S13B-1990

Repeating earthquakes and prospecting for temporal change in rock properties associated with geodetic deformation at Kilauea Volcano, Hawaii

E. D. Montgomery-Brown(1), C. H. Thurber(1), E. M. Syracuse(1), C. J. Wolfe(2), P. Okubo(3), M. P. Poland(3), and A. Miklius(3)

1. Geoscience, University of Wisconsin - Madison, Madison, WI, United States.; 2. University of Hawaii at Manoa, Honolulu, HI, United States. 3. U.S.G.S. Hawaiian Volcano Observatory, Hawaii National Park, HI, United States.

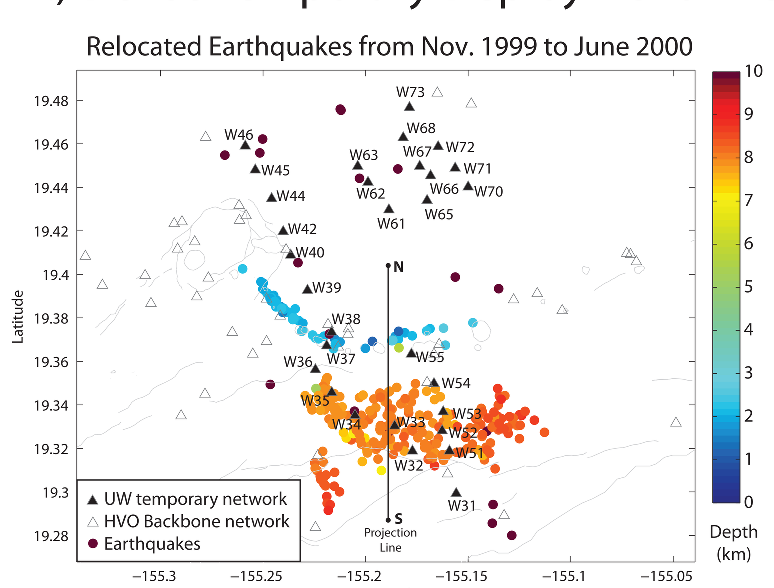
Abstract Temporary seismic deployments on Kilauea Volcano from Nov. 1999 to June 2000 and Feb. to Aug. 2007 provided dense observations of earthquakes during two east rift zone intrusions (Feb. 23, 2000 and June 17-21, 2007). We identify clusters of earthquakes based on waveform similarity. Waveform pairs with cross correlation coefficients greater than 0.8 between 1 and 10 Hz in 1999/2000 and 3-10 Hz in 2007) are grouped together. Clusters are separated when a stack of grouped waveforms is cross correlated with another stack and the inter-cluster cross correlation coefficient is less than 0.7. Many earthquakes during the 1999/2000 deployment had similar waveforms. Site W33 on the south flank recorded the largest number of earthquakes and also had the most pairs of similar earthquakes. The maximum cross correlation coefficient between a pair of earthquakes was 0.99, and the largest cluster contained 193 earthquakes. Rift zone sites (e.g. W37 and W38) had very few similar earthquakes, suggesting site effects might play an important role in the ability to identify clusters. Further analysis will help determine if focal mechanism variations or more widely separated locations contribute to the reduced similarity at these sites.

Seismicity rates increased during the Feb. 2000 intrusion, but the waveforms of these earthquakes are similar to those that were occurring before and after the intrusion. Thus, the stress change due to the intrusion appears to have increased activity on continually active clusters of earthquakes (also shown by Rubin et al. [JGR, 1998] during the 1983 intrusion). Also during the 1999/2000 deployment, a M5 earthquake occurred on the south flank. Active clusters of smaller flank earthquakes were "turned off" by the large earthquake, while new clusters activated after the earthquake in nearly the same locations, but with slightly different waveforms.

Despite having significantly more observed earthquakes, repeatability of waveforms during the 2007 temporary deployment was very low. Background noise levels were higher during this deployment, possibly due to elevated tremor levels or the near-coast locations of the 2007 deployment. The maximum cross correlation coefficient between earthquake pairs at site SEQA1 is 0.97, but the largest cluster, has only 19 earthquakes.

