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An update of the current climate prediction activities at BSC with EC-Earth

Pablo Ortega

J Acosta, R Bernardello, R Bilbao, LP Caron, R Cruz-García, M Donat, E Exarchou, V Lapin, V Sicardi, Y. Ruprich-Robert, E Tourigny, D Verfaille, S Wild

APPLICATE.eu Advanced prediction in polar regions and beyond

EUCP European Climate Prediction system

PRIMAVERA

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CCiCC

EC-Earth Meeting - Reading May 2019

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An update of the current climate prediction activities at BSC with EC-Earth

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Computational Earth Sciences Group

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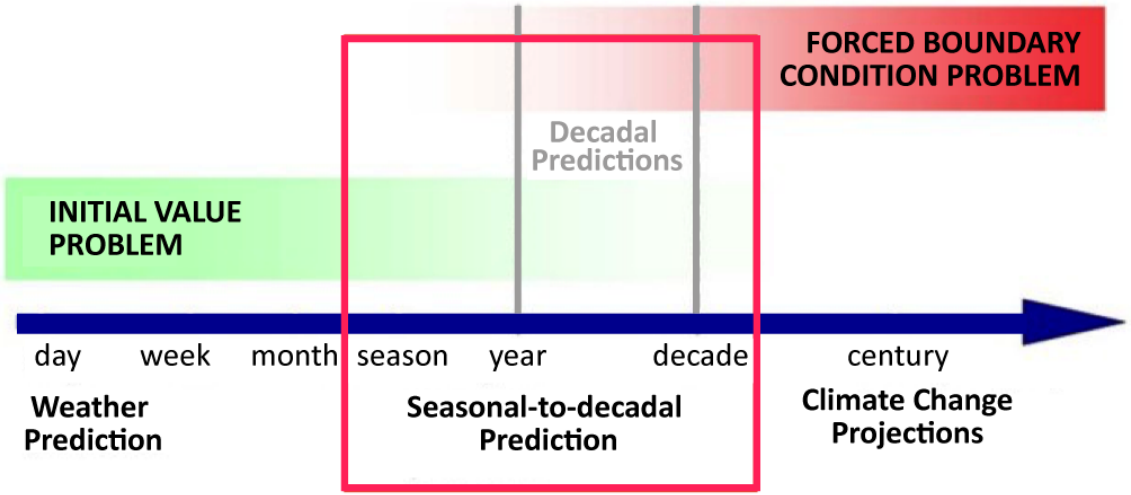
EC-Earth Meeting - Reading May 2019

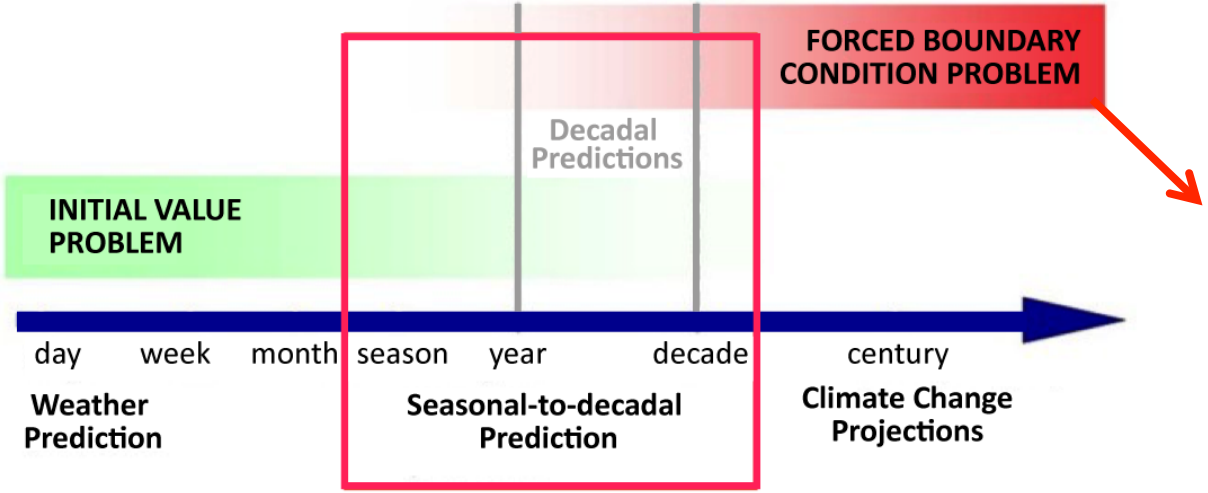
Cornerstones of climate prediction

Meehl et al 2009



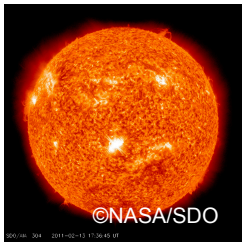
Cornerstones of climate prediction

Meehl et al 2009



Predictability relying on good guess of future changes in the forcing

Solar Activity

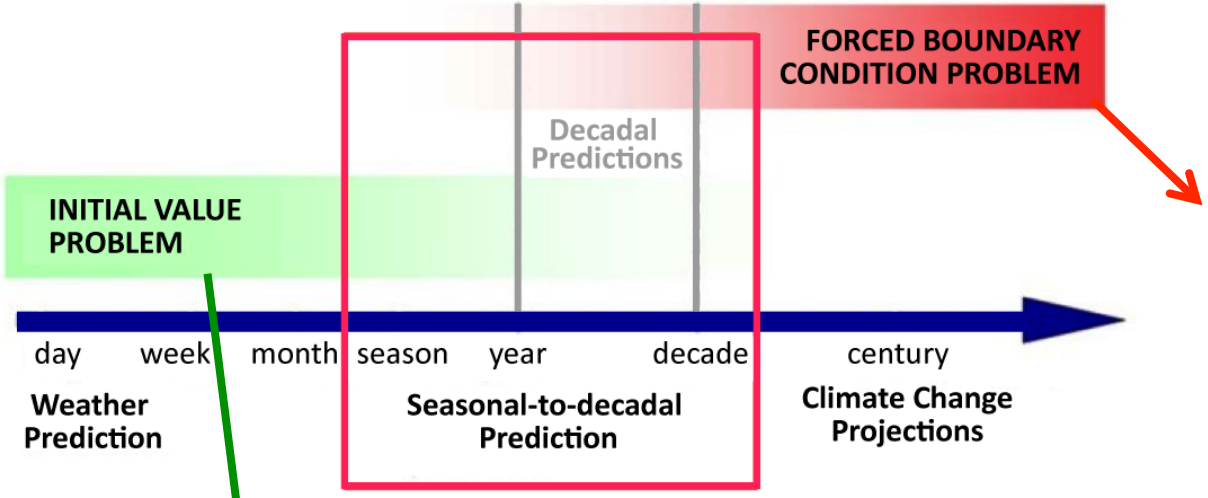


Volcanic Aerosols

GHGs

Cornerstones of climate prediction

Meehl et al 2009



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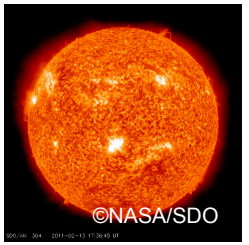
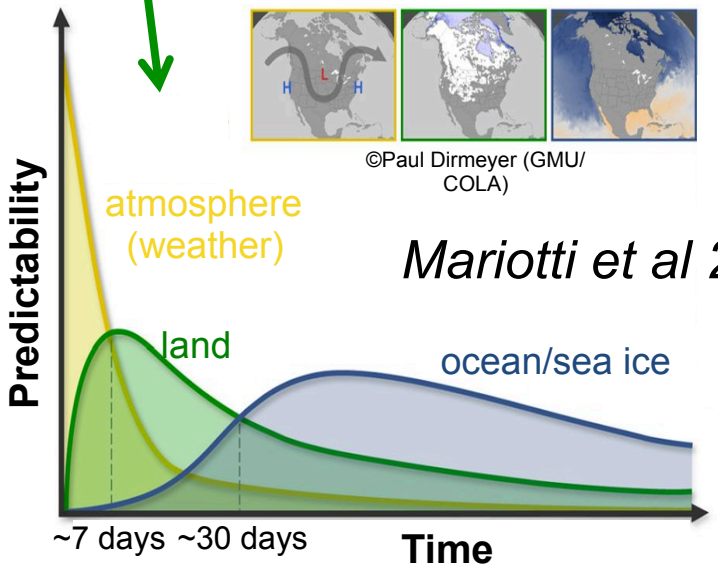


