

Statistical Downscaling at University of Cantabria - INM - ARPA with Self-Organizing Maps and Bayesian Networks

UC



José M. Gutiérrez

Antonio S. Cofiño

Miguel A. Rodríguez

Dpto. de Matemática Aplicada y C.C.

Instituto de Física de Cantabria,

CSIC / Universidad de Cantabria

INM

Rafael Cano

Instituto Nacional de Meteorología

<http://grupos.unican.es/ai/meteo>

Structure of the Talk

Analog
technique

Bayesian
nets

Seasonal
forecast

Future
work

Short-Term
(perfect-prog)

Seasonal

- **Brief Reminder of the SOM Clustering Analog Downscaling Technique.**
- **Improvements by Considering Spatial Dependence and Persistence (Dynamic Bayesian networks).**
- **Some preliminary results about the application of the above techniques to Seasonal Forecast.**
- **Future work.**

REMINDER: The SOM Clustering Model

We used atmospheric circulation patterns at 1200UTC of **ERA-15 (1979-1993)** reanalysis

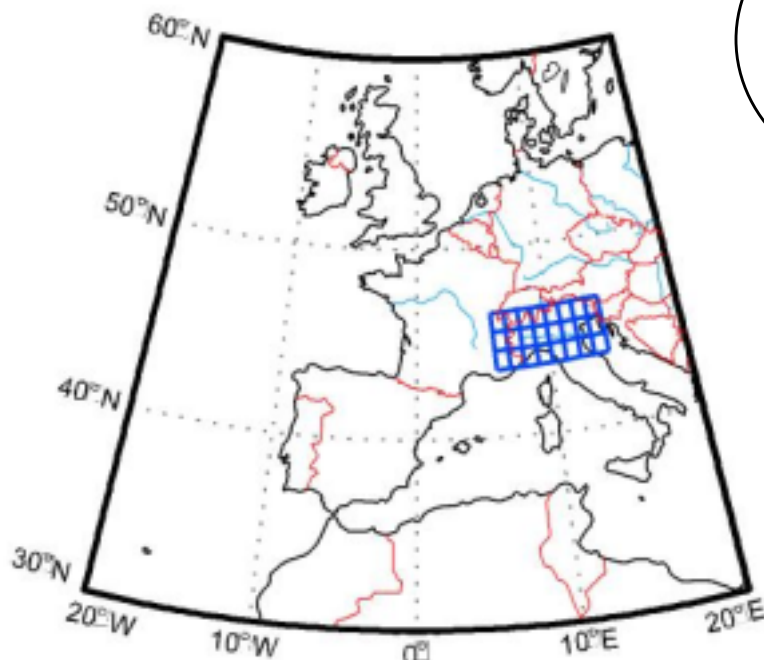
- Iberian Peninsula (daily weather downscaling)
- Po basin (ARPA, crop yield)

Analog technique

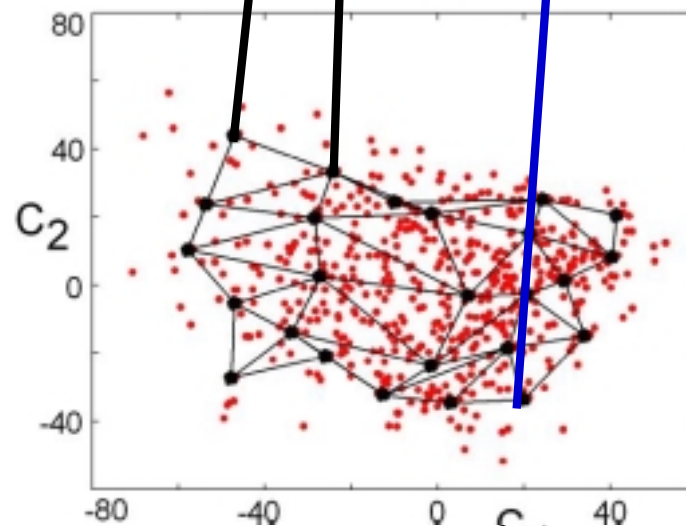
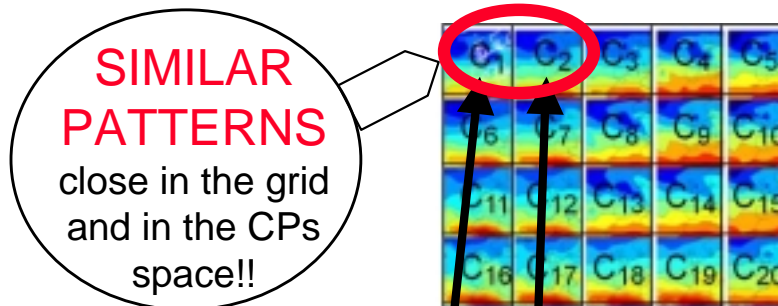
Bayesian nets

