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Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

Impact of resolution and initialisation in climate seasonal predictions

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What

Environmental forecasting

Why

Our strength …

… research …

… operations …

… services …

… high resolution …

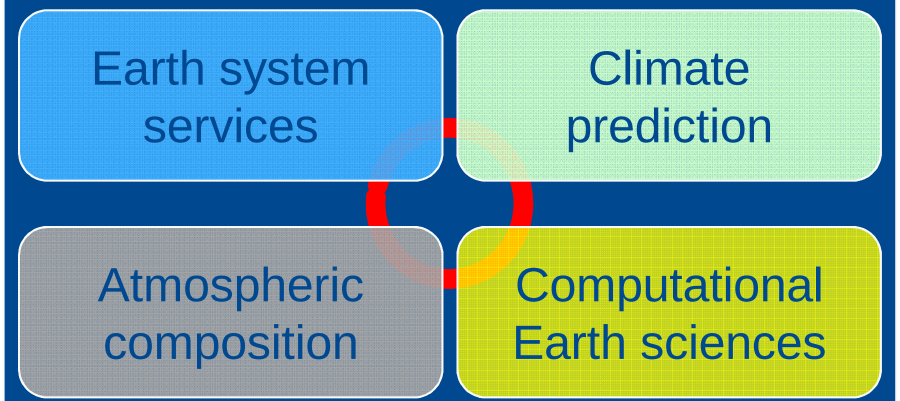
How

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

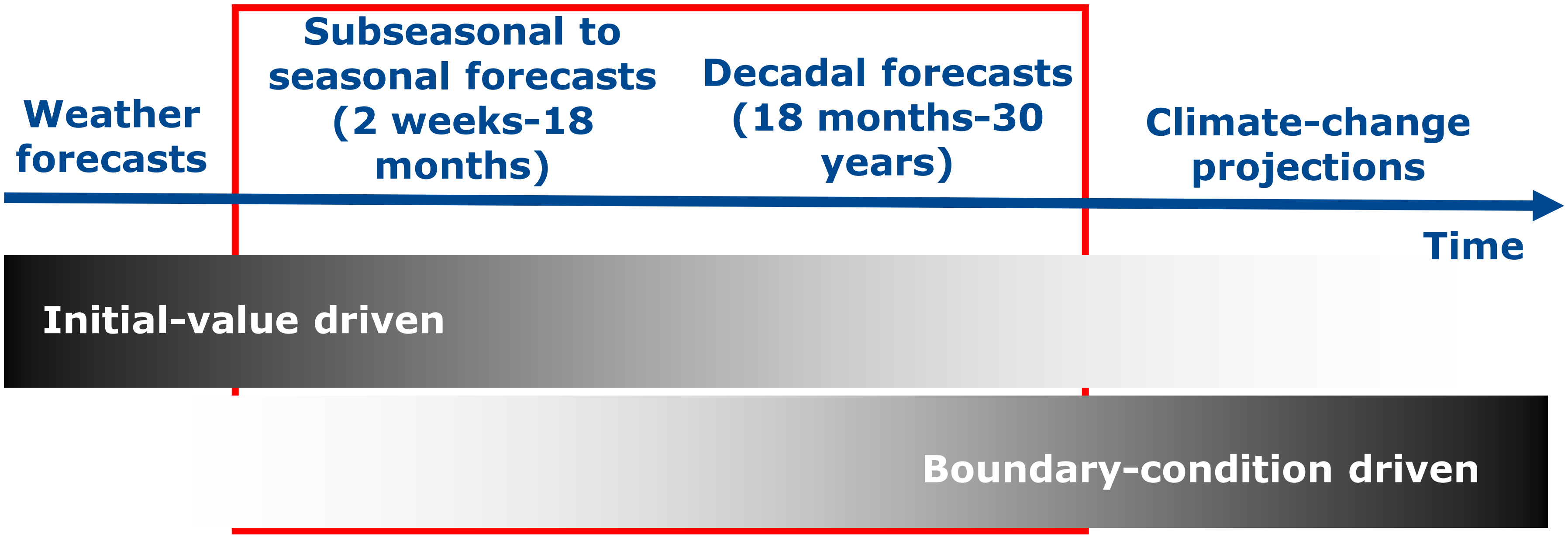
Develop user-oriented services that favour both technology transfer and adaptation

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



Climate prediction

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.

