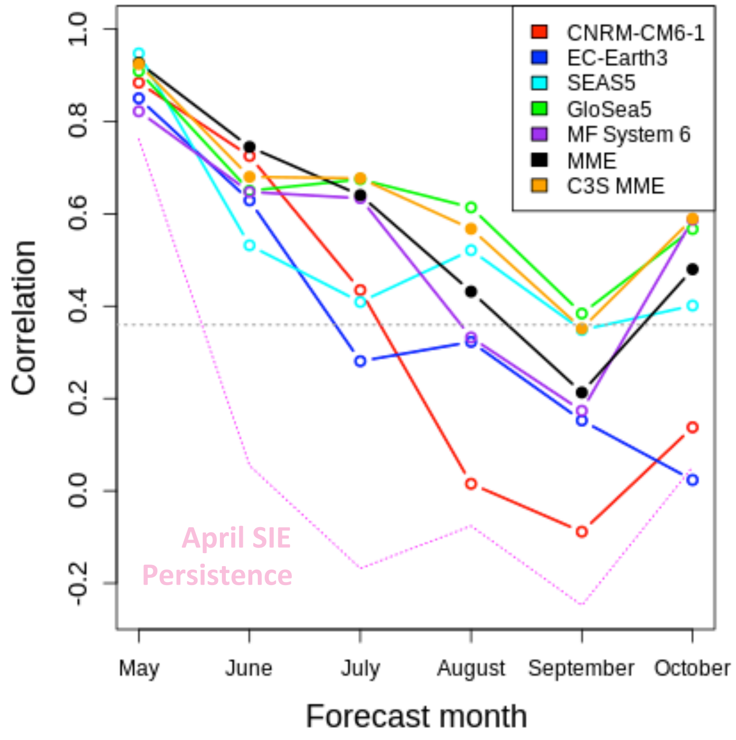
Lauriane Batté

STREAM 1 + C3S systems

RMSE of total Arctic SIE



ACC of total Arctic SIE



Most models exhibit **skill up to 3-4 months** lead

Forecasting **September SIE minimum** is still **challenging**

1st May Initialized Forecasts (1993-2014)

WP5: Role of Initialization

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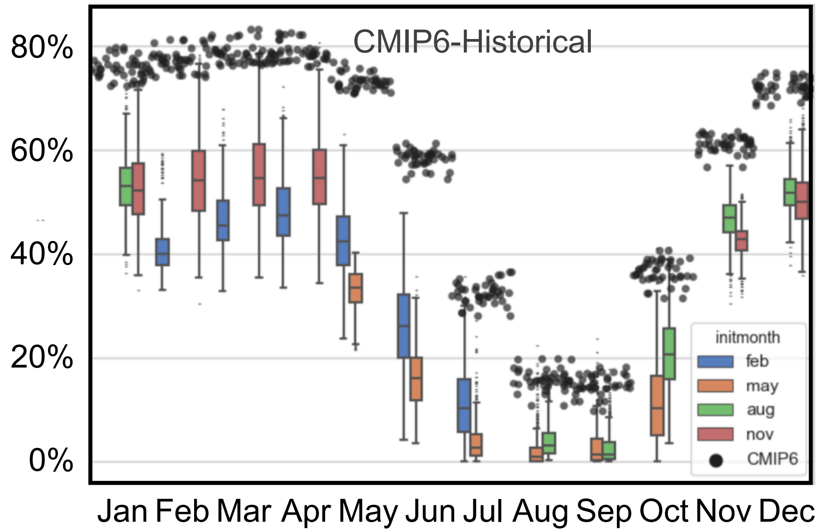
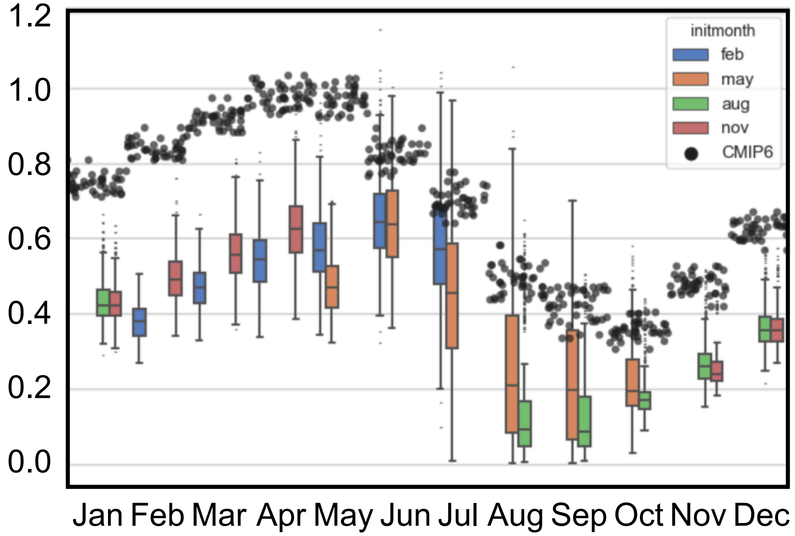
Ilona Valisuo

Greenland Sea

Sea Ice Concentrations



Sea Ice Thickness



CMIP6-Historical has **too much and too thick** ice in Greenland Sea

Forecasts show **huge spread in thickness** during the **melt season**

Systematic error not fully developed by the end of the forecasts

CNRM-CM6-1 Seasonal Forecasts (1993-2014)

