Validation of Seasonal Forecasts: Statistical Methods and Downscaling

WCRP Seasonal Predicton Workshop
Barcelona, Spain, 4-7 June 2007

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Universidad de Cantabria
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Applied Meteorology Group

http://www.meteo.unican.es

Outline of the Talk

1. **Sources of seasonal predictability (ENSO).**
2. **Description of data (model simulations and observations in the tropics and extra-tropics)**
3. **Skill in the Tropics (Peru)**
    1. ***Direct model output vs. Statistical downscaling.***
    2. ***Assessing the confidence of a particular forecast.***
    3. ***Weighting the models.***
4. **Skill in the Extra-Tropics (Spain)**
5. **Teleconnections in Europe.**

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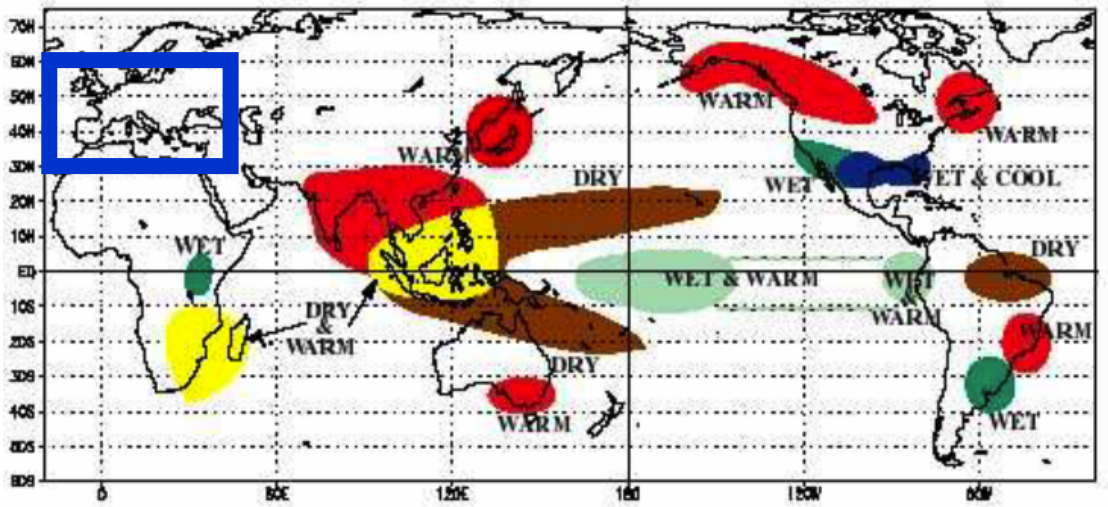
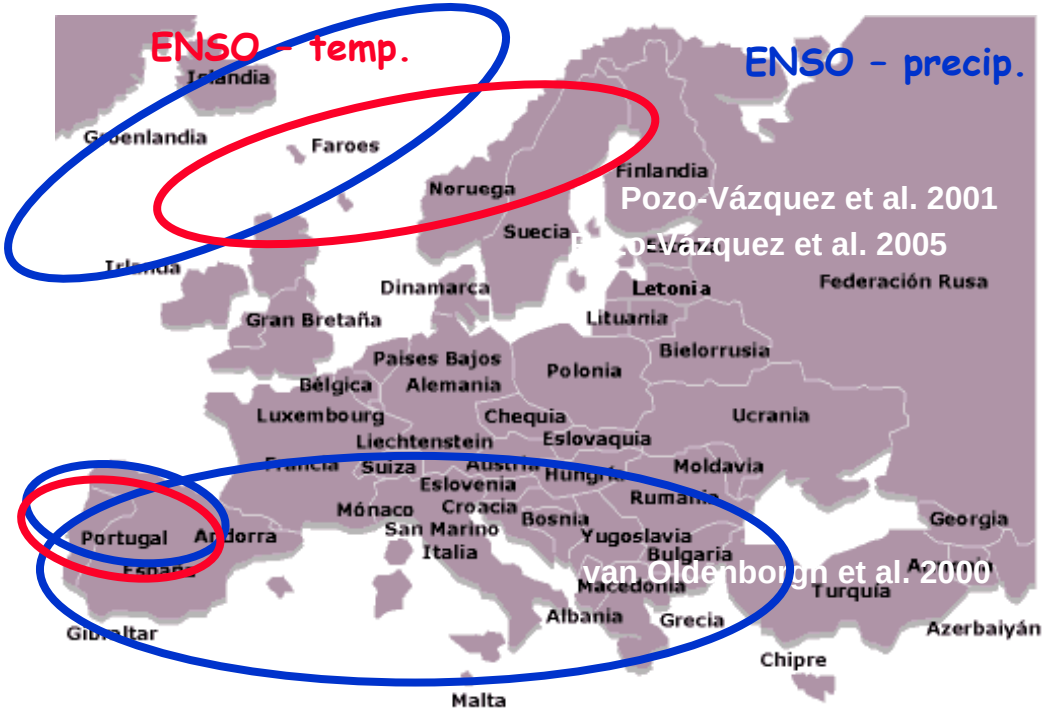
Sources of seasonal predictability. ENSO

The main source of seasonal predictability is ENSO and the different El Niño / La Niña teleconnections

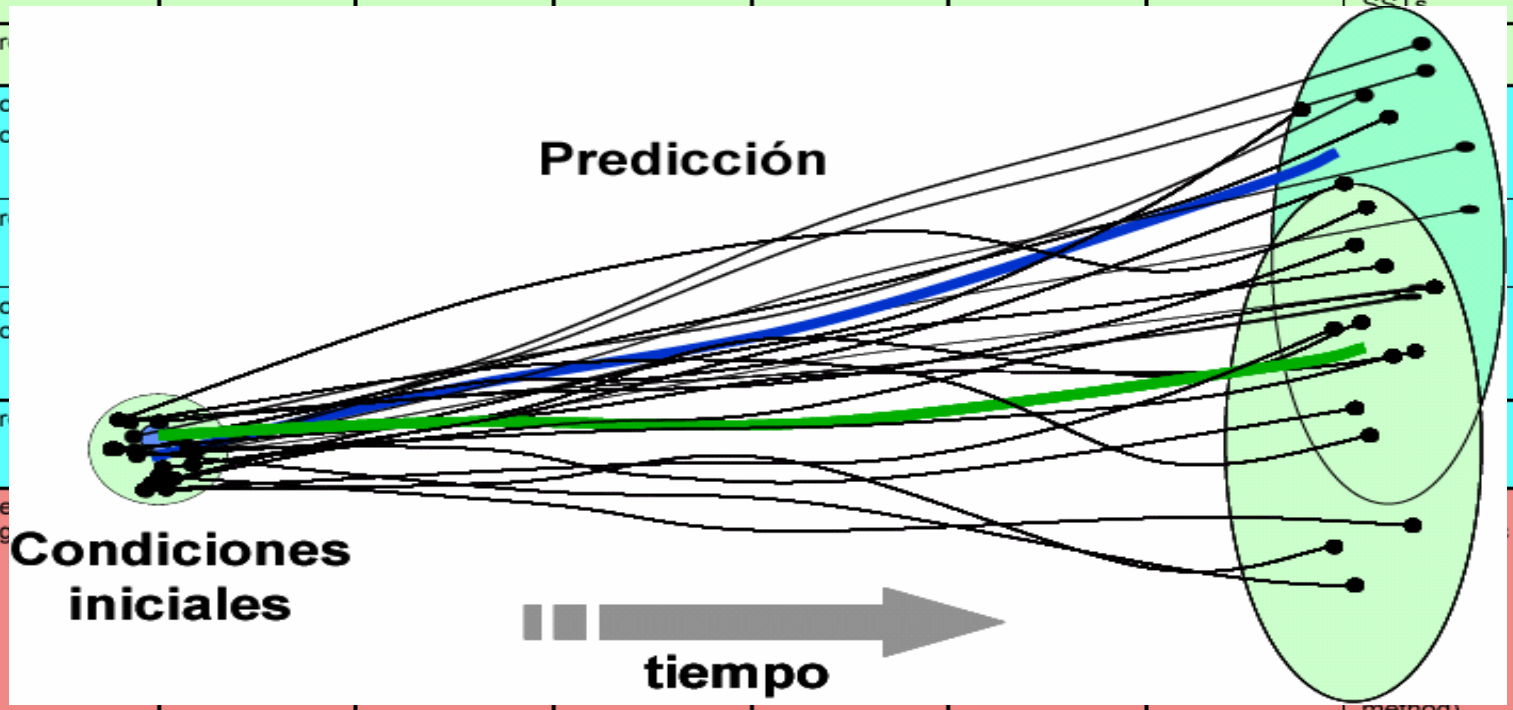


Some teleconnections with Europe have been reported in the last years, both for precipitation and temperature.



