Using ECMWF ensemble forecasts for hydrological forecast purpose at Hungarian Meteorological Service

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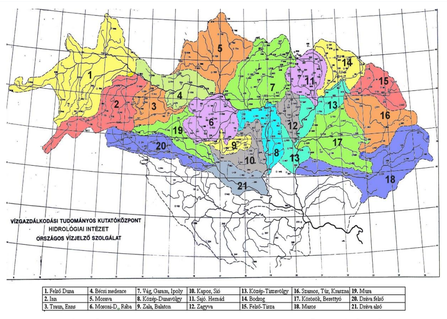
Introduction

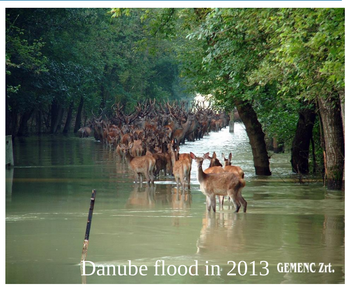
One of the most challenging aspects of ensemble prediction is transforming the vast amounts of model output into an operationally relevant and useful form. For this purpose a wide of range ensemble products are generated like ensemble mean, plumes and spaghetti diagrams, and probability of different weather elements. We also use the clusters developed by our Service that take only the Central-European domain into account. These different ENS products used by OMSZ are shown in our poster.

Almost a quarter of the total area of Hungary can be influenced by floods. Hungary's endangerment in terms of floods can be compared only to the Netherlands' in Europe. Therefore, the precipitation forecast for hydrological purposes plays important role in Hungary. This is based mainly on the HRES forecast, but the hydrologist pay also more and more attention to the ensemble forecasts especially in cases when the results of the HRES forecast differ significantly from the ENS mean.

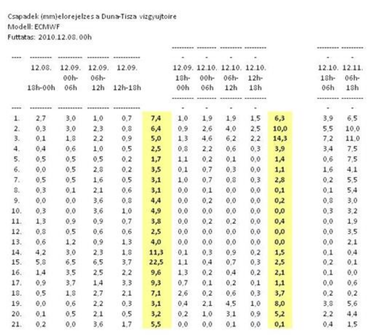
In our case study we investigated the performance of the ensemble forecasts and the HRES during Danube flood 2013. Taking all cases and all elements into account our verifications show that the ensemble mean forecasts generally produces better results than the HRES after 4-5 days. However it is remarkable that in this case in Alps region the HRES forecast, due to its higher resolution provided better results not only for the first 1-3 days, but up to 4-5 days as well, because this version was more able to capture the orographic effect. At the same time the HRES has jumpiness quite often compared to ENS from run to run, while the ENS has more stability day to day. often compared to ENS from run to run, while the ENS has more stability day to day.

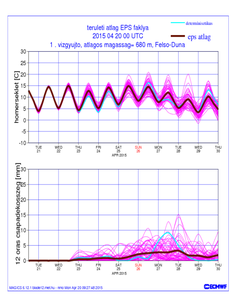
Weather forecast to help water management at OMSZ

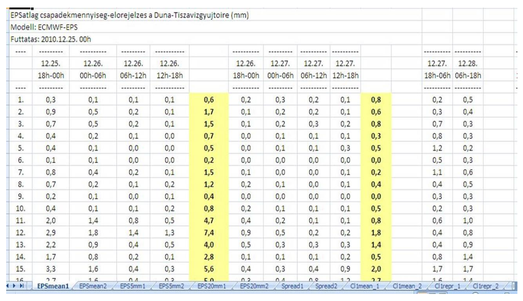




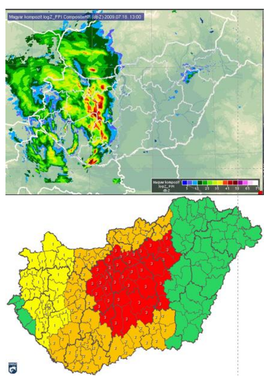
OMSZ prepares meteorological forecasts to help water management for 10 days and 13 sub-basins of the Danube River and 8 ones of the Tisza River (in 6-hour time step) based mainly on ECMWF HRES model.