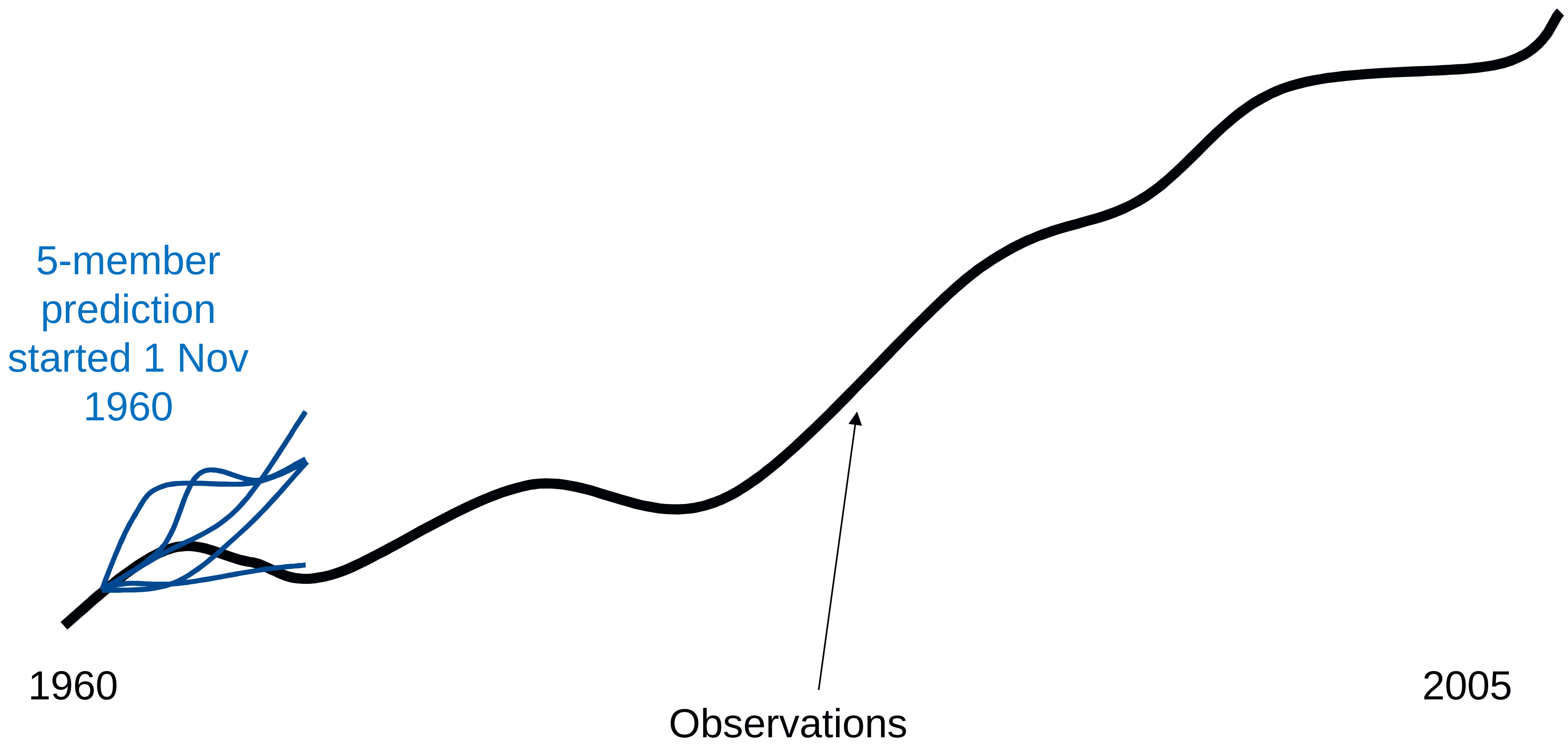


Adapted from Meehl et al. (2009)

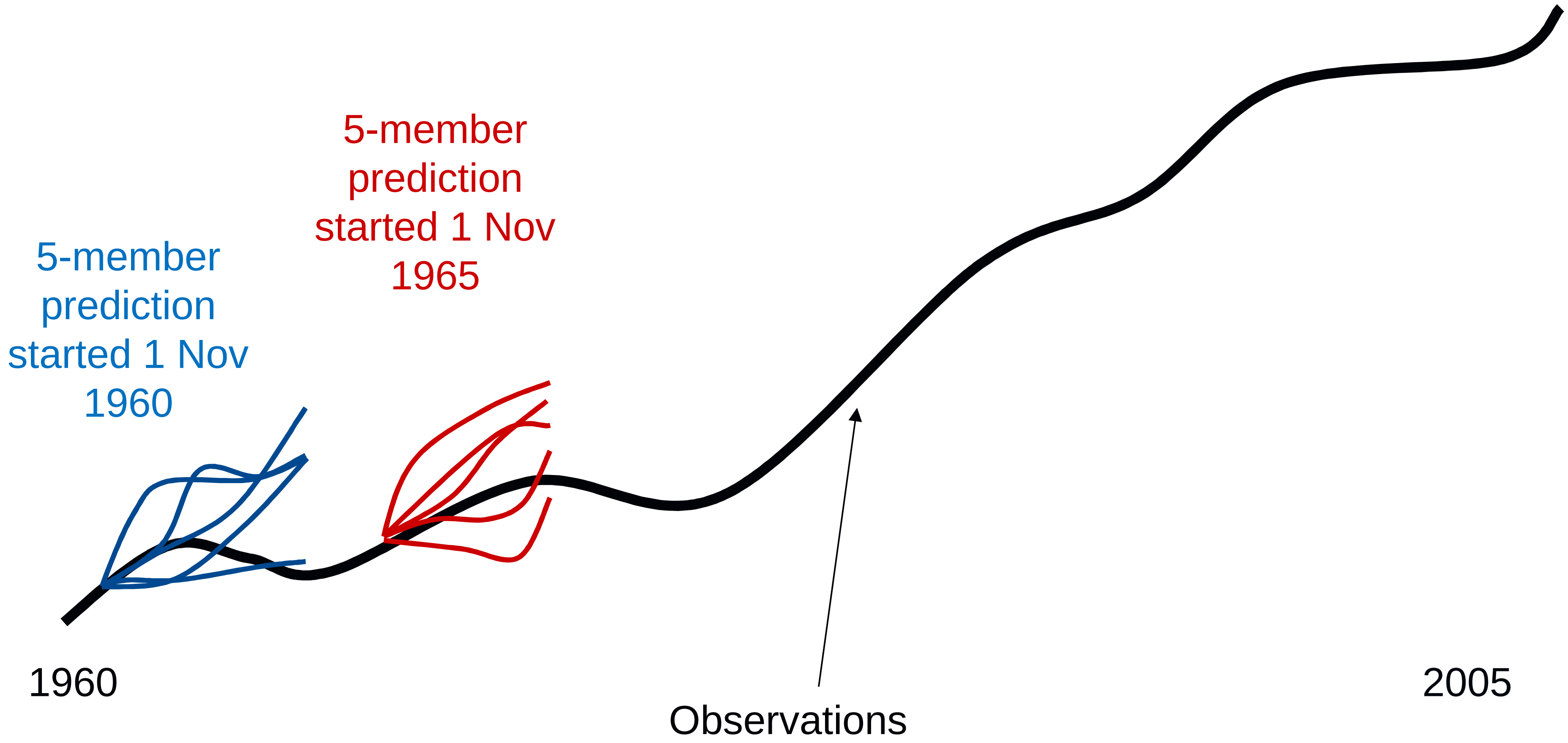
Initialising climate predictions

- Why initialising a climate model? To address the internal variability uncertainty and make a skilful forecast, one of the requirement is an accurate knowledge of the initial state of the system.
- Steps to initialise an ensemble climate forecast system:
  - make the most of the available observations to rebuild the best estimate of the system state (reanalysis).
  - transfer such information to the model avoiding imbalances, i.e. initialise the climate prediction system
  - run the ensemble with initial perturbations to account for the initial-state uncertainty

