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Brussels, 9 March 2016

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

Climate prediction and climate services activities at the Barcelona Supercomputing Center

François Massonnet and
the BSC Earth Sciences Department

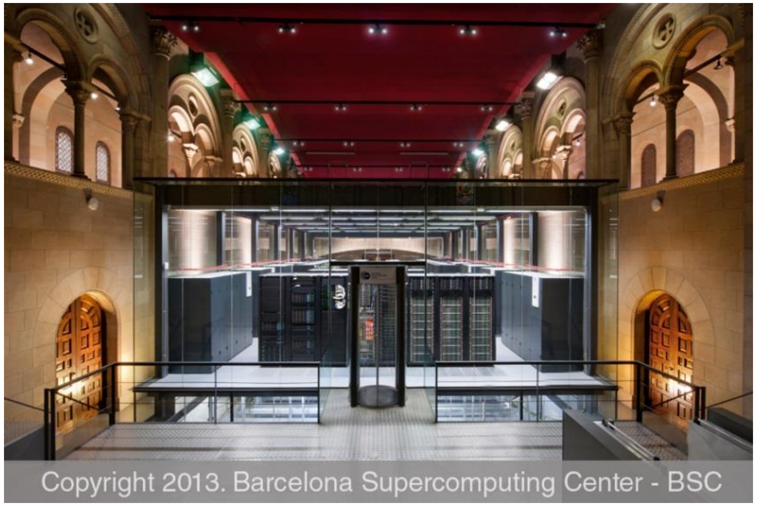
Barcelona Supercomputing Center

Barcelona Supercomputing Center – Centro Nacional de Supercomputación (BSC-CNS) is the premium HPC center in Spain located on **UPC** campus in Barcelona

More than 400 members (from more than 30 countries) are organized in 5 departments:

- → Computer Sciences
- → **Earth Sciences**
- → Life Sciences
- → Computer Applications
- → Support and Services

MareNostrum III (housed in Torre Girona) is one of the most powerful supercomputers in Europe (48,128 processors with 1.1 Pflops peak performance) ➠ this year it will be replaced with **MareNostrum IV**



BSC Earth Sciences Department

What

Environmental forecasting

Why

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

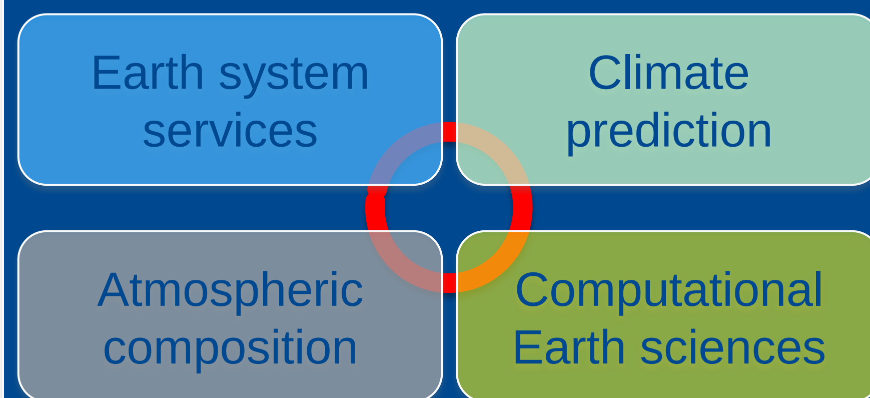
How

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

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

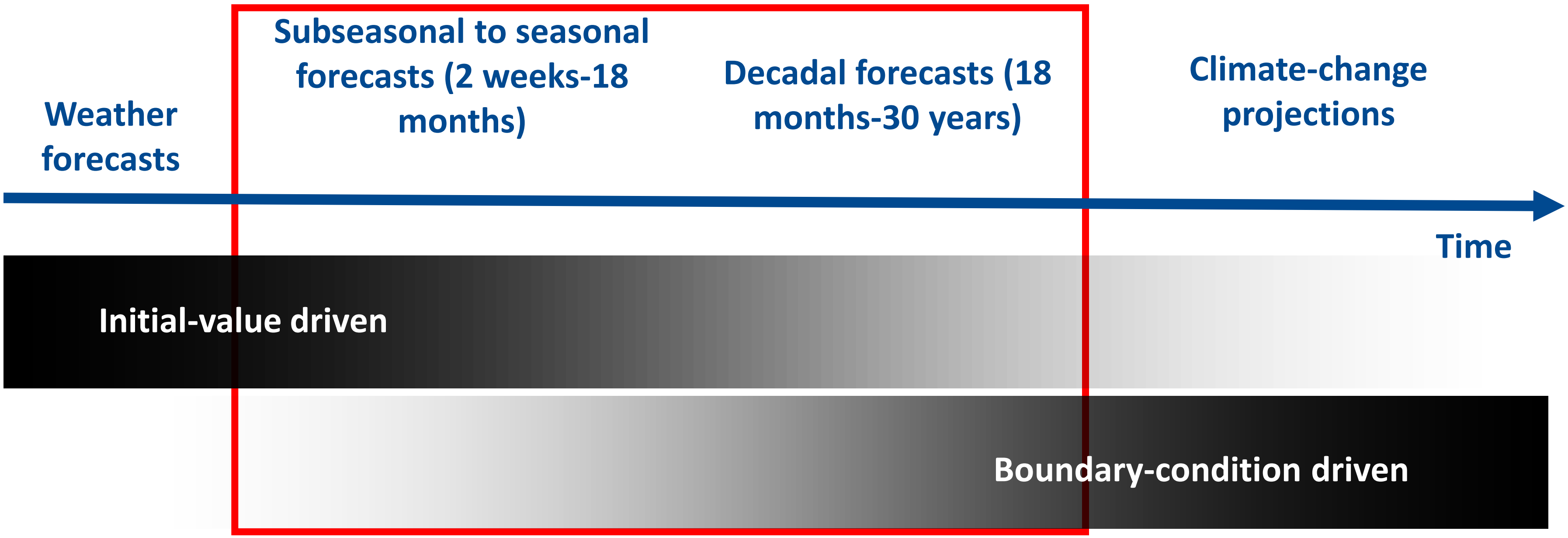
Develop user-oriented services that favour both technology transfer and adaptation

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



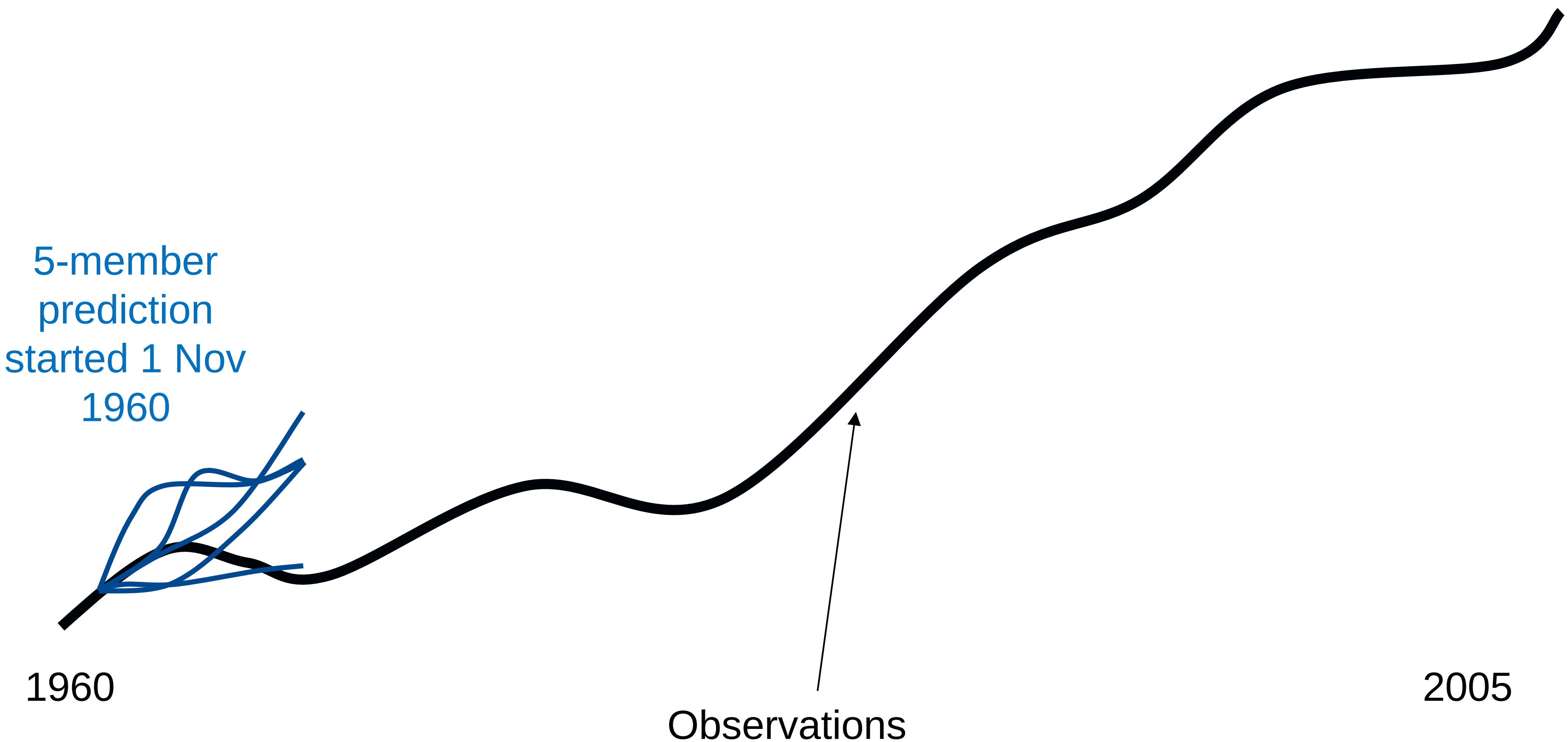
Climate prediction time scales

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.

