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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Typhoon Haiyan's sedimentary record in coastal environments of the Philippines and its palaeotempestological implications" *by* Dominik Brill et al.

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Dear reviewer,

Thanks for the thorough and constructive comments to our submission. We think integration of these suggestions will help to further improve our manuscript. In the following we will address each of the comments separately.

Dear Editor and authors, The research presented in this paper is a valuable contribution to the documentation of the sedimentary record of storms. Documenting the sedimentary record of Haiyan is critical because it is a very large storm and there is a need for data on erosion and deposition for extreme storms. The scope of the field in-

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Discussion paper

vestigation is impressive and the wide variety of laboratory analyses performed create a large data set that can be used to discriminate storm deposits from tsunami and other high-energy deposits. The figures are informative and well done. I recommend that this paper be published after revision. I suggest possible ways to improve the paper below.

Main comments:

Perhaps because of the amount of data presented I found the paper hard to follow. I suggest two things to help the reader: (1) a table summarizing all the sites visited and their important characteristics [source sediment available for transport, topography, etc.] and Haiyan deposit metrics [inland extent, maximum thickness, number of layers, grain size, etc.],

Response: The suggested compilation of the most important storm deposit characteristics at each investigated site is reasonable. This was also suggested by reviewer 1. We will provide this summarizing information as a new figure 14, which will combine information in table form with conceptual figures for the generation of the different sediment types (i.e. sand sheets, washover fans, and coral ridges).

and (2) adding text in the introduction, or in a new section, about published reports on geometries and thickness/grain size trends for storm and tsunami deposits to give context for Haiyan deposits.

Response: To provide more context for typical storm and tsunami signatures we will add references for the geometry, grain size, thickness and sediment sources of well-investigated, modern analogues in the introduction section: “Although all potential discrimination criteria have been observed for both tsunami and storm deposits from a global perspective (Shanmugam, 2012), local comparisons assign several decimeter thick, laminated deposits with inland extents of a few tens to hundreds of meters that often show foreset bedding and tend to thin and fine landwards to typical storm signatures, while tsunami deposits tend to be rather thin, are composed of a few layers with massive or normally graded structure, and may extend inland for several kilometers

(Tuttle, 2004; Morton et al., 2007; Switzer and Jones, 2008; Goto et al., 2011)." Likewise, in response to a comment of reviewer 1, we will add information on discrimination criteria between tsunami and storm deposits in the discussion section.

I am not entirely sure, but it appears that all the figures use distance along transect rather than distance from the shoreline. This is supported by the text on Page 6, Line 24, "shallow reef outcrops occur at 180 m transect length." I also measured the distance along transect at Tolosa (Fig. 5). TOL14 is about 120 m inland from the shoreline, but is plotted at about 145 m in Figure 3 and 5. I measured the distance along transect at Tolosa to be about 140 m. Do all the figures use distance along transect rather than distance from the shoreline? If so, they need to be corrected. Distance along transect is meaningless because a change in transect orientation results in a different distance along transect for the same distance from the shoreline, the physically meaningful parameter.

Response: The trenches are indeed plotted against distance along transects in all figures (only flood marks at TOL are already plotted with distance to shoreline). Since we agree that the distance perpendicular to the shore is the physically meaningful parameter, we will adjust all distances in figures 2, 3, and 5 to be consistent with distance to shoreline. The new numbers for distance to shoreline will also be implemented in the text.

I disagree with the statement on Page 1, Line 20 in the Abstract that Haiyan deposits, "might also function as a benchmark example for a general discrimination between storm and tsunami deposits." The Haiyan deposits are part of a spectrum of possible storm deposits; however, because of the presence of surf beat creating a tsunami-like bore they may not be typical. If so, although valuable to illustrate the spectrum of possible storm deposits, they may be more atypical than typical and therefore not a "benchmark example for a general discrimination between storm and tsunami deposits."

