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Natural Hazards and Earth System Sciences
Discussions

NHESSD

3, C1668–C1686, 2015

Interactive Comment

Interactive comment on "Analysis of a landslide multi-date inventory in a complex mountain landscape: the Ubaye valley case study" *by* R. Schlögel et al.

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Dear Referees and Editor,

Once again we would like to thank you for the constructive and very detailed comments provided for the improvement of the manuscript entitled "Analysis of a landslide multi-date inventory in a complex mountain landscape: the Ubaye valley case study". We also want to apology for the delayed revision.

We agreed that the previous version of the manuscript could be improved in term of clarity, coherence and scientific background. We also recognize that there was lack of explanations about the (interrelated) uncertainties of the mapping due to the products available (geometric errors etc.) and the land coverage. The methodological framework takes into account multi-source data with different spatial resolutions. Despite the good knowledge of the field, some interrelated uncertainties are present. In the updated version of the manuscript, they have been assessed, analyzed and discussed with caution in order to avoid biases in the multi-date landslide inventory.

1. Paper structure (Referees #1&2)

The clarity of the manuscript has been improved by changing its structure as suggested by Reviewer #1. Moreover, the main objectives have been modified to redefine the aim of the paper and some precisions about some chosen criteria. They are the following: (i) to propose a multi-date landslide inventory map from multi-source data; (ii) to identify and quantify uncertainties and interpretation errors associated to the mapping; (iii) to propose indicators to estimate the interpretation errors in order to improve the reliability of the landslide inventory maps and (iv) to analyse quantitatively the multi-date inventory.

The general structure of the paper is now the following: 1. Introduction; 2. Study Area; 3. Data; 4. Methods; 5. Results; 6. Discussion and 7. Conclusion. Moreover, the results sections are described in the methodological sections. The 'Methods' sections have also been renamed such as: 4.1. The multi-date landslide inventory; 4.2. Uncertainty estimation of the data sources; 4.3. Landslide activity and, 4.4. Statistical analysis of the landslide inventory maps, whereas the 'Results' sections correspond to: 5.1. Analysis of landslide density; 5.2. Analysis of descriptive statistics; 5.3. Results of frequency-area distribution and, 5.4. Results of the temporal probability assessment. As suggested, the section mentioning the "relationships between landslide activity and triggering events" has been entirely removed. We also don't expect anymore redundant information. However, we keep the table 2 which describes all the multi-source datasets while the Figure 2 shows the spatial and temporal coverages of the orthophotograps, the geomorphological maps and the SAR images. As suggested by Reviewers

#1 and #2, we integrated the temporal coverage of the main datasets (time line, previously Fig. 3) into the Fig. 2.

As suggested, a discussion section has been added. However, we decided to focus it on the comparison of landslide activity using different sources of products: the multi-date inventory, the punctual catalogue of event (covering a longer time-lapse) and some dendrogeomorphological observations available for landslide sites. Then, we discussed their differences and similarities.

2. Uncertainties and biases (Referees #1&2)

A new sub-section was added in the methodological framework. Indeed, new landslide mapping have been prepared in order to take into account uncertainties: (1) related to expert-based skills and (2) considering data-based properties as well as landslide activity visibility. Landslides contours have been remapped as described in section 4.2. We assume that the inventory is highly dependant on the skills of the geoscientist and the data properties, this is why we proposed this qualitative 'landslide interpretation uncertainty index' which is directly attached to the landslide attribute table. In addition, we assumed that landslide under forest are definitely less visible than others which is function of the data considered and the percentage under coverage. Therefore, we proposed to estimate the minimum uncertainty by combining the both data resolution information and land use information (called "quantitative mapping uncertainty" in the paper). We propose to multiply the spatial resolution of the dataset considered for mapping the landslide (e.g. 0.5 m for the orthophotograph of 2009) by a factor of 5 if the landslide is more than 50% under forest. If the orthophotograph is shifted, we propose to take into account this shift (i.e. for 2000) as 'spatial resolution'. This empirical factor Moreover, we decide to consider the available land use shapefiles which evolve over time and depends on the human impact. We think that the precision of landslide contours are less visible when there are located under forest even if there are less influenced by human activities as suggested by Bell et al., 2012. But according to Bradinoni et al. (2003), landslide inventories mapped from orthophotos might

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be considerably less complete on forested areas. In addition, forest harvesting is observed and may still induce instability. This new conceptual framework underlying the chosen criteria is therefore suggested to deal qualitatively and quantitatively with the different uncertainties. The related biases and uncertainties are mentioned in the conclusion, we were even able to assume that: “our dataset allows us to detect most of the landslides having a displacement larger than a distance of twice the data resolution”.

