Subduction Zones in USGS NSHMs

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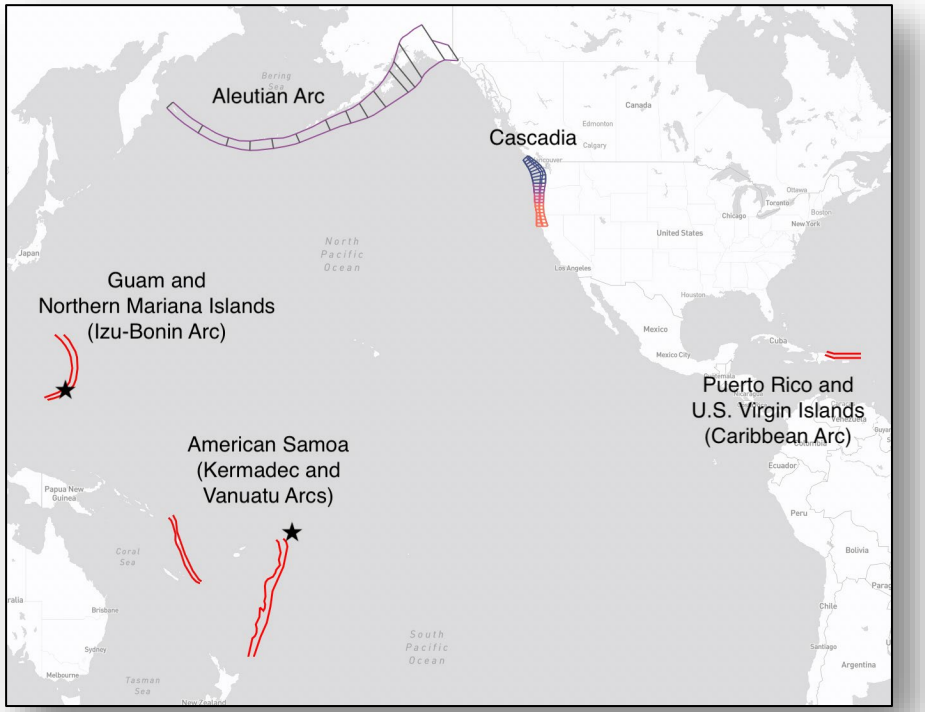


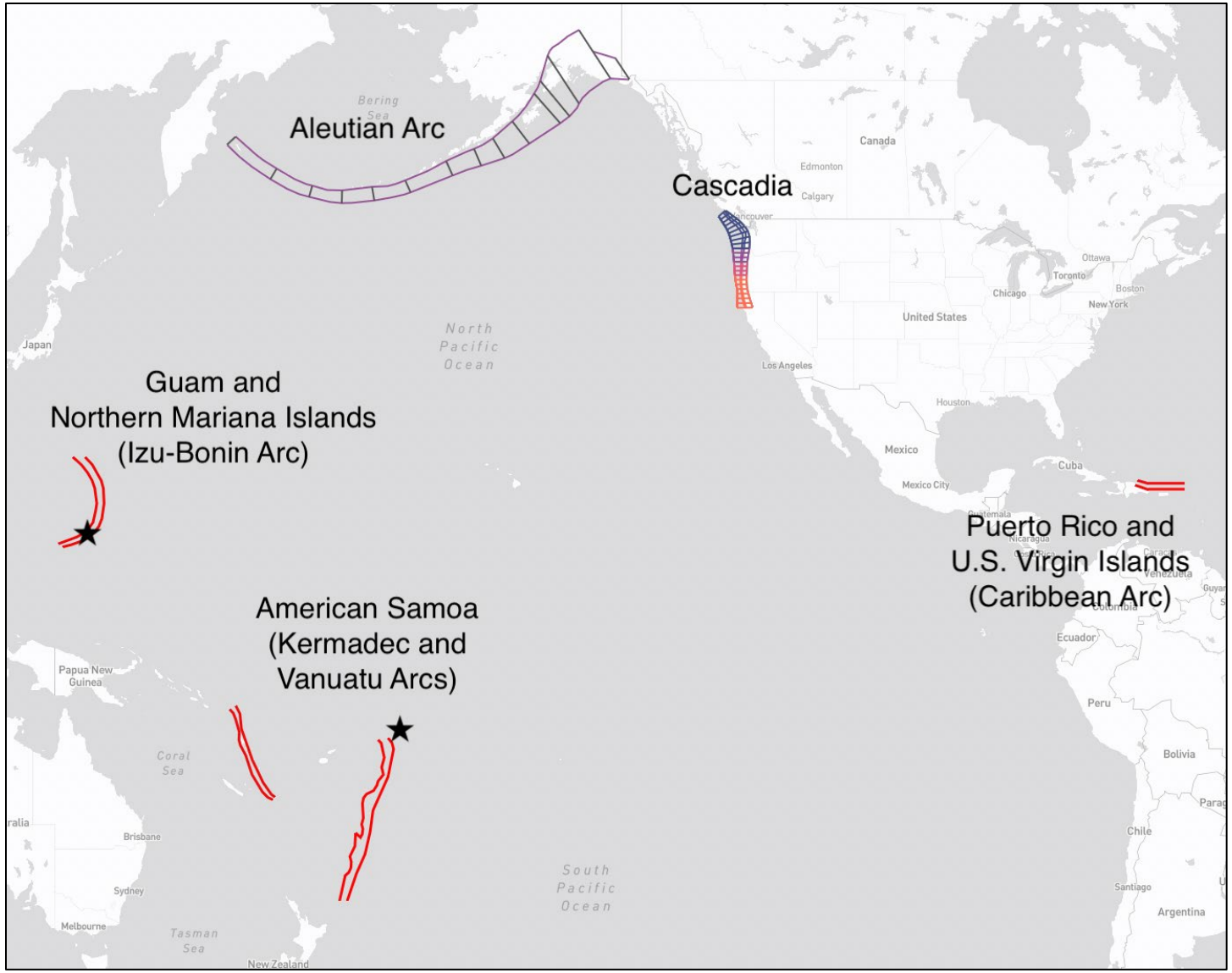
NSHM Subduction Zones

NSHM Components

- Subduction interface
  - Large M finite sources (defined by a surface, can be fixed or floating rupture)
  - Small M gridded seismicity (point) sources
- Subduction Intraslab
  - Gridded seismicity (point) sources
- Ground motion models (GMMs)

