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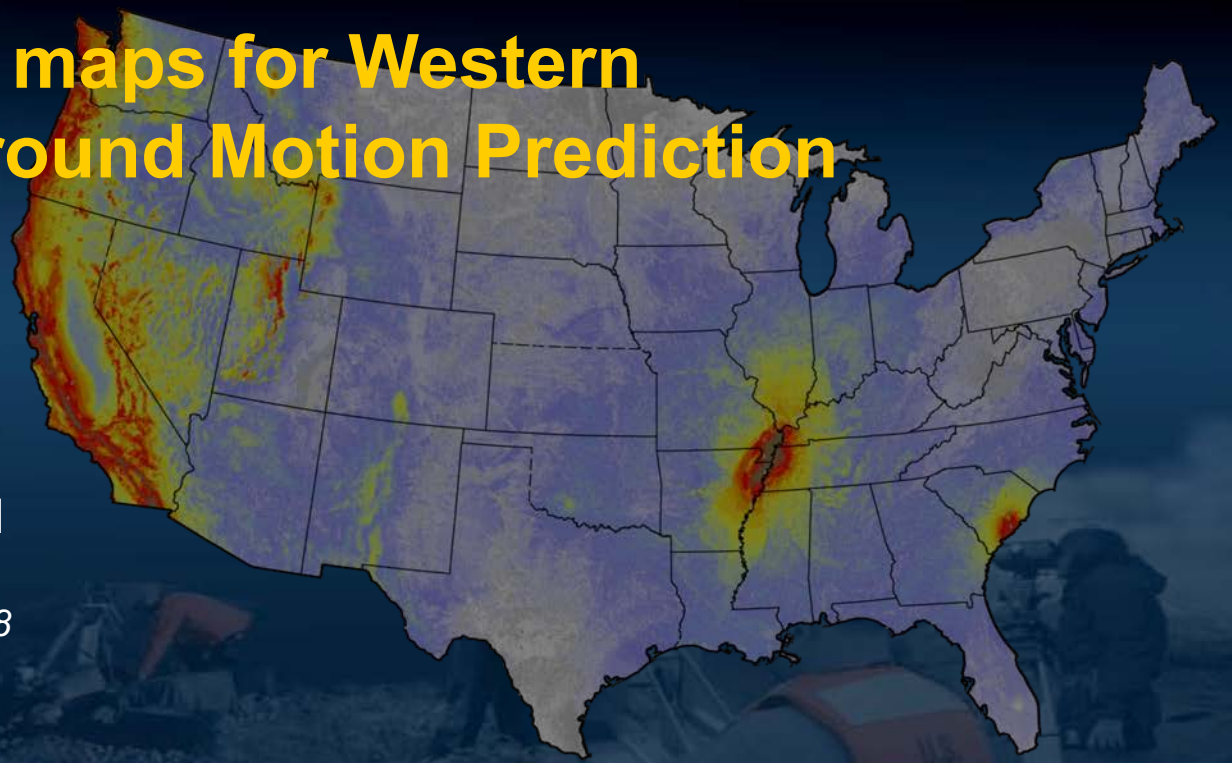
Z_X 'Basin Depth' maps for Western United States Ground Motion Prediction Equations



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U.S. Department of the Interior
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- **Brandon Schmandt and Weisen Shen**—Providing national scale seismic velocity models
- **Eric Thompson**—Calculate ground motion residuals

Z_X Estimates for WUS GMPEs

Types of Z_X Estimates

- Local velocity models (high resolution, low uncertainty but highly variable within study area)
  - Boreholes, gravity, seismic refraction/reflection, other geophysical methods
- National velocity models (low resolution, medium uncertainty with uniform coverage)
  - Various seismic methods: Tomography, H/V, receiver functions, etc.

