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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Boulder accumulations related to extreme wave events on the eastern coast of Malta" *by* S. Biolchi et al.

Anonymous Referee #2

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General comments

The paper by Biolchi and co-authors deals with a subject, which has been attracting great attention in the last decades, i.e. the possibility of distinguishing the phenomena (storms or tsunamis) responsible for the deposition of boulders along coasts. Such topic is of primary importance in the tsunami science not only for pure hydrodynamic modelling, but also for the reconstruction of the impact of historical or prehistoric tsunamis along the coasts and for the estimation of the frequency and magnitude of extreme storm waves in the coasts, hence for coastal hazard assessment.

The paper is set on Malta Island and, after all, it can be considered an application of the methods described and discussed several times by some of the Authors. What is not clear to me is why the Authors, after having well described several boulder sites and

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done many measurements, did not use their data altogether. Indeed, all the methods used throughout the paper (see table 1 and 3) consider only the wave heights (of storms and tsunamis) and not the final position of the boulders, both as distance from the coastline and elevation a.s.l., according to Pignatelli et al. (2009), Barbano et al. (2010, 2011); Goto et al. (2011), Lorang (2011) and Engel and May (2012) for instance. The minimum tsunami and storm wave heights required to detach a boulder from the cliff-edge is useful only to model the force to move the boulders but not the mechanism responsible for their emplacement. The Authors indeed state: "research attention has shifted its focus on the role of impacting wave height compared to the wave length and to the wave period. Different theories have been proposed and applied (Goto et al., 2007, 2009; 2010; Hansom et al., 2008; Imamura et al., 2008; Pignatelli et al., 2009; Nandasena et al., 2011), suggesting that in order to evaluate the wave impact on a rocky coast, these parameters should be considered all together". Actually, the Authors did not consider all the parameters.

In their discussion (page 20 lines 20-25) they state: "In comparing their results, these equations provide values which are too different from each other, etc. Moreover, parameters such as the distance from the coastline, the elevation of a boulder and the local topographical characteristics of the sea bottom are not taken into consideration. These are the reasons why, it can be concluded that the hydrodynamic approach as a standalone method is not sufficient to distinguish between storm and tsunami waves". Why did they use it?

Finally, they dated some boulders and associated the most recent to storms and the oldest to tsunami events. Why? Storms are usually more frequent than tsunamis. Can the Authors estimate the recurrence time of the biggest storms in the Malta Islands?

They give emphasis for witnesses who observed the boulders moved and emplaced by storm waves, but they did not describe the tsunamis observed in Malta Islands.

The correlation between boulders and some tsunamis that are likely to have not af-

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fected the Malta coast is very bizarre. The 1743 event is well documented only in Apulia, while the 1349 is a probable tsunami occurred during an eruption of Mt Etna (see Tinti et al., 2004). Furthermore, the false event of 963, reported by Tinti et al. (2004), cannot be considered a real event just based on two datings (with their associated error).

The language is not always fluent and precise (but I am not an English mother tongue, so I suggest a slight revision of the language too). The title is pertinent, but the abstract should report more clearly the results. In the manuscript, there are several inaccuracies, lacks about earthquakes, and the tsunami impact on the Malta coast is missing (see specific comments). The manuscript needs a good revision of the discussion and conclusion.

Specific comments about the manuscript are reported below.

Criticism to this version of the manuscript regards:

1 - The lack of a detailed description of historical data on tsunamigenic sources (earthquakes) and tsunamis that affected the Malta coast. The Authors state that numerical modelling gives results that are in good agreement with historical data, but they should report historical run-up values or flooding of tsunamis to strength their results (e.g. Bertolaso et al., 2008 for the 1908 tsunami on the Malta coast, p.122).

2 – The models used by the Authors to distinguish storm boulders from tsunami boulders are not appropriate.

3 – The association of boulders with tsunamis just based on some dating and lacking of data on the extreme storm frequency.

Technical points

Page 3, line 9: “seismicity activity”? Seismic activity or better seismicity.

Page 3, line 9: “related mainly to Malta Escarpment, the Sicily Channel Rift Zone and

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the Hellenic Arc". How the Authors can state that Malta was affected by tsunamis originated by these sources? Can they cite historical reports? Furthermore, do they know tsunamis originated in the Sicily Channel?

Page 3, lines 15-25: please rephrase statements, explaining better your results.

Page 4, lines 10-15: the tsunamis of Apulia and Sicily regard only these regions; please describe tsunamis that affected Malta Islands.

Page 4, lines10-13: The 1908 earthquake-generated tsunami. . . destroying everything and determining tens of thousands of casualties". The 1908 tsunami caused about 1500 casualties (see Bertolaso et al., 2008).

