

Validation of Seasonal Forecasts: Statistical Methods and Downscaling

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



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Applied Meteorology Group
<http://www.meteo.unican.es>

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Universidad de Cantabria
Santander





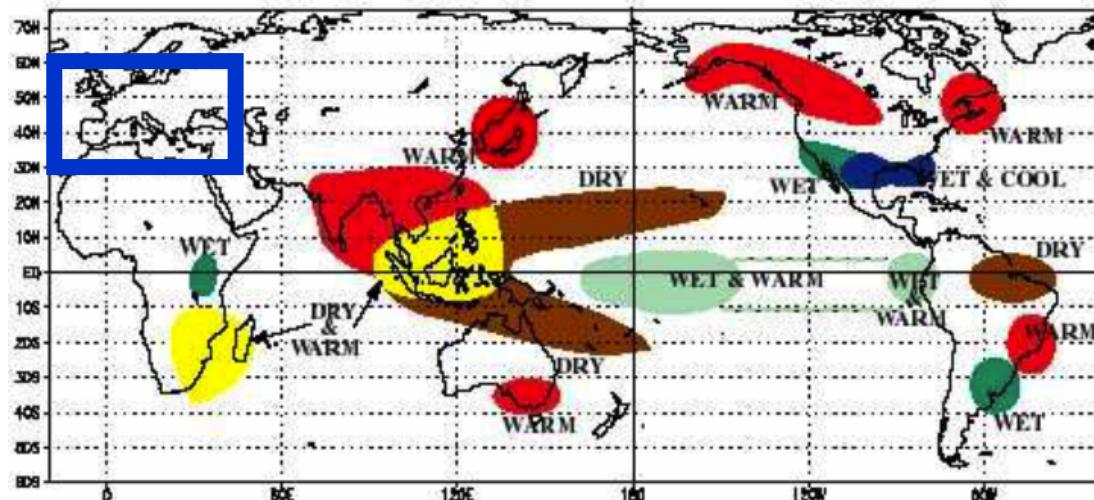
Outline of the Talk

- 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.**

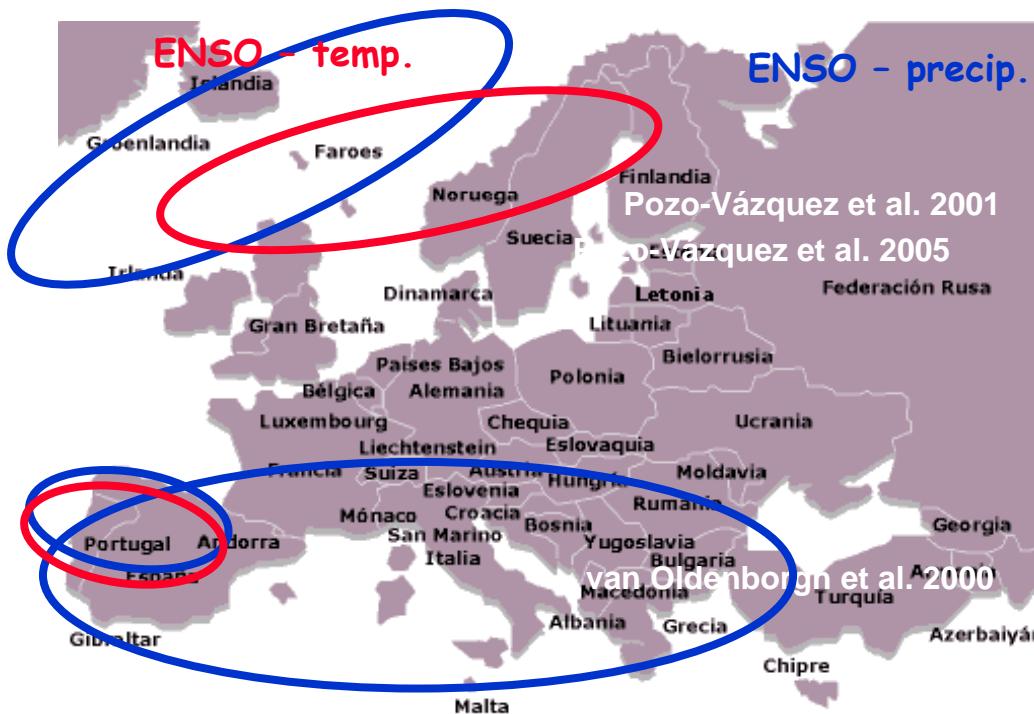


Sources of seasonal predictability. ENSO

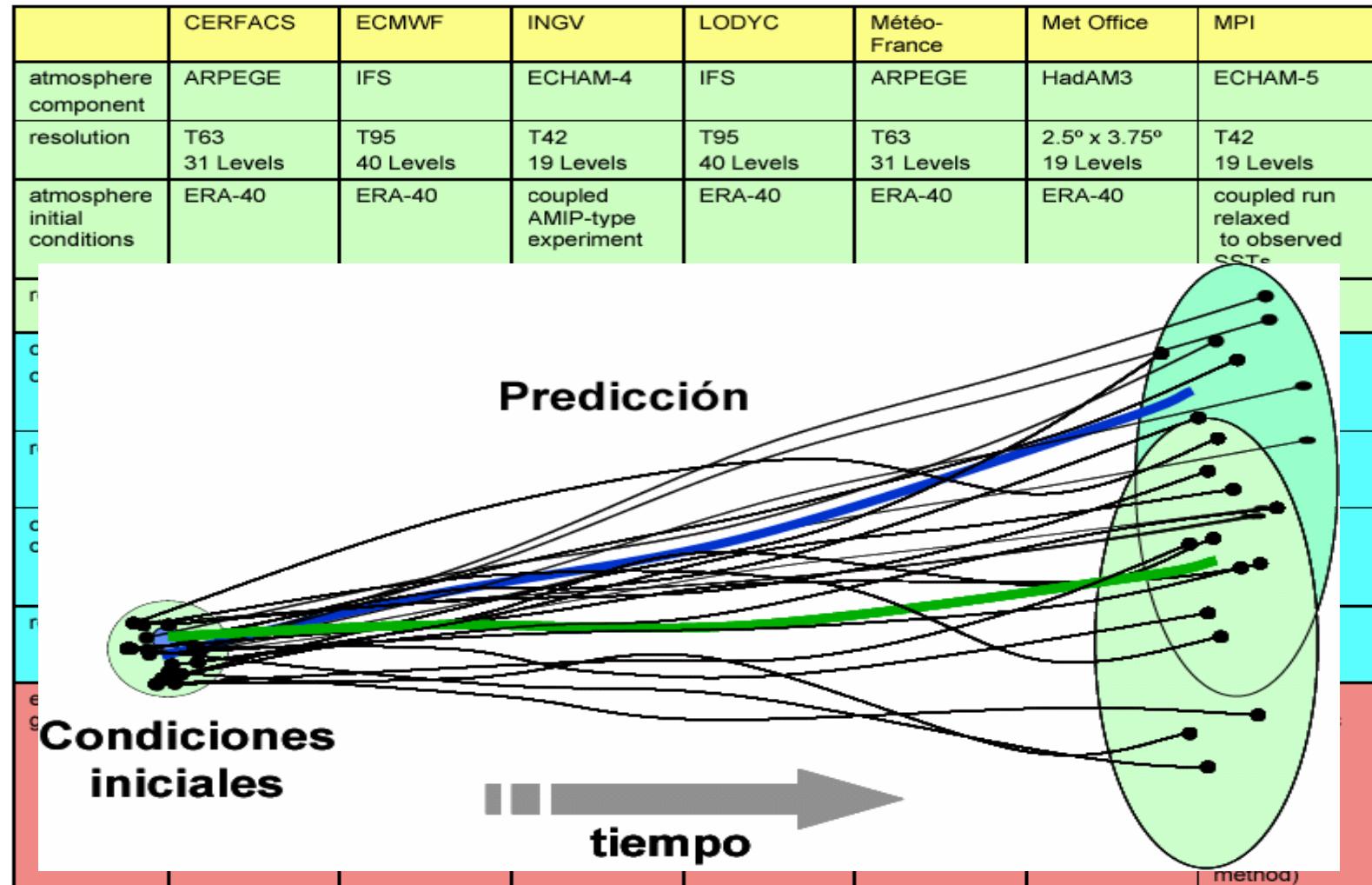
The main source of seasonal predictability is ENSO and the different El Niño / La Niña teleconnections



