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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Operative and reliable landslide forecasting and influence of geology to predictability" *by* E. Intrieri and G. Gigli

E. Intrieri and G. Gigli

emanuele.intrieri@unifi.it

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Reviewer: The authors state the importance of kinematics over geomechanics, based on their interpretation of results. I would suggest that not only does geomechanics play a major role in the kinematics of some of their case studies, but also that predictability of other landslide types not included in the database in this paper are likely controlled by the geomechanics. Clear examples are landslides in sensitive clays and other materials.

Authors: The authors did not mean to diminish the obvious importance of geomechanics to predictability. However, since this point has been unclear for all the reviewers, it is evident that we failed in our explanation. What we mean is that even though geomechanics is unquestionably a key factor, it is sometimes difficult to have a deep

knowledge of the geomechanical features of a landslide, especially in the field and in emergency situations, although some safe assumptions can always been done by observation and a broad knowledge of the area. What it may be known about them is in part thanks to what is derived from displacement data. Like in a black box model, even if the real properties of a phenomenon are not known, we can draw conclusions from the output of those properties (i.e. the kinematics). In this case, importance has been done to kinematics because what is generally measured by monitoring are displacement data and because many other unknown factors (rainfall, ground saturation, earthquakes, anthropic disturbance) are included in the black box together with the geomechanics; this makes it virtually impossible to know in advance what may be the degree of influence of geomechanics alone with respect to other factors, thus leading to focusing on kinematics instead. Moreover, even though geomechanics is a key element, landslide prediction can be carried out with a variety of different geomechanical settings. This explanation can be added in the conclusions, while in the rest of the text every misleading comment that may have reduced the importance of geomechanics will be changed or removed.

R: The authors should also discuss the issue of timely predictability. Methods used to predict landslides that are based on displacement monitoring assume that slope collapse will be preceded by accelerations, sufiňĄciently in advance to make adequate predictions followed by emergency measures. Again, landslides in sensitive clays and other collapsible materials are examples where this assumption might not be valid. Moreover, the recent failure of the Mount Polley Dam (IEEIRP, 2015) suggest that, under certain conditions, undrained responses leading to failure might not provide enough warning time for emergency plans to be in place. It is suggested the authors state such limitations of the methods proposed.

A: Indeed this is an important issue. Our test sites are all cases where timely predictions were possible. However these limitations are not addressable to the method proposed rather than to all the forecasting methods currently available to the scien-

tific community, since some types of landslide still do not allow for a timely prediction. However we agree that this issue could be commented on in the text.

R: The methodology presented addresses the variability of the forecasting methods used. The reliability index, based on this variability, the convergence and non convergence of forecasts; appears to be a measure of data scatter and trend variation, rooted in the behavioural nature of the landslide in its pre-failure stage. To assess the reliability of any forecasting method, the range of forecasts for a number of case studies needs to be compared against observed time of failure. This requires, in my opinion, to subdivide the case dataset in groups of same landslide type, kinematics, materials, triggers, etc., and compare the forecasts with the observed times of failure.

A: The variability, convergence and non convergence of forecasts are already compared with the observed time of failure. In fact, as stated in the text, during the evaluation of the predictability index the time of failure (Tf) is always considered: “1 point: the prediction plot never converges on a single tf (typically tf increases at every new datum available). 2 points: the predictions vary considerably at every new iteration. An average time of failure (t ÌĚ_f) can be extracted but with high uncertainty. 3 points: the predictions oscillate around Tf, although with a certain variance. 4 points: the predictions have a low variance although t ÌĚ_f is slightly different than Tf. Note that when the variance was low, t ÌĚ_f and Tf never differed greatly. 5 points: the prediction plot is clearly centred on Tf therefore the reliability of t ÌĚ_f is high.” Predictions that oscillate far from Tf are already addressed. Concerning the suggestion of clustering the landslides according to type, kinematics, materials, triggers, etc., we think that, due to the not so large number of landslides, every group would be represented by only few examples and therefore would not be meaningful. However comparisons of behaviours between landslides of the same or different type, kinematics, material, trigger, etc. can easily be done by readers using tables 1 and 2. In any case, as we stated in the text, we already studied such comparisons and did not made interesting findings.

R: 1.- How was brittleness assigned for the cases in Table 1?

A: It was assigned based on information derived from the reference articles. Since it was rarely explicitly stated, we assumed a qualitative level of brittleness based on the type of material, the presence of a reactivated landslide, the weathering and the shape of the displacement curve. Since this leads to approximations we decided to evaluate the brittleness with broad and qualitative definitions.

R: 2.- In Table 1, the event at Vaiont is classiïňĄed as a "Rock Avalanche". This term refers to the material (rock) and its post-failure behaviour. I suggest it should be classiïňĄed following its detachment process, as this is what we are monitoring prior to failure and would give more insight into the role of landslide kinematics vs. predictability.

A: We agree with your observation. Rock slide would be more appropriate. 3.- What are the artiïňĄcial landslides? We mean landslides recreated in laboratory. Although from the original paper there is not mention of the dimensions of the artificial slope, a photograph shows that it is big enough not to be called a scale model. We can specify this in the paper.

R: 1.- I suggest the improvement of the excel ïňĄgures. fonts are too small, and layout is not technical. The text refers to dashed black and grey lines that appear continuous red and blue in the ïňĄgures.

A: Thank you for your observation.

R: 2.- Should the title read "...inïňĆuence of geology on predictability" rather than "...inïňĆuence of geology to predictability"?

A: The title has been changed as suggested by all the reviewers. It is now “Of reliable landslide forecasting and factors influencing predictability”.

Sincerely, Emanuele Intrieri

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