Combining Observed Elastic Basin Amplification Factors with 1D Nonlinear Site Response Analyses

Chris de la Torre

Brendon Bradley

NSHM Wellington Basin Group

UNIVERSITY OF CANTERBURY

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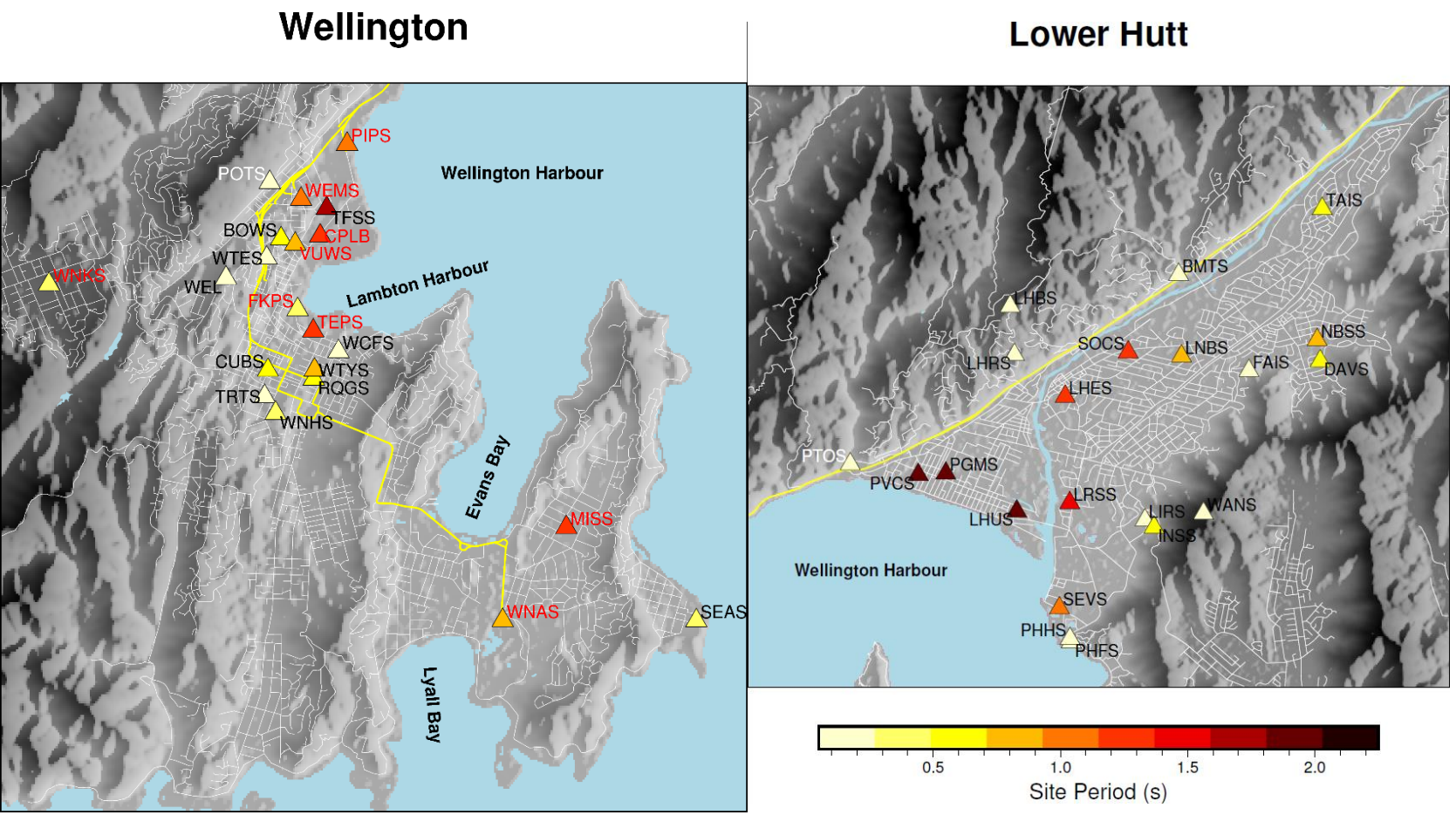
QuakeCoRE

