

# M3FLOOD: AN INTEGRATED SYSTEM FOR FORECASTING, ALERTING AND MANAGING HYDRAULIC EMERGENCY

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## ABSTRACT

M3Flood – “*Monitoring, Managing, Mitigating*” is a modular decision support tool, which is both scalable and interoperable with existing and future external systems. It is targeted at organizations responsible for the management and mitigation of flood based emergencies for example: Civil Protection Authorities (regional and national), Regional Water Authorities, and Meteorological Offices. The intuitive user interface can be managed by operators from diverse scientific backgrounds and levels, an asset which is supported by the clear hierarchical end user profile structure.

The system presents a real-time monitoring and forecasting tool, utilising hydro-meteorological data input, coupled with a series of analytical utilities dedicated to assist rapid and precise interpretation and decision making under adverse situations. The user interface based in GIS offers the end operator with a complete view of past, current and forecast conditions. In addition, the M3Flood system can be complemented with numerous specific modules, facilitating flexibility and customisation to individual organisation specifications.

## CONTEXT

River floods are natural disasters during which human lives, property and infrastructure may be threatened. In modern times, floods have caused more casualties and damage than any other destructive natural event. Furthermore, over the globe, and especially in Europe, a noticeable increase in the magnitude of destruction (associated with increased average, and extreme flood events to some extent influenced by anthropogenic activities), has been observed. This, in turn, has attracted a high media profile, thereby increasing public awareness and concern. As a direct result, there is an ever-increasing demand for efficient flood management and mitigation systems. To fill this niche, an optimised combination of prevention, early warning, crisis and post-crisis activities, and standard terminology, based on one commonly available platform is required. In this context, the M3Flood system has been developed from the prototype denominated Mushroom (Multiple Users Service for Hydro-geological Risk Open & Operational Management).

Mushroom was instigated as a project in the V EC Framework Programme, e-Ten (Trans European Network) Programme, by a consortium of private companies and public organizations in Italy, Spain and the United Kingdom. Datamat S.p.A. (IT) has coordinated the Consortium, with the participation of Telespazio (IT), Geosys S.L. (SP), ProGeA s.r.l. (IT) for the system and service development. The Province of Modena (IT), ARPA Emilia Romagna – Hydro-meteorological service (IT), Technical Basin of the river Reno (IT), IMIDA (SP) and the Confederación Hidrográfica del Segura (ES) are current end users. The project assessment has been carried out by NuWater (UK).

## DESCRIPTION

M3Flood is a modular system, scalable and interoperable with external systems both current and foreseen, supporting organizations responsible for the managing and mitigation of emergencies derived from floods.

The system provides agile tools for:

- The management and real-time monitoring of hydro-meteorological data, on reference basins, flood forecasting, and related analysis and evaluation of on-going events, using an integrated GIS application;
- The generation of warnings and alerts based on observations and forecasts for responsible organisations such as Civil Protection authorities;
- The informed management of hydraulic emergencies.

The M3Flood system has been successfully tested on European trial basins in Spain and Italy. The system was customised to meet specific end user requirements with regard to language, reports and communications, data incorporation and model calibration.

## THE SPANISH TRIAL CONTEXT

The Segura basin is situated in the south east of the Iberian Peninsula covering an area of almost nineteen thousand square kilometres. The basin has been witness to devastating floods that have caused loss of life and important economic consequences. Topographically the basin is a territory of great orographic variety, with an alternation of valleys, depressions and plains, with maximum altitudes above two thousand meters. In terms of lithology, most of the territory is impermeable or semi-impermeable, thereby seriously hindering infiltration. One main watercourse, the River Segura, and a group of tributaries, principally on the right margin such as the River Argos, River Quipar and the River Mula, dominate the basin. In general the left margin of the river network down river from the confluence with the River Mundo consists of a network of ephemeral streams or wadis, not connected with the aquifers of the basin, typified by erratic almost unpredictable flashy hydrographs in flood episodes interspaced with long inactive dry periods. The climate is of the Mediterranean type tending towards semi-arid, characterized by a mean precipitation of 365 mm with extremes of 200 and 1000 mm in the southwest and north west corners of the basin respectively. The maximum values for precipitations are more typical in the autumn months; however, it is not uncommon to register important storms during the spring. An additional negative factor is the great variability of the inter-annual distribution of precipitation, giving rise to important periods of drought alternated with occasional but strong torrential rains. These rains, normally of convective origin can be the source of important floods. Mean temperatures in the basin range from 10 – 18 Celsius with extremes reaching 45 degrees Celsius. The potential evapotranspiration has been estimated between 600 and 950 mm/year.

