DETECTING THE PREPARATORY PHASE OF INDUCED EARTHQUAKE AT THE GEYSERS (CALIFORNIA) USING K-MEANS AND LSTM

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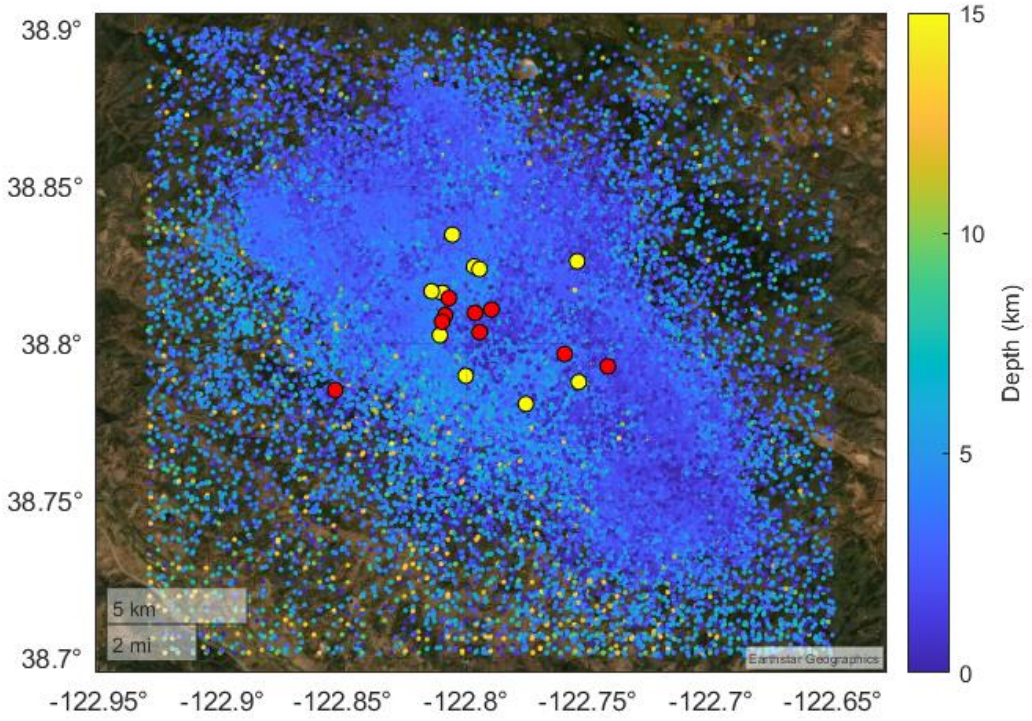
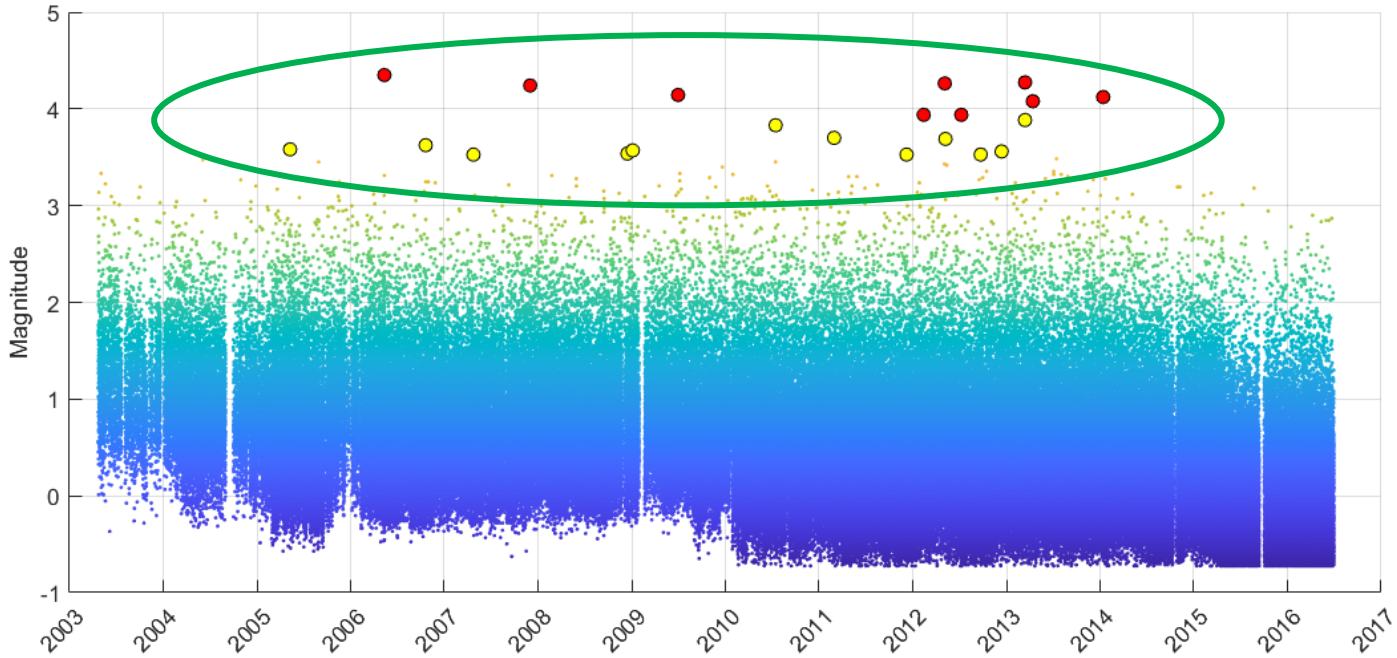
THE GEYSERS DATASET



