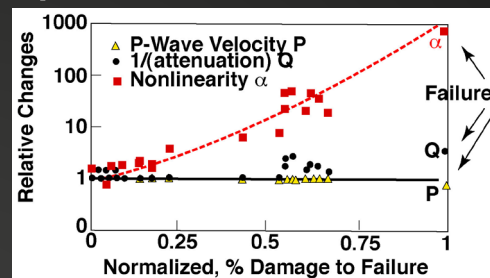


Probing the Damage Zone at Parkfield (San Andreas Fault)

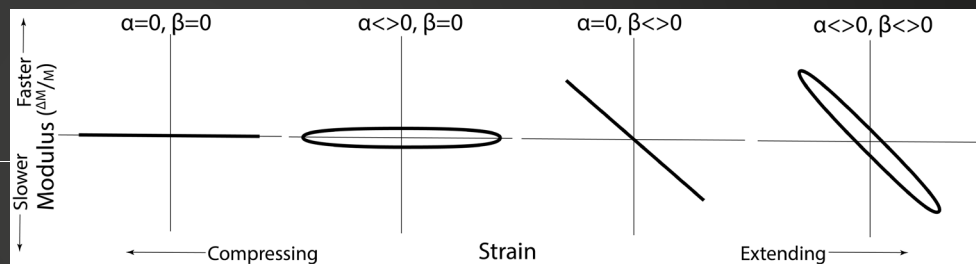
- We often use linear elastic measurements to infer material damage or other properties related to damage, such as permeability and pore pressure.
- However, nonlinear elastic parameters are much more sensitive to material damage than attenuation ($1/Q$) or linear elasticity.



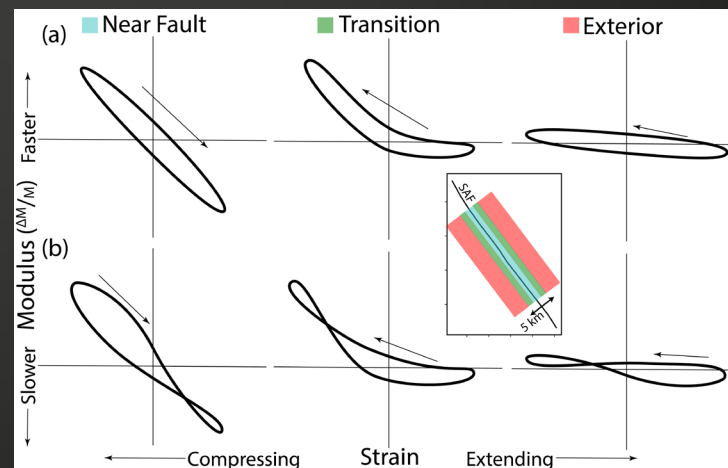
Modified from Van Den Abeele et al., 2002

Nonlinear Elastic Equation

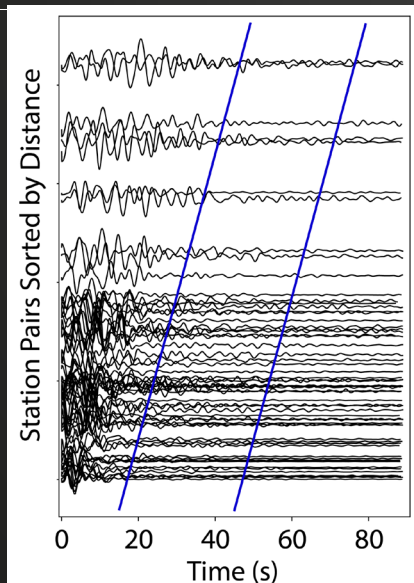
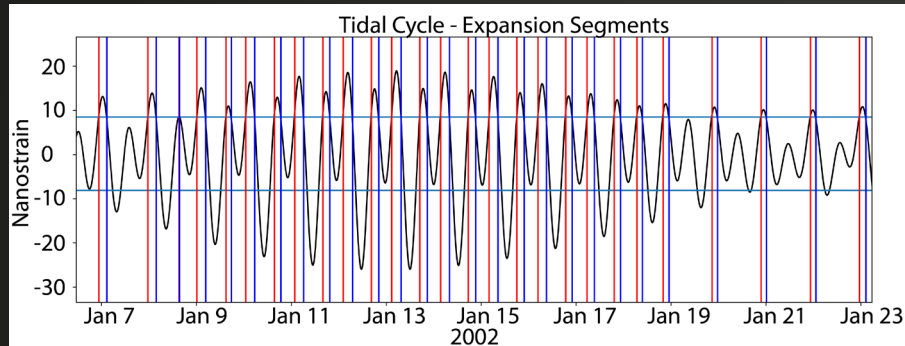
$$\sigma = M_0 \varepsilon [1 + \beta \varepsilon + \alpha f(\varepsilon, \dot{\varepsilon})]$$



We measure nonlinear behavior as a function of distance from the San Andreas Fault in California and detect increasing damage with decreasing distance to the fault.

