Answer to referee #2

The authors analyze the size distribution of wildfires in the Mediterranean using the MODIS burnt area product, ERA-interim climatic data, and cellular automata modelling. The authors state that under moderate wind conditions the size of burnt areas decrease.

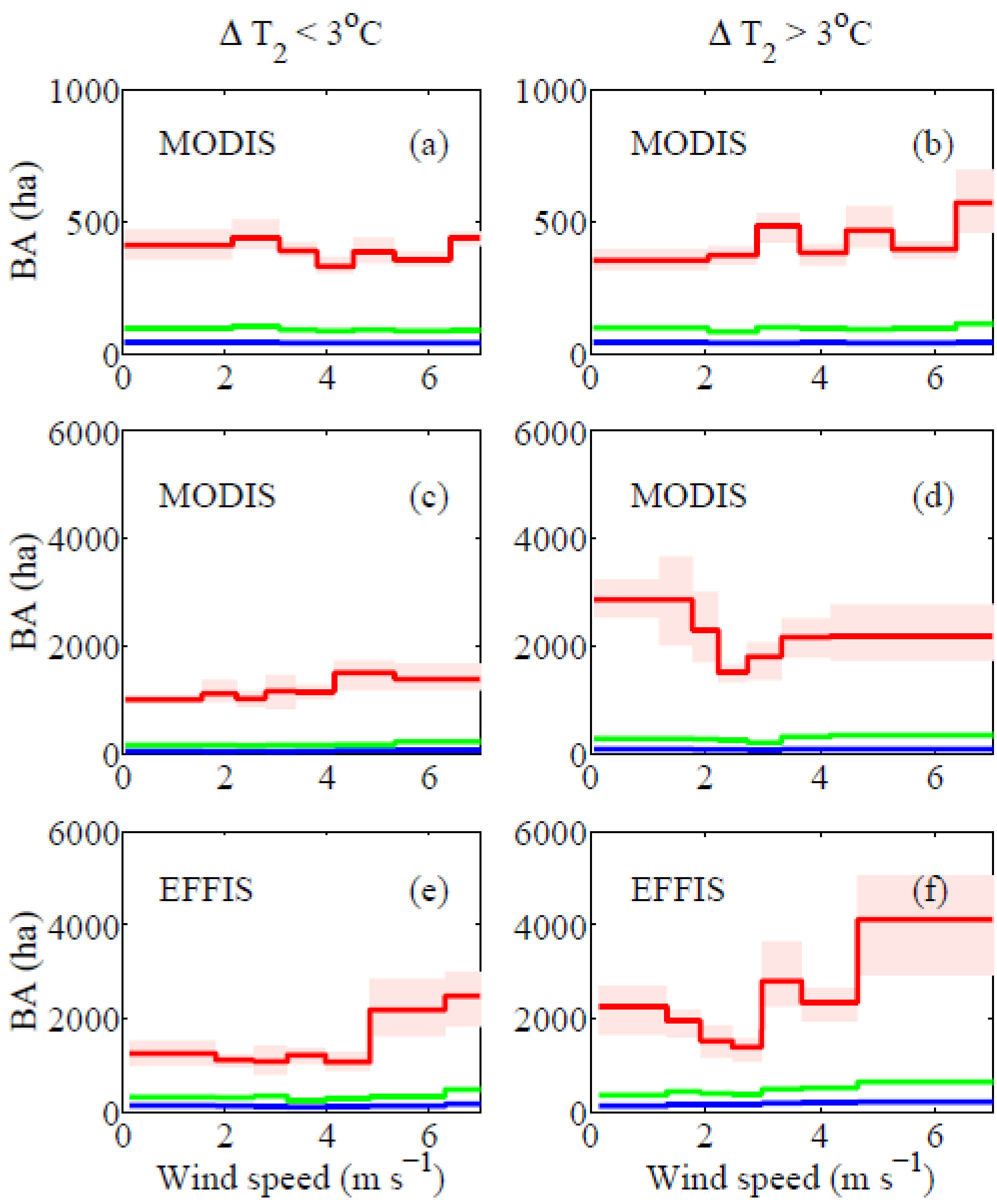
We thank the referee for his/her thorough reading of our work.