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



Seasonal Predictions: DEMETER Multi-Model Ensemble



DEMETER → ENSEMBLES (Paco Doblas-Reyes' Talk)

Observations in the Tropics and Mid-Latitudes

ERA40.

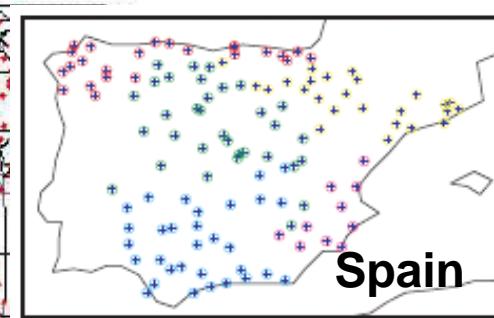
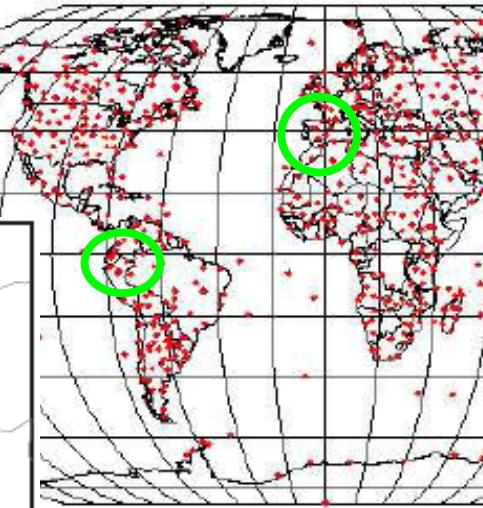
*Observations
in model space.*

Networks:



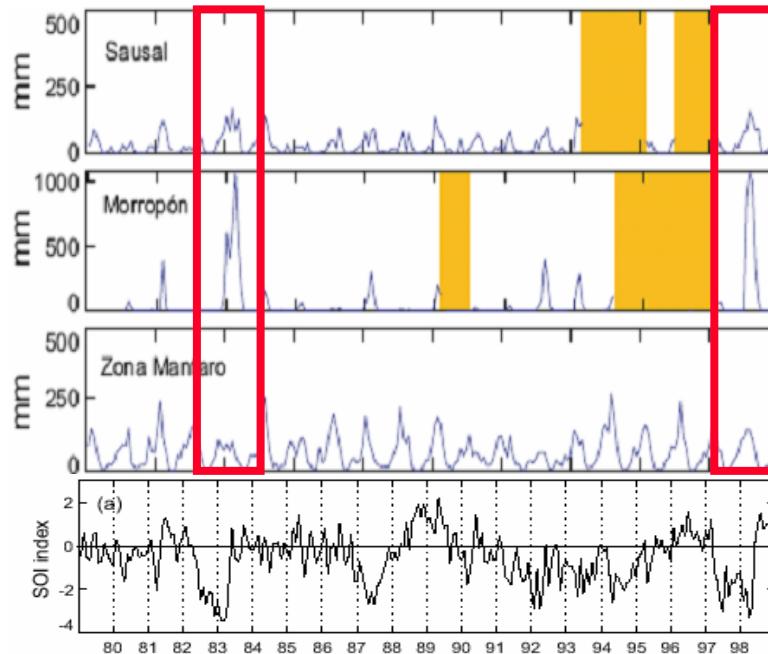
Perú

#



Spain

Precipitation
Temperature máx.
and min.



mm

Sausal

mm

Morropón

mm

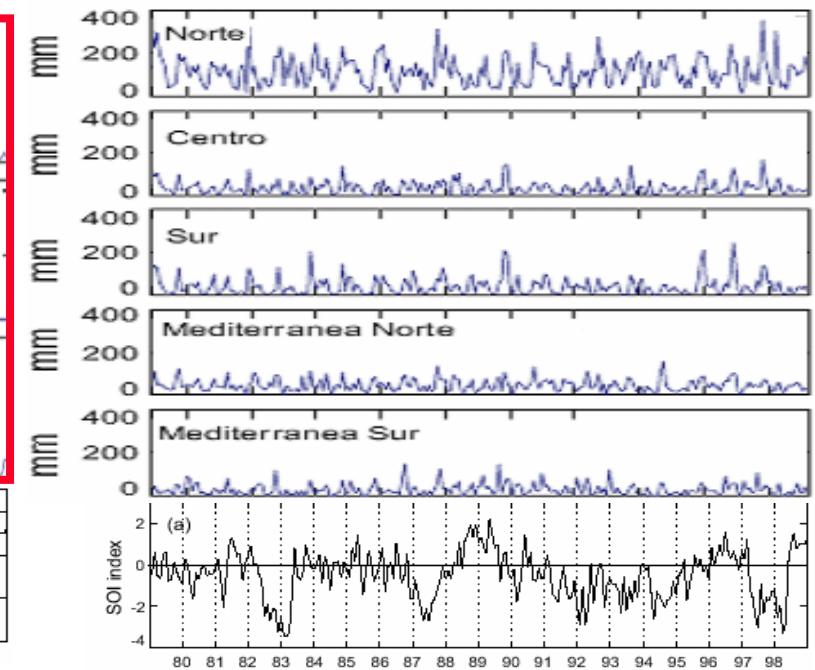
Zona Manaro

mm

(a)

SOI index

80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98



mm

Norte

mm

Centro

mm

Sur

mm

Mediterranea Norte

mm

Mediterranea Sur

mm

(a)

SOI index

80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98



Skill in the Tropics and Mid-Latitudes (Z500)

Many validation measures:

Deterministic:

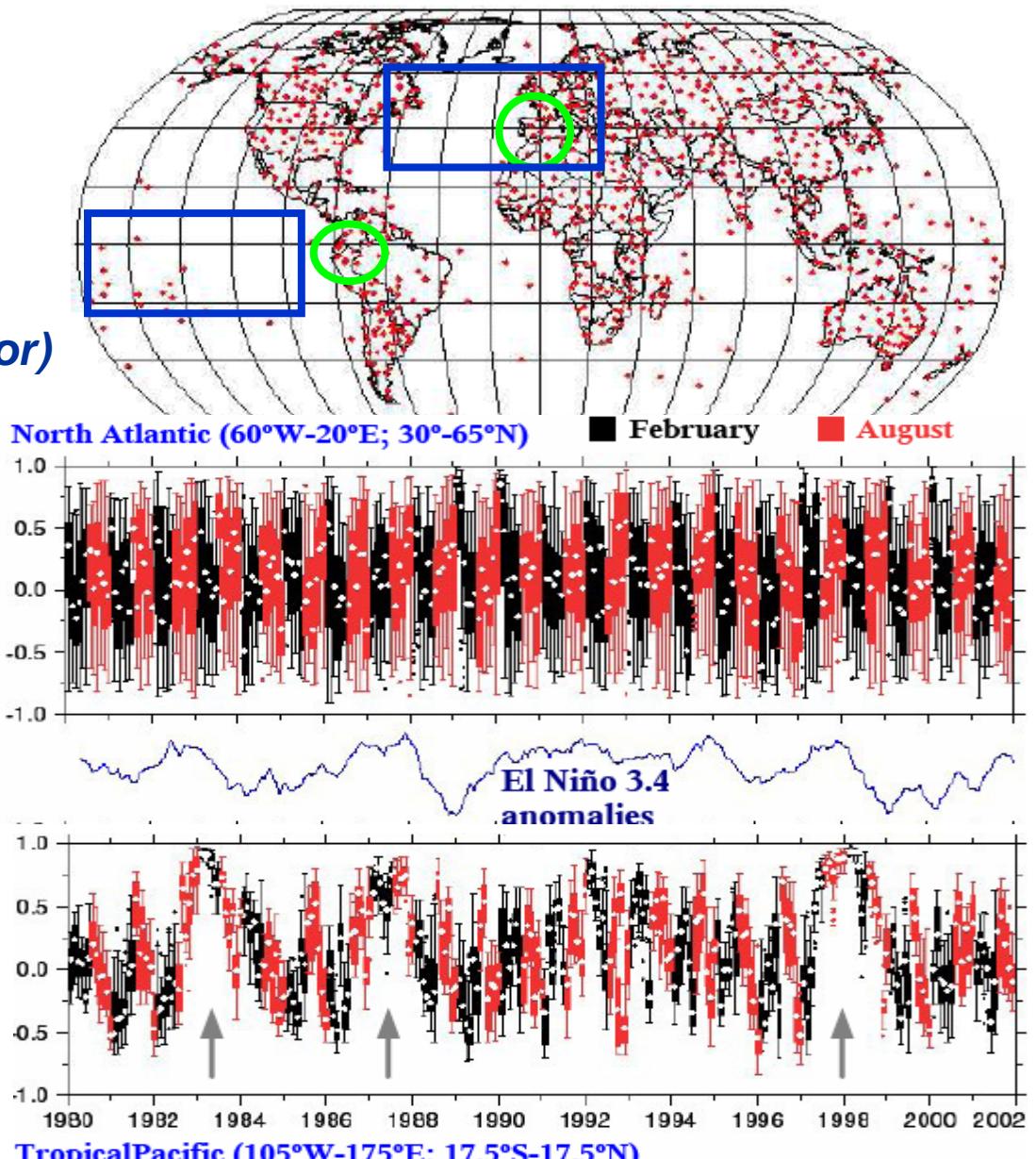
- ACC (Anom. Correlation coef.)
- RMSE (Root Mean Squared Error)

Probabilistic:

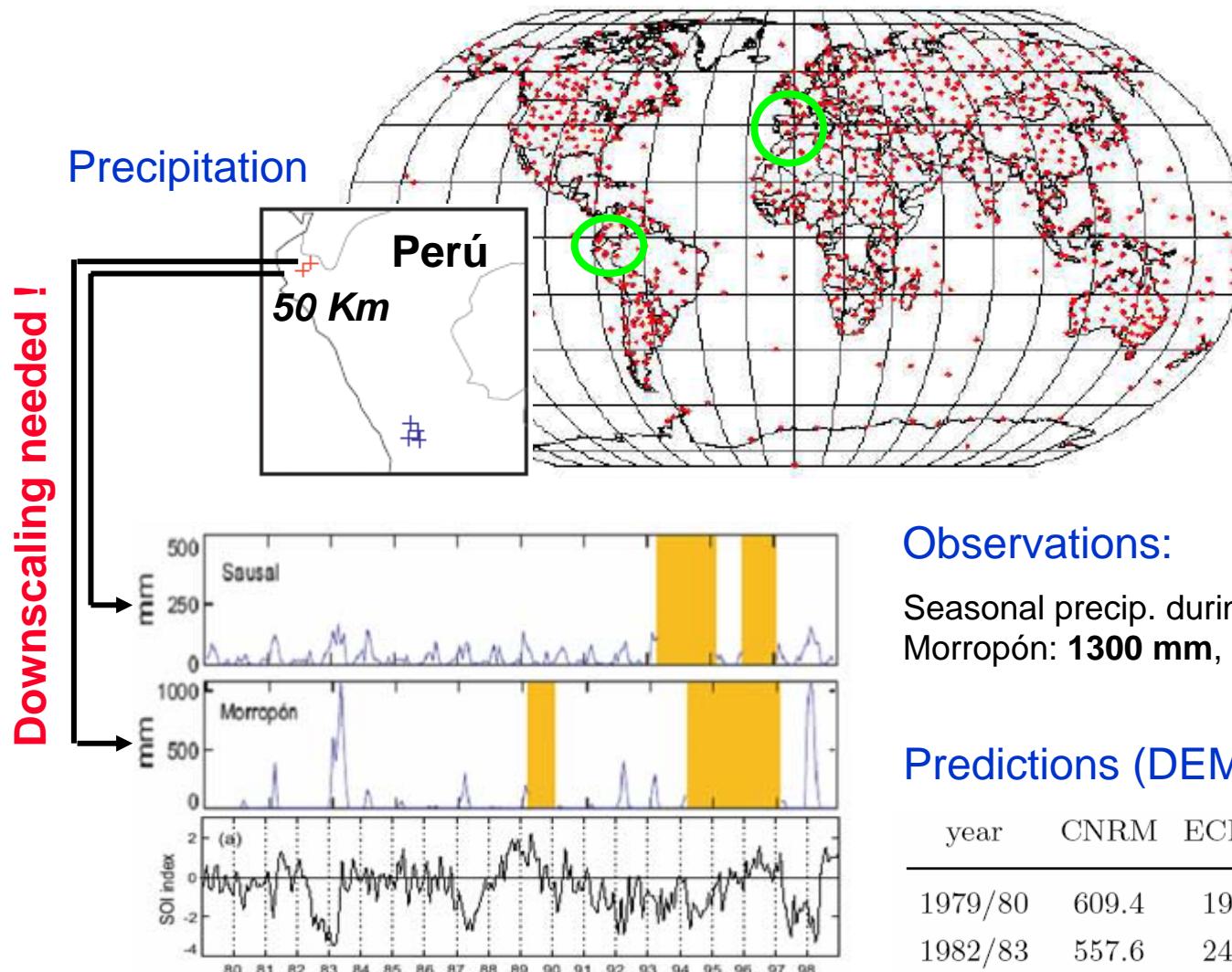
- Brier Score / Brier Skill Score
- ROC Area / ROC skill Area
- Economic Value
- Entropy / Information Theory

