HYDROLOGICAL EVALUATION OF A NOWCASTING TECHNIQUE APPPLIED TO FLOOD FORECASTING

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1. INTRODUCTION

Floods are the most important natural hazard in the Mediterranean areas and anticipation (even of a short lead time) is important for flood forecasting and warning. In this framework, a number of works have shown the utility of radar information to provide good flow estimates using a rainfall runoff model even if a dense network of rain gages exists (see Sempere-Torres et al., 1999).

To extend the anticipation time of the output flows of the model, a nowcasting technique may be used to forecast rainfall fields. Recently, it has been proposed to do the forecast filtering smallest scales (Germann and Zawadzki, 2002; Seed, 2003) as the predictability of rainfall patterns depends on their scale (Bellon and Zawadzki, 1994).

The aim of this study is to assess the performance of these nowcasting techniques not only from the point of view of forecasted rainfall fields but also from the perspective of the hydrographs calculated by a distributed rainfall-runoff using the forecasted rainfall fields. Finally, the results are compared with those obtained with a simpler advection technique.

2. THE NOWCASTING TECHNIQUE

The nowcasting technique is very similar to S-PROG (Seed, 2003) and consists in a two-way analysis of the most recently measured radar scans to do the forecast (see Fig. 1):

2.1. Tracking algorithm

The echo motion field is estimated using a TREC technique with a resolution of 32 km.

2.2. Scale analysis

Since the predictability of rainfall patterns depends on their scale, the idea of this analysis is to decide which scales are not predictable.

A reflectivity field can be decomposed into a group of fields that represent the variability in different ranges of scales. It is done in the spectral domain, applying the FFT to the dBZ field, by means of a band-pass filter.

$$dBZ_{i,j}(t) = \sum_{k=1}^{n_k} X_{i,j,k}(t) \qquad (1)$$

After normalizing each field X_k, the autocorrelation coefficients are calculated. These coefficients give us an idea of the predictability of the patterns for each range of scales.

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2.3. Forecasting

The forecast is done by advection of radar echoes according to a backward scheme.

During the advection, the reflectivity field is still decomposed in scale levels whose evolution is supposed to be well represented by an AR(2) model. The model coefficients $\phi_{k,1}$, $\phi_{k,2}$ are obtained from $\rho_{k,t}(1)$ and $\rho_{k,t}(2)$ previously calculated (from the Yule-Walker equations).

Finally, the forecasted reflectivity field is obtained as the sum of the scale levels (as in (1)).

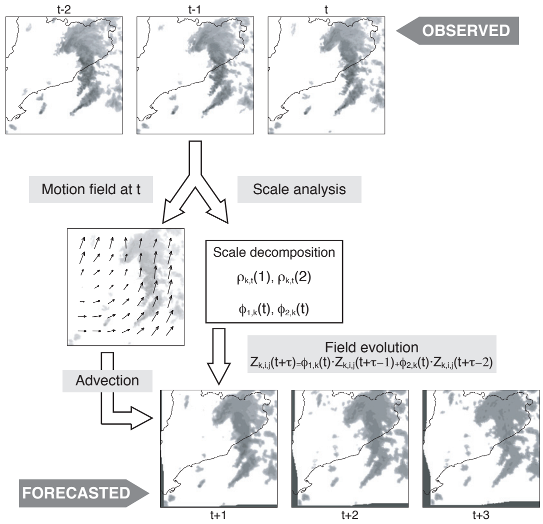

Fig. 1. Scheme of the nowcasting algorithm.

3. THE RAINFALL-RUNOFF MODEL

The rainfall-runoff model TOPDIST (Corral et al., 2001) has been used to transform the estimated distributed rainfall field into flow in different points of the catchment. The model needs the basin to be splitted into *hydrological cells* (1x1 or 2x2 km^2) where a lumped model is applied. The final hydrograph is obtained as the sum of the flow calculated at every cell, after being routed to the outlet of the catchment by a Unit Hydrograph derived from the drainage system.

4. CASE STUDY

The nowcasting technique has been applied over data from the INM C-band radar (located near Barcelona), with a 10-minutes and 1-km resolution and covering an area of 256x256km^2.

Three significant rain-flow events in the Besos river (B3 in Fig. 2) have been chosen to assess the performance of the technique from the point of view of the forecasted rainfall fields and from the perspective of the flows generated in the Besos basin.

