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Santa Cruz, 7 April 2016

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

Climate prediction in the North Atlantic basin

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

BSC-ES Objectives

What

Environmental modelling and forecasting

Why

Our strength …
… research …
… operations …
… services …
… high resolution …

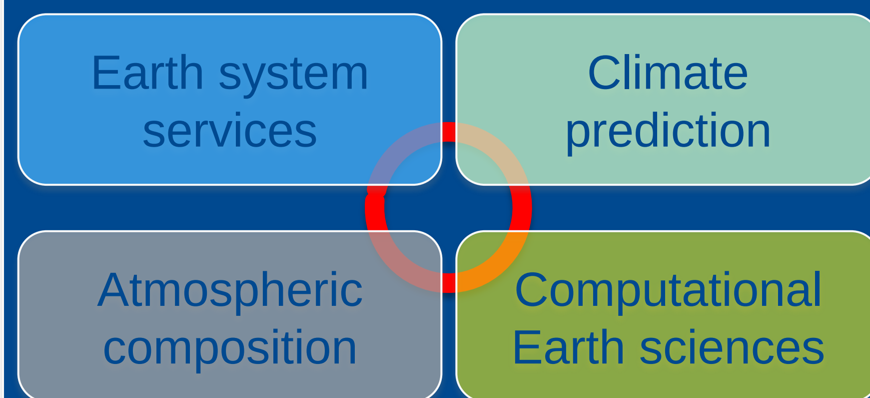
How

Develop a capability to model air quality processes from urban to global and the impact on weather, health and ecosystems

Implement climate prediction system for subseasonal-to-decadal climate prediction

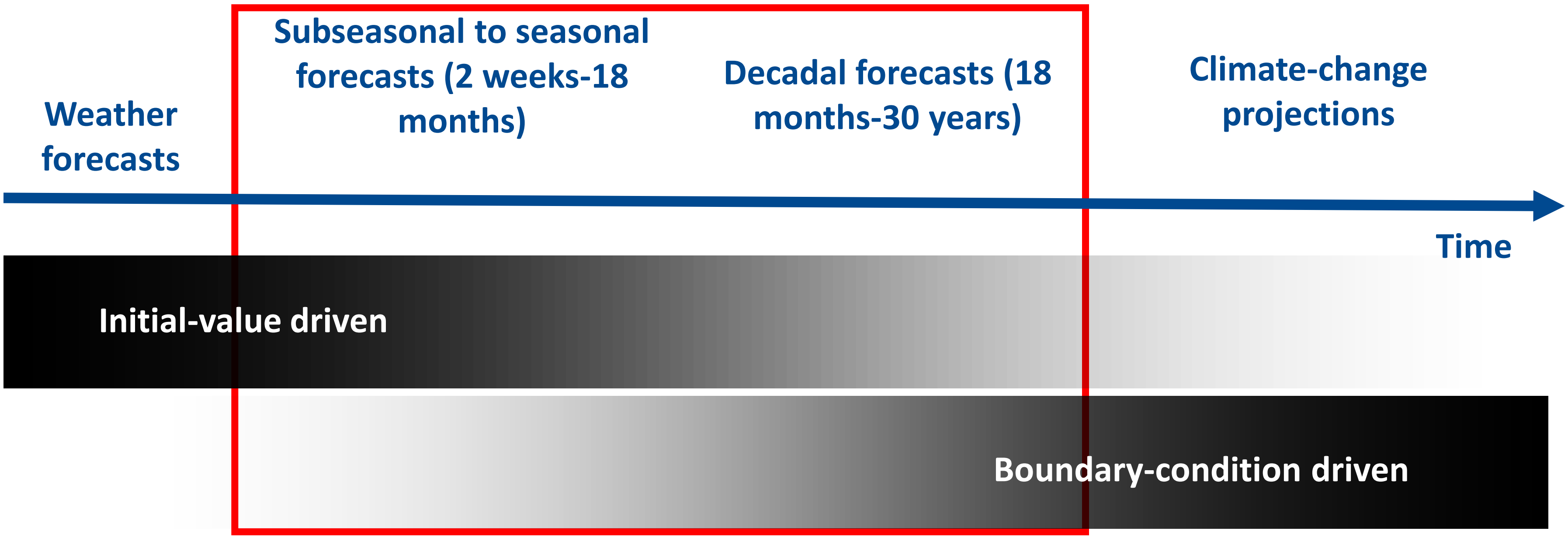
Develop user-oriented services that favour both technology transfer and adaptation

Use cutting-edge HPC and Big Data technologies for the efficiency and user-friendliness of Earth system models



Climate prediction time scales

Progression from initial-value problems with weather forecasting at one end and multi-decadal to century projections as a forced boundary condition problem at the other, with climate prediction (sub-seasonal, seasonal and decadal) in the middle. Prediction involves initialization and systematic comparison with a simultaneous reference.

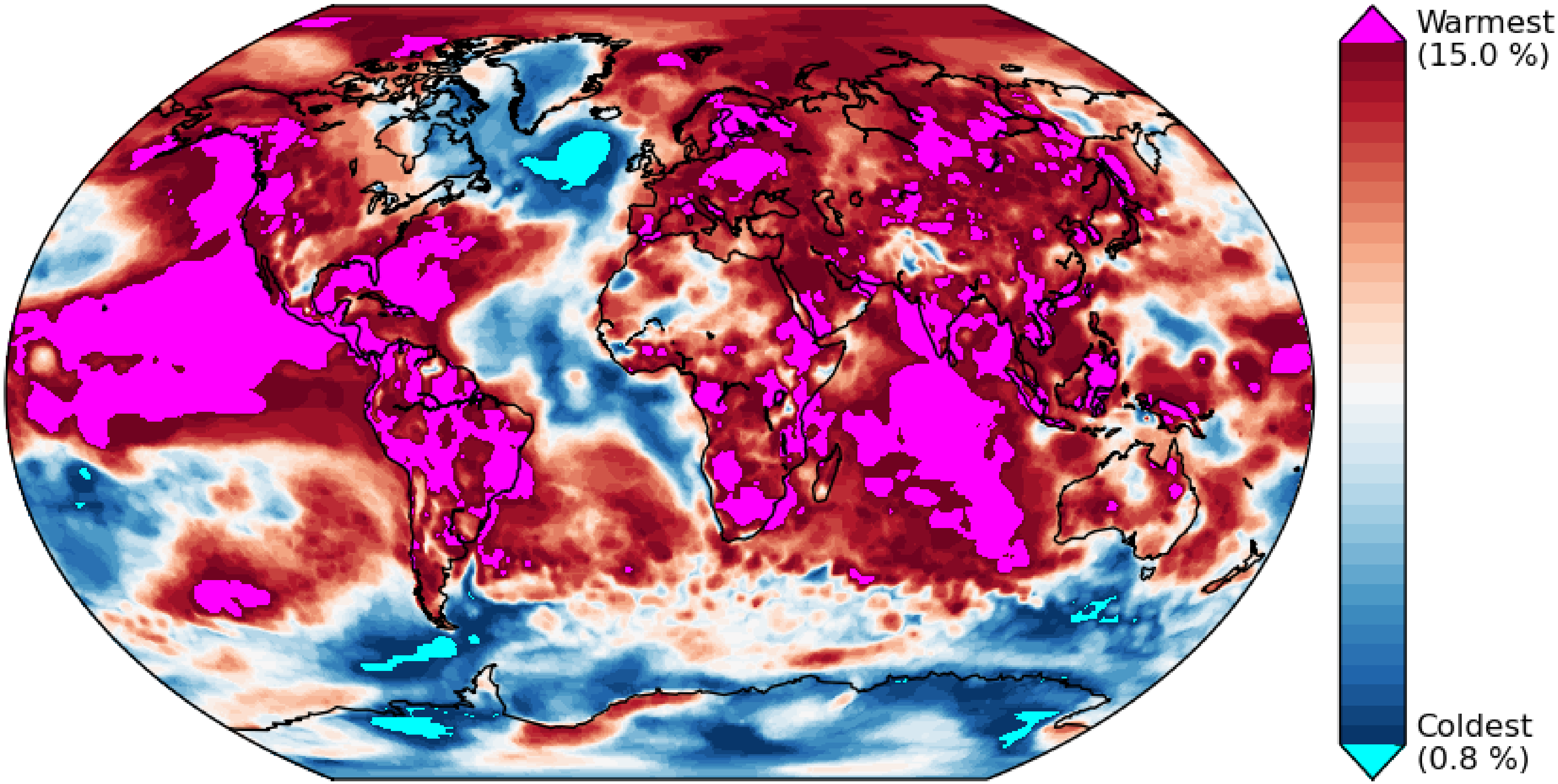


Adapted from Meehl et al. (2009, BAMS)

Climate change is taking place

Rank of the 2015 annual mean temperature over the last 37 years from ERA Interim.

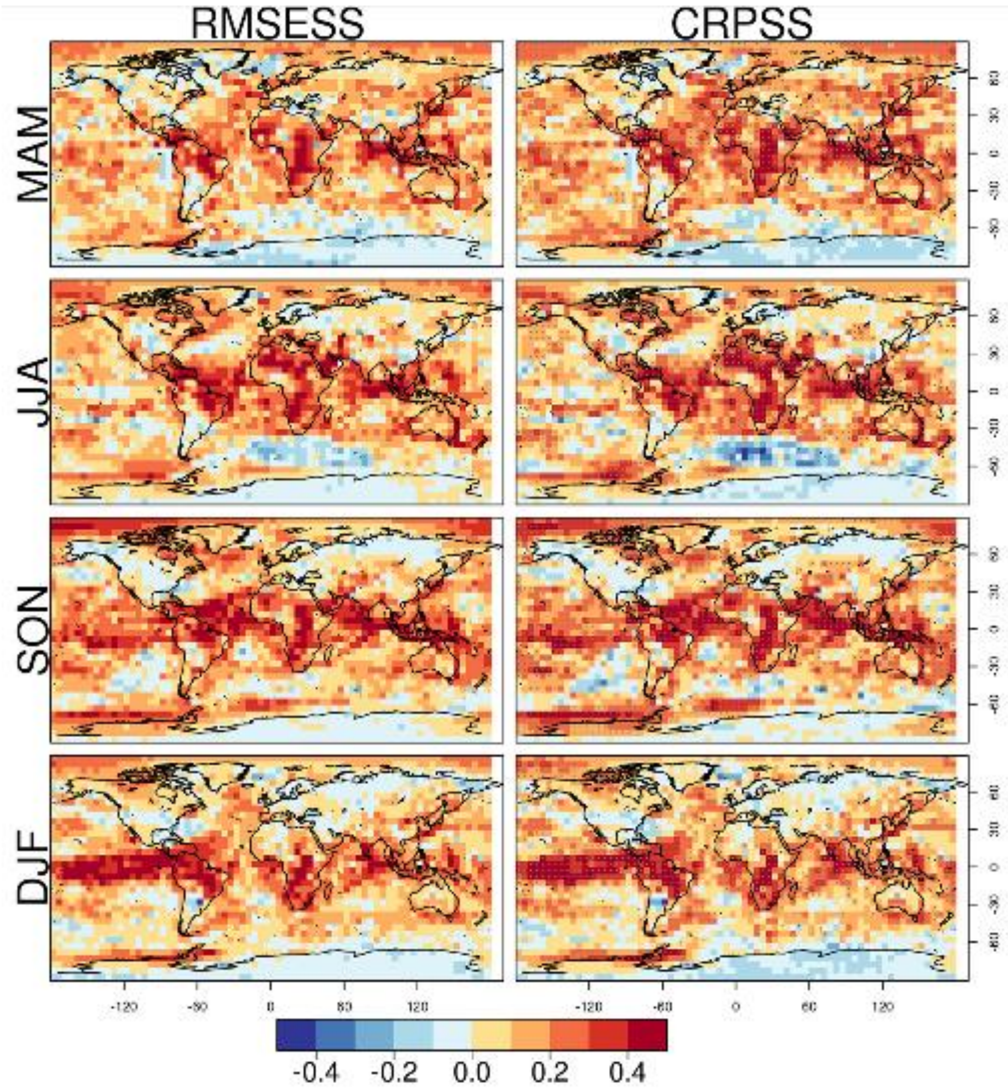
Annual mean 2m temperature
Rank of year 2015 (reference: 1979-2015)