3. Specifying criteria (Referee #1)

Grid resolution and landslide threshold are specified in the text. In section 4.4.2, we indicated that: “Criteria were chosen according to the high variability of the landslide sizes in this area: mean landslide areas around 27000 m^2 with standard deviation of ca. 80000 m^2)”. We decided to mention only the landslides that were detected by the analysis of SAR interferograms and reformulated the sentence into: “In 2012, the field survey aiming to inspect these signatures concludes that 110 SAR signals were expected to correspond to landslide events”. A section of the methodological framework (4.3) defines the activity types, such as relict, dormant and active has been added. Then, the procedure to evaluate the landslide activity (based on the vegetation indicator) over periods of time is detailed.

4. Specific topics and language (Referee #2)

Links between landslide types, densities and slope orientations have been added in section 5.1, such as: “Deep-seated rotational slides are less present in zone 1 and rarely observed to the East of the Riou-Versant (Fig. 7b). Their average size is around 85 700 m^2 in zone 1 (0.6 landslide per square kilometre), 25 420 m^2 in zone 2 (1.8 landslide per square kilometre), and 109 500 m^2 in zone 3 (0.3 landslide per square kilometre). The landslide average area is almost ten times larger for rotational slides than for translational slides in zone 3. The slopes orientated to the West are more affected by landslides (i.e. mean slope orientations of 220° and 226°; Figs. 7a, 7b and 8a). The average value of the mean landslide slope angles reaches 25° with a standard deviation of 4°. Deep-seated landslides and the three complex mudslides have been mostly reactivated in regolith deposits (i.e. moraine and weathered marls) while shallow landslides are half in bedrocks.“

We mentioned the involved material (rock and debris) to describe the different type of landslides in the study area section.

5. Modifications of figures

In Figure 1a, some study sites mentioned in the text have been integrated in order to locate them. A flowchart was not integrated as we found that we describe the methodological framework and then, analyzed the results in agreement to them. We added the figure 4 representing the quantitative mapping uncertainty (a) and the re-activations recorded thanks to the qualitative vegetation indicator integrated into the inventory attribute table (b). The last figure (Fig. 14) was simplified by removing the rainfall dataset as the triggering factors are not analyzed anymore. In addition, some corrections were added to some other figures to be in agreement with the manuscript.

Hoping that you are going to consider these corrections with the highest attention,

Sincerely,

R. Schlögel, on behalf of the co-authors

Please also note the supplement to this comment:
http://www.nat-hazards-earth-syst-sci-discuss.net/3/C1668/2015/nhessd-3-C1668-2015-supplement.zip

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Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 3, 2051, 2015.

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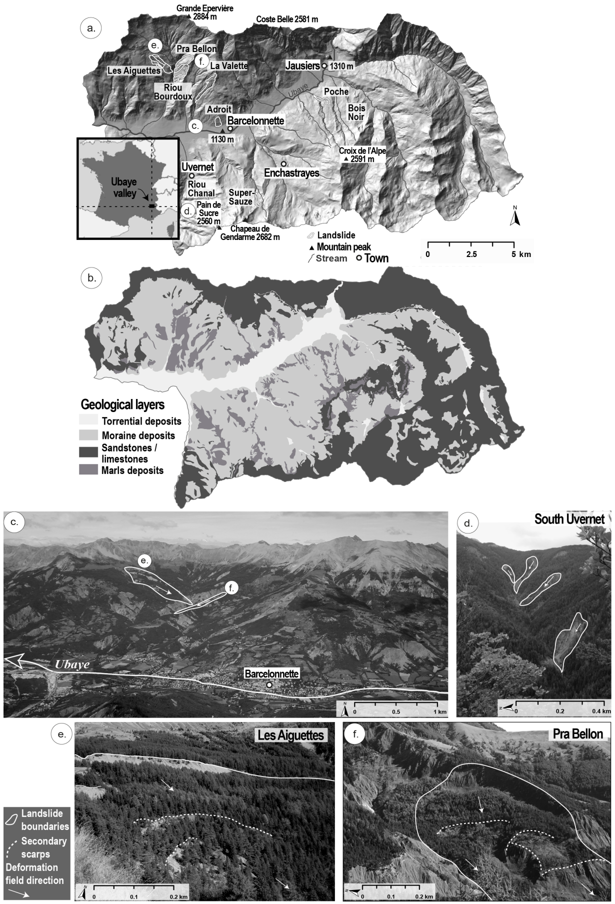

Fig. 1.