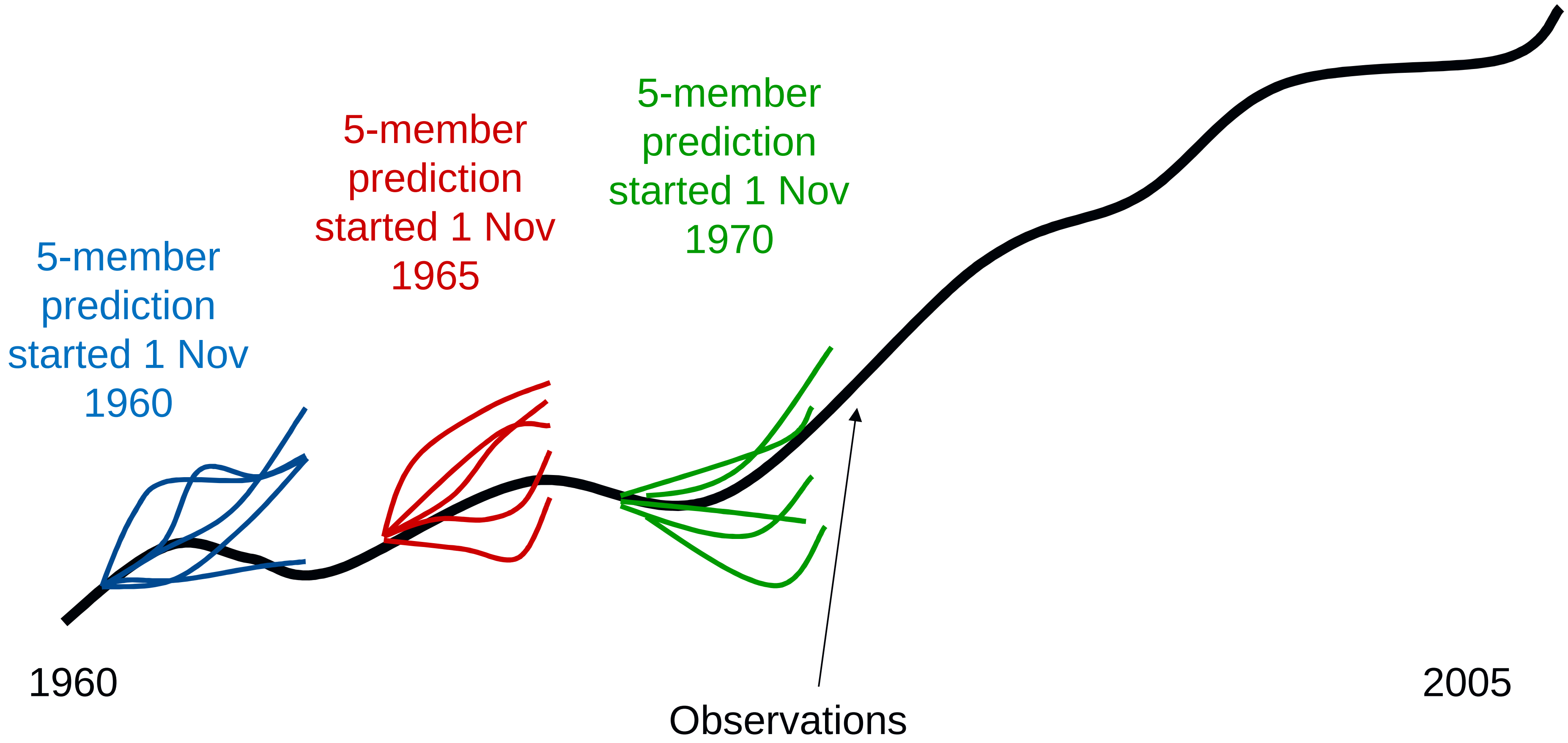
Climate prediction experiments



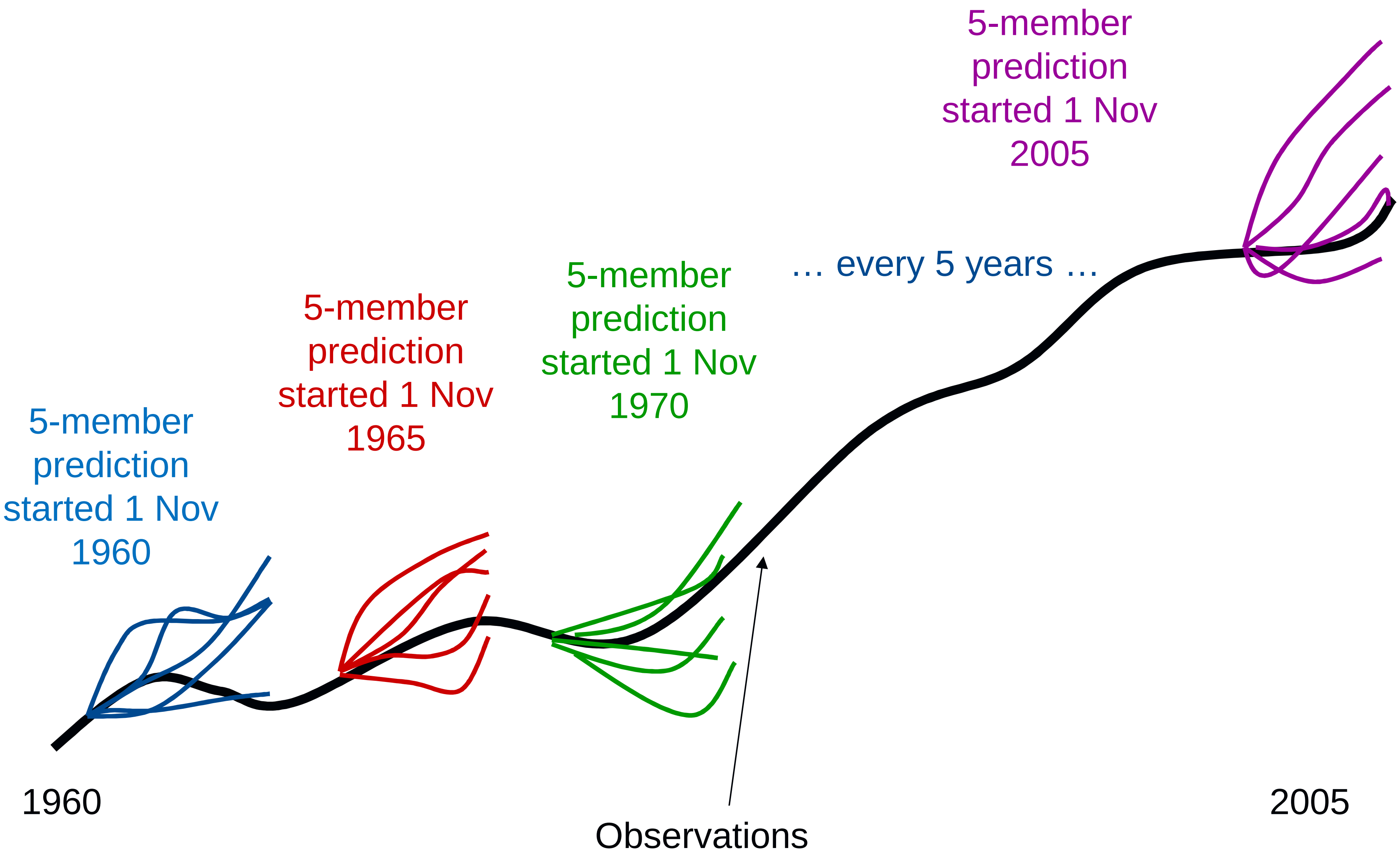
Climate prediction experiments



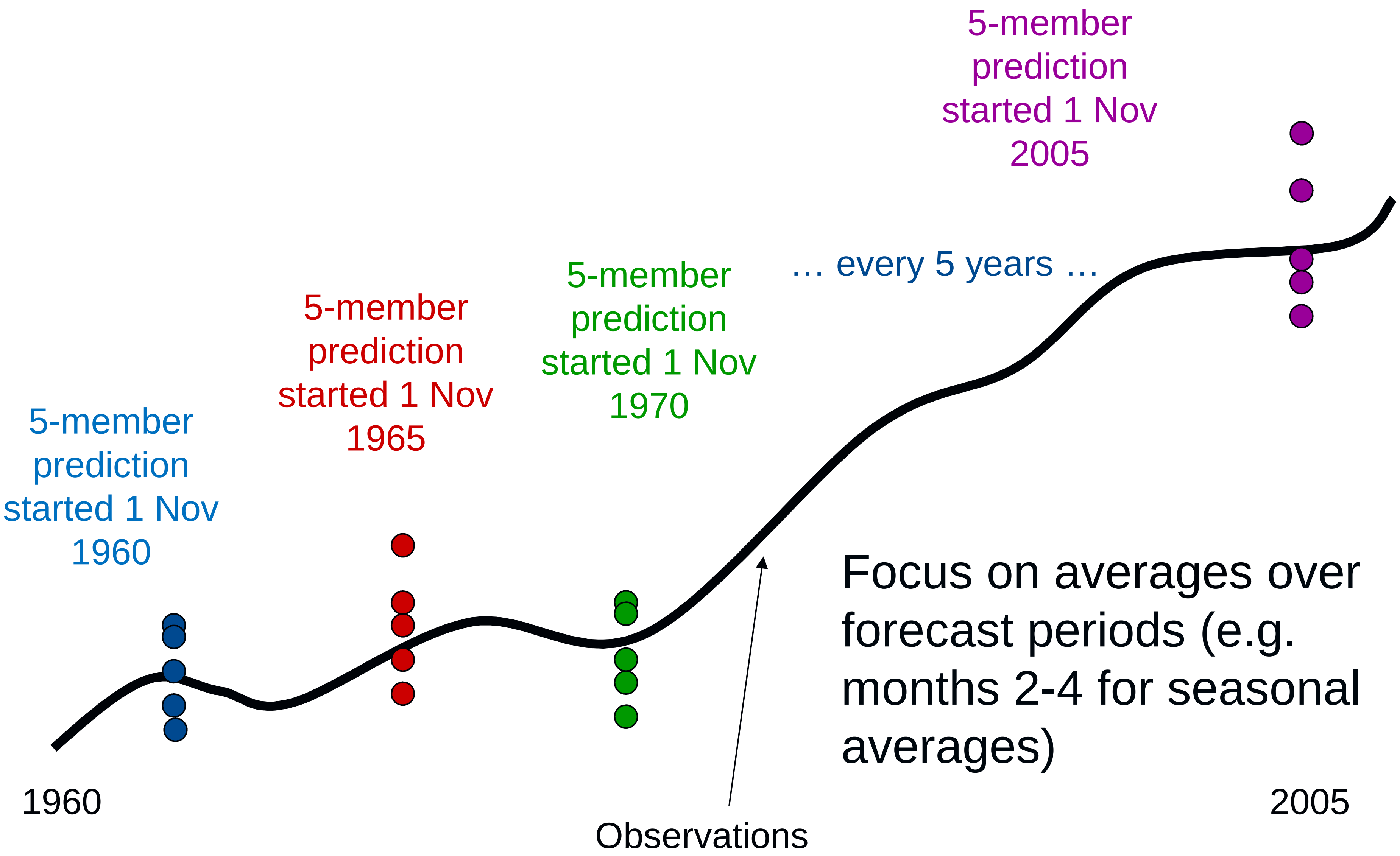
Climate prediction experiments



Climate prediction experiments



Climate prediction experiments



