

Interactive comment on “Meteorology triggering factors analysis for rainfall induced hydrogeological events in alpine region” by Andrea Abbate et al.

Andrea Abbate et al.

andrea.abbate@polimi.it

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REPLY TO REFEREE 1

Title: Meteorology triggering factors analysis for rainfall induced hydrogeological events in alpine region

We are kindly grateful for your accurate revision of our work. We have really appreciated your hints and suggestions and in this brief reply we are going to discuss them.

Overview and general comments: Authors studies the past meteorological (mainly rainfall) conditions that lead to certain hydrogeological events. They applied a systematic

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analysis, and fairly self-criticize their results. The study is relevant for particularly landslide researchers that use rainfall I-D curves. Although the technical framework of the manuscript seems sound and robust, the presentation of the work is rather poor in the current state. Overall, I got the impression that this manuscript is not properly edited before submission. There are several tiny mistakes in the text, which makes it hard to follow. With proper editing the manuscript will get considerably shorter and understandable. This manuscript deserves publication, after considerable changes in its current presentation.

We are aware that the work is not properly ready for a direct submission because several topics we have analyzed should be more integrated.

MAJOR COMMENTS Authors evaluate/discuss the rainfall I-D curves only based on “false negatives”, but ignore “false positives”. A certain rainfall might remain above the I-D curve of Guzzetti et al. (2007) or Mid-latitude Climate without triggering any landslide as well. The authors avoid discussing their results on a broader scale beyond their study area. They rather give an event summary in the analyses. They should extend their discussion and explain what do we learn from this study that is valid also for other high relief areas?

Our goal and the scope of the paper was to extend the Rainfall analysis. Commonly, rainfall is considered as a precursor of the shallow movements of terrain but due its spatial variability on complex territory can lead to false-negative, as we have assessed in the paper or false-positive, depending on the I-D curve considered. In this we agree that a broad discussion about I-D method uncertainties should be extended: site specific curves, poor rainfall data also in the Alps that is the most monitored range all over the world, radar failures in complex terrain etc. that may help or not to correct the rainfall intensity estimation. These facts bring to an approximate representation of the rainfall intensity and led to wrong interpretation of triggering events using this approach. So, it is useful to move to other approaches to estimate the intensity of the triggering events considering also other meteorological variables that are correlated with but can reduce

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the uncertainties in rainfalls analysis.

MINOR COMMENTS There are wrong use of words and tenses throughout the manuscript. It should be proof read. Authors prefer to use passive voice; I believe this practice is not recommended anymore. Excessive use of connecting statements, such as “on the other hand”, “conversely”, “Therefore”, “In conclusion”. Please omit the ones that are not absolutely necessary. Title can be a bit punchier.

The language style was not improved too much in this first submission, but we agree to avoid the passive voice and try to reduce the connecting statements. We are going to consider a Proofreading of the work. Title: We know that is a bit general and not specific.

Abstract It is long and it lacks providing a motivation and a take home message. For example, first two sentences of the abstract sounds similar. There are also a few sentences without any information, e.g. “The results obtained from the application of the two methodologies have been discussed.”. It also does not involve any clear take home message at the end, as expected.

Abstract REPLY:

Again, we agree with you that is general and should be more focused on the results of the paper.

Introduction The introduction is really hard to follow, it does not develop logically leading to the research questions of - Are these approaches sufficient for a complete description of triggering factors? - Can rainfall analysis be improved considering also other meteorological variables, which could better describe the rainfall events and the linked consequences? Why “other meteorological variables” are not mentioned before? Which approaches could be an alternative? These questions are not returned at the discussion one more time. A topic in a paragraph is returned after a few paragraphs again that confuses the reader. There are a few references, e.g. Guzzetti; Rosi;

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Gao, that appear frequently in different paragraphs. Authors should review the global literature carefully and reformulate the introduction leading to the research questions also beyond their study area. Line 47: “However, for shallow landslides: : :” I can't understand this sentence. Line 52: “These thresholds data are calibrated looking at the past events occurred in the area and directly correlated with the nearest rain gauge measures (Rappelli, 2008).” Rainfall intensity might vary considerably during an event, gauge data might miss this variation. We see this especially when rainfall radar estimates are compared with the gauge observations. Authors should also mention this effect in the same paragraph. Line 58: “: : :rainfall thresholds have been widely used in different parts of the world.”, but the authors refer usually to the studies from Italy, if I am not wrong. Line 74-82: Similar statements are mentioned in the Abstract as well as early in the Introduction, please refrain using same statements again and again.

Introduction REPLY:

Looking again at our introduction it seems that we are turning around the paper topic, but we do not explain clearly the question we have raised. Here the literature should be extended to formulate the problem we are analyzing in a clear and linear way, posing the questions and then start with the presentation of our own strategy to solve it.

We agree with the LINE comments: LINE 47: Deep seated landslides or big landslide have a complex triggering mechanism where geology and local morphology have an important role that can overcome the meteorological triggering effects. This is not the case for shallow movements that are related to the oversaturation of superficial terrain that is highly dependent on rainfalls triggering. So that Rainfall can be assumed as a predictor for failure. LINE 52: We agree with this suggestion and we will include. LINE 58: It is true because a lot of studies has been carried out in Italy. Also in other part of the world such as JAPAN and California these approach have been studied. We can include these citations. LINE 74-82: we can skip them in order to not refrain the same statement.