Data: ERA-Interim. Figure: F. Massonnet - BSC

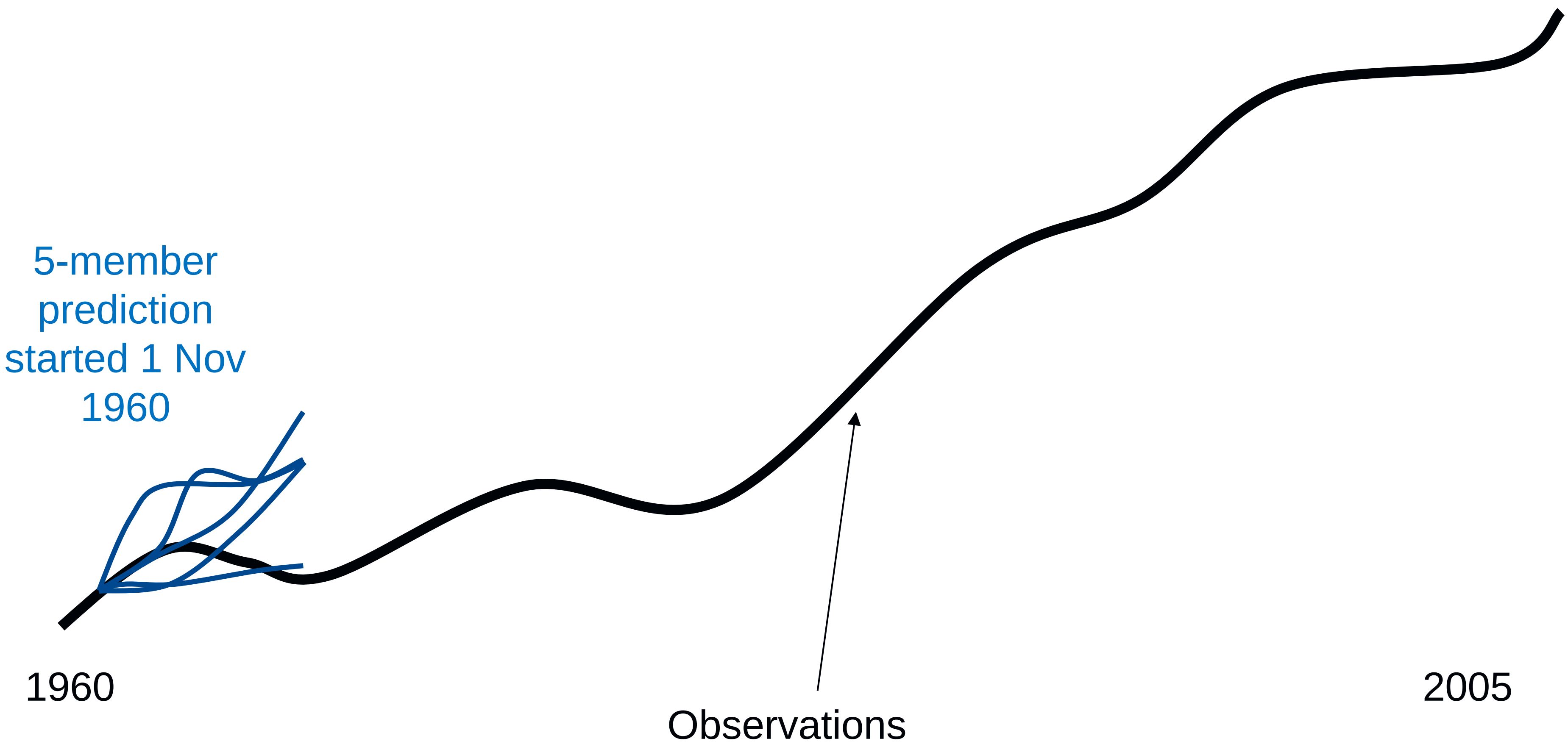
Empirical climate forecasts

Empirical forecasts of one-month lead temperature using a wide range of observed predictors. A benchmarking opportunity.

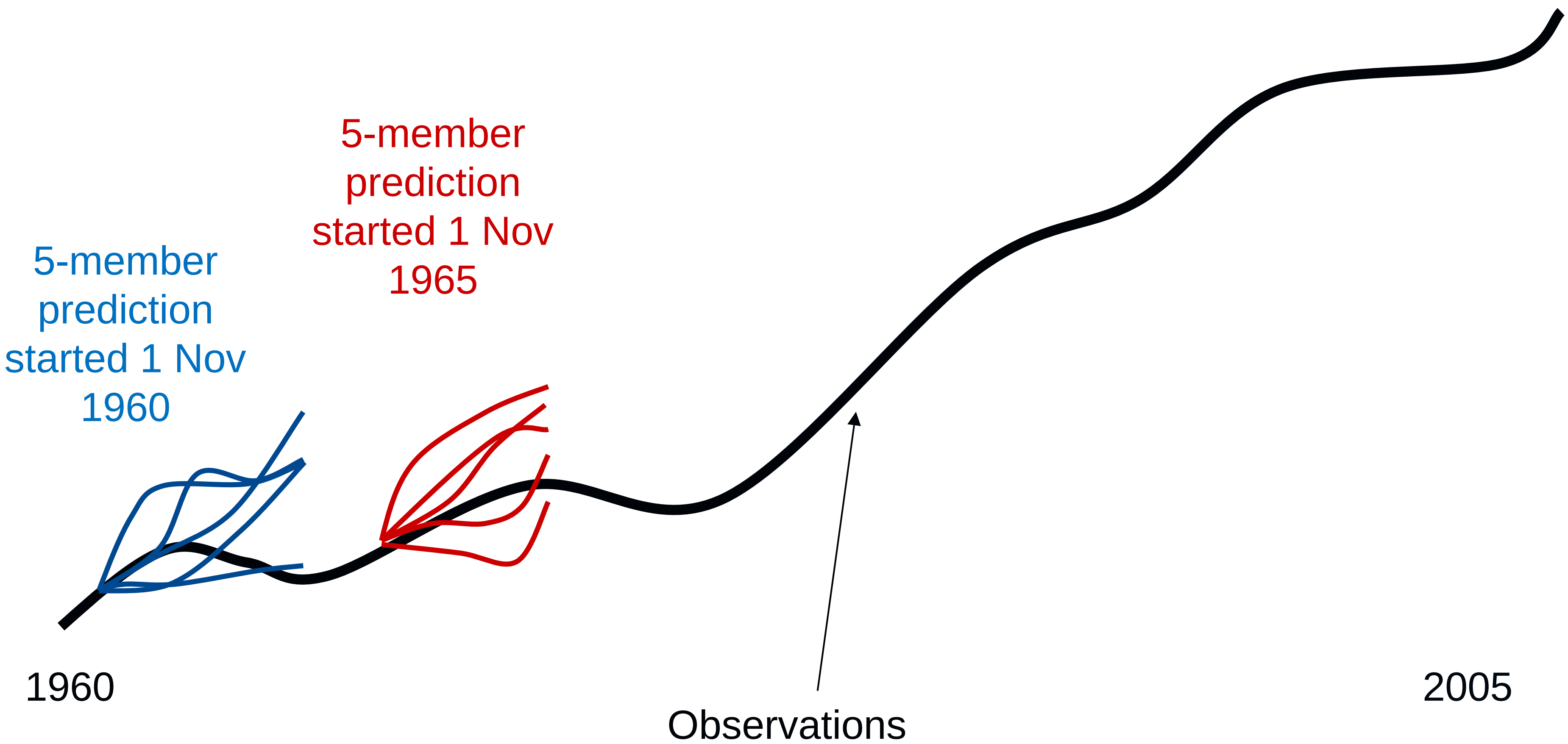


Eden et al. (2015, GMD)