More than 400.000 events, with magnitude range of (-0.7,4.3).

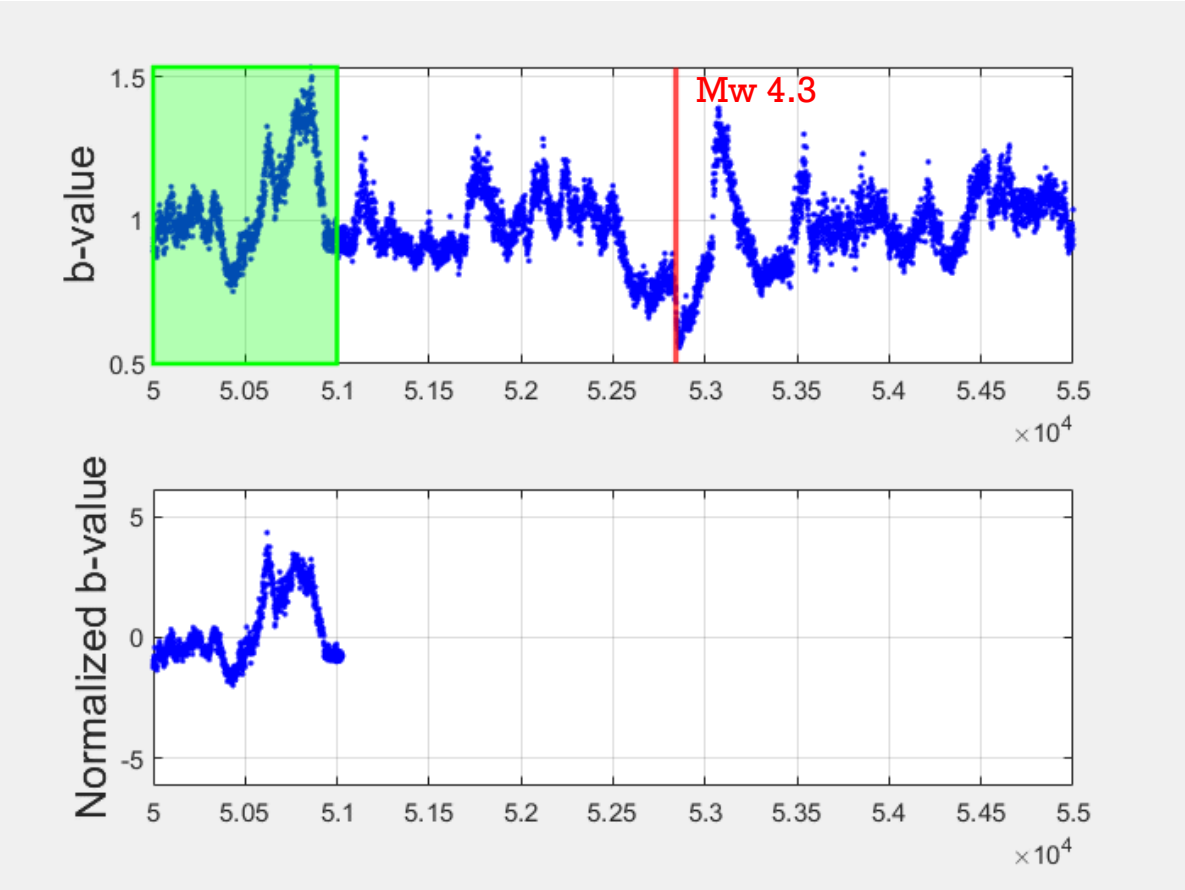


FEATURES NORMALIZATION

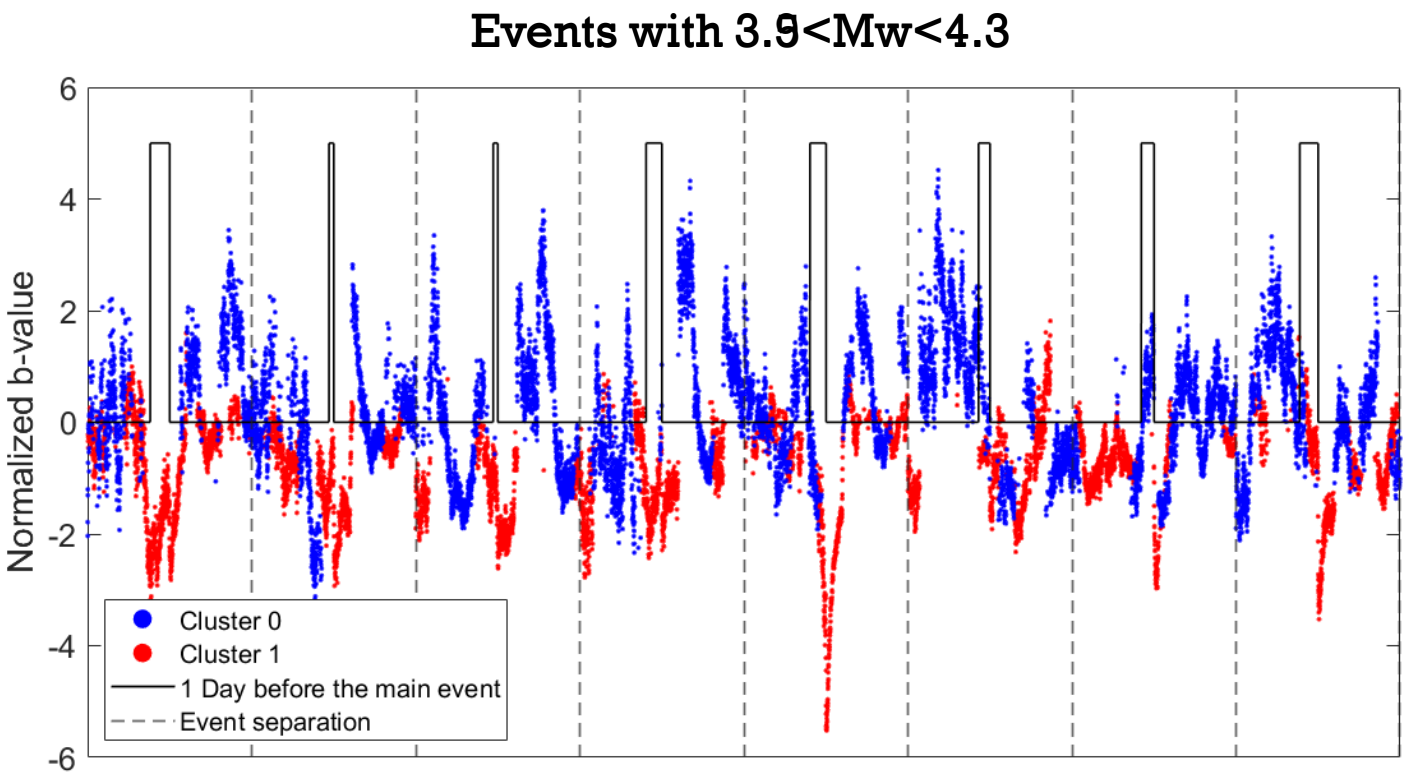
Following the results of our previous work (Picozzi and Iaccarino, 2021), we computed physics-related features using a 200-event moving window on catalog information.