Volcanic Aerosols

GHGs

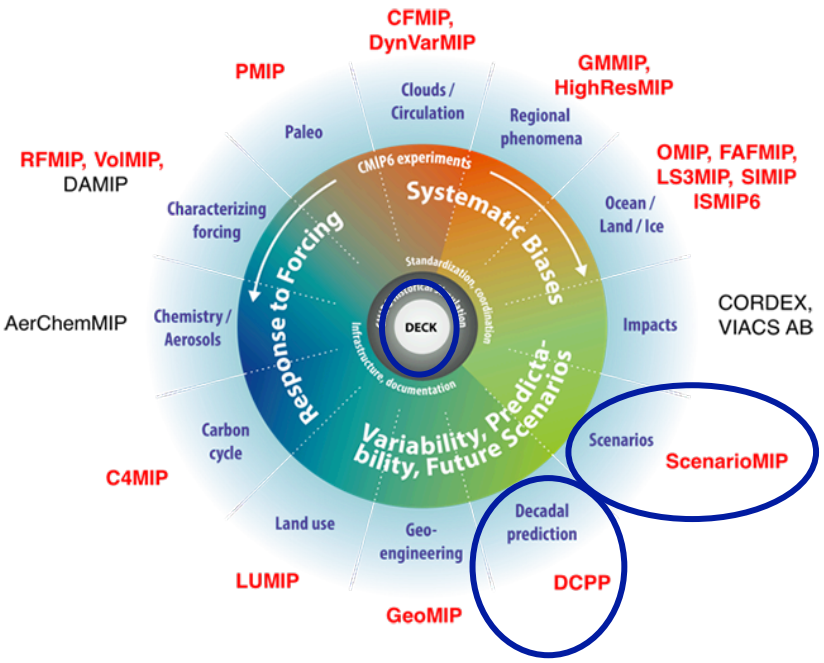
©Paul Dirmeyer (GMU/ COLA)



Mariotti et al 2018

Predictability arising from the memory of slow processes/ components in the climate system

Decadal climate prediction within CMIP6



Contributions to CMIP6

EC-Earth 3.3.1 in standard resolution (~1°)

DCPP Component A:
Retrospective Predictions [1960-2017]

DCPP Component B:
Near-real time Forecasts [2018 onwards]

DECK+ScenarioMIP:
Historical+SPSS2-4.5 [1850-2100]

WCRP CMIP6
World Climate Research Programme

Other H2020 activities

With EC-Earth 3.3.1 in high resolution (~0.25°)

EUCP
European Climate Prediction system

DCPP Component A-like:
Retrospective Predictions [1960-2017]

Real-time decadal climate predictions

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Multi-model decadal forecast exchange

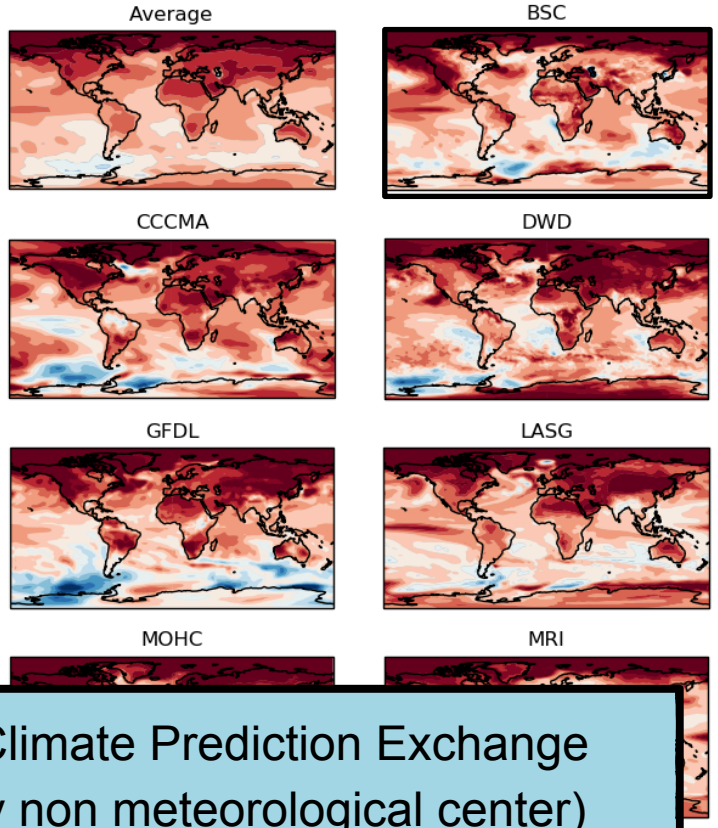
The Met Office coordinates an informal exchange of near-real time decadal predictions. Many institutions around the world are developing decadal prediction capability and this informal exchange is intended to facilitate research and collaboration on the topic.

The contributing prediction systems are a mixture of dynamical and statistical methods. The prediction from each institute is shown below, alongside an average of all the models. When possible, observations for the period of the forecast are also shown. Currently three variables are included: surface air temperature, sea-level pressure and precipitation. These are shown as differences from the 1971-2000 baseline. More diagnostics, including ocean variables are planned for the future. Please use the drop-down menus below to explore the data collected to date.

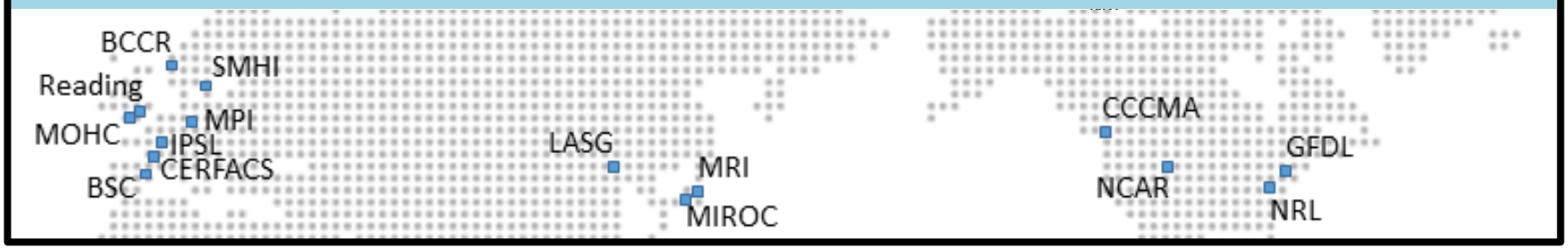
This work is supported by the European Commission SPECS project.

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

2018 predictions for 2019 SAT
based on EC-Earth2.3



15 centers will contribute to Annual Decadal Climate Prediction Exchange
4 applied for WMO-designation (**BSC** the only non meteorological center)



Reliability of decadal predictions

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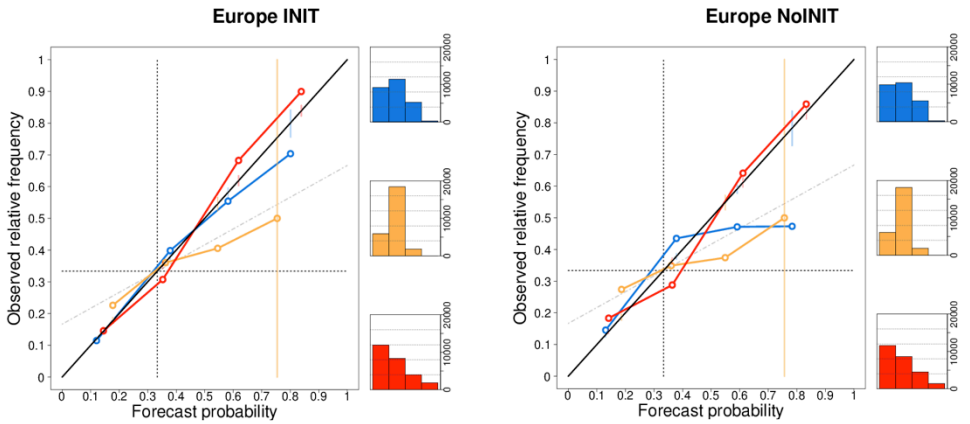
Multimodel assessment

Verfaille et al. (in preparation)

Compare initialised decadal predictions (**INIT**) and non-initialised projections (**NoINIT**)

Reliability = *agreement between predicted probabilities & observed relative frequencies of an event*

