www.bsc.es

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

Predicción Climática Decadal Global con el modelo Ec-Earth*:

Avanzando hacia una predicción Operativa en Tiempo Real

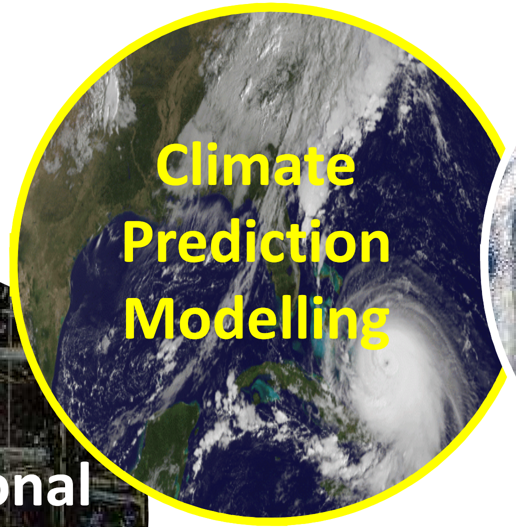
P. Ortega, R. Bilbao, L-P. Caron, F. Doblas-Reyes, M. Menegoz, D. Verfaille, S. Wild

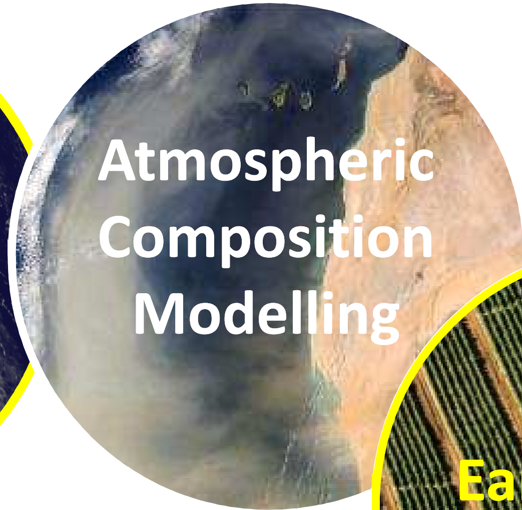
European Climate Prediction system

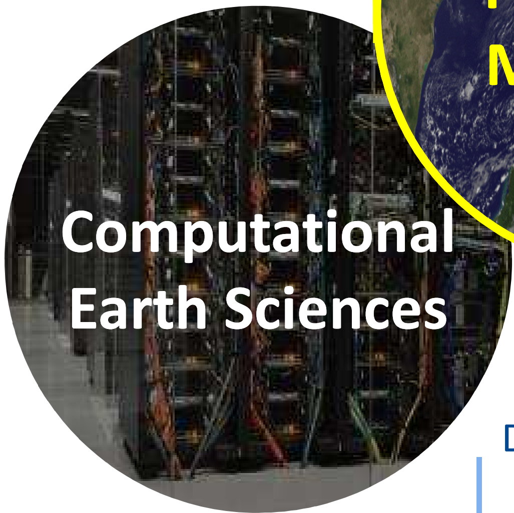
* trabajo desarrollado entre 2010-2018 en IC3 + BSC-ES

Earth Science Department

Environmental modelling and forecasting, with a particular focus on weather, climate and air quality







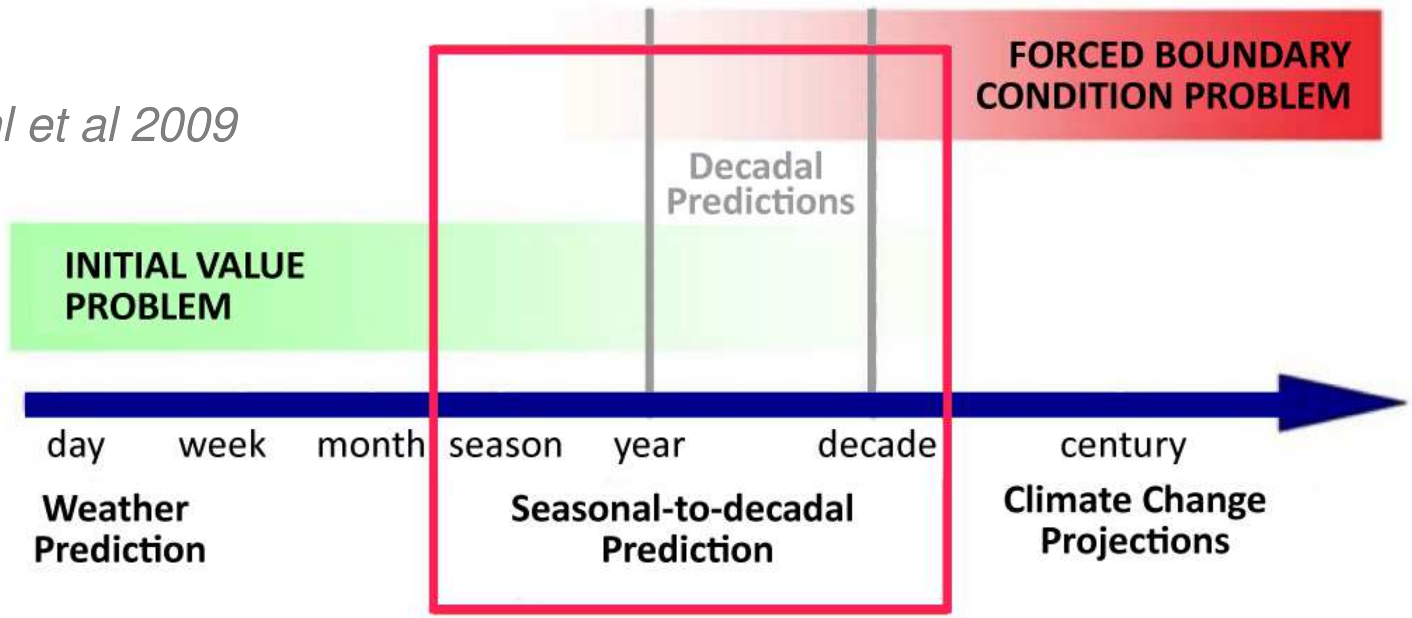
Director: **Francisco Doblas-Reyes**

- 72 people
- Leading: H2020 projects, COPERNICUS contracts, ERC Consolidator Grant and hosts an AXA Chair