This result is counter-intuitive, and the authors did not present any statistical tests that examine whether their claim is statistically significant (in section 2.3).

We agree with the referee and we now provide a more in-depth analysis of the uncertainties (see subsection 2.3). To do so, we:

1. compared the MODIS and the EFFIS products over the common region. A similar behavior of the burnt area with respect to temperature anomaly and wind speed is found with EFFIS dataset (see revised figure 2 below)
2. performed an analysis on several sub-domains as suggested by the referee (see below). Even though statistically less robust, a similar behavior is also found over different sub-domains
3. provided the confidence level of our data analysis. Our results are valid at the 70% confidence level. We modified our figure 2 in the revised manuscript by adding bootstrap confidence intervals at the 70% confidence level (see revised figure 2 below).

The use of the PCA models is finally used as a theoretical tool which allows to support and explain the cause of such behavior.



In Figure 2a there is no trend of increase in burnt area size with wind speed.

We agree with the referee. We wrote in the submitted manuscript (P1208L21): "In the EAST domain, wildfire size is nearly independent of the wind speed for $\Delta T_2 < 3K$ and slightly increases with wind speed for $\Delta T_2 > 3K$".

In Figure 2 the authors should also present scatter plots and examine the relationship between wind speed and burnt area statistically. Why did the authors focus just on the 95th quantile? Quantile regression may be used in addition to traditional correlation coefficients.

Showing scatterplots would make Figure 2 unreadable. The high number of points to display (8206 for MED/MODIS, 17453 for EAST/MODIS and 4912 for MED/EFFIS) and the very high skewness of the considered sets (35.83 for MED/MODIS, 119.80 for EAST/MODIS and 15.29 for MED/EFFIS) would make this scatterplot hardly legible. Displaying the burnt area versus the wind speed with the associated confidence intervals is already analyzing their relationship statistically.

We chose to focus on the 95 th quantile because fires above this quantile are responsible for more than 50% of the total area burned in our EFFIS and MODIS data sets. Furthermore, the variability of wildfire size to ΔT2 and wind speed is only seen in extreme fires. In order to emphasize this point, Figure 2 now shows also the 50 th and 75 th quantiles of fire size. We added the following passage to the 2.3 subsection: “For consistency we also show the median (blue) and 75 th (green) quantiles of fire size. It can be noted that they do not show strong responses to the chosen meteorological parameters. We will therefore focus only on largest wildfires only.”

