



# Work on Seasonal Forecasting at INM. Dynamical Downscaling of System 3 And of ENSEMBLE Global Integrations.

B. Orfila, E. Diez and F. Franco

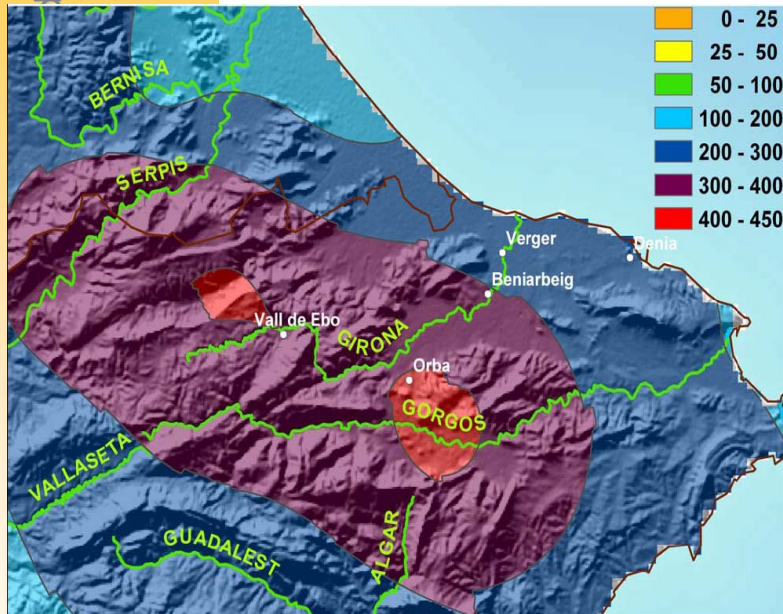


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- Introduction
- INM approach and General Aspects
- Models Used and Ensembles Built
- Results of DEMETER and ENSEMBLES
- Examples of forecasts and verification
- Conclusions
- Further actions

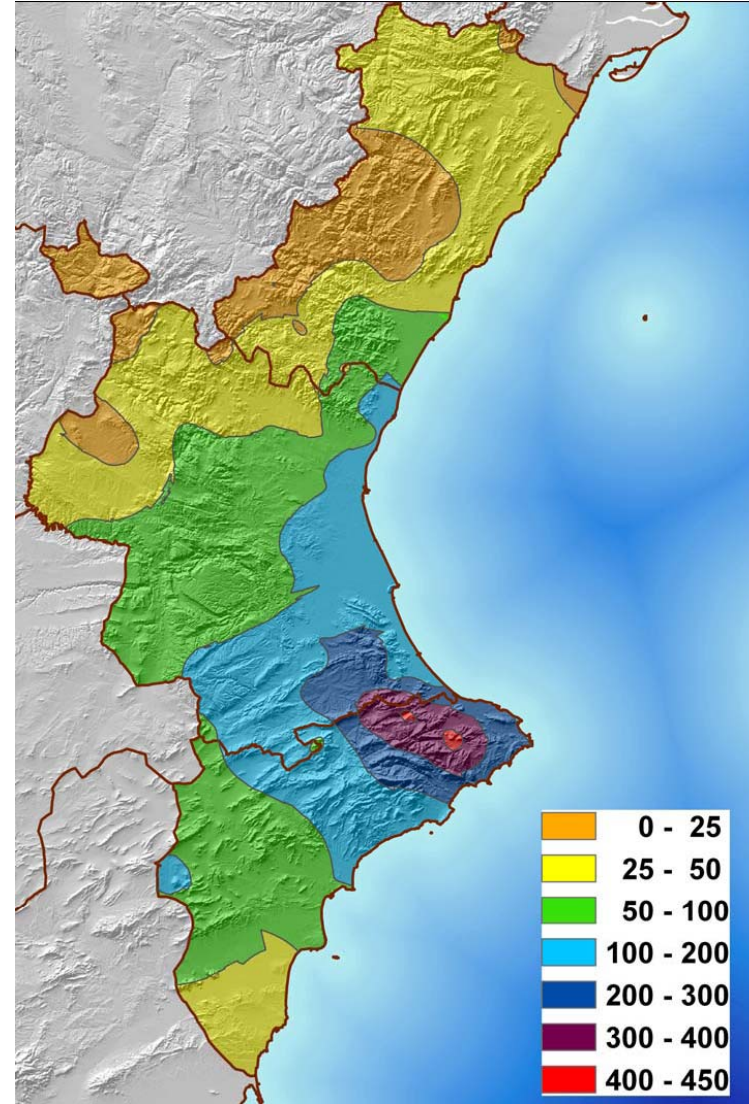


# INTRODUCTION



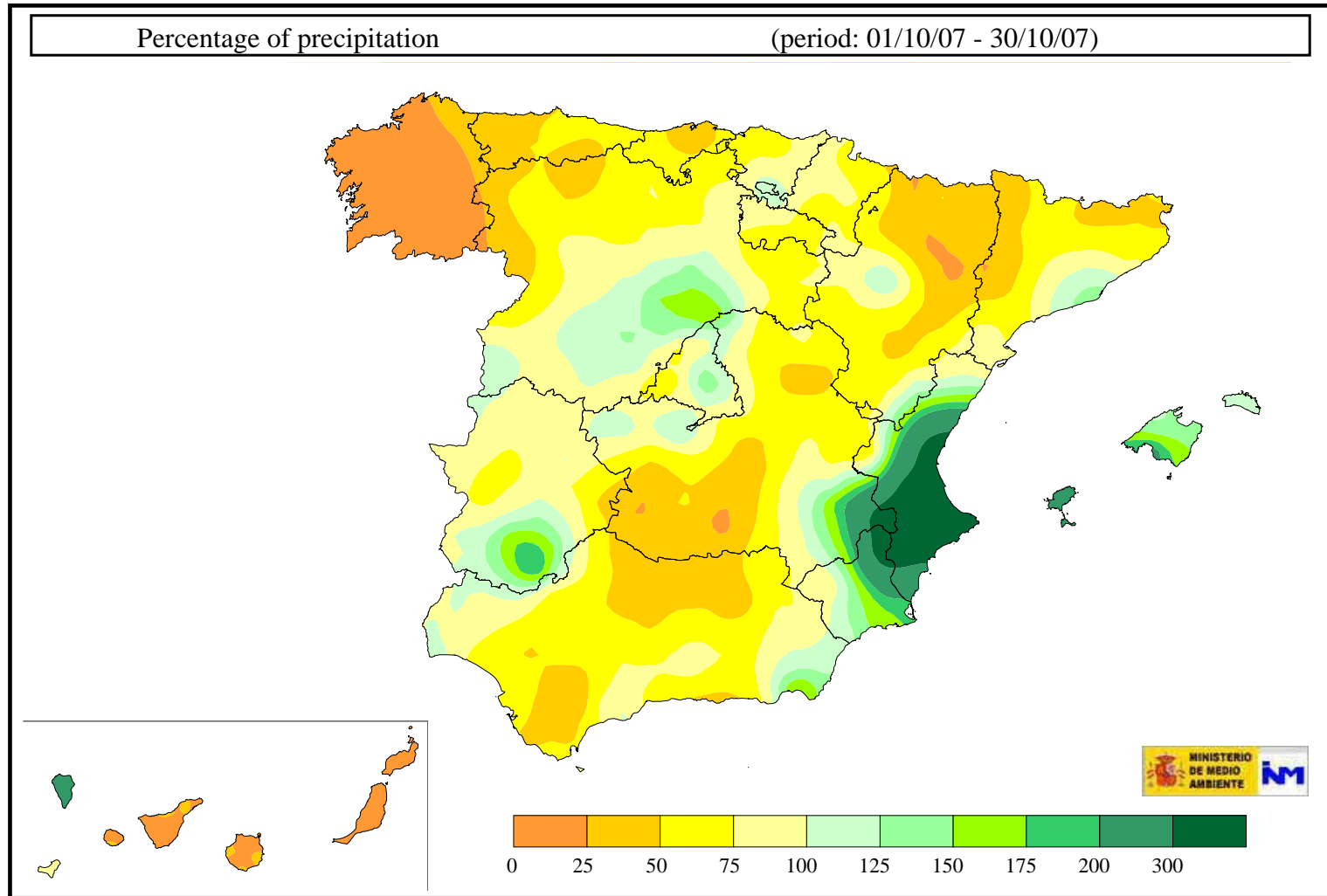
11/12 October 2007

Reading (ECMWF),  
7-9 november 2007



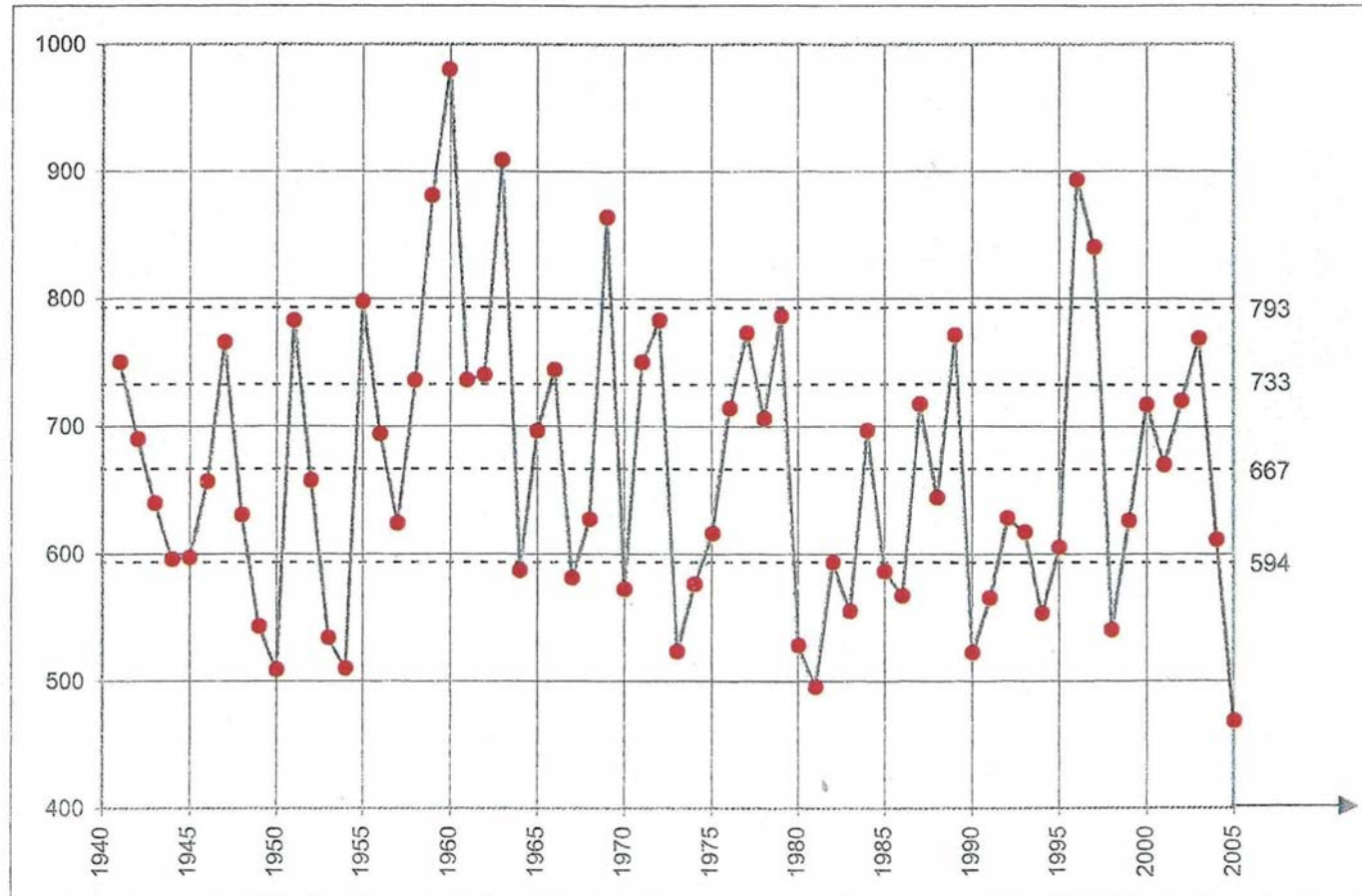


# INTRODUCTION





# INTRODUCTION

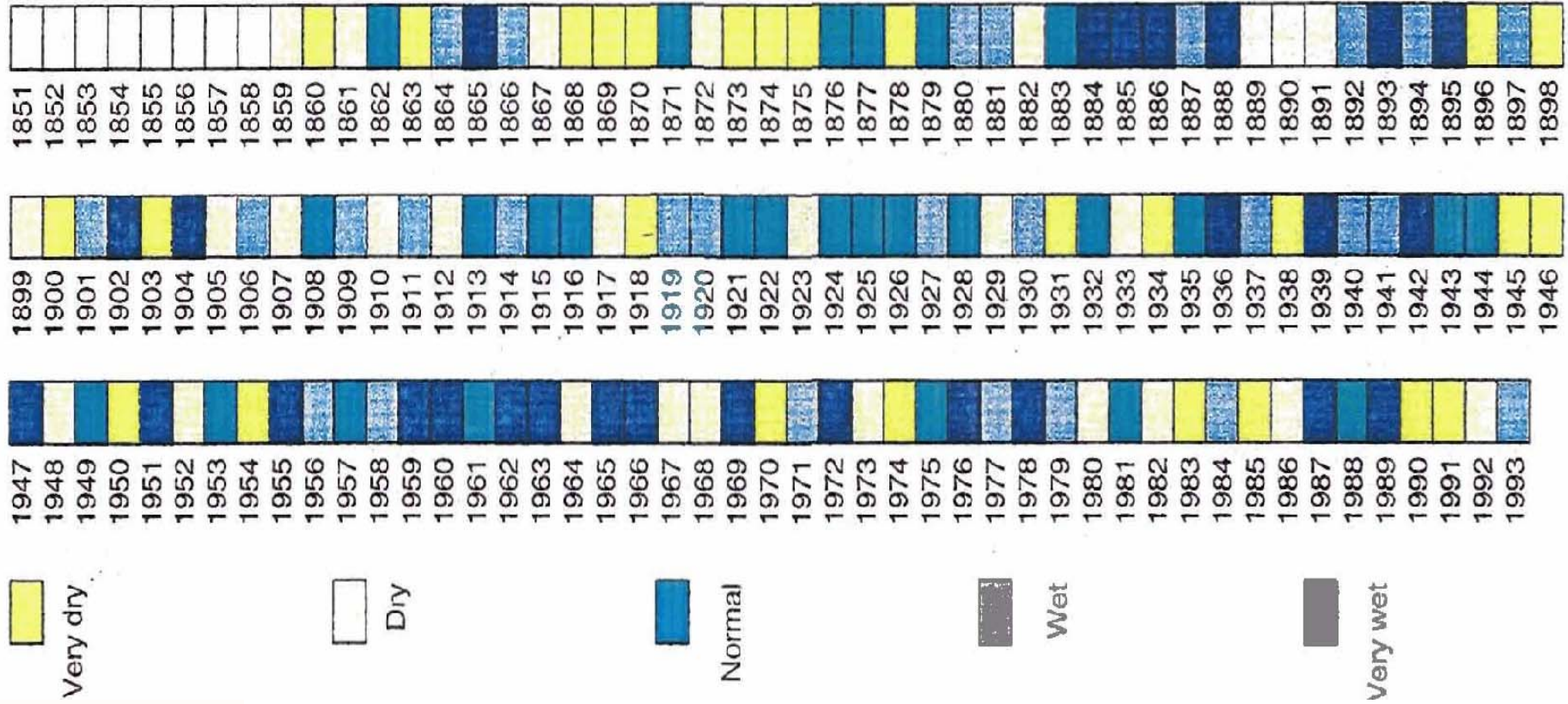


Mean annual precipitation in the Peninsular Spain 1941-2005



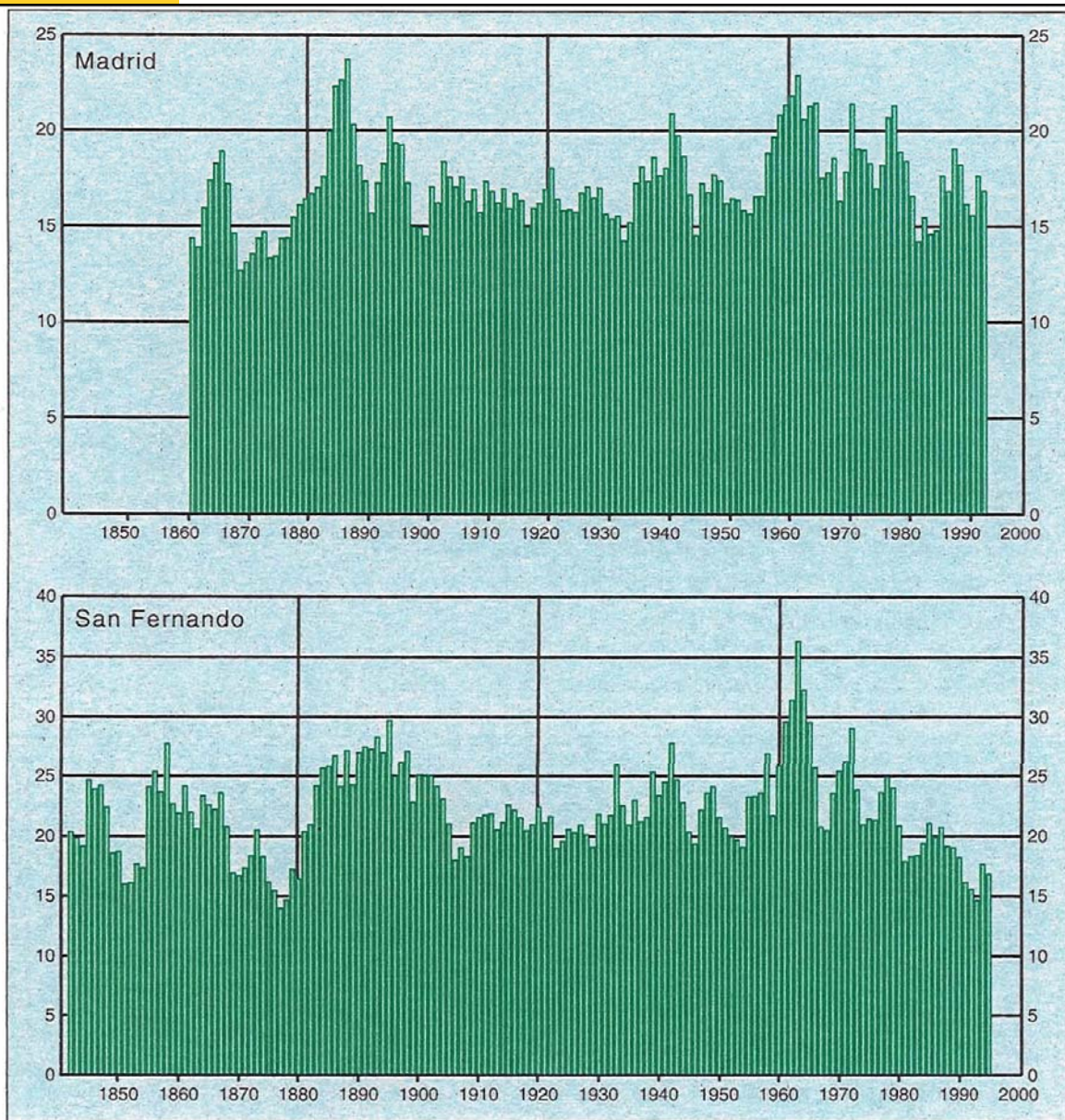
# INTRODUCTION

Quintils of Precipitation on Madrid in referred to the 1958-1993 period





# INTRODUCTION



Four-year accumulated precipitation at Madrid and San Fernando (unit  $10^2$  mm)

