

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

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### General reply to the three referees

The reviews from the three referees share a common approach of what must be the data associated with the presentation of a new tsunami deposit. In our mind, our paper was the description of an important overwash deposit in Martinique, FWI, that we managed to relate to a tsunami event thanks to archaeological and geomorphic analysis: our goal was not to lead a sedimentary study of this deposit. However, we understand that our result would be more useful to the tsunami community with sedimentary data. The sedimentary analysis is now under process and some results are shown below. If possible, we could add our colleague sedimentologist as a co-author. We have also

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noticed that, in general, our archaeological and geomorphic analysis should be refined, in addition with a detailed description of Martinique climate and Fort-de-France topography.

We report below in detail the responses to the remarks of referee #1.

Reply to M. Engel, referee #1 :

P C2, §1 : the sedimentological analysis and interpretation

When we received this review, we sent for analyzing samples from our excavation site 1 (Court of Appeal) and from the river mouth to get sedimentary information. Later, we sent sample from Fort-de-france Bay and our colleagues in charge of excavation site 2, the Police building, sent samples to the same laboratory. We have got the analyzes of the first samples, and those from site 2 and from Fort-de-france Bay will be done for the end of February. We now have the grain size distribution (Figure 1) and other parameters (mean and median size, variance, skewness, kurtosis, etc). We'll add this information in our paper.

These analyses also include compositional data with: Ba, Sb, Sn, Cd, Pd, Ag, Mo, Zr, Sr, Rb, As, Se, Au, Pb, W, Zn, Cu, Ni, Co, Fe, Mn, Cr, V, Ti, Ca, K, Al, P, Si, Cl, S, Mg, SiO<sub>2</sub>, MgO, Al<sub>2</sub>O<sub>3</sub>, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O, CaO, TiO<sub>2</sub>, MnO, Fe<sub>2</sub>O<sub>3</sub>, U, Th, Hg, Sc, Cs, Te. We'll report it in our paper.

P C2, §2: “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.”

We do not ignore the major hurricane of 1780, which devastated all the Lesser Antilles and a part of the Greater Antilles, from St Vincent to Jamaica. The analysis of historical

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reports from the construction indicates that the Court of Appeal was built before 1773. In addition, the results from site 2 archaeological analysis are now available (Navetat, Nadeau et al, 2016): The construction of the Police Station building began after 1761 and not later than 1770. In site 2, the deposit layer is everywhere above the mangrove and just below the first embankments. This clearly indicates that the deposit predates 1770. We note that our demonstration is poorly written. We'll make appear clearly in our reviewed paper that the observed deposits at site 1 and site 2 predate the 1780 hurricane, although the cartographic documents that we used give an age bracket between 1726 and 1782.

P C4 §2: "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."

We agree with referee #1 that interesting results could have been achieved by coring the area. Unfortunately, it has not been possible to schedule such a coring within the very short period of the 3-week excavation: one must remember that the main objective of these excavations were to better understand Fort-de-France first settlement and to improve our knowledge of the successive construction stages. When we began to work on the overwash deposit layer at site 1, it was the end of the excavation, as it corresponds to the lower depths reached: there was no more time to get the only core drill of the island, and impossible to get a core drill from another country.

P C4 Minor edits: L5: "tropical cyclone" vs "hurricane"

We'll check in our paper, at each occurrence of the terms "cyclone" or "hurricane", the appropriate word. However, going to NOAA website (<https://oceanservice.noaa.gov/facts/cyclone.html>), we found these definitions that we assume to be correct: "Once a tropical cyclone reaches maximum sustained winds of 74 miles per hour or higher, it is then classified as a hurricane, typhoon, or cyclone depending upon where the storm originates in the world" and "Hurricanes, cyclones,

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and typhoons are all the same weather phenomenon; we just use different names for these storms in different places. In the Atlantic and Northeast Pacific, the term "hurricane" is used. The same type of disturbance in the Northwest Pacific is called a "typhoon" and "cyclones" occur in the South Pacific and Indian Ocean."

P C5 Minor edits: L5: "One notable exception concerns deposits sealed by subsequent events" – What does this mean?

We wanted to speak about a subsequent event for which dating is possible with precision, which provides an age bracket for the overwash. We'll change this sentence.

P C5 Minor edits: 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.

In the initially submitted paper, our sedimentary analysis was rough and it is why we do not mention it in the abstract. We'll change it in the revised version, adding the analysis done during this review process.

P C5 Minor edits: L7: "...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."

We agree with referee #1 that the way we reached this conclusion can be improved by a better description of the local geomorphic and sedimentary context, which is not well described in our paper. We'll add a paragraph in the revised paper.

P C5 Minor edits: P1L15 ff.: Hayes et al., 2014

The reference is correct. It is: "Geophys. J. Int. (2013) doi: 10.1093/gji/ggt385, Quantifying potential earthquake and tsunami hazard in the Lesser Antilles subduction zone of the Caribbean region, Gavin P. Hayes, Daniel E. McNamara, Lily Seidman and Jean Roger, Accepted 2013 September 20. Received 2013 September 17; in original form

2013 June 20.

P C5 Minor edits: P1L17: As I perceive the cited literature, the estimation amounts rather to M8.0–8.5 than >8.5

Yes, it is right. We wanted to write >8.3, and a conservative magnitude should be 8. We'll change it to "M8.0–8.5".

P C5 Minor edits: 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.

About 1690 earthquake, from Bernard and Lambert (1988): "Recently, Feuillard (1984) showed that the intensity IX reported by Robson (1964) in Guadeloupe for the 1690 earthquake on the basis of a British document is very likely to have concerned the islands of Ste. Eustache and St. Christophe, which were French at this moment, and not the French island of Guadeloupe. The few documents that Feuillard could find in Guadeloupe suggest a more likely intensity of VI on this island. This moves the source area towards the North, and considerably reduces its extension."

