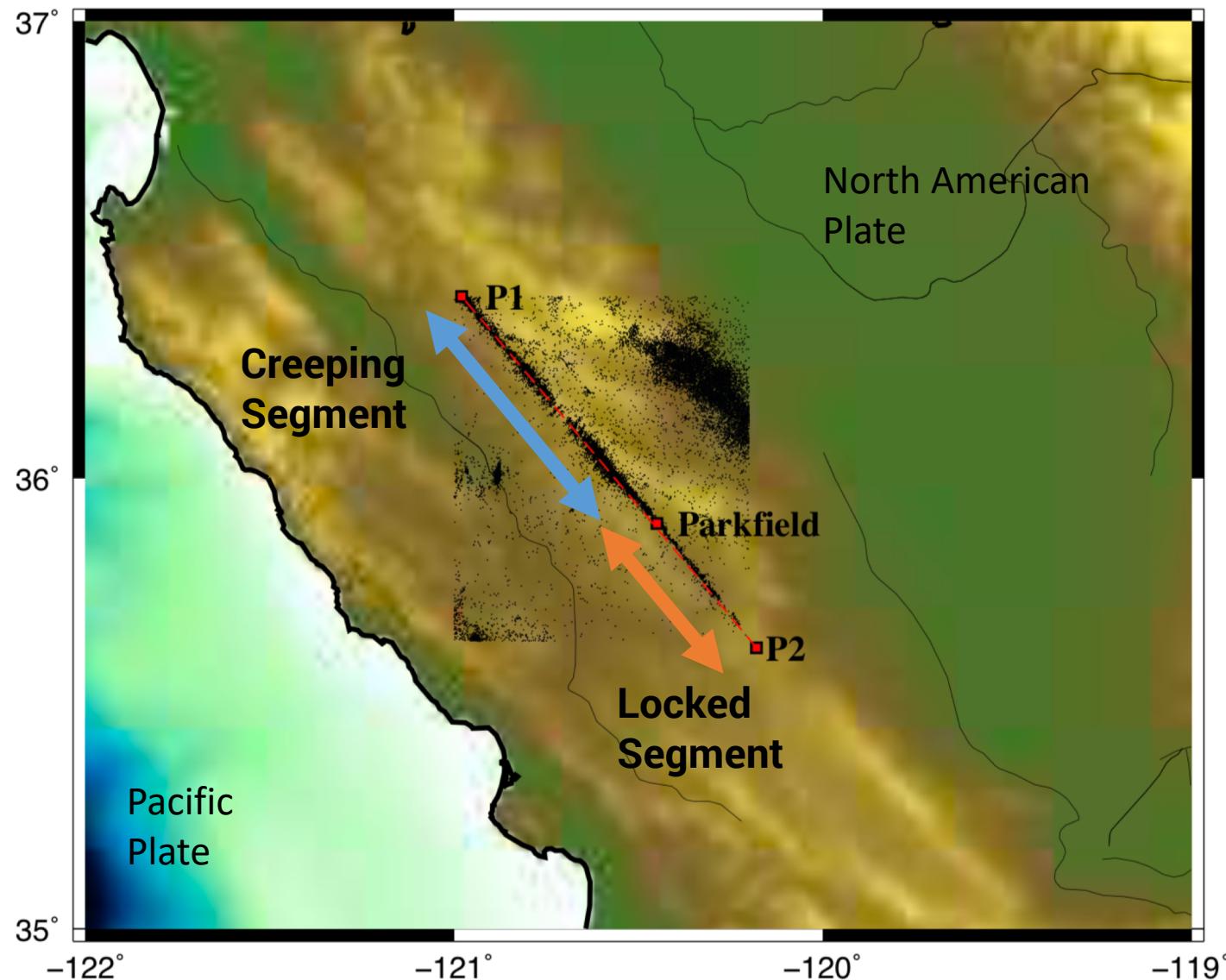


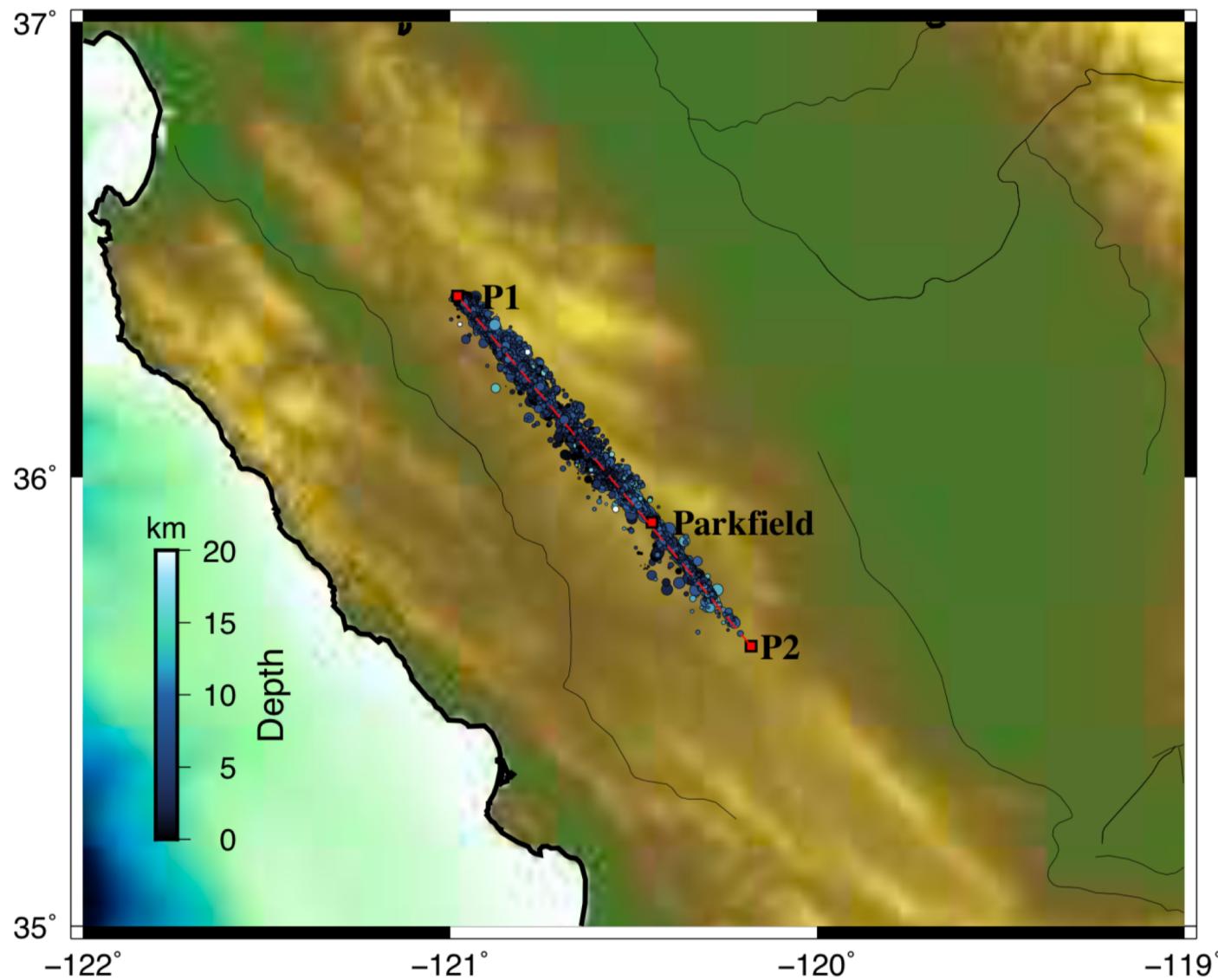
Spatial and temporal variation in b-values in the Parkfield segment of San Andreas Fault

