We would like to thank R#1 for his throughout review and comments.

Response to editorial comments

[R#1]: Overall, the paper reads well, but in places the text is difficult to read, and follow. Other parts of the text are not really necessary, and could be deleted, shortened, or moved to an appendix.

- 5 As an example, the description of the single modelling components (rainfall time series, TRIGRS modelling, slope stability modelling), does not add much to what is already known in the literature. The description of these model components should be shortened, or moved in specific appendixes, where they can be properly described.
- [A]: We will re-organize the paper as suggested, and improve figure quality. The comments from
 this reviewer and the others invite us to give more details on the Monte Carlo simulation method and on the application section hence the paper will benefit from moving the description of already-known model components in specific appendixes.

[R#1]: The Abstract and the Conclusions are not fully clear, and should be rewritten. In the Abstract should state briefly the purpose of the research, the principal results and the major conclusions, and must be able to stand by itself. In the Conclusions, the authors should list only the main

conclusions and relevant findings of their work.

15

45

[A]: Abstract and conclusions will be improved as suggested by this reviewer.

[R#1]: In the text, the authors use the term "hyetograph". A hyetograph is a graphical representation of the distribution of rainfall over time i.e., a rainfall record or a rainfall time series. Indeed, for their work the authors have used rainfall records, and not hyetographs. This should be clarified throughout the text.

[A]: The reviewer seems to question the fact that the term "hyetograph" is used for either the graphical representation of a rainfall time series and the time series itself. In our work the term "hyetograph" is used to mean "the water-input vs. time for a given rainfall event" (see Dingman,

25 2002), while a "rainfall time series" may contain multiple rainfall events (i.e. hyetographs). In our view D'Odorico et al. 2005 used the term "hyetograph" with the same meaning. We do not feel that it is the case to change "hyetograph" into "rainfall time series". Nevertheless, we will clarify somehow this detail in future versions of the MS, by giving explicitly the definition of hyetograph.

[R#1]: In section 3, the definition of the threshold and the evaluation of the performance of the 30 threshold should be separated in two different sections, or sub-sections at least.

Quality of the figures should be improved. Text and labels in the figures are small, and can be difficult to read. When modifying the figures the authors should consider their final size in the journal, considering that figures can occupy one or two columns. Some of the figures (e.g. Figures 4, 5) are very small, and difficult to read. Parts of the charts (e.g., in Figure 4) do not show data.

35 These parts can be removed from the charts, to make them larger. Authors should consider that use of colours is possible, I believe with no extra cost, in HESS. Some of the figures may improve significantly is colours are used.

[A]: We thank the reviewer for these suggestions, which will be taken into account to improve paper presentation quality.

40 **Response to specific comments**

[R#1]: Abstract, Line 1, "Rainfall thresholds are the basis of early warning systems able to promptly warn about the potential triggering of landslides in an area". This is a vague, and partly misleading statement. First, rainfall thresholds are not the only basis for landslide early warning systems. Second, "prompt" warning or alarm is not base solely on the exceedence (or not exceedance) of a threshold. A substantial amount of human judgment is involved in giving a warning,

or an alarm. [Note that the same comment holds for the first sentence of the Introduction].

[A]: We agree that the statement is vague and partially misleading in the sense that the referee indicates. We will properly take into account of his comments, both in the Abstract and in the Introduction, adding a comment on these issues.

- 50 Introduction, page 2761, lines 19, 20. "Reliability of thresholds derived by the analysis of observed data is generally limited by the quality and availability of such data". There are other factors that influence the reliability of rainfall thresholds, including the uncertainty associated with the definition of the thresholds. See e.g. doi:10.1016/j.geomorph.2011.10.005.
- [A]: We agree that many factors affect the reliability of rainfall thresholds, and we will add to the55 MS a brief description of uncertainty that affects threshold reliability, taking also into account the suggested reference doi:10.1016/j.geomorph.2011.10.005.

[R#1]: Introduction, page 2761, line 27. "... critical duration D...". The authors should be aware that "critical" is used with different meanings in the literature related to the definition of rainfall thresholds. See e.g., doi:10.1016/j.enggeo.2004.01.007, Govi and Sorzana (1980), Heyerdahl et al (2003), doi: 10.1007/s00703-007-0262-7.