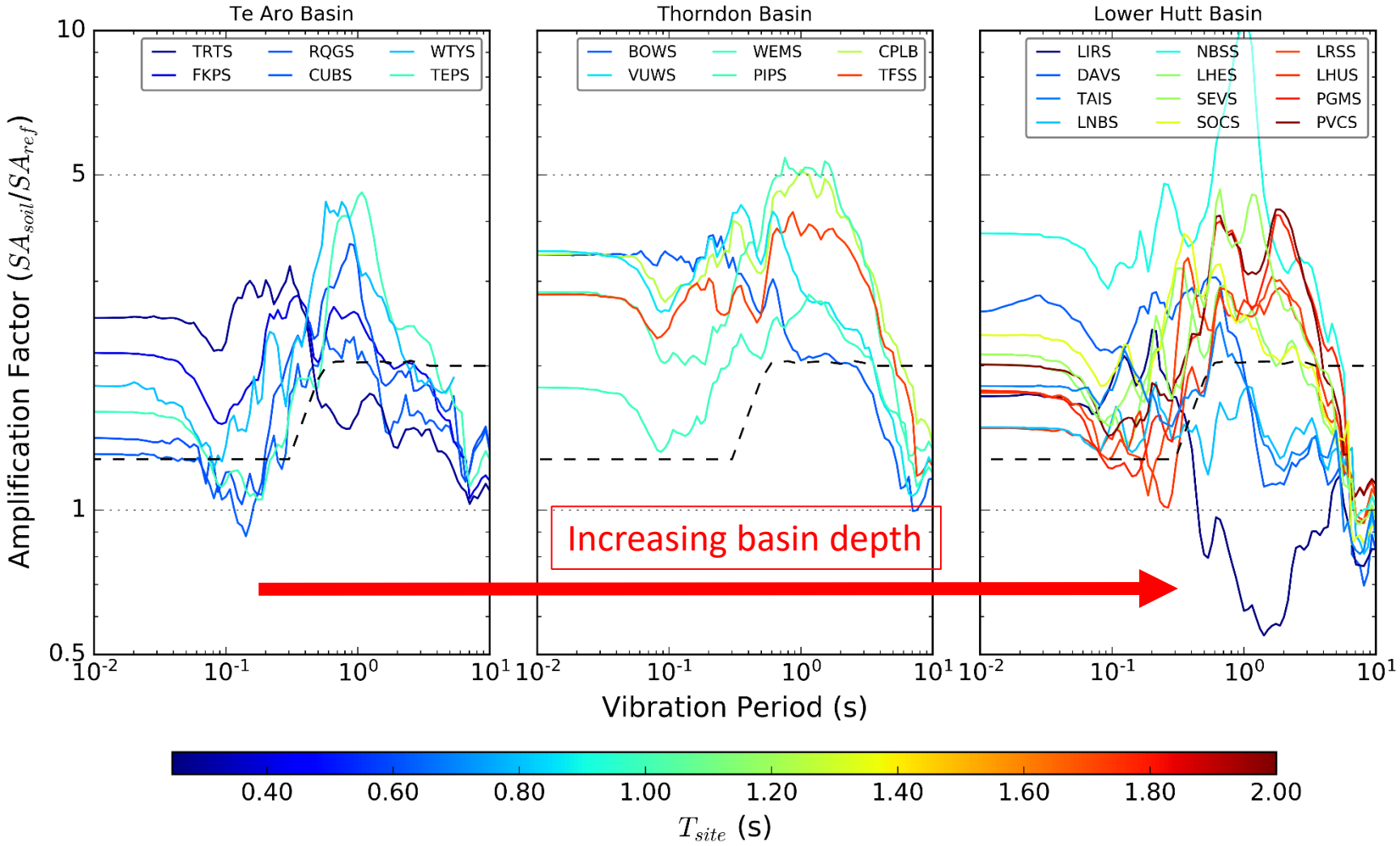
NZ Centre for Earthquake Resilience

Wellington Basins and Sites Considered



- Wellington CBD and Lowe Hutt
- 3 basins
- 43 station
- 9 stations for nonlinear site response

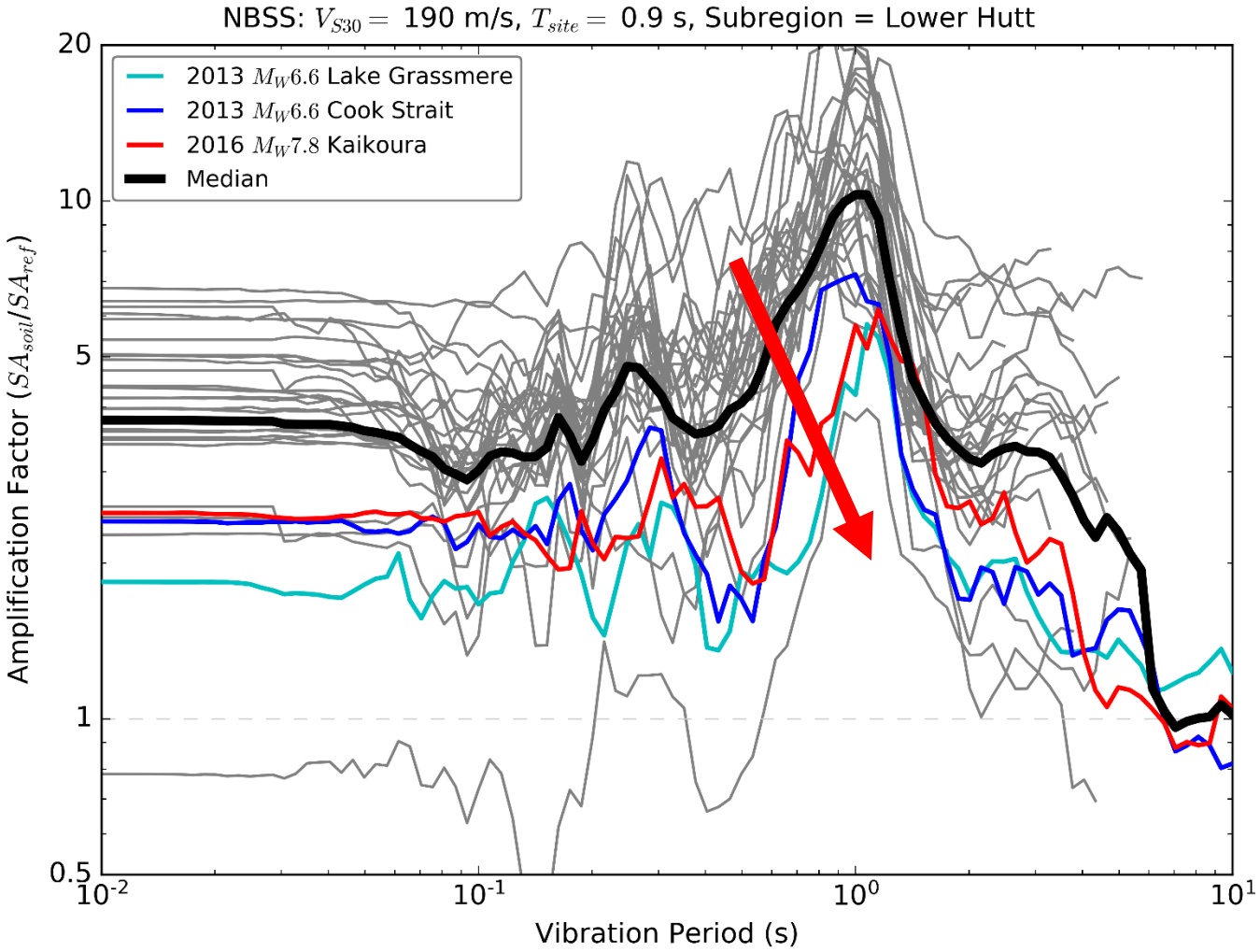
Observed Basin/Site Amplification in Wellington



- Average values for each site
- Weak to moderate ground motions
- "Linear" site response