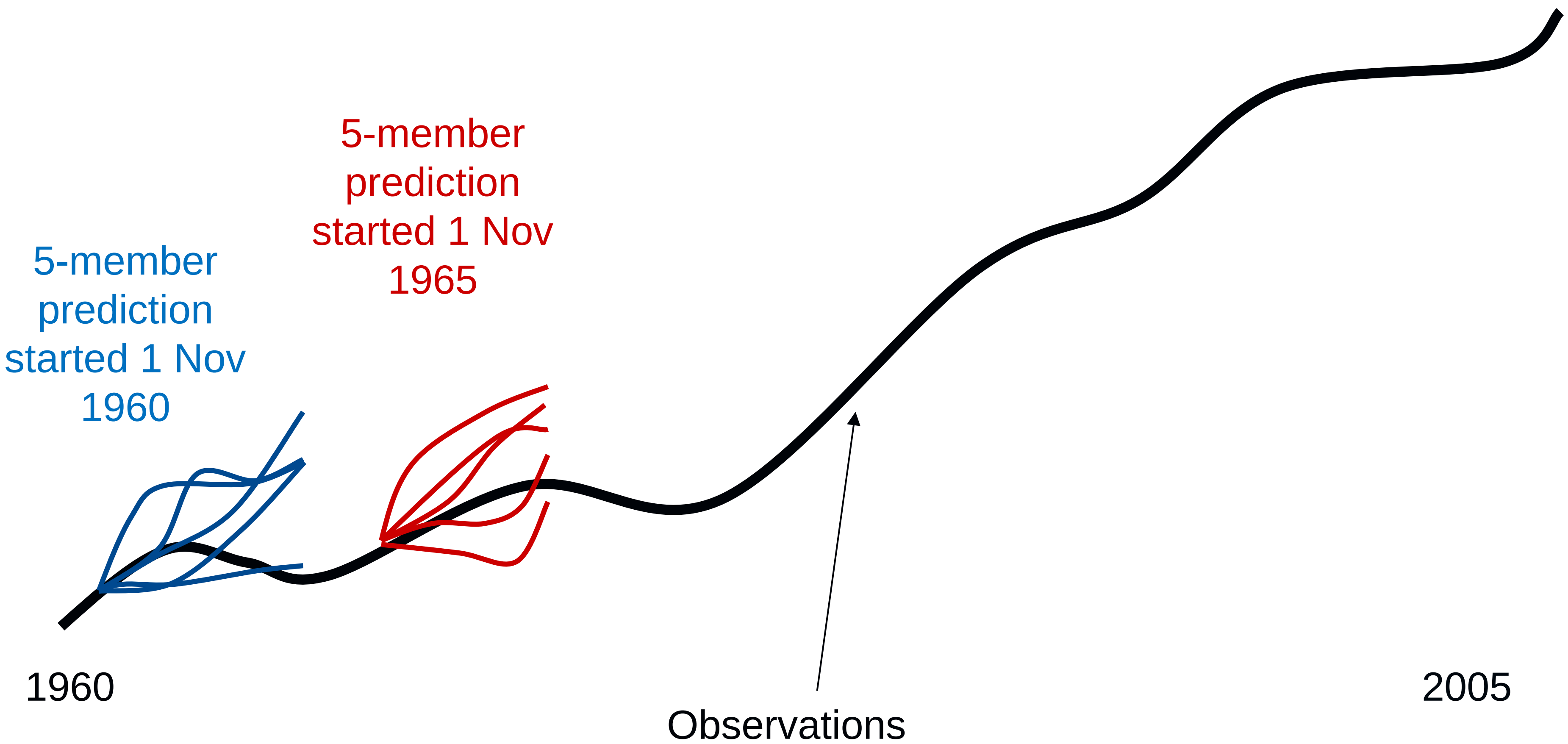


Adapted from Meehl et al. (2009)