T over Europe, forecast year 1



Model setup:

- Multi-model, INIT and NoINIT, same ensemble size
- 1961-2005, forecast year 1 and forecast years 1 to 5

Analysis:

- rank histograms & reliability diagrams
- different variables and indices (GMT, AMV index)

Predictability of idealised volcanic eruptions

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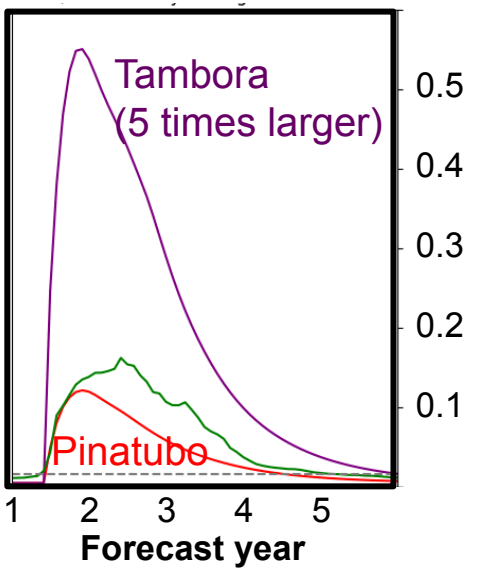
Perfect model experiments with EC-Earth 3.2

Martín et al. (in preparation)

Idealised **Pinatubo** (1991 eruption)
Idealised **Tambora** (1815 eruption)
CTRL (background aerosols)

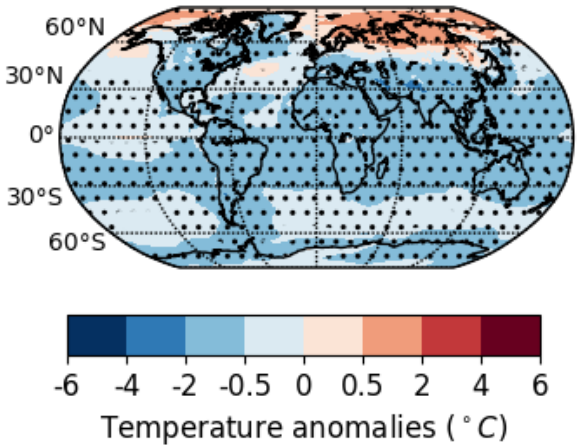
} Initialized from **20 different initial states** (common to the three ensembles)

Zonally averaged total AOD

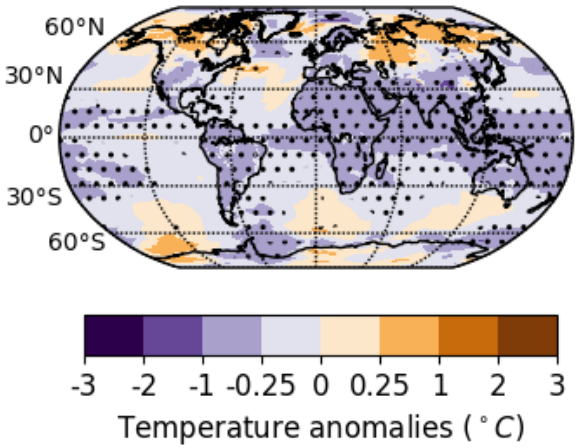


Predicted surface air temperature response (1st year)

Tambora - CTRL



Pinatubo - CTRL



Similar climate impacts: a **global cooling** and regional **warming over the Arctic**

VOLMIP

CMIP
The World Climate Research Programme's Coupled Model Intercomparison Project

Predictability of idealised volcanic eruptions

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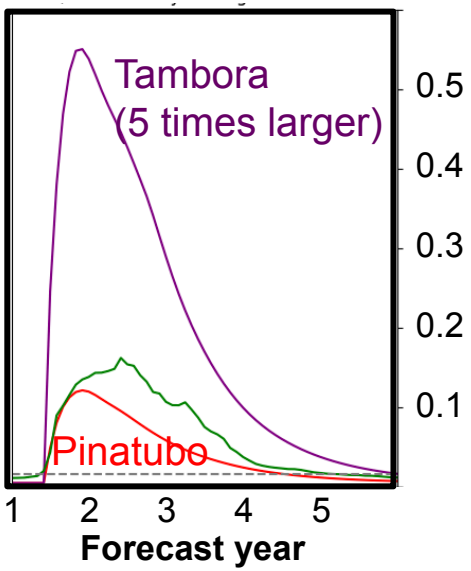
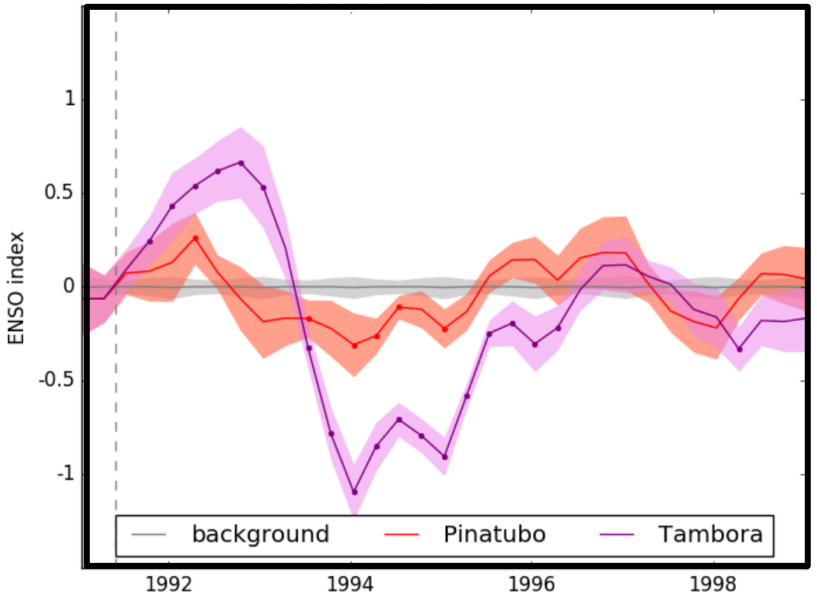


Predicted ENSO3.4 after the eruptions



Both volcanic eruptions also excite responses in **El Niño region**

Similar climate impacts: a **global cooling** and regional **warming over the Arctic**

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Skill from interbasin telecomnections

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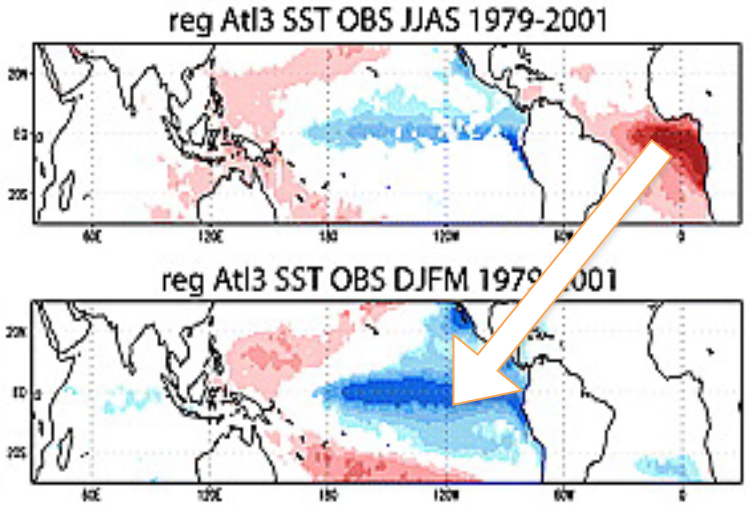
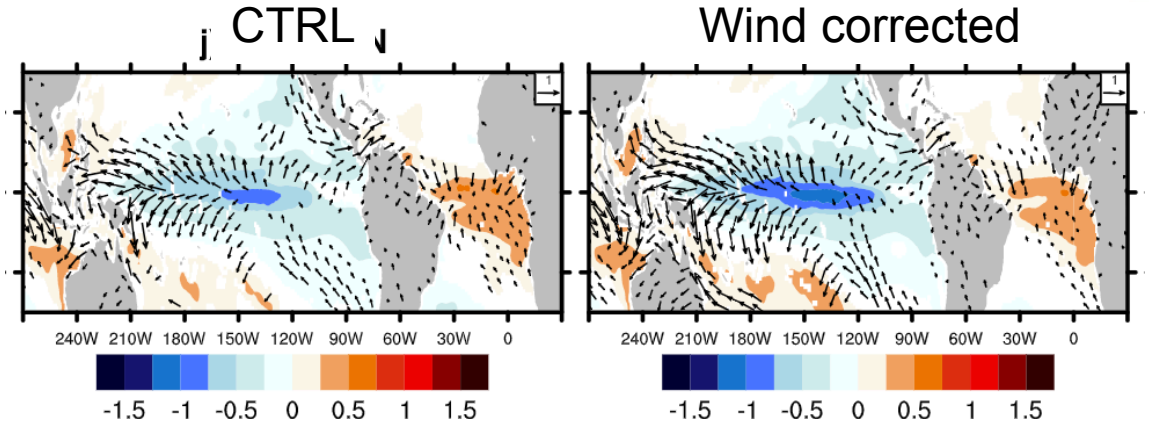
Exarchou et al. (in preparation)