For the Spanish trials the flashy River Mula system with the following morphology was selected. This sub-basin was chosen given that several significant rainfall/flood episodes have been registered here, and also because of its geographic proximity up river of Murcia city. The Mula basin within the Segura is outlined in the following figure.

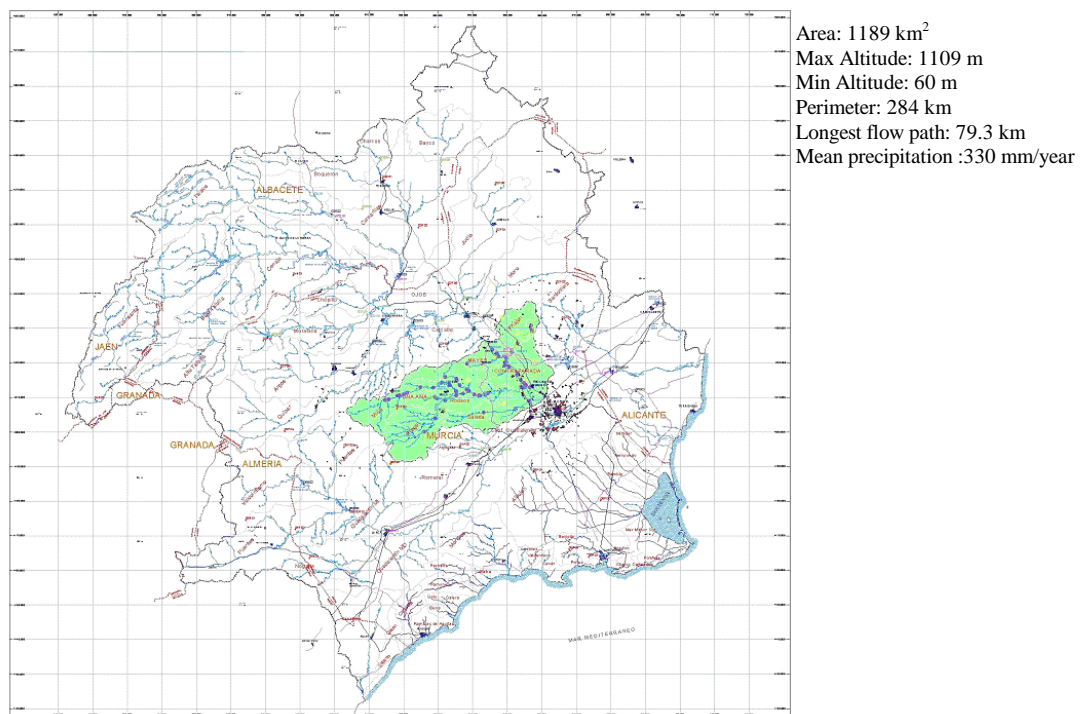


Figure 1. Mula sub-basin indicated in the Spanish trial case

## OVERVIEW

To provide proper support during emergency management, M3Flood system imports real-time data from hydro-thermo-precipitation sensors networks, together with meteorological forecasts, radar and satellite data. Taking into account these data, R/R and hydraulic internal models provide 24h forecasts on selected river sections.

