www.bsc.es

Norrköping, 13 September 2015

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

BSC-ES/IC3-CFU Climate prediction activity

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

IC3-CFU merges into BSC-ES

Barcelona Supercomputing Center
Centro Nacional de Supercomputación
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Climate Forecasting Unit (IC3), ~25 people

Earth Sciences Department (BSC), ~25 people

Earth Sciences Department (BSC), ~50 people

Strategic plan end of January 2015

- **Software development**
- **Atmospheric composition**
- **Climate prediction**
- **Services**

BSC-ES: Objectives

What

Environmental forecasting

Why

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

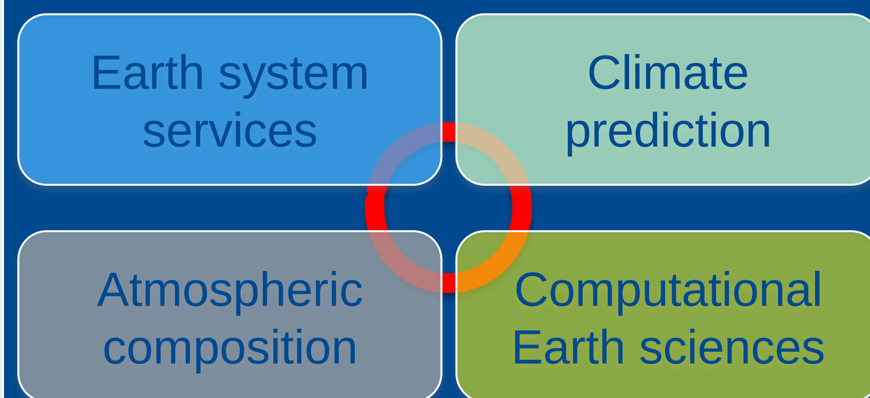
How

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

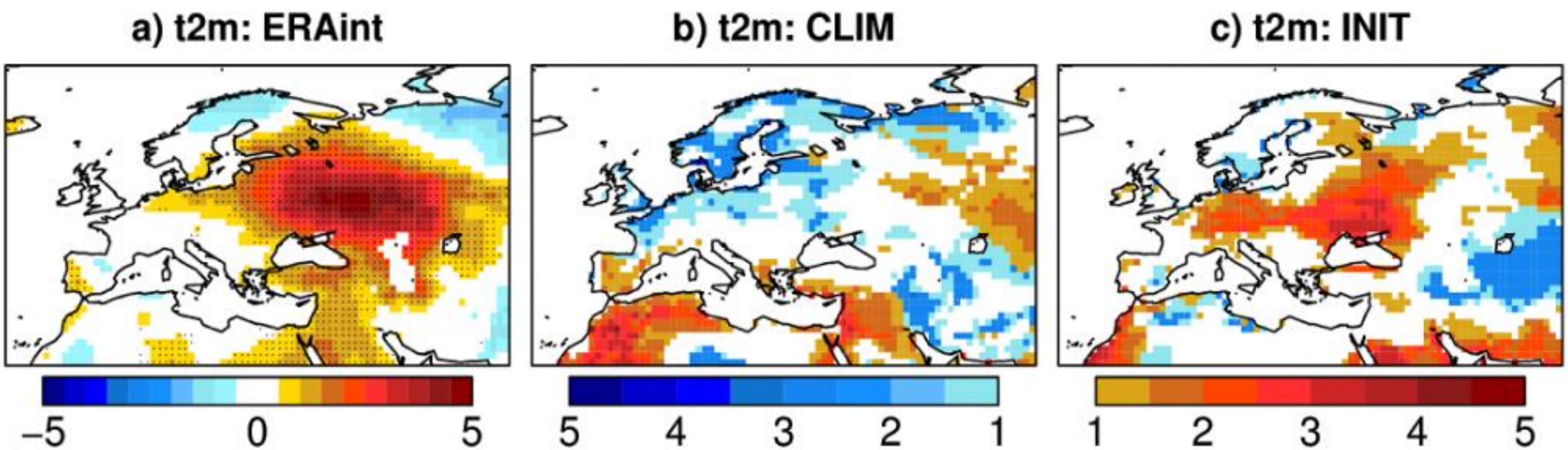


Improving temperature forecasts

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

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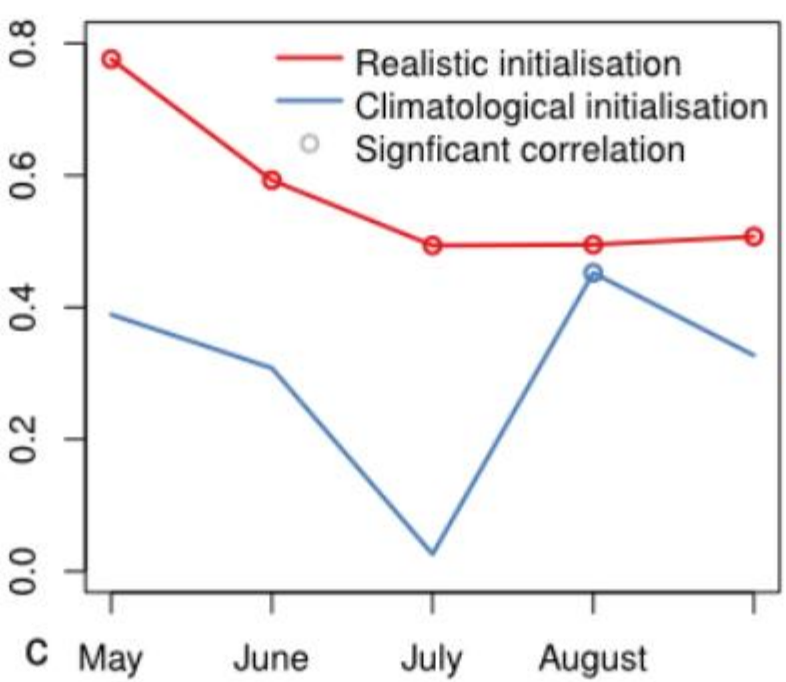
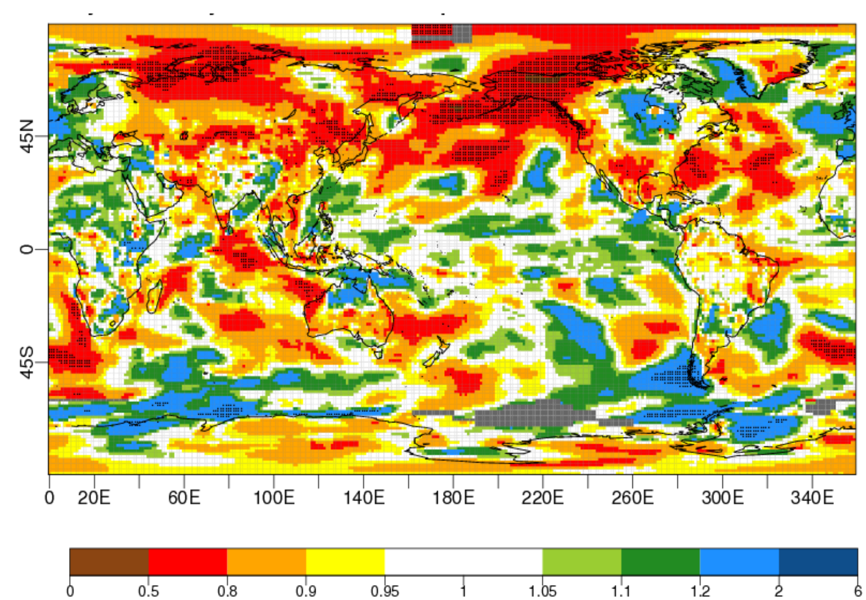
Predictions with EC-Earth started every May (left) and November (right) over 1993-2009 (let) and 1979-2010 (right) with ERAInt and ORAS4 initial conditions, and internal sea-ice reconstruction. Two sets, one initialised with realistic and another one with climatological sea-ice initial conditions.

Arctic sea-ice area



Ratio RMSE Init/Clim hindcasts 2-metre temperature (months 2-4)