Earth 483: Final Presentation
Prithvi Thakur

Study Area



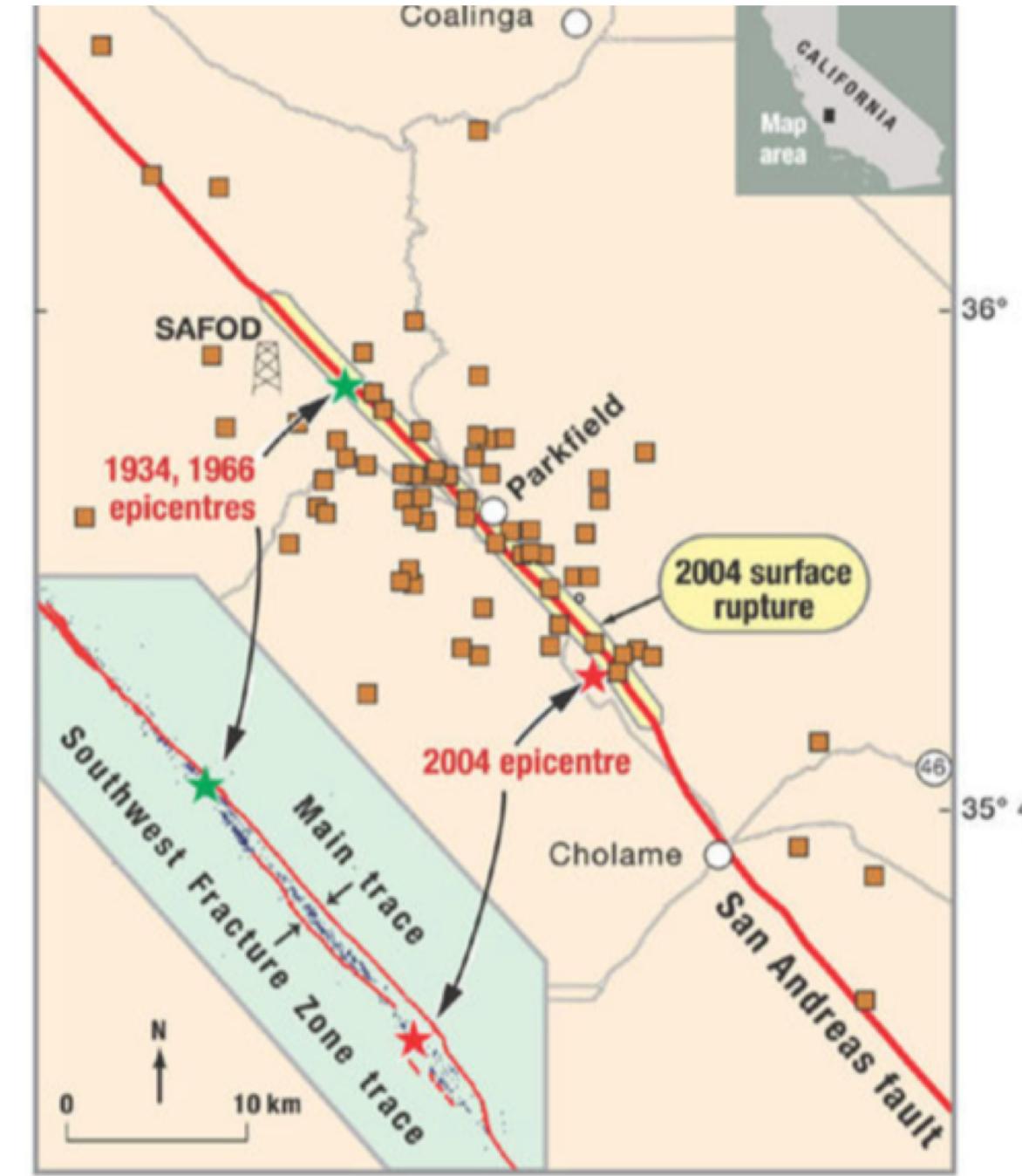
Study Area



The Parkfield Conundrum

- History of ~M 7.0 earthquakes periodically repeating in time.
- Past two earthquakes: 1934, 1966.
- SAFOD experiment setup to predict the next one.
- Predicted: Before 1993; Actually happened in 2004.
- 1966, 1934 ruptures propagated in opposite direction to the 2004 one.

Image: Bakun et al., 2005.



Research Questions

- How does the b-value vary along depth and along strike of the fault segment?
- How did the b-value distribution change after the Mw 6.0 2004 earthquake, the biggest one since 1967? Does the b-value distribution go back to its previous values after the event?
- Is this change in agreement with the variation in stress drop?