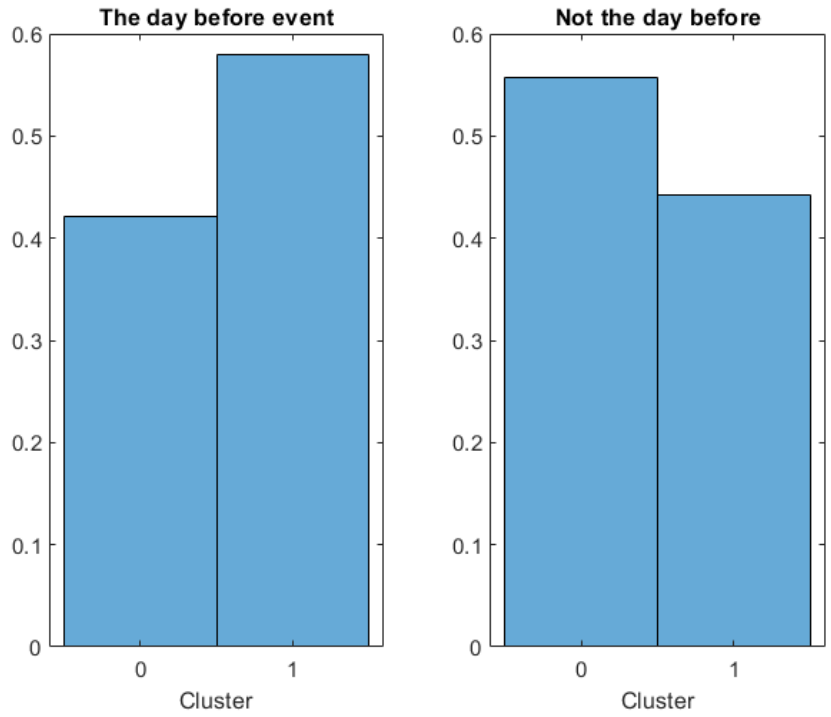
We used 5 features (b, Mc, Dc, dt, ΔT) to unveil the possible presence of preparatory phase.

We standardized these feature using a moving procedure, in order to maintain the causality of the method.



