# Experiments of clustering for central European area especially in extreme weather situations

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## 1 Introduction

Hungarian Meteorological Service became co-operating state of the ECMWF in 1994, since March 1996 12 UTC cluster products have been operationally received via fax. After upgrading the telecommunication line between Reading and Budapest EPS cluster products have been receiving in GRIB format since April 1998. Since March 2003 00 UTC cluster products are also available for our forecasters. Comprehensive description of clustering is available in User Guide to ECMWF Products (http://www.ecmwf.int/products/forecasts/guide/EPS_clustering.html)

## 2 Clustering above Central Europe

Some clusters products are operationally available for Member States and Co-operating States via dissemination system (http://www.ecmwf.int/services/dissemination/3.1/). Clusters, or groups, of similar forecasts are computed within the ensemble of 51 (i.e. the 50 perturbed forecasts plus the control forecast); for five different areas of clustering - domains

- General European Area (75N 20W 30N 45E)
- North West Europe (70N 27.5W 40N 10E)
- North East Europe (72.5N 0W 50N 45E)
- South West Europe (57.5N 15W 32.5N 17.5E)
- South East Europe (57.5N 2.5E 32.5N 42.5E)

Up to 6 clusters are produced, depending on the overall spread of the ensemble. The measure of similarity between individual forecasts is based on the geopotential at 500 hPa over the particular domain area for the period from day 5 to day 7, so that the clusters are fully consistent within that range. For each cluster, the mean and standard deviation of its elements are computed every 12 hours from day 3 to day 7 for 500 hPa geopotential, 500 hPa temperature, 850 hPa temperature, and 1000 hPa geopotential.

Operational version of clustering made at the ECMWF covers 5 domains above Europe. Domain of General European Area covers all Europe, Northwest corner 75N, 20W, southwest corner 30°N, 45°E. Our forecasters found it would have been useful to generate locally cluster products above Central European Area (55N, 10E, 40N, 30E) (Figure 1) and some new type of products belonging clusters were asked.

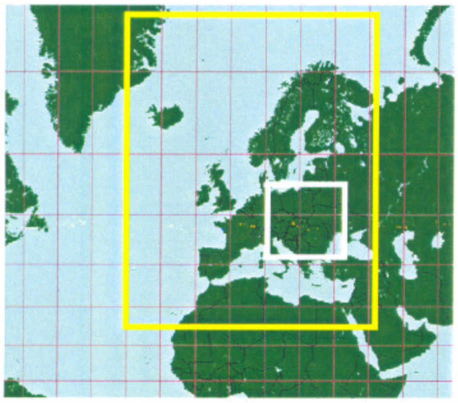


Fig. 1 General European Area (yellow rectangle), Central European Area (white rectangle)

The operational procedure contains the following steps:

Step 1 Make clusters based on geopotential field valid for day 5 at 500 hPa / slightly modified macro for hierarchical clustering in Metview installation package, original Metview macro was developed by Frederic Atger. /

Step 2 Calculate cluster mean and standard deviation, GRIB files created with EMOS for wide range of meteorological fields

Step 3 Calculate probabilities for each cluster, GRIB files created with EMOS for wide range of meteorological fields

Step 4  Create NetCDF files from GRIB files for meteorological workstations

Step 5  Create charts by using MAGICS for printing and intranet

Step 6  Archive GRIB files for verification

The following products are operationally available:

- T2 (cluster mean + std)
- T850 (cluster mean + std)
- geopotential 500 hPa (cluster mean + std)
- Mean sea level pressure (cluster mean + std)
- Precipitation (cluster mean + std & probabilities 1, 5, 10, 20 mm)
- Wind speed (10m) (cluster mean +std & probabilities: <2m/s, >5m/s, >10m/s, >15m/s)
- Cloudiness (cluster mean + std & probabilities: <2 okta, >7 okta)