Focus on averages over forecast periods (e.g. months 2-4 for seasonal averages)

Climate prediction in Europe

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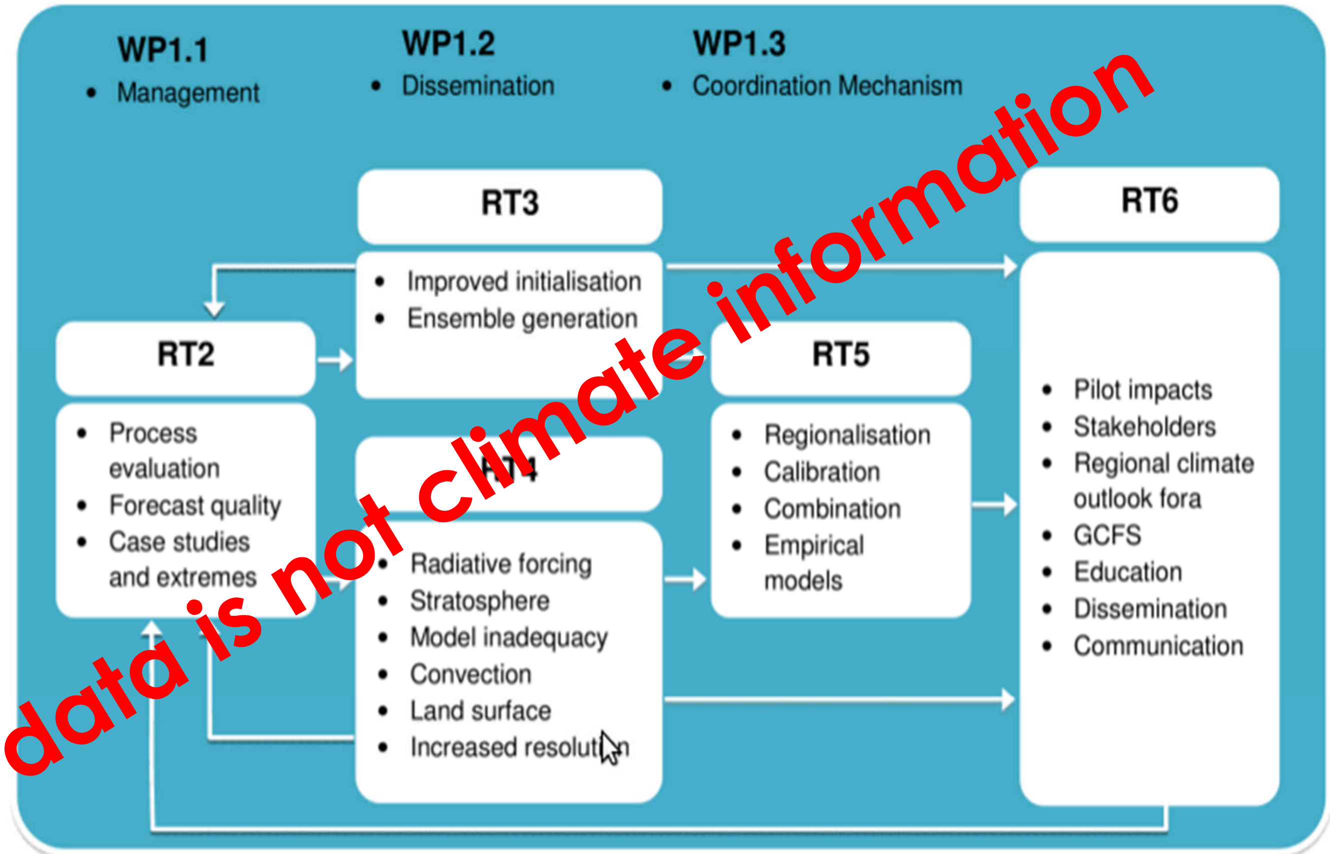
Forecast System	Project Partners
CNRM-CM5	CNRM, CERFACS
EC-Earth	KNMI, SMHI, IC3, ENEA
IFS/NEMO	ECMWF, UOXF
IPSL-CM5	CNRS
MPI-ESM	MPG, UniHH
UM	UKMET