CNRM
cnrs
METEO FRANCE

WP5: Role of Initialization

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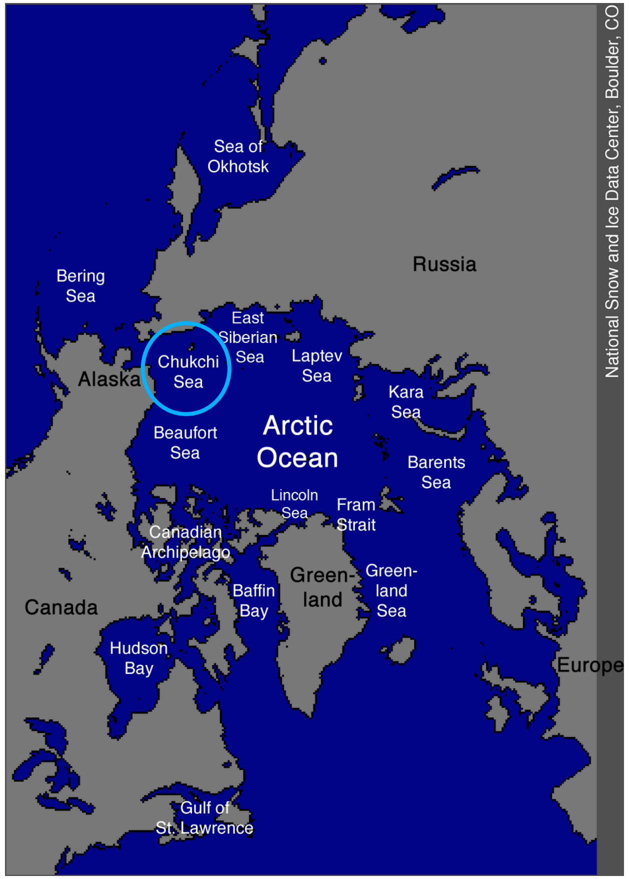
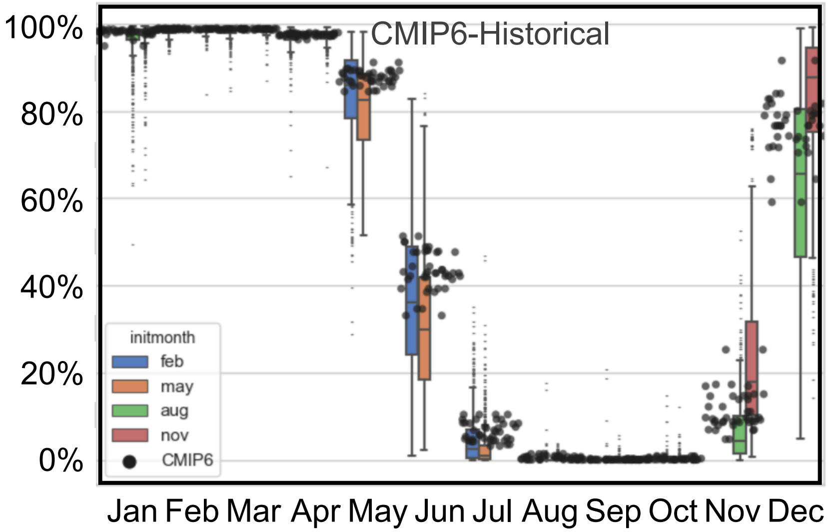
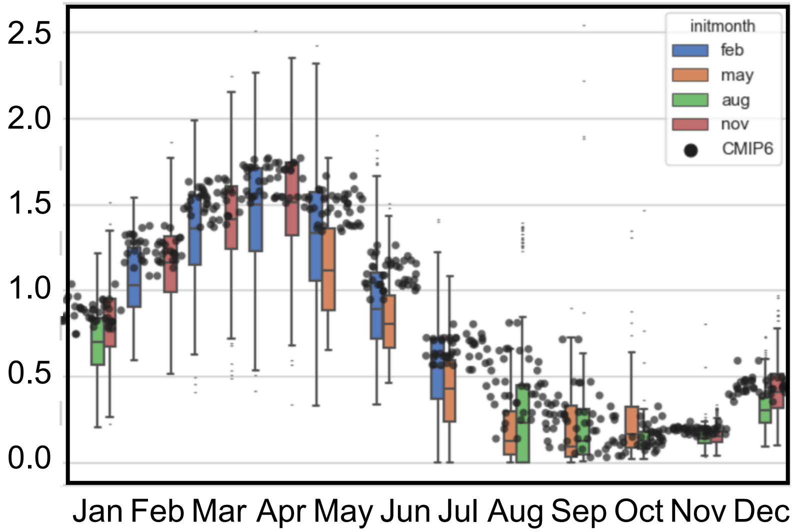
Chukchi Sea



Sea Ice Concentrations



Sea Ice Thickness



Better agreement between **initialized/non initialized** forecasts

CNRM-CM6-1 Seasonal Forecasts (1993-2014)

