Proposed Implementation of Basin Effects into the 2018 NSHM: Overview and Methods

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Background 2014 GMM consideration of basin effects

- **CEUS - GMMs** did not explicitly consider basin depths (Implicit)
- **WUS - GMMs** applied default basin depths for each Vs30 provided by NGA-West2 (Implicit)
- Recently engineers have wanted to consider multi-period and site class ground motions but we have 2 problems:
  - we don’t have a published velocity model for the WUS to define the input parameters.
  - we don’t have published methods to account for basin effects for subduction GMMs.

Definition: Default basin GMM

- Ground motion model applies an “**average”** basin depth for a specified Vs30 (model dependent).

- Typically used if you don’t have any information on basin depth.

- Soft soils already include basin amplification because much of data overlies sedimentary basins.
  - Vs30 of 260: Z1 default 0.5 km, Z2.5 about 2 km.

Default Basin Depths (km) Calculated from NGA-W2

Site Class	V_{s30} (m/s)	ASK14($Z_{1.0}$)	BSSA14($Z_{1.0}$)	CB14($Z_{2.5}$)	CY14($Z_{1.0}$)
A	2000	0.000	0.000	0.201	0.000
A/B	1500	0.000	0.001	0.279	0.001
B	1080	0.005	0.005	0.406	0.005
B/C	760	0.048	0.041	0.607	0.041
C	530	0.213	0.194	0.917	0.194
C/D	365	0.401	0.397	1.40	0.400
D	260	0.475	0.486	2.07	0.485
D/E	185	0.497	0.513	3.06	0.513
E	150	0.502	0.519	3.88	0.519

1. Vs30 decreases with increase in basin depths
2. For depth less than default basin depths, deamplification compared to default GMM
3. Most of the basin effects are significant beyond ~ 1 s SA.

Definition: Local basin GMM

- Ground motion model that considers detailed seismic velocity model that is developed using gravity, borehole, reflection data, etc.

- Provides local Z1.0 (depth to the 1.0 km/s shear wave velocity horizon) and Z2.5 (depth to the 2.5 km/s shear wave velocity horizon) which can be used as input NGA-W2 equations if available.

- These Z depths have uncertainty that should be accounted for in the assessment of ground shaking. Some would say that the uncertainty in Z1.0 is larger than the uncertainty in Z2.5.