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Frias M.D. (2005) Ph. D. Thesis
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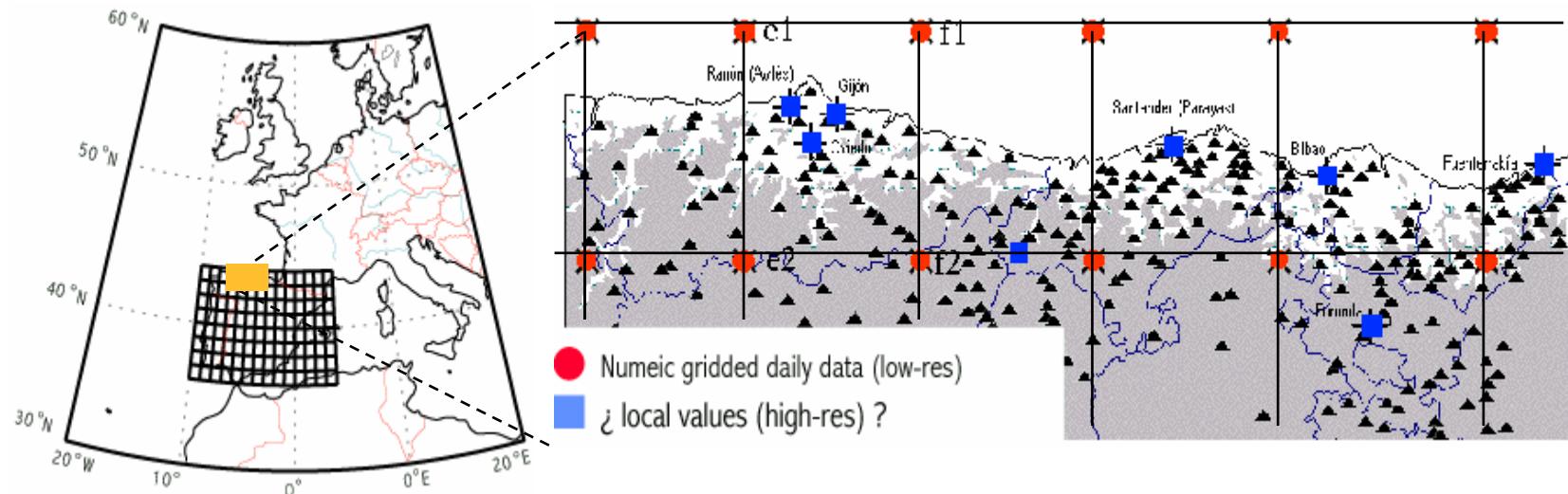


Skill in the Tropics (Precipitation)



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).

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 & weather typing | Nonlinear (Gutiérrez et al. 2005). |
| Weather generators (Bayesian networks) | Temporal downscaling , Feddersen and Andersen 2005, Garbrecht et al. 2004 |

Statistical Validation and Downscaling Tools

Climate Explorer: Starting point - Mozilla Firefox

Archivo Editar Ver Historial Marcadores Herramientas Ayuda

Portal for reanalysis data access and statistical downscaling - Mozilla Firefox

Archivo Editar Ver Ir Marcadores Herramientas Ayuda

Anterior

Downscale - Mozilla Firefox

Archivo Editar Ver Ir Marcadores Herramientas Ayuda

Anterior

Home

Web port

One of the ensemble resources cover the are requir

→ This p regional n

legutierjm WaimetHome - AiMet ... Citibank España | Tarj... GPCP Cantabria

home logout admin user info user manager

Web portal for statistical downscaling
Applied Meteorology Group
(INM & University of Cantabria)

ENSEMBLES

Predictors Predictand Downscale

Switch to easy mode

Project: DEMETER Models: scnr Years: 1973 Analysis month: Feb Forecast Month: Mar

