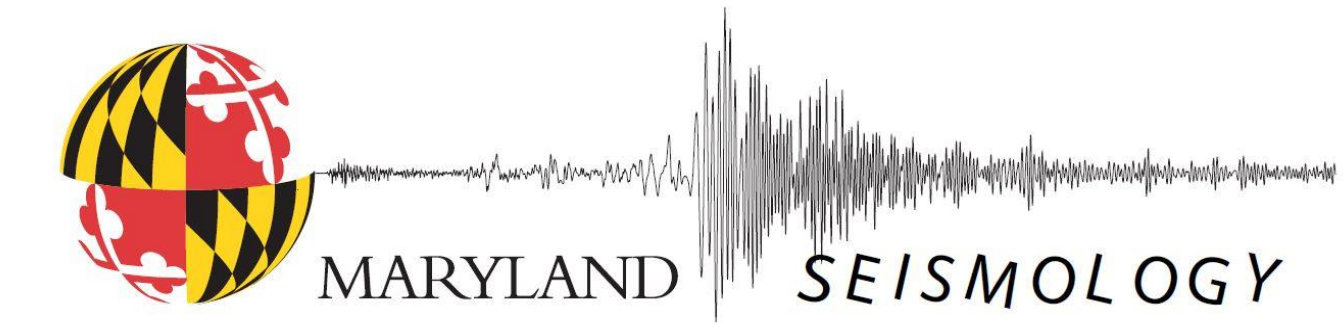


Characterizing Seismic Swarm Morphology

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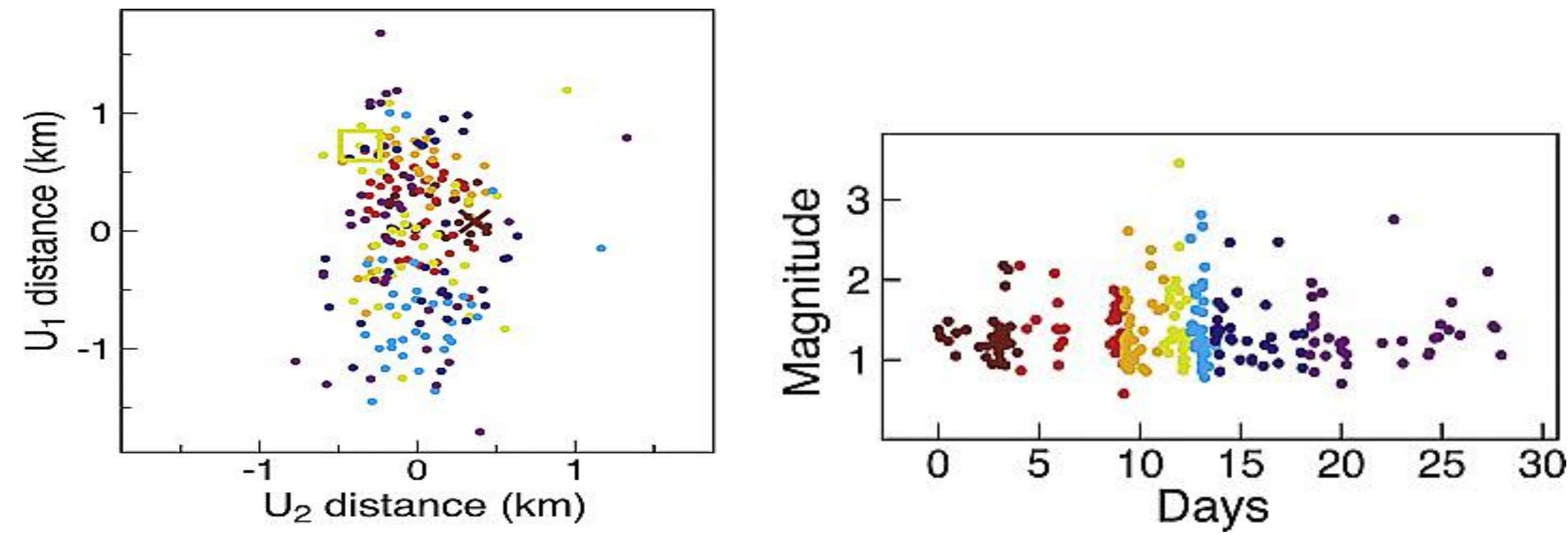


ABSTRACT

Seismic swarms are characterized by an anomalously large number of earthquakes occurring in a relatively small area, typically ranging from a few to several kilometers, over a short period of time, typically ranging from days to weeks. I propose that if a full seismic swarm catalog were to be compiled and analyzed, the sequences will demonstrate a much more even distribution in space and that a larger fraction of swarms will be shown to migrate in both time and space. Finally, I propose that over time, a smaller fraction of swarms will exhibit an exponential decay in event occurrence over time.

