ENSEMBLE METEOROLOGICAL FORECAST FOR THE UPPER RHONE RIVER BASIN

Javier Garcia Hernandez[1], Paul Sirvent Gimenez[1], Frédéric Jordan[2], Jean-Louis Boillat[1], Anton Schleiss[1]

[1] Laboratoire de Constructions Hydrauliques (LCH), Ecole Polytechnique Fédérale de Lausanne.
EPFL-ENAC-ICARE-LCH Station 18, CH-1015 Lausanne, Switzerland,
E-mail: javier.garciahernandez@epfl.ch
[2] e-dric.ch eau énergie environnement ingénieurs conseils,
Grand-Chemin 73, CH-1066 Epalinges, Switzerland

Abstract
A semi-distributed hydrological model was developed for the Upper Rhone River basin in Switzerland. It is currently operational for a real-time flood forecast in the Rhone Valley. It simulates the snow and glacier melt, soil infiltration and run-off processes, flood routing in rivers as well as hydropower scheme operations.

For the computation of flood prediction, the numerical meteorological forecasts COSMO-LEPS, COSMO-7 and COSMO-2, provided by MeteoSwiss, have been assimilated. The forecast errors are analyzed by comparing the performance on different time periods, regarding the observed and the predicted rainfall and temperature over the entire catchment area as well as in punctual locations. The influence of the lead time is described with the aim of providing an estimation of the forecast error. A performance evaluation is achieved considering indexes like Brier Score and Relative Operating Characteristic.

Keywords: *Deterministic and ensemble meteorological forecast, Brier Score, Relative Operating Characteristic*

1 INTRODUCTION

Forecasting precipitation is a complex task because the formation of precipitation involves interactions between many different types of processes related to synoptic-scale, mesoscale dynamics, boundary conditions, etc. Further complexity occurs in mountainous regions where the topography influences in an important way the cloud dynamics and the precipitation microphysics.

Ensemble prediction system (EPS) is a feasible way to complete deterministic forecasts with an associated occurrence (Buizza & al., 2005). The existing uncertainty about the current state of the atmosphere is taken into account by calculating different forecast scenarios with an associated probability. EPS constitutes one of the most promising avenues in the meteorological research (Demeritt & al., 2007).

COSMO-LEPS is the limited-area EPS (Ensemble Prediction System) developed within the COSMO consortium (Consortium for Small-scale Modeling) since 2002. This system combines the benefits of the ensemble approach with the high-resolution of the limited-area model integrations. The COSMO-LEPS system provides daily ensemble forecasts with high resolution (horizontal mesh-size of 10 km) based on a 16-member ensemble for central and southern Europe with a lead time of 132 hours. Initial and boundary conditions are representative members of the global ECMWF (European Centre for Medium-Range Weather Forecasts) ensemble. The purpose of COSMO-LEPS is the improvement of the early and medium-range predictability of extreme and localized weather events, particularly when orographic and mesoscale-related processes play a crucial role (Marsigli & al., 2007).

Deterministic forecasts COSMO-7 and COSMO-2 are complementary to COSMO-LEPS. The regional COSMO-7 is driven by the global model of ECMWF and covers most of western and central Europe. It is calculated twice daily for 72 hours lead time on a grid spacing of about 6.6 km. The local COSMO-2, driven by COSMO-7, covers the Alpine region with Switzerland at the center and is computed on a grid spacing of about 2.2 km. It is provided 8 times daily for 24 hours lead time. Both COSMO-2 and COSMO-7 offer the benefit of the nowcasting and short range forecasting.

Meteorological predictions are finally used as input for the hydrological model, created with Routing System (García & al., 2007), producing hydrological ensemble forecasts as well as deterministic forecasts for the flood prediction in the Upper Rhone River basin (Jordan, 2007).

2 METEOROLOGICAL INDEXES

Indexes like the intensity or temperature bias and volume or average temperature bias for different time periods as well as indexes commonly used in meteorology such as the Brier Score (BS) and the Relative Operating Characteristic (ROC) are used to evaluate the forecast performance.

