Response to Reviewer 1

We thank the anonymous referee for the positive comments on the paper and his suggestions, which we fully taken into account in the revised version of the paper. We modified the manuscript following the reviewers suggestions and highlighted the modified parts in bold in the revised manuscript.

1) Pag. 5, line 4: delete "of below"

Amended as suggested

2) Considering the buoy data, the authors analyse three different datasets on the base of their total duration: 20 year, 10 years and 5 years. The total duration of the dataset constrains the maximum available timescale that is respectively about 2 years, 1 year and 6 months. The AF computed for timescales above such maximum does not have so much sense. Figs. 5-7 show the AF for all the data in a time scale range between 0.1 days and about 300 days, which is only consistent with the 10 years long datasets. It would be probably better to show the AF taking into account the reliable maximum timescale for each group of datasets.

We agree on the suggestion by the reviewer about being consistent with different groups of data. We decided to exclude the newer buoys from the analysis. This was done because the group is non-homogenous itself (time series within this group have different lengths) and we had already enough support for the validation from other measurements. Text and figures are changed/removed consequently.

3) As rightly observed in the short comment by Serinaldi, the seasonality would affect the AF curve producing that "hump" centred at about 180 days. And this implies that the increase of the AF on the left-side of such "hump" is not a signature of fractal behaviour. The suggestion to compare the AF curves of the original data with those obtained by a cyclic Poisson process is good. However, from a visual inspection it seems that before 20-50 days the AF appears well approximated by a straight line, and the interpretation as a signature of fractality or clustering at timescales below 20- 50 days seems to be appropriate.

We agree with the reviewer consideration on the AF patterns and we carried out further analysis to clarify the nature of the processes that occur at different time scales as shown in the AF plots. We did this by using the approach described in Serinaldi and Kilsby (2013). We compared the AF pattern of a time series (hindcast in this case) to the AF distribution of a population of point processes with the same cyclic characteristics and intensity of the reference one. First we used the Fourier analysis to determine the dominant cyclic components in the time series; this led to identify 5 dominant components corresponding to the yearly cycles and, with much smaller amplitudes to cycles with periods of six, three, one months and one week. With the amplitudes and periods of these cycles we simulated a cyclic, hence non-homogeneous Poisson point process. This was done with the Integrate and Fire (IF) technique by Serinaldi and Kilsby (2013), for which Dr Serinaldi kindly provided a script. Subsequently, we compared the distribution of the AF of 1000 realisations of this process to the AF found in the time series under study, results are shown in the new Figure 7. The results of this analysis confirmed the reviewer's conclusions, i.e. that the AF corresponding to time scales longer than 50 days is associated to the cyclic components, while at time scales shorter than 50 days there is a significant departure from a Poissonian AF pattern and, as the reviewer correctly pointed out, there is a clear trend that gives us confidence in interpreting *this as clustering. We also included the 95% confidence intervals to further identify the scales at which the AF pattern is within the limits of the cyclic process. We think that this analysis clarifies the significance of alpha and AF.*

As a consequence of this analysis the paper has been revised and a subsection discussing the results of the comparison with a surrogate population of AF is added and it reads:

"4.2 Comparison with a simulated non-homogeneous point-process

The AF pattern found from data and hindcast time series is compared with that of a simulated non-homogeneous Poisson process. This is generated using the IF technique employed in Serinaldi and Kilsby (2013). The rate function of the simulated hon-homogeneous Poisson process is generated as a sum of sinusoidal components with amplitudes, 5 periods and phases obtained from the Fourier analysis of the reference signal. A Monte Carlo simulation of 1000 time series is then carried out and the simulated population of AF is compared with the reference one. Hindcast points A, G and O (see figure 2) are chosen for this analysis because they show different AF patterns in the time scales $\tau < 50$ days. This analysis reveals that, as expected, the dominant cyclic component for all the considered time series is the one with 1-year period. This was also noted for the RON data in Briganti and Beltrami (2008), where the amplitude of the annual cycle component was estimated to be around 0.25 m in Alghero, which is consistent with what found in the present work. Together with the annual cycle also the components with periods of six, three, one months and one week have been considered to simulate the non-homogeneous Poisson processes. The results of the comparison are shown in figure 8. For all three points it is clear that the simulated cyclic Poisson process well explains the pattern of the AF at $\tau > 50$ days in all cases. As expected, this is the signature of the annual cycle, which strongly influences the occurrence of above-threshold events. The AF departs from the Poisson distribution at $\tau < 50$ days, above all in points A and G. Note that these results show also that the α for $\tau > 50$ days is always above 1 and shows very little variability among points. For scales in which a departure from a Poissonian behaviour is seen, it has to be noted that this occurs at very low values of α, as for example in point O. However, data often show oscillations, above all for $\alpha < 0.1$, and it is not possible to make conclusions about the existence of a clustering regime."

4) So, the authors may consider to focus their study only on the small timescale ranges for all the data, re-plot the figures and re-discuss the results accordingly.

We clarified the nature of the process at the different scales, hence we retained the AF at those scales and we explained that the process is a non-homogeneous and Poissonian in this region of τ.

5) As additional analysis, it would be better to show also the 95% confidence limit for the Poissonian surrogates at each of the considered timescale (in the range below 20-50 days) in order to check the significance of the clustering.

As explained above, this has been done and shown in Figure 8.

Response to Reviewer 2

We thank Dr Wahl for the positive comments on the paper and his suggestions, which we fully taken into account in the revised version of the paper. We modified the manuscript following the reviewers suggestions and highlighted the modified parts in bold in the revised manuscript.

One aspect I believe should be discussed a bit more is the issue of significance, i.e. how large can AF (or alpha) get by chance? This is important to be able to interpret the results. There is for example a paper by Serinaldi and Kilsby (2013; http://dx.doi.org/10.1016/j.physa.2012.11.015) where this is addressed.

We discussed the nature of the processes described by the Allan Factor (AF) using the same approach described in Serinaldi and Kilsby (2013), according to which the AF pattern of a time series is compared to the AF distribution of a population of point processes that share the same cyclic characteristics and intensity. In order to do so, we followed a series of steps. First we analysed the time series to find the dominant cyclic components; this led to identify 5 dominant components corresponding to the yearly cycles and, with much smaller amplitudes to cycles with periods of six, three, one months and one week. With the amplitudes and periods of these cycles we simulated a cyclic, hence non-homogeneous Poisson point process. Subsequently, we compared the distribution of the AF of 1000 realisations of this process to the AF found in the time series under study. This analysis showed that the AF corresponding to time scales longer than 50 days is associated to the cyclic components, hence the underlying point process is non-homogeneous Poissonian. At time scales shorter than 50 days there is a significant departure from a Poissonian AF pattern. The presence of a clear trend also gives us confidence in regarding this as a non-poissonian process.

We think that this analysis clarifies the significance of alpha and AF. Following the approach indicated by Dr Wahl we clarified that alpha=1.15 in the time scales longer than 50 days is consistent with the alpha showed in the cyclic Poissonian population, while alpha=0.15-0.3 at shorter time scales is consistent with a departure from a cyclic Poisson process. As for the significance of alpha, we noticed that although departure from Poissonian is seen at very low values of alpha, it is not possible to distinguish.

We modified the text in multiple locations in the paper to reflect these findings and we added a new subsection that describes the tests. You can find the text of the section below and the rest of the modifications in the revised manuscript.