Subduction zone source data

- Interface and Intraslab geometry (Slab 2)
  - Earthquake catalogs
  - Active source studies and tomography
- Segmentation, coupling, rupture rate
  - Paleoseismology
  - Geodesy / GPS
  - Earthquake catalogs
- Magnitude scaling relations
  - Rupture properties of historic earthquakes
- Ground motion models (GMMs)
  - NGA-Subduction



Alaska NSHM: Earthquake Catalogs & Gridded Seismicity Sources

2007:

- Depth slices to distinguish crustal and intraslab with special treatment for shallow interface zone

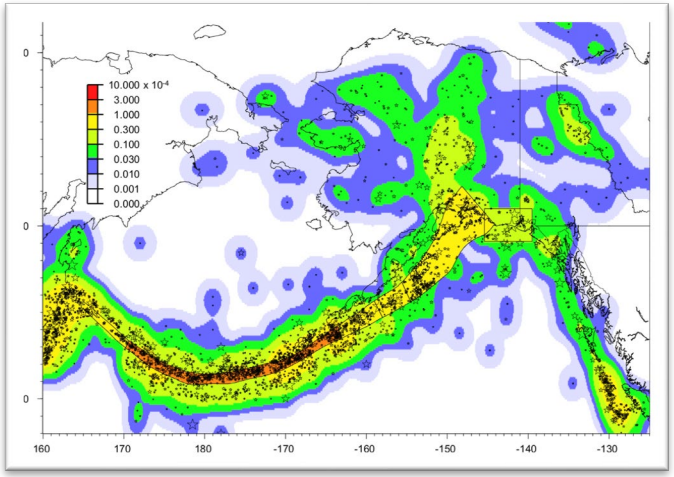
2023:

- SLAB2 Probabilistic EQ Associator (K. Haynie)

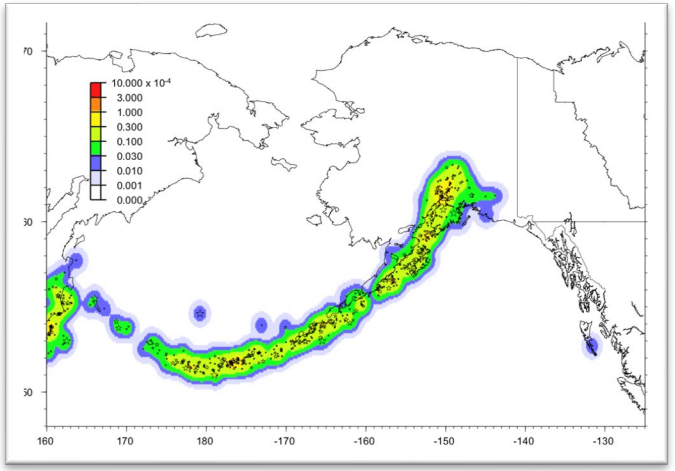
Application:

- Separate gridded seismicity models for crustal, intraslab, and interface EQs

Crustal and interface earthquake rates:
0 – 50 km (Wesson et al., 2007)



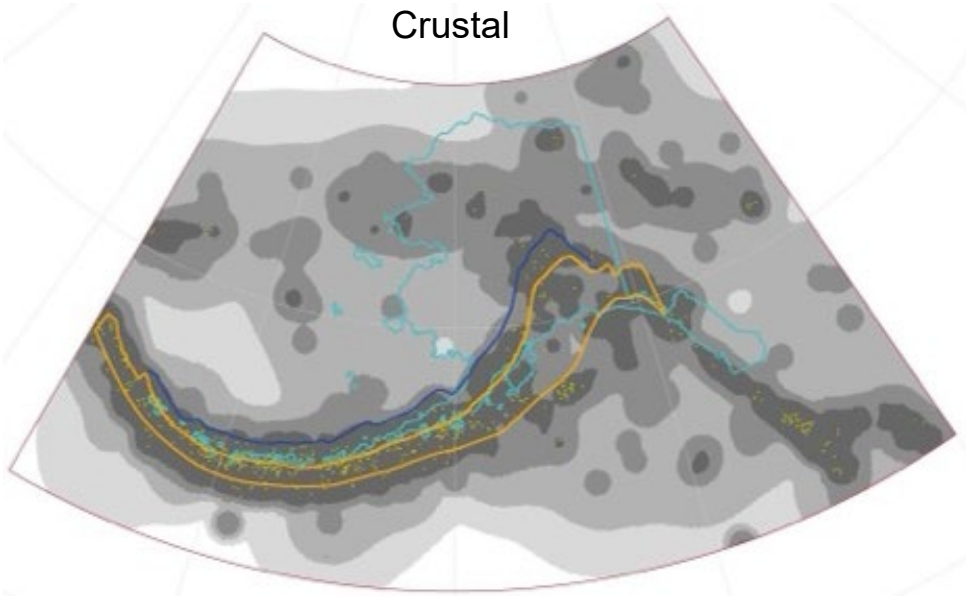
Intraslab earthquake rates:
50 – 80 km (Wesson et al., 2007)

