Generation of Surface Rupture Profiles in Wavenumber Domain

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Research Motivation

Coseismic surface displacements due to large earthquakes pose a significant threat to structures located above fault crossings. The goal of this study is to provide an alternative model in accessing the surface rupture hazard by addressing simplified assumptions in the existing model, such as along strike correlation and soil effects. A key challenge has been to develop a robust methodology to regress available data sets that may exhibit sparse and biased sampling.

Current Objectives:

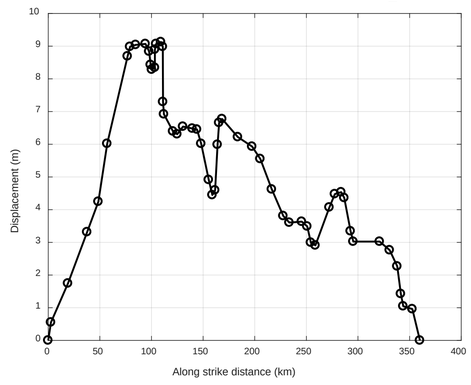
- Properly consider the along strike correlation in displacement variability
- Develop and validate the methodology to analyze non-uniformly spaced data in wavenumber domain

Future Objectives:

- Capture soil effects in fault rupture propagation
- Develop a model for distributed displacements

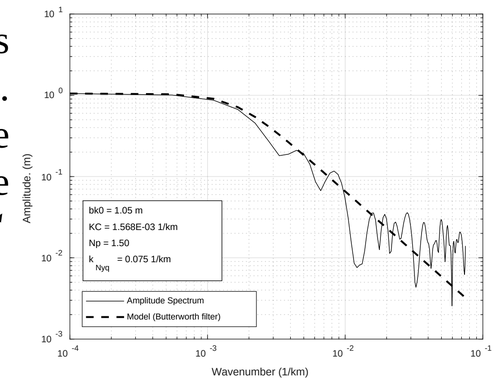
Wavenumber Analysis - Concept

Any slip profile can be decomposed into a series of sinusoidal functions of different wavelengths. Their relative amplitude and offset can be represented in an amplitude spectrum and phase derivative distribution respectively.

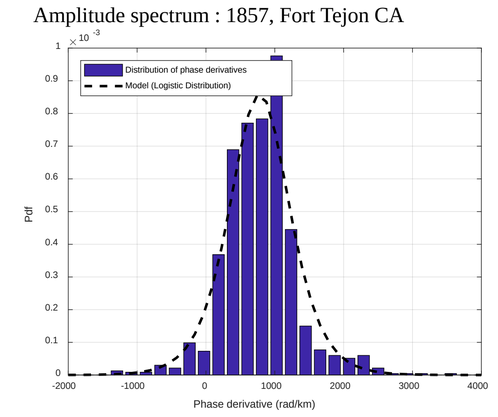


Surface rupture profile: 1857, Fort Tejon CA

Space-domain



Amplitude spectrum : 1857, Fort Tejon CA



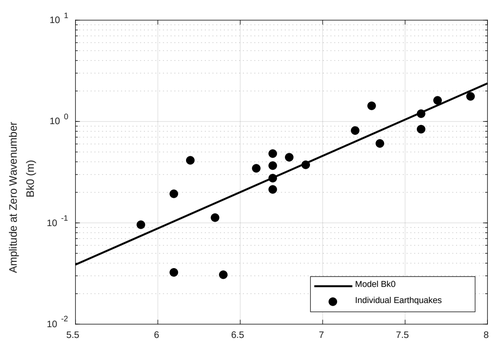
Phase derivative distribution: 1857, Fort Tejon CA

Wavenumber-domain

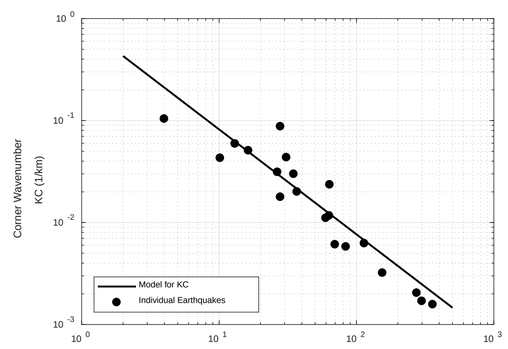
A similar procedure has been used successfully to describe the slip on the fault plane in the (Somerville et al., 1999) study.

Amplitude Model

The functional form of a Butterworth filter is used to describe the amplitude model. It is defined with three parameters: bk0, KC and Np. Np is fixed to 1.5 due to high correlation with KC.



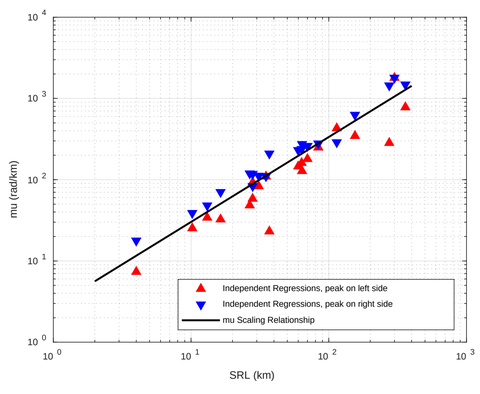
Scaling relationship of Zero Wavenumber Amplitude (Bk0) versus Moment magnitude (M_w)



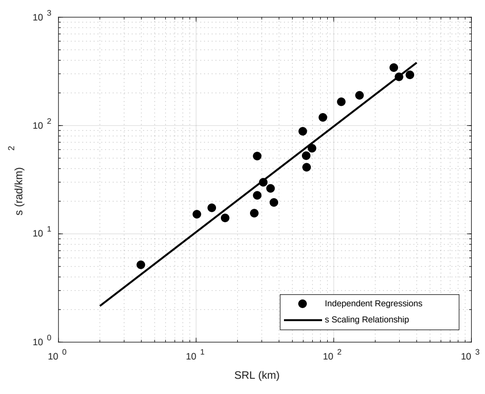
Scaling relationship of Corner Wavenumber (KC) versus Surface Rupture Length (SRL)

Phase Derivative Model

Phase derivatives were modeled with a logistic distribution which is defined with two parameters (mu and s).