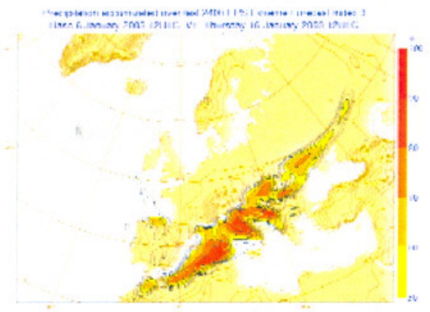
standard fields every 6 hours

Precipitation: 12 & 24 hours (06-18 UTC, 18-06 UTC, 06-06)

Clustering based on 12 UTC EPS products has been operationally done since 1 July 2003, similar 00 UTC products have been generated since 1 January 2004

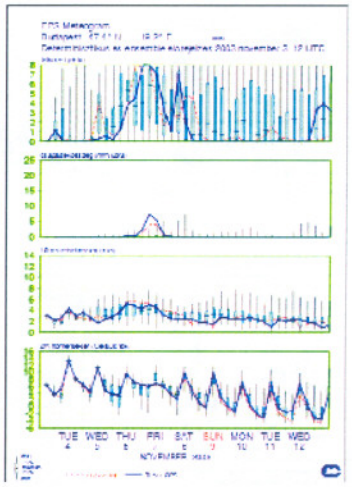
## 2 Case studies

Four interesting case studies are shown this paper. First two caused heavy snowing in Hungary last winter (Fig. 2.). Intensive Mediterranean cyclones strongly influenced the weather; there were significant changes between west and east Hungary, cluster products focused on significant differences (Figure 3). The third situation is connected to retrograde cyclone (Figure 4, right part). Finally, the fourth situation is connected to a Mediterranean cyclone last November (Figure 4, left part)

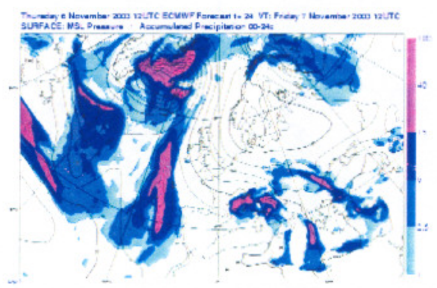


Extreme Forecast Index, precipitation accumulated over last 240 h. Base: 12 UTC 6 January, VT 16 January 2003

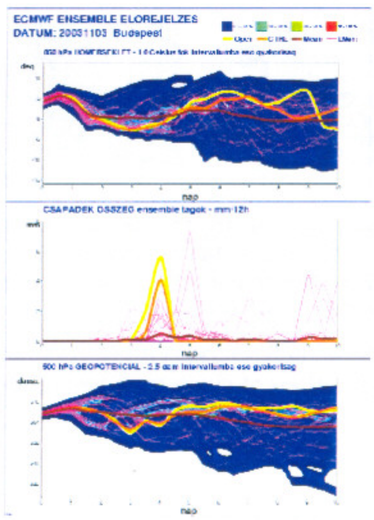
Winter in Hungary



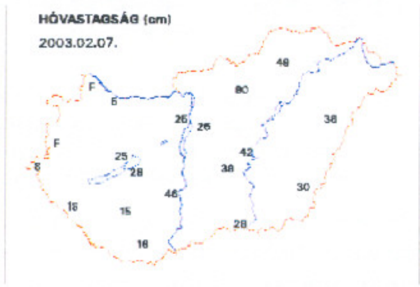
EPS meteogram Base 12 UTC 3 November



24 h precipitation, Base 12 UTC 6 Nov. 2003, VT: 12 UTC 7 Nov. 2003




EPS plume Base 12 UTC 3 Nov. 2003




Snow depth 7 February 2003

Fig. 2 Charts and graphics connected to selected case studies.

In the beginning of January and February intensive Mediterranean cyclones caused heavy snowing in central and eastern part of Hungary. All clusters show Mediterranean cyclone but position of cyclone is slightly differs, cluster 3 at day 4 forecasts the most hazardous event.

