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Géosciences de surface (Hydrologie–Hydrogéologie)

Prévision des crues éclair

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Résumé

Les crues de fréquence faible générées par des événements météorologiques intenses et localisés sont par essence rares, dévastatrices et donc difficilement observables et par suite mal documentées. Dans le Sud de la France, la crue sur l'Orbieu de novembre 1999 en est un parfait exemple. La complexité des processus physiques générateurs de la crue ainsi que les variables et paramètres qui les décrivent semblent incompatibles avec le peu de temps alloué aux prévisionnistes pour estimer le risque encouru et gérer la crise. Nous sommes donc amenés à faire des choix portant sur la simplification des modèles physiques. MARINE (Modélisation de l'Anticipation du Ruissellement et des Inondations pour des évéNements Extrêmes) est l'outil utilisé pour modéliser ce type de crue en temps réel. Il s'agit d'un modèle à base physique et distribué pour tous les compartiments de la modélisation : en amont, la genèse de la crue par le ruissellement de la pluie sur les versants (modèle pluie–débit) ; en aval, la propagation de la crue dans la rivière (résolution des équations de Saint-Venant). Il intègre des données issues de technologies récentes – satellitales pour les modèles numériques de terrain, le réseau de drainage ou l'occupation des sols et radars hydrologiques pour la variabilité spatiale et temporelle de la pluie. L'objectif final de MARINE est de fournir des informations pertinentes pour les utilisateurs en temps réel. Les résultats des simulations obtenus pour la crue de l'Orbieu montrent que MARINE peut fournir des prévisions directement exploitables par les prévisionnistes pour anticiper ce type de crue éclair. Par ailleurs, ce modèle est déjà testé dans le Service d'annonce des crues en Haute-Garonne. ***Pour citer cet article : V. Estupina Borrell et al., C. R. Geoscience 337 (2005).***

Abstract

Flash-flood anticipation. Flash-flood events resulting from paroxystic meteorological events concentrated in time and space are insufficiently documented as they produce destructive effects. They are hardly measurable and present single features that are not transposable to another event. In the South of France, the flash flood of November 1999 gives a perfect illustration of these characteristics. The physical complexity of the process and consequently the volume and the variety of the data to take into account are incompatible with the real time constraint allocated to the forecasters confronted to the occurrence of such phenomena. So, we have to make choices to afford acceptable simplifications to the complete mechanical model. MARINE

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('Modélisation de l'Anticipation du Ruissellement et des Inondations pour des évéNements Extrêmes') is the operational and robust tool we developed for flash-flood forecasting. This model complies with the criterions of real-time simulation. It is a physically based distributed model composed of two parts: first the flood runoff process simulation in the upstream part of the basin modelled from a rainfall–runoff approach, then the flood propagation in the main rivers described by the Saint-Venant equations. It integrates remote sensed data – Digital Elevation Model, land-use map, hydrographic network for the observations from satellites and the rainfall evolution from meteorological radar. The main goal of MARINE is to supply real time pertinent information to the forecasters. Results obtained on the Orbieu River (Aude, France) show that this model is able to supply pertinent flood hydrograph with a sufficient precision for the forecasting service to take the appropriate safety decisions. Furthermore, MARINE has already been tested in the French National Flood Forecasting Service of Haute-Garonne in real conditions. ***To cite this article: V. Estupina Borrell et al., C. R. Geoscience 337 (2005).***

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Keywords: Flash floods; Forecasting; Remote sensed data

Abridged English version

1. Introduction

Flash floods are defined as floods with sudden apparition, difficult to prevent, with rapid rising time and important specific flow. These flash floods are linked to intense rain events and occurred on little basins [2,19,24]. Their socio-economic consequences are important and their anticipation is a problem of great interest on economic and scientific points, as the flash flood of November 1999 in the South of France demonstrated.

Needs for hydrological simulation are very different from those for hydrological prediction [10]. The use of models like TOPMODEL [5], for example, gives satisfactory information for simulation but cannot supply any prediction [12,13].

The rareness of these events makes the statistical analysis and the calibration of deterministic hydrological models delicate. A simplified hydrological physically based model taking into account the spatial variability of the different processes involved (including the rain) seems to be an available solution for improving flash-flood forecast. With a view to that, we conceived the model MARINE, which is a hydrological model adapted to the peculiarities of real-time operational prediction. MARINE is distributed, deterministic, perceptual and physically based [12]. Montz and Gruntfest [24] insist on the fact that a few minutes lost during the crisis phase can have catastrophic consequences: we have to choose between a precise forecast and a sufficient anticipation. In accordance with the experienced forecasters ('Services d'annonces des crues', Météo France), with the remote sensed data suppliers, and of course with different fields researchers, we decided to prioritise the calculation rapidity (a few minutes are available), the integration in real time of all the available data and of remote-sensed data, and the pertinence of the supplied information. The results of the simulation of the flood of November 1999 are in accordance with the observations and furthermore they can be obtained in real time for risk-management applications.

The will to improve the flooding-risk management (flash floods in the South of France, plain floods in the North) over its different phases (prevention, early warning, crisis, post-crisis) led the French Ministry of Research and the French Space Agency (CNES) to start, in January 2000, a two-year pre-operational application project, called PACTES [3,11]. PACTES is a transverse, multi-disciplinary effort that associates the operational users (Civil Protection, Flood Warning Services, regional land planning services), leading scientific institutions in the domains of meteorological and hydrological simulation, and the space industry. This has led to the pre-operational deployment of a demonstrator in three French watersheds: Moselle, Hérault, and Thoré. About the Thoré Basin, the goal of PACTES was to include MARINE, which integrates remote-sensed data, to forecast flash floods in real time.

In front of the successful PACTES experience, a follow-up project applied to the 'Midi-Pyrénées' Region started.