Observed teleconnection of Atlantic Niño with winter NIÑO



Rodriguez-Fonseca et al (2009)

Regression JJA ATL3 vs SON SST



PREFACE

Skill from interbasin telecomnections

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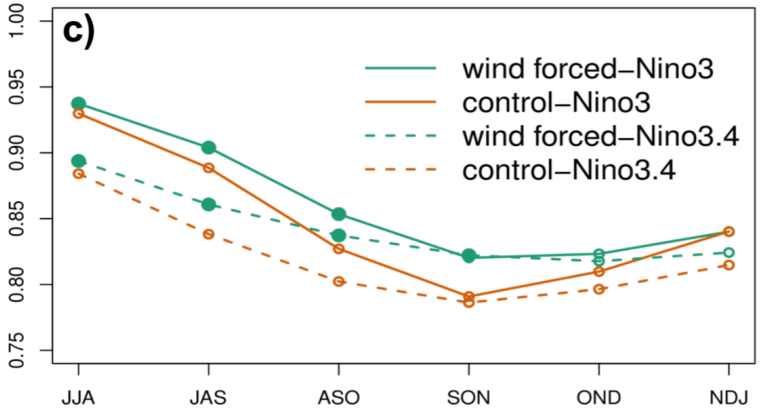
ACC for NINO34



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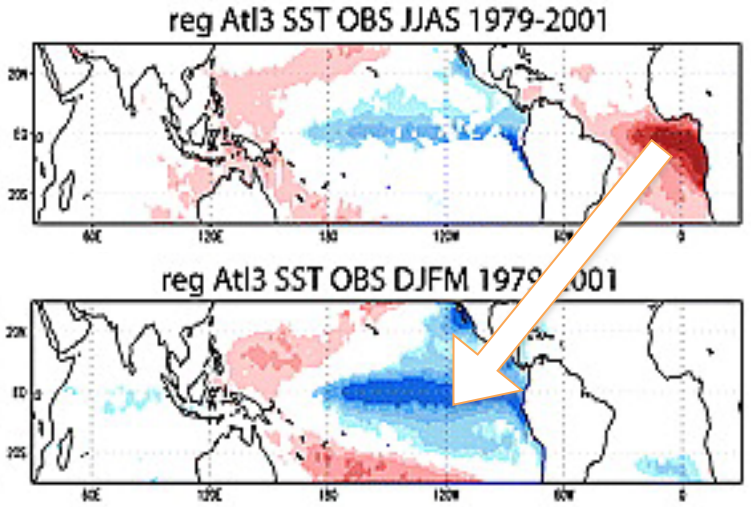

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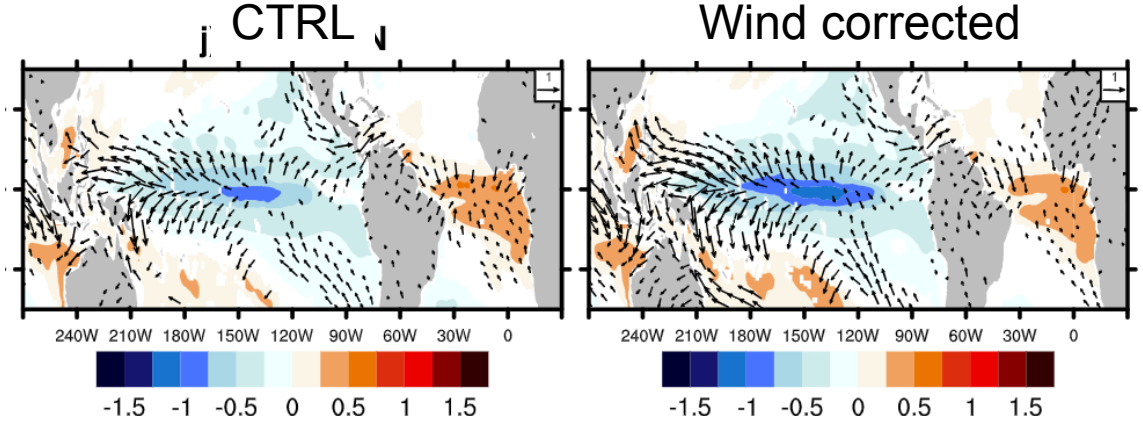

PREFACE

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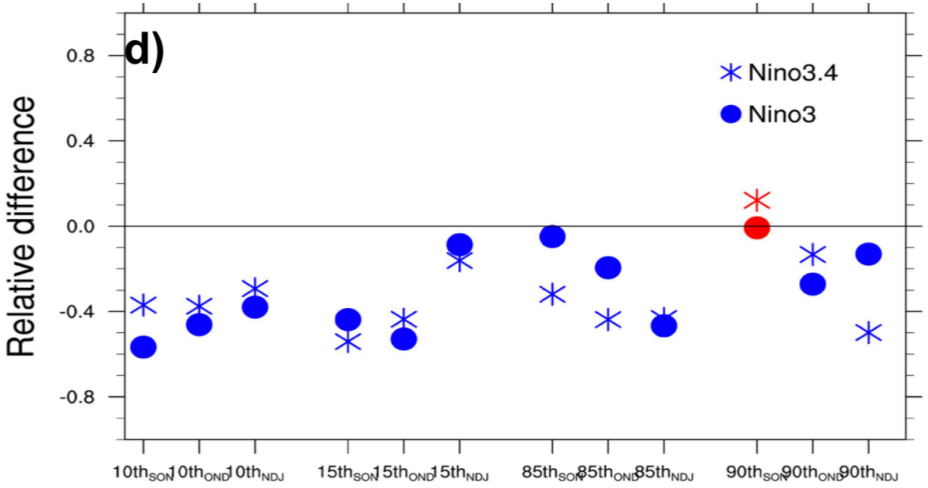
Relative difference Brier Score (Wind-CTRL)



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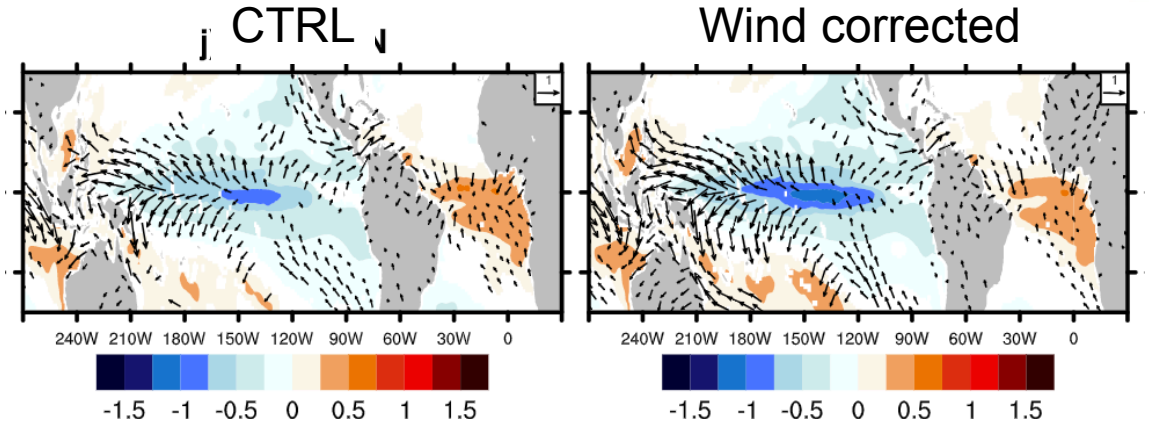