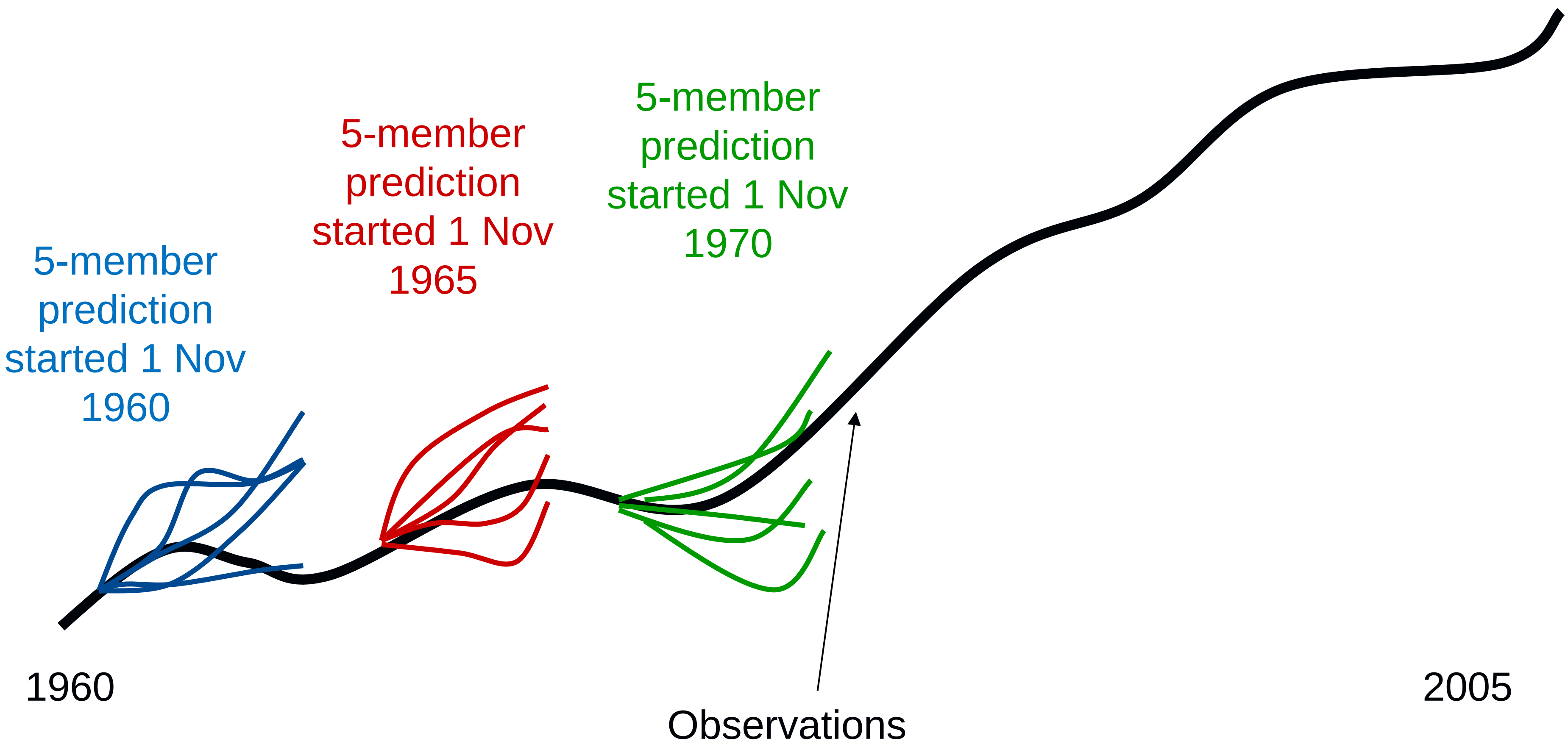
Dynamical climate predictions



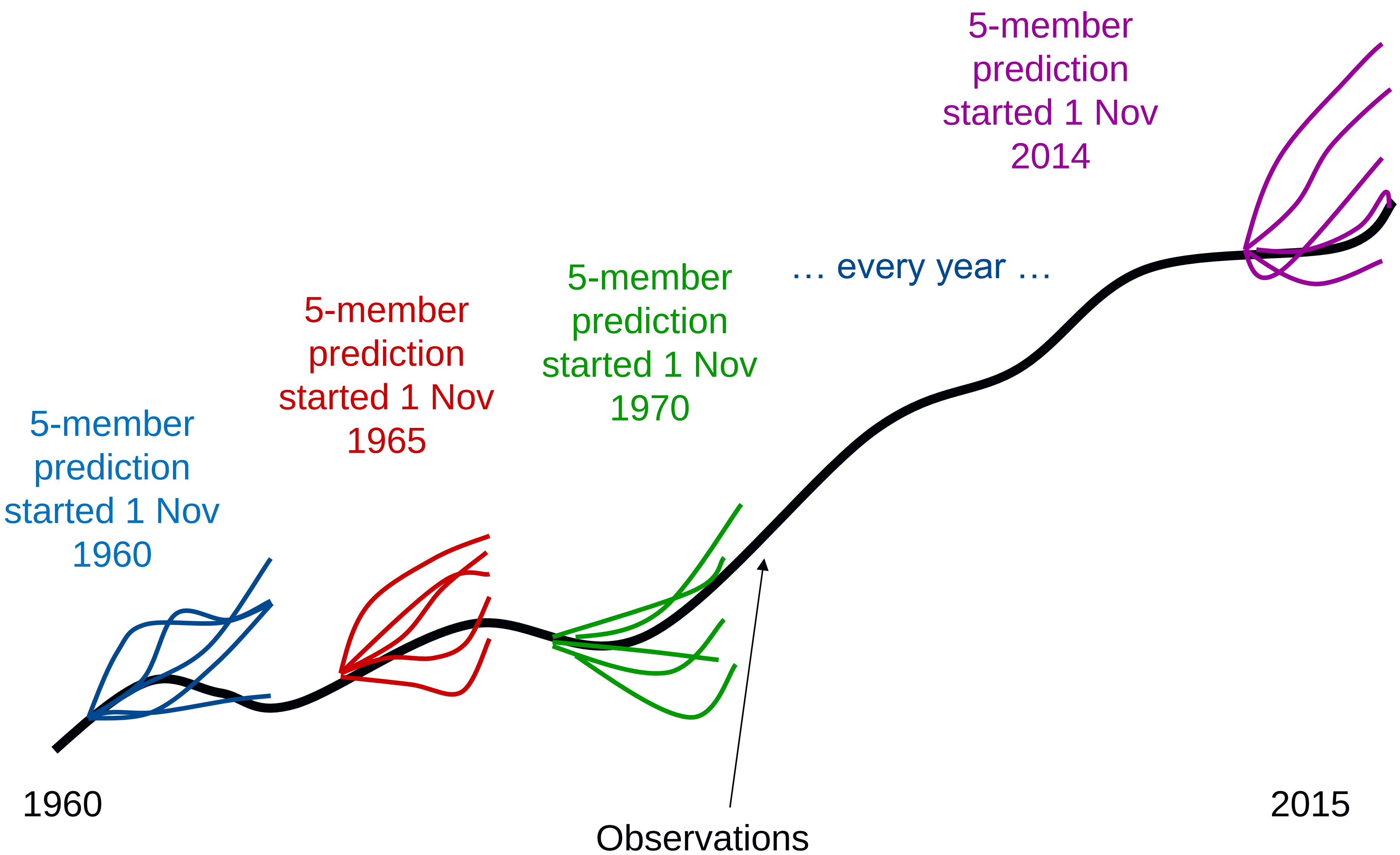
Dynamical climate predictions



Dynamical climate predictions



Dynamical climate predictions



Dynamical climate predictions

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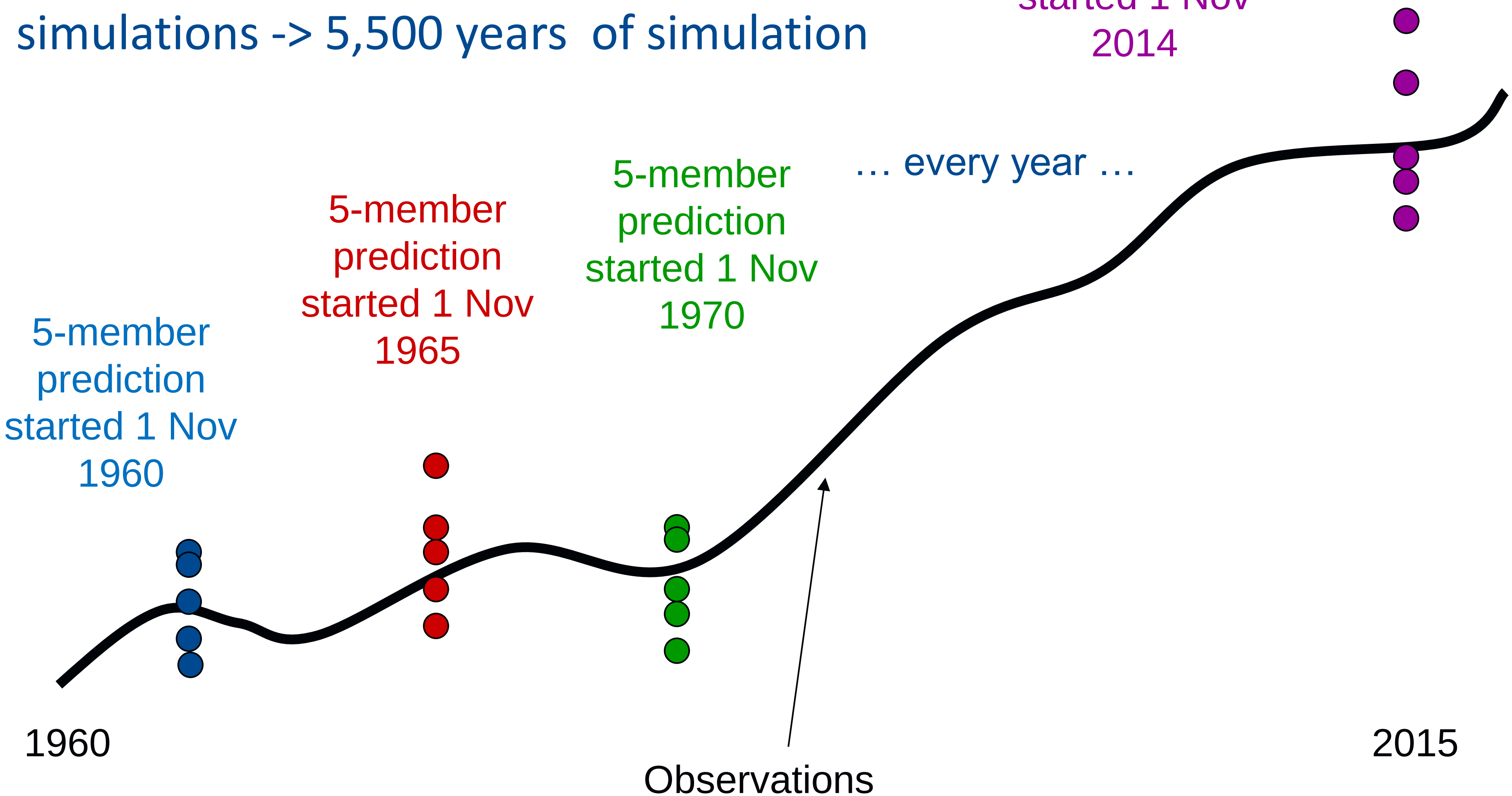
Typical sizes: ten members, ten forecast years, 55 start dates -> 550 independent simulations -> 5,500 years of simulation

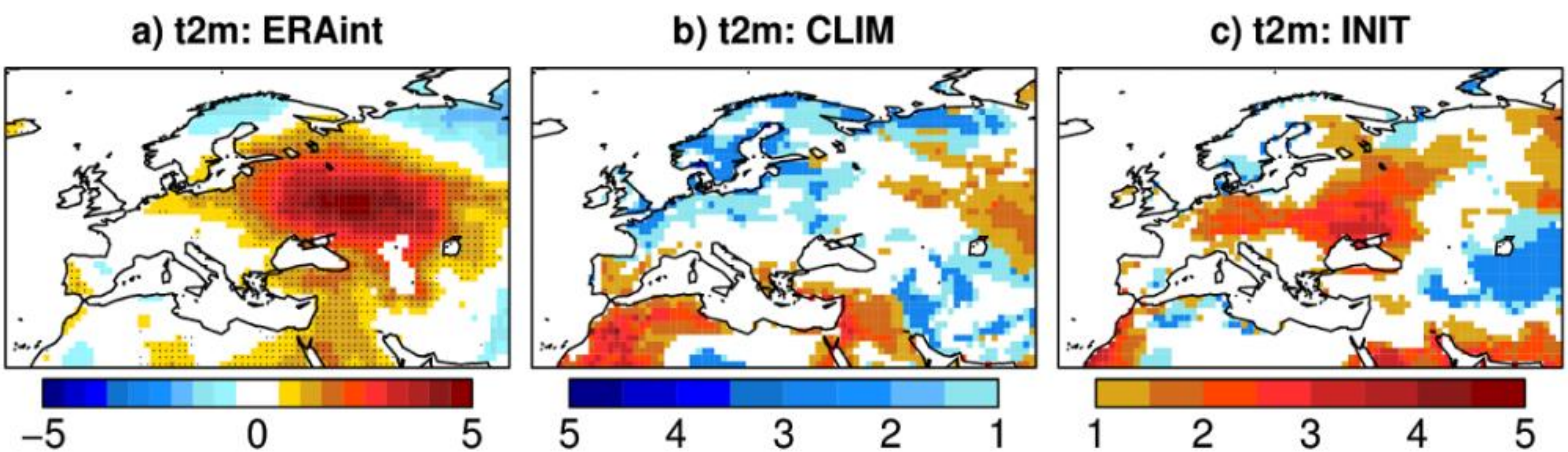


Predicting seasonal heat waves

JJA near-surface temperature anomalies in 2010 from ERAInt (left) and experiments with a climatological (centre) and a realistic (right) land-surface initialisation.