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

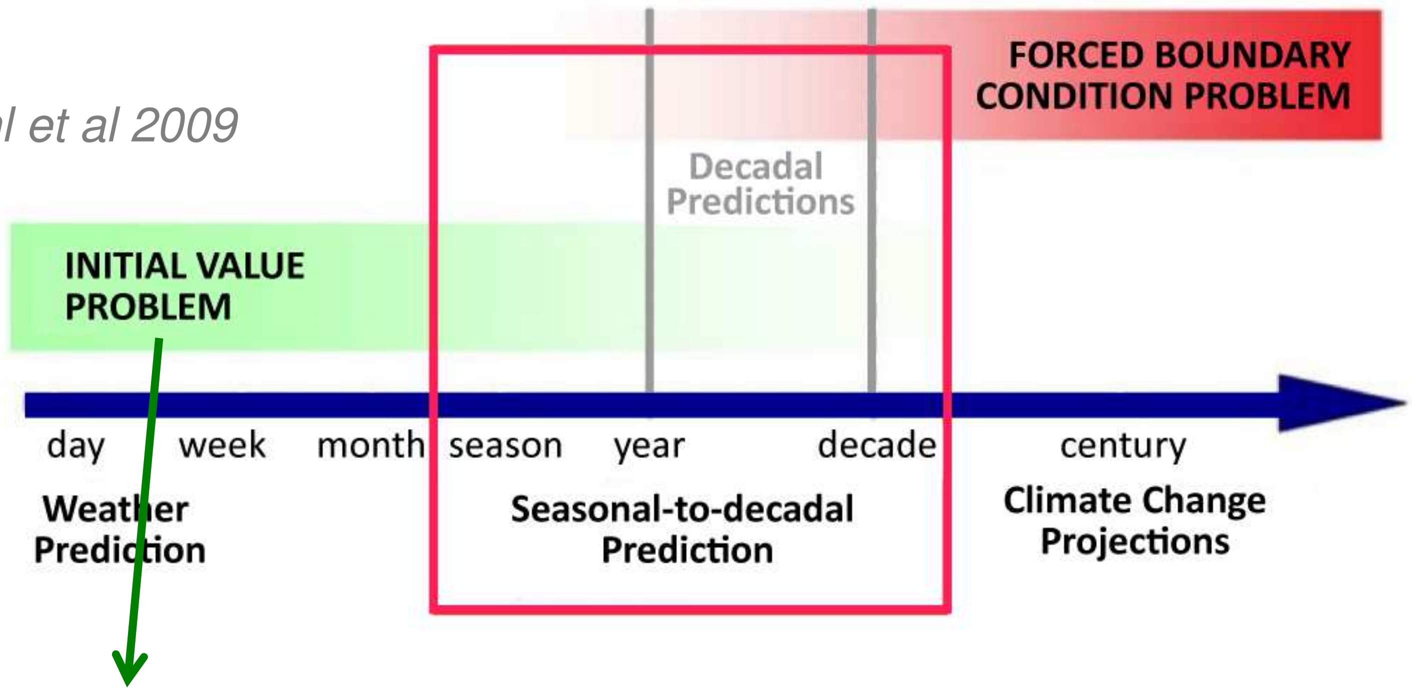
Cornerstones of Climate Prediction

Meehl et al 2009

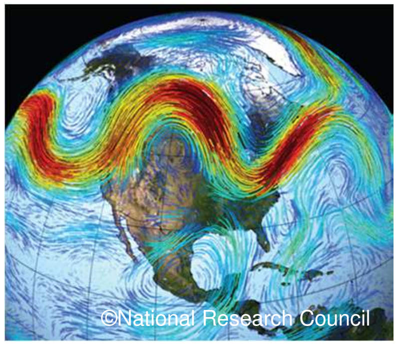


Cornerstones of Climate Prediction

Meehl et al 2009



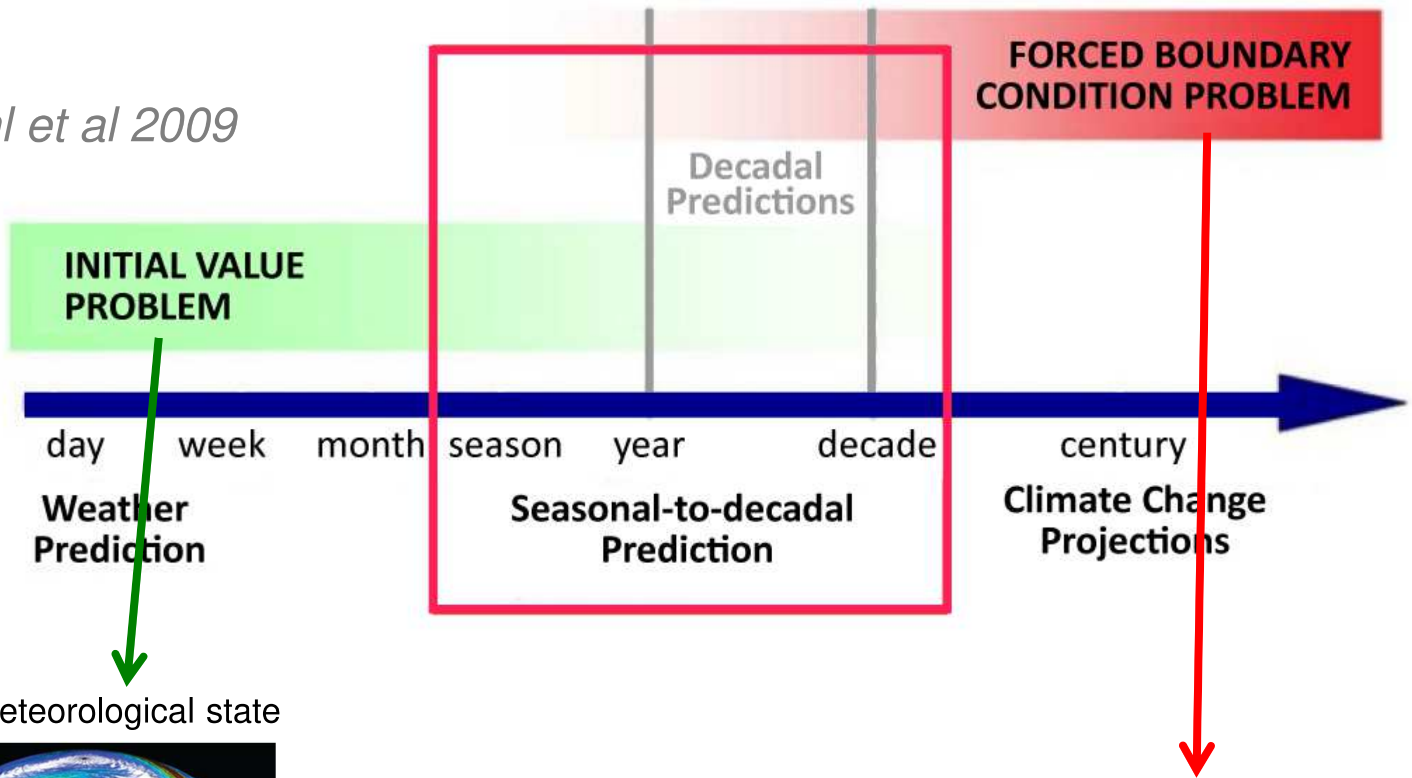
Current Meteorological state



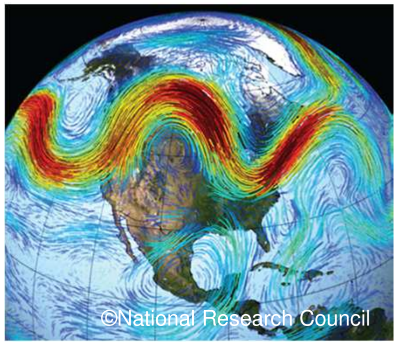
Correct Initialization of internal sources of predictability

