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Hidromet: a weather radar based warning system for supporting exploitation and management of water-treatment plants

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1 Introduction

The Hidromet project is an initiative of technological innovation in the field of support systems devoted to the operation of services of production and distribution of potable water. This pilot project aims to facilitate the operation of water-treatment plants by means of the use of rainfall products derived from weather radar.

2 Description of the problem

The metropolitan area of Barcelona has hydric resources coming from superficial waters, rivers Llobregat and Ter, and from underground resources of the Baix Llobregat water-bearing. The water-treatment plant of Sant Joan Despí catches up to 5 m^3/s of superficial water of the Llobregat river and approximately supplies 1.5 million inhabitants of the metropolitan area. The resources of the Baix Llobregat water-bearing are of strategic nature. They are used in periods of drought, or alternative during episodes of low quality in superficial waters. These episodes mainly affect to the superficial water collected by the water-treatment plant of Sant Joan Despí: up to 50 situations of plant shutdown per year are registered. Most of the shutdown cases are related with sudden increase of turbidness and pollution in the main stream of the river, produced by drag of soil from a basin (Riera de Rubi basin) located up to the intake of the water-treatment plant (see figure 1).

Riera de Rubi gathers waters of a river basin highly populated and industrialized. Its regular volume is intercepted by a small damp that turns aside the water, usually of low quality, towards an interceptor channel that runs parallel to the Llobregat river and that pours the water behind the intake of the water-treatment plant. During intense or prolonged precipitation phenomena, the volume surpasses the interceptor and the flow goes directly into the main river stream. In this situation the water is highly polluted by urban and industrial agents that deteriorate the quality of the main river.

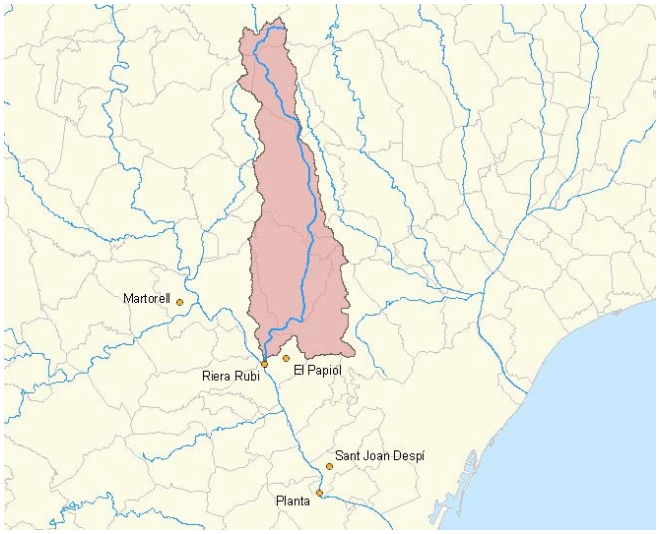

Fig 1. - General situation map of the basin and the water-treatment plant.

Fig 2. - Detail of the Interceptor of Rubi basin and the taking of the channel.

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The enterprise in charge of operating the plant of Sant Joan Despí, Waters of Barcelona (Agbar), has been equipped with a raingauge network and a water quality alert system to operate in such situations. The quality information facilitated by this system (turbidity and conductivity) helps to evaluate the time of propagation of pollution between the interceptor of Rubi basin and the intake of the water-treatment plant (see figure 3).

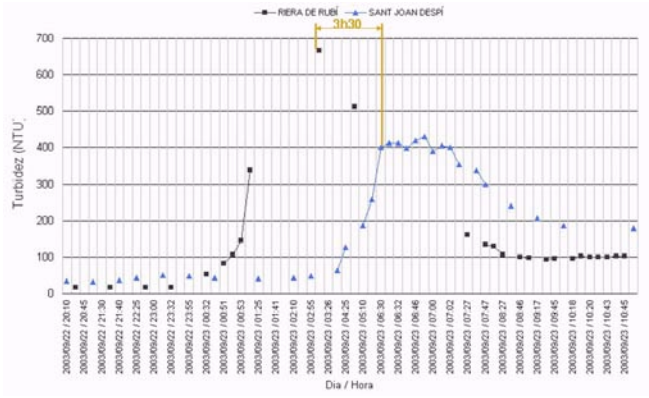

Fig 3. - Example of an event with contamination by turbidity.

Repeating this estimate for different historical events, and depending on the circulating volumes, the times of propagation varies from 2 to 4 hours between the interceptor and the intake. With these hours of anticipation it is possible to close the intake, but it is a limited time to activate in advance an alternative water source (as underground resources of the Baix Llobregat water-bearing). On this regard a weather radar derived product has been develop in order to increase the time anticipation to such phenomena.

