Rainfall nowcasting for landslides early warning systems: an integrated modeling approach.

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Abstract

Effectiveness of floods and landslide early warning systems can be clearly improved by reliable quantitative predictions of rainfall, which represents the main precursor. With this aim, a methodology for probabilistic rainfall nowcasting, based on a coupling between a stochastic model and outputs provided by a Numerical Weather Prediction (NWP) model is proposed in this paper. The coupling among different types of models usually allows for improving the prediction, as the positive aspects of all the model components are merged. In this paper, the hybrid model, named PRAISE-ME (Prediction of Rainfall Amount Inside Storm Events with MEteo), is proposed. This model allows improving the rainfall prediction at hydrological scales, where only NWP models are not so suitable and the simple use of stochastic models provides the same forecast, regardless of weather forecasts as they depend only on previous rainfall. PRAISE-ME provides probabilistic quantitative predictions and it can be easily set up as input in other models for Rainfall-Runoff or Landslide prediction, as in the application case here illustrated. In this work, PRAISE-ME was used with the empirical FLaIR model (Forecasting of Landslides Induced by Rain-fall, Capparelli and Versace 2011) in order to obtain in real-time indications about exceedance probabilities associated to specific thresholds. The procedure was applied for a landslide case study, occurred in Montenero di Bisaccia (Central Italy) in March 2006. The obtained results encourage the use of this methodology as a component of early warning systems.

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PRAISE-ME calibration results			
ν (h)	8	p_{00} (-)	0.737
α_0 (-)	0.804	p_{10} (-)	0.015
α_1 (-)	0.065	p_{01} (-)	0.163
α_2 (-)	0.039	p_{11} (-)	0.085
α_3 (-)	0.027	$\alpha_{h,r}$ (mm^{-1})	1.013
α_4 (-)	0.021	$\beta_{h,r}$ (-)	0.758
α_5 (-)	0.017	$\gamma_{h,r}$ (mm^{-1})	1.123
α_6 (-)	0.014	$\delta_{h,r}$ (-)	0.750
α_7 (-)	0.012	$\theta_{h,r}$ (-)	2.109
χ (-)	0.10	$\alpha_{h,0}$ (mm^{-1})	1.558
		$\beta_{h,0}$ (-)	0.685
		$\gamma_{0,r}$ (mm^{-1})	3.718
		$\delta_{0,r}$ (-)	0.456

Table 1. PRAISE-ME calibration results

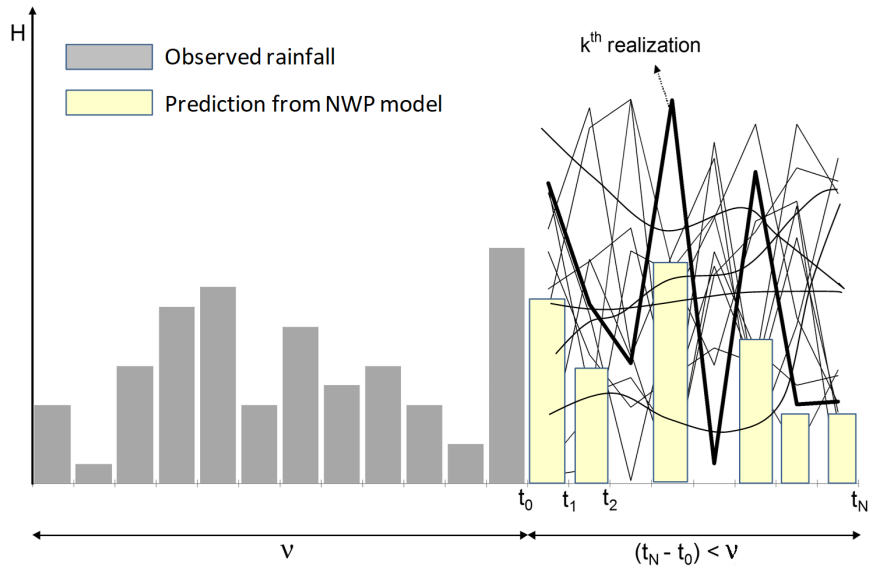

Figure 1. Qualitative example of a "spaghetti" plot (Adapted from De Luca, 2013)