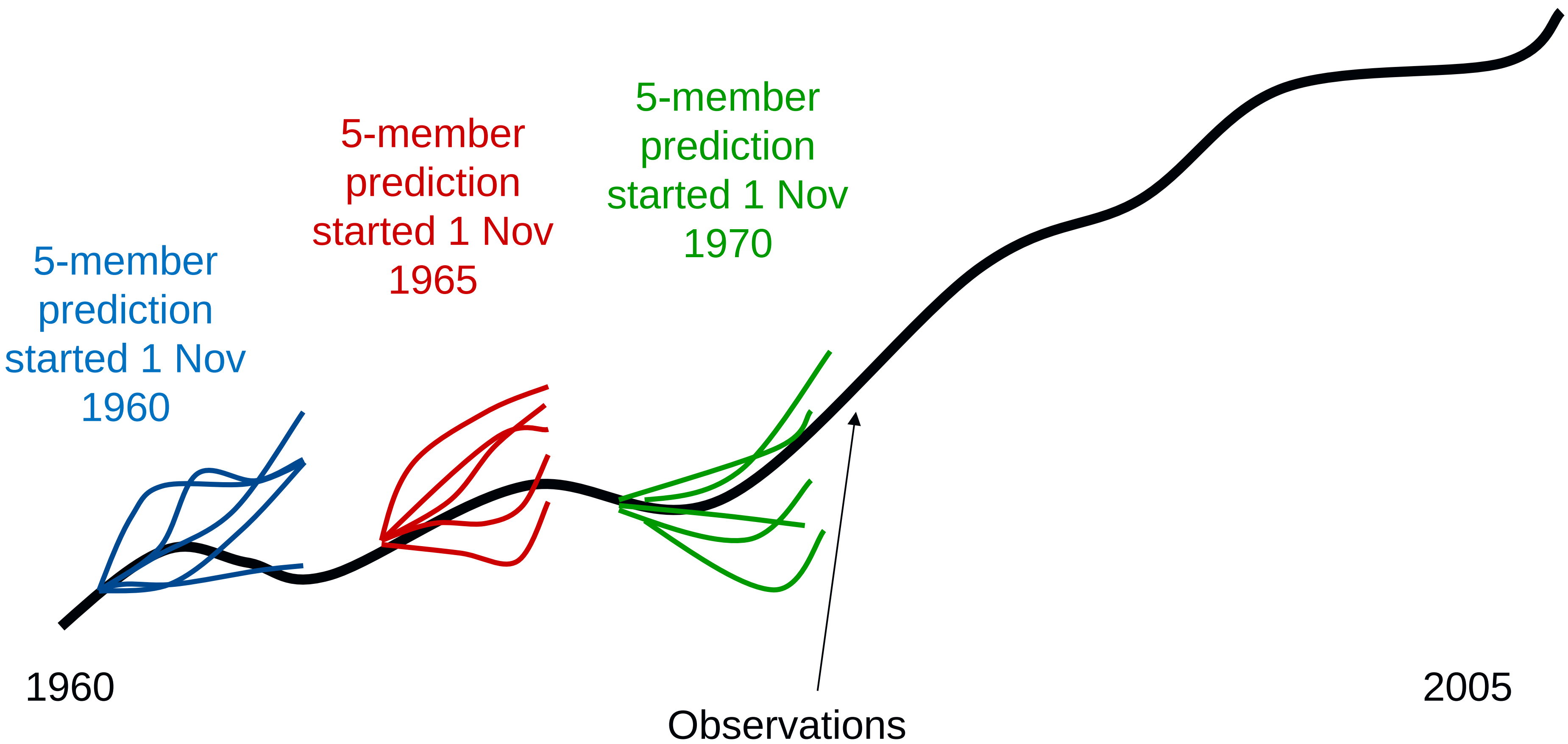
Climate prediction experiments



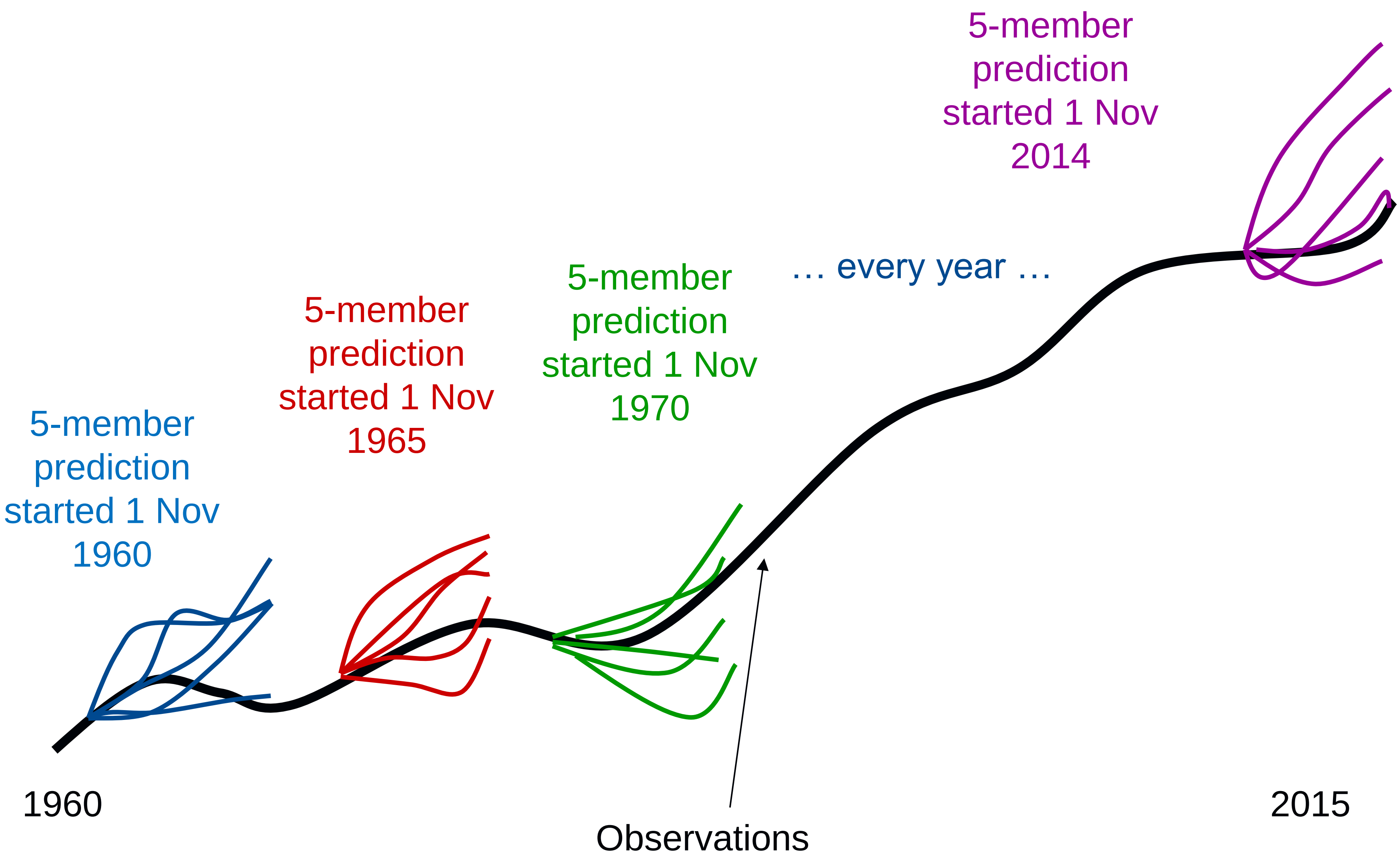
Climate prediction experiments



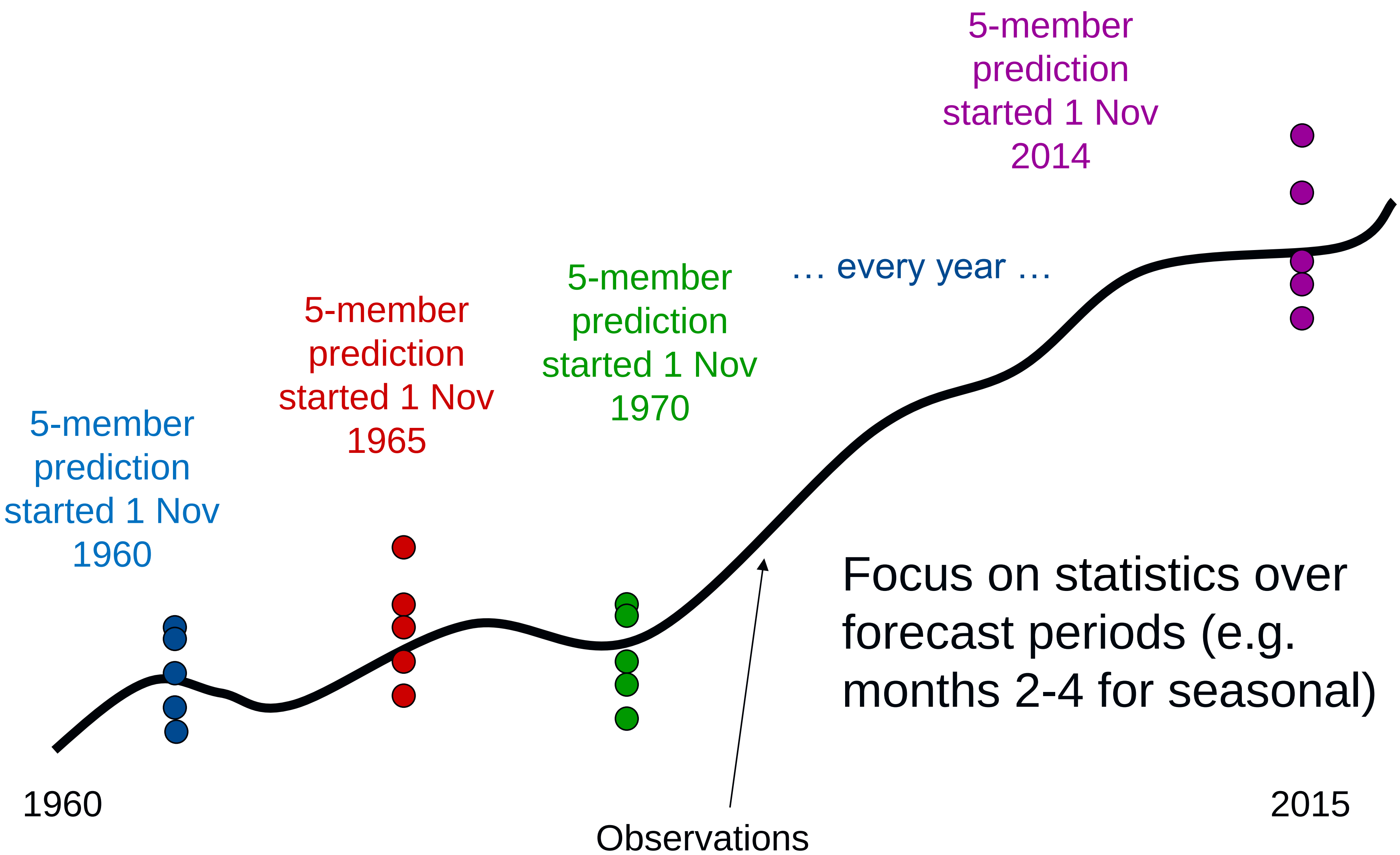
Climate prediction experiments



Climate prediction experiments



Climate prediction experiments

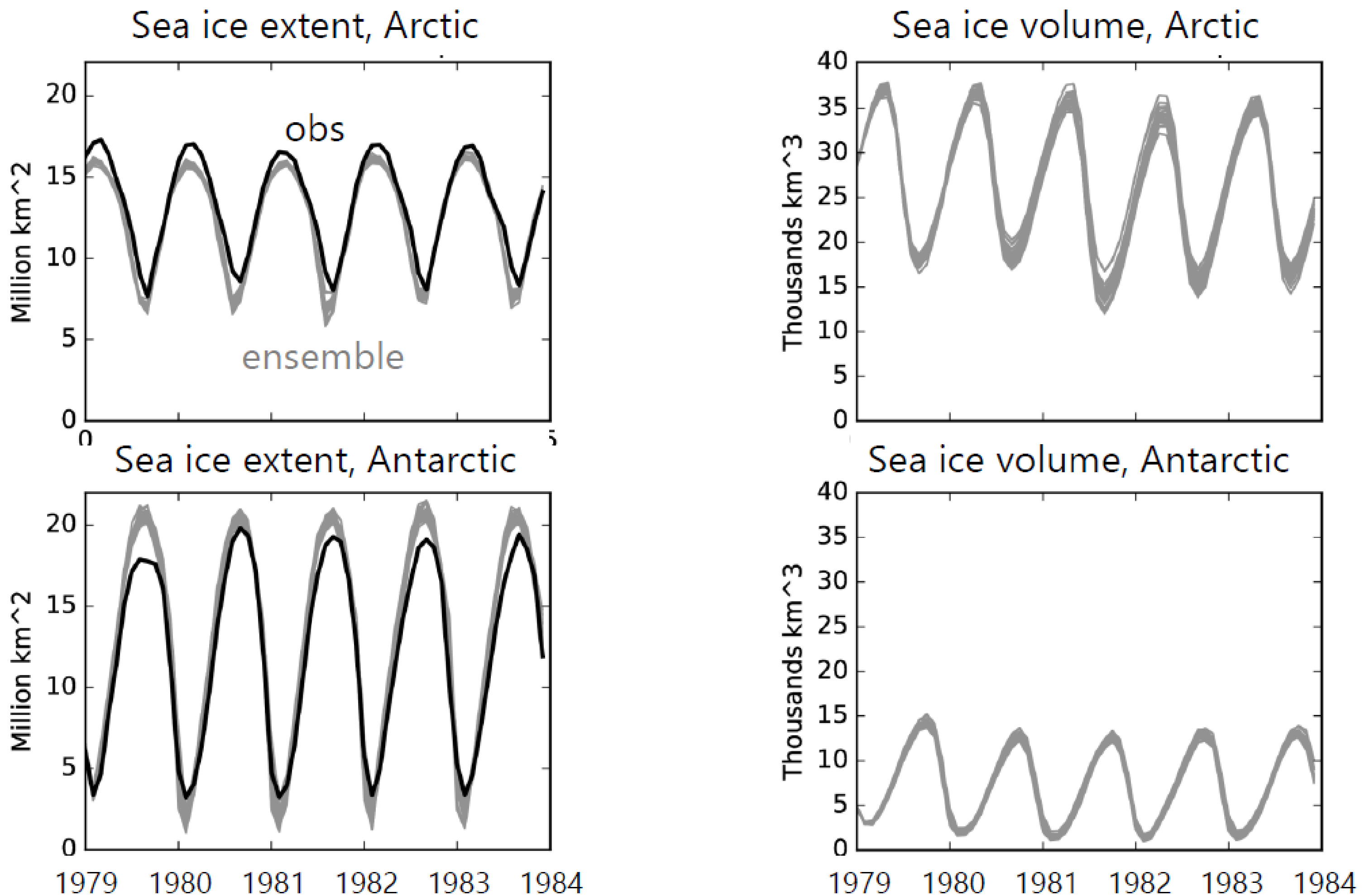


Climate prediction and service activities

1) Generation of in-home sea ice **reconstruction / reanalyses** – data assimilation techniques to exploit existing atmospheric and oceanic reanalyzes – development of initialization methods (anomaly versus full-field)
2) Analyses of **mechanisms leading to model bias** and development of **bias correction techniques** accounting for sensitivity of bias to prediction start date
3) Improvement of forecast systems through better process representation : inclusion of **new parameterizations**, new model components, **high resolution**, parameter calibration
4) Identifying **sources of skill** such as soil moisture, sea ice thickness, aerosols, biogeochemistry through multi-faceted forecast quality assessment and sensitivity experiments
5) Development of reliable techniques for **attribution** of extreme events, analysis of case studies : 2014 Antarctic sea ice maximum, 2010 heat wave
6) Wind energy sector : prototype website **delivering seasonal wind predictions**
7) Agriculture/viticulture : identification of possible **opportunities** for **land investment**
8) Tropical cyclone damages : hosting of an **operational website** for the next hurricane season gathering predictions from all existing centers