WP5: Development of forecast errors

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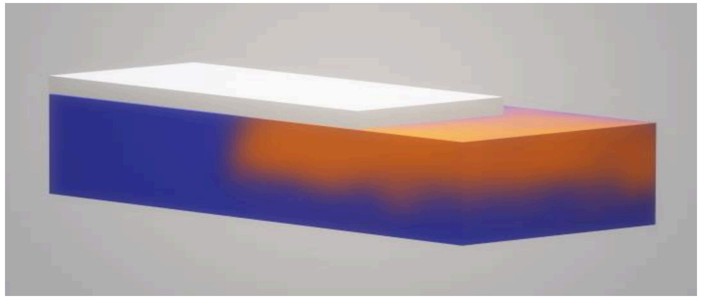
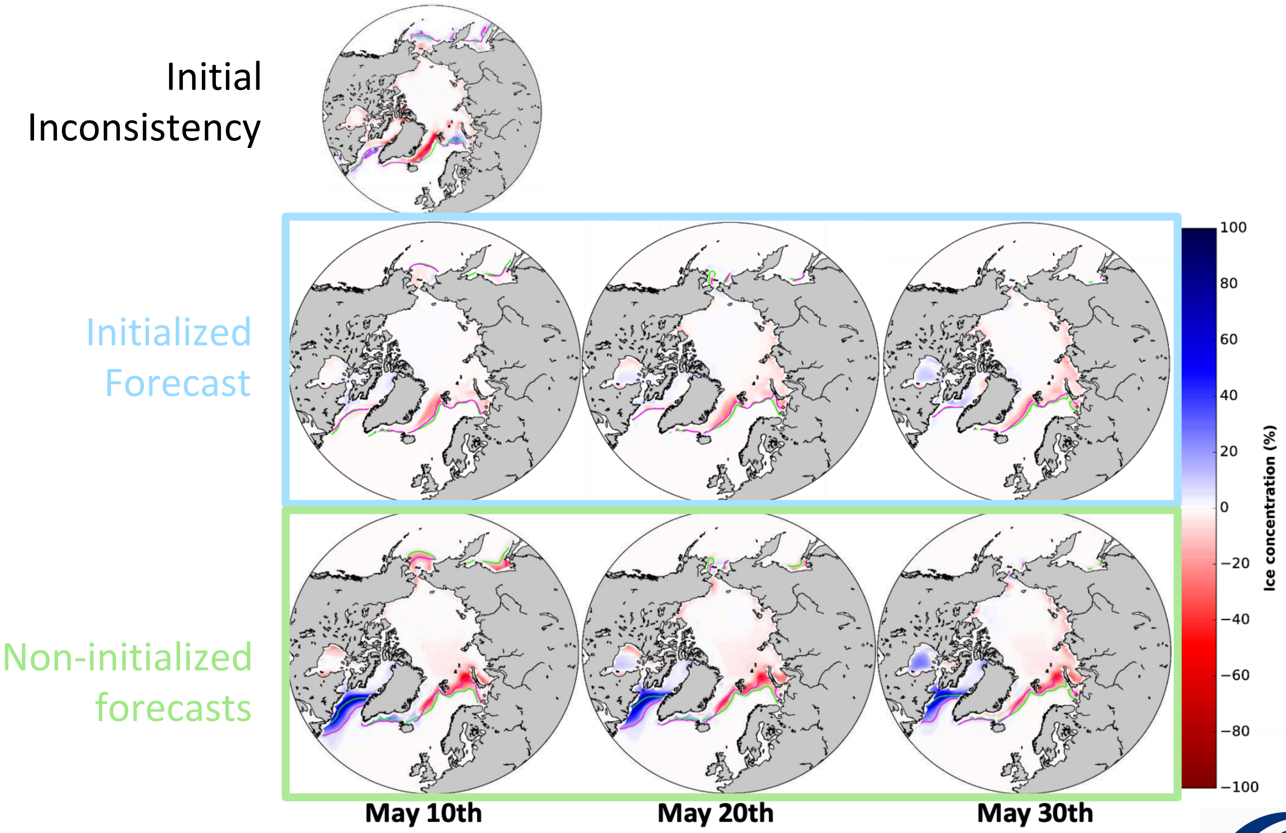
Ruben Cruz-García

Inconsistency of ICs



Evolution of errors with forecast day



Initialization Strategy

Sea Ice: NEMO-LIM3 forced w. ERA-Interim
ENKF assimilation of SICs from ESA

Ocean: ORAS4

Atmos: ERA-Interim

EC-Earth3.2 Seasonal Forecasts (1993-2008)

WP5: Development of forecast errors

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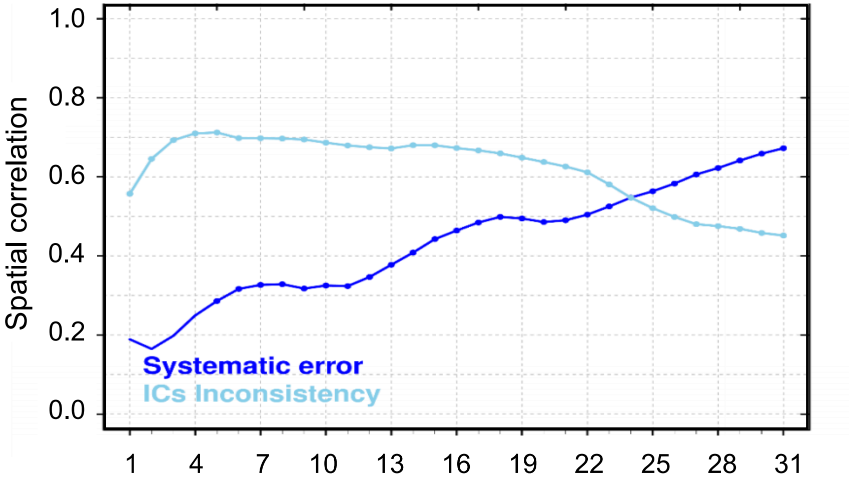
IC inconsistency vs systematic error