Read 7-9 n



# INTRODUCTION

## Temporal location of the 1, 2, 4 and 10-year driest periods in 22 observatories in the 1860-1991 period, in percentage

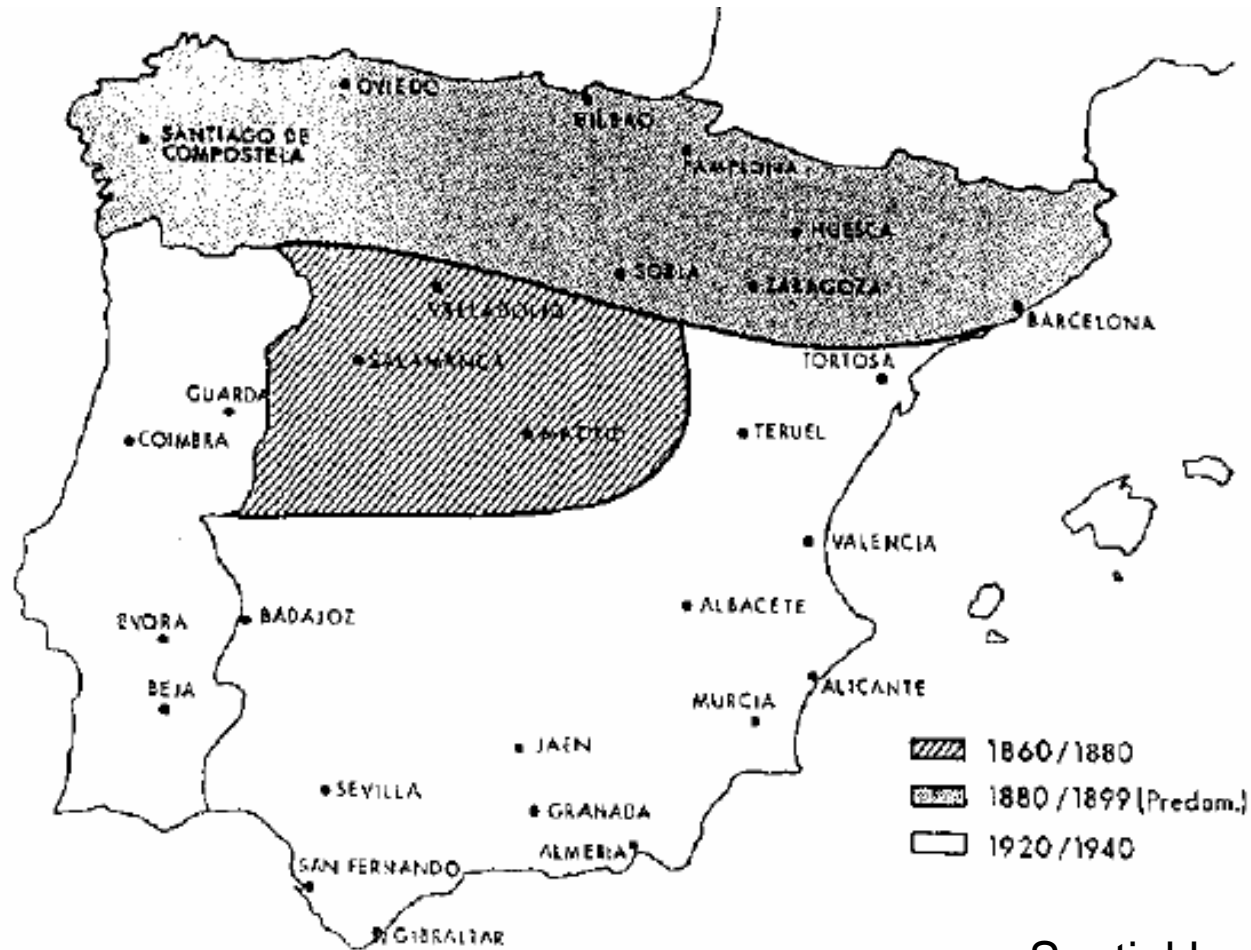
Period	1- year	2 -year	4 -year	10 -year
1860/99	45	50	50	41
1900/39	23	18	14	32
1940/91	32	32	36	27

Re  
7-9 november 2007





# INTRODUCTION



Spatial location of the 20-year driest period



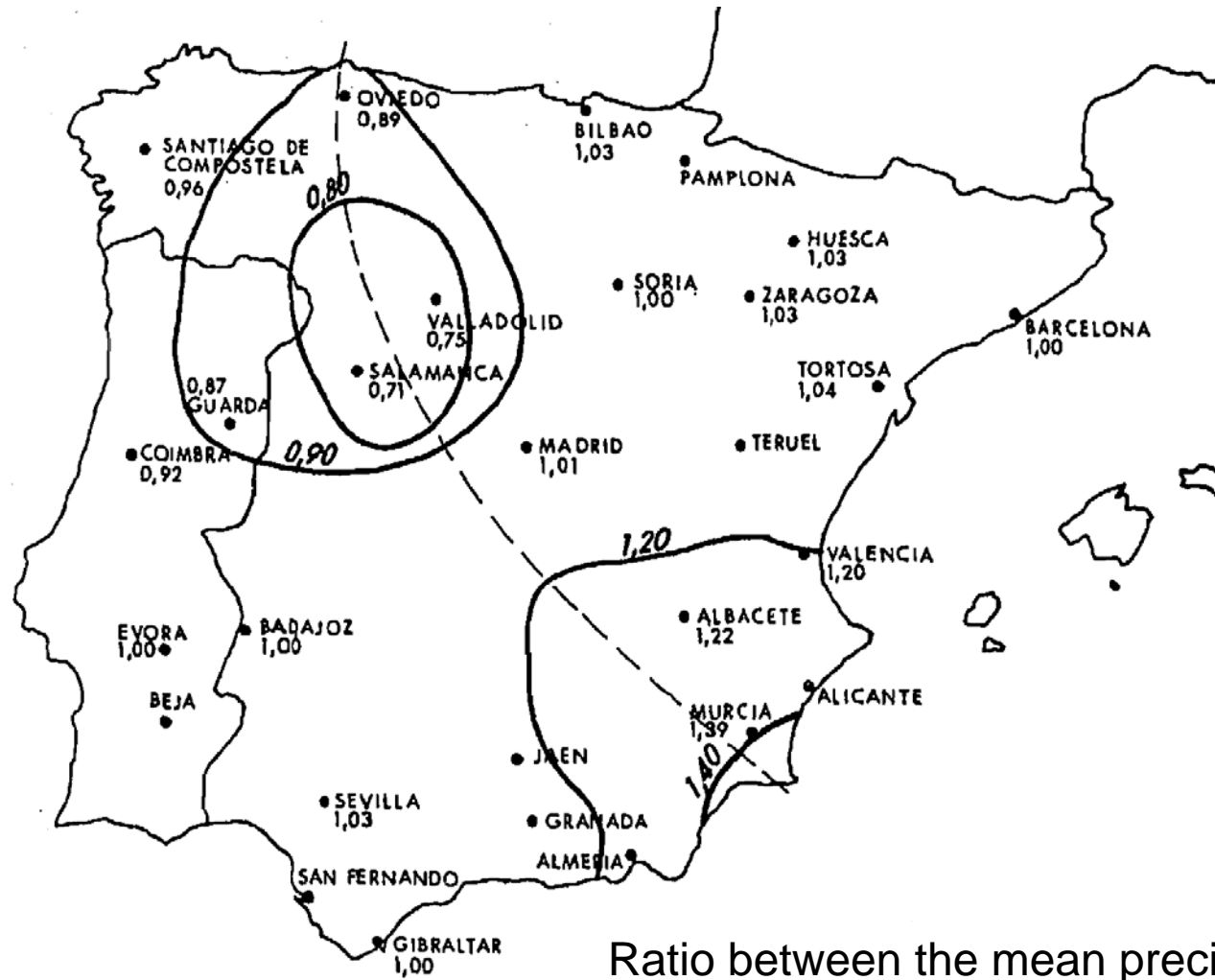
# INTRODUCTION



Spatial location of the 20-year wettest period



# INTRODUCTION

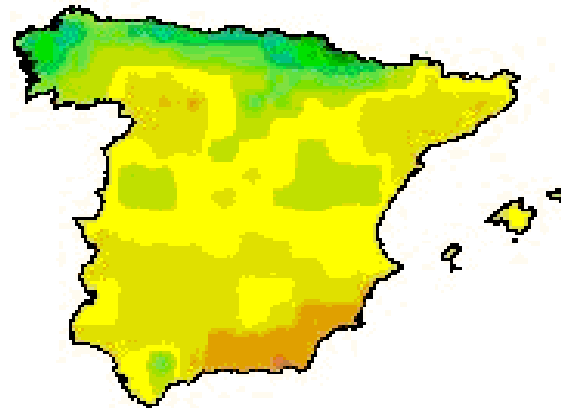
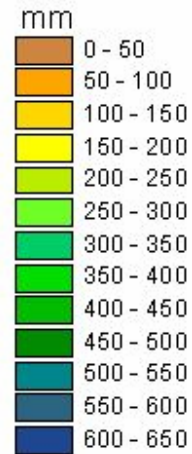


Ratio between the mean precipitation Of the periods 1860-99 and 1900-1939

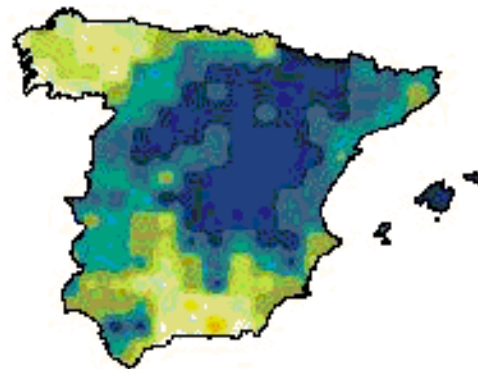
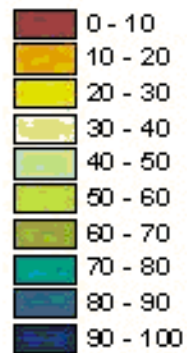


# INTRODUCTION

Observed precipitation FMA 07



Observations percentiles (1981-2004) FMA 2007





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## INM Approach and General Aspects

- INM started seasonal forecast activities in mid-nineties
- Volume of precipitation in basins vs SST in oceans (lagged correlations)
- Seasonal predictability over Spain
- Participation in DEMETER
- Participation in ENSEMBLES
- Experimental forecasts with System 2 and System 3

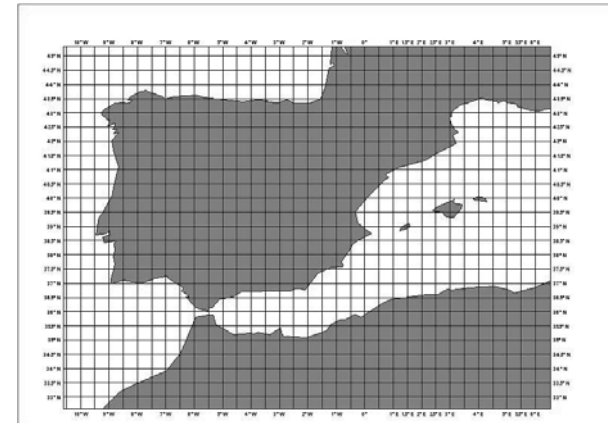


## INM Approach and General Aspects

- Starting point: ensemble of seasonal forecasts from coupled AOGCMs
- Single model vs multimodel forecasts
- Direct model output from global models
- Statistical downscaling
- Dynamical downscaling
- Dynamical + statistical downscaling
- Probabilistic and Deterministic forecasts
- Convenience of a many years hindcast for calibration with observations



# Availability of daily, monthly and seasonal data

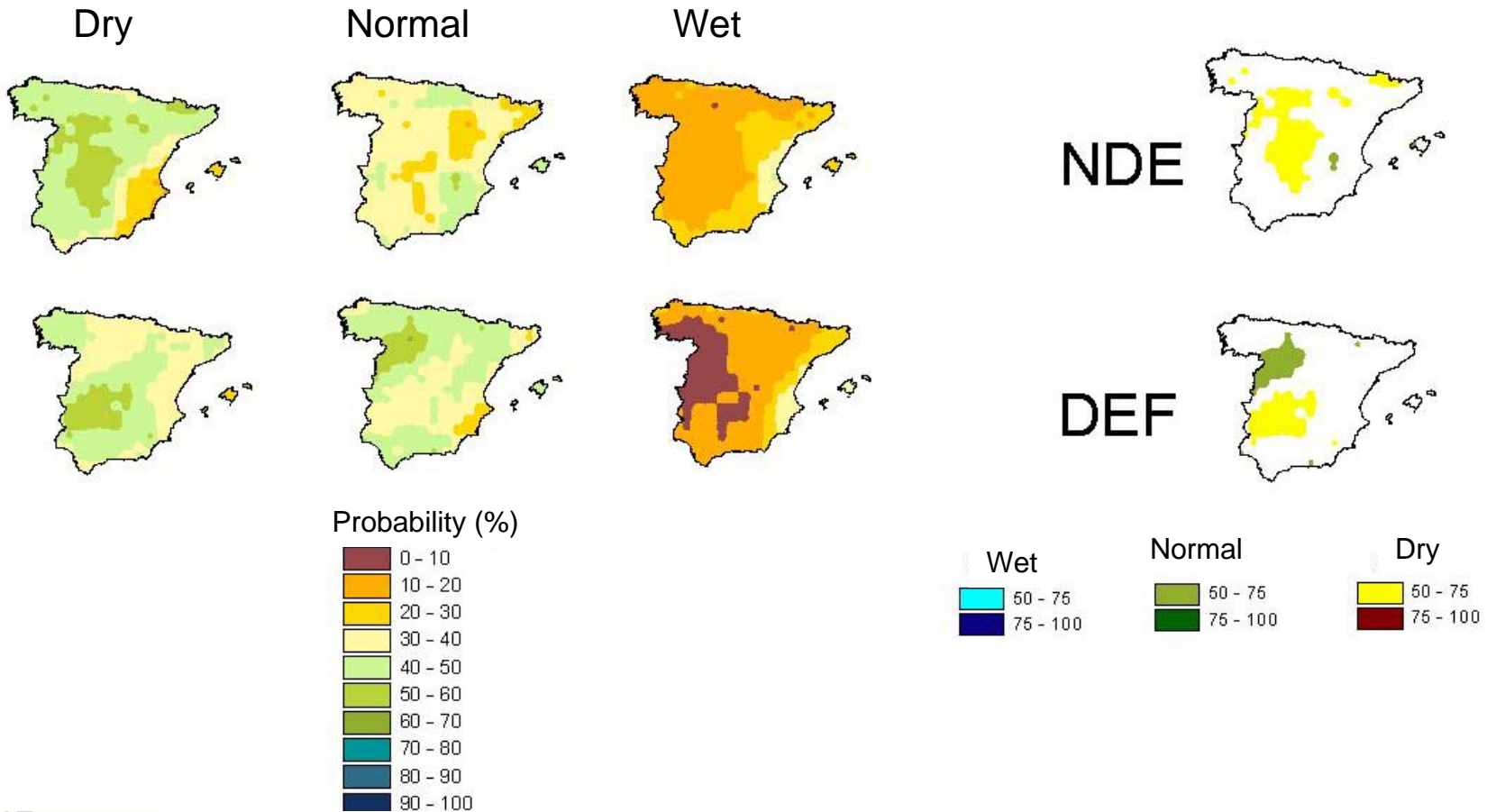






# INM Approach and General Aspects

## Probabilities of Dry, Normal and Wet events, lead time 1 and 2 from October 2007



# INM APPROACH AND GENERAL ASPECTS

## Probabilistic forecast for JJA, Lead time 1 Analog

Autonomia	Provincia	Min	PS	T1	PN	T2	PH	Max
Islas Baleares	Mallorca	0.0	<b>22.0</b>	12.6	<b>31.7</b>	46.0	<b>46.3</b>	116.0
La Rioja	La Rioja	11.6	<b>29.3</b>	76.6	<b>39.0</b>	150.7	<b>31.7</b>	349.3
Madrid	Madrid	4.0	<b>24.4</b>	30.7	<b>39.0</b>	75.0	<b>36.6</b>	157.3
Murcia	Murcia	0.0	<b>19.5</b>	16.6	<b>34.1</b>	37.9	<b>46.3</b>	103.9
Navarra	Pamplona	42.4	<b>24.4</b>	126.4	<b>39.0</b>	253.8	<b>36.6</b>	614.8
Pais Vasco	Bilbao	22.9	<b>24.4</b>	100.3	<b>41.5</b>	185.5	<b>34.1</b>	452.8
Pais Vasco	S. Sebastian	70.8	<b>26.8</b>	164.9	<b>43.9</b>	276.5	<b>29.3</b>	653.7
Pais Vasco	Vitoria	9.6	<b>22.0</b>	72.0	<b>46.3</b>	125.9	<b>31.7</b>	368.7