Types of Z_X Estimates

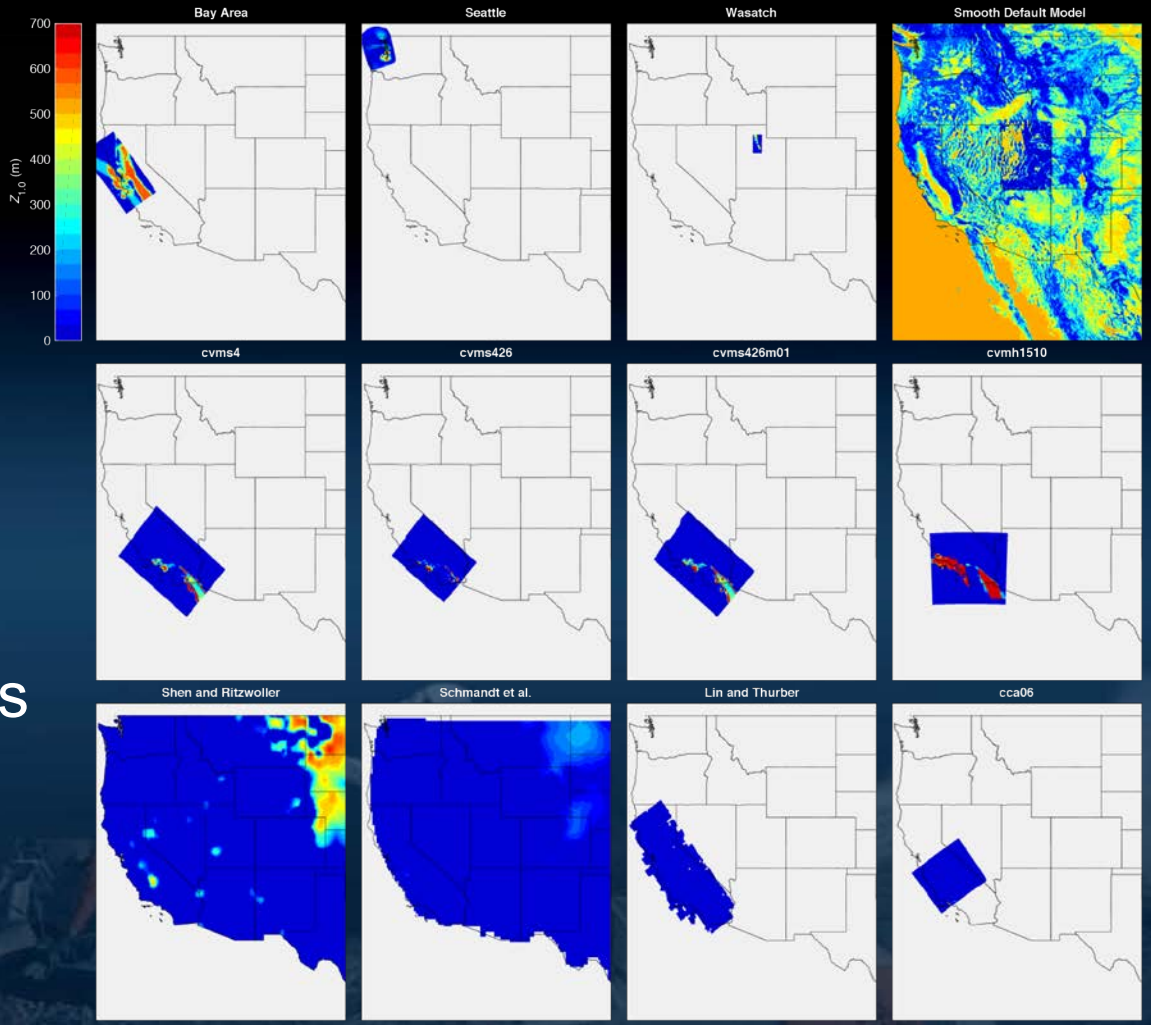
- Proxy models (high resolution, high uncertainty, uniform coverage)
  - $Z_X(V_{S30})$ where, for example, V_{S30} is based on topography and geology
- Scaling relationships (resolution and coverage depends on input, high uncertainty)
  - $Z_{1.0}(Z_{2.5}, V_{S30})$
- Default GMPE relationships

Z_X Models in the WUS

- From local and national velocity models, depths to 1.0 and 2.5 km/s shear-wave velocity ($Z_{1.0}$ and $Z_{2.5}$) are extracted.
- Also consider smoothed V_{S30}-based Z_X model