METHOD DESCRIPTION

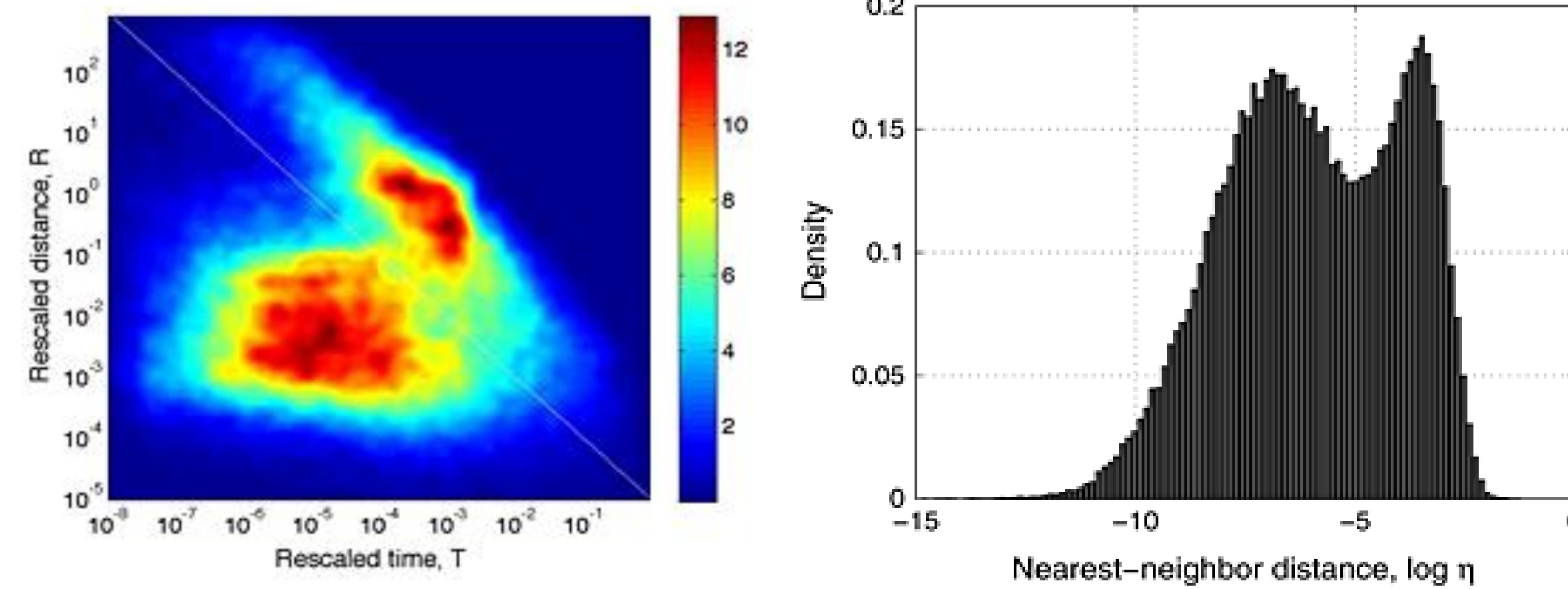
Vidale and Shearer (2006) (VS2006):



Used a set of arbitrary thresholds criteria

- 1) An initial event must be followed by at least 39 events within a radius of 2 km in 28 days
- 2) There must be 3 or fewer events in the prior 28 days within the same 2 km radius
- 3) No more than 20% more events can occur between 2 and 4 km from the initiating event in the same 28 days afterwards.

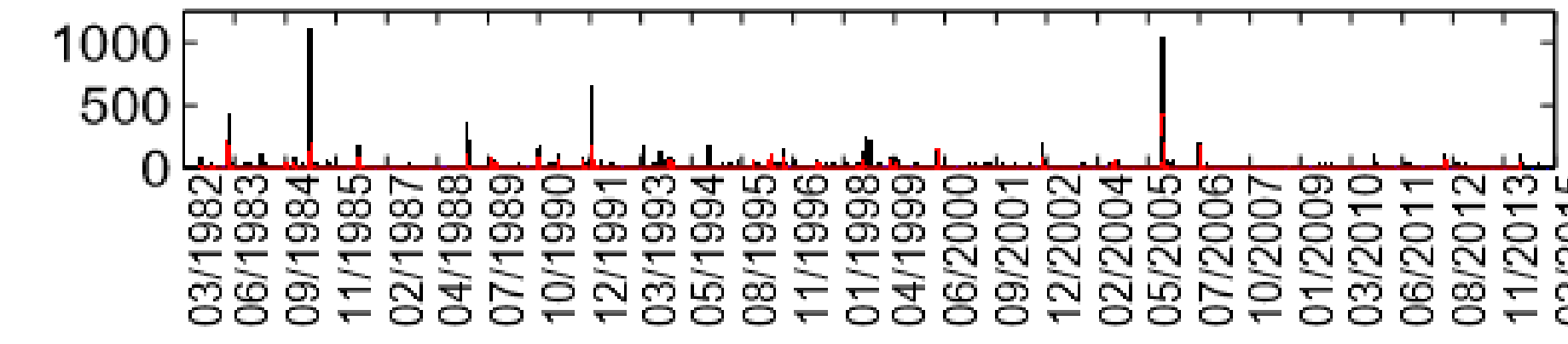
Zaliapin et al. (2008) (Z2008):