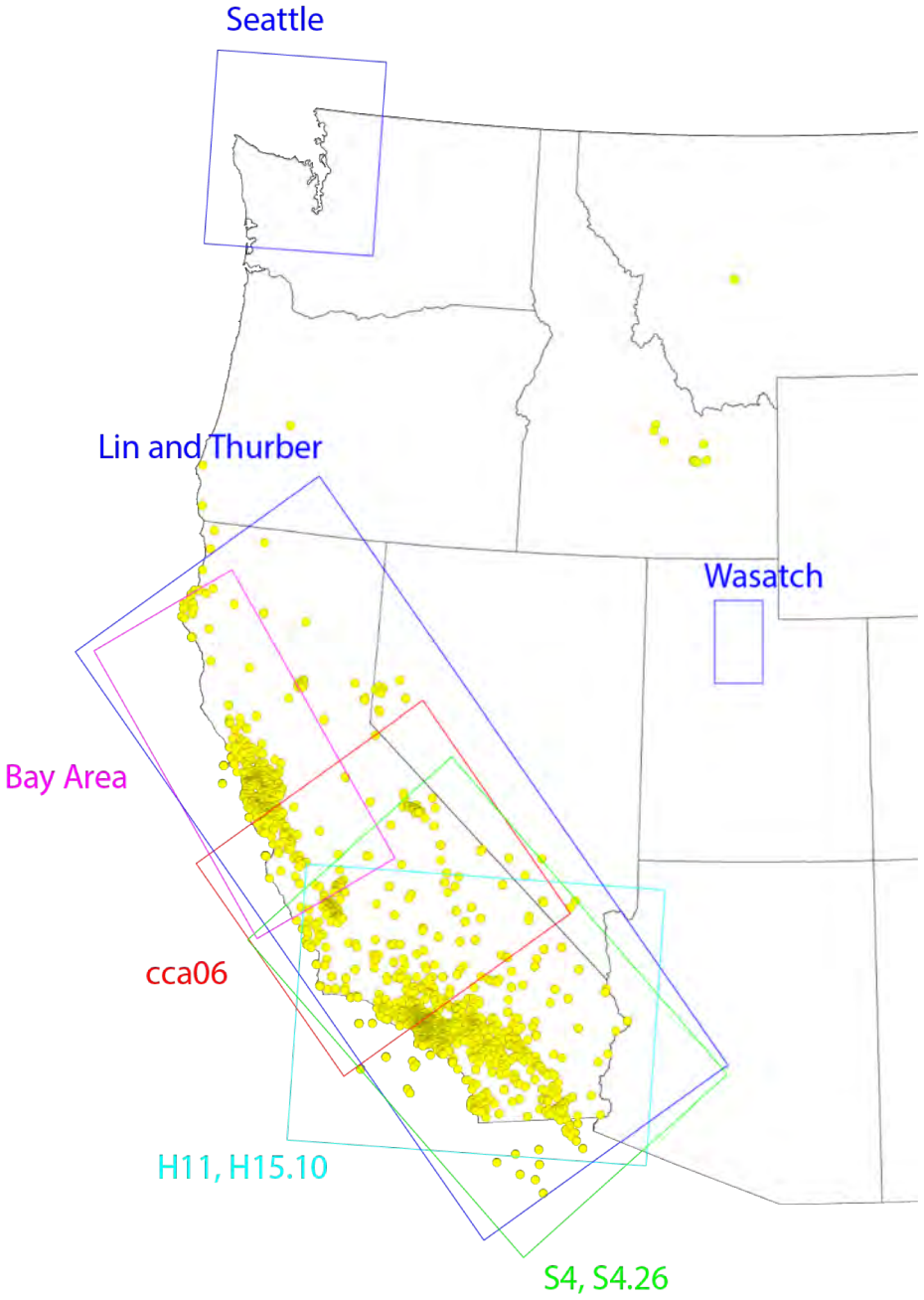
Background

Four regions have local velocity models (Los Angeles, San Francisco Bay Area, Salt Lake City, and Seattle).

Other areas only have regional models which will be discussed by Oliver Boyd.