Cornerstones of Climate Prediction

Meehl et al 2009

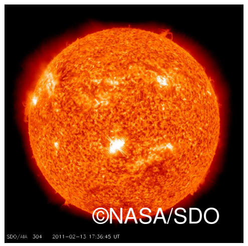


Current Meteorological state



Correct Initialization of internal sources of predictability

Solar Activity



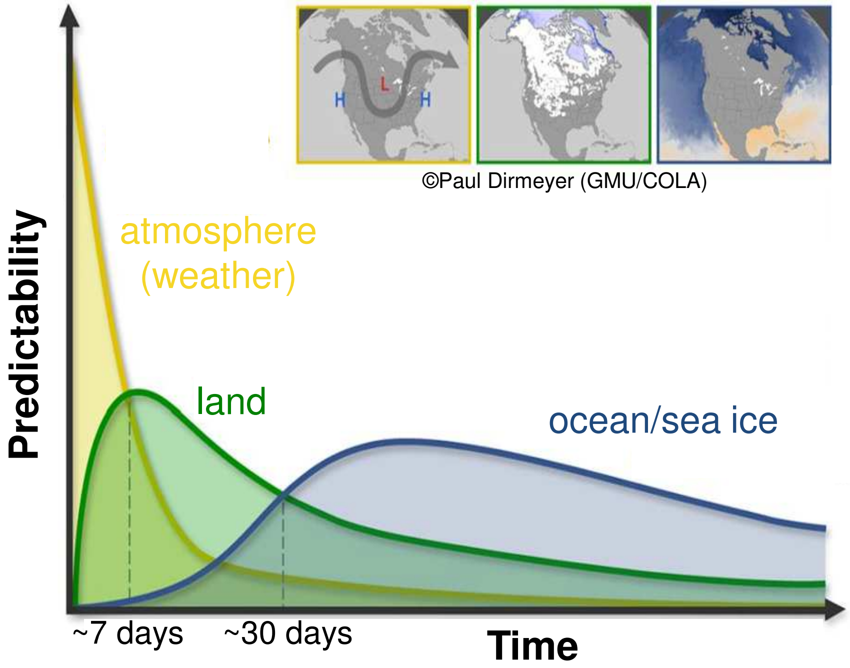
GHGs

Volcanic Aerosols

Good guess of future changes in the forcing

Internal sources of Climate Predictability

Mariotti et al 2018

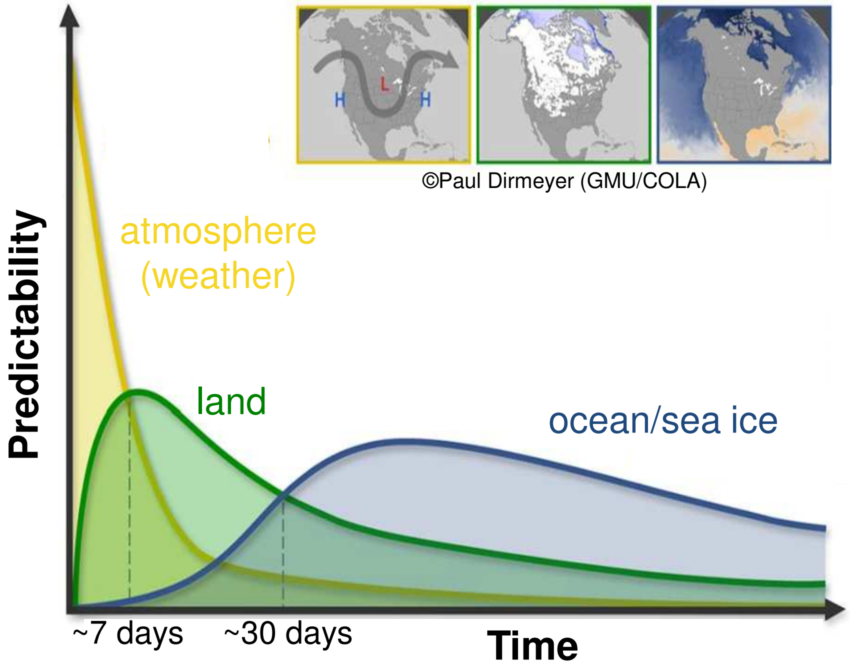


Weather prediction time horizon **~ 10 days**

Because of the chaotic nature of atmospheric variability

Internal sources of Climate Predictability

Mariotti et al 2018



Weather prediction time horizon **~ 10 days**

Because of the chaotic nature of atmospheric variability

Climate prediction time horizon **Weeks Decades**

It relies on the longer memory of other elements of the climate system

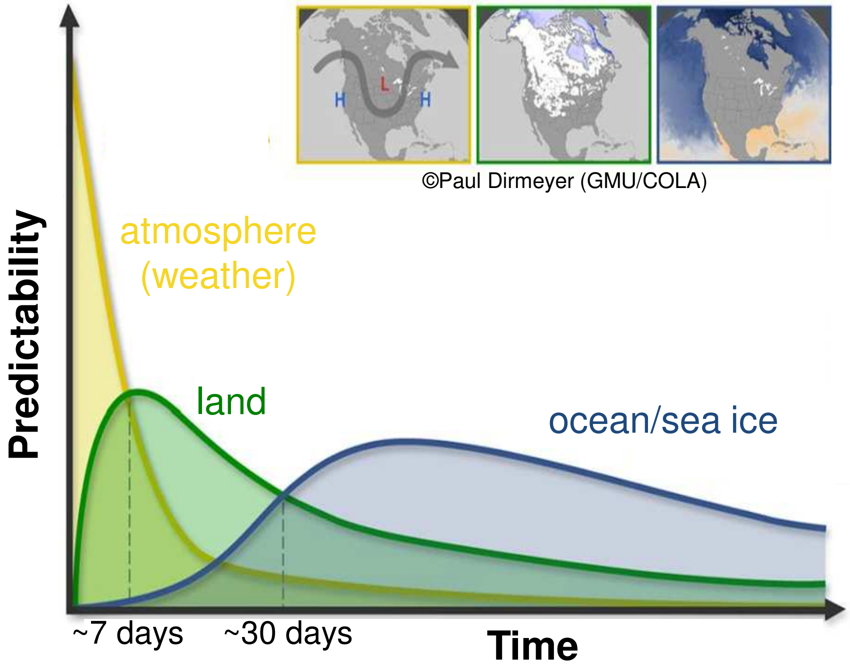
ocean

sea ice

soil moisture

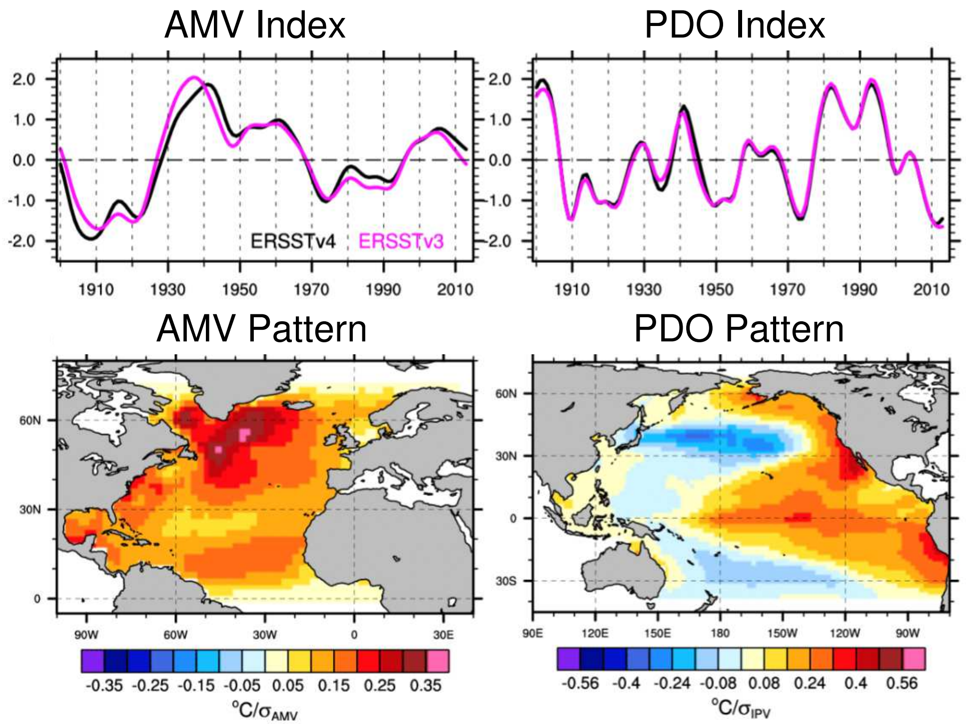
Internal sources of Climate Predictability

Mariotti et al 2018



ocean

The **ocean** exhibits modes of **decadal variability** both in the **Atlantic** and **Pacific** basins



Cassou et al, Technical Note for DCPP-Component C

Introducing our main prediction tool

Barcelona Supercomputing Center
Centro Nacional de Supercomputación
EXCELENCIA SEVERO OCHOA

Model Components

IFS (Atmospheric Model):

T255 (0.75º) ~80km
L91 (top 0.01hPa) ~mesosphere
IFS-HTESSEL (Land Model)

NEMO (Ocean Model):

Nominal 1° Resolution
L75 levels (thousands km deep)
PISCES (Biogeochemistry Model)

LIM (Sea-ice Model):

Multiple (5) ice category

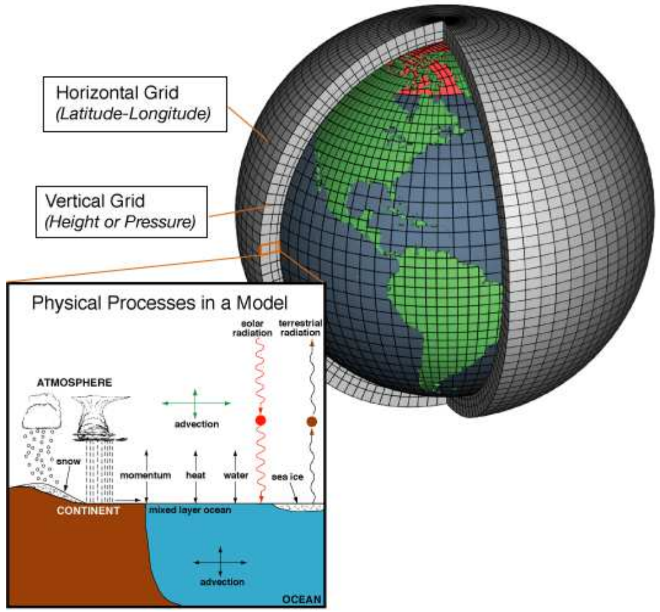
ECMWF Open IFS

IFS-HTESSEL

EC EARTH 3

LIM NEMO PISCES

EC-EARTH
Global Coupled model



Introducing our main prediction tool

Model Components

IFS (Atmospheric Model):