Min: Minimum value of the observed climatology for 1981-2004

PS: Probability of a dry

T1: Value of 33 percentile of the observed climatology for 1981-2004

PN: Probability of a normal event

T2: Value of 66 percentile of the observed climatology 1981-2004

PH: Probability of a wet event

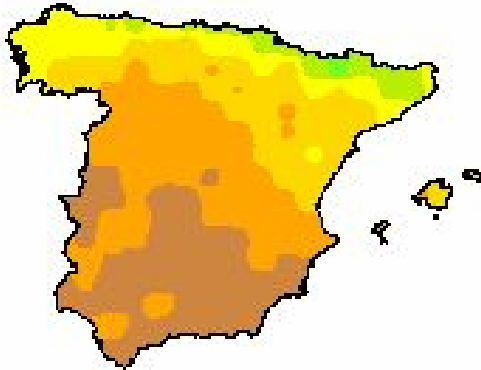
Max: Maximum value of the observed climatology for 1981-2004



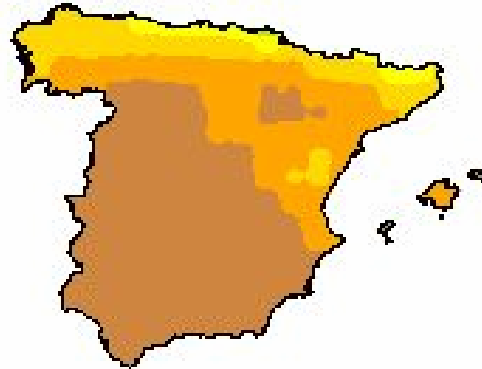
# Deterministic forecast, calibration with observations JAS (1-lead time) Analog

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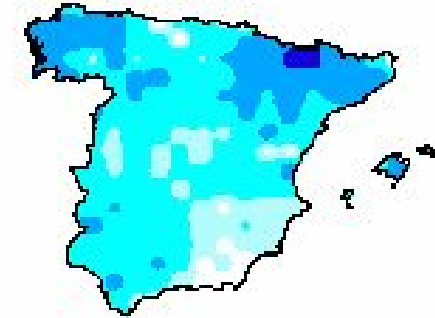
Corrected



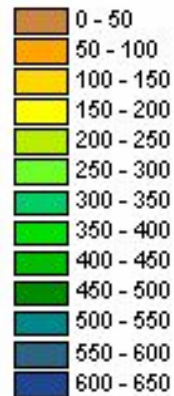
Model



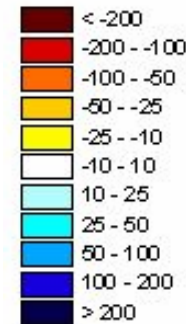
Corrected - Model



mm



mm

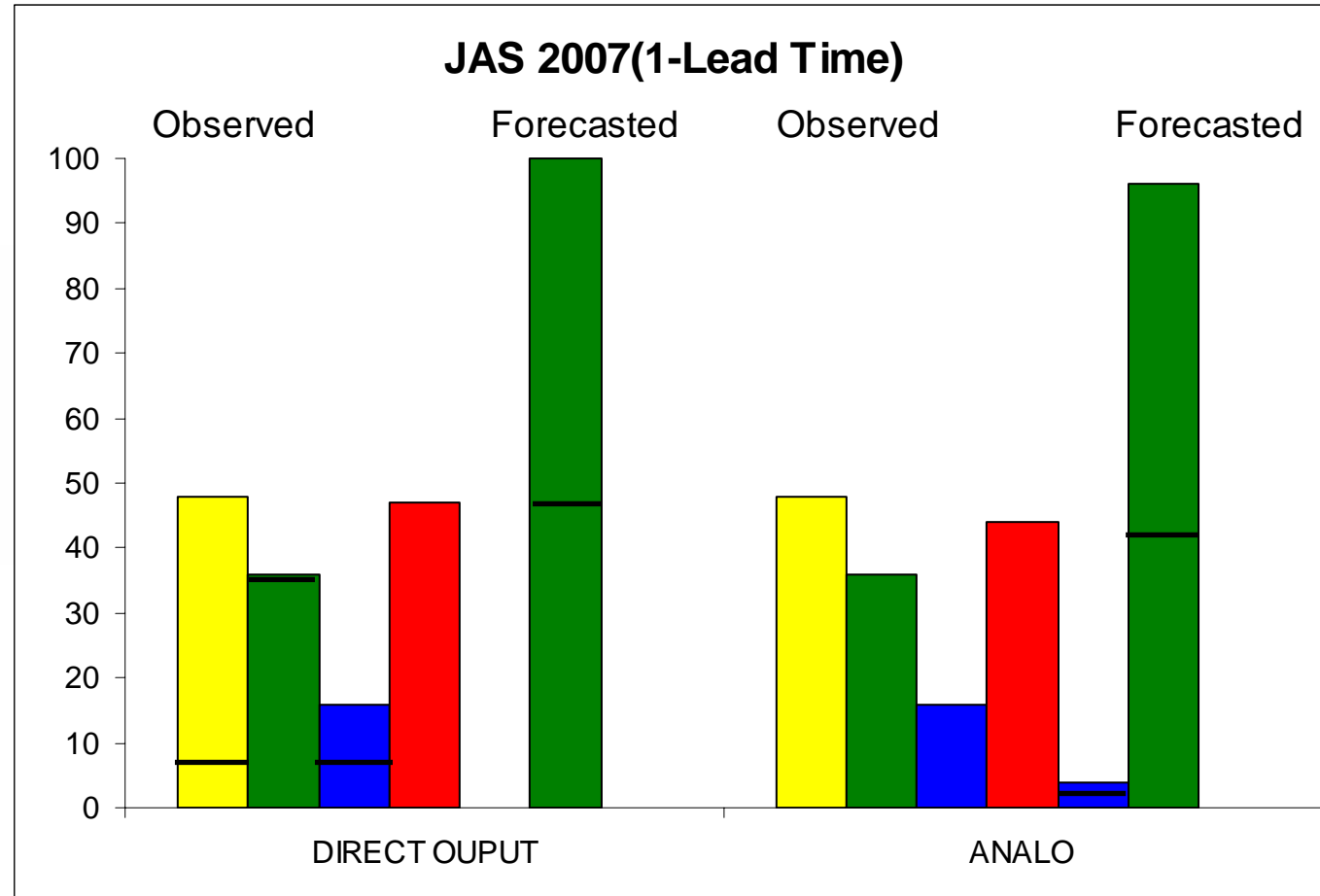


Reading (ECMWF),  
7-9 november 2007



# Run quintil criterium for validation of deterministic seasonal forecast

(Percentiles of the forecast and of the verifying observation differ in less than 20 percentiles)



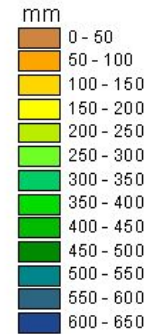


# JAS 2007 PASADA 06

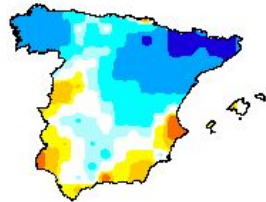
Analogo corregido



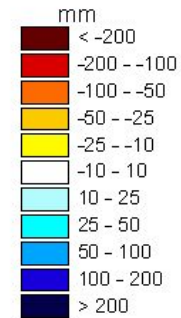
Salida Directa corregido



Diferencia Analogo Corregido - Observacion



Diferencia Sal Directa Corregido - Observacion



Anomalia Analogo Corregido - Media



Anomalia Sal Directa Corregido - Media



Observación JAS 2007



Media Climatológica JAS



Anomalia de la observación (Observación - media) JAS





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# MODELS USED AND ENSEMBLES BUILT

	DEMETER	ENSEMBLES	SYSTEM2	SYSTEM3
ECMWF	2	1	2	2
UKMO	2	1		
EC-RCA	2	1		1
MO-RCA		1		

Reading (ECMWF),  
7-9 november 2007

1 Direct model outputs  
2 Direct model + ANALO-ONE outputs



## RCA Model

- The regional atmospheric climate model developed at the Rossby Centre
- Scheme:
  - Convection: Kain-Fritsch
  - Radiation: Savijarvi-Sass
  - Turbulence: CBR
  - Soil: ISBA modified
- 31 levels in the vertical
- Horizontal resolution  $0.5^{\circ}$
- Area: European Atlantic domain ( $15.5^{\circ}\text{N}$ - $65.0^{\circ}\text{N}$  and  $67.0^{\circ}\text{W}$ - $31.0^{\circ}\text{E}$ )





# Dynamical Downscaling Technique

- Boundaries conditions
  - ECMWF (European Centre for Medium-Range Weather Forecasts)
    - Atmosphere component: IFS
      - Resolution: T95 (Ensembles:CY29R1 40 levels, System3:CYy31R1, 62 levels used 31 levels)
    - Ocean component: HOPE-E
      - Resolution:  $1.4^{\circ} \times 0.3^{\circ}$  -  $1.4^{\circ}$  29 Levels
    - Coupling:
      - frequency of coupling:1-day
    - Ensemble size: 9
  - UK Met Office (Hadley Centre for Climate Prediction and Research)
    - Atmosphere component: HadAM3
      - resolution:  $2.75^{\circ}$  latitude by  $3.75^{\circ}$  longitude 19 Levels
    - Ocean component: GloSea OGCM based on HadCM3
      - Resolution:  $1.25^{\circ} \times 0.3^{\circ}$  -  $1.25^{\circ}$  40 Levels
    - Coupling:
      - frequency of coupling:1-day
    - Ensemble size: 9



- ANALO is a two-step standard analogue technique which is based on the search for analogues of 1000- and 500-hPa geopotential height and 1000-, 925-, 850- and 700-hPa relative humidity fields of the ECMWF models.
- In the first step, 100 analogues are obtained using information from the geopotential; afterwards, the analogue ensemble is lowered down to 30 members using information from the humidity fields



# TIME PROJECTION AND RUNS PER YEAR

Workshop on Ensemble Prediction

	DEMETER Feb,may,aug,nov	ENSEMBLES May,nov	SYSTEM2 monthly	SYSTEM3 monthly
ECMWF	6 months	6 months	6 months	7 months
UKMO	6 months	6 months		
EC-RCA	6 months (May,nov)	6 months		5 months
MO-RCA		6 months		

Reading (ECMWF)  
7-9 november 20



# Number of members and size of the hindcast

Workshop on Ensemble Prediction

Dynamical	DEMETER	ENSEMBLES	SYSTEM2	SYSTEM3
ECMWF	9/12	9/11	40/15*5	41/25*11
UKMO	9/12	9/11		
EC-RCA	3/3 may 3/4 nov	9/11		11/25*5
MO-RCA		9/11		

Statistical with ANALO-ONE	DEMETER	SYSTEM2	SYSTEM3
ECMWF	9/12	40/15*5	41/25*11
UKMO	9/12		
EC-RCA	3/3 may 3/4 nov		



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## Results of DEMETER

- The main goal of the INM participation in the EU DEMETER Project was to compare the skill of seasonal DEMETER precipitation forecasts over Spain obtained both from the direct model outputs and by applying statistical and dynamical downscaling techniques
- Article in the Tellus issue devoted to DEMETER (pag 409)
- Only a subset of the DEMETER material was used (two models: ECMWF and UKMO, and 12 years)
- Only seven forecasts until 6 months with RCA (7 forecasts \* 3 members = 21 integrations)
- Statistics were referred to the 1986-1997 period.

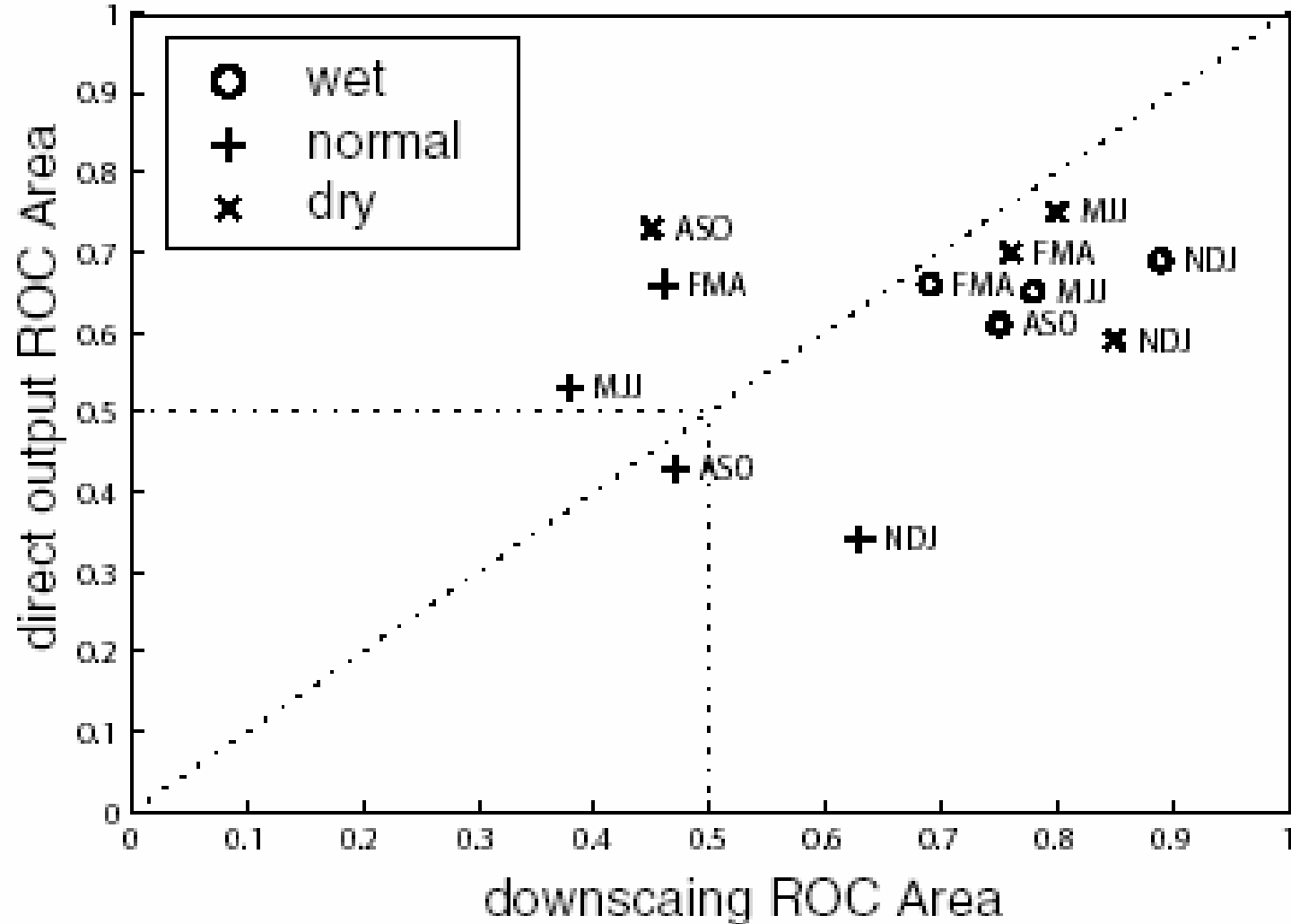


## Results of DEMETER

- Comparison of the probabilistic forecasts from the ECMWF Global Model and from the Statistical Downscaling. It is done using a scatter diagram of ROC Skill Areas.
- The Run quintile criterium is applied to deterministic forecasts from the global model outputs (EC+MO) and RCA and their corresponding analogue versions.
- Conclusions