1) Large ensemble sea ice reconstructions

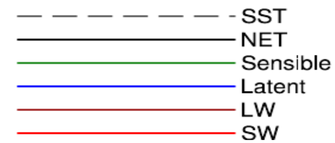
NEMO 3.6 – OSISAF & ESA-CCI sea ice concentration assimilated with EnKF – perturbations of the surface forcings based on covariance matrix

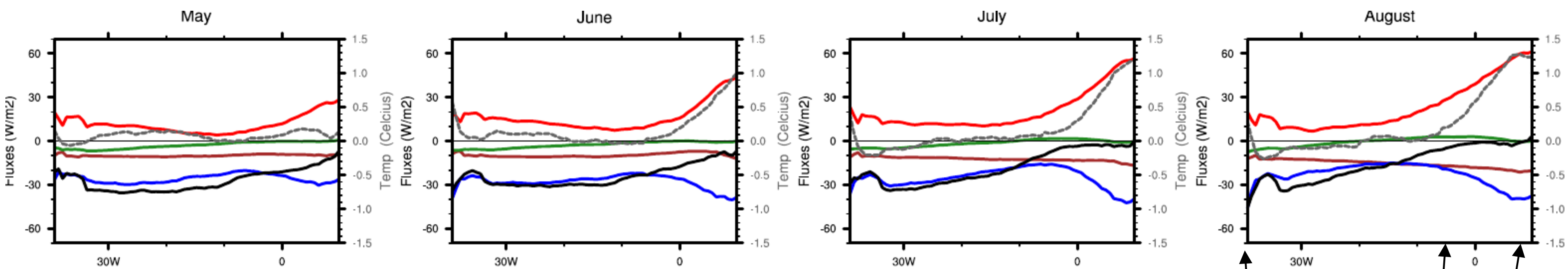


2) Understanding Tropical biases

Ec-Earth3.1 5-member seasonal climate forecasts initialized on 1st May from 1993 to 2009 from ERA-interim and GLORYS2v1 reanalyzes

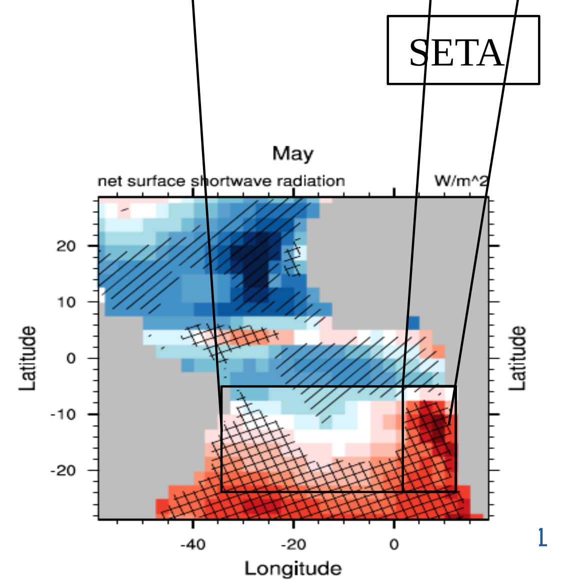
Increased solar fluxes (red line), in the model in the coastal boundary, contribute to the warm SST bias in the coastal upwelling region





Surface heat fluxes observations: Tropflux (Kumar et al, 2012)

Increased solar fluxes (red colors), in the model occur because of less clouds (dashed pattern) compared to observations



ISCCP: Rossow, W.B., and Schiffer, R.A., 1999: Advances in Understanding Clouds from ISCCP. Bull. Amer. Meteor. Soc., 80, 2261-2288.

3) Climate response to volcanoes

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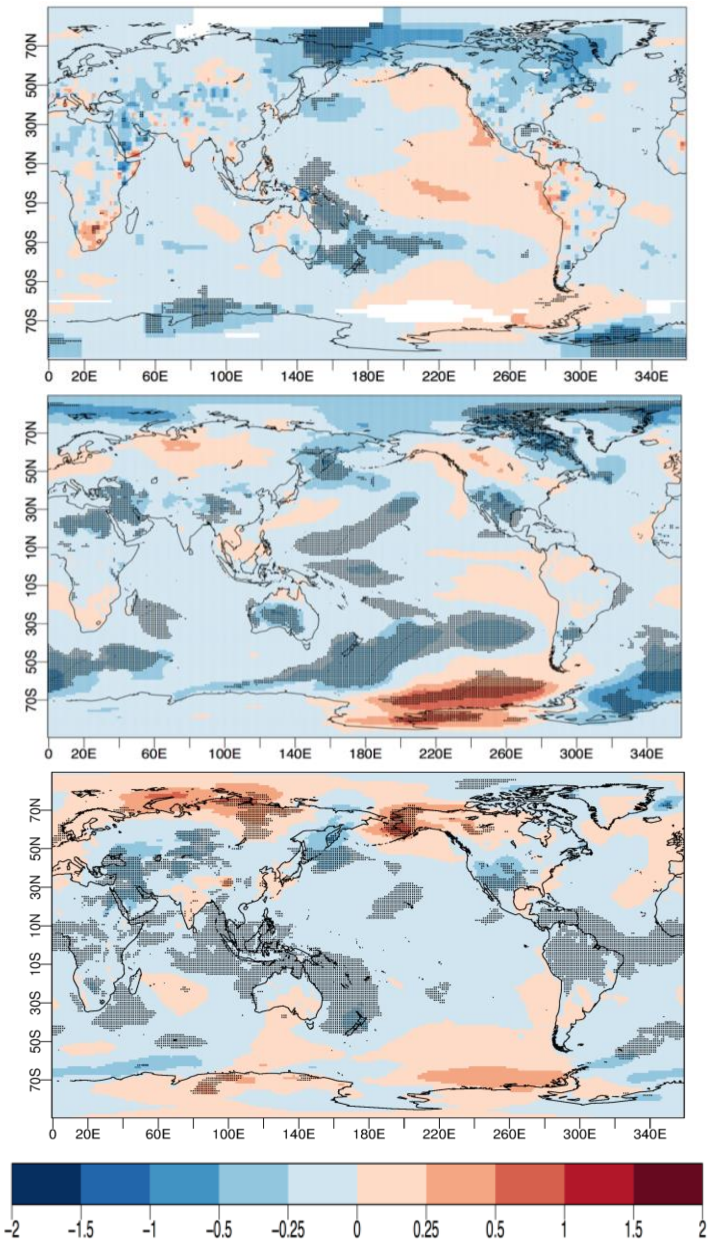
Ec-Earth2.3 5-member decadal climate forecasts initialized on 1st November from 1960 to 2005 with observed or idealized volcanic forcings. Surface temperature anomaly averaged over forecast years 1-3 averaged over forecasts initialized right before the Pinatubo, Agung and Chichon volcanic eruptions

Observation

Hindcast using observed volcanic forcing

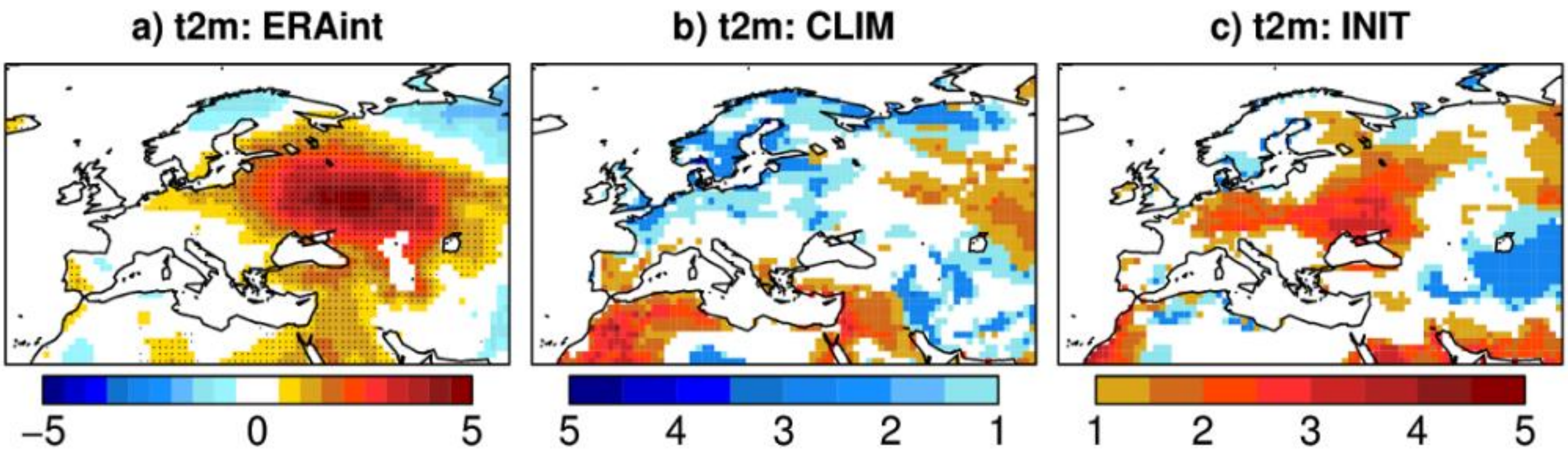
Forecast using idealized volcanic forcing



M. Ménégoz (BSC)

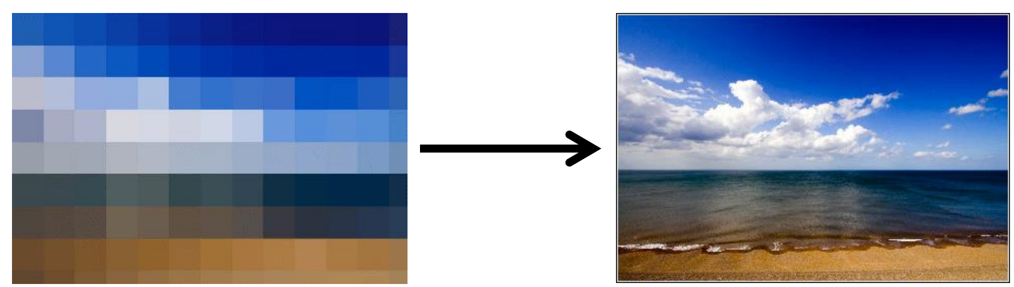
4) Impact of land surface initialization

JJA near-surface temperature anomalies in 2010 from ERAInt (left) and odds ratio from 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.