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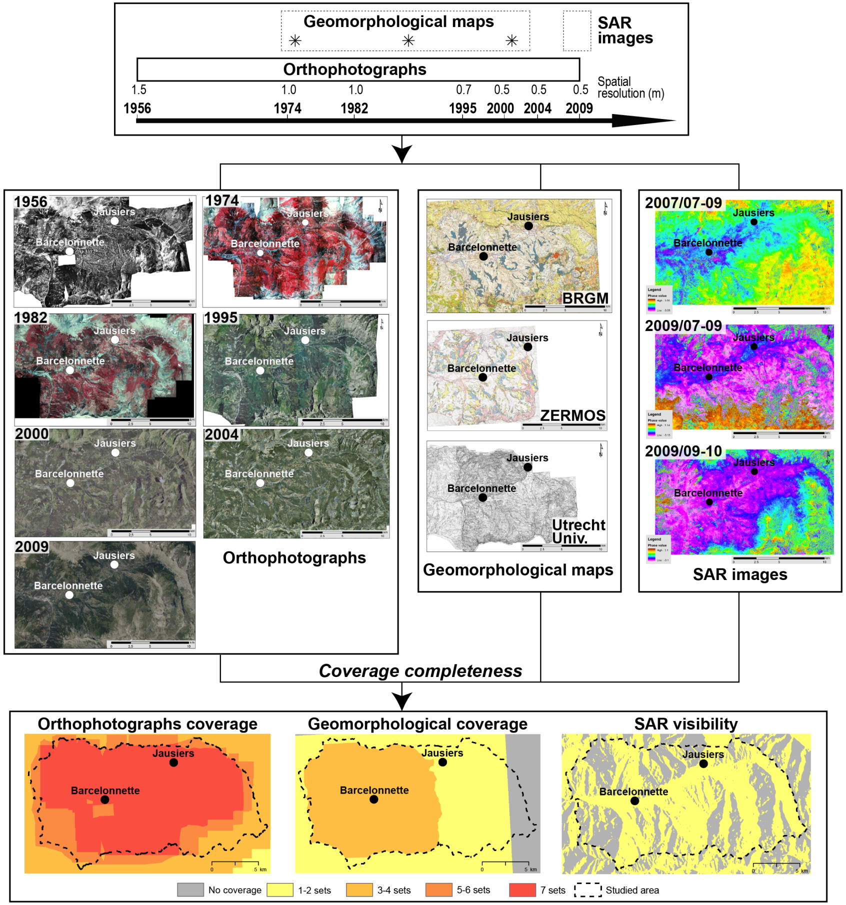

Fig. 2.

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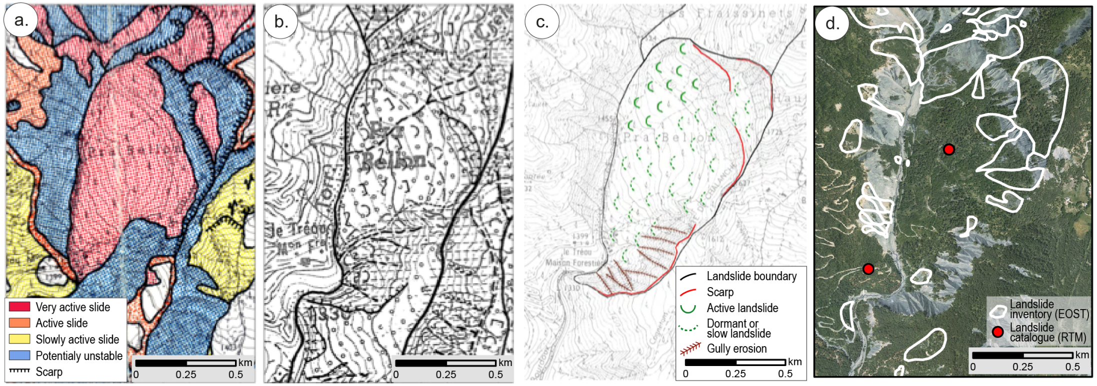