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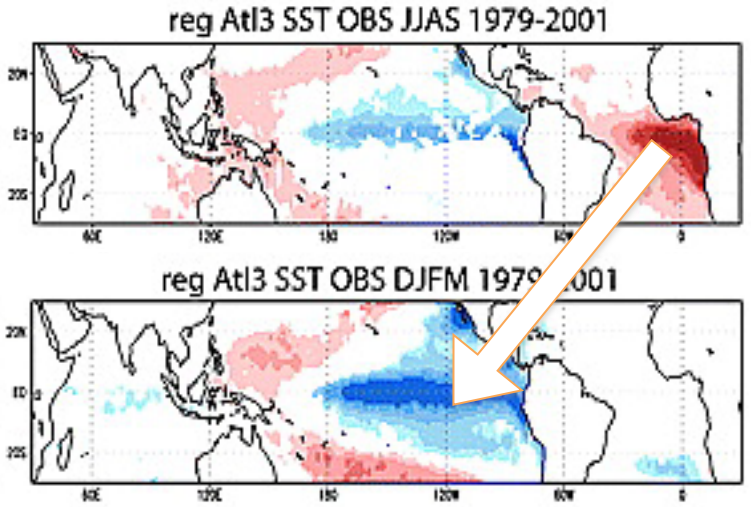

Rodriguez-Fonseca et al (2009)

PREFACE

Interbasin-teleconnections

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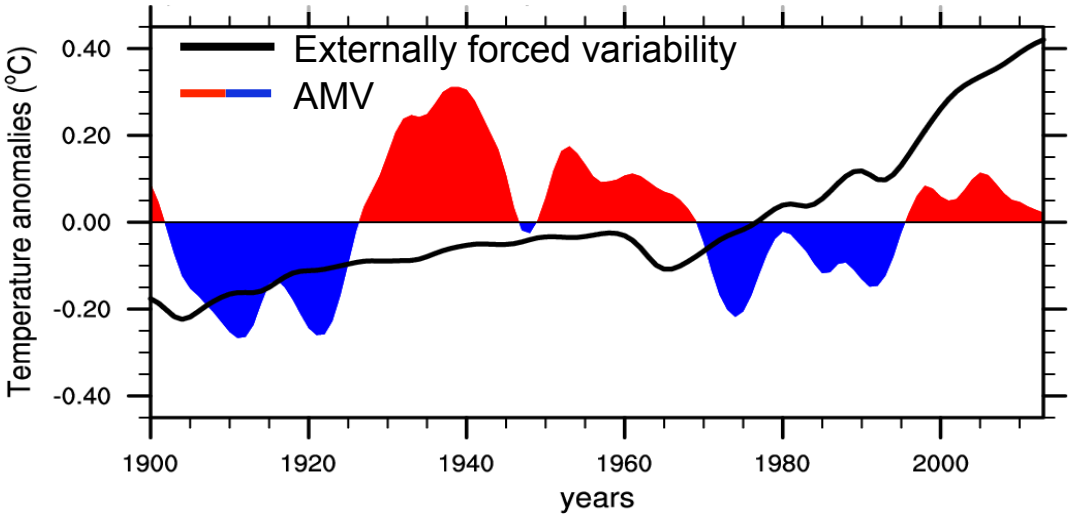
Y. Ruprich-Robert

DCPP Component C: Predictability, mechanisms and case studies

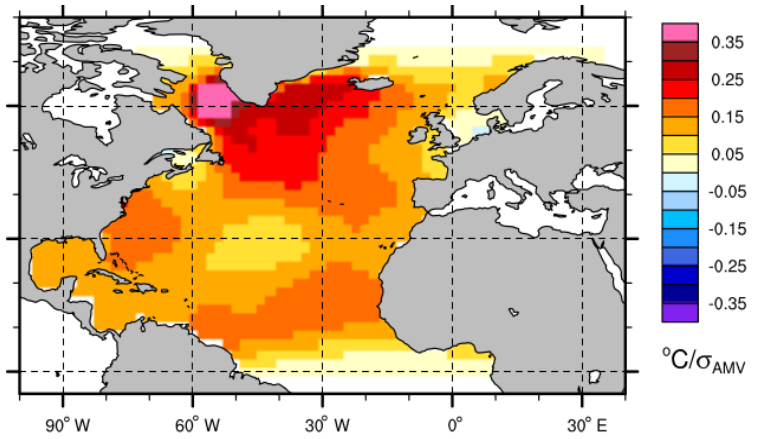
Attribution of observed decadal climate variability to Atlantic-Pacific SST variations

Idealized Atlantic Multidecadal Variability (AMV) experiments

North Atlantic SST time series (Ting et al. 2009)



AMV pattern



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DCPP CMIP
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Interbasin-teleconnections

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Restoring of SST via non-solar surface surface fluxes

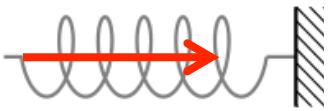
Y. Ruprich-Robert

$$\frac{\partial SST}{\partial t} = \ldots + \frac{\gamma_T}{\rho C_P h}\left(SST_{model} - SST_{AMV}\right)$$

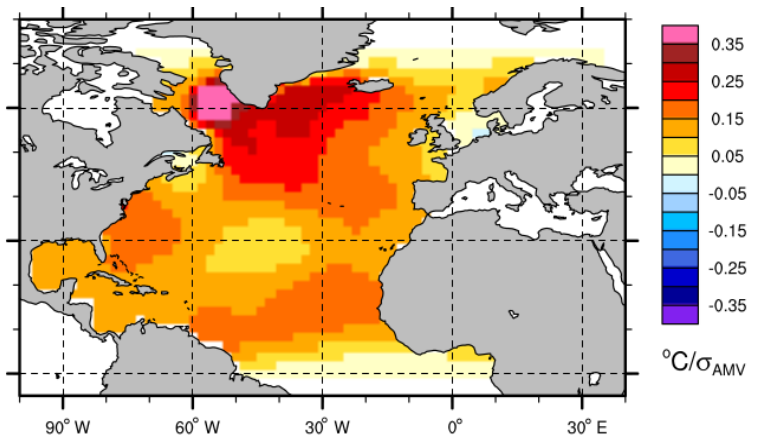
Restoring coefficient of γ_T **= -40W/m²/K** over North Atlantic (Eq-70ºN)

Free ocean-ice-land-atmosphere interactions outside of North Atlantic

SST_{AMV} **= Climatology + AMV pattern**



AMV pattern



By running this protocol in **coupled mode** we will be able to explore the **atmospheric linkages** responsible for the **AMV impacts** in the other basins.

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Predictability from Sea Ice

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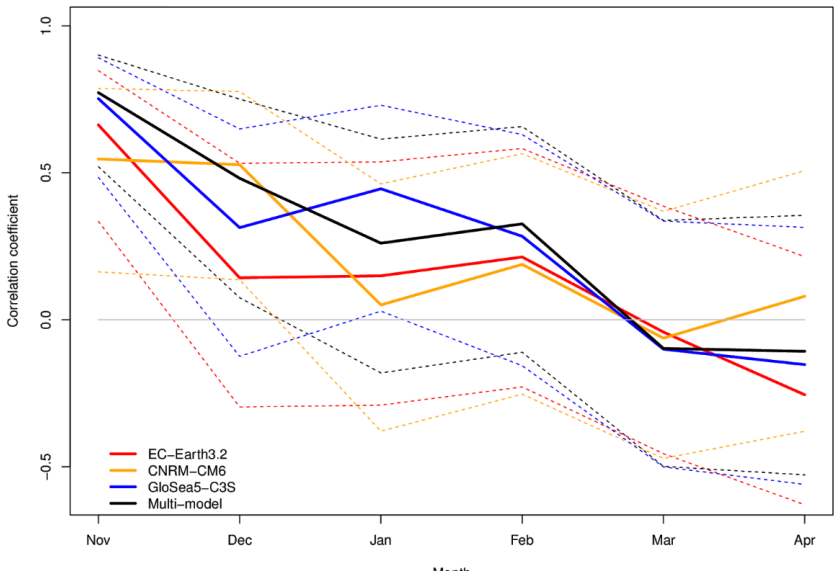
Ensemble of Seasonal Prediction Forecasts