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Data, Methods and Models Authors should consider using dedicated chapters as “Data” and “Methods”. The method part explains how the computation works but lacks information about the meaning of the results for the current study. Line 96: “: : :estimated in 2 billion of euros.” reference missing. Line 98: “: : :glacier melting increased by high-altitude summer temperatures.” reference missing. Line 143: “: : :extratropical cyclone structures” Different type of rainfalls that effect the regions might be important for the entire study. Authors should consider providing more info about these effect in the introduction. Line 146: “: : :the traditional rainfall approach and the meteorological reanalysis approach.” They are not mentioned before. Line 154: “: : :by several authors.’ Who are they and how they mention it? Line 187: “: : :extratropical cyclone (EC), as described in Figure 2” I am not sure whether I can see the message in the figure.

Data and Methods REPLY: Data and methods will be presented in two different sections, with a better explanation of the attended results. LINE 96 and 98: we missed them, but we will include. LINE 143: we will include a brief explanation of EC in the Introduction as said before. LINE 146: again, this could be included in the introduction. LINE 154: reference is missing, we should include it. LINE 187: it should be more explained within the Caption of fig. 2 where are evidenced the typical structure of EC cyclones.

Results and Discussion It is hard to follow what is the new result and what is the discussion point. Please consider using a dedicated section for each, “Results”, “Discussion”. Line 236: “: : :rain rate ĀĖĹĪRĖĜ ij: : :” I guess rain intensity Line 255: “: : :possible indicator of the magnitude of the hydrogeological events...” : : :of: : :of: : : Line 262: “: : :does not permit: : :”, do you mean “hinders”, I recommend authors to use either negative prefixes and suffixes, or negative verbs directly instead of negative verb conjugation throughout the manuscript. For example, in line 281: “: : :it does not exist a unique method for the magnitude assessment: : :” : : :a unique method lacks that assess the magnitude: : :”

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Result and Discussion REPLY: We agree that information stored in the result section should be discussed in the dedicated section. In fact, comparisons among the Rainfall Analysis approach and the Meteorological Analysis are crucial to motivate our study. We agree with the LINE comments LINE 236: Yes, Rain Intensity LINE 262-281: We agree with the English style

Conclusion The section is dedicated to summarize the applied analyses, I could not really find a clear take home message that evolved from the results and discussion. Line 384: What are those “hydrogeological issues”? After reading the entire manuscript, I am still not sure about this term? Are the authors refer to hydrogeological evets, such as rainfall induced landslides? Or are there other events?

Conclusion REPLY: We think that with a more structured discussion the conclusion part will be easier to write in a more incisive style. What we want to say is this: Rainfall Analysis can help to identify the triggering events that have caused hydrogeological issues, but we must be aware of the uncertainties around that method. Considering the new possibility coming from meteorological analysis, the definition of the triggering event can be assessed not only considering the rainfall data, but evaluating an index that consider the evolution in space and in time of the entire meteorological event. The latter is not site-specific, and it is physical based but can be applied only for a category of meteorological phenomena (EC). We have tested it and we demonstrated that it can be useful and can be correlated to the magnitude of the hydrogeological issues, giving comparable results with the Rainfall Analysis we carried out. ***LINE 384: for hydrogeological issues we intend all the hydrogeological phenomena that can be triggered mainly by rainfalls, such as shallow landslide, debris flows, flash floods etc.

Tables: Table 1: The caption is repeating the column titles of the table. Figures: There are several bar plots, which does not provide so much information. They may be fit for the appendix, but they are poor for the main body of the manuscript. Authors should consider re-generating figures that provide clear messages. They could consider com-

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binning several of the figures in a more creative manner. Figure 1: X and Y labels and ticks are missing. Fonts are larger than in the main text. Figure 2: What is the purpose of the arrows? Figure 4: What is mid-latitude-and highlands climate? Figure 6 and figure 7: I cannot understand the message of these two, especially the figure 7 shows nearly constant Geostrophic velocity ($\pm 42 \pm 5$ km/h) Figure 8: Location of the Alps are different in each subplot; Lat Lon data is missing the numbers on the isolines are too small to read.

Tables and Figures REPLY: We have tried to be as clear as possible, but we know that synthesis is appreciated in the captions. However, we agree that a more creative representation of the figures should be achieved to facilitate the message we want to show to the reader. TAB 1: we make it shorter FIG 1: we should put a georeferentiation of the map and uniform the text height FIG 2: the arrow indicates the southerly flow that characterize the EC structure. Southerly flow (in Italy called Scirocco) is a moist air flow that it is responsible of the torrential rainfalls that are triggered around the Alps range when it is forced to rise by the mountains. FIG 3: Mid latitude and Highlands represent the classification proposed by Guzzetti for dividing the triggered hydrogeological phenomena respect to the climate location. Mid-Latitude refers to the Temperate climate (Italy is in this) and the Highlands are related to the High Mountains area (where ice and frost are present. In our region, central Alps both environments are present, so we have considered both. FIG 6: represents the two indicators m1 and m2 and their average for the different event type. FIG 7: Geostrophic velocity is a rough indicator of the intensity of the EC structure. Generally, strong ECs show strongest velocities that ranges around 40 km/h. It is a confirmation that all the event we analysed are associated with EC structures. We have presented them because have a key role in determining the value of the SLPT index. FIG 8: The Alps Range was added just as a reference, but we can improve its representation.

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