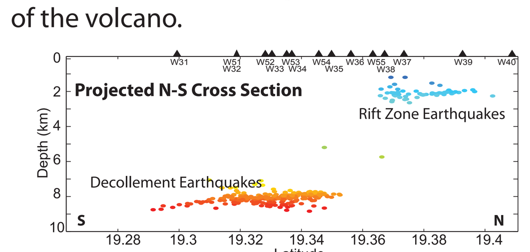
Relocating additional earthquakes plus analyzing the waveforms for changes in seismic velocity and shear wave splitting will allow us to relate the seismic observations to deformation and stress changes derived from geodetic data.

1.) Dense Temporary Deployment - Nov. 1999 - June 2000



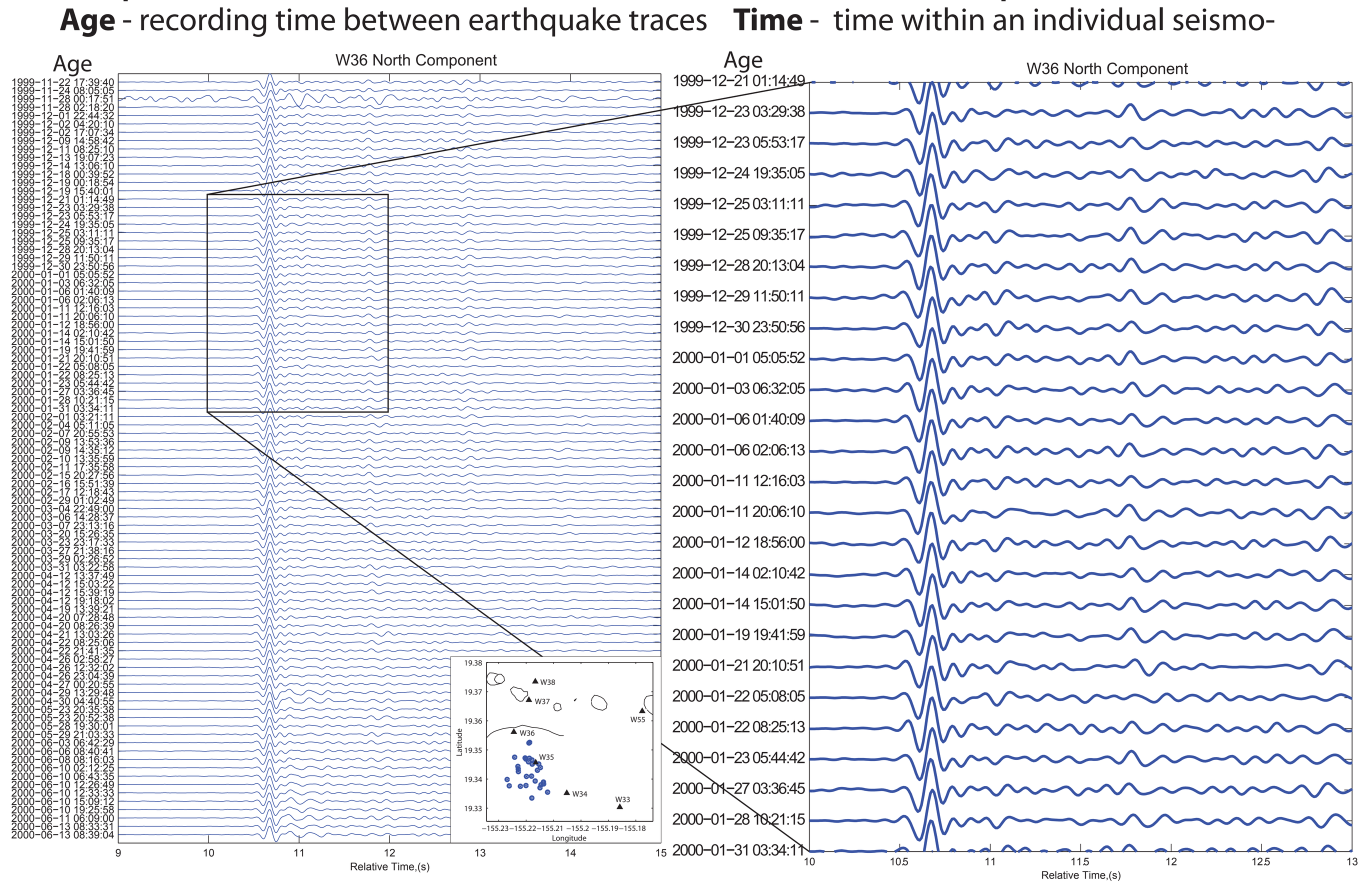
Temporary network of seismometers deployed from November 1999 to June 2000.

