# Predictability and prediction in the SPECS project

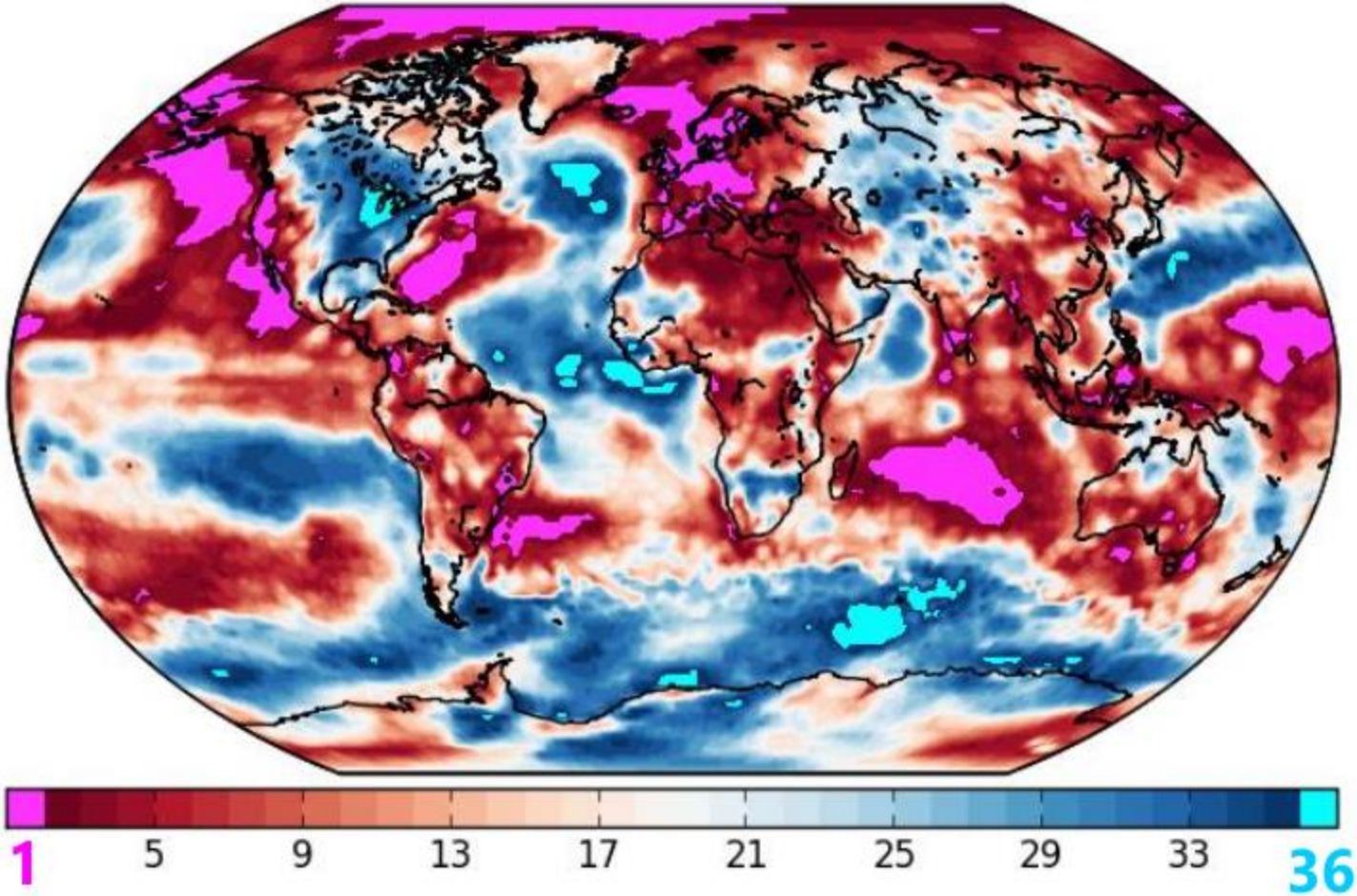
F.J. Doblas-Reyes
ICREA, BSC and IC3, Barcelona, Spain

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

iCrea BSC IC3

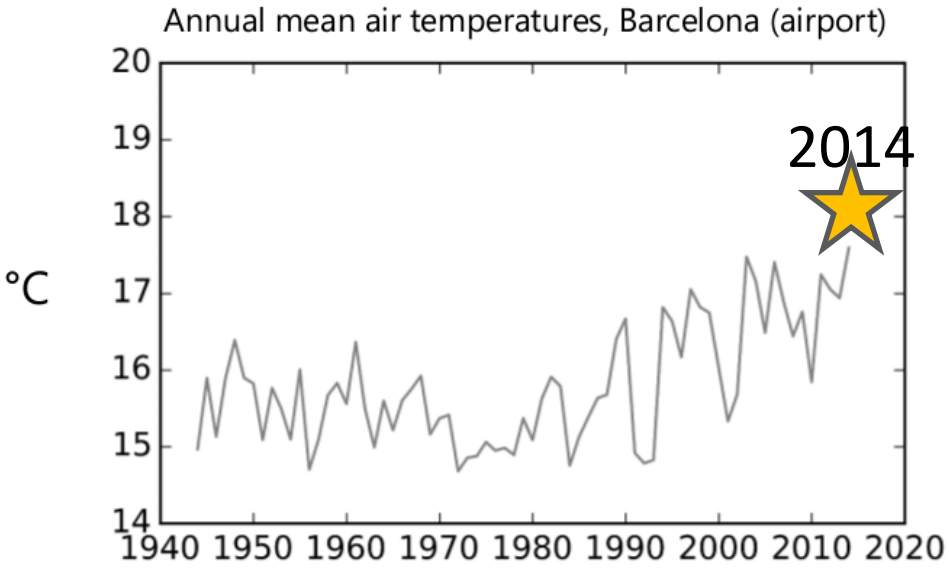
# What people feel

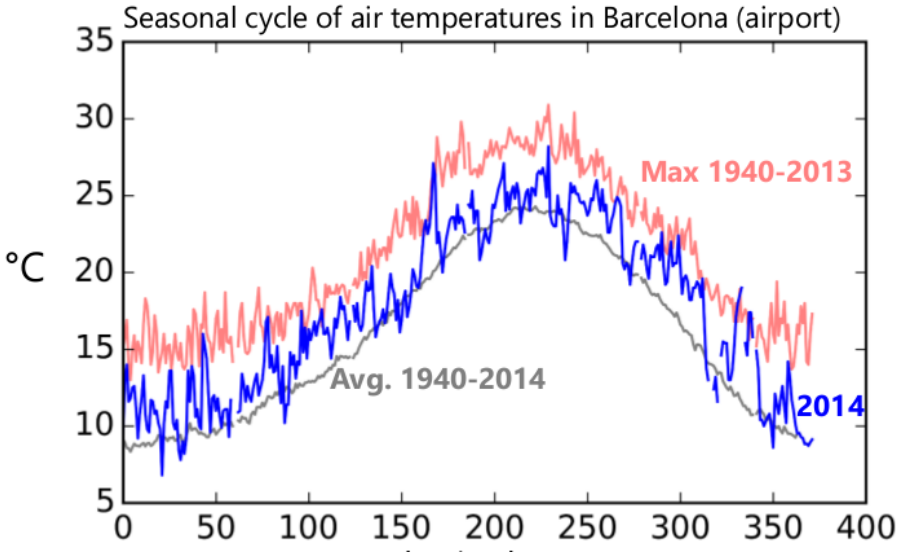
Rank of the 2014 annual mean temperature over the last 36 years from ERA Interim.