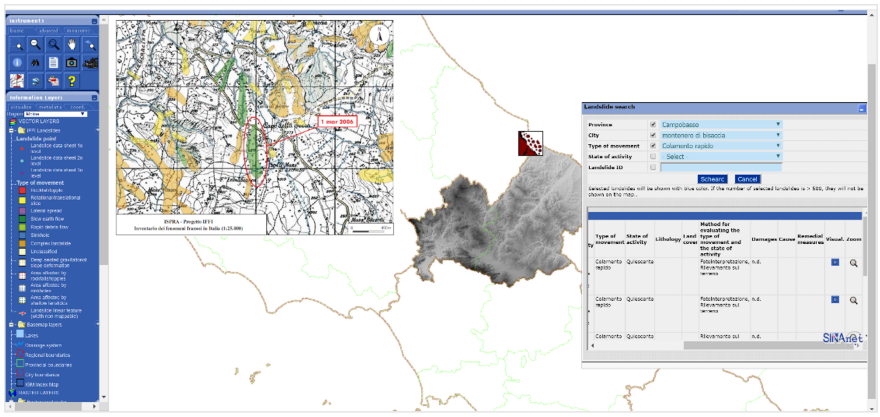

Figure 2. Details on Montenero di Bisaccia landslide (from www. progettoiffi.isprambiente.it)

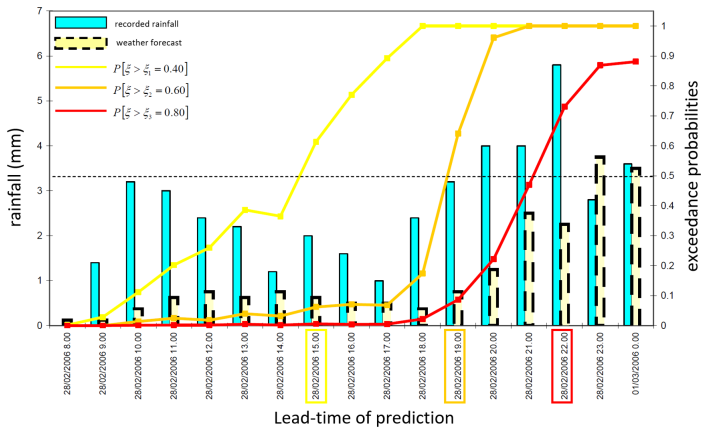

Figure 3. Temporal trend of the exceeding probability of the thresholds ξ_1, ξ_2, ξ_3 within 6 hours the lead-time of prediction

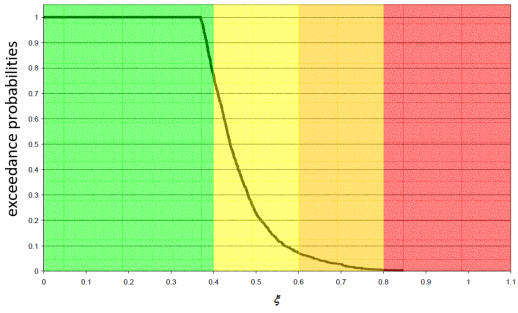

Figure 4a. Exceedance probabilities of the thresholds in the time interval *3*:00 9:00 pm (28/02/2006)

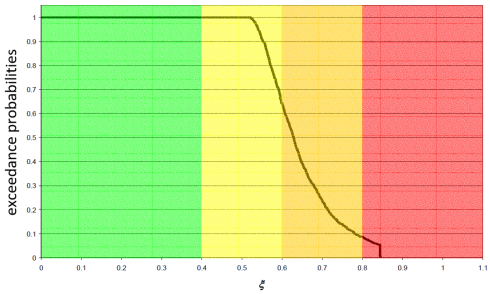

Figure 4b. Exceedance probabilities of the thresholds in the time interval *7*:00 pm (28/02/2006) 02:00 am (01/03/2006)

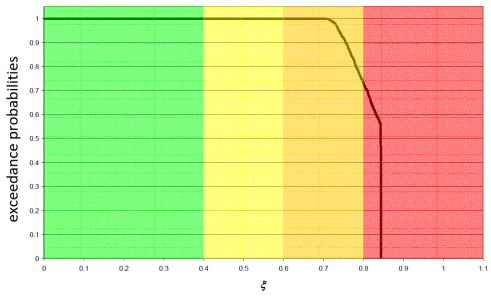

Figure 4c Exceedance probabilities of the thresholds in the time interval *10*:00 pm (28/02/2006) 04:00 am (01/03/2006)