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STORM^3: a new flood forecast management and monitoring system in accordance with the recent Italian national directive

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Abstract. The effectiveness of alert systems for civil protection purposes, defined as the ability to minimize the level of risk in a region subjected to an imminent flood event, strongly depends on availability and exploitability of information. It also depends on technical expertise and the ability to easily manage the civil protection actions through the organization into standardized procedures.

Hydro-geologic and hydraulic risk estimation, based on the combination of different technical issues (in this case meteorological, hydro-geological, hydraulic matters), but also socio-economic ones, requires the integration between quasi-static and time-varying information within the same operative platform. Beside the real-time data exchange, a Decision Support System must provide tools which enable knowledge sharing among the civil protection centres. Moreover, due to the amount and heterogeneity of information, quality procedures become necessary to handle all forecasting and monitoring routines within operative centres, according to the latest national directive.

In Italy procedures on the civil protection matter have been condensed into the Prime Minister's Directive (27 February 2004)[1].

STORM^3, an innovative management and monitoring System for real-time flood forecasting and warning, takes in the Directive, supporting the operator step by step within the different phases of civil protection activities.

1 Introduction

During the last years, scientific and social communities have made many efforts trying to define tools and activities addressed to prevent and mitigate risk caused by extreme meteorological events.

Operative instructions to manage regional and national alerts have been recently condensed into Prime Minister's Italian Directive (27 February 2004)[1] , which describes the functions and responsibilities of the National Department of Civil Protection, Operative Regional Centres, Expert Centres. This framework implies the need of a System which provides a real time data exchange among centres. In fact, the effectiveness of civil protection alerts, aimed to minimize the level of risk in a region subjected to an imminent flood event, depends on information availability on territory assets, atmospheric parameters and their possible evolutions in real time. However the task of this kind System cannot be limited to the data exchange, but should also provide appropriate tools which allows real connections between centers involved in the activities.

2 Involved information

The evolution of forecast chains for civil protection purposes, as well as the enormous amount of involved information, has led to implement information technologies of increasing complexity. In fact, hydro-geologic and hydraulic risk estimation is based not only on the combination of different technical issues (basically meteorology, hydro-geology, hydraulics), but also on socio-economic ones. Such a difficult evaluation requires, within the same operative platform, the integration between time-varying information representing the hazard level and quasi-static or time-varying information indicating both exposure and vulnerability of the area.

STORM3 is able to assume, validate, elaborate, delivery and visualize at same time different typologies of information: qualitative and quantitative observations from meteo-pluvio-hydrometric ground network, from the national meteo-radar network; hydraulic, hydrologic, geologic, geomorphologic data; imagery from different satellite platforms like Meteosat7 and the new Meteosat Second

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[1]"Indirizzi operativi per la gestione organizzativa e funzionale del sistema di allertamento nazionale e regionale per il rischio ideologico ed idraulico ai fini di protezione civile".

Generation (MSG). Benefit of using and comparing all these types of information could become void (or even negative), if not intrinsically driven by the system itself. In fact, although such a comparison is usually possible from the point of view of informatics, it must respect well defined rules and limitations imposed by their physical significance at their typical temporal and spatial scale.

In addiction to observation, "STORM^3" can, continuously and in real-time, treat results from meteorological, hydrological, hydraulic models, through which predictions on meteorological evolution and its ground effects can be locally or remotely performed.

2.1 Alert areas and criticality threshold

The Directive introduces the concept of "alert areas" as those portions of national territory where a unique level of criticality of a predicted event can be assumed. "Alert areas" have to be defined by many factors, mostly due homogeneity of the processes that lead to significant ground effects. The level of criticality has to be evaluated on the basis of the exceedence of pre-set rainfall thresholds by predicted rainfall.

"STORM^3" implements a first attempt by the National Department of Civil Protection to split the whole Italian territory into 102 alert areas and for each one the system computes level of criticality of the predicted event for a given class of catchments. The quantitative rainfall thresholds according to CNR-GNDCI project (Boni et al., 2003) were aggregated into single alert areas. Four levels of criticality (null, low, medium and high) have been set up taking into account both the frequency of occurrence, through a regionalization procedure of historical series for extreme event, and soil moisture condition. Then each threshold was coupled with four catchment classes depending on the corrivation time.

Comparison between pre-set rainfall thresholds and the predicted rainfall gives the level of criticality for each class of catchment.

Deterministic and probabilistic prediction of discharge and observed hydrometric levels are continuously compared with hydrometric thresholds.

3 Uncertainty estimation

"Time-varying" information, namely information with high temporal variability, includes both observations of meteo-hydrological parameters and predictions provided by their elaborations at different levels. Furthermore, the Directive explicitly points out the relevance of the evaluation on forecast reliability: every forecast has to be associated with its uncertainty quota. Particular attention should be paid to Ensemble Prediction System (EPS), which allows to overcome the uncertainty on meteorological forecast (uncertainty at external scales), through a probabilistic approach. In particular "STORM^3"includes outcomes of Limited-Area Ensemble Prediction System (LEPS), which gives the probability of occurrence of different five rainfall scenarios.Five runs of non-hydrostatic limited-area model Lokall Model are performed every day by ARPA-SMR[2], nested on five selected members of three consecutive 12-hour lagged ECMWF [3] global ensembles (Montani et al., 2003). A special visualization apparatus, endowed with triple monitor allows the simultaneous display of the five runs.

Other techniques are employed to measure the uncertainty at internal scales. Particular elaboration are introduced in forecast chains to face problems in coupling meteorological and hydrological data, caused by the incoherence in spatial and temporal scales between quantitative precipitation forecasting and the typical processes of flood formation and propagation within small basins. Down-scaling methods involved into the system are generally based a static filter applied to stochastic field obtained by an autoregressive linear process (Rebora et al., 2003–2004).

4 Knowledge sharing

Another relevant aspect is the need for knowledge sharing among centers in several civil protection activities like models implementation, data and results interpretation and bulletins delivery. Close relationships have to be kept especially by those "Expert Centers" which have to support all the other Regional Centres' actions.

Thanks to the advanced technologies involved into the system itself, such as video communication devices, shared work sessions, and remote control services, "STORM^3" allows connections among centres both in prediction and monitoring phases. These peculiarities make STORM^3 different from a mere data exchange software, perfectly matching the aim of the Directive.

5 Conclusions

"STORM^3" is an innovative management and monitoring system for real-time flood forecasting and warning, which is able to take in the recent Italian Directive in matter of civil protection.

The system integrates different types of information and advanced scientific techniques to predict extreme events and assess their ground effects. The problem of uncertainty in prediction is also addressed, providing solution at different scale.

The enormous amount of information can be easily handle thanks to standardized procedures which support the operator into distinct phases of civil protection activities.

Useful technological tools are implemented into the system to allow a real knowledge sharing among the operative centres, in perfect agreement with the aim of the Directive.

[2]ARPA-SMR Regional Meterological Service of Emilia-Romagna, Bologna, Italy.

[3]ECMWF European Centre for Medium-Range Weather Forecasts

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