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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Tsunami deposits in Martinique related to the 1755 Lisbon earthquake" *by* Valérie Clouard et al.

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The manuscript "Tsunami deposits in Martinique related to the 1755 Lisbon Earthquake" by Valérie Clouard and colleagues is dedicated to the identification of tsunami deposits in a so far largely neglected region. The Caribbean Basin is exposed to the hazard of near- and far-field tsunamis, whereas long-term recurrence patterns are very poorly known due to the short and and in some places fragmented historical record. Better constraints on the distribution of tsunami deposits is urgently needed to address regional, long-term coastal risk assessment. But also regional tsunami deposits clearly assigned to historical events are strongly required as a reference for palaeotsunami deposits.

Clouard et al. present a sand layer of c. 8+/-2 cm thickness with a thin basal layer of light sand and broken shells overlain by a sub-horizontally bedded layer of black coarse sand containing marine shells, small pebbles and few pieces of wood. Its chronology is highly interesting, as it is vertically confined by well dated archaeological layers, building horizons or building foundations, respectively. Deposition must have occurred between 1726 and 1783 (hard to say: while the text gives 1983 on Page 4, Line 5, Figure 2 says 1782). However, while the stage is set perfectly for a thorough study on tsunami deposits by unequivocal historical and archaeological chronology – and as much as I regret having to says this – the list of shortcomings regarding the core of the manuscript, i.e. the sedimentological analysis and interpretation, is rather long.

There is no data of the tsunami deposit's sedimentary characteristics apart from some superficial descriptions. New sites of tsunami deposits are desperately needed in the Caribbean, but they only help when thorough documentation and data are provided. In their benchmark paper on progress in palaeotsunami research, Goff et al. (2012, p. 83) state that "defining whether a deposit relates to a palaeotsunami as opposed to palaeostorm is far more complex and can only be achieved convincingly through a multidisciplinary approach using a suite of proxies." I would also extend this statement to historical deposits. In a Caribbean context, "studies using high-resolution methods of bedform and stratigraphical documentation and generating consistent chronological models with independent age control [this, however, is provided in an excellent way by the present study!], combined with refined inverse and forward models of sediment transport and deposition, are required to reconstruct long-term patterns of magnitude and frequency of palaeotsunamis in the Caribbean – a prerequisite for reliably mapping hazard-prone areas" (Engel et al., 2016, p. 290).

Unfortunately, the authors do not present efforts to validate their field-based estimation of sub-horizontal bedding by high-resolution grain size measurements. No taxonomic or taphonomic data on macro- or microfossils or geochemical or mineralogical data is given to better constrain sediment source areas and local flow patterns. No further data on spatial extent and geometry of the deposit is given apart from the archaeological trench and a diffuse outlook towards another local site. Sedimentary changes on the trench scale are not presented, as tsunami deposits in many cases often show small scale but significant changes over distances of only a few metres. Details of the stratigraphic sections are poorly visible in the photographs, sub-horizontal lamination cannot be inferred by the reader. On a trench scale, rip-up clasts should be expected if the lower contact was erosional (even though the reader does not learn about sedimentary details of the vertically confining layers). In Chapter 3, references are made to the source area ("The thin lightly-colored layer at the basement of the deposit can be attributed to the bottom of Fort-de-France's Bay, which presently exhibits the same kind of materials."), but standards of scientific research demand a proof of these similarities based on sedimentological data of both deposits presented in the paper. Taking pictures of beach sand and the trench (Figure 4) definitely is not sufficient to convince the reader of the sediment source of the deposit. Also Chapter 4 contains many speculations not based on sediment data. I rate the documentation of the present deposits as below standards required for international science publishing.