"4.2 Comparison with a simulated non-homogeneous point-process

The AF pattern found from data and hindcast time series is compared with that of a simulated non-homogeneous Poisson process. This is generated using the IF technique employed in Serinaldi and Kilsby (2013). The rate function of the simulated hon-homogeneous Poisson process is generated as a sum of sinusoidal components with amplitudes, 5 periods and phases obtained from the Fourier analysis of the reference signal. A Monte Carlo simulation of 1000 time series is then carried out and the simulated population of AF is compared with the reference one. Hindcast points A, G and O (see figure 2) are chosen for this analysis because they show different AF patterns in the time scales $\tau < 50$ days. This analysis reveals that, as expected, the dominant cyclic component for all the considered time series is the one with 1-year period. This was also noted for the RON data in Briganti and Beltrami (2008), where the amplitude of the annual cycle component *was estimated to be around 0.25 m in Alghero, which is consistent with what found in the present work. Together with the annual cycle also the components with periods of six, three, one months and one week have been considered to simulate the non-homogeneous Poisson processes. The results of the comparison are shown in figure 8. For all three points it is clear that the simulated cyclic Poisson process well explains the pattern of the AF at $\tau > 50$ days in all cases. As expected, this is the signature of the annual cycle, which strongly influences the occurrence of above-threshold events. The AF departs from the Poisson distribution at $\tau < 50$ days, above all in points A and G. Note that these results show also that the α for $\tau > 50$ days is always above 1 and shows very little variability among points. For scales in which a departure from a Poissonian behaviour is seen, it has to be noted that this occurs at very low values of α, as for example in point O. However, data often show oscillations, above all for α < 0.1, and it is not possible to make conclusions about the existence of a clustering regime."*

Below is a list of more specific comments:

P1, l. 3. 'spanning the period'

Amended as requested

P1, l. 9. 'longer scales'

Amended as requested

P1, l. 12. 'the occurrence'

Amended as requested

P1, l. 17. Another paper has recently been published where storm surge clusters are investigated in much more detail around the UK: http://www.nature.com/articles/sdata2016107

We added the reference to the suggested paper.

P2, l. 8. The selection of example references is heavily biased toward one author, if AF is such a prominent method there should be other examples where it has been used.

We included more references as suggested by the referee These are:

Cavers, M. and Vasudevan, K.: Brief Communication: Earthquake sequencing: analysis of time series constructed from the Markov chain model, Nonlinear Processes in Geophysics, 22, 589, 2015.

García-Marín, A., Jiménez-Hornero, F., and Ayuso, J.: Applying multifractality and the self-organized criticality theory to describe the temporal rainfall regimes in Andalusia (southern Spain), Hydrological processes, 22, 295–308, 2008.

and of course:

Serinaldi, F. and Kilsby, C. G.: On the sampling distribution of Allan factor estimator for a homogeneous Poisson process and its use to test inhomogeneities at multiple scales, Physica A: Statistical Mechanics and its Applications, 392, 1080–1089, 2013.

P. 3, l. 3. Close bracket after 'heights'

Amended as requested.

P. 3, l. 10. The way I know AF the denominator should be multiplied by two. If it is just a typo it is an easy fix, but if the analysis has been performed this way everything needs to be repeated.

The typo was corrected as indicated. Computations were carried out with the correct formula.

P. 3, l. 12. 'depends on'

Amended as requested.

P. 5, l. 30 to P. 6, l. 7. Somewhere here the authors should refer to Fig. 2 where the locations of the wave buoys are displayed.

We added the reference to the figure on Page 5 Line 29.

"The locations of the buoys are indicated in Fig. 2."

P. 6, l. 7-10. I don't think this is necessary; it has been said already that only the original stations are used so no need to go into detail what the other station time series look like.

We removed the lines as suggested since only the original stations were used.

P. 6, l. 13ff. What about the "wobbles" that exist at all example sites for the 99.5% threshold in the model data at ~5 and ~25 days, it seems to be something systematic.

We also noticed these oscillations in the AF patterns, however we did not find an obvious explanation of these in comparing our AF pattern to cyclic Poisson Processes. Following the suggestions from Serinaldi we looked at the effect of cycles of period shorter than one week, but they do not influence the AF significantly. In other words we cannot associate the wobbles to any cyclic pattern. Therefore, at the moment, we cannot explain the nature of these oscillations.

P. 6, l. 17. Delete 'and Mazara', it is not included in Fig. 5.

Deleted as indicated.