Results for EC-Earth2.3 started in May with initial conditions from ERAInt, ORAS4 and a sea-ice reconstruction over 1979-2010.

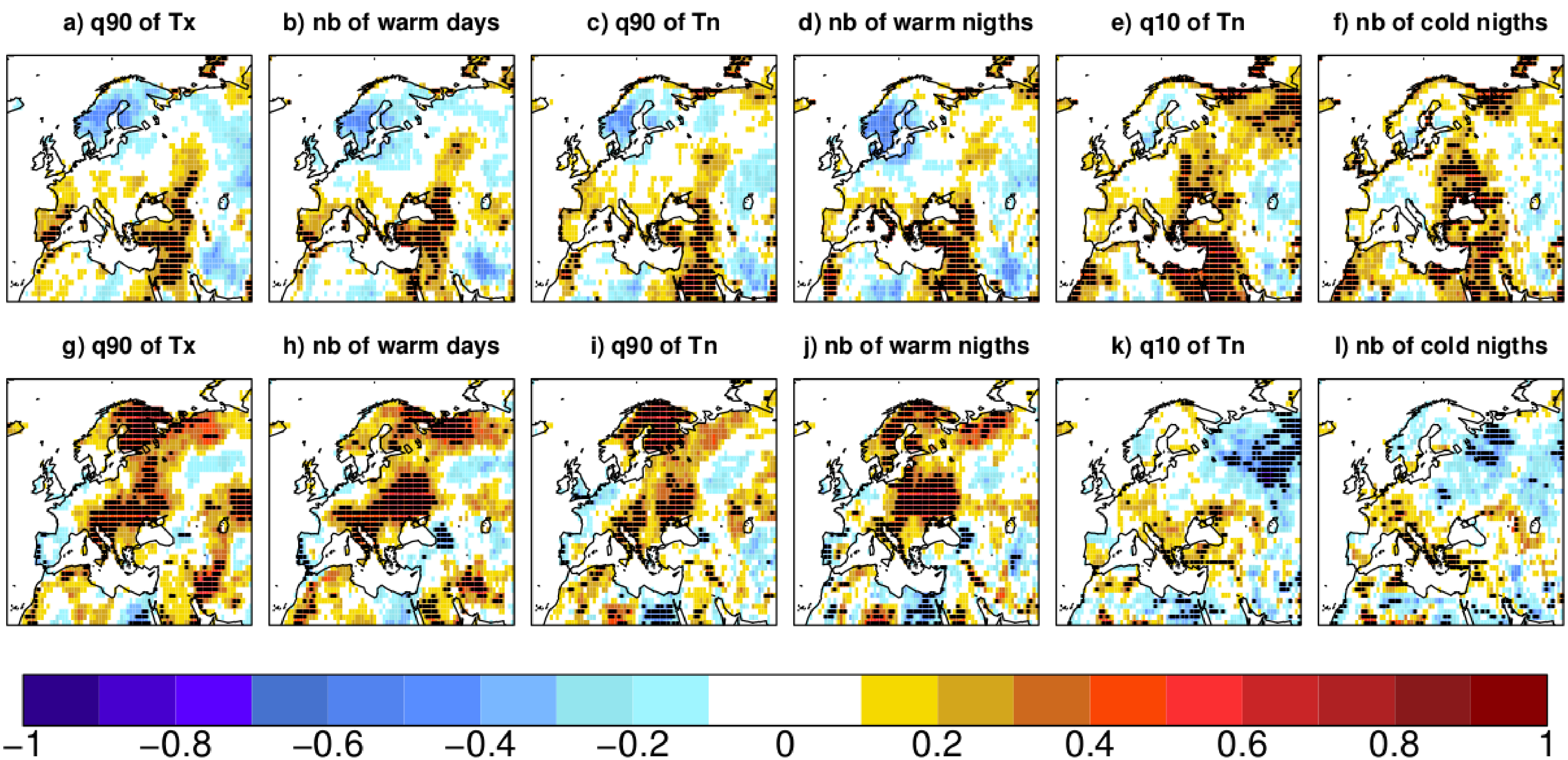
Land-surface initialization is relevant to predict extreme events.



Prodhomme et al. (2015, Clim. Dyn.)

Predicting seasonal extremes

JJA near-surface temperature correlation of the ensemble mean from experiments with a climatological (top) and difference with one with realistic (bottom) land-surface initialisation. Results for EC-Earth2.3 started in May over 1979-2010.



Prodhomme et al. (2015, Clim. Dyn.)

NAO and model resolution

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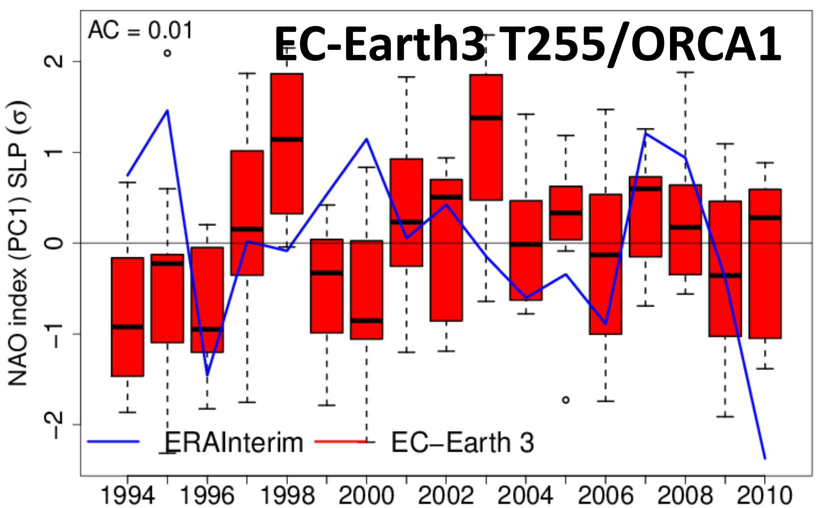
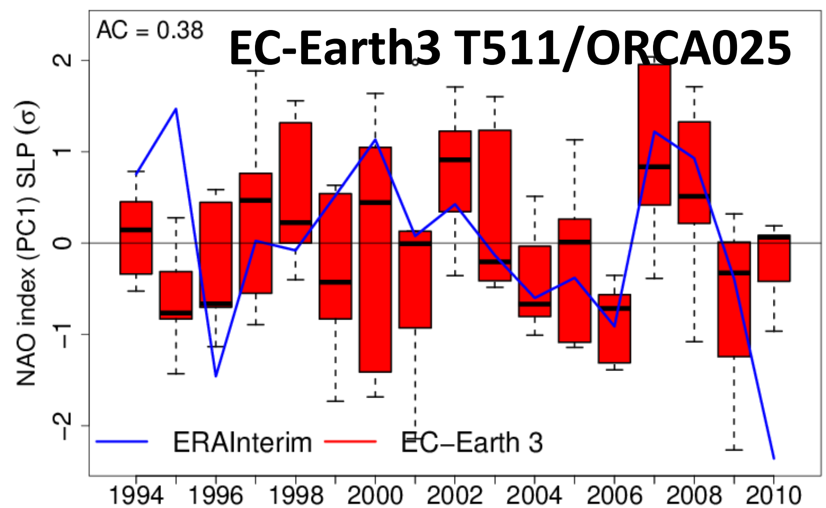
Predictions of DJF NAO with EC-Earth3 at low and high resolution started in November over 1993-2009 with ERA-Interim and GLORYS initial conditions and five-member ensembles. Correlation of the ensemble mean on top left.



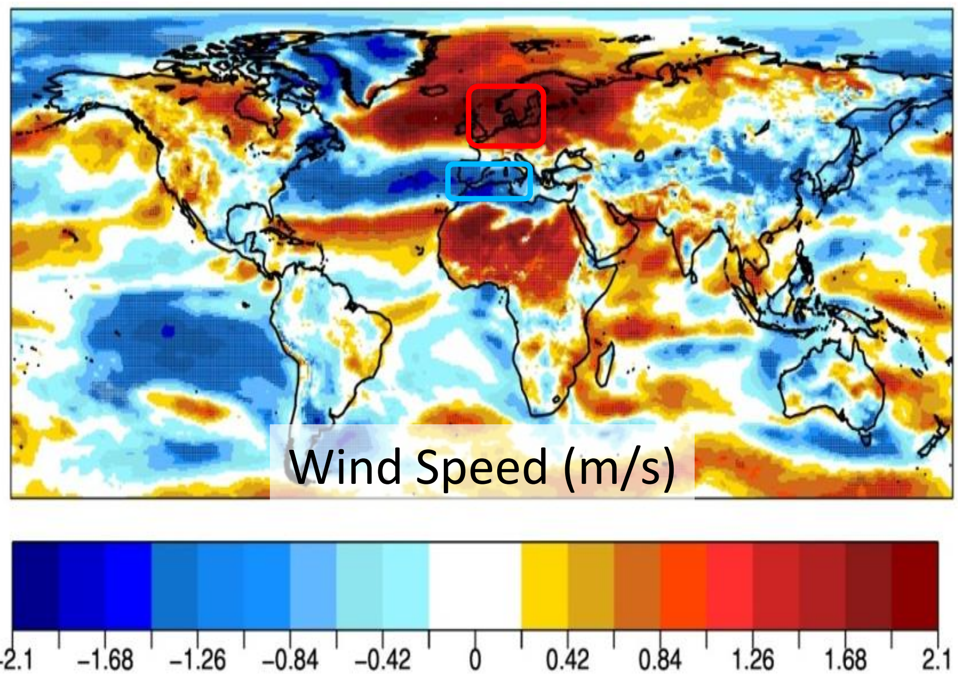


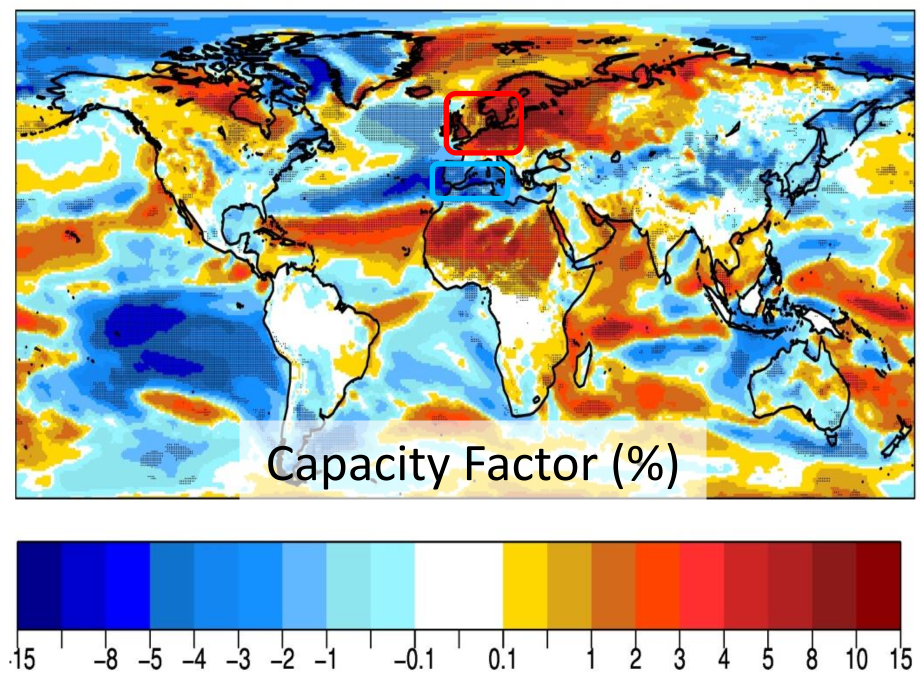
Prodhomme et al. (2016, J. Clim.)

