

## ***Interactive comment on “Sediment transport on the inner shelf off Khao Lak (Andaman Sea, Thailand) during the 2004 Indian Ocean tsunami and former storm events: evidence from foraminiferal transfer functions” by Y. Milker et al.***

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We want to thank both referees for their constructive and relevant comments, which touch several issues of the manuscript. We believe we are able to address these concerns. Our response to the individual comments by the referees is given below. The original comments are highlighted and are followed by our response. Additionally to the corrections suggested by the referees we have made slight corrections of the species and core names in Table 2, Figures 2 and 5.

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### Anonymous Referee #1

“This paper addresses relevant scientific questions within the scope of NHESS. It concentrate on the reconstruction of re-deposition processes based on data on the provenance of benthic foraminifers associated with the deposits of the 2004 Indian Ocean tsunami and earlier storm events from the inner shelf off Khao Lak. In order to achieve this the Authors recorded the modern sediment samples in non-tsunamigenic as a recent calibration data set for generating a transfer function for water depth that was applied to the fossil faunas investigated from two cores. Unlike most micropaleontological, studies which have been based on qualitative information of bathymetric species ranges the methodology applied in the present study enabled obtaining quantitative accurate bathymetric information for the first time. In the light of the above, the present manuscript adds important and innovative approach that is valuable for modeling studies of tsunami waves and thus represents a very significant contribution to the understanding of natural hazards. The paper is generally well written and sufficiently illustrated. The scientific data is presented in a clear, concise, well-structured way and the results discussed in an appropriate and balanced way. Only a few minor scientific questions/issues (“specific comments”), summarized below and some technical corrections should be addressed prior to publication.”

### Specific comments:

“1 Introduction \*Page 4 lines 8-9: Since your major conclusion is dealing with similar results obtained by transfer function for tsunami and storm waves then you should probably add a paragraph (I think in line 10, page 3, you can add it) about our knowledge, so far, regarding the differentiation between these high-energy events or diagnostic criteria per each of them, even though onshore, and alternatively similar results to your, obtain in other studies by other methods.” Examples: Kortekaas and Dawson, 2007; Morton et al., 2007; Dahanayake and Kulasena, 2008”

The referee is right with this comment. Consequently, we have included the “state of

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the art” regarding the differentiation between high energy events (storms vs. tsunamis) based on specific sedimentological characteristics into the introduction.

“4 Results The Storm layers and the 2004 tsunami deposits detected in the two cores were mostly represented by one or two samples, thus if it’s possible (not compulsory) to add a few sample (mainly to the thick layers) which will add reinforcement to the interpretations and the conclusions.”

This a perfectly reasonable statement and we are fully agree with the referee. Our study was designed as a pilot study. Our main goals was to test whether shallow water and particularly foraminifera are suitable to estimate tsunami-related re-deposition processes. Based on the presented results in the manuscript, more comprehensive studies are conceivable in the future. The sampling strategy would be another, e.i. a denser sampling interval for investigation more than one or two samples per event and also between event layers to analyze the “background” sediment. We are now address this in the manuscript.

“3 Material and methods 3.1 Surface sediment samples and sediment cores \* Page 5 lines 20-21: Your fossil data set is represented by 17 samples in total (9+8) but when you specify (the same page, lines 22-24) how many samples are characterized by coarse grained and fine sediments there is one extra sample (?)- please check.”

We have checked this and made corrections on the text accordingly.

“\* Page 5 line 25: “Two surface samples were taken onshore. . .” - What is the elevation (MSL) of these samples (was not mentioned in table 1)? Why are the samples not shown in Fig. 1? I don’t understand this sentence: Are you sure that it’s correct to use these samples to investigate re-deposited specimens during the tsunami 2004. Three years had passed since the tsunami event; I think these samples represent the recent sediment onshore. OR maybe you meant that you want to compare the recent relocated species with the tsunami identified in the core. . .in that case you should rewrite this sentence. On the other hand. . .I didn’t see that you used these two

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samples, neither in the results nor in the discussion (???)”

It is correct that two onshore samples were investigated during the study. The aim was to compare the foraminifera in these samples with the foraminifera in the offshore samples. The referee is correct - we are neither present the results of this comparison, and more importantly, nor they were included in our analyses presented in the manuscript. Therefore, we decided to remove the samples from Table 1 and the related part of the text.

“3.2 Lithology and structure of sediments and sediment cores \* Page 6 line 1: I suggest changing this title maybe to: “Lithology and sediments characteristics” \*More importantly this section should be moved to the results. \*”

We have changed the title of section 3.2 and moved this section into the first part of the results according to the referee’s suggestion.