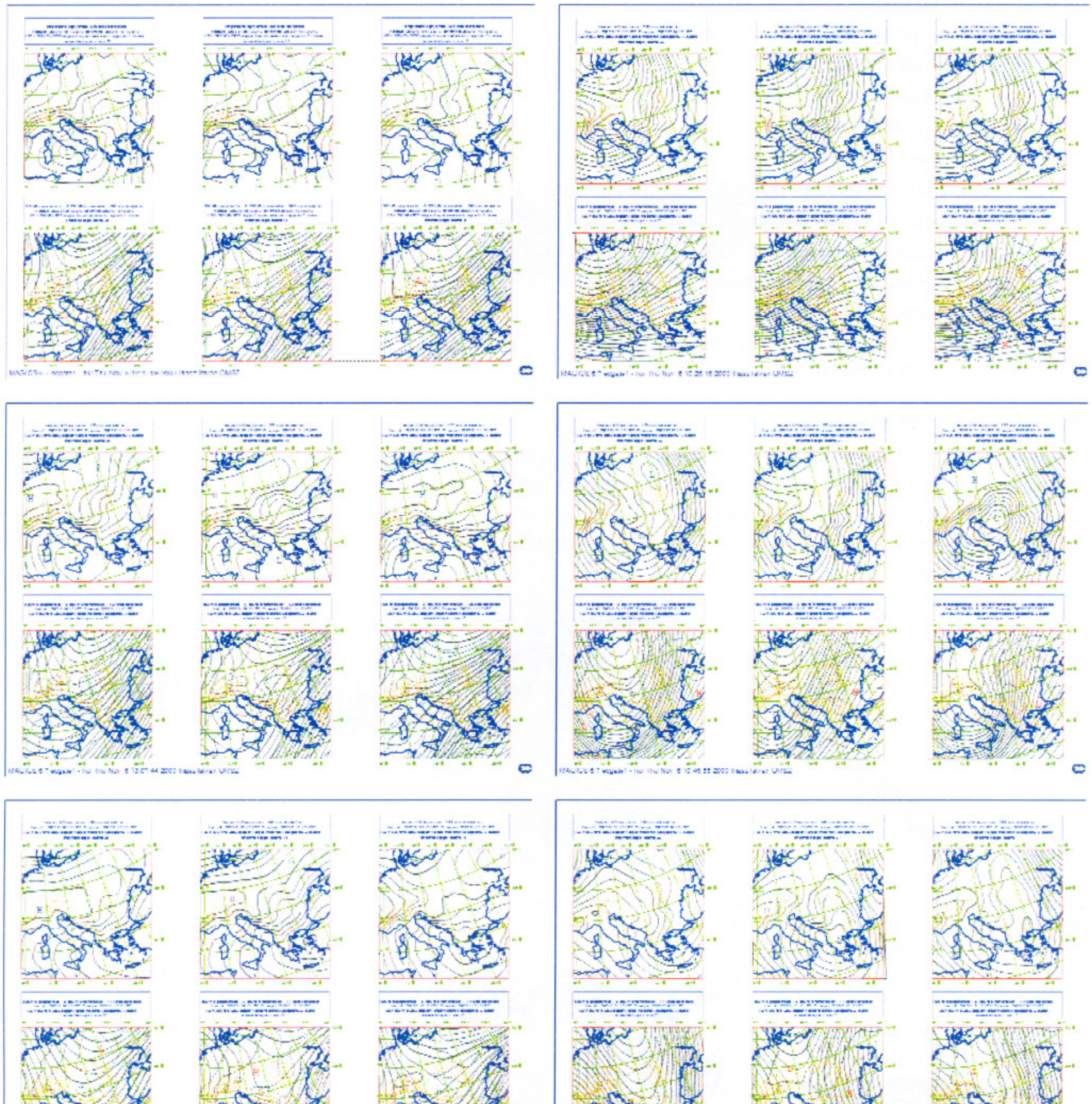


Fig. 3 Cluster mean products: Left column: +96, + 120 and + 144 hour cluster forecasts valid for 10, 11 and 12 January 2003. Forecast is based on analysis 12 UTC 6 January 2003. Right column: +96, + 120 and + 144 hour cluster forecasts valid for 4, 5 and 6 November 2003. Forecast is based on analysis 12 UTC 31 November 2003. Upper charts show mean sea level pressure, lower charts show geopotential on 500 hPa and temperature on 850 hPa.