Each time the system receives new data from external providers, these data are automatically analysed and compared with reference thresholds (criteria configurable by the users) in order to identify the “risk status”, allowing the system to alert supervising staff in charge of emergency management using specific automatic communications according to the pre-defined emergency plan. This detail is of extreme importance in the flashy Mediterranean basins where rising limbs of hydrographs can be almost vertical, reaching peaks superior to three metres in less than fifteen minutes. Real-time point information can be visualised in an integrated GIS application together with thematic cartography relevant for each activity: for instance hydro morphologic analysis for event evaluation and alert or specific information for civil protection emergency management. M3Flood also permits the comparison of episodes with historical data obtained from previous critical events thereby facilitating the identification possible similarities and hence improving management efficiency. Furthermore, the system provides automatic and manual periodic dissemination of information (reports, bulletins, charts, maps, etc.) to the defined managers involved in the emergency management and automatic and manual dissemination of alert and warning information (by means of web pages, e-mails, faxes, SMSs).

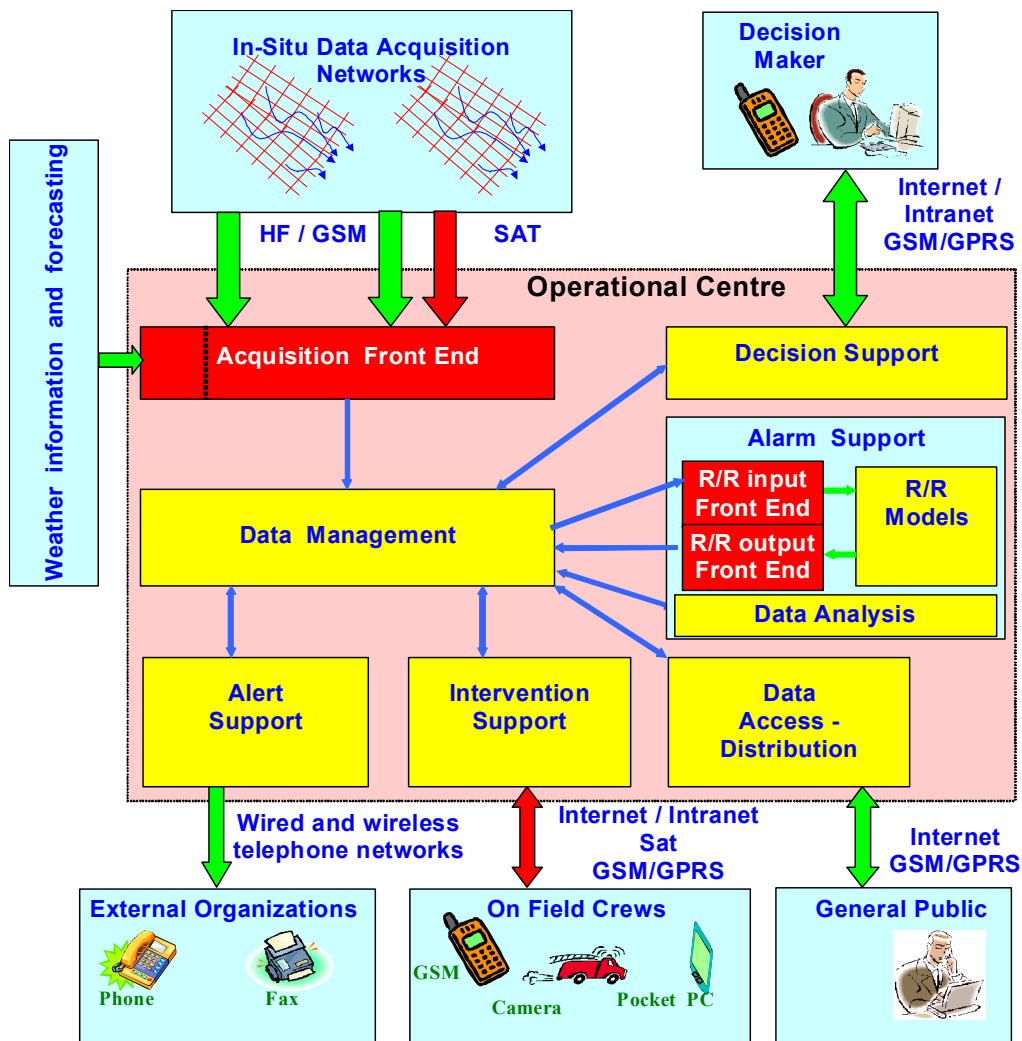


Figure 2. Overview of the M3Flood system

## DESCRIPTION OF THE SYSTEM

M3Flood software is composed of a set of “modules”, each one satisfying specific operational requirements. The available modules are the following:

- Main module; this module is in charge of:
  - Administration: a graphical environment allowing the system administrator to manage and configure, up to a certain extent, the system (e.g. stations, sensors, address book, emergency plan, interfacing with data providers);
  - Data management and access, including a relational database containing all data managed by M3Flood (real-time, historical, simulated, GIS, system administration);
  - Decision support: a common environment, GIS based, that allows user interaction with all the real-time, historical, simulated, GIS information in the database in order to allow the emergency actor to take the right decision. Standard capabilities are provided (querying, reporting management, charting, simulation, activities planning, monitoring);

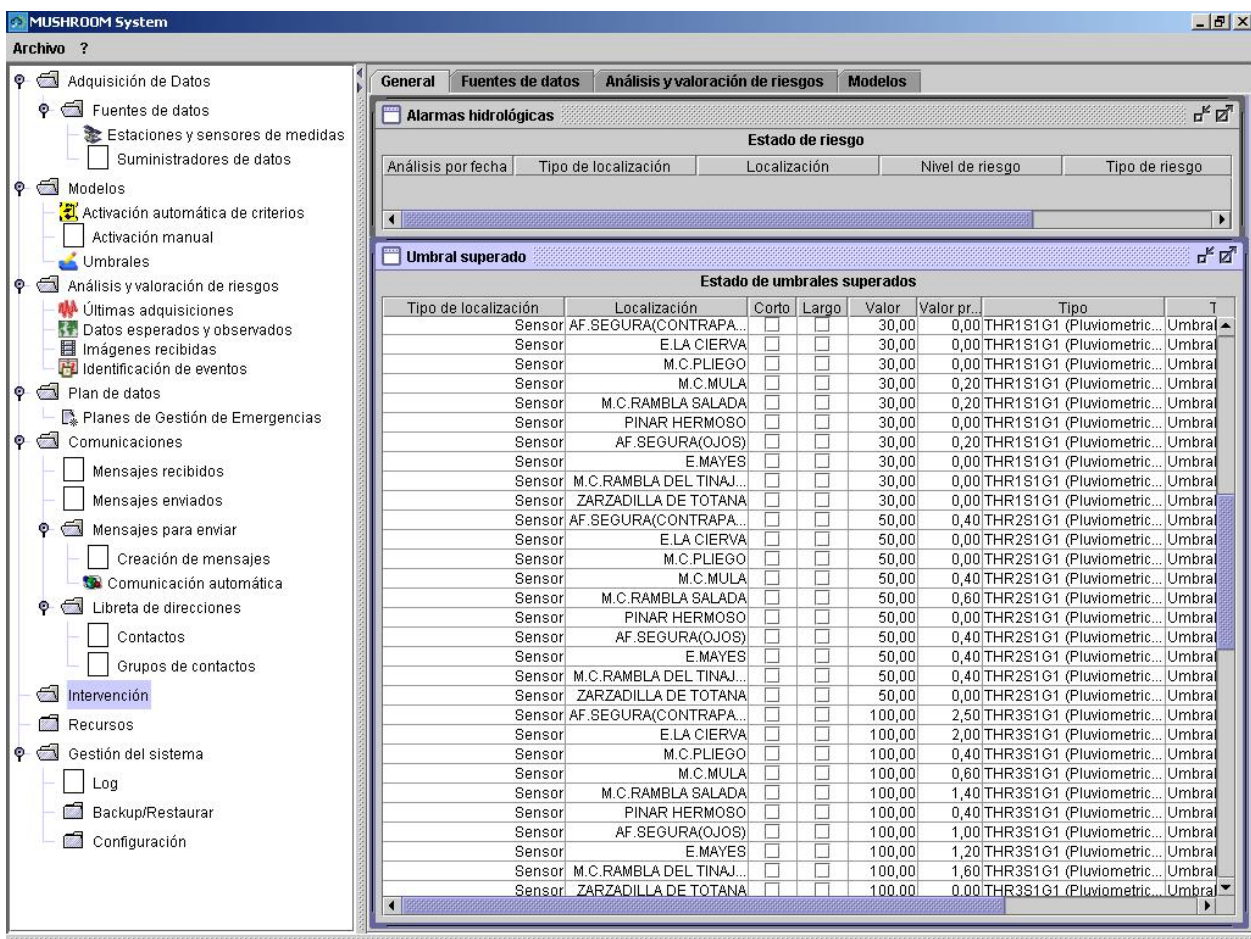


Figure 3. Main module of the M3Flood system

- Simulation, allowing the user with the ability to run an off-line analysis, also during system operation;
- Data analysis: according to predefined thresholds and criteria configurable, up to a certain extent, by the users;
- Automatic acquisition of telemetry information, weather forecast data, radar data, satellite data; each data type requires an optional sub-module called also driver;
- Automatic acquisition of hydrologic forecasts and/or flood extent mapping forecasts coming from other systems; each data type requires an optional sub-module called also driver.