Seasonal Predictions: DEMETER Multi-Model Ensemble

	CERFACS	ECMWF	INGV	LODYC	Météo-France	Met Office	MPI
atmosphere component	ARPEGE	IFS	ECHAM-4	IFS	ARPEGE	HadAM3	ECHAM-5
resolution	T63 31 Levels	T95 40 Levels	T42 19 Levels	T95 40 Levels	T63 31 Levels	2.5º x 3.75º 19 Levels	T42 19 Levels
atmosphere initial conditions	ERA-40	ERA-40	coupled AMIP-type experiment	ERA-40	ERA-40	ERA-40	coupled run relaxed to observed SSTs

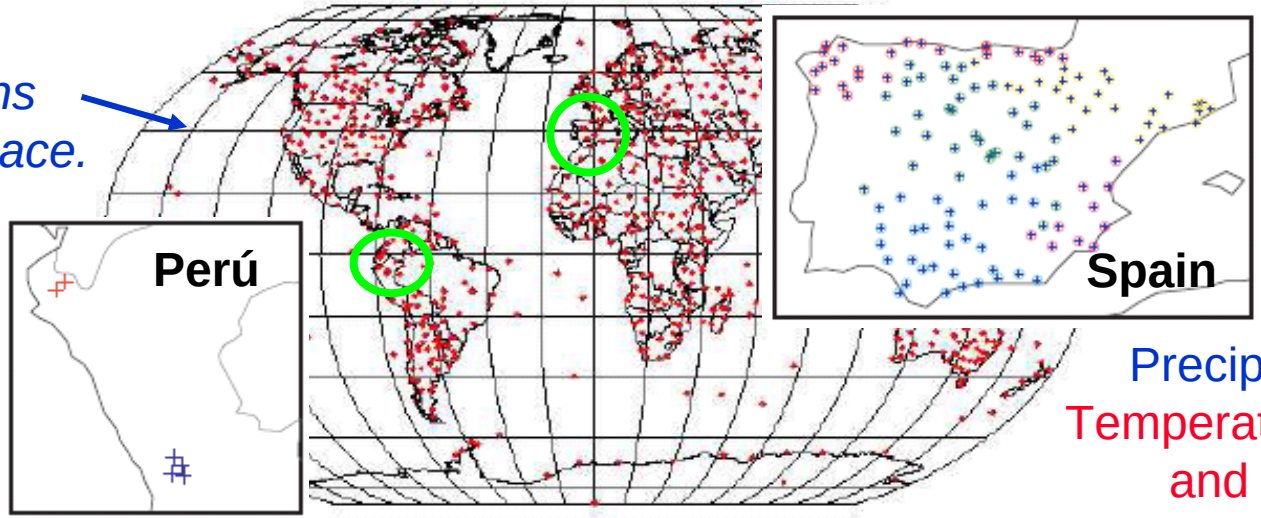


DEMETER ➔ ENSEMBLES (Paco Doblas-Reyes' Talk)

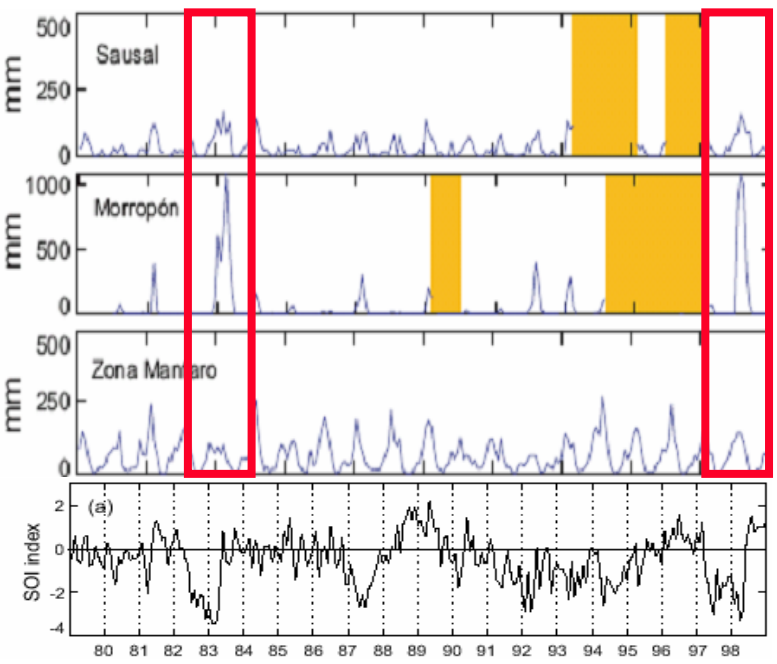
Observations in the Tropics and Mid-Latitudes

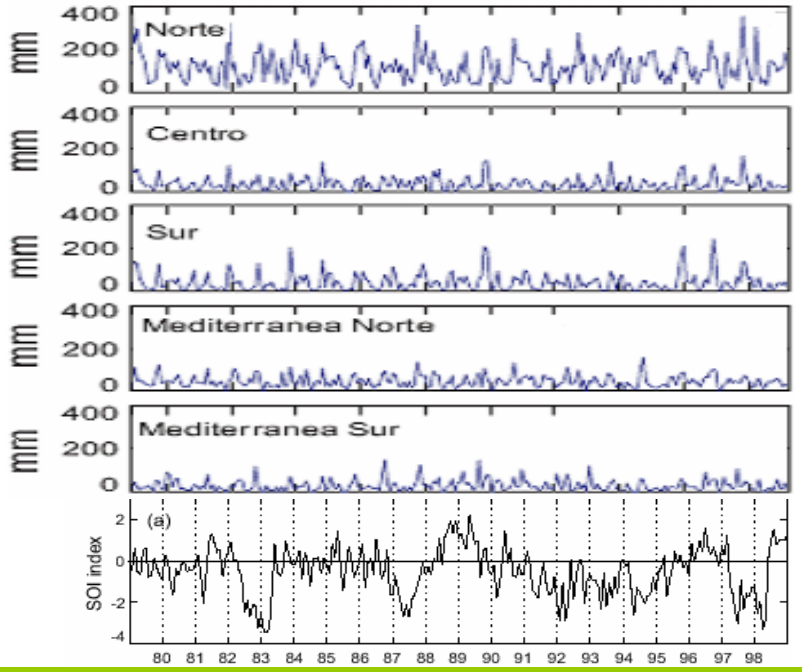
ERA40.
Observations
in model space.

Networks:



Precipitation
Temperature máx.
and min.