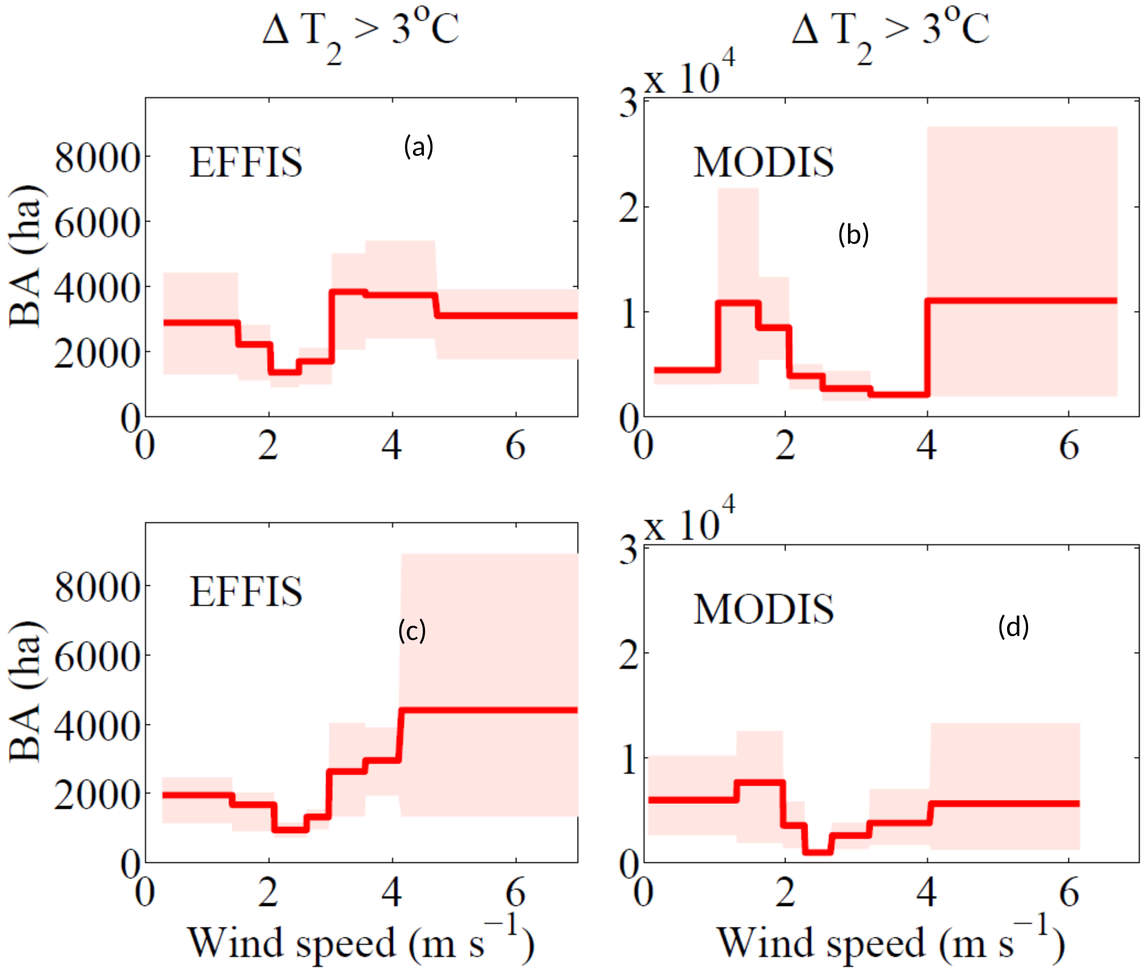
Non-linear techniques of quantile regression (for example GAMs, GLMs, MARS or neural networks) lead to plots where it is harder to understand what is the signal and what is the behavior caused by the lack/excess of flexibility of the regression model. We think our piecewise display of the 95 th quantile is the best way to show evidence of the link between burnt area and wind speed. No parasite behavior coming from an excess of regression model flexibility is expected. The method of construction of Figure 2 was therefore explicitly added to the revised subsection 2.3.: “In Fig. 2, the wildfire-wind speed pairs are placed in 7 bins according to wind speed, with an equal number of samples in each bin and therefore varying wind speed ranges for each bin. These 7 bins constitute separate sets for which we compute the value of the 95 th quantile of fire size and its corresponding 70% confidence interval by bootstrapping this statistic 1000 times”.

In two places in the manuscript the authors report results but do not show them (e.g., p 1209 l 6, p 1213 l 17). Results should be shown. The authors should also examine and present the correspondence between wind and temperature anomalies for the MED and EAST regions, or better yet, for smaller regions.

In order to address the issue noted by the referee we now show in Figure 2 the results for the EFFIS data set (comment of p.1209).

Regarding soil moisture and aridity, we removed the reference to such link. Indeed, summer precipitations are very weak in the Mediterranean basin and so the drought signal is a background signal for summer Mediterranean climate. Conversely, the temperature anomaly (i.e. heatwave occurrence) has a much clearer and direct correlation with fire occurrence (Pereira et al., 2005; Bedia et al 2014). Such temperature anomaly are associated with anticyclonic weather conditions which favor the absence of precipitation (Stéfanon et al 2012). The link with aridity level is found at longer time scales which is not the time scales under investigation in this study. Indeed, the link between heatwave occurrence and preceding spring precipitation deficit has been shown by Vautard et al. (2007) and Stéfanon et al. (2012). Even longer time scales can be at stake (Koutsias et al., 2013). Therefore, in this study, only the direct effect of temperature anomaly and wind speed intensity are analyzed. No mention is made on soil moisture and droughts issues.