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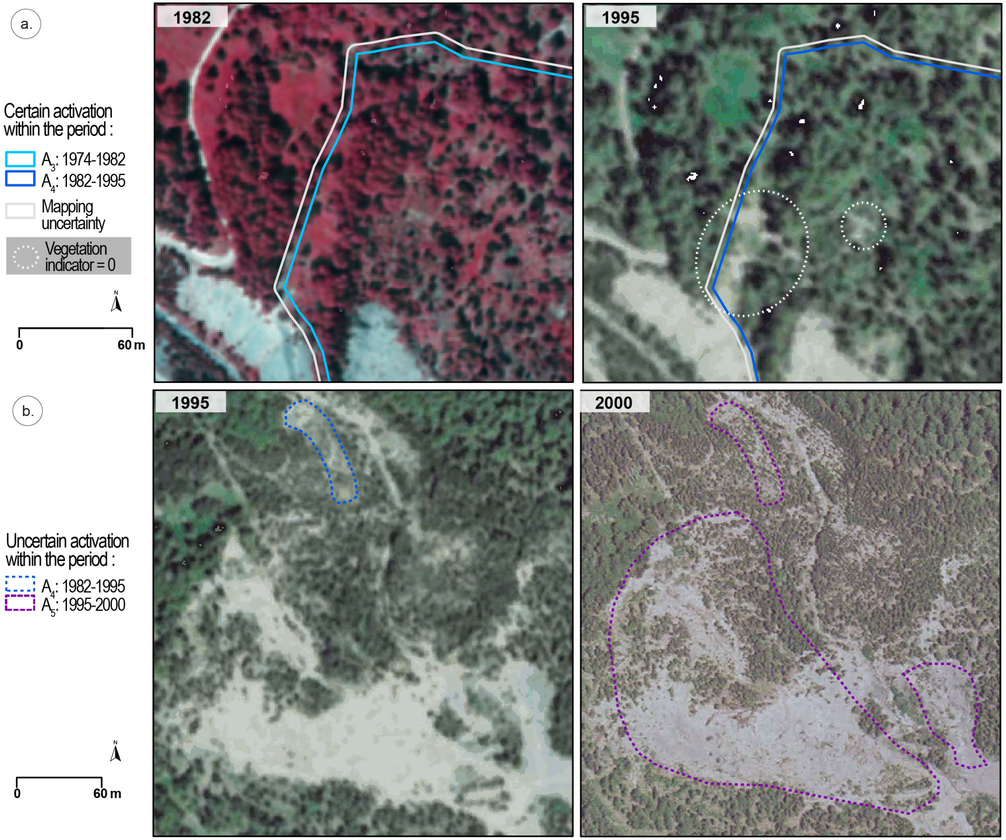

Fig. 4.

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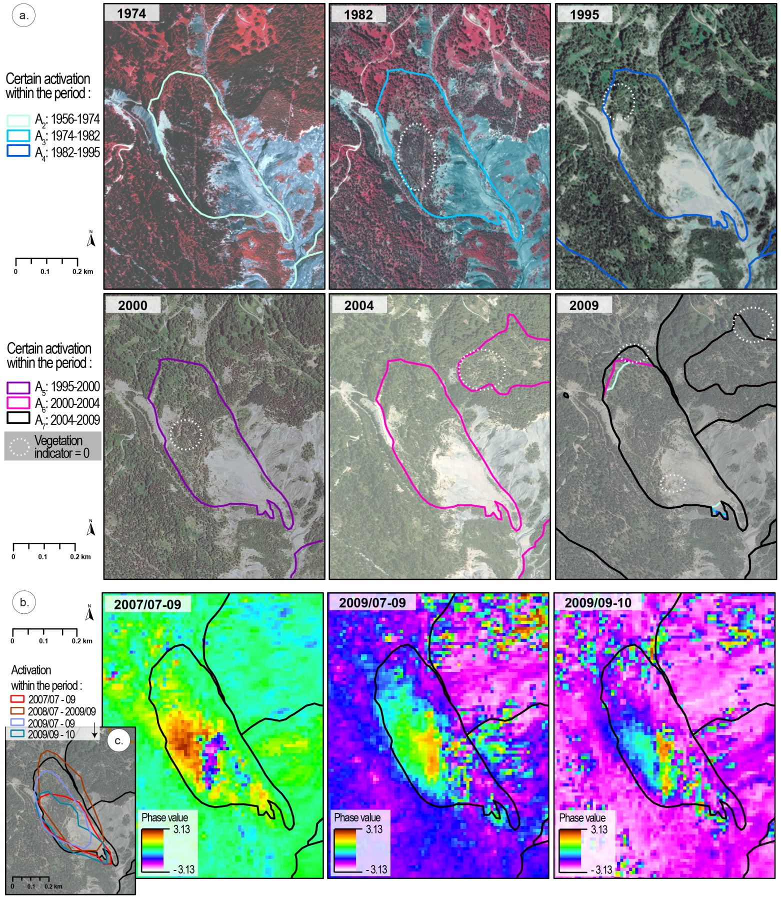

Fig. 5.