# What people feel

Temperatures in Barcelona airport from the ECAD dataset.



# Need for near-term information

Bodegas Torres (a Spanish winery) is looking for new locations for its vineyards (and it's not the only one doing it).

Land is being purchased closer to the Pyrenees, at higher elevation. They are considering acquiring land in South America too, in areas where wine is currently not produced.

Bodegas Torres requests local climate information (including appropriate uncertainty assessments) for the vegetative cycle of the vine, which lasts 30-40 years.

Some users need to make the decision now.

Climate services is just a concept, decadal prediction is just a tool

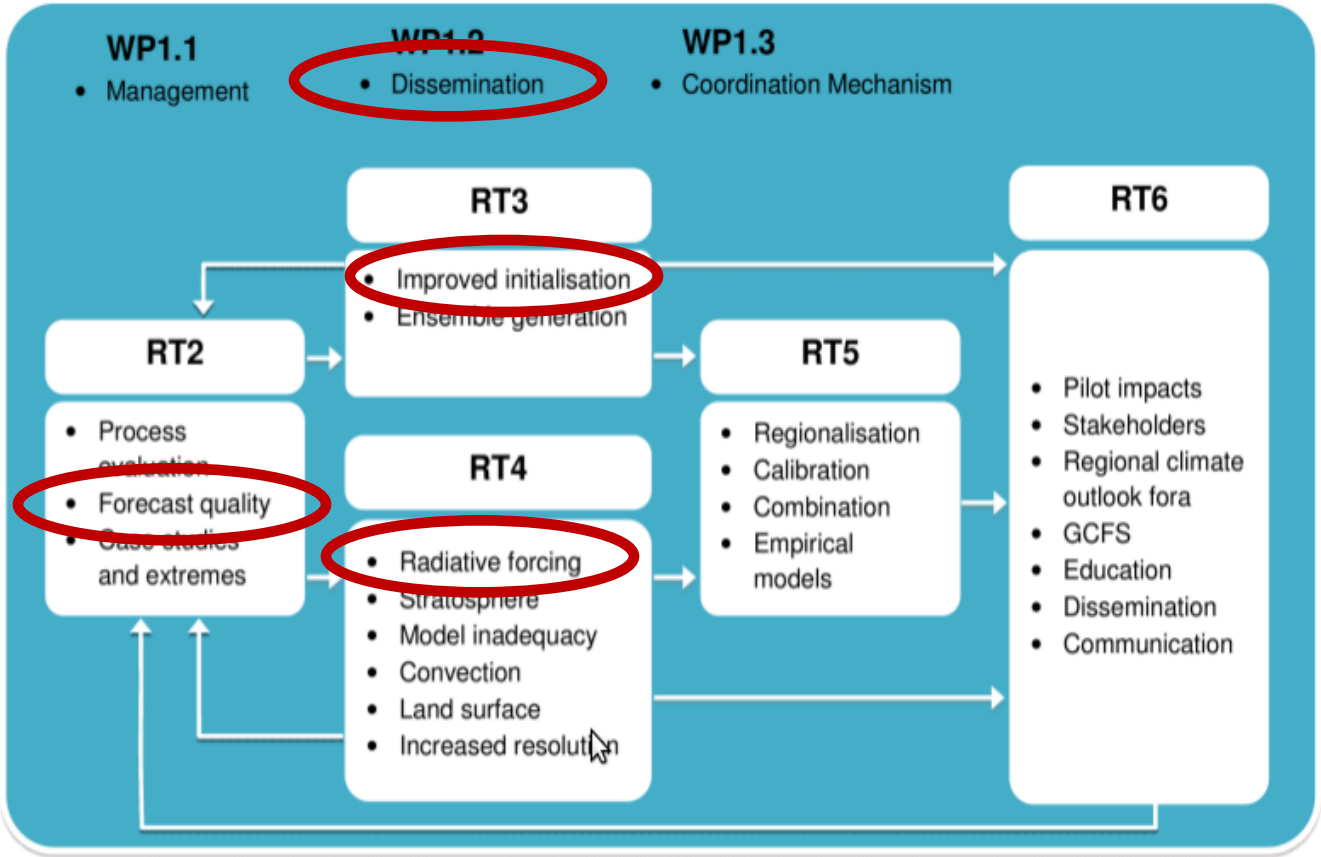
# Climate services as the driver


Climate data is not climate information

# SPECS: Overall strategy

Links to EUPORIAS/NACLIM, but also IS-ENES2, PREFACE, EUCLEIA, CLIPC, …

| 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 |

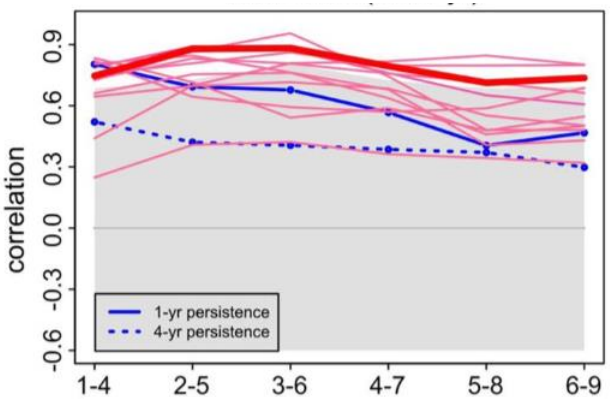



WP1.1: Management
WP1.2: Dissemination
WP1.3: Coordination across EUPORIAS, NACLIM & SPECS
RT2: Evaluation of current s2d forecast systems
RT3: Forecast strategies
RT4: Improved systems
RT5: Calibrated predictions at the local scale

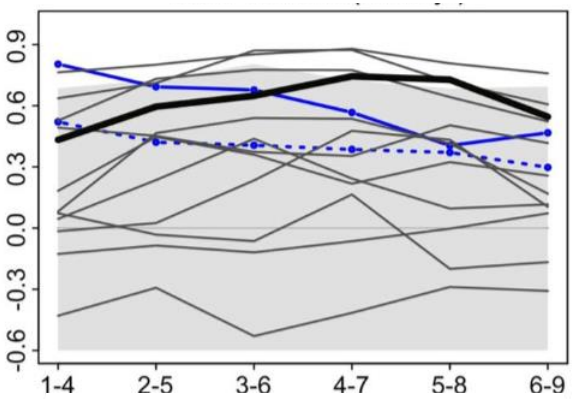
# CMIP5 decadal predictions

Correlation of the ensemble mean of the AMV against GHCN/ERSST3b as a function of forecast time.