3 Weather radar products

The Hidromet project uses the hydrometeorological products generated by the radar network of the Servei Meteorològic de Catalunya (SMC) (Figure 4 shows an image of the SMC present network). An Integrated Hydrometeorological Forecasting Tool (EHIMI) has been developed in order to obtain quantitative products from radar data. EHIMI aims to deal with all the process of hydrometeorological exploitation of the SMC weather radar network: 1) the application of algorithms that correct the most significant errors that affect rainfall estimation by radar, 2) the generation of hydrometeorological product, 3) the development and implementation of distributed hydrological models, and 4) the development of decision tools to operate the system.

EHIMI chain of corrections includes several data corrections: lost azimuths, radar signal stability, errors in radar orientation, orographic corrections (beam blocking and ground clutter removal and substitution), suppression of secondary lobes contamination, and speckles removal. From corrected data various types of quantitative products are generated:

- Identification of types of precipitation (from a series of algorithms that allows to determine the convective areas, and areas with presence of stratiform rain or snow), and alert associated to convective/bright-band zones.
- Alert/correction of attenuation problems, in cases of very intense convective events.
- Accumulated rainfall products.
- Network products (that combine data from different radars).

Throughout 2006 it is foreseen to include new developments in the processing chain:

- Improvement of the ground clutter removal by means of a fuzzy-logical methodology that allows the combination of various parameters.
- Development of a VPR correction to improve quantitative rainfall estimation (extrapolation of radar data measured aloft to the ground and Z-R conversion will be based on the type of precipitation).
- Development of forecasting products based on radar data.
- Quantitative products derived from combination of radar and raingauge data.

As an example Figure 5 compares the accumulated rainfall calculated by means of basic procedures of correction and by the chain of corrections of the EHIMI tool.

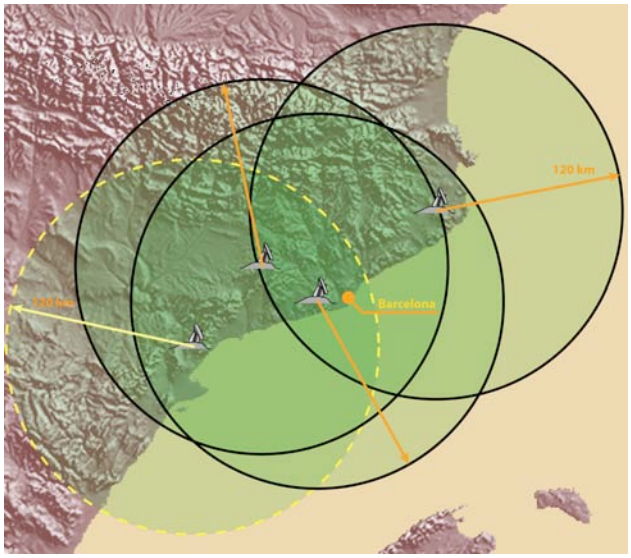

Fig 4. - C band Radar network of the SMC, three radars operate at present moment and a fourth is foreseen for 2007 (dotted).

Two radar products have used for the Hidromet project:

1. The field of reflectivity and intensity of precipitation from instantaneous radar data.
2. The 1/2-hour accumulated precipitation field.

In both cases the products are generated each six minutes from the combination of data of the three radars of the network of the SMC (for the accumulated product a moving

window is used to calculate the 1/2-hour accumulation each six minutes).

