Work on seasonal forecasting at INM: Dynamical downscaling of the ECMWF System 3 and of the global integrations of the EU ensembles project

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Summary

Some recent seasonal forecasting activities undertaken in INM are described. They cover INM participation in the EU DEMETER and ENSEMBLES projects and the implementation in INM of an experimental quasi- operational seasonal forecasting system. Ensembles of statistically and dynamically downscaled forecasts are built from ensembles of global seasonal forecasts. Both results and verifications of probabilistic and deterministic forecasts undertaken in the frame of these projects and systems are presented. The Rossby Centre Atmospheric Model (RCA) is the main tool for the regional dynamical downscaling. It allows expanding of downscaling made with analog methods, which are dependent on local observations to areas further afield than Iberia.

1. Introduction

Seasonal forecasting is an issue in Spain, due to the high spatial and temporal variability of some meteorological variables like precipitation. It is illustrated in Fig 1 and fig. 2. They show the evolution of the annual amount of precipitation in Spain from 1940 to 2006 (the character of precipitation in 2007 was very dry with an amount of 531mm), and the spatial distribution of rain during the last quarter of 2007, which was dry or very dry in most Spain, but significantly wet in the Valencia region in the East. Anticipating the character of the precipitation a season ahead is a necessity that currently cannot be satisfactorily achieved, but that has to be pursued.

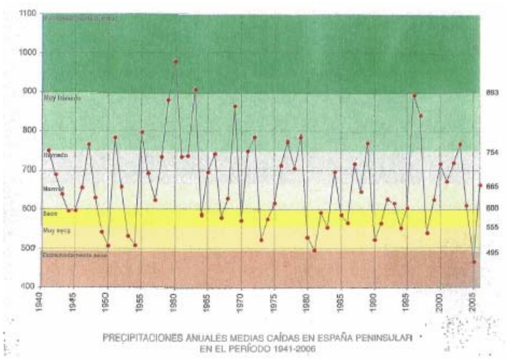

Figure 1: Mean annual precipitation in the Peninsular Spain 1941-2006, referred to the climatological period 1971-2000

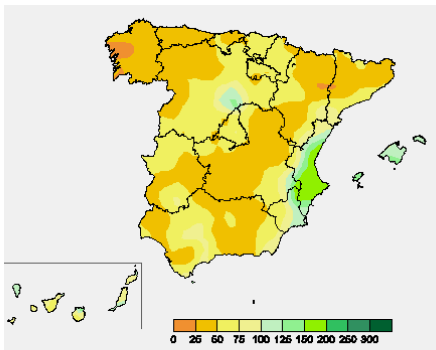

Figure 2: Spatial distribution of precipitation during the last quarter of 2007. Percentage of precipitation with respect to the climatology of this period.

INM activities in seasonal forecasting started in INM in mid-nineties. These activities were focused to the search for lagged correlations between Atlantic and Pacific SSTs and seasonal amounts of precipitation over the Spanish river basins. Participation in the DEMETER project (Palmer et al, 2004) was an important step forward in achieving expertise in the use of downscaling techniques. Section 2 deals with some general aspects of downscaling applied to the topics covered later. Section 3 describes the models used and the ensembles obtained from them. INM contributions to the EU DEMETER and ENSEMBLES projects and some of the results obtained are covered in Section 4. A description of the experimental quasi operational seasonal forecasting system implemented in INM covering examples and some verification results is presented in Section 5. A section of conclusions and another of further work to be done close this contribution.

2. General aspects

In order to make seasonal forecast outputs useful for different end-users, it is necessary to perform some form of downscaling process to the climate model output, either by some statistical empirical scheme or by nesting a high-resolution limited area model to the coarser resolution global climate model. Dynamical and statistical downscaling methods can be used in combination, not only as alternatives, obtaining the best skill scores in specific cases as the one presented in 4.1.2 below.

Statistical downscaling methods work by mapping one or more large-scale fields from a reanalysis project to the simultaneous records of fine scale observations required by applications models. Among the many useful statistical techniques a local downscaling algorithm, the method of analogues, has been used in INM. Different relationships between model outputs and fine-scale variables are locally established considering daily neighborhoods of patterns in the reanalysis database (see a more detailed description in 4.1.1).

Dynamical downscaling models work by nesting a high resolution model to the GCM in areas of interest. These methods do not require local observed data and have the potential to outperform statistical methods, particularly regarding the prediction of extreme events.

Ensembles prediction systems provide both probabilistic and deterministic seasonal forecasts (for instance, the mean of the ensemble is usually considered a deterministic forecast). When the prediction is spatially extended over a network, or mesh, of stations, then a deterministic precipitation forecast can be displayed as a map of accumulated precipitation, a map of anomalies or a map of terciles reflecting the dry/normal/wet character of the season. Validation can be performed by comparing the seasonal forecasts with the accumulated precipitation observed at each station, obtaining maps of errors, or maps of percentiles by which the precipitation and observation differ, regarding the climatology. The percentage of Spanish area below a certain error or with a difference of percentile less than a certain amount (typically one quintile, i.e. 20 percentiles) is useful to estimate the overall quality of the forecast over Spain.

To represent the spatial and overall performance of these methods, different scatter diagrams, plots, and maps of precipitation over Spain have been used. Moreover, standard validation techniques, such as ROC Skill Area (RSA) and economic value curves, have been used to compare different deterministic and probabilistic forecasts.

The spatial and temporal variability of precipitation in Spain can only be appropriately characterized using a high resolution network. The INM network has about 4000 stations. For the purpose of statistical downscaling and validation of the seasonal forecasts their data are interpolated to a 203 point mesh. Fig. 3 displays both the network and the mesh, jointly with the 0.5º grid resolution used by the dynamical downscaling model.

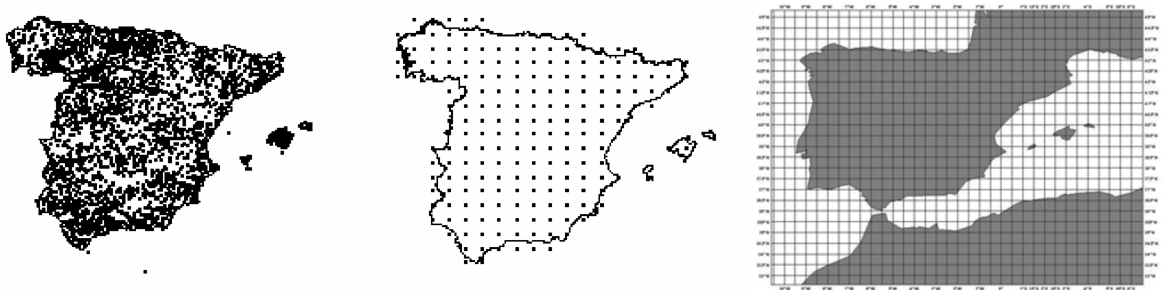

Figure 3: From left to right, pluviometric network, 203-point mesh and 0.5_grid resolutions of the regional RCA model over the Iberian peninsula, respectively.

3. Models used and ensembles built

INM activities in seasonal forecasting have included its participation in the EU research projects DEMETER and ENSEMBLES and the preparation of monthly experimental seasonal forecasts from the ECMWF System 2 and System 3. This has been done by use of direct model outputs from these systems and by adapting and running downscaling methods both dynamical and statistical. Table 1 summarizes the different ensembles built from the dynamical global or regional models for each of these projects and systems. The global models are the ECMWF and UKMO, the regional atmospheric model is the Rossby Centre atmospheric model, RCA, nested to both global models. Number 1 in the table corresponds to direct model outputs; Number 2 indicates that, in addition, an ensemble of analogues have been computed from the dynamical models.