K-MEANS CLUSTERING

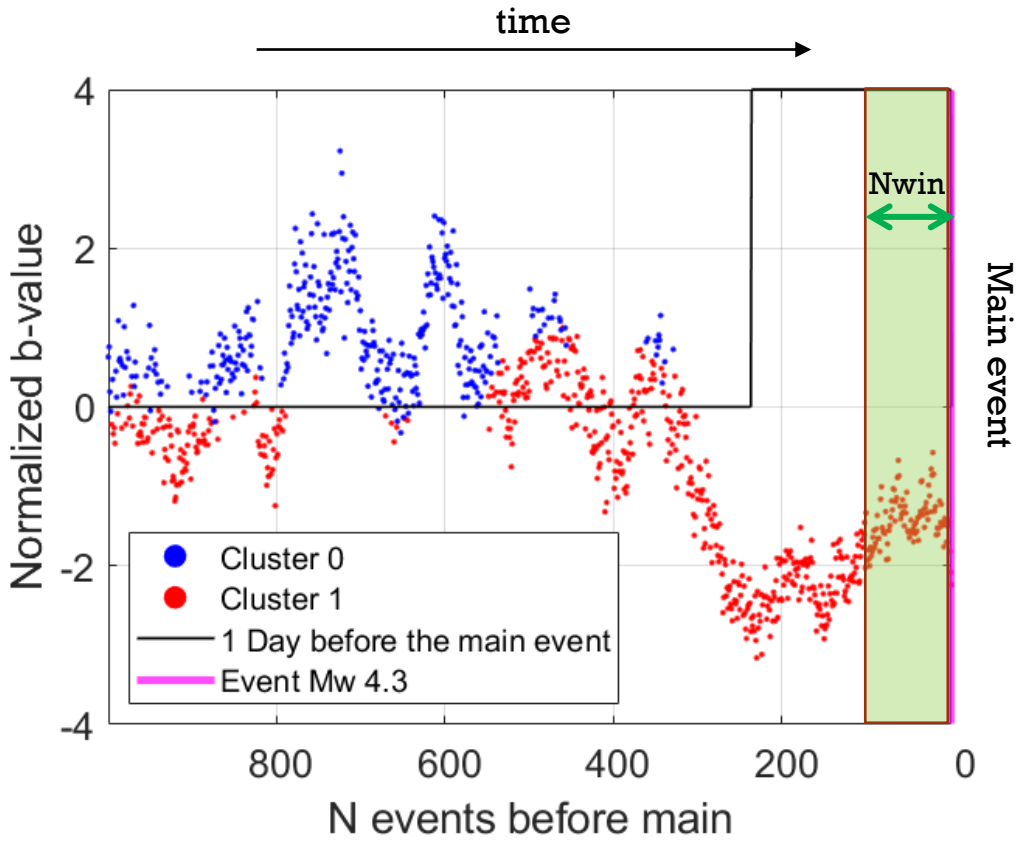




LABELING THE PREPARATORY PHASE FROM CLUSTERING ANALYSIS

Let's define the deviation from homogeneity (Δ_{Cl1}) in this way:

$$\Delta_{Cl1}(N_{win}) = \frac{N_{cl1}(N_{win})}{N_{win}} - \frac{N_{cl1}(1000)}{1000}$$



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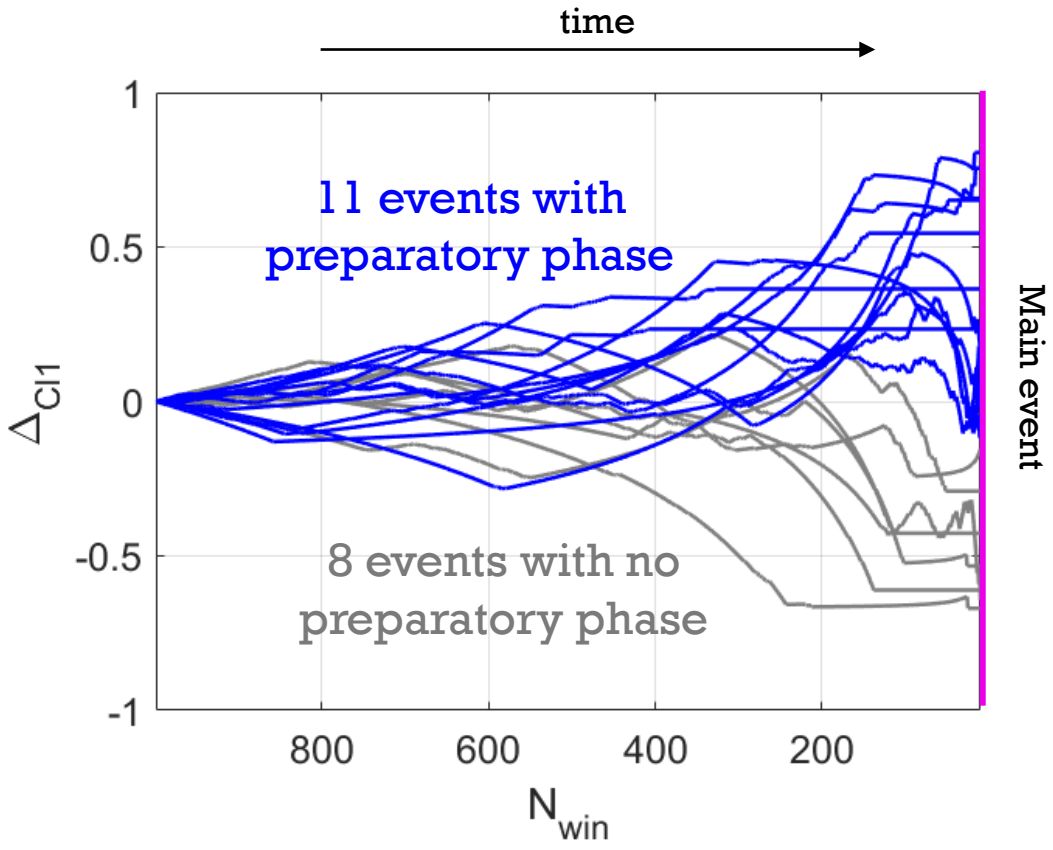
Finally, we found a prepatory phase for 11 events on 19.