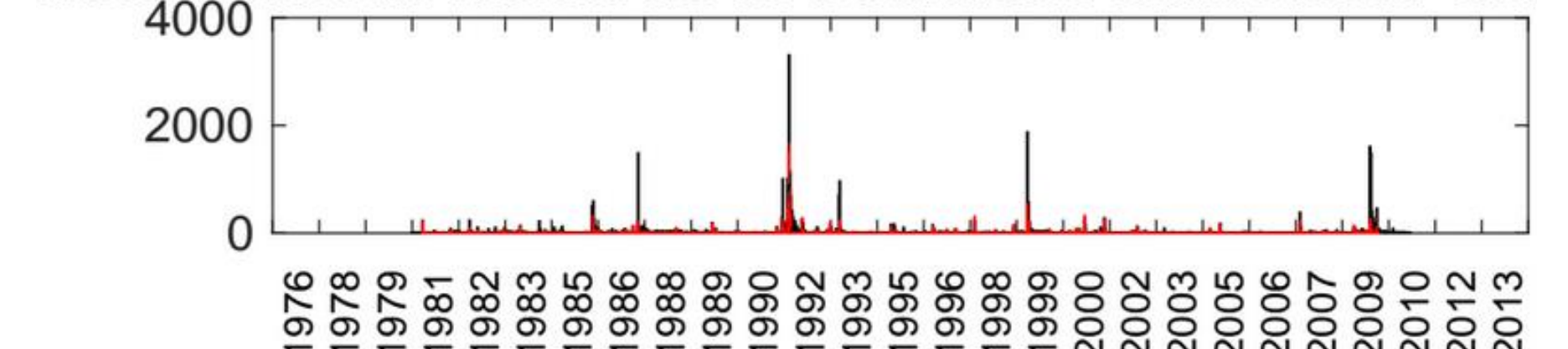
- Calculated normalized interoccurrence time (T_{ij}) and spatial distance (R_{ij}) between pairs of events
- Multiplied these two parameters to produce a nearest neighbor distance η_{ij} .
- Used to identify two statistically distinct earthquake populations
- Concluded that seismic swarms could be identified using their clustering in the spatial-temporal-energy domain.

CLUSTERING ANALYSIS: Z2008 VS VS2006

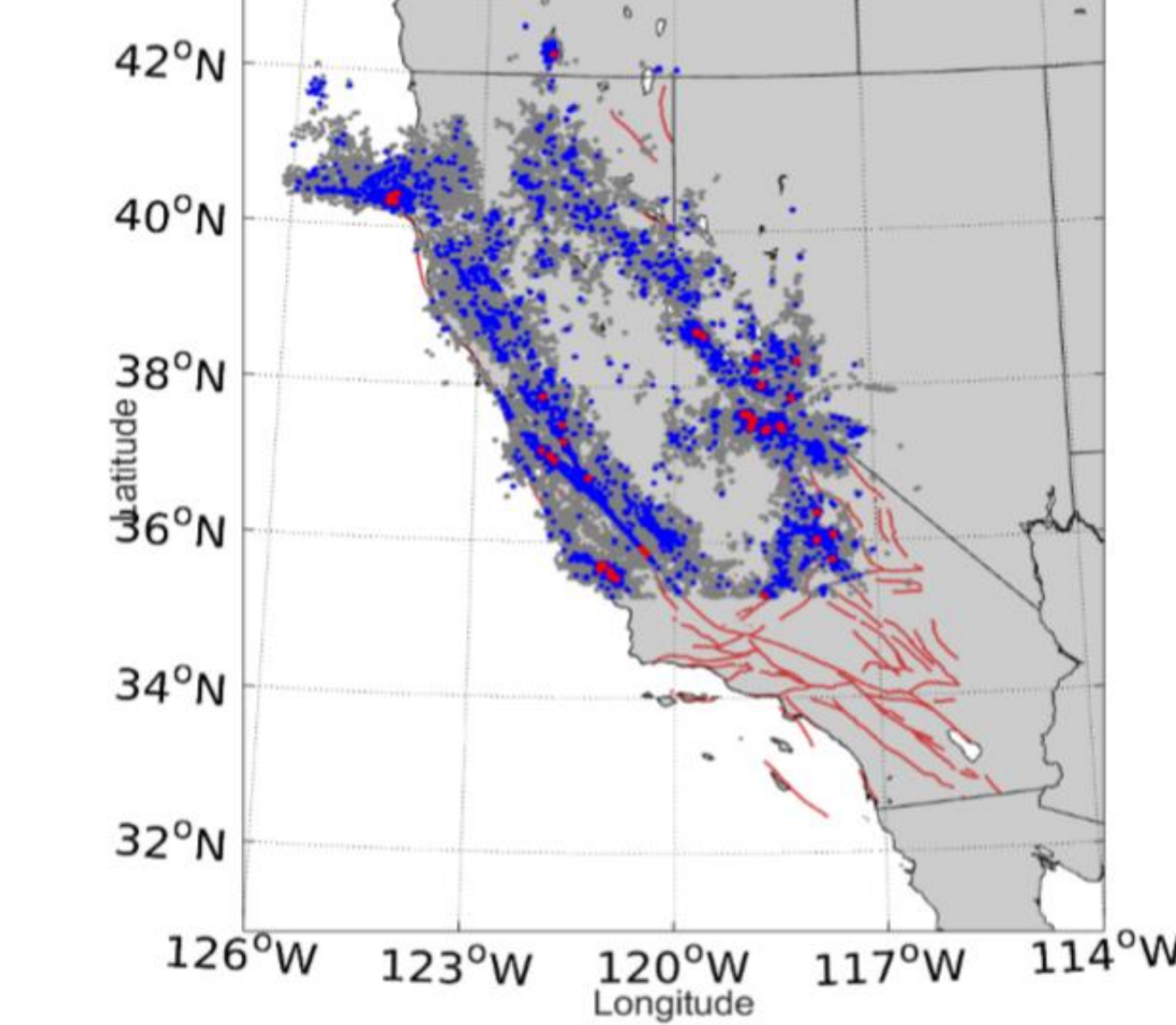
NCA Time Distribution both Methods: Original Thresholds