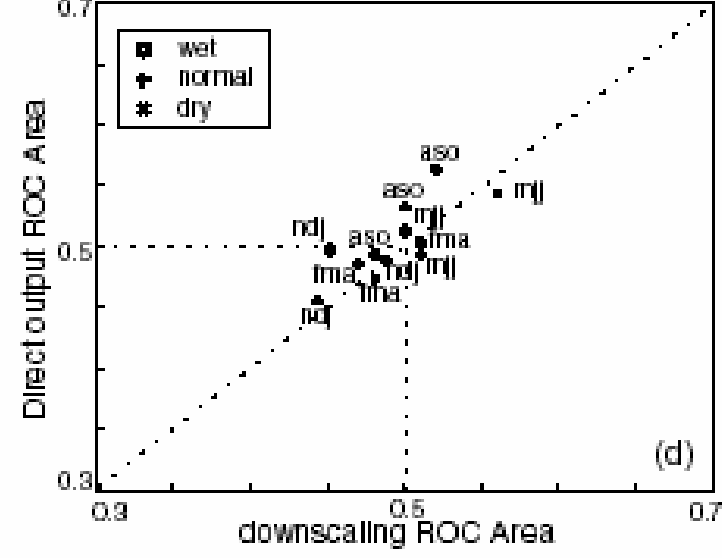
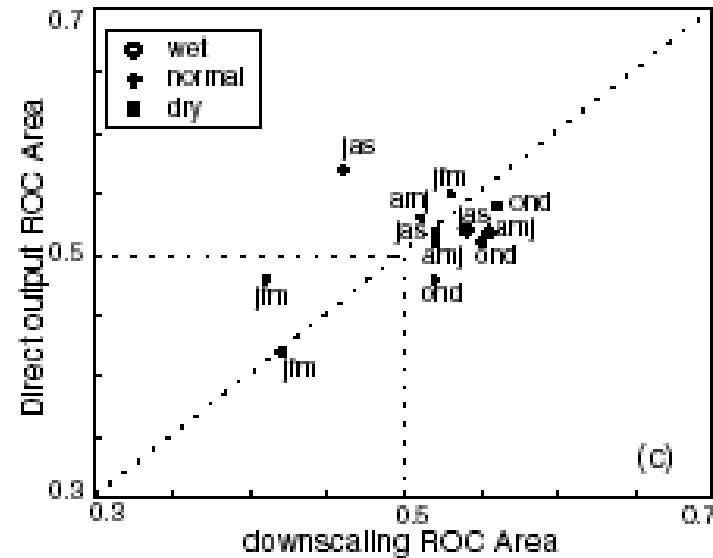
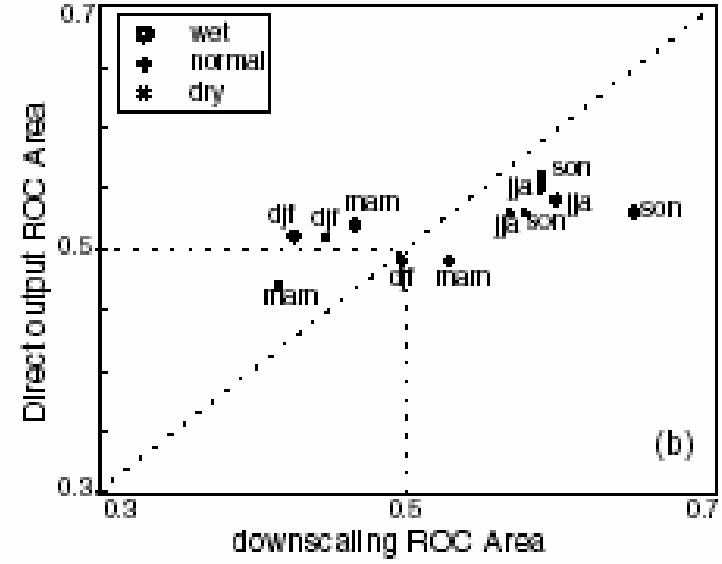
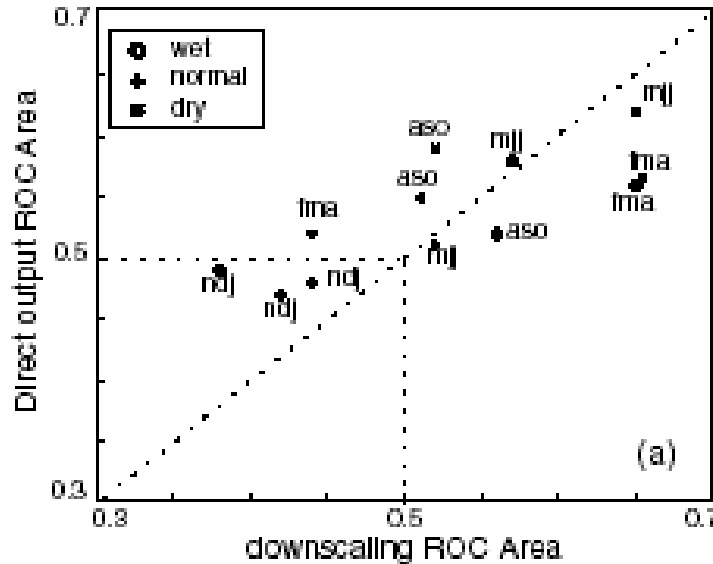
# RSA comparison of the direct output and downscaled values, zero-month lead time, for a particular El Niño period (Nov1986- Oct 1988) in the South of Spain







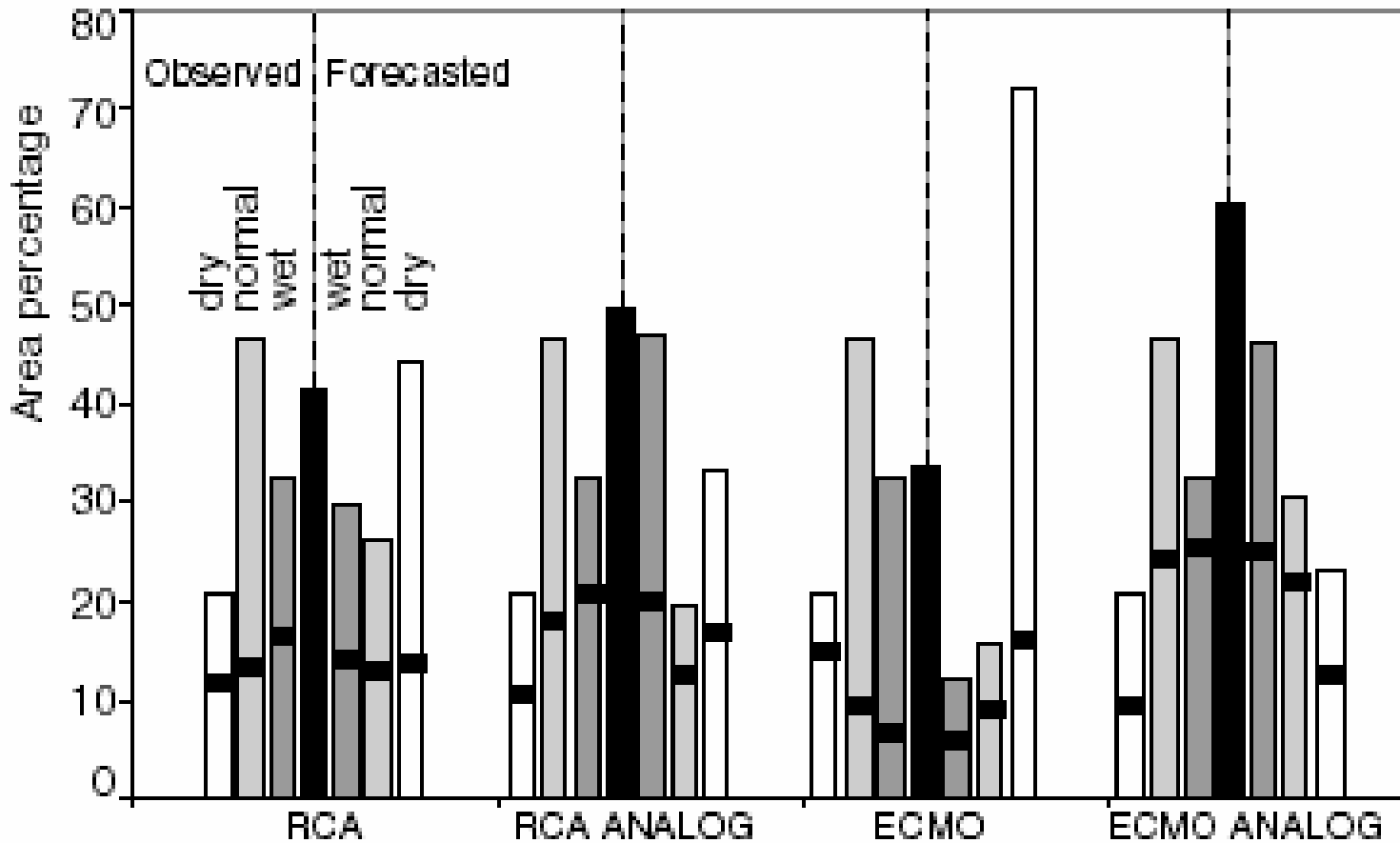
# RSA comparison of the direct output and downscaled values for the whole area of Spain at the period 1986-1997 (lead times 0 to 3)





# Deterministic forecast for November-January 1986/1987 and 1987/1988 case during an El Niño event

Workshop on Ensemble Prediction

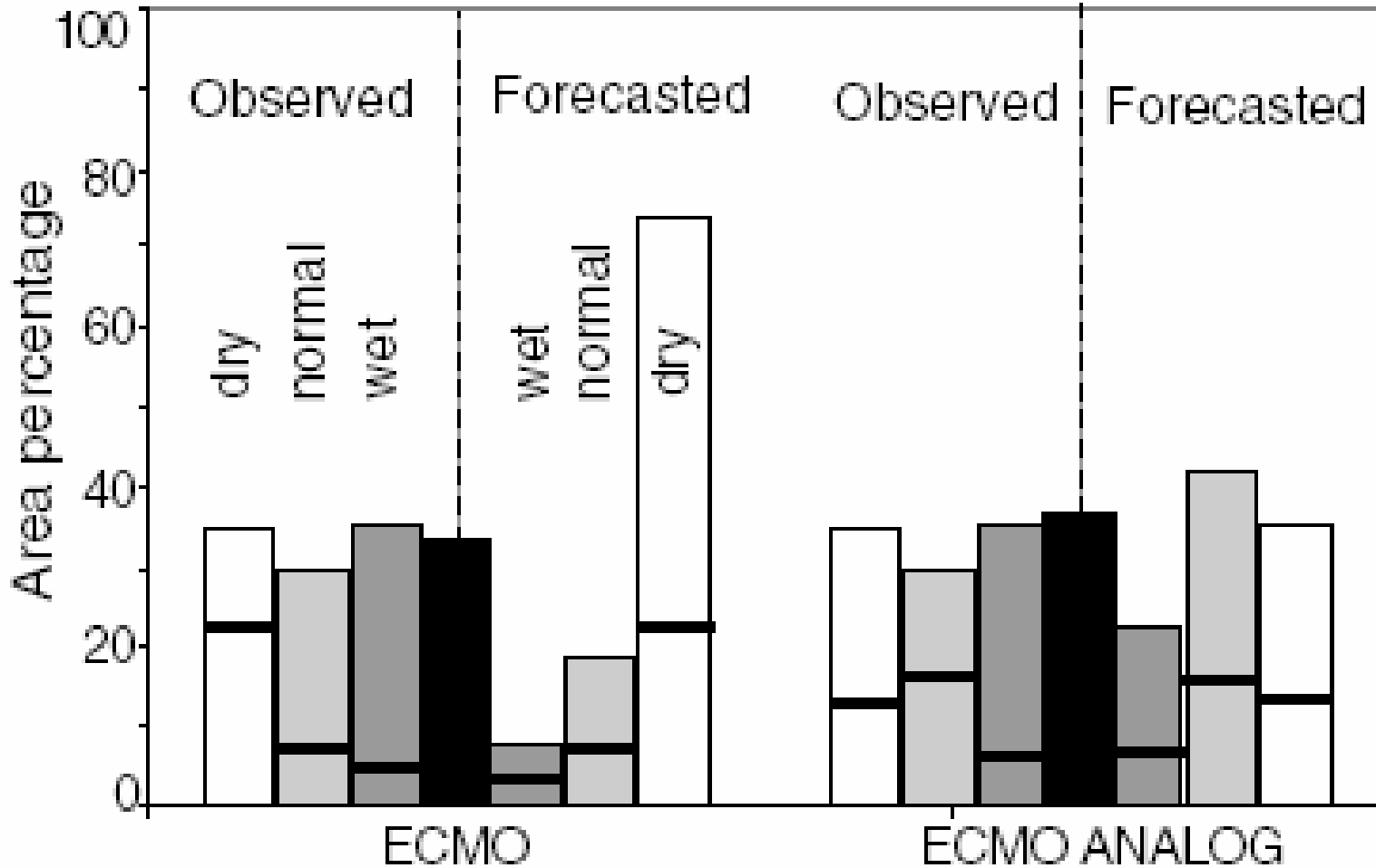


Reading (EC 7-9 november 2007



# Bar diagram of area percentages for NDJ 1986-1987 for ECMO (18 ensemble members) methods and the analogue versions

Workshop on Ensemble Prediction

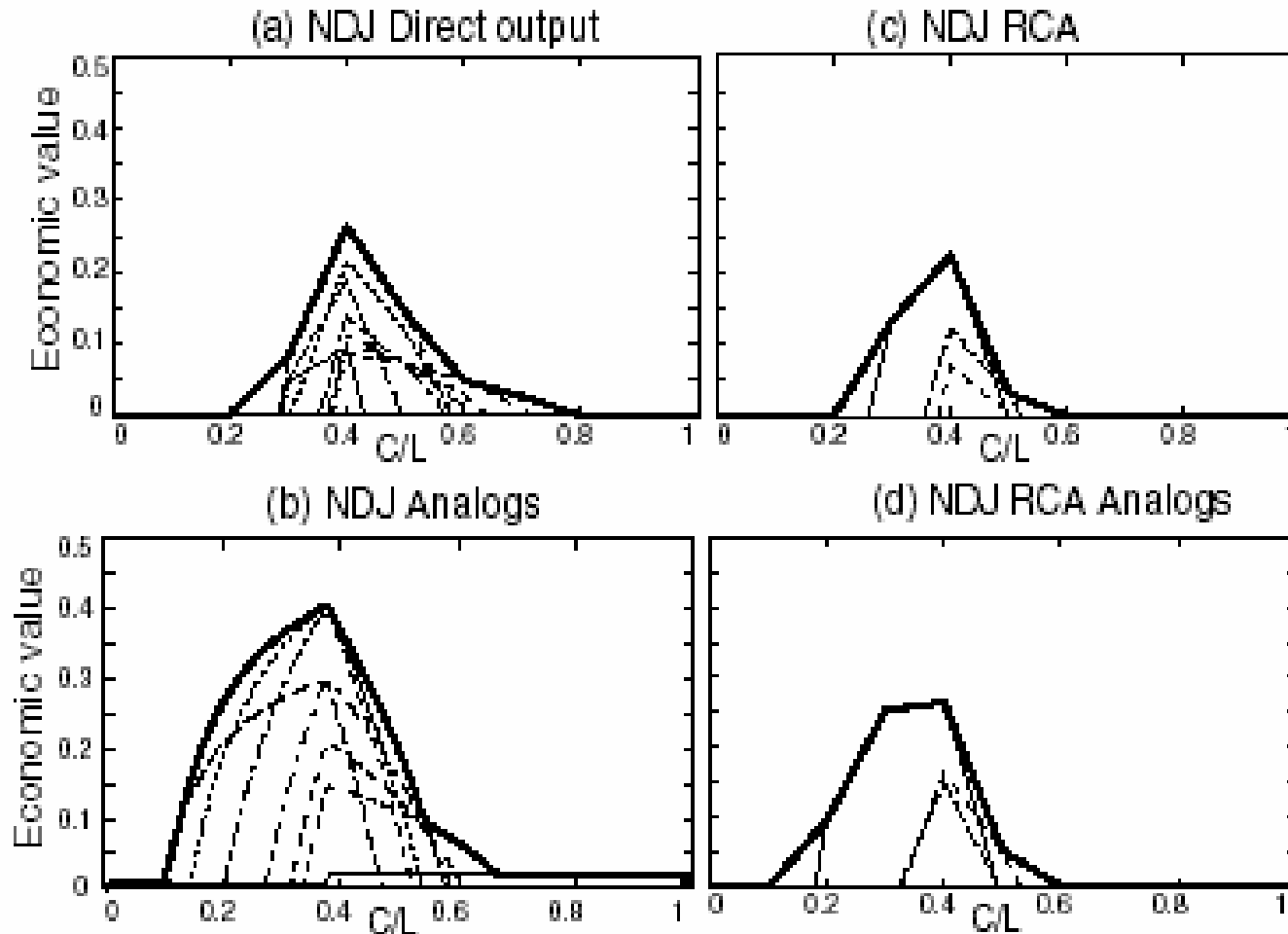


**Regions of Spain where the difference between the observation and forecast differ less than 20 percentile in two (black), one (dark grey) and zero (light grey) case out of the two NDJ seasons for the ECMO18AN in the period 1986-1987**



