Natural Hazards
and Earth System
Sciences

Discussions

Interactive comment on "Liquefaction susceptibility assessment in fluvial plains using high-resolution airborne LiDAR data: the case of the 2012 Emilia earthquake sequence area (Italy)" by R. Civico et al.

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General comments

The authors use high resolution DEMs from LIDAR data to map fluvial landforms in detail and correlate the type of landform with presence of liquefaction during the 2012 Emilia earthquake sequence. While correlation between liquefaction and specific landforms have been known for a while, a more thorough correlation is only possible now with use of high resolution DEMs and aerial photography acquired immediate after the

events or immediate science field response after events. This study is novel is the use of high resolution geomorphic mapping to assess liqefaciotn susceptibility. This topic is of relevance to NHESS and certainly provides relevant data and methods that can substantially improve liquefaction susceptibility maps, and the understanding of the process leading to deposition of highly susceptible sediments . However, I am not convinced that the methodology that they suggest is an alternative to the traditional geotechnical approach to susceptibility maps (more on this below), as they suggest (or at least they sound like that). The paper is well written and clear. I have enjoyed reading it. I have some suggestions below that mainly address the issue of only exploring positive correlations. I suggest also looking at negative correlations (within the mapped fluvial landforms) to make most used of the data. I recommend it for publication after the following suggestions have been addressed.

Specific comments

Page 4533 , lines 8-15: This paragraph is confusing. The authors say that liquefaction only occurred during the main events 20 and 29 May but then they say that on certain locations there were 5 liquefaction events "for both 20 and 29 May". I do not quite understand what they mean by 5 liquefaction events.

Page 4535, Line 20: what do you mean by alluvial ridges? Are they not the same as leeve ridges?

Page 4536, Line 13: it will be good for the reader to understand what the authors mean by "liquefaction effects" . I understand it is explained in the EMERGEO Working Group report but authors can add brief descriptions here. By looking at the photos (e.g. Fig. 2), the type of liquefaction ejecta is very similar to what we found in Christchurch (see examples in: Villamor et al 2014 at \http://www.eqc.govt.nz/research/research-papers/3787-Exploring-methods-paleoliquefaction-Canterbury; Quigley et al 2013 , Geology; Bastin et al 2015 GSA). There we saw, often along inner part of meanders, that sand blows coalesce along a few –meter- long fissures and those fissures aligned

along longer fissures (tens of meters). Any of these three can be regarded as a liquefaction effect. Are the points in Figure 6 individual sand blows, or fissures with coalescing sand-blows? This can give the reader a better idea of the correlation that authors are trying to make and a qualitative understanding of the amount/severity of liquefaction (more sand was ejected along fissures than along isolated sand blows).

Page 4536, lines 20-24: do you mean that of the 53%, 63% are on alluvial ridges and ... and 20% on ...? Please note that you only have 53% of correlation – I will come back to this point latter with respect to final conclusion.

Page 4537, Line 3 : again , to better understand the liquefaction density parameter , this manuscript needs to include a brief description of what the authors mean by "liquefaction effects" . While I think it is a simple good approach to define an index/parameter like this I am not sure if is represents severity of liquefaction (or how can it be used as a proxy for severity) . It probably does but it will be easier to understand it if reader knows what are the points of Fig 6. Is it possible to associate the points mapped with a rough volume of ejected sand? I do not mean for each point but if you can do this analysis is a small part of the study you may be able to assign the mean value to all the points. Not sure if this comment is correct without understanding what is each point.

Page 4537, Lines 8-10: In Figure 6 , it is clear that the "liquefaction effects" are concentrated on a few on the fluvial landforms mapped, but there are numerous landforms that do not show much liquefaction. I am missing here an analysis of why is this the case (density of liquefaction seems to vary greatly within the fluvial landforms mapped). For example, is there ground water table data that can also be overlain with the other datasets? Are the fluvial landforms with higher liquefaction density index close to current river course? Also in the area represented in Fig 6, is there substantial difference of PGA across it? (perhaps you can add the epicentres to this figure). There seems to be very high density of liquefaction along the Reno River (your Fig. 8) than other rivers closer to the epicentre, why? I think it is as important to address the lack of correlation as it is to address positive correlation.