The temporary deployment of 29 3-component seismometers along profiles perpendicular to the rift zone [Haslinger et al., 2001; Hansen et al., 2004], providing the potential to document spatial and temporal changes in seismic properties of the volcano.

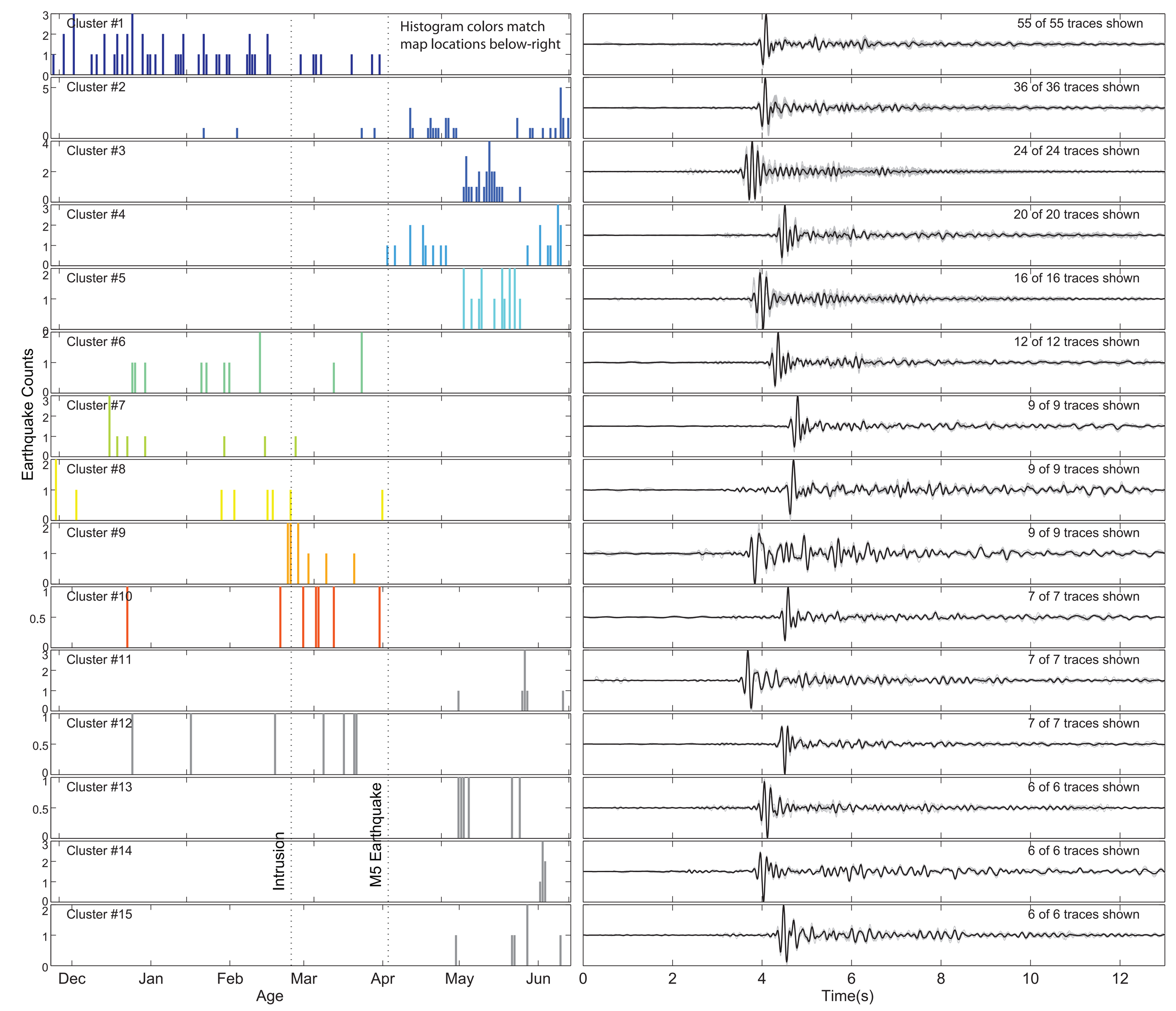


2.) Repeatable waveforms from south flank earthquake clusters

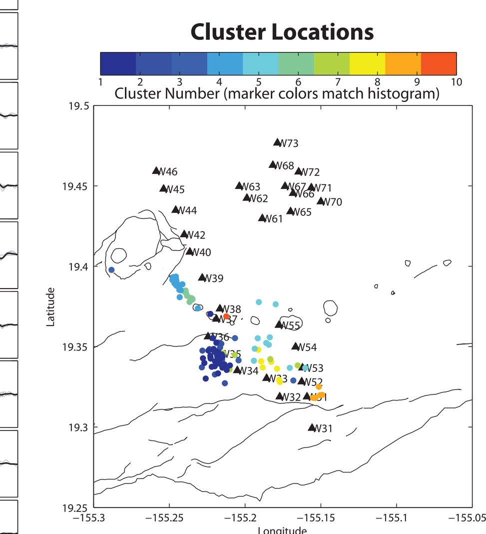
Age - recording time between earthquake traces **Time** - time within an individual seismo-



3.) Temporal patterns of repeating earthquake clusters



Clusters and occurrences identified by waveform similarity. Clusters are identified using the GISMO software package (M. West) by cross-correlating all waveforms against each other and then forming a cluster tree, which is subdivided at a cutoff cross correlation coefficient of 0.7.



