

Interactive comment on “Monitoring and prediction in Early Warning Systems (EWS) for rapid mass movements” by M. Stähli et al.

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This is a well-written manuscript that provides a review of the current state of landslide early warning systems throughout the world. The manuscript is in good shape, but I do have some suggestions for improvement as follows.

Most important suggestions:

1) p. 7151, lines 19 and 20. Please define the types of rapid mass movements that are covered by the EWS described in this paper. From reading the entire manuscript, it seems that those included are: snow avalanches, shallow landslides, debris flows, rock falls, rock slides, and some deep-seated landslides. Those not included seem to be: rock avalanches, debris avalanches, earth flows, failures of quick clays, and possibly

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others. I think it would be useful to the reader to know right away in the Introduction what types of movements are covered and what types are not. Part of this definition should probably include a quantitative or qualitative definition of “rapid”. Somewhere around line 19 or 20 would be an ideal place for a definition.

2) p. 7155, lines 17-20. Very nicely stated! I totally agree. I think there are two primary keys to successful warning systems: 1) having more than one person to maintain field instrumentation (assuming the system is at least partly field based), and 2) having more than one person to properly interpret incoming data. The importance of having people dedicated to EWS seems very important to me and should probably be added to the Abstract. I don't think that EWS work can be properly accomplished “on the side” as a secondary job. Given this, I think it is still difficult (even for trained people looking at good data) to make an accurate determination on when a slope will fail. The best, most recent example we have of this is the Mount Mannen slope in Norway, which has shown periods of acceleration, but has not yet failed (at least at my last check).

3) p. 7156, line 2, it would be helpful to the reader if you defined the difference in the way that you use “alerts” and “alarms”. The use of “alert” could cause some confusion (at least for readers in the U.S.) because “alert” is used to describe varying warning levels, which become more serious as progressing from “outlook” to “watch” to “warning”.

For details see: Chleborad, Baum, Godt, and Powers, 2008, A prototype system for forecasting landslides in the Seattle, Washington, area: In Landslides and Engineering Geology of the Seattle, Washington, area, Geological Society of America Reviews in Engineering Geology XX, p. 103-120.

When a “warning” is issued, it means that landslides are already happening or have a very high probability of happening. “Alert” has also been used in the U.S. as a low-level warning, see http://www.usgs.gov/blogs/features/usgs_top_story/usgs-issues-landslide-alert-for-hurricane-sandy/

4) p. 7156, lines 14-29; p. 7157, all lines; p. 7158, lines 1 and 2. I suggest numbering each of these shortcomings/limitations so they can be easily referred to later in the text. Also, I suggest adding another shortcoming/limitation, that is, many current EWS don't include estimates of how mobile the predicted landslides will be (i.e., how fast and how far will the landslides travel?). I think this mobility issue is nicely described by Iverson et al., in press, Landslide mobility and hazards: implications of the 2014 Oso disaster: Earth and Planetary Science Letters. For the precursor shortcoming (number 4, if numbers are added), I think you should also state that in some cases, there are a lack of precursors and/or not adequate time between the precursors and the rapid movement. For example, see Kean, J. W., Staley, D.M., and Cannon, S.H. (2011), In situ measurements of post fire debris flows in southern California: Comparisons of the timing and magnitude of 24 debris flow events with rainfall and soil moisture conditions, Journal of Geophysical Research, 116, F04019, doi:10.1029/2011JF002005.

5) p. 7158, Section 4. I think the individual sub sections within section 4 should be linked back to the shortcomings/limitations that were just listed on the previous pages. For example, section 4.1 is related to shortcomings/limitations numbers 1 and 2. I think it would be helpful for the reader if you stated what shortcomings each of the section 4 sub-sections addresses. It would also be helpful if the subsections listed in section 3 and those listed in section 4 were in the same order. That is, section 4.1 dealt with developments that could help to address shortcoming number 1 given in section 3. To help set this organization up, on p. 7158, lines 8 and 9, I suggest changing inserting "that could improve existing shortcomings and limitations" between "aspects" and "of".

6) p. 7160, lines 22-24, this sentence reminds me about a fundamental issue (lack of knowledge) that causes problems when running most models for regional forecasts of shallow landslides and debris flows. That is, an accurate determination of initial soil conditions (soil depth, soil moisture, pore pressure, etc.) within the region. This strikes me as something that could be added to the list of shortcomings/limitations of EWS, maybe within the precursor shortcoming (number 4)? Somewhere in the manuscript it

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would also be worthwhile mentioning the need for a remote sensing system capable "sensing" soil depth and moisture.

7) p. 7164, lines 2-9, you could mention the potential usefulness of continued development of portable ground-based radar systems for determining local rainfall in shadow areas. For an example, see Jorgensen, D.P., Hanshaw, M.N., Schmidt, K.M., Laber, J.L., Staley, D.M., Kean, J.W., and Restrepo, P.J. (2011), Value of a dual-polarized gap-filling radar in support of southern California post-fire debris-flow warnings, Journal of Hydrometeorology, 1581-1595, doi:10.1175/JHM-D-11-05.1.

Minor suggestions:

p. 7151, line 24, substitute "gravity-driven" for "gravitative".

p. 7153, line 6, insert "for research purposes" after "systems".

p. 7153, lines 14 and 15, change "flow depth increase of" to "an increase in flow depth that indicate".

p. 7154, line 8, the meaning of the phrase "but is conducted on a broader basis" not entirely clear. Please add some additional words here to help the reader understand.

p. 7154, line 15, replace "category" with "classification".

p. 7154, lines 17 to 26. I suggest using full sentences to describe each of these criteria.

p. 7154, line 26, please define "sufficient". I think "sufficient" will vary at each site, but I suggest saying that here.

p. 7155, line 15, replace "is" with "was".

p. 7165, line 21, insert "the" before "least".

p. 7166, line 23, replace "serve as a playground for testing" with "be used to test". The term "playground" may be realistic, but it doesn't sound too professional.

p. 7168, line 3, change "frame" to "framework".

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Best of luck with your revisions. I look forward to seeing the manuscript published.

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