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Skill in the Tropics and Mid-Latitudes (Z500)

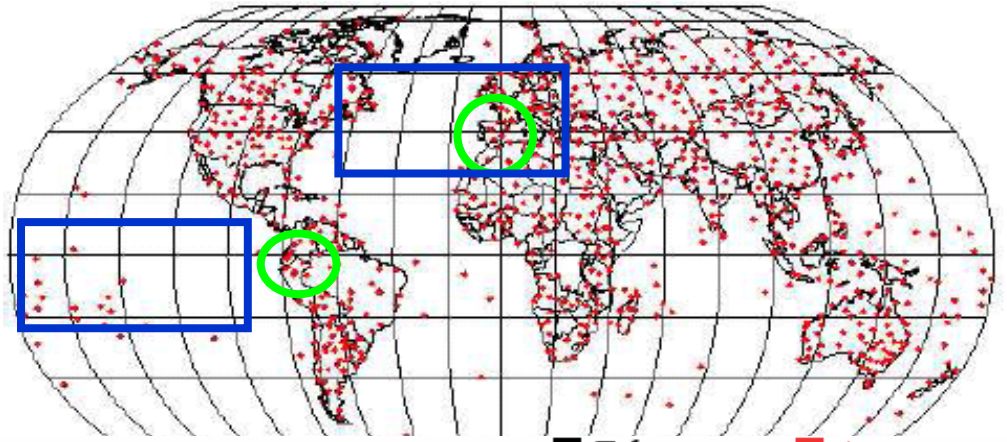
Many validation measures:

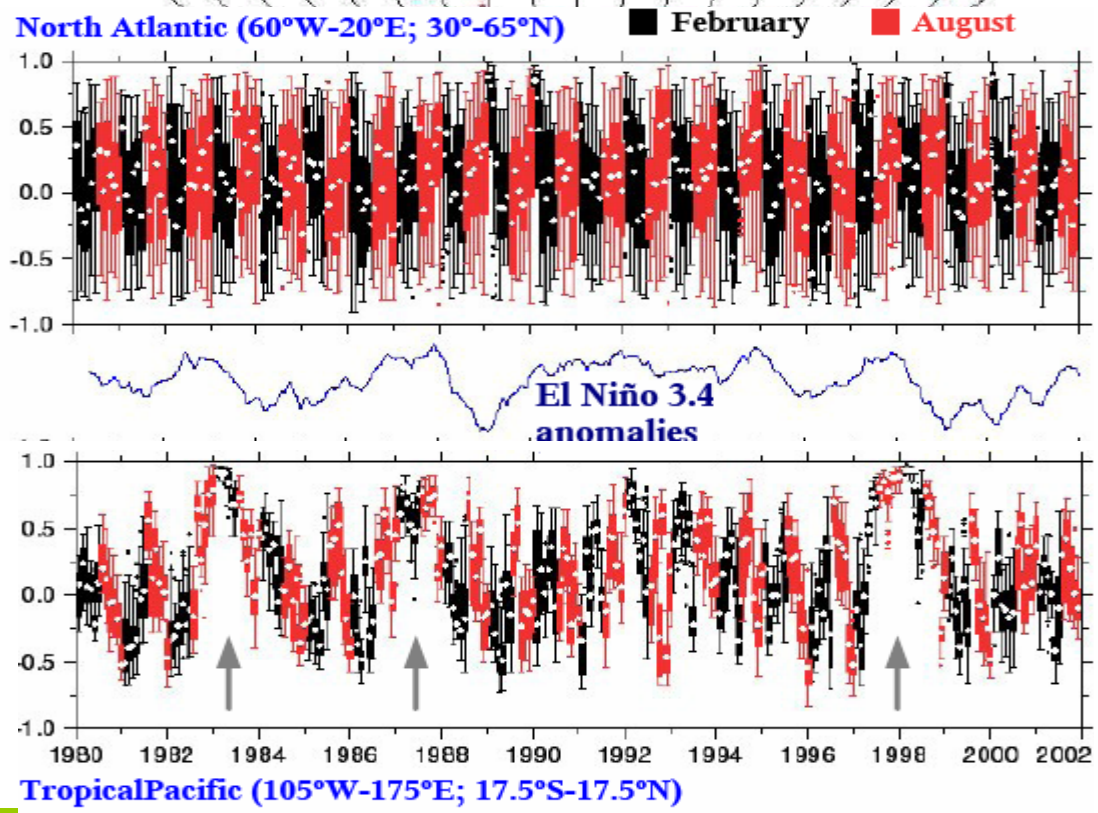
Deterministic:

- ***ACC (Anom. Correlation coef.)***
- ***RMSE (Root Mean Squared Error)***

Probabilistic:

- ***Brier Score / Brier Skill Score***
- ***ROC Area / ROC skill Area***
- ***Economic Value***
- ***Entropy / Information Theory***





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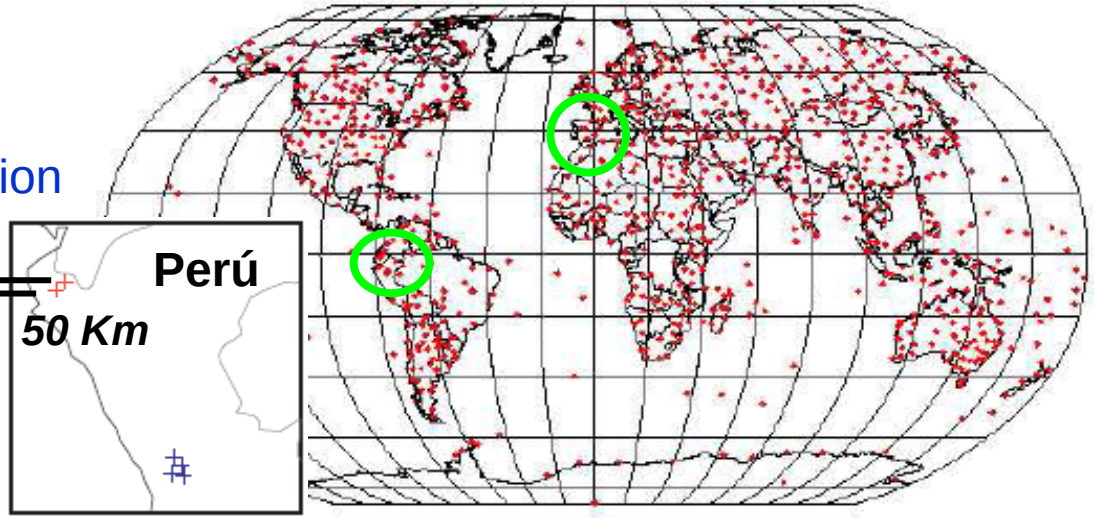
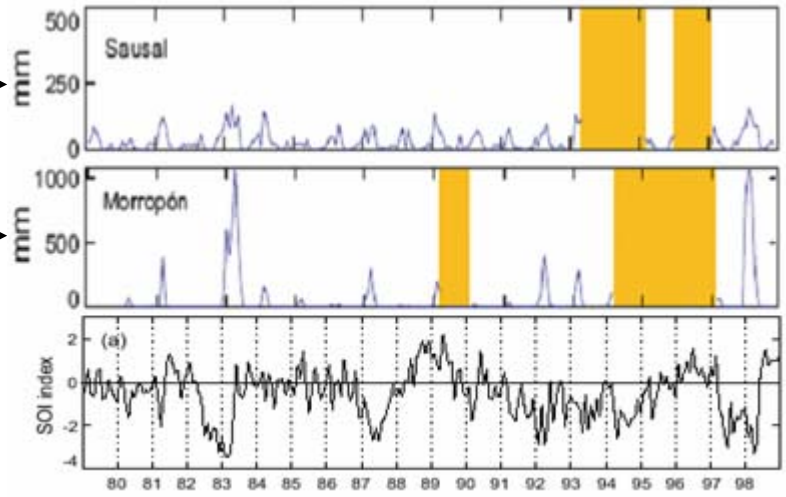
Frias M.D. (2005) Ph. D. Thesis
"Predictability of temperature over the Iberian Peninsula using general circulation models and statistical downscaling techniques" Univ. of Salamanca

Skill in the Tropics (Precipitation)

Precipitation



Downscaling needed !