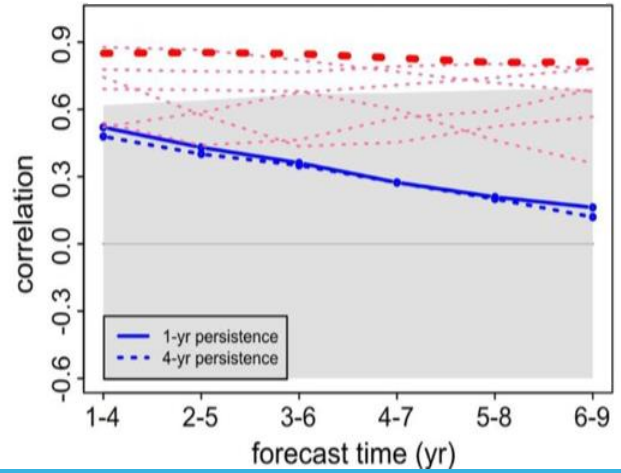
Init every 5 years



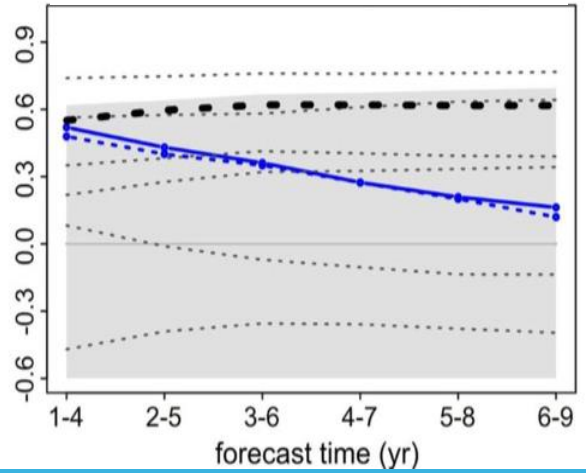

NoInit every 5 years




Init every year




NoInit every year

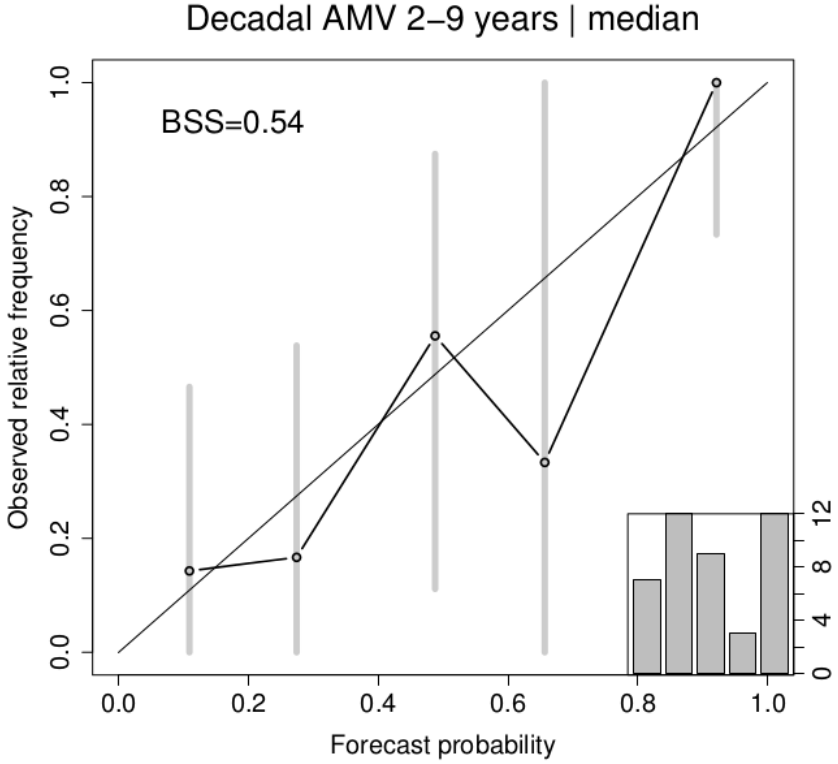


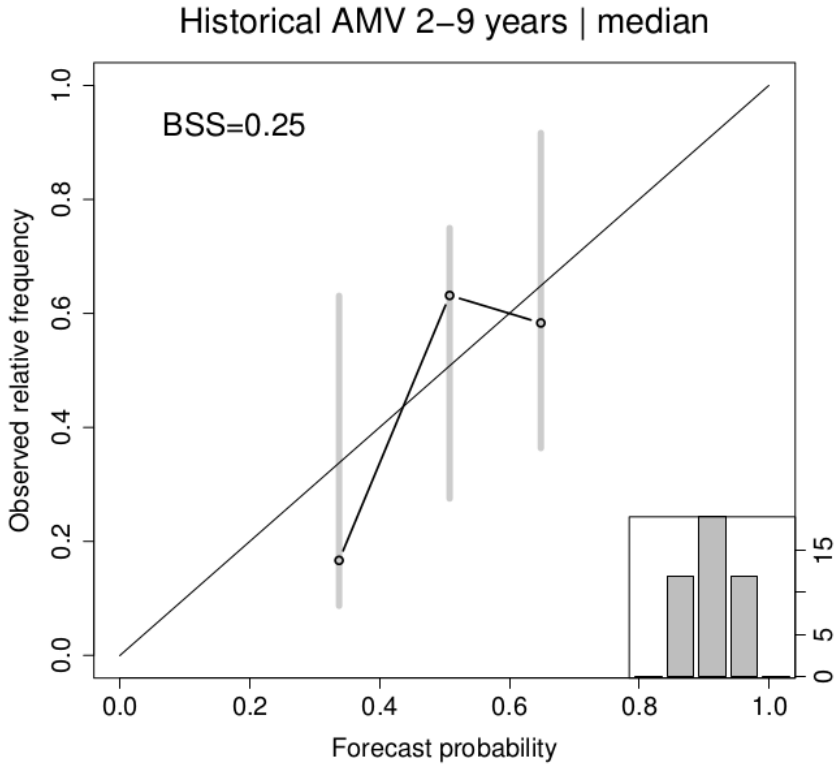

García-Serrano et al. (Clim. Dyn., 2014)

# Reliability, a key piece for users

Reliability diagrams of left) initialised and right) uninitialised MME simulations for the **Atlantic multi-decadal variability**. Results for 2-9 year averages above the climatological median over 1961-2009.