Climate data is not climate information

WP1.1: Management
WP1.2: Dissemination
WP1.3: Coordination across EUPORIAS, NACLIM & SPECS
RT2: Evaluation of current s2d forecast systems
RT3: Forecast strategies
RT4: Improved systems
RT5: Calibrated predictions at the local scale

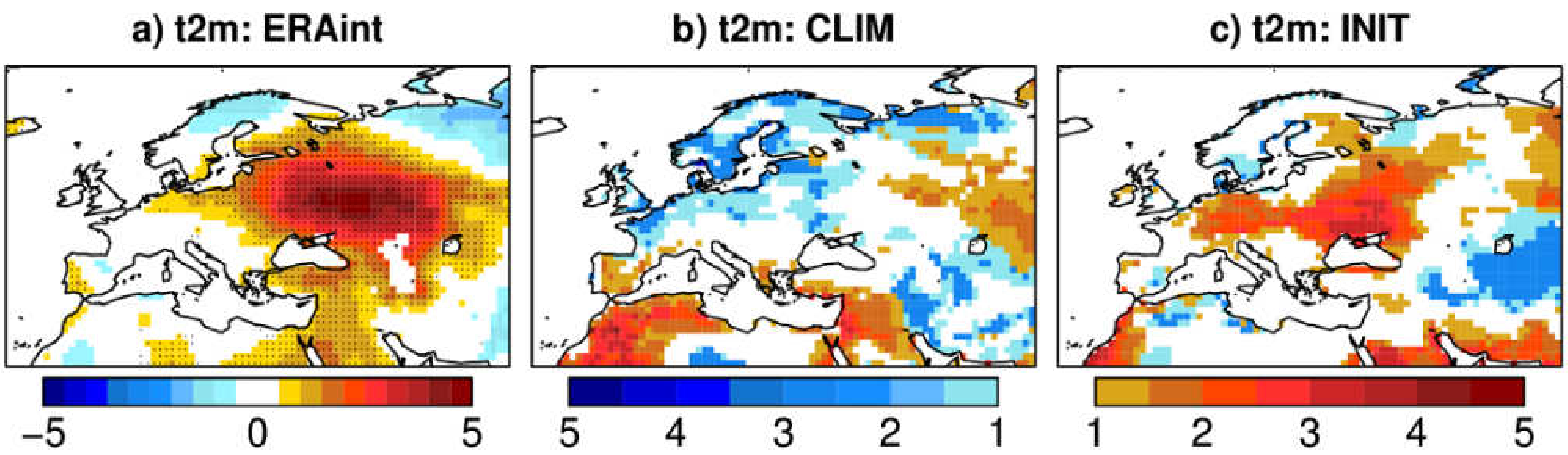
SPECS
Seasonal-to-decadal climate Prediction for the improvement of European Climate Services

Improving temperature forecasts

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.

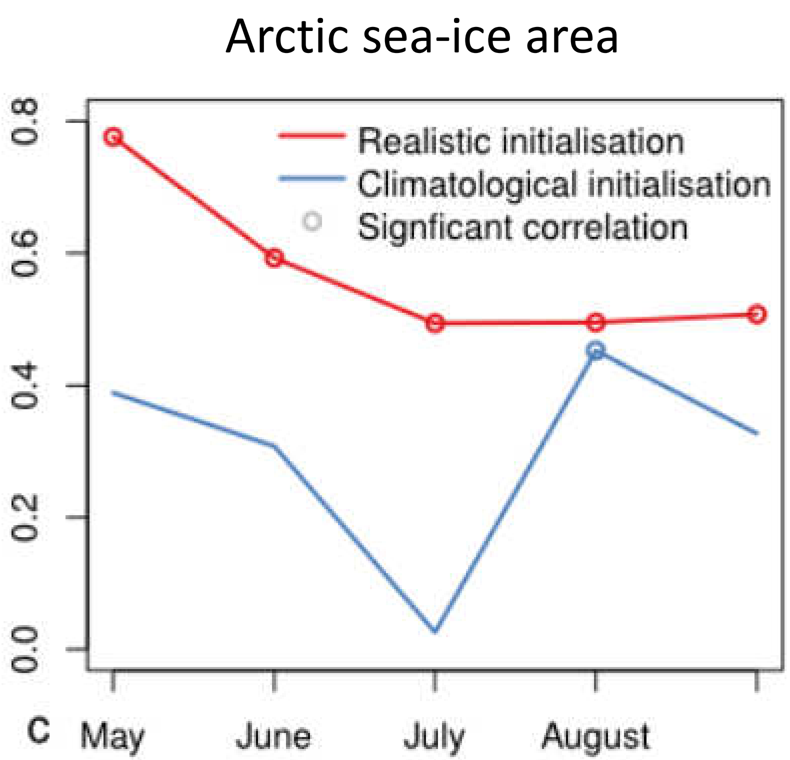
Similar results found for EC-Earth3 and high resolution (25 km).