Seasonal forecast

Future work



Atmospheric circulation pattern:
 (T(1000 mb), T(850 mb),...,Z,H...)
 Dimension reduction: Principal Comp.



5 x 5 Self-org.
map (SOM)

Projection of ERA-15
using the first 2 PCs

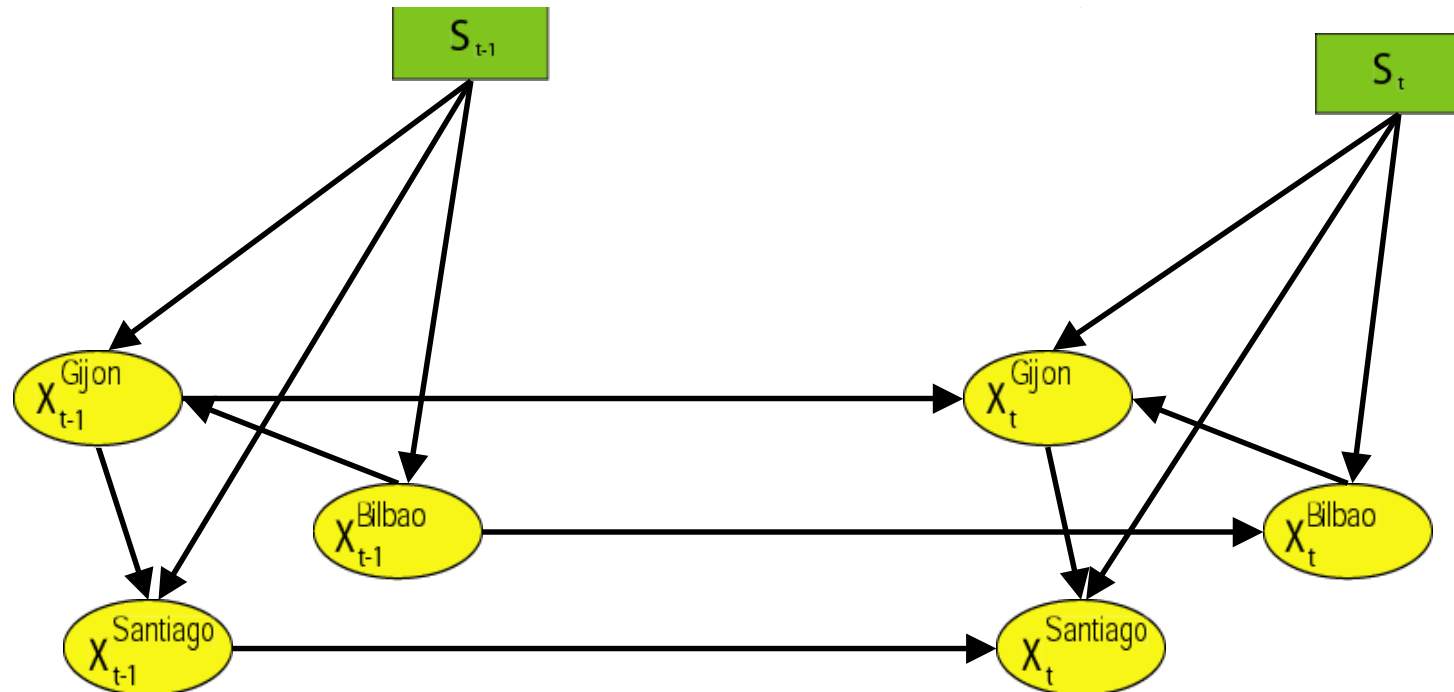
Patterns are clustered using a self-org. map which arrange together on a grid similar classes.