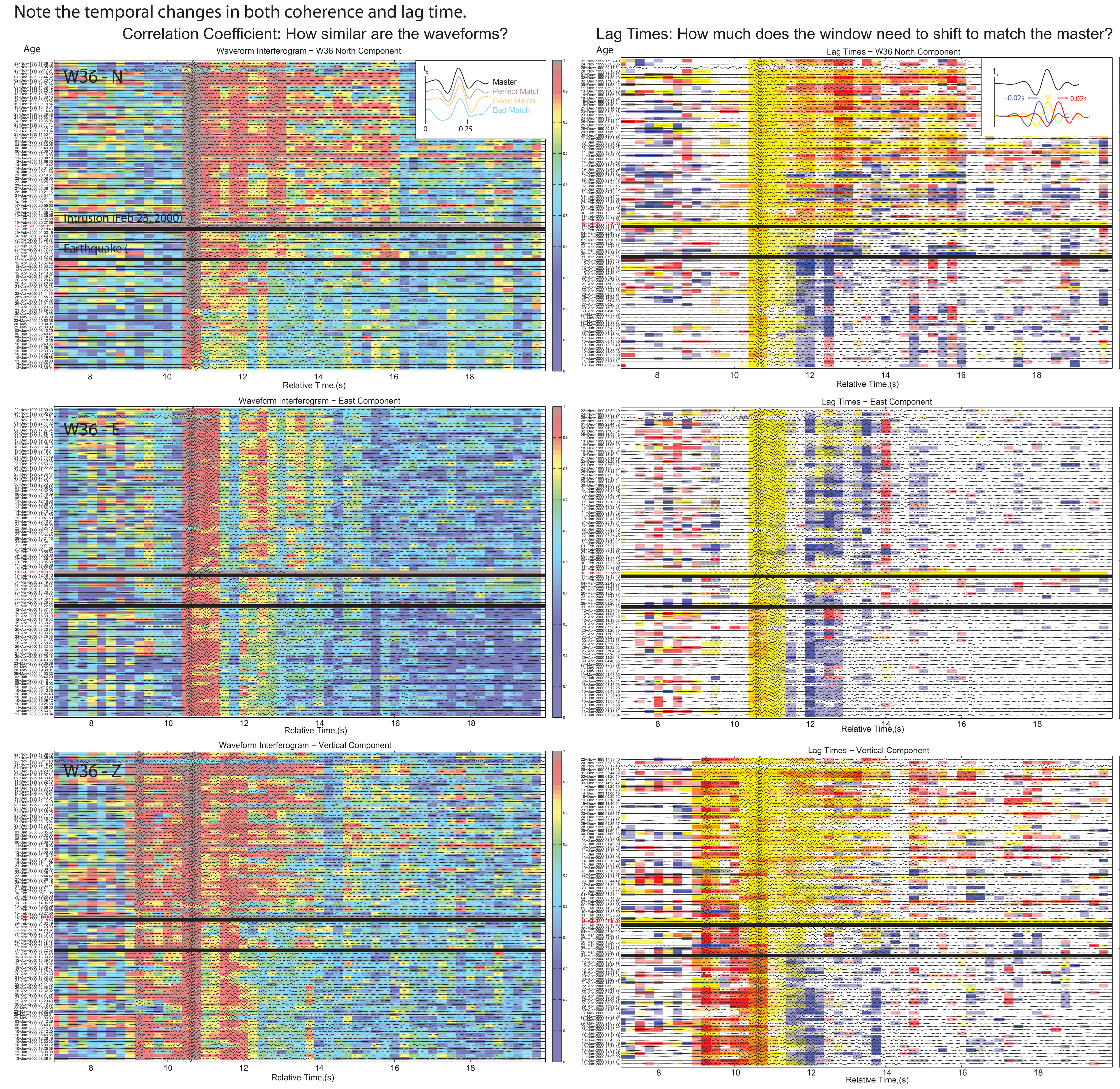
Only steeply arriving waves are useful

$i_o = \sin^{-1}(V_s/V_p)$ (Nuttli, 1961)

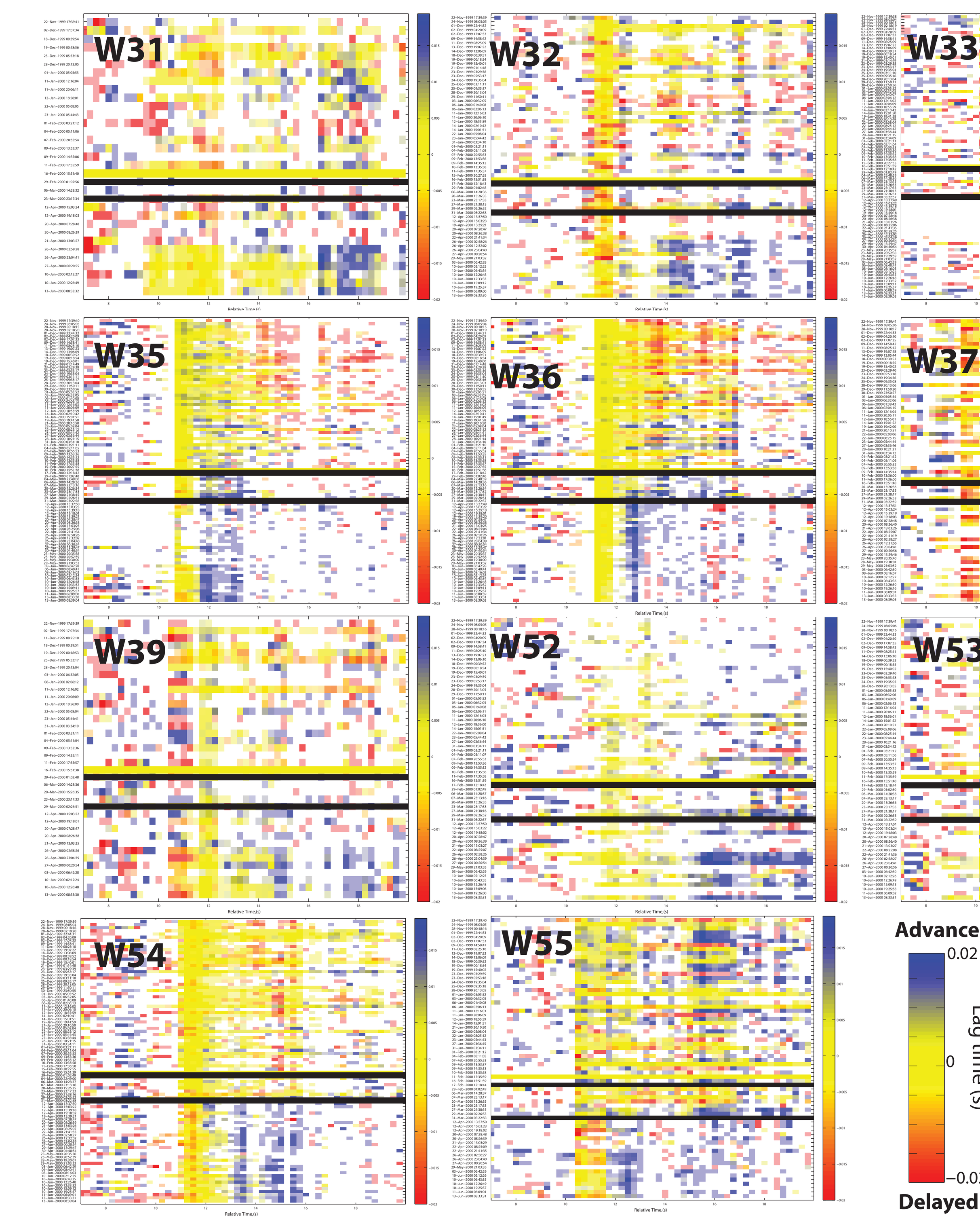
For V_s/V_p ratios of ~1.7 (Hansen et al., 2004), and earthquake depths of ~8km, earthquakes must have epicenters within ~4km radius of the observing station.