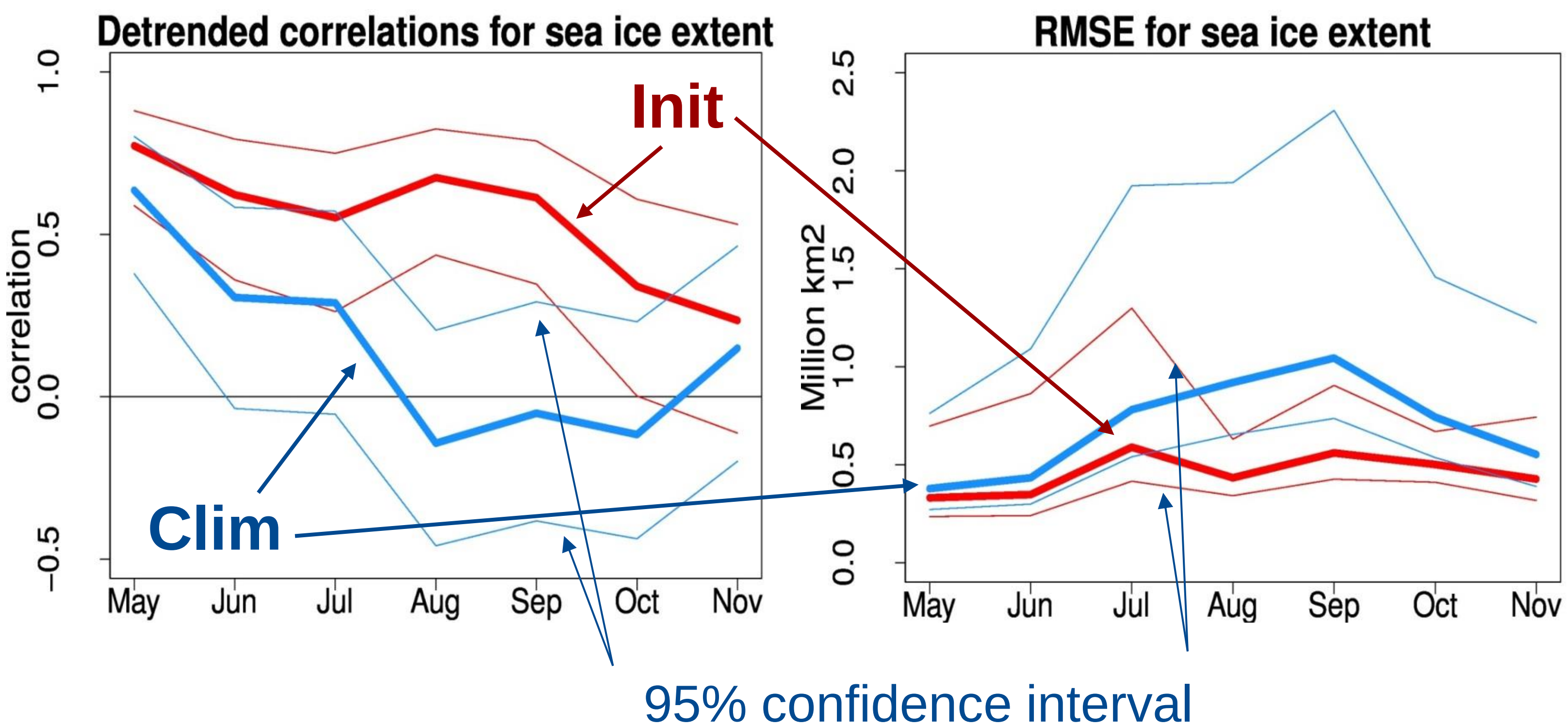
Similar results found for EC-Earth3 and high resolution (25 km).

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



4) Impact of Arctic sea ice initialisation

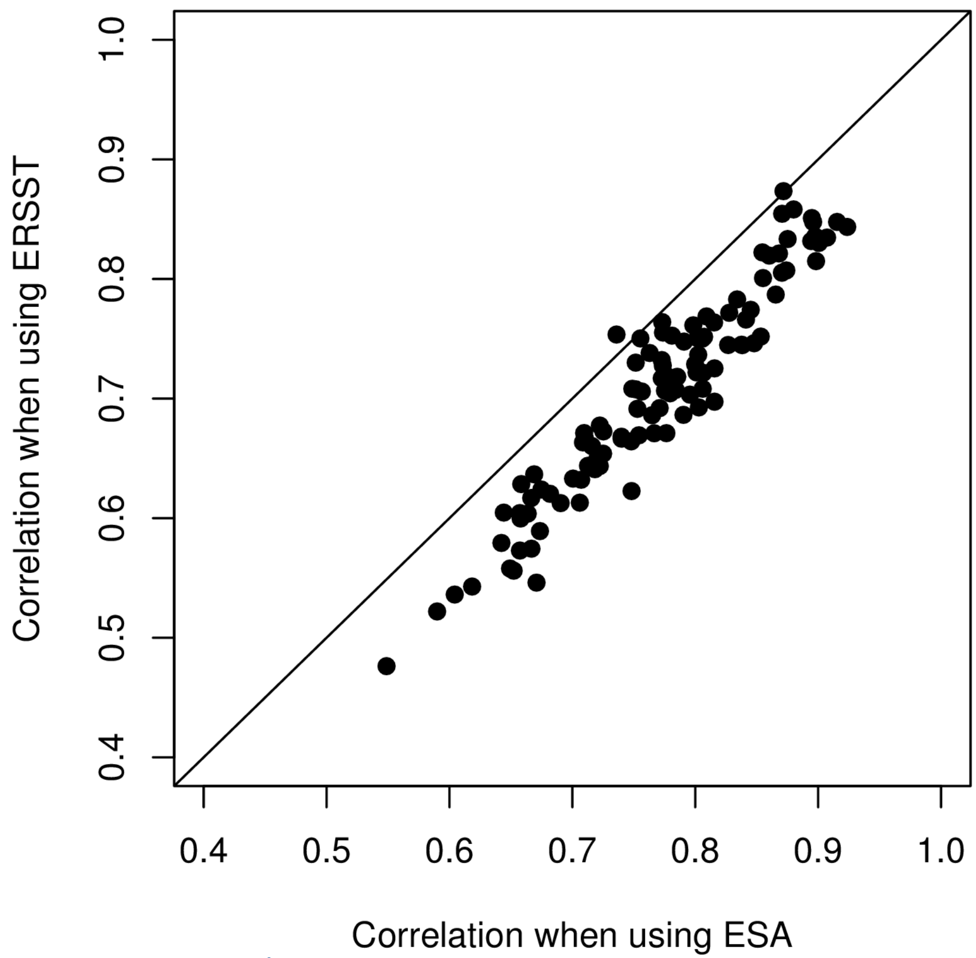
Ec-Earth2.3 5-member seasonal climate forecasts initialized on 1st May from 1979 to 2012 from either a sea ice reconstruction (Init) or a climatology of this reconstruction (Clim). No impact on the atmosphere prediction skill



Guemas et al (2016, GRL)

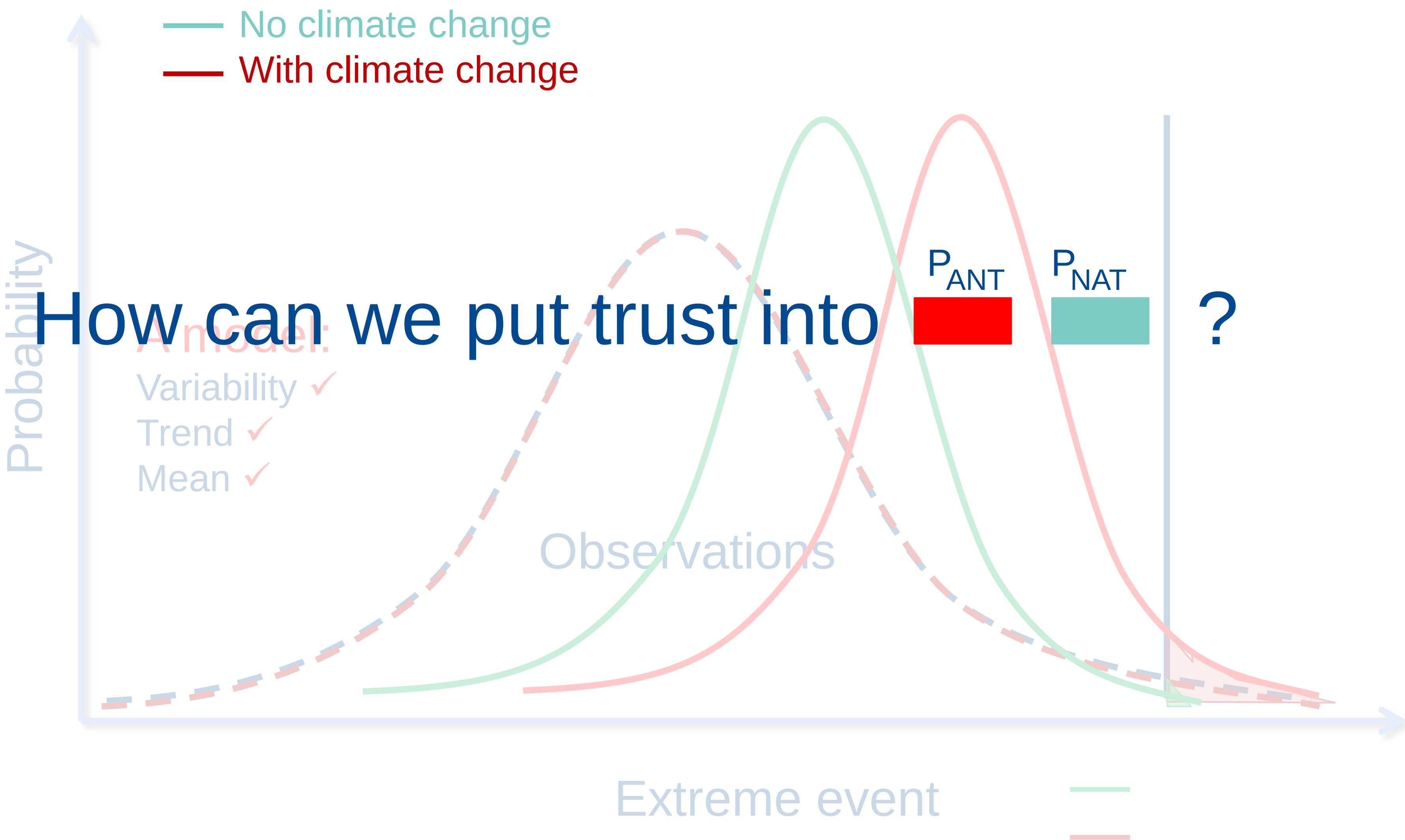
4-5) Observational uncertainty

Using advanced products for verification of seasonal forecasts yields systematically better skill to these forecasts