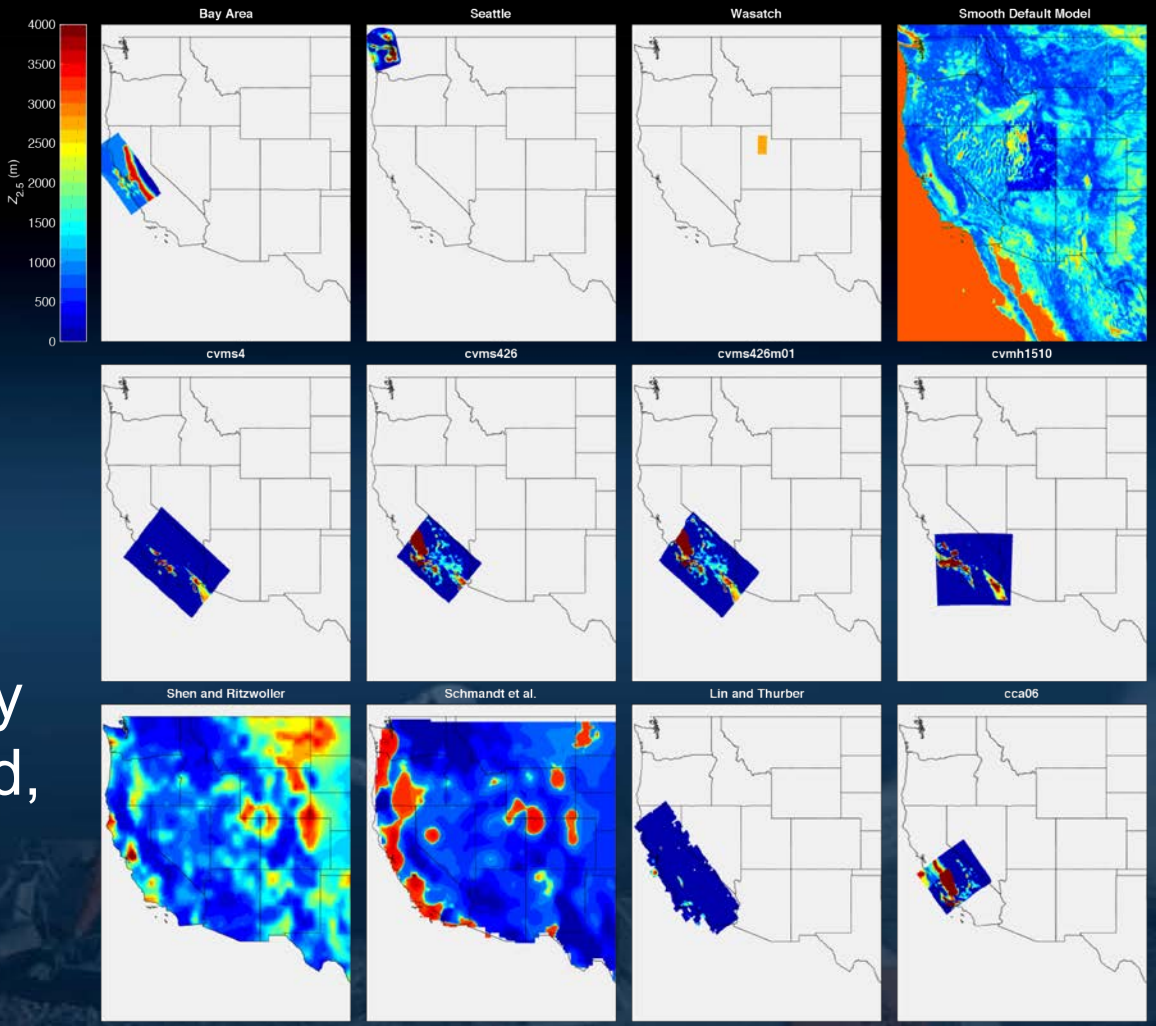
Original $Z_{1.0}$ Models

- Large areas of values of $Z_{1.0}$ equal to zero, likely unresolved



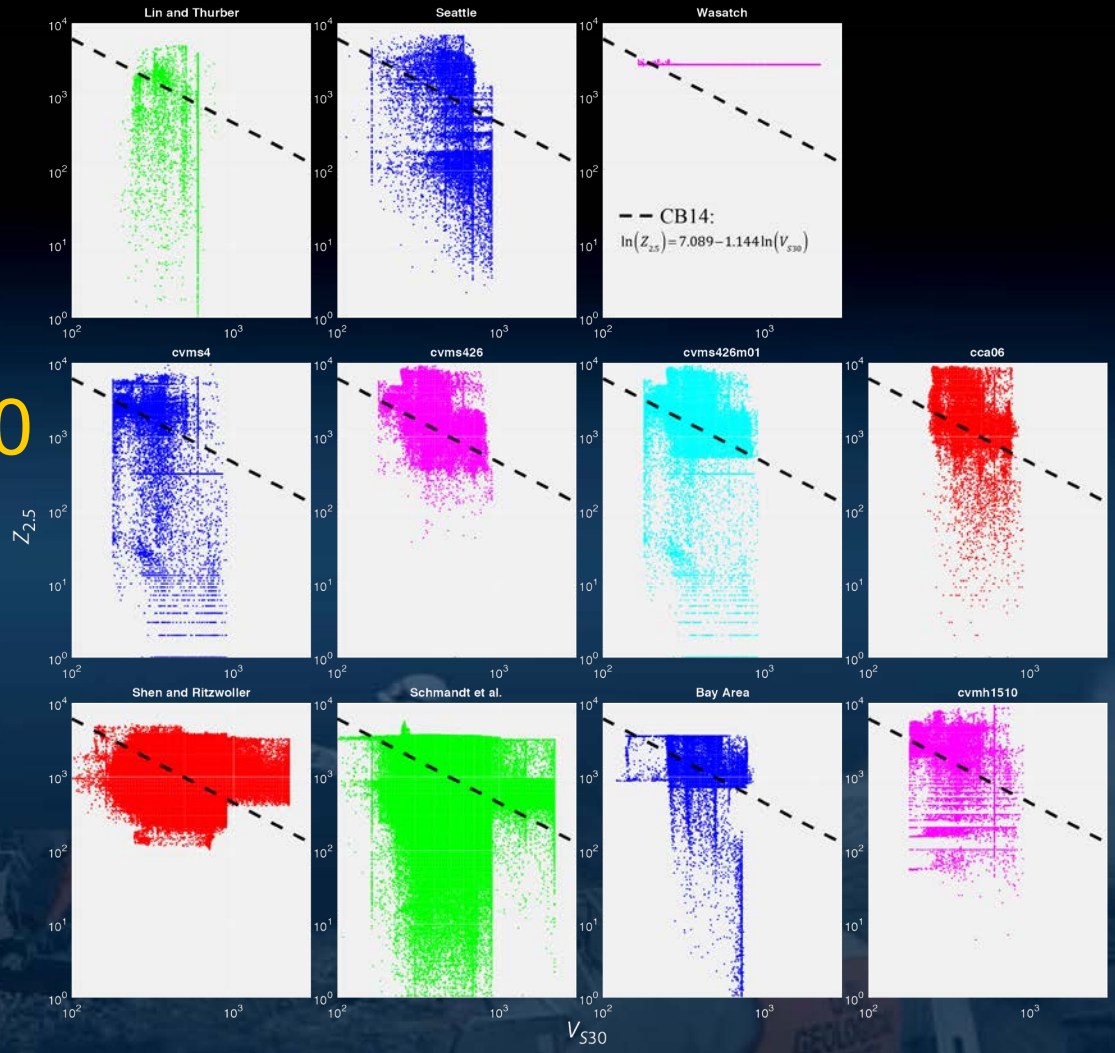
Original $Z_{2.5}$ Models

- Smaller areas of very low, likely unresolved, values of $Z_{1.0}$



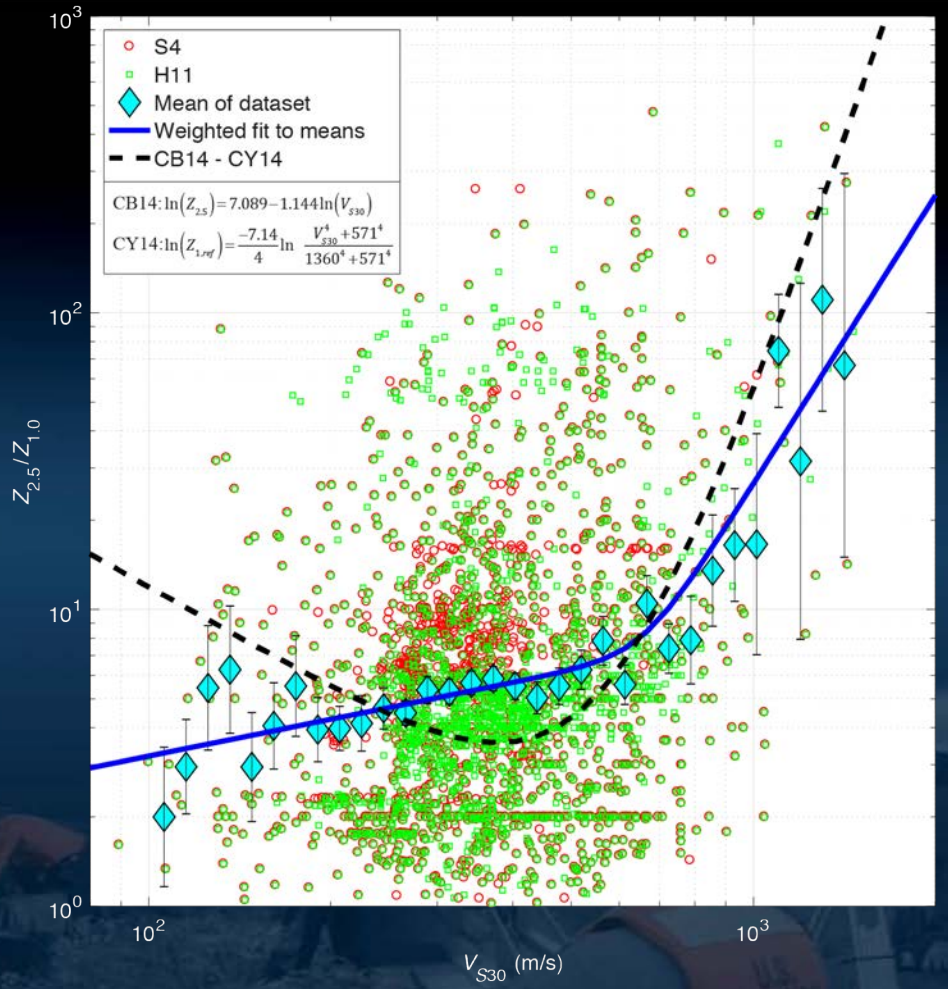