Response: We agree that the expression “benchmark” example might be misleading. What we want to express is that the deposits formed by Haiyan describe an extreme case of storm deposition that should be considered for the discrimination of cyclone and tsunami deposits. A similar observation could be made for boulders along the coast of Samar that were moved during Haiyan (May et al., 2015): due to the exceptional hydrodynamic conditions related to Haiyan’s storm surge (i.e. the generation of surf beat), much larger boulders than typically related to storms could be moved, which is a valuable information for the discrimination of storms and tsunamis in the geological record, although Haiyan might rather be an atypical example. We will modify the section to: “As these sediments and landforms were generated by one of the strongest storms ever recorded, they not only provide a recent reference for typhoon signatures that can be used for palaeotempestological and palaeotsunami studies in the region, but might also increase the existing spectrum of possible cyclone deposits. Although a rather atypical example for storm deposition due to the impact of infragravity waves, it nevertheless provides a valuable reference for an extreme case that should be considered when discriminating between storm and tsunami deposits in general.”

A discussion of preservation potential of the Haiyan deposits would provide insight into whether the deposits observed in this study would be found in the geologic record. Instead of using “geological imprint” in the first sentence of the Conclusions (Page 17, Line 2) use “deposits” because preservation of the deposits is not addressed. Preservation of storm deposits in environments investigated in this study is a rather large topic and worthy of another paper. But, although it might seem like semantics, the “geological imprint” is unknown at this time because whether the deposit will be preserved is unknown and how it will be altered as time passes is also unknown. Same comment about using “geological legacy” in the next sentence (Page 17, Line3). I suggest using “deposits” again.

Response: The reviewer is of course right. The terms “geological record” or “legacy” imply information on the preservation of the deposits that we do not – and within the

frame of this paper cannot – present. Meanwhile we collected some data about the preservation of some of the documented deposits, but including this new data and discussing it would be too much for a single paper. Therefore, we will strictly use the term “deposits” in the revised version of the manuscript.

Also in the conclusion is the statement, “the sandy onshore deposits left by Haiyan are very similar to those generated by tsunamis.” Rather than give a qualitative qualifier of “very similar”, which means different things to different people, list the similarities.

Response: At this point we will only list the major similarities between Haiyan induced sand sheets and washover fans on the one hand, and the respective tsunami features on the other hand: sedimentary structure, sediment sources, and granulometry. For more details we will refer to the new overview figure (Fig. 14), which summarizes the main characteristics of each type of deposition during Haiyan, and refers to references reporting similar deposits generated by tsunamis.

In the Abstract (Page 1, Line 3) and Conclusions (Page 17, Line 4) it would help the reader if you clarified what “Extended onshore sand sheets”/“extensive sand sheets” mean. Is there an inland distance that a sand sheet extends inland that you classify as “extended”/”extensive”? Perhaps it would be better to specify how far inland the sand sheets extend. How readers define extended/extensive will vary and it is better to be specific.

Response: We agree that the description is subjective and should be replaced by a number. We will replace the phrase by “Onshore sand sheets reaching 100-250 m inland. . .” in the revised version of the manuscript.

Shell fragments are present in the Haiyan deposit at some locations. Grain size is measured by laser diffraction and Camsizer and does not account for particle density or shape, both of which would be quite different for shells than other components and affect their settling velocity and transport in suspension. I suggest discussing how the presence of shells affect your interpretation of the grain size data. Woodruff et

al. (2008) address the differences between settling velocities of shells and siliciclastic particles. Figure DR2 in the data repository summarizes their results. The citation for Woodruff et al. (2008) is: Woodruff, J.D., Donnelly, J.P., Mohrig, D., Geyer, W.R., 2008. Reconstructing relative flooding intensities responsible for hurricane-induced deposits from Laguna Playa Grande, Vieques, Puerto Rico. Geology 36, 391–394.

Response: Shell fragments settle significantly slower compared to siliciclastic particles of the same size. Thus, larger shell fragments are found in a matrix of siliciclastic sand with much smaller grain diameter. This will make deposits with a large percentage of shells (i.e. parts of the deposits at BAN) appear coarser than they would be for siliciclastic grains only, without being related to any changes in flow dynamics. For storm deposits at TOL (no carbonates) and HER (nearly 100% carbonates without platy shell particles) no significant effects are expected. We will address this aspect in the methods section by adding "It should be noted that both approaches do not consider differences in particle shape and density, which significantly influence the settling velocity of the grains (Woodruff et al., 2008). This is particularly important for the interpretation of granulometric variations in storm deposits with a significant percentage of shells"). In addition, it will be addressed when discussing the granulometry of storm deposits at BAN in section 5.1.1: "On the other hand, the coarsening trend could just be an artefact of the reduced settling velocity of platy shell fragments, which are particularly abundant in this section of BAN 4 (Fig. 7), compared to more spherical grains (Woodruff et al., 2008)".