60

[A]: We agree that the term "critical" is used with different meanings in literature. We will cite the literature indicated by the reviewer and write in the paper about this potentially misleading terminology.

[R#1]:Introduction, page 2763, lines 16-17. "... thus casting some doubts on the use of parametric power-law as a proper functional form in deriving rainfall thresholds.". A conclusion of the work is that the power law threshold model fits well the modelled data. The authors should comment this finding, in view of the findings of e.g., Rosso et al., 2006; Salciarini et al., 2008.

[A]: Power law thresholds have been introduced by Caine (1980) and have become a sort of a standard form of landslide triggering thresholds, as proved by the high number of studies that

- 70 propose them (cf. e.g. Guzzetti et al., 2007). Nevertheless, as stated by Brunetti et al. 2010 (www.nat-hazards-earth-syst-sci.net/10/447/2010/) "selection of a power law as the threshold curve is independent of any physical (i.e. geological, geomorphological, hydrological, meteorological) criteria, and [...] different forms of the threshold curve can be selected (Crosta and Frattini, 2001)". And in fact some thresholds, derived from physically-based models, are of a different form of a
- 75 power law (see eqn. (23) of Rosso et al., 2006 and eqn. (9) of Salciarini et al., 2008). Because such thresholds were derived from a physically-based model, this may be interpreted as an evidence that the use of the power law form is not supported by a physically-based standpoint. Nevertheless, in such studies the meteorological aspects were analysed in a simplistic way, because the thresholds do not indeed consider variability of rainfall intensity during events. In our study we derive thresholds
- 80 from a model that takes into account the geological, geomorphological, hydrological (TRIGRS, drainage and slope stability models) and *meteorological* (NSRP rainfall model) aspects, and find out that power-law thresholds perform well when pressure head memory is low. Otherwise antecedent rainfall is important to improve performances of the thresholds.
- More precisely, in our paper we do not exactly conclude "that the power law threshold model fits 85 well the modeled data [R#1 C716]". What is stated in our work may be explained as follows. The response to a given rainfall event is given by the sum of an initial pressure head ψ_0 (i.e. an initial water table height h_{in}) and a transient pressure head ψ_1 . The first is related to rainfall before current event, the second to rainfall of the current event.

Let us now analyze only the transient part, by letting $h_{in} = 0$. In this case:

- 90 When a uniform rainfall-rate event is considered as input to the TRIGRS v.2 unsaturated model the derived (D, I) rainfall threshold deviates from a straight line. The "strength" of this deviation varies with the hydraulic, geotechnical and geomorphological characteristics of the soil.
- When a time variable rainfall-rate event is considered as input to the TRIGRS v.2 unsaturated model, the simulated triggering points may be separated with a very good approximation (TSS close to 1) from the non-triggering ones by a power-law ID equation. This indicates that this model is adequate to represent the triggering part due to transient infiltration produced by rainfall events.

In the general case the h_{in} is not zero, and depends on antecedent rainfall. This results in a de-100 crease of the prediction performance of ID thresholds (including those of power-law form) – that do not account for antecedent conditions. The conducted sensitivity analysis shows that performances decrease as the A/B ratio increases, the hydraulic conductivity K_S decreases, the critical wetness ζ_{cr} decreases, the soil depth d_{LZ} decreases and the leakage c_d decreases. More correctly instead of the K_S and A/B the time constant of the drainage model may be considered $\tau = \frac{\frac{A}{B}(\theta_s - \theta_r)}{K_s \sin \delta}$.

Nevertheless, the minimum acceptable value of the performance index (in our work we refer to the TSS) depends on the level of acceptable risk. A TSS = 0.8 still represents high performances, and we have obtained (see extended sensitivity analysis in the response to R#2) that when τ < 3 days (A/B = 10 m, θ_s - θ_r = 0.3050, K_s = 2 × 10⁻⁵, sin δ = 0.643) and the soil depth is not to shallow d_{LZ} > 1 m and ζ_{cr} > 0.5, performances are acceptable (TSS> 0.8). An increase of performances was also obtained with higher leakage rates (higher c_d ratio).