Correcting shallow values of $Z_{1.0}$ using $Z_{2.5}$

- All models have reasonable values of $Z_{2.5}$ in some areas.



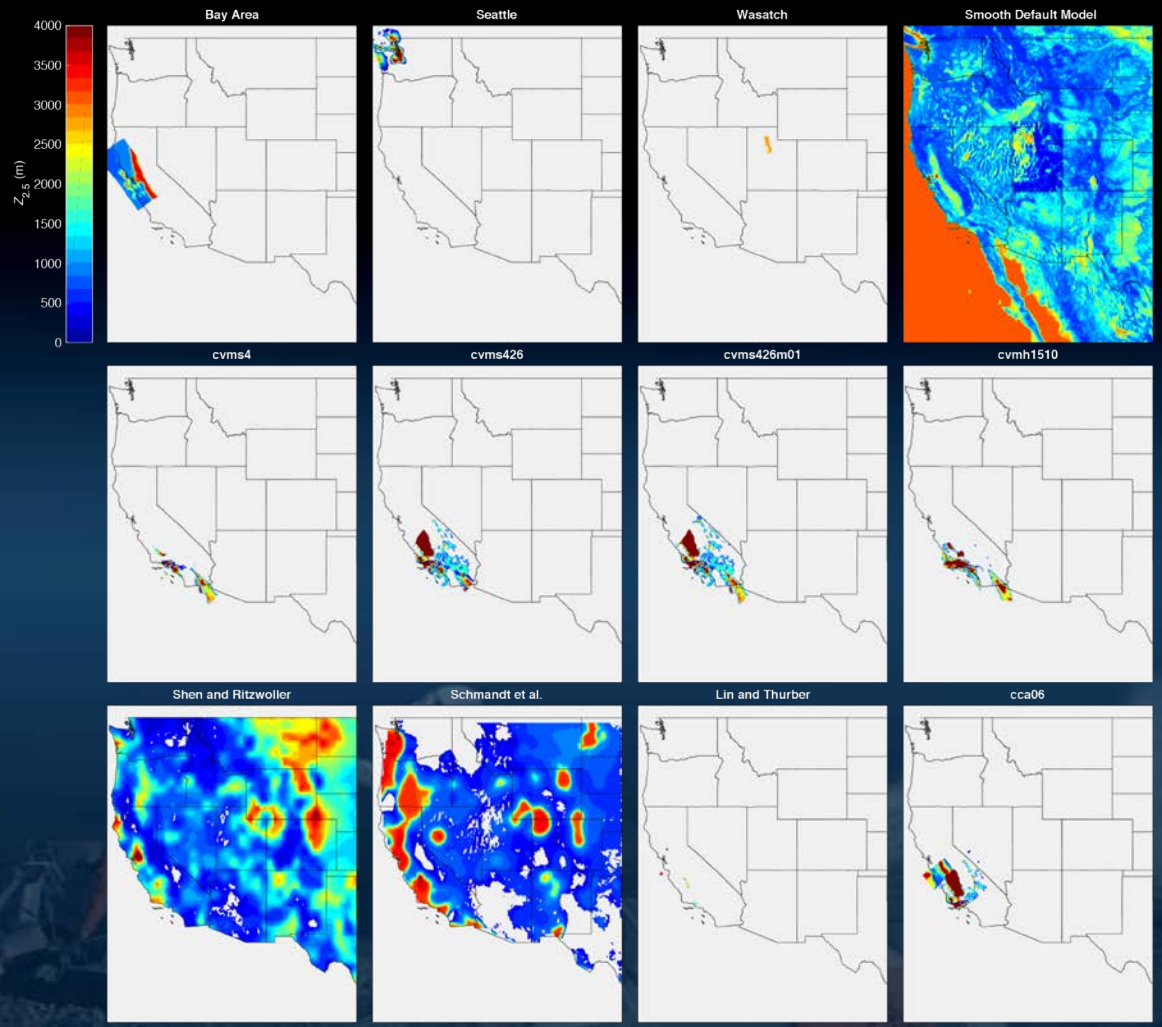
Correcting shallow values of $Z_{1.0}$ and $Z_{2.5}$

- Relationship of $Z_{1.0}$, $Z_{2.5}$, and V_{S30} in NGA-West2 database.