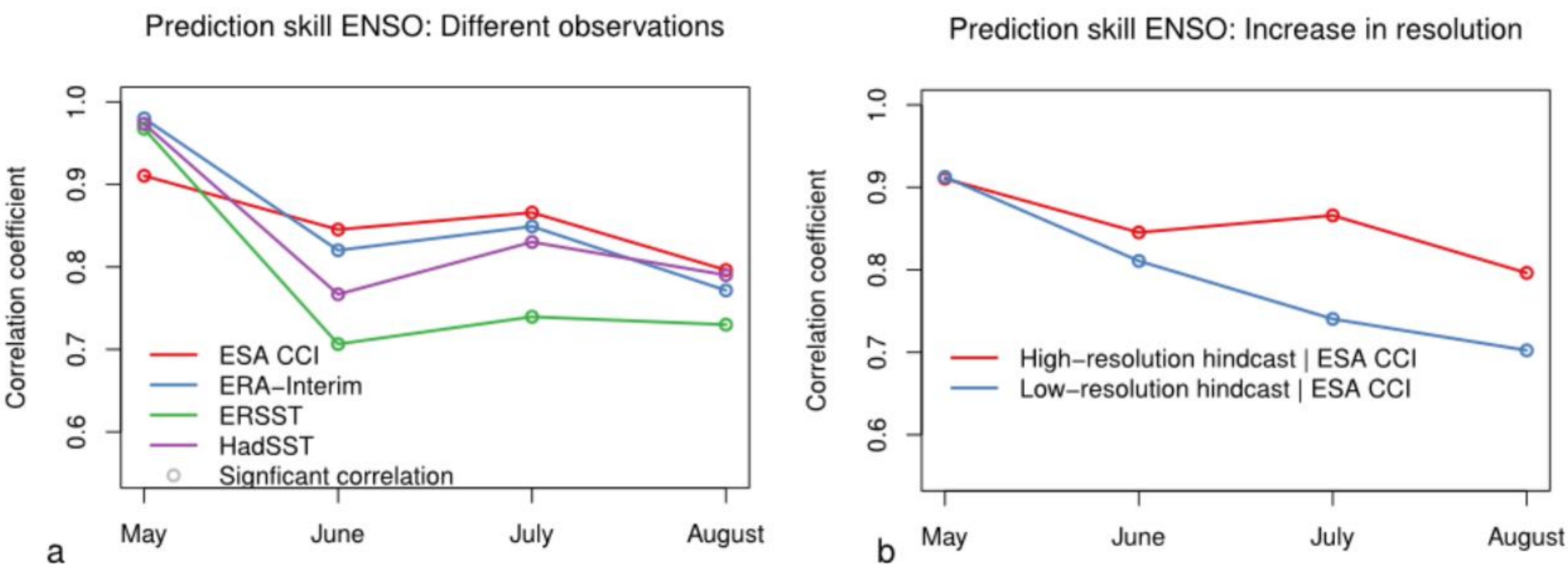


Guemas et al. (2015, GRL)

Bellprat et al. (2015, IC3 Tech Note)

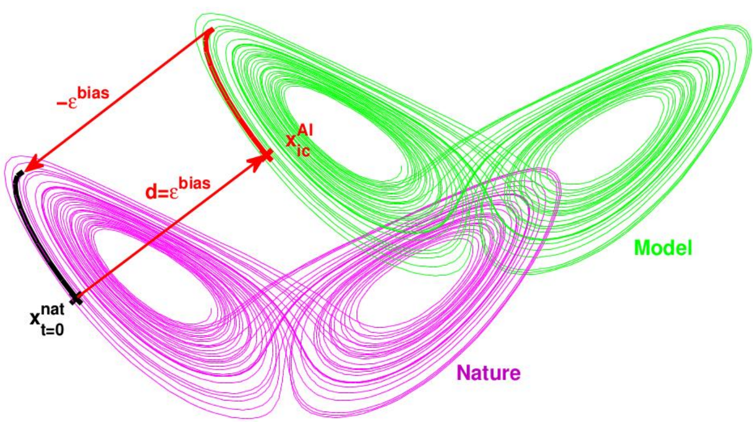
Observational uncertainty

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

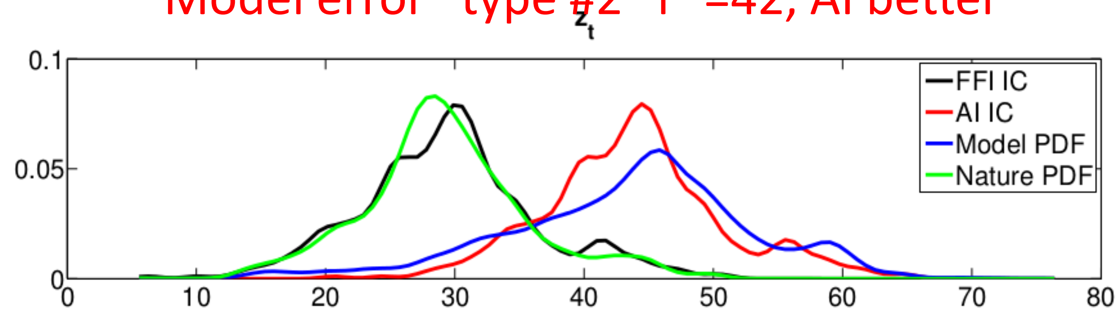


Bellprat et al. (2015, IC3 Tech Note)

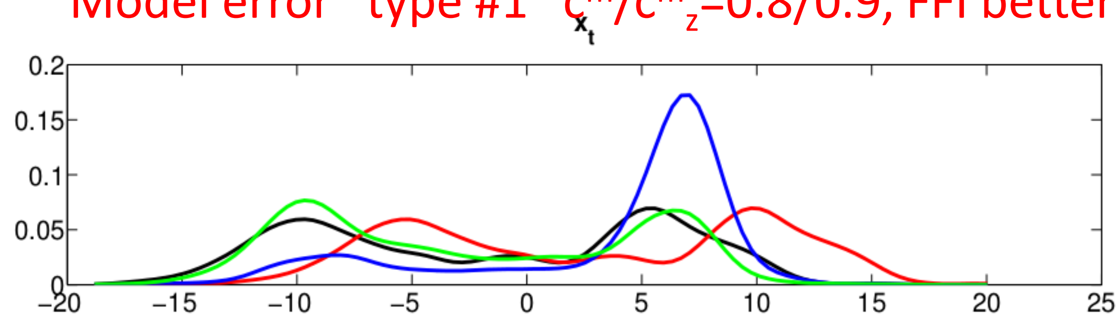
PDFs of initial conditions (black and red) and of the model and "nature" climatologies (blue and green) for the Peña and Kalnay model with three compartments (ocean, tropical atmosphere and extra-tropical atmosphere).