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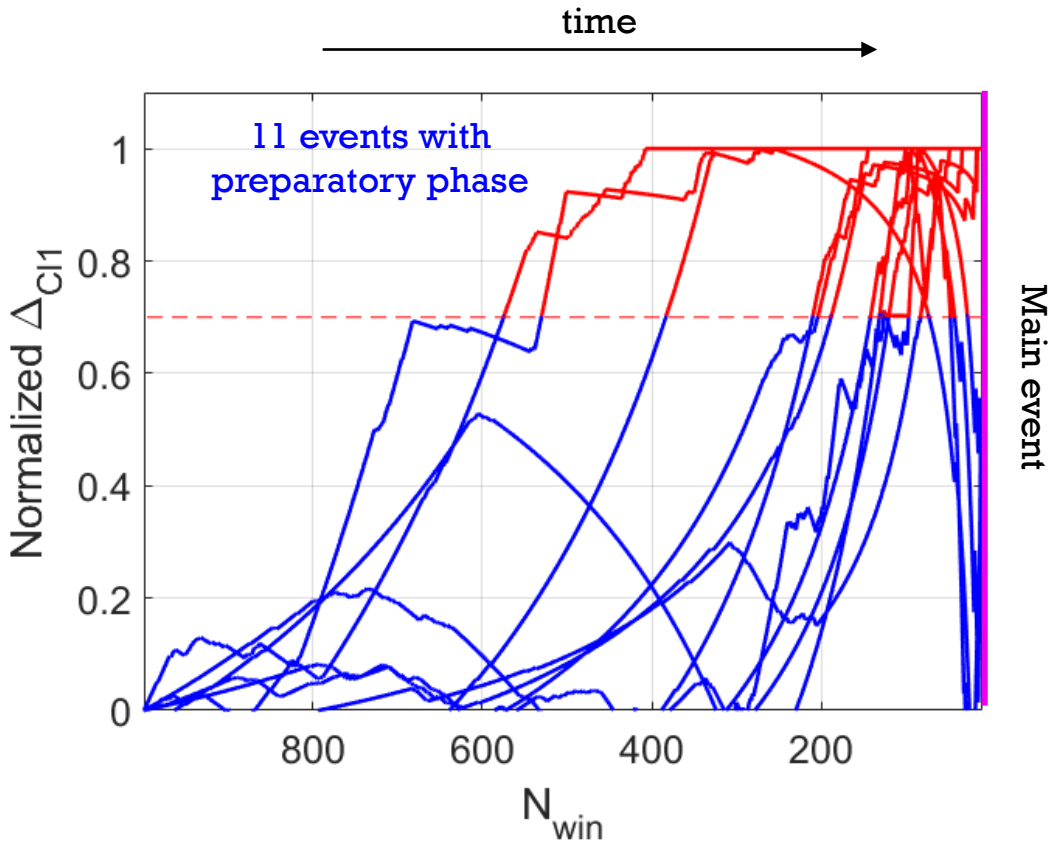
$$\Delta_{Cl1}(N_{win}) = \frac{N_{cl1}(N_{win})}{N_{win}} - \frac{N_{cl1}(1000)}{1000}$$

Finally, we found a prepatory phase for 11 events on 19 with a duration that goes from 14h to 4 days.