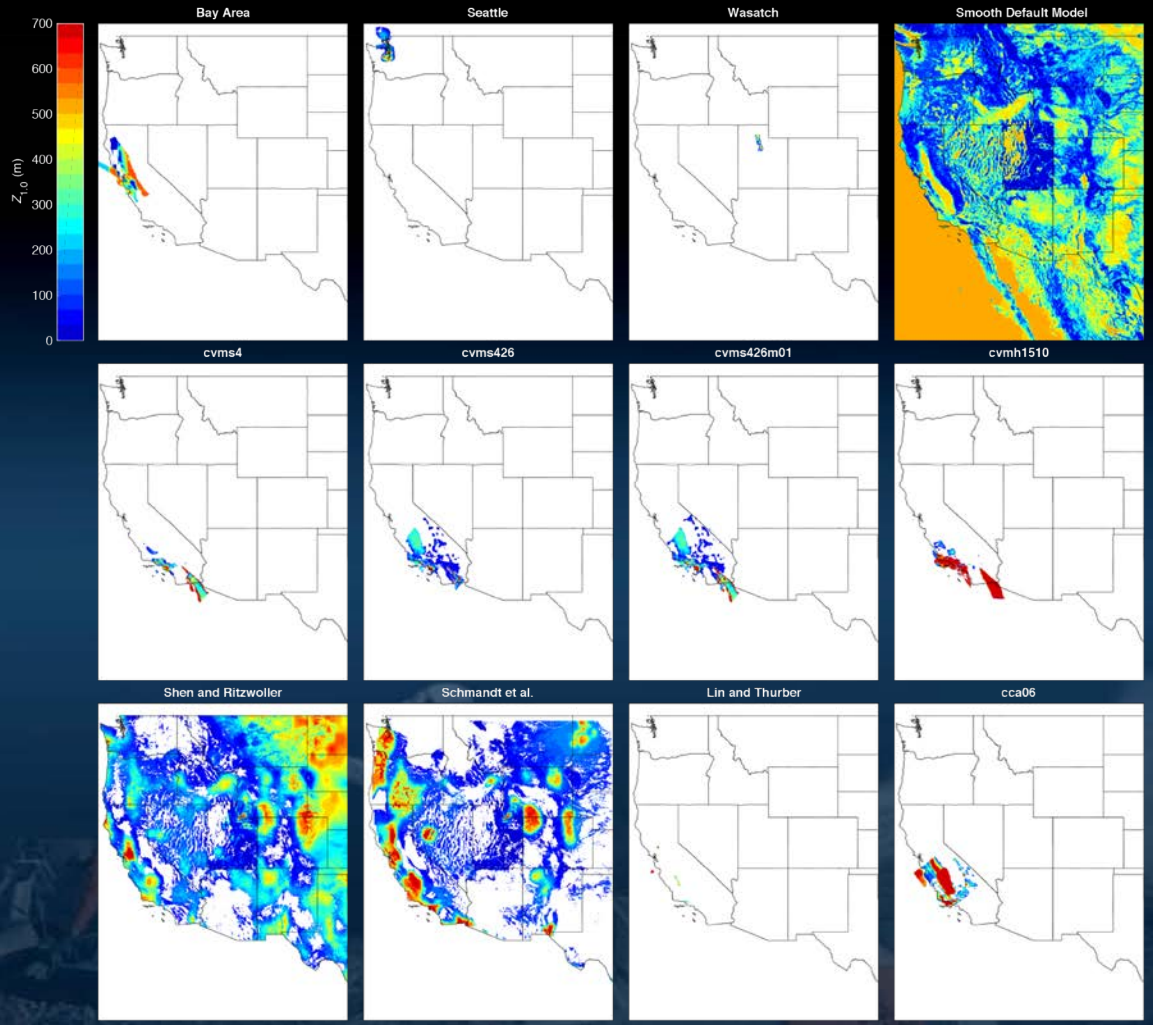


Remove low values of $Z_{2.5}$

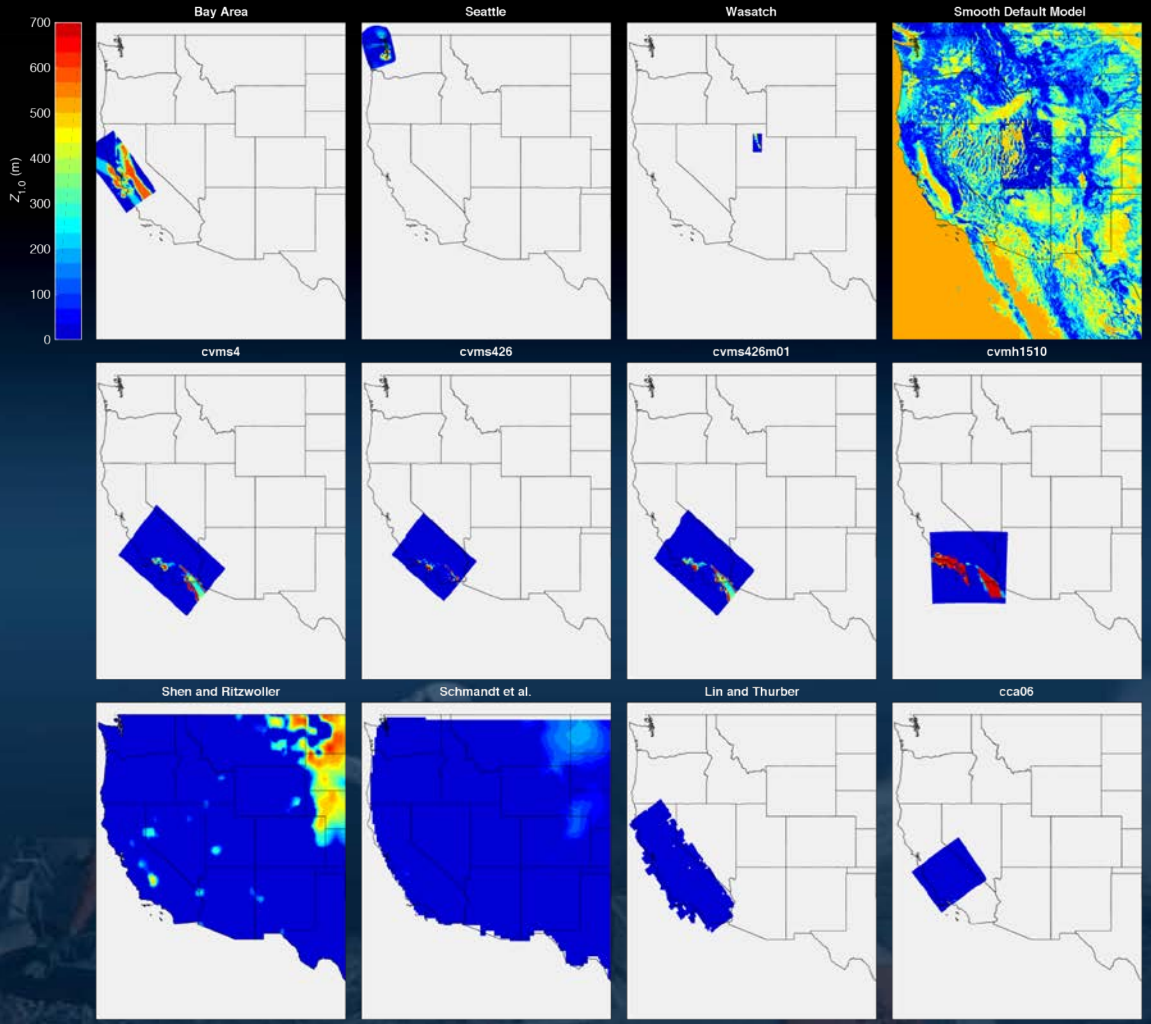
- Calculate $Z_{1.0}$ given $Z_{2.5}$ and V_{S30}.



Replace or remove low values of $Z_{1.0}$



Original $Z_{1.0}$ Models



Combining models

- Preweighting of original models
  - Models are extrapolated to the full domain with inverse distance weighting. Model weight prefactors drop from 1 where the model is well resolved to zero elsewhere.
- Logic tree weights based on, for example, variance reduction of intra-event residuals, log-likelihood methods, inherent model uncertainties, expert opinion, etc.

