Using ECMWF’s forecasts (UEF 2015)
8-10 June 2015, Reading

Predictability of the precipitation forecasts based on ECMWF ensemble model for the catchment of the Danube and Tisza rivers

Amarilla Mátrai (amarilla0526@gmail.com) - Department of Meteorology, Eötvös Loránd University, Budapest, Hungary
István Ihász (ihasz.i@met.hu) - Hungarian Meteorological Service, Budapest , Hungary

Key words: preciptation forecast, catchment, ensemble forecast, density function calibration, reforecast, case study

Introduction

The precipitation, as the one of the most variable meteorological parameter, has an important role in the weather forecasts. The forecast of the precise geographical and temporal distribution of the quantity of precipitation poses is a great challenge even with the application of modern numerical weather prediction models. The reason of this is that the micro physical processes related to precipitation are extremely complex. In the mountainous regions the task is more complex, as during the creation of precipitation, deriving from terrain characteristics, other trigger effects occur as well. In the forecasts, the precipitation fallen within a shorter period of time and in large quantity, get a stressed role, which can even cause flood.
The aim of the study to examine and improve the precipitation forecasts in the large rainy weather situations. As the forecast of precipitation is a relatively insecure task, the application of ensemble forecasts are particularly reasonable, namely the probability forecasts express the reliability of forecasts as well.

Examined areas

The predictability of the precipitation examined on 21 catchments base of the Danube and Tisza rivers which involving the Hungarian area. According to the topographical characteristics basins were divided into three groups: upland, lowland and mixed. The categorization is used in the investigation to find out how topography affects the rainfall forecast.

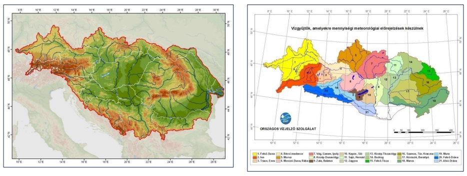

Fig 1. River basins (topography map and catchments)

Calibration

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 were 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. The more different from each other, the observation and the reforecast climate, the greater correction seen in the calibrated ENS forecast. If the two climates are almost identical, then the calibration of the forecast will result in only small improvement.

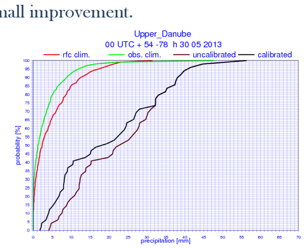

Fig 2. Selected case studies for calibration in the Upper-Danube catchment at May-June 2013 (red: reforecast climate, green: observed climate, brown: raw ENS, black: calibrated ENS)

Examinations of reforecast climates

The reforecasts are made in the ECMWF from March 2008. During our examined period every week on Thursday a 5 membered, 32-days forecast running with the current model version for the last 20 years. From these reforecast projections can be produced a climate reforecast distribution function for each of the 20 catchment on a weekly basis.
Since 2008, there has been a number of occasions of model development that has changed the horizontal and vertical resolution of the model, so the reforecast model climates had also changes.

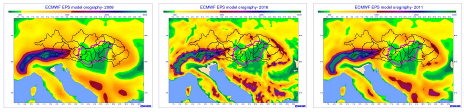

Fig 3. Horizontal and vertical resolution of ensemble model

Kolmogorov-Smirnov test was applied for the investigations of the comparison of the climates, which on the one hand, we looked at how the different climates differ; on the other hand, we examined the 2008, 2011 and 2014 reforecast climates differ significantly from the observed climate. The differences were statistically significant, so we should use the calibration for the forecasts.

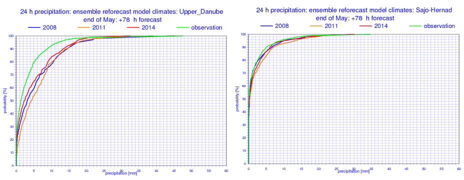

Fig 4. Differences between reforecast climates and observed climate. On the left side Upper-Danube catchment (too wet), on the right side Sajo-Hernad catchment (quite good).