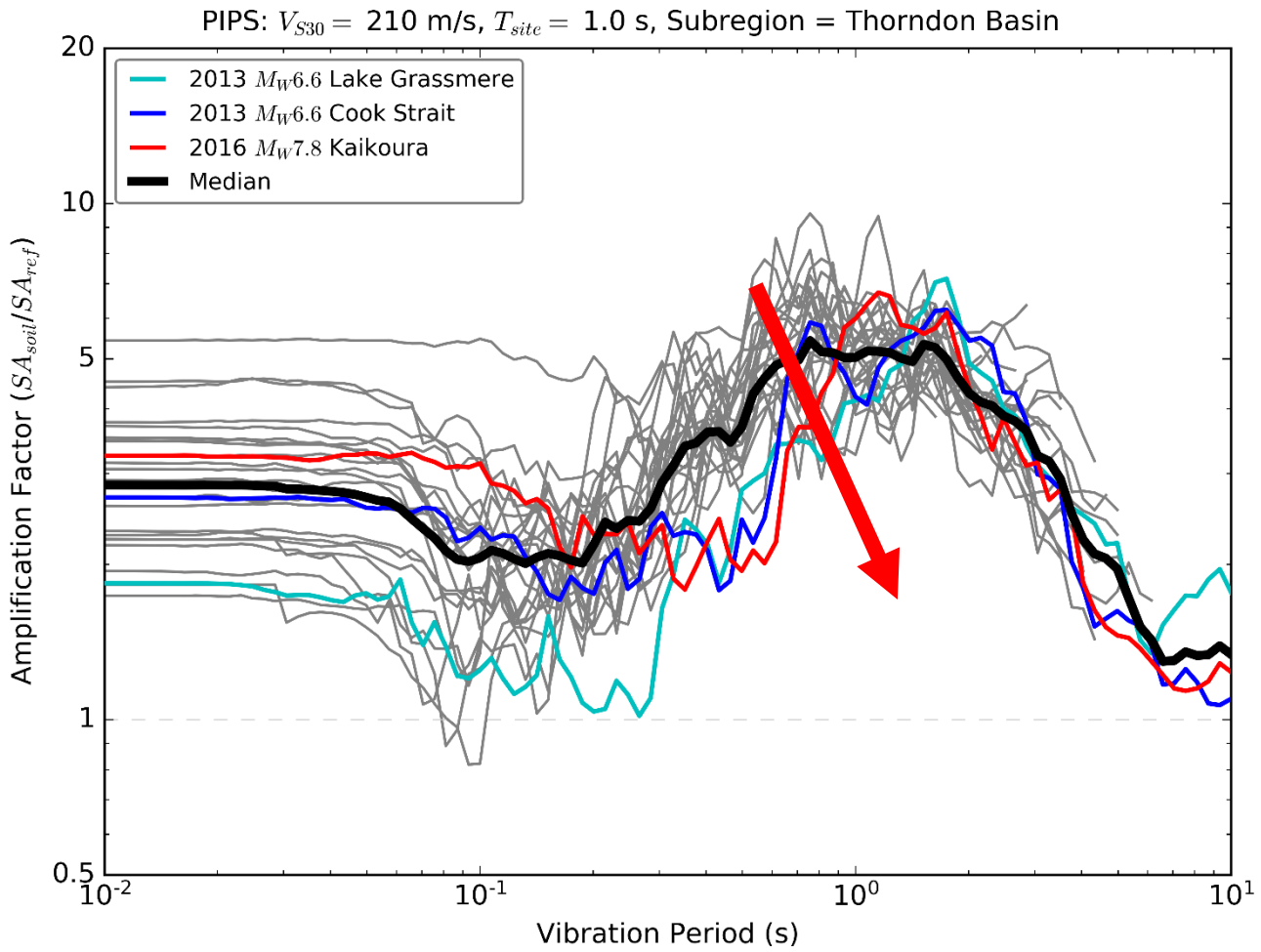
Are these amplification factors reasonable for design-level ground motions?

Influence of Nonlinearity on Observations?



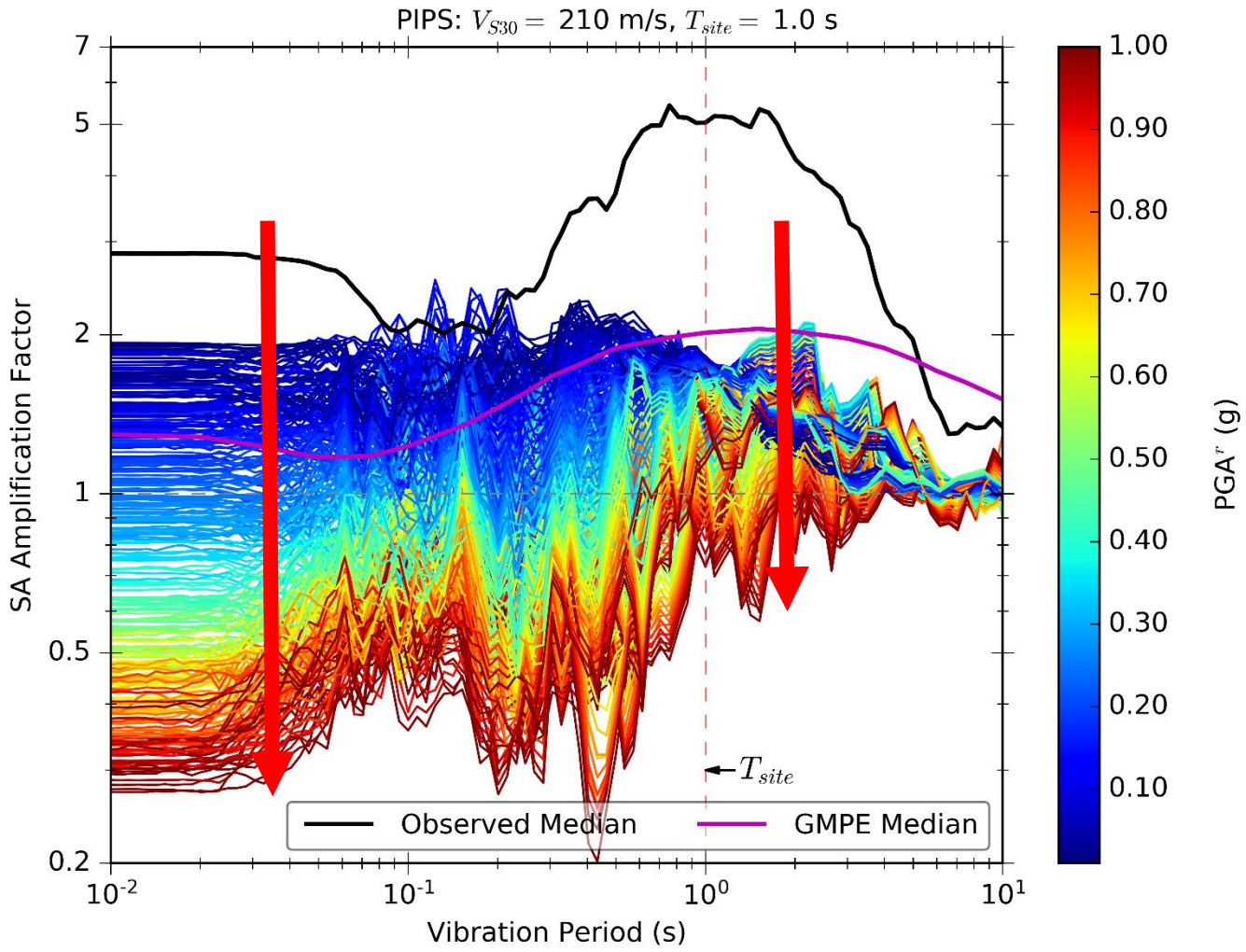
- Observations for all events
- Soft site (V_{S30} = 190 m/s)
- Effects of nonlinearity?
- Max PGA_{soil} ≈ 0.2-0.25 g
- How to validate future events with PGA > 0.5 g??
  - Scale 3 large EQs motions up to PGA^r = 1 g

Influence of Nonlinearity on Observations?



