# SOME GUIDELINES TO THE USE OF EPS PRODUCTS IN THE MEDITERRANEAN REGION

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## Abstract

This work aims to provide some insight about the short to medium–range weather prediction (from day 2 onwards) over the Mediterranean area using ECMWF Ensemble Prediction System (EPS) products. Bearing in mind previous studies on the ability and limitations of EPS in predicting extreme events over localized regions, some guidelines are provided to operational forecasters, in order to increase the amount of information extracted from EPS products, to make predictions over the Mediterranean basin more reliable. A new type of weather parameter display is introduced, this assisting the forecasters in a more accurate evaluation of the forecast uncertainty. Some case studies are presented in which this tool is used.

# 1 Introduction

The continuous improvement of mathematical models and of the ability at describing initial conditions (analysis + observations) lead, in the last 30 years, to augment the skill of meteorological forecasts, increasing the range of reliable prediction up to 6 days in the 1990s (Kalnay, 1998; Simmons, 1995). Despite this progress, there are still unavoidable limitations in the atmospheric models, in the observational network and especially in simulating the chaotic behavior of the atmosphere. As a result, the tendency of deterministic forecast skill is a sort of asymptotic curve where any appreciable improvement has to be obtained only with a lot of effort.

The Ensemble Prediction System (EPS) developed at the European Centre for Medium–Range Weather Forecasts (ECMWF) is designed to extend the useful forecast range using a different approach, giving a forecast obtained as an average of many different simulations that started from similar initial conditions (Molteni et al., 1996). The averaging operation is acting as a flow dependent filter, able to filter out only the unpredictable components of a certain meteorological situation. Moreover the EPS provides different scenarios and an estimate of the reliability of the forecast that is different day by day and from a place to another. In order to generate small differences in the initial conditions, representative of actual uncertainties in the analysis, the reference analysis is perturbed over 'sensitive' areas recognized by the system. Amongst these, it has been decided to choose the 25 perturbations (referred to as singular vectors), which grow the most rapidly in the first 48 hours of the model integration (Buizza and Palmer, 1995). Linear combinations of these perturbations, when added and subtracted from the unperturbed (or control) analysis enable to generate $25 \times 2 = 50$ different initial conditions. On aggregate, we have 51 starting points from which to run 51 different integrations of the ECMWF T159L31 forecast model. The results from this set of integration form the "ensemble".

In the following sections, we briefly review the major developments of ECMWF EPS. Then, some guidelines especially addressed to assist the operational forecaster, are provided. Ability and limitations of EPS over the Mediterranean region are discussed. Finally, a new type of weather parameter display is presented.

## 2 Developments of EPS

The technical features and major developments of ECMWF EPS can be summarized as follows:

- *May 1994 – start of daily dissemination of EPS*
  horizontal resolution: T63, corresponding to 220 km
  vertical resolution: 19 levels
  Ensemble size: 33 (1 unperturbed + 32 perturbed)

- *December 1996 – major upgrade*
  horizontal resolution: T159 corresponding to 120 km
  vertical resolution: 31 levels
  Ensemble size: 51 (1 unperturbed + 50 perturbed)
  **Main result**: increased ensemble spread in the medium–range; since this moment, the Ensemble Mean has been more skillful than the control forecast.

- *March and October 1998 – major upgrade*
  Introduction of evolved singular vectors and random model errors related to physical parameterizations.
  **Main result**: better simulation of surface parameter uncertainties especially during the early forecast range (Buizza, 1999).

## 3 Brief glossary for probabilistic forecast

EPS produces every day a great amount of data. In order to represent in a synthetic but exhaustive way the amount of information, a certain number of products have been designed. These products, that are currently disseminated by ECMWF, are:

- Ensemble Mean (EM): applied at 500 hPa geopotential height is the average over the whole ensemble. The average procedure enables the EM to be more consistent and more skillful in the medium–range than the operational high resolution forecast (Atger, 1998). An apparent disadvantage of the EM can be the smoothness of its fields sometimes in the medium–range; nevertheless this will be the predictability limit of the atmospheric flow in that case. In other words, this means that it is not possible to extract information with further spatial details.

