The LM_PL14 & LM_PL07 Model Forecasts as Input into a Hydrological Forecasting Model

Malgorzata Mierkiewicz, Janusz Zelazinski and Jan Parfiniewicz

Institute of Meteorology and Water Management, Warsaw, Poland

Precipitation (rainfall or snow) is the most important factor releases with a hydrological response.

Hydrograph forecasts for a few days are necessary in operational activity for effective prevention and rescue action, first of all in a flood situation. An adequate hydrograph forecast based on observed precipitation can be only prepared several hours ahead because of very short time of a river basin reaction. Prolongation of the lead-time can be achieved by the use of the quantitative precipitation forecast (QPF) as input into the hydrological forecasting models.

One of sources of such forecasts is the mesoscale meteorological model LM, which is running operationally in the Institute of Meteorology and Water management, Warsaw, Poland. The LM model uses two different calculation networks and gives the QPF for each grid point with the 1(3)-hours time step (1h for the first 30 hours) and for three days (78h) ahead in the version with the 14x14 km network and for practically one day (30h) ahead when the 7x7 km network is used.

Responsibility for the hydrological forecasting over Poland (comprise of about 92 basins) is shared between 5 regional IMGW branches. The system explored in Warsaw comprises the lowland part of Poland of over 15 basins. In forecasting practice for such rivers the time step shorter than 1 day is not needed and three days ahead forecasts are a standard.

As an example of implemented routine the catchment of the Pilica River has been chosen (the area about 4000 km^2). Since April 2002 following data have been collected:

- Observed daily precipitation and mean daily air temperature (necessary in winter season) for 10 meteorological stations situated in the Pilica River basin – average precipitation and temperature over a basin area is estimated by using of a special procedure,
- Observed discharge at the gauge water station that closes the river basin,
- Forecasts of precipitation and air temperature, which are averaged for whole basin based on grid values,
- Forecasted discharge as an output of the rainfall-runoff forecasting model (the Swedish model HBV).

The QPF error analysis was performed taking into account following points of view:

- Is it possible to decrease uncertainty that is concerned with future precipitation in forecasted lead-time?
- How do errors of forecasted precipitation influence forecasted discharge?

The goodness of the computed hydrograph fit still depends on the QPF, however the relation between the QPF and forecast error (i.e. differences between synchronic values of observed and forecasted discharge) depends on the initial conditions (first of all on the actual soil moisture conditions).

It is possible to calculate different quality indexes of forecasts. Here, the efficiency (E) of the forecasting method is measured by $E = \sigma_M/\sigma_I$, where σ_M denotes the standard error of the model forecast, and σ_I is the standard error of the inertial forecast (remaining the same as observed at the initial moment of the forecast).

$$\sigma = \sqrt{\frac{\sum_i^n (y_{obs_i} - y_{prog_i})^2}{n}},,$$

where y_{obs_i} are the observed values, y_{prog_i} are the forecasted values and n is the number of elements.

So the index E is considered as a comparison of forecast errors to the errors of "no forecast case". Thus, if the model produces errors equal or greater than inertial forecast it means that the model does not contribute any information gain. The value $E \geq 1.0$ disqualifies the model, the value E between 0.8 and 1.0 presents an index of little progress produced by model, and $E < 0.8$ can be considered as an index of fair model performance.

Values of statistical estimates are presented in Table 1 respectively to precipitation itself averaged over the basin area, and, in Table 2 as referred to the rainfall-runoff model discharge forecasts. Stress, that in Table 2 forecasts errors of discharge were calculated for two scenarios

Table 1: The LM model for networks 14x14 km and 7x7km for the Pilica River basin, period: April - November 2002. Standard errors (σ) and efficiency indexes (E) of precipitation forecasts.

	1 day ahead		2 days ahead		3 days ahead	
	σ	E	σ	E	σ	E
Precipitation forecast for 14x14 km network	3.96	0.84	5.07	0.81	4.60	0.70
Precipitation forecast for 7x7 km network	3.86	0.82				

Table 2: The rainfall-runoff model HBV for different variants of precipitation forecasts for the Pilica River basin, period: April - November 2002. Standard errors (σ) and efficiency indexes (E) of discharge forecasts.

	1 day ahead		2 days ahead		3 days ahead	
	σ	E	σ	E	σ	E
Discarge forecast for observed precipitation	1.84	0.49	2.42	0.46	2.94	0.39
Precipitation forecast for 14x14 km network	2.12	0.57	3.96	0.76	6.14	0.82
Precipitation forecast for 7x7 km network	2.11	0.57				

of precipitation:

(1): precipitation forecasts taken from the LM (14&07) model,
(2): forecasted precipitation equals to the observed one.

As indicated from above tables the efficiency of the HBV model discharge forecasts is quite reasonable for the first day forecast, and substantially better than that measured respectively precipitation field itself. It reduces substantially for the second, and especially for the third day of forecast, becoming less then index calculated in Table 1 for the precipitation itself. The issue why QPF errors for LM_07 does not give gain as compared to LM_14 should be investigated over other basins, if possible in respect to mountains catchments with denser then 1_per_day time resolution on input to the HBV model.

The analyses has been made also based on visual comparison of probability distributions of absolute errors of forecasts and observed values (in a probability scale). As an example results of errors of 1-day ahead LM_07, LM_14 and "observed precipitation" forecast are presented on Figure 1. Although such graphical comparison is rather subjective, it gives comprehensive view of model properties performance.

The analyses of all graphs (including above one) give that:

- The quality of the forecast output is not quite satisfactory, especially for rather rare but heavy rain episodes,
- the probability distribution of observed precipitation is similar to the distribution of errors of forecasted precipitation - that means, the range of QPF errors is comparable to the range of observed precipitation (especially for two and three days lead-time),
- where the QPF is the input, it creates additional considerable errors but despite of that obtained flow forecasts are reasonably good.

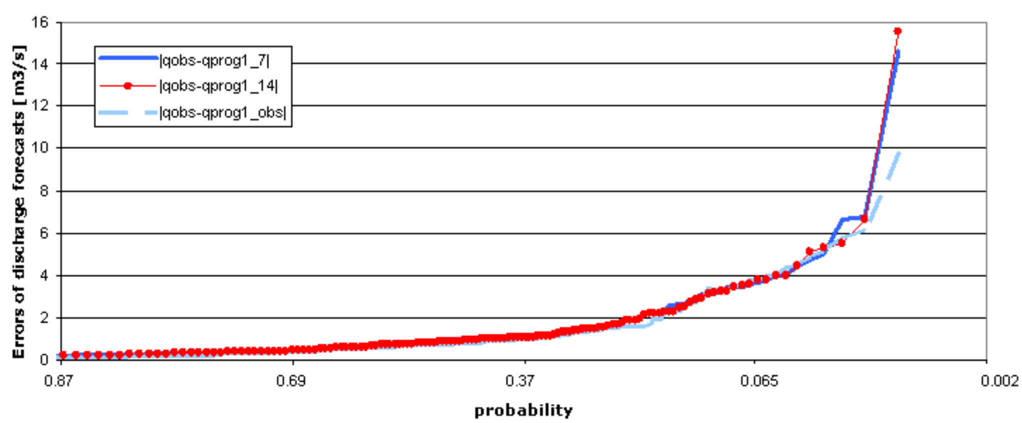

Figure 1: Probability distributions of absolute errors of forecasts and observed values – see text.