T255 (0.75º) ~80km
L91 (top 0.01hPa) ~mesosphere
IFS-HTESSEL (Land Model)

NEMO (Ocean Model):

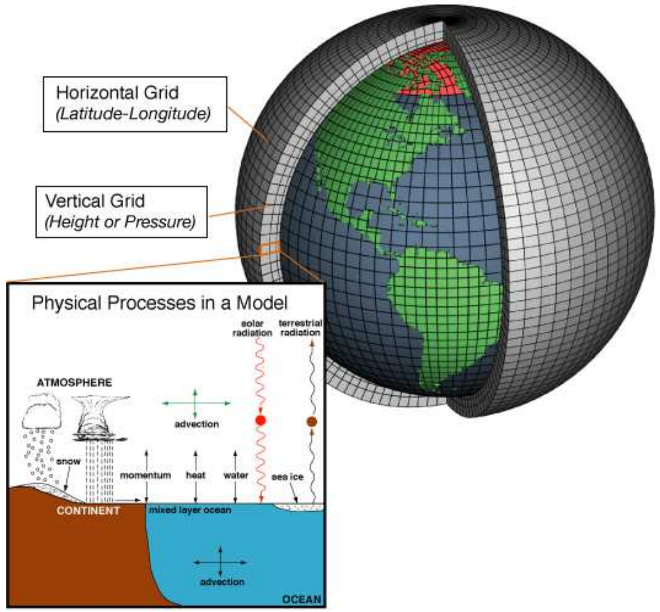
Nominal 1° Resolution
L75 levels (thousands km deep)
PISCES (Biogeochemistry Model)

LIM (Sea-ice Model):

Multiple (5) ice category

IFS-HTESSEL

EC-EARTH
Global Coupled model



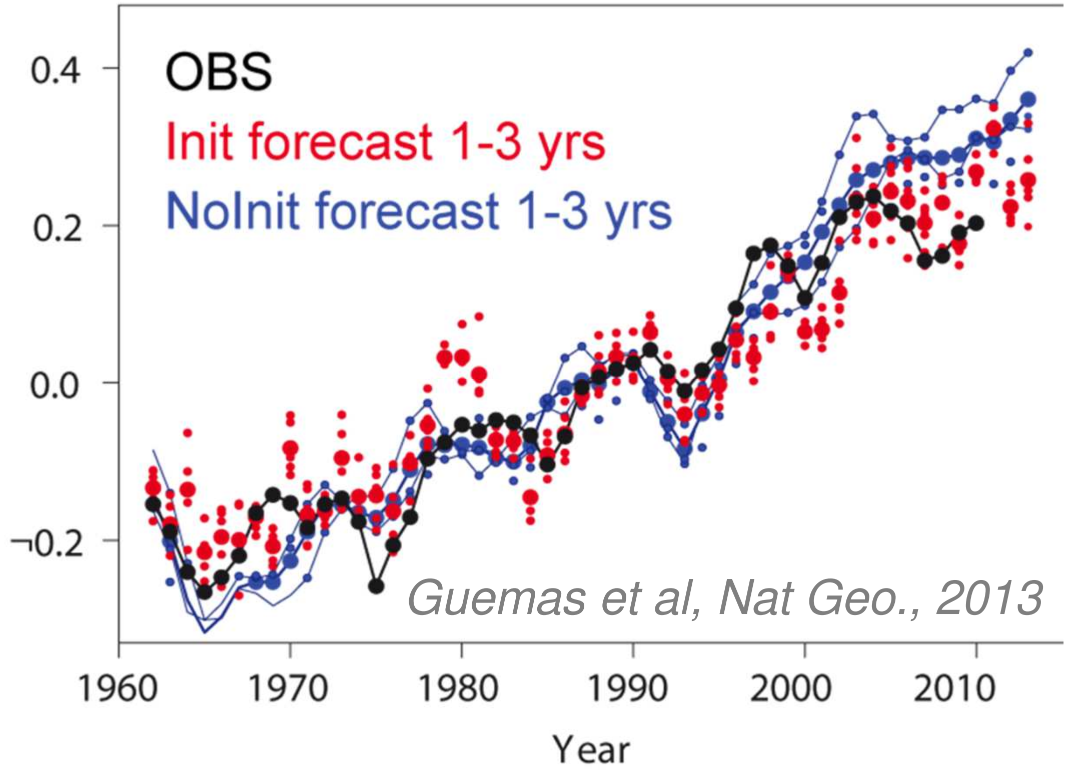
Initial Conditions

produced in-house

Atmosphere reanalysis (**ERA-Interim**)	Sea Ice reanalysis (**IC3/BSC**)
Land reanalysis (**ERA-Land**)	Ocean reanalysis (**ORAS4**)

Two examples in decadal prediction (II)

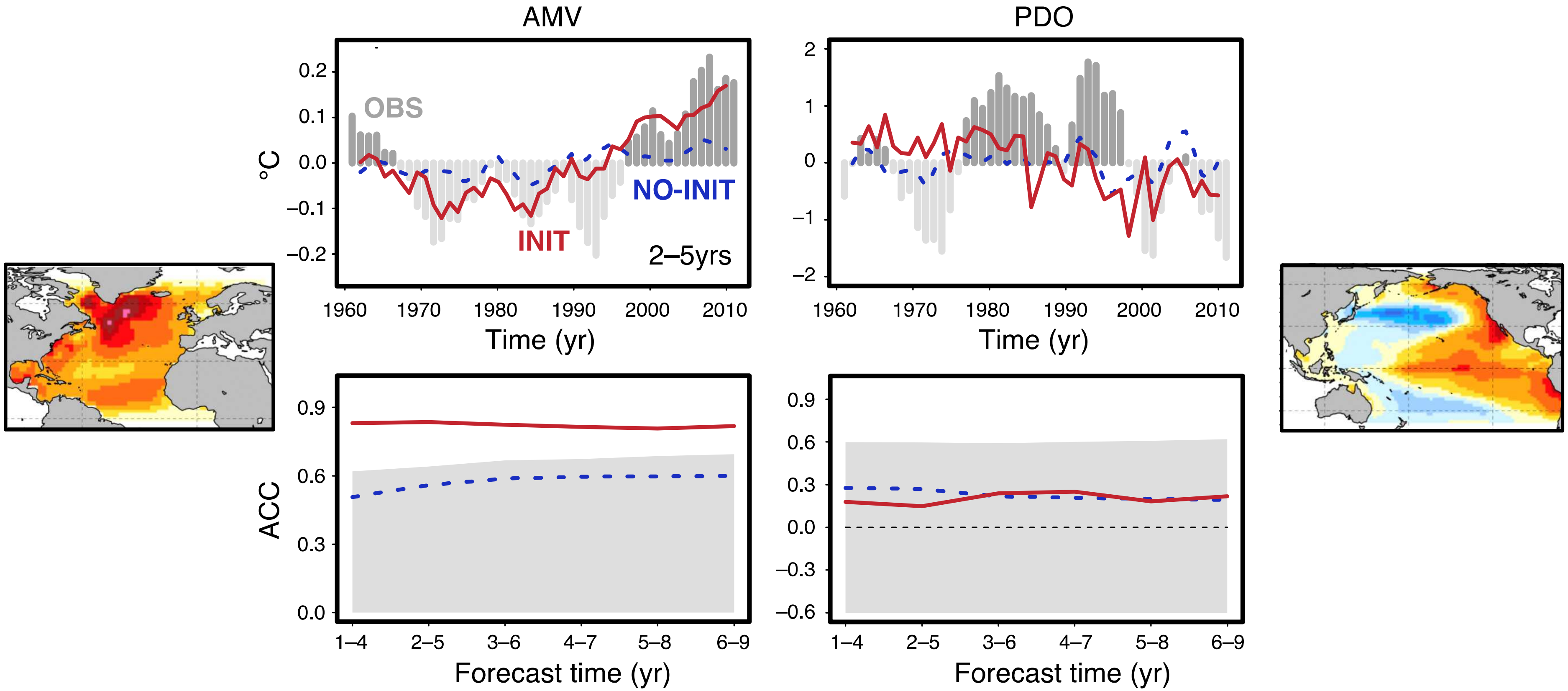
Predictive skill of **global mean surface-air temperature** (Ec-Earth2.3)