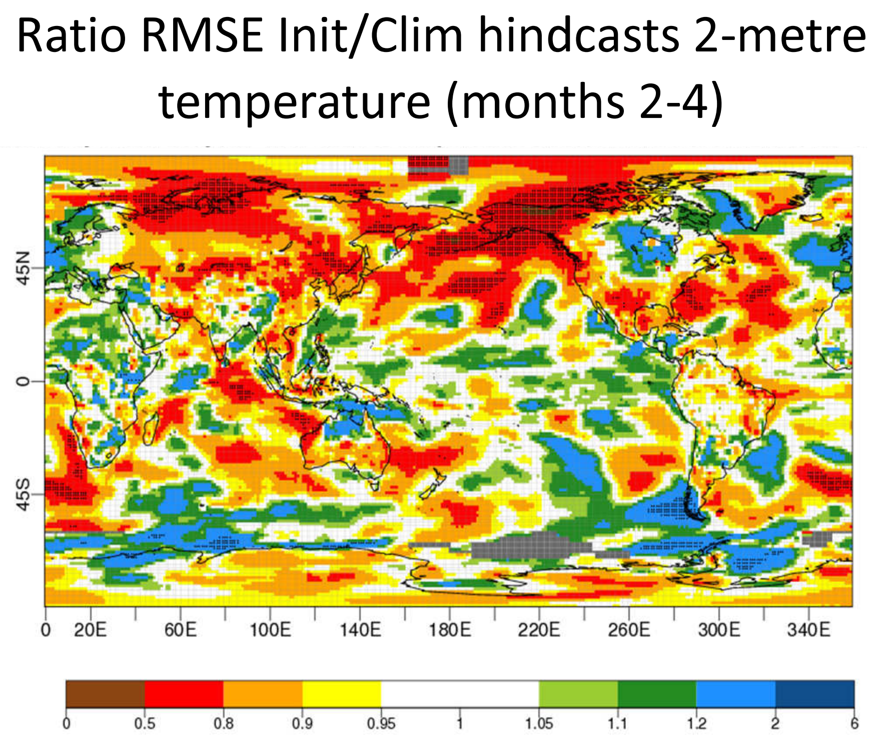


Prodhomme et al. (2015, Clim. Dyn.)

Improving Arctic forecasts

Predictions with EC-Earth started every May (left) and November (right) over 1993-2009 (let) and 1979-2010 (right) with ERAInt and ORAS4 initial conditions, and internal sea-ice reconstruction. Two sets, one initialised with realistic and another one with climatological sea-ice initial conditions.



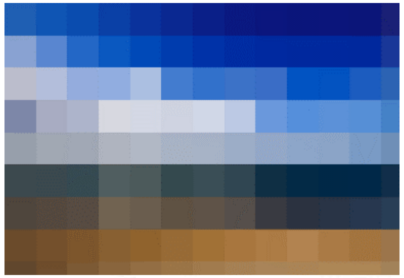


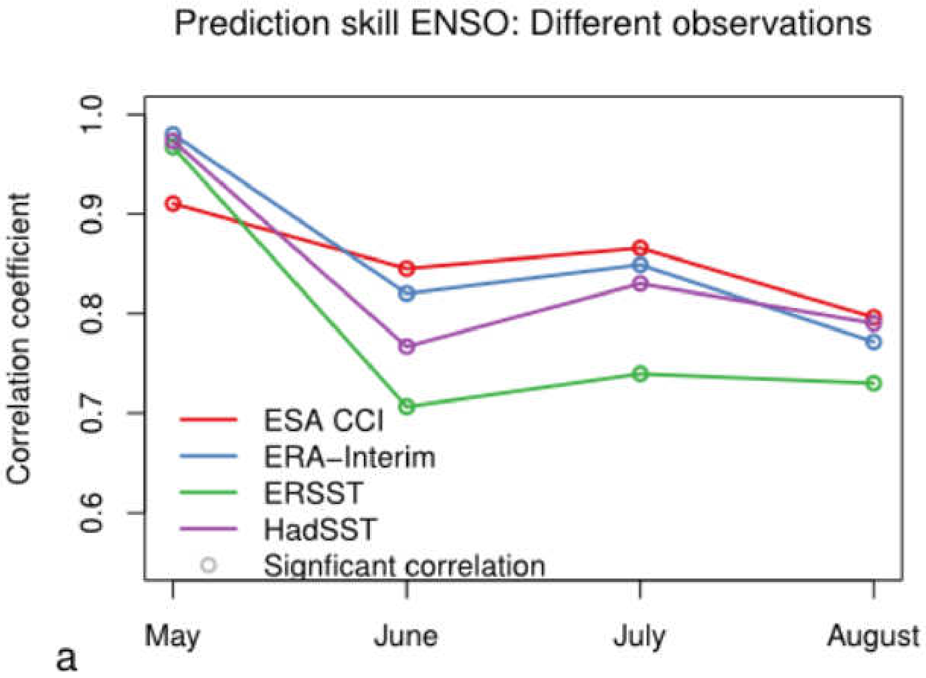
Guemas et al. (2015, GRL)

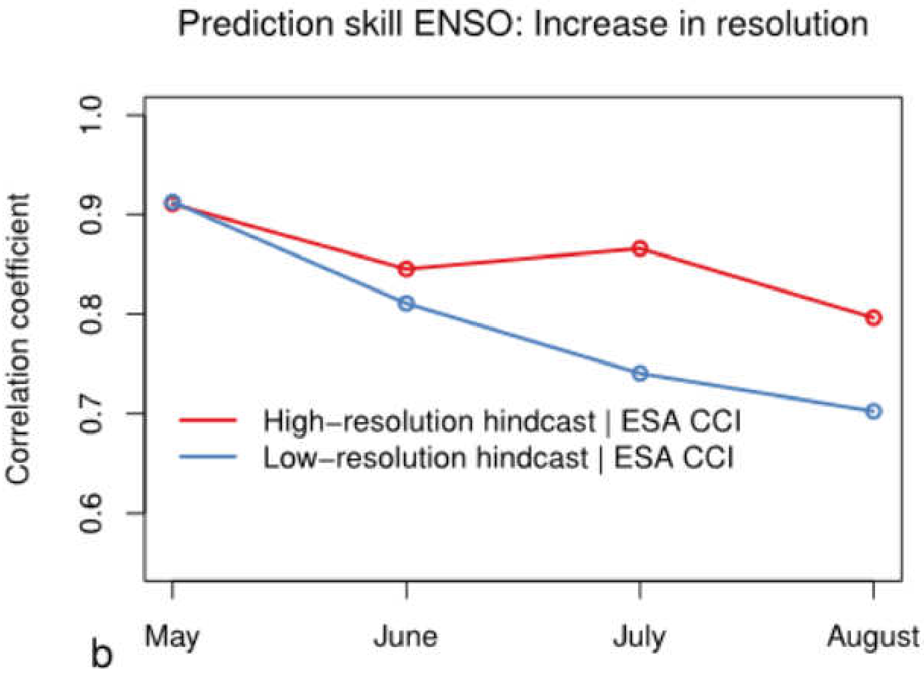
Bellprat et al. (2015, IC3 Tech Note)

Resolution & observation uncertainty

Predictions with EC-Earth3 started every May over 1993-2009 with ERAInt and GLORYS2v1 initial conditions, and IC3's sea-ice reconstruction.