Scaling relationship of mu versus Surface Rupture Length (SRL)

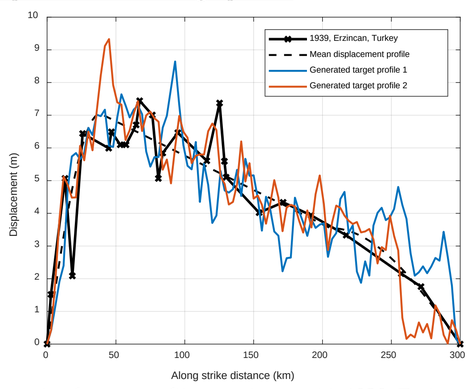


Scaling relationship of s versus Surface Rupture Lenght (SRL)

Validation Tests

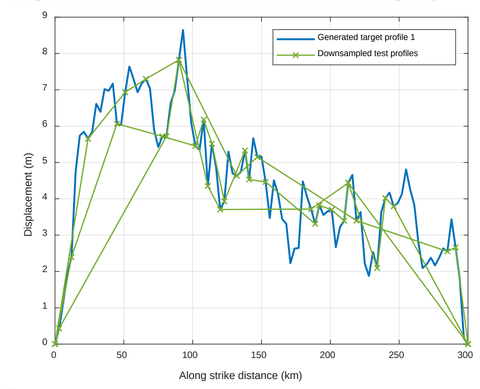
A key challenge in this project is the validation of the procedure to estimate the coefficients of the amplitude model from non-uniform sparsely spaced sampling points.

Step 1. Generation of target profiles



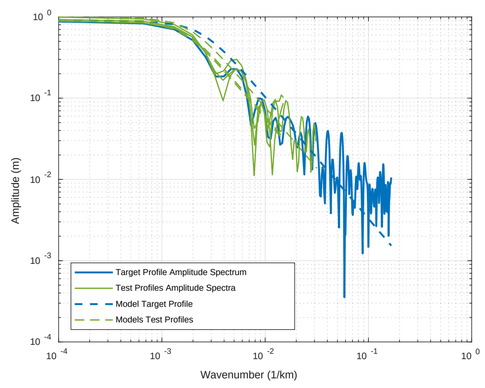
Example of target profiles consistent with 1939, Erzincan, Turkey rupture profile and correlation structure

Step 2. Creation of test data set by down sampling



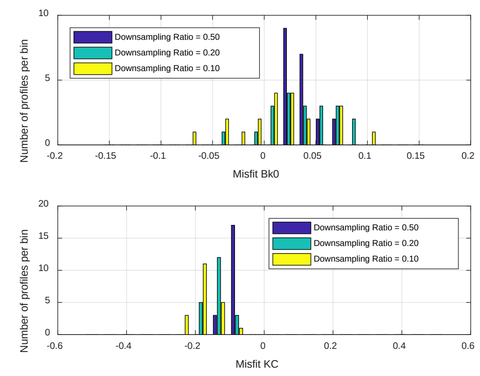
Example of down sampled test data set

Step 3. Regression of test data set



Comparison of target amplitude model (blue line) versus amplitude models of test data set

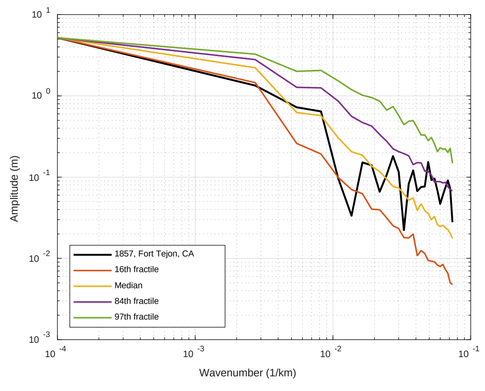
Step 4. Calculation of misfit from target coefficients



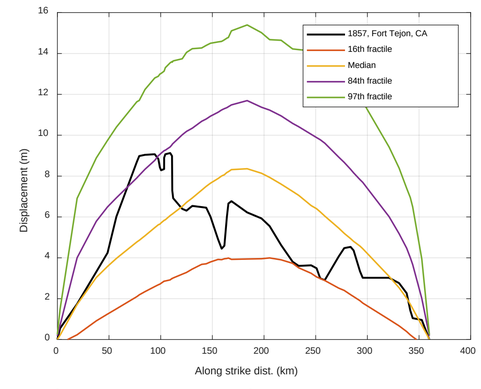
Misfit between target and test dataset amplitude model coefficients

Example Forward Calculation

In forward calculations the amplitude and phase derivative models can be sampled and combined to generate future realizable profiles.



Simplified example, sample range in wavenumber domain



Simplified example, implied fractiles in space domain

Research Partners

Pacific Gas and Electric Company

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