Analysis and Downscaling Multi-Model Seasonal Forecasts in Peru using Self-Organizing Maps by J. M. Gutiérrez, R. Cano, A. S. Cofiño, and C. Sordo, **Tellus 57A**, 435-447 (2005).

Observations:

Seasonal precip. during DJF 1997/98 at Morropón: **1300 mm**, Sausal: **360 mm.**

Predictions (DEMETER):

year	CNRM	ECMWF	MPI	UKMO
1979/80	609.4	1938.9	398.6	761.9
1982/83	557.6	2424.7	473.9	740.2
1984/85	598.3	2952.2	207.1	747.9
1997/98	544.0	2905.1	621.7	771.7

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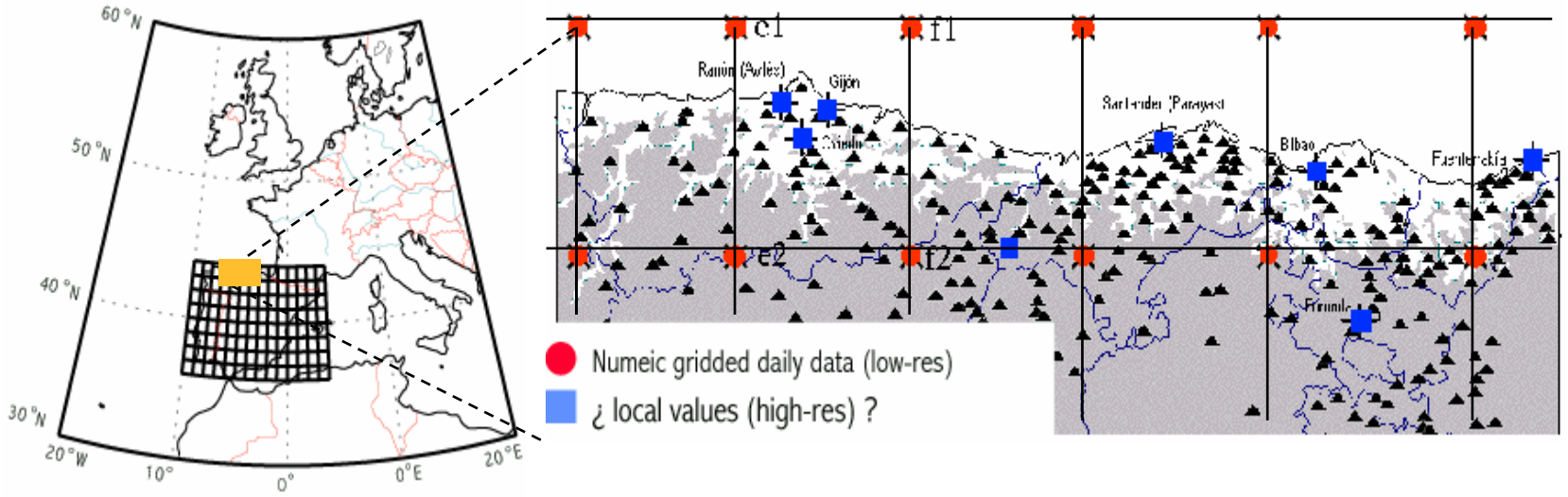
Statistical Downscaling Methods



Time series	Blanford, 1884. van Oldenborgh et al., 2003
Lineal regression	Linear. Need to reduce dimension of input space.
Canonical correlation	Linear. Mostly monthly data. (Frías 2005)
Neural networks	Nonlinear. Need to reduce dimension.
Analog & wather typing	Nonlinear (Gutiérrez et al. 2005).
Weather generators (Bayesian networks)	**Temporal downscaling**, Feddersen and Andersen 2005, Garbrecht et al. 2004

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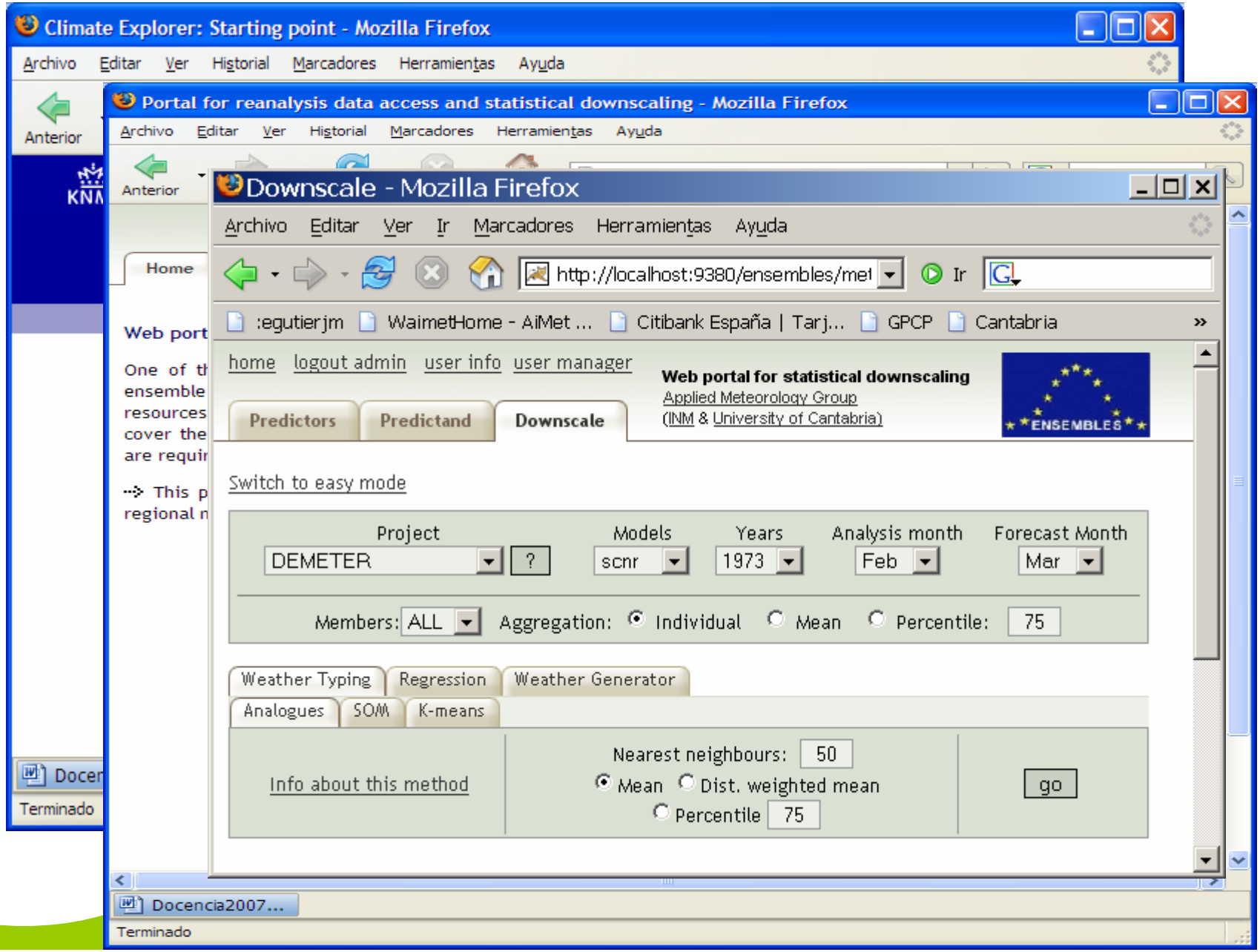
Statistical Validation and Downscaling Tools