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



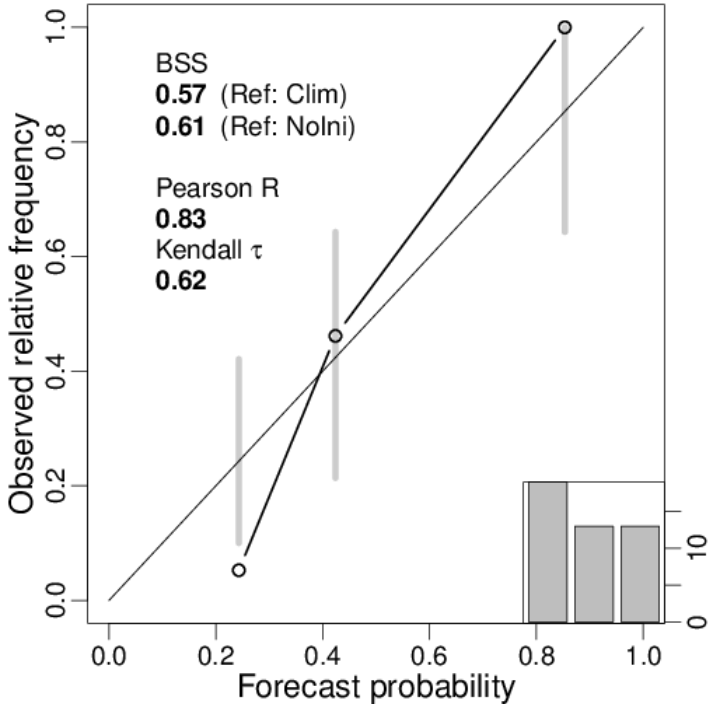



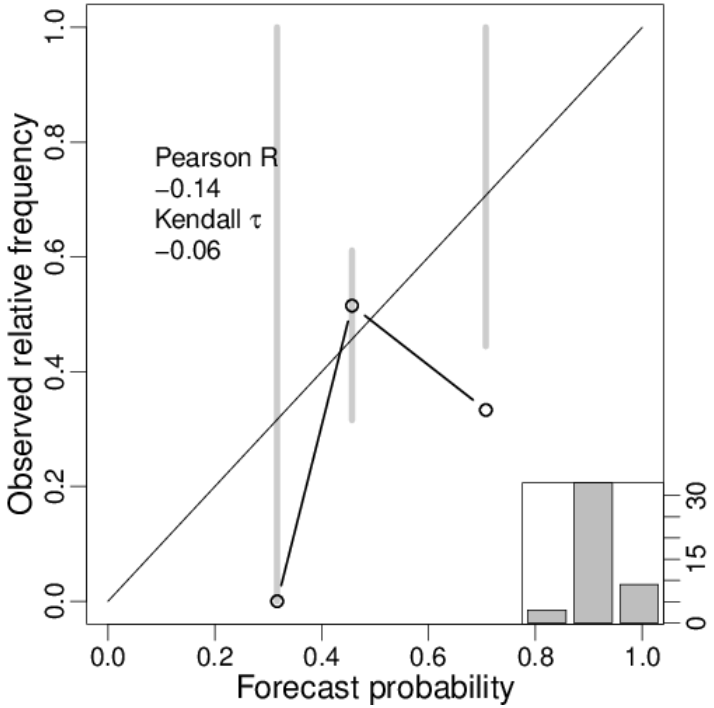

O. Bellprat, J. García-Serrano (IC3)

# 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**.

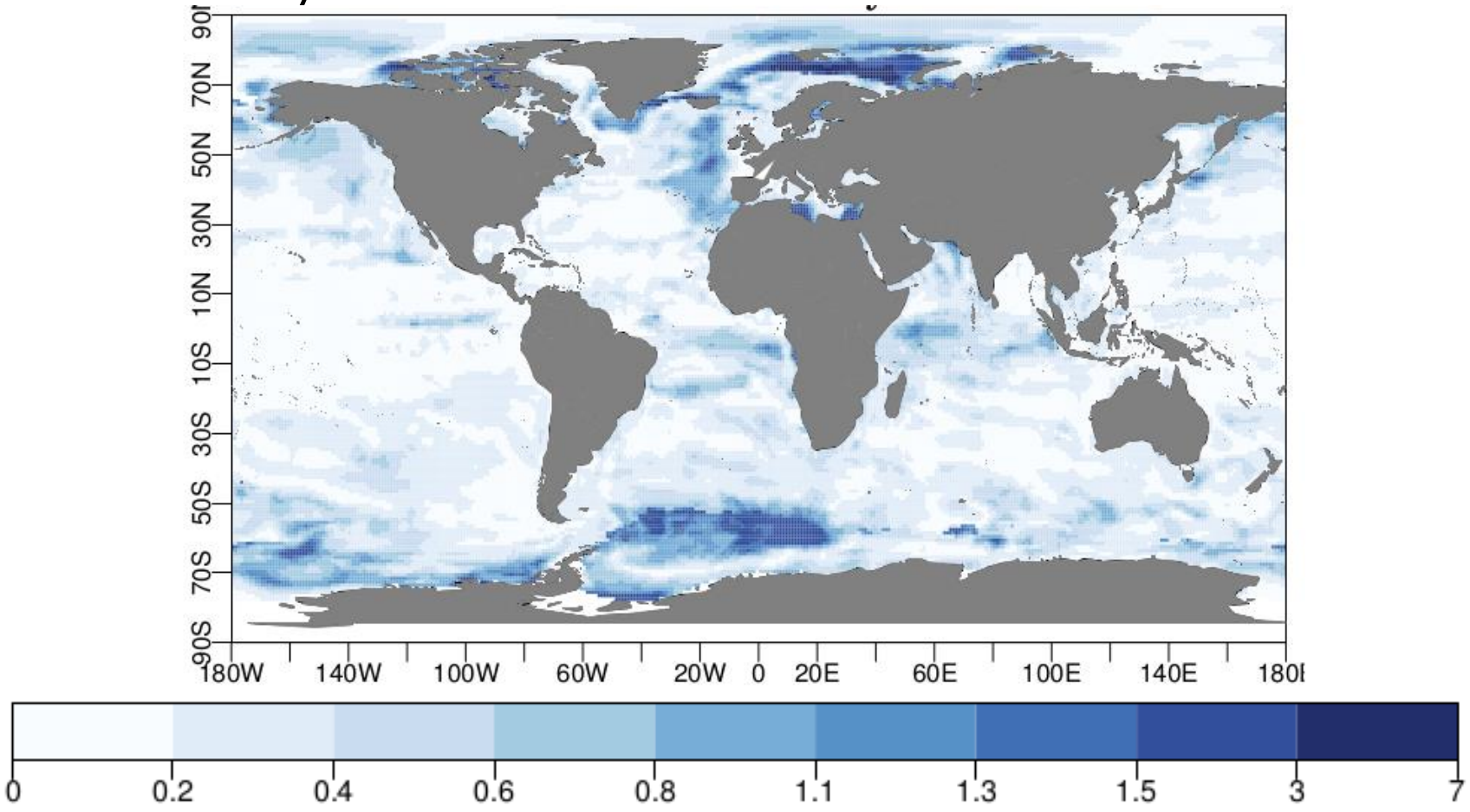



Caron et al. (GRL, 2015)

# Revisiting the initialization

Ratio between the RMS difference of density in traditional (T and S) and revised (T and rho) anomaly initialization and the RMS of the observed density in ORAS4.



