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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We thank the Reviewer for the comments and suggestions. In the following, we present a description of how and where we have addressed the Reviewer's concerns.

1. RC: Page 4530 lines 2-5: "Differently, few studies applied a mainly geomorphological approach. . .". Please elaborate on the different approaches applied in previous studies.

1.1. AC: We explained more in detail the approaches applied in the cited previous stud-

ies. In more detail, we added the following text in the introduction section: "Wakamatsu (1992) grouped sedimentary deposits in three categories of liquefaction susceptibility (likely, possible and not likely) using geomorphological criteria and classifying geomorphological units such as natural levee, former river channel, sandy dry river channel and artificial fill as the highest level of liquefaction potential. Witter et al. (2006) and Ganapathy & Rajawat (2012) combined geomorphic expression and geological characteristics to define and distinguish lithological units and to produce liquefaction susceptibility maps for the central San Francisco Bay region (USA) and Chennai city (India), respectively. Historical accounts, maps and aerial photographs allowed Wotherspoon et al. (2012) to identify areas of land reclamation and old channels that have had flow diverted away in and around the town of Kaiapoi (North of Christchurch, New Zealand). Their findings show that these areas correlated well with many of the areas having significant liquefaction damage following the 2010 Darfield earthquake (New Zealand)."

2. RC: Page 4533 line 13-15: can the authors explain why do they think that only in 5 cases did liquefaction occur in both mainshocks in the Emilia sequence?

2.1. AC: We rephrase this section and clarified that based on repeated field and aerial surveys, reports from local people and Web-based surveys, we have evidence for only 5 sites where sand blows reactivated following the 2nd mainshock (29 May). Liquefaction reactivations occurred only in the San Felice sul Panaro municipality (see Fig. 4 in EMERGEO Working Group, 2013), that is located less than 10 km from both mainshocks.

3. RC: Page 4536 line 18 and further on: the authors give percentage for the distribution of liquefaction phenomena among the different fluvial landforms. The percentages they give are unclear: are they percentage from the entire 1306 population, or from the population of the liquefaction occurrences that coincide with fluvial landforms? It seems that the latter is correct when stating that crevasse splays account for 20%, but the 63% of alluvial ridges and abandoned fluvial beds don't work either way. Please correct.

3.1. AC: We rephrase this section. The modified text is as follows: "The analysis of the spatial distribution of the liquefaction effects shows that 699 out of a total of 1306 observed liquefaction phenomena (53%) are located exactly in coincidence with mapped fluvial landforms, which notably represent only the ~15% of the whole study area. Among the liquefactions observed on mapped fluvial landforms, alluvial ridges and levee ridges hosted the 63% of observed liquefaction effects, while crevasse splays account for the 20% and abandoned river beds for the 17% (figure 7). As for the liquefaction effects observed outside mapped fluvial landforms, most of them (about 500) appear randomly distributed over the floodplain. Conversely, less than 100 liquefaction effects show a spatial distribution (e.g. meander-like alignments, etc.) that can potentially be related to concealed/undiscovered fluvial features."

4. RC: The authors present a new method for generating liquefaction susceptibility maps, that is, areas that are more likely to experience liquefaction during an earthquake, and therefore require further investigation. In no way can this remote sensing analysis replace the geotechnical analysis, which estimates the liquefaction potential at a certain point, including factor-of-safety calculations. I therefore suggest being more modest when comparing the method to geotechnical methods. Furthermore, I feel that there is some confusion in the introduction section with regards to liquefaction susceptibility, hazard and potential maps, which are different products (page 4529, line 25 and on).

4.1. AC: We followed the reviewer's suggestion and we modified the text accordingly in the introduction and discussion paragraphs. DEMs derived from LiDAR are going to greatly improve our ability to better identify and map landforms that are prone to liquefaction. We may need to use high-resolution geomorphic mapping as a first/preliminary approach to estimate liquefaction susceptibility over large areas. This is particularly effective in: a) filling the gap of punctual information in areas with poor or no geotechnical data, and/or b) in refining maps that are based on geotechnical-derived indexes. Integrating high-resolution geomorphic mapping with geotechnical analysis can also help

reducing the cost of liquefaction susceptibility assessment over very large areas. Notably, our study area is dominated by agricultural fields, and thus the majority of the geotechnical data are present only in small towns and villages, preventing a comprehensive estimate of liquefaction potential over the entire 2012 coseismic area.

In addition, the other technical corrections requested were all accomplished.

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