	DEMETER	ENSEMBLES	SYSTEM 2	SYSTEM 3
ECMWF	2	1	2	2
UKMO	2	1		
ECMWF-RCA	2	1		1
UKMO-RCA		1		

Table 1: See explanation in the text.

3.1. Characteristics of the RCA model

Two versions of the Rossby Centre regional climate model have been used. Version 2 (Rummukainen M. et al, 2001) was used in the DEMETER project, and version 3 in the ENSEMBLES project and System 3. They were implemented with 31 and 40 levels respectively in the vertical, and with a horizontal resolution of 0.5º. The area is the European Atlantic domain (15.5ºN-65.0ºN and 67.0ºW-31.0ºE).

3.2. Characteristics of the ECMWF global model

Two versions of the AOGCM have been used. For the IFS atmospheric component they differ in the number of vertical levels and the cycle: 40 levels and CY29r1 for DEMETER and System 2, and 62 levels and CY31r1 for ENSEMBLES (stream 2) and System 3. Horizontal resolution has been the corresponding to T95 for both versions. For the ocean component the model used has been HOPE-E with horizontal resolution: 1.4º x 0.3º - 1.4º and 29 levels. The frequency of coupling is 1 day.

3.3. Characteristics of the UKMO global model

The atmospheric component of the coupled model is HadAM3. The horizontal resolution is 2.75º latitude by 3.75º longitude. The number of vertical levels is 19. The Ocean component is GloSea based on HadCM3 with horizontal resolution: 1.25º x 0.3º - 1.25º and 40 levels. The frequency of coupling is 1 day.

3.4. Characteristics of the ANALO Statistical downscaling method used.

The method used, 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 and UKMO models. In the first step, one hundred analogues are obtained using information from geopotential; afterwards, the analogue ensemble is lowered down to 30 members using information from the humidity fields. This method is currently used operationally for short-range precipitation forecast (Fernández et al., 2001) in Spain. The empirical Probability Density Function (PDF) given by the ensemble of analogues provides a probabilistic forecast for any event of interest. Moreover, this function is also the key for obtaining a numeric forecast, such as the weighted mean, or a given percentile. The estimation based on the weighted mean is shown to underestimate the observed values. A skill oriented procedure was conducted to obtain the optimal percentile for each of the stations, based on the whole ERA-40 results. The obtained percentile was close to 75 in most pluviometric stations, so this value is used as consensus estimation for the accumulated precipitation from the ensemble of analogues.

When applied to an ensemble forecasting system, the method of analogues can be used in probabilistic mode (considering the joint PDF obtained by combining the analog sets for each of the ensemble members), or in deterministic mode (considering the percentile 75 estimation of the set of analogues for each of the ensemble members). In this last case, the result is an ensemble of numerical forecasts and can also be validated using RSA and economic values.

Table 2 presents the time projections and starting months of the runs for the different integrations. Table 3 presents the size of the forecast and hindcast ensembles including the cases when ANALO has been used.

	DEMETER Feb, May, Aug, Nov	ENSEMBLES May, Nov	SYSTEM 2 monthly	SYSTEM 3 monthly
ECMWF	6 months	6 months	6 months	7 months
UKMO	6 months	6 months		
ECMWF-RCA	6 months (May, Nov)	6 months		5 months
UKMO-RCA		6 months		

Table 2: Time projections and starting months of the runs.

DYNAMICAL	DEMETER	ENSEMBLES	SYSTEM 2	SYSTEM 3
ECMWF	9/12	9/11	40/15*5	41/25*11
UKMO	9/12	9/11		
ECMWF-RCA	3/3 may, ¾ nov	9/11		11/25*5
KMO-RCA		9/11		

STATISTICAL WITH ANALO	DEMETER	SYSTEM 2	SYSTEM 3
ECMWF	9/12	40/15*5	41/25*11
UKMO	9/12		
ECMWF-RCA	3/3 may, ¾ nov		

Table 3: Number of members and size of the hindcasts

4. INM participation in the EU DEMETER and ENSEMBLES projects

4.1. Goals and results of INM contribution to DEMETER

The main goal of INM contribution to DEMETER was exploring the skill of seasonal forecasts of precipitation over Spain (Diez et al, 2005), and assessing the feasibility of statistical and dynamical downscaling techniques applied to global direct model outputs to gain detail in the precipitation forecasts. Both statistical methods and regional dynamical climate models are tested and compared. The statistical method ANALO is a particular implementation of the standard analogue technique based on close neighbours of the predicted atmospheric geopotential and humidity patterns. This method is applied to the outputs of the ECMWF and the UKMO DEMETER models (nine + nine ensemble members) for the period 1986-1997; the resulting precipitation downscaled forecasts were compared with the direct outputs, and the skill for each season computed. On the other hand, dynamical downscaling was performed using the Rossby

Centre Climate Atmospheric model (RCA), which is nested to the ECMWF model output, and run in climate mode for six months. Due to the computational cost, only a limited number of regional experiments to test the skill of dynamical downscaling methods could be performed. In particular, a 0.5º resolution RCA model with a 3-member ensemble during the period 1986-89 was run. These experiments allowed for an overall comparison of the two direct model outputs (global and regional) and the statistical method for this period.

4.1.1. Comparison of probabilistic forecasts from the ECMWF Global model and of the ANALO method when applied to those forecast outputs: Overall performance

The overall performance of the statistical downscaling method when applied to the DEMETER data in seasonal mode is shown in Fig. 4. Ensembles of 18 members for 180-day integrations combining the ECMWF and the UKMO DEMETER models (ECMO) during the 1986-1997 period are considered. This figure shows the RSA values obtained from the direct ensemble output versus the RSA values obtained from the corresponding downscaled forecasts (using the percentile 75 as estimator). Results for different lead times are reported on different panels, from a 0-month lead time (seasons NDJ, FMA, MJJ, ASO) to a 3-moth lead time (in this last case the seasons coincide with those of the 0 month lead time, so the influence of lead time in four different seasons can be compared). In all cases, results for wet, normal and dry seasons are shown separately (according to the observed climatological terciles of the grid points for the period of analysis). From these figures it can be shown that, as the skill of the direct output increases, the statistical downscaling method outperforms the direct output of the models (note that, in those cases where the model skill is poor, the downscaling method is not expected to improve the forecast, since it introduces an additional source of uncertainty). These figures show that, when considering the 1986-1997 period and the whole area of Spain, the highest skills (above 0.6) are associated with early and late spring, summer and autumn seasons at 0 and 1 month lead times. On the other hand, winter season exhibits a poor performance. Overall, no season and no lead time exceed the RSA 0.65 for this period of 11 yr, as could be expected in this mid-latitude region.