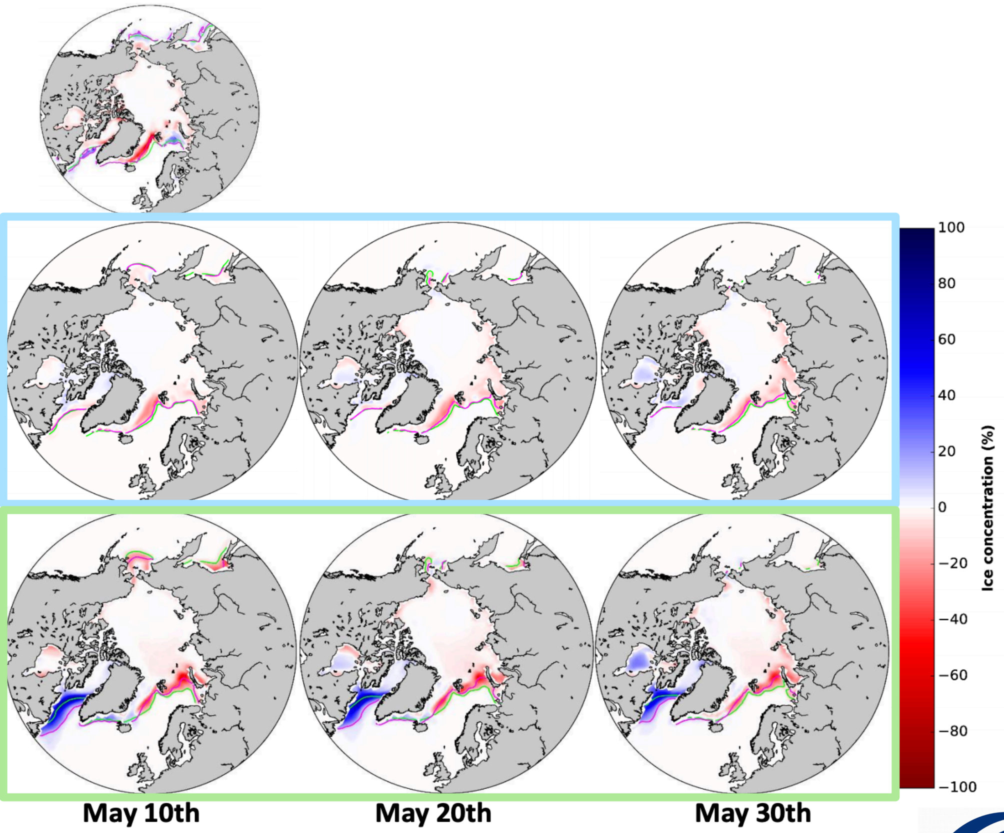


Evolution of errors with forecast day

Initial Inconsistency

Initialized Forecast

Non-initialized forecasts



EC-Earth3.2 Seasonal Forecasts (1993-2008)

WP5: Impact of model resolution

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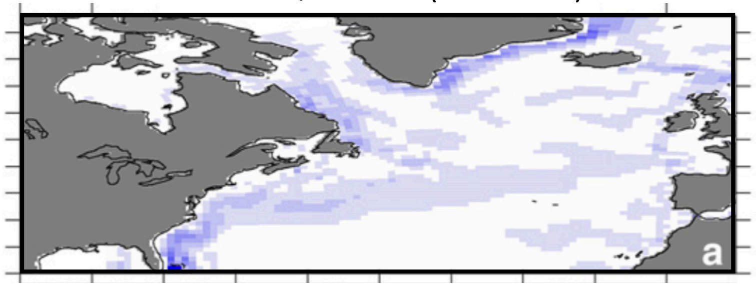
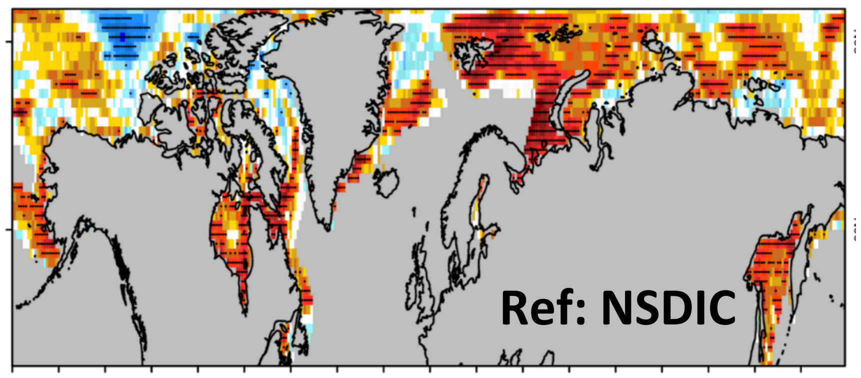
NEMO/LIM3 (**ORCA1**)

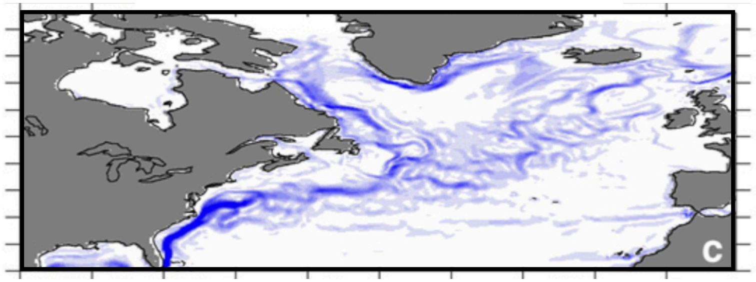


Ocean ICs: forced run nudged to **ORAS4**

ACC in Sea Ice Concentration in DJF (ORCA1)

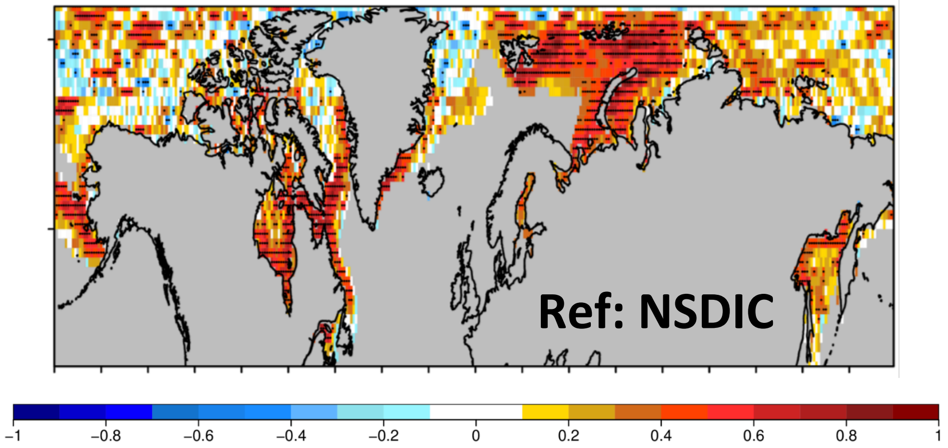


NEMO/LIM3 (**ORCA025**)



Ocean ICs: forced run nudged to **ORAS5**

ACC in Sea Ice Concentration in DJF (ORCA025)