NAO and wind energy

Difference in winter (DJF) standardised 10-metre wind speed (left) and capacity factor (right) for seasons with above normal and below normal North Atlantic Oscillation index.

Daily capacity factor (%) calculated from ERAInterim 10-metre wind speed and temperature data using an idealised power curve, a log scaling law to transform the wind to hub height wind, and a Rayleigh distribution to model diurnal variability.

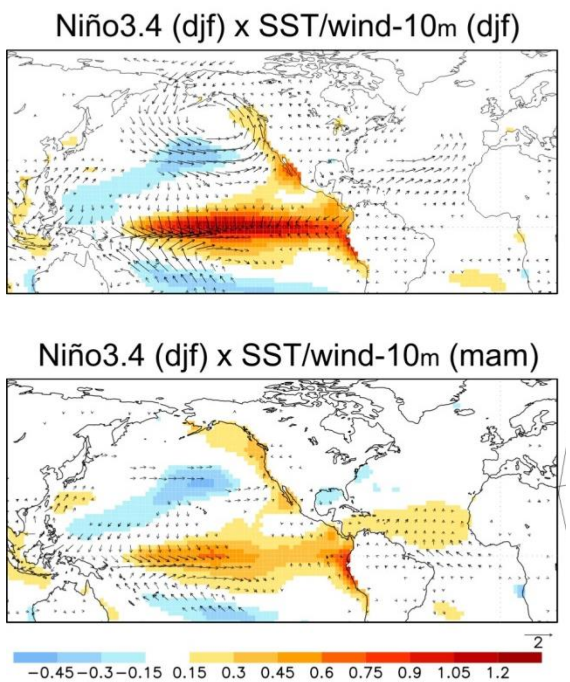


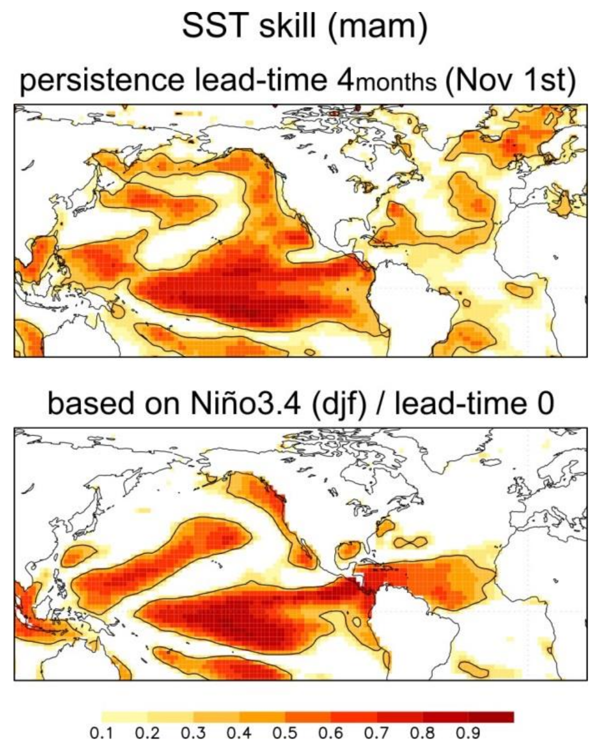


Tropical north Atlantic

A predictable component of TNA SST variability is linked to ENSO. This could lead to improvements in forecasting the WAM, European heat waves, Atlantic hurricanes, rainfall in Brazil.

The connection involves a Gill-type response in the Atlantic in spring, which suggests an added value of Niño3.4 predictions (beyond persistence) when the teleconnection is correct in the models.

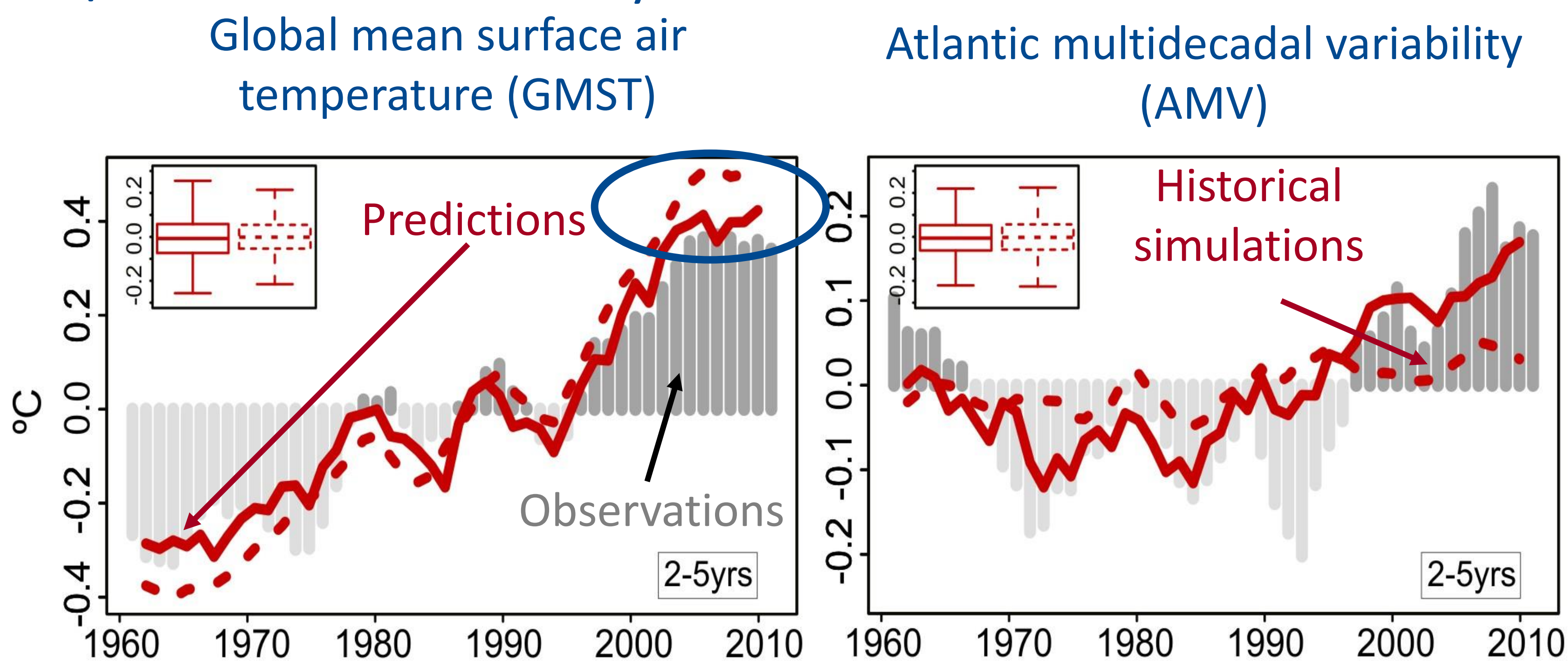




García-Serrano et al. (2016, J. Clim.)

Decadal climate predictions

Global-mean near-surface air temperature and AMV against GHCN/ERSST3b for forecast years 2-5.

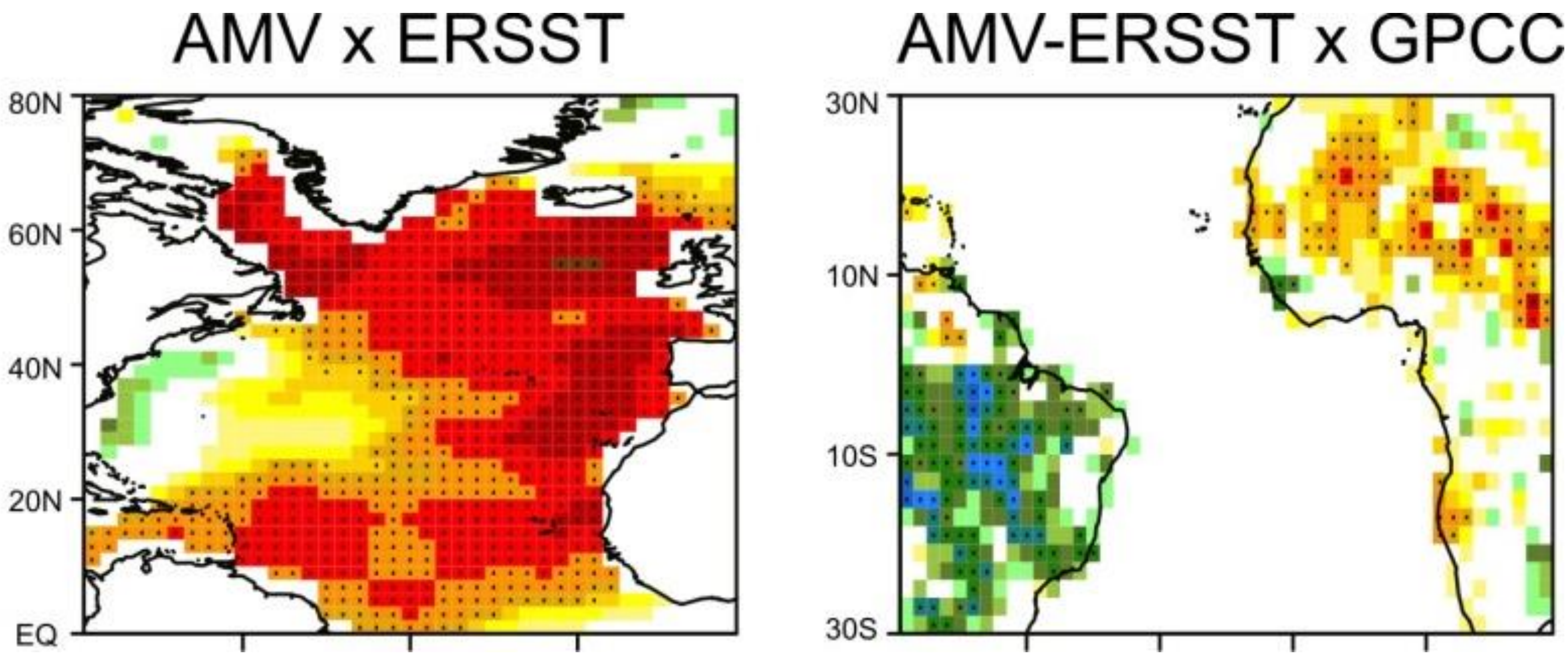


Initialised simulations reproduce the global temperature and some of the AMV tendencies and suggest that initialization corrects the forced model response and phases in internal variability.