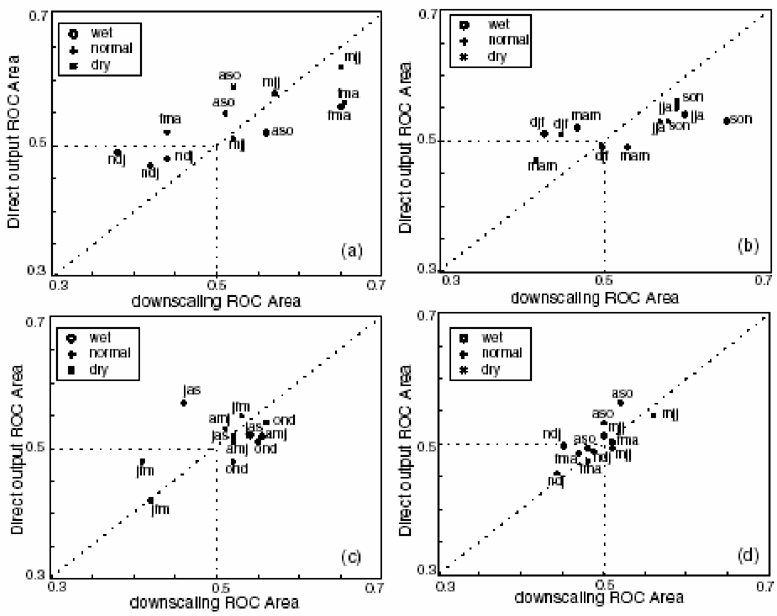

Figure 4: RSAs of the probabilistic forecasts at the 203 grid points of Fig. 3 stations for each of the 21 seasonal forecasts started in November, February, May and August and all the years overall. (a)-(d) correspond to the lead times 0-3.

However, the skill of the method can be higher in particular periods, at least in some regions of Spain. For instance, Fig. 5 shows the comparison of the direct output and the downscaled values for a particular El Niño period (1986-1988) in the south of Spain. This figure shows a clear division between normal events (with poor performance) and wet and dry periods, with high RSA values (in the range 0.7-0.85) for all seasons. This is not surprising, because dry precipitation anomalies have been found in Spain in connection with El Niño events (Rodo et al., 1997). The high skill found in this period for the winter season is also remarkable, as opposed to the poor performance found in the previous general case. Moreover, the downscaling method outperforms the direct ensemble output in all cases with significant skill.

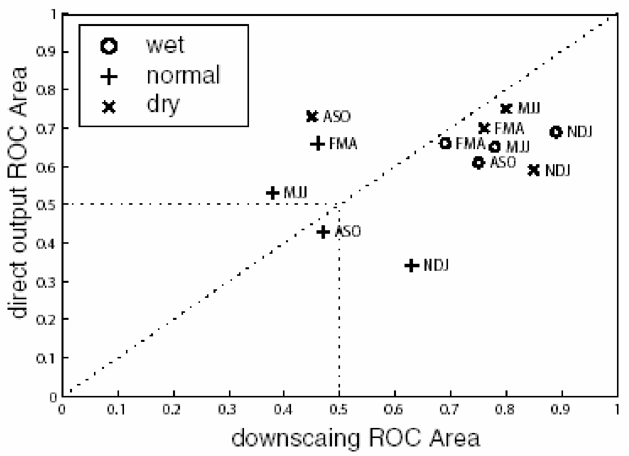

Figure 5: ROC area for the four zero-month lead time seasons (NDJ, FMA, MJJ, ASO) for the south of Spain and the period November 1986 to October 1988 (including an active El Niño period).

4.1.2. The November-January 1986/87 and 1987/88 Case during an El Niño Event

In this section we present comparative results of the statistical and dynamical techniques for one specific case. It corresponds to the November-January quarters of 1986/87 and 1987/88 during one ‘El Niño’ event. The following four deterministic ensembles precipitation forecasts are compared: The 18-member joint ECMWF/UKMO direct model outputs, ECMO; the three-member RCA direct model output, RCA; and the ANALO downscaled forecasts both from the joint ECMO and from the RCA model, ECMO ANALO and RCA ANALO respectively. Fig. 6 shows a bar diagram for the join period NDJ1986/87 and NDJ1987/88 and for the outputs corresponding to ECMO, ECMO ANALO, RCA and RCA ANALO. In each of the four panels the first three bars from left to right correspond to the percentage of grid points where the character of the precipitation has been dry, normal and wet (given by the terciles of the 1961-90 series). The horizontal black lines inside the bars indicate the percentage of those grid points where the forecast is less than 20 percentiles away from the observation (i.e., like a hit rate conditioned to the wet/normal/dry observed character). On the other hand, the first three bars from right to left correspond to the percentage of grid points where the forecasted precipitation has been dry, normal and wet, respectively; in this case, the horizontal black lines indicate the percentage of grid points where the observation was less than 20 percentiles away from the prediction. A summary measure of the overall quality of the forecast is given by the height of the central bar (the black one) which shows the percentage of points where the observation and prediction differ less than 20 percentiles (note that this value is the sum of the horizontal black lines either on the left or on the right of the central bar). Therefore, the bars on the left and on the right of the figure allow us to compare observed and forecasted dry/normal/wet areas.

In this case the best forecast is achieved with the ECMO ANALO, which agrees with the observations in 59% of the Spanish area. However, note that for this specific case the deterministic forecast RCA and RCA ANALO performs better than ECMO. In order to check the significance of the above forecasts, Fig. 7 displays the same diagram for the period 1986-97 for the ECMO model. In this case, the performance of the method decreases and both the direct output and the analogue downscaling exhibit similar performance.

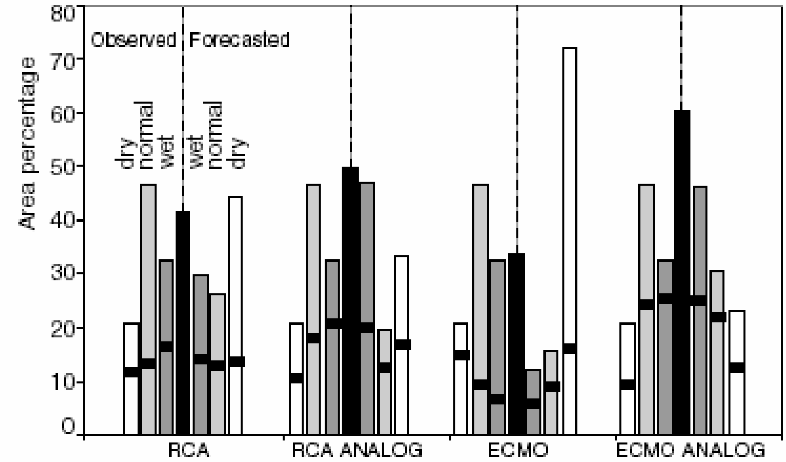

Figure 6: Bar diagram of area percentages for the period NDJ 1986/1987 and 1987/1988 for the methods ECMO (18 ensemble members) and RCA (three ensemble members) together with the analogue versions.

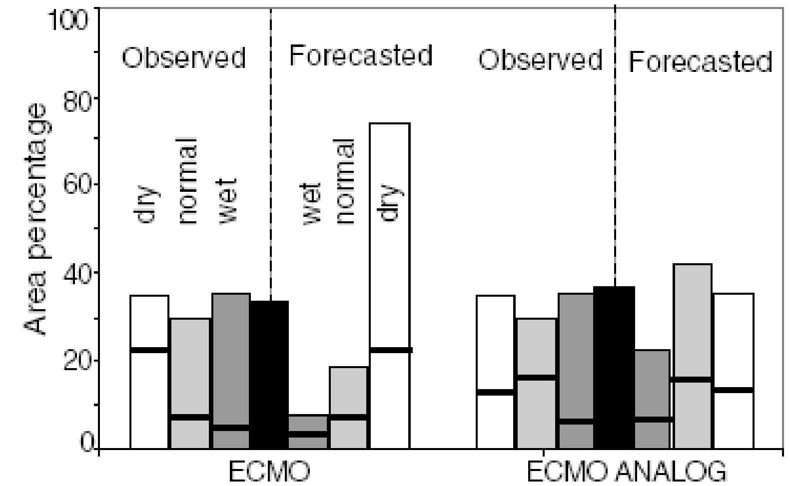

Figure 7: Bar diagram of area percentages for NDJ 1986-1997 for the methods ECMO18 (18 ensemble members) and the analogue versions.