4.) Waveform Interferograms

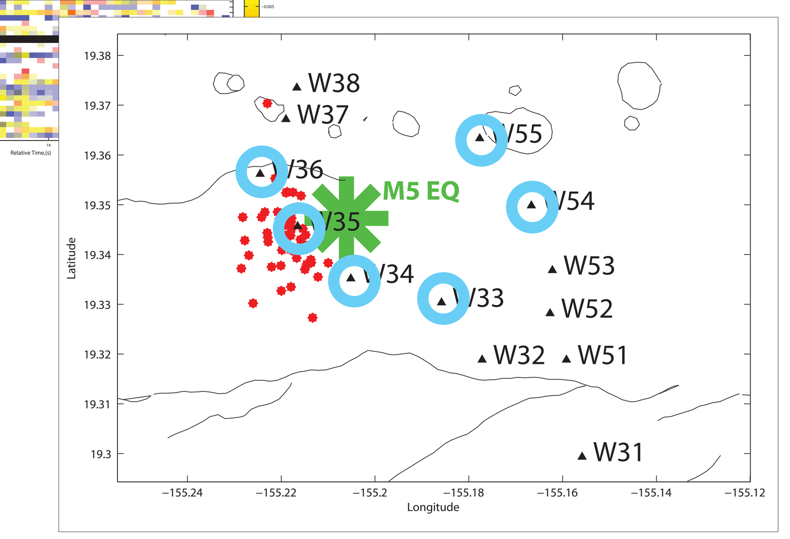
A moving window (width 0.25, no overlap) cross correlation shows in more detail how each waveform changes with age.
Note the temporal changes in both coherence and lag time.



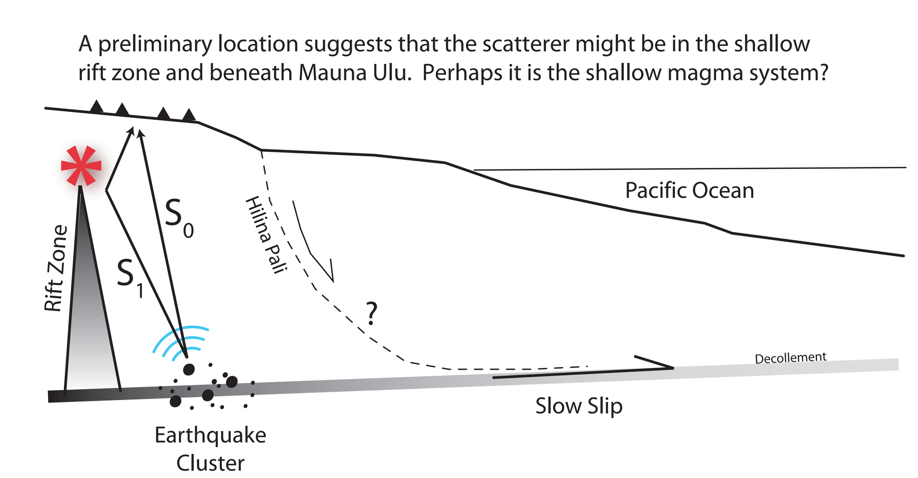
5.) Temporal changes in lags are observed at several stations just south of the rift