Page 4, line 15: The Stromboli tsunami did not destroy harbour structures and other facilities situated along the adjacent coasts of Calabria and Sicily, where did you find this information? Can a Stromboli tsunami influence the coast of Malta? Usually the tsunamis due to the Stromboli volcanic activity affect only Stromboli and sometimes the other Aeolian Islands (see Tinti et al., 2004).

Page 5, lines 21-23 "The aims of this paper are to identify the physical processes responsible for the accumulation of the boulders and to evaluate the vulnerability level of these Maltese coasts due to their exposure to such high-energy waves" These were the aims of the paper, but neither in the abstract nor in the conclusion I can read statistical data on the exposure to high-energy waves of the Malta coast.

Page 6, lines 10-13 How do you define a high level of crustal seismicity? Please, show all the earthquake epicentres you describe in a map.

Page 6, lines 23-25 "Several earthquake-generated tsunamis struck the Ionian coast of south-eastern Sicily and the Maltese Archipelago in historical times such as in AD 1169, 1693 and 1908 (Tinti et al., 2004)". Please, report data for these tsunamis on the Maltese coast. Moreover, with respect to the tsunamis generated in the Hellenic Arc, the fact that "several tsunami crossed the Mediterranean Sea having been generated

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in the Hellenic arc area" does not mean that the Maltese Islands were attached.

Page 7, line 9 "wave-cut platforms which host boulders accumulations". wave-cut platforms, which host boulder accumulations

Page 7-8. Lines 25-30, and 1-10 The Maltese sedimentary succession: it is not clear why you reported this detailed description; it is not important according to the aims of the paper. On the other hand, what is important is the boulder formation.

Page 8, lines 20-21. How did you decide the most representative boulders?

Page 8, lines 25-28. How did you select the equations to be used? None of your equations takes into account elevation, distance from the coastline and impacting wave height compared to the wave length and wave period. All the equations calculate the minimum tsunami and storm wave heights required to detach a boulder from the cliff-edge.

Page 9, line 15: "only the upper 50% has been averaged", of what?

Page 9, lines 18-20. How did you determine the most probable setting (submerged, sub-aerial, etc.) prior to transportation? In addition, why did you carry out detailed submerged profiles of the four coastal sites by direct underwater surveys? Perhaps to see if the waves are amplified on the shoreline? Why do you report only two submerged profiles (fig. 3f and 6 f)?

Page 19, line 24-26: "Bulk density of the boulders has been evaluated in. . ." Are they average values from Table 2? Why do you report them? In the equations, you used values for single boulders.

Page 20, lines 1-2: "the application. . . has highlighted the lack of correlation between density and volume values and the obtained results", but you consider them together and it is the weight of boulders, is not it? Have you some correlation with the weight of boulders?

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Page 20, lines 16–17: please, show the significant wave heights in terms of their frequency in order to compare with the age of dated boulders.

Page 20, lines 17–20: “on the coast, the height can exceed 10 m since the superimposed effect of the sea bottom and coastline topographies can oversize the impacting waves”. You can use the very nice underwater profiles shown in Fig. 3 and 6 to compute amplification factor.

Page 21, Line 3,” gave back very interesting results”. Please, rephrase this sentence see general comments

Page 21, lines 14-15: “The other radiocarbon datings seem to be related to events occurred in a span of time ranging from the 514_104 BC to the AD1723_40. They have been compared with historical events”. Do you mean tsunamis? Why do you exclude the possibility that they can be storms?

Page 22 lines 3-5: what event do Agius de Soldanis describe in his 1746 accounts? The 1693 or 1743 earthquake? Likely the 1693 because it occurred on 11 January, whereas the 1743 Ionian earthquake occurred on 20 February. Please specify in the text. Furthermore, the 1743 tsunami was observed only in Apulia, while at Malta there were only some damages (see Guidoboni et al., 2007-2013).

Please complete this reference: Baratta, M.: I terremoti d’Italia; saggio di storia geografia e bibliografia sismica italiana. Torino, [ristampa anastatica, A. Forni Ed., Sala Bolognese, 1980], 950 pp., 1901.

In table 2 the boulder density is likely wrong add 1 before 670: QW1 LCL Qawra Peninsula 29 Jan 2015 15: 670 =1670

Fig. 1. Please, add epicentres of the tsunamigenic earthquakes.

Fig. 3f. Increase, font dimension of the bathymetry.

Fig. 6f. Increase, font dimension of the bathymetry.

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Fig 7. At Armier Bay-Ahrax, point elevation a.s.l. are missing.

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