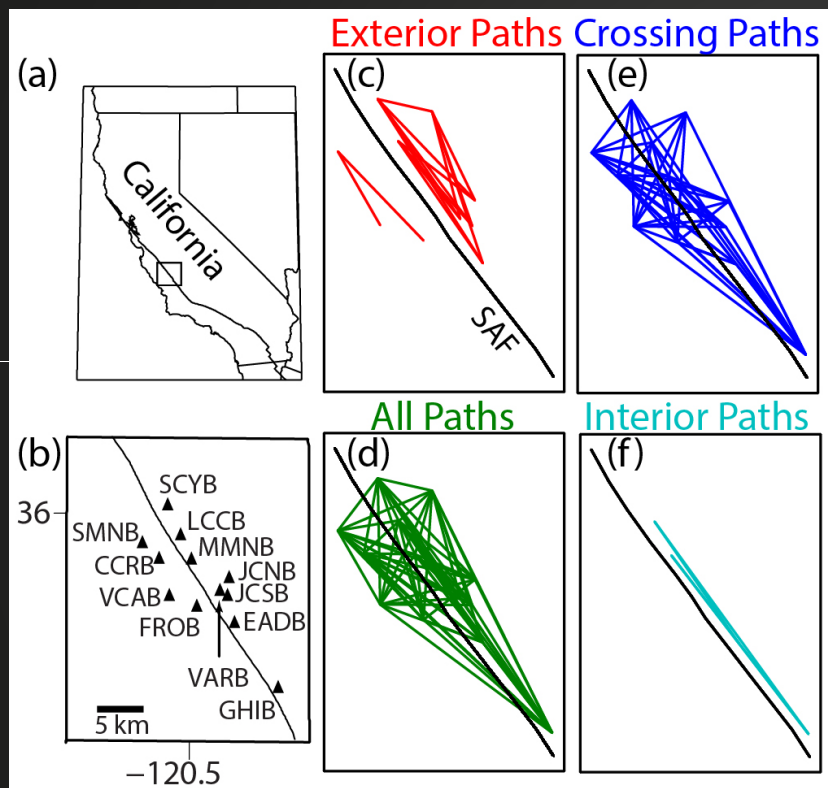


Methods



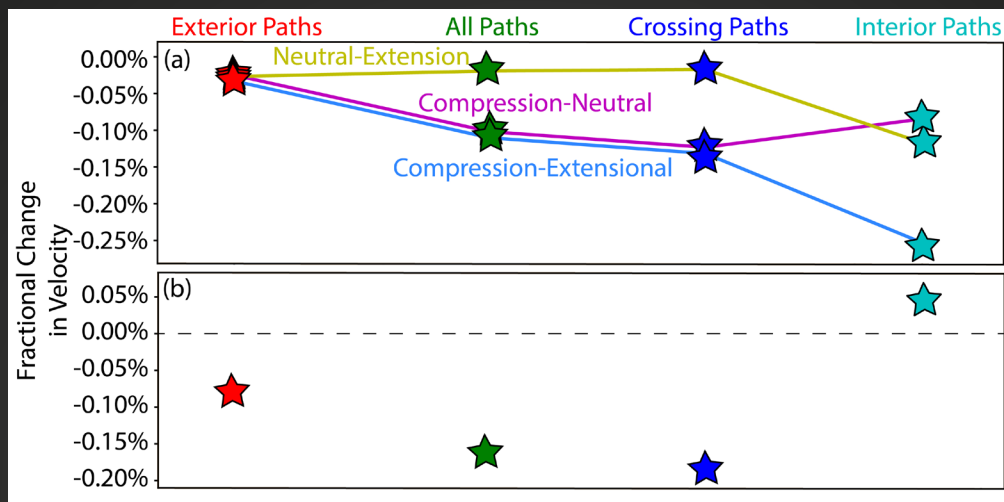
- We select periods of time with negative, neutral, and positive strain and strain rate due to solid earth tides, for a total of six bins.
- We calculate separate EGFs for each of the six bins.
- We measure travel time differences for 5 second waves between the different EGFs and use the differences to constrain the nonlinear elastic behavior

Methods



- We use empirical Green's functions (EGF) calculated using station pairs from the High Resolution Seismic Network.
- We select four set of pairs that sample different regions within the fault region.

Results



- (a) Strain Results
 - Velocities are slower when the Earth is in extension versus when in compression.
 - The velocity difference between the two cases increases with decreasing distance to the fault.
- (b) Strain Rate Results
 - For all but interior paths, the Earth is faster when compressing versus when expanding.
 - For interior paths, the Earth is faster when expanding versus when compressing

Discussion

Nonlinear Elastic Equation

$$\sigma = M_0 \varepsilon [1 + \beta \varepsilon + \alpha f(\varepsilon, \dot{\varepsilon})]$$

- We detect increasing material damage with decreasing distance to the fault.
- Both β and α , must be nonzero.
- By improving time resolution, we will better be able to constrain the magnitudes of the nonlinear coefficients.