Conclusions will be modified to explain better these findings, i.e. briefly: power-law ID thresholds are adequate to represent triggering due to transient infiltration. In general antecedent rainfall has to be taken into account, though power-law ID thresholds may still perform adequately in predicting shallow landslides in small basins with relatively high critical wetness ratios and hydraulic conductivity, a situation that is not rare to encounter in nature. Moreover, the performances of ID power

115 tivity, a situation that is not rare to encounter in nature. Moreover, the performances of ID powe laws increase in the presence of a fractured leaking bedrock at the base of the permeable layer.

[R#1]: Introduction, page 2764, line 4. "For this last point we adopt a precise rainfall identification criterion." Precise criterion? What does this mean? It seems to me that the authors have established a criterion, and have used it. There is no evidence that this criterion is accurate (or precise).

[A]: What it is meant with "precise criterion" is that it is "objective" and not subjective (i.e. varying from one event to another). We will replace "precise criterion" with "objective criterion". Nonetheless, in a certain sense it is also "precise", because the time instant at which the factor of safety FS drops below 1, is precisely identified.

125 [R#1]: Introduction, page 2764, line 18. "From their study..." Unclear how is "they".

120

[A]: A brief description of the paper by D'Odorico et al. (2005) is provided in our MS (p. 2764 lines 12-18). They have computed the return period corresponding to variable beta-shaped hyetographs and find out that in comparison to uniform hyetographs the return period associated with a FS \leq 1 is lower. Hence they have concluded that variable hyetographs have a stronger desta-

130 bilizing effect than the constant ones and that, in general, the variability of hyetograph shapes adds uncertainty to the assessment of landsliding triggered by rainfall. We will add these details in the MS, though for a complete description of their work and the assumptions they made one may refer to their paper.

[R#1]: Introduction, page 2764, line 21. Provide references for the NSRP model.

135 [A]: Introduction, page 2764, line 21. The following references will be provided at this point: Cox and Isham (1980) and Rodriguez-Iturbe (1987).

[R#1]: Monte Carlo modelling, page 2765, lines 8-9, "A stochastic rainfall model, calibrated on observations at a representative site, is used to generate a 1000-years long hourly rainfall time series." This is a tricky point that may ingenerate some confusion. The rainfall time series is "virtual",

140 as it is its length of 1000 years. It is not a climatic series that actually spans a 1000-year period. The difference is significant. As far as I can tell, no climatic information was used to generate the series, and the series was generated ignoring known of possible changes in the climatic signal. This should be clarified by the authors.

[A]: The scope of our analysis is not to model climate change nor to account for it somehow.145 Our series is stationary (although it accounts for seasonality) and the analysis is meant to provide results that are valid under the current climate conditions. Prevalent use of stochastic models is of this type, even though they are suitable to account for climate change. The scope of our paper goes beyond aspects related to climate-change. Nevertheless, we will add a comment on this issue in

future versions of our work.

150 [R#1]: Monte Carlo modelling, page 2765, line 14. Why have the authors decided to use a day (24 h) to separate rainy from dry (non-rainy) periods? Monte Carlo modelling, page 2765, line 20. What is this "basal boundary"?

[A]: 24 hours is the time necessary to have completion of the transient response to rainfall. In other words, for the range of simulated properties, the peak of pressure head due to a given rainfallevent occurs always before 24 h after the end of rainfall events. This issue is discussed in more detail

in the response to comment by R#2 (implications of the choice of the inter-event time). The basal boundary is the top of the impervious layer of the hillslope (see Figure 2 of MS).

[R#1]: Monte Carlo modelling, page 2766, lines 21-22. What is this "storm origin"? This is not at all clear? "Storms" and "rainfall" can be very different, and the authors should make this clear.

- 160 [A]: The meaning of "storm origin" is explained in the text and in Fig. 1 of the MS, and it is consistent with literature on NSRP rainfall models (cf., e.g., Salas 1993), and on the so-called "cluster stochastic rainfall models" in general. The meaning of "storm" in this context is of "a group/cluster of rainfall pulses". A rainfall pulse is a "cell". Hence "storm" and "cell" in this context may have different meanings of those in meteorology or other contexts, though this terminology is
- 165 somehow related to a conceptualization of physical processes beyond precipitation formation (see, e.g., Foufoula-Georgiou and Guttorp, 1987). These details will be better explained in future versions of the MS.

[R#1]: Monte Carlo modelling, page 2767, line 3. What is this "cell origin"? Again, this is not clear.

170 [A]: See response to previous point.

