THE REAL TIME USE OF SOIL MOISTURE SENSORS TO IMPROVE THE ACCURACY OF FLOOD FORECASTING MODELS AND FOR THE DETECTION OF THE LANDSLIDES TRIGGER IN UMBRIAN CATCHMENTS IN THE TERRITORY OF COMPETENCE OF THE TIBER RIVER BASIN AUTHORITY

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1 Introduction

The soil moisture in the vadose zone represents a key factor in the modelling of the hydrologic cycle and is significant both for the forecast of floods and shallow landslide triggering. The knowledge of this quantity is essential to determine the catchment response in terms of runoff and erosion; moreover, acting on the pore water pressure, soil moisture modulates the strength-stress ratio in soils and so is a precondition for the triggering of landslides maybe as important as thresholds based on accumulated rain values as shown from recent works performed by Umbria Region Functional Centre (CFD).

Compared to other European countries, Italy is one of the most flood risk prone areas and, more in particular the Umbria Region, located in central Italy, is almost yearly affected by landslide and flood events at different

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spatial and temporal scales. Umbria Region covers almost the Upper Medium Tiber River catchment.

Currently, the estimation of soil moisture can be addressed by field (or in-situ) measurements, remote sensing techniques and soil water balance simulation models.

During the last 30 years, in situ observation of soil moisture are becoming more and more available. The most important advantages of these techniques are: high temporal resolution, rapidity of acquisition and repeatability (precision) of measurements. Moreover, in many cases, a specific calibration is not required. On the other hand, measurements provide information about a small volume of soil and the monitoring of large areas could be quite expensive, when at least not possible.

Being potentially a powerful technique for mapping soil moisture over large areas, a growing interest has also been addressed by remote sensing retrievals from space. The two most attractive features of remote sensing are: the good cost-effectiveness ratio and the ability to provide regular and reliable large area measurements avoiding errors induced by sensor-to-sensor variability. However, the interpretation of remotely sensed signals is not straightforward. In addition, issues on the low and poorly defined investigation soil depth and, for some applications, on the inadequate space and time resolution make the use of remote sensing sensors still difficult.

Many water (and energy) balance models are available for calculating soil moisture, also for the whole soil profile. In this case, drawbacks can be identified in the parameterization and structure, as well as in the data requirement.

The integration of these three techniques can provide reliable estimates of soil moisture at the temporal and spatial resolution required for operational activities related to floods and shallow landslides.

On these bases, for this study, the CFD, in cooperation with the Institute for Geo-Hydrological Protection of the National Research Council (IRPI-CNR), developed and tested a continuous real time physically based soil water balance model (now in a test phase), for estimate soil moisture

condition over Umbria Region. In-situ observed soil moisture data were used for the development of the structure of the model and also for its parameterization. Moreover, since the rainfall thresholds used at the CFD to evaluate the criticity level for hydrogeological risk depend on the soil saturation conditions, the output of the soil water balance model is also used to analyze the influence of soil moisture on landslide triggering.

2 Results

The soil water balance model was tested with experimental measurements made in a multi-year period (half hour time step) in two experimental areas of Central Italy (Brocca et al., 2008), achieving satisfactory results (Figure 1) during calibration and verification. In particular, the model has proven reliable in the estimation of the time evolution of soil moisture, even if calibrated with a limited number of observations. This ensures the robustness and exportability of the model across different areas.

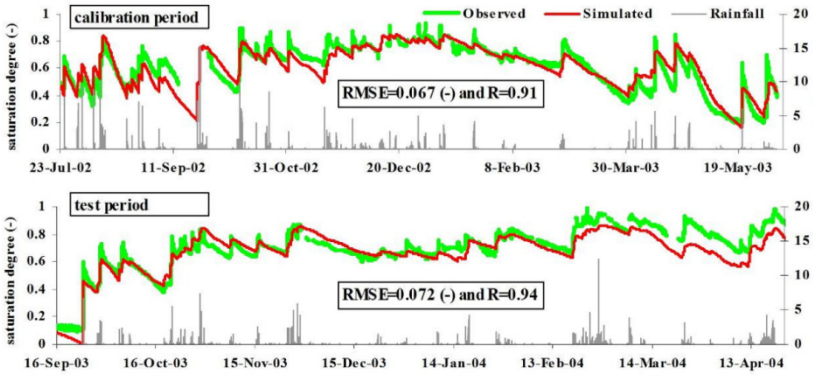

Figure 1. Comparison between the observed and simulated saturation degree by the Soil Water Balance model for a 15 cm depth.

The analysis of several landslide events (extracted from the data set of "Aree Vulnerate Italiane" AVI) occurred in the Umbria region for the period 1990-2005 demonstrated the strong influence of the soil moisture content on the triggering of landslides (Ponziani et al, 2009). For instance, Figure 2 shows that the accumulated rainfall needed to trigger a landslide decrease with increasing soil moisture.

At the same time, high risk landslides are now monitored using a pre-alert system based on observed and predicted rainfall along with real time soil

moisture data extracted from the soil water balance model. Based on rainfall and soil moisture conditions, the system furnish a specific threshold useful for civil protection actions.

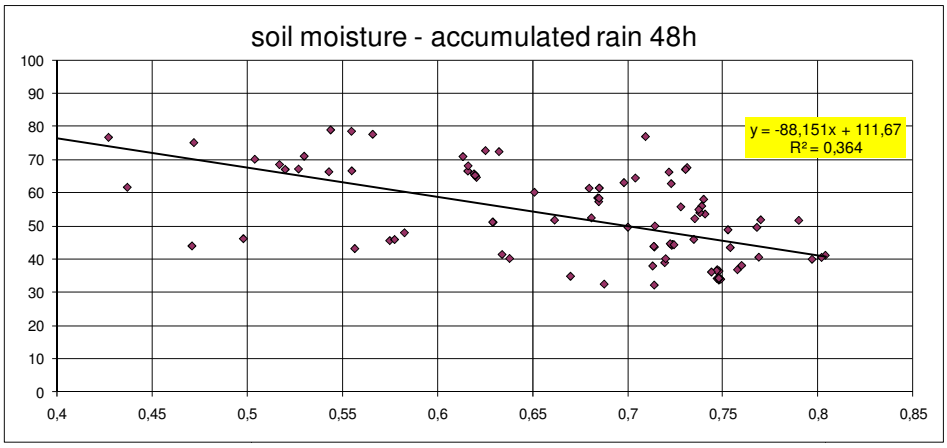

Figure 2. Relative soil moisture conditions vs. max accumulated rain values on landslides sites.

3 Conclusions

Based on these preliminary results. the CFD is testing a procedure aimed to the evaluation of the soil moisture content at regional and local scale, and the emission of pre-alert advices in case of intense meteorological event observed or predicted.

The real time soil moisture data, even though referred to few points, can furnish a reliable estimation of the average conditions of the water content at the catchment scale, allowing to improve the reliability, robustness and performances of the soil water balance model as well as of the rainfall thresholds.

References

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