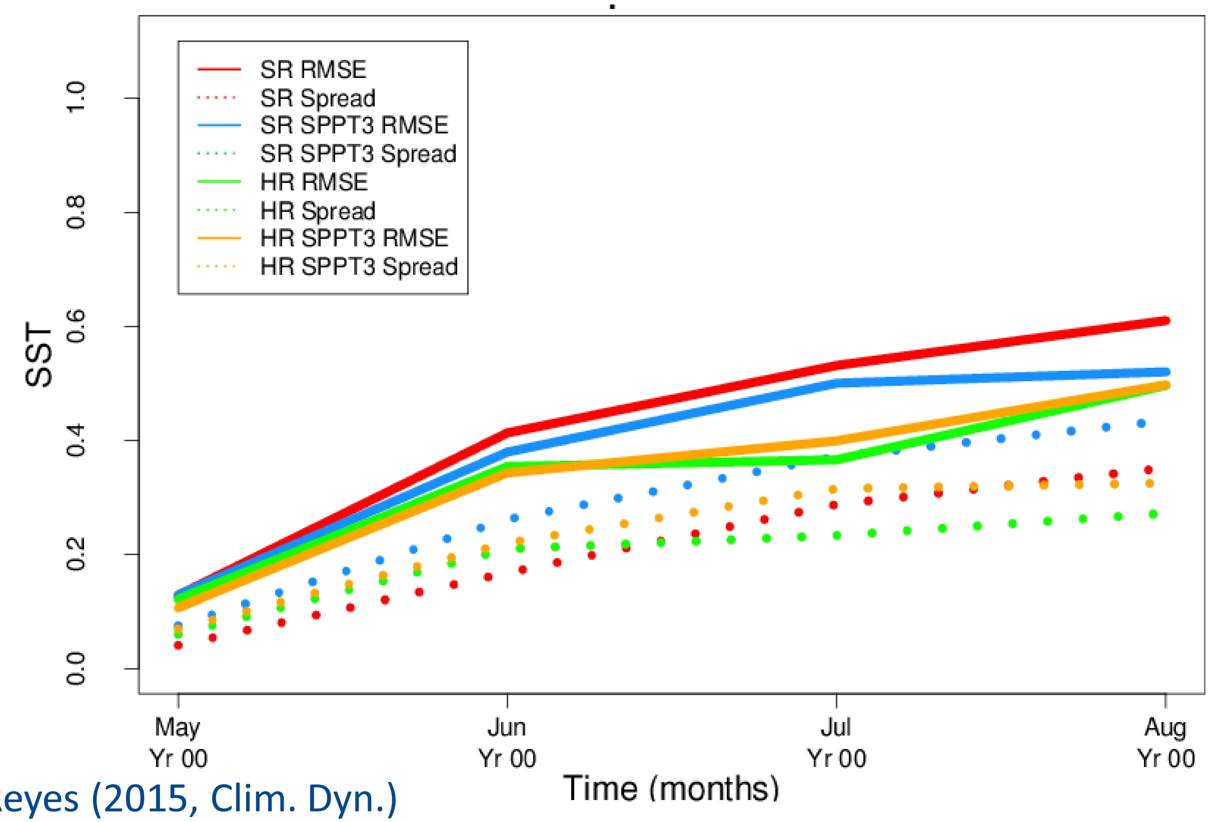


Bellprat et al. (2015, IC3 Tech Note)

High-resolution seasonal forecasts

High resolution has been thoroughly tested in climate prediction mode. The same applies to the stochastic physics.

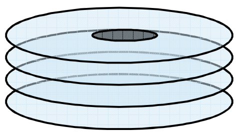
RMSE and spread of Niño3.4 SST (versus ERSST) from EC-Earth3 simulations: standard resolution (**SR**, **T255/ORCA1**), high resolution (**HR**, **T511/ORCA025**) without and with stochastic physics (**SPPT3**). May start dates over 1993-2009 using ERA-Interim and GLORYS and ten-member ensembles.



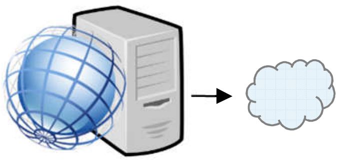
Batté and Doblas-Reyes (2015, Clim. Dyn.)

S2dverification is an R package to verify seasonal to decadal forecasts by comparing experimental data with observational data. It allows analysing data available either locally or remotely. It can also be used online as the model runs.

s2dverification package



LOCAL STORAGE



ESGF NODE
or
OPeNDAP SERVER

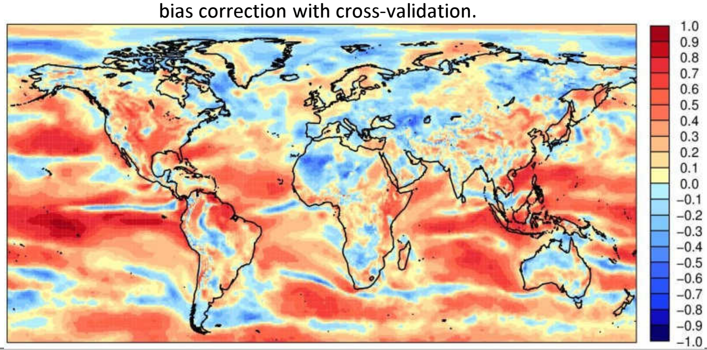
- Supports datasets stored locally or in ESGF (OPeNDAP) servers.
- Exploits multi-core capabilities
- Collects observational and experimental datasets stored in multiple conventions:
  - NetCDF3, NetCDF4
  - File per member, file per starting date, single file, …
  - Supports specific folder and file naming conventions.

BASIC STATISTICS

SCORES
Correlation, ACC, RMSSS, CRPS, ...