Members: ALL Aggregation: Individual Mean Percentile: 75

Weather Typing Regression Weather Generator

Analogues 50M K-means

Info about this method Nearest neighbours: 50

Mean Dist. weighted mean Percentile 75

go

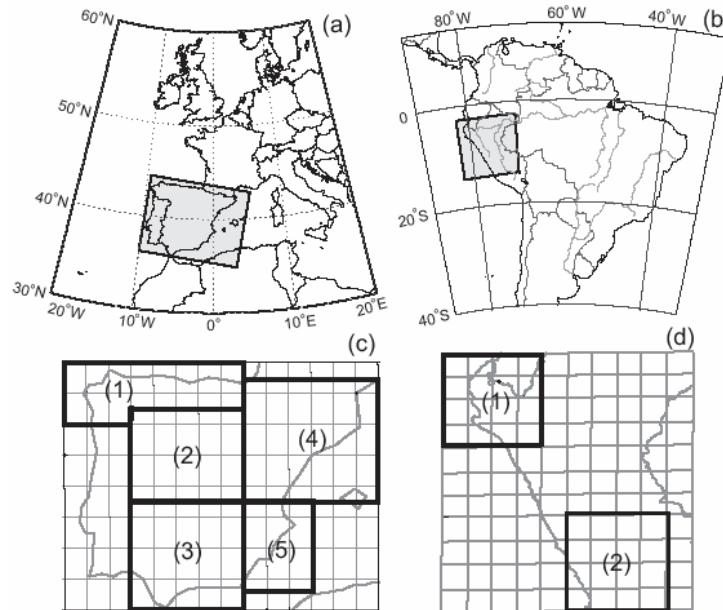
Docencia2007... Terminado

Docencia2007... Terminado

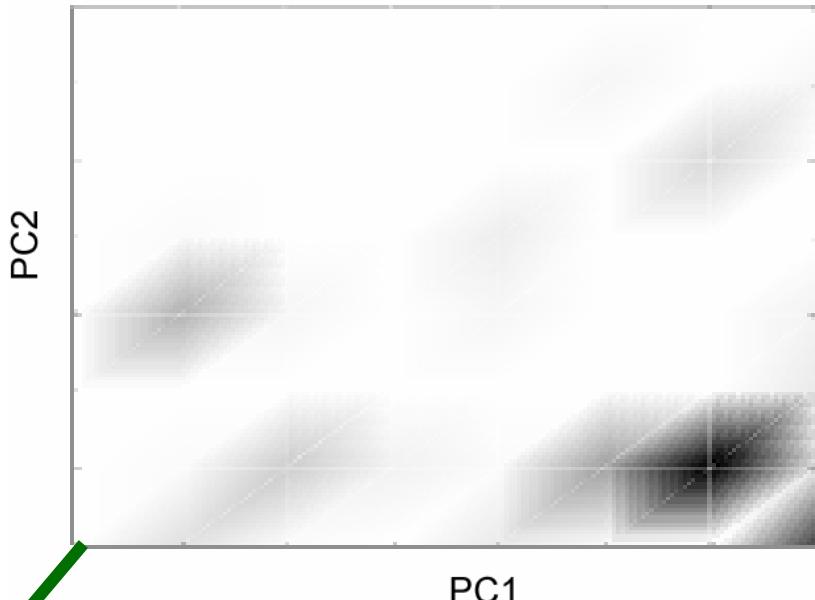
The screenshot shows a Mozilla Firefox window with three tabs open. The active tab is 'Downscale - Mozilla Firefox' which displays a web-based interface for statistical downscaling. The interface includes dropdown menus for 'Project' (DEMETER), 'Models' (scnr), 'Years' (1973), 'Analysis month' (Feb), and 'Forecast Month' (Mar). It also includes a 'Members' dropdown set to 'ALL' and aggregation options: 'Individual' (selected), 'Mean', and 'Percentile' (set to 75). Below these are tabs for 'Weather Typing' (selected), 'Regression', and 'Weather Generator', with sub-options like 'Analogues', '50M', and 'K-means'. A sidebar on the left contains links for 'Home', 'Web port', and 'One of the ensemble resources cover the are requir'. A large green arrow points from the left towards the title bar.



Example: Bayesian Weather Typing.

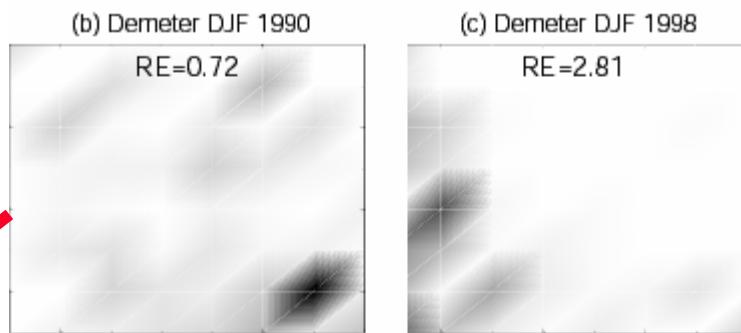


(a) Demeter DJF 1979-1993



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

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

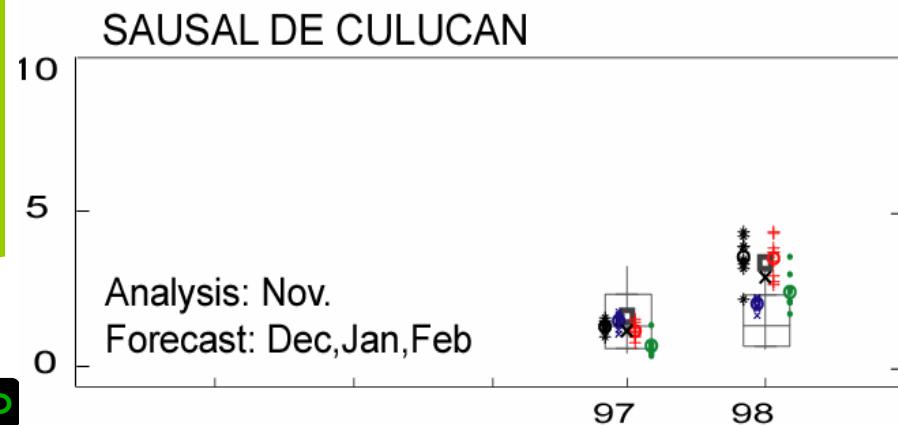
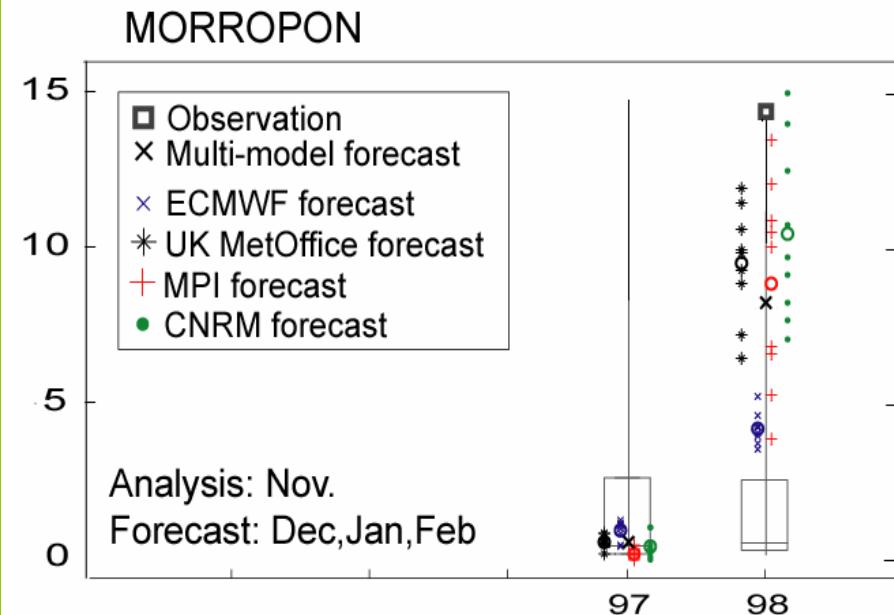


A Probabilistic Bayesian Adaptation of
the Analog Downscaling Method for
Ensemble Forecast Systems.
Submitted.