The earthquake catalogue

Northern California Earthquake Data Center
01/01/1967 - Present

Time Period 1:
01/01/1967 – 08/30/2004

- Interseismic Period
- ~11,000 events

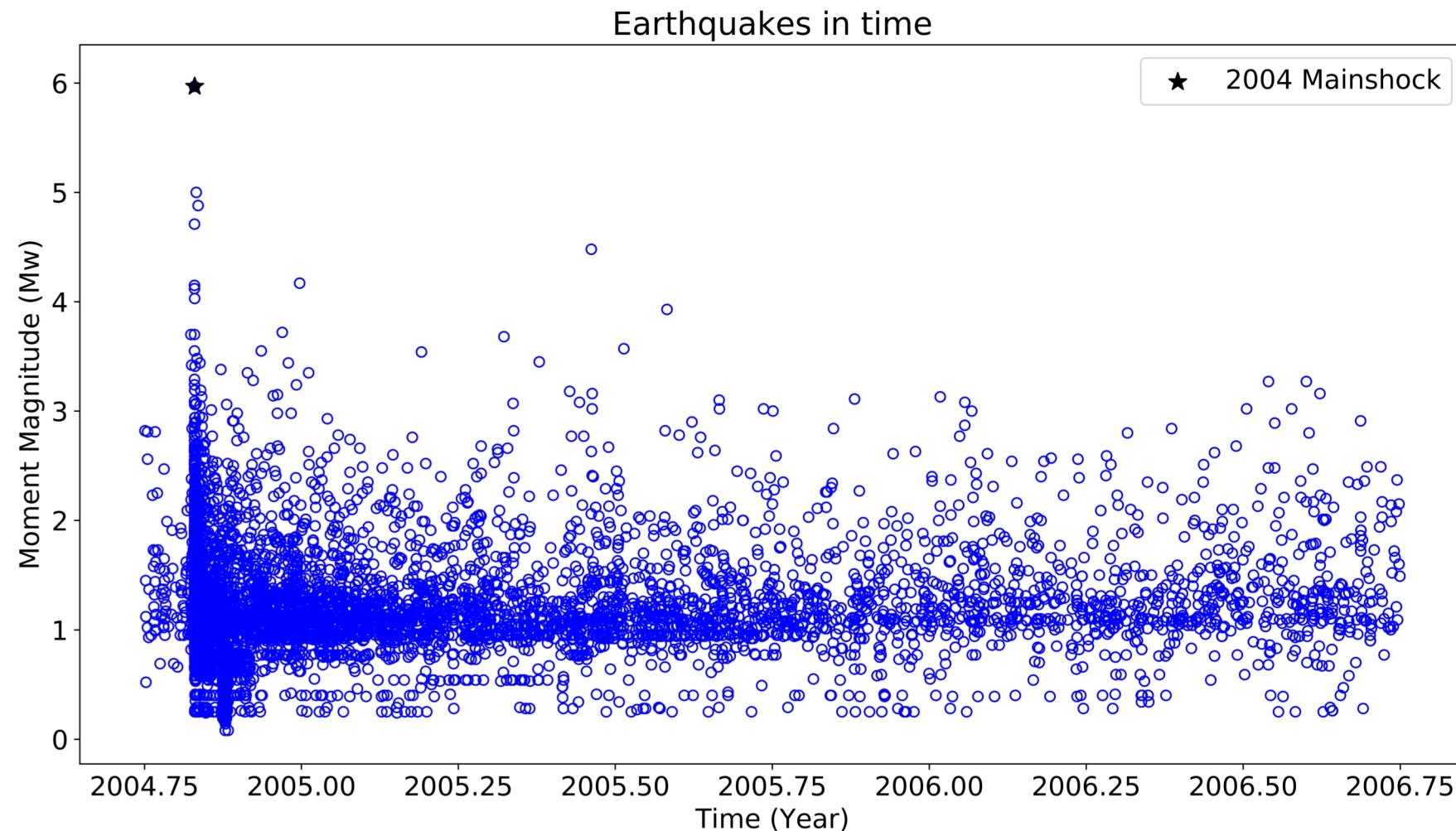
Time Period 2:
08/30/2004 – 08/30/2006

- Seismic Period