EC-Earth3.3 November Forecasts (1993-2014)

WP5: Impact of model resolution

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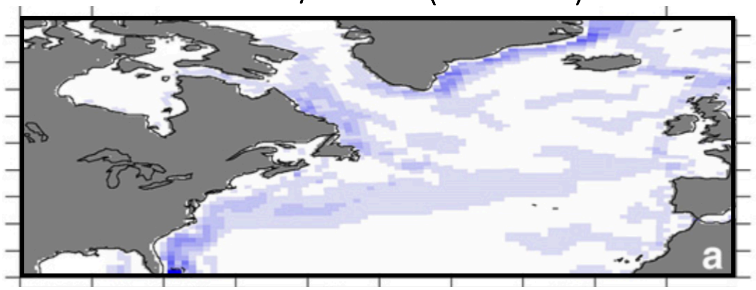
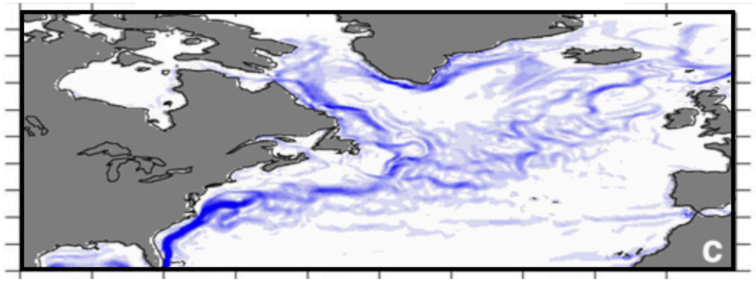
NEMO/LIM3 (**ORCA1**)



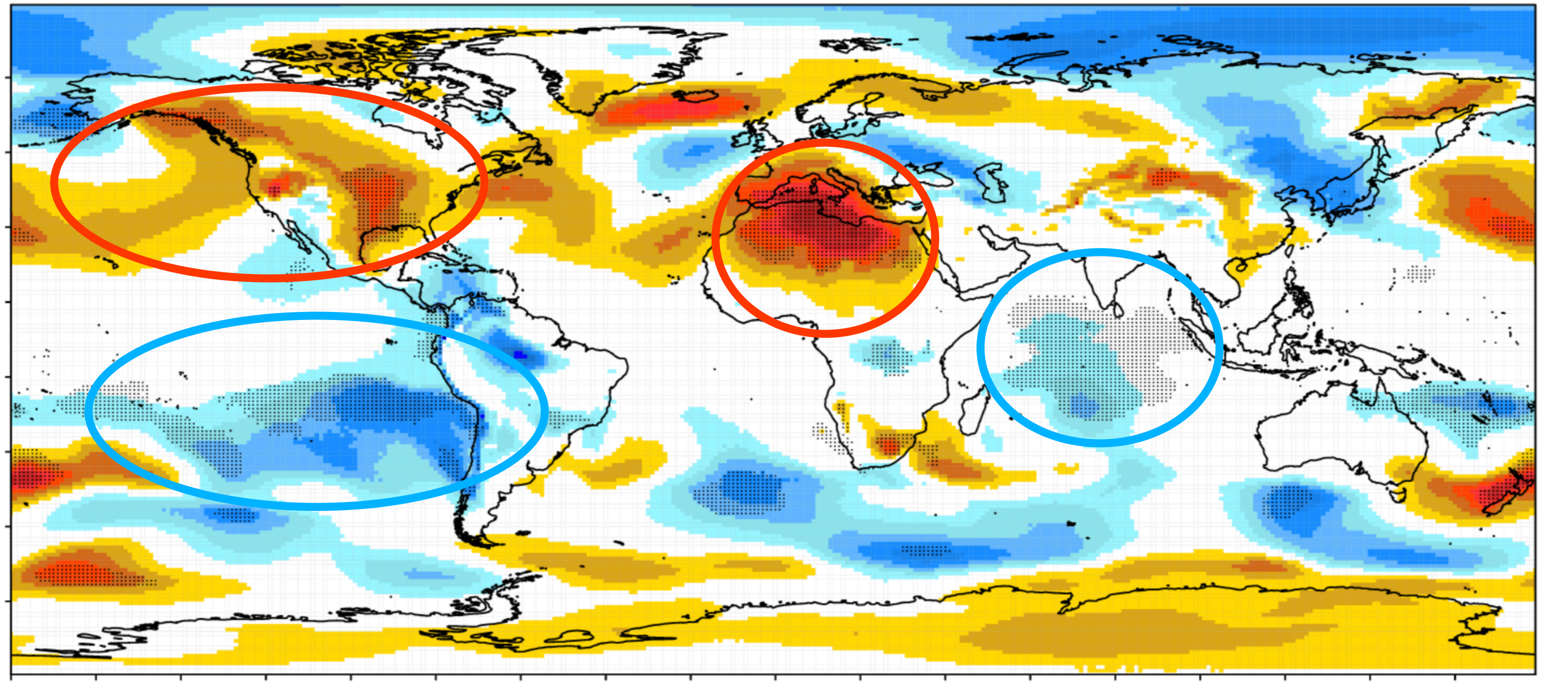
Ocean ICs: forced run nudged to **ORAS4**

NEMO/LIM3 (**ORCA025**)



Ocean ICs: forced run nudged to **ORAS5**

ACC difference in DJF SLP (ORCA025 – ORCA1)



Ref: ERA-Interim

EC-Earth3.3 November Forecasts (1993-2014)

