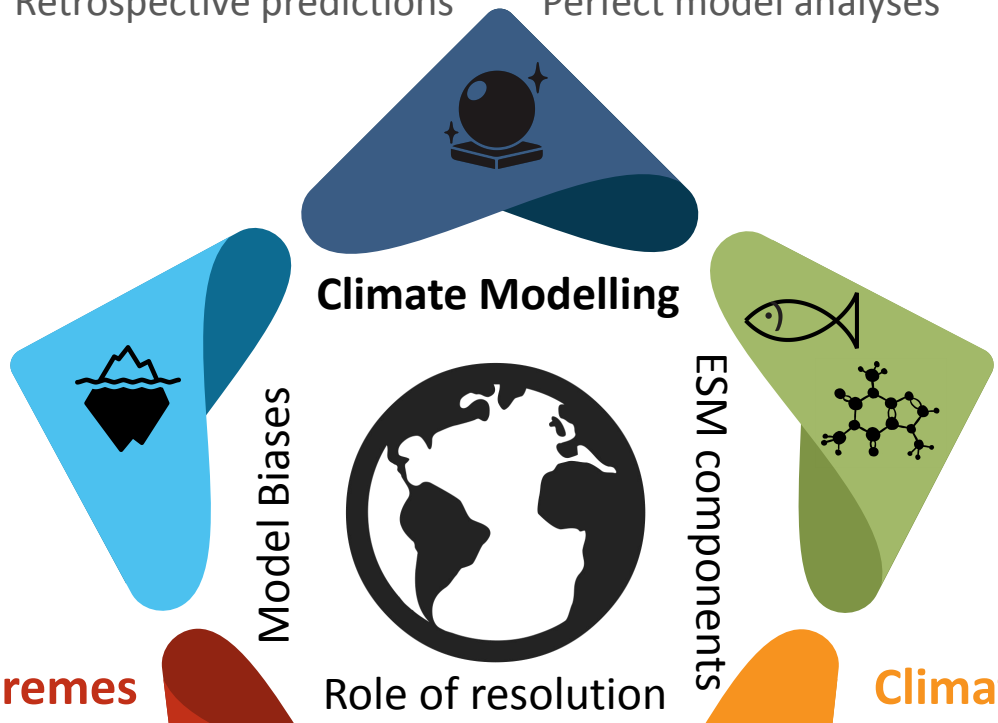
Climate Prediction Group

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

Seasonal-to-decadal Climate Prediction

Real time predictions
Retrospective predictions
Initialization/Assimilation
Perfect model analyses



Cryosphere

Predictability
Feedbacks
Remote Impacts

Biogeochemistry

Marine ecosystems
Carbon cycle
Wildfires
Predictability
Climate Change Mitigation

Climate Extremes

Tropical/extratropical storms
Heatwaves
Heavy precipitation
Attribution to climate drivers
Feedbacks

Climate Mechanisms

Interbasin teleconnections
Bias-development
Initial shocks
Sensitivity studies

EUCP (Decadal Climate Prediction)

Goal of the project: Producing actionable climate information for risk-based planning for the next 1-40 years, combining information from climate predictions and projections.

- Producing and analysing **EC-Earth3 decadal climate predictions** (***decadal.bsc.es***)
- Improving the initialisation: producing **historical reconstructions** (coupled nudging) and investigating **initialisation methods**.
- **High resolution** predictions.

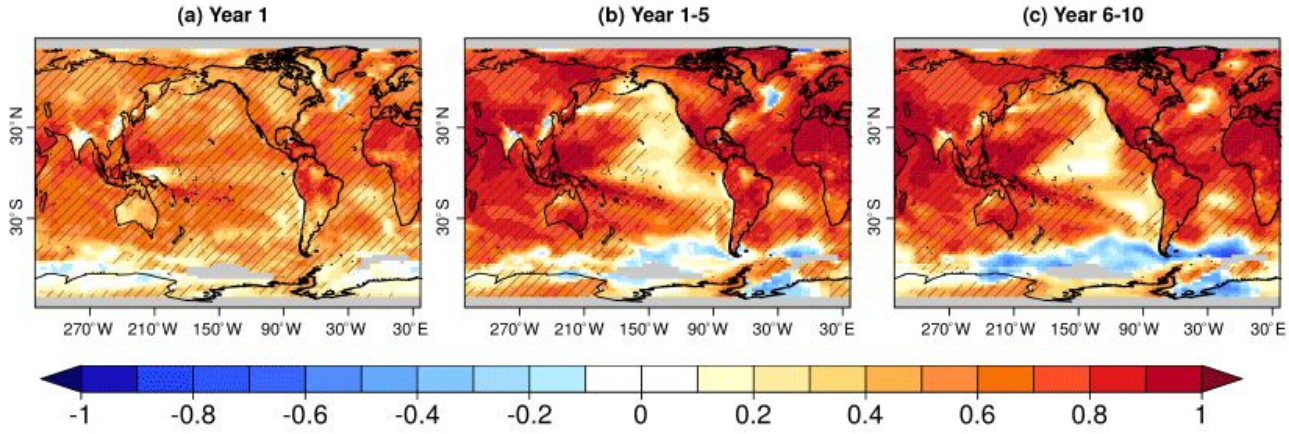


Fig. Anomaly correlation coefficient (ACC) for the annual surface temperature (SAT and SST blend) in EC-Earth3 decadal predictions.

People involved: F. Doblas-Reyes, M. Donat, S. Wild, R. Bilbao, R. Mahmood, D. Bojovic, A. Carreric, C. Delgado-Torres, Y. Ruprich-Robert, B. Solaraju, V. Lapin, F. López

EUCP (Multi-Decadal Climate Prediction)

Barcelona Supercomputing Center
Centro Nacional de Supercomputación
EXCELENCIA SEVERO OCHOA

- Understanding **predictability** with idealised simulations:
  - Atlantic Multidecadal Variability
  - Volcanic Eruptions
  - 'Perfect model'
- Exploring the predictability of **application-relevant features**, e.g. weather regimes, winter storms, wind speeds, drought (in collaboration with ESS).
- **Constraining climate projections** using decadal predictions.

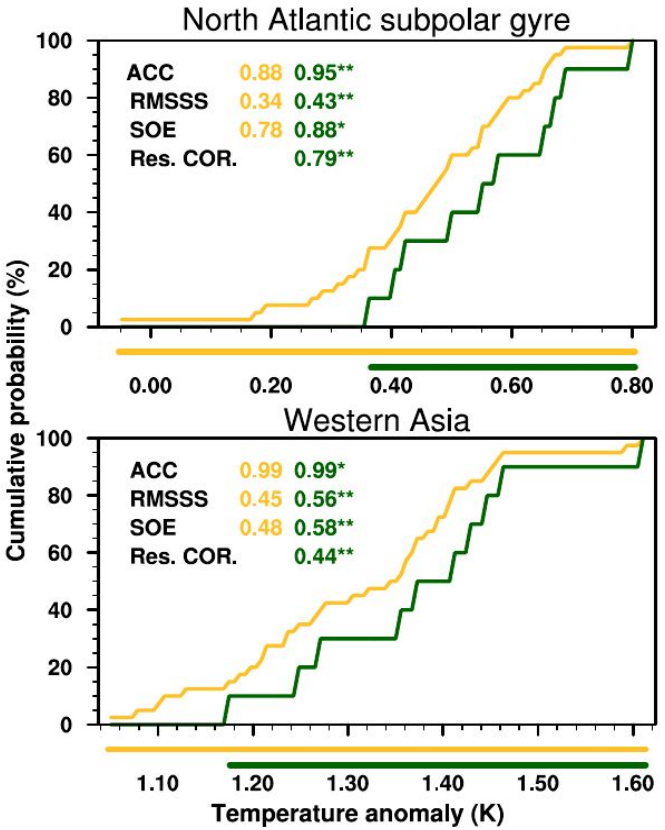


Fig: Near-term summer temperature projections. Cumulative distribution functions of 20-year average (i.e. 2016-2035) projections of summer surface air temperature anomalies (Mahmood et al., submitted)

EUCP
European Climate Prediction system

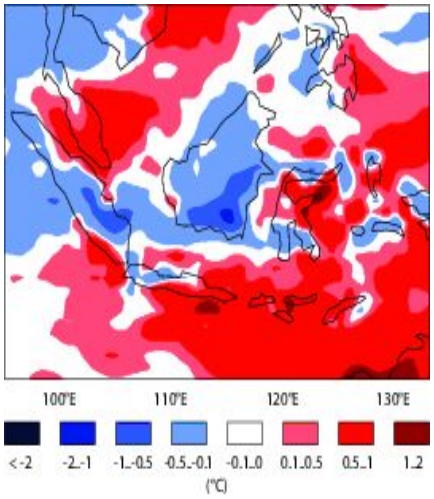
People involved: F. Doblas-Reyes, M. Donat, S. Wild, R. Bilbao, R. Mahmood, D. Bojovic, A. Carreric, C. Delgado-Torres, Y. Ruprich-Robert, B. Solaraju, V. Lapin

CONFESS (Seasonal and Decadal Prediction)

Barcelona Supercomputing Center
Centro Nacional de Supercomputación
EXCELENCIA SEVERO OCHOA

Goal of the project: Improve the representation of global trends and regional extremes in next generation of C3S earth system reanalyses and seasonal forecasts.