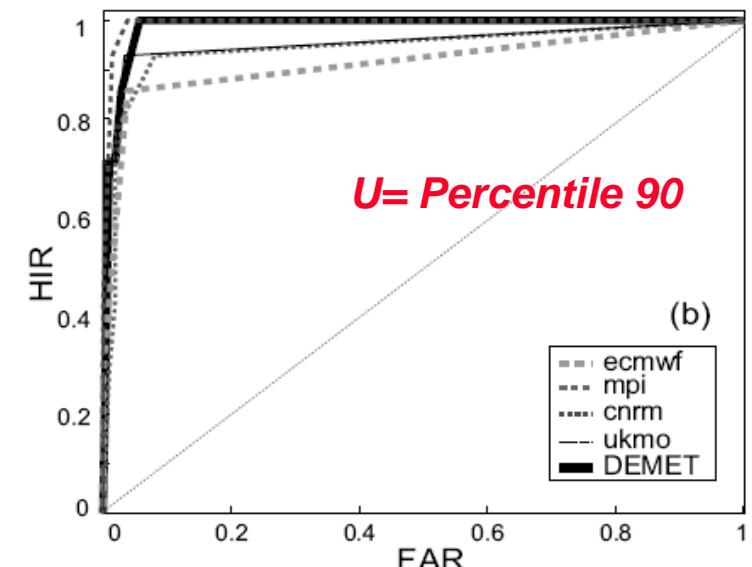
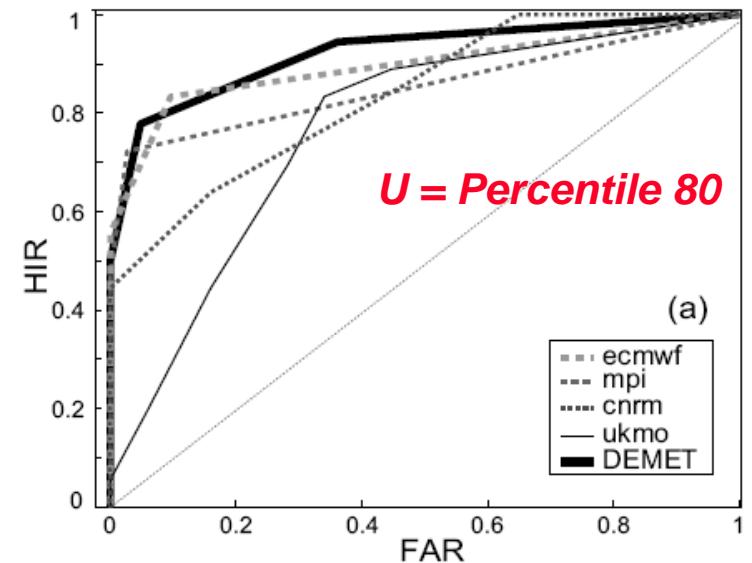


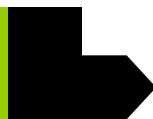
Downscaling Method (Numeric vs Probabilistic). Skill.

Numeric Forecast: Precip = *



Probabilistic: $P(\text{precip} > u) = ^*$



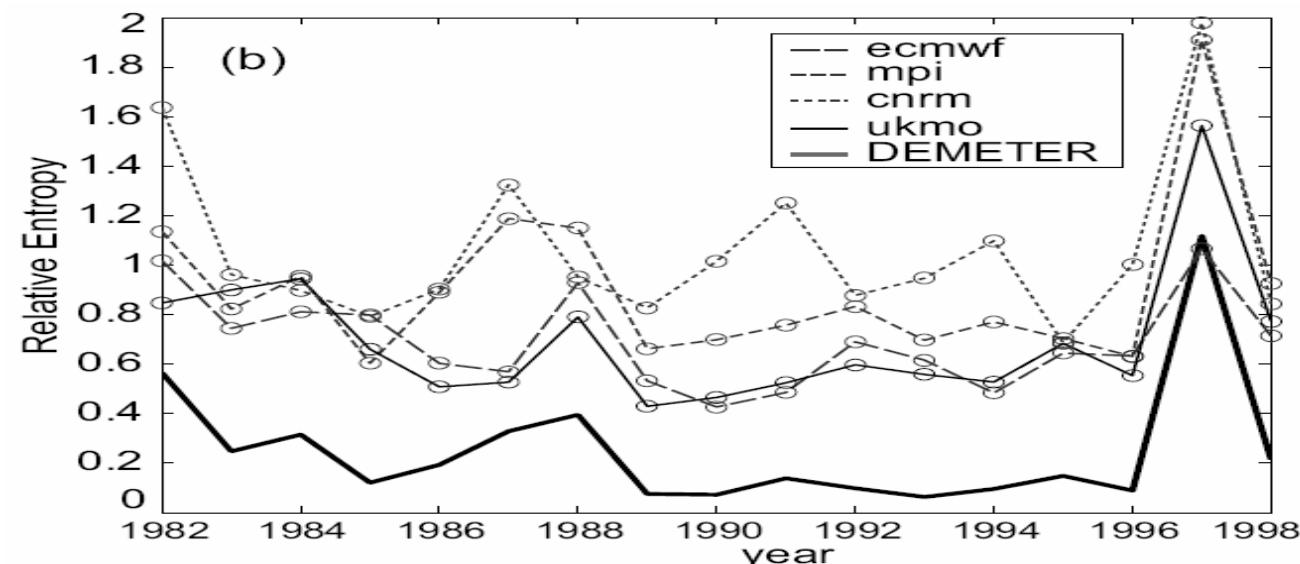
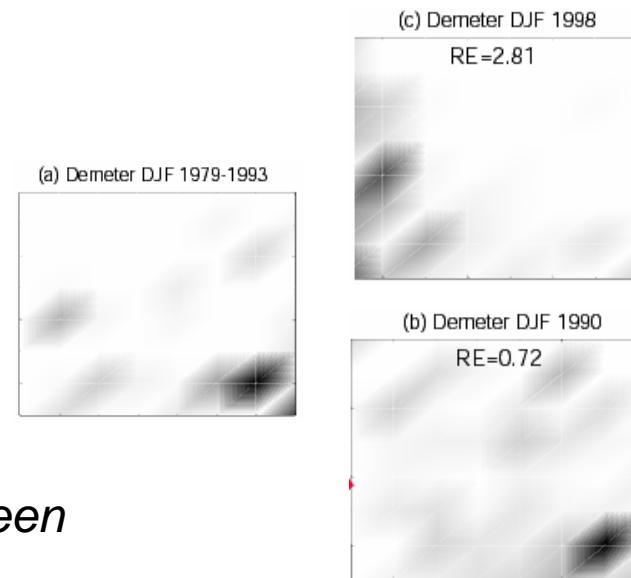


Assessing the Confidence of a Particular Prediction.

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

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

Measures the “distance” between two distributions.