WP5: Impact of model resolution

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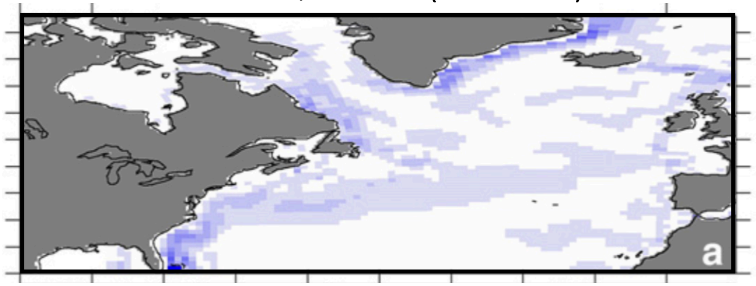
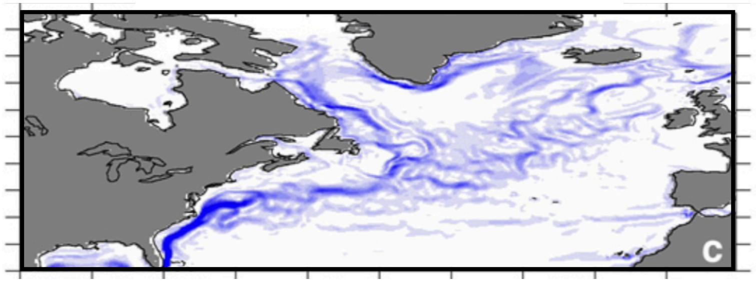
NEMO/LIM3 (**ORCA1**)



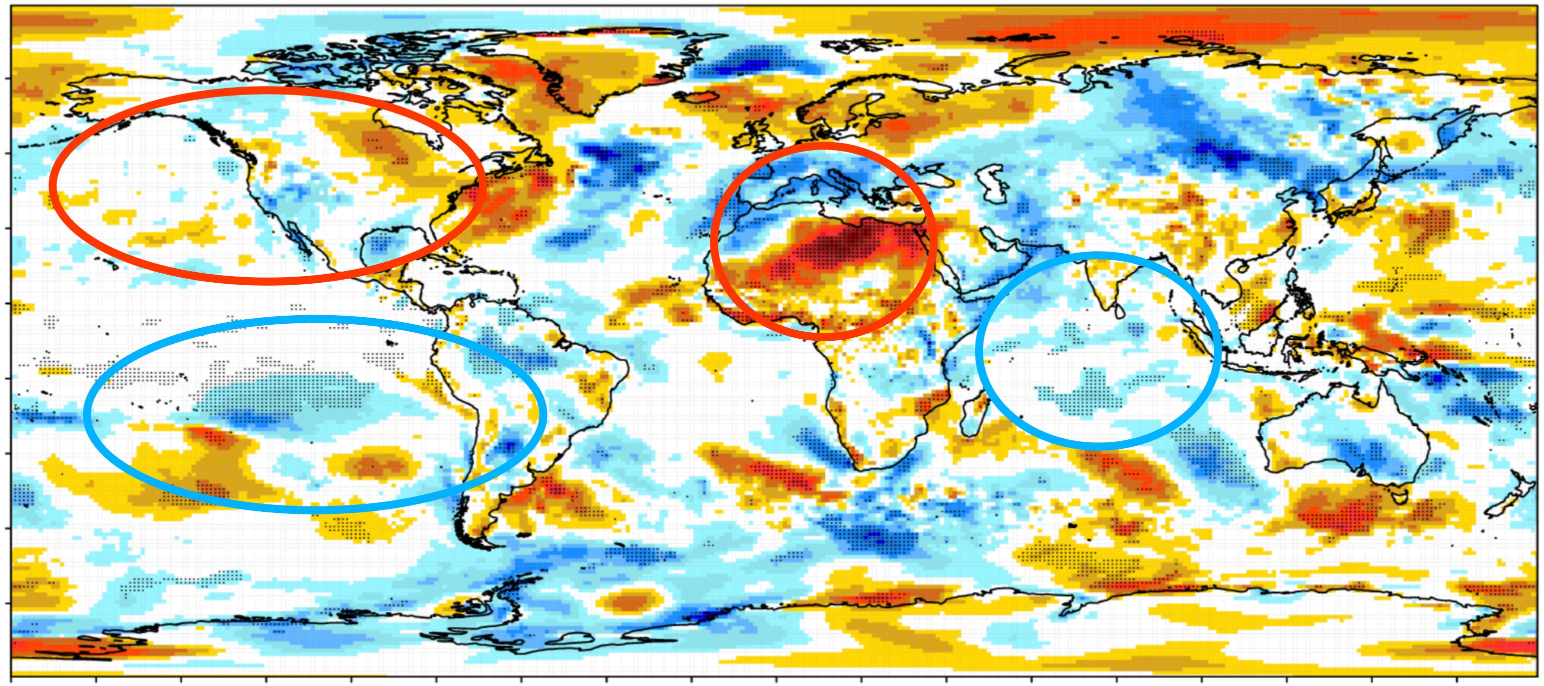
Ocean ICs: forced run nudged to **ORAS4**

NEMO/LIM3 (**ORCA025**)



Ocean ICs: forced run nudged to **ORAS5**

ACC difference in DJF TAS (ORCA025 – ORCA1)



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EC-Earth3.3 November Forecasts (1993-2014)

WP5: Impact of model resolution

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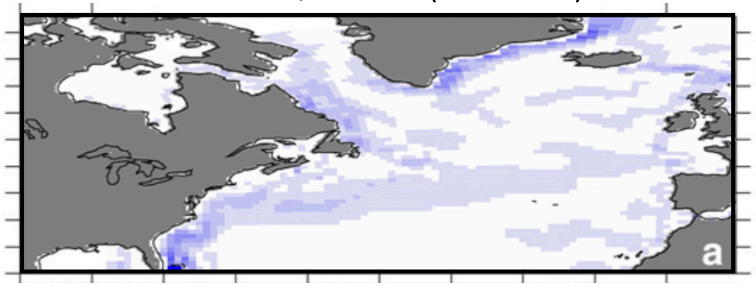
NEMO/LIM3 (**ORCA1**)