Implement the capability to anticipate emissions of **biomass burning.**

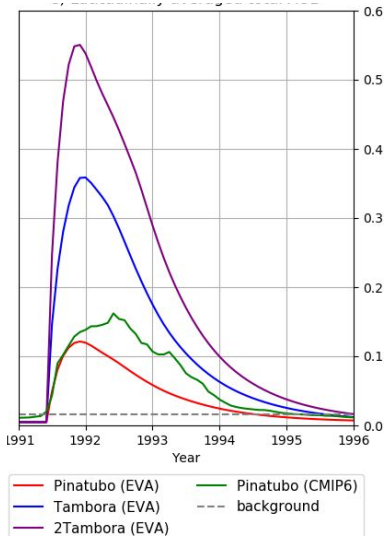


Cooling due to smoke aerosols predicted 6 months ahead.

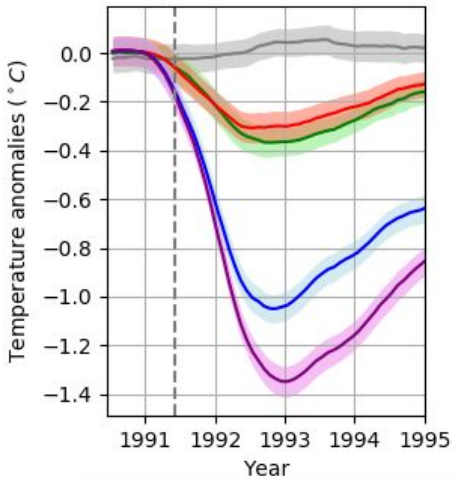
2m Temp anomaly Oct 2015 Forecast from 1st May With "perfect" aerosols

Implement the capability to respond to **volcanic eruptions.**

a) Aerosol Optical Depth



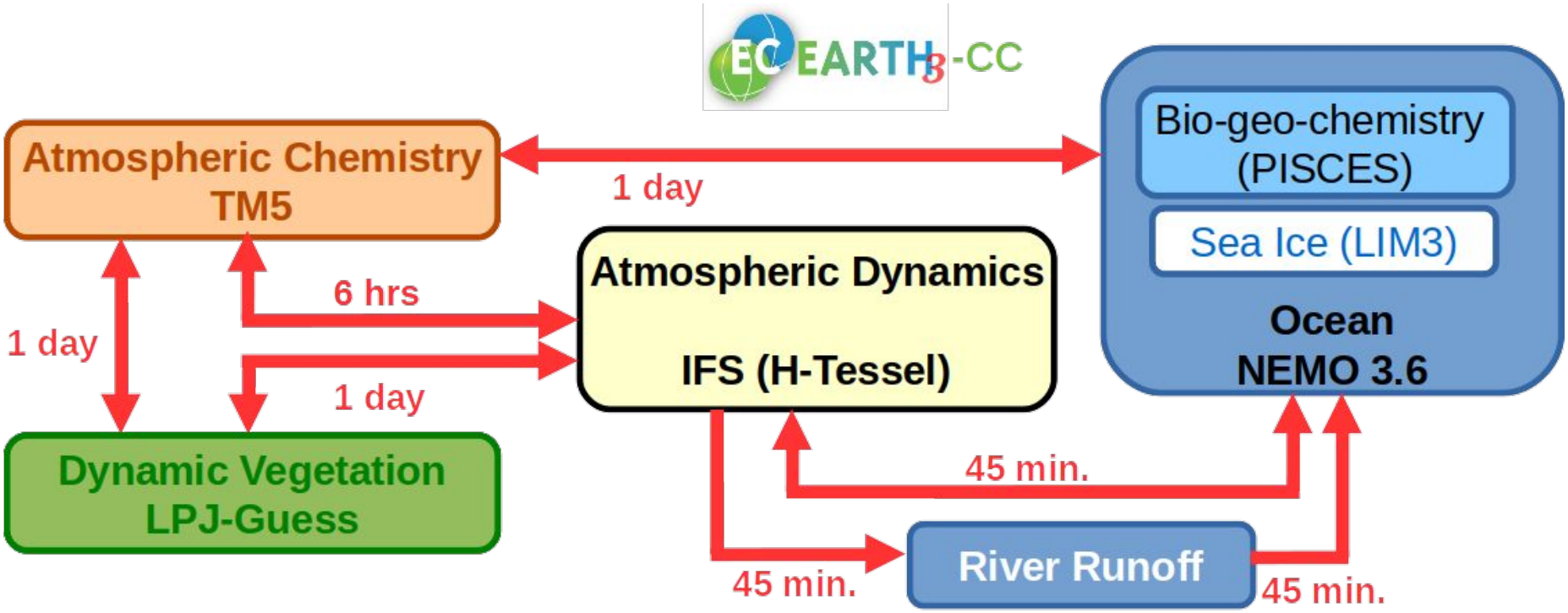
b) Global Mean Temperature Response



People involved: R. Bilbao, E. Tourigny, C. Gomez Gonzalez, G. Carella, P. Ortega, M. Donat

CONFESS
Consistent representation of temporal variations of boundary forcings in reanalyses and seasonal forecasts

Earth System Model - EC-Earth3-CC



LANDMARC

TRIATLAS

Climate-Carbon Interactions in the Current Century

DeCUSO - OPERA

GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN

ORCAs ReSPonSe

JuniorLeader Postdoctoral Fellowships Programme BECASCAIXA

4 MIP

People involved: E. Tourigny, R. Bernardello, V. Sicardi, V. Lapin V., A. Ramos, P. Ortega, M. Galí, Y. Ruprich-Robert, J. Llort, M. Falls, M. Gonçalves, E. Bergas, C. Pérez

4C (s2d predictions in Earth System Models)

Goal of the project: To reduce the knowledge gap in the climate sensitivity to CO2 emissions and to develop predictive systems of near-term atmospheric CO2 growth rate

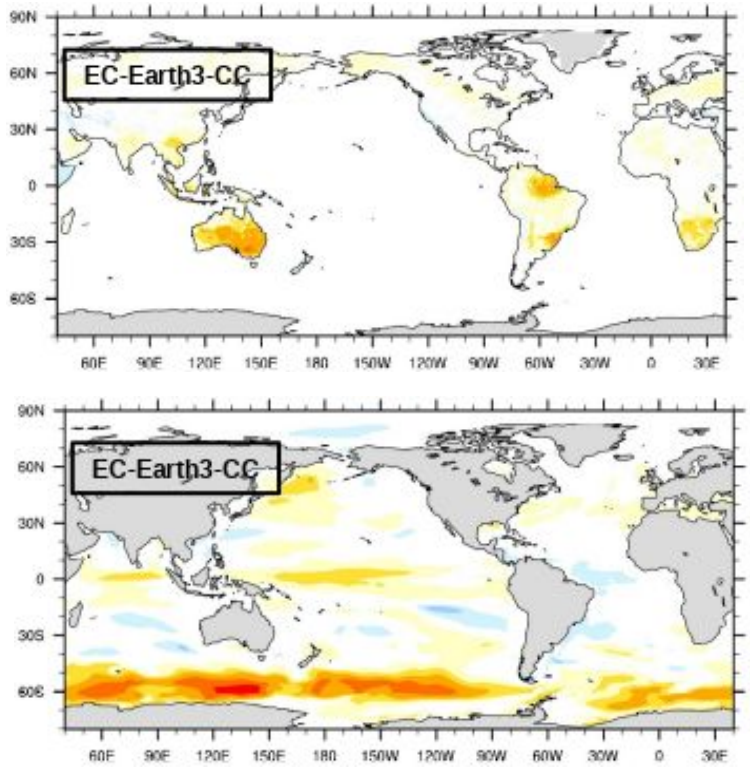
Potential predictability of carbon sinks and atmospheric CO2 concentrations