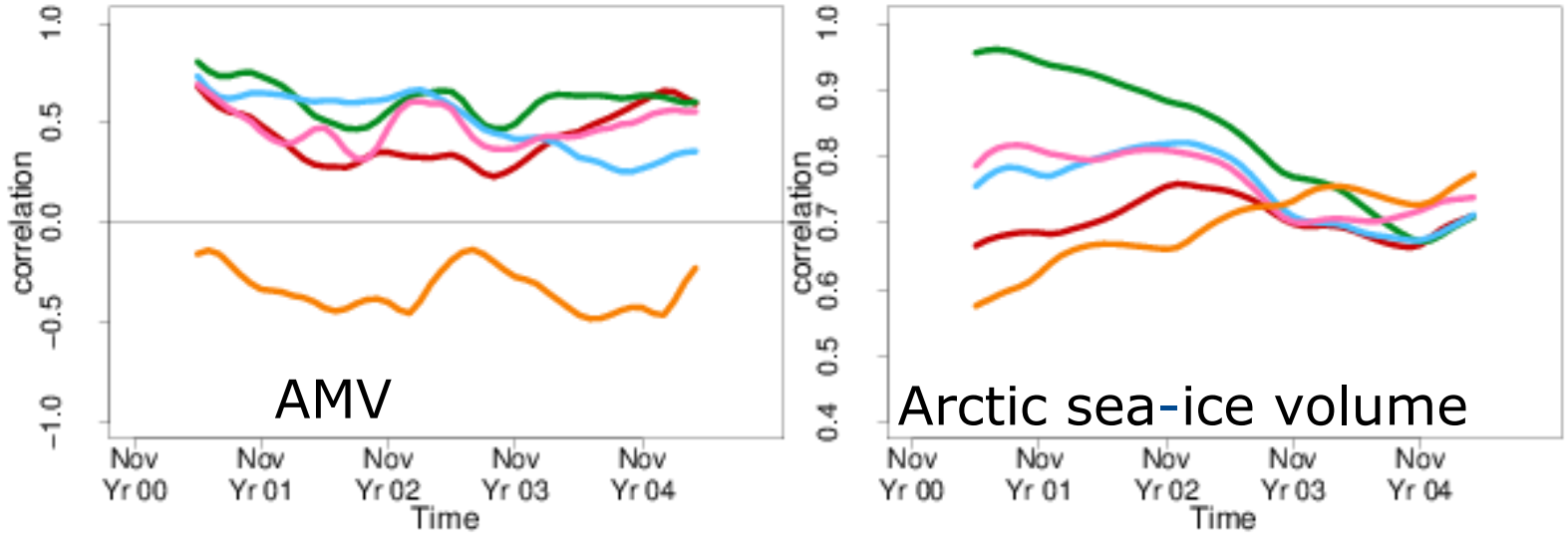

Volpi et al. (Clim. Dyn., submitted)

# Initialization approaches

Assessment of full-field (red), anomaly in the ocean (blue), weighted anomaly in the ocean and the sea ice, with initialization of temperature and density instead of the usual temperature and salinity (green), and weighted anomaly nudging in the ocean (pink).

Decadal prediction experiments run with EC-Earth2.3. Comparison with historical ensemble simulation (orange). 5 ensemble members, one start date every 2 years.

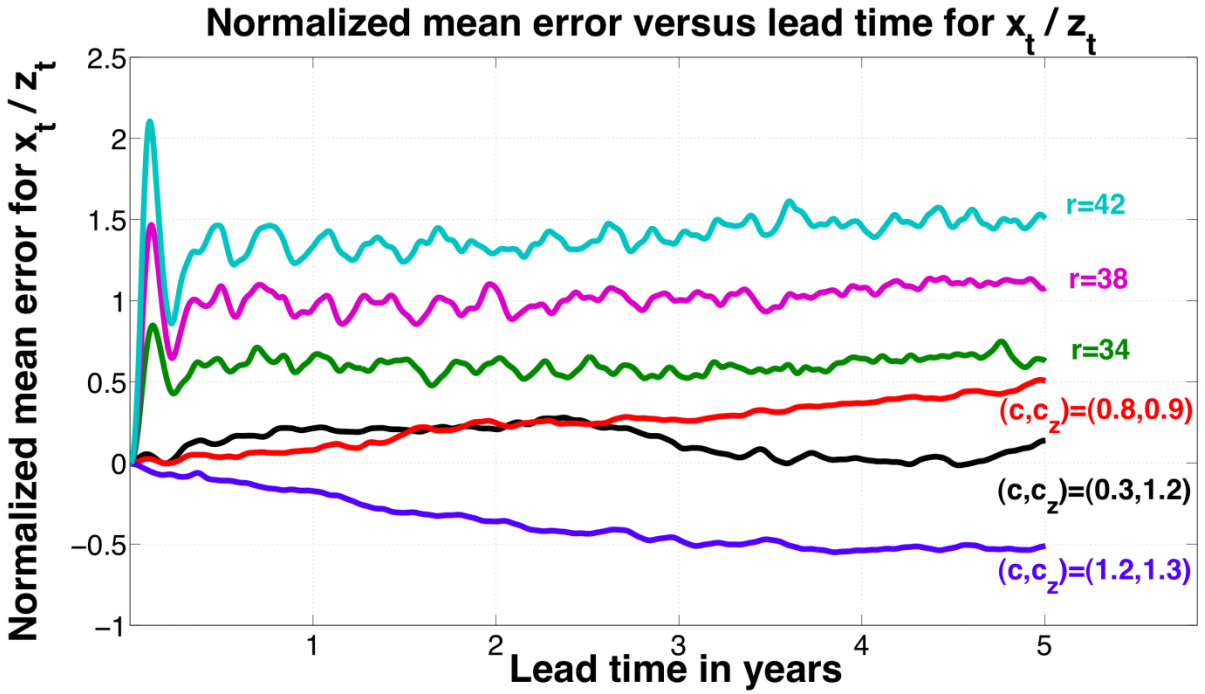
Reference data: ERSST for AMV and SST, sea-ice reconstruction from Guemas et al. 2013 for sea-ice area and volume.




Volpi et al. (Clim. Dyn., submitted)

# Back to simplified models

Mean error of two variables from 360 decadal predictions performed with the Lorenz model with three compartments (ocean, tropical atmosphere and extra-tropical atmosphere). The configurations where AI outperforms FFI are associated with a strong initial shock and a larger bias.



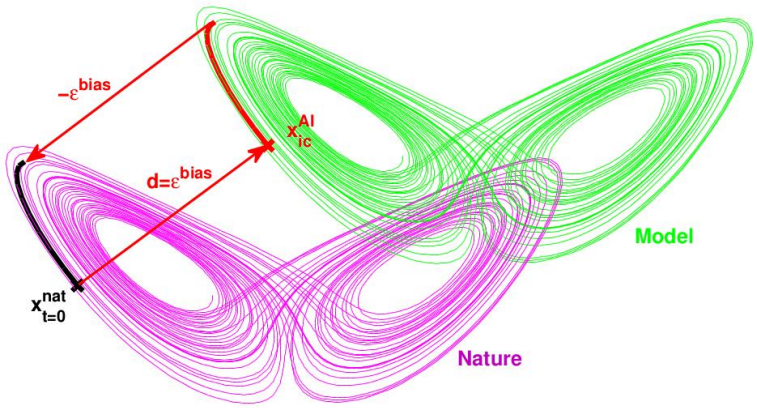

Model error "type #2"

Model error "type #1"

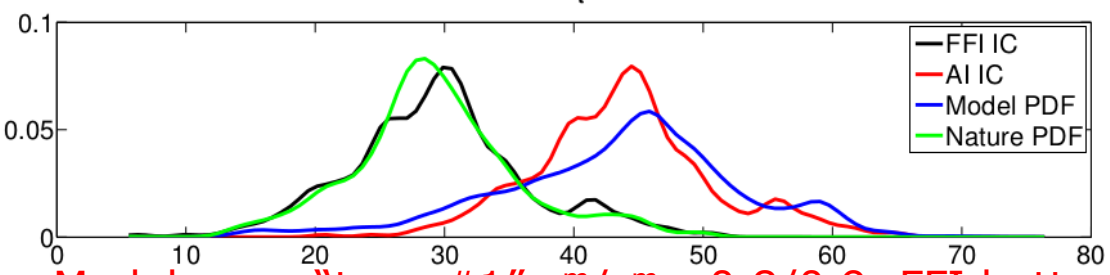
Carrassi et al. (NPG, 2014)

# Back to simplified models

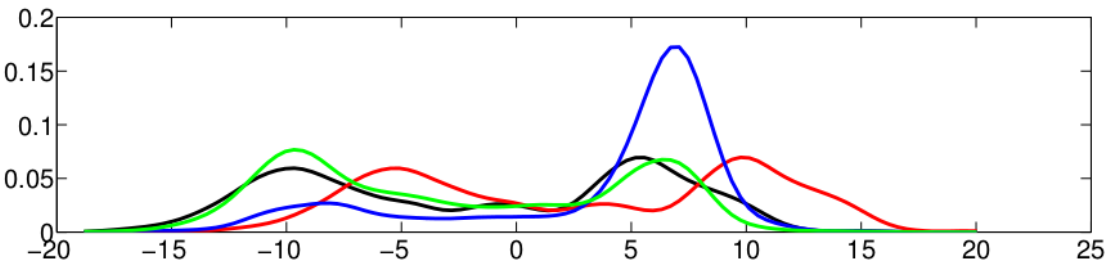
PDFs of initial conditions (black and red) and of the model and "nature" climatologies (blue and green) for the Peña and Kalnay model with three compartments (ocean, tropical atmosphere and extra-tropical atmosphere).