Ocean ICs: forced run nudged to **ORAS4**

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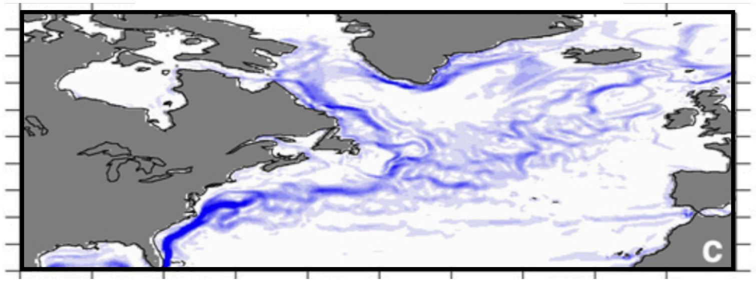

Ocean ICs: forced run nudged to **ORAS5**

Systematic Analysis with three GCMs

METEO FRANCE
CNRM-CM6

Environment Canada
CanCM

EC-Earth3

EC-Earth3.3 November Forecasts (1993-2014)

WP5: Statistical climate predictions

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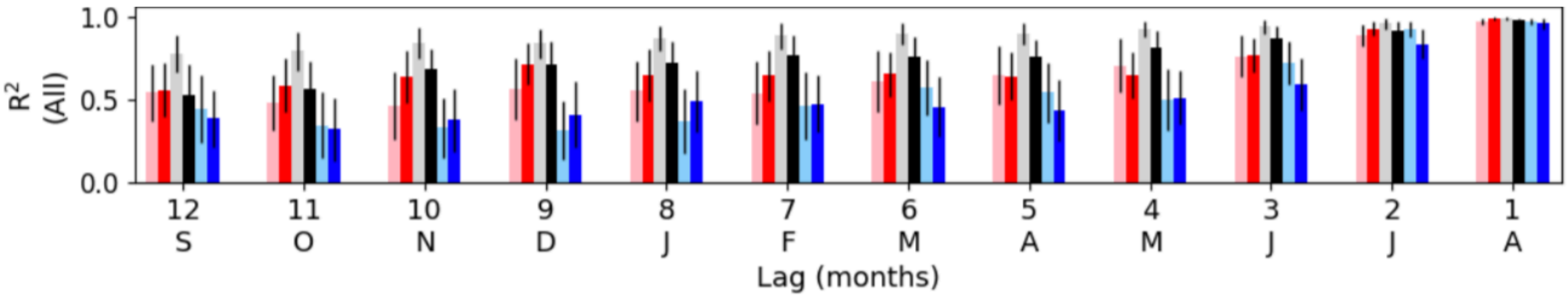
7 different predictors

SIV: Sea Ice Volume	SIA: Sea Ice Area
OHT: Ocean Heat Transport	SIT: Sea Ice Thickness
SIC: Sea Ice Concentration	SST: Sea Surface Temperature
SID: Sea Ice Drift	

Outputs from 6 models

HadGEM3-LL
HadGEM3-MM
ECMWF-LR
ECMWF-HR
AWI-LR
AWI-HR

Statistical predictability of September SIV Anomaly for 1 to 12 preceding months



Statistical Predictions: Perfect model (1950-2014)

UCLouvain

WP5: Optimal sampling locations

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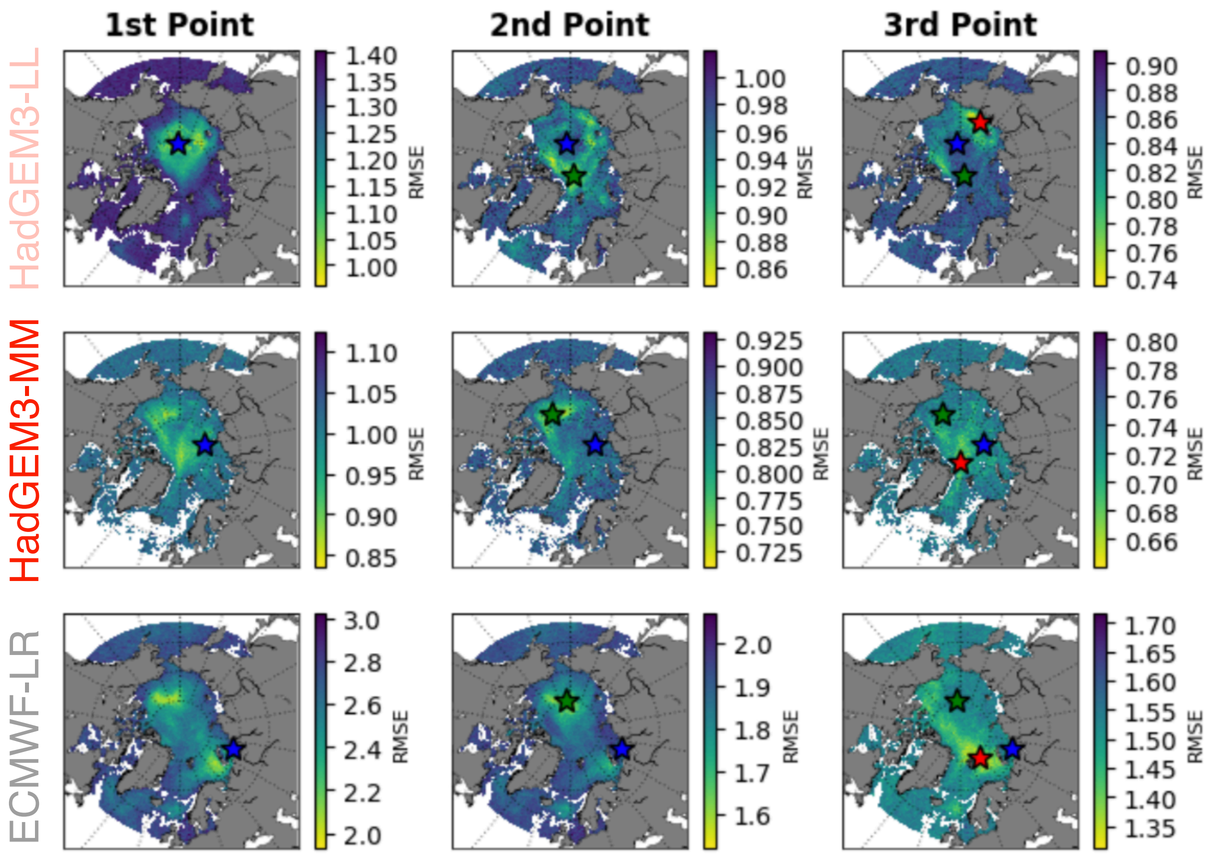
4 predictors (easily observable)