The most remarkable argument pro-1755 Tsunami in Chapter 2 – one that really left me puzzled – is that during the narrow time window of the possible age of the deposit, historically constraint by the age of two buildings (1726 and 1783), no major hurricanes occurred on Martinique. For some reasons, no mention is made of The Great Hurricane of 1780, the deadliest hurricane in Caribbean history with ca. 22,000 fatalities mostly on Martinique and Barbados. At the moment, I do not have access to the most detailed sources on this event (e.g. Ludlum, 1963; Depradine, 1989), but in St. Pierre, the former capital of Martinique on the slopes of Mt. Pelée, the storm surge and waves seemed to have washed away many houses and took vast numbers of lives (Neely, 2012). Not considering this iconic event in the history of Martinique falling into the time window of the deposit exposes a degree of carelessness in the discussion and interpretation of the deposit which is not complying with common standards in tsunami geoscience.

Furthermore, there are many tools available regarding inverse modelling based on high-resolution grain-size distribution in order to infer flow characteristics of a tsunami which are well accessible. Such data would be helpful to compare with existing historical accounts and the inundation model of Roger et al. (2011) in order to further substantiate the interpretation of a tsunami. Regarding literature on both regional and global tsunami deposits, some of the relevant state-of-the-art literature is not cited (see details in minor edits).

Last but not least, why have the authors not dug deeper (or took a sediment core) in order to search for predecessor deposits? The site seems to provide a good potential and there is a historical deposit to compare with.

Recommendation:

The authors have discovered a highly interesting deposit, a site with a high potential, which may be related to the 1755 tsunami. As the current state of investigations, in my opinion, does not justify international publication based on the reasons detailed above and below, I suggest to study the deposit in much more detail at Site 1 and in the new locations (Site 2 and elsewhere) by applying a multi-proxy approach. Coming up with high-resolution sedimentology and spatial extent (maybe using near-surface geophysical prospection), it could indeed represent an important reference deposit for the entire region and make a very useful future publication. I sincerely hope this review is being perceived as constructive - which is its pure intention! -, even though I am aware that it may not exactly be what the authors were hoping for.

P.S.: Apart from this rating, the manuscript would benefit from language editing, as wording is sometimes not straightforward and grammatical tenses got mixed up in some sections.

Minor edits:

L5: If considering tropical islands in general, the correct term is "tropical cyclone", "hurricane" can only be used in a regional text

L5: "One notable exception concerns deposits sealed by subsequent events" – What does this mean? Preservation of a deposit by a subsequent (gradual/long-term or event) deposit(?) automatically enables differentiation between tsunami or storm deposit?

L6-7: Only archaeological remains? What about sedimentological evidence, which a tsunami hypothesis should be based on? The main sedimentary criteria and data supporting the tsunami hypothesis should be listed here.

L7: It is very unusual to take thickness as the main sedimentary criterion for tsunami deposition. Thickness of an event deposit is more a function of sediment availability at the source, onshore topography, surface roughness, and distance to the shoreline (and post-dpositional preservation potential) than just the hydrodynamic character of the event. Therefore, I think that the sentence "We explain the thickness of the deposit by a tsunami-induced bore in the mangrove drainage channels of Fort-de-France" is not appropriate as it does not consider the entirety of the local sedimentary and geomorphic environment into account.

P1L9: "indicate" – put another gerund here

P1L15 ff.: Hayes et al., 2014

P1L15: two large

P1L17: As I perceive the cited literature, the estimation amounts rather to M8.0–8.5 than >8.5

P1L18-19: The case of the 1690 tsunami with a seismic source near Antigua should not be dismissed here, even though the exact mechanism is not entirely clear. Some earlier sources treat 1843 as a successor of 1690 (e.g. Kelleher et al. 1973)

P1L19: contain

P1L20: 4-ft rise

P2L1-3: Delete French, English translation is sufficient.

P2L5: Better cite the much more complete O'Loughlin and Lander (2003) instead of Lander et al. (2002).

P2L9: The 1867 tsunami has also been observed at the even though no precise details are available (Reid and Taber, 1920).