Initialised forecasts with EC-Earth reproduce the global temperature, and **describe more accurately** than the non-initialized ones the recent **HIATUS** period, which suggests a **key contribution of internal climate variability**

Two examples in decadal prediction (II)

Predictive skill of **modes of multi-annual climate variability** (in CMIP5)



Doblas-Reyes et al, Nat. Comm., 2013

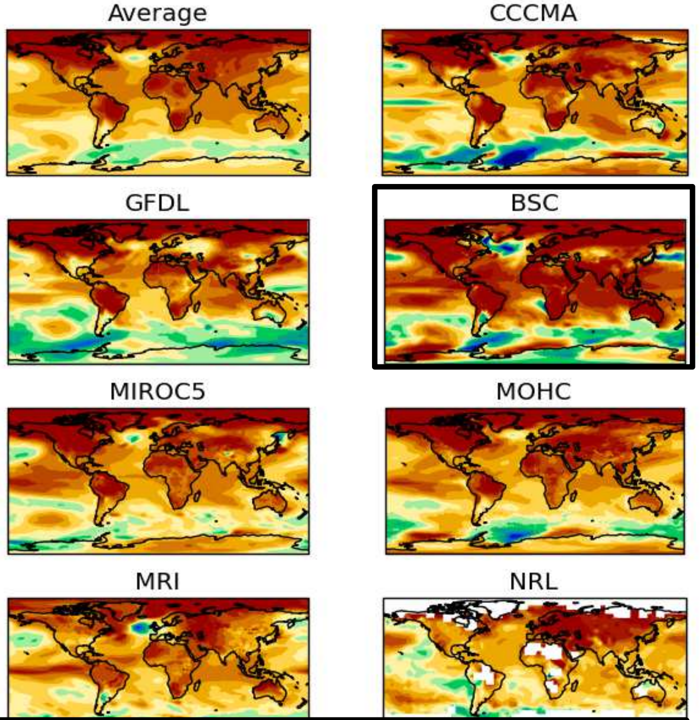
Only in the **Atlantic Ocean**, the **initialized forecasts** show significant **predictive skill** and beat persistence**,** for forecast times of **up to 10 yrs**

Towards Real Time Decadal Climate Prediction

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

2015 predictions for 2016 SAT



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

Smith et al. (2013, ClimDyn)

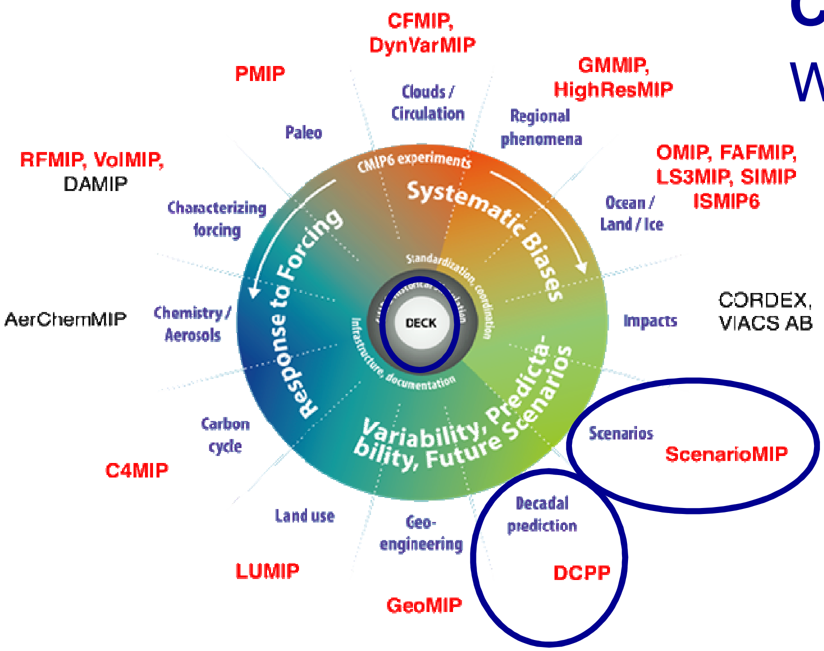
15 centers will contribute to Annual Decadal Climate Prediction Exchange

4 applied for WMO-designation (**BSC** the only non meteorological center)

für Meteorologie
Met Office
Atmospheric Science
SMHI

Next decadal climate prediction activities

Simpkins (2017)



WCRP CMIP6
World Climate Research Programme

Contributions to CMIP6

With EC-Earth 3.2 in standard resolution (~1°)

DCPP Component A:
Retrospective Predictions [1960-2017]

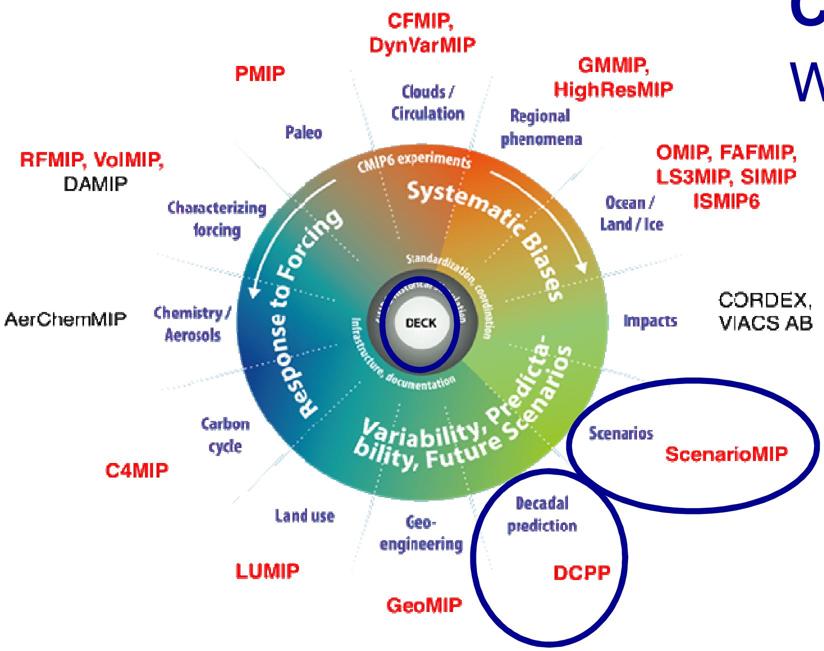
DCPP Component B:
Near-real time Forecasts [2018 onwards]

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

Next decadal climate prediction activities

Barcelona Supercomputing Center
Centro Nacional de Supercomputación
EXCELENCIA SEVERO OCHOA

Simpkins (2017)



WCRP CMIP6
World Climate Research Programme

Contributions to CMIP6

With EC-Earth 3.2 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]

Other H2020 activities

With EC-Earth 3.2 in high resolution (~0.25°)

EUCP
European Climate Prediction system

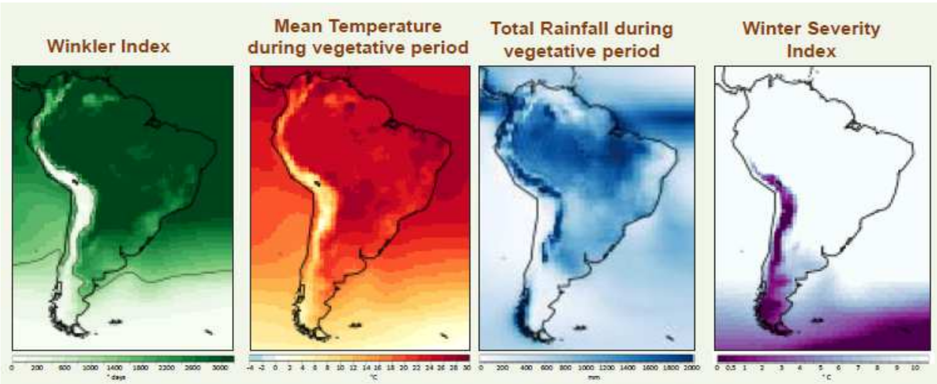
DCPP Component A-like:
Retrospective Predictions [1960-2017]

Decadal climate prediction → Climate Services

Bodegas Torres (and other wineries) are looking for **new vineyard locations**

They have purchased high elevation terrains near the Pyrenees

They are considering South America, in areas with no current wine production



Bodegas Torres is thus requesting **local climate information** (with uncertainty assessments) relevant for the **vegetative cycle of grapes**.