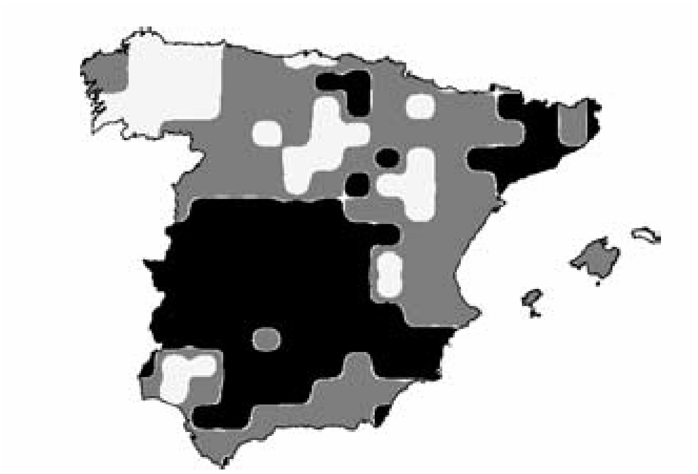

Figure 8: Regions of Spain (interpolated from the 203 mesh) where the difference between the observations and forecast differ less than 20 percentiles in two (black), one (dark grey) and zero (light grey) cases out of the two NDJ seasons for the ECMO18AN in the period 1986-1987.

Fig. 8 shows the regions of Spain where the forecast is more accurate. For the two seasons NDJ 1986/87, 1987/88 the percentile criterion was applied to the 203-point mesh; differences between predictions and observations smaller than 20 percentiles were considered right. The map shows the regions with two right forecasts (black), one (dark grey) and zero (light grey). This figure shows that the Southern region of Spain is more skilful during this El Niño period.

In order to check the performance of the different downscaling techniques when considering a probabilistic framework, Fig. 9 displays the economical values of the probabilistic forecasts obtained with the different downscaling models for the period (note that now the ensemble PDFs are used as forecasts, instead of means or percentiles obtained from this distribution. It shows that the economical value corresponding to the two ensemble forecasts from ECMO with 18 members presents a higher peak and a wider range of the C/L than the corresponding to the two ensembles from RCA3 with only 3 members.

ECMO ANALO forecast is the best ranked for deterministic and probabilistic forecasts, but the ECMO model is no longer the fourth, as it was in the deterministic forecast (see Fig. 6) when the ensemble forecast was considered. In Fig. 10 we also present the economic value for Southern Spain. In this case, the economic value of the ensemble seasonal forecasts is remarkably high.

The feasibility and results of dynamical downscaling for seasonal forecast as shown in this and other cases of the 1986-1989 period suggested that it would be worth extending this dynamical downscaling to a longer period and to other global models. It has been undertaken it in the ENSEMBLES project.

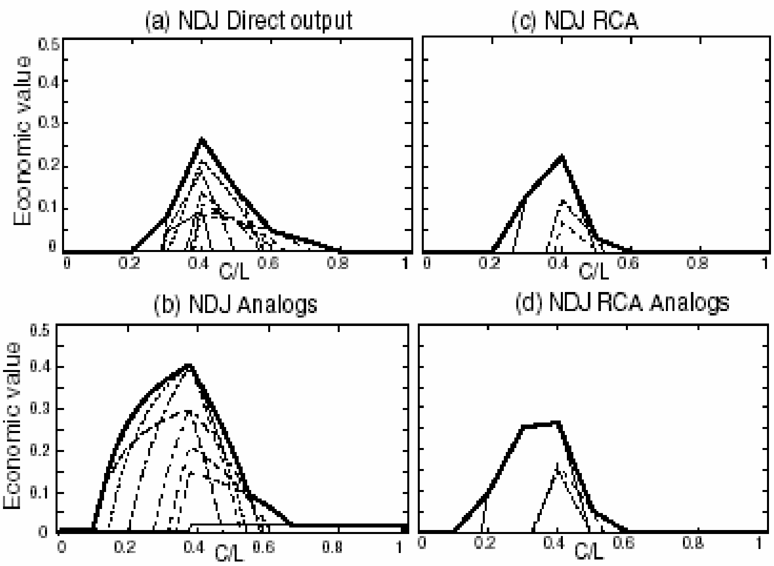

Figure 9: Economic values and their envelopes for the ‘wet’ event during NDJ of 1986/1987 and 1987/1988 for ECMO18 (18 ensemble members) and RCA (three ensemble members), and the analogue versions. Economical values are shown as a function of C/L. The thin lines show the individual graphs for probability thresholds. The think lines show the maximum economical value.

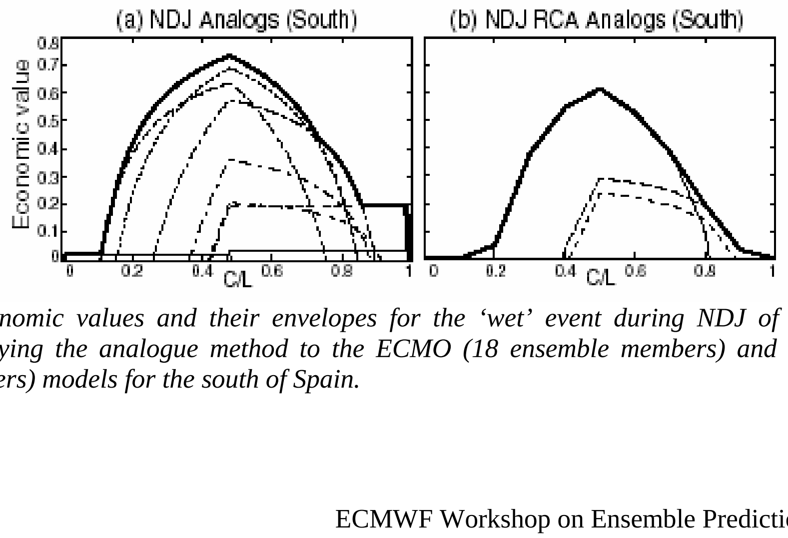

Figure 10: Economic values and their envelopes for the ‘wet’ event during NDJ of 1986/1987 and 1987/1988 applying the analogue method to the ECMO (18 ensemble members) and the RCA (three ensemble members) models for the south of Spain.

4.1.3. Bias-correction and calibration.

Some preliminary work was performed to correct the bias of DEMETER models, thus reducing this source of error from the forecast. The bias was derived from the available forecasts and observed seasonal precipitation values from 1961-1997. For the 11 years 1986-1997, new RSA outputs using the bias-corrected seasonal values were computed. However, no clear conclusions about the improvements attained with the bias reduction of the combined ECMWF and UKMO DEMETER models could be established, and further research was considered necessary to address this point. The bias of the ECMO18AN results could not be corrected because the statistical downscaled values for 1961-1986 were not available.

As shown in Table 3 new ensembles of dynamically and statistically downscaled seasonal forecasts from ENSEMBLES and System 3 are currently available. Likely, the size of the ENSEMBLES hindcasts is not enough long to test new calibration techniques. However it can be tried with the 25-year ensembles from the ECMWF System 3 (see table 3). One of the envisaged techniques is based on the use of the percentiles of the forecast and observed series.