Finally, the figure below shows the variations of the burnt area (EFFIS and MODIS data sets) for two different regions of the Mediterranean Basin, Iberia (upper row) and northern Algeria (bottom row). The left column corresponds to the EFFIS data set and the right column to MODIS. In red is the estimated value of the 95 th quantile of BA and in shaded pink the associated 70% confidence interval.



Although being less illustrative, this figure shows patterns similar to what is found over the whole Mediterranean region. When ΔT2 > 3°C, the burnt area decreases with increasing wind speed and then increases after a wind speed threshold around 2-3 m/s (in the ERA-I reanalysis). If we number the bins 1 to 7 from left to right, we see in the panel b of the figure that bins #4, #5 and #6 are significantly lower than bin #3. Bin #6 is also significantly lower than bin #7. We see in panel d the same pattern, with bin #4 being significantly lower than all other bins. Similar analysis can be made in panels a and c with the EFFIS dataset.

Overall the manuscript should be edited by a native English speaker as there are many errors throughout the text. In addition, the manuscript is not clearly divided into Introduction, Methods, Results and Discussion sections.

Several language errors and non-idiomatic sentences were present in the submitted manuscript, which has been edited accordingly.

The manuscript organized differently from the standard of Introduction, Methods, Results, Discussion and Conclusion. This division is a choice of the authors, not a mistake. We wish to provide the clearest format for the understanding of our article and mixing the PCA and the observational methods together in an independent method section would add confusion. A potential Results section would mix these two components together again. We separated them in order to simplify the reading of our article.

In the text the authors use two different units for area: hectares and squared kilometers, sometimes in the same sentence. For consistency, please choose one of the measurement units and stick to it.

We modified the manuscript to take this remark into account. We now only use the hectare as an area unit.

In the Introduction the authors provide examples of studies concerning climate conditions and wildfires, however these are mostly from North America. Additional examples should be given from the Mediterranean, e.g.:

Boboulos, M., & Purvis, M. R. I. (2009). Wind and slope effects on ROS during the fire propagation in East-Mediterranean pine forest litter. Fire safety journal, 44(5), 764-769.

Dimitrakopoulos, A. P., Vlahou, M., Anagnostopoulou, C. G., & Mitsopoulos, I. D. (2011). Impact of drought on wildland fires in Greece: implications of climatic change?. Climatic Change, 109(3-4), 331-347.

Levin, N., & Saaroni, H. (1999). Fire weather in Israel synoptic climatological analysis. GeoJournal, 47(4), 523-538.

Levin, N., & Heimowitz, A. (2012). Mapping spatial and temporal patterns of Mediterranean wildfires from MODIS. Remote Sensing of Environment, 126, 12-26.

Pausas, J. G., & Fernández-Muñoz, S. (2012). Fire regime changes in the Western Mediterranean Basin: from fuel-limited to drought-driven fire regime. Climatic change, 110(1-2), 215-226.

Pausas, J. G., & Vallejo, V. R. (1999). The role of fire in European Mediterranean ecosystems. In Remote sensing of large wildfires (pp. 3-16). Springer Berlin Heidelberg.

The referee is correct and we therefore added the following paragraph in our introduction: "Fire occurrences in the Mediterranean region are driven by human (e.g. land use) and environmental (e.g. weather and topography) factors (Ganteaume et al 2013). The synoptic weather conditions favorable to Mediterranean wildfires are either blocking (Pereira et al 2005) or trough (Levin and Saaroni 1998). Temperature anomalies (Bedia et al 2014) and summer droughts (Dimitrakopoulos et al 2011) are also critical to explain fire occurrence in the Mediterranean Basin. On longer time scales, the aridity level is also linked with large fire occurrence (Pausas and Paula, 2012). In Greece, Koutsias et al (2013) found a positive correlation between 2 years lagged precipitations and burnt area. This climatic driving of burnt area will be impacted by climate and land cover changes. In particular the combination of several factors including rural depopulation and increased fire frequency due to rising temperatures in southern Europe could lead to a general change in the dominant vegetation species, with a predominance of shrublands over forested areas (Moreira et al 2011). Other studies suggest that the change in fire regime will be different whether the climate shifts towards warmer-drier (less fire activity) or warmer-wetter (more fire activity) conditions in the Mediterranean Basin (Batllori et al 2013), a question which remains unanswered."