Model error "type #2" r^m=42, AI better



Model error "type #1" c^m/c^m_z=0.8/0.9, FFI better

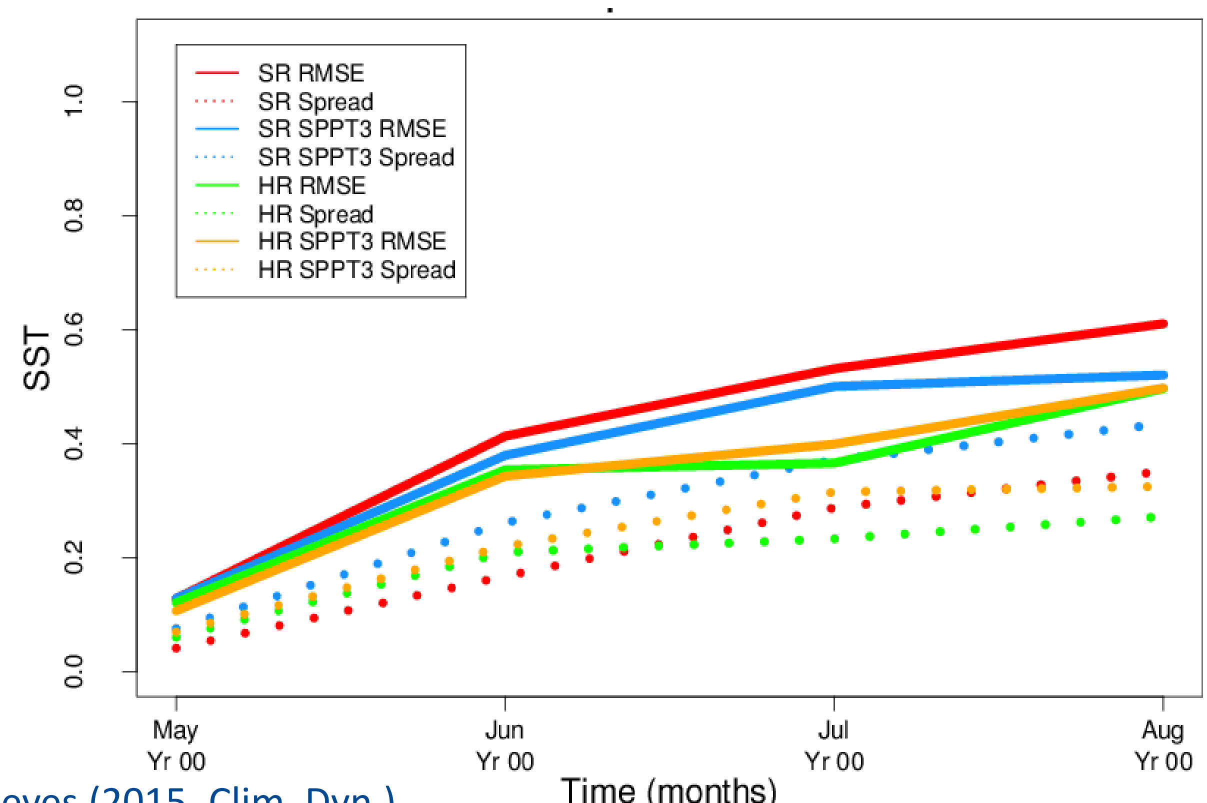


Weber et al. (2015, MWR)

Pre CMIP6: High resolution

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.)

Post CMIP5: Volcanic aerosol

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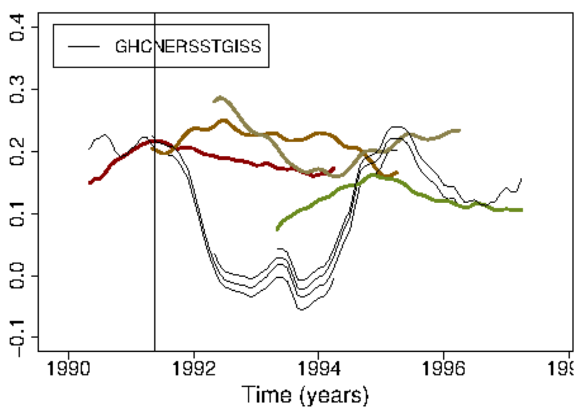
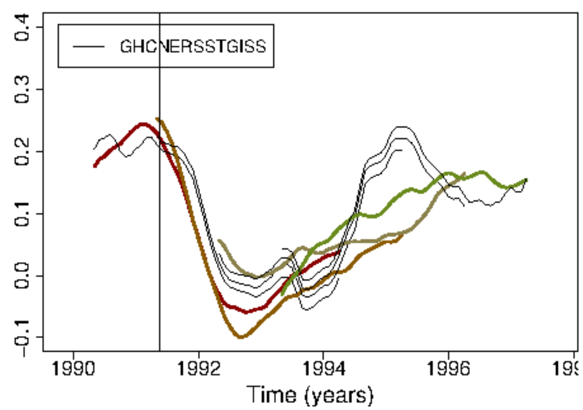
Global-mean surface temperature before and after the Pinatubo eruption simulated by EC-Earth 2.3 with five-member ensemble hindcasts. Observational data is a mix between GHCN, ERSST and GISS.

