Ocean Sci. Discuss.,
doi:10.5194/os-2015-108-AC1, 2016

Ocean Science Discussions

Interactive comment on "Statistical Analysis of Wave Energy Resources Available for Conversion at Natural Caves of Cape-Verde Islands" *by* W. M. L. Monteiro et al.

W. M. L. Monteiro et al.

wilson.monteiro@docente.unicv.edu.cv

Received and published: 16 April 2016

Report No.3: Answers to the Anonymous Referee #1 The Authors: W. M.L. Monteiro A. J. Sarmento, A.J. Fernandes and J.M. Fernandes 16-04-2016 Dear Anonymous Referee #1, First we want to thank you for all the comments and suggestions you made in relation to our paper. In fact, the improvement of the paper is notable after yours comments. 1. Answer to the general comments (GC) GC1: A part for being an interesting/particular area to study, the paper reads more as a technical report than a scientific paper and it is difficult to fully understand with many references to statistical software A) In fact, several statistical software packages (XLStast, R, Minitab17 and gretl) were used in the study because of the particulars in dealing with the various

parameters in the problem.

GC2: In the presentation of the results there are some points that remain unclear and not fully discussed: 1) the monthly averages do not show any trend in time, but then looking to the annual time series a decreasing trend is present. Should this decreasing trend be present also in the time-series of monthly average power? 2) If a decreasing trend is present analysing the historical data, how can you justify that the future forecast does not show any trend? Is the future forecast not calculated on the basis of the historical data analysed?

B) In fact, the monthly average power does not show any trend. However, the inter-annual average power presents a downward trend. If we delve deeper into the analysis of data we find that the trend shown in time-series of the inter-annual average power is illusory and caused by the aggregation effects of data. This situation is now well discussed in the paper. C) The time-series of the predicted values of the inter-annual average power follows the trend of the historical data. A new figure is added to the paper to reinforce this fact. However, a better ARIMA model to predict the future values of the inter-annual average power is found using the R software. The new version of the paper expand on this subject. GC3: The paper is missing a state-of-the-art section pointing out which are the techniques usually used for quantifying the wave energy power availability and what are the novelties presented in this work. For example are there statistical methods used that go beyond the state-of-the-art of commercially available software? The methodology (and the data used) should be better presented, which would allow to show the scientific novel aspects presented in this paper.

A) The procedures and software available for mapping wave energy resources ignore, in general, some important statistical aspects that can lead to errors in wave energy assessment. The outliers that may be present in the time-series of wave data, as a result of a specific event such as extreme storms, could significantly influence the available average wave power. The present study have as novel aspect, the using of the adequate statistical tools to identify possible outliers in time-series of wave data, and the

subsequent analyses of their influence in the inter-annual average power calculation. B) Another subject barely mentioned in papers, that can lead to error in the wave energy resources characterization are the effects of data aggregation. The information about the temporal behaviour of the wave data is lost due to the aggregation effects. The present study shows that the aggregation effects may be a real problem that deserves to be analyzed when characterizing wave energy resources. Finally, based on the wave regime characteristics, this paper calculates the time duration necessary to carry on the experiments at Natural Caves aimed to quantify their output power with a minimum sample size that will guarantee its time representativeness. The estimation of the referred time duration is very important as it helps us to evaluate correctly the energetic performance of NCs. In fact, the statistical procedure presented in this paper for quantifying the mentioned time duration can be followed by any researchers to make a better sense of the behaviour of their models of Wave energy devices, through the experimental studies in ocean, or in Lab, using irregular waves. All of these new aspects are now added to the paper. So, we kindly ask you to read a new version of the paper. 2. Answer to the Specific comments (SC)

SC1:Abstract Page 1 – Line 11. A reference to the SOWFIA project should be added to allow the reader to have more information on the data used in the paper.

C) The reference to the SOWFIA project can be found in new section added to the paper. SC2: Introduction Adding a state-of-the-art section in the Introduction would help to situate the work and to understand the novel aspects presented. Furthermore, a literature overview of the wave climate in the Cape Verde area, if available, could help to strengthen the paper findings.

D) A paragraph is added to the data section to highlight the methodology used to evaluate wave energy resources and the novel aspects of the present work. See the answers to the GC3. A state of the art section is added to the paper. In this section we highlight the importance of the present study for Cape-Verde and the real positioning of this country in the context of wave energy utilization. The detection of outliers of in time-

series of the inter-annual average power, their influence in quantifying this quantity, the statistical procedure presented to calculate the time for realization of the experiments on Natural Caves to determining their energetic performance are some aspects of the paper that deserve to be highlighted.