175

[R#1]:Monte Carlo modelling, page 2768, line 4. Say something about the "assumptions of Rosso et al. (2006)."

[A]: Monte Carlo modeling, page 2768, line 4. In re-organizing the description of model components we will give a better description of the assumptions by Rosso et al. (2006). Briefly, their modeling framework leads to a linear reservoir drainage model where the recession constant is a function of hydraulic and geometric properties of the hillslope.

[R#1]:Monte Carlo modelling, page 2769, line 1. "The ratio A/B is the well-known specific upslope contributing area A/B"? Text is unclear. What does it mean that A/B is ... A/B?

[A]: Monte Carlo modeling, page 2769, line 1. This was just a typing error: we will rewrite the sentence as follows: "A/B is the well-known specific upslope contributing area, an important variable on which the topographical control on shallow landslide triggering depends (Montgomery and Dietrich, 1994). Furthermore, equation (2) of MS will be modified as follows:

$$h_{i} = \frac{\psi(d_{LZ}, t_{f, i-1})}{\cos^{2} \delta} \exp\left(-\frac{K_{s} \sin \delta}{\frac{A}{B}(\theta_{s} - \theta_{r})} \Delta t_{i}\right)$$

because $A/B = N_d B$ only in the case that the D8 method is used. Since A/B may be computed with several methods (see, e.g., Holmgren, 1994) this version of the formula is more general.

[R#1]:Threshold derivation, page 2771, lines 4-6. "For a hillslope of given properties, Monte Carlo simulations lead to a series of computed failures, i.e. time instants at which the factor of safety drops below the value of 1." Although the statement is correct, I see a conceptual potential problem. It is well known that so called "deterministic models", including TRIGRS, underestimate

185 the stability conditions of the areas where they are applied. Indeed, it is common that the application of TRIGRS in a study area results in widespread (predicted) instability, which does not match the actual (real) abundance of event landslides (that is typically less, or much less than what is predicted by TRIGRS, or other similar models). Reasons for this behaviour are manifold, and not really important for this study. What is important is the fact that if TRIGRS predicts "instability" (e.g. FS)

< 1), not necessarily a slope failure occurs. This has an impact on the number of true positive and 190 true negatives, and the related analyses. The author should comment this issue in their work.

[A]: We agree with the reviewer that we should add a comment on the fact that "TRIGRS predicts instability (e.g. FS < 1)" that does "not necessarily" mean that "a slope failure occurs". Indeed it is very difficult to discern which unstable cells may result in a actual slope failure, and in fact, works

195 that use deterministic models to derive rainfall thresholds (see Rosso et al. (2006) and Salciarini et al (2008)), actually assume that thresholds for slope instability can be, conservatively, considered as thresholds for landslide triggering. We will add these comments in future version of our work.

[R#1]:Threshold derivation, pages 2771-2. I can think of additional reasons for the scatter of empirical points in a I/D chart that the two listed by the authors. One is the natural variability of 200 rainfall induced landslides. It is well known that a simple (possibly too simple) threshold model, like the I,D model adopted in this work, cannot capture the (large!) natural variability and complexity of rainfall induced landslides. Stating that (only) two factors control the joint presence of I/D events that have and have not resulted in landslides in an I/D log-log plot is too simplistic, and (partly) misleading.

- 205 [A]: It is true that there are uncountable sources of uncertainty in analyzing historical observed series: natural variability of rainfall induced landslides, spatial variability of rainfall, local factors, etc. Our framework enables to isolate and measure the uncertainty related to rainfall intensity variability and variability of initial conditions (induced by variability of rainfall patterns occurred before current event). This provides a more realistic manner to exploit physically-based models to derive
- 210 thresholds of landslide triggering, than the one usually proposed (cf. e.g. Rosso et al., 2006 and Salciarini et al., 2008) which are based on constant-intensity hyetographs and prefixed initial conditions. From another standpoint, the framework attempts to exploit the available observed dataset better then to use it directly for empirical analysis, to provide a good balance between the classical empirical and physically-based approaches. It is beyond of the scope of the paper to model all the 215
- sources of uncertainty involved in landslide triggering analysis.

[R#1]:ROC analysis, pages 2771-2774. Most of what is written in this section of the text is not really new, or innovative. This part of the text can be shortened considerably. In the very (very!) large literature on the assessment of forecasts using contingency tables, the zillions of related performance indexes, ROC plots, etc., there is indeed confusion and significant overlaps.