- Time of Mainshock:
09/28/2004
- ~6,000 events

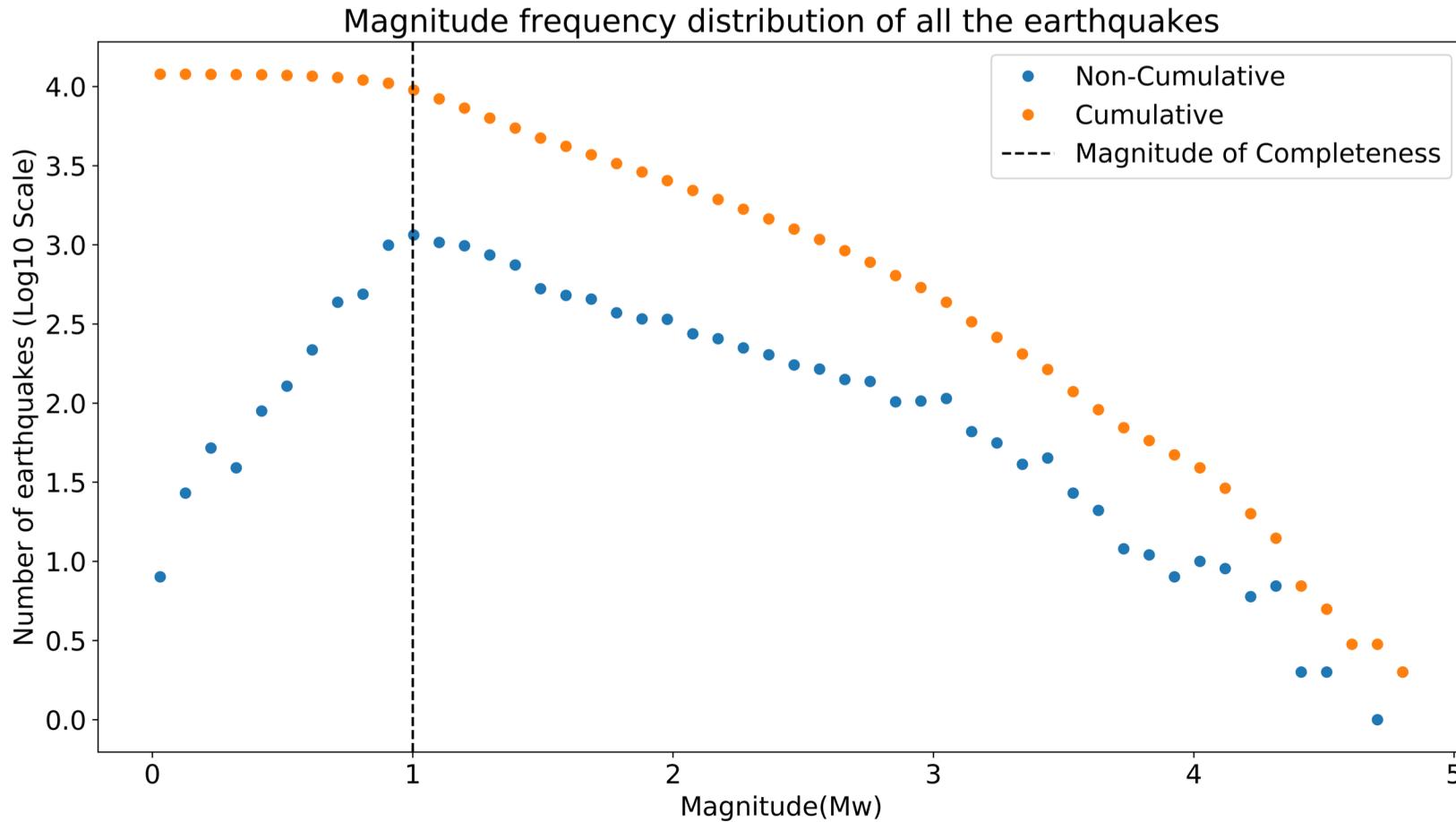
Time Period 3:
08/30/2006 – Present

- Interseismic Period
- ~8,800 events

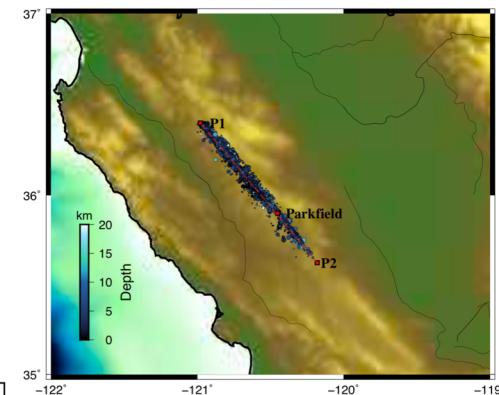
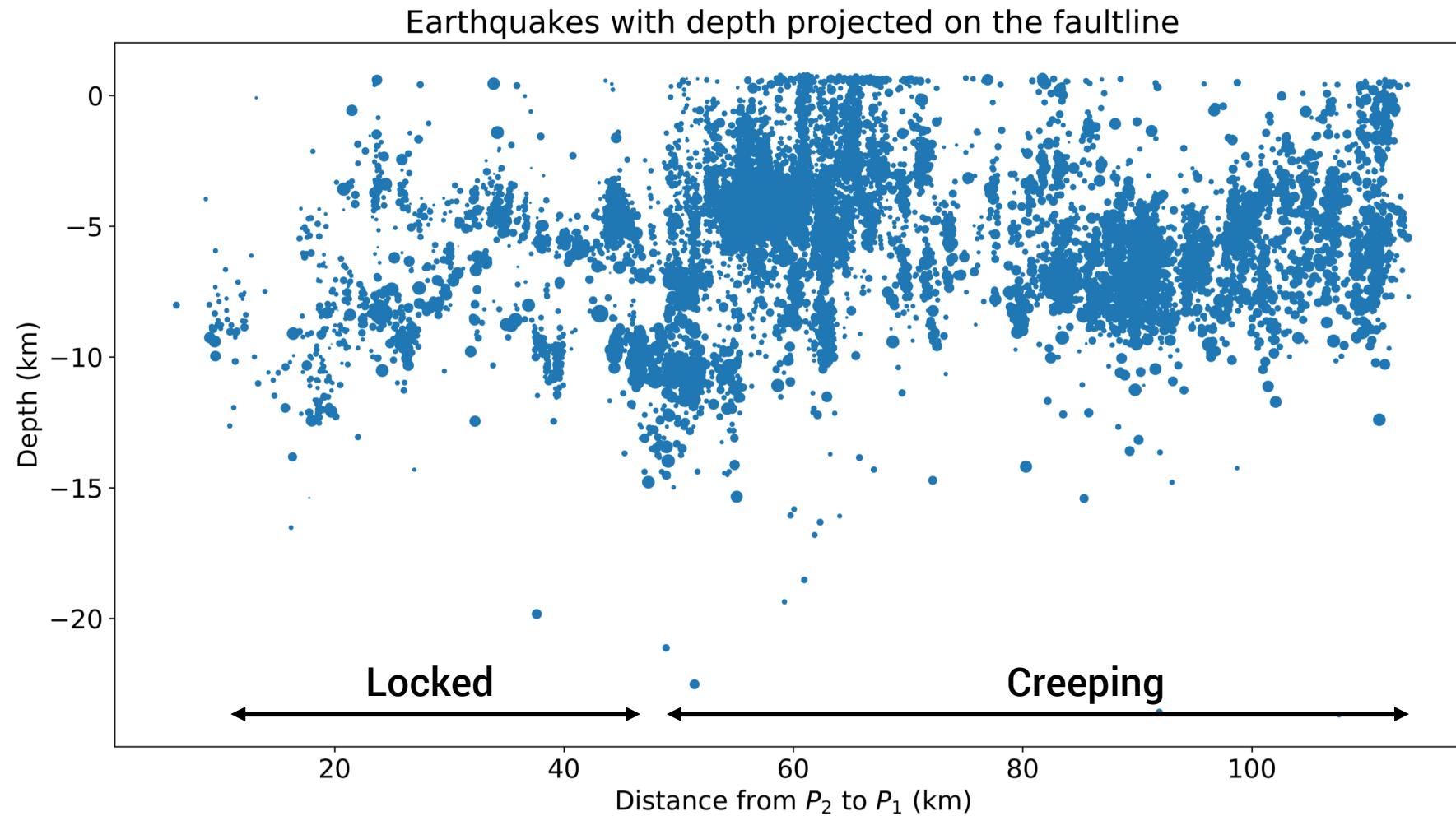
The seismic period