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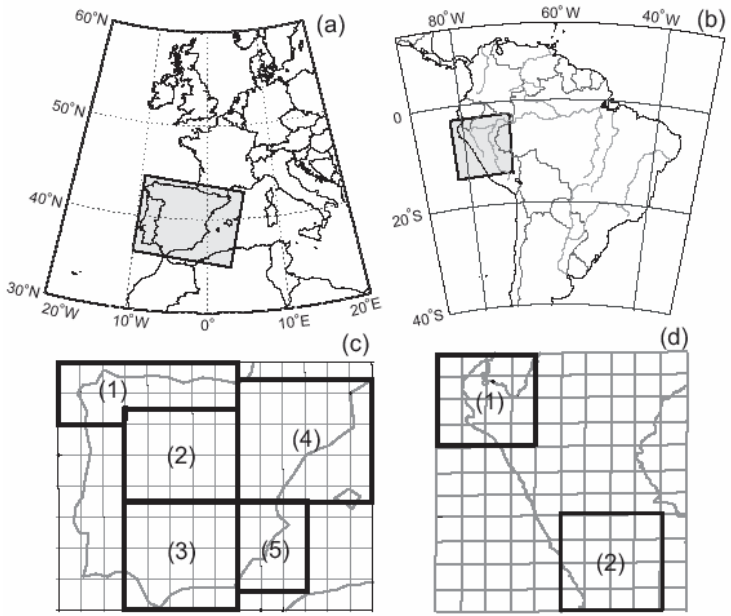
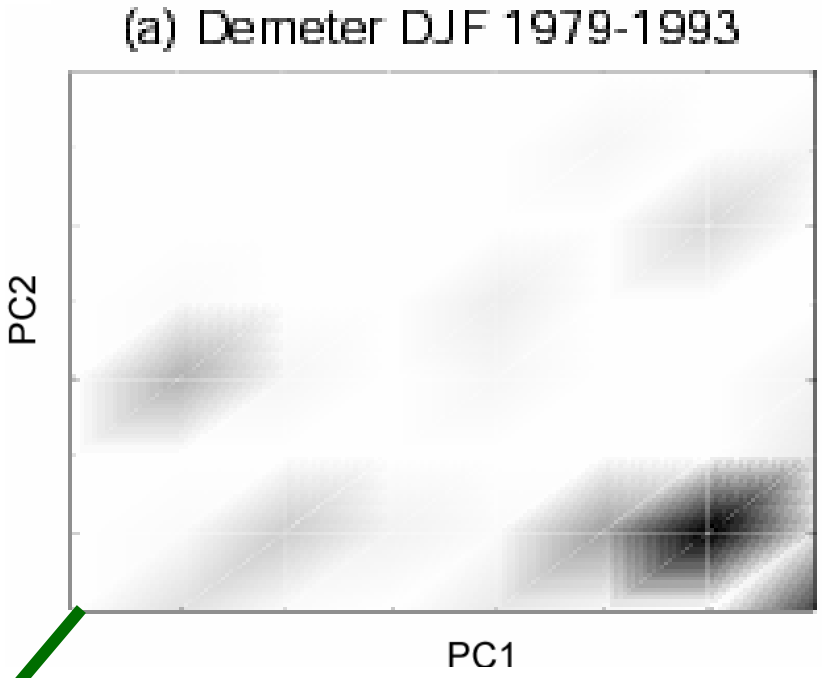
Example: Bayesian Weather Typing.



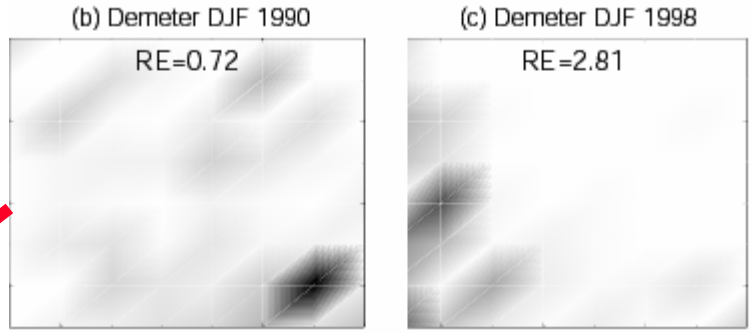


P_{clim} (precip > u) =

$\sum_{Ck}$ P(precip > u | Ck) P_{clim}(Ck)

$P_{forecast}$ (precip > u) =

$\sum_{Ck}$ P(precip > u | Ck) **$P_{forecast}$(Ck)**



A Probabilistic Bayesian Adaptation of the Analog Downscaling Method for Ensemble Forecast Systems. Submitted.

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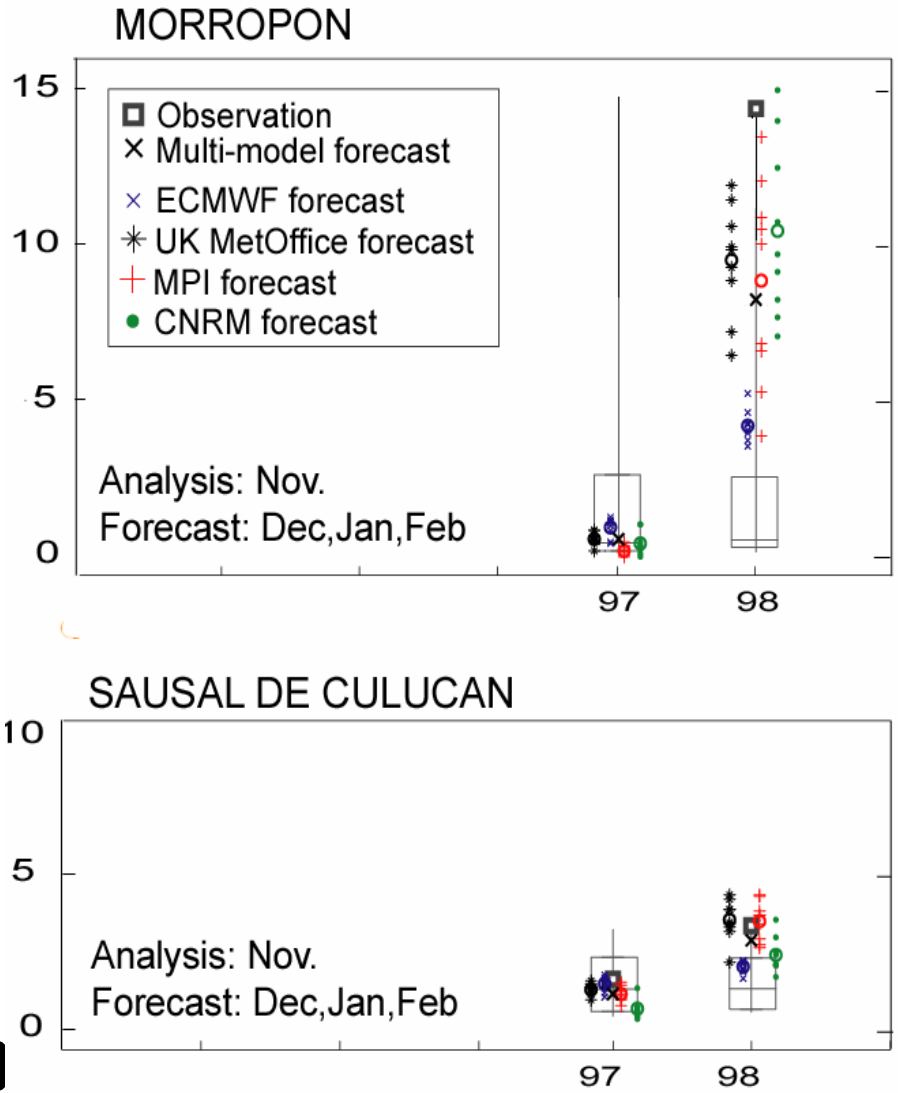
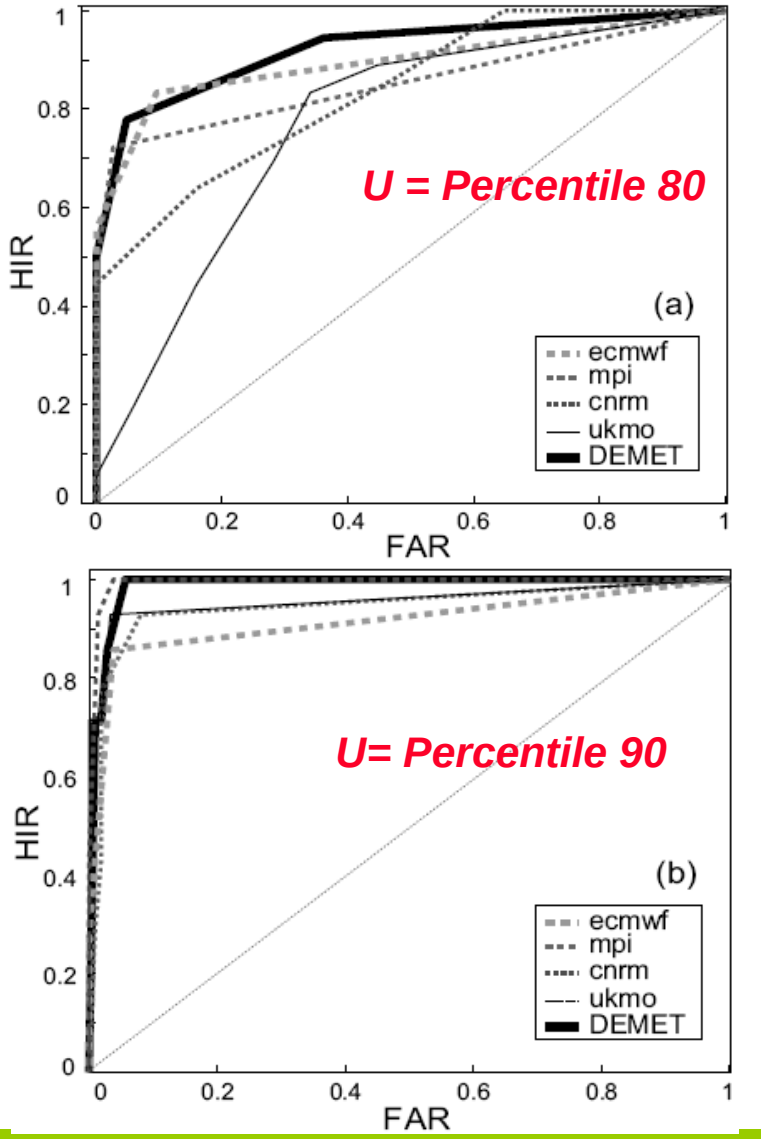
Downscaling Method (Numeric vs Probabilistic). Skill.