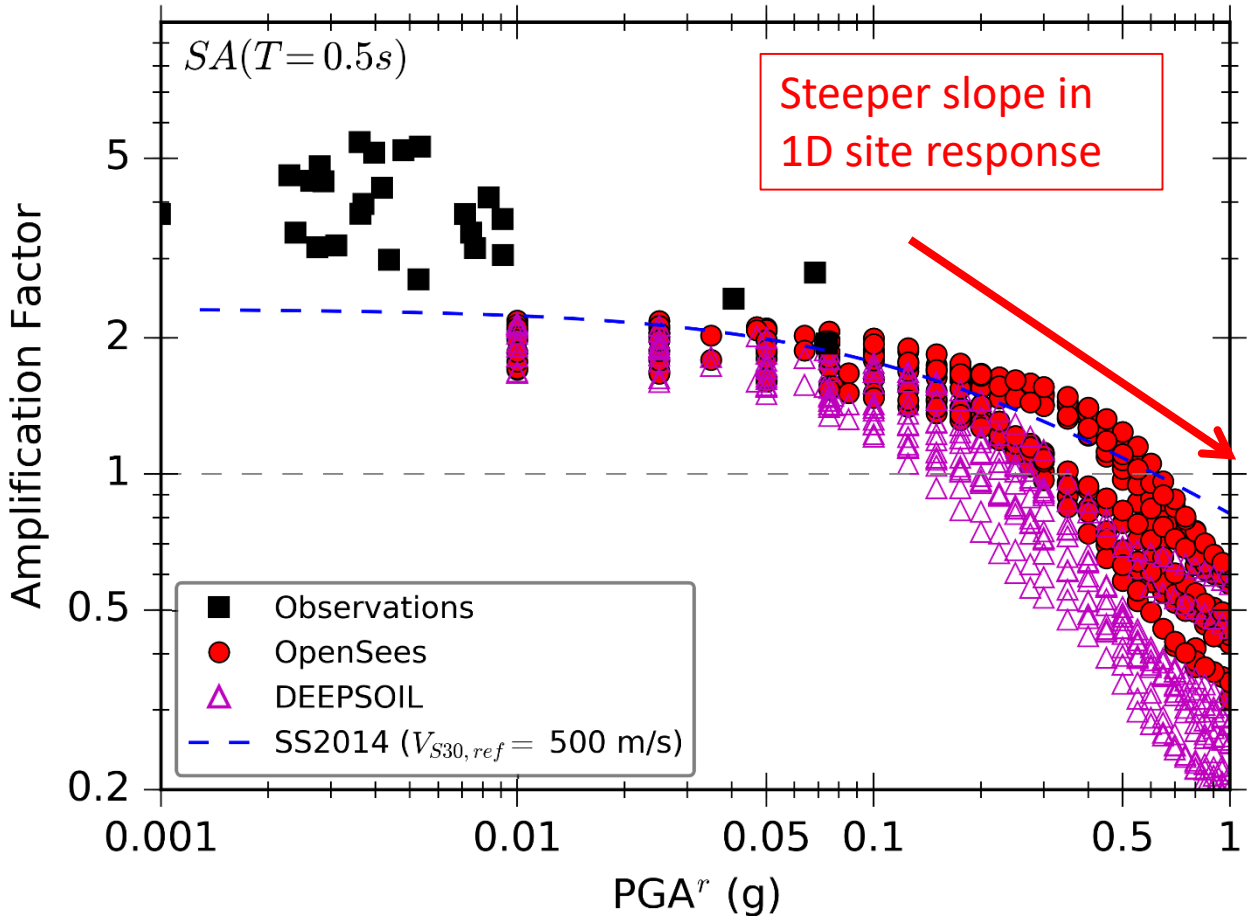
- Observations for all events
- Soft site (V_{S30} = 210 m/s)
- Effects of nonlinearity?
- Max PGA_{soil} ≈ 0.2-0.25 g
- How to validate future events with PGA > 0.5 g??
  - Scale 3 large EQs motions up to PGA^r = 1 g