P. 6, l. 19. 'sometimes'

Amended as requested

P. 6, l. 21. How can I see from the figures that alpha is between 0.2-0.3 or 1.1-1.2? There is no reference as can be found in the other figures.

We amended all the figures and consistently added a trend line for α in all the figures

P. 6, l. 22. 'on average'

Amended as requested

P. 11-14. Why exactly are the alpha values of 0.25 and 1.15 shown as reference? This is related to my comment above on significance of the results. The same applies to Fig. 12, is it possible to highlight grid points where the results (in this case the slope) is significantly different from zero (or the Poisson assumption)?

The slopes in the figures are selected as they are representative of the slopes found in the AF curves, hence they are only indicated as reference. We specified this better in the text. We selected alpha=0.2 as representative of the slope for time scales and alpha=1.15 for longer time scales. As for the significance of alpha, as we discussed this previously, it is difficult to identify a well defined regime when alpha<0.1. We clarified this also in the discussion:

"The results presented highlighted the presence of two distinct scaling regimes for the arrival of above threshold wave storms: one for time scales shorter than τ < 1200 hours (50 days) that is associated to a departure from the Poisson distribution. This regime is characterised by α = 0.15−0.3 and is more evident in the North-West of the Mediterranean Sea. In the rest of the basin α is closer to zero and the AF pattern is characterised by oscillations, without a well defined regime."

We also concluded that it is not possible to say that the magnitude of the departure from a Poisson process is large or small as, at the moment, there is no comparison with other Seas. We added this consideration in the Discussion and Conclusions section:

"The values of α found in the present study do not allow to draw conclusions on whether this deviation from a Poisson distribution is large or small for the phenomenon at hand, as there is no comparison with other basins. Because of this, it is important to analyse further basins. "

P. 15, l. 1. Delete 'the' before Southern Spain

Deleted as requested

P. 16, l. 5-7. I didn't understand the last part of this sentence.

This part has been rewritten, following the analysis by Serinaldi and Kilsby (2013).

P. 16, l. 17. 'to exacerbate'

Amended as requested.

Response to Dr Serinaldi comments

First of all we would like to thank Dr Serinaldi for his detailed constructive comments on the paper and his subsequent correspondence with us. We are also grateful to Dr Serinaldi for providing a script to carry out the analysis of the AF curves and we acknowledged this in the dedicated section of the paper.

To understand if what we saw in the AF curves was a signature of a departure from a Poisson distribution or that of a non-homogeneous Poisson process we used the approach described in Serinaldi and Kilsby (2013). We compared the AF pattern of a time series (hindcast in this case) to the AF distribution of a population of point processes with the same cyclic characteristics and intensity of the reference one.

Following your suggestions we carried out the following steps:

1- *We carried out a Fourier analysis to determine the dominant cyclic components in the time series; this led to identify 5 dominant components corresponding to the yearly cycles and, with much smaller amplitudes to cycles with periods of six, three, one months and one week. Note that cyclic components associated to typical tidal cycles (i.e. 28, 14 days) do not show significant energy. This is expected as the Mediterranean is a microtidal sea. Also the time series analysed are in deep waters, which makes already small sea level oscillations negligible.*
2- *With the amplitudes and periods of these cycles we simulated a cyclic, hence non-homogeneous Poisson point process. This was done with the Integrate and Fire (IF) technique by Serinaldi and Kilsby (2013). Here we used the script that you kindly provided.*
3- *Subsequently, we compared the distribution of the AF of 1000 realisations of this process to the AF found in the time series under study. The results of this analysis are shown in Figure 7 of the revised version of the paper.*

The results confirm that the AF corresponding to time scales longer than 50 days is associated to the cyclic components, while at time scales shorter than 50 days there is a significant departure from a Poissonian AF pattern. At the moment, however we are unable to draw conclusions on the oscillations that appear at some locations in the scale where departure is detected. We think that further analysis is needed and we will analyse other basins, possibly macro-tidal.

Again we would like to thank you for the very productive discussion during the revision of the manuscript.