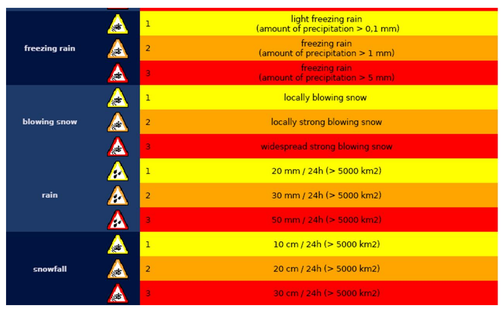


Precipitation forecasts for 21 sub-basins of the Danube based on HRES model (left panel), 2m temperature and precipitation plume diagram for hydrological purposes for the sub-basins of the Drava river (in the middle), and different ENS information for hydrological purposes like ENS mean, probability of 5 and 20 mm precipitation, cluster information (mean and representative member) (right).

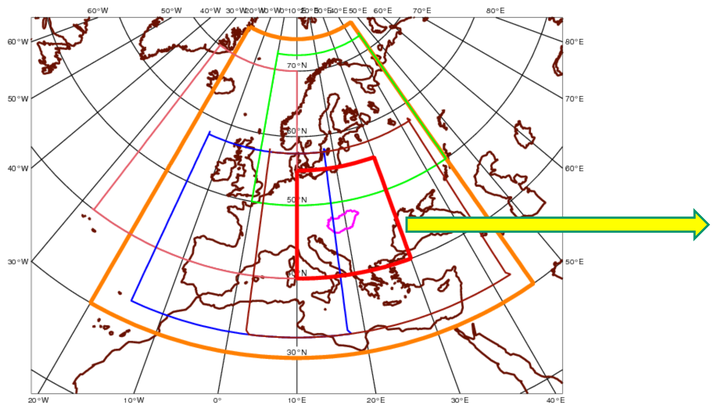


Warning for heavy precipitation event for very short range and for small areas for flash flood forecast purposes.

Radar measurement and warning for 174 small district (left panel) and the warning criteria for large amount of precipitation in Hungary (right panel).



Clustering for Central-Europe made by OMSZ

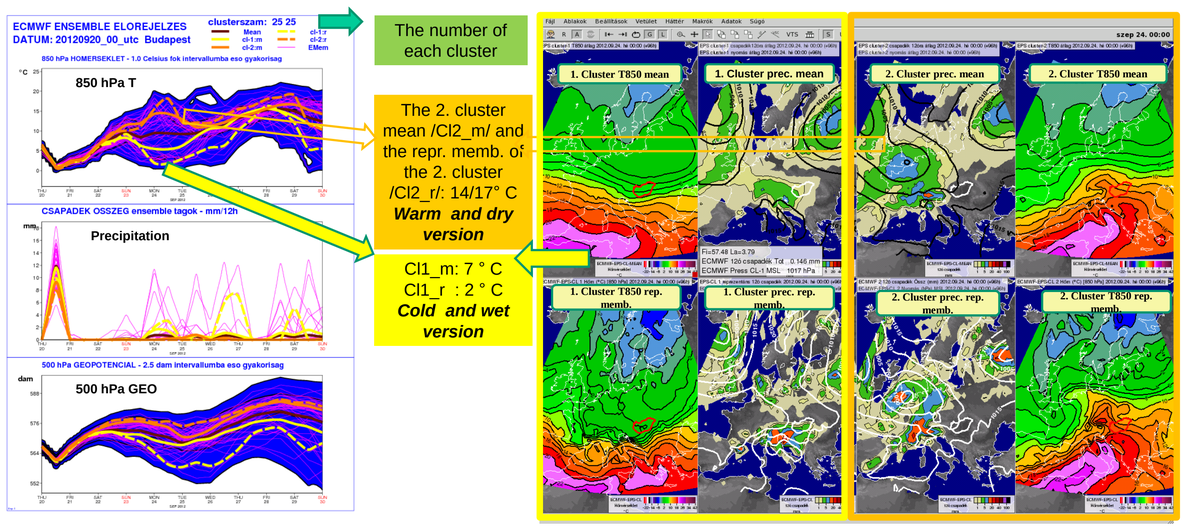


„Early medium range" clustering based on 120 hours forecast of 500 hPa geopotential field.