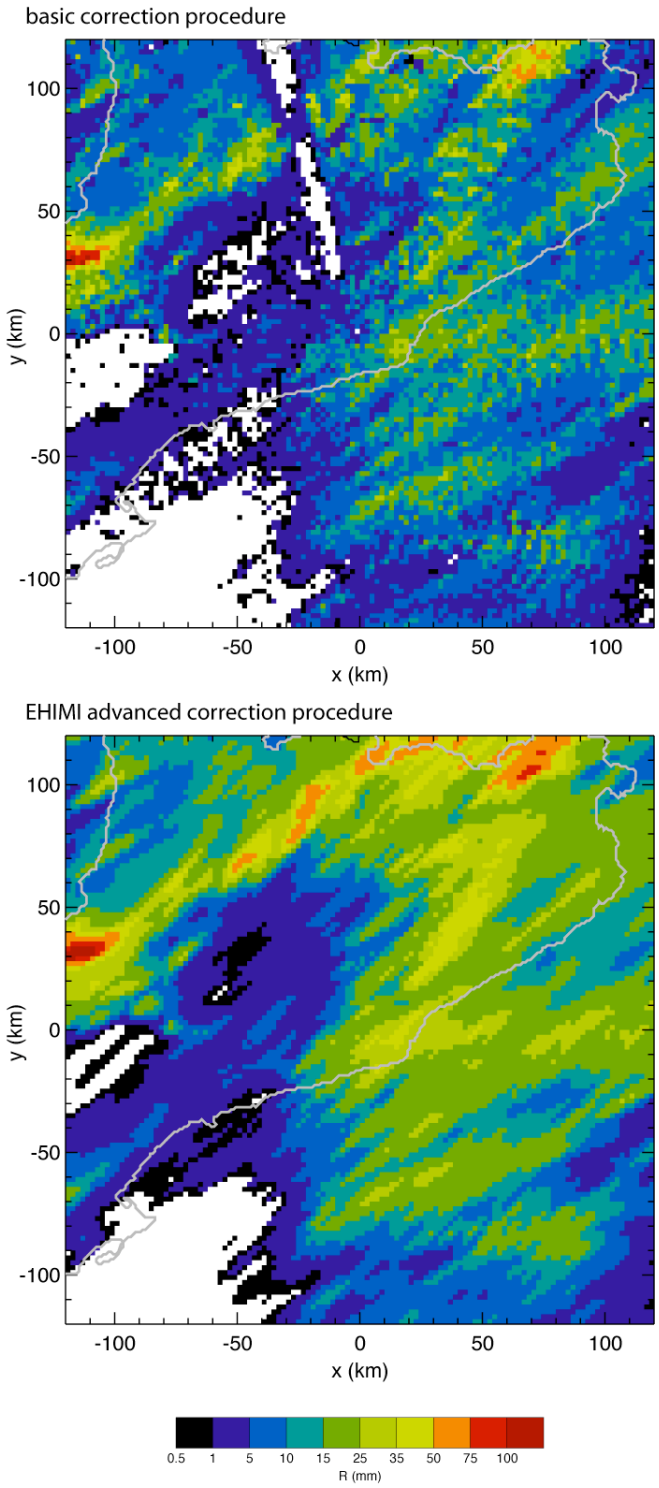

Fig 5. – Comparison of accumulated rainfall by radar by means non-optimized processing and using the system of corrections included in the EHIMI tool.

4 The alert system

The alert system consists of a module of visualization and a generator of alerts in the Control center of Planta de Sant Joan Despí, from where the automatic acquisition of radar products generated in the SMC is made. The visualization module represents the dynamic sequence of images of intensity of precipitation or accumulated precipitation. Also, it allows to select and keep the more significant episodes of precipitation, for later analysis and possible training of the plant operators. The visualization tool lets to select the cartographic layers to be represented, and has various levels of zoom, two of them fitted on the river basin of Riera de Rubi.

The visualization tool also allows identifying the quality of the radar products (basically, lacks of radar data for composite or accumulated product). The alert module provides four alert indexes (0 to 4) if the accumulated intensity of precipitation or instantaneous precipitation surpasses certain predefined thresholds over an area. These thresholds are applied 1- over a circle surround the Riera de Rubi basin to provide a first level of alert and 2- over the basin area to provide the regular alert. The alert thresholds could be modified by the user, on the basis of the operation experience.

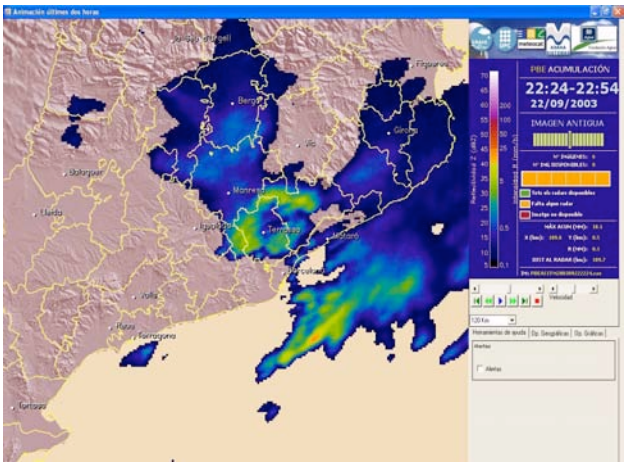

Fig 6. – Example of the visualization tool with accumulated data.