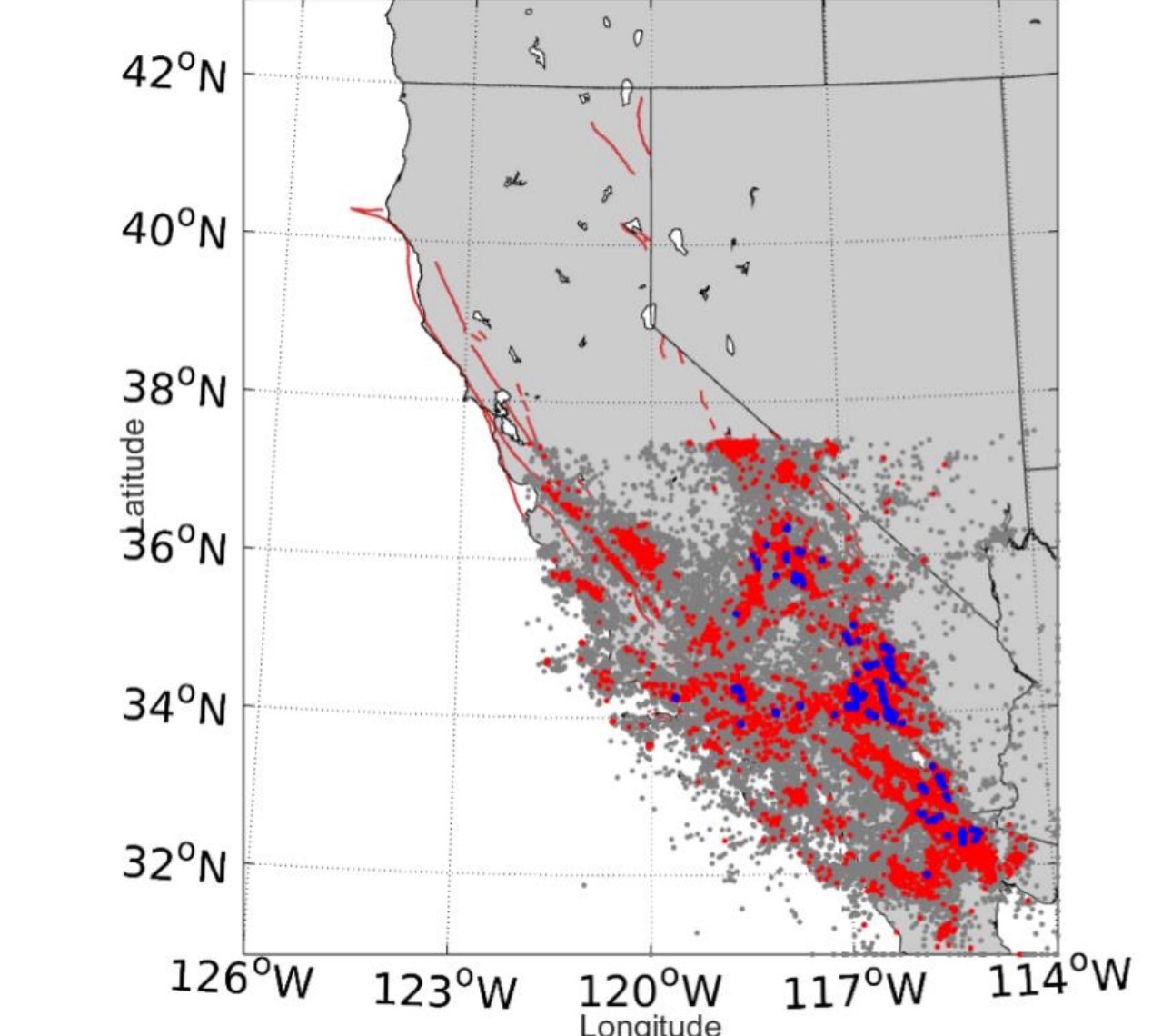
SCA Time Distribution both Methods: Original Thresholds