Types of Uncertainty

- Uncertainty in Z_X
- Uncertainty in how Z_X is modeled in the GMPE
  - functional form
  - model coefficients
  - model parameters and whether Z_X should be an integrated measure of subsurface properties

NGA-West2 Observations

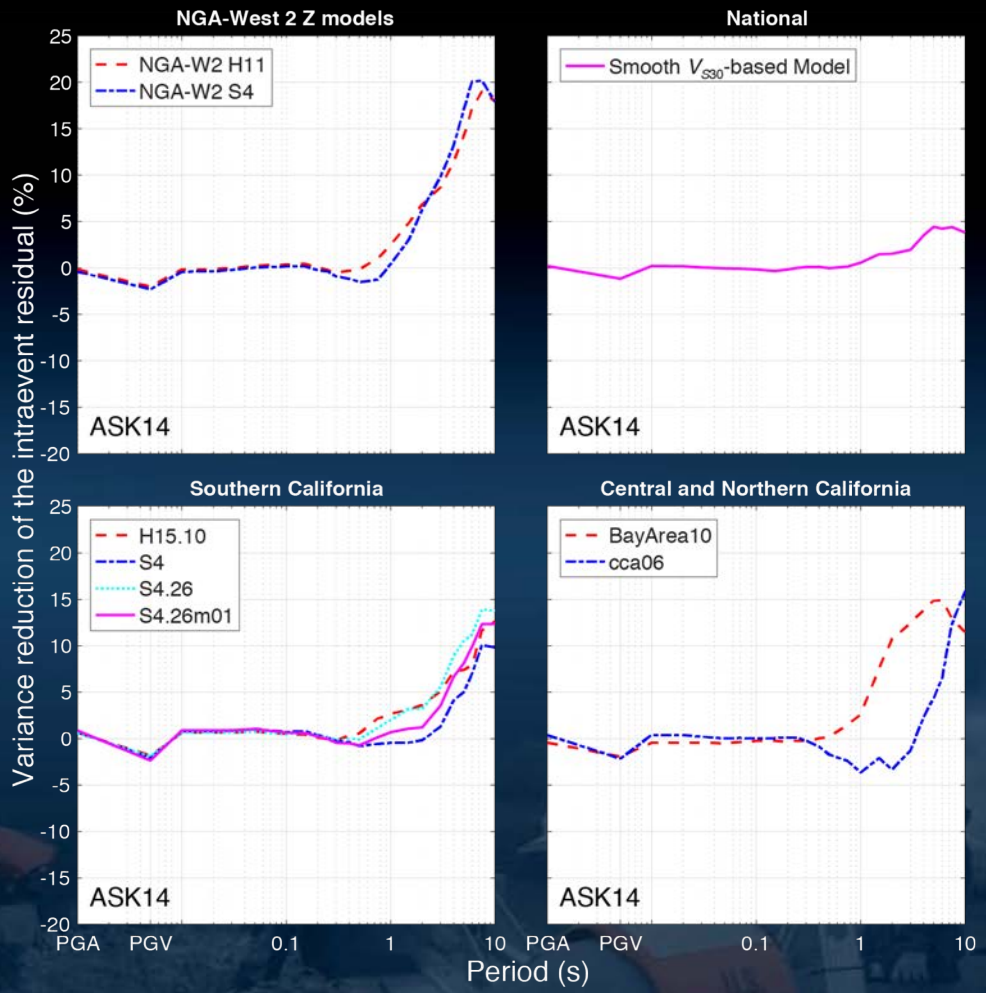
- Station locations (yellow circles) primarily in California
- No stations in Seattle or along the Wasatch Front

NGA-West2 Observations

$Z_{1.0}$

Abrahamson et al. (2014)

Variance reductions relative to default values using the *VS*30 in the NGA-West2 database. Site terms removed.

