THE OPERA PROJECT: EO-BASED FLOOD RISK MANAGEMENT IN ITALY

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1. INTRODUCTION

Successful flood risk management requires the capability of predicting and assessing the evolution of two broad classes of processes: the hydro-meteorological chain of events that contribute to the formation of hazardous flood waves and the land and urban vulnerability that translate the flood hazard in actual damages and life losses. The time scales of the these processes are such that existing, ground based, flood risk management practices are too often inadequate. Italy is a typical example where, due to the characteristic Mediterranean climate and land morphology, the prediction of fast-forming flood events requires a complex chain of meteorological, hydrological and hydraulic models. The reliability of such models has been generally proven to be scarce when fed with sparse point information only. As for the vulnerability and damage assessment, ground based cartographic and in situ surveys are also too slow when compared to the fast land cover dynamics in the presence of high levels of anthropization. Despite the general agreement on the crucial role of Earth Observation from space in filling these gaps and the existence of a wealth of studies on satellite data assimilation into meteorological and hydrological models, a systematic assessment of the impact of EO on a complete operational flood management system at national scale is not yet available. The OPERA project, joining the efforts of the Italian Space Agency with the new COSMO-SkyMed mission and the Italian Civil Protection with the newly up-scaled Network of Functional and Competence Centers, has been designed and implemented in order to produce such a kind of an assessment within a three-year+ implementation and demonstration period. The results of the first months of on-line demonstration, started January 2009, will be also presented.

2. GENERAL STRUCTURE OF THE OPERA PROJECT

The OPERA project aims at demonstrating the performance improvement of a state-of-art system for the civil protection from floods when Earth Observation from space is used in conjunction with ground data. Such system covers all the various phases of the flood risk management, from the planning and preliminary vulnerability assessment to the prediction, the emergency management and the post-event damage assessment. Using an ad-hoc data and models distribution infrastructure and a variety of satellites and sensors, the demonstration builds on the feeding of a large number of EO products from a central EO Competence Center to managing central and peripheral Functional Centers. These products are hence subdivided according to four main categorical functionalities and two types of use, al listed below:

1st Functionality: Base knowledge for civil protection operation.

Products for Users: Maps of vulnerable structures and infrastructures and general vulnerability; map of hydraulic structures interfering with river dynamics; map of river beds and flood ways hydraulic characteristics; high resolution DEM of river beds and flood ways; maps of critical antecedent soil moisture conditions; maps of critical rainfall and river stage thresholds.

Products for Models: High resolution optical imagery of potential flooding areas; high resolution DEM of potential flooding areas; 3-d virtual model of urban environment.

2nd Functionality: Soil moisture monitoring

Products for Users: High resolution (target areas) soil moisture maps; medium and coarse resolution soil moisture maps.

Products for Models: Maps of energy fluxes at he soil-atmosphere interface; map of aerodynamics surface roughness; cloud cover mask; vegetation cover map; land use map; maps of vegetation indices; map of incoming radiation; map of land surface temperature.

3rd Functionality: Flood alerting and monitoring.

Products for Users: Extent of water bodies; river stage predictions; map of overtopping of critical river stages; map of overtopping of critical rainfall thresholds; predicted flooding scenarios.

Products for Models: Extent of water bodies.

4th Functionality: Emergency management and damage assessment.

Products for Users: Map of flooded areas; damage map.

Products for Models: Map of flooded areas; change map.

Products for users are EO-based products that can directly enter the decision system in the flood management chain without further post-processing. Products for models are intended mainly for data assimilation or data input into models. In this sense, the typical river forecast products or alike of the 3rd functionality are here intended as EO-based when the underlying hydrologic and/or hydraulic prediction models are fed with other EO-based products, such as the river-bed characterization or the soil moisture maps. Note also that the assessment and demonstration of EO-products targeted to the improvement of the precipitation forecast is not included in the OPERA project, but they are instead included in an accompanying demonstration project (PROSA).

3. ROLE OF THE COSMO-SKYMED MISSION

The OPERA project is intended as a multi-mission demonstration, but specific attention is given to new missions such as the constellation of COSMO-SkyMed satellites. The imagery from the X-band SARs are being tested for several products spanning across the four main functionalities of the flood risk managing system. Typical examples are the high resolution, meter scale, construction of Digital Elevation Model of potentially flooded areas, the fast assessment of actual flooded areas and the posterior precise estimation of consequent land changes. Beyond the specific algorithms for the various X-band products, the projects gives a precious opportunity to test, in a simile-operational and nevertheless real-time framework for civil applications, some of the specific advantageous characteristics of the mission: the tandem and spot acquisition capabilities, the very-short and medium-short revisiting times depending of the required acquisition geometry similarity.

4. DEMONSTRATION SET-UP

In order to effectively quantify the EO-based improvements to the flood risk management system, the demonstration is based on the real-time continuous parallel running of two different flood prediction and assessment chains: the first one is a mirroring of the chain actually used by the Italian Civil Protection and its regional Functional Centers, the second adds to it the EO-based products listed above. To make this comparative quantification as much meaningful as possible, the demonstration needs to take into account environmental and organizational heterogeneities, the rapid evolution of both modeling and remote sensing technologies, a time span long enough to test the performance of various system components on real flood emergency cases. Again, as a specific example, EO products based on the COSMO-SkyMed mission are still under preliminary evaluation and their quality and operational availability are expected to sharply increase in the very next few years. The algorithms based on other missions such as MSG will also shortly reach different maturity. In order to accommodate these requirements, the demonstration is targeted over three different river basins (Tanaro, Arno, Basento) that are different in terms of morphology and extent (from about $10^{\wedge 3}$ to about $10^{\wedge 4}$ km^2), climate (from the semi-humid northern Italy to the drier southern) and complexity of regional prediction models (from simple lumped rainfall-runoff to hydraulic-based flood routing and soil moisture assimilation capabilities). As for the temporal structure, the demonstration of three different system releases have been planned. The first one, just started and whose preliminary results will be presented, is being based on the engineering of state-of-art yet consolidated EO algorithms. Preliminary tests for second release algorithms (see other contributions to IGARSS-09 by same authors) and rationale for the third final release will be also briefly discussed.