NCA Original Thresholds: VS2006 and Z2008 Plotted Over All Events



SCA Original Thresholds: VS2006 and Z2008 Plotted Over All Events

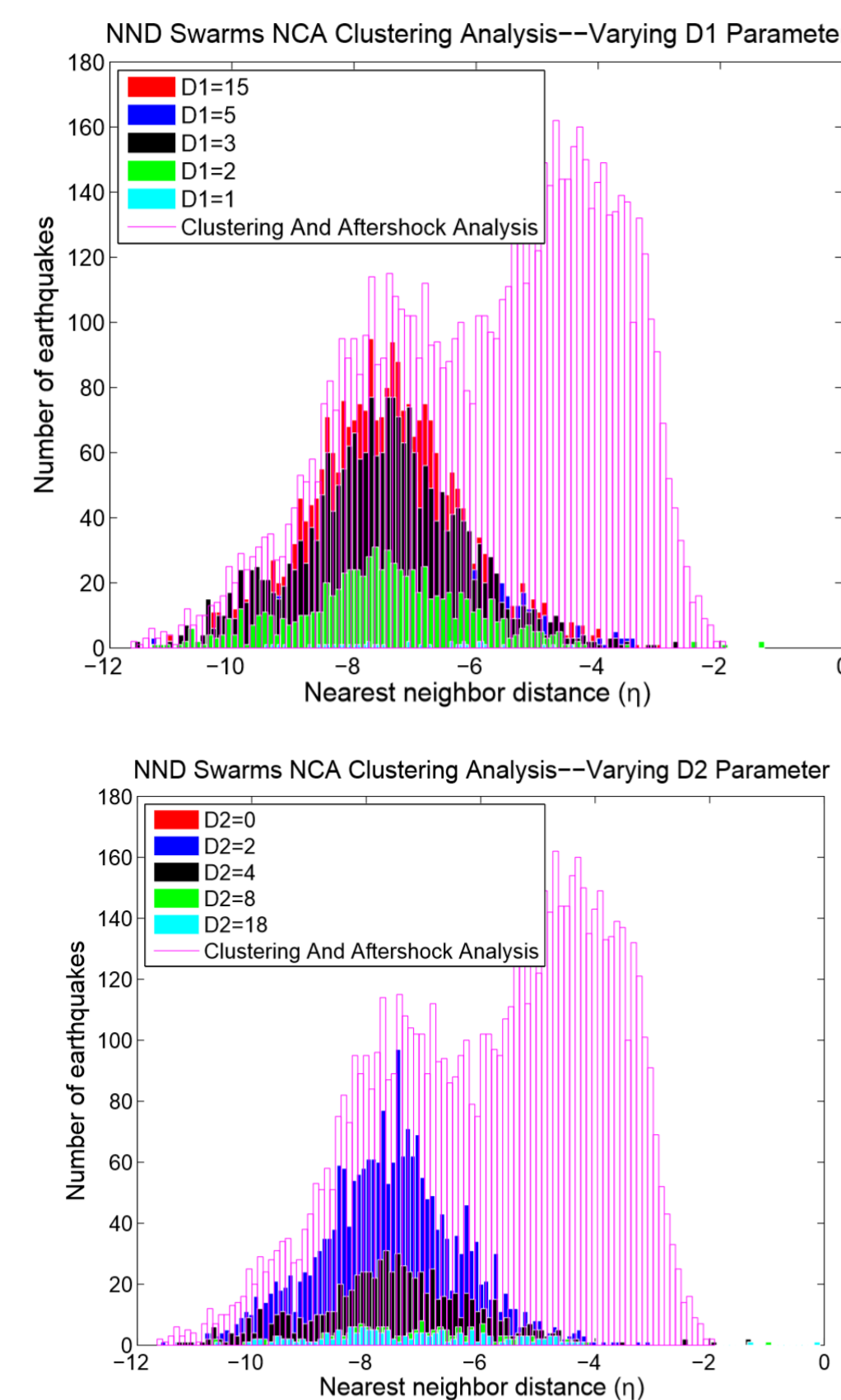
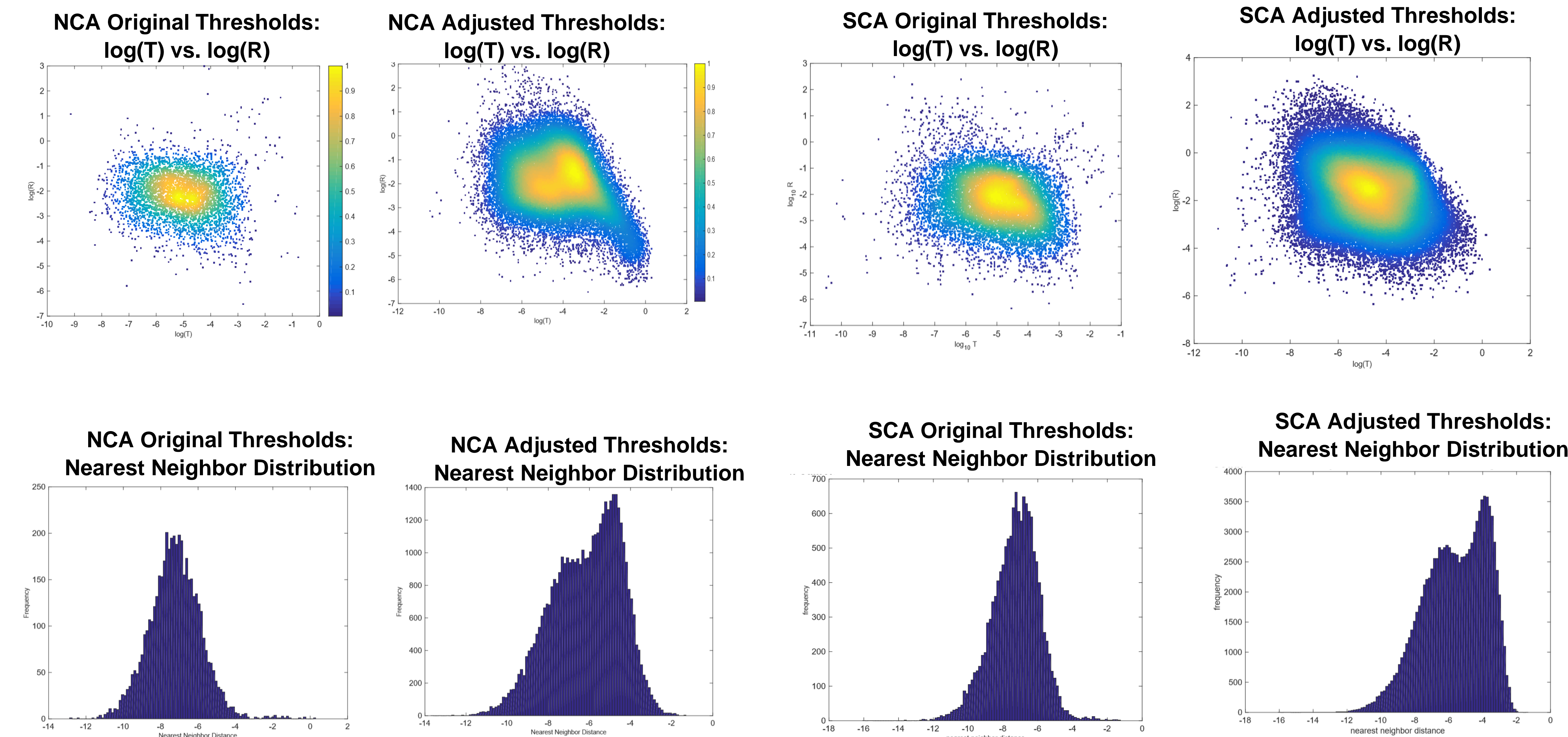