Key regions and drivers

First atm CO2 predictions to assist implementation of the Paris Agreement

Improved climate projections

Improved carbon cycle reconstructions



Tropical forests, S Ocean and Eq Pacific main drivers

People involved: E. Tourigny, Y. Ruprich-Robert, R. Bernardello, V. Sicardi, P. Ortega, V. Lapin, A. Ramos

4C Climate-Carbon Interactions in the Current Century

TRIATLAS (s2d prediction in Earth System Models)

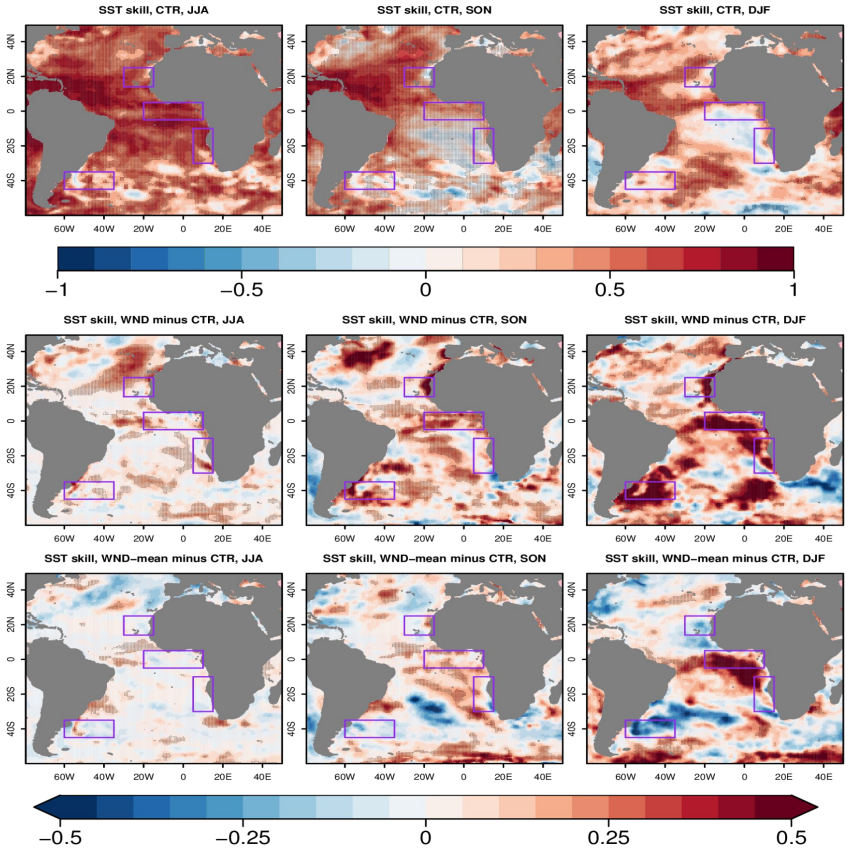
Barcelona Supercomputing Center
Centro Nacional de Supercomputación
EXCELENCIA SEVERO OCHOA

Goal of the project: To assess the South and Tropical Atlantic marine ecosystems and develop a framework for predicting its future changes

Part 1: Assessment of model biases on the ESM seasonal prediction skill

Part 2: Perfect model prediction study: Evaluate the potential predictability of relevant biogeochemical variables

Part 3: Providing frontier seasonal to multi-decadal forecasts and multi-decadal to centennial scenario simulations with TRIATLAS ESMs



People involved: E. Exarchou, J. Llort, R. Bernardello, V. Sicardi, P. Ortega

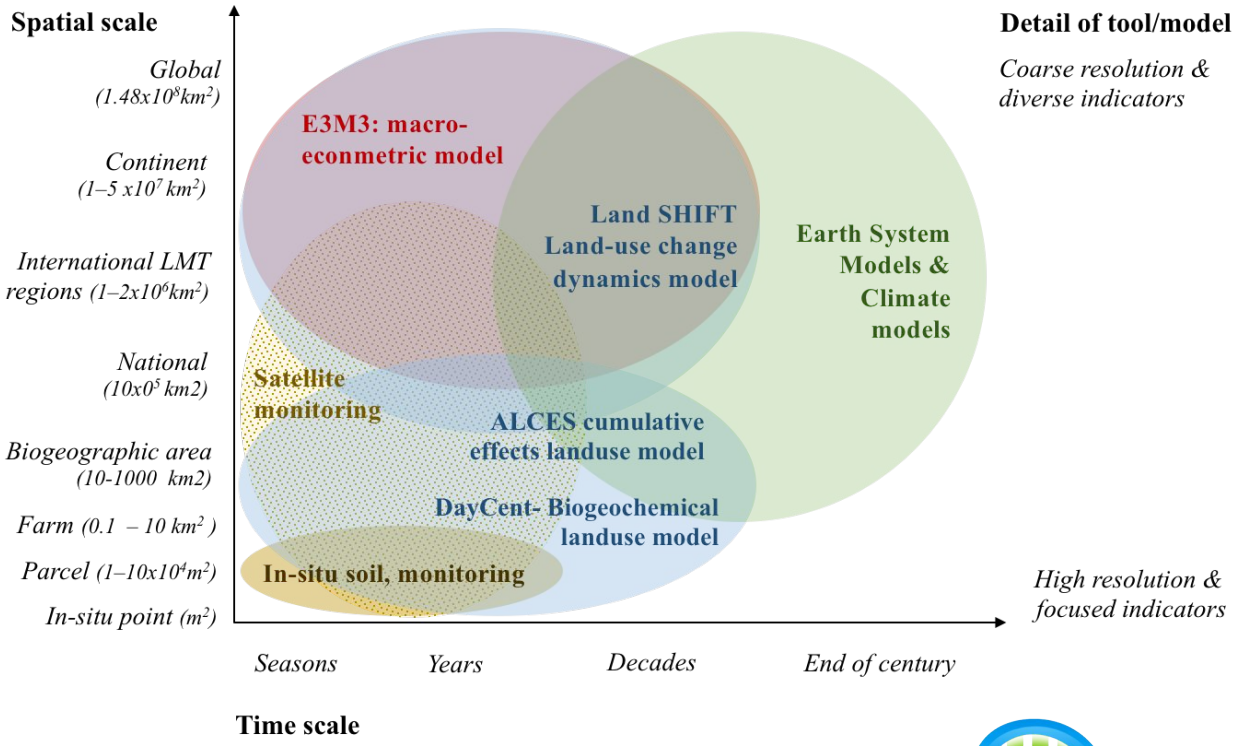
LANDMARC (Climate Change Mitigation)

Barcelona Supercomputing Center
Centro Nacional de Supercomputación
EXCELENCIA SEVERO OCHOA

Goal of the project: Explore the negative emissions / climate change mitigation potentials from large-scale implementation of land-based mitigation technologies (including reforestation, adjusted agricultural techniques, etc.)