Extending the Analog Model. Dynamic Bayesian networks

Considering Spatial Dependences and Persistence

- Learn a dependency graph from data (ERA-15).
- Consider also this learnt graph for $t-1$
- Put dependencies for stations, from previous values.

$$P(\text{Santiago}) = P(\text{Santiago} \mid \text{Gijon}_t, \text{Bilbao}_t, \mathbf{S}_t; \mathbf{S}_{t-1}, \dots)$$



Analog
technique

Bayesian
nets

Seasonal
forecast

Future
work

Validation in the Iberian peninsula (Bayesian net vs Analog)

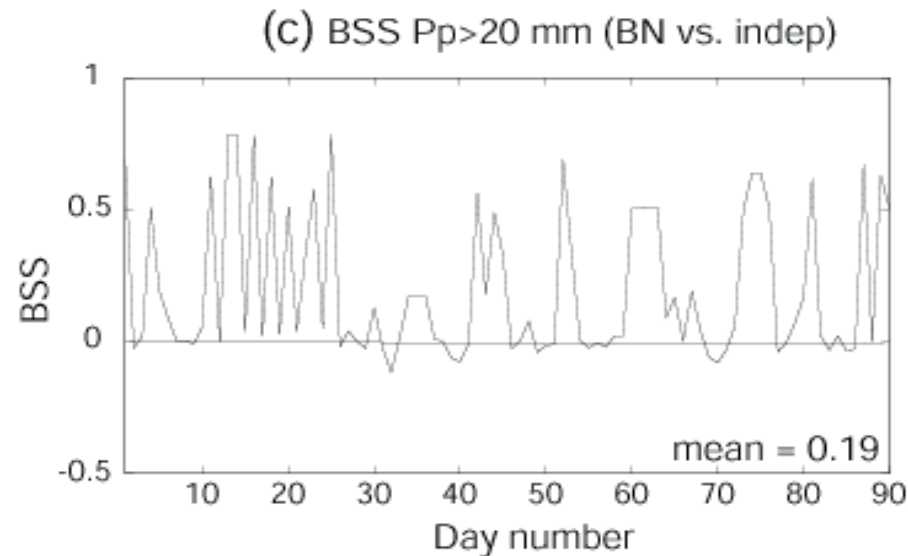
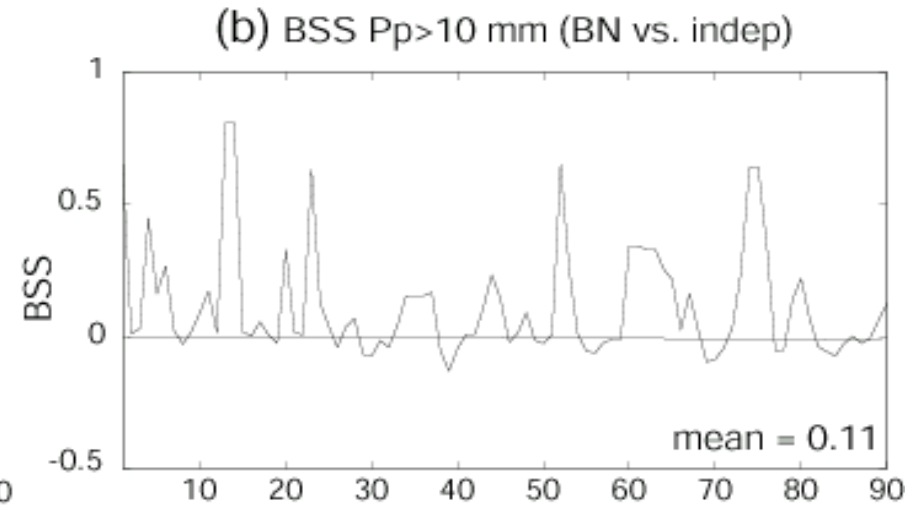
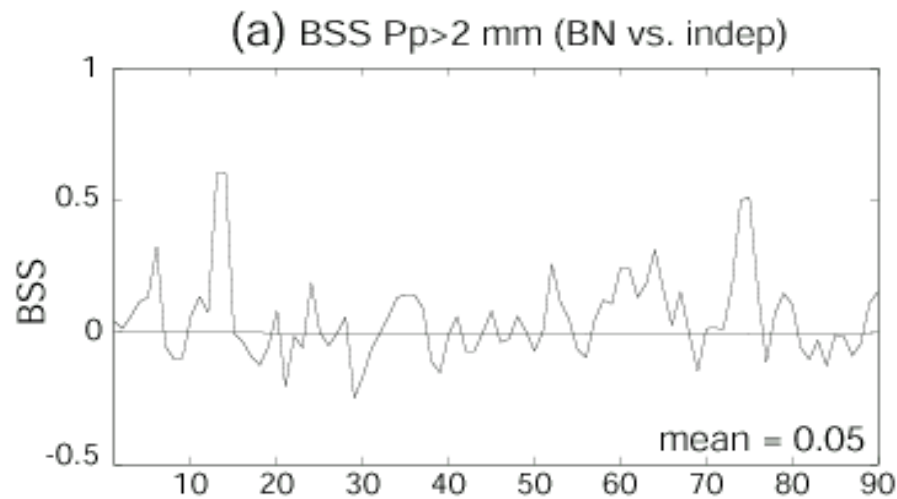
96 stations in the Northern basin of the Iberian peninsula. (D+1): DJF 1999