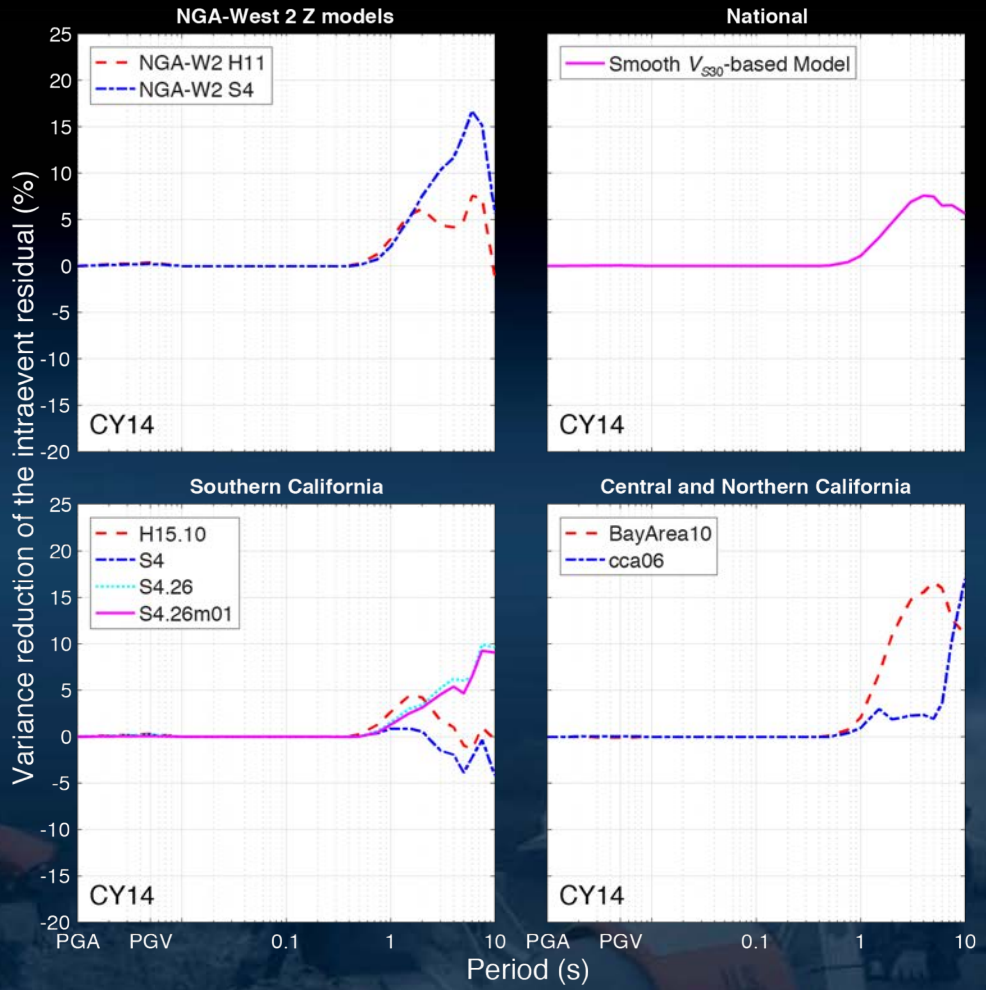


NGA-West2 Observations

$Z_{1.0}$

Chiou and Youngs (2014)

Variance reductions relative to default values using the *VS*30 in the NGA-West2 database. Site terms removed.