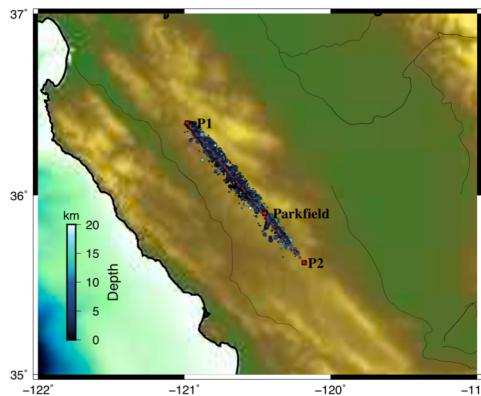
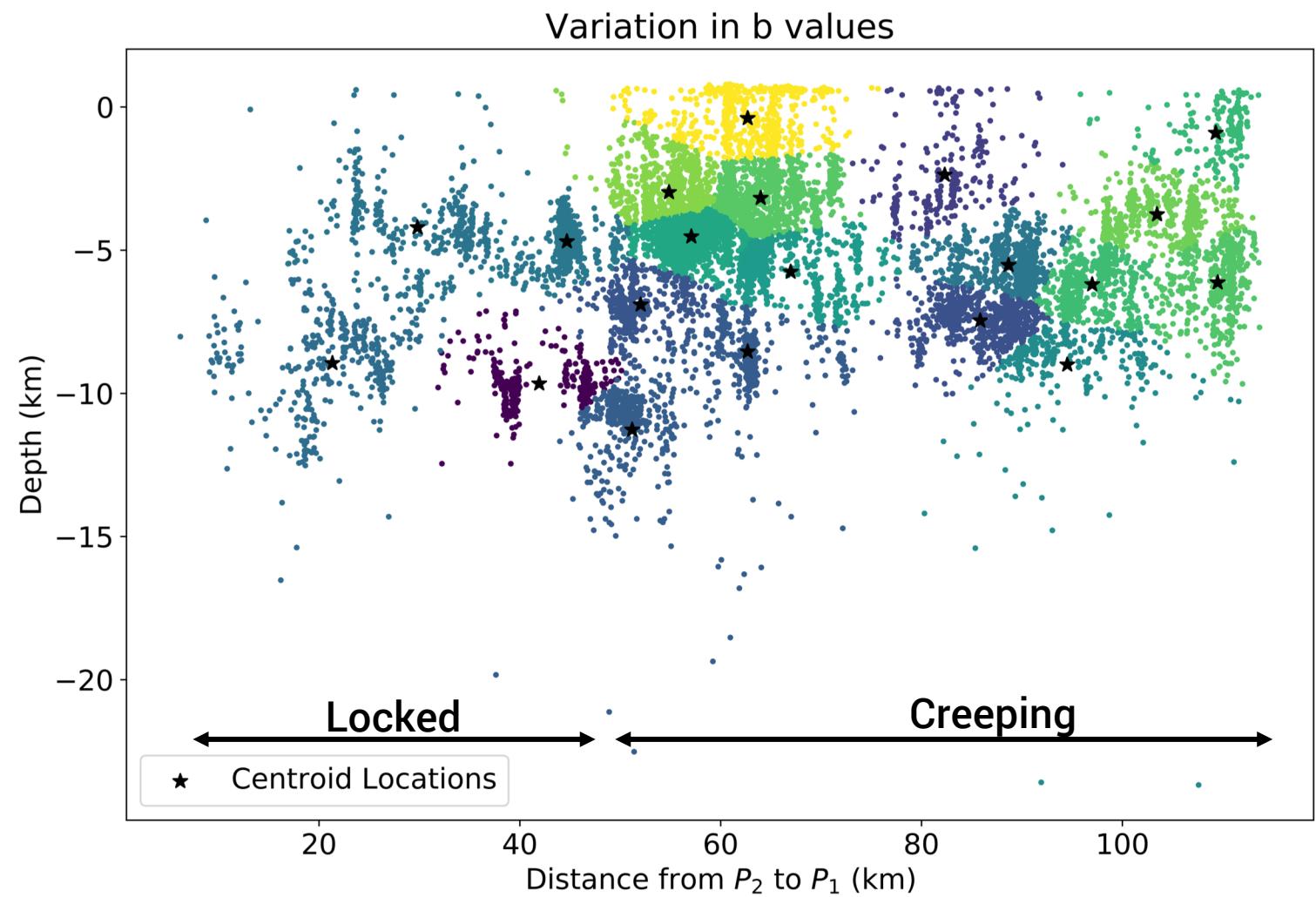
Magnitude Frequency Distribution



Time period 1

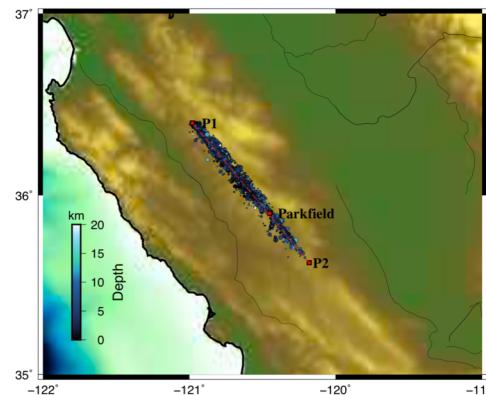
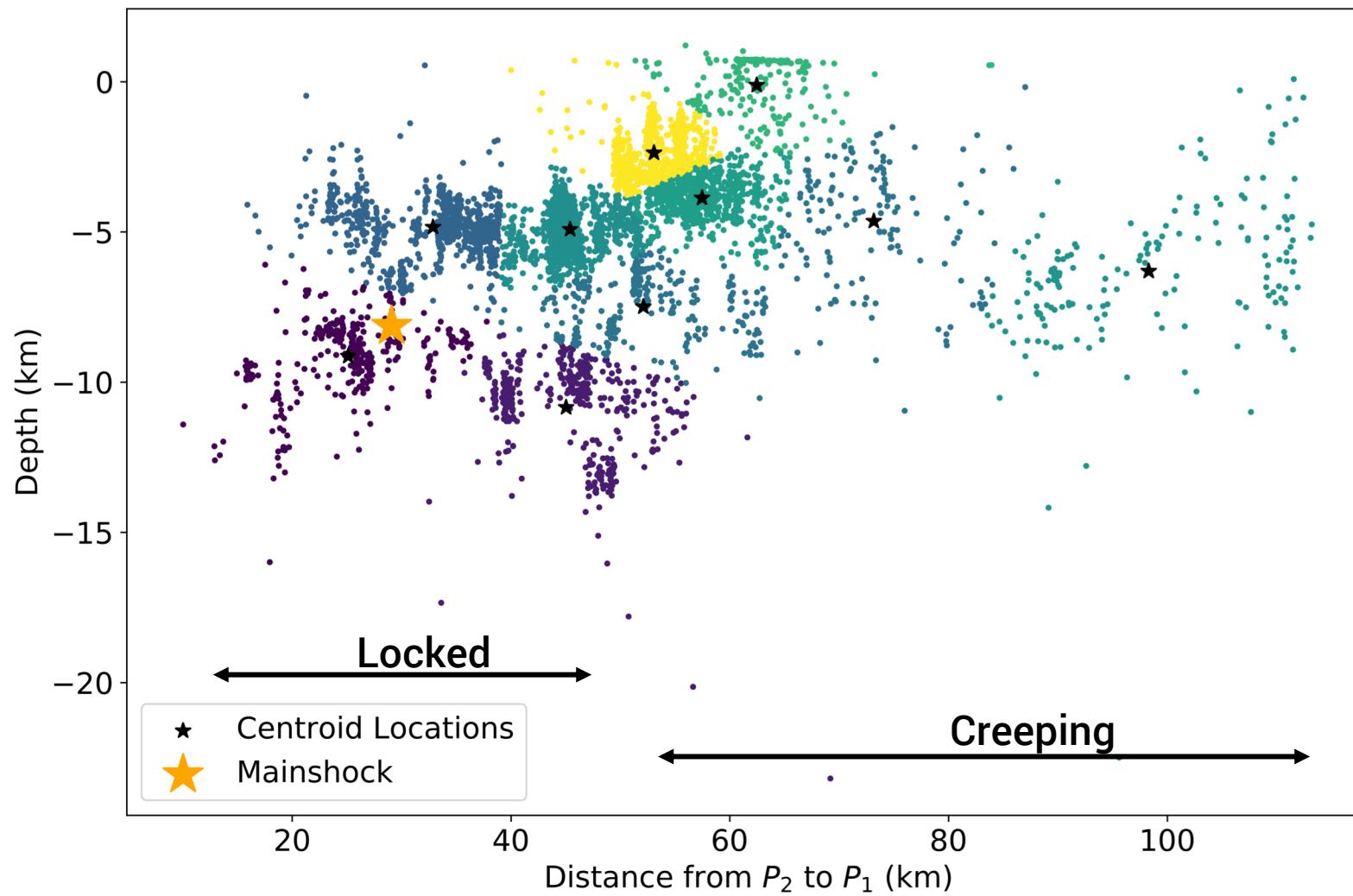


