Clustering of eruptive events from high precision strain signals recorded during 2020-2022 lava fountains at Etna volcano (Italy) by L. Carleo, G. Currenti and A. Bonaccorso

My apologies for the day in making the review.
The manuscript shows an application of a machine learning technique for classification of lava fountain events at Mt Etna. To do so, they consider the period between December 2020-February 2022 when more than 60 lava fountain events took place. They cluster strain changes records in terms of features as the duration, the amplitude and the time derivative of the strain signal. The authors propose a novel approach to show the power of machine learning techniques to elude the subjective biases of manual classification of lava fountain episodes in terms of behavior. The manuscript shows an innovative method that could be very useful to an objective classification of eruption events. Nevertheless, the authors should improve the way the results are presented.

General comments

1. Introduction
The introduction is well structured. Some things to take into account that can be helpful to easily follow the work can be a very short description of the classification of eruption styles at Etna that is afterwards used at "Discussion and Conclusions" (TA, LF, LSLF, etc). This description can be introduced in paragraph that contain line #15.

2. Strain Changes during the Etna lava fountains in 2020-2022
The strain and strain rate signals are described in three parts. How is this description related to the change of curvature (inflection point) of the strain signal?

The use of 10 nstrain/ as the threshold to define the onset of period should be shortly explained at the text.

Figure 1b could be removed since there is not any reference to the figure at the main text of the manuscript.

Figure 2 (a,b) could be improved by adding shadows to the graphics to show up the different periods of the sequence of lava fountains. Furthermore, it could be helpful to print a vertical line on Figure 2(b) to highlight the strain event shown at Figure 2(c) .

3. Clustering of lava fountains
This section should be completely re-organized. A brief introduction about k-means method in terms of the way that the objects are grouped would be very welcome at the beginning of this section. Furthermore, I would explain main concepts such as centroid, points, etc as well as the drawbacks of the method.

Appendixes A and B are intended to explain the procedures developed to avoid the drawbacks of k-means algorithm and to show their quality. Nevertheless, the description of the results as well as the graphic results should have been removed from the appendixes and be thoroughly explained in the main text. The Table B1 with the features considered in the cluster analysis should be part of the main text too. Some attention should be paid to improve the way graphic results (Figure B1, Figure B2) are presented. Some ideas: the x-axis of Figure B1a and FigureB1b should be the same (both of them the parameter k which indicates the number of clusters). What is the meaning of elbow in Figure 1Ba? I am not able to discern the average silhouette values for k = 4 mentioned in the main text. Figure B2 can be presented in a more compact way…

I think Table 3 should be Table 1.

4. Discussion

It is mentioned in the text (section 2) that 58 strain signals are used for the analyzed period. What is the ratio of these strain signals with respect to the total number of lava fountains? Is this an usual observational ratio for this kind of events? Is this ratio enough to describe the eruption different behaviors observed at Etna? How representative is the studied period in terms of the classification of the eruption behavior at Etna?
Although these aspects are briefly described in the first paragraph, some lines about quantification and significance of these aspects will be very welcome.

The classification is made with different features that are described in Table B1. Some comments about the final choice of the features to make the classification in terms of both the way the algorithm works and the relationship with the eruption styles and some of the possible physical processes involved will be very welcome. The time interval between the events is not included between the features considered to make the classification. Could you comment on that?

k-means algorithm allows the identification of cluster 4. In previous works, the events of cluster 4 are classified in different way. Could you briefly comment on the impact of this fact? It should be done in terms of the power of the method for objective classification; in terms of eruption styles and in terms of the transition between Cluster 2 and Cluster 1 that Cluster 3 does not provide. Are the number of elements (Cluster 4 consists of 2 points ) enough to describe an eruption style? Any idea of what properties can modulate this behavior in terms of the eruption styles? Is there any relationship between the features that define the clusters and the characteristics of the eruption styles? In that case, what does it mean?

Figure 4 should include the temporal line showing the different periods (just the same as in Figure 2).