C1582

Page 4540 Line 7-8: the way this statement is worded suggests that author are proposing and alternative approach to geotechnical studies. I do agree with the authors that DEMs derived from LIdar are going to greatly improve our ability to better map liquefaction susceptibility. We are working towards the same goal (see preliminary results in Villamor et al 2014 at \http://www.eqc.govt.nz/research/research-papers/3787-Exploring-methods-paleoliquefaction-Canterbury). However, at this stage until we have a better understanding of why those landforms are more prone to liquefaction and why sometimes they are not, we may need to use geomorphic mapping a either a first approach (perhaps for areas with not geotech data) or as a way to refine maps that are based on geotechnical data. The danger of only using landforms for liquefaction susceptibility mapping is that certain landforms may be given large probabilities (which is not bad as a conservative measure) but alluvial plains may be given too low probability. When dealing with susceptibility based on landform mapping, it is also important to understand where the liquefaction is coming from. For example, in the SE of Christchurch mentioned above we are finding that one of our sites is on a crevasse splay but the liquefied sands come from deeper levels that the crevasse splay (crevasse splay sediments are neither liquefiable based on their particle size analysis nor water-saturated). We still do not understand the role of the crevasse splay; there is substantial liquefaction associated with it but hard to tell why at this stage (PhD student working on it). So perhaps in some of your sites, it is the landforms covered by the crevasse splay that are important.

Technical corrections.

The paper is very well written. The word "moreover " is overused in the manuscript. I suggest finding alternatives.

-EMERGEO Working group 2012b is not mentioned in the text.

Response to specific journal questions:

1. Does the paper address relevant scientific and/or technical questions within the

C1583

scope of NHESS? Yes

2. Does the paper present new data and/or novel concepts, ideas, tools, methods or results?yes

3. Are these up to international standards? Yes

4. Are the scientific methods and assumptions valid and outlined clearly? Yes, some stroing statements need toning down.

5. Are the results sufficient to support the interpretations and the conclusions? Yes

6. Does the author reach substantial conclusions? Yes

7. Is the description of the data used, the methods used, the experiments and calculations made, and the results obtained sufficiently complete and accurate to allow their reproduction by fellow scientists (traceability of results)? Some descriptions need to be added for clarity.

8. Does the title clearly and unambiguously reflect the contents of the paper? Yes

9. Does the abstract provide a concise, complete and unambiguous summary of the work done and the results obtained? Yes

10. Are the title and the abstract pertinent, and easy to understand to a wide and diversified audience? yes

11. Are mathematical formulae, symbols, abbreviations and units correctly defined and used? If the formulae, symbols or abbreviations are numerous, are there tables or appendixes listing them? N/A

12. Is the size, quality and readability of each figure adequate to the type and quantity of data presented? Yes

13. Does the author give proper credit to previous and/or related work, and does he/she indicate clearly his/her own contribution? Yes

14. Are the number and quality of the references appropriate? Yes. 15. Are the references accessible by fellow scientists? Yes.

16. Is the overall presentation well structured, clear and easy to understand by a wide and general audience? yes

17. Is the length of the paper adequate, too long or too short? Could be a bit longer.

18. Is there any part of the paper (title, abstract, main text, formulae, symbols, figures and their captions, tables, list of references, appendixes) that needs to be clarified, reduced, added, combined, or eliminated? Adding some more info as per my detailed reviews.

19. Is the technical language precise and understandable by fellow scientists? Yes

20. Is the English language of good quality, fluent, simple and easy to read and understand by a wide and diversified audience? Yes

21. Is the amount and quality of supplementary material (if any) appropriate?

Hope this review is useful,

Pilar Villamor