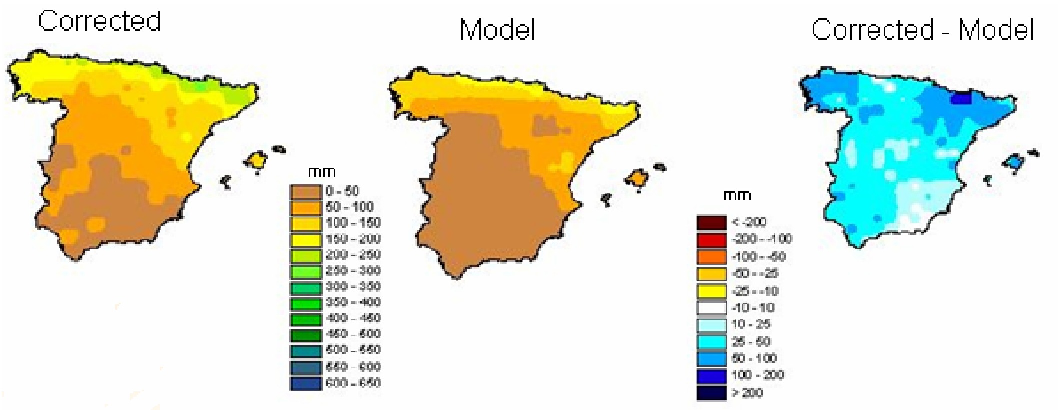

Figure 11: The corrected forecast using percentiles method (left), JAS 2007 (1-lead time) ANALO forecast (centre) and map of differences (right).

For the probabilistic forecast and once established the probability of occurrence of each event with respect to the hindcast terciles, the terciles of the observed series for the same 25 years are taken as the threshold to which the probability forecast is referred to. For a deterministic forecast the same percentile in both the hindcast and the observed series may be used to translate the forecast from the first to the second. One example of it is given in Fig. 11. A systematic validation of this technique is in progress.

4.2. INM contribution to the ENSEMBLES project

The main goals of the INM participation to the EU FP6 ENSEMBLES Project have been the contribution to the development of a web portal located in the University of Cantabria where several statistical downscaling methods can be easily tested (see http://www.meteo.unican.es/ensembles), and the expansion of the dynamical downscaling exercise with RCA to the 11 years 1991-2001 taking as boundaries the outputs of the ECMWF and UKMO global models. The study of results is still under way.

An example of this multimodel, (only two models!) exercise is presented in fig. 12 where the panels present the 1-month lead time deterministic seasonal forecast of the surface pressure for JJA of 1998 from the RCA integrations using as boundaries nine ECMWF and nine UKMO model outputs (top right and bottom left) and the average of those 18 members (bottom right). The ERA-40 field (top left), acts as verifying field. In order to see if a two model ensemble introduces some improvements in the downscaling, the Anomaly Correlation Coefficient (ACC) score for the full area and each of the 11 JJA seasons has been computed and displayed in Fig. 13. As only 5 members for ECMWF (stream 2) were available this has been the size of the ECMWF-RCA and the UKMO-RCA ensembles used, and ten members those used for the two-model ensemble. It can be seen that in five cases, and for the 11 years, the two-model ensembles performs better than in the others cases; in four cases it is UKMO-RCA which performs better and in two cases ECMWF-RCA.

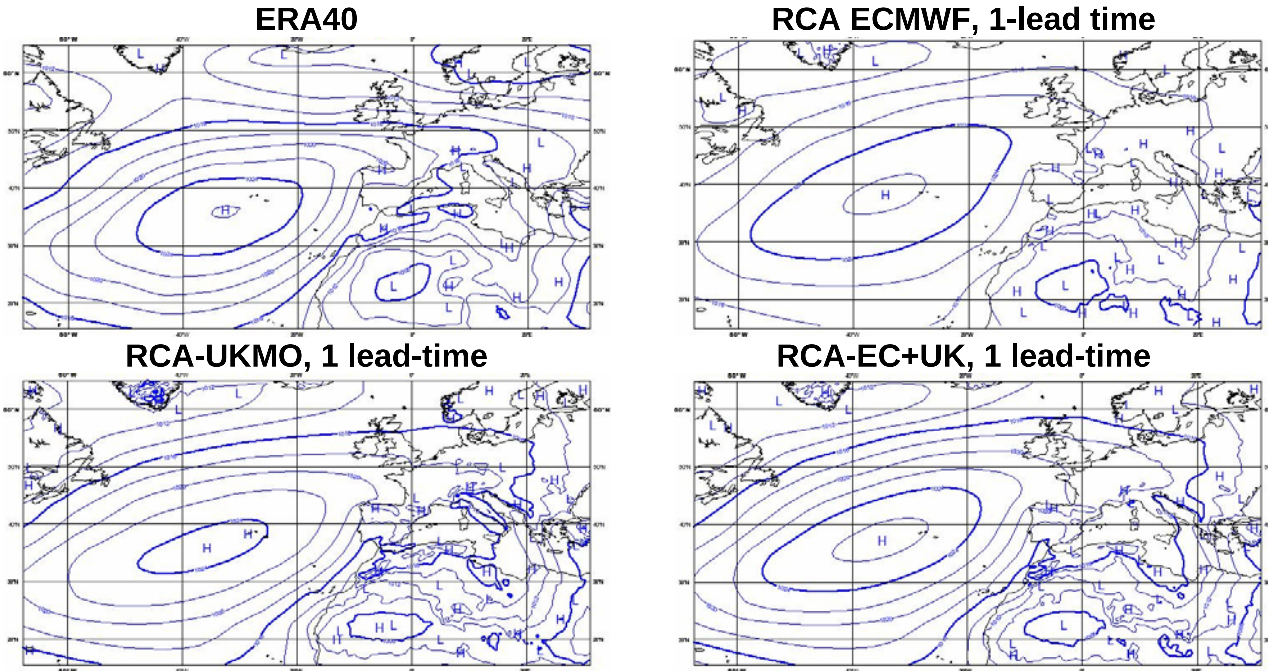

Figure 12: ENSEMBLES project forecast: Mean Sea Level JJA 1998

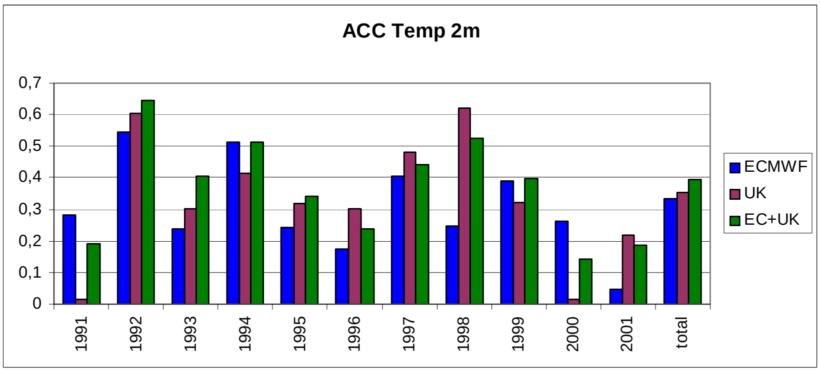

Figure 13: Verification of RCA ensembles. ACC of 2m Temperature, JJA See explanation in text.