“Page 6 line 6: Where the Grain size results can be seen (table? supplements?)?”

The grain size data of the surface and core samples will be given in the supplement.

“5 Discussion \* Page 17 line 6: “The paleo-water depths estimated in the storm layers are 15.32 +/- 1.54 m for the storm layer in lithological unit 4. . .” –Although this sample was estimated as bad analogue based on the WA-PLS?”

We understand the referee’s reservation regarding the usefulness of paleo-water estimates based on bad analogues and we agree with the referee that reconstructions based on bad analogues should be handle with care. Regarding to Woodroffe (2009), the modern analog technique (MAT) often fails to separate “good” from “bad” analogues. We have made similar observations in an earlier work (Milker et al., 2011). Woodroffe (2009) finally expands the criterion for distinguishing between good and bad analogues by using the largest dissimilarity coefficient (MinDC) in the training data set as a threshold to separate good from bad analogues. According to this criterion, we would have only one bad analogue in core 0303010C3 at 33-34 cm depth while all

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other fossil samples would have good analogues in the modern samples. Due to the lack of better methods for validating the transfer function reliability, we applied the MAT but used a much stronger criterion in our study based on the coefficient percentiles to distinguish between good and bad analogues as described e.g., in Horton and Edwards (2006), and Kemp et al. (2009).

“\* Page 18 lines 1-8: in core 030310-C3 you are interpreting the occurrence of *A. radiate* in high percentages and the *Peneroplis pertusus* absence as the uprush event ALTHOGHO in the lower part of lithological unit 2 both species have relatively elevated percentages (the latter species has in general lower % of <3). How do you explain this?”

We understand the referee comment regarding the distribution of these two species in the upper event layer of core 030310-C3. Reconstructing the provenance of the sediment with data from only two species (from that one species have only a relative abundance) might be problematic. Accordingly, we have calculated the total relative abundance of species in the sediment cores we have found at shallower and deeper water depths in the surface samples, respectively. And we have further restricted our interpretations. From our data alone, it is difficult to differentiate between uprush and backwash effects and further studies are needed to test the potential of foraminifera to distinguish between these different events.

Technical corrections:

“2 Study area \*Page 4 line 24: Add space (“31.5 and33 psu”)”

Done.

“3 Material and methods 3.1 Surface sediment samples and sediment cores \* Page 5 line 19: “and 15.5 m water depth (core 050310-C4, length 56 cm)” According to table 1 the water depth of core 050310-C4 is 15.3 m- please correct.”

Corrected.

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“5 Discussion \* Page 16 line 13: delete “and””

Deleted.

“\* Page 18 line 15: “Our paleo-water depth estimates in core 030310-C3, retrieved from 15.3 m water depth” – should be “9.5 m””

Corrected.

“References \* Jones (1994) (page 7) is not found in the ref. list “

Jones (1994) is now in the reference list.

“\*Mojtahid et al., 2010 (page 17) is not found in the ref. list “

This reference is now in the reference list.

“\* Page 16: Hori et al., 2007”

This reference is now in the reference list.

“Figure captions \* Figure 1: Delete the two cores which you are not address-“

These two cores has been deleted form Fig. 1.

Comments made in pdf file:

We have corrected the manuscript according to the minor comments by the referee. All other comments are listed below:

“Dating results, although preliminary, must be presented”

Our identification of the 2004 Tsunami layer is based on sedimentation rates using the decay of <sup>210</sup>Pb activity in a nearby sediment core (Sakuna et al., 2012) and their correlation to the presented cores.

“How did you choose which species to show graphically? Did you follow any rule to group these species? Do the species are the most significant species > 10% abundant

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(although two species do not follow this rule)? or does the selection was based on observation? RDA results?...Explain in the captions." [Fig. 3]

For this figure, we only have selected those modern species showing a distinct vertical zonation in the study area as mentioned in the figure caption. Our opinion behind was to underline that foraminifera in our modern data set that have been used for the paleo-water depth reconstruction, containing species with a clear relation to the water depth. But to be more consequent, we now present only species with a relative abundance of >5% resulting in a slight revision of Fig. 3 as we have replaced *P. pertusus* by *B. schlumbergeri* because the former species has a relative abundance of <5% on the recent assemblages. We have re-written the caption accordingly.

"It's hard to distinguish between the light blue circles and the blue circles- please give other symbol " [Fig.8]

The color of the cycles has been modified and hopefully, it is now easier to distinguish between the different blue cycles.

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