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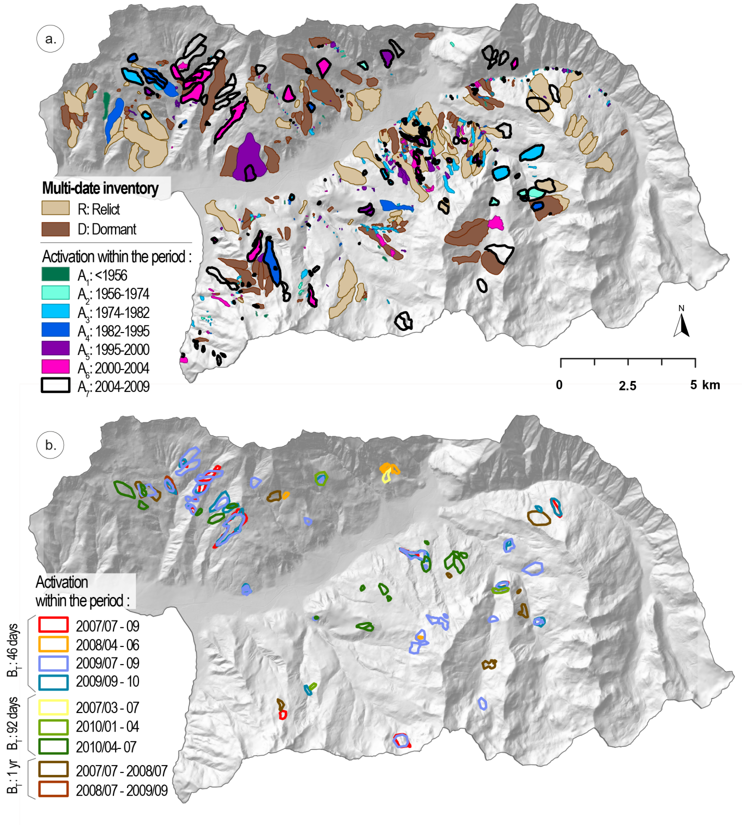

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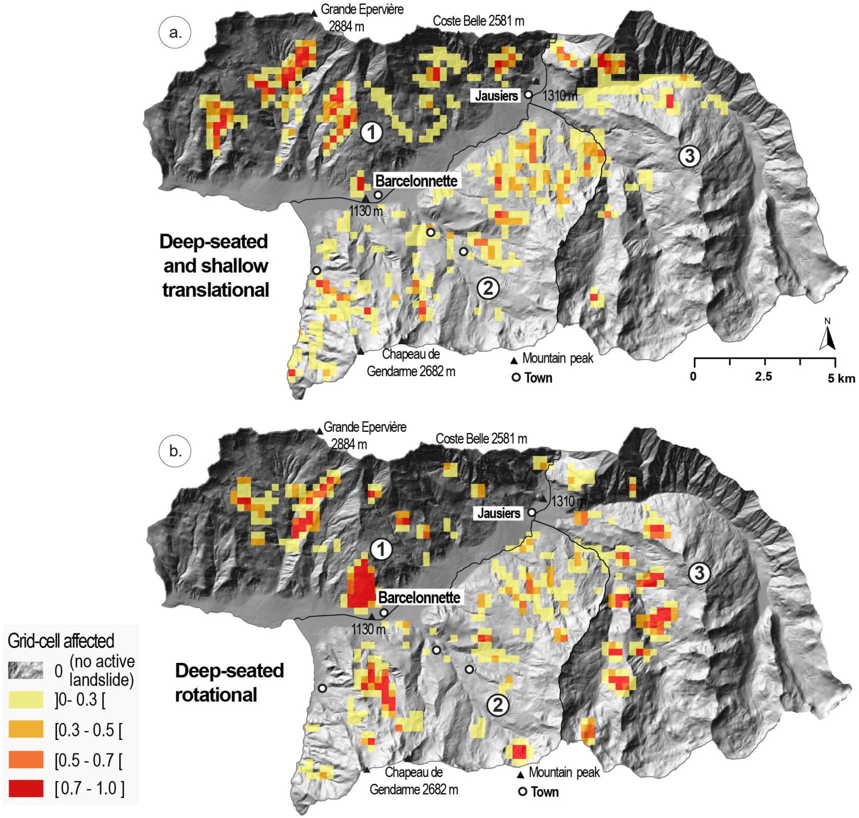

Fig. 7.

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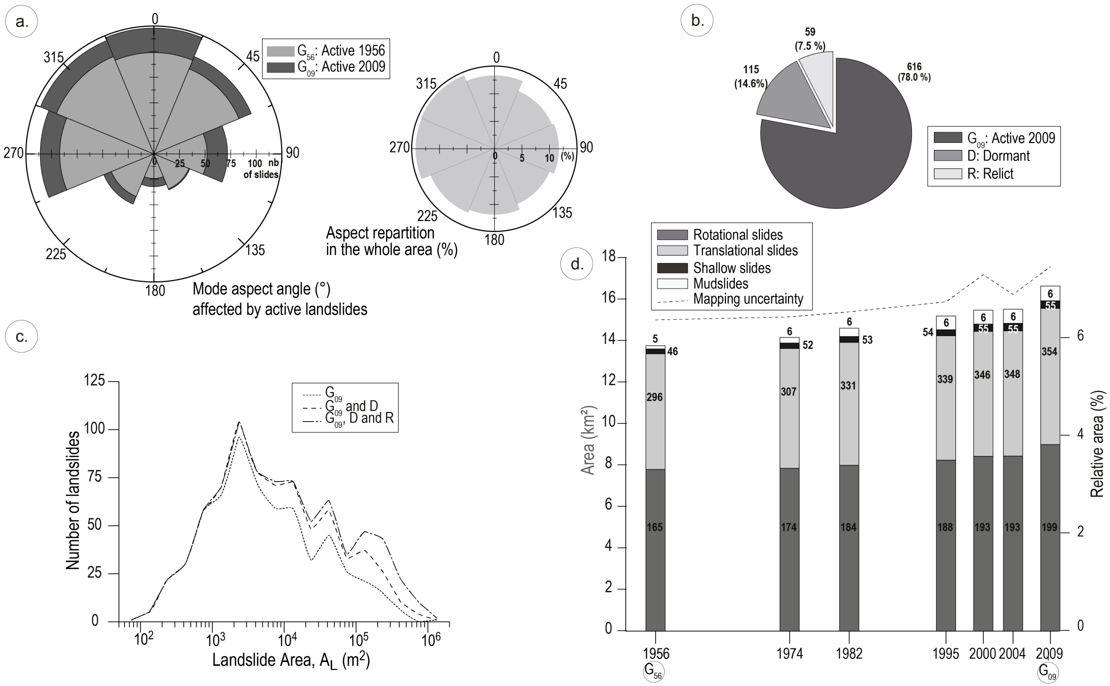