5. Experimental seasonal forecasting in INM: examples and verification.

Since 2004 experimental seasonal forecasts of precipitation have been prepared in INM. Until March 2007 they were obtained by statistical downscaling from the ECMWF operational System 2 (ANALO) and, since then, from its successor the System 3. On the other hand, since May 2007 dynamical downscaling forecasts have been regularly prepared in the ECWMF facilities using version 3 of the LAM Rossby Centre Atmospheric model (RCA) nested to the System 3 outputs. For System 2 the size of the forecast ensemble was 40 members and the size of each season hindcasts 75 (5 members for each of the years 1987-2001). For System 3 and RCA, they are respectively 41 members and 275 (11 members for the years 1981-2005) and 11 members and 125 (5 members for the years 1981-2005).

A remarkable case is presented in Fig. 14. It corresponds to the 1-month lead time probabilistic forecast for FMA 2007 with ANALO. The probability of occurrence of the wet event is higher than 40% for most of the points of the mesh and even higher than 50% for a substantial part of them (see top and top right of fig. 14). The verifying maps (bottom of fig. 14) show the percentiles of the observed precipitation. They confirm the wet character of the season and underline the area where the precipitation amount has been higher than the percentile 60. For the same seasonal forecast the bar diagrams of fig 15 show that the deterministic forecasts both from the direct model output and ANALO methods satisfy the running quintile verification criterion in more than 70% of the mesh. The geographical distribution of the areas satisfying this criterion for each of the 4 lead times verifying in this season is presented in fig 16. In addition to the consistency of these good forecasts, it can be noted that only for lead time 0 the ANALO forecasts overcome the direct model ones (the figures at the bottom of each map indicate the size of the area satisfying the criterion).

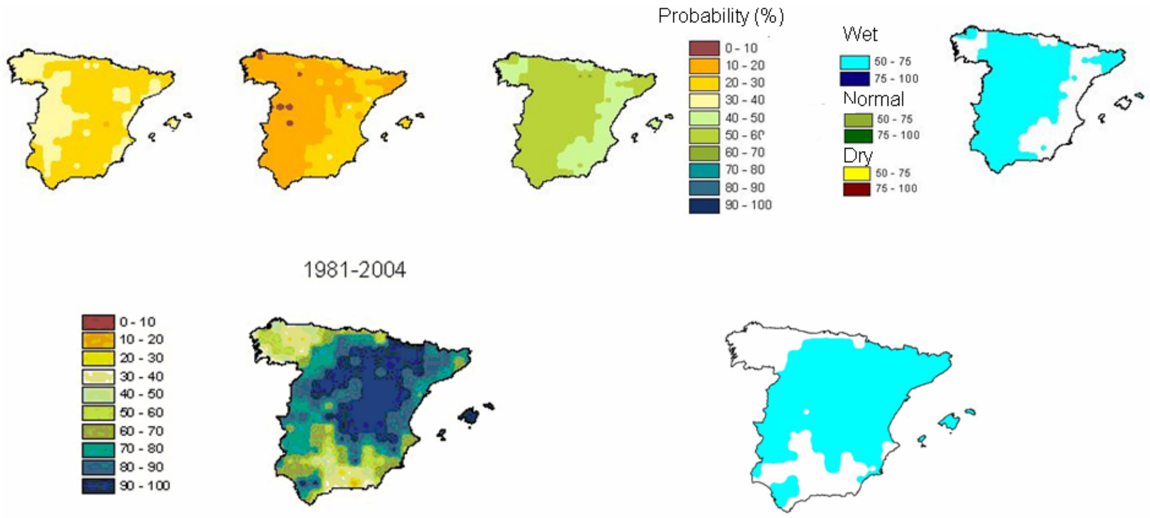

Figure 14: Probabilities of Dry, Normal and Wet events, 1-lead time, ANALO (FMA 2007) and observed percentiles.

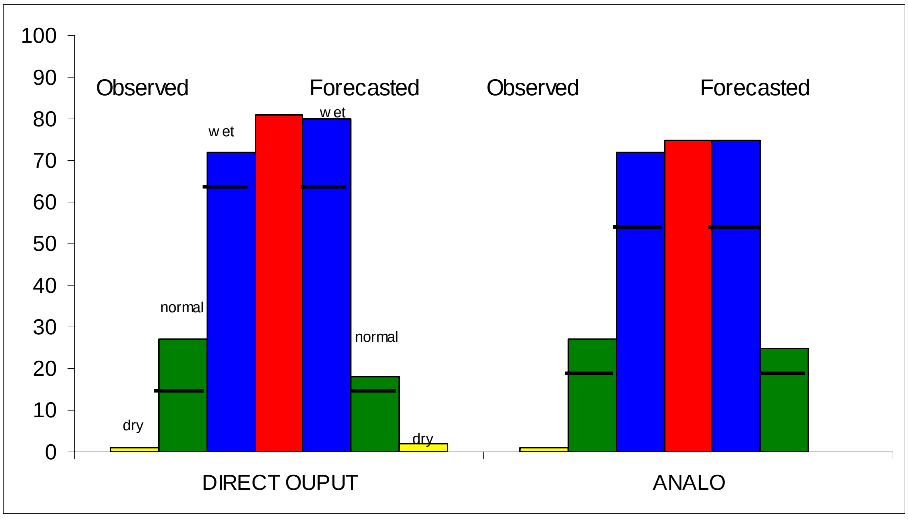

Figure 15: Deterministic forecast FMA 2007 1-lead time. Results applying the run quintile verification criterion

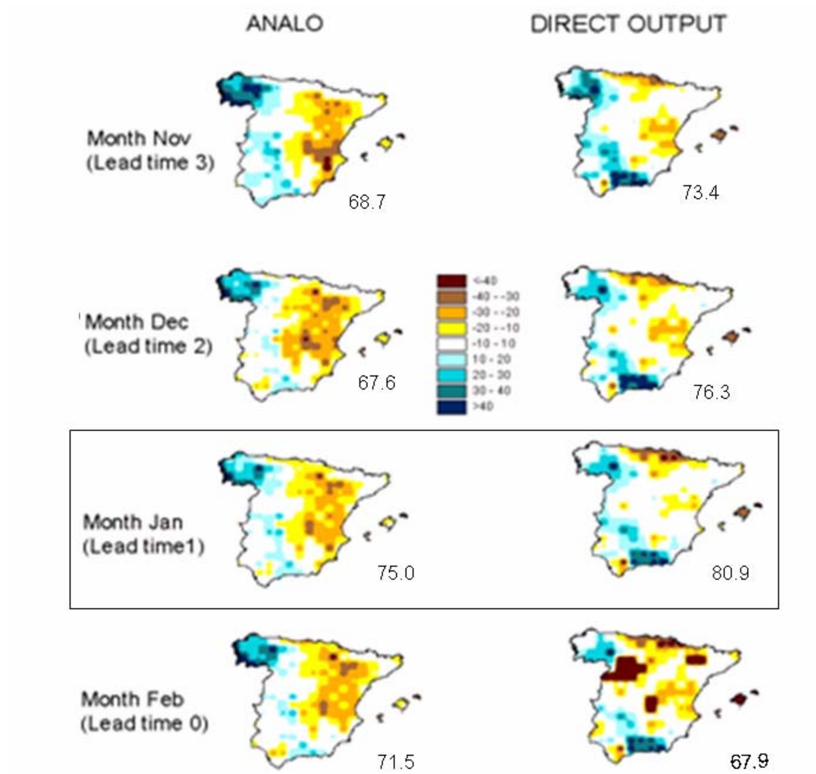

Figure 16: Case of FMA 2007. The geographical distribution of the areas satisfying the run quintile verification criterion for each of the 4 lead times verifying in this season both for direct output and ANALO.