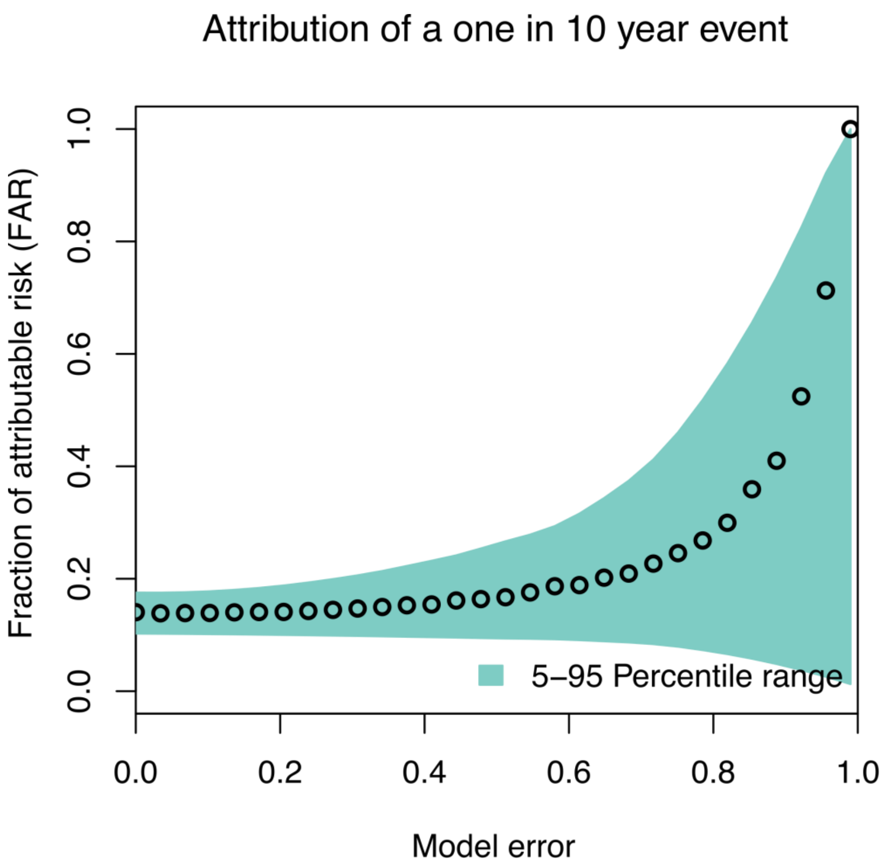
Massonnet et al. (2016, in preparation)

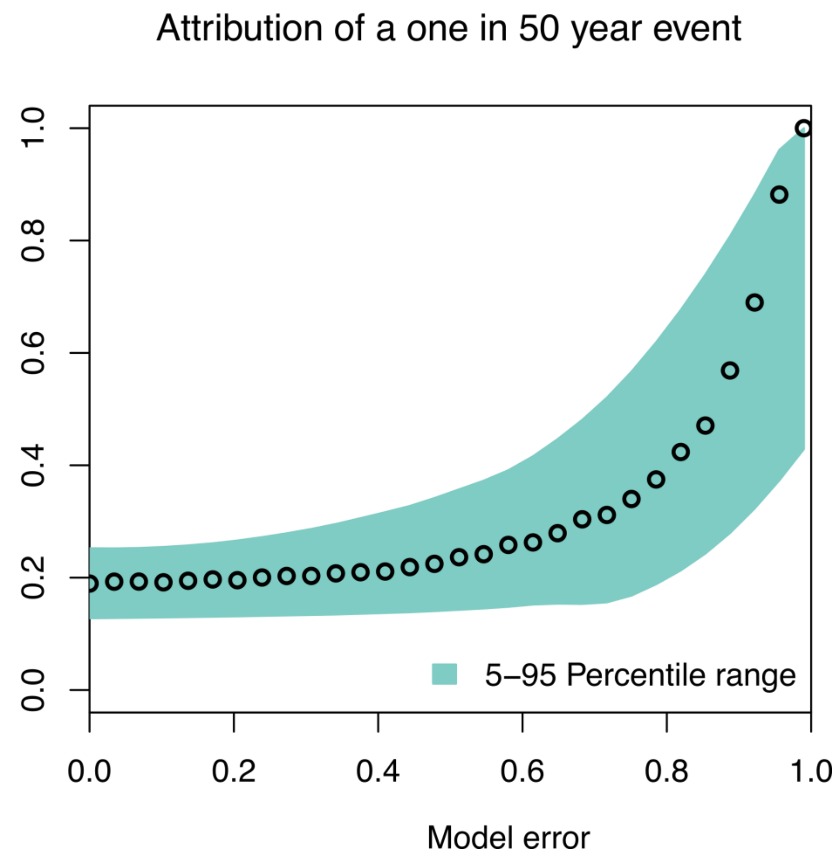
5) Event attribution



How can we put trust into P_{ANT} P_{NAT} ?

Statistical model. Relationship between Fraction of Attributable Risk (FAR) and model error set in the statistical model. The FAR increases with model error.

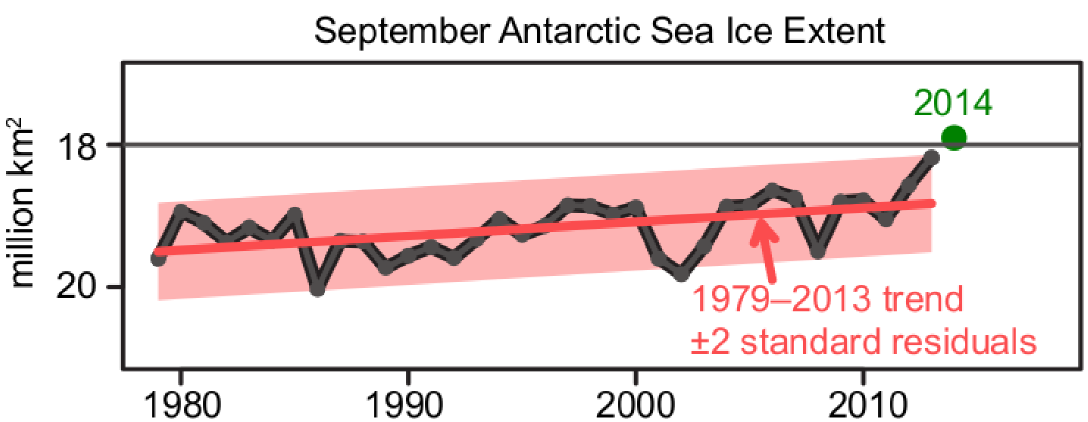


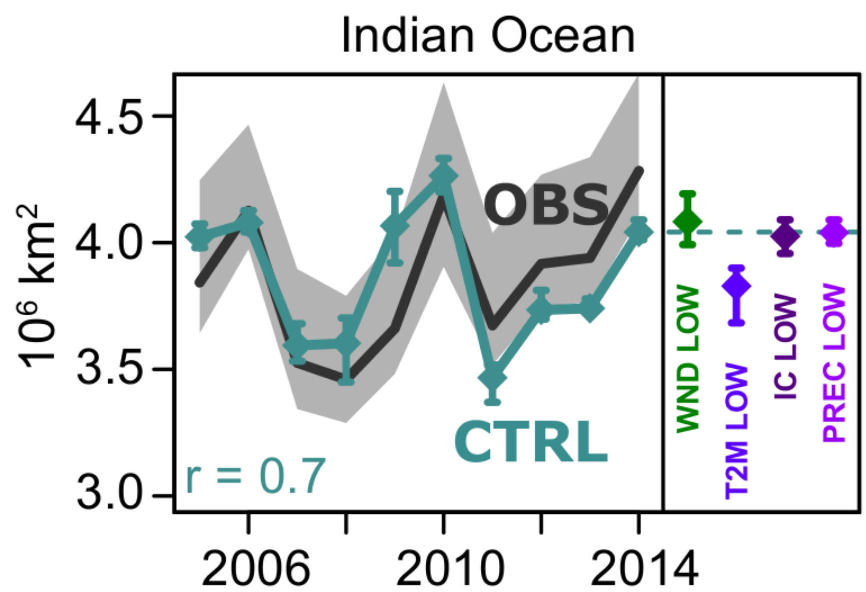


Bellprat and Doblas-Reyes (2016, GRL)

5) Antarctic sea ice record maximum

2014 was an exceptional year for the Antarctic sea-ice extent. A set of sensitivity experiments with NEMO allows to attribute it to anomalous southerly advection of cold air (Indian sector) and ocean pre-conditioning (Ross Sea).