Fig. 8.

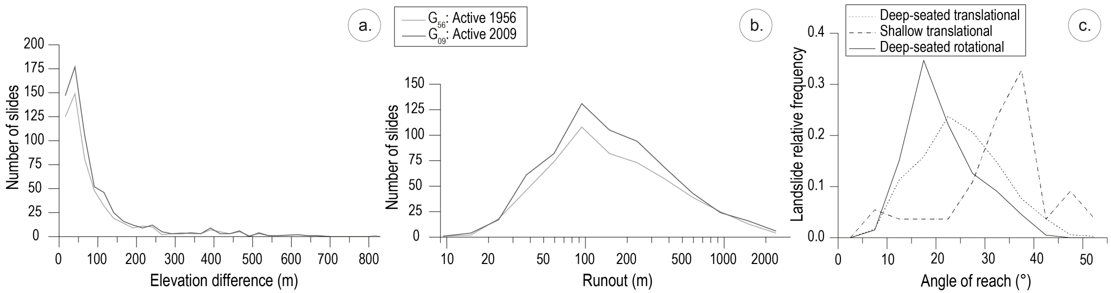

Fig. 9.

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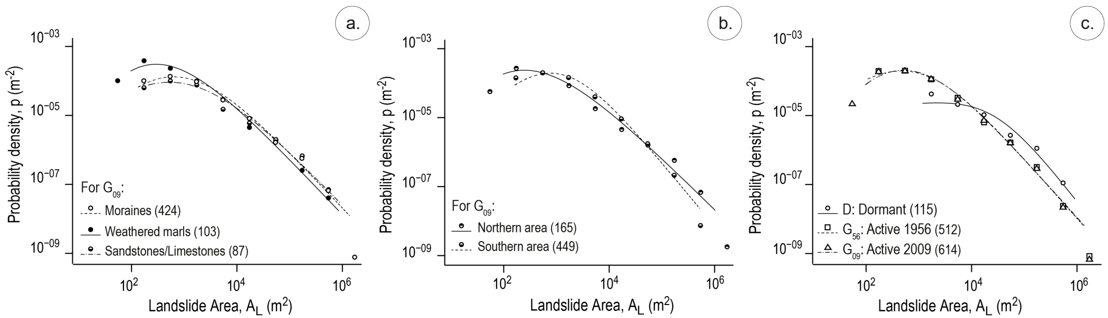

Fig. 10.

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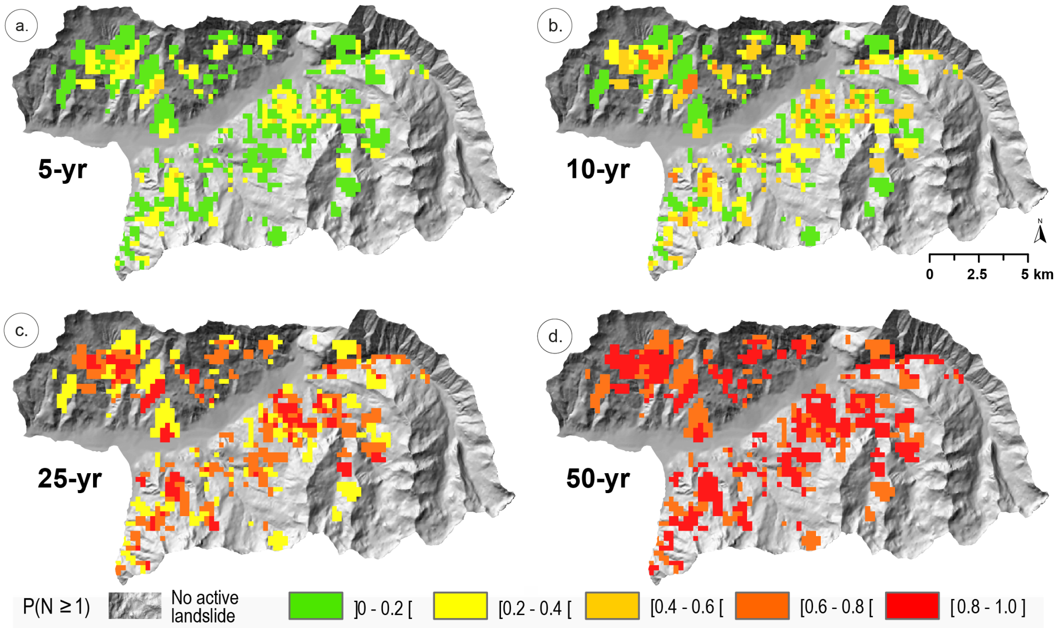