- 85 clusters missed total

CONSTRAINTS ON THE THRESHOLDS

EXTENDING THE ORIGINAL THRESHOLDS

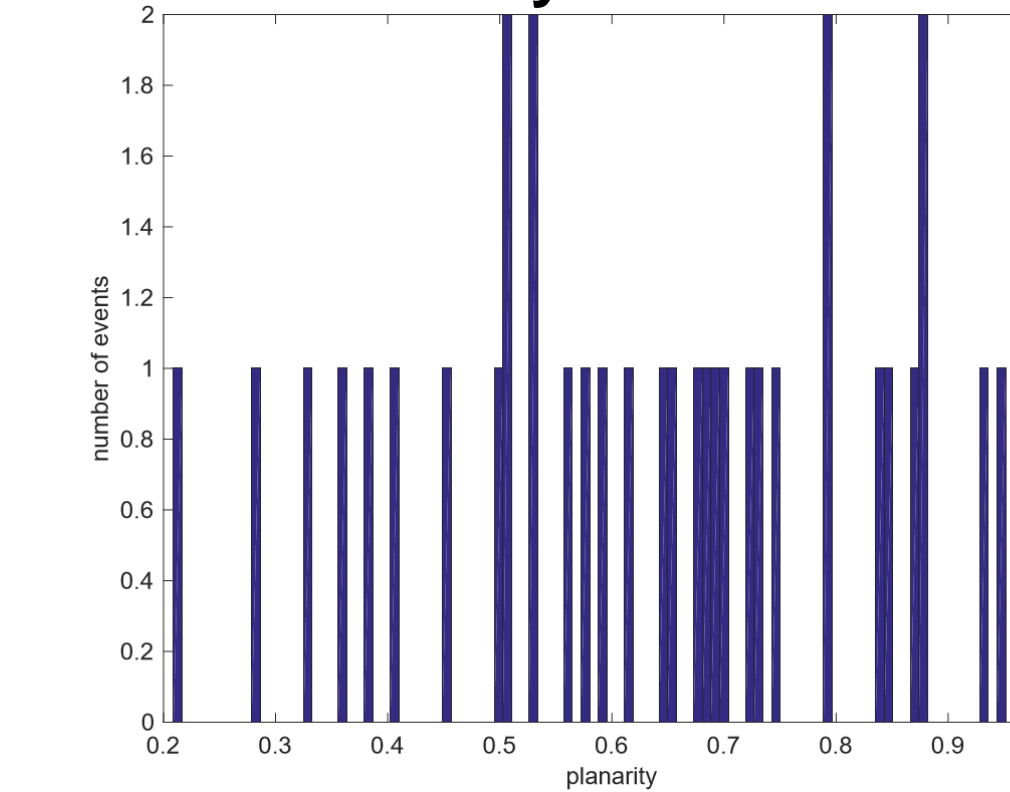
ANALYSIS OF ORIGINAL VS ADJUSTED THRESHOLDS