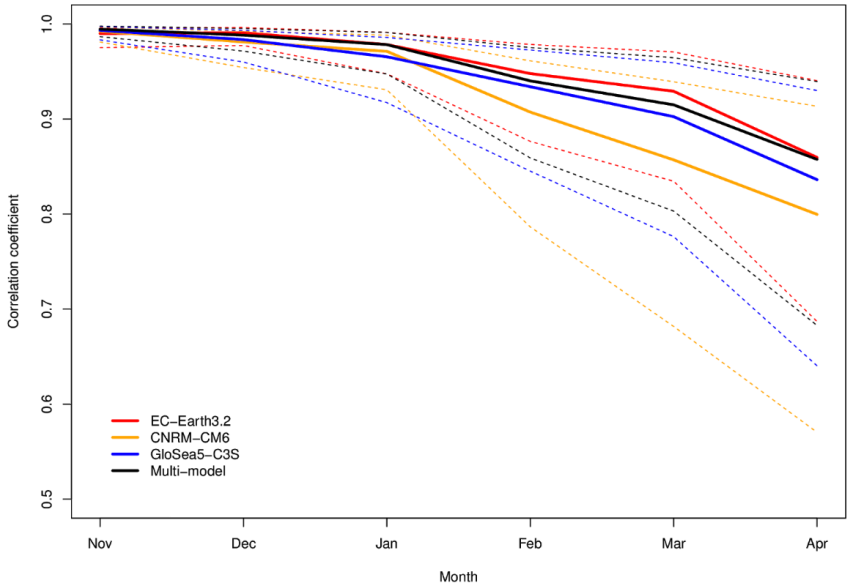
Acosta et al (in preparation)

25 members for: EC-Earth 3.2, CNRM-CM6 and GloSea5-C3S

ACC skill in NAO



ACC skill in ENSO



Currently exploring the links between the differences in skill performance and model biases in Arctic Sea Ice

APPLICATE

Characterization of forecast biases

Barcelona Supercomputing Center
Centro Nacional de Supercomputación
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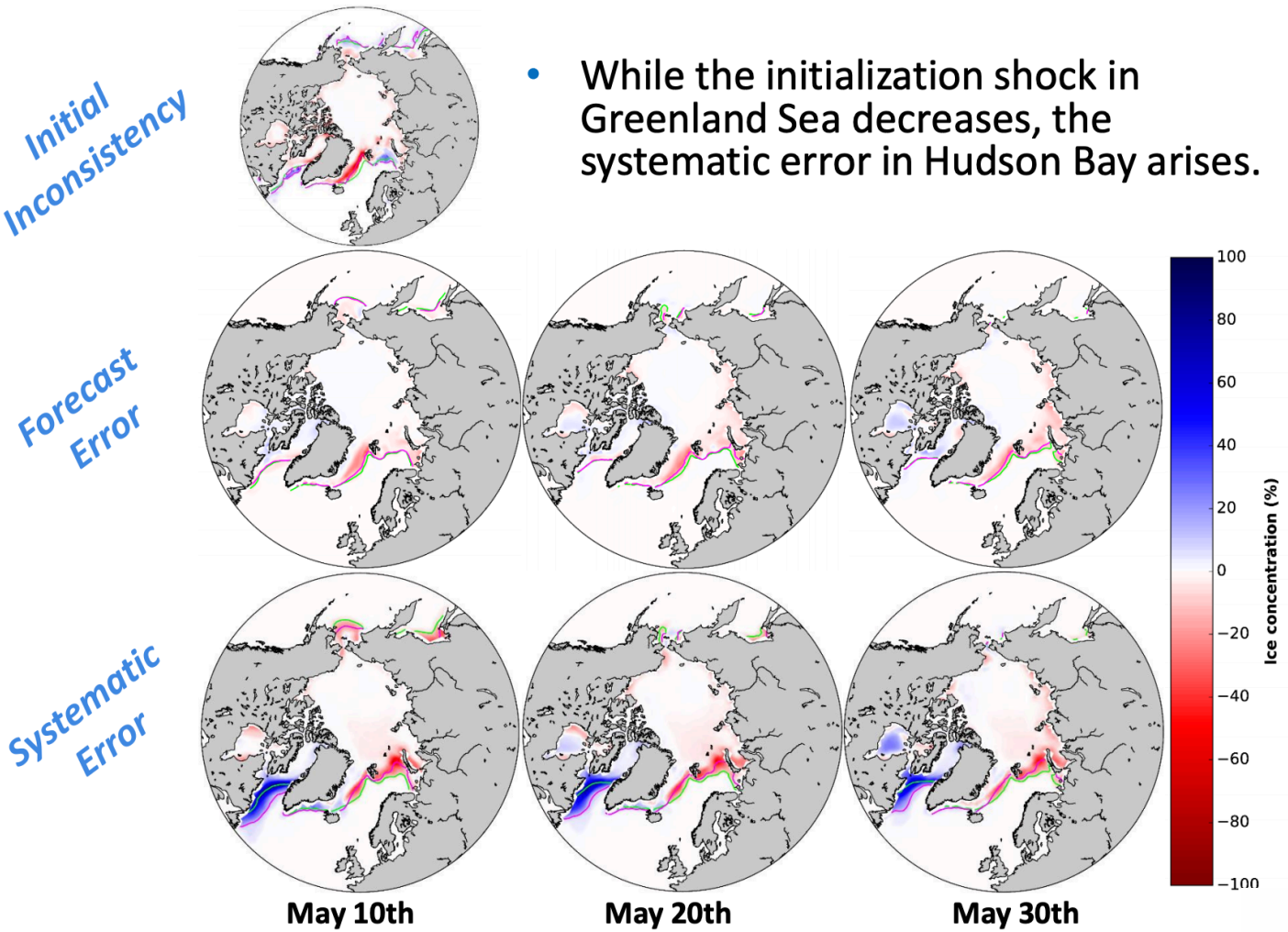
May-initialized forecast system with EC-Earth 3.1

Cruz-García et al (Submitted)

- While the initialization shock in Greenland Sea decreases, the systematic error in Hudson Bay arises.



APPLICATE

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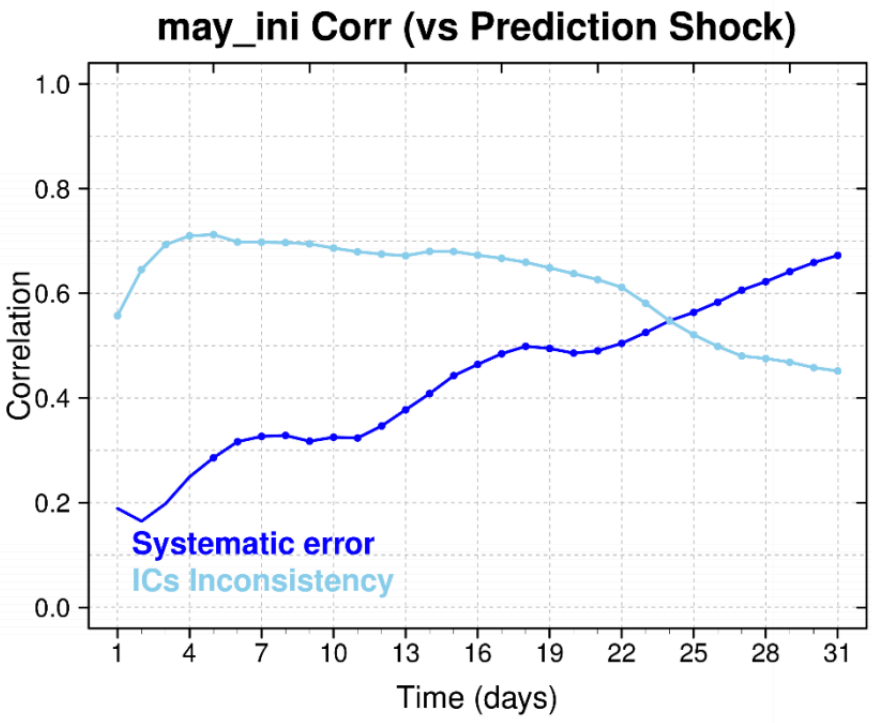