Sea Ice Drift	(in-situ)
Sea Ice Thickness	(in-situ)
Sea Ice Concentration	(satellite)
Sea Surface Temperature	(in-situ)

Optimal locations:
Placed at the grid points where predictors minimise RMSE in SIV

RMSE of Sea Ice Volume



Statistical Predictions: Perfect model (1950-2014)

UCLouvain

WP5: Optimal sampling locations

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4 predictors (easily observable)

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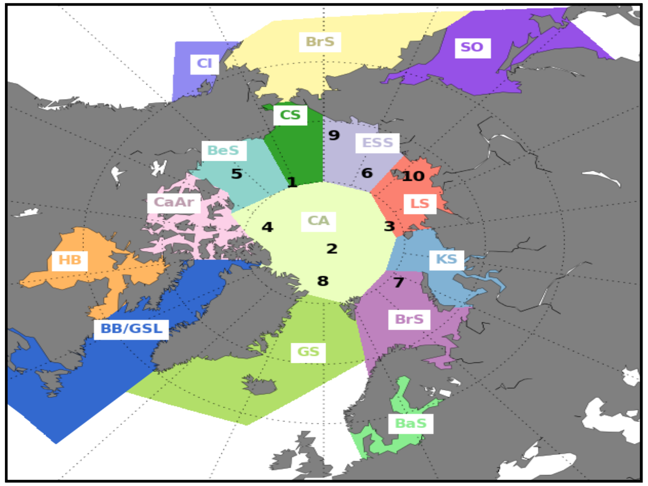
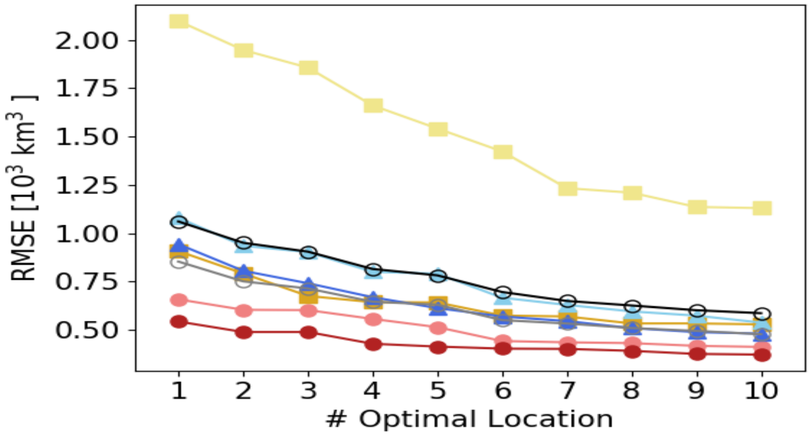
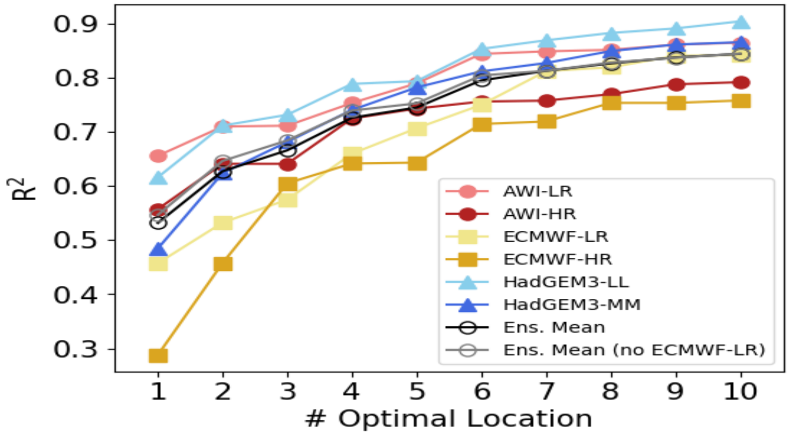
Sea Ice Thickness	(in-situ)
Sea Ice Concentration	(satellite)
Sea Surface Temperature	(in-situ



RMSE of Total SIV



R^2 of Total SIV



5 to 6 locations can guarantee a relatively **low RMSE and high R**

ECMWF-LR has a **strong RMSE bias**, which creates too thick sea ice

Statistical Predictions: Perfect model (1950-2014)

UCLouvain

APPLICATE in a nutshell

APPLICATE.eu
Advanced prediction in polar regions and beyond

- Advances predictive capacity in polar regions and beyond:
  - Develops models with enhanced representation of Arctic processes
  - Contributes to improving the Arctic observing system
- Enhances our understanding of Arctic-midlatitude linkages (also from a prediction perspective)
- Brings different communities closer together

Highlights of APPLICATE WP5

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Experimental framework to foster the predictive skill over the Arctic

- APPLICATE Stream 1 seasonal forecasts show **skill to predict summer SIE up to 3-4 months** beforehand
- Increasing the resolution seems to lead to higher predictive skill in the Northern Hemisphere, although it is unclear if the improvement comes from the ICs or from the resolution itself
- Statistical models can achieve high level of skill up to 12 months ahead

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Thanks for your attention!!

For further questions, please contact me at: pablo.ortega@bsc.es