Medium range clustering based on 192 hours forecast of 500 hPa geopotential field.

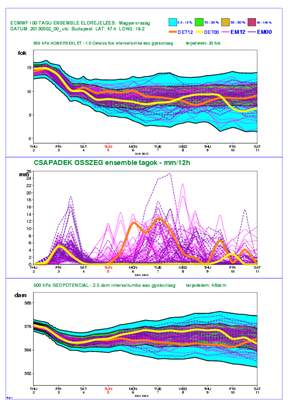
In the future we are planning taking into account more parameters (T850, RHU 700)

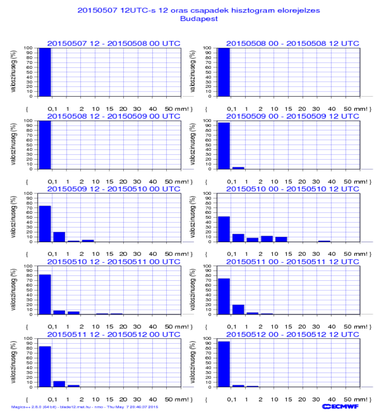
Hungary has an own clustering method developed by OMSZ taking into account only Central-European domain.

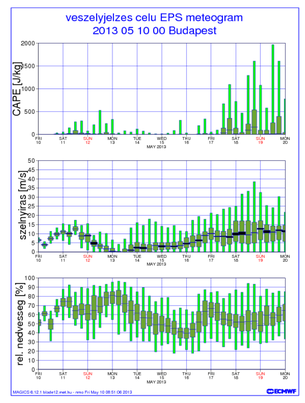


Plume diagram for Budapest issued at 00 UTC on 20 September 2012 (left) and the predicted 850 hPa temperature, MSLP and precipitation fields for cluster 1 and 2 focusing on Central-Europe (right) as shown in the Hungarian visulation system (forecasts issued at 00 UTC on 20 September 2012, valid: 24 September 2012. 00 UTC).

Some other plumes, meteograms and histogram for hydrological purposes

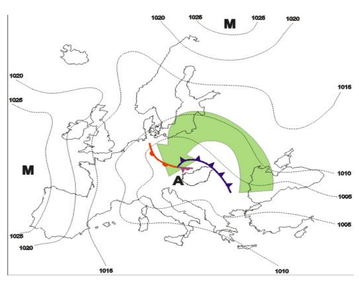


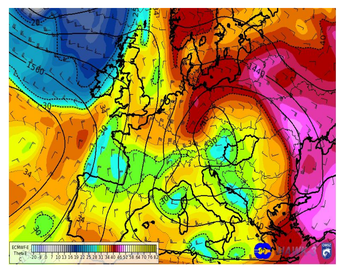




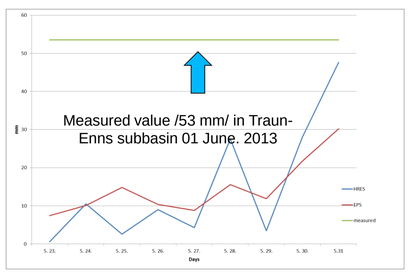
Combined plume diagram taking into account the two latest runs with all the 102 ENS members and two deterministic runs (left), precipitation histogram for Budapest (in the middle) and ENS meteogram for weather alarm purposes (CAPE index, wind shear and relative humidity) (right).