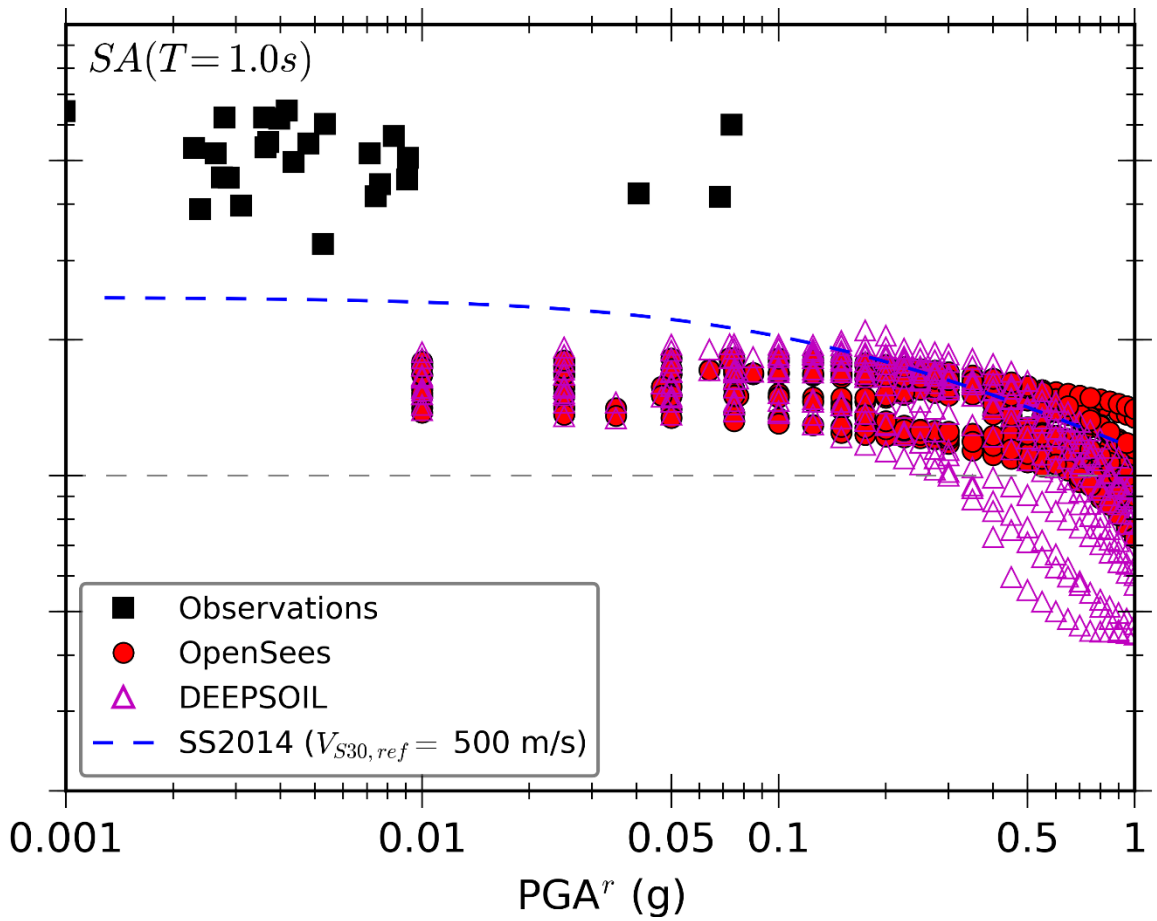
Softer Site: PIPS – V_{S30} = 210 m/s, T_{site} = 1.0s



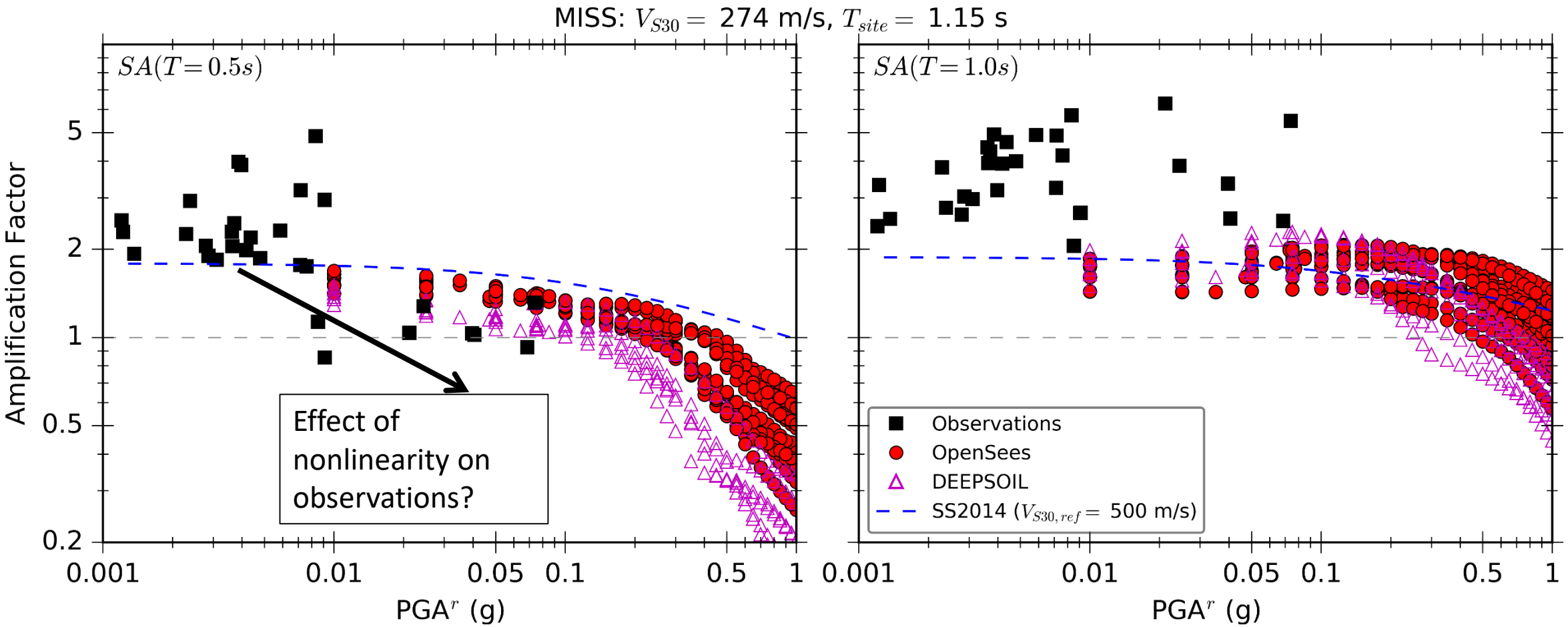
- Scaled input motions
  - PGA^r = 0.01 to 1 g
- 1D analysis doesn't capture basin amplification
- GMPEs don't capture basin amplification
- Significant deamplification at short periods
- Reduction in amplification at long periods.