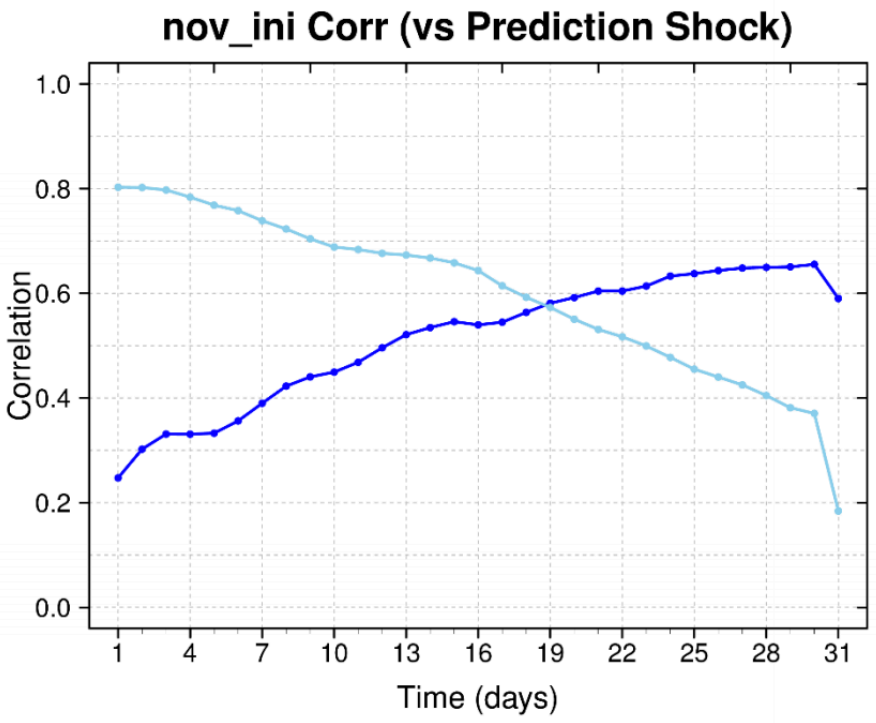

After **25 (19)** days the **systematic model error** becomes the **largest contributor** to the forecast error in **May (November).**

APPLICATE

Predictability of atmospheric carbon

Barcelona Supercomputing Center
Centro Nacional de Supercomputación
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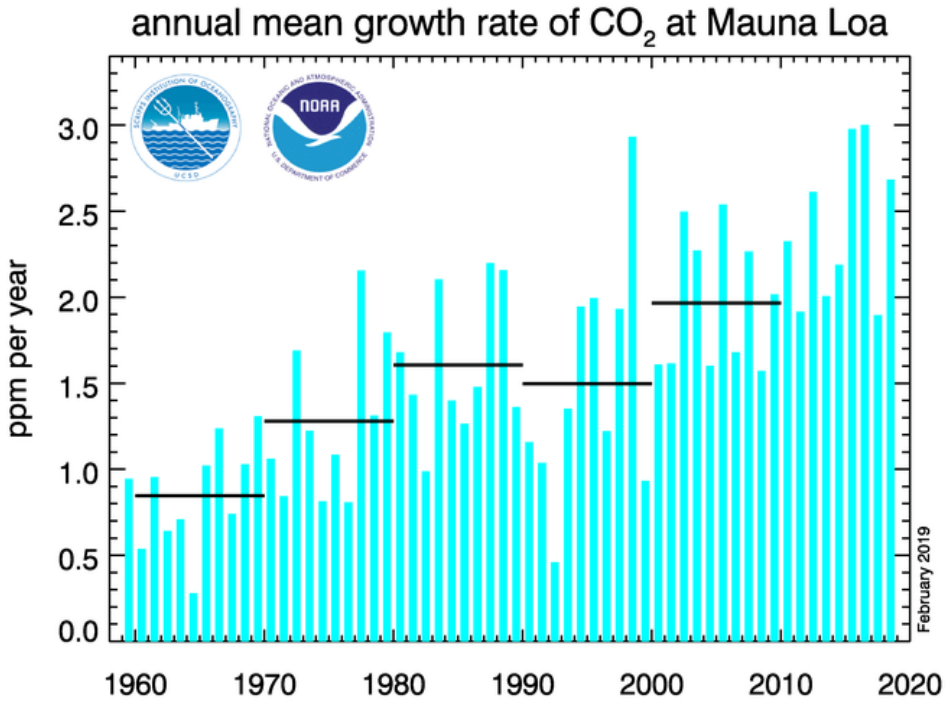
Towards a near-term prediction of the climate and carbon cycle interactions in response to Paris Agreement emission trajectories

R. Bernardello

[Global **carbon stocktake** every **5 years**]

Variability in atm CO2 growth rate is mostly due to natural variability



Testing different ocean biogeochemical reconstructions as initial conditions

Retrospective decadal predictions of ocean and land carbon uptake

Idealized perfect-model experiments to investigate mechanisms of C uptake predictability in the ocean.

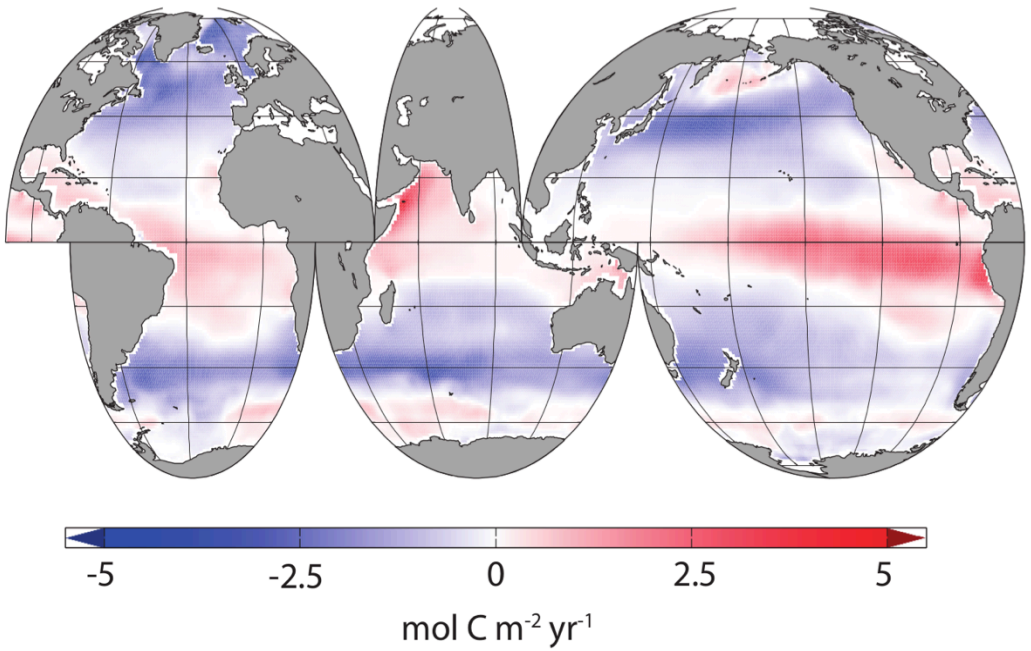
CCiCC

Predictability of S. Ocean Carbon Uptake

R. Bernardello

Investigating mechanisms of variability of Southern Ocean Carbon uptake and the role of the Biological Carbon Pump

Validation using satellite obs-based reconstructions of air-sea CO2 flux



Transport Matrix Method (TMM) with NEMO for fast equilibration of bgc tracers

Retrospective decadal predictions of ocean carbon uptake

Impact of the BCP uncertainty on total carbon uptake estimates

DeCUSO

Predictability of Atlantic Marine Ecosystems

Barcelona Supercomputing Center
Centro Nacional de Supercomputación
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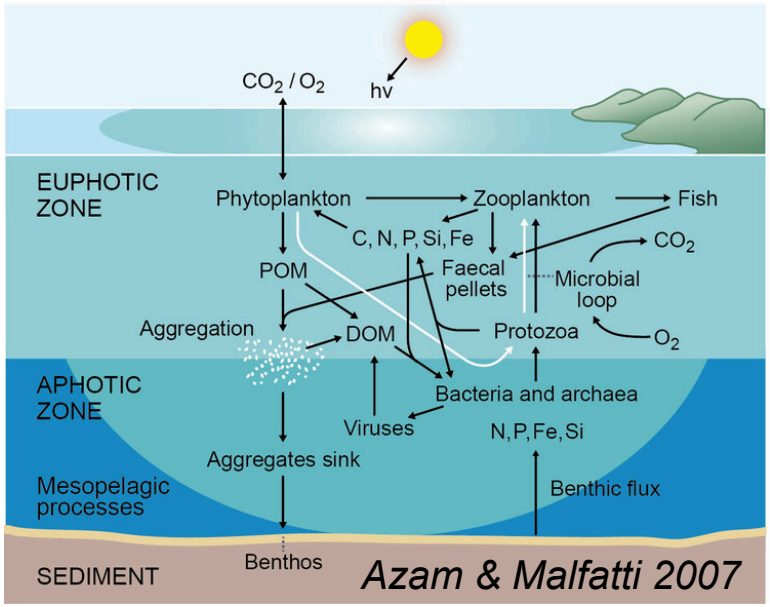
R. Bernardello