Numeric Forecast: Precip = *



Probabilistic: P(precip>u)=*



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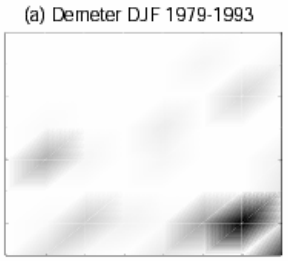
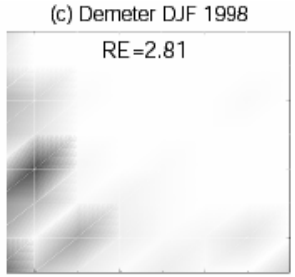
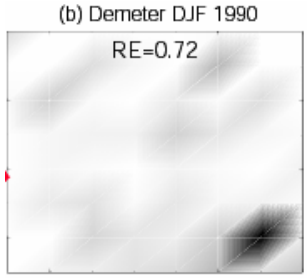
Assessing the Confidence of a Particular Prediction.

$$E(P) = -\sum_i p_i \, log p_i.$$

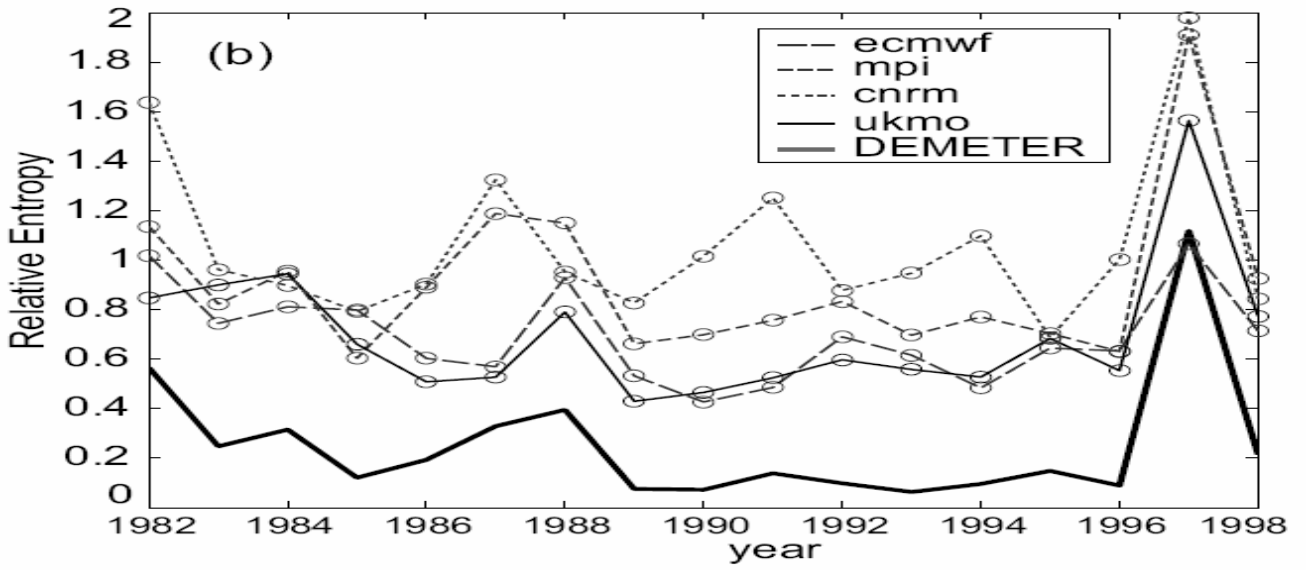
$$RE(P|Q) = \sum_{q_i \neq 0} p_i \, log \frac{p_i}{q_i}.$$







Measures the "distance" between two distributions.