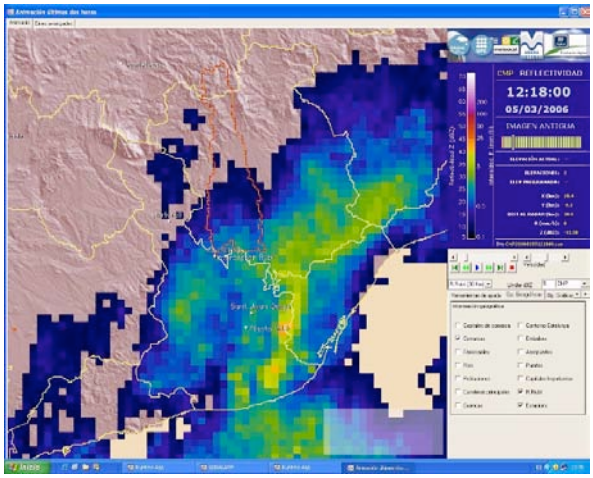

Fig 7. - Visualization of the field of intensity of precipitation intercepted by Riera de Rubi.

Level	Radius	Treshold	Number of pixels
0	30	10 mm/h	8
1	R.Rubí	10 mm/h	8
2	R.Rubí	20 mm/h	8
3	R.Rubí	30 mm/h	8
4	R.Rubí	40 mm/h	8

Fig 8. - Initial plan of alert thresholds. According to the value of the alert index different operative procedures will be triggered, not only for the operation of the plant, but also for the management of the global strategy of the hydric resources.

5 Real time application

For the adjustment of the alert historical information from the 2000 – 2005 period has be used: hour of beginning and duration of the events of plant shutdown, daily accumulated precipitation in the 12 rain gauges of the Agbar network in the area, days when interceptor is exceeded and daily spilled volume. Table 1 shows the annual evolution of the number of days with plant shutdown and the days when the interceptor is surpassed.

Year	Days of exceeded interceptor	Plant shutdown days
2000	28	33
2001	34	28
2002	45	67
2003	42	50
2004	62	57
2005	24	58
Total	**235**	**293**

Table 1. - Number days with shutdown of plant and days when the interceptor is surpassed.

Simply by the information at daily level it is difficult to distinguish a clear relation between interceptor surpassed and the plant shutdowns. However, in some years of small rain amounts, like 2005, it is observed that the relative impact of Riera de Rubi diminishes. It is then necessary to make a detailed analysis, considering the relation between the daily volume spilled over the interceptor and the hours of plant shutdown, like the example of figure 9.

This information allows to identify that more of 50% of the situations of plant shutdown are associated to episodes of precipitation that cause the surpassing of the interceptor. A more detailed analysis enables to make a selection of the most significant episodes. This analysis of episodes will allow to verify the consistency of the adjustment of the alert thresholds, and asses the capacity of anticipation that can be obtained by means of the hydrometeorological information. Also, it will serve as bases for the training of the technicians and operators of the plant.

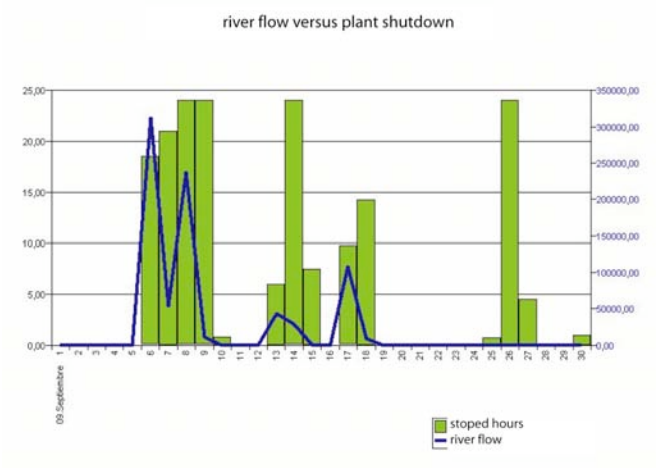

Fig 9. - Representation of the volume spilled as a function of the hours of plant shutdown.

6 Perspectives and awaited benefits

With the developed alert system based on radar products it is desired to obtain capacity of anticipation in the operation decisions before unfavorable situations. The main consequence will be the improvement in the global operation of production and transport of the potable water, guaranteeing the quality of the service to the supplied population. The alert system is compatible with the evolution of radar products generated by the SMC and the EHIMI system. New improvements and corrections in the correction chain will be reflected immediately in the performance of the alert system. Additionally the system must be improved in the future in order to considerate other cases affecting the plant, associated to hydrometeorological phenomena in other subriver basins of the Llobregat, like the Anoia and the Cardener. In any case, the developed decision tool will allow the integration of these new catchments.

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