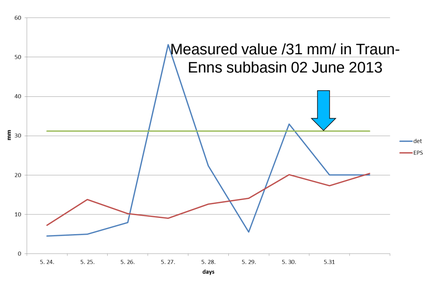
Case study: Danube floods 2013

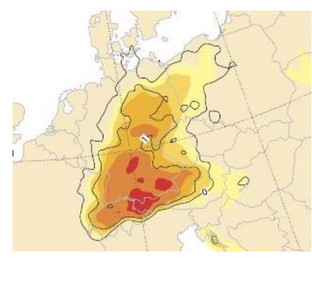




Danube flood in Budapest (left), the weather situation with the moist conveyor belt which reached the back side of the cyclone and it was perpendicular to the Alps. (in the middle) and ECMWF equivalent potential temperature at 850 hPa 31 May 2013 00 UTC (right).

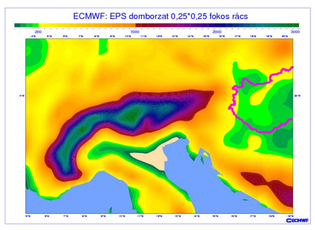


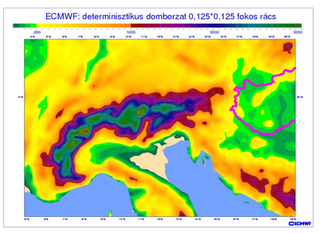


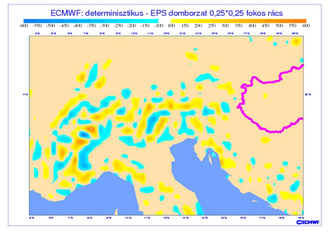


Comparison of ECMWF HRES and ENS mean: Precipitation forecast for Traun and Enns subbasins (left and middle). Forecasts valid for 01 June 2013 (left) and 02 June 2013 (middle). The HRES (blue line) has jumpiness quite often compared to ENS (red line) from run to run, while the ENS has more stability from day to day. Extreme Forecast Index (based: 29 May 2013, 12 UTC, valid: 31 May-03 June 2013) (right) */source: www.ecmwf.int/.*

The Extreme Forecast Index (EFI) measures how far away from the model climatic distribution the EPS forecast is. It scales from -1 to 1 (all members reach respectively unprecedented small and unprecedented large values).







Orography of the ECMWF ENS (left), orography of the ECMWF HRES (in the middle), and differences of the orography of the ECMWF HRES and the ECMWF ENS. In this case the HRES forecast in Alps region, due to its higher resolution provided more better results for the first 2-4 days, because this version was more able to capture the orographic effect. (The ridge is higher by 300-500 m in the HRES model.)

Calibration by using ensemble reforecasts

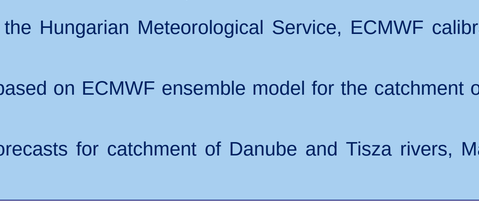
5 members ensemble reforecasts have been provided once for the last two decades a week by ECMWF since March 2008. Calibration for 24 h amount of the precipitation for area mean of the catchments based on comparison of the cumulative distribution functions of the observed monthly climatology and reforecasts monthly climatology. 100 extreme precipitation events have been collected between 2008 and 2013. Ensemble verification based on these events clearly shows calibration can successfully improve the forecasts in extreme events too.

For the probability forecast of precipitation used the ensemble calibration method. The calibration method based on the distribution functions fitting, which has the advantage that each meteorological parameter to apply and requires no complicated mathematical calculations. The innovation of the calibration procedure that we used this method for the river basins forming a regional averages and given different climates.

To calibrate, three things are needed:

- Reforecast climate, (from ECMWF reforecasts)
- Observed climate, (observations)
- ENS forecast, (from ECMWF MARS data base)

The calibration method is applied for correction of the raw ensemble forecasts. The essence of the method is that the current ensemble forecasts are modified depending on the relation of cumulative density functions between the reforecast model climate and observed climate on weekly based



Calibration in the Upper-Danube catchment at May-June 2013 (red: reforecast climate, green: observed climate, brown: raw ENS, black: calibrated ENS)

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