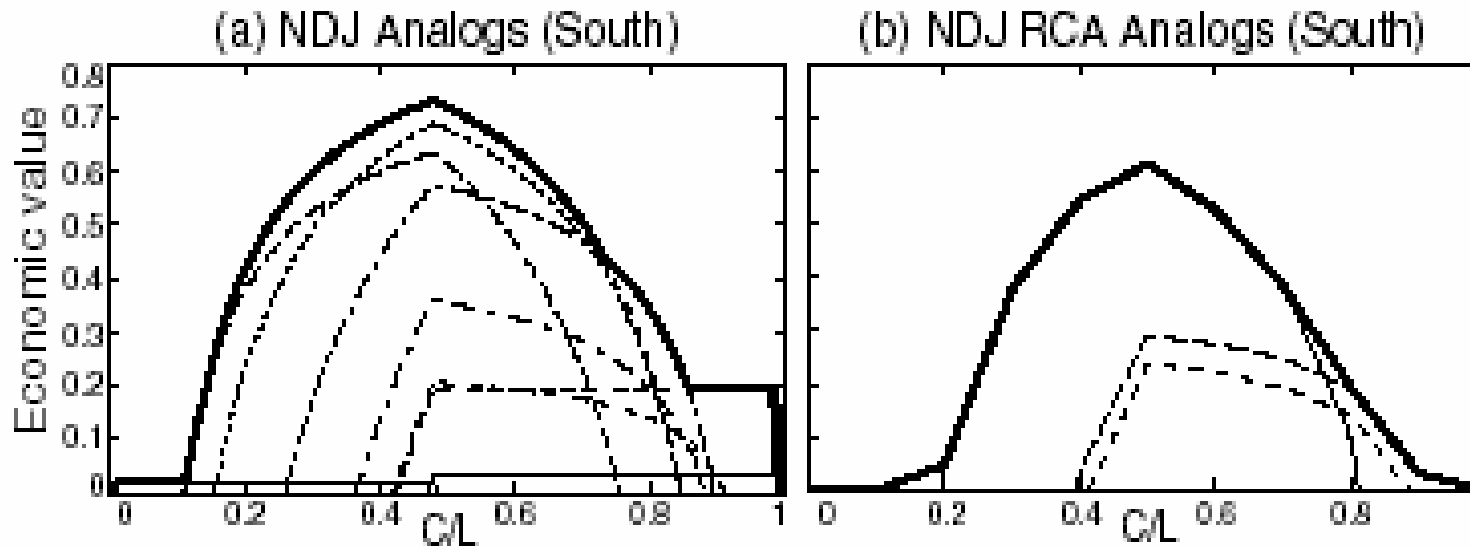


# Economic values and their envelopes for the “wet” event during NDJ 1986/1987 and 1987/1988 for ECMO18 and RCA3 and the analogue versions





# Economic values and their envelopes for the wet event during NDJ of 1986/87 and 1987/88 applying the analogue method to the ECMO (18 ensemble members) and RCA (3 ensemble members) models for the south of Spain





## Results of DEMETER

- Seasonal deterministic forecasts benefit from an increase of resolution of the dynamical model (only from a sample of 7 forecast -21 integrations- for the period 1986-1989, which includes one El Niño event).
- The analogue methods overall improve the forecast for the period 1986-1989.
- It would be worth making a detailed validation of the skill of direct and downscaled outputs considering different areas in Spain and longer periods including different El Niño events.



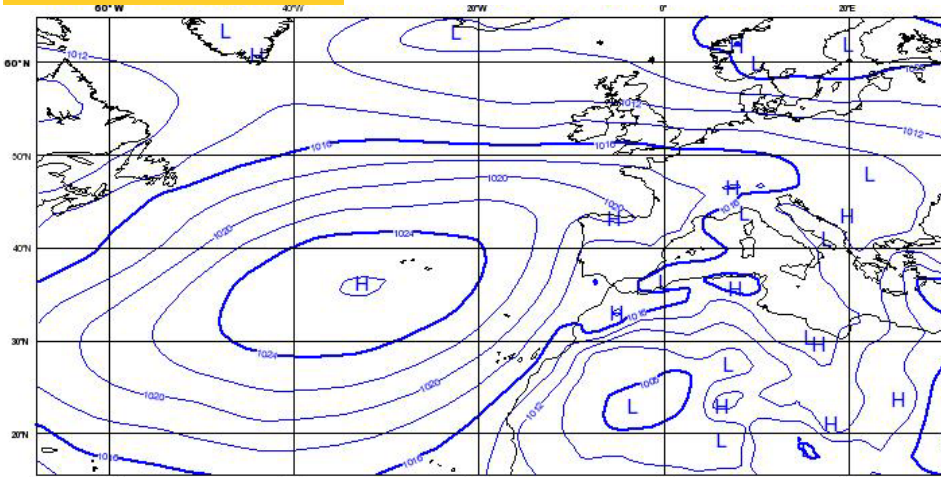
## INM contribution to the EU FP6 ENSEMBLES Project

- The main goals of INM contribution to the ENSEMBLES has been
  - Contribution to the development of a Web portal located in the U. Cantabria, where several statistical downscaling methods can be easily tested  
<http://www.meteo.unican.es/ensembles>
  - Expand to more years the Dynamical downscaling exercise undertaken in DEMETER taking as boundaries the outputs of ECMWF and UKMO
- Study of results still to be undertaken

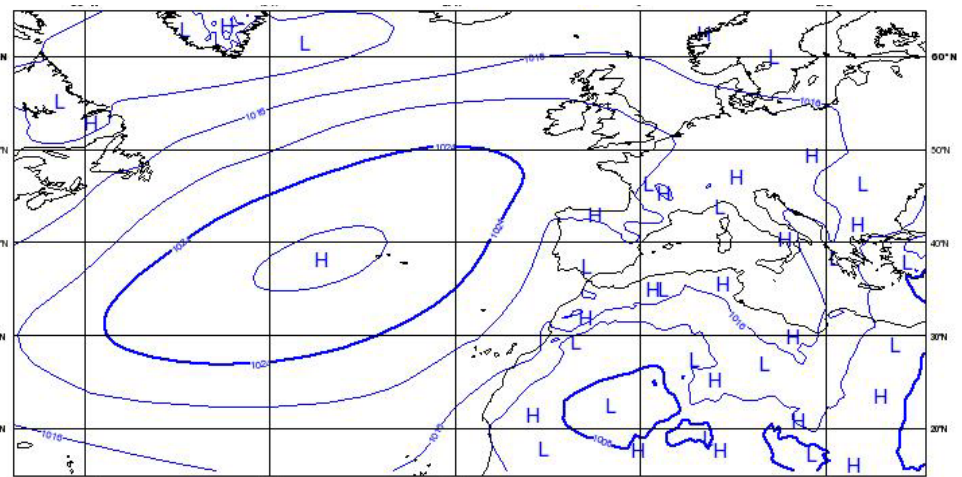




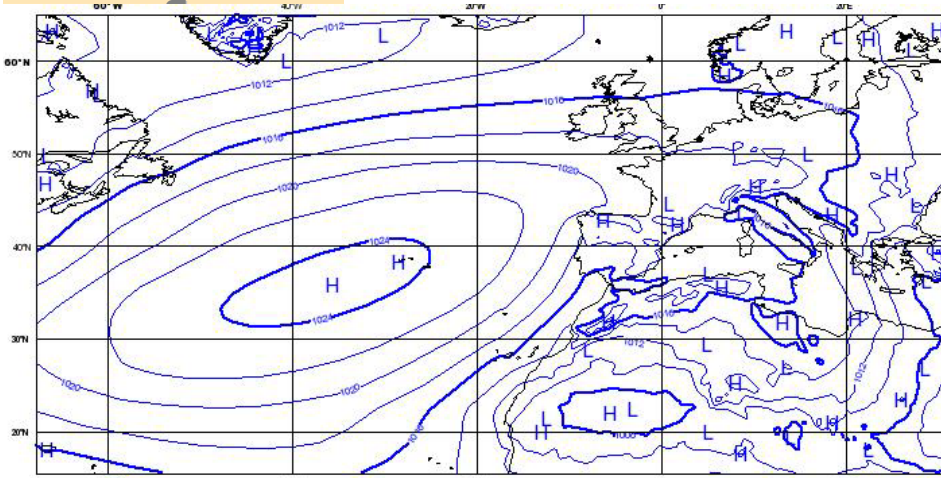
# ENSEMBLES PROJECT FORECAST: Mean Sea Level JJA 1998



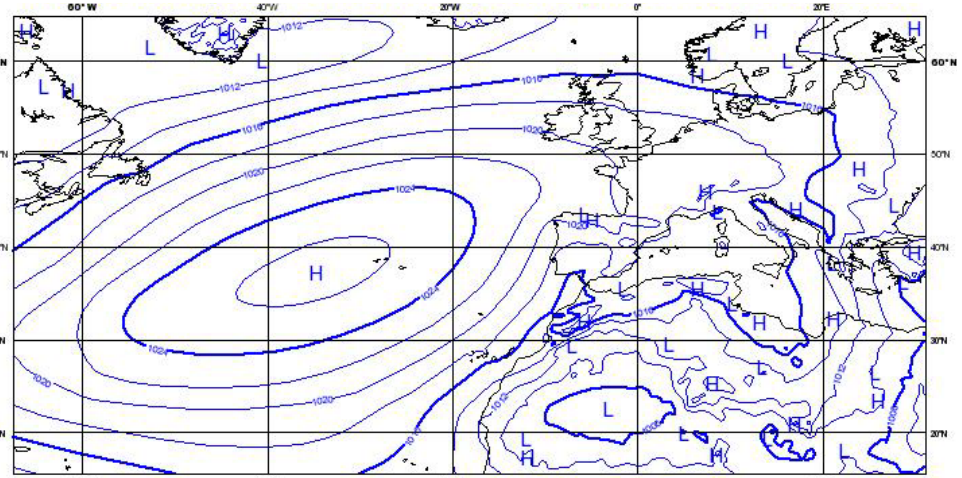
**ERA40**



**RCA-ECMWF, 1-lead time**



**RCA-UKMO, 1-lead time**



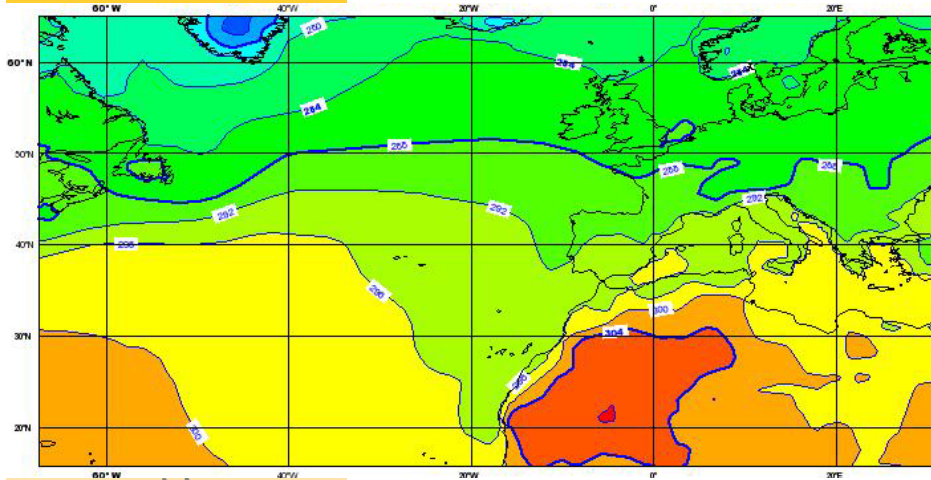
**RCA-EC+UK, 1-lead time**



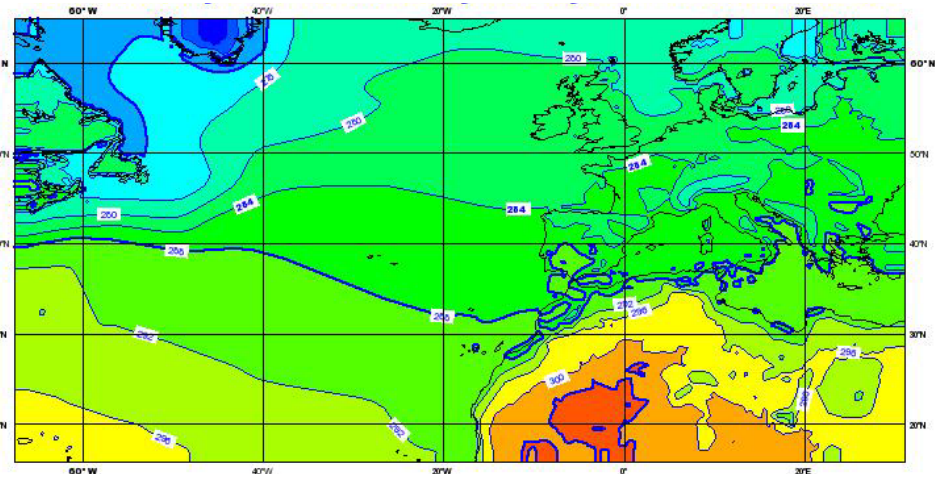
MINISTERIO DE MEDIO AMBIENTE

INSTITUTO NACIONAL DE METEOROLOGÍA

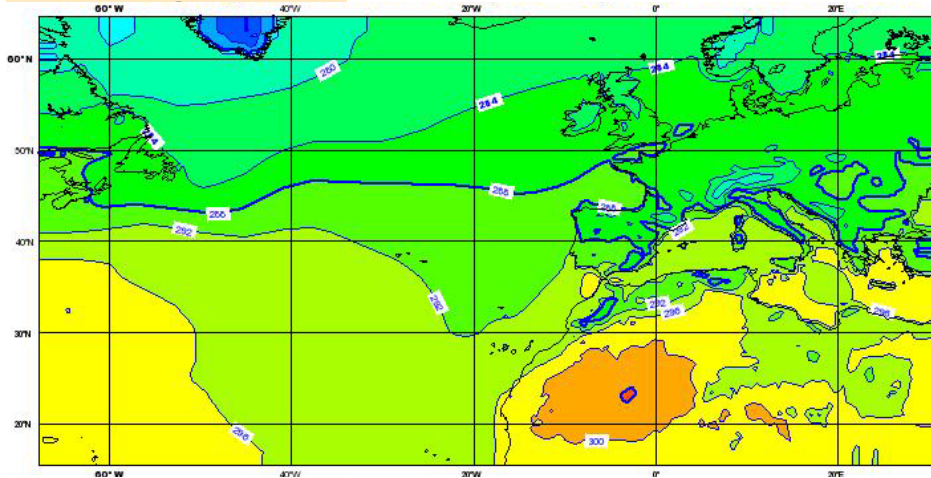
# ENSEMBLES PROJECT FORECAST: 2m TEMPERATURE JJA 1998