Doblas-Reyes et al. (2013, Nat. Comms.)

The AMV

Atlantic multidecadal variability (AMV) pattern from ERSST data (left) and regression of the AMV index on the GPCC precipitation (right) over 1960-2010 using four-year averages.

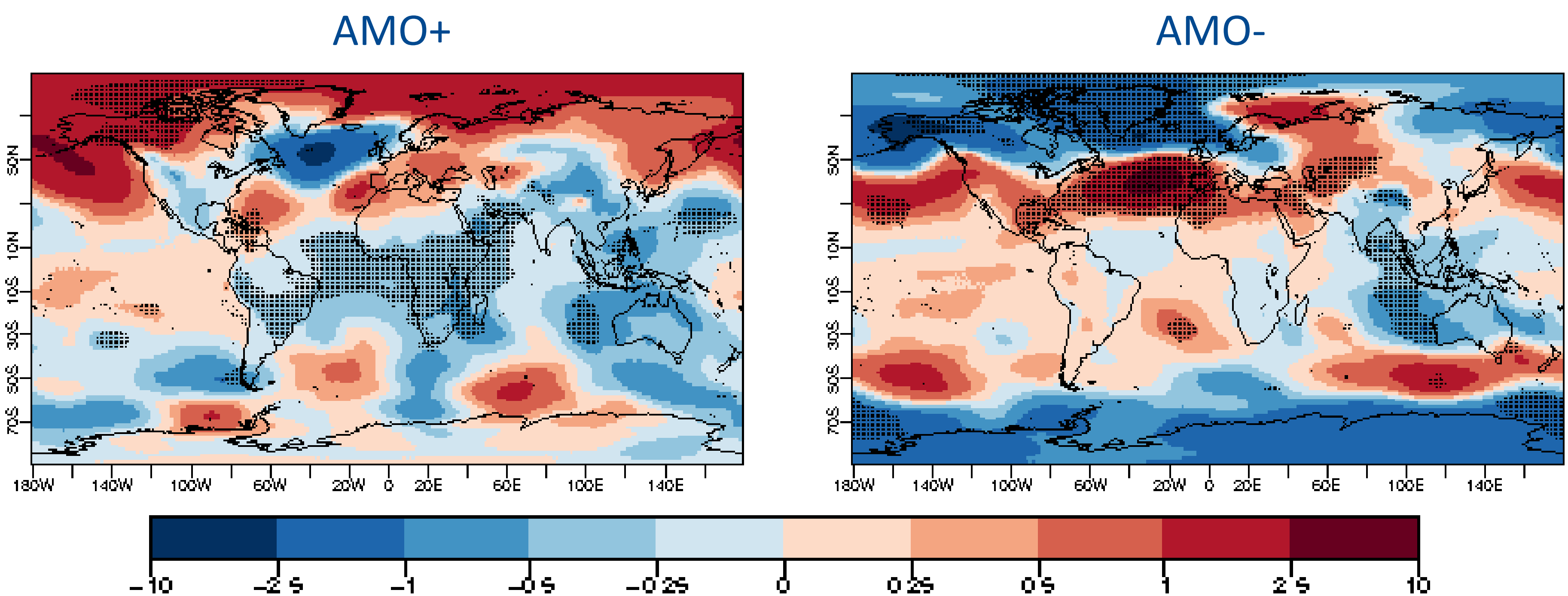


García-Serrano et al. (2014, Clim. Dyn.)

The forcings in a prediction context

SLP anomaly (hPa) induced by a Pinatubo eruption in the first three years after the eruption. Thirty-member simulations performed with CNRM-CM5.

NAO+ signal occurring the third winter after the eruption, only when the AMO is negative (in this model).



M. Ménégoz (BSC)

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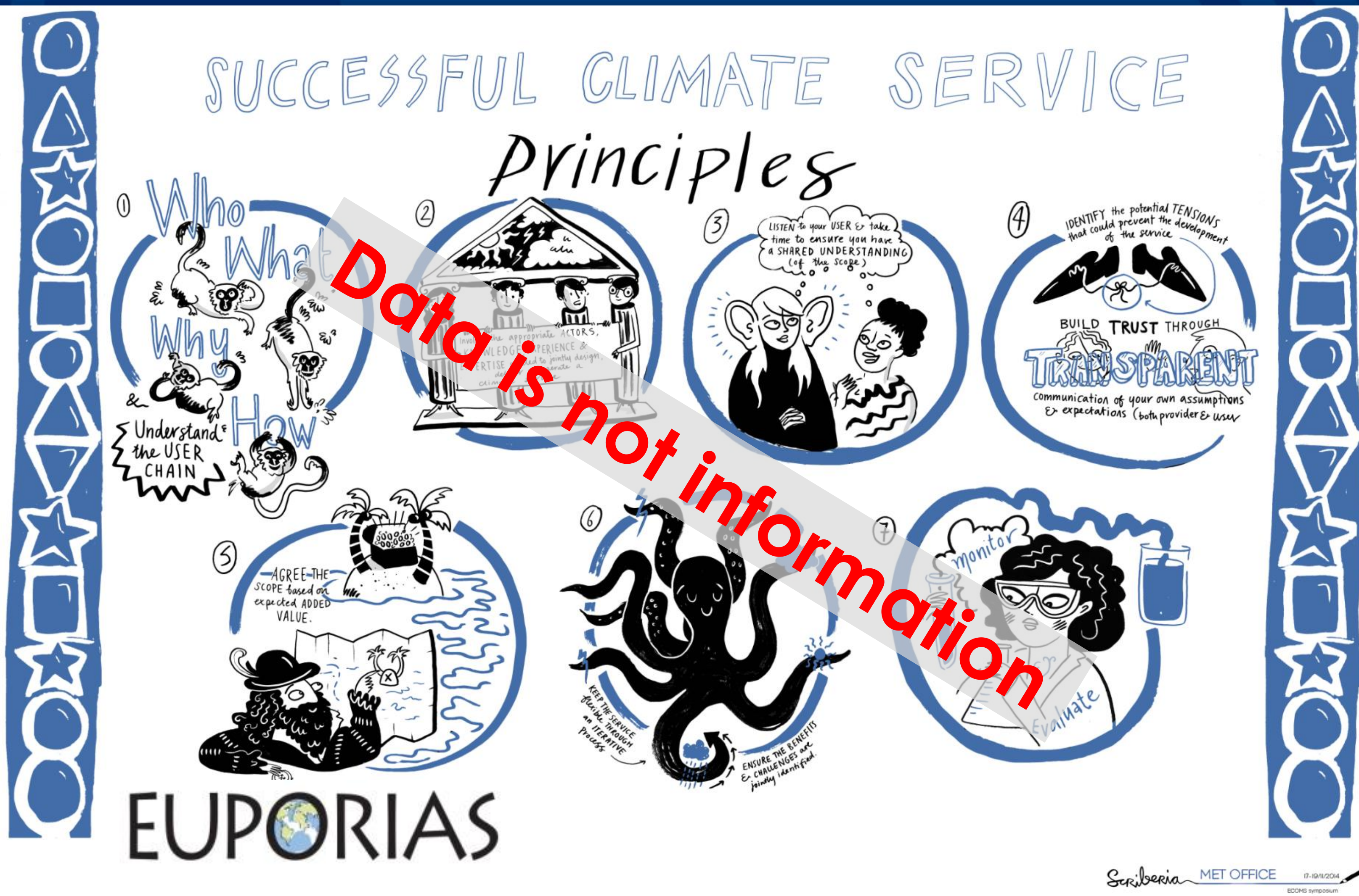

Ethical Framework for Climate Services four core elements: integrity, transparency, humility and collaboration.

Seasonal wind speed predictions

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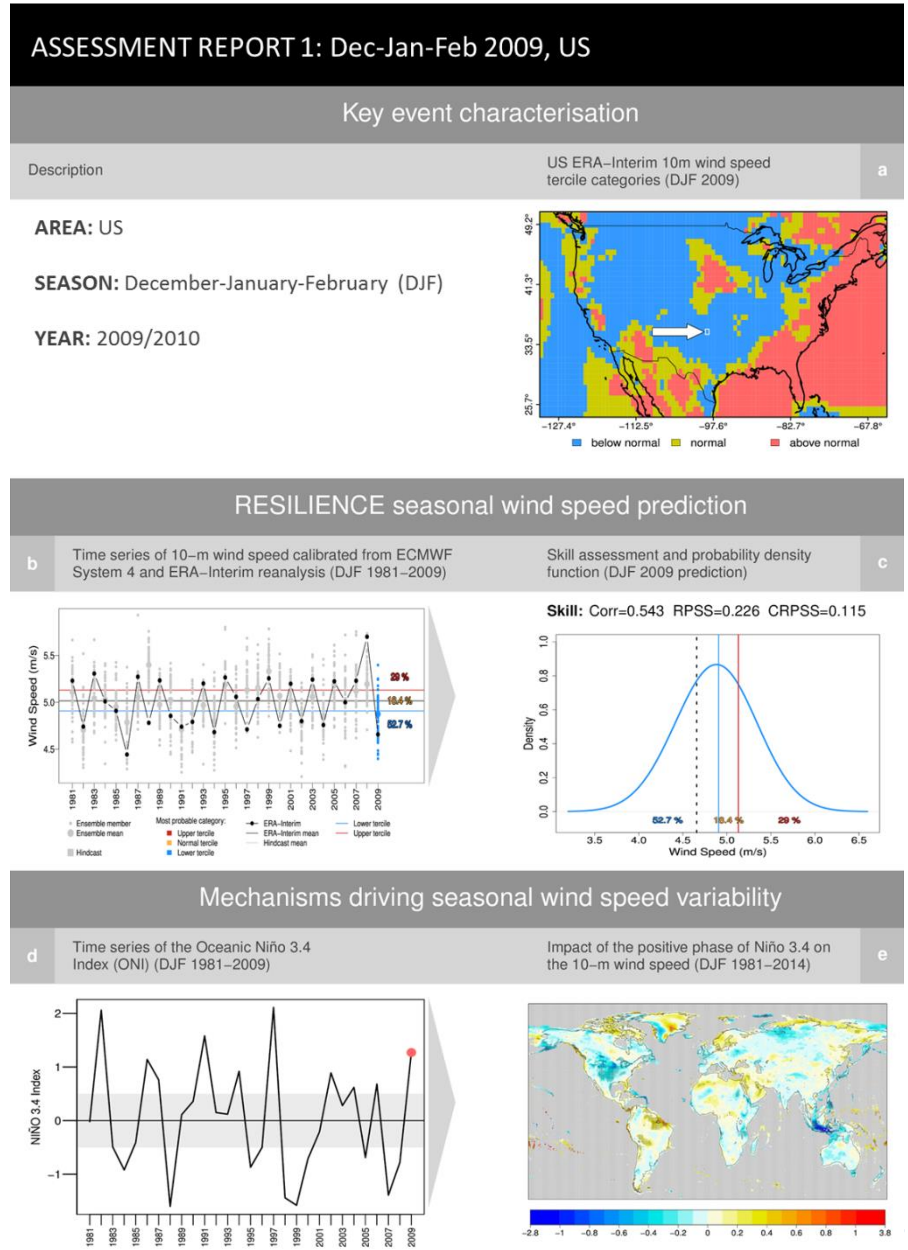
RESILIENCE
PROTOTYPE