Concluding remarks

Decadal Climate Prediction relies on the **proper initialization** of regions with internal multi-annual climate variability, usually associated with the ocean

Multi-model decadal predictions within DCPP will be a **key contribution to CMIP6**, helping to:

- identify the **regions/variables robustly predictable**

- better **understanding** the origin of **systematic errors**

Decadal Climate Predictions provide important **strategic information** to guide future decisions by **stakeholders and policymakers**

Real-time decadal prediction exchange will continue and will be **enhanced** if the BSC is finally recognised by the WMO as a **global producing center**

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

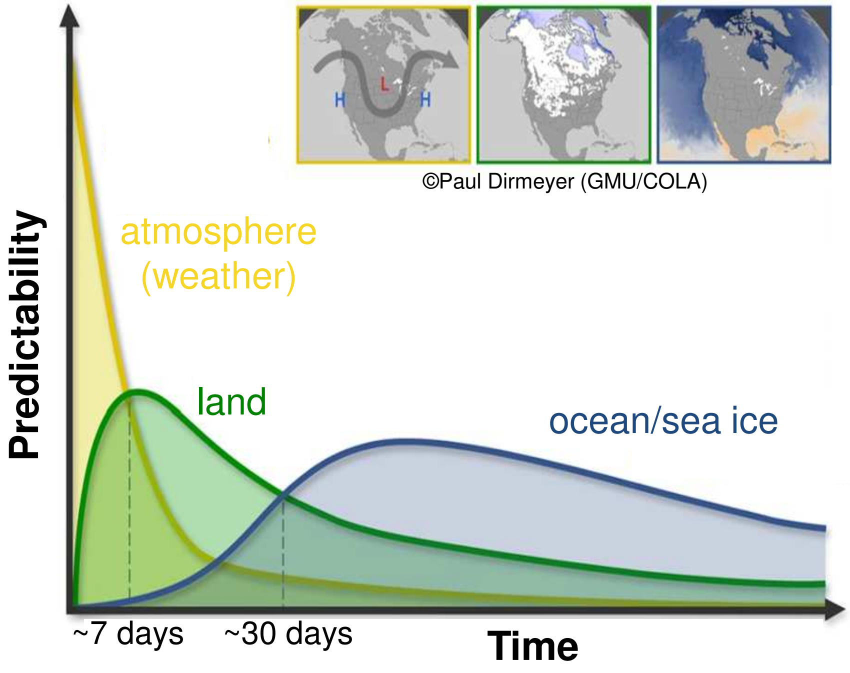
Thank you!

pablo.ortega@bsc.es

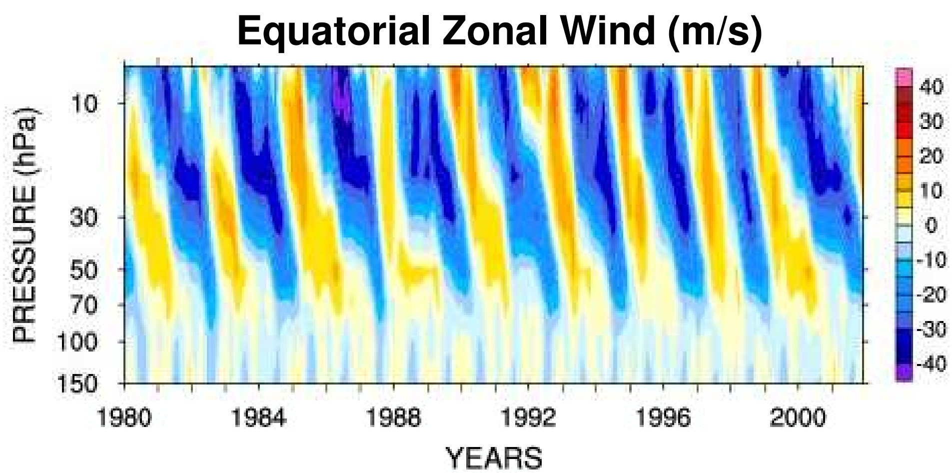
Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Internal sources of Climate Predictability

Mariotti et al 2018

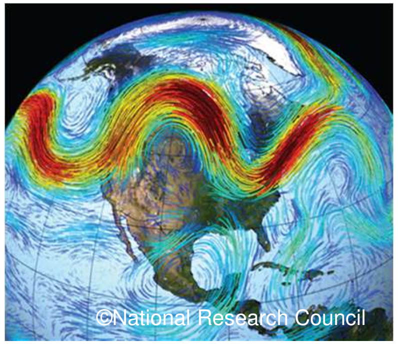


The **atmosphere** can also provide **memory** beyond monthly timescales



Monier & Weare (2011)

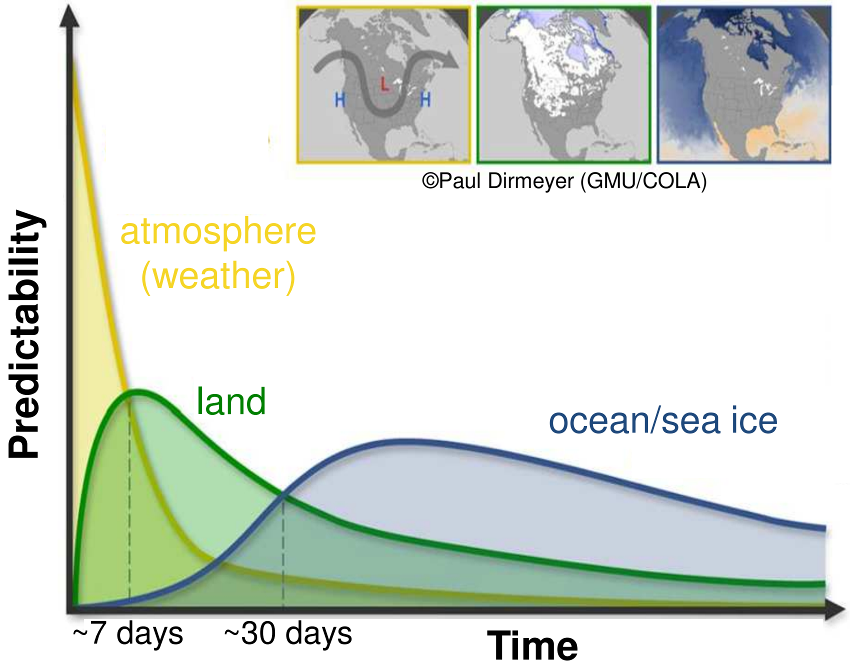
atmosphere



Through its key role on wave propagation that can further impact the polar vortex strength, the **Quasi-biennial Oscillation** can contribute to Northern Hemisphere predictability at <u>seasonal and interannual timescales</u>.