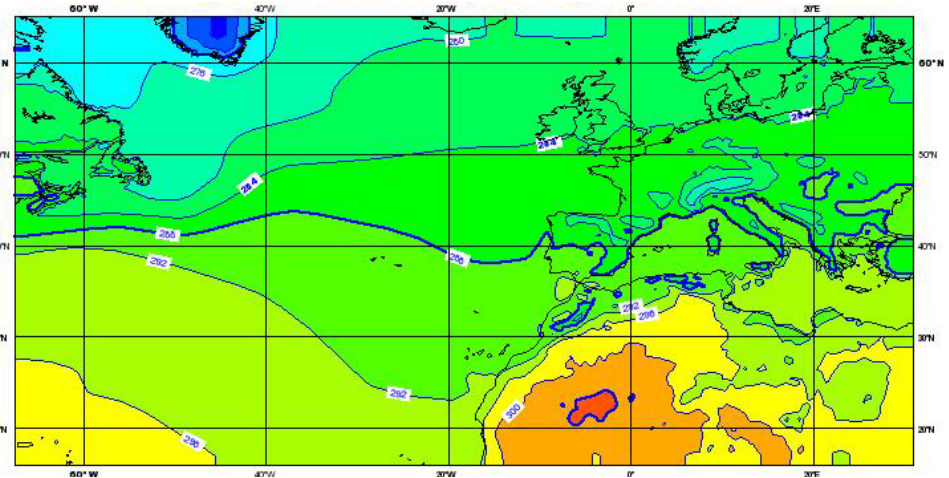
ERA40



RCA-ECMWF, 1-lead time



RCA+UKMO, 1-lead time



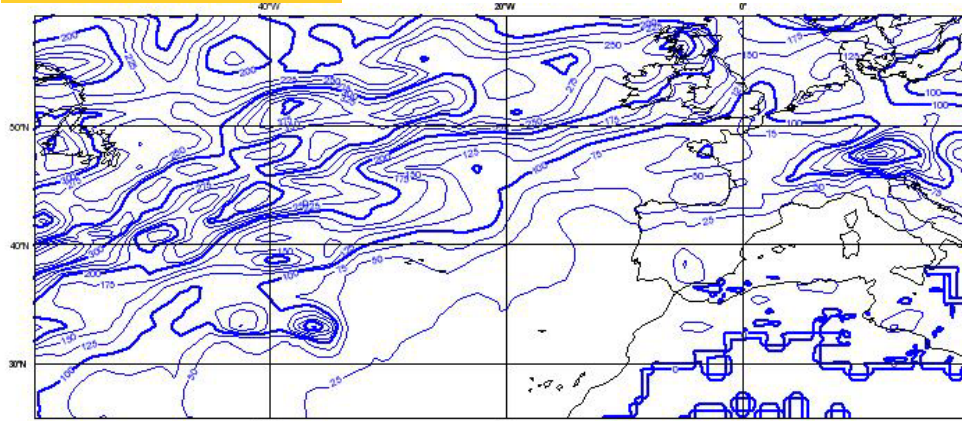
RCA-EC+UK, 1-lead time



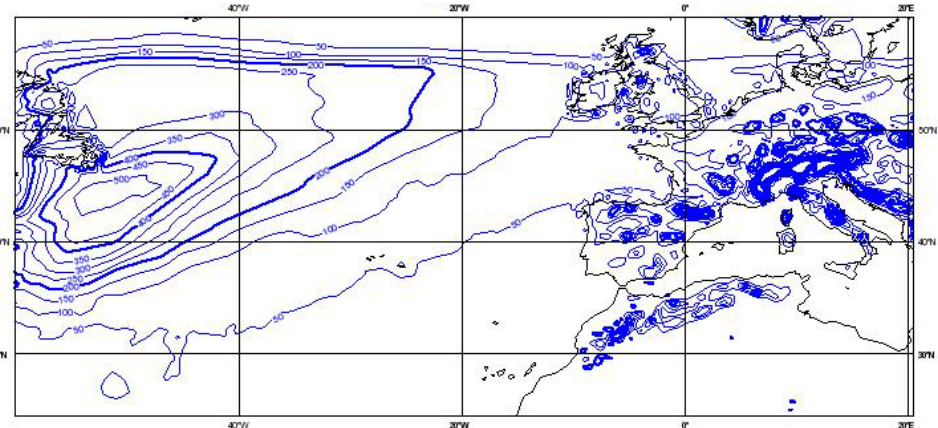
MINISTERIO DE MEDIO AMBIENTE

INSTITUTO NACIONAL DE METEOROLOGÍA

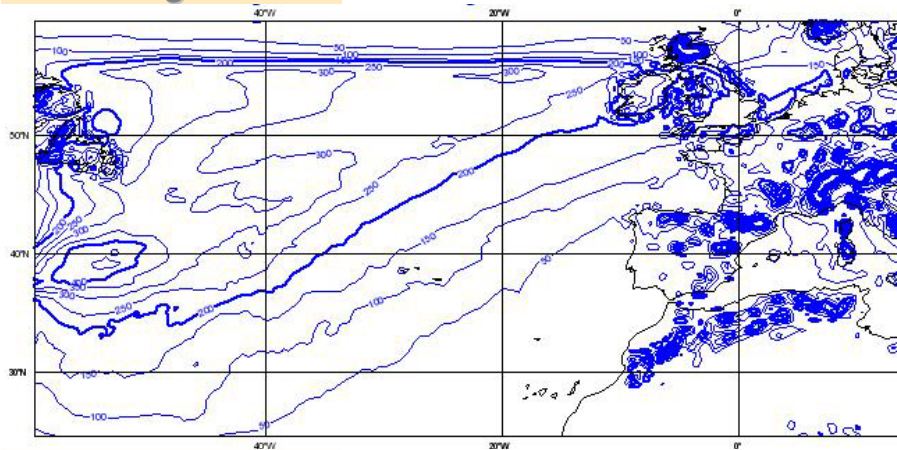
# ENSEMBLES PROJECT FORECAST: Precipitation JJA 1998



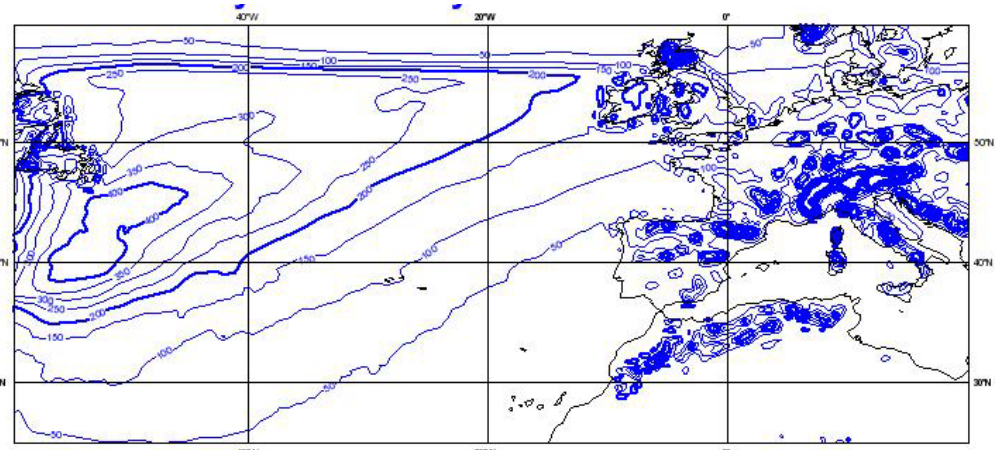
ERA40



RCA-ECMWF, 1-lead time



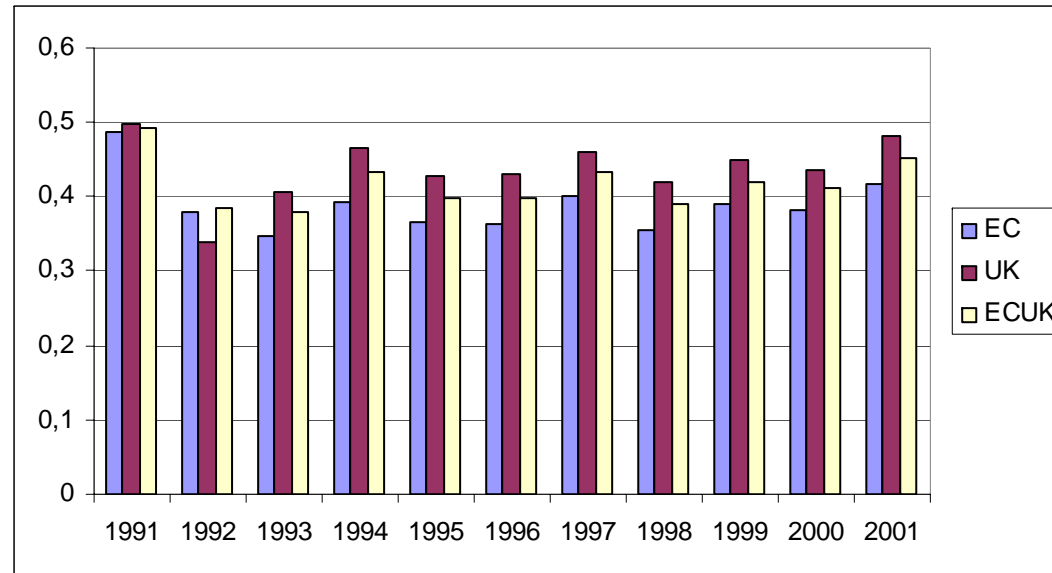
RCA-UKMO, 1-lead time



RCA-EC+UK, 1-lead time



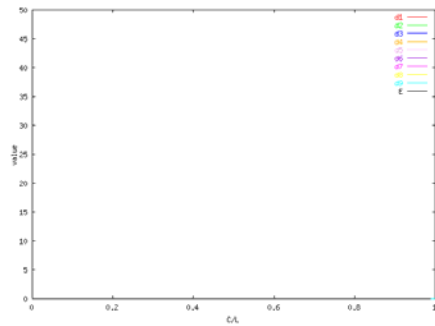
# VERIFICATION ENSEMBLES RCA



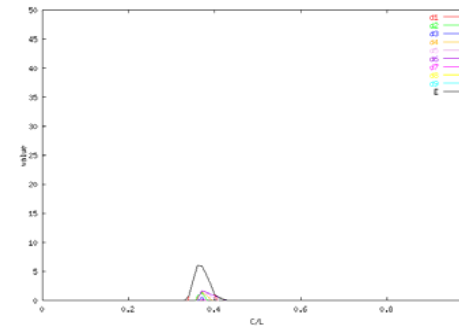
ACC 2m Temperature JJA



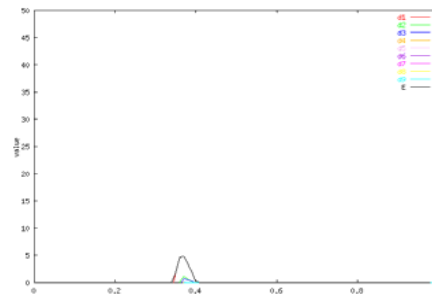
Roc Area over Spain November 1-month lead time (DJF)	Wet	Normal	Dry
ECMWF-RCA	0.47	0.47	0.50
UK-RCA	0.50	0.49	0.53
ECMWF+UK-RCA	0.50	0.48	0.53



Economic values over Spain for RCA-EC “dry” event, November 1-lead time (DJF)



Economic values over Spain for RCA-UK “dry” event, November 1-lead time (DJF)



Economic values over Spain for RCA-ECWF+UK “dry” event, November 1-lead time (DJF)



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## Experiment seasonal forecasts in INM is available

- Since 2004  
from the ECMWF System2 direct model  
output and the statistical downscaling  
ANALO
- Since March 2007  
from the ECMWF System 3 direct model  
output and the statistical downscaling  
ANALO
- Since May 2007  
from the dynamical downscaling with RCA  
and boundary conditions of the ECMWF  
System 3



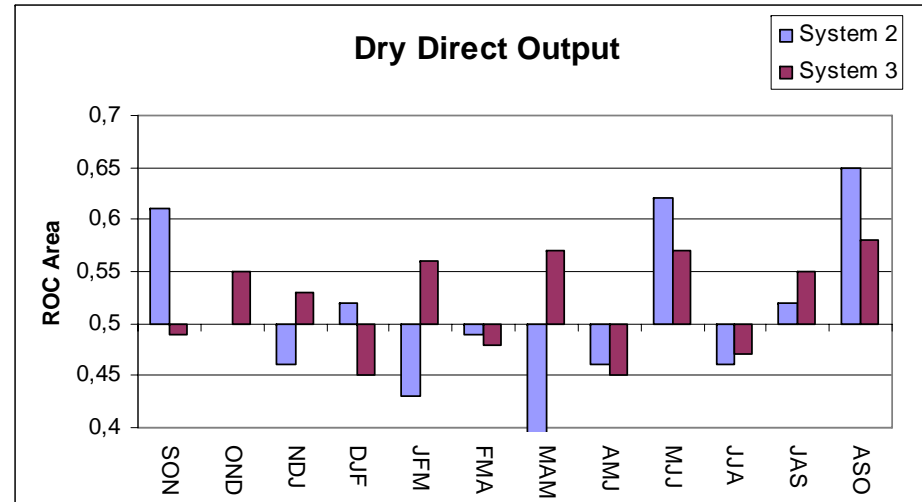
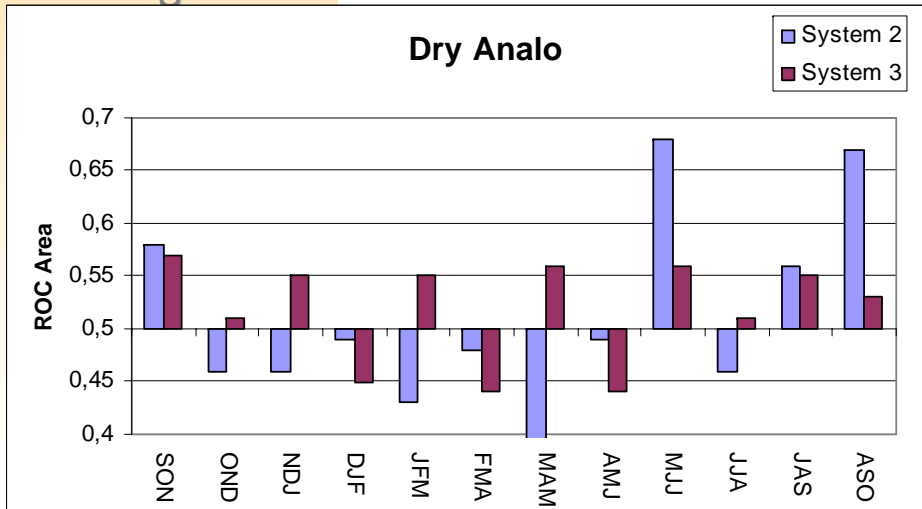
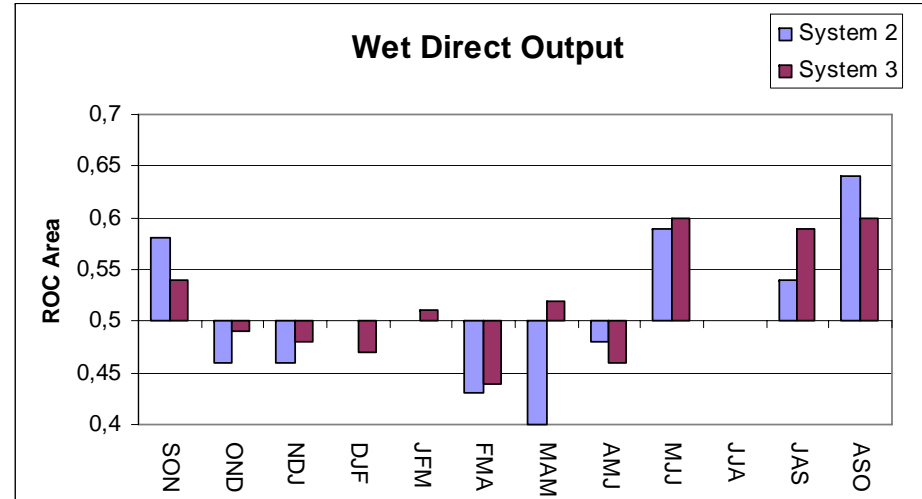
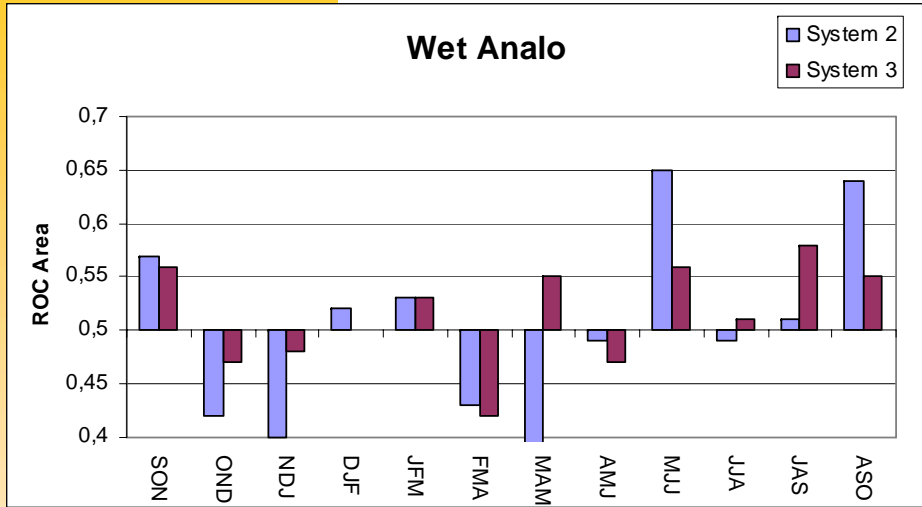
## Experiment seasonal forecasts in INM is available

- System 2 and ANALO
  - 15-year hindcasting (1984-2001) of 5 members and 40 forecasts
- System 3 and ANALO
  - 25-year hindcasting (1981-2005) of 11 members and 41 forecasts
- RCA
  - 25-year hindcasting (1981-2005) of 5 members and 11 forecasts



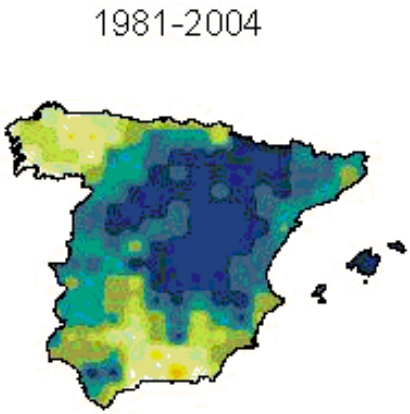
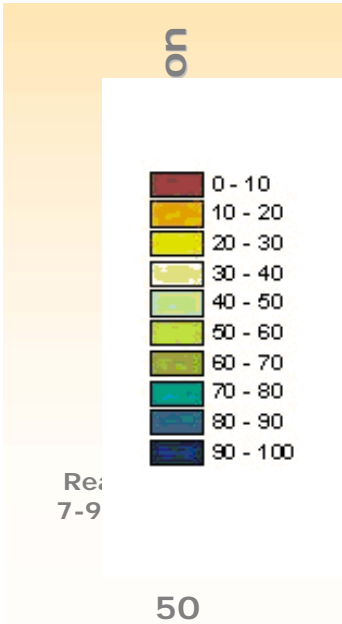