Between 7 and 9 November 2003 a cyclone followed retrograde path, between 27 and 29 November 2003 an intensive Mediterranean cyclone good caused heavy rain in large part of Hungary. Different clusters show significantly different weather situations.

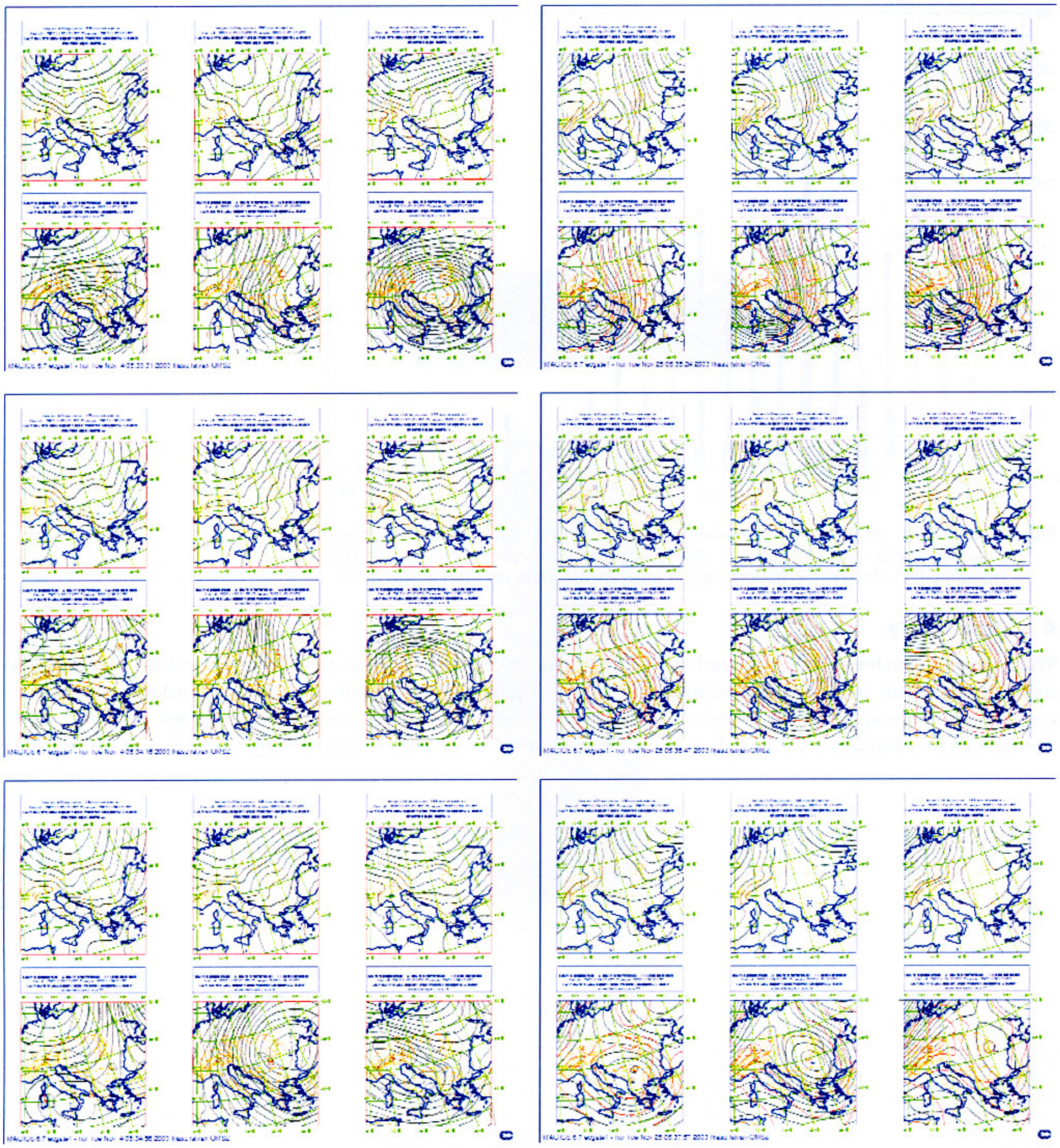


Fig. 4 Cluster mean products: Left column: +96, + 120 and + 144 hour cluster forecasts valid for 10, 11 and 12 November 2003. Forecast is based on analysis 12 UTC 6 November 2003. Right column: +96, + 120 and + 144 hour cluster forecasts valid for 27, 28 and 29 November 2003. Forecast is based on analysis 12 UTC 23 November 2003. Upper charts show mean sea level pressure, lower charts show geopotential on 500 hPa and temperature on 850 hPa.

## 3 Validation and verification

Objective verification and subjective evaluation is regularly made for cluster products. Average number and distribution of ensemble members have been calculated. Average numbers of ensemble members in first, second and third cluster are 26, 16 and 9. Figure 9 shows the distribution of members for each cluster.