Analog
technique

Bayesian
nets

Seasonal
forecast

Future
work



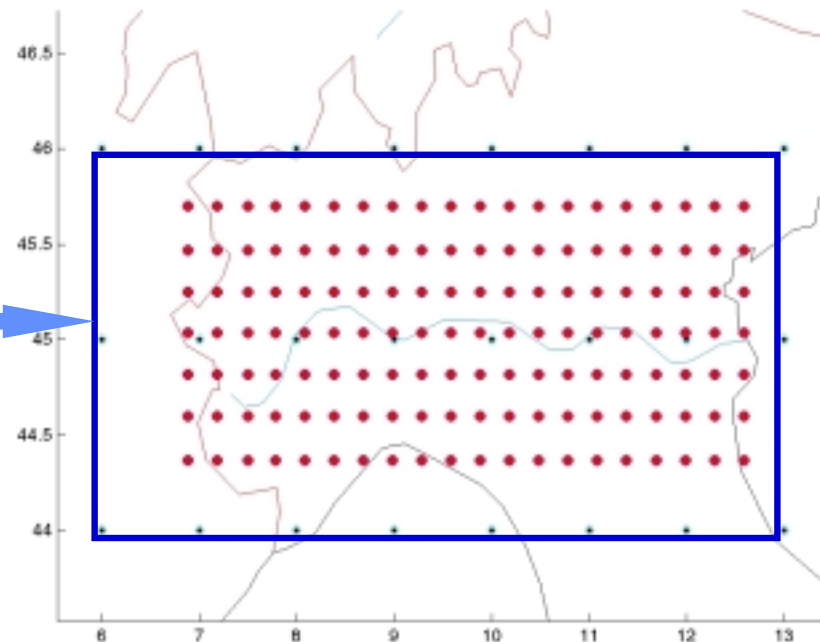
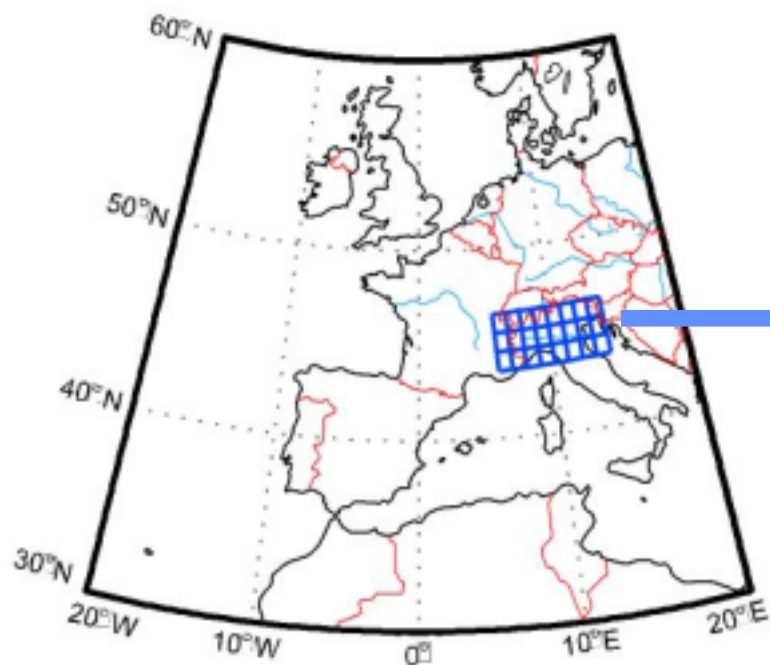
Validation in the Po valley (deterministic version)

Analog
technique

Bayesian
nets

Seasonal
forecast

Future
work



Downscaling to 140 precipitation grid points interpolated from observations.