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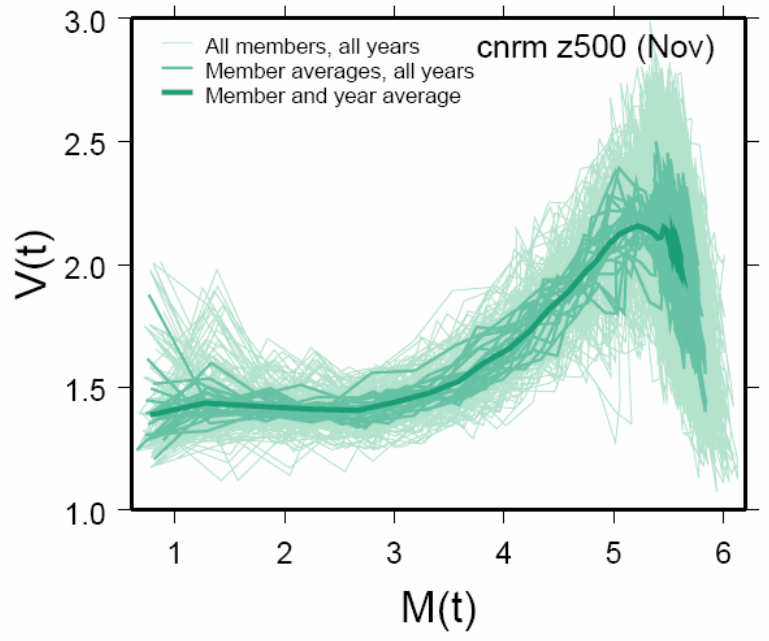
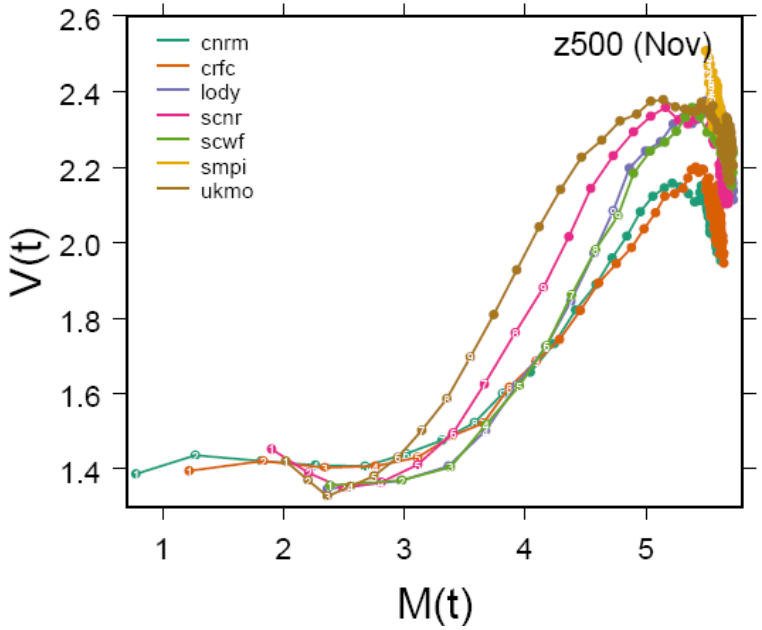
Combining the Models of the Ensemble.

In most of the cases, equal probabilities are assigned to each of the models forming the ensemble. There are some alternatives:

•**Bayesian model averaging** uses model's performance in a reference period to weight the models.





Error Growth Patterns in Systems with Spatial Chaos: From Coupled Map Lattices to Global Weather Models
C. Primo,I. G. Szendro,M. A. Rodríguez, and J. M. Gutiérrez, Physical Review Letters **98,** 108501 (2007)

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Skill in Mid-Latitudes (Z500)

Many validation measures:

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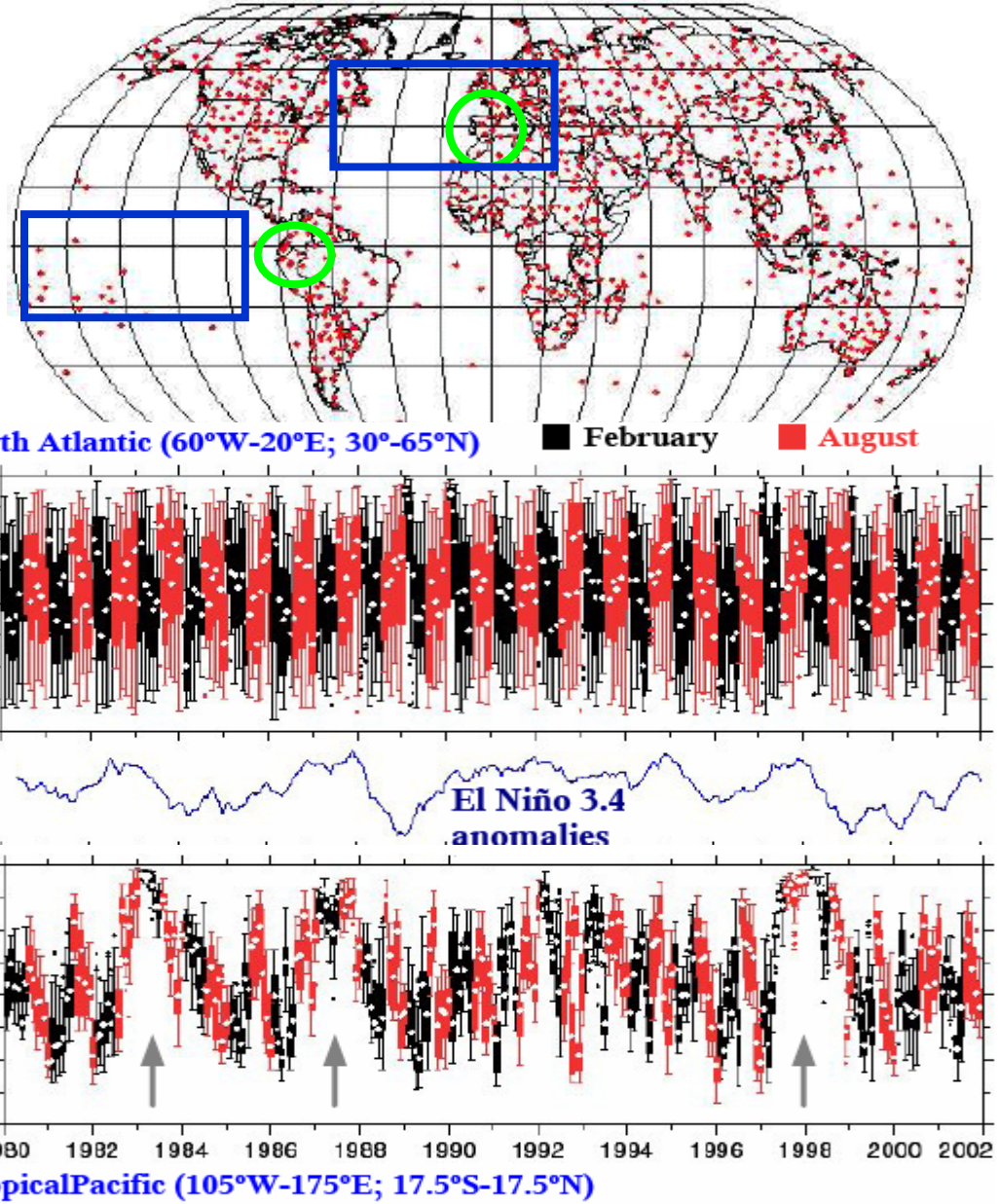