- Clusters and Tubes: methods to reduce ensemble size by grouping together members with similar/different features at 500 hPa geopotential height. With the clustering technique we aggregate together those members showing similar evolution patterns over the European area between D+5 and D+7 in the forecast. The cluster number ranges from one to six and its population is related to the probability of the evolution scenario of the cluster. On the other hand, with the Tubing algorithm, the most different members from the ensemble mean are highlighted and taken as extreme evolution scenarios within the ensemble.

- Probability maps: they provide the probability of occurrence of a certain event. Once a certain event or threshold has been fixed, for example daily precipitation exceeding 20mm, the spatial distribution of the probability is displayed.

- Probabilistic Meteograms: it provides the time evolution of a set of surface variables over a certain location, with the associated uncertainty.

- Ensemble spread: it provides a measure of the divergence of the EP-S members with respect to the EM throughout the forecast range and it is assumed to be related to the predictability of the atmosphere. Every time the spread is large, the atmospheric evolution is less predictable and, then, statistically, the high resolution deterministic forecast can be assumed to be less reliable.

## 4 Guidelines to the forecasters

On the basis of the operational use of the products presented above, we propose a checklist which should assist the forecaster in maximizing the information from EPS products.

- THE MOST LIKELY WEATHER EVOLUTION: based on the Ensemble Mean;

- UNCERTAINTY ASSOCIATED AT THE FORECAST: based on the ensemble spread;

- POSSIBLE WEATHER VARIANTS: based on Clusters and/or Tubes;

- LIKELIHOOD OF SPECIFIC EVENTS: based on weather parameter probabilities and meteograms;
- CONVERSION OF PROBABILITY INTO CATEGORICAL DECISION (YES/NO): based on cost/loss analysis (Richardson, 1998).

# 5 Abilities and limitations of EPS over the Mediterranean region

- EUROPEAN CLUSTERS ARE SOMETIMES VERY SIMILAR. The strong gradient associated to the polar jet front dominates, in the clustering algorithm, over relative small difference in terms of geopotential experienced by the Mediterranean area, especially in summer. For this reason is better to cluster over sub-domains. A discussion on the sensitivity to the choice of the clustering area can be found in Grazzini, 1999. A more expensive (in terms of computer power) alternative to overcome this problem is to produce a Targeted Ensemble (Hersbach et al., 1999), in order to maximize the growth of the perturbation, and hence the spread, over a target area.
- POSSIBLE PROBLEMS IN FORECASTING OROGRAPHIC DEPENDENT PHENOMENA DUE TO LOW HORIZONTAL RESOLUTION OF ENSEMBLE MEMBERS (about 120 km). Orographic precipitation, lee cyclogenesis and others Mesoscale phenomena can be affected.
- SOMETIMES WEATHER PARAMETER FORECAST DOES NOT PROVIDE HIGH CONFIDENCE (high percentage of high/low probabilities). After D+5 the forecaster is advised to consider the total rainfall or the probabilities of a certain event cumulated over more than one day. This has been proved to be beneficial in increasing the confidence and to obtain a more stable and reliable forecast up to D+10 (Persson, 1998); for longer cumulating periods, the confidence increases significantly.
- REMARKABLE SKILL IN FORECASTING AIR MASSES CHANGES AND LARGE SCALE PHENOMENA. Examples: cold or warm advection, precipitation over large areas, deep cyclones and strong winds.

## 6 New type of weather parameter display

In order to display EPS weather surface parameters in a clear and synthetic way, a new type of representation was designed by the first author during the year spent at ECMWF. The EPS meteogram, that represents the time evolution of a set of surface variables over a certain location, with the associated uncertainty, is presented in figure 1. The four panels, from top to bottom, show the total cloud cover, the total precipitation, the 10m wind speed and the 2m temperature. The forecast values of the four nearest grid point are interpolated over the location. Optionally 2m temperature can be adjusted by applying a fix lapse rate accounting for difference between model and actual orography. Full and dotted lines represent respectively the evolution of the deterministic and control forecast, while the boxes show the range containing the 50% of the members. Vertical solid lines on the top and bottom of the boxes (whiskers) join the extremes of the ensemble range. The horizontal line inside the box is the median of the distribution. Fig. 1 as well as fig. 2 show two examples of very good performance of EPS in contrast with the deterministic run. The first case refers to a heat wave which affected Northern Italy and lasted several days, during August 1999. The deterministic run (solid line) fails to predict the persistence of high temperature after day 6 over Bologna, while the EPS performs much better, showing a constant trend towards high temperatures, as it actually happened. On the other hand, the second example refers to precipitation forecast in the early–medium range. Medium to high precipitations (up to 40 mm/day) were observed over the entire Emilia–Romagna region (Northern Italy) on 20 September 1999, mostly concentrated in the afternoon. The deterministic run predicts a small amount of rainfall concentrated only in the morning, while EPS, also in subsequent runs, for shorter forecast ranges (not shown), is consistently showing the main peak of precipitation during the afternoon, indicating high probability of heavy rainfall in the region.