Massonnet et al. (2015, BAMS)

6-7-8) Service-driven climate research

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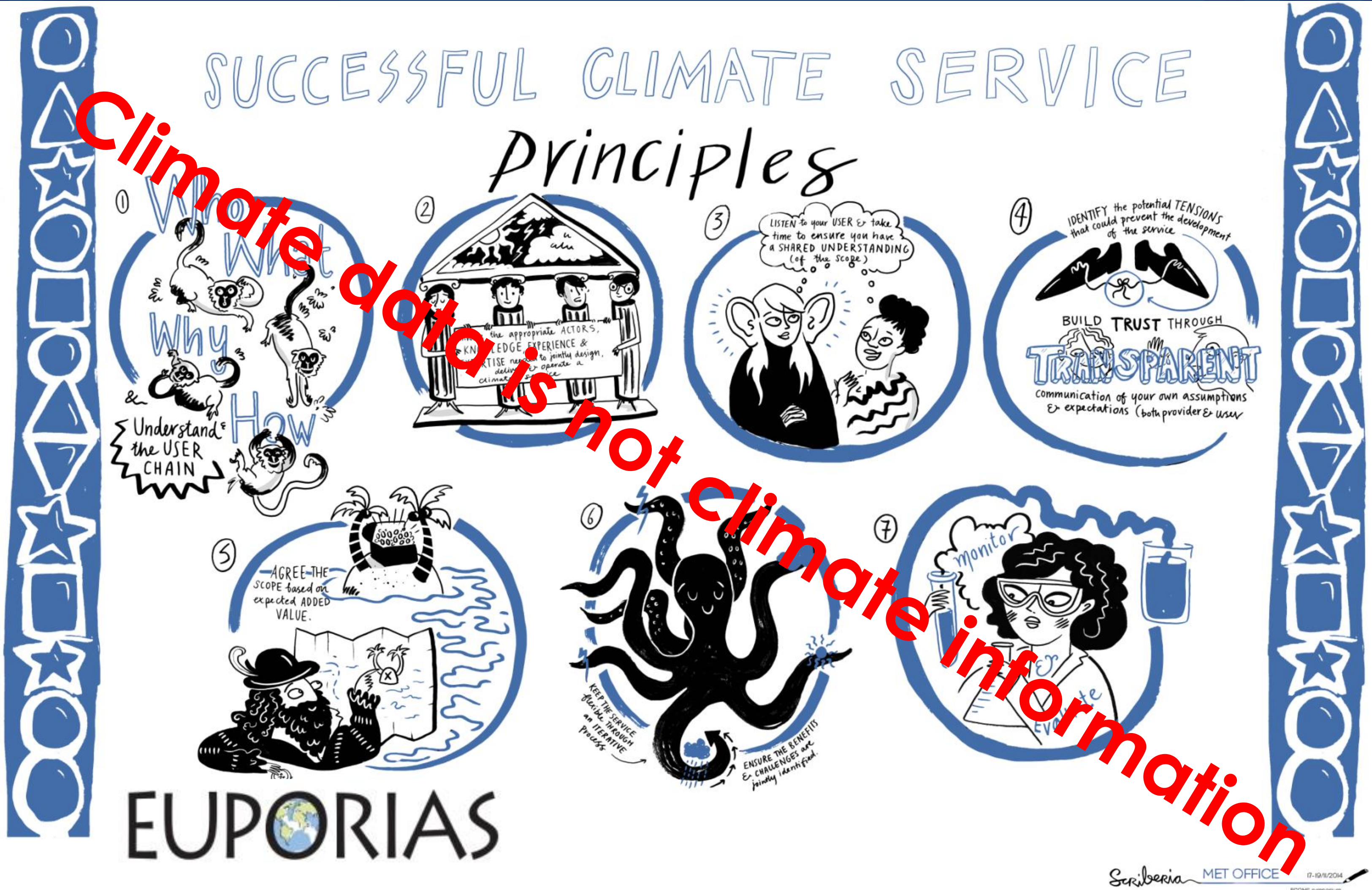

Ethical Framework for Climate Services four core elements: integrity, transparency, humility and collaboration.

6) Temperature forecasts for energy

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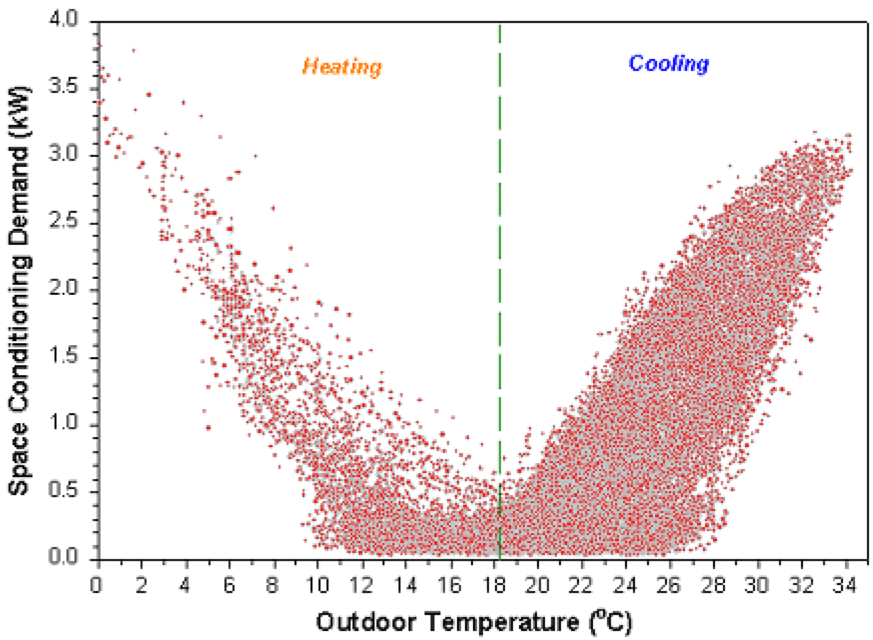
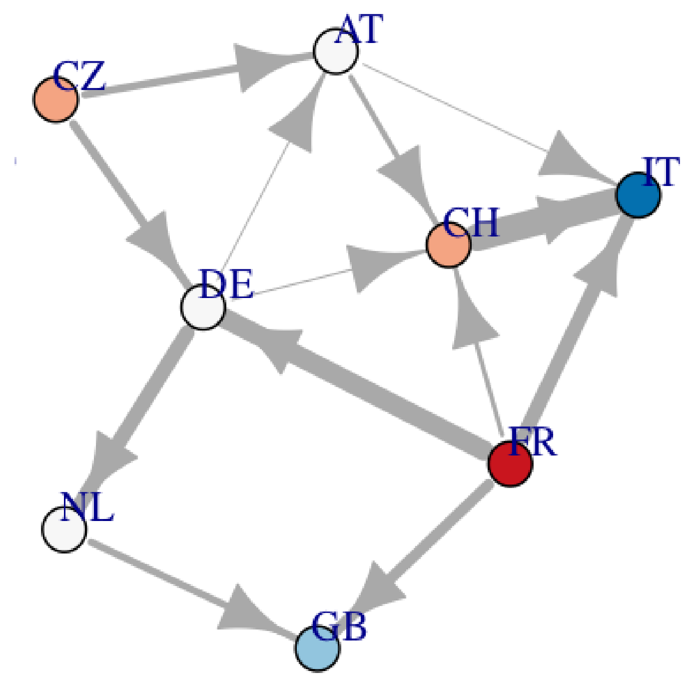
European electricity flows for Jan-Feb (left) and June-July (right). Red nodes are the main exporters and blue the main importers. For clarity only the eight countries with the highest exchange are shown.

Data from ENTSO-E (2003-2014).