Fig. 11.

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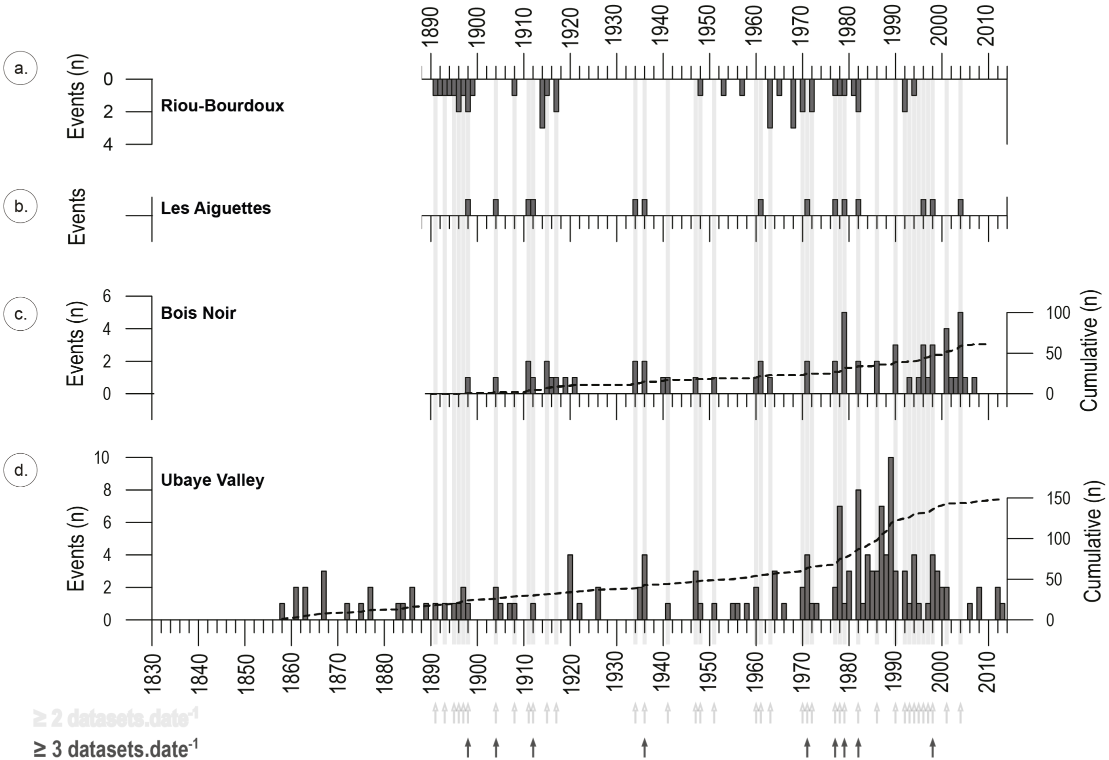
a.
Events (n)
Riou-Bourdoux
b.
Events
Les Aiguettes
c.
Events (n)
Bois Noir
Cumulative (n)
d.
Events (n)
Ubaye Valley
Cumulative (n)
≥ 2 datasets.date-1
≥ 3 datasets.date-1

Fig. 12.