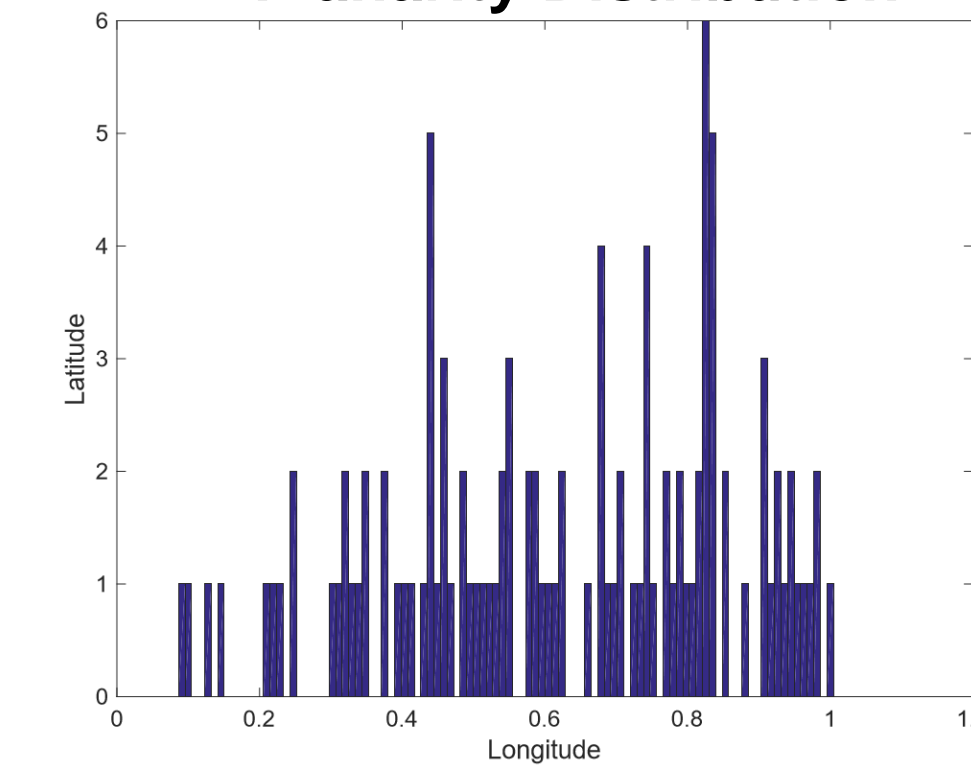
Strongest controls on whether thresholds would identify swarms:

- Time
- Radius of swarm
- How many events occurred in prior same number of days

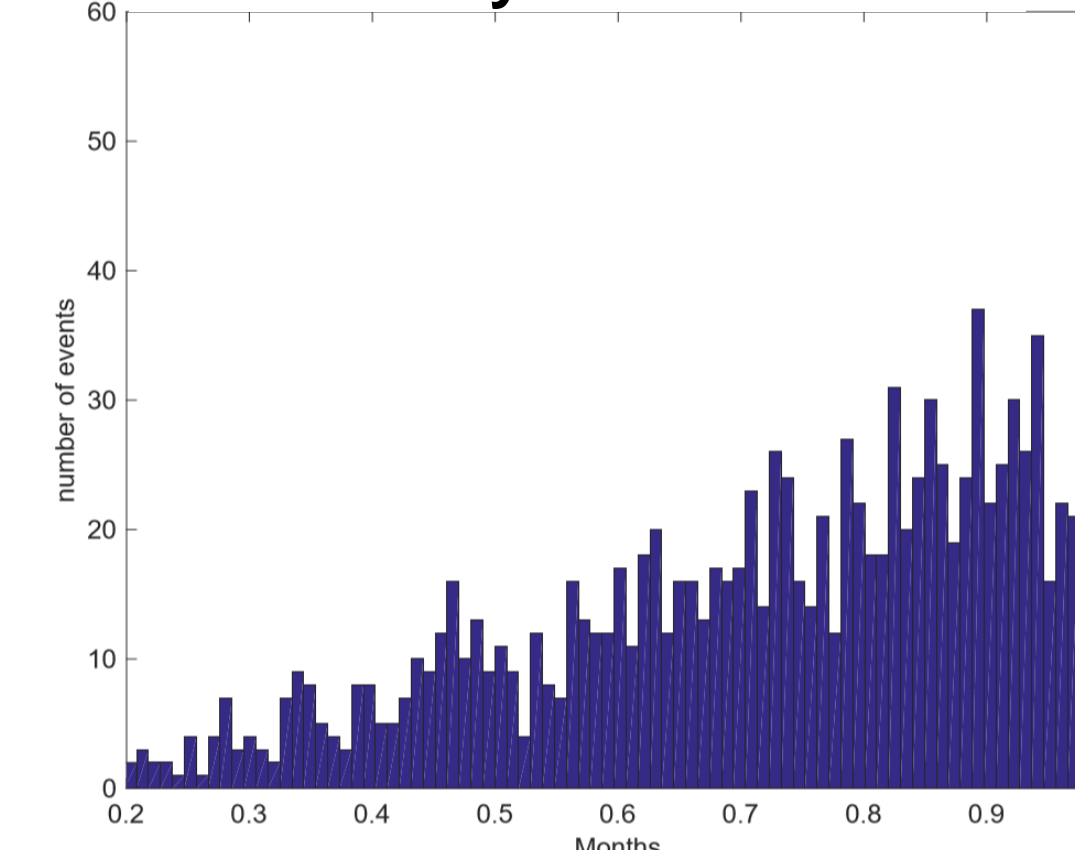
NCA Original Thresholds: Planarity Distribution