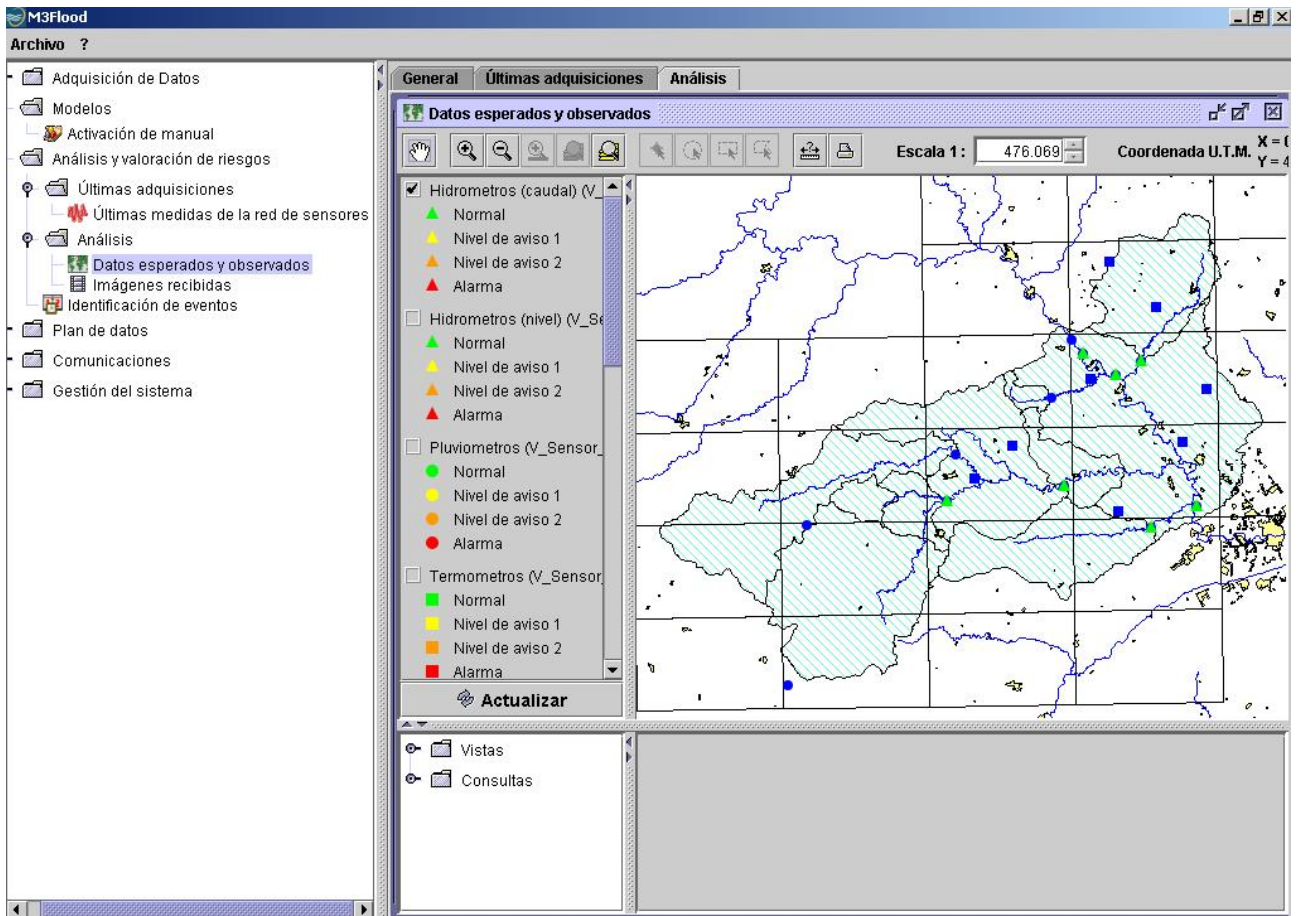


Figure 4. GIS module of the M3Flood system

- Processing (interpolation, validation, gap filling, data shifting);
  - Automatic acquisition of alerts and messages coming from other external systems/organisations (by means of SMSs, e-mails, faxes, phone calls);
  - Automatic and manual dissemination of alert and warning information (by means of web pages, SMSs, e-mails, faxes, automatic phone calls);
  - Automatic and manual periodic dissemination of information (by means of web pages, e-mails, faxes).
- GIS population module:
    - This module is in charge of supporting the user in defining the information that will be stored in the GIS section of the database of his specific M3Flood customisation (specifying the static metadata GIS section of the M3Flood database) and to consequently populate the M3Flood database;