WP4: Climate risk assessment for the LMT implementations

WP7: Assess mitigation potential from upscaled LMT implementations in ESM simulations



People involved: M. Donat, E. Tourigny, R. Bernardello, N. Pérez Zanón

LANDMARC

PhD Bianca Mezzina (Teleconnections)

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

Goal of the PhD: Understanding the dynamics and impacts of the ENSO (El Niño-Southern Oscillation) teleconnection in the North Atlantic and Europe in late winter

Supervisors: Javier García-Serrano (UB/BSC), Ileana Bladé (UB)

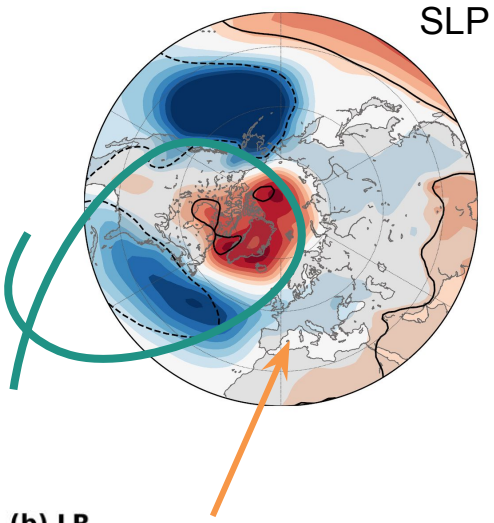
Research activity 1:

✔ Signal over **North Atlantic** robust

✗ Dynamics unsettled:

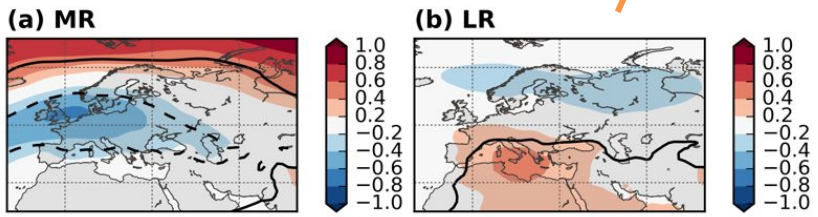
How does it get there?

⟶ Tropospheric vs. stratospheric pathway



Other ongoing activities:

The signal over **Europe** is *not* robust! :(



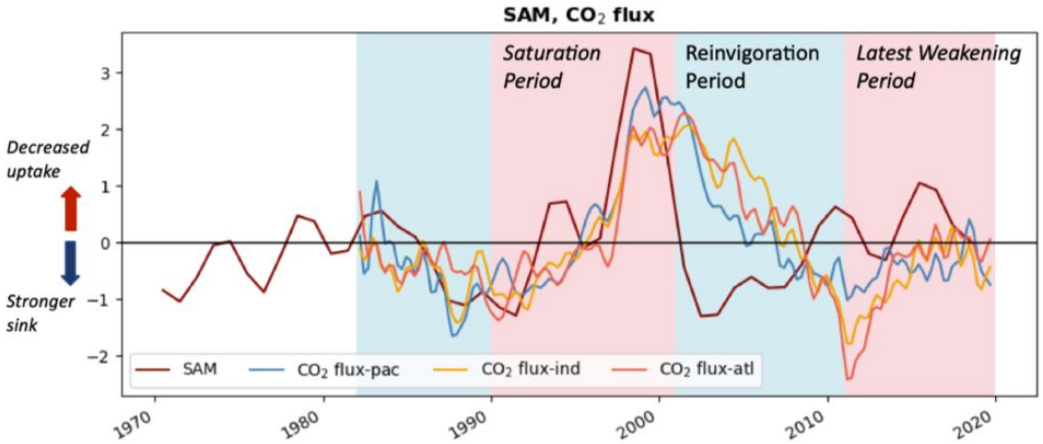
PhD Elif Yilmaz (Decadal Variability)

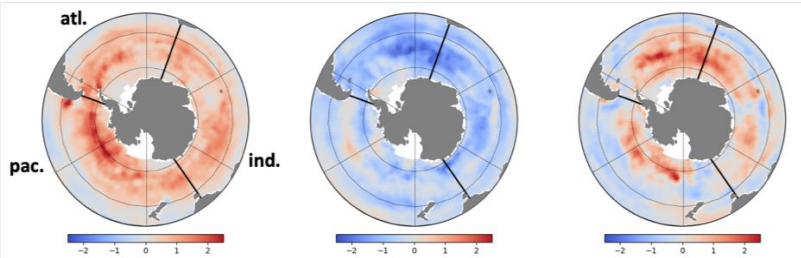
Barcelona Supercomputing Center
Centro Nacional de Supercomputación
EXCELENCIA SEVERO OCHOA

Goal of the PhD: To identify the driving mechanisms of CO2 uptake decadal variations in the Southern Ocean.

Supervisors: Raffaele Bernardello (BSC), Adrian P. Martin (NOC)

Research activity 1: Investigating the response of the Southern Ocean surface *p*CO2 components to the leading atmospheric mode: Southern Annular Mode.





Linear trends of C fluxes during the last 3 decades.

Other ongoing activities: Quantifying the impact of the relative spatial distribution of biologically-driven uptake and water masses formation on the net uptake of carbon in the Southern Ocean.

PhD Carlos Delgado (Decadal Prediction)

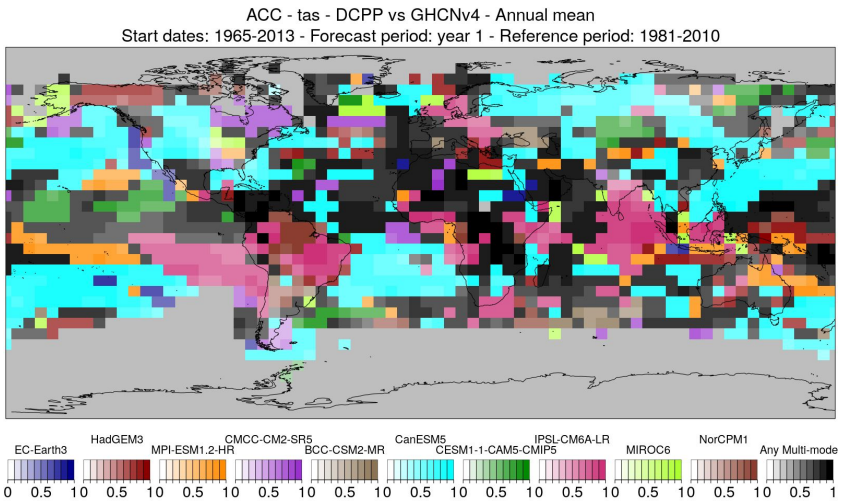
Barcelona Supercomputing Center
Centro Nacional de Supercomputación

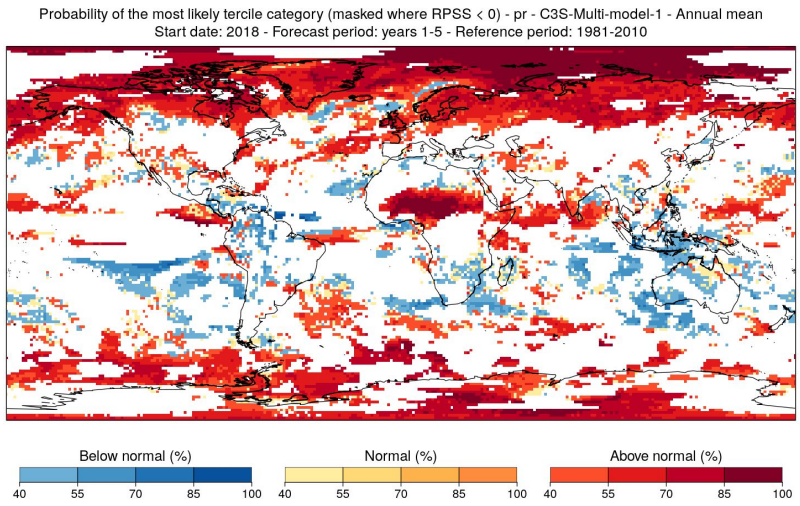
EXCELENCIA SEVERO OCHOA

Goal of the PhD: Estimate and understand the predictability of climate events relevant to climate services (e.g. wind energy production and demand), and further their physical understanding by attributing the occurrence of such events to large-scale drivers.