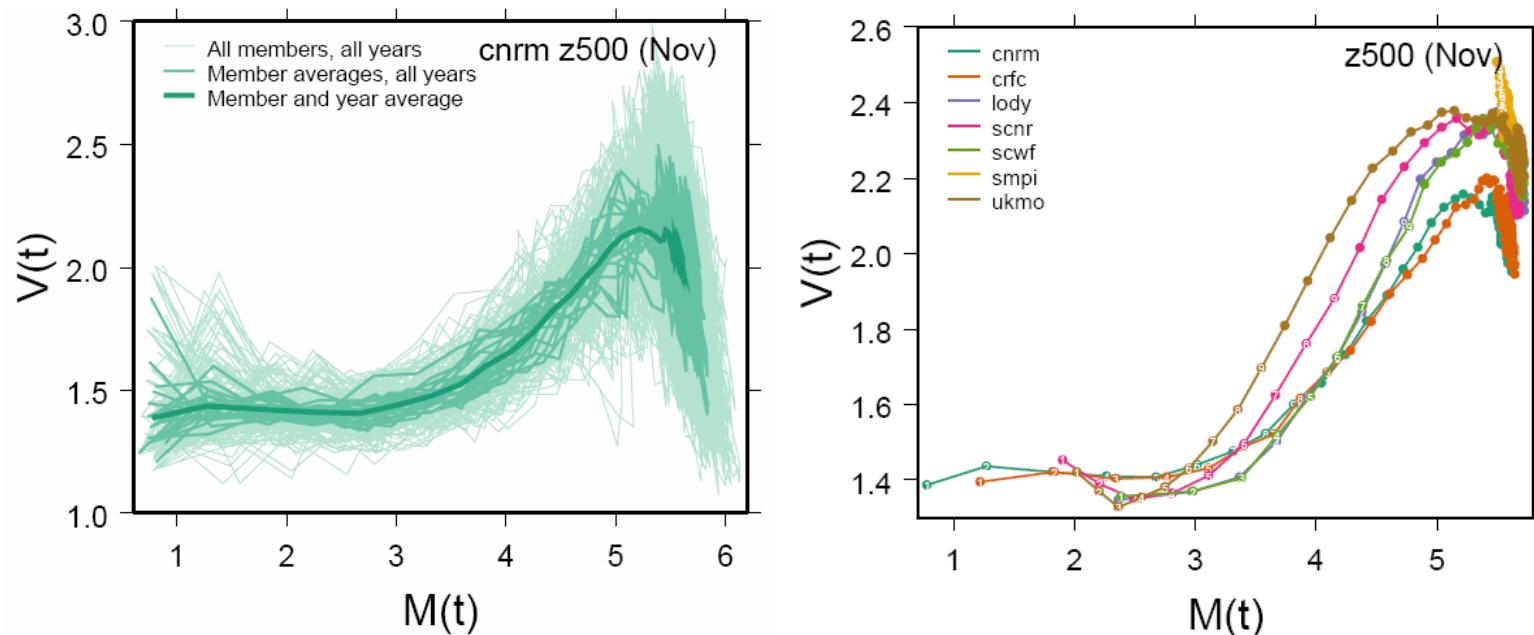




Combining the Models of the Ensemble.

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)



Skill in Mid-Latitudes (Z500)

Many validation measures:

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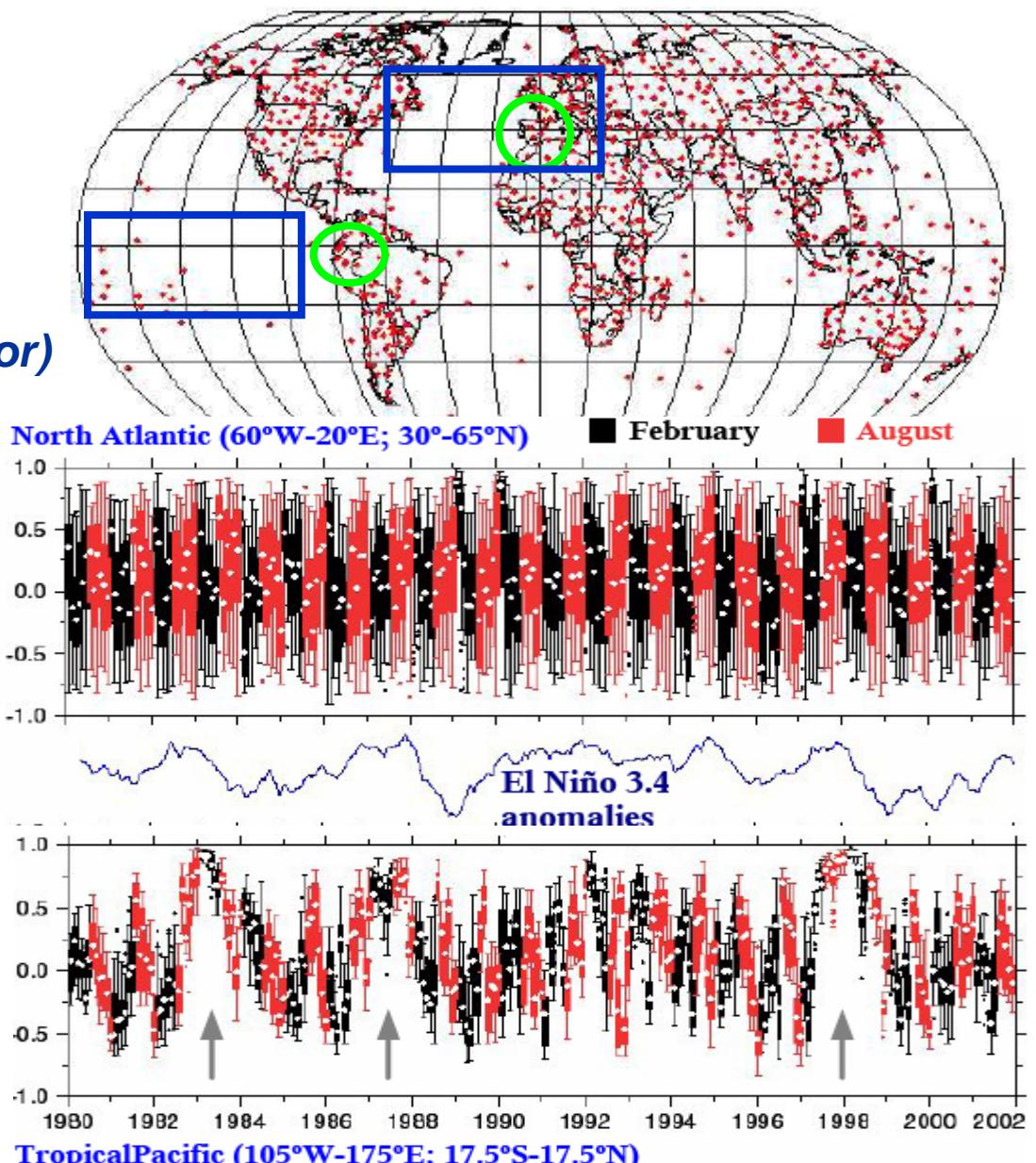
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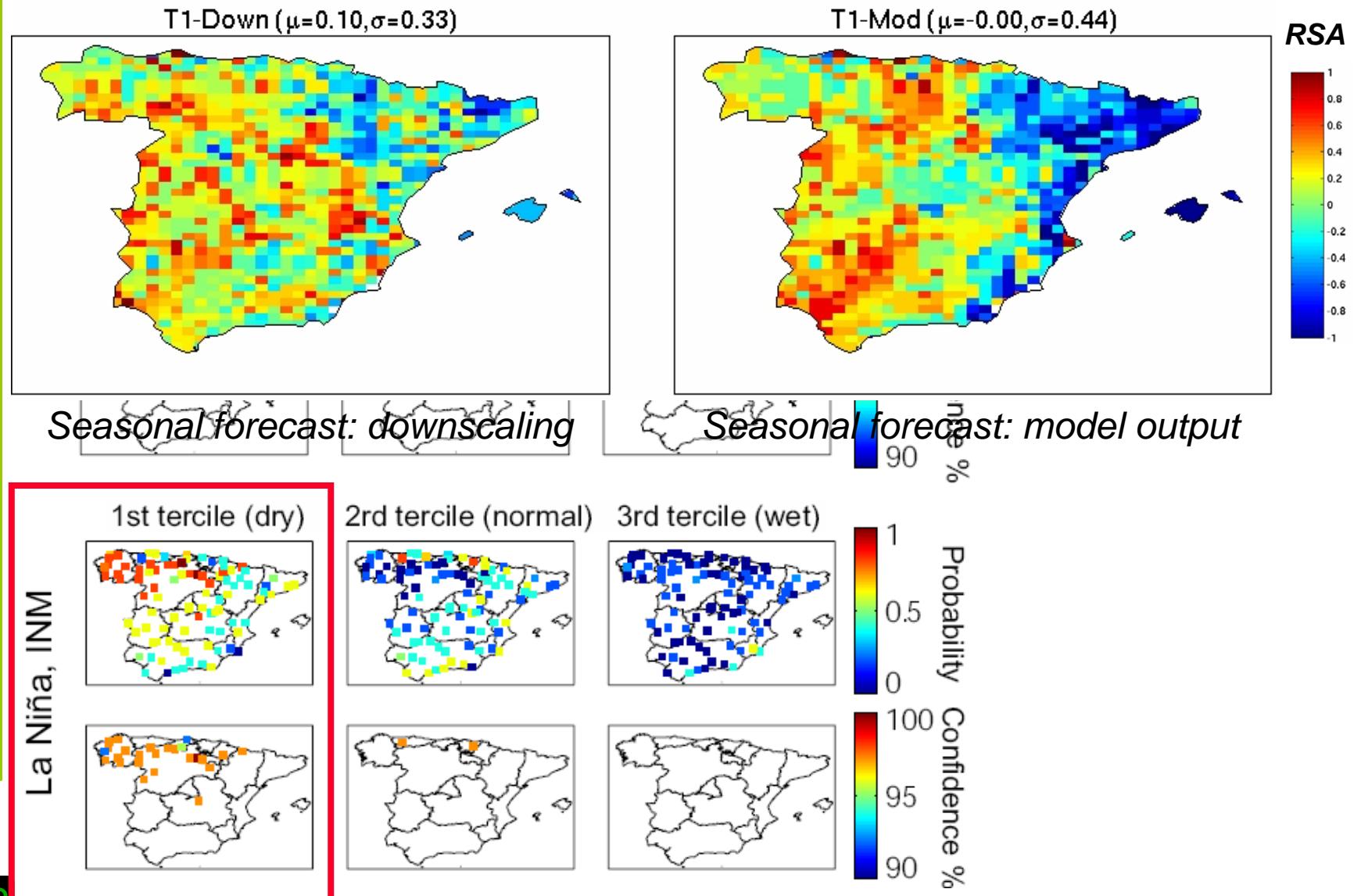
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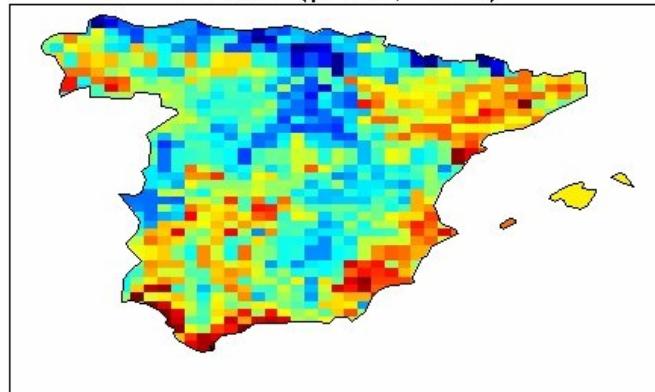
Teleconnection with ENSO Events. Precip Winter DJF