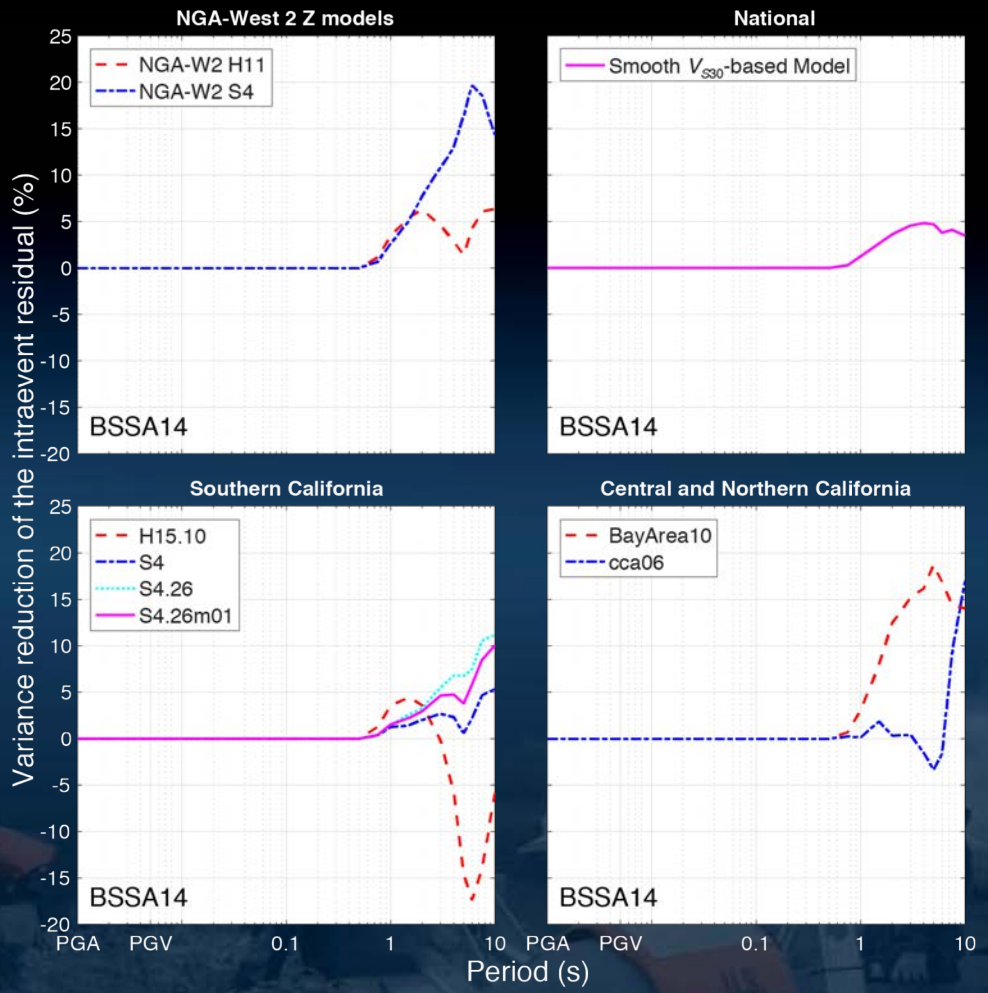


NGA-West2 Observations

$Z_{1.0}$

Boore et al. (2014)

Variance reductions relative to default values using the *VS*30 in the NGA-West2 database. Site terms removed.

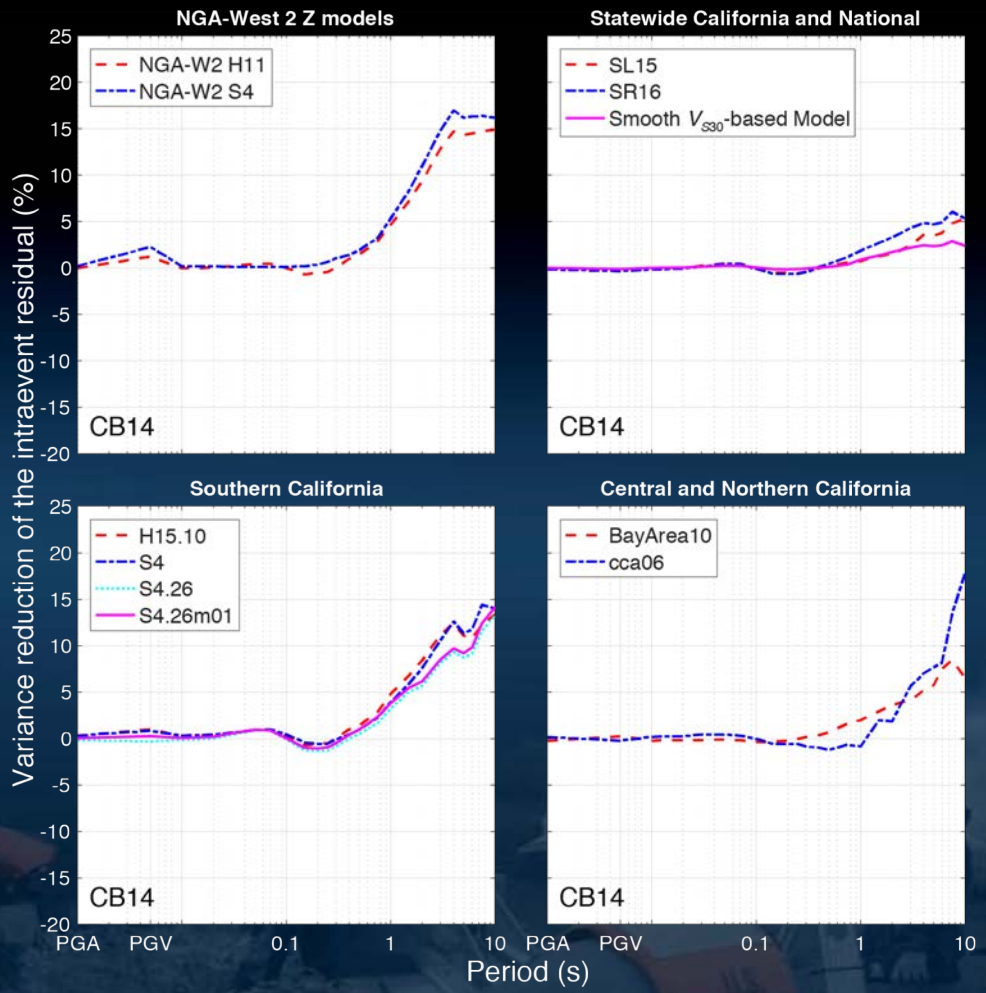


NGA-West2 Observations

$Z_{2.5}$

Campbell and Bozorgnia (2014)

Variance reductions relative to default values using the *VS*30 in the NGA-West2 database. Site terms removed.



Conclusions

- All models have reasonable values of $Z_{2.5}$
- National velocity models can reduce intra-event residuals for the $Z_{2.5}$-based GMPE
- Smoothed V_{S30}-based proxy models can reduce residuals for all GMPEs
- Local models yield the greatest variance reduction
  - Best resolved with least uncertainty
  - Used to derive the GMPEs

Possibilities for a composite model: weighting

- Variance reductions of intra-event residuals to guide relative weighting of models
- Log-likelihood methods
- Expectations of Z_X model uncertainty
- Expert Opinion

Local models get greatest weight

National models and smoothed VS30-based proxy model fill in the background.