Softer Site: PIPS – V_{S30} = 210 m/s, T_{site} = 1.0s

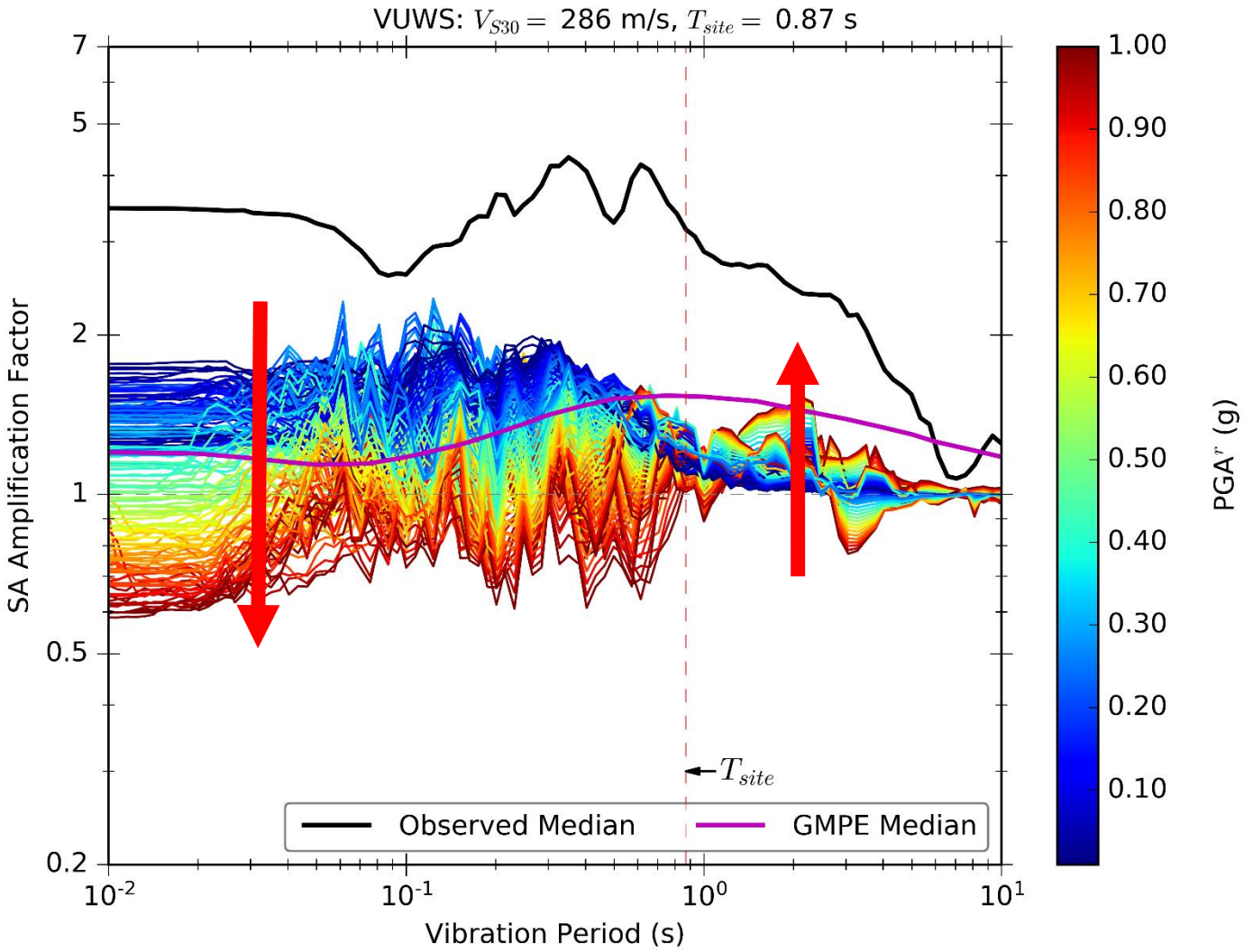




Another Soft Site: Nonlinearity in Observations?