Time period 1



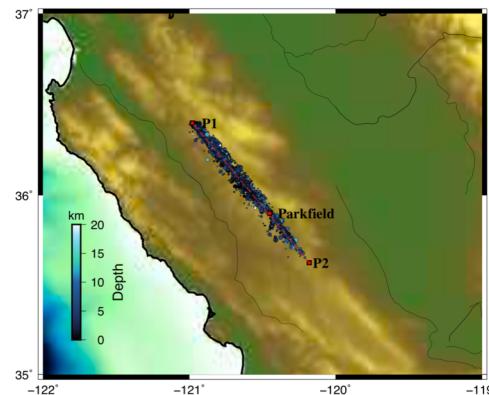
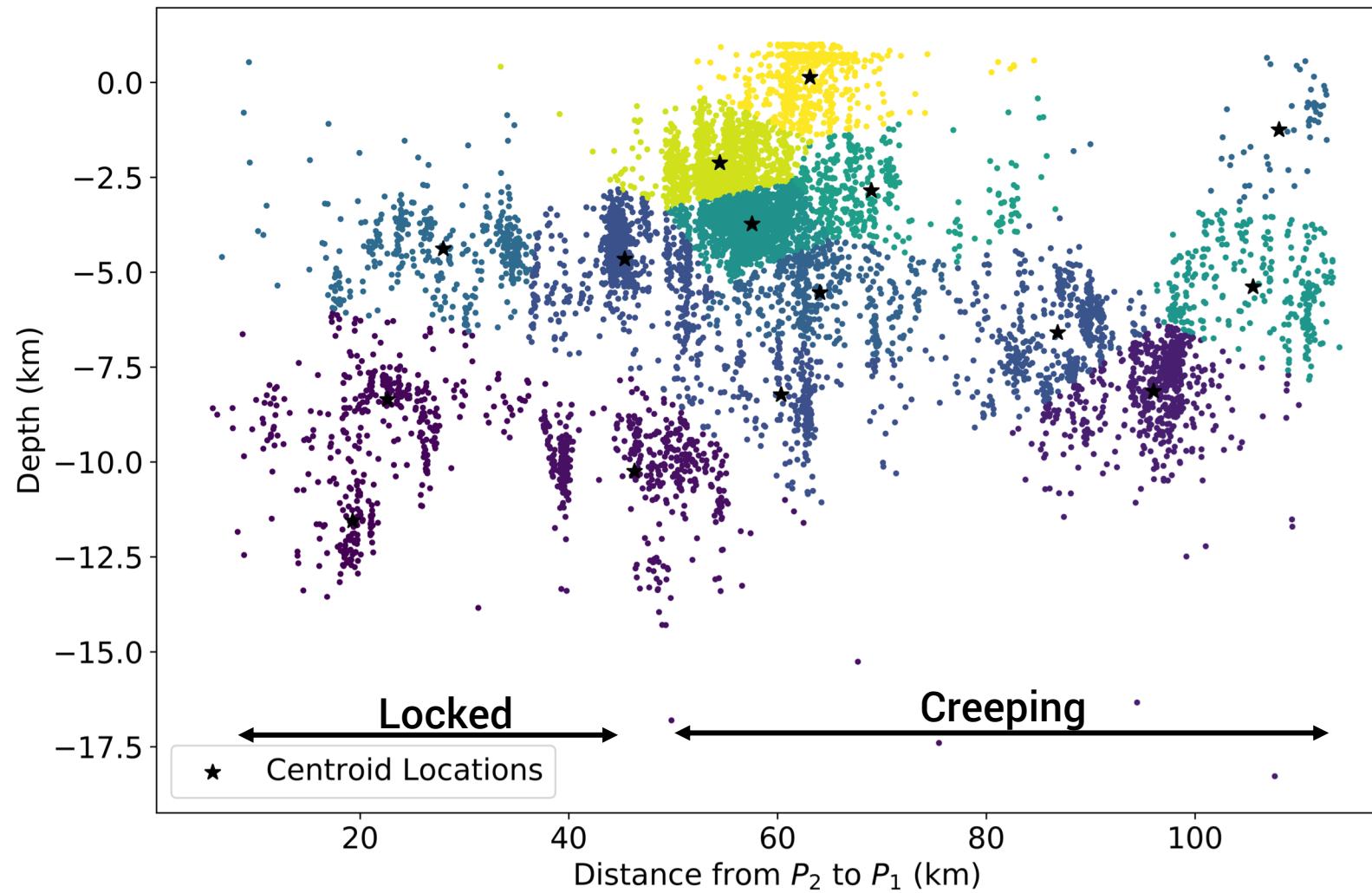
Time period 2