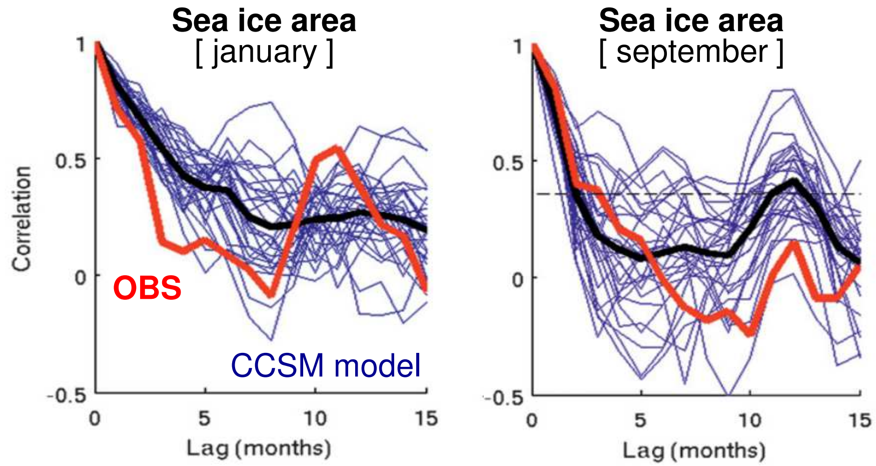
Internal sources of Climate Predictability

Mariotti et al 2018



sea ice

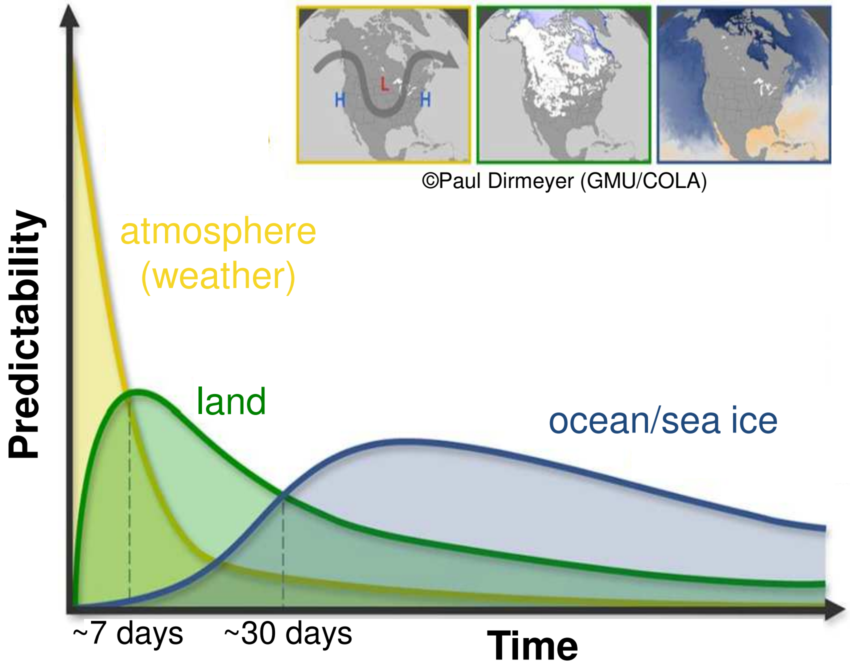
Re-emergence mechanisms in Arctic **sea ice** can provide memory and thus predictability at **seasonal scales**



Blanchard-Wrigglesworth et al 2011

Internal sources of Climate Predictability

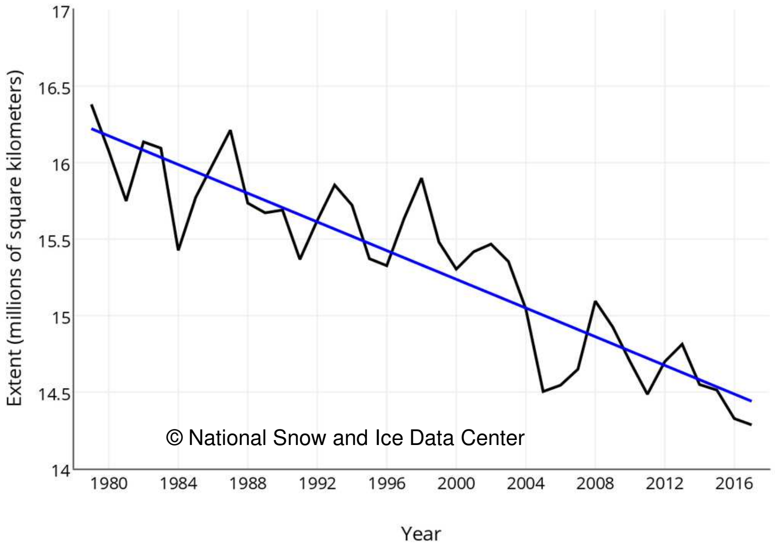
Mariotti et al 2018



sea ice

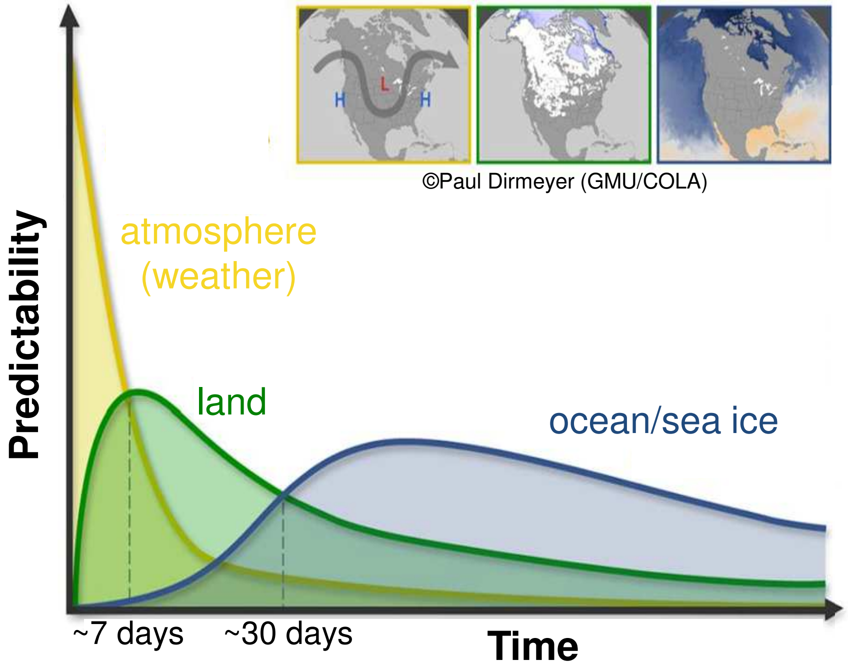
And at longer time-scales Arctic sea ice is experiencing long-term decline

Average Arctic Sea Ice extent
[February 1979-2017]



Internal sources of Climate Predictability

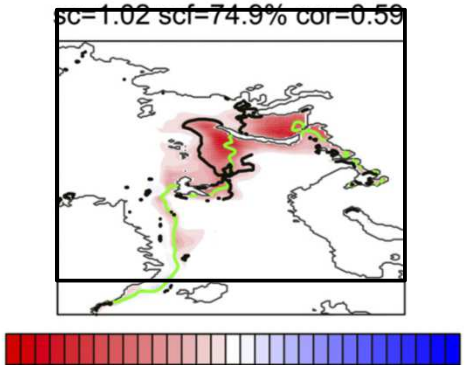
Mariotti et al 2018



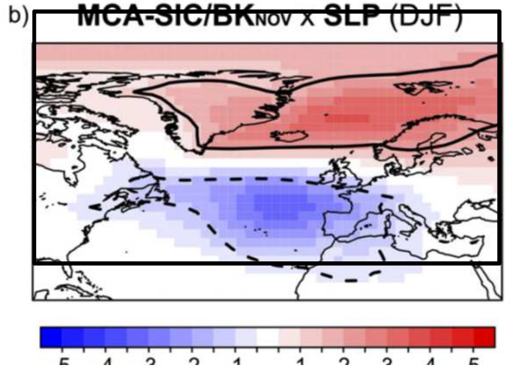
sea ice

While many studies report **important impacts** of Arctic sea **on the climate of the mid-latitudes**

1st EOF of November Sea Ice Cover (SIC)



Predicted DJF Sea Level Pressure



García-Serrano et al 2014

For example, on Europe at **seasonal timescales** through an influence of Barents-Kara Sea SIC changes on the **North Atlantic Oscillation**