Subjective evaluation of daily cluster products has been done for two full years (2002 and 2003). First and second cluster was the best in 45-45 % of the cases and third cluster was the best in 10 % of the cases. Since 1 January 2004 forecasters have been operationally chosen the preferred cluster. Comparison of objective verification of ensemble mean, cluster means and preferred cluster is weekly done.

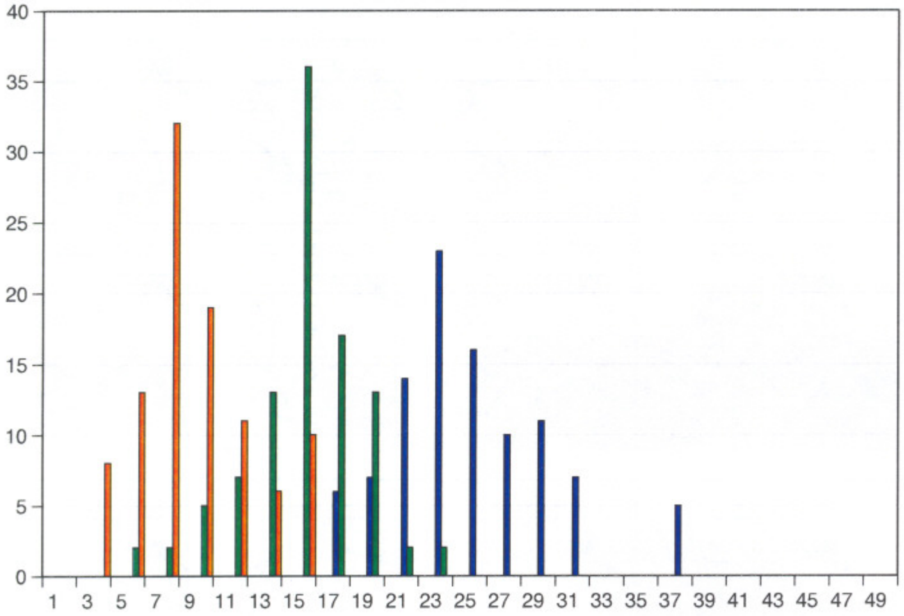



Fig. 5 Distribution of ensemble members for each cluster (blue cluster 1, green cluster 2, red cluster 3). X-axis shows ensemble number, y-axis shows frequency (%). Population covers period between January and December 2003.

## 4 Summary

Wide range of cluster products operationally generated for central European area. Forecast probabilities of predefined threshold for several meteorological fields are calculated. Products are available on workstations for forecasters and internal users on intranet. Subjective and objective verification of products are regularly done. Combined use of 00 and 12 UTC EPS forecasts is considered to generate cluster products in the near future.