220 Indeed, this does not help. However, attempts to limit the confusion exist. The authors should consider doi: 10.1175/WAF1031.1 and specifically doi: 10.1175/2009WAF2222300.1. The performance index "Delta" used by the authors is not really new, but well known in the literature. I have notices that a public comment to this paper has pointed out the issue already. The authors are advised to check the references listed in this public comment http://www.hydrol-earthsyst-sci-225 discuss.net/11/C624/2014/hessd-11-C624-2014.pdf.

[A]: Regarding this issue please see our response to SC by S.L. Gariano.

[R#1]:ROC analysis, pages 2773, line 21. "... model deterministic thresholds ...". I have a problem with this definition of a "deterministic threshold". A (pseudo-)deterministic model like the one used in this work, does not result in a "deterministic" threshold, necessarily. The authors should clarify the meaning of "deterministic threshold", and if their definition implies that the threshold is 230 accurate, clear-cut, or fuzzy. This is crucial for the paper.

[A]: This comment makes us think that the terminology used in our paper could be improved. In the MS for "model deterministic threshold" it is meant a threshold derived from a physically-based model under the assumption of an input given by uniform hyetographs and initial conditions that are

235 not computed based on past rainfall history (i.e. they are in fact prefixed), see e.g. eq. (23) of Rosso et al. (2006) and eq. (9) of Salciarini et al. (2008). Perhaps it will be appropriate to replace "model deterministic thresholds" with "constant-intensity-input physically-based thresholds". Conversely, the MC-derived thresholds may be named "stochastic-input physically-based thresholds". Once they are derived, both types of thresholds are intended to be used as clear-cut in our MS. In the case of a

deterministic input no uncertainty results evident, because once the rainfall duration-intensity (D, I)240 pair is fixed there is no variability in input conditions (which will be a uniform hyetograph of the duration D and intensity I, and a prefixed initial condition), hence in this sense the whole threshold is also "deterministic". On the other hand, in our MC framework, to a fixed pair (D, I) generally different patterns of rainfall and initial conditions may correspond, hence uncertainty stems from 245 this variability and this is measured by the ROC indexes.

[R#1]:Investigated area and data, page 2774, lines 7-10. More information should be given on the location and size of the study area. Figure 3 is not really sufficient. Accurate or approximate location of the considered landslides should be shown in Figure 3. Depending on the location of the landslides, use of a single rain gauge may be reasonable, or not. This should be clarified.

- 250 [A]: We do agree with the reviewer that more information should be given on the location and the size of the study area and in general on the case study area. Since such information has been requested R#4 and R#2, we have produced a separate supplement that collects all required information on the case study area (http://www.hydrol-earth-syst-sci-discuss.net/11/C2076/2014/hessd-11-C2076-2014-supplement.pdf)
- [R#1]:Investigated area and data, page 2774, lines 15-17. "Based on a preliminary analysis 255 of monthly statistics, six homogeneous rainfall seasons have been identified: (i) September and October, (ii) November, (iii) December, (iv) January–March, (v) April and (vi) May–August." More should be said on how these "homogeneous rainfall seasons" were identified. Is this statistically significant, given the very short period covered by the rainfall time series? This needs to be clarified.
- 260 [A]: Nine years of rainfall data are statistically sufficient to develop the NSRP model, since its calibration is at hourly scale. There are examples in literature that use shorter recordings to develop similar models, see, e.g., Rulli and Rosso (2002) and Obeysekera et al. (1987). Moreover, significance of the series is supported by the fact that it contains a good number (4) of landslide-triggering events. Regarding the identification of homogeneous rainfall seasons, this may be done by investi-
- 265 gating the monthly variations of moments used in model calibration (cf. Salas, 1993). In particular, we have referred to the plot shown in Figure 1 (see description). These details will be added to future versions of the MS.

[R#1]:Results and discussion, page 2775, line 5. Is the number of 19,826 rainfall events in a (virtual) 1000-year period realistic, or not? This is an "average" of 20 rainfall events per year? Is this reasonable for the study area? How does it compare with the number of real rainfall events in 270 the considered period?