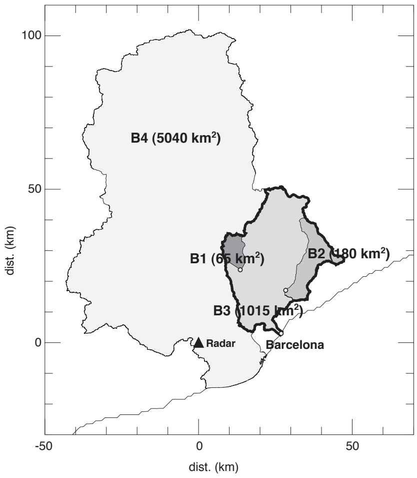

Fig. 2. Area of study. The hydrological model has been applied over the Besos basin (B3 -bold line-).

4.1. Forecasted rainfall fields

Forecasted rainfall fields are evaluated with the RMSE in terms of rainfall intensity (mm/h) over different-sized basins (B1 to B4 in Fig. 2).

TABLE 1 summarizes the results of applying SPROG along the three studied events compared to a simple advection scheme (without scale filtering).

4.2. Forecasted hydrographs

The *forecasted hydrographs* corresponding to a certain lead-time have been generated with the value of flow forecasted at each time step during the event (this kind of hydrographs represents the runoff estimates forecasted some time in advance –even if they are not "real" hydrographs-).

In TABLE 2, the results of applying the analyzed technique to provide the rainfall forecasts to TOPDIST are presented in terms of the Nash efficiency between forecasted hydrographs and those calculated "offline", with the full series of precipitation fields from radar.

5. CONCLUSIONS

In this study a nowcasting technique (SPROG) has been evaluated for hydrological purposes.

The main conclusion is that, while from the point of view of the forecasted precipitation fields SPROG provides better estimates than a much simpler technique (simple advection), when these rainfall fields are used as input of a rainfall-runoff model, the quality of the forecasted hydrographs does not differ significantly from those obtained when the precipitation field is forecasted by advection.

Although the quality of the forecasts vary with the size of the analyzed basin, differences in the quality of the performance of the two analyzed nowcasting techniques do not seem to depend on the size of the basin.

From a qualitative point of view, it has been stated that good estimations of the motion field, as well as the average rainfall evolution over the basin are crucial points to obtain good forecasted hydrographs (specially in the case of small basins).

15-16Jan2001 (mainly stratiform).

Lag(min)	Basin B1	Basin B2	Basin B3	Basin B4
20	3.2 (3.2)	2.1 (2.3)	2.1 (2.2)	1.0 (1.0)
40	3.7 (3.4)	2.6 (2.9)	2.6 (2.8)	1.3 (1.3)
60	3.8 (3.7)	2.6 (3.3)	2.7 (3.0)	1.3 (1.4)

14-16Jul2001 (mainly convective).

Lag(min)	Basin B1	Basin B2	Basin B3	Basin B4
20	2.4 (3.8)	3.8 (4.2)	3.8 (4.4)	2.7 (3.2)
40	2.5 (2.7)	4.1 (4.7)	4.2 (4.6)	2.9 (3.3)
60	2.5 (2.8)	4.1 (4.2)	4.2 (4.4)	2.9 (3.1)

14-16Dec2001 (stratiform with embedded convective cells).

Lag(min)	Basin B1	Basin B2	Basin B3	Basin B4
20	2.6 (3.8)	2.8 (3.1)	2.7 (3.2)	1.5 (1.9)
40	2.8 (3.9)	3.0 (3.3)	2.9 (3.5)	1.7 (2.5)
60	2.9 (3.8)	3.0 (3.2)	2.9 (3.4)	1.8 (2.8)

TABLE 1. RMSE (mm/h) in basins B1 to B4 (Fig. 2) for the forecasts obtained with the analyzed techniques (SPROG and simple advection –in parentheses-).

Basin B1 (65 km^2)

Lag(min)	Jan2001	Jul2001	Nov2001
60	0.94 (0.93)	0.96 (0.93)	0.82 (0.44)
90	0.63 (0.69)	0.75 (0.76)	0.14 (-0.62)
120	0.20 (0.45)	0.58 (0.68)	-0.08 (-0.40)

Basin B2 (180 km^2)

Lag(min)	Jan2001	Jul2001	Nov2001
90	0.93 (0.93)	0.98 (0.94)	0.75 (0.68)
120	0.74 (0.85)	0.91 (0.85)	0.46 (0.38)
180	0.58 (0.53)	0.75 (0.53)	-0.22 (-0.15)

Basin B3 (1015 km^2)

Lag(min)	Jan2001	Jul2001	Nov2001
90	0.94 (0.96)	0.98 (0.97)	0.70 (0.70)
120	0.87 (0.91)	0.93 (0.94)	0.38 (0.40)
180	0.55 (0.67)	0.87 (0.82)	0.00 (0.00)

TABLE 2. Nash efficiencies of the forecasted hydrographs calculated with TOPDIST using SPROG and simple advection (in parentheses) relative to the hydrographs calculated offline at basins B1 to B3.

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