Variation in b values

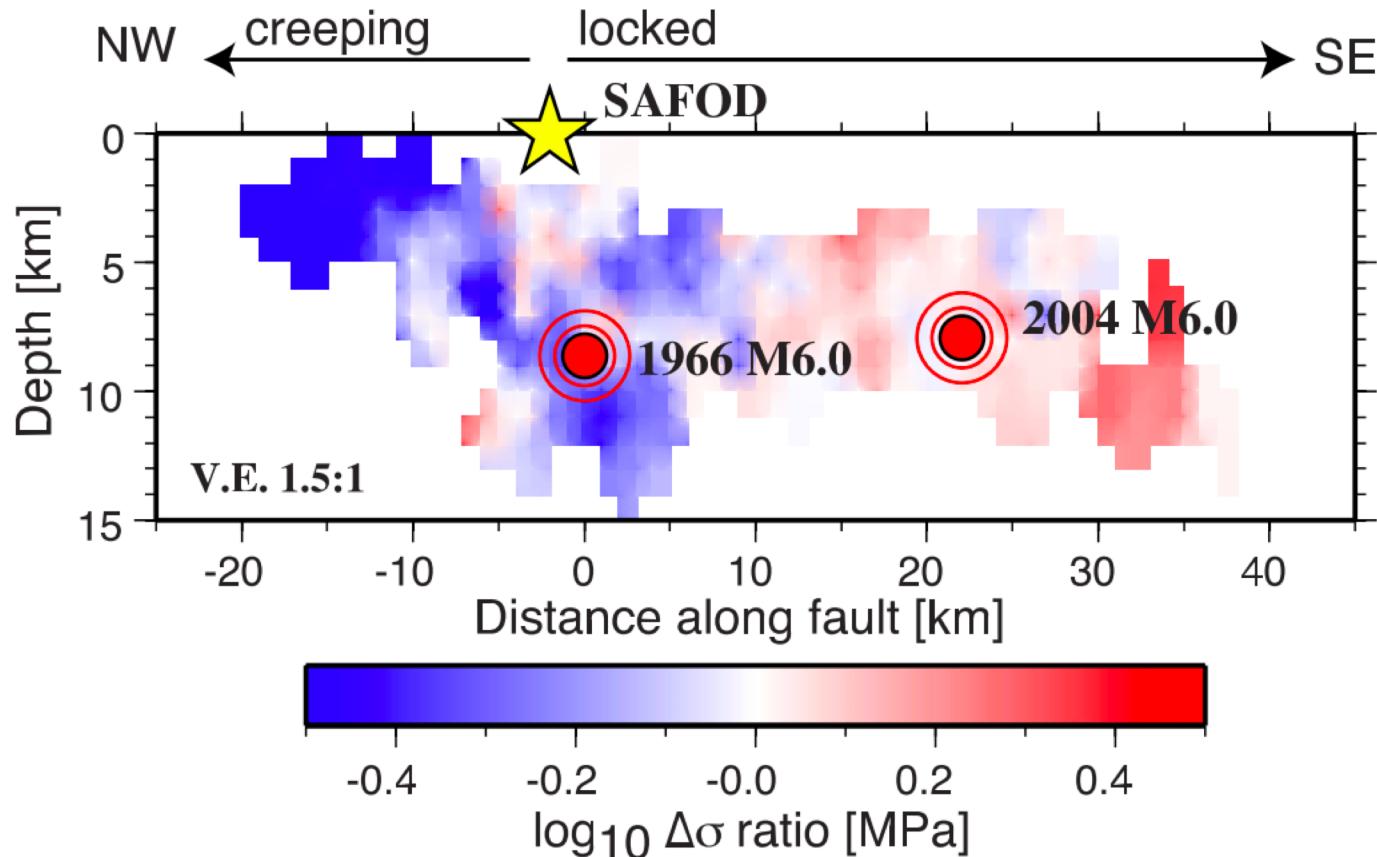


Time period 3

Variation in b values



Stress drop variation



Ratio of stress drop before and after the mainshock. Negative values indicate an increase in stress after the earthquake. Allman and Shearer, 2007.

Research Questions

- How does the b-value vary along depth and along strike of the fault segment?

b-value seems to decrease with depth, which is in contrast to laboratory experiments that show an increase in b-values with increasing thermal gradient (Warren and Latham, 1970).

Research Questions

- How did the b-value distribution change after the Mw 6.0 2004 earthquake, the biggest one since 1967? Does the b-value distribution go back to its previous values after the event?

The overall b-values increased after the earthquake, and it did not go back to the previous values during the second interseismic period. The increase in b-values are more pronounced at the boundary of creeping region, possibly due to larger stress drop in the locked region, and therefore relative increase in stress in the creeping region.

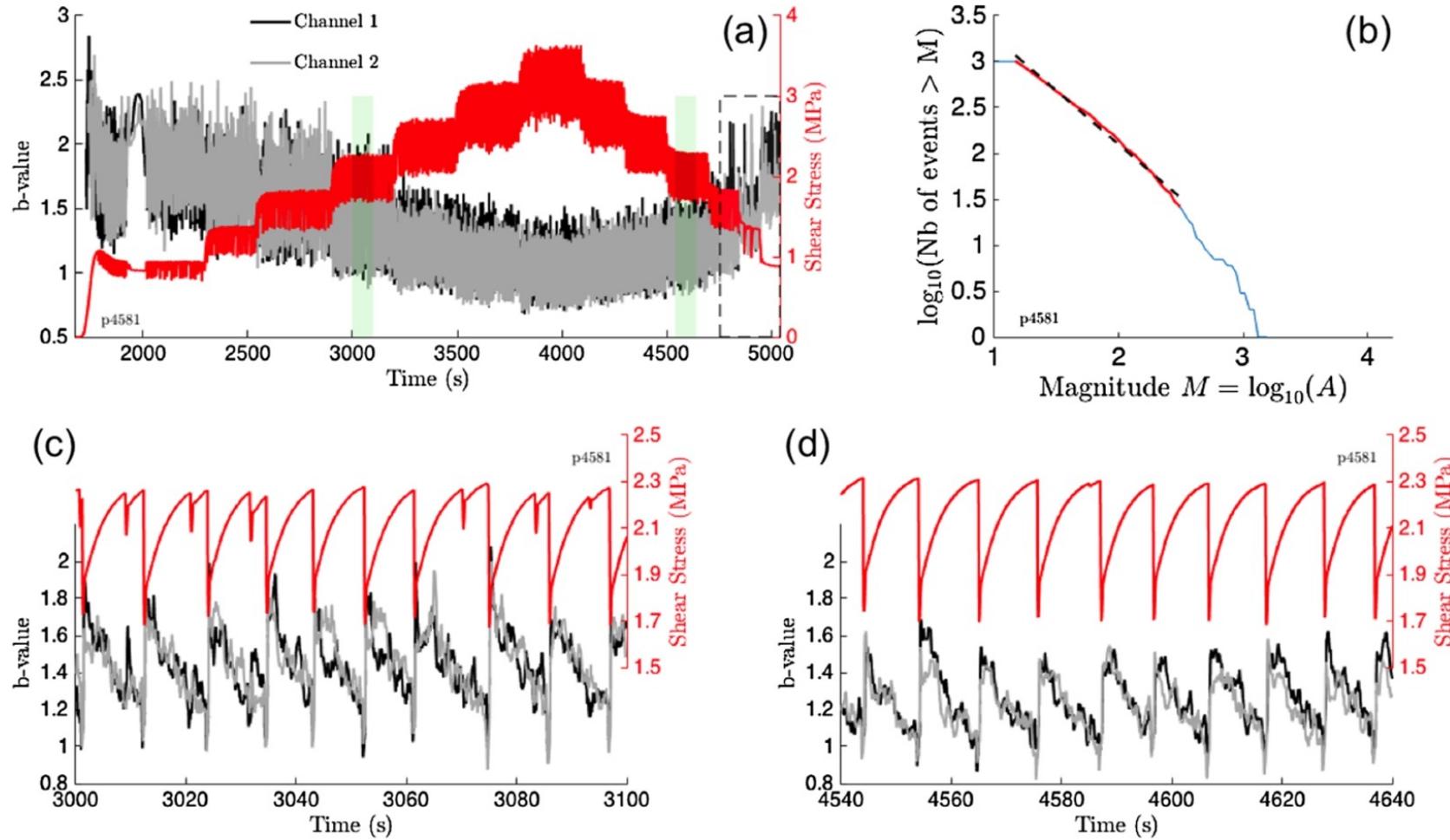
The relative distribution in space did not change during or after the earthquake.