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




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



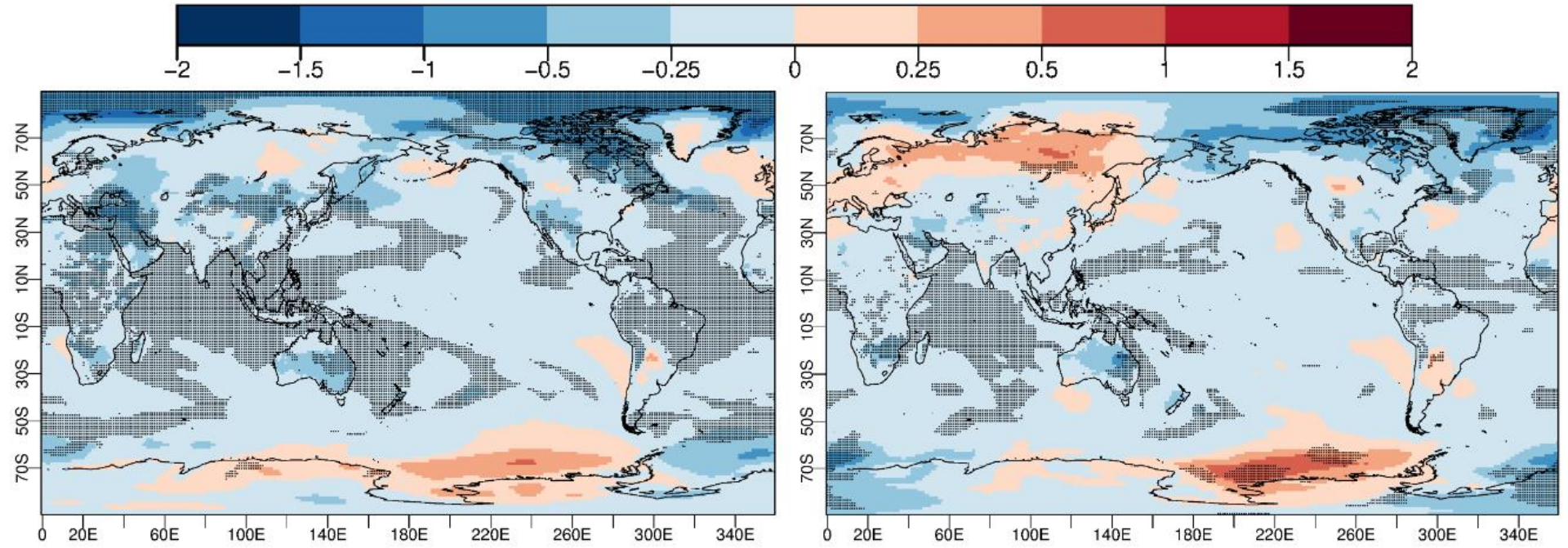

Weber et al. (MWR, 2015)

# Volcanic forcing

Near-surface air temperature difference in hindcasts (initialized) with and without volcanic forcing after the Agung, El Chichón and Pinatubo eruptions simulated by EC-Earth2.3 with five-member ensemble hindcasts. Stippling for statistically significant differences at 5%.

1-3 forecast years

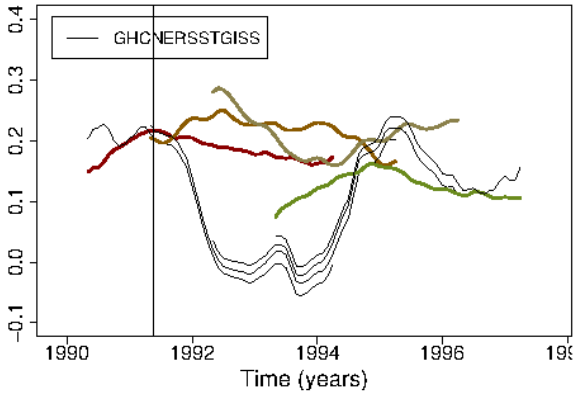
3-5 forecast years



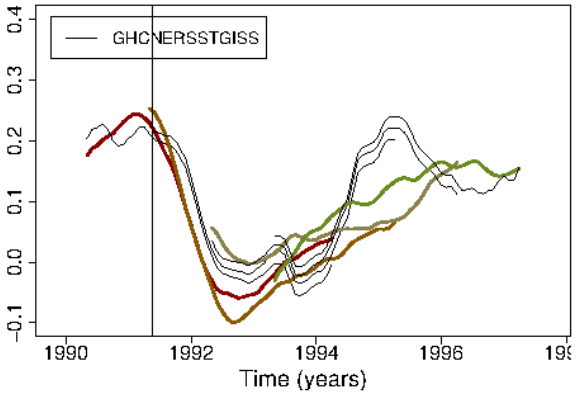
# Volcanic forcing

Global-mean surface temperature before and after the Pinatubo eruption simulated by EC-Earth2.3 with five-member ensemble hindcasts. Observational data is from GHCN, ERSST and GISS.

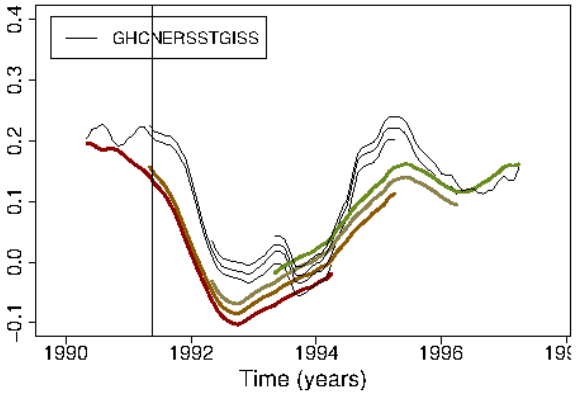
Both the initialization and the volcanic forcing specification improve the simulations.




