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ScienceDirect
Procedia Earth and Planetary Science 16 (2016) 81 – 88
Procedia
Earth and Planetary Science

The Fourth Italian Workshop on Landslides

Differences in results yielded by different approaches adopted for the interpretation of a rapid flowslide in a pyroclastic cover

Luca Pagano[a,]*, Alfredo Reder[a,b], Guido Rianna[b]

[a]Dipartimento di Ingegneria Civile, Edile ed Ambientale, University "Federico II", Via Claudio 21, Napoli 80125, Italy
[b]Regional Models and geo-Hydrological Impacts, Fondazione CMCC Euro-Mediterranean Center on Climate Change, Via Maiorise, Capua (Caserta) 81043, Italy

Abstract

The paper interprets a case-history of rainfall-induced flow-like landslide in pyroclastic soils by adopting different approaches inmodelling the boundary value problem. In particular, two adopted approaches take into account both rainfall and evaporation effects, while the simplest one disregards the phenomenon and considers only the effects of the rainfall-history. The work shows how increasing model complexity in accounting for most of influencing meteorological factors permits predicting a more pronounced hydrological singularity at the landslide time.

Peer-review under responsibility of the organizing committee of IWL 2015
*Keywords:*Landslide; unsaturated soils; pyroclastic soils; numerical analysis; evaporation.

1. Introduction

The ingredients of the predictive models adopted for early warning of rainfall induced landslides have to mediate between two contrasting needs. The first is the rapidity of the prediction, compulsory to eliminate people exposure and typically involving model simplifications. The other one is the prediction accuracy, needed to minimize false and missed alarms and that would conversely require accounting for all influencing factors. An effective strategy that may be followed in performing at best the predictive tool is based oncalibration of model ingredients in the context of the interpretation of well-documented case-histories.

* Corresponding author. Tel.: +39 0817683478
E-mail address: lupagano@unina.it

Peer-review under responsibility of the organizing committee of IWL 2015
doi:10.1016/j.proeps.2016.10.009

In silty pyroclastic covers placed in slope, the chain of main phenomena that, from the beginning of a hydrological year, concur in inducing a flow-like landslide are, nowadays, quite clear: precipitations infiltrate the cover over time, reducing progressively suction levels; suction vanishing throughout the cover determines then a predisposing state for triggering. This predisposing state in terms of suction distribution has been found to be induced by an exceptional, persistent precipitation event, lasting several hours, following a prolonged wet period of several months[1-3] (Figure 1).

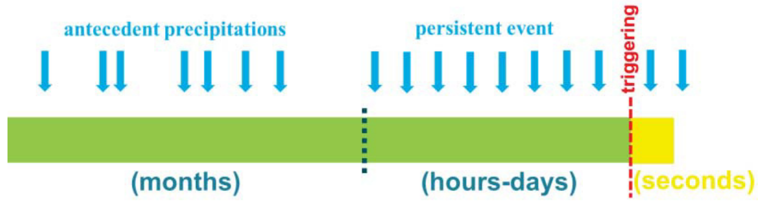

Fig. 1. Sequence of phenomena.

Over an effective meteorological window lasting several months, persistent evaporation or evapotranspiration phenomena, even if not intense, may cumulate in significant amounts, so to play a key role in contrasting rainfall infiltration effects. Modelling the problem by neglecting evapotranspiration is usually considered time-saving and conservative, since evaporation extracts water from the soil increasing suction. The question naturally arises whether prediction accuracy significantly reduces by neglecting evaporation so that too much false alarms are in this way generated. The present work attempts to answer this question by comparing results yielded by different models, accounting and not accounting for evaporation, in the context of the interpretation of a well-documented case-history.

2. The case-history

The Lattari chain is the backbone of the Sorrentine Peninsula which bounds the south side of the Bay of Naples. Such calcareous mountains have been mantled by air-fall deposits from Somma-Vesuvius eruptions during the last 10,000 years. Such pyroclastic covers are periodically mobilized by rainfall. After a killer event occurred in 1997, a meteorological station was installed at the foot of the hill slopes rising behind NoceraInferiore. Hourly records of different meteorological variables are available between 1January 1998 and 31May 2009. Precipitations, temperature and relative humidity data allow to account for rainfall intensity and potential evaporation effects in predicting the hydrological state evolution of pyroclastic covers. This reference time period includes 28 rainfall events with daily cumulative values at least equal to minimum observed in previous landslide events in the area (see Figure 2).

The first rainfall event induced the catastrophic Sarno debris flow[4] only 8 km far from the rain-gauge site. Event no. 15 triggered a flowslide in the afternoon of 4th March, 2005 (16.00 h), on the northern slope Mt. Sant'Angelo di Cava, upslope of the town of NoceraInferiore (Figure 3), hundreds of meters from the rain gauge. The cumulative rainfall height in the last 24 hours (h24) and the 2 months were respectively 149 and 540 mm: in particular, the first one results the heaviest recorded daily rain since 1950 (at the end of the same day, rain heights approached 200 mm).

It is worth mentioning that the 2005 NoceraInferiore flowslide is a unique case for which a meteorological station is placed only a few hundreds of meters away from the centre of the landslide making availablethe actual rain history leading to a landslide in pyroclastic soils. The landslide affected a triangular shaped area of 24,600 m^2 and a soil mass of 33,000 m^3 covering a 36° open slope (Figure 3). In the uppermost part of the landslide, where the slope angle is almost 39° [5], the pyroclastic cover is made up of 2 m thick loose non-plastic silty sand (volcanic ash). Locally, pumice lenses are interbedded in the cover. The bedrock consists of a highly fractured limestone located at a depth ranging from 1 to 2 m. It presents some parallel morphological steps, normal to the direction of the slope, which are revealed by the same profile of the ground surface.