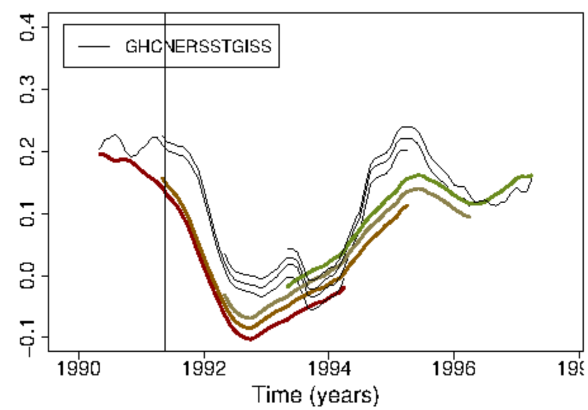
Both the initialisation and the volcanic forcing specification improve the simulations.



Initialisation and no volcanoes



Initialisation and volcanoes

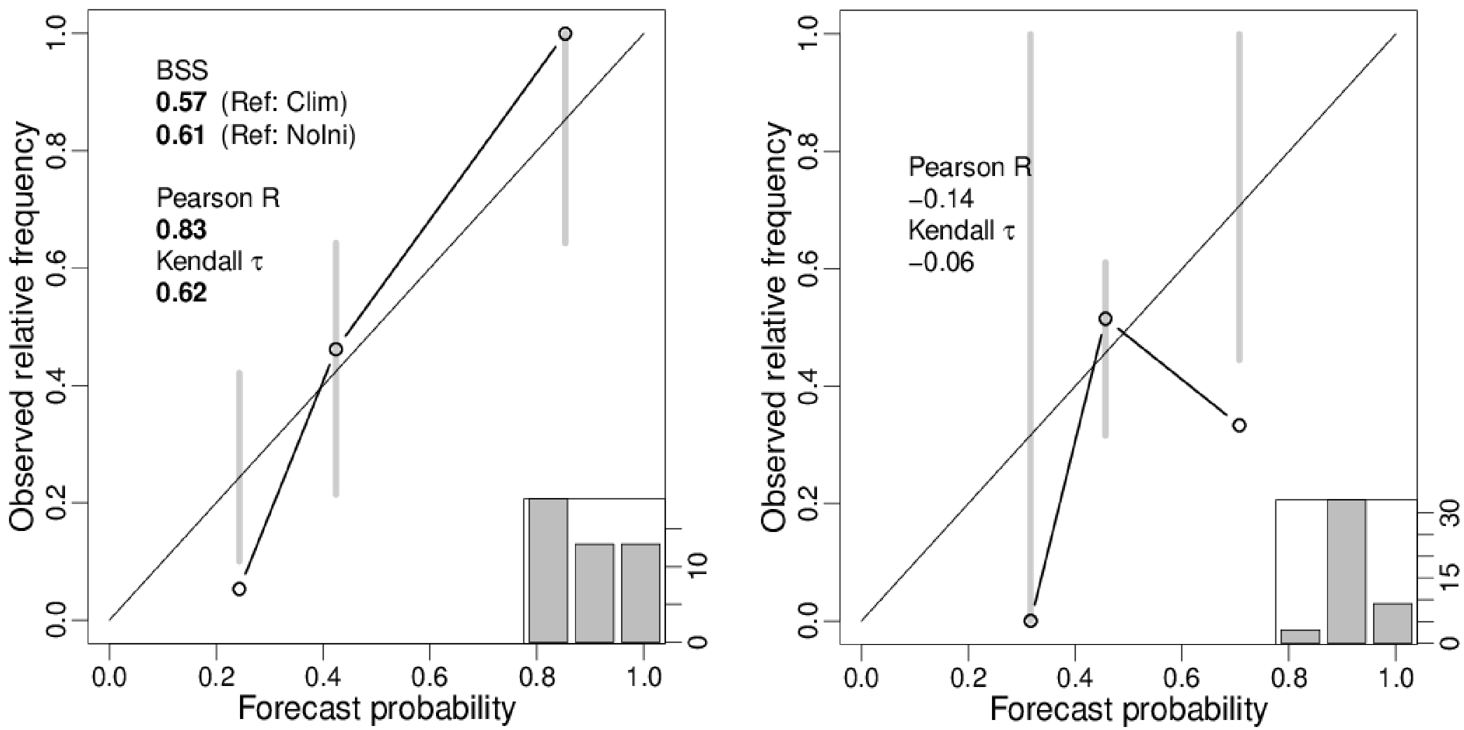


No initialisation and volcanoes

Service-driven predictions

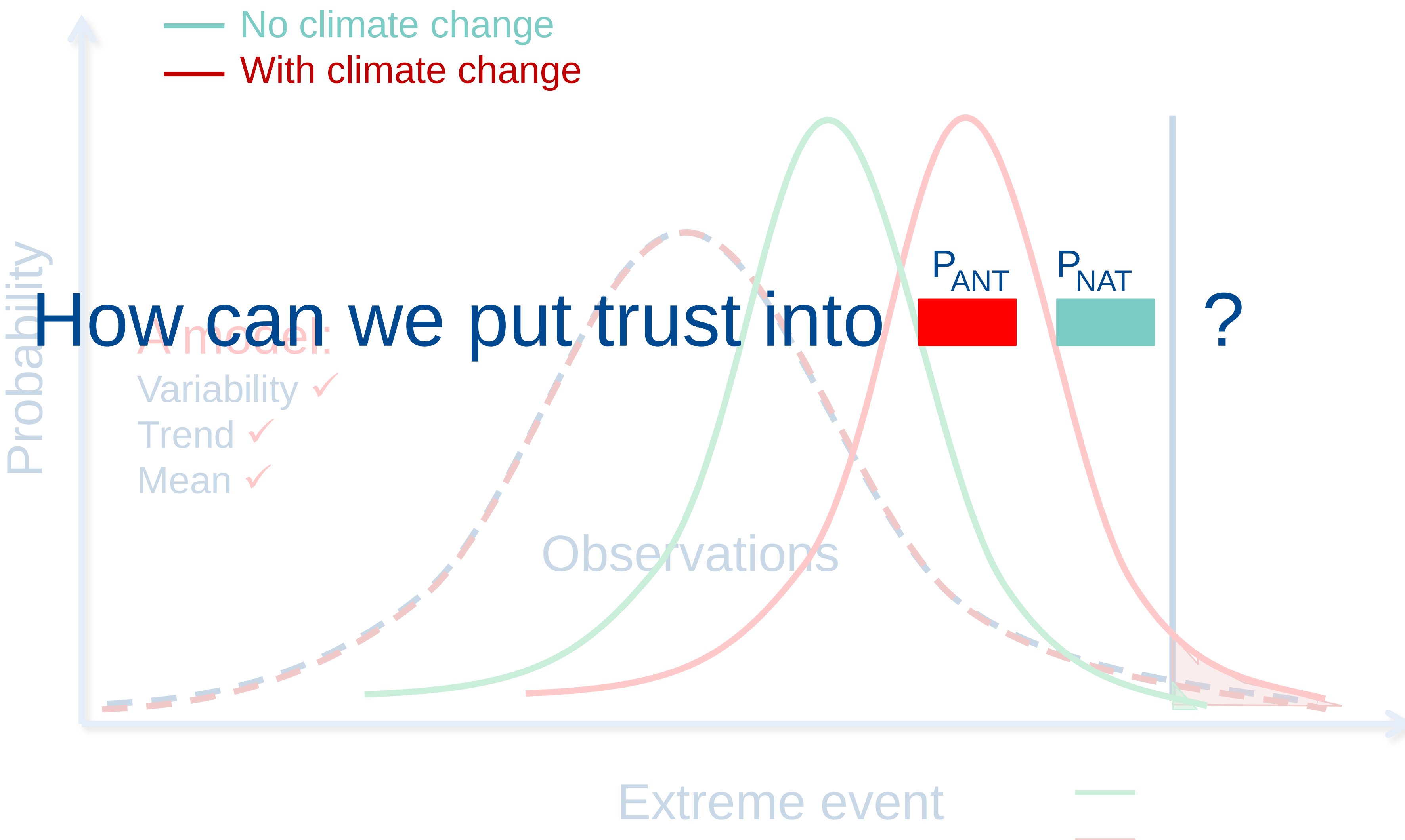
Reliability diagrams of left) initialised and right) uninitialised MME simulations for basin-wide **accumulated cyclone energy** (ACE). The results are for 2-9 year averages above the climatological median over 1961-2009. Statistically significant values are in bold.

Some of the added value of the predictions is their better management of uncertainty, which leads to increased **credibility**.



Caron et al. (2015, GRL)