# System2 and System3 Probabilistic Forecast of Precipitation. ROC Skill Area Scores



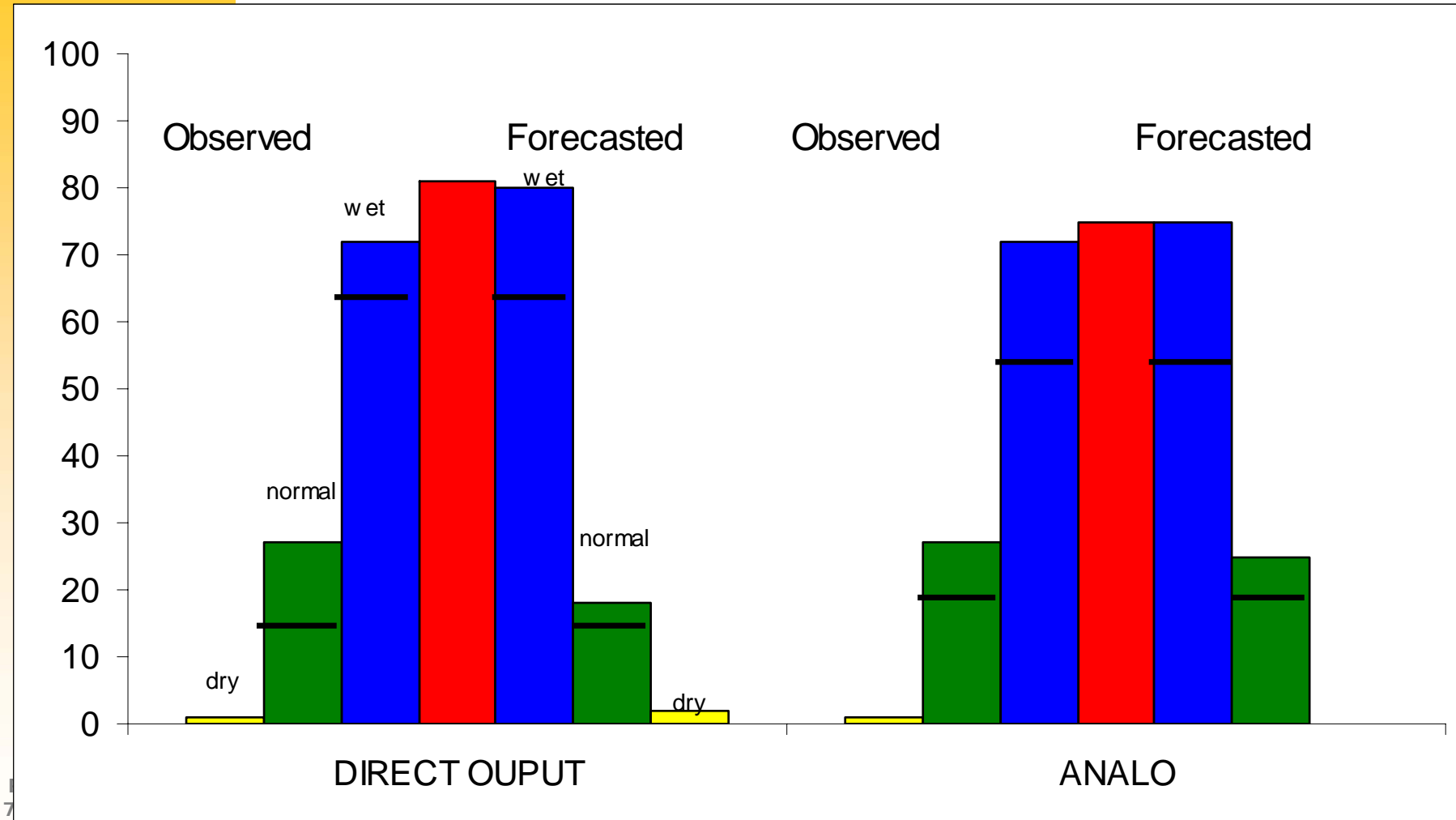
# Case of FMA 2007

Probabilities of Dry, Normal and Wet events, 1-lead time, ANALO





# Deterministic forecast FMA 2007 1-lead time



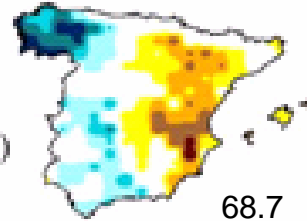


# Case of FMA 2007

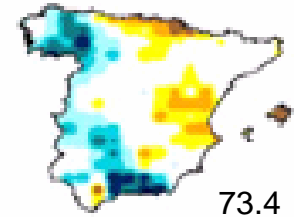
ANALO

DIRECT OUTPUT

Month Nov  
(Lead time 3)

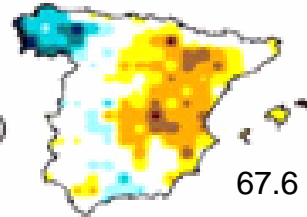


68.7

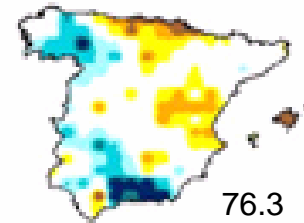


73.4

Month Dec  
(Lead time 2)



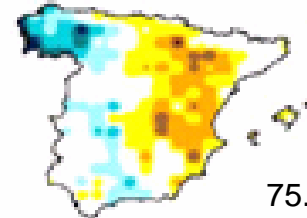
67.6



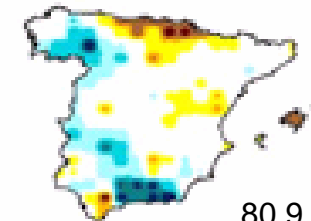
76.3



Month Jan  
(Lead time 1)

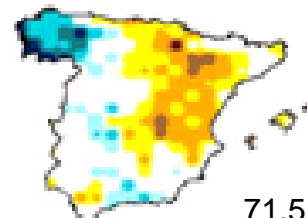


75.0

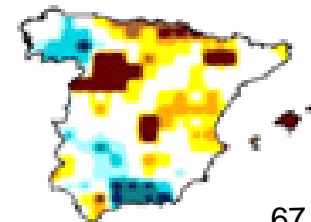


80.9

Month Feb  
(Lead time 0)



71.5



67.9



# OND(200709)

Precipitación acumulada  
downscaling estadístico



mm



Precipitación acumulada  
Salida Directa



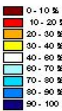
Anomalia  
downscaling estadístico



Anomalia  
Salida Directa



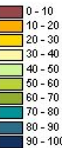
Probabilidad  
downscaling estadístico



Probabilidad  
Salida Directa



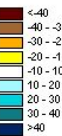
Percentiles  
downscaling estadístico



Percentiles  
Salida Directa



Anomalías percentiles  
downscaling estadístico



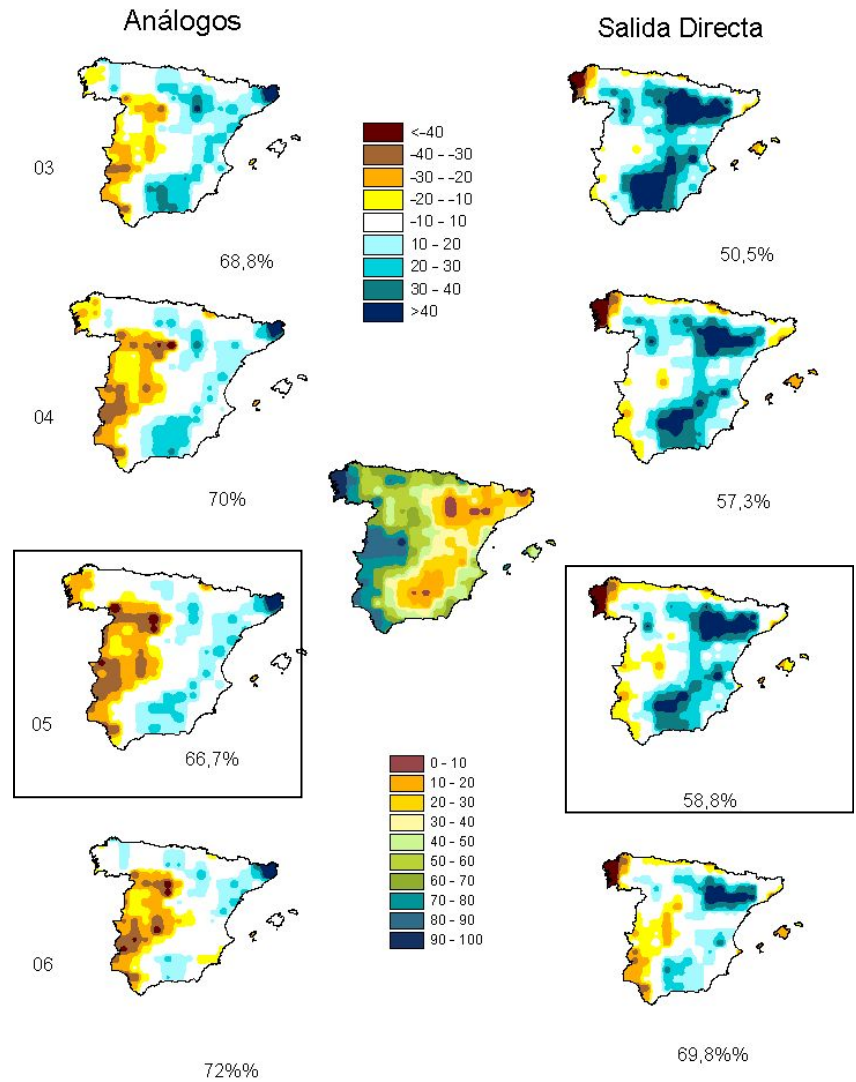
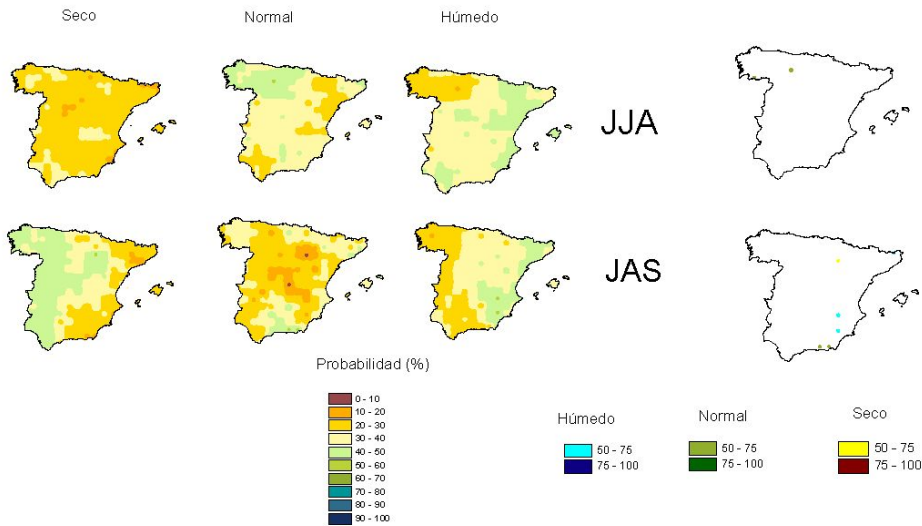
Anomalías percentiles  
Salida Directa





### Validación JJA 2007 con percentiles 1981-2004 Area entre (-20,20) system3

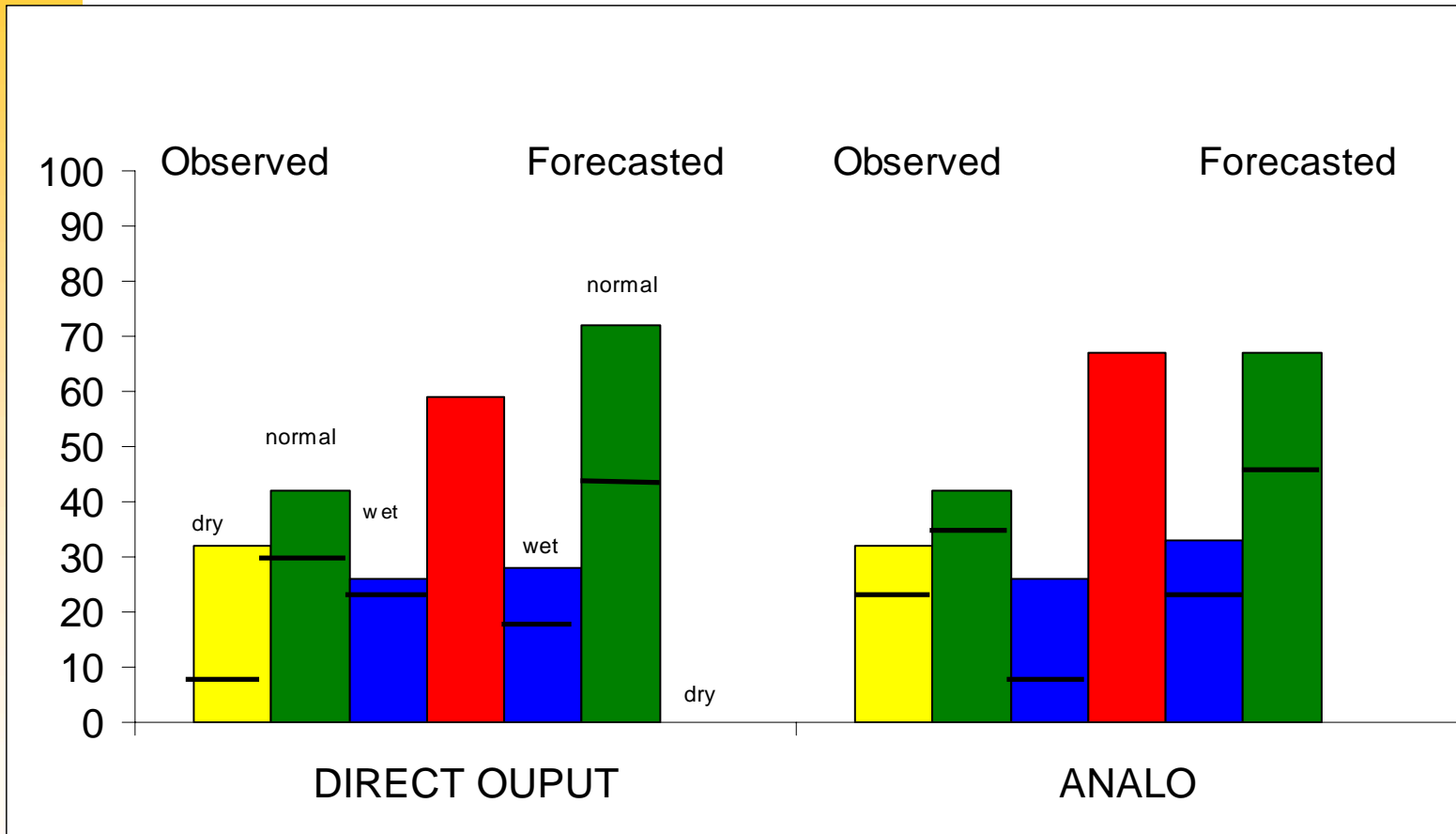
### Probabilidades seco-normal-húmedo 200705 Downscaling estadístico System3



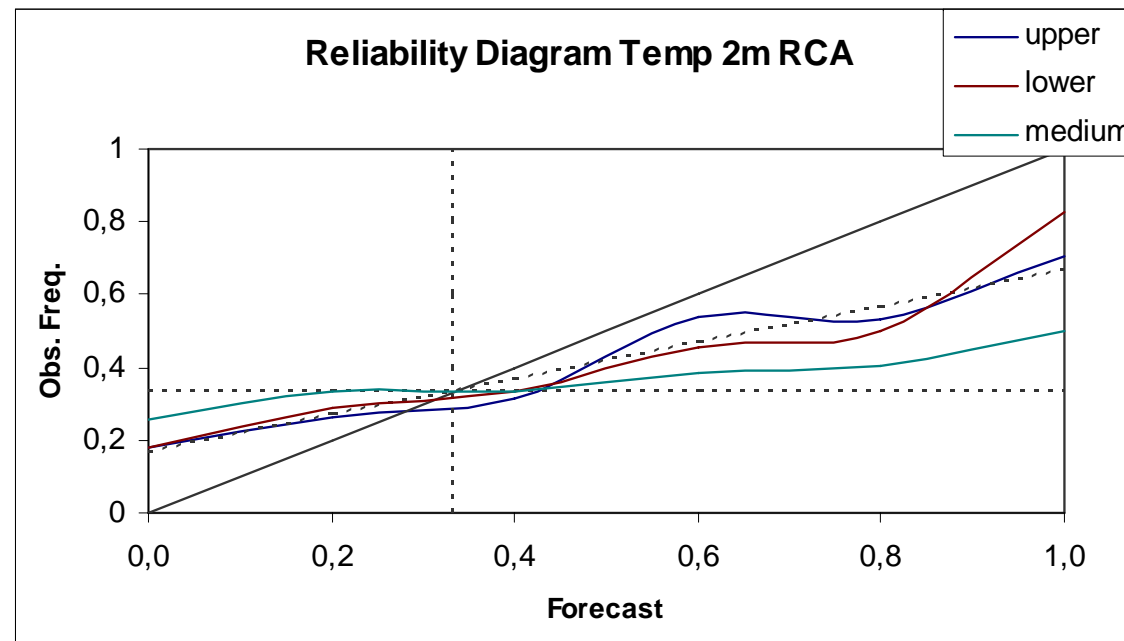
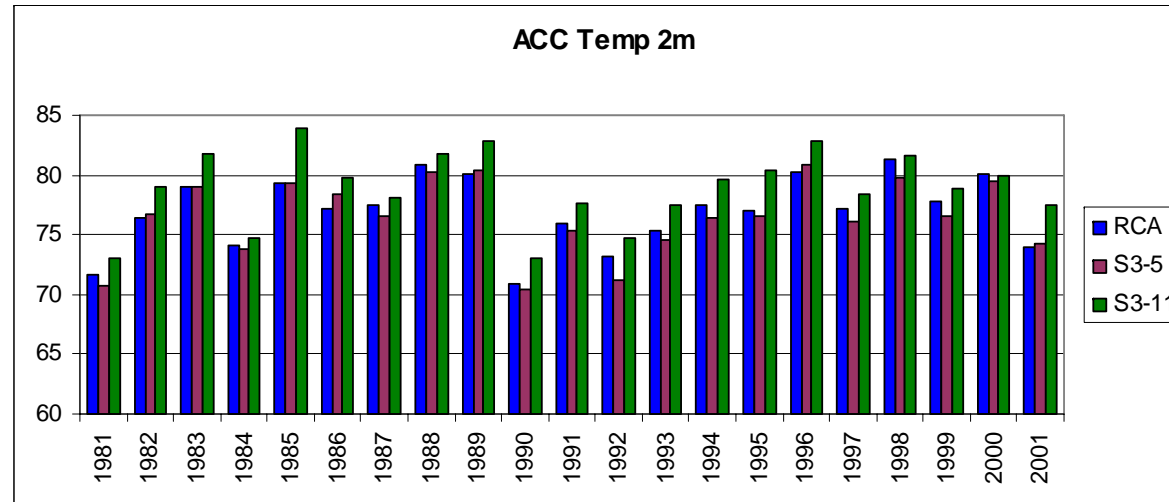
Reading (ECMWF),  
7-9 november 2007