Supervisors: Markus Donat and Albert Soret

Research activity 1: Predictability of weather regimes (EUCP)
Research activity 2: Multi-model forecast quality assessment and product generation (C3S-34c / EUCP)

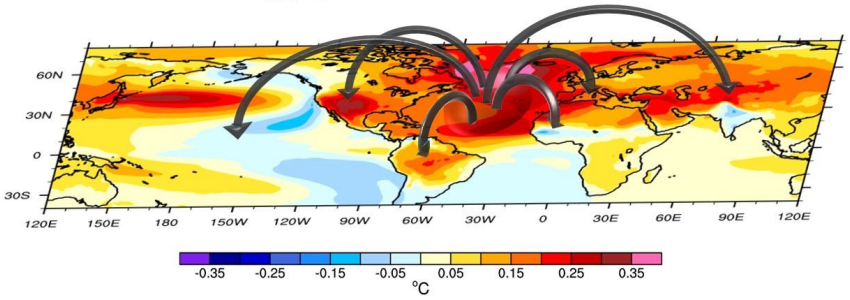




Other group activities (Senior grants)

ReSPonSe

JuniorLeader Postdoctoral Fellowships Programme BECASCAIXA



North Atlantic climate teleconnections: is their realism affected by model biases?

Development of EC-Earth3-CC version with reduced surface biases

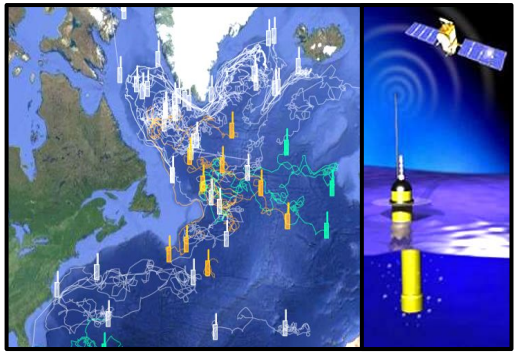
Grantee: Yohan Ruprich-Robert

ORCAS

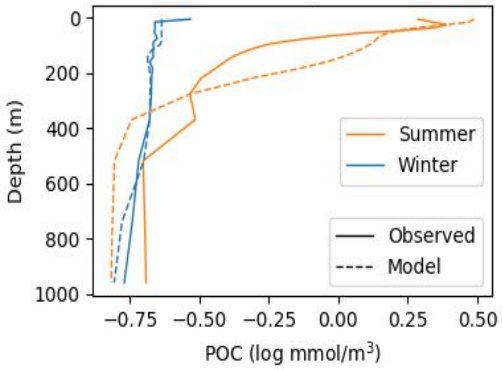
JuniorLeader Postdoctoral Fellowships Programme BECASCAIXA

Ocean carbon cycle: Can we improve models using robotic ARGO float observations?

Grantee: Martí Galí Tàpias



PISCES-1D parameter optimisation with a **genetic algorithm** within AUTOSUBMIT

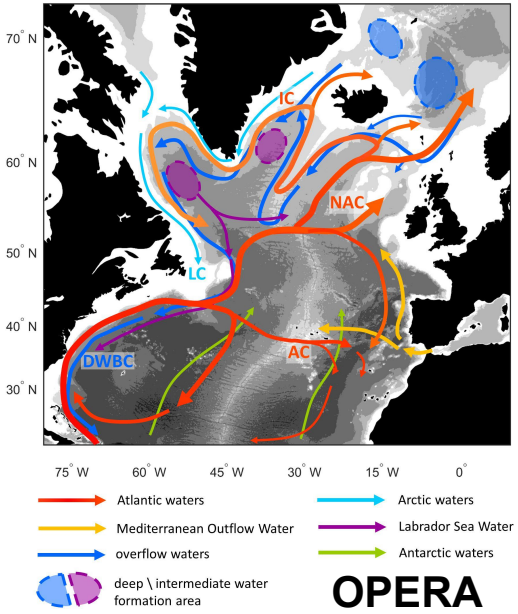


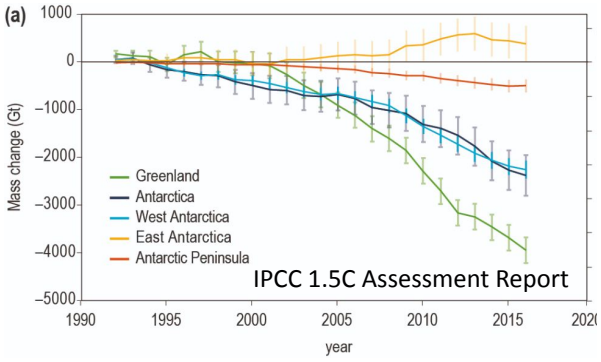
Other group activities (Projects)

Organic carbon in the North Atlantic twilight zone:

- Targeted experiments with NEMO4-PISCESv2 to <u>understand particle budgets, advection patterns, and their interannual variability</u>
- Model evaluated and constrained using BGC-Argo, satellite and in-situ observations.

People involved: Martí Galí and Yohan Ruprich-Robert (co-PIs), Joan Llort, Vladimir Lapin, Javier Vegas-Regidor, Marcus Falls, +Andrea Orihuela (soon)





Ice sheet melting:

How does it affect polar climate prediction and projections?

Multiple insights from regional and global models

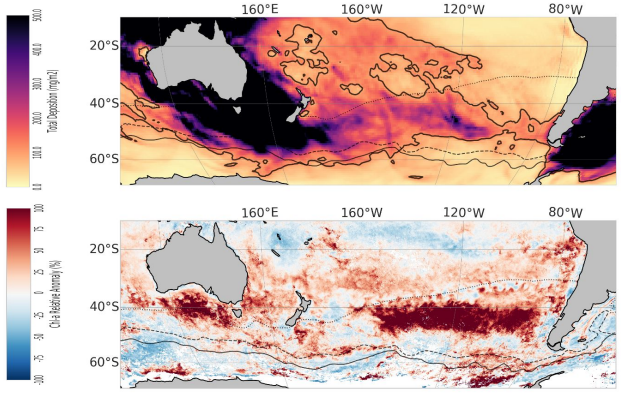
People involved: Eduardo Moreno-Chamarro

Other group activities (Earth system)

Earth System Model development (going beyond EC-Earth3)

- **EC-Earth4:** IFS-OpenIFS / NEMO / LPJ-GUESS
- ECMWF contract for IFS land surface refactoring / hydrology

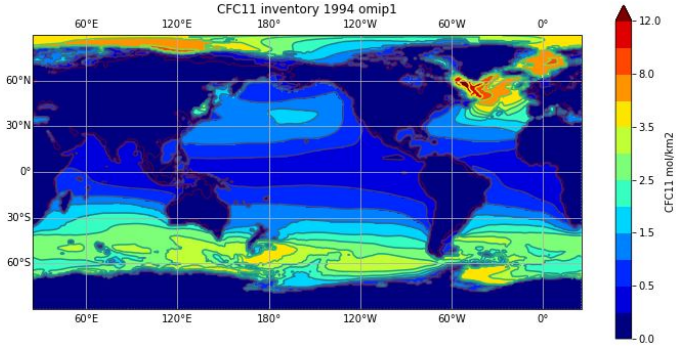
People involved: Etienne Tourigny, Iria Ayan, Mario Acosta, Miguel Castrillo, Xavier Yepes, many others from CP and CES



Wildfires ashes and ocean phytoplankton: are they connected?

Observed for the first time (& published in *Nature*!)

People involved: Joan Llort and Sara Basart



Ocean CFCs and biogeochemistry (BGC): What can we learn from CFCs of the large-scale ocean BGC dynamics and related model biases?

People involved: Valentina Sicardi, Raffaele Bernardello and Marcus Falls

Other group activities (ESA contracts)

Barcelona Supercomputing Center
Centro Nacional de Supercomputación
EXCELENCIA SEVERO OCHOA

Climate Modelling User Group (CMUG)

esa

Linking the climate modelling community and satellite Earth observation experts across the CCI programme.