SOM downscaling	Climatology	
RMSE = 4.9 mm	RMSE = 8.3 mm	All ERA-15 days
RMSE = 5.7 mm	RMSE = 13.3 mm	Ppc > 0mm

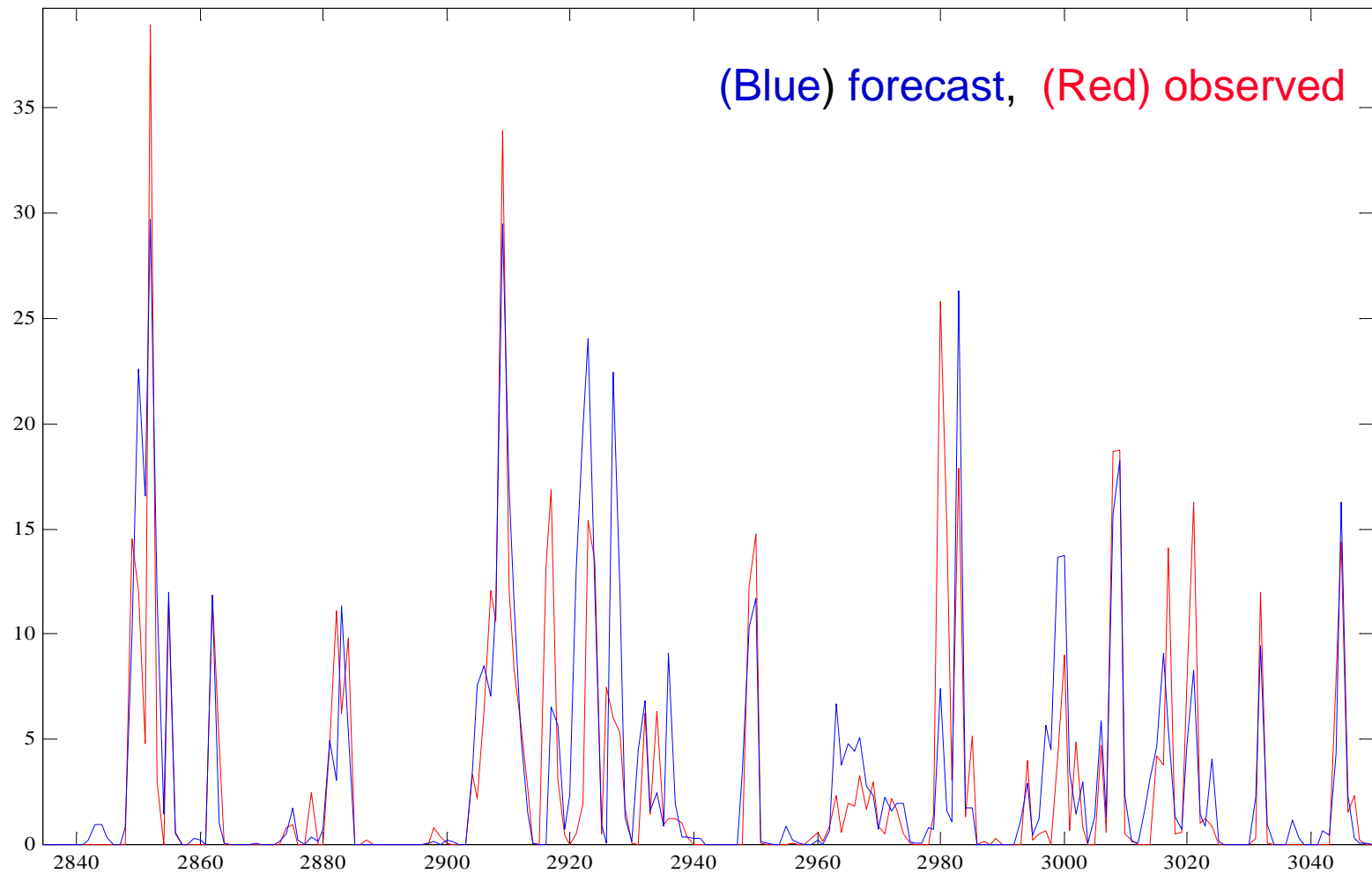
Time Series for a particular station (Po valley)

Analog
technique

Bayesian
nets

Seasonal
forecast

Future
work



Seasonal Anomalies Forecast.