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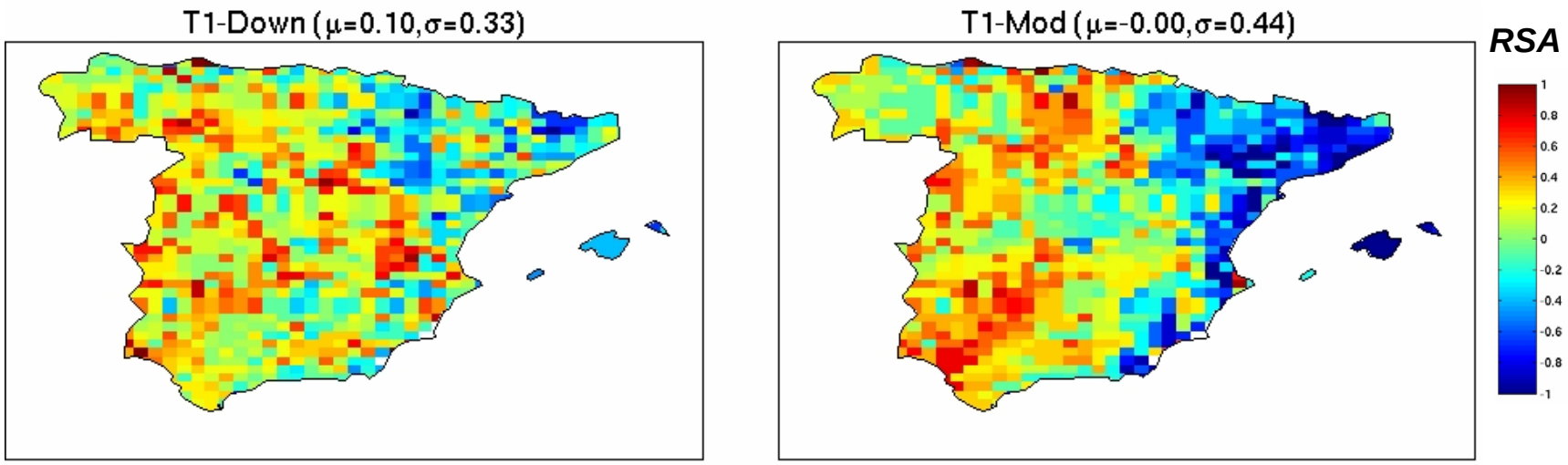
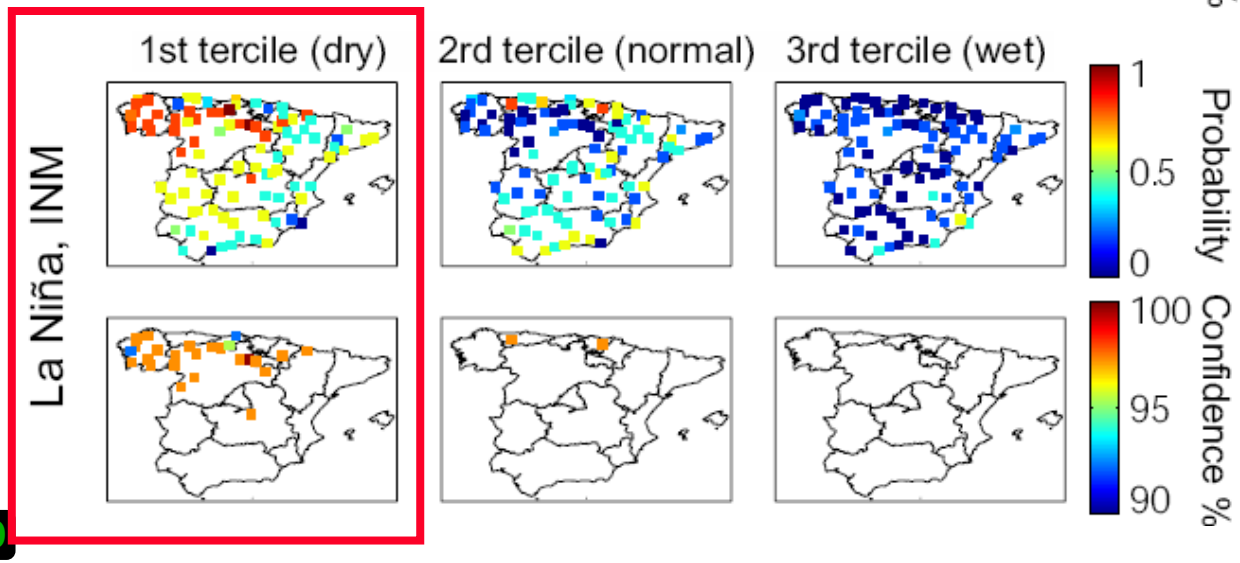
Teleconnection with ENSO Events. Precip Winter DJF



Seasonal forecast: downscaling *Seasonal forecast: model output*



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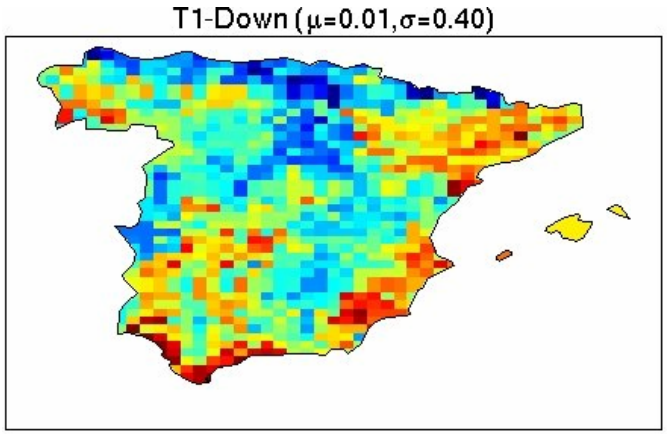
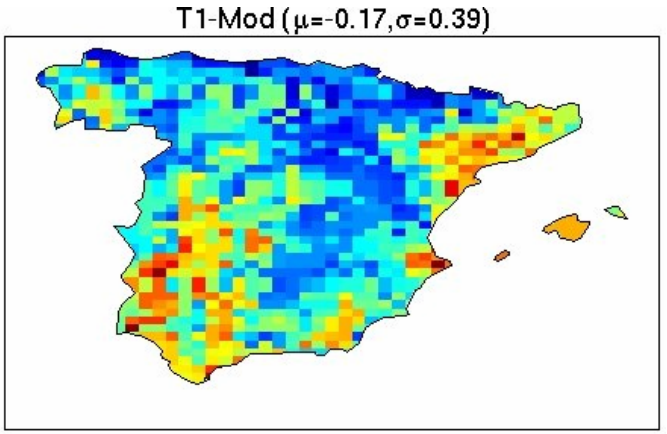
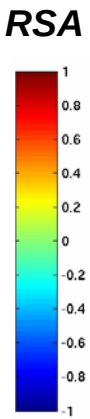
Teleconnection with ENSO Events. Precip Spring MAM

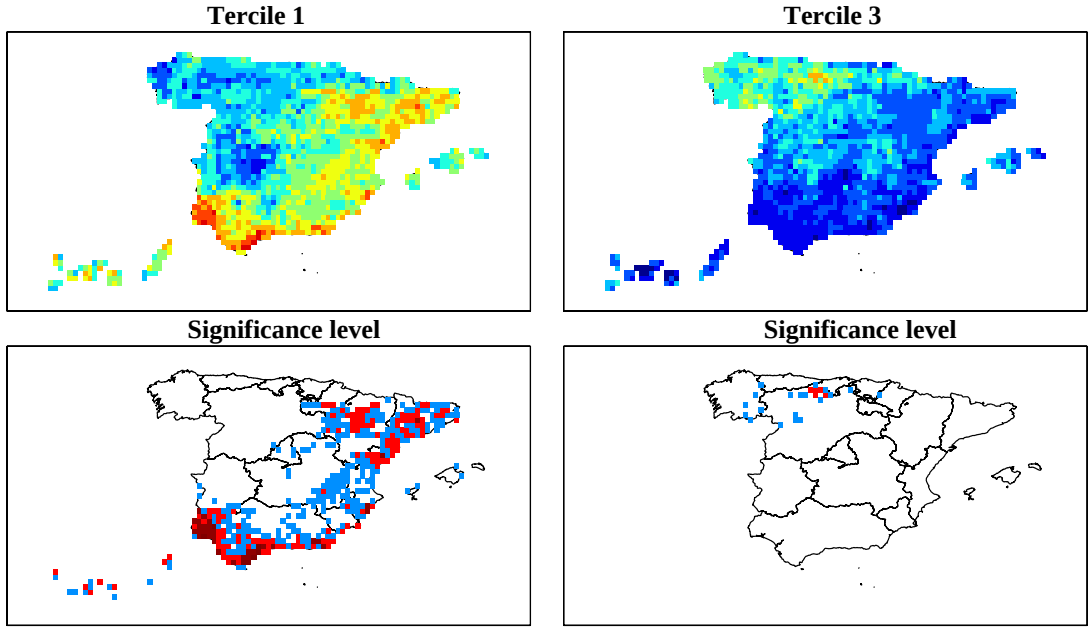


Seasonal forecast: downscaling



Seasonal forecast: model output





Poster Session III – Seasonal prediction regional skill applications

Seasonal predictability over the Iberian peninsula associated with ENSO Events
M.D. Frías et. al.

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Teleconnection with ENSO Events. EUROPE