P2L14-15: I do not agree: There is abundant well-constraint sedimentary evidence in southern Portugal. The Algarve is dotted with well-dated tsunami deposits of 1755 at Martinhal, Praia do Barranco, Boca do Rio, Salgados Lowland, Quateira or Carcavai, and there are much more convincing records across the border to Spain (Huelva, Donana, Valdelagrana, Barbate, Los Lances etc.), not to forget possible evidence through boulders at Cabo Trafalgar or in Morrocco. I am happy to share references, if necessary. Based on the fact that the history of very large tsunamis in this region basically only consists of the 1755 tsunami and most studies are accompanied by thorough sedimentary investigations pointing to tsunami deposition, physical dating is not so much of an issue in most cases.

P2L15: I do not agree: There is very likely sedimentary evidence of the 1755 tsunami on Anegada (Atwater et al., 2012, 2017; Watt et al., 2012, and others in the same journal issue) and on St. Thomas (Fuentes et al., 2017).

P2L19: Parsons and Geist (2009)

P2L21: Define the "studied area": The sentence before indicates that this is the Lesser Antilles, which, geographically, extend from the Spanish Virgin Islands in the north to the ABC Islands in the south. Many possible tsunami deposits have been published in this area (see Engel et al., 2016, for an exhaustive compilation). No mention has been made so far in the text that the study area under consideration is limited to Martinique or a certain part of the island.

P2L24-26: This “characteristic pattern of alternation of soil and tsunami” only occurs in very specific coastal lowland environments, therefore I would not put this statement as general as it is at the moment.

P2L26: “. . .whereas boulders can eventually outcrop.” – Wording is a bit imprecise: Boulders shifted by tsunamis do not miraculously outcrop, but have a clear local source and their transport pathway and depositional pattern provides useful constraints on flooding processes.

P2L28: Not exhaustive. During a tropical cyclone, boulders are in most cases shifted by storm waves, not the surge. Other processes may also play a role. During Supertyphoon Haiyan, massive boulders were shifted by infragravity waves (May et al., 2015; Soria et al., 2017) or jets of extreme vertical velocities with high acceleration in cliff-edge positions (Kennedy et al., 2017).

P2L32: From a geographical point of view, when considering tropical island environments, I suggest to consider and cite preservation studies from humid tropical environments instead of temperate environments, as the range and intensity post-depositional processes significantly differ. Better refer to the observations of Nichol and Kench (2008) or Szczuciński (2012).

P2L19-L35: This overview on the formation of tsunami deposits is very general and, let’s say, not really spot-on, for reasons mentioned above. The regional examples (Anegada, Guadeloupe) seem random and only cover potential coarse-clast transport by tsunami, while the study presented here covers sand in a stratigraphic sequence. The group of Anja Scheffers conducted research on most of the larger island of the Lesser Antilles island arc (Scheffers, 2006; Scheffers and Kelletat, 2006; Scheffers et al., 2005), why is only the Guadeloupe example randomly chosen? Anyway, I strongly suggest to focus on sand-sized sediment, also in the general descriptions. There has been one unsuccessful attempt to localize sandy tsunami deposits in a wetland on Basse-Terre, Guadeloupe (Morton et al., 2006), could be relevant here.

P3L1-4: The topic is very interesting and relevant, but it is somehow curious to have a potential tsunami deposit identified solely based on “historical data” (P3L2) and “archaeological remains” P1L5-6).

P3L8ff.: 17th century, check entire manuscript

P3L18-21: past tense

P3L25: includes

I stopped here for looking at minor edits.

Figures:

Fig. 2d) May be I just get it wrong, but how can the younger (i.e. 1782) stonework or ground (not sure which shade of grey. . ..) be beneath the suggested 1755 tsunami layer? Simple clearing does not convincingly explain how the horizontal foundations of 1782 - by the way at the same level of the 1726 building - reach beneath the suggested tsunami layer.

Fig. 3, caption: Check wording

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