A fining trend in modal grain size is reported for Hernani (page 7, lines 2 and 3; Figure 3). However, the mean grain size trends of Hernani are more complicated. If trends in modal grain size are reported, please discuss how mean grain size trends are different and justify why you assign a "fining landward" trend based on modal grain size.

Response: We will add a description of the trend in mean grain size to allow comparison. Since a definition of landward fining based on modal grain size is indeed not common, we changed the sentence to read "While mean grain size does not show any

fining trend in the deposit, modal grain size decreases from 1.3 cm to 220 μm along the same section (Figs 3, 4a)". Although it may not be adequate to assign a fining trend based on modal grain size, the mode data at least indicate that there are changes in particle size along the transect (even though these do not affect the mean).

Are the statistics in Figure 3 for grain size for the entire deposit? That is, are they averages for all the grain size data for deposit? Please clarify for the reader.

Response: The data presented in the original version of the manuscript are based on mean grain size and sorting for the entire storm deposit. We will adjust the figure to show both average data for the deposit, as well as trends for individual units where appropriate. All trend lines will be labeled accordingly.

Please explain further how it was determined that sediment from the foreshore and deeper water are part of the Haiyan deposit (Page 132, Line 16). Are there grain sizes present in the Haiyan deposit that are not from the beach? Can this be sediment picked-up landward of the beach? Were there samples collected from the foreshore and nearshore close in time to when Haiyan impacted the Philippines that have grain size data?

Response: Unfortunately, reference samples were only collected and analyzed from the beach. Additional samples from the foreshore, deeper water, and terrestrial environments were not collected. The interpretation that minor proportions of the Haiyan deposits are derived from sources different from the beach are based on the differences between the beach reference samples and the typhoon deposits in terms of granulometry and faunal composition (species and abrasion). This other sediment sources could in principle be areas seaward of the littoral zone, but also areas landward of the storm deposits. In response to this comment and a similar comment made by reviewer 1 we will change the section to read: "Nevertheless, obvious differences in the granulometry and faunal composition of the sand sheets and modern beach sand (Fig. 8b, S4) may indicate also minor contributions of sediments from other source areas (the

foreshore, deeper water, or landward areas), as reported by Pilarczyk et al. (2016) for deposits of Typhoon Haiyan from Tanauan (Leyte) and Basey (Samar). Alternatively, at least the differences in foraminifer taphonomy may reflect alteration of the sediments due to wearing and fracturing of foraminifer tests during transport in high energy flows (Quintela et al., 2016)."

What is meant by "a rather normally graded structure of these sand sheets" (Page 13, Line 9)? This is important because grading of deposits may be a discriminator of storm versus tsunami deposition. Were the Haiyan deposit suspension graded, as has been observed for deposits formed by several recent tsunamis and for paleotsunami deposits? (for an explanation of suspension grading see: Jaffe, B.E., Buckley, M.L., Richmond, B.M., Strotz, L., Etienne, S., Clark, K., and Gelfenbaum, G., 2011, Flow speed estimated by inverse modeling of sandy sediment deposited by the 29 September 2009 tsunami near Satitoa, east Upolu, Samoa, Earth-Science Reviews, v. 107, p. 23-37, doi:10.1016/j.earscirev.2011.03.009.)

Response: This should read "mostly normally graded structure". While slight normal grading could be detected for thicker layers (close to the coast), the small thickness of the sand layers further inland did not allow for unambiguous identification of grading. We assume that even the thinner parts of the sand sheets might be normally graded, but cannot prove this by measurement data. However, regardless of normal grading can be observed or not, it is hard to say if they are suspension graded or not. Particularly, since the assignment of most normally graded sections within sand sheets is not based on laboratory analyzes (because they were not sampled in higher resolution). Only at BAN B sand sheets were sampled by pushcores and high-resolution data are available. Although the grain size distributions are not multimodal, improved sorting with decreasing grain size cannot be observed. A clear assignment of suspension-grading is therefore not possible.