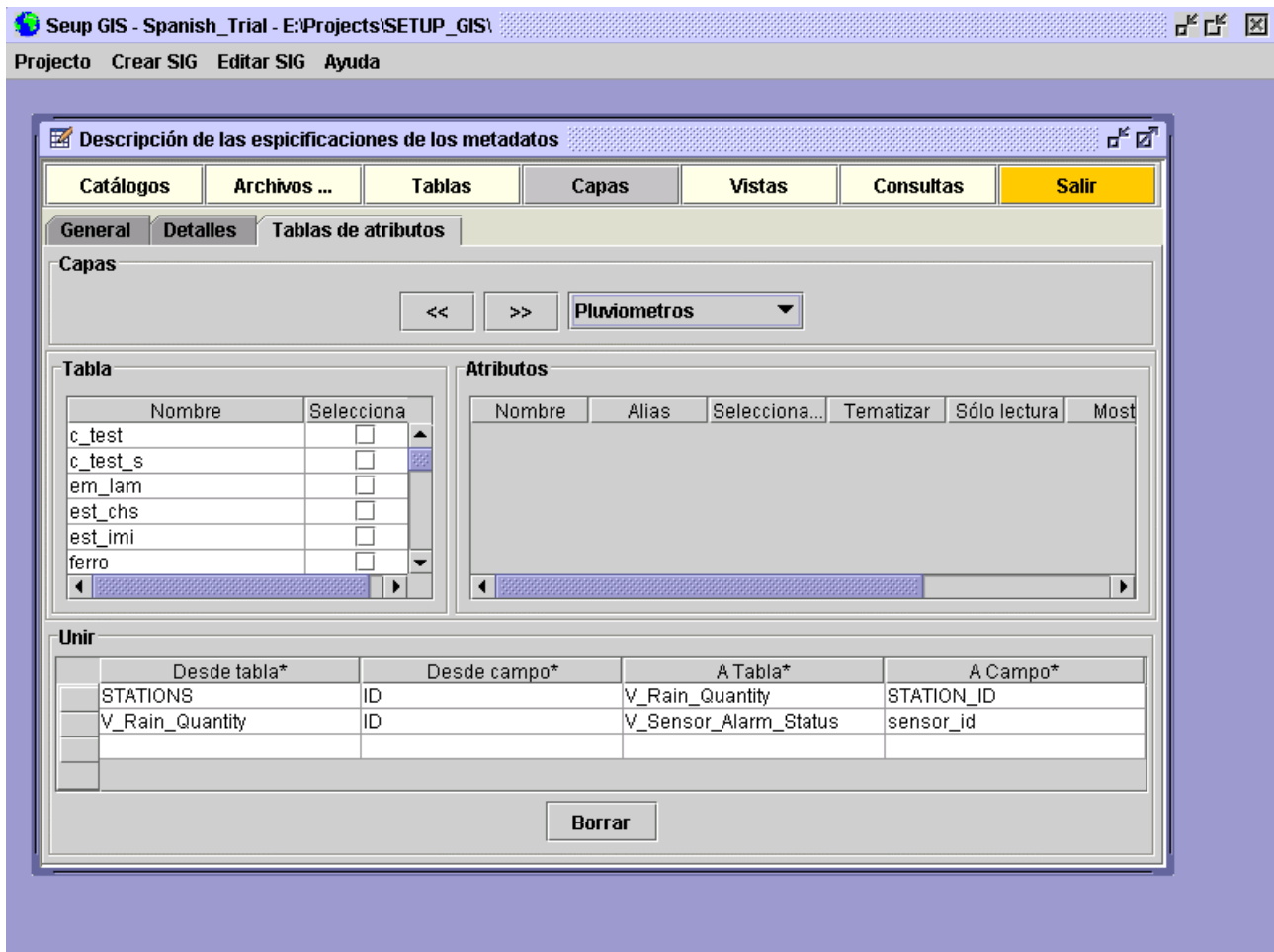


Figure 5. GIS Population module of the M3Flood system

- Forecast module; this module is in charge of:
  - Flood forecasting, integrating the following models: R/R TOPKAPI model, stochastic model for correction of prediction on the base of hydrometric measure, and providing as output rivers levels/discharges. Run of models is automatic and in real-time, including input and output data management;
  - Hydraulic model (incorporated in an optional sub-module);
  - Interfacing to external hydrologic models and/or flood extent mapping models; each model requires an optional sub-module and associated driver.
- Intervention support module; this module is in charge of:
  - Team localisation and basic information exchange between control centre and teams;
  - Team activity planning (resources management, allocation/optimisation of activities to teams, etc.) (Incorporated in a first available sub-module);
  - Team/control centre activity reporting management (incorporated in a second available sub-module);
  - On-field flood contouring (incorporated in a third available sub-module).
- Training module; this module is in charge of supporting training activities of operators.
- Programming module:
  - This module allows, supplying a complete set of Java APIs, to write java proprietary applications using available information stored in database, to develop new drivers, to interface models, to acquire new type of data (in-situ network, radar, meteorological forecast, satellite, etc.), or to distribute available information stored in database.

