Predicción Climática Decadal Global con el modelo Ec-Earth*:
Avanzando hacia una predicción Operativa en Tiempo Real

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* 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

- Climate Prediction Modelling
- Atmospheric Composition Modelling
- Earth System Services
- Computational Earth Sciences

Director: Francisco Doblas-Reyes

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

Meehl et al 2009

INITIAL VALUE PROBLEM

Weather Prediction

day week month season year decade century

FORCED BOUNDARY CONDITION PROBLEM

Decadal Predictions

Seasonal-to-decadal Prediction

Climate Change Projections
Cornerstones of Climate Prediction

Correct Initialization of internal sources of predictability

Meehl et al 2009

Initial Value Problem

Weather Prediction

Current Meteorological state

FORCED BOUNDARY CONDITION PROBLEM

Decadal Predictions

Seasonal-to-decadal Prediction

Climate Change Projections
Cornerstones of Climate Prediction

Correct Initialization of internal sources of predictability

Meehl et al 2009

FORCED BOUNDARY CONDITION PROBLEM

Solar Activity

GHGs

Volcanic Aerosols

Good guess of future changes in the forcing
Internal sources of Climate Predictability

Mariotti et al 2018

Weather prediction

Because of the chaotic nature of atmospheric variability
Internal sources of Climate Predictability

Mariotti et al 2018

Weather prediction  

\[ \text{time horizon} \sim 10 \text{ days} \]

Because of the chaotic nature of atmospheric variability

Climate prediction  

\[ \text{time horizon} \text{ Weeks Decades} \]

It relies on the longer memory of other elements of the climate system
The ocean exhibits modes of decadal variability both in the Atlantic and Pacific basins.
Introducing our main prediction tool

**IFS (Atmospheric Model):**
- T255 (0.75°) ~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

EC-EARTH
Global Coupled model
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**Initial Conditions**
- Atmosphere reanalysis (ERA-Interim)
- Sea Ice reanalysis (IC3/BSC)
- Land reanalysis (ERA-Land)
- Ocean reanalysis (ORAS4)

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

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

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

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)
Next decadal climate prediction activities

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]
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Other H2020 activities
With EC-Earth 3.2 in high resolution (~0.25°)

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

Simpkins (2017)
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.
Thank you!
pablo.ortega@bsc.es
Internal sources of Climate Predictability

Mariotti et al 2018

The atmosphere can also provide memory beyond monthly timescales

Equatorial Zonal Wind (m/s)

Monier & Weare (2011)

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 seasonal and interannual timescales.
Internal sources of Climate Predictability

Mariotti et al 2018

Sea ice area
- January
- September

OBS
CCSM model

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

Blanchard-Wrigglesworth et al 2011

Time
Predictability

~7 days ~30 days

atmosphere (weather)
land
ocean/sea ice

©Paul Dirmeyer (GMU/COLA)

© National Snow and Ice Data Center
Internal sources of Climate Predictability

Mariotti et al 2018

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

Average Arctic Sea Ice extent
[ February 1979-2017 ]

© National Snow and Ice Data Center
Internal sources of Climate Predictability

Mariotti et al 2018

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

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

Scientific research and development of tailored indicators

Prediction of extreme drought (August 2017)

Developing a Climate Service

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**

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Adapted from: Antonio Graça, SOGRAPE VINHOS SA, 2014
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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°)
PaMIP: Constraining the long-term impacts due to Arctic Sea Ice decline