Missing reference for Haiyan surf beat: Roeber, V and Bricker, J., 2015, Destructive tsunami-like wave generated by surf beat over a coral reef during Typhoon Haiyan,

Nature Communications (6), DOI: 10.1038/ncomms8854.

Response: We meanwhile had already realized the missing reference and included it in the paper and reference list.

Other comments:

Page 2, Line 8- Suggest changing “coastal disasters in the immediate past” to “recent coastal disasters”.

Response: Okay, will be changed accordingly.

Page 2, Line 15- Suggest ending the sentence after “records” and change the next part of the sentence to a new sentence “This discrepancy is great because cyclones usually follow an inverse power law (Corral et al., 2010).

Response: Okay, will be changed accordingly.

Page 2, Line 18- Suggest changing “even events of the highest magnitudes” to “large events”.

Response: Okay, will be changed accordingly.

Page 2, Line 25- Suggest changing “are particularly” to “are”.

Response: Okay, will be changed accordingly.

Page 3, Line 16- Suggest changing “the significance of seasonality” to “seasonal variability”.

Response: Okay, will be changed accordingly.

Page 4, Lines 10-18 and later in the paper as well- (i), (ii), (iii) are not needed and are distracting.

Response: As already mentioned in our reply to reviewer 1, all numberings will be removed in the revised version of the manuscript.

Page 4, Line 31- Suggest changing “typically shows” to “is characterized by”.

Response: Okay, will be changed accordingly.

Page 4, Line 31- Again, (i), (ii), (iii) are not needed in this paragraph.

Response: Okay, see reply to comment above.

Page 4, Line 32- The fetch over the Pacific, not the narrow shelf, is the reason that Eastern Samar has high swell waves.

Response: We agree that the fetch is clearly the dominating factor for swell generation. Therefore we will delete the narrow shelf as an additional argument in the revised version of the manuscript.

Page 5, Lines 13 and 14- The times of day for the DGSP are not relevant and should be omitted.

Response: We agree that this information is not required to understand the presented data. We will delete it in the revised version of the manuscript.

Page 5, Line 15- Suggest changing “were recorded by levelling” to “were documented by measuring elevations of”.

Response: Okay, will be changed accordingly.

Page 5, Line 20- Suggest deleting “directly”.

Response: Okay, will be changed accordingly.

Page 5, Line 23- Define what you mean by representative. Typical thickness? Typical sediment grain size? Typical structure?

Response: Push cores were taken from deposits with sedimentary structures typical for the respective sites. This was supposed to guarantee sampling of all stratigraphical units documented at a site (and documentation of the differences between units). Since grain size and thickness of individual units vary in lateral direction, the push cores can

only reflect part of this spectrum.

Page 5, Line 27- Chemical formula contain subscripts for the number of atoms for elements

Response: This might be a formatting problem in the PDF version. We will, however, take care that the formula are shown with correct formatting.

Page 6, Line 17- Is Barangay capitalized?

Response: Okay, will be written in capital letters in the revised version.

Page 6, Line 19- Suggest changing “the two tropical storms/depressions recorded between Haiyan and this field survey on January 19th and February 1st respectively” to “the two tropical storms/depressions hitting the Philippines on January 19th and February 1st, respectively, which is after Haiyan and before this field survey”.

Response: Okay, will be changed accordingly.

Page 7, Line 6- Are the values for grain size in “)”thinning and fining landward from 8 cm and a mean of 570 _m at 130 m from the shoreline (HER 8) to only 3 mm and a mean of 223 _m at 260 m (HER 3) (Fig. 3).” for the mode or mean? It appears from Figure 3 that they are for the mode, but I am not sure because this for Unit 1 and it is not clear what is shown in Figure 3.

Response: The values are indeed for the mode, which is as well shown in figure 3. We will clarify both text (replace mean by mode) and figure 3 (state the respective units grain size trends are plotted for) in the revised version of the manuscript.