# Deterministic forecast JJA 2007 1-lead time



# Verification of RCA and System 3 from the July run for ASO (1-lead time)

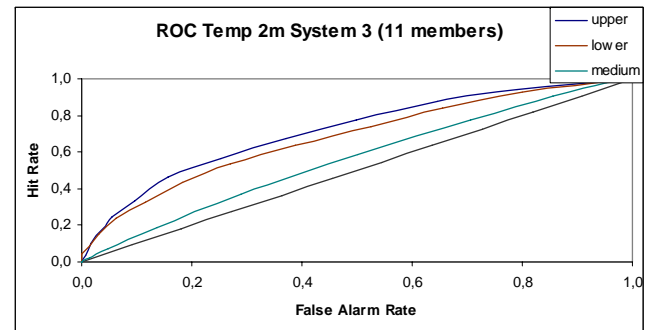
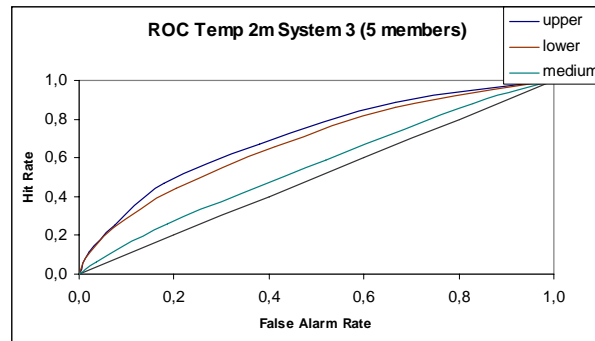
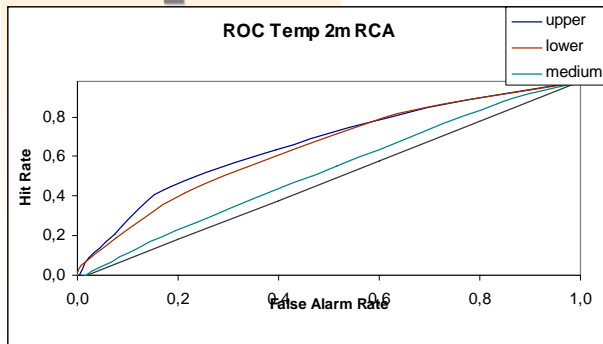
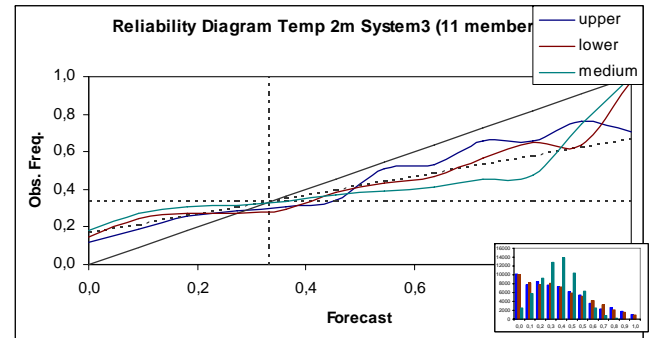
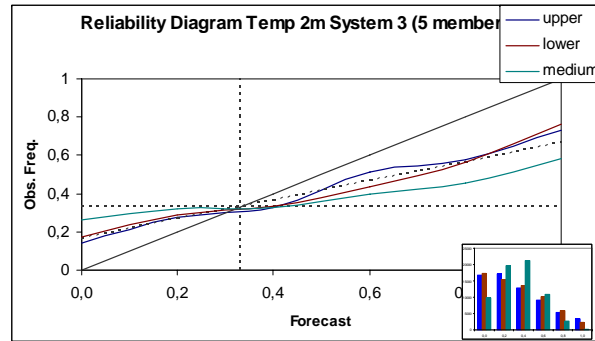
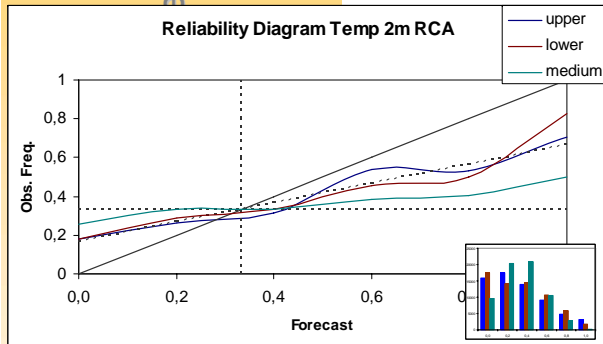
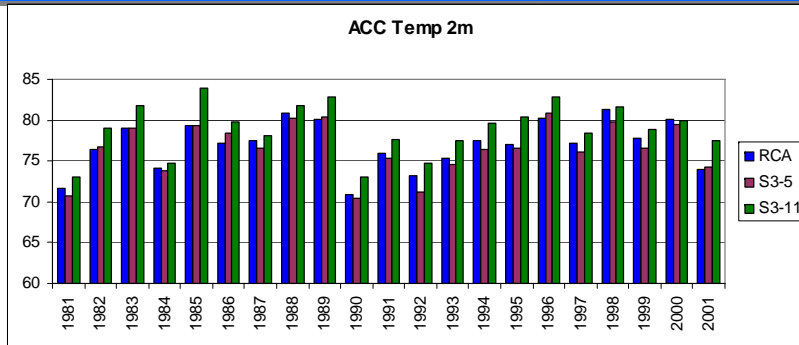






# Verification of RCA and System 3 from the July run for ASO (1-lead time)

Prediction





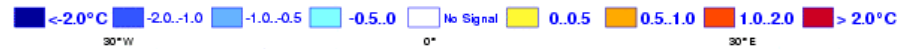
MINISTERIO DE MEDIO AMBIENTE

INSTITUTO NACIONAL DE METEOROLOGÍA

# SYSTEM 3-RCA DETERMINISTIC FORECAST

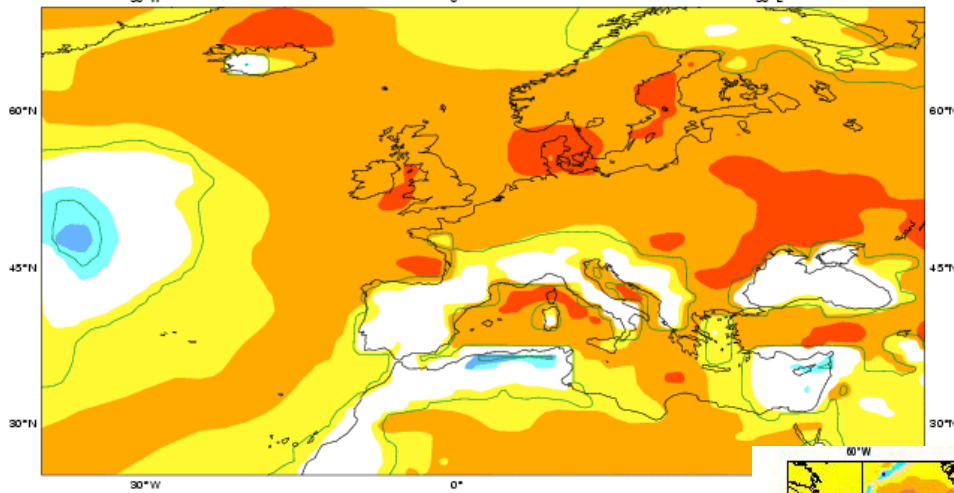
ECMWF Seasonal Forecast  
Mean 2m temperature anomaly

Forecast start reference is 01/05/07  
Ensemble size = 41, climate size = 275



System 3  
JJA 2007

Shaded areas significant at 10% level  
Solid contour at 1% level



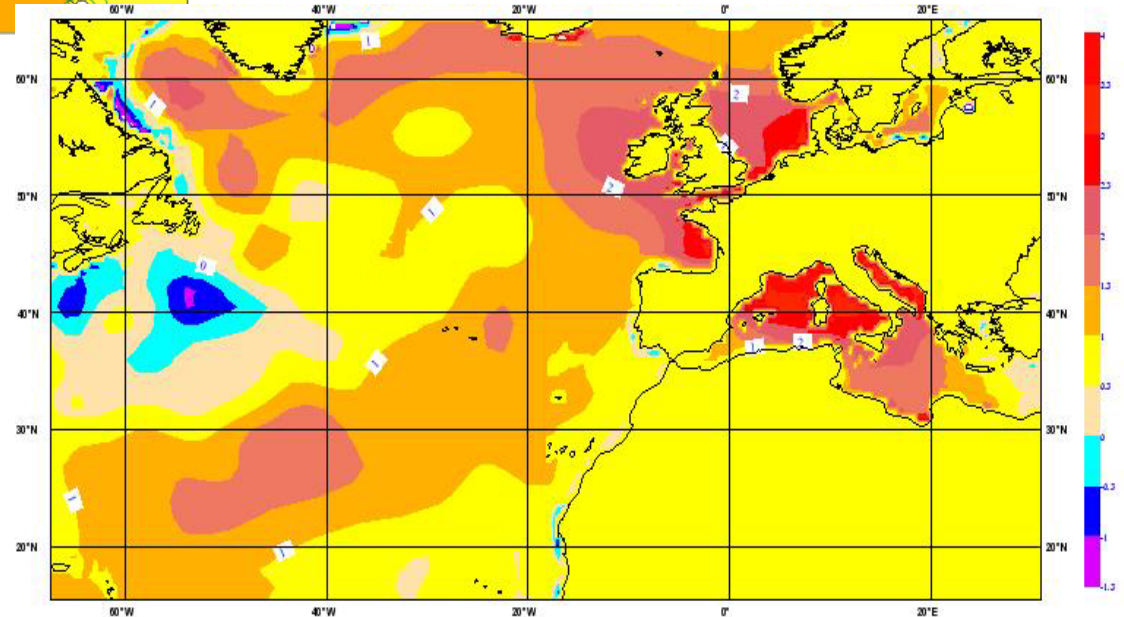
JJA 2007 1-lead time  
2m Temperature anomalies

Forecast issue date: 15/05/2007

Works

Reading (ECMWF),  
7-9 november 2007

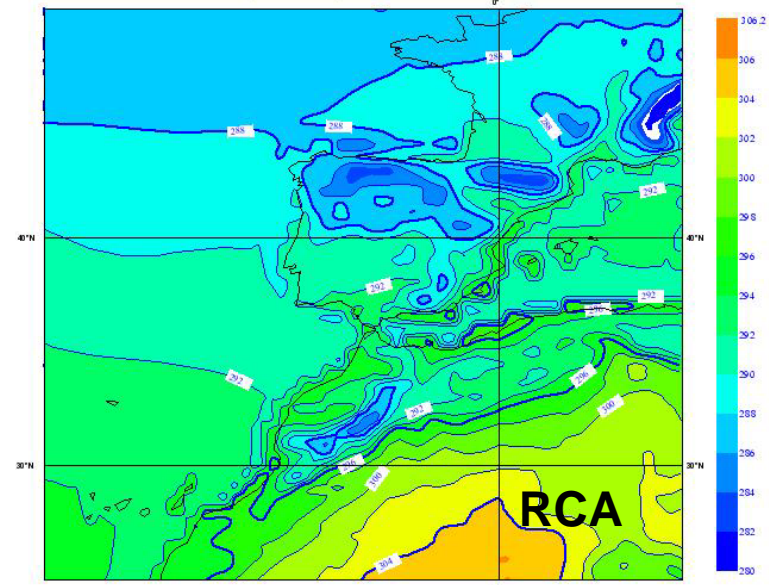
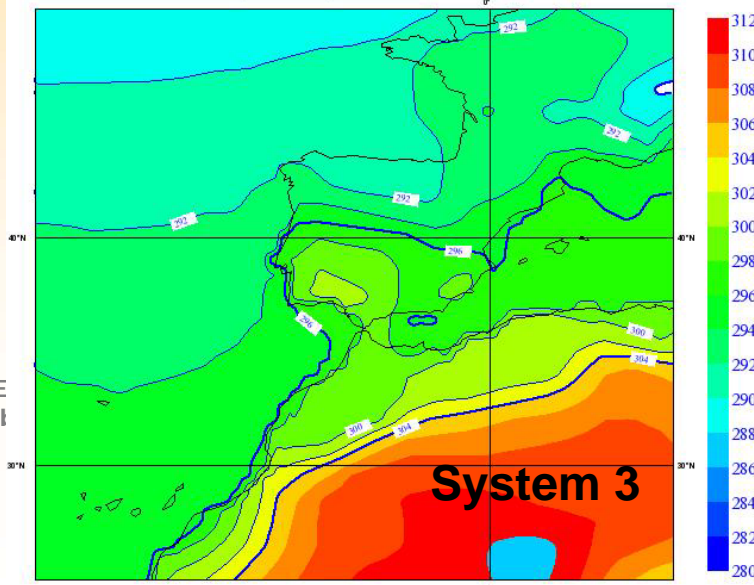
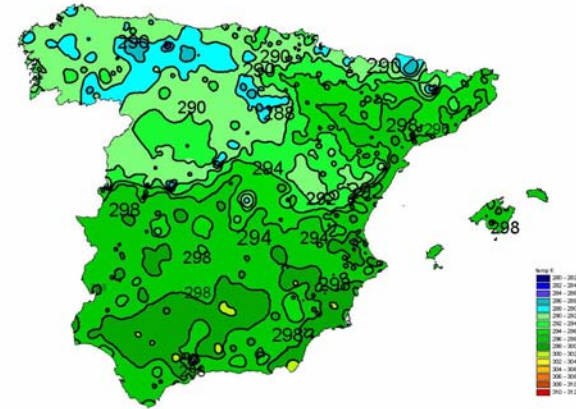
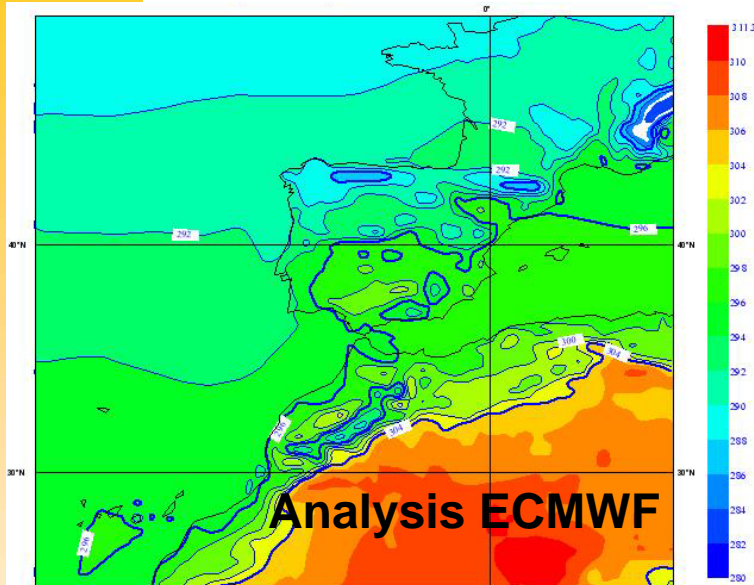
58





# May 2007, 1-lead time (JJA), 2m temperature

Workshop on Ensemble Prediction



Reading (E 7-9 noveml)



## CONCLUSIONS

- Overall, performance of System3 for 1-lead time probabilistic precipitation forecasts over Spain is slightly better than System 2 performance both for dry and wet events, and either when direct model or ANALO-ONE methods are used.
- A recent remarkable case of useful and lead time consistent deterministic forecast of precipitation over Spain, those verifying in FMA07 has been presented.
- Dynamical downscaling of the ECMWF System3 seasonal forecasts using the RCA model is affordable and has started in INM.
- Dynamical downscaling of ENSEMBLES global models using RCA as a LAM are already available.



## FURTHER WORK

- To add MF-RCA to the set of available ENSEMBLES dynamical outputs available
- To prepare statistical downscaling from the outputs of ENSEMBLES
- To take advantage of the Web portal in UC to progress in the study of results and improve operations with it.
- To apply statistical downscaling to the outputs of EUROSIP.
- To make global dynamical atmospheric downscaling experiments using the ECMWF IFS, taking as surface boundaries those of the ECMWF System3