Analog
technique

Bayesian
nets

Seasonal
forecast

Future
work

For a given season, the daily ERA-15 patterns define a density on the SOM grid (the frequency of points falling in each of the clusters). Since the SOM is "continuous" the resulting density is also continuous.

For instance the period NDJ:

11 / 1 / 1979

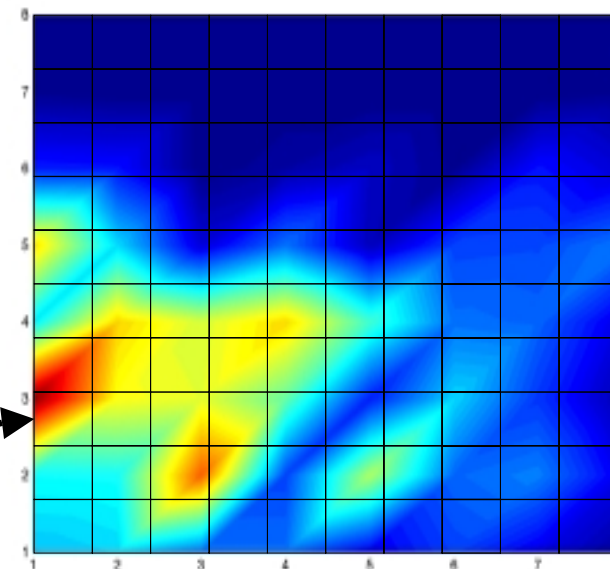
11 / 2 / 1979

...

1 / 31 / 1993

	117								
	184		132						
	312	197							
	220		129						
		186		104					

Density of clusters for NDJ
(1979-1993)



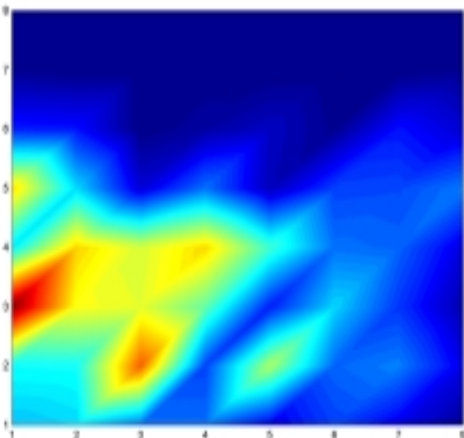
Most frequent cluster for season NDJ

From the seasonal ECMWF operative model we obtain 90 atmospheric patterns for a given season. These patterns also define a density on the SOM. Differences and similarities of the resulting density when compared with the climatological one indicate the presence or absence of wet or dry anomaly signal.

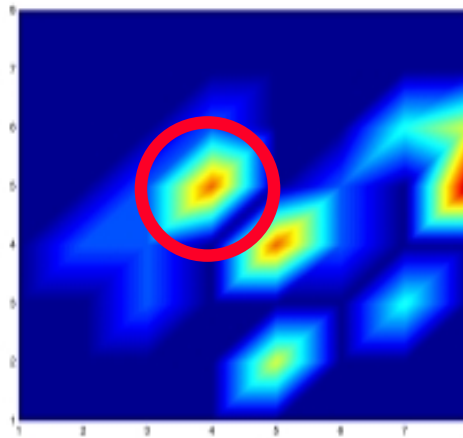
A Simple Experiment using ECMWF Operational Model

