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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Groundwater fluctuations during a debris flow event in Western Norway – triggered by rain and snowmelt" *by* Stein Bondevik and Asgeir Sorteberg

Anonymous Referee #2

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GENERAL COMMENTS

The manuscript provides continuous data about precipitation, air and groundwater temperature, snow depth, pore-water pressure, monitored on a site in Western Norway that in November 2013 was involved in a weather-induced debris flow after a storm that caused about 142 landslides and 7 snow avalanches in the same region. The reported data allow, in particular, to compare the weather and piezometric conditions responsible of the debris flow with those occurred in the past not able to induce any failure.

The paper is well written and contains very accurate figures. The availability of infor-

mation exactly during the landslide event represents undoubtedly a valuable aspect not to be overlooked. However, as also correctly recognized in the text by the Authors, two evident limitations exist: i) the pore-water pressure data are measured only by one piezometer (located upslope); ii) information about the properties of the involved soils are absent. Of course, the first aspect, that prevents to model the piezometric regime along the slope, can not be solved. On the contrary, I hope that some data about the physical, hydraulic and mechanical soil properties should be added because a full comprehension of the landslide is very hard without them. In particular, the absence of information regarding the shear strength parameters makes impossible analyzing the slope stability conditions. Some specific suggestions, aimed to improve the quality of the manuscript, are reported in the following section.

SPECIFIC COMMENTS

Line 30. The availability of real-time water level data during rapid landslides are effectively rare, but, on the contrary, many papers provide the pore pressure in slopes involved in active slow landslides, cyclically reactivated by seasonal weather events. Therefore, the sentence "rare because it is difficult to predict which slope will fail" should be replaced by "rarely provided during rapid landslide events".

Lines 39-40. Snow avalanches are not landslides. Therefore, the sentence "Most of the slides were debris slides and flows (114), but rockfalls (28) and snow avalanches (7) also occurred" should be replaced by "Most of them were debris slides and flows (114), but rockfalls (28) also occurred. Some snow avalanches (7) were observed too".

Figure 1. The term "slides" in the legend can not be used to indicate at the same time the three types of phenomena. It should be replaced by a term like "Events". Moreover, I suggest to indicate them according to the following order: i) Debris flow and slide; ii) Rockfall; iii) Snow avalanche.

Caption Figure 2. I suggest to simplify it, inserting in a table (to be cited in the text) all the provided information regarding the three shown landslides: date and hour of

the occurring events, landslide length, upslope and downslope altitudes, mean slope inclination, range of thickness, etc.

Section 2. This section should contain a table reporting the available information (eventually deriving them by other papers) about the mean values of physical, hydraulic and mechanical properties of the involved soils: grain size, in-situ porosity and degree of saturation, unit weight, hydraulic conductivity, strength parameters. Such values are very important to allow a full understanding of the infiltration and seepage processes and, as a consequence, of the induced landslide mechanism. Line 90. Indicate at which altitude and distance from the toe of the landslide the piezometer has been installed.

Line 125. Indicate the total length of the debris flow.

Figure 5A. Clarify which "Distance" is reported in the X-axis. Is it the distance from the toe of the landslide ?

Figure 6. According to the results, the influence of the snow cover melting on the water level is particularly important. Therefore, I suggest to insert in this figure the data about the snow depth (shown only by the supplementary Figure S9) and about the air temperature (partially shown in Figure 8).

Caption Figure 7. Indicate at which depth and altitude the piezometer of the weather station has been installed.

Figure 8. Due to the important role of the snow melting, I suggest to insert in this figure the data about the snow depth (shown by the supplementary Figure S9).

Line 222. The second important weak point of the manuscript regards the absolute absence of information about the soil properties. As already suggested, I hope that you are able to provide them. For instance, some information about the strength parameters could help (at least) estimating the slope stability conditions.

Lines 265-266. Differently from what observed in November 2013, the piezometric

peaks monitored in April and May 2013 were caused only by rainwater infiltration (and not by snow melting). Why do you consider such evidence so relevant to not induce sliding ? The corresponding measured peaks of 33 cm (measured in April) and 28 cm (measured in May) below the ground surface are very close to the critical estimated value of 30 cm in November 2013 (such value was extrapolated from the groundwater level curve measured from 19:00 and 23:00, as clarified in Lines 237-238). As a consequence, being the local shear strength approximatively the same at the onset of the three attained maximum water levels, the corresponding local slope stability conditions should be essentially the same too. Unfortunately, the availability of only one piezometer does not allow to make a reliable evaluation of the general slope stability conditions, therefore your consideration seems rather rash. Please make some comments.

Lines 276-279. The emphasis of provided considerations is rather strange. It's well known that the initial conditions are crucial to determine the weather-induced effects. Once given an initial monitored piezometric value, the main challenge should be, of course, associating a landslide hazard to a forecasted weather event. At the same time, associating a very low landslide hazard to severe weather event if the initial measured groundwater level is located below a "safe" value should be also very useful for the implementation of an early warning system. I encourage the Authors to make some comments about this topic.

TECHNICAL CORRECTIONS

Title. Is the hyphen "-", between "Norway" and "triggered", necessary ?

Caption Figure 1. "114 debris flows, slides" should be replaced by "114 debris flows and slides"

Line 109. The word "from" at the end of the line should be replaced by "carried out".

Line 163. The sentence "has also been" should be replaced by "already".

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