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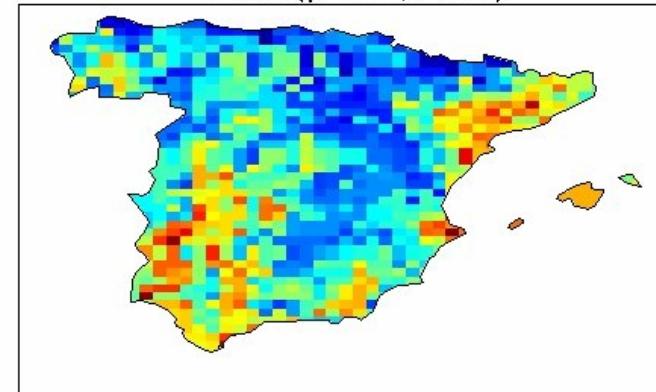
Teleconnection with ENSO Events. Precip Spring MAM

T1-Down ($\mu=0.01, \sigma=0.40$)

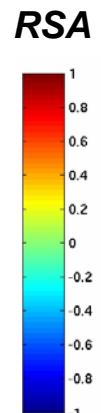


Seasonal forecast: downscaling

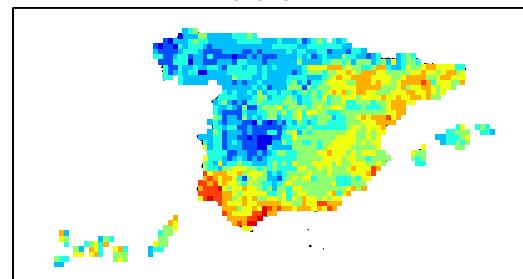
T1-Mod ($\mu=-0.17, \sigma=0.39$)



Seasonal forecast: model output

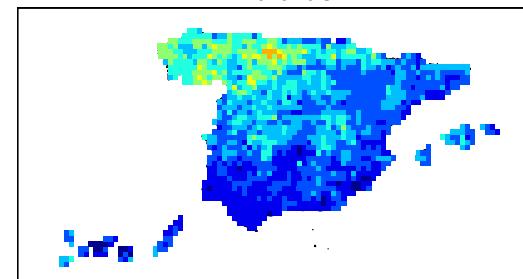


Tercile 1

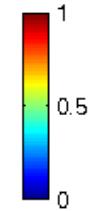


Significance level

Tercile 3

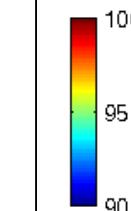
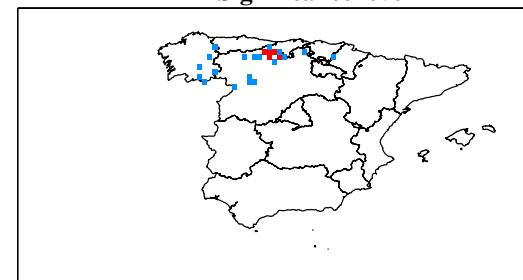
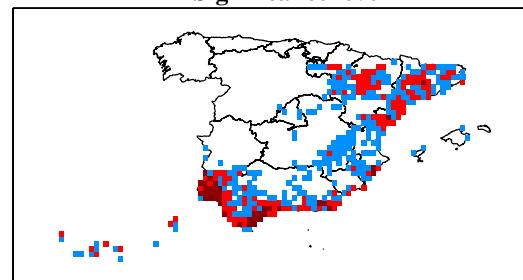


Significance level



Poster Session III –
Seasonal prediction
regional skill applications

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



Teleconnection with ENSO Events. **EUROPE**