The authors should report the accuracy of the MCD45 fire product, as well as the minimum size of fire detected using this product.

In the submitted manuscript we wrote by mistake that we used the MCD45 fire product for our study. In fact we use a modified version of the MCD64 product, taking into account the methodology developed by Turquety et al. (2014). The horizontal resolution of the pixel is 25 ha, and the uncertainty of the detection can be high if only one single pixel is detected burnt.

However, there is no lower bound for the size of the detected wildfires in the dataset, since only the fraction of the pixel covered by vegetation is considered as burnt, which can thus be small. This has been corrected in our revised manuscript. We now also use the EFFIS data set in our revised article. . It is provided by the Joint Research Center of the European Commission, and is built using MODIS images at 250 m horizontal resolution. A first step of automated classification is used to isolate fire events and a post-processing using human visualization of the burnt scar is performed. A cross-analysis using the active fire MODIS product, fire event news collected in the EFFIS News module as well as land-cover datasets is finally done to ensure a low number of misclassifications (http://forest.jrc.ec.europa.eu/effis/). The system records burnt areas of approximately 40 ha and larger (Sedano et al. 2013). In our study, the area of the shape of the wildfire is the burnt area and the location of the wildfire, the centroid of its shape. The EFFIS data sets includes fires smaller than 40 ha but the uncertainty for these wildfires is higher. In order to provide additional proof of the differences in the behavior of BA, we modified figure 2 so that the 95 th quantile of burnt area derived from the EFFIS dataset is also. The revised figure 2 show similar results with MODIS and EFFIS datasets (see figure above). This was included in our revised manuscript.

Sedano, F., Kempeneers, P., San-Miguel-Ayanz, J., Strobl, P., and Vogt, P., 2013: Towards a pan-European burnt scar mapping methodology based on single date medium resolution optical remote sensing data. *Int. J. Appl. Earth Obs. and Geoinformation*, **20**, 52-59.

In all figure titles, when terms are used (e.g., P0, Yi, etc) these terms should be fully explained in the title, as titles should be self explanatory. Otherwise the readers will find it hard to understand what does P0 mean etc.

We agree with the referee's concern, and we modified the figure captions so that the figures become self explanatory.

Figure 3: "Polar plot of the function f(V,θ) for values of wind speed V equal to 0 (blue), 5 (green), 10 (red), 20 (cyan) and 30 m s^{-1} (purple). The f function expresses the dependency of the local fire propagation probability to wind speed and angle of propagation. Here the wind follows the x-axis direction."

Figure 4: "Evolution of the fraction of burnt cells y_2^{final} – with y_2 the fraction of cells in state "burnt" in the PCA grid – as a function of p_0 when the fire is extinct in a grid constituted of 101 x 101 cells. The simulation is performed in the absence of wind. The quantity p_0 is the constant part of the local fire propagation probability, which can be seen as a proxy of fuel density, type and moisture. The quantity p_0^{crit} is the percolation (infinite propagation in the PCA) threshold."

Figure 5: We precise here again the definition of the percolation threshold in parentheses. "p_0^{crit} the percolation (infinite propagation in the PCA) threshold" …

Figure 7: "Ratio ($p_{0,max}^{crit}$ – $p_{0,0}^{crit}$) / $p_{0,0}^{crit}$ for different values of the c_1 and c_2 parameters governing the function of local fire propagation probability. $p_{0,max}^{crit}$ is the maximum of the percolation threshold for increasing wind speeds and $p_{0,0}^{crit}$ is its value for 0 wind. The black diamond shows the (c_1, c_2) pair chosen by Alexandridis et al (2008). A strictly positive value indicates that p_0^{crit} has a maximum value for a non-zero wind speed, which ensures that the burnt area has a local minimum for moderate values of wind speed."