Research Questions

- Is this change in agreement with the variation in stress drop?

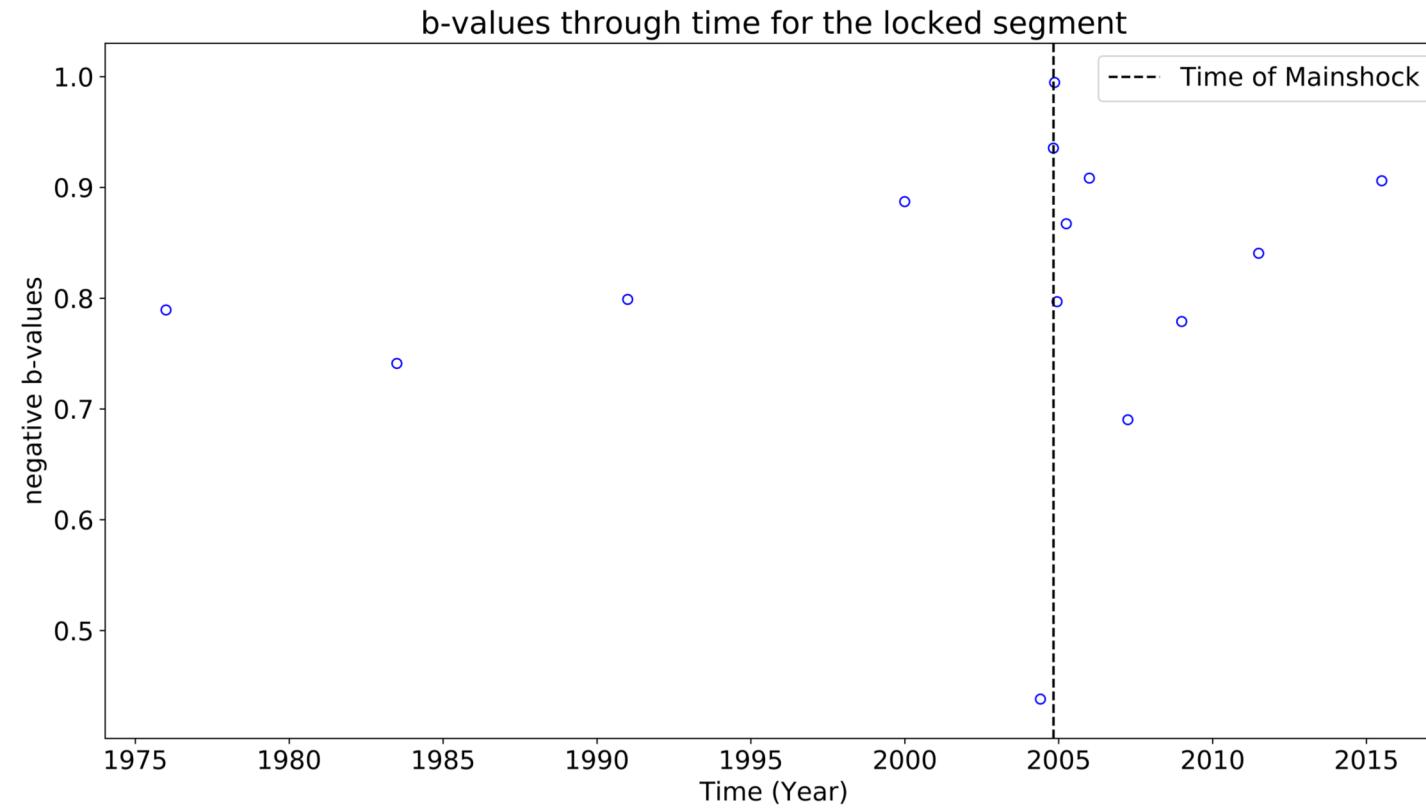
Yes, stress drop is higher in the locked region, implying a lower b-value. The creeping segment has lower stress drop due to stress not being accumulated, thus showing an increase in b-value.

Temporal variation in b-values



Laboratory experiments in evolution of b-values as a function of shear stresses within multiple seismic cycles. From Rivere et al., 2018.

Temporal variation in b-values



In contrast to the laboratory experiments, the b-values seem to increase during the interseismic periods. There is an anomalously low b-value right before the event, and a sudden jump in b-value during the event, which is in agreement with the experiments.

References

- Bakun, W. H., Aagaard, B., Dost, B., Ellsworth, W. L., Hardebeck, J. L., Harris, R. A., ... & Michael, A. J. (2005). Implications for prediction and hazard assessment from the 2004 Parkfield earthquake. *Nature*, 437(7061), 969.
- Allmann, B. P., & Shearer, P. M. (2007). Spatial and temporal stress drop variations in small earthquakes near Parkfield, California. *Journal of Geophysical Research: Solid Earth*, 112(B4).
- Schorlemmer, D., Wiemer, S., & Wyss, M. (2004). Earthquake statistics at Parkfield: 1. Stationarity of b values. *Journal of Geophysical Research: Solid Earth*, 109(B12).
- Rivière, J., Lv, Z., Johnson, P. A., & Marone, C. (2018). Evolution of b-value during the seismic cycle: Insights from laboratory experiments on simulated faults. *Earth and Planetary Science Letters*, 482, 407-413.