Investigating the current state and future changes of the Atlantic marine ecosystems



Predictive skill of climate and bio-geochemical drivers at seasonal and decadal scales

Perfect model experiments to investigate the potential predictability and the skill loss due to the limited observations

Performing bias-correction predictions to illustrate potential skill improvements

TRIATLAS

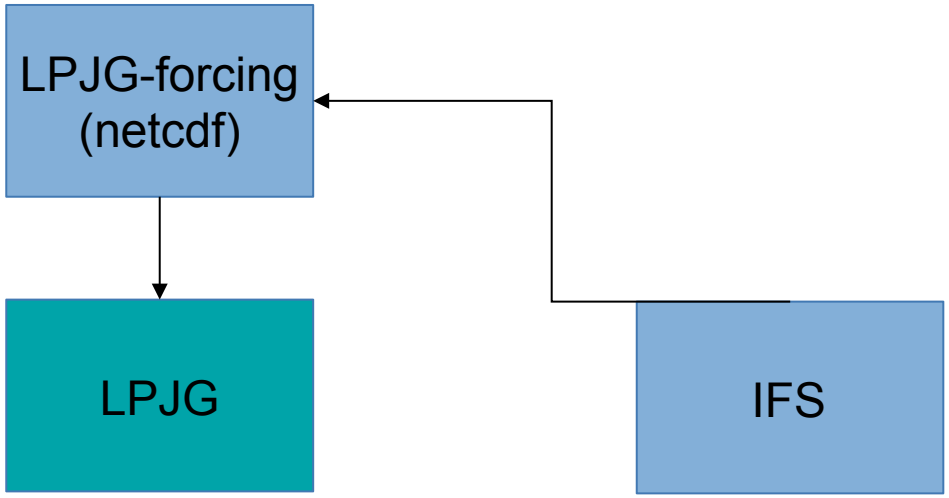
THE EU FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION
HORIZON 2020
EXCELLENT SCIENCE
COMPETITIVE INDUSTRIES
BETTER SOCIETY

Decadal Prediction of wildfire

E. Tourigny

DCPP LPJG-offline experiment :

- LPJG initial states from Klaus' t613 run (EC_Earth-Veg)
- Daily output from BSC's DCPP hindcasts (1960-2015), 5 years, 5 members
- Allows to test the fire model before doing fully-coupled decadal hindcasts of the carbon cycle (CCiCC)

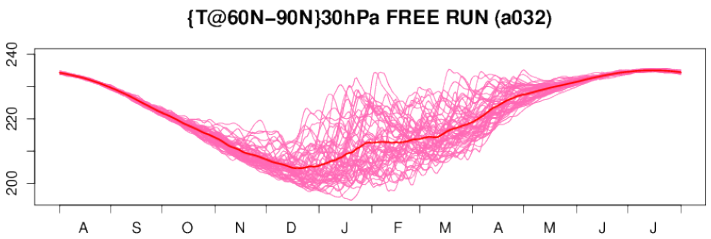


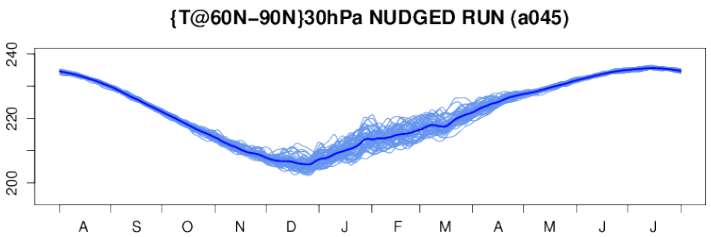
Initializing next generation of forecasts

Assimilation experiments in coupled mode with:

V. Lapin

Atmospheric nudging





J. García-Serrano

Ocean nudging

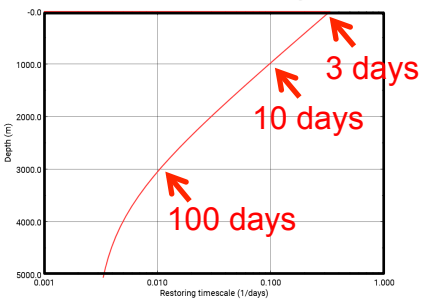
V. Sicardi

Surface restoring

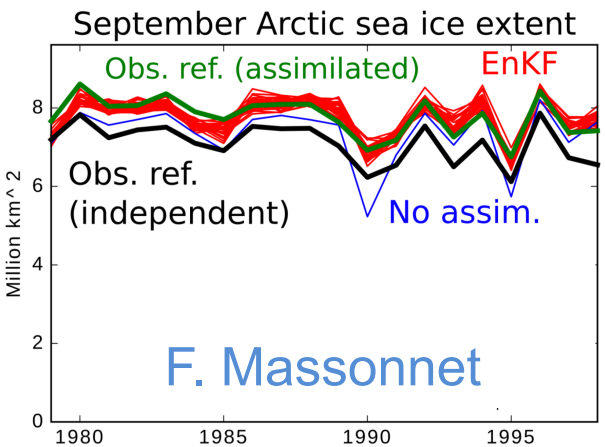
γ_T = -40W/m²/K

γ_S = -150 kg/m2/s/psu

3D Restoring



Sea Ice EnKF Assimilation



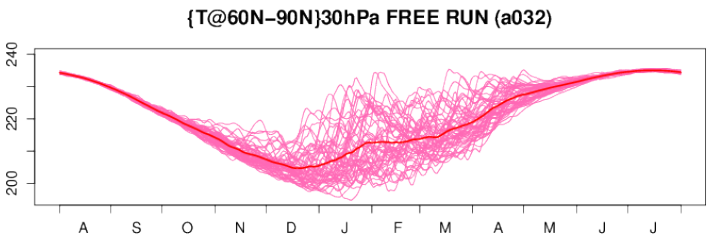
F. Massonnet

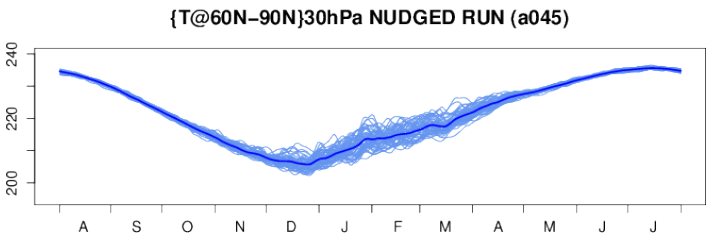
Initializing next generation of forecasts

Assimilation experiments in coupled mode with:

V. Lapin

Atmospheric nudging





J. García-Serrano

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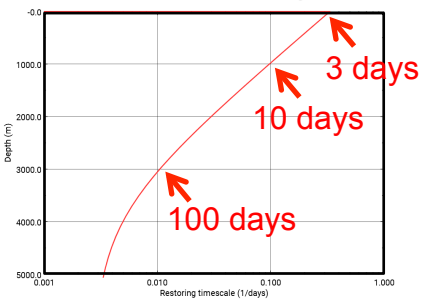
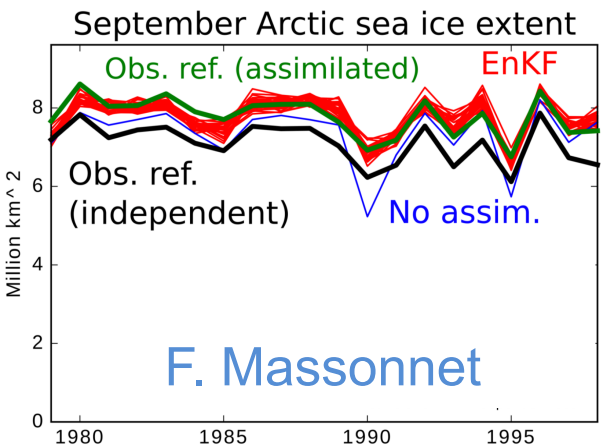


Sea Ice EnKF Assimilation



F. Massonnet

Thank you!
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