According to the types of the catchments, the largest differences occurred in the mountainous catchments. Based on the distribution functions, it seems that in case of low amount of precipitation in lowland would not be necessary to calibrate, because between reforecast climates (particularly than 2014) and observed climate had small differences. However, in the case of heavy precipitation the climates were very different from each other, it was therefore appropriate calibration. The least difference was between the 2014 reforecast climate and observed climate.

Table 1. Differences between 2014 reforecast climate and observed climate on the left side, and 2008 and 2014 reforecast climates on the right side. (values on %)

RFC 2014 - Observed	
Year	79
Spring	92
Summer	79
Autumn	77
Winter	72

RFC 2008 - RFC 2014	
Year	15
Spring	13
Summer	27
Autumn	15
Winter	8

The Kolmogorov-Smirnov test was investigated annual and seasonal differences between the 2008 and the 2014 reforecast climates and observed climate. The most of the difference was in the spring and summer months. We may conclude that by the horizontal resolution of the ensemble model the summer precipitation were difficult to predict. Since the floods mainly in the spring and summer seasons occur, and also found the biggest differences between the climates in these times, so it was advisable to use the calibration. The improvement of forecasts for each river basin must be carried out separately. Because each types of catchments were no defining characteristics based on the differences between the climates.

Case study

At the end of May, 2013 the Danube flood was resulted a record water levels. The flood was caused by the cold drop which located above the north-eastern regions of the Alps. The 4-day rainfall was further enhanced by the mountain ranges of the Alps, which due to the air mass lifting effect powerful cloud formed and precipitation caused. Most of the rain fell on June 2. The 24-hour precipitation amount - regional average - in the Upper Danube river basin was 34.6 mm, Inn was 48.2 mm, Traun-Enns was 53.1 mm.

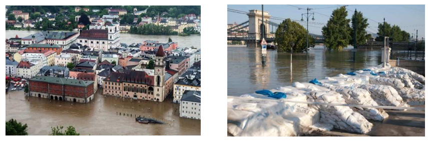

Fig 6. Influence of the flood in Passau and Budapest in May-June 2013

The high resolution (HRES) and the ensemble model (ENS) of the ECMWF the spatial location and extreme extent of the precipitation were well predicted several days before of event occurred. The HRES model overestimated the extent of the extreme precipitation during the investigation period, however in the case of the ensemble mean underestimation was specific. These differences may occur from the different resolution of the different models (the resolution of the ENS was the half of the HRES model), the variability of the forecasted weather event, the complexity of the terrain.

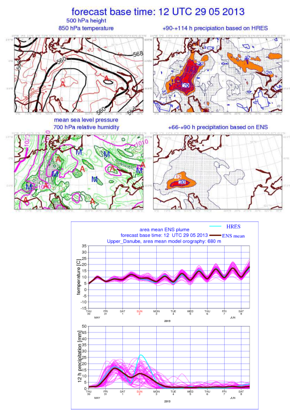

Fig 7. Examination of the May-June flood in 2013. Map visualization and plume diagram.

Conclusion and future plans

The precipitation forecast even in today's modern numerical models is uncertain, especially in mountainous areas. It is therefore necessary forecasts are needed to be improved by postprocessing. The differences between the reforecast climates and observed climate also indicate that it is necessary to improve forecasts, it is advisable to carry out the calibration. The examinations also demonstrate that the calibration of the ensemble forecasts can be improved, although to different degrees, it should take into account the terrain characteristics. In the precipitation forecast the high resolution and ensemble model of ECMWF should be considered together, because the differences from the different resolutions appear on the spatial and quantitative forecast of precipitation as well.
In the future, the presented ensemble calibration method we would like to extend for a longer period. The calibration procedure is to be used for operational work, too, to help the work of the forecaster meteorologists.

References

Mátrai, A. 2015: The examination of the predictability of the precipitation forecasts based on probability forecasts for the catchment of the Danube and Tisza rivers, Master thesis, Eötvös Loránd University, Budapest