Comparison of the performance of System 2 and System 3 probabilistic forecast of precipitation from the direct model output and the ANALO method is presented in fig. 17. RSA (ROC Skill Area) scores correspond to the 1-lead time forecasts for dry and wet events. RSA is plotted versus the verifying seasons. Overall, System 3 performs slightly better than System 2. This is because RSA scores for System 3 are higher than 0.5 in more cases that for System 2, although occasionally System 2 can reach higher values.

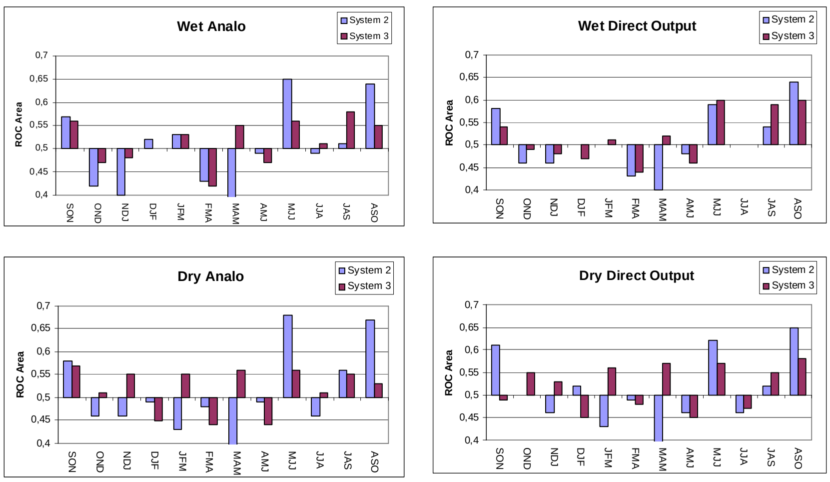

Figure 17: System 2 and System 3 Probabilistic forecast of precipitation. ROC Skill Area Scores

Dynamical downscaling with RCA allows the availability of downscaled T2m seasonal temperatures. Comparison of the performance of RCA and System 3 direct model outputs for JJA is presented in fig. 18 using the ACC (Anomaly Correlation Coefficient) score (top), reliability diagrams (medium) and the ROC diagram (bottom). For RCA the scores are computed for the 5-member hindcast. For System 3 two sets of scores are computed: those for the equivalent to RCA 5-member hindcast and those for the full 11-member hindcast. Thresholds for the reliability and ROC diagrams are the terciles of the 25-year series of the hindcast. The area used is that of fig. 19 and the verifying data those of the ERA-40 Re-analysis.

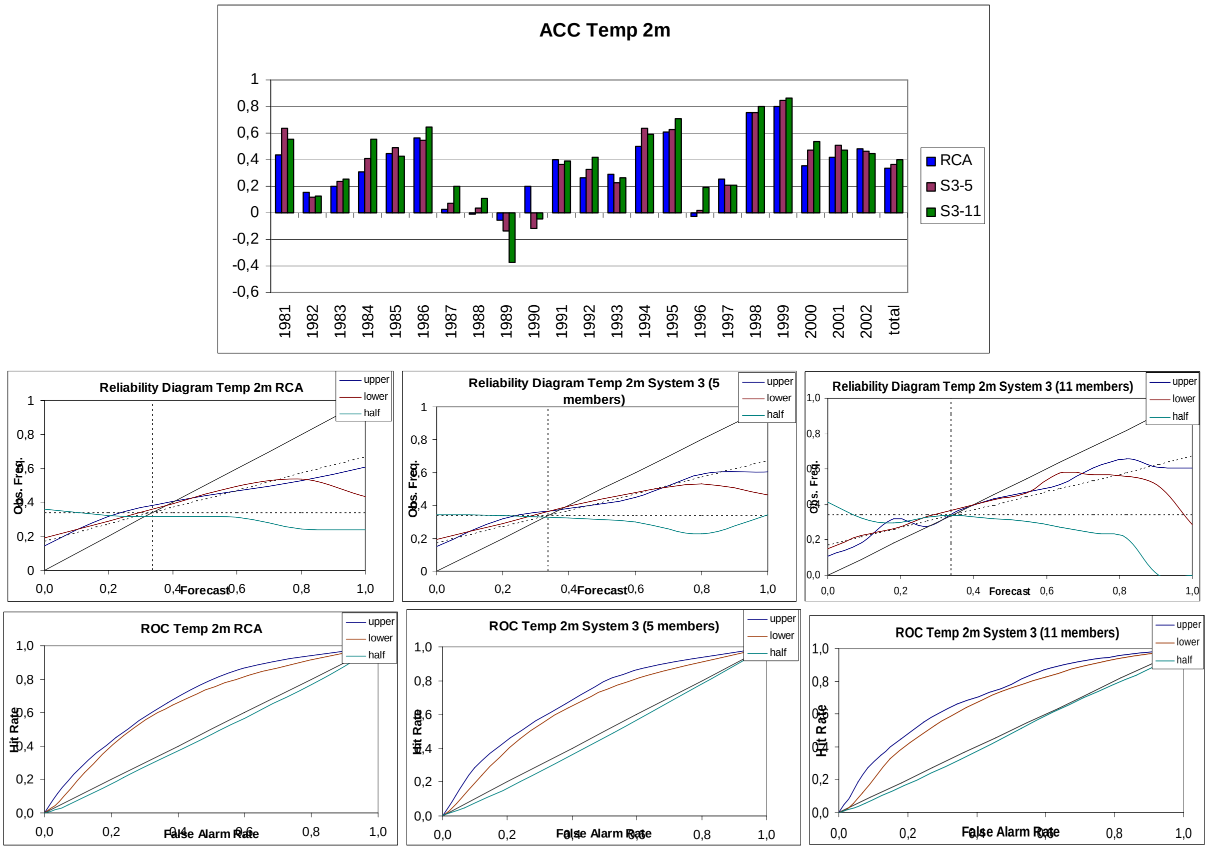

Figure 18: Verification of RCA and System 3 from the May run for JJA (1-lead time) 2007.

Year by year ACC values fluctuate between 0.84 and -0.4. The better ROC scores correspond to the third tercile, and in general the reliability curve is partially kept between the diagonal and the skill line. Overall the best results are for the 11-member hindcast of System 3. Only occasionally, eight of 22 cases, RCA overcomes System 3 for the 5-member hindcast.

Fig. 19, bottom, shows the 1-lead time temperature forecast for JJA 2007 from both System 3, with 11 members, and RCA. The verifying fields from the ECMWF ERA-40 and from the observed high resolution mesh are presented in the two top panels of the figure. The configurations of the fields over the northwest part of Spain present good similarities.

For the same forecast, Fig 20 allows the comparison of the maps of anomalies as displayed by the ECMWF in its web page and as computed by RCA. Similarities and differences can be easily observed.