Improving forecast initialization (sea ice, ocean, land)
Forecast verification (sea ice, ocean surface, land, atmosphere)

People involved: J. Acosta Navarro, R. Bilbao, V. Lapin, A. Carreric, E. Tourigny, P. Ortega, J. Escribano, E. Di Tomaso, C. Pérez García-Pando

4DAtlantic – Regional Initiatives Science

DOMOS

Atmospheric iron cycle and its impact upon ocean biogeochemistry

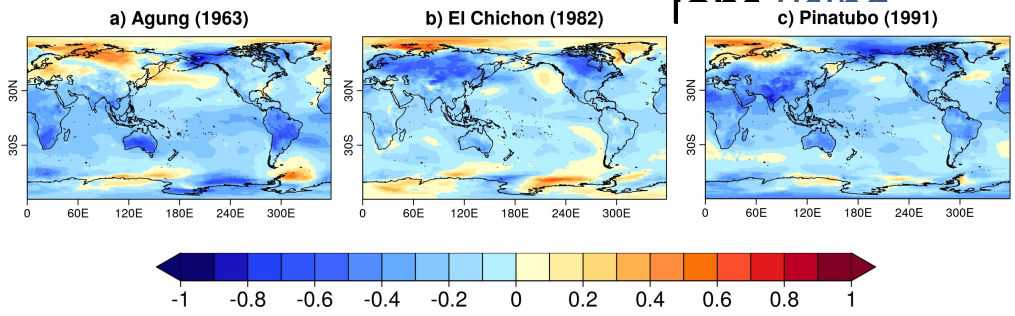
4DAtlantic OHC

First users of state-of-the-art observations of ocean heat content

People involved: E. Di Tomaso, C. Pérez García-Pando, J. Escribano, E. Bergas, S. Basart, M. Gonçalves, R. Bernardello, J. Llort, Y. Ruprich-Robert, R. Bilbao, V. Lapin, P. Ortega

EUCP (Multi-Decadal Climate Prediction)

- Idealised simulations to understand **predictability**:
  - Atlantic Multidecadal Variability
  - Volcanic Eruptions
  - 'Perfect model'
- Exploring the predictability of application-relevant features, e.g. weather regimes, winter storms, wind speeds, drought (in collaboration with ESS)
- **Constraining climate projections** using



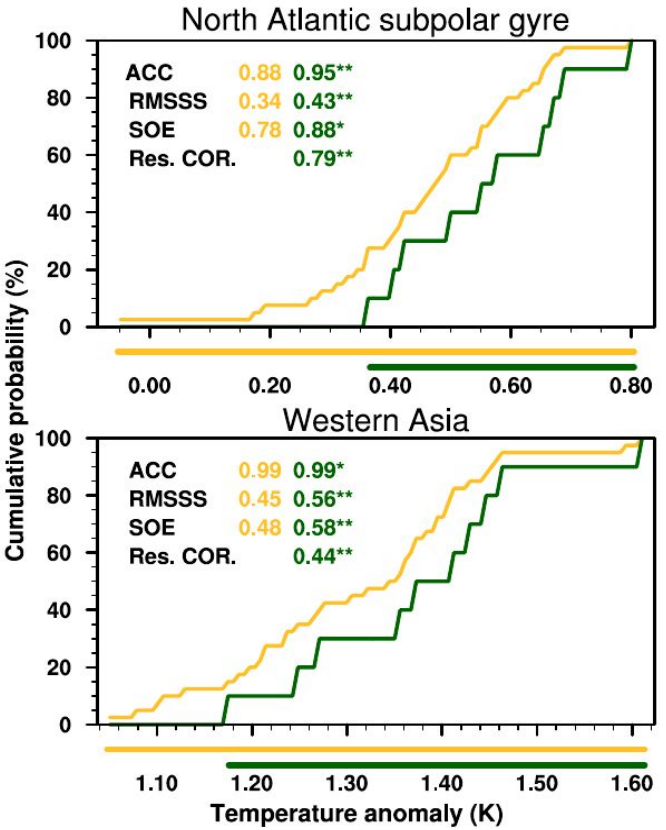


Fig: Near-term summer temperature projections. Cumulative distribution functions of 20-year average (i.e. 2016-2035) projections of summer surface air temperature anomalies (Mahmood et al., submitted)

EUCP
European Climate Prediction system

People involved: F. Doblas-Reyes, M. Donat, S. Wild, R. Bilbao, R. Mahmood, D. Bojovic, A. Carreric, C. Delgado-Torres, Y. Ruprich-Robert, B. Solaraju, V. Lapin

EUCP (Decadal Climate Prediction)

- Understanding **predictability** using ‘perfect model’ decadal predictions.
- Predictability of the main **modes of variability** and their impacts (e.g. AMV).
- Impact of **volcanic eruptions** on predictions.
- Case studies: **agriculture** and **wind energy** sectors.

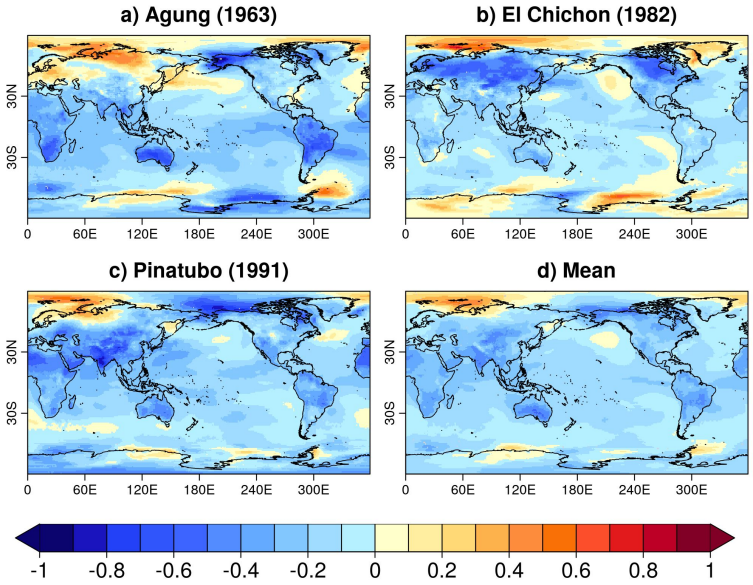
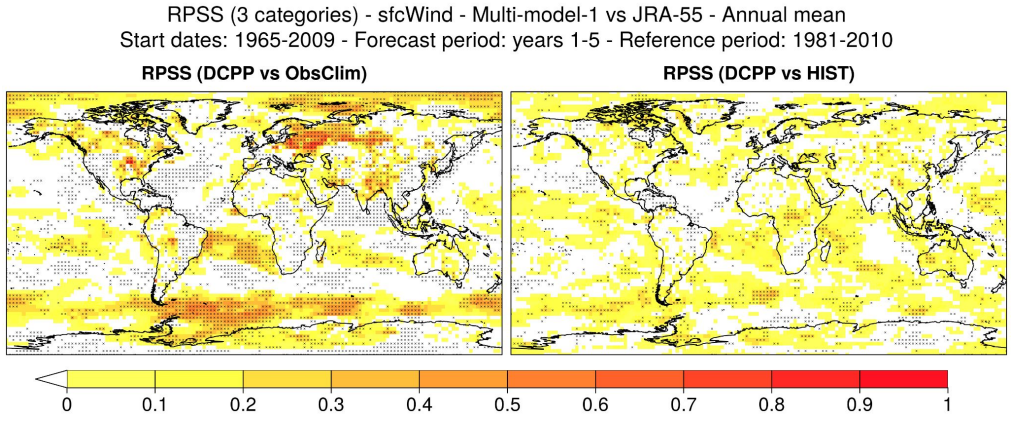


Fig: Surface temperature response the first year following the major volcanic eruptions in decadal predictions.