Example of **climate service** for the agriculture sector: **wine yields**

Engaging with the users to understand their needs

SOGRAPE VINHOS

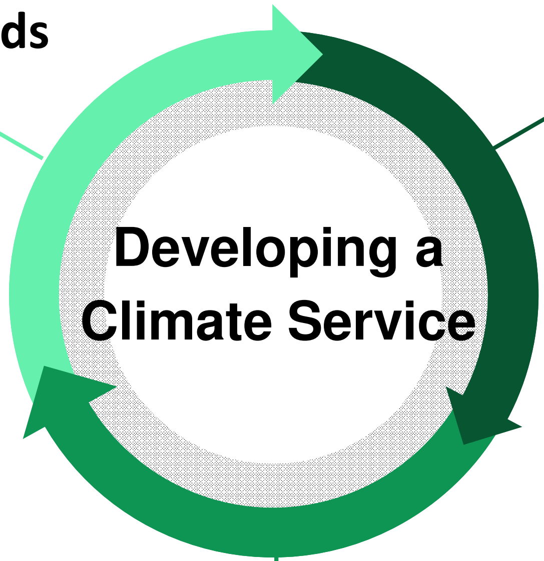
TORRES

RAIMAT

Joint Research Centre JRC

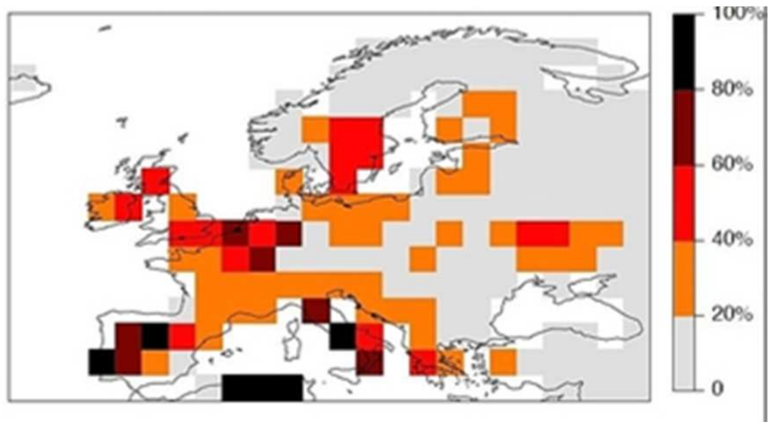
Barilla

DCOOP



Scientific research and development of tailored indicators

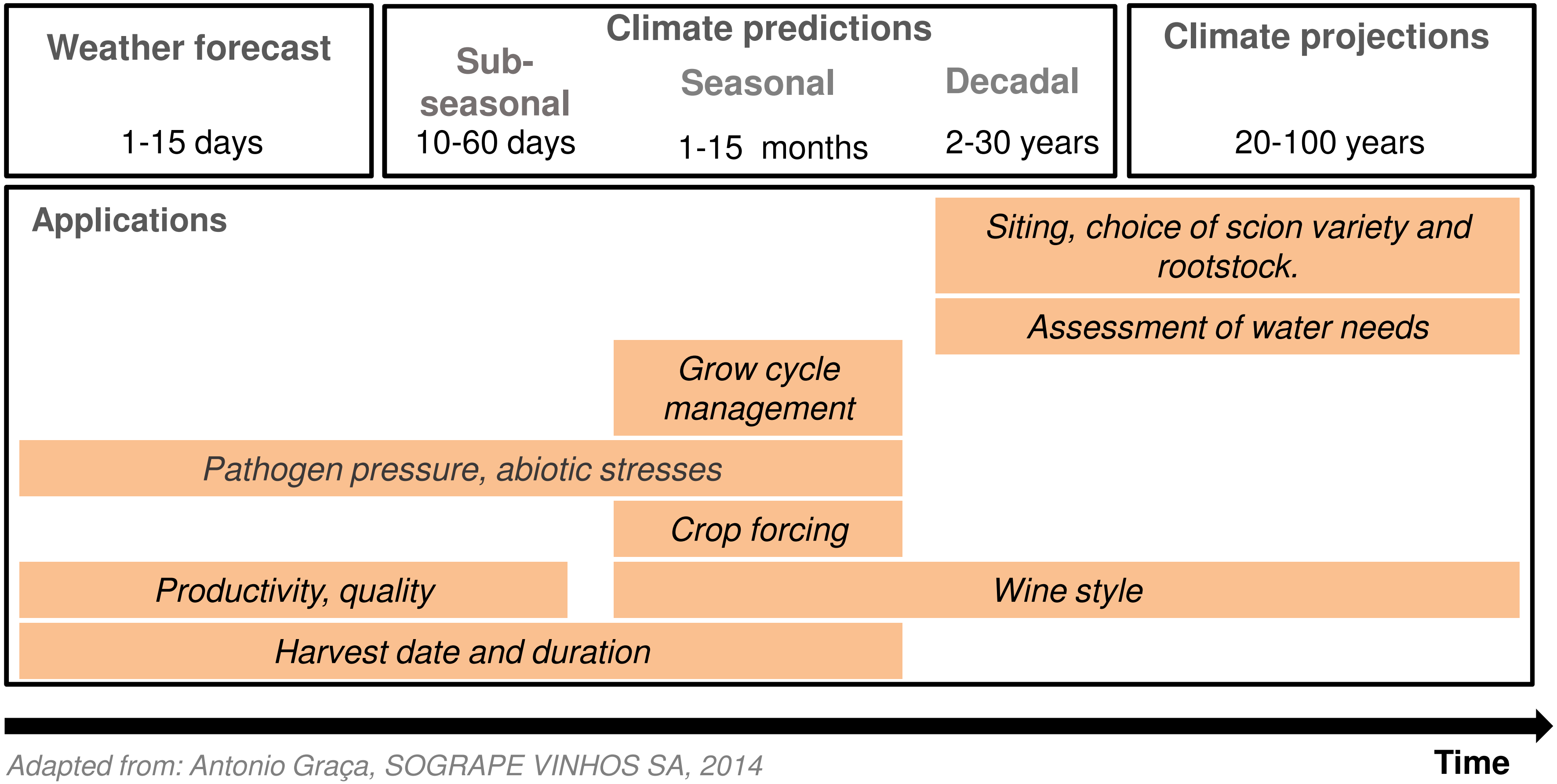
Prediction of extreme drought (August 2017)



Tools and assessment of decision making processes

Terrado, M., I. Christel, D. Bojovic, A. Soret and F. Doblas-Reyes (2017) "Climate change communication and user engagement: ***a tool to anticipate climate change****". Published in Handbook of Climate Change Communication*

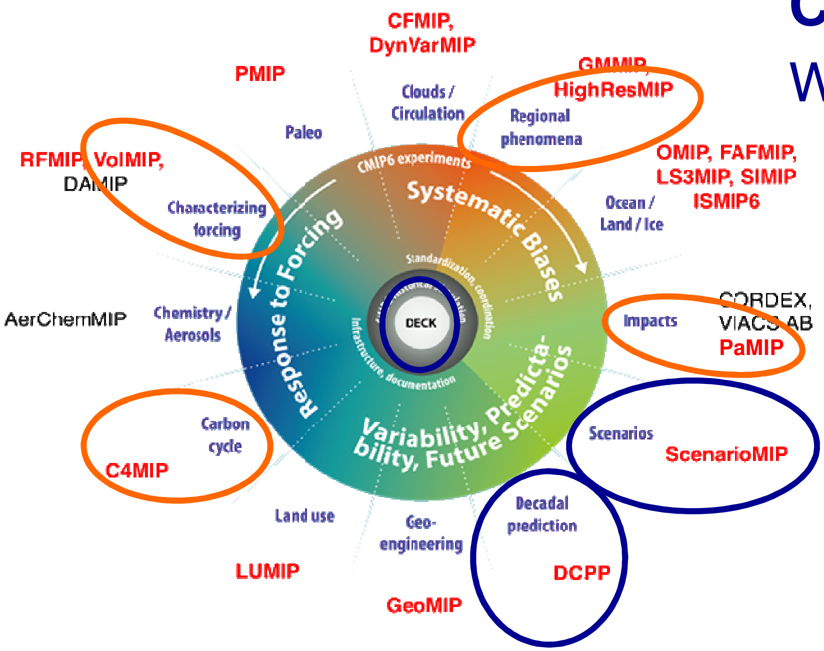
Example of **climate service** for the agriculture sector: **wine yields**



Adapted from: Antonio Graça, SOGRAPE VINHOS SA, 2014

Next decadal climate prediction activities

Simpkins (2017)



Contributions to CMIP6

With EC-Earth 3.2 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 CMIP6 contributions

VolMIP: Evaluating the predictability associated to volcanoes

C4MIP: Investigating the predictability of the carbon cycle

HiResMIP: Determining the advantages of super high resolution (1/12°) PRIMAVERA

PaMIP: Constraining the long-term impacts due to Arctic Sea Ice decline APPLICATE.eu