Initialisation and no volcanoes



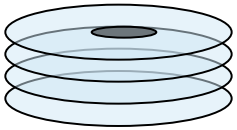

Initialisation and volcanoes



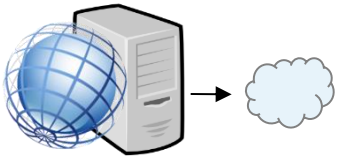

No initialisation and volcanoes

# Common tools for verification

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



**LOCAL STORAGE**



**ESGF NODE or OPeNDAP SERVER**

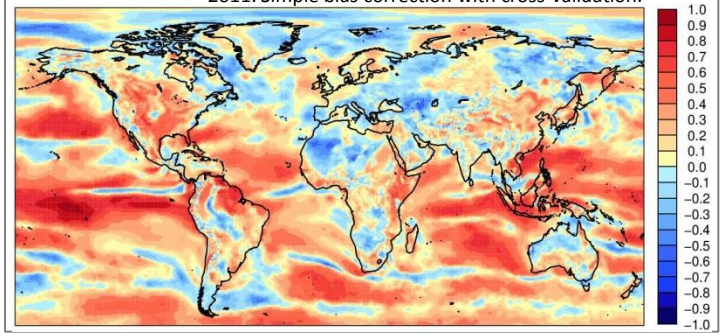
- Supports datasets stored locally or in ESGF (OPeNDAP) servers.
- Exploits multi-core capabilities
- Collects observational and experimental datasets stored in multiple conventions:
  - NetCDF3, NetCDF4
  - File per member, file per starting date, single file, …
  - Supports specific folder and file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

**BASIC STATISTICS**

**SCORES**
Correlation, 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.



# Communication

A series of fact sheets has been started (available from the SPECS web site). Common vocabulary with EUPORIAS, targeting a wide audience, mimicking some material already existing to explain what climate change is.

SPECS Fact sheet #2 **What is a decadal prediction?** October 2014

Weather is chaotic which limits its predictability to one or two weeks This means that it will never be possible to extend normal weather forecasts to seasonal time-scales and beyond.

For example, we will never be able to predict the weather on a specific date in a specific place years in advance. However, **changes in *prevailing* weather over the course of several months to years are potentially predictable**. For instance we may be able to say if a particular region might expect, on average, colder winters or drier summers. Such changes in weather patterns occur due to the interaction of the atmosphere with more slowly varying parts of the Earth system.

Weather is a result of energy moving through the Earth system. Energy is originally radiated to the Earth from the Sun, with most being re-emitted or reflected back to space. The amount that remains in the Earth system is modulated by many things: some emerge naturally within the system (*internal variability*), whilst others are controlled by external factors such as variations in solar output, greenhouse gases, and atmospheric particles

# Data dissemination

- The SPECS datasets are 80 TB of data stored at BADC and published on the ESGF
- NetCDF4 format (1.5 to 2x space saving)
- Double time axis to encode start date and forecast time
- Add start date in the name of the file

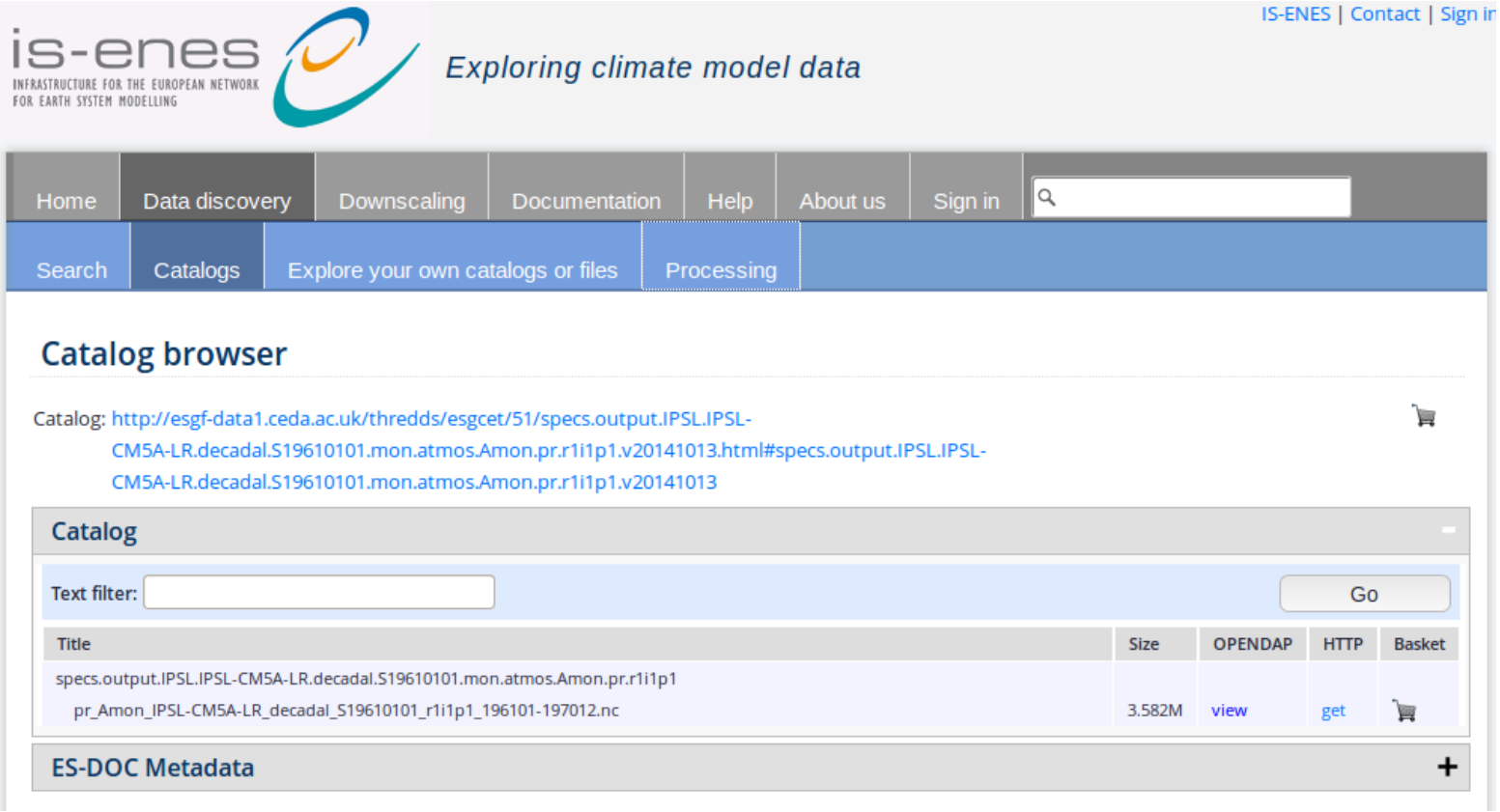
IPSL-CM5A-LR/decadal/S19890101/mon/ocean/tos/r3i1p1/tos_Omon_IPSL-CM5A-LR_decadal_S19890101_r3i1p1_198901-199812.nc

- New attributes: initialization and physics description, associated experiment
- Creation of "deposit receipts" when data is published
- As CMOR3 is under development, SPECS is trying to ensure that the needs of the climate prediction community are taken into account

# Downstream services

The SPECS data are now visible from the Climate4impact portal http://climate4impact.eu.