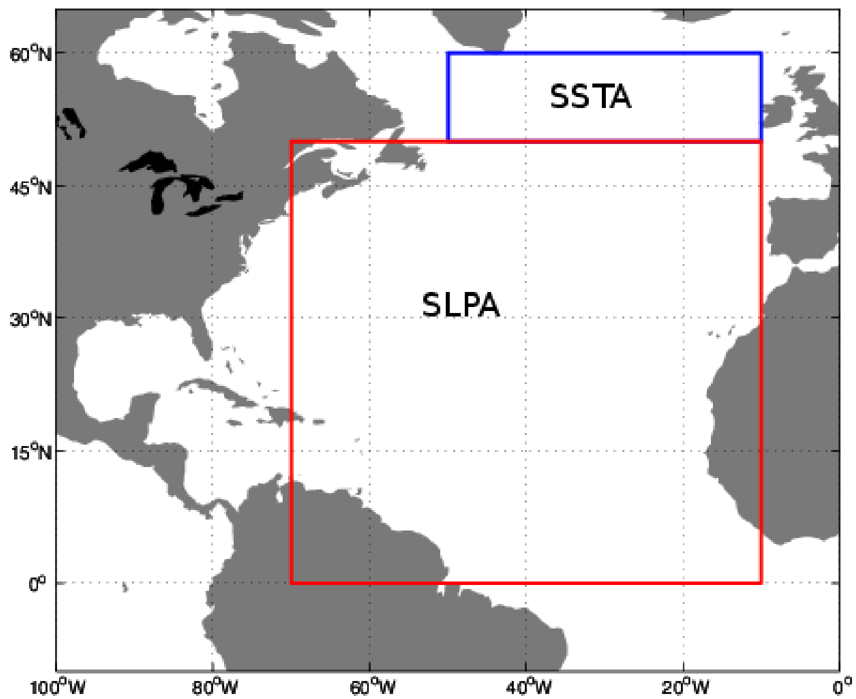
- Seasonal forecasts from ECMWF S4, soon a multi-model
- We assess the global behaviour providing **probabilistic information of the resource**
- Aggregated output in **terciles**:
  - Above normal
  - Normal
  - Below normal

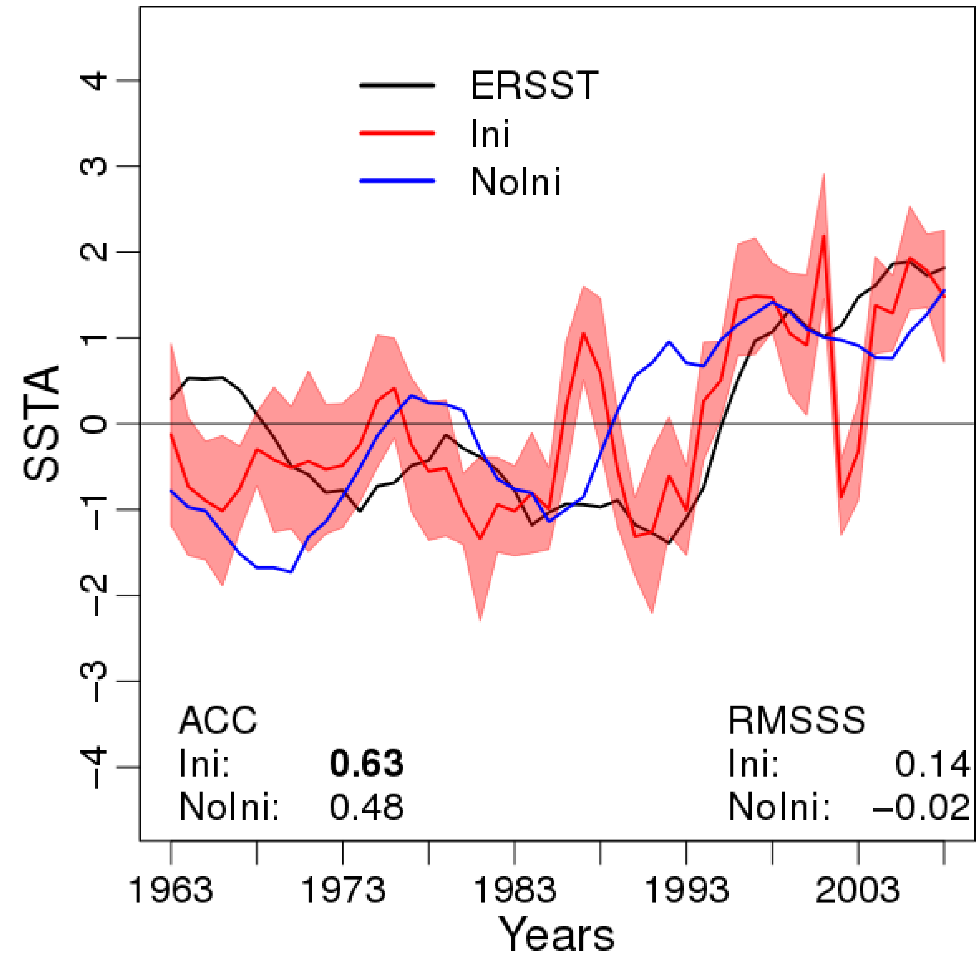
  Other options possible



Service-driven predictions: TCs

Tropical cyclone (TC) predictions: SST averaged over the subpolar gyre and North Atlantic SLP to estimate basin-wide **accumulated cyclone energy** (ACE). Results are for 1-5 year averages 1961-2006. Statistically significant scores are in bold.





Caron et al. (2015, GRL)

Service-driven predictions: TCs

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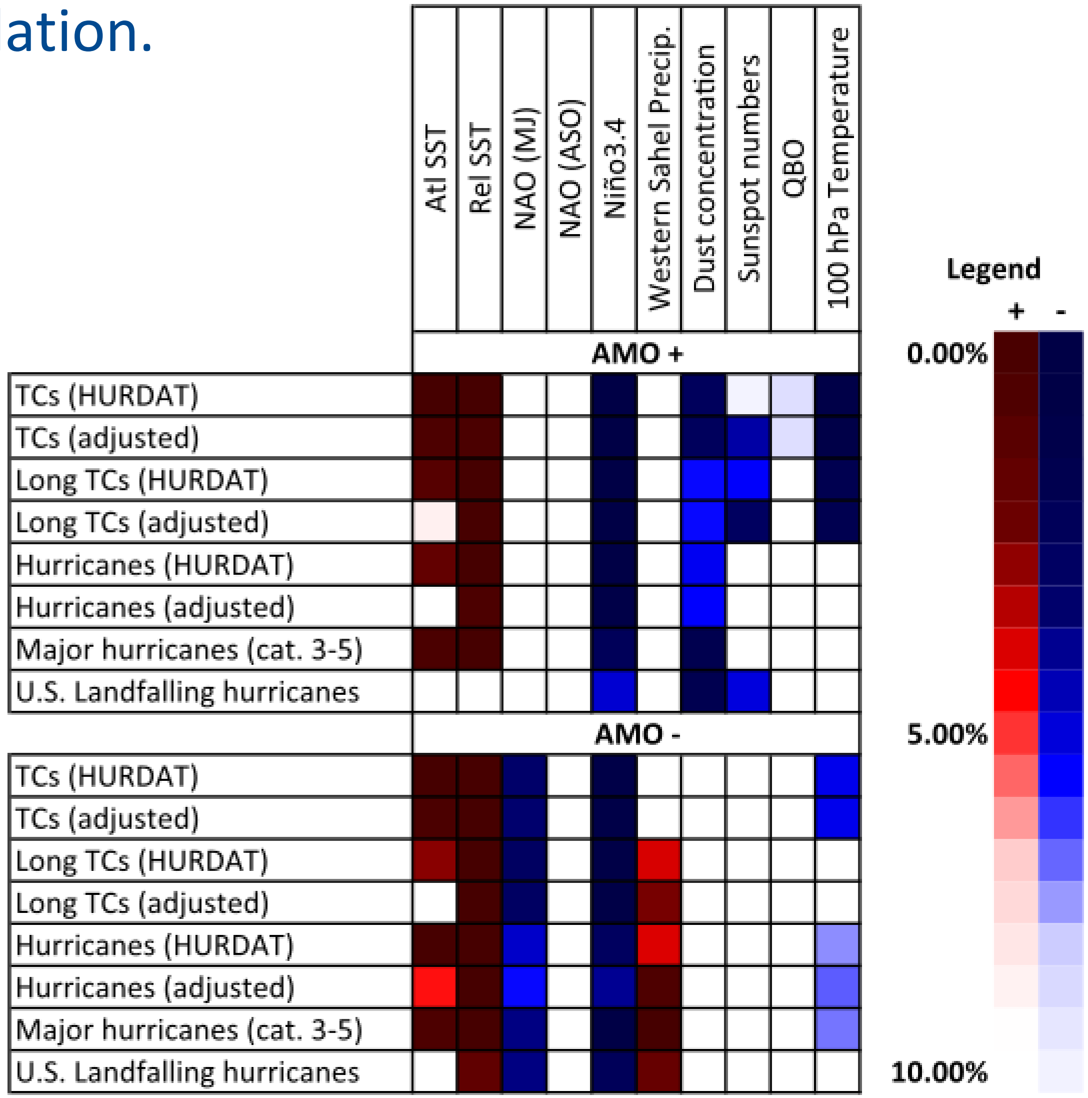
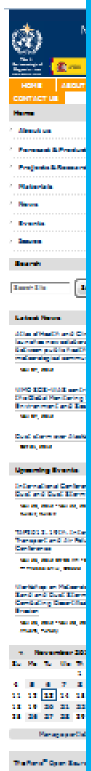
Factors affecting different tropical cyclone (TC) characteristics stratified by the phase of the AMO. The colour scale corresponds to the p-value of the correlation.



Caron et al. (2014, Cli m. Dyn.)

The WMO dust forecast centres

NMMB is used for, among many other things, producing operational dust forecasts.

