

Interactive comment on “The Norwegian forecasting and warning service for rainfall- and snowmelt-induced landslides” by Ingeborg K. Krøgli et al.

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We inform that we have read the feedbacks and comments provided by the two reviewers and we would like to thank them for their careful review and their valuable comments. We have appreciated all the comments and suggestions provided.

We agree with the comments. We consider them very constructive and useful to improve the quality of the manuscript. We will try to address all suggestions preparing a new version of the manuscript.

Our replies to general and specific comments of Reviewer #2.

C1

Anonymous Referee #2

Overall comment The paper “The Norwegian forecasting and warning service for rainfall- and snowmelt-induced landslides” gave detailed descriptions of the history, developments, scientific results, applications and case study of the warning service. Besides, this paper not only addressed essential components of Early Warning System (EWS) e.g. meteorological forecasts, hydrological models, landslide database, thresholds and verifications, but also pointed out some challenges that need to be overcome. Therefore, this paper fitted in with this special issue as well as NHESS journal.

We thank Referee #2 for this positive comment. We are glad to hear that our work is interesting for colleagues outside Norway and the NHESS readers.

However, there were still several issues need to be clarified/revised before publication:

(1) What types of landslide does this EWS deal with? Considering different types of landslide (e.g. deep-seated landslide, shallow landslide, rockfall, debris flow or any others) should refer to different early warning models, if there were not just only one type of landslide included in this EWS, the authors might need to add a table to tell readers the types of landslide, the early warning models and the parameters used in this system.

Respond: Thank you for this important comment. In Norway, it yearly occurs a large variety of landslides, but the Norwegian landslide EWS, described in the manuscript is designed to warn only rainfall- and snowmelt induced landslides. Under this general name we include, soil slides (e.g. clay/silt slides), debris slides (e.g. gravel/sand/debris slides), debris avalanches, debris flows, debris floods as defined by Hungr et al. (2014). In addition to these, we warn also slushflows, described in Hestnes (1985). We use the same thresholds for the all of them. However, we know that soil saturation is significantly for soil slides, but the amount of rain and snowmelt is more important for the triggering of debris flows. We will include a figure that illustrates this in the manuscript. However, for slushflows we have defined other separate thresholds in based on both

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weather, snow (depth and structure) and hydrological conditions (as frost). We are still working on improving the thresholds for slusflows. Rock falls, clay slides, quick clay slides and rock avalanches are not included in this EWS. We will address this issue and try to explain it better in the manuscript.

Major floods and landslides in Norway

(2) Page 6, Line 3-4: The authors listed several dates of important landslide events, however, readers might not be able to understand how important or how special they were. A table with more detailed information such as rainfall intensity, accumulated rainfall, duration, geological and geomorphological conditions might need to be added.

R: Thank you for this remark. We agree. We will work on a better and more interesting presentation of the historical events.

The Norwegian landslide forecasting and warning service

(3) Section 3: Although several references were provided throughout section 3, the authors are recommended to briefly explain some important methods such as warning models and thresholds with equations or figures so that the readers might be able to get a picture of the theory running in the system more quickly.

R: Thank you. This part need a better explanation. We can present the figure with our thresholds or eventually other diagram explaining the methods used.

Thresholds

(4) Page 9, Section 3.2.4: It is suggested that at least probability of detection and probability of false alarm should be demonstrated here or in section 5.

R: The chapter you are considering are “3.2.4 Thresholds” and “5 Validation of the forecasting service”. We understand that this is an interesting topic for the readers and that we have not explained it enough. We will work on a way to address this in the manuscript without making it too long. Thank you for this comment.

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Technical performance

(5) Page 18, Line 1-4: The authors mentioned that over 95% of the assessment were considered as correct during 2013-2016, but the methods and data for the validations of threshold values, hydrological simulations, weather forecasts and the judgements of forecasters in duty were not shown here.

R: Thank you for this comment. We see that this topic ought to be discussed in the manuscript. We will work on a section where we explain how the daily evaluation of performance is made.

The case study

(6) Page 20, Table 3: How many days ahead does this EWS provide landslide/flood forecasting warnings? In section 3.2.1, the authors mentioned that AROME forecasts the weather for the next 66 hours while EC forecasts for nine days ahead. On the other hand, in page 11, line 9-10, the authors said forecasting weather are provided for the next 6 days on the website Xgeo.no while in page 12, line 31, the authors said forecasting warnings are provided for the next 3 days on the website varsom.no. If this EWS provides forecasting warnings only for the next 3 days, then it is suggested that the days beyond 3 days should not fill in green color in table 3 since this might lead to the misunderstanding that warning level of 4th Oct. can be predicted on 28th Sep. Besides, in the table of flood warning, the “day for which the warning was valid for” might be typos because 4th followed by 30th and 1st.

R: Thank you for this comment. We see now that this theme was not adequately described and that it can be confusing. We will work on improving this section. When we talk about the “The next six days” we meant 3 days + 6 days (the period of the short-term prognosis, and the further 6 d from the long-term prognosis). Still, we only publish awareness levels for landslide for three days (today, tomorrow and the day after tomorrow), since the short term prognosis is more reliable than the long-term prognosis. We will correct this in the new manuscript and we will try to visualize better

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the dynamic of prognosis and warnings. And thank you for pointing out the writing error in table 3.

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