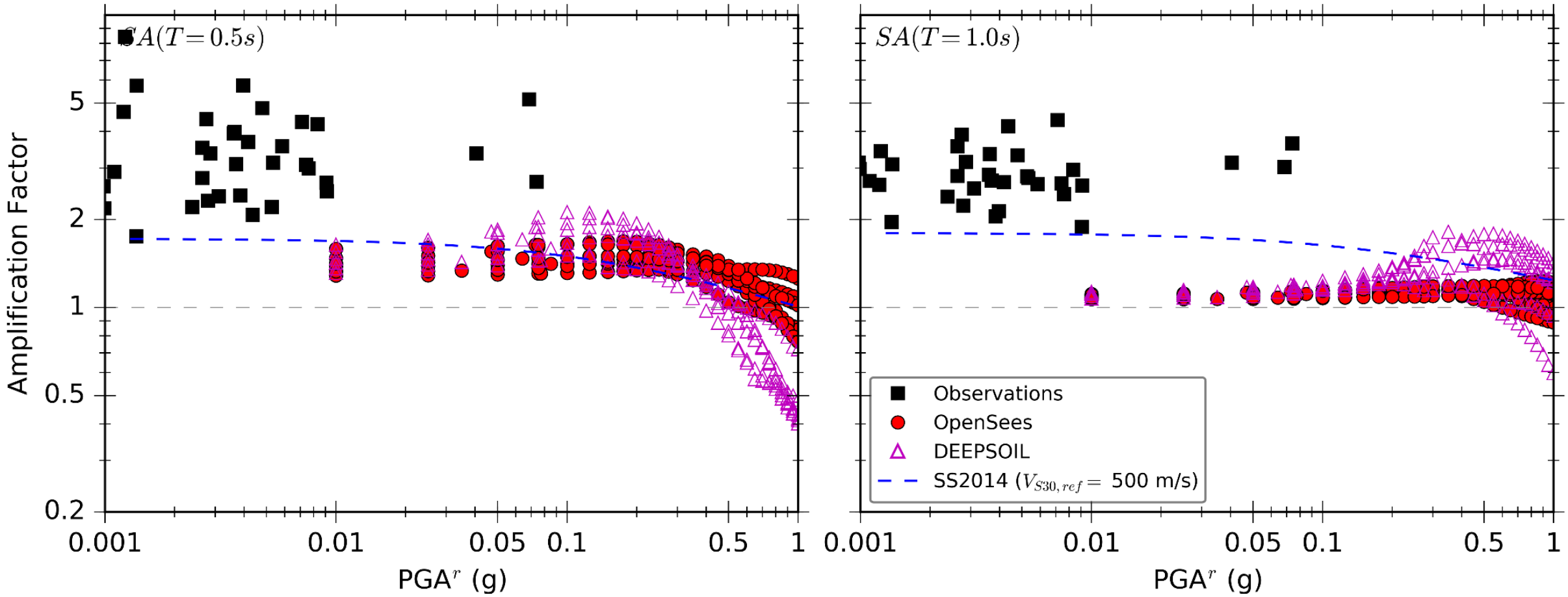


Stiffer Site: VUWS – V_{S30} = 286 m/s, T_{site} = 0.87s



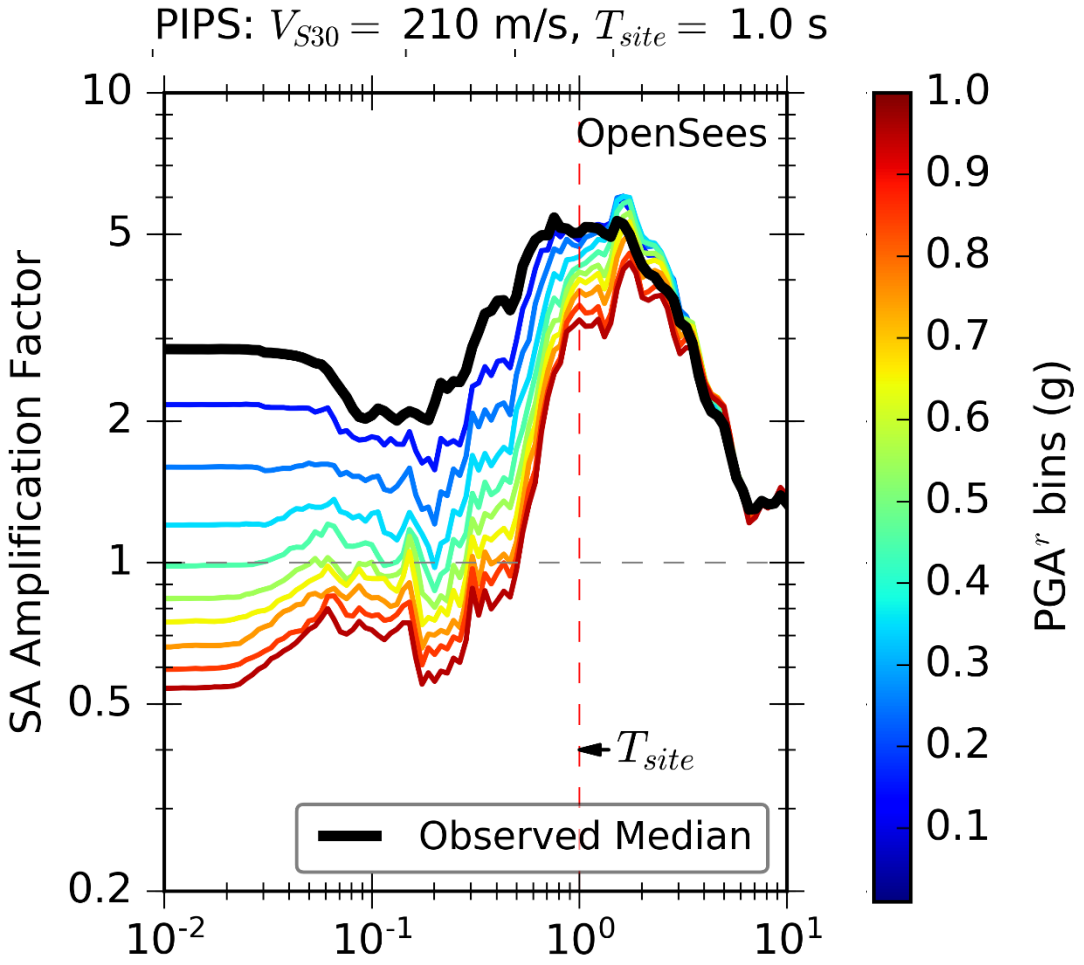
- Less deamplification at short periods
- Increase in amplification at long periods.
  - Period elongation from moderate nonlinearity?