European Climate Prediction system

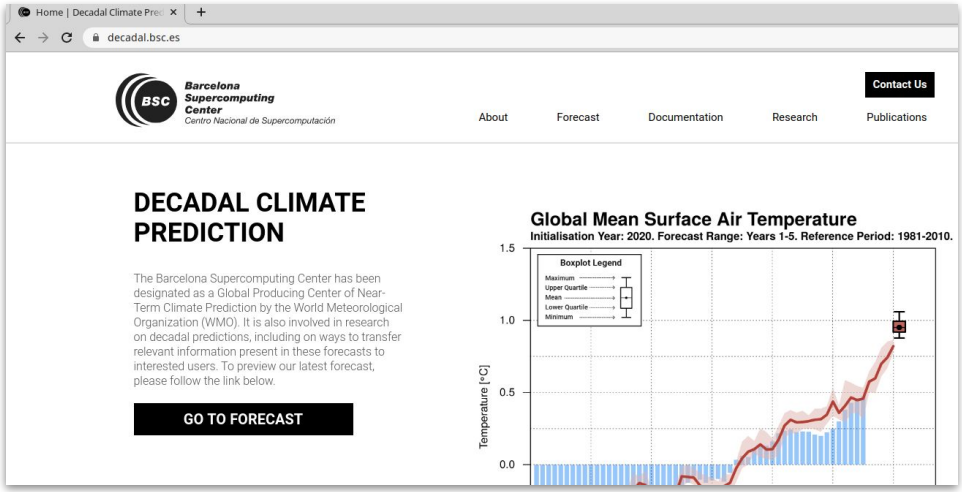
People involved: F. Doblas-Reyes, M. Donat, S. Wild, R. Bilbao, R. Mahmood, D. Bojovic, A. Carreric, C. Delgado-Torres, Y. Ruprich-Robert, B. Solaraju, V. Lapin

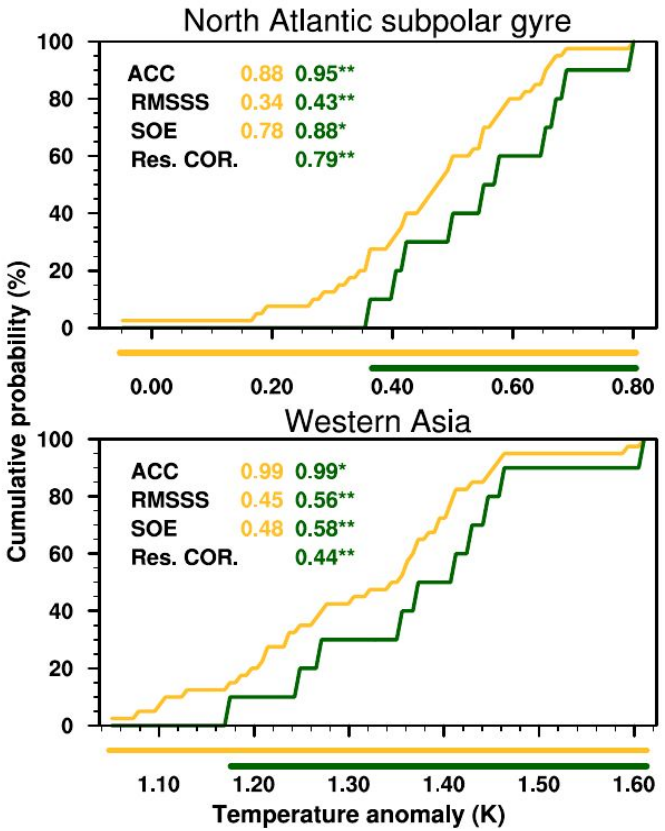
EUCP (Multi-Decadal Climate Prediction)

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

- Evaluation of forecast quality of **European winter windstorms**.
- **Constraining climate projections** using decadal predictions.
- BSC Decadal Prediction Website: ***decadal.bsc.es***





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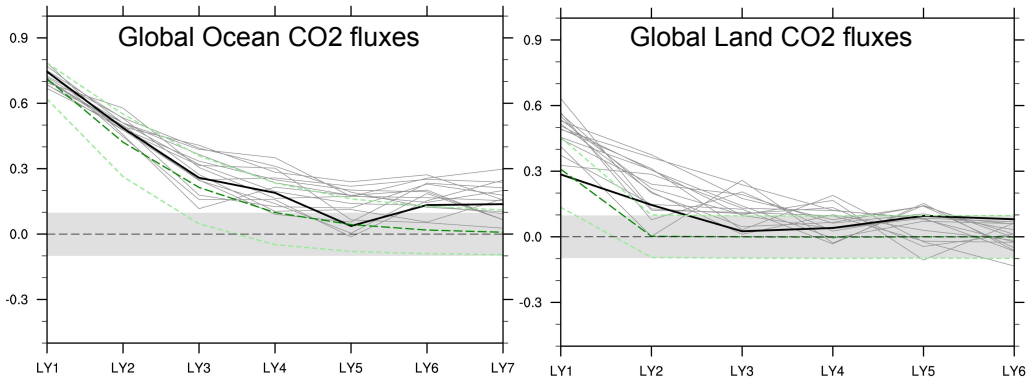
4C (s2d predictions in Earth System Models)

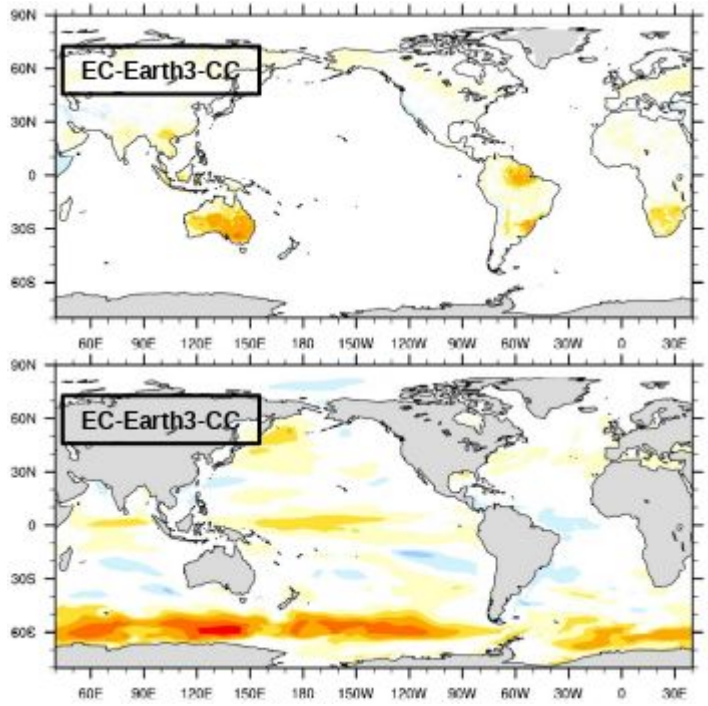
Goal of the project: To reduce the knowledge gap in the climate sensitivity to CO2 emissions and to develop predictive systems of near-term atmospheric CO2 growth rate

Potential predictability of carbon sinks and atmospheric CO2 concentrations



Ocean predictable up to 7 years
Land predictable up to 3 years
Atmospheric CO2 predictability limited by land

Key regions and drivers



Tropical forests, S Ocean and Eq Pacific main drivers

People involved: Y. Ruprich-Robert, R. Bernardello, E. Tourigny, V. Sicardi, P. Ortega, V. Sicardi, V. Lapin

4C Climate-Carbon Interactions in the Current Century

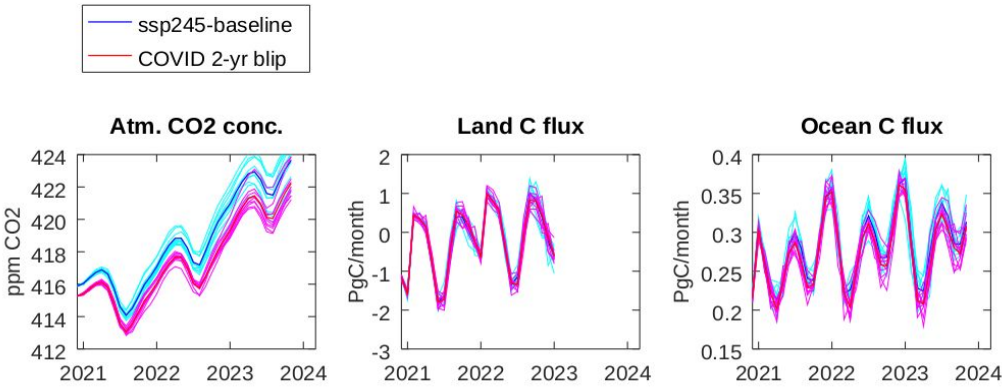
4C (s2d predictions in Earth System Models)

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

Provide relevant information to assist the implementation of the Paris Agreement on climate (i.e. global stocktake 2023)