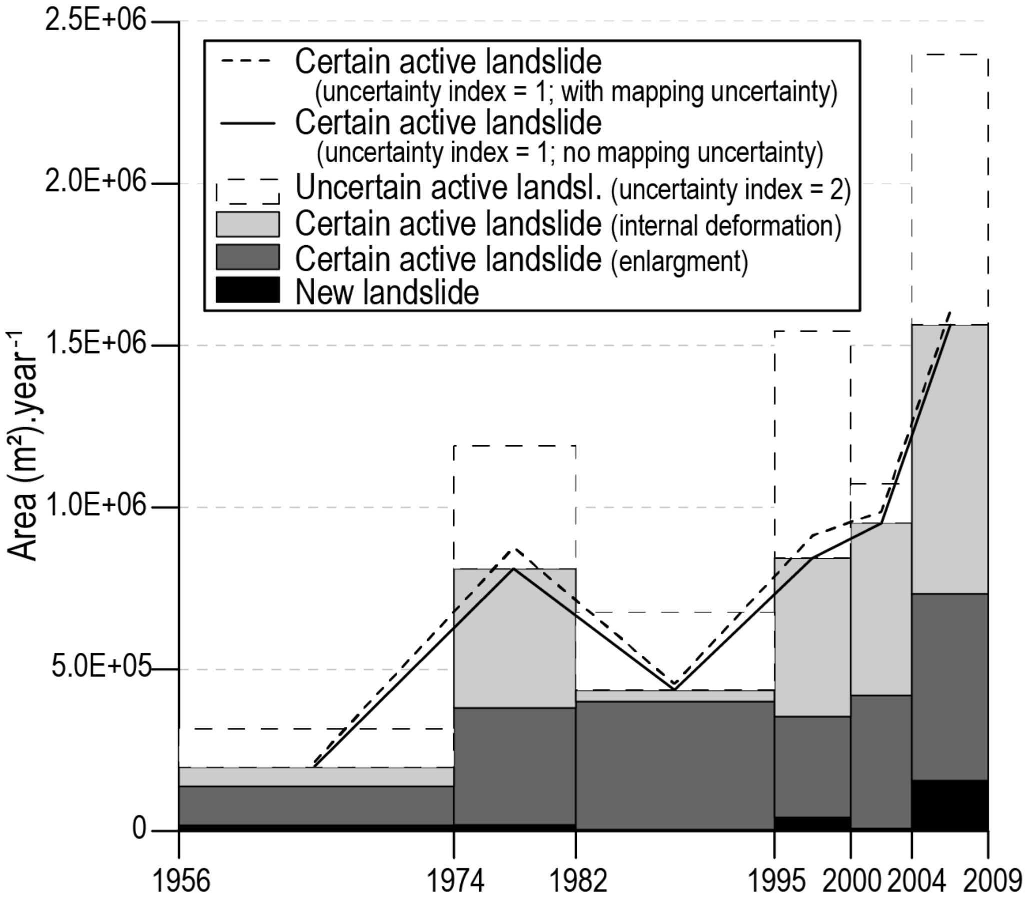

Fig. 13.

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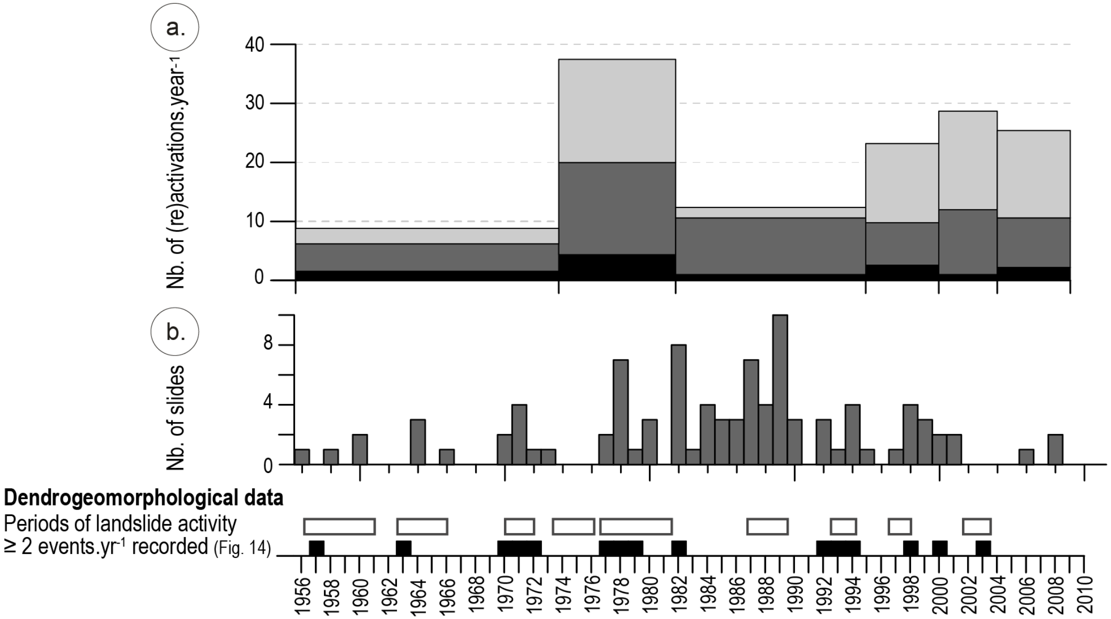

Fig. 14.