PLOTS

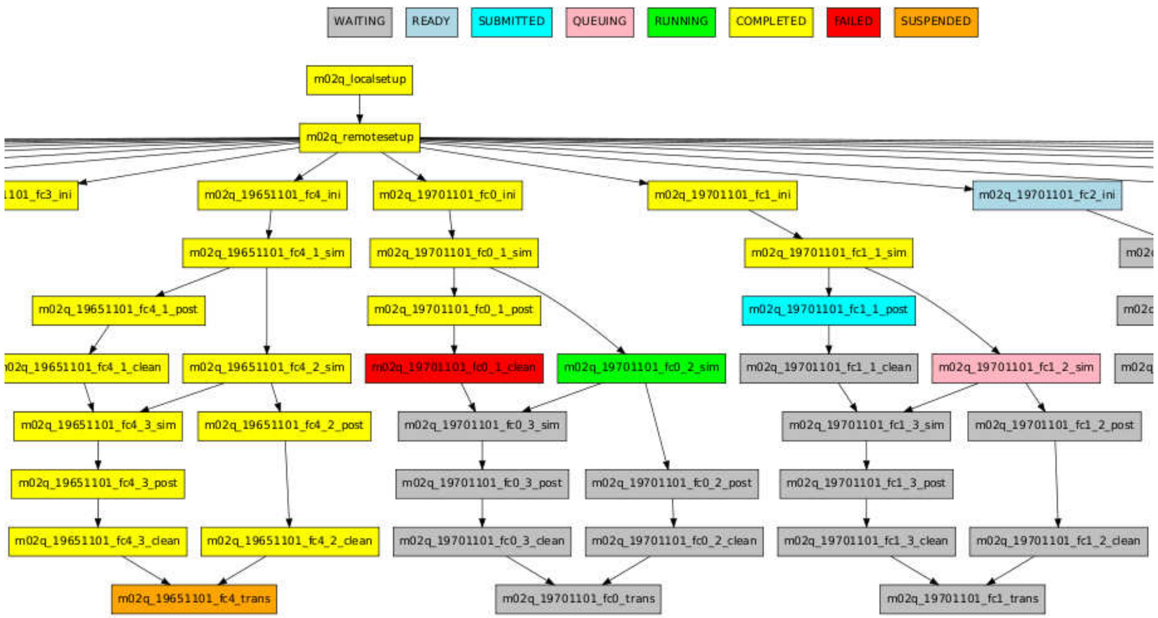
Anomaly Correlation Coefficient. 10M Wind Speed ECMWF S4 1 month lead with start dates once a year on first of November and Era-Interim in DJF from 1981 to 2011. Simple bias correction with cross-validation.



Workflow management: Autosubmit

- **Automatisation:** Preparing and running, postprocessing and output transfer, all managed by Autosubmit. No user intervention needed.
- **Provenance:** Assigns unique identifiers to each experiment and stores information about model version, configuration options, etc
- **Failure tolerance:** Automatic retrials and ability to repeat tasks in case of corrupted or missing data.
- **Versatility:** Currently runs EC-Earth, Also NEMO, WRF and NMMB models.

Workflow of an experiment monitored with Autosubmit (yellow = completed, green = running, red = failed, …)



D. Manubens, J. Vegas (IC3)

Climate predictions for wind energy

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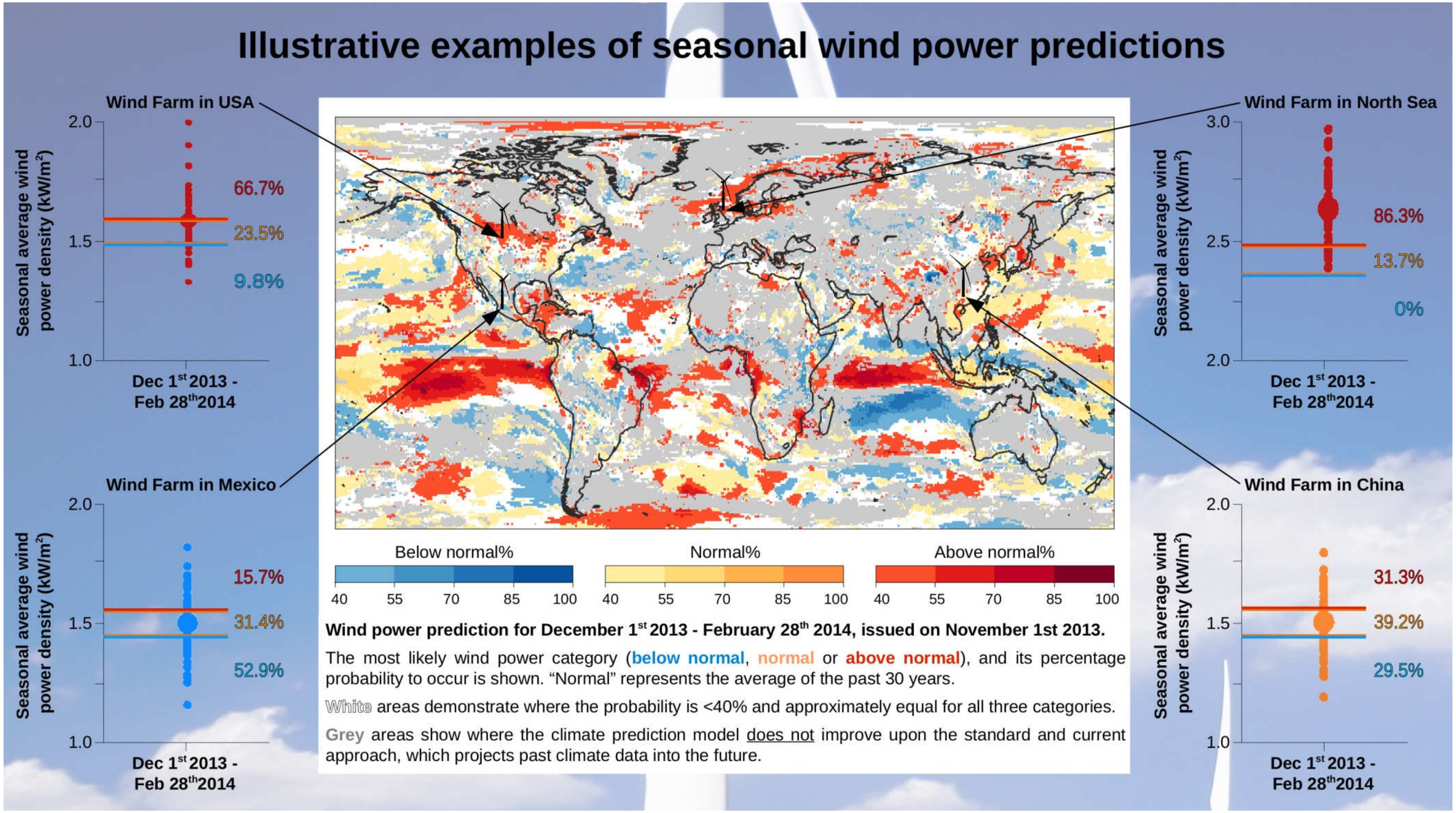

Summary

- Requests for climate information for the next season comes from a broadening range of users and should be addressed from a climate services perspective.
- The initialisation of both soil moisture and sea ice increases the forecast quality at the regional level, and possibly also remotely.
- The increase of model resolution is a substantial technical challenge and requires at least resources an order of magnitude larger than currently available, but shows clear signs that is one of the most promising ways to improve the quality of the predictions.
- 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.