[A]: 20 events appear to be low, because this number results from neglecting rainfall of the months from April to August (rainfall is low in these months, and no landslides have been observed in the past in these months, see previous point) and the events with rain intensity lower than the leakage

275 flow. This number is comparable with the number of rainfall events in the observed series subject to the same preprocessing. Please see our response to comment a similar comment by R#2 for further details, that will be of course added to future versions of our MS.

[R#1]:Results and discussion, page 2775, lines 12-13. The count of Positives (N) and Negatives (N) can be misleading. See previous comment: Threshold derivation, page 2771, lines 4-6.

- 280 [A]: Referee is concerned about the fact that "slope instability (FS < 1)" does not necessarily imply "slope failure", and that hence the count of positives (P) and negatives (N) is different in the two cases. These aspects are behind the scope of our work. We neglect the decision process (human intervention) as well, that may also change TP, TN, FP, and FN. We will add a caution phrase regarding these issues to the MS.
- 285 [R#1]:Results and discussion, page 2775, lines 1-2. It is not clear to me how the contributing area, and the specific catchment areas were determined. In spatial modelling, this is usually done exploiting a DEM, of a given resolution. However, this is not the case in this work. This should be clarified.



Fig. 1. Moments for each month for Fiumedinisi SIAS hourly rainfall data. In particular μ denotes the mean, γ the variance, $\rho(1,1)$ the linear autocorrelation coefficient at lag = 1, ϕ the probability of a dry interval, ϕ_{DD} the probability that a given interval is dry after another dry one, ϕ_{WW} the probability that a given interval is wet after another wet one. These moments have been used in calibration of the NSRP model via the method of moments. It can be seen that there are low differences of most of the moments within the following groups of months: Sept-Oct, Nov, Dec, Jan-March, April, May-August. The period April-August has been neglected from the successive analyses because precipitation rates are so low that it is extremely unlikely that a triggering event may occur in such period.

[A]: Contributing areas and specific contributing areas have been computed with the D8 method based on the 5×5 resolution DTM. See supplement on the case study area (http://www.hydrol-earth-290 syst-sci-discuss.net/11/C2076/2014/hessd-11-C2076-2014-supplement.pdf).

[R#1]:Results and discussion, page 2776, lines 28-29. "...but may still be acceptable." Why? What do you mean, exactly?

[A]: Regarding this comment we will like to remember that any threshold model is not perfect, 295 and hence may lead to warning errors. In many cases, in literature this has been neglected because thresholds were derived based on the triggering events only. It is just recently that researchers are including uncertainty analysis, by considering also non triggering events. "May still be acceptable" means that the TSS remains high (> 0.80) and hence, depending on the degree of uncertainty that may be accepted (related for instance to the damage that a landslide may lead in an area), they may 300 still be acceptable. See also our response to comment by this reviewer to Introduction, page 2763, lines 16-17.

305

[R#1]:Results and discussion, page 2777. Eq. (12). How does this threshold compare to similar thresholds for the same area, of for nearby areas. As an example, thresholds have been recently proposed for Calabria, to the N and NE of the study area. See: doi:10.5194/nhess-14-317-2014. Other thresholds may be available for Sicily, or for similar areas.

[A]: Pubblication doi:10.5194/nhess-14-317-2014 (Vennari et al., 2014) is relative to Calabria, and hence we think that the thresholds that are proposed there are not representative for Sicily, even though one may think of similarities for the two areas, due to their geographical vicinity. Part of the Authors of doi:10.5194/nhess-14-317-2014 have published a conference paper proposing thresholds

- 310 for Sicily (Gariano et al., 2013). In particular, the following threshold, in terms of cumulative event rainfall $E = I \times D$ and event duration D, corresponding to a (triggering events) exceedance frequency of 1% results from the historical dataset they have analysed ("the 138 events that remain by excluding rockfalls") : $E = 10.4D^{0.22}$ which is equivalent to $I = 10.4D^{-0.78}$. It is interesting to notice that the exponent is practically equal to the one that results from our analyses ($a_2 = -0.8$).
- Furthermore, this threshold exceeds one triggering event of the MC simulated data, which equals the 1% of the triggering-rainfall dataset (see Table 4 of the MS: 0.01 × (TP+FN) = 0.01 × (104+11) = 1.15). This is an interesting result that supports the validity of the proposed MC approach to simulate rainfall-landslide data. In our opinion, Figure 2 also supports the importance to analyze non-triggering rainfall (too many false alarms are likely to be given by the threshold by Gariano et al., 2013).