We used this results to label the data.

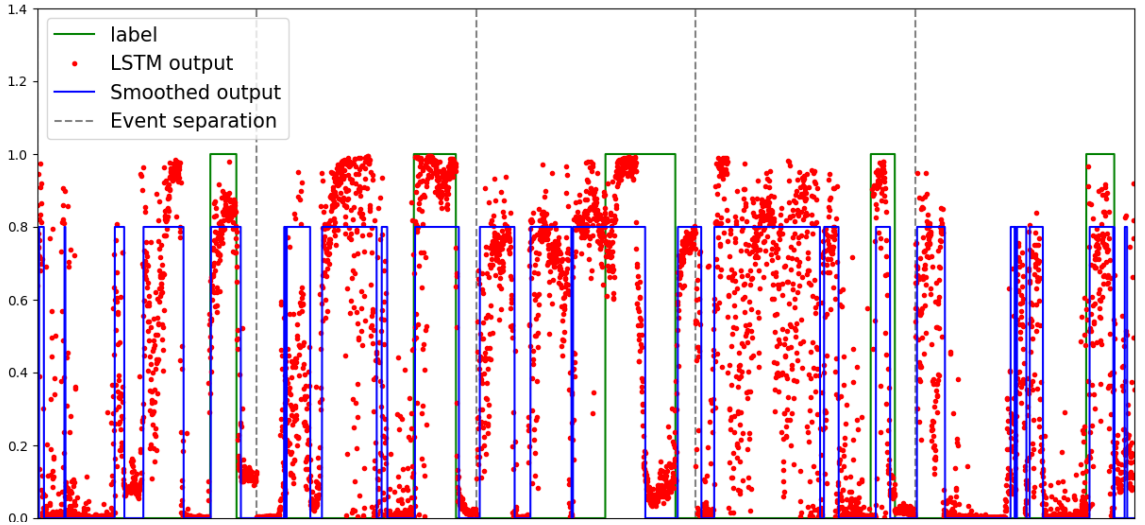


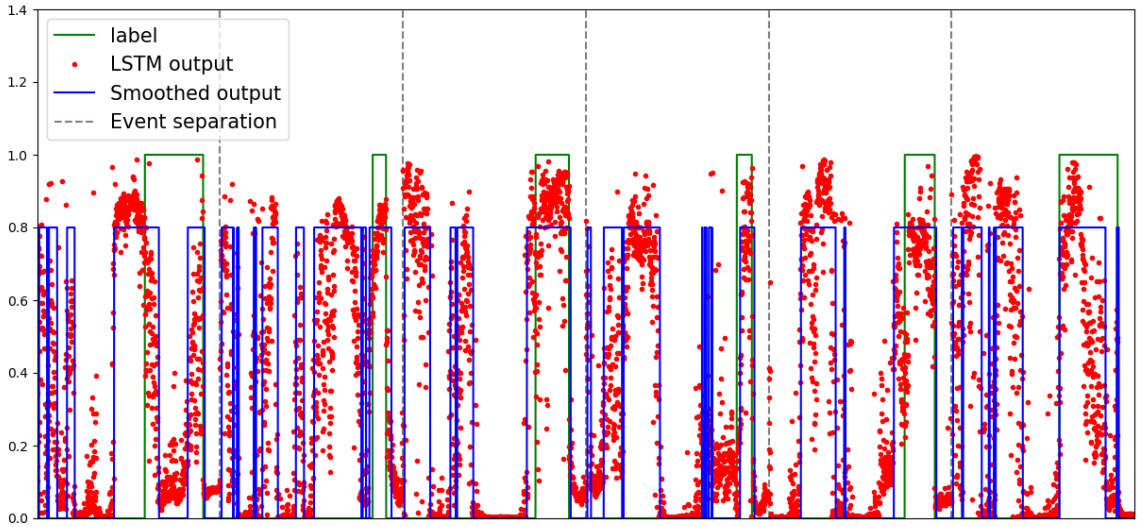
LSTM ANALYSIS

For this analysis, we divided the 11 labelled events into training (6 events) and testing (5 events) sets.