Analog
technique

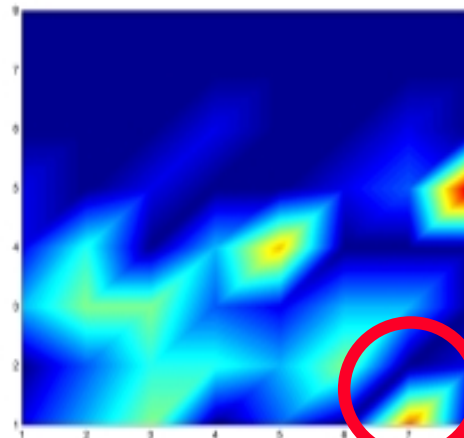
Density of clusters
for NDJ 1979-1993



Observed density
for NDJ 1989



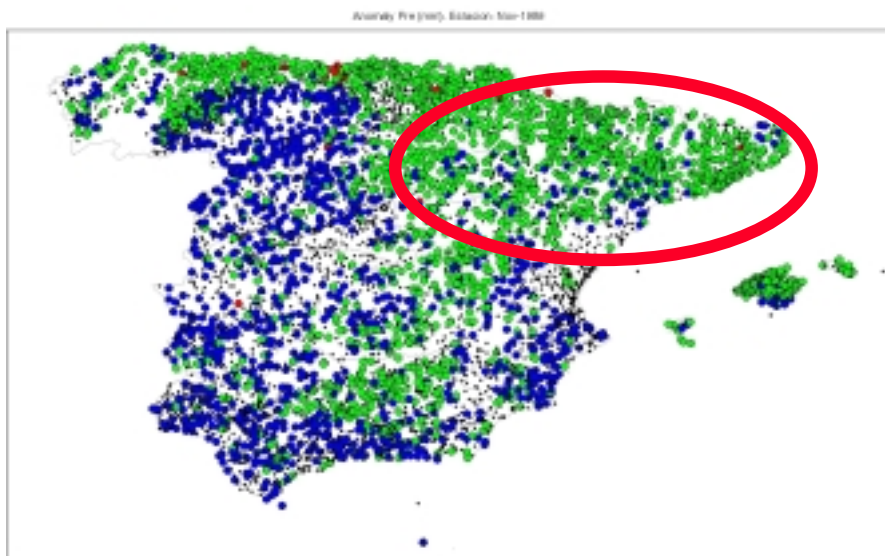
Forecasted density
for NDJ 1989



Bayesian
nets

Seasonal
forecast

Observed Anomalies NDJ1989



Downscaled Anomalies NDJ1989



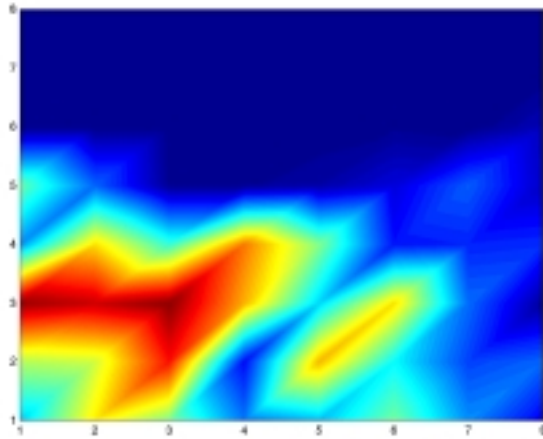
Future
work

(Blue) wet anomalies (percentil 90), (Red) dry anomalies (percentil 10)