The bias represents the report between the predicted and observed values. The BS allows comparing the forecast probability of an event and its occurrence (Brier, 1950). It depends on three factors: reliability, resolution and uncertainty. The ROC curve defines the ability of a probabilistic forecast system to distinguish between situations predicting the occurrence and the non-occurrence of an event (Mason & Graham, 1999). It is frequently applied to assess the ability of ensemble forecast systems to discriminate between the occurrence and non-occurrence of precipitation accumulations over a specific threshold.

3 RESULTS

The proposed indexes allow the comparison of deterministic COSMO-7 (C7) and COSMO-2 (C2) and probabilistic COSMO-LEPS (CL) forecasts for different time periods.

Bias indicators show a big dispersion in the precipitation intensity for the deterministic forecasts as well as for the weighted average of the probabilistic one. Besides, an overestimation of the precipitation is in general produced which increases by a long way the forecast period.

Temperatures are usually rather well predicted and similar in all the forecasts. The hourly error is around 2.5°C and the daily average error around 2°C.

BS commonly show values smaller than 0.4 for all studied forecasts (Figure 2, left). Forecasts are generally better than the persistence (prolongation of the first day measured observation). However, a severe assessment is necessary for higher rain intensities. This will be possible as soon the re-simulations of past events (September 1993 and October 2000) from MeteoSwiss will be achieved.

The ROC index proves that the probabilistic forecast is better for the prediction of an event exceeding a threshold (Figure 2, right). Thresholds of 5 to 50 mm/24h have been studied, being the performance of the probabilistic forecasts higher for smaller thresholds, as well as for deterministic meteorological forecasts. Although, re-simulations will also be required for heavier precipitation data. Regarding the Correct Alarm Ratio and the Miss Ratio (Mason & Graham, 1999), probabilistic forecasts provide also better results.

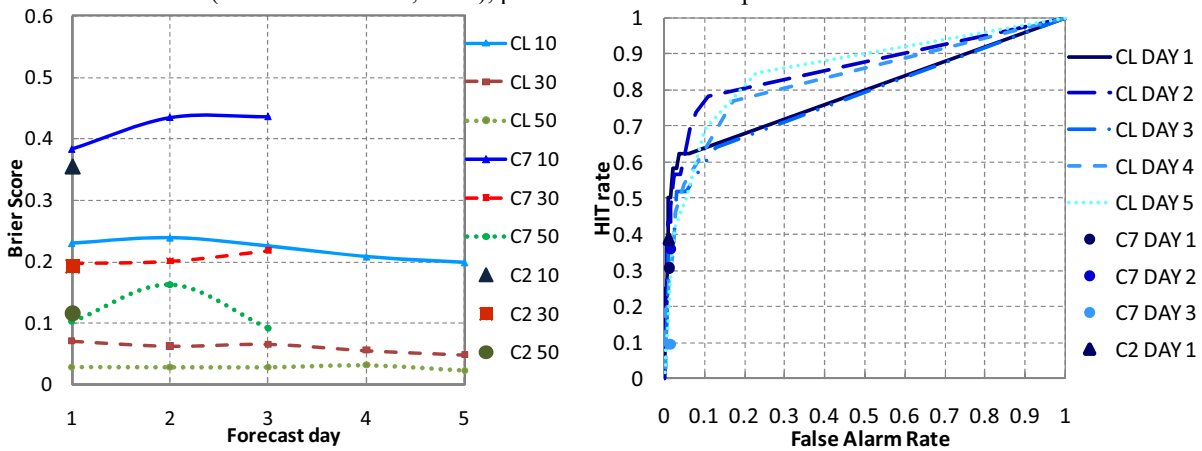

Figure 1: Left: Brier Score for different thresholds (10, 30 and 50 mm/24h), forecasts from 01.07.2008 to 02.28.2009. Right: ROC for the 30mm /24h threshold, forecasts from 01.07.2008 to 02.28.2009.

4 CONCLUSIONS

The indexes used to evaluate the forecast performance show the improvements of the EPS in the meteorological area. The results provided decrease the uncertainty in the flood forecasting domain, where the methods of risk analysis have taken more importance during the last years, allowing the decision-makers to know the rationality of their decisions.

More events of extreme precipitations are necessary for the assessment of high thresholds in order to have a large sample providing representative results. That is the motivation of events re-simulations by MeteoSwiss.

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