Extreme event attribution

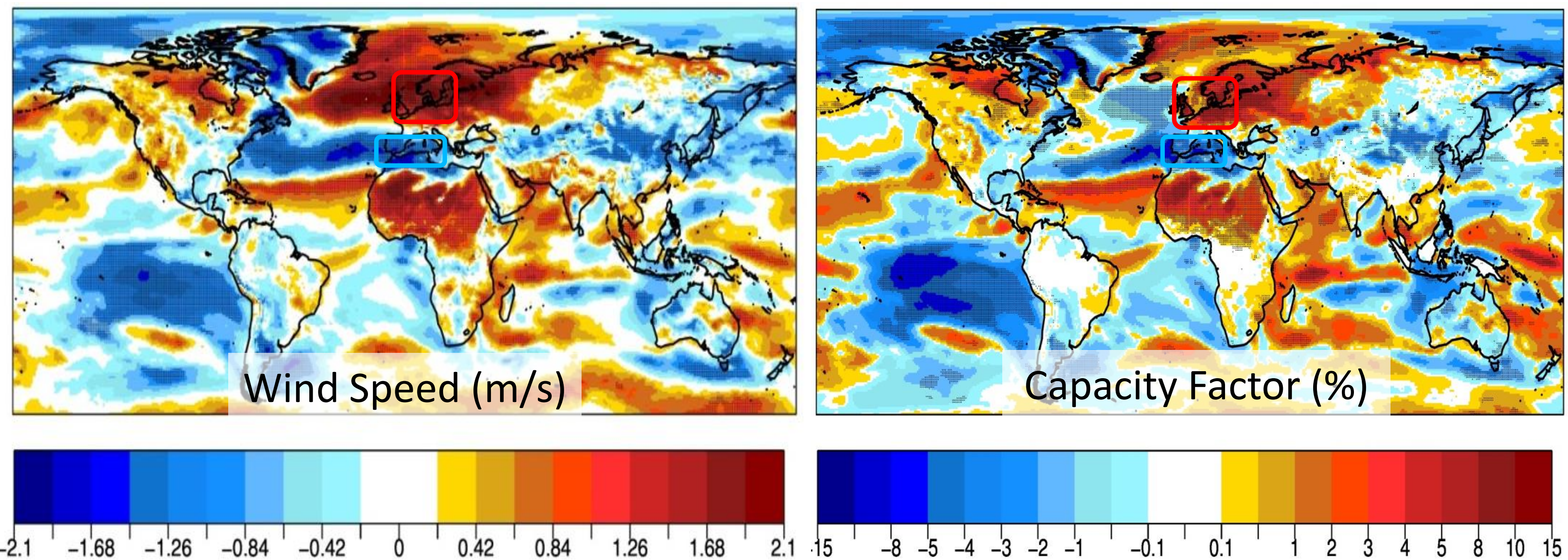


How can we put trust into [red box] [teal box] ?