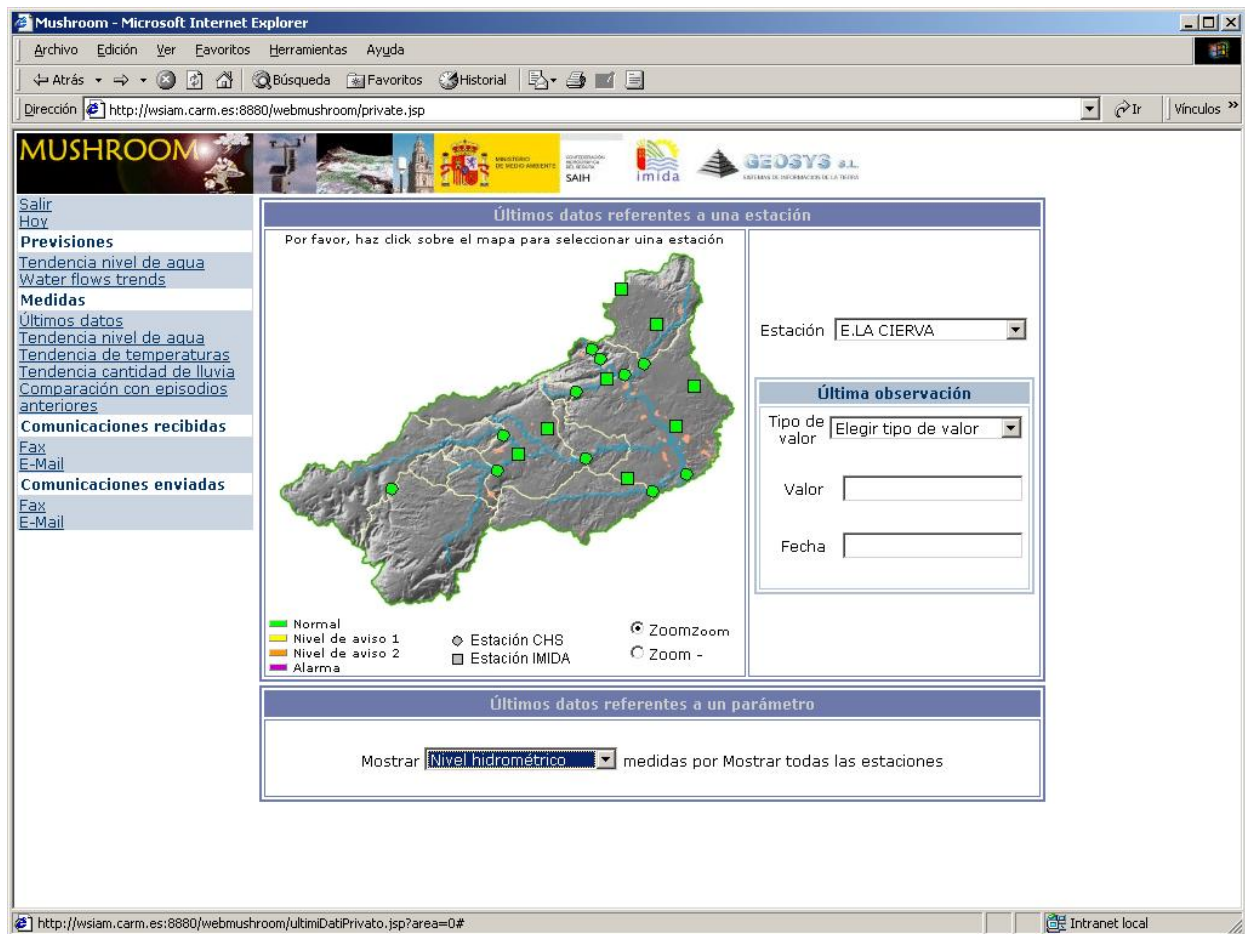


Figure 6. Disseminating real time information via web, using GIS module of the M3Flood system

## CONCLUSIONS

The adoption of integrated flood management systems is becoming an essential element in local, regional and national environmental protection strategies, and is already a high priority in many countries, especially in Europe.

Originally these systems were dedicated user interfaces built around hydrological models from one side or alternatively built around proprietary observation networks (in-situ sensors, radars, satellites).

More recent developments in weather prediction, radar and satellite data and the extension of sensor networks, as well as availability of complete sets of historical time series data, emergency plans, risk maps, territorial information, etc. have, however, resulted in an increasing focus on the importance of quality raw data and the incorporation and processing within flood management.

Together with the advances in GIS and database technology, hydrological modelling, communication capabilities (both terrestrial, fixed and mobile, and satellite) and on-line data availability, current modern flood forecasting and warning systems are required to offer integration of large data sets, specialised data processing modules, and open interfaces to legacy systems.

In this context, M3Flood arises in the market offering such an innovative, integrated and complete solution for forecasting, alerting and managing hydraulic emergency, offering software and related services implementing such requirements.

## REFERENCES

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- Website of Mushroom project : <http://www.mushroom-project.com>