SC3: Page 5 – Line 14. An additional section “Data” should be added to the manuscript. This will allow the reader to understand better the methodology used. A short description of the data used is at the beginning of the Results section (page 9 – line 10-14), that can be moved here and further described.

E) A data section is added to the paper. In this section we make a statement of the SOWFIA project and present a real nature of our data and the inaccuracy associated with them. F) Average Power SC4: Page 5 – Line 20-21-22. The wave power energy presented in Eq. (1) is valid for any wave spectrum, not only for the Pierson-Moskowits wave spectrum. Yes. We agree and new equations for significant wave height calculation is added to clarify this situation. SC5: Page 6 – Line 1-7. This paragraph is a bit confusing. The significant wave height comes from the integration of wave spectrum too. If you add a “Data” section the description of significant wave height and peak period can go there.

Page 6 – Line 8-15. Have you calculated the wave spectrum using the Pierson-Moskowits parametrization? If not, it is not worth mentioning. After reading this paragraph, it is not clear which is the approach you finally used to calculate the energy period. If you started your analysis from a dataset of significant wave height and peak period, this paragraph can go also in the “Data” section, presenting the starting point of your analysis.

Page 6 – Line 22-24. You could add further discussion and references to other studies about the wave climate in the Cape Verde region. You found that there is a seasonality in the wave power distribution. What happens to the annual trend if one year instead of spanning from January to December (solar year) goes from September to August next

year? Page 7 – Line 1-2. Please explain how data is collected and made available at SOWFIA, in the “Data” Section.

No, we do not calculated the wave spectrum using the Pierson-Moskowits parametrization. We used an approximation Te=Tp, considered by Hagernam (2001) as we find it very good to make a preliminary study of wave energy resources. In fact, the R software detected seasonality in the monthly average power, if all values of this quantity are aggregate together. But, as mentioned before, the trend in the inter-annual average power is illusory. The data collection by SOWFIA project is presented in the data section. G) Statistical Analysis SC6: Page 8 Line 8. Add a reference to the XLSTAT and Minitab Software. 2.5 Representativeness: Page 8 Line 28. Add a reference to the Minitab Software.

All reference suggested are now added to the paper. H) Results

SC 7: Page 9 – Line 10-14. This paragraph can be moved to the “Data” Section. It might be helpful to have a map showing the location of the data collection point and the position of the NC of Cape Verde. Are the waves recorded at 3700 m representative of the wave climate at the NC of Cape Verde? How is the bathymetry in the area?

We completely agree with your comment and, as suggested, the paragraph is moved to the Data section. Further study on the wave transformation from deep to shallow water must be carried out using information about the local bathymetry. Unfortunately, detailed bathymetric data is available only at some bays and harbour. This lack of information increases the difficulties in producing more realistic results of wave energy resources available at shorelines regions.

SC 8: Page 10 – Line 12-13. Can be more information be added to reinforce your “suspect”?

New information and diagram are added to the paper to better explain the bimodal distribution.

SC9: Page 12-13 – Figure 6 and Figure 8. If the annual averages come from the average of the monthly averages, it sounds strange that the monthly averages do not show any trend for any of the months, while the annual average time-series show a decreasing trend.

The trend observed in the inter-annual average power is results of the aggregation effects of data. This problem is, now, well commented in the text. In fact, this effect appears on the September and October months.

SC10: Page 19 – Line 7-10. Not clear what you are doing here. Is this an estimate of days of measurements during hypothetical operation of NC in Cape Verde?

The quantification of the number of days of measurements of performance parameters of a real Natural Caves operation is one of the important aspects of the present paper. The excitation of real Natural Cave is a time-varying phenomenon. The statistical procedure used in the paper, is based on the wave regime nature to calculate the duration of the experiments to be realized on a real Natural Cave and guarantee the representativeness of the data to be collected during its operation is new. SC11: Page 21- Line 3. “Table 6” should be “Table 7”. Looking to Table 7, if I have less numbers of days of measurements during Spring and Summer, what are the implications? Is that important? In fact, the results show that the number of days of measurements is lower in spring (March to May) and summer (June to August). This is due to the lower level dispersion of wave data for these seasons, in comparison with the rest of the months. I) Others suggestion: Typos All others suggestion relative to the graphics aspects of the paper, improvement of figures were taken into account. J) Others news aspects of the paper News paragraphs, graphics section and subsections are added to the paper to clarify many situations of our study.

Please also note the supplement to this comment:
http://www.ocean-sci-discuss.net/os-2015-108/os-2015-108-AC1-supplement.pdf