We tuned the LSTM through cross-validation on the training set and apply the best model.

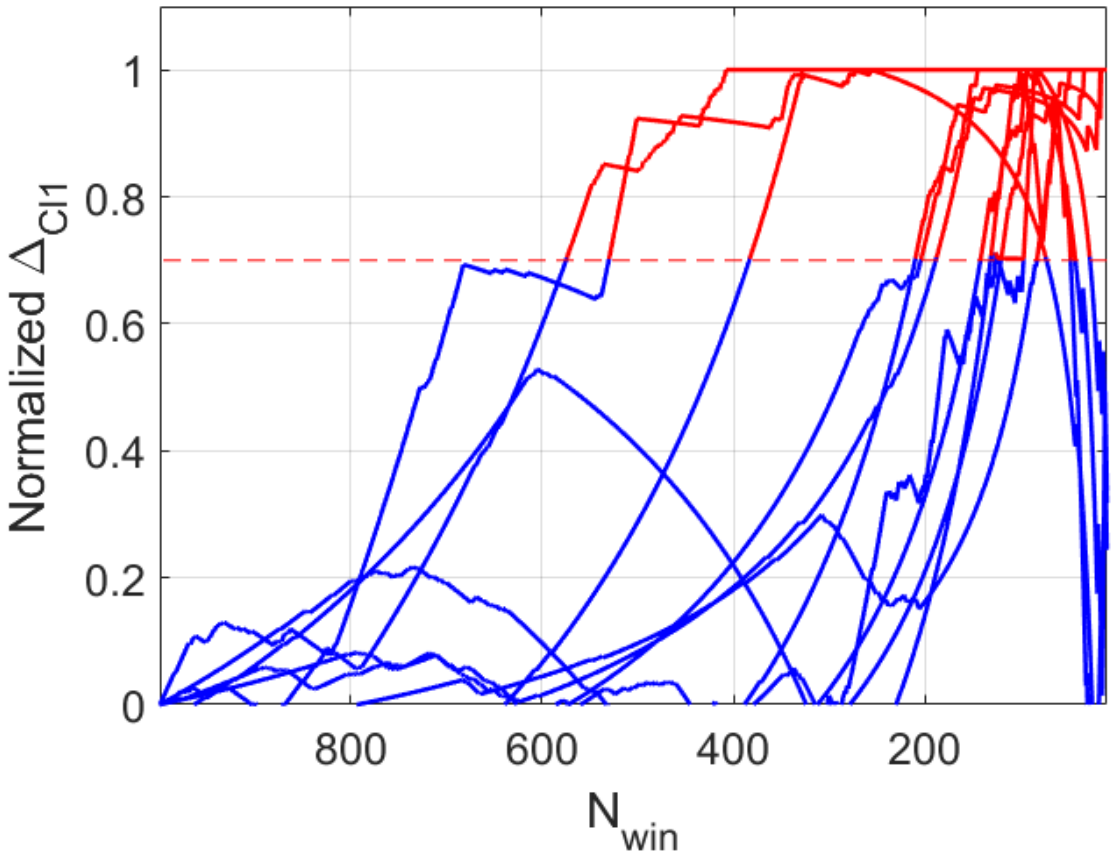
We mostly retrieve the results of the k-mean analysis also on the testing set.





CONCLUSIONS

- We selected 19 events M3.5+ from The Geysers dataset and looked for the presence of a preparatory process through seismicity-related features
- We maintained the causality of the features performing a moving standardization.
- We firstly used a K-mean clustering, finding that is possible to divide the seismicity into two clusters. We associated one of them to background seismicity and the other to a preparatory phase.
- We find a preparatory process for 11 M3.5+ that goes from 14h to 4 days and used these results to label the preparatory phase.
- Then we used these labelled data into a LSTM recurrent neural network confirming the presence of preparatory process for those events.



THANK YOU FOR THE ATTENTION!