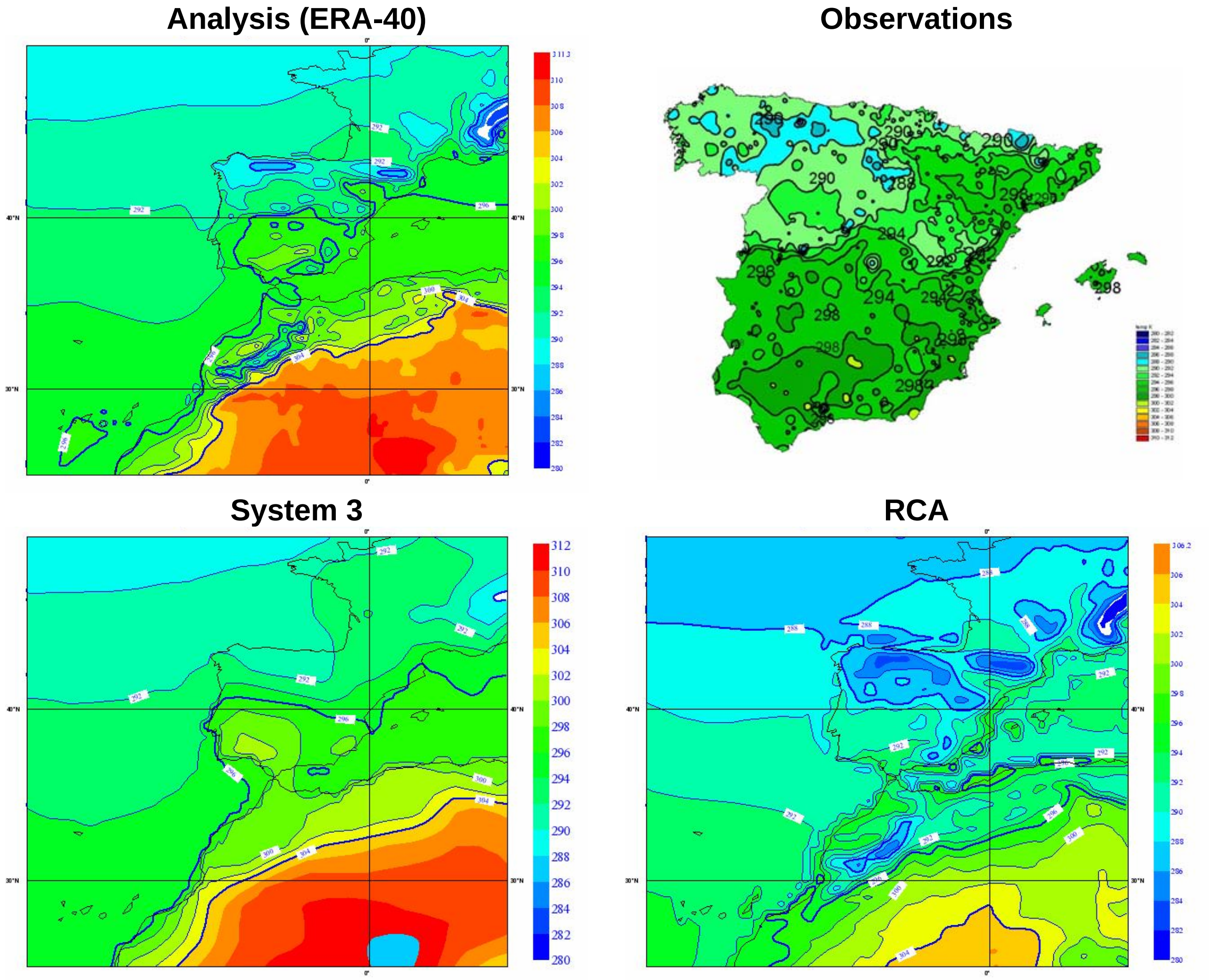

Figure 19: May 2007, 1-lead time (JJA), 2m temperature forecast

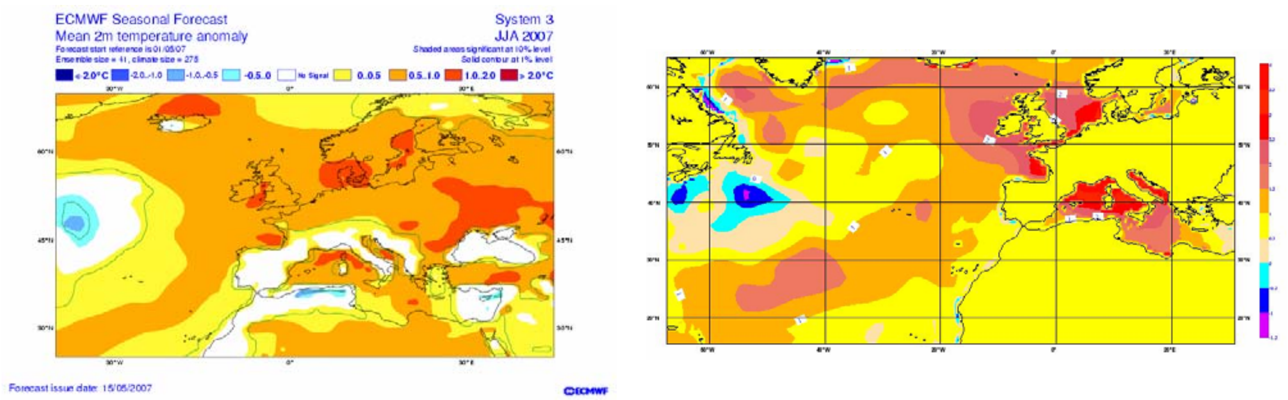

Figure 20: JJA 2007 (1-lead time), 2m temperature anomalies forecast

6. Conclusions

Since May 2007, an experimental seasonal forecasting system has been implemented in INM. This system downscales dynamically and statistically the forecasts produced by the ECMWF seasonal forecasting System 3. It is the successor of the system which, since 2004, downscaled the former System 2 statistically. They were based on the developments and results undertaken by the INM participation in the DEMETER Project, which concluded that the analogue methods in general improved the forecast for the period 1986-1989 and that for the same period, which included one El Niño event, seasonal deterministic forecasts benefit from an increase of resolution of the dynamical model.

Overall, the performance of the System 3 probabilistic precipitation forecasts over Spain for 1- lead time is slightly better than those of System 2 both for dry and wet events, and both when System 3 direct model outputs and the ANALO-ONE method are used.

Probabilistic and deterministic results of a recent freak case of statistically downscaled precipitation forecasts over Spain have been presented. They correspond to the four seasonal forecasts with lead times 0 to 3 verifying in FMA07. They are outstanding for their consistency through the lead times and the high quality of the deterministic forecast measured by the area of Spain satisfying the running quintile verification criterion.

Although a RCA dynamical downscaling of the ECMWF System 3 seasonal forecasts is possible and has been implemented in INM, a comparison made with the 5-member, 25-year hindcast, 1-lead time for JJA shows that the scores of these forecasts are below the values of those from the corresponding 11-member hindcast of the global model. Results compare better when only subsets of 5 members of the global model used to nest the RCA model are used.

Tests with RCA downscaling applied to a two model ensemble – with 5 members from the ECMWF System 3 (corresponding to Stream 2 of the ENSEMBLES project) and five members from the UKMO model of the ENSEMBLES project- show better ACC scores than those from each individual model.

7. Further work

To develop and test additional calibration tools taking advantage of the relatively long hindcasts available, 25 years, from the System 3.

To undertake global dynamical atmospheric downscaling experiments using the ECMWF IFS model, taking as surface boundaries those of the ECMWF System 3.

To apply the available statistical downscaling tools, including those of the portal of University of Cantabria to the direct outputs of the ENSEMBLES project models (global and regional) and those of the European Operational Seasonal Interannual Project, EUROSIP.

8. Acknowledgements

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Most part of the content of subsection 4.1 ‘Goals and results of INM contribution to DEMETER’ have been taken from Díez et al., 2005 in the Tellus issue devoted to the DEMETER project.

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