Fig. 2. Comparison between the proposed threshold and the one proposed by Gariano et al., 2013.

References

Brunetti, M. T., Peruccacci, S., Rossi, M., Luciani, S., Valigi, D., and Guzzetti, F.: Rainfall thresholds for the possible occurrence of landslides in Italy, *Nat. Hazards Earth Syst. Sci.*, 10, 25 447–458, doi:10.5194/nhess-10-447-2010, 2010. 2762, 2771

- 325 Cox, D.R., and Isham, V. 1980 *Point Process*. London: Chapman and Hall. Crosta, G. B. and Frattini, P.: Rainfall thresholds for triggering soil slips and debris flow, in: Proceedings of the 2nd EGS Plinius Conference on Mediterranean Storms, edited by: Mugnai, A., Guzzetti, F., and Roth, G., Siena, Italy, 463–487, 16–18 October 2001.
- Guzzetti, F., Peruccacci, S., Rossi, M., and Stark, C. P.: Rainfall thresholds for the initiation 25 of
 landslides in central and southern Europe, *Meteorol. Atmos. Phys.*, 98, 239–267, 2007. 2761, 2762
 Dingman, S. L. (2002) Physical hydrology 2nd edition. Prentice Hall. ISBN 0-13-099695-5
 - D'Odorico, P., Fagherazzi, S., Rigon, R. Potential for landsliding: Dependence on hyetograph characteristics (2005) Journal of Geophysical Research F: Earth Surface, 110 (1), art. no. F01007.
- Foufoula-Georgiou, E., and Guttorp, P., Assessment of a Class of Neyman-Scott Models for Tem-335 poral Rainfall, *Journal of Geophisical Research*, vol. 92, no D8, pages 9679-9682, august 20, 1987.
- Gariano, S.L., Iovine, G., Antronico, L., Brunetti, M.T., Melillo, M., Peruccacci, S., Terranova, O. Rainfall thresholds for the initiation of shallow landslides in Sicily (2013) Rendiconti Online Societa Geologica Italiana, 24, pp. 155-157.

Holmgren, P. (1994) Multiple flow direction algorithms for runoff modeling in grid based elevation models: an empirical evaluation, Hydrological Processes, 8, 327-334

- Montgomery, D. R. and Dietrich, W. E.: A physically based model for the topographic control on shallow landsliding, Water Resour. Res., 30, 1153–1171, 1994. 2763, 2764
- JTB Oberysekera, GQ Tabios III and JD Salas (1987). On parameter estimation of temporal rainfall models. Water Resources Research vol. 23 no 10, p 1837-1850.
- 345 Rodriguez-Iturbe, I., Cox, D.R., Isham, V. 1987. Some models for Rainfall Based on Stochastic Point Processes, *P. Roy. Soc. Lond. A Mat.*, 410, 296-288, 2766, 2767.
 - Rosso, R., Rulli, M. C., and Vannucchi, G.: A physically based model for the hydrologic control on shallow landsliding, *Water Resour. Res.*, 42, 1–16, 2006. 2763, 2768, 2773
- Rulli, M.C. and Rosso, R.: An integrated simulation method for flash-flood risk assessment: 1.
 Frequency predictions in the Bisagno River by combining stochastic and deterministic methods, Hydrol. Earth Syst. Sci., 6, 267-284, doi:10.5194/hess-6-267-2002, 2002.
 - JD Salas (1993) Analysis and Modeling of Hydrologic Time Series, Chapter 19, Handbook of Hydrology (ed. D.R. Maidment), McGraw-Hill.
- Salciarini, D., Godt, J. W., Savage, W. Z., Baum, R. L., and Conversini, P.: Modeling landslide recurrence in Seattle, Washington, USA, *Eng. Geol.*, 102, 227–237, 2008. 2763, 2773
 - Vennari, C., Gariano, S. L., Antronico, L., Brunetti, M. T., Iovine, G., Peruccacci, S., Terranova,
 O., and Guzzetti, F.: Rainfall thresholds for shallow landslide occurrence in Calabria, southern Italy,
 Nat. Hazards Earth Syst. Sci., 14, 317-330, doi:10.5194/nhess-14-317-2014, 2014.