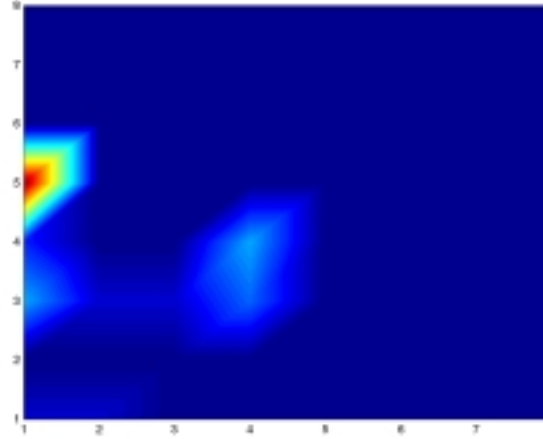
An Example Where the Model has no Skill

Analog
technique

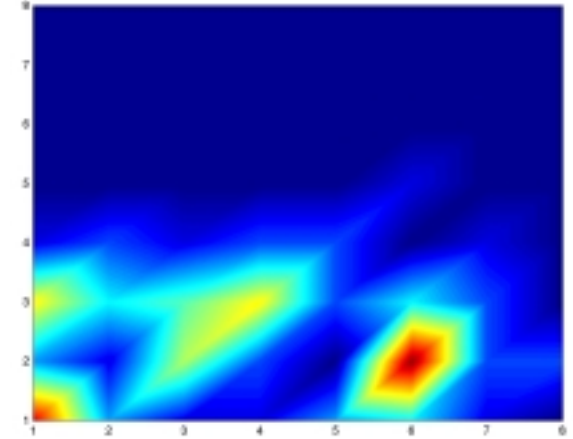
Density of clusters
for JFM1993



Observed density
for JFM1993



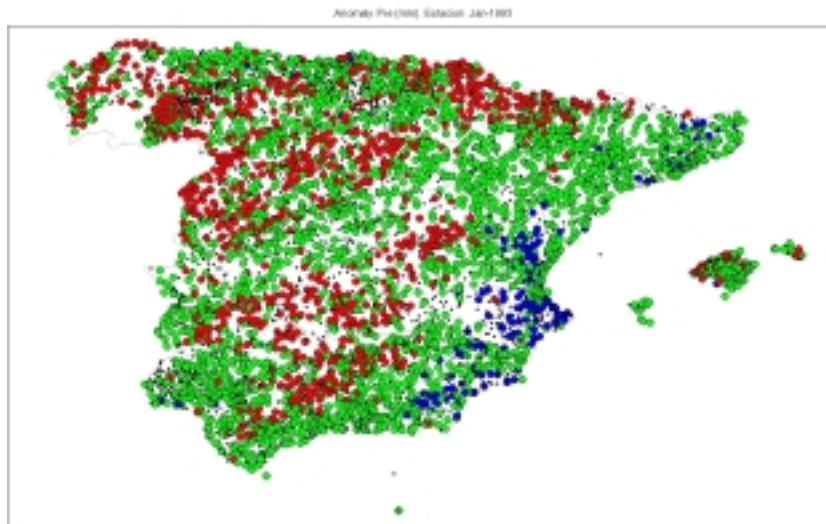
Forecasted density
for JFM1993



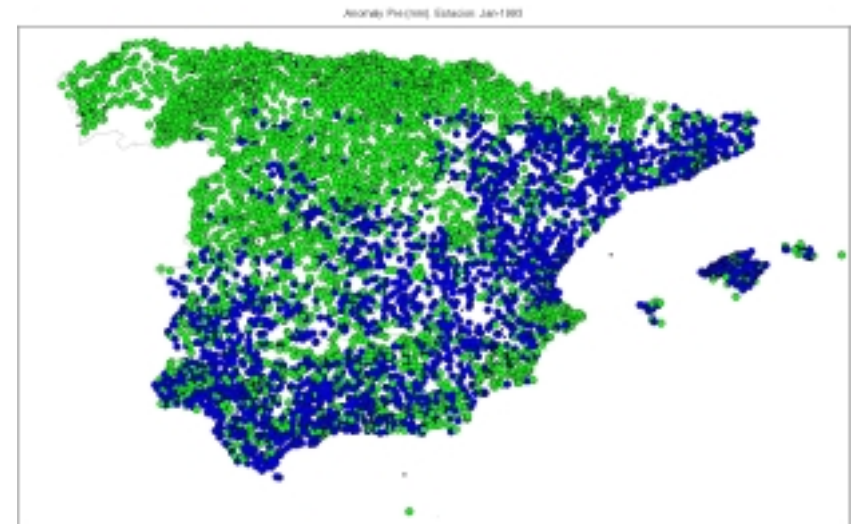
Bayesian
nets

Seasonal
forecast

Observed Anomalies JFM1993



Downscaled Anomalies JFM1993



Future
work

Future Work. Demeter Multimodel Ensemble Data

Analog
technique

Bayesian
nets

Seasonal
forecast

Future
work

*The above method is **easily applicable** to deal with multiple forecasts both from*

- *an **ensemble of a single model** and*
- *ensembles of multiple models.*

*Obtaining the **most representative classes** from the ensemble can be done with the help of the density of clusters.*

MeteoLab: A Matlab Toolbox for Weather Forecast