Velocity Models

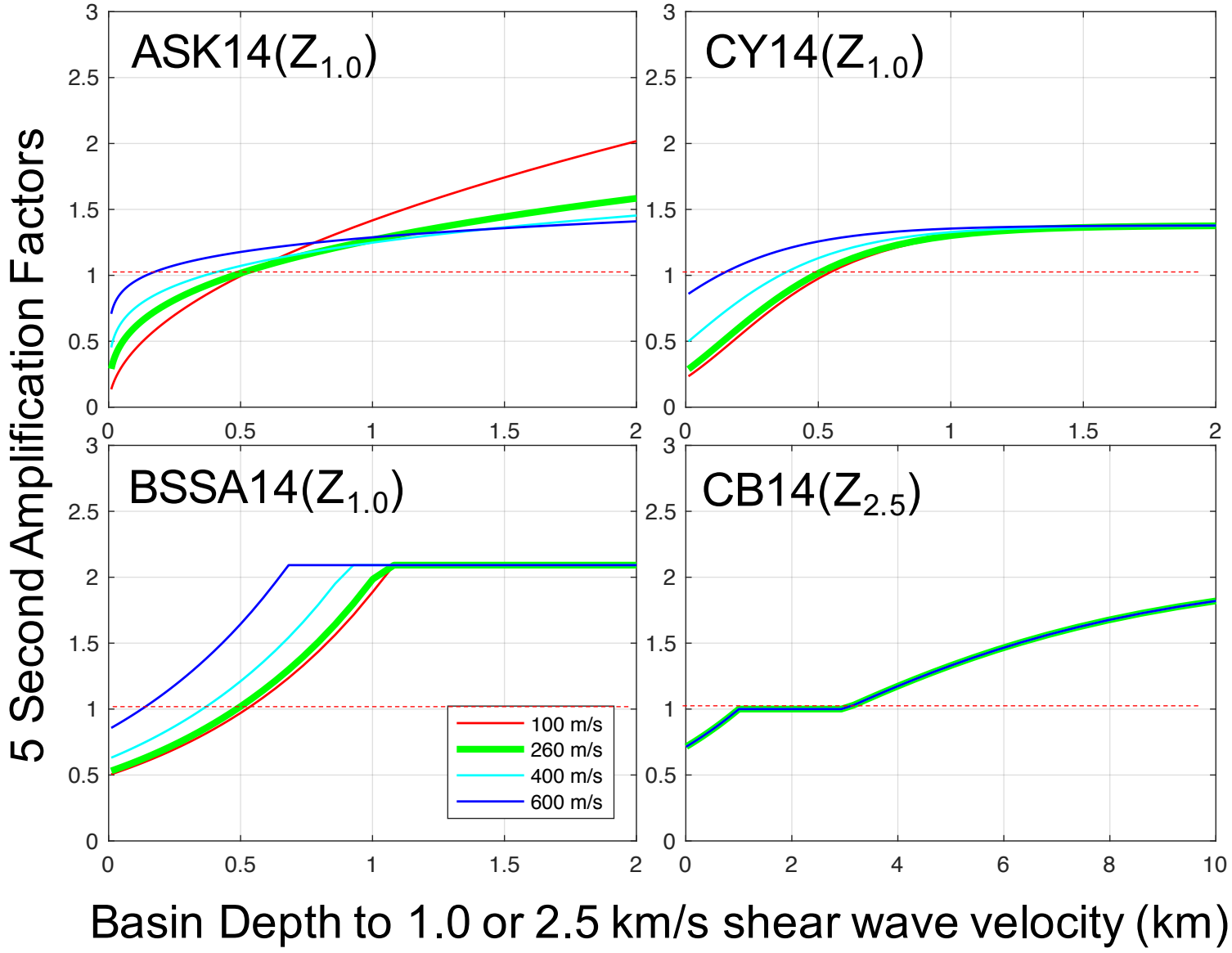
BayArea10 (Aagaard *et al.*, 2010)
S4.26m01 (Lee *et al.*, 2014)
Seattle07 (Stephenson, 2007)
Wasatch08(Magistrale *et al.*, 2008)



GMM basin amplification

The NGA-W2 modelers have amplified ground motions for basins in the following way:

1. Amplification increases with depth
2. Deamplification occurs in shallow parts of basins (typically less than 0.5 km for Z1 and below 1-3 km for Z2.5).



Basin Amplification for Subduction Zone GMMs

- Apply basin term from Campbell and Bozorgnia (2014) Z2.5 as recommended for Seattle in USGS OFR.
- Gail Atkinson will discuss subduction basin effects.

Considerations/Issues

1. Should we consider basin depth terms (Z1.0 and Z2.5) from a local velocity model in calculating long-period ground shaking for the four regions (i.e., Seattle, San Francisco, Salt Lake, Los Angeles) and default ground motions everywhere else? NSHMP: We should consider basin effects where Z2.5 is greater than 3 km depth in four areas and default ground motion everywhere else. However, we may want to consider a logic tree to weight alternatives.

Considerations/Issues

2. How much should we trust the deamplifying characteristics of the GMMs when depths are below the defaults. Should we consider the entire local velocity model and accept that portions of the basin will deamplify with respect to the default ground motions? NSHMP: not sure but Ken Campbell and Art Frankel will discuss

Considerations/Issues

3. Should we use the Z2.5 and the Z1.0 based GMPEs in calculating ground motions or only the Z2.5 GMPE as suggested by investigators in Seattle for subduction earthquakes? NSHMP: not sure but we are considering methods to incorporate all equations (conversions between Z2.5 and Z1.0).

Considerations/Issues

4. What local velocity models should we use? What should we do, if anything, outside the local models? NSHMP: only use local model weighted 100% and defaults outside of those areas. Oliver Boyd will discuss other alternatives.

Considerations/Issues

5. How do we model the subduction ground motion model to allow for basin response? NSHMP: add amplification terms to Vs30=760 model, see Atkinson discussion.