First atmospheric CO2 predictions with EC-Earth3-CC

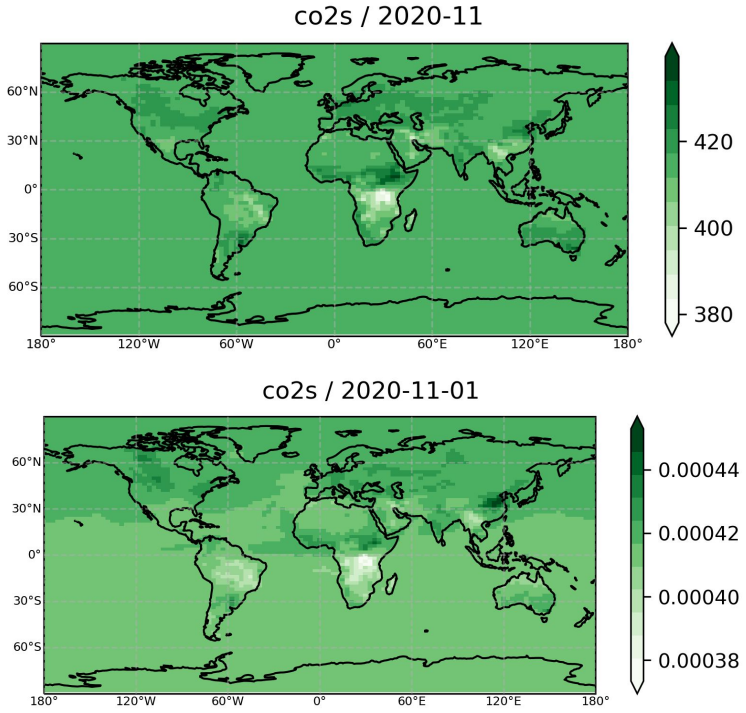


Baseline scenario SSP2-45 against 2-year blip COVID scenario

System continuously being improved

Forecast to be repeated every year

New initialization procedure for atmospheric CO2



People involved: E. Tourigny, R. Bernardello, Ortega P., Lapin V., Sicardi, V.

4C Climate-Carbon Interactions in the Current Century

TRIATLAS (s2d prediction in Earth System Models)

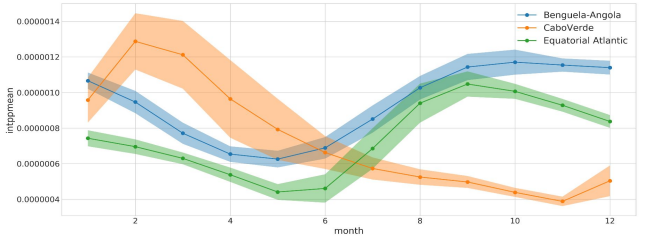
Barcelona Supercomputing Center
Centro Nacional de Supercomputación

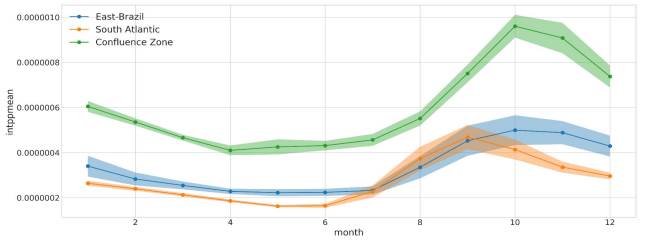
EXCELENCIA SEVERO OCHOA

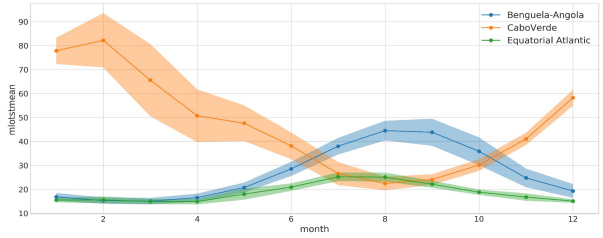
Part 2: Perfect model prediction study

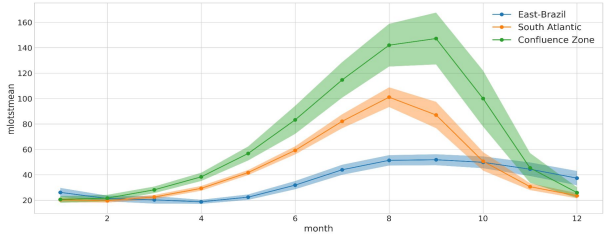
Evaluate the potential predictability of relevant biogeochemical variables in three different hypothetical cases:

1) Perfect Initial conditions
2) Nudging Temperature and Salinity from a reference run
3) Nudging Temperature, Salinity and surface Chlorophyll from a reference run









People involved: E. Exarchou, J. Llort, R. Bernardello, V. Sicardi, P. Ortega

Other group activities

Earth System Model development

- EC-Earth / IFS-OpenIFS / NEMO / LPJ-GUESS
- ECMWF contract for IFS land surface refactoring / hydrology

People involved: Etienne Tourigny, Iria Ayan, Mario Acosta, Miguel Castrillo, Xavier Yepes, many others from CP and CES

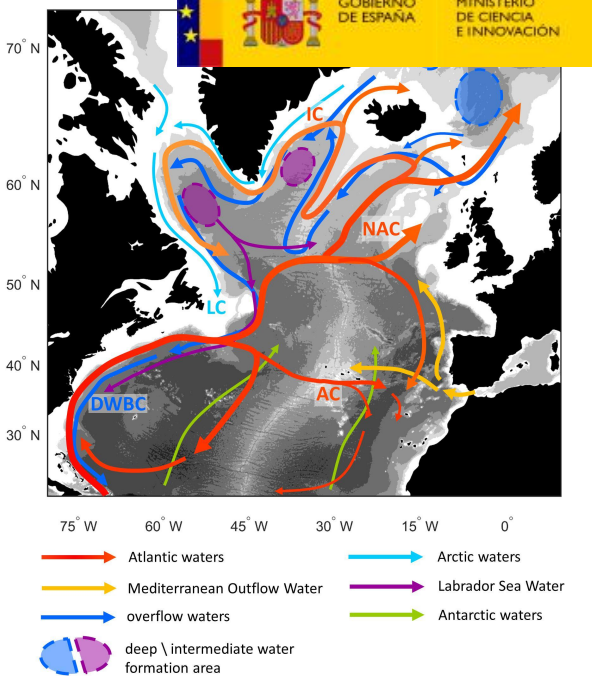
Organic carbon in the North Atlantic twilight zone

- Targeted experiments with NEMO4-PISCESv2 to understand particle budgets, advection patterns, and their interannual variability
- Model evaluated and constrained using BGC-Argo, satellite and in-situ observations.

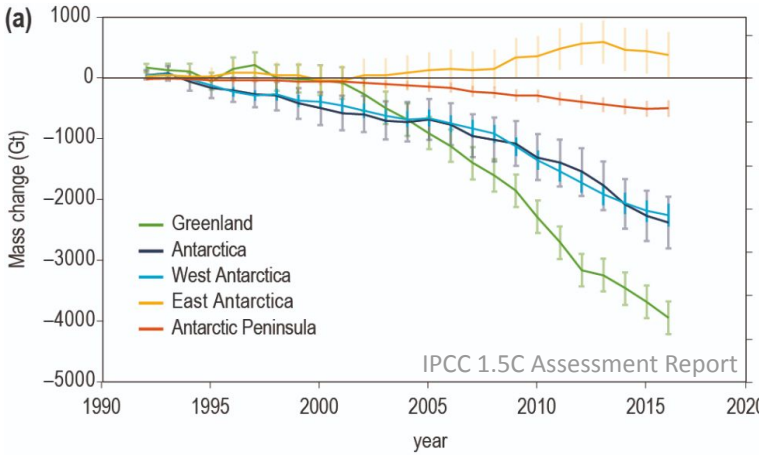
People involved: Martí Galí and Yohan Ruprich-Robert (co-PIs), Joan Llort, Vladimir Lapin, Javier Vegas-Regidor, Marcus Falls, +Andrea Orihuela (soon)

OPERA

GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN



Other group activities (3-4 per page)



PARAMOUR

The global ice sheet is melting: how does it affect polar climate decadal prediction?

Combining regional and global climate models

Interested? Contact Eduardo Moreno-Chamarro

Research activity 2, persons involved, related project (if any)

ECMWF contract on land surface calibration?

Add more as needed… and also additional slides if needed

Other group activities

OPERA

GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN

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