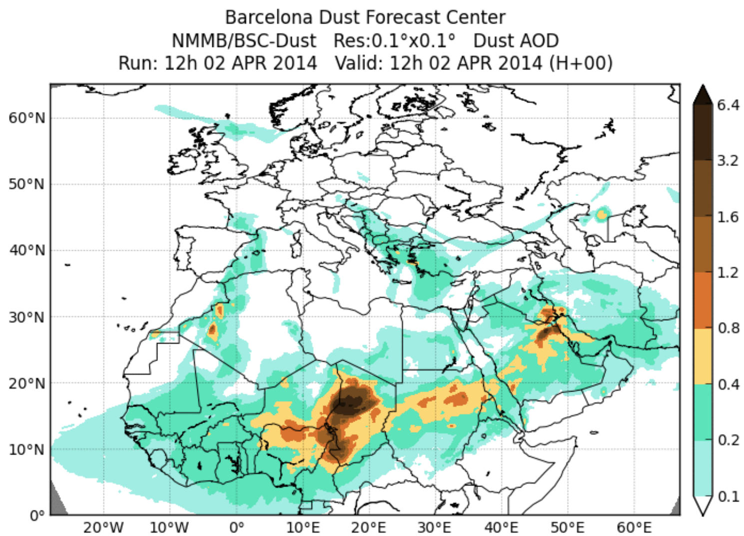


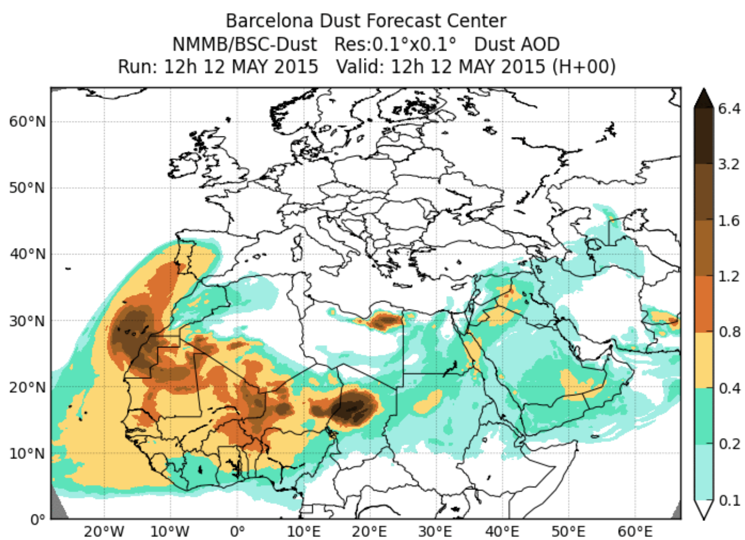
MODEL	RUN TIME	DOMAIN	DATA ASSIMILATION
BSC-DREAM8b	12	Regional	No
MACC	00	Global	MODIS AOD
DREAM-NMME-MACC	12	Regional	MACC analysis
NMMB/BSC-Dust	12	Regional	No
MetUM	00	Global	MODIS AOD
GEOS-5	00	Global	MODIS reflectances
NGAC	00	Global	No
EMA REG CM4	12	Regional	No
DREAMABOL	12	Regional	No

WMO Sanc
Advisory and Assessment System Regional Center for Northern Africa, Middle East and Europe http://sds-was.aemet.es

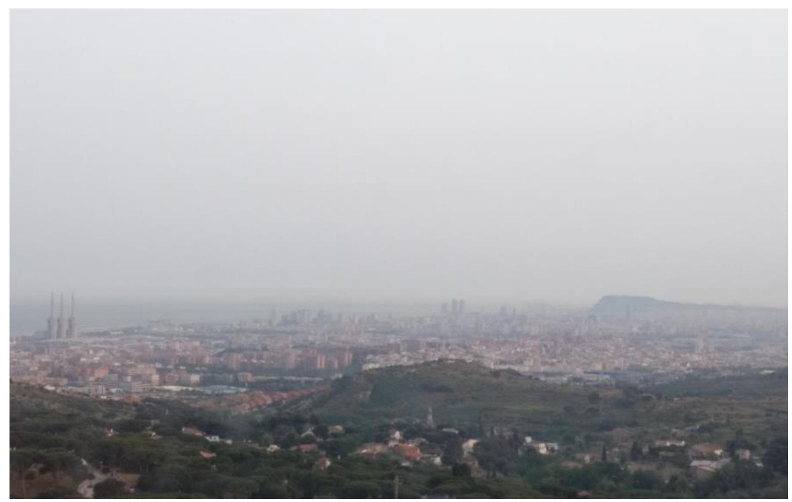
ter
http://dust.aemet.es

The WMO dust forecast centres



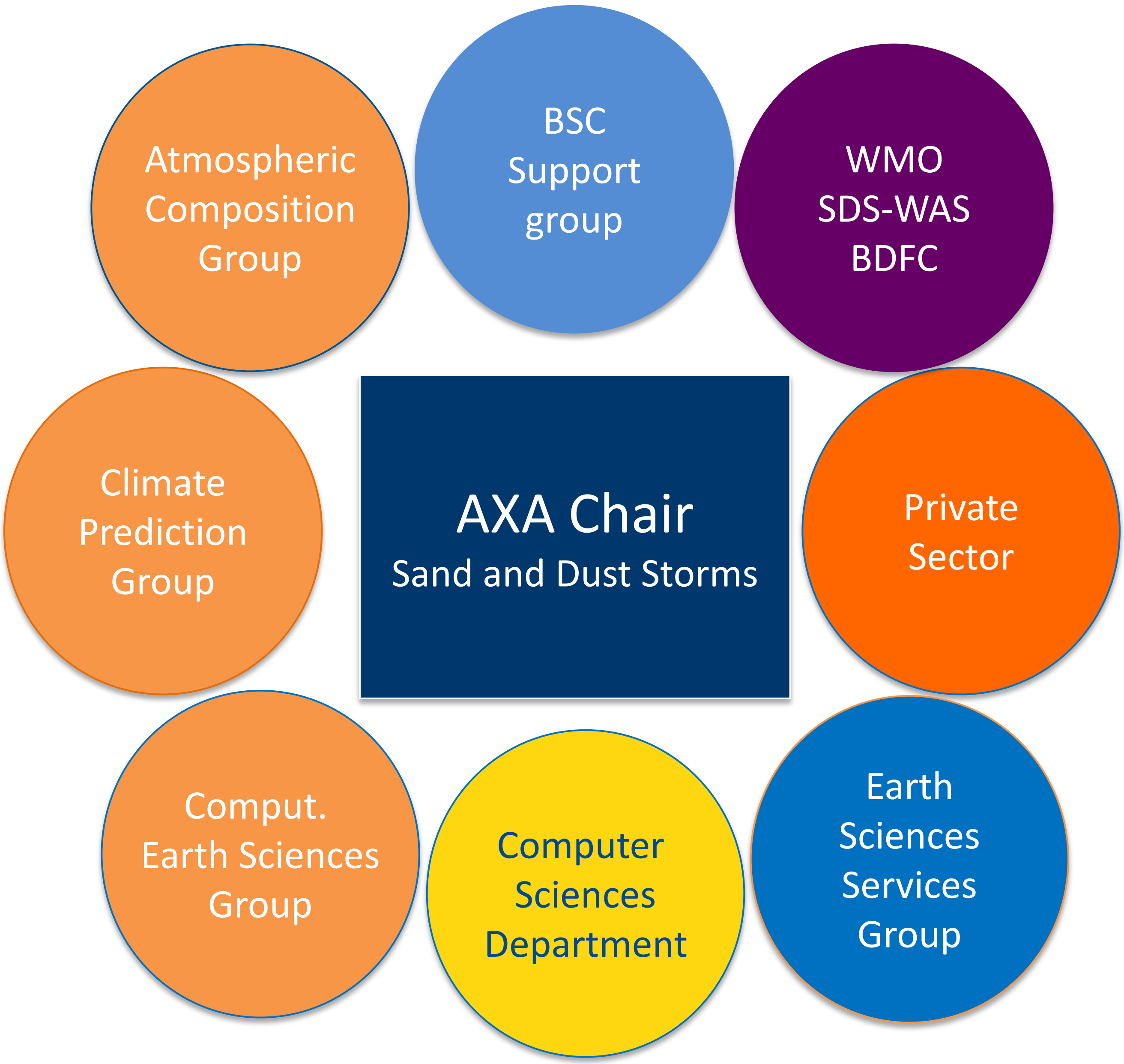


Barcelona Observatori Fabra, dust rain



Barcelona, dust layer at 1200-1500 m

A comprehensive programme



Fundamental Research
from weather to climate scales

Technology
Tools, models, forecasts, computing

Services
Impact research, technology transfer, services development

Education and outreach

The AXA Chair

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AXA Chair Holder: Carlos Pérez García-Pando, starting October 2016

AXA CHAIR on Sand and Dust Storms

GOALS	GOAL 1 DUST PROCESSES & VARIABILITY	GOAL 2 EFFECTS UPON WEATHER & CLIMATE	GOAL 3 FORECASTS & PRODUCTS	GOAL 4 IMPACTS & MITIGATION	GOAL 5 DISSEMINATION & PUBLIC ENGAGEMENT
FOCUS AREAS	• Present-day dust sources • Wind gusts and dust mobilization • Dust variability	• Dust composition • Weather and climate • Atmospheric chemistry and iron	• Data assimilation and model evaluation • Global and regional dust forecasting • Ensemble dust forecasting • Long-range dust prediction • Dust reanalysis	• Health • Agriculture • Solar energy and transportation	• Scientific community • Industry • National Weather Services & decision-makers • General public

TWO-WAY GOALS INTERACTIONS

- Scientific community
- National weather services, Industry & Decision-makers

HOST INSTITUTION: EARTH SCIENCES DEPARTMENT STRUCTURE

- ATHMOSPHERIC COMPOSITON GROUP
- CLIMATE PREDICTION GROUP
- COMPUTATIONAL EARTH SCIENCES GROUP
- EARTH SCIENCES SERVICES GROUP
- WMO SDS-WAS Regional Centers *
- BSC Communication Dpt. **

* Centers in collaboration with AEMET / ** Support service of the BSC-CNS to all its departments

The questions

- Long-term observation programs: what have we learnt?

No climate research is possible without long-term observations. New variables are required.

- How long-term observation programmes should evolve?

In collaboration with modelling efforts to identify common needs.

- Capabilities to assess the impacts of future climate?

Observations should come along with uncertainty measures. In particular, gridded (satellite?) products should provide solutions to propagate the uncertainty to different spatial and time scales.

Summary

- Requests for climate information for up the next 30 years as a continuous stream come from a broadening range of users and should be addressed from a climate services perspective.
- Different tools are available to provide near-term climate information (global and regional projections, seasonal and decadal predictions, empirical systems, etc). Merging all this information into a reliable, unique source is a problem still not solved.
- The BSC Earth Sciences Department is now positioned to develop a unique programme around the impact of atmospheric composition changes on climate prediction.
- None of this will materialize without appropriate investment in observational networks and reduction of all aspects of model error, plus infrastructures that rationalize the investments in climate-modelling research.