Stiffer Site: VUWS – V_{S30} = 286 m/s, T_{site} = 0.87s

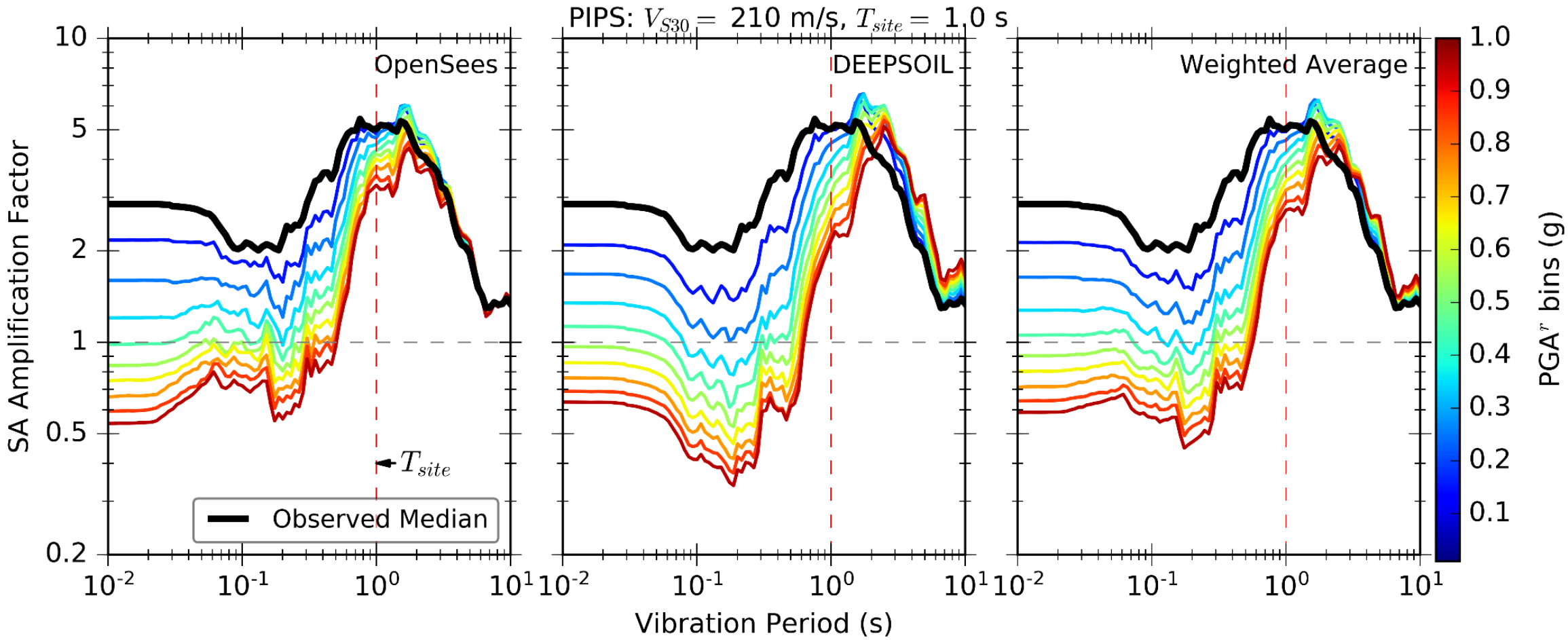


Combining Observations and Analyses

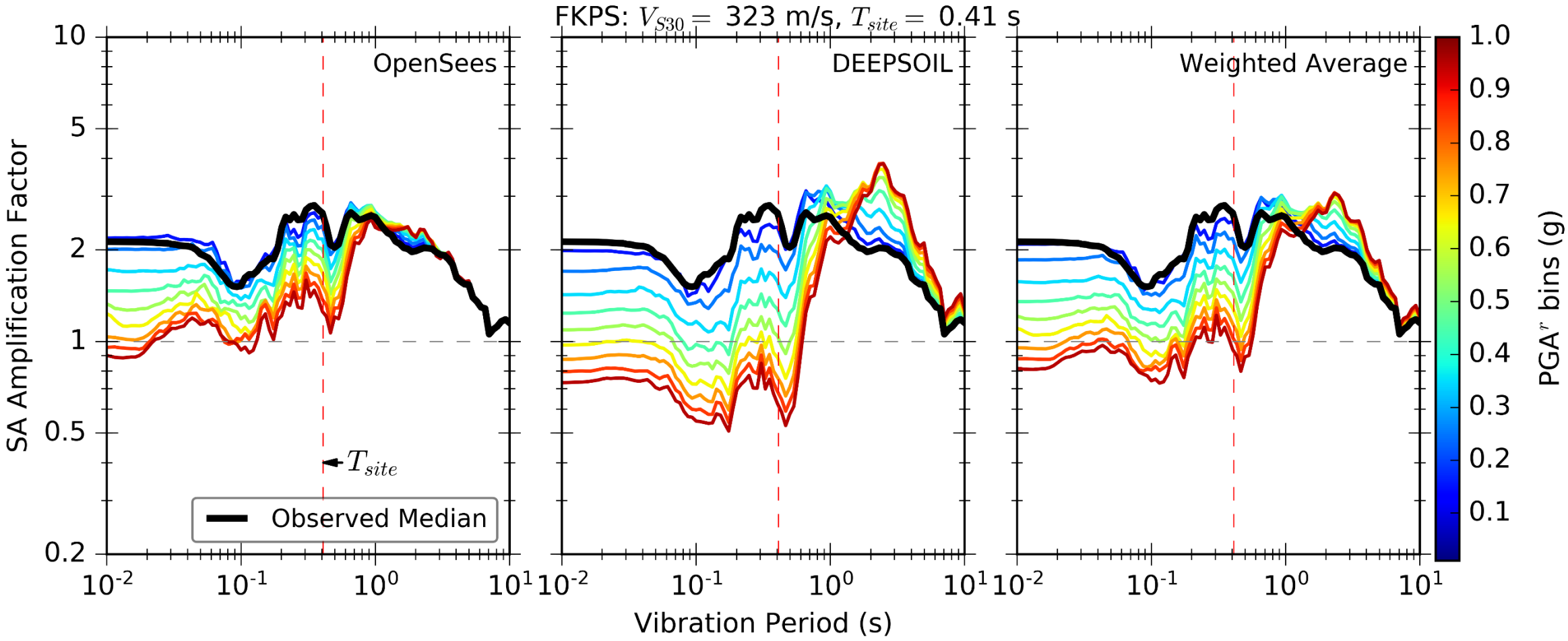
- 1D amplification factors (AF) for $PGA^r < 0.05$ g → "elastic" reference.
- Bin PGA^r into 0.1 g bins.
- Calculate average AF for each bin.
- Nonlinear modifier = $AF_{elastic} / AF_{bin.}$
- Apply nonlinear modifier to observed median "elastic" site terms



Combining Observations and Analyses: Soft Site Example

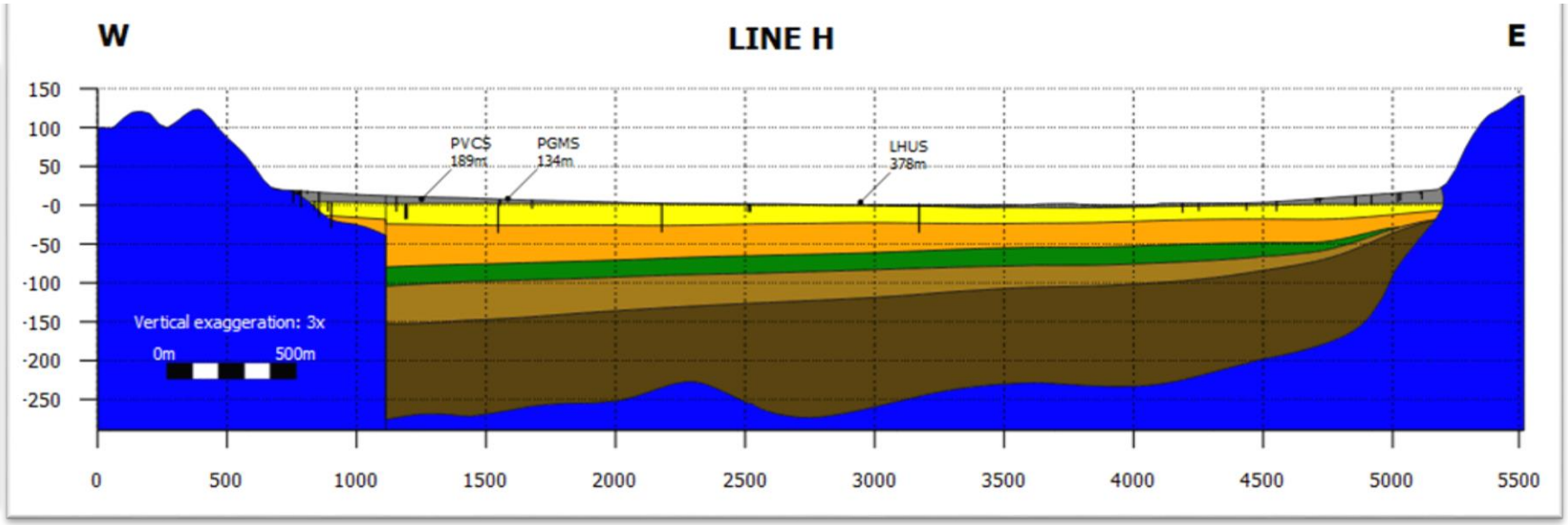


Combining Observations and Analyses: Stiff Site Example



Future Work

- Investigate the coupling between geometric amplification (i.e., basin effects) and impedance amplification/surface nonlinearity.
  - Using 2D nonlinear models
- Assess corrected HVSR as predictor of total site response in Wellington.
  - Basin + Site effects (elastic)
  - Large HVSR database in Wellington



Thank You

Questions?