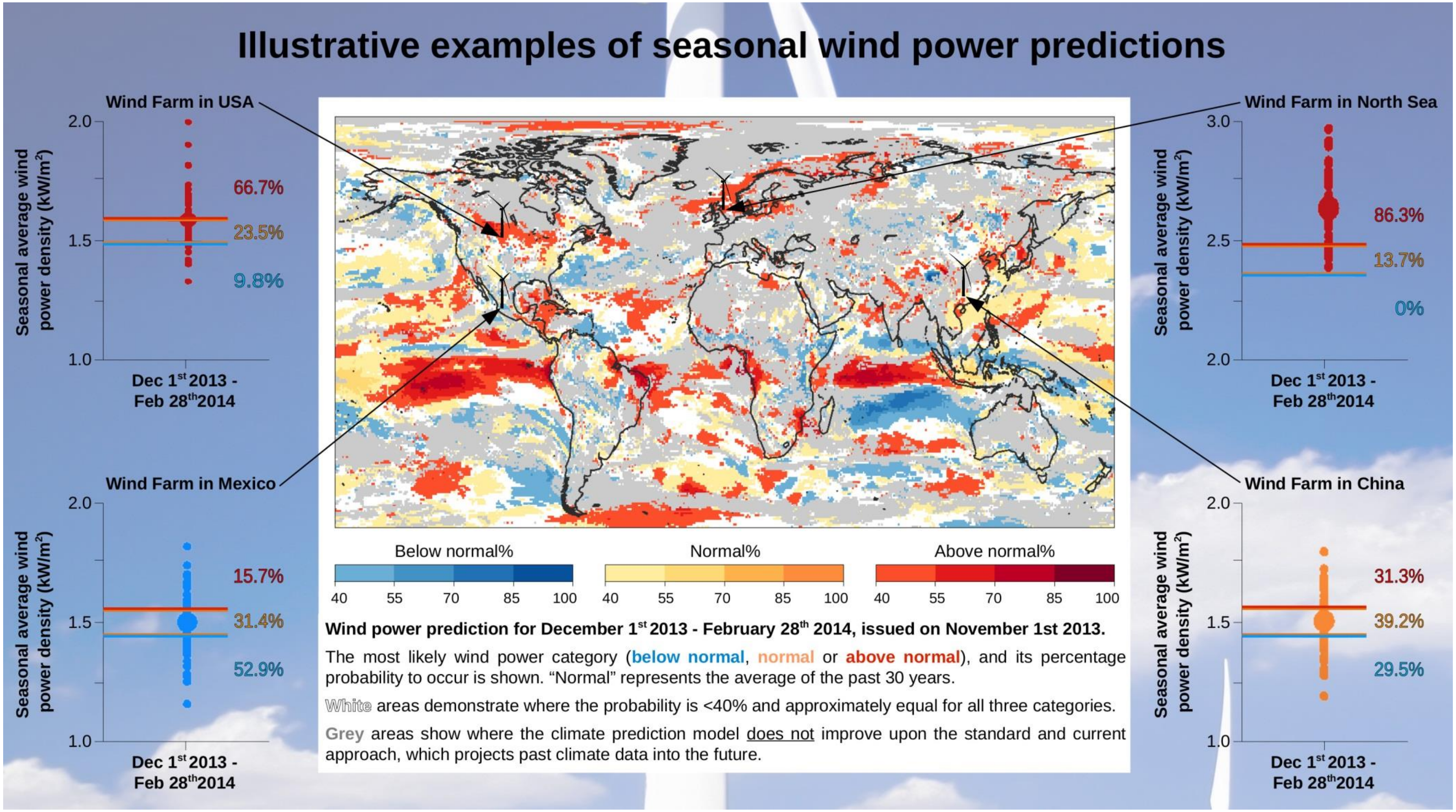
NAO and wind energy

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.



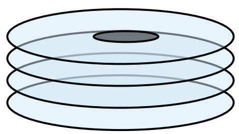
Climate data for wind energy



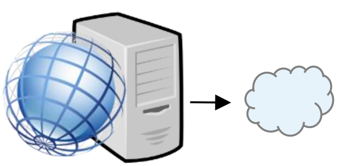
Data analysis

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

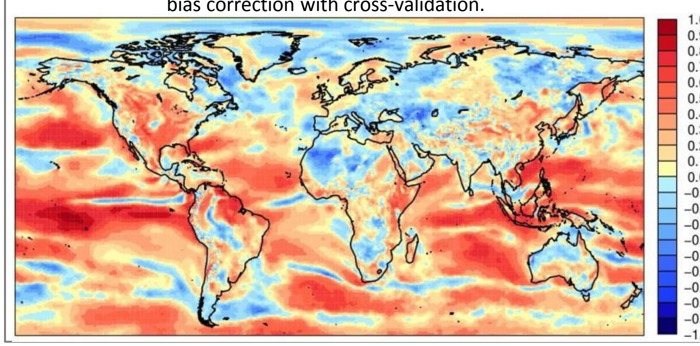
- Supports datasets stored locally or in ESGF (OPeNDAP) servers.
- Exploits multi-core capabilities
- Collects observational and experimental datasets stored in multiple conventions:
  - NetCDF3, NetCDF4
  - File per member, file per starting date, single file, …
  - Supports specific folder and file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

BASIC STATISTICS

SCORES
Correlation, ACC, RMSSS, CRPS, …

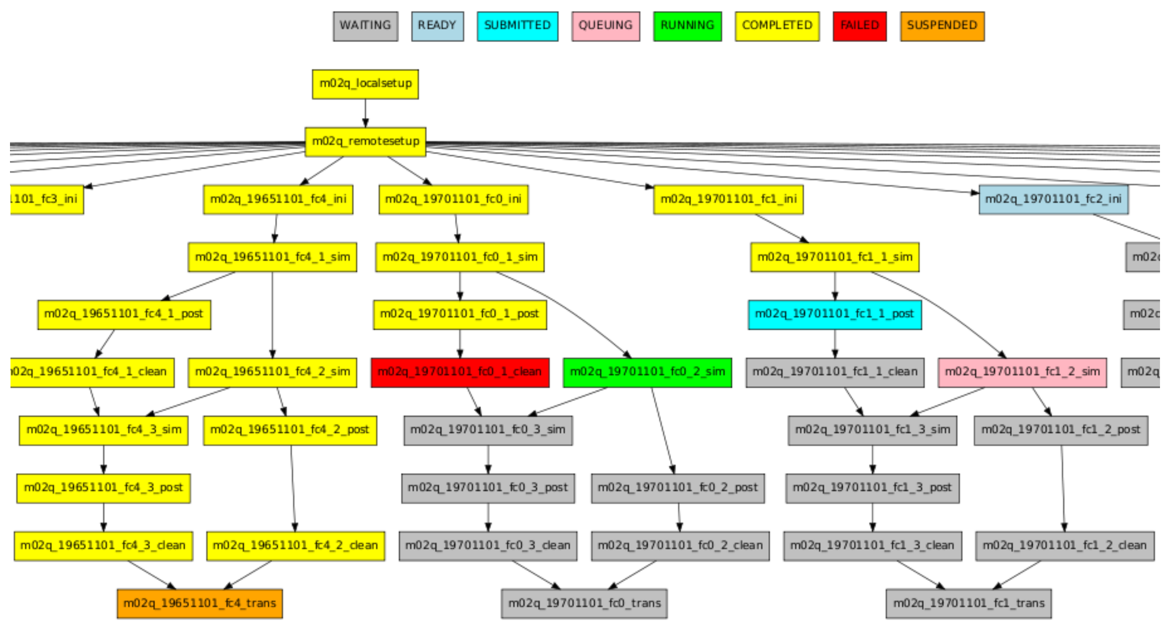
PLOTS

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.



Infrastructure: 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 run EC-Earth. NEMO and NMMB models on several platforms.



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