## 7 Conclusions

The main products of ECMWF EPS have been presented. Guidelines for the operational use of these products have been provided as well as a quick review of the EPS performance over the Mediterranean area. These results are based on previous studies and our experience gained in the daily use of EPS both in the operational and research sections. Finally a new type of weather surface parameter display has been introduced and its

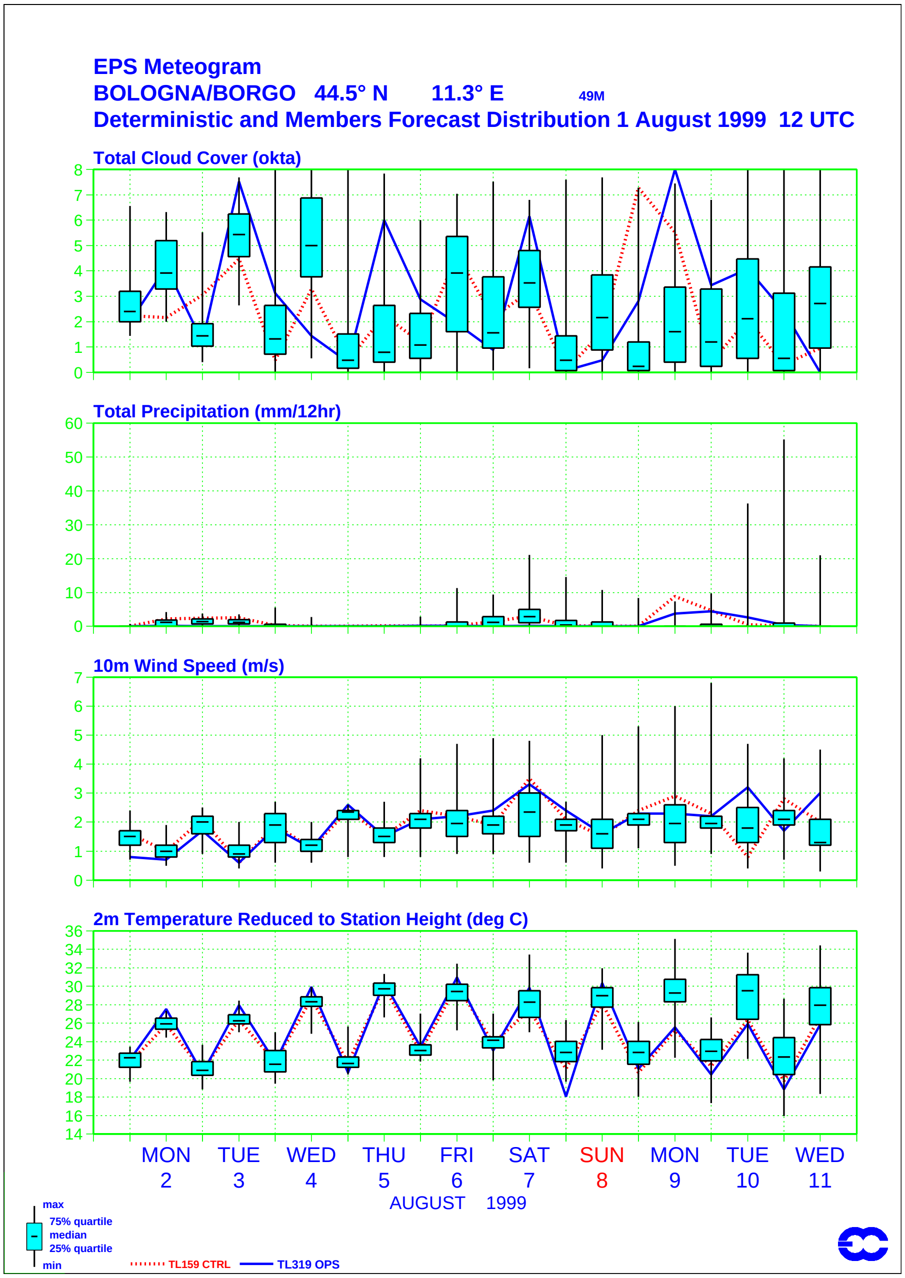


Figure 1: EPS meteogram valid over Bologna for forecasts starting at 12 UTC of 01 August 1999.