Page 7, Line 21- Delete “According to”.

Response: Okay, will be changed accordingly.

Page 7, Line 22- Suggest changing “bushes, Haiyan” to “are evidence that Haiyan”.

Response: Okay, will be changed accordingly.

Page 7, Line 30- Suggest changing “Pre and post-typhoon” to “Pre- and post-typhoon”.

Response: Okay, will be changed accordingly.

Page 8, Line 9 and later in the text- The use of the word “profiles” is not standard. Suggest changing “profiles TOL 7-14” to “trenches TOL 7-14”. This suggestion applies everywhere in the text where “profile” is used to describe a trench.

Response: Okay, will be changed accordingly.

Page 8, Line 15- Specify what “slightly inclined” means.

Response: The laminae are dipping landwards with an angle of $\sim$10-15°. We will add this information in the revised version of the manuscript.

Page 8, Line 21- What is meant by “moderate flooding”. I have no idea what is moderate. Please be specific by giving a spatial extent and/or a water depth.

Response: Since information on flooding was inferred from eyewitness observations, exact (i.e. measured) values for flooding extent and water levels cannot be provided. However, based on the observations, estimations for flooding extent (not more than a few 10s of meters) and water levels (not more than $\sim$3 m above msl) will be stated in the revised version of the manuscript.

Page 8, Line 25- How thin are the sand patches?

Response: The documented sand deposits do not exceed a maximum thickness of 10 cm; most of them are in the range of 1-3 cm thickness.

Page 9, Line 1- Delete “single”. It is not needed.

Response: Okay, will be changed accordingly.

Page 9, Line 1- Suggest changing “in either direction” to “crest elevation”.

Response: Okay, will be changed accordingly.

Page 12, Line 30- Suggest changing “show comparably large inland extents exceeding 100 m” to “extend at least 100 m inland”.

Response: Okay, will be changed accordingly.

Page 13, Line 13- Suggest changing “dedicated” to “attributed”.

Response: This section will be changed in response to a comment of reviewer 1. In this context the mentioned expression will be removed anyway.

Page 16, Line 21- Suggest changing “confined” to “indicated”.

Response: Okay, will be changed accordingly.

Page 25, Figure 3- Be consistent with line types in each panel. Sorting is a different line type for HER 3-9 than for TOL 3-14 and BAN 1-3. A minor point, but why not make it easier on the reader to compare panels? Also, a solid line is used for both the mode and mean in different panels. Why not use a solid line for the mean and another line type for the mode?

Response: We agree with the reviewer that a consistent style for all panels would facilitate reading the figure. The line styles for mean, mode and sorting will be homogenized in the revised version of the manuscript.

Page 25, Figure 3- Why does the thickness scale for TOL 3-14 start at -2? This makes it difficult to determine the thickness of the more landward deposits. Why not start the scale at 0 to make it easy to determine the thickness of landward deposits?

Response: We see the point and will adjust the scale for thickness.

Page 25, Figure 3- Why is there a vertical dashed line at 40 m in the TOL 3-14 panel? Please explain this line in the caption.

Response: The vertical line is a drawing artefact that has no important meaning and will be deleted.

Page 25 Figure 3 caption- The mean grain size of HER 3-8 doesn't monotonically fine landward. See earlier comment on mode versus mean and description/definition of landward fining.

Response: It is true that the fining trend at TOL is restricted to the mode but does not apply to the mean. We will adjust the figure caption to match this observations.

Page 29, Figure 6- For consistency, add the column that indicates grading by the shaded triangles.

Response: Okay, will be added in the revised version.

Page 29, Figure 6 caption- The transect is not coast-perpendicular.

Response: The figure caption will be changed to read "Transect illustrating the succession of typhoon deposits in landward direction".

Page 33, Figure 10 caption- The transect is only shore-perpendicular for trenches 1 and 2, not 3.

Response: The figure caption will be changed to read "onshore sediments of Haiyan were investigated in three trenches (MOL 1–3) along a landward transect (T1)".

Please also note the supplement to this comment:
http://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2016-224/nhess-2016-224-AC2-supplement.pdf

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