Lots of work still missing: e.g. use cases and processing demonstration video for climate predictions, etc

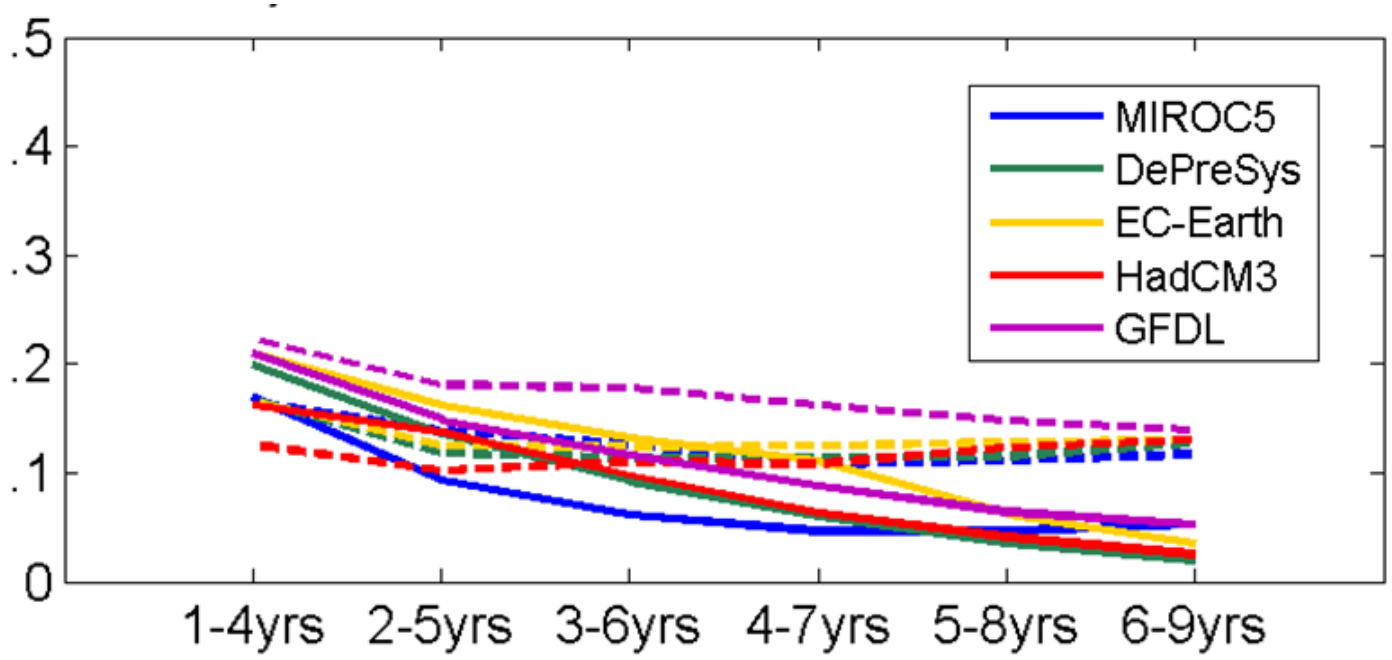


# Summary

- Requests for climate information for the next 30 years 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, decadal predictions, empirical systems, etc). Merging all this information into a reliable, unique source is a problem still not solved.
- The community is maturing quickly and there are successful stories of interactions with users.
- None of this will materialize without appropriate investment in observational networks and reduction of all aspects of model error.

# The South Pacific

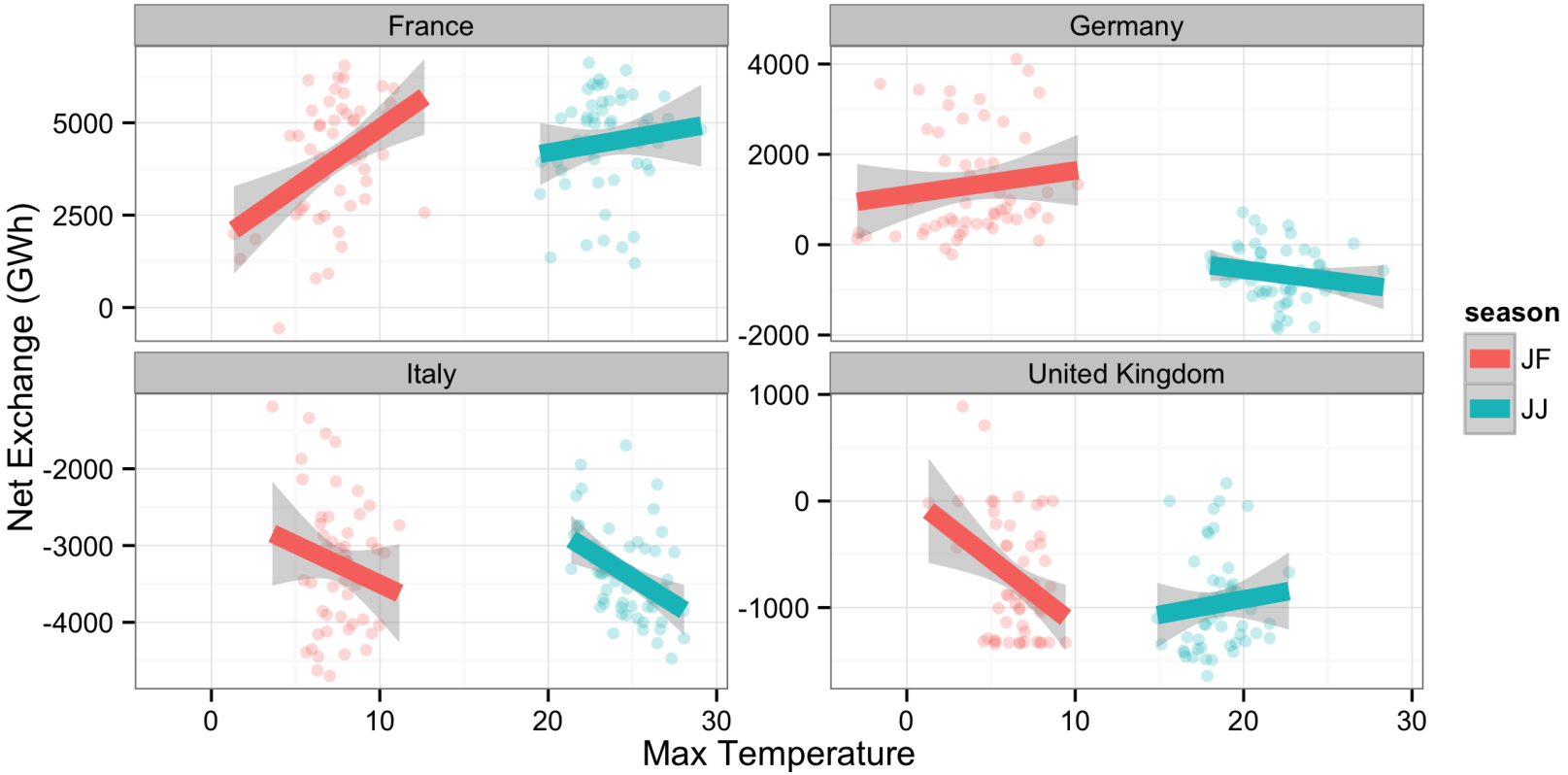
Correlation of the ensemble-mean of decadal predictions started every year over 1960 to 2005 over the South Pacific (20ºS-65ºS) as a function of forecast time. Solid lines for simulations initialized in extreme phases of ENSO and dashed lines for those initialized in neutral phases.




Saurral and Doblas-Reyes (Clim. Dyn, submitted)

# Climate and energy export

Climate affect exchanges via electricity demand (heating or cooling, from the customer point of view) and renewable-energy production.



# Sudden coupled phenomena

Changes in atmospheric circulation will advect the freshwater accumulated in the Arctic Ocean in the last 15 years (e.g. the GSA).

SLP (black lines, hPa), wind (large arrows) and Ekman transport (blue small arrows) typical for ACCRs (left, Ekman transport converging) and CCRs (right, Ekman transport diverging).