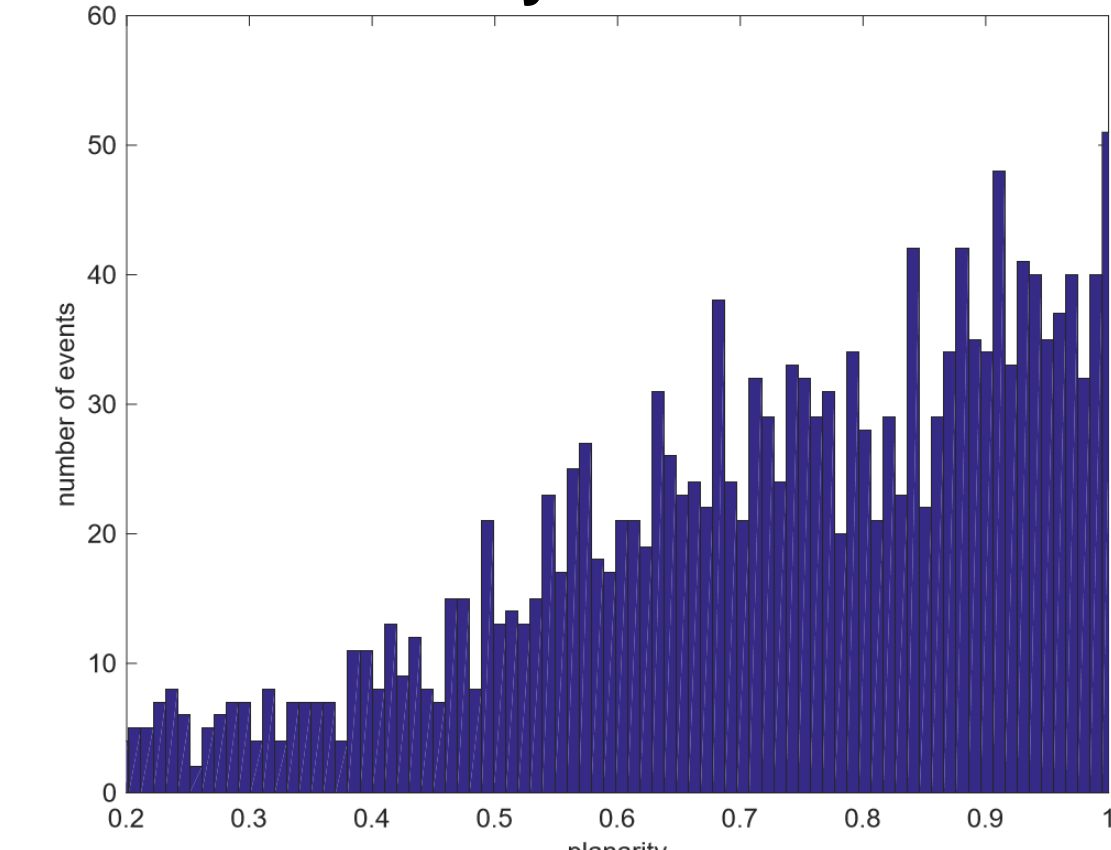
SCA Original Thresholds: Planarity Distribution



NCA Adjusted Thresholds: Planarity Distribution



SCA Adjusted Thresholds: Planarity Distribution



Time ratio between 0.8-1.5:

- Original thresholds in NCA and SCA: 1/37 and 10/108 swarms
- Adjusted thresholds in NCA and SCA: 323/39,756 and 376/83,479 swarms

Expansion ratio between 0.8-1.5:

- Original thresholds in NCA and SCA: 9/37 and 26/108 swarms
 - Adjusted thresholds in NCA and SCA: 455/39,756 and 1730/83,479 swarms
- Planarity distribution between 0.8-1.5
- Original thresholds in NCA and SCA: 3/37 and 94/108 swarms
 - Adjusted thresholds in NCA and SCA: 1052/39756 and 1456/83479 swarms

CONCLUSIONS

By expanding the original thresholds, able to demonstrate a more complete catalog of seismic swarms of which a larger fraction did not exponentially decay, were shown to have an even distribution in space, and migrated through time compared to the original thresholds.