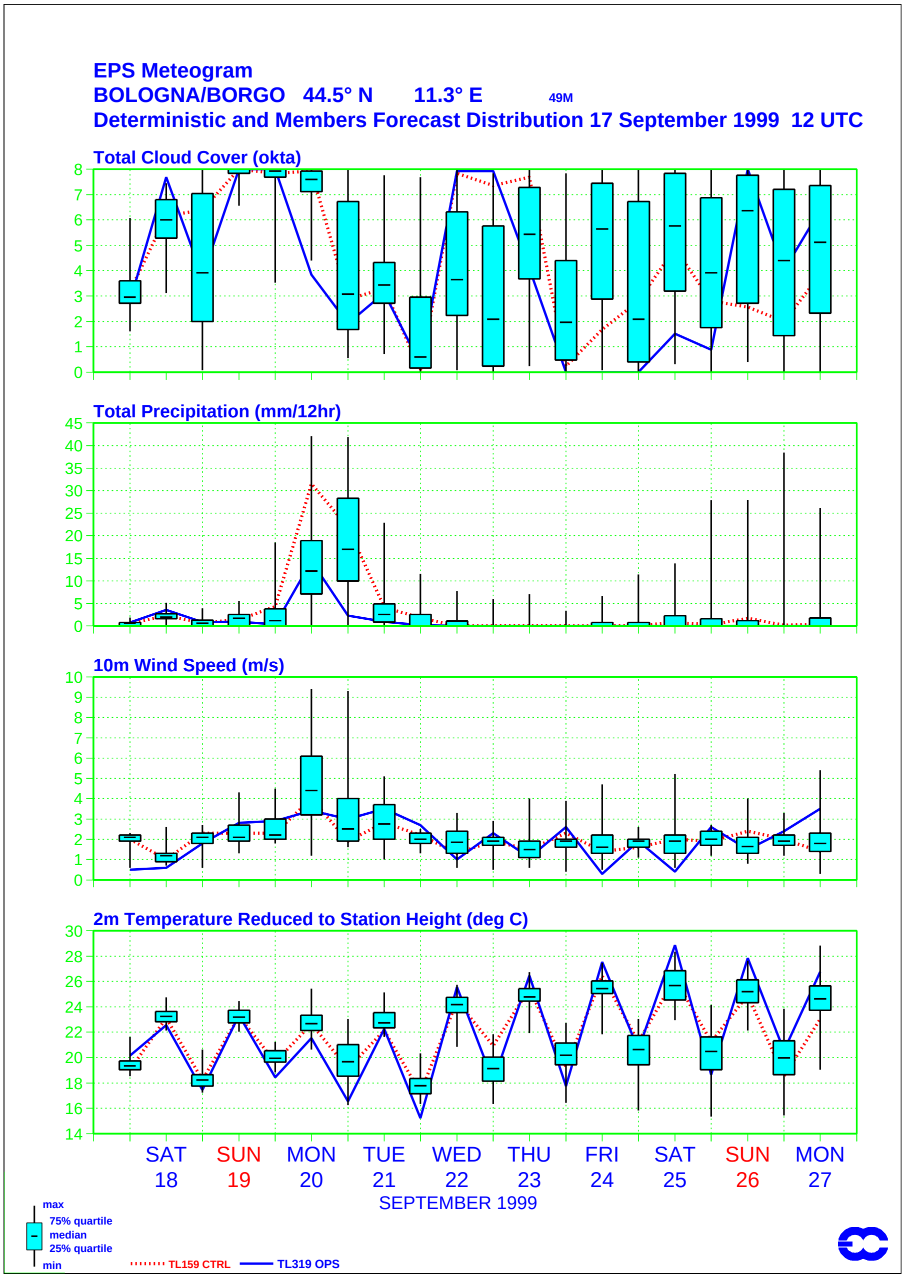


Figure 2: The same as figure 1 but starting at 12 UTC of 17 September 1999.

application has been shown for a couple of case studies.

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