In Feuillard (1984), there are several French documents to justify this assumption. It is also reported in Feuillet et al (2011), where it is proposed that it ruptured the en echelon fault system to the west of the volcanic arc. Our paper is indeed not the place to discuss this specific event, but according to these analysis, it is doubtful that 1690 earthquake was a thrust event. In addition, the tsunami is described in Feuillet et al. (2011): "This earthquake probably triggered a tsunami, since it was reported that the sea withdrew over a distance of 200 m in Charleston (western part of Nevis) and returned after 2 min." This 2-min return period could be more easily associated with a local landslide. We'll try to better take it into account in our paper.

P C6 Minor edits: P2L5: Better cite the much more complete O'Loughlin and Lander (2003) instead of Lander et al. (2002).

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We used the Science of Tsunami Hazards article as it was published prior to O'Loughlin and Lander's book and easiest to get. We'll also cite O'Loughlin and Lander's book.

P C6 Minor edits: P2L9: The 1867 tsunami has also been observed at the even though no precise details are available (Reid and Taber, 1920).

We'll add the 1867 tsunami in our list of historical tsunami, line 28 of our paper although Reid and Taber (1920) have written "The waves were also noted at Martinique, but we have no description of them."

P C6 Minor edits: P2L14-15: I do not agree: There is abundant well-constraint sedimentary evidence in southern Portugal...

Our phrasing is clumsy as we wanted to highlight the lack of serious evidence of deposits in North and South America and in the Caribbean. Information on 1755 deposit does exist in Europe and we reported it Table 1, by site. If we forgot references, we apologize. What we wanted to underline is that 1755 tsunami impact evidence on the western side of the Atlantic Ocean is mostly based on historical records. Recently, B. Atwater et al. (2017) proposed in a conservative way that it could be present in Anegada : "More extensive overwash, perhaps by the 1755 Lisbon tsunami, is marked primarily by a sheet of sand and shells found mainly below sea level beneath the floors of modern salt ponds. This sheet extends more than 1 km southward from the north shore and dates to the interval 1650–1800 cal yr CE." We'll change our phrasing in the revised paper.

P C6 Minor edits: 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).

We know Atwater et al. (2012, 2017) and Watt et al. (2012) articles. The paper from Fuentes et al (2017) was not yet published when our paper was submitted. One can note that in NOAA database, Fuentes et al (2017) is now (there was none when we

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submitted) the only reference to 1755 in the Americas. We'll add this reference to our revised version.

P C6 Minor edits: P2L19: Parsons and Geist (2009)

2008 will be corrected to 2009.

P C6 Minor edits: 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.

The term "Lesser Antilles" is indeed a misnomer in our text, although often used in the Antilles. We meant "the islands of the recent volcanic arc of the Lesser Antilles". We'll change that.

P C7 Minor edits: P2L24-26: This "characteristic pattern of alternation of soil and tsunami ... whereas boulders can eventually outcrop" only occurs in very specific coastal lowland environments, therefore I would not put this statement as general as it is at the moment.

We'll change this sentence, too short to describe in general all kind of tsunami deposit.

P C7 Minor edits: 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 Szczucinski (2012).

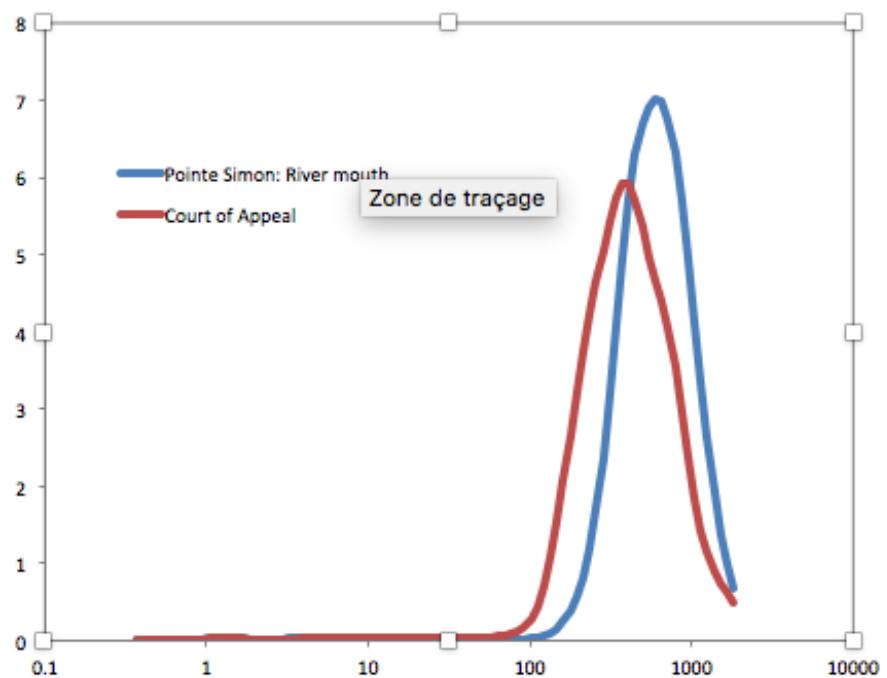
We agree to use examples from similar islands. However, the study from Nichol and Kench (2008) takes place in the Maldives archipelago, composed of atolls, which environment is not the same than our elevated islands. We'll refer to Szczucinski's (2012) study.

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Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., <https://doi.org/10.5194/nhess->  
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2017-238, 2017.

### Mean grain size distribution



**Fig. 1.** Mean grain-size ( $\mu\text{m}$ ) distributions of the samples

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