P 1205 l 7 "such wildfires" – large? Numerous? What do you mean?

This whole group of sentences was not clear and we removed it from the revised manuscript.

P 1205 l 12: “these” – which wildfires? by various conditions such as fuel

The sentence was modified as such: “Wildfire propagation is impacted by various conditions such as fuel moisture and load, human activities and short to long term weather (Flannigan et al., 2009)”.

P 1206 l 31 – define “percolation threshold”

The passage selected by the referee was rephrased for further clarity. “ In order to investigate this assessment we will perform a theoretical study using the formalism of PCA with varying wind speed.” We introduce the concept of percolation later in the text. The percolation threshold is the limit in terms of propagation probability above which infinite propagation in the model is possible.

P 1207 l 21-22 – not clear, please rephrase

We removed the sentence from the manuscript since the following passage helps understand what a connected component algorithm is. We also added a reference for the precise algorithmic implementation (Haralick et al 1992).

P 1207 l 24 – define what was considered as large fires in this study

Only large wildfires are investigated in the present study and they are defined as the 5% largest wildfires. These large wildfires cause the majority of the destruction (more than 50% of the burnt area in the EFFIS and MODIS datasets). This was included in our revised manuscript (section 2.3).

P 1207 l 25 – the main weakness of what? I did not understand the rational behind combining individual fire events into a single fire event, of fire events that may be 20km apart from each other.

Section 2.2 was rephrased for further clarity. We were talking about the main weakness of the application of a connected component algorithm to our 10-km-resolved gridded fire data (MODIS set). Combining individual fires into a single event allows the analysis of wildfires larger than 10000 ha (10km x 10km). At this resolution we cannot know if the events are individual or part of a single fire. It should be noted that the possible assembling of distant separate event could impact the left tail of the fire size distribution but allows for a better right tail than if we do not use the connected component algorithm. This right tail is of critical importance for the analysis of top 5% wildfires.

P 1209 l 8-11 – what is this conclusion based on?

We do not understand the referee’s remark on this point. No conclusion is present at the p.1209 lines 8-11. The highlighted passage is “Indeed, the main reason is that those models give the rate of spread as a function of wind and other parameters (such as slope or vegetation state) but do not derive total burnt area.” This sentence lacking clarity and being superfluous, we decided to remove it from the revised manuscript.

P 1214 l 15 – should the simulation domain be increased in size so as to overcome this problem?

In the case where percolation is possible in one direction, as it is the case with strong winds, the propagation will always reach the border of the simulation domain, whatever its size. Increasing the size of the simulation domain would therefore not allow to overcome this problem. In more realistic simulations the burnable domain would be finite, leading to a finite burnt area.

P 1214 l 24 – “as if to each” – this is one of many examples where English needs to be corrected

This sentence was corrected in our revised manuscript. The rest of the text was improved.

P 1215 l 9 – why (1-p) to the order of 3?

As stated in the article, in the presence of wind we can assure that in this simplified model the propagation occurs only along the wind. There is therefore 1 direction right along the wind and 2 diagonal possibilities. These are the 3 possible directions of propagation.

P 1215 l 27 – where is Spetses Island, provide a reference

The Spetses island belongs to Greece. We added the geographical location and the reference to Alexandridis et al (2008) in our revised manuscript.

P 1216 l 8 – which is case study? Provide reference. Is one case study enough for validation?

The case study we are referring to is Alexandridis et al (2008). One case study is not enough for validation of the (c_1,c_2) parameters. That is why we test the robustness of the observed phenomenon versus these two parameters (submitted Figure 7).

Figure 3 – what do the values on the x and y axes mean?

Figure 3 is a polar plot of f(V,θ), therefore the x and y values are the coordinates of f(V,θ). Figure 3 was modified so that the fact that it is a polar plot is more straightforward. See new figure 3 below.