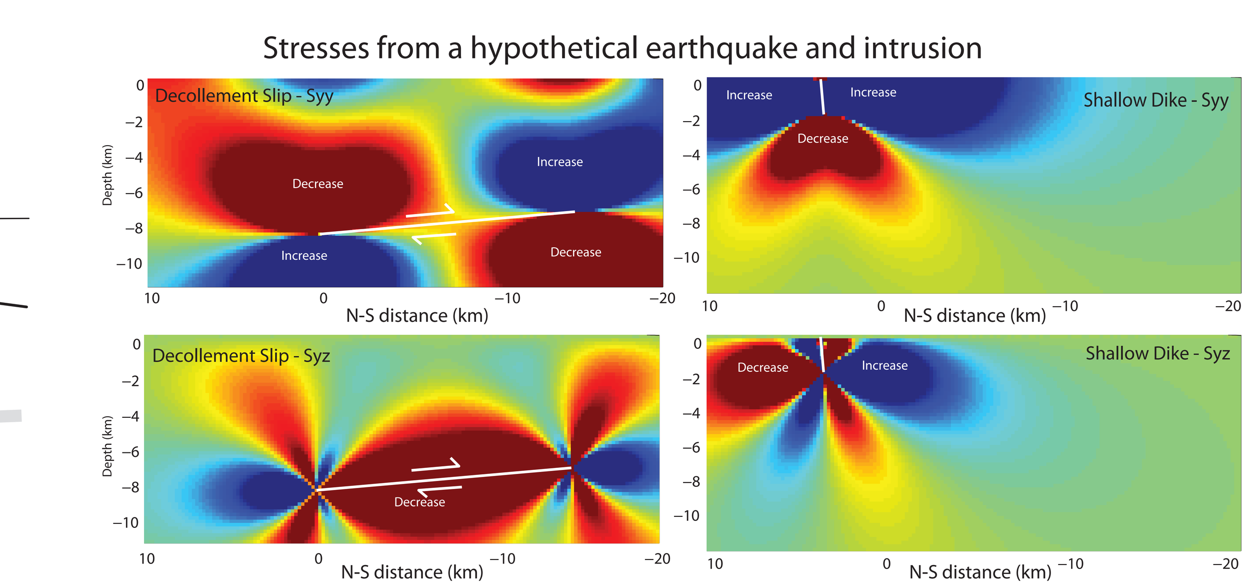


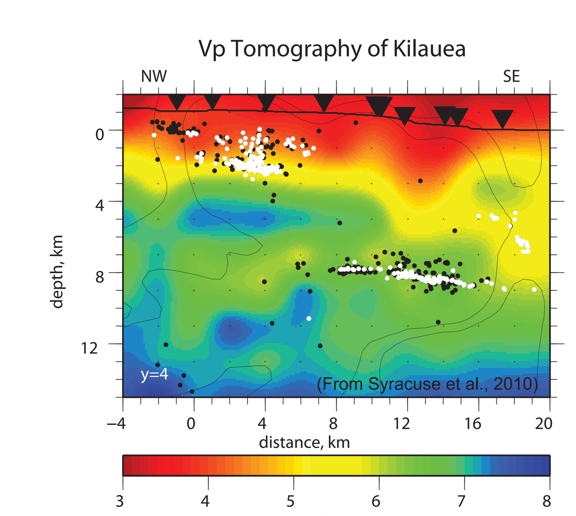
Lag times from the scattered phase are advanced by up to 0.02 s following the intrusion and M5 south flank earthquake.



6.) What is the scatterer?







Conclusions

Clusters of earthquakes on Kilauea's south flank provide an opportunity to study the changing rock properties of the volcano by observing coda changes.

A change in the correlation and lag time of a scatterer was observed following a small intrusion and M5 decollement earthquake.

A preliminary location of the scatterer suggests that it might be in the shallow rift zone.

Acknowledgements

This work is supported by an NSF Geophysics Postdoctoral Research Fellowship. Seismic analyses were accomplished using the GISMO software package by M. West, Univ. of Alaska - Fairbanks.

References

Hansen, S., C. Thurber, M. Mandernach, F. Haslinger, and C. Doran (2004), Seismic velocity and attenuation structure of the east rift zone and south flank of Kilauea Volcano, Hawaii, Bull. Seismol. Soc. Am., 94(4), 1430– 1440.

Nuttli, O., 1961. The effect of earth's surface on the S-wave particle motion, Bull. seism. Soc. Am., 51, 237–246.

Syracuse, E. M., C. H. Thurber, C. J. Wolfe, P. G. Okubo, J. H. Foster, and B. A. Brooks (2010), High-resolution locations of triggered earthquakes and tomographic imaging of Kilauea Volcano's south flank, J. Geophys. Res., 115, B10310, doi:10.1029/2010JB007554.