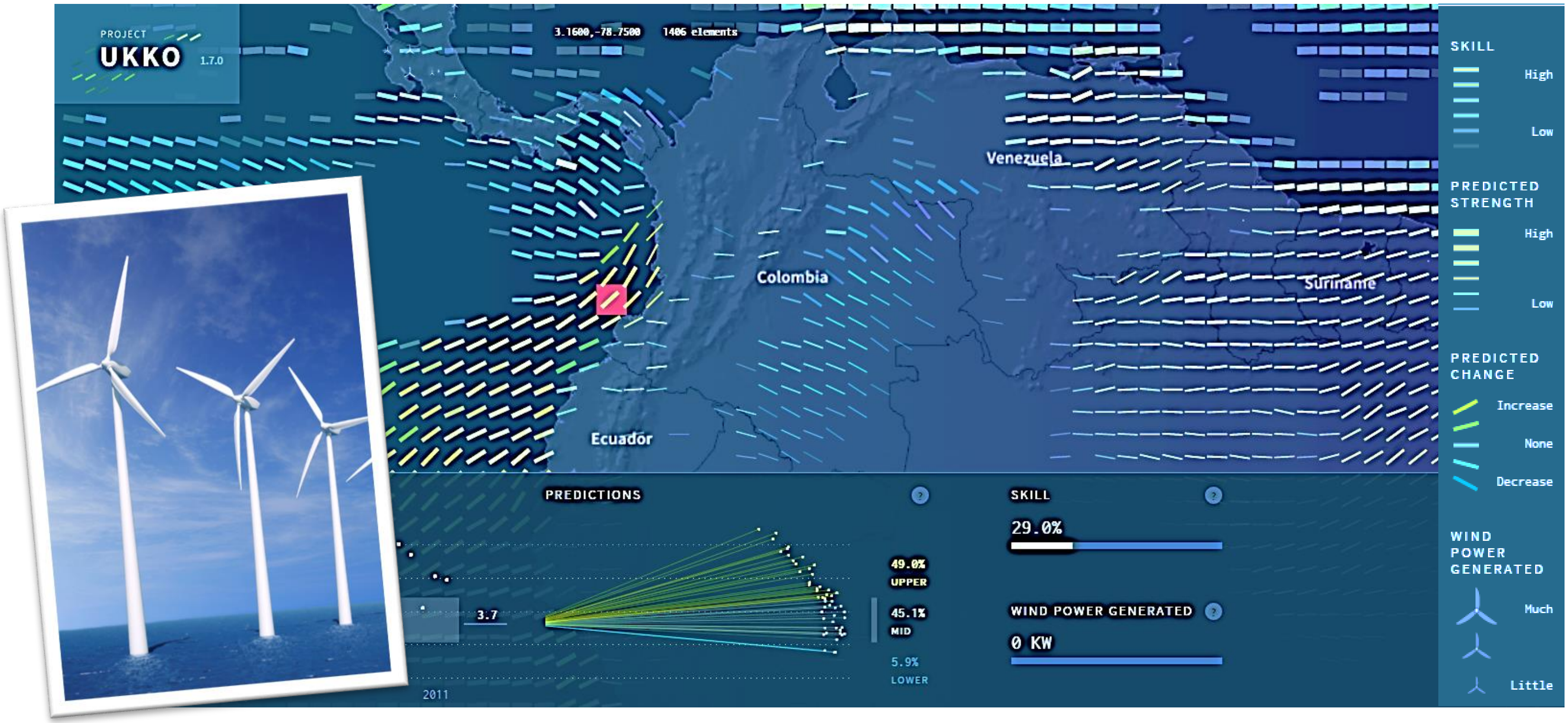


http://www.fsec.ucf.edu/en/publications/html/FSEC-PF-369-02/



M. De Felice (ENEA)

6) Seasonal wind power predictions

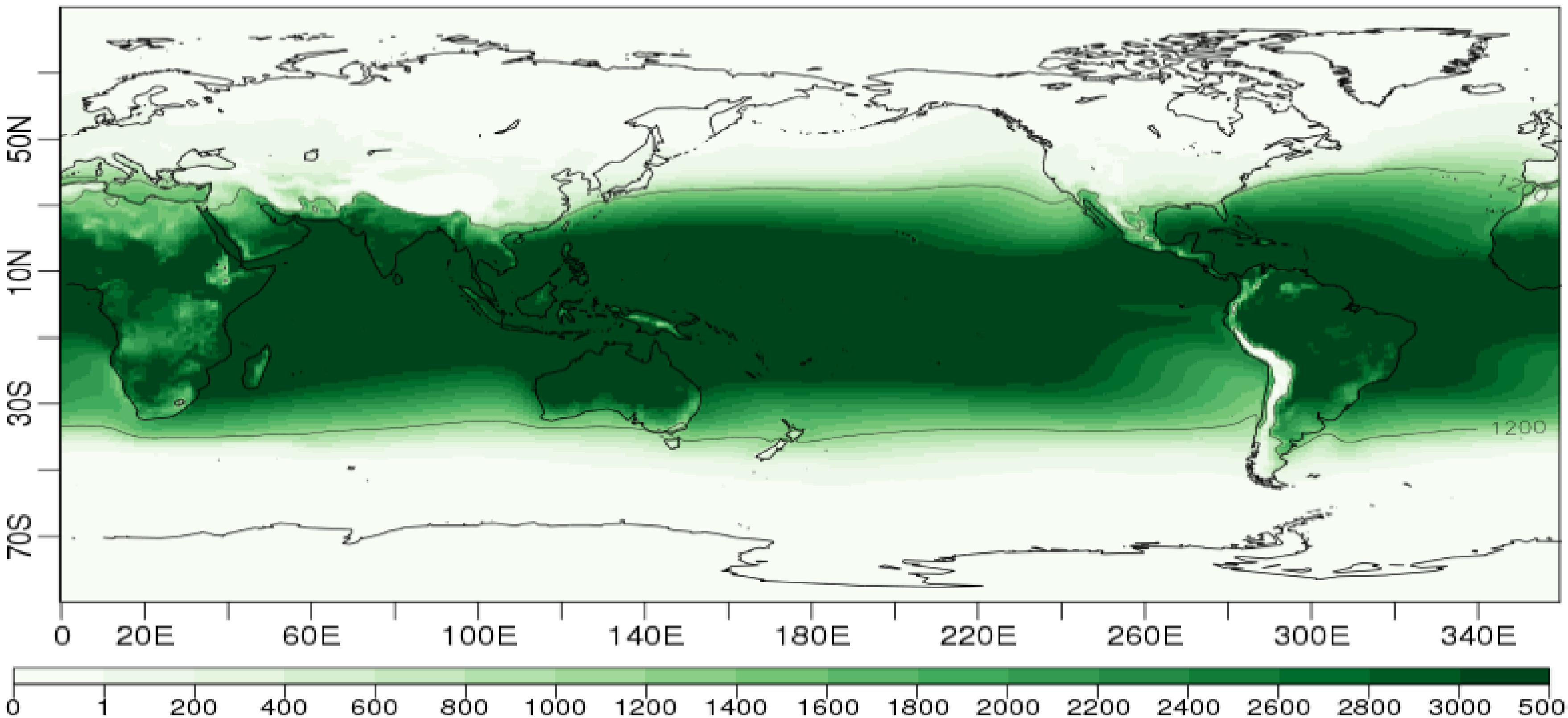


RESILIENCE PROTOTYPE

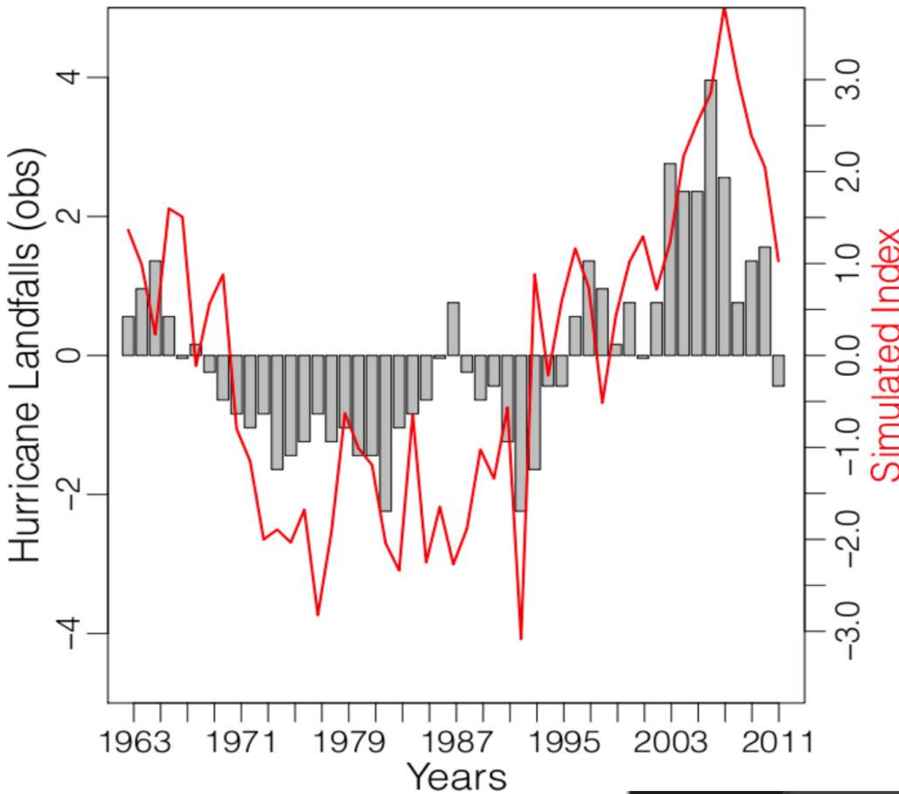
SPECS
EUPORIAS
SEVENTH FRAMEWORK PROGRAMME
Clim4Energy
NEWA
EDF
edp renewables
ALSTOM
VORTEX
natural power
EnBW

7) Agriculture.

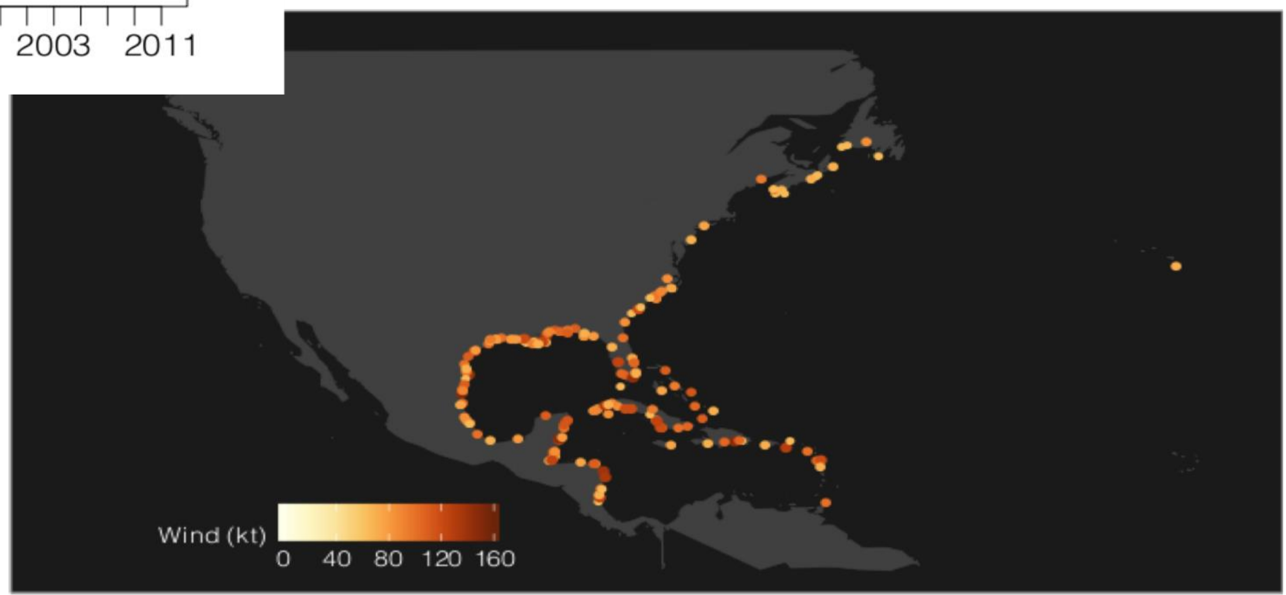
Winkler Index: Oct-Apr



8) Hurricane landfall predictions



Decadal climate predictions initialized every year from 1960 to 2005. Hurricane landfall anomalies averaged over forecast years 1-5



L.P. Caron (BSC)

Summary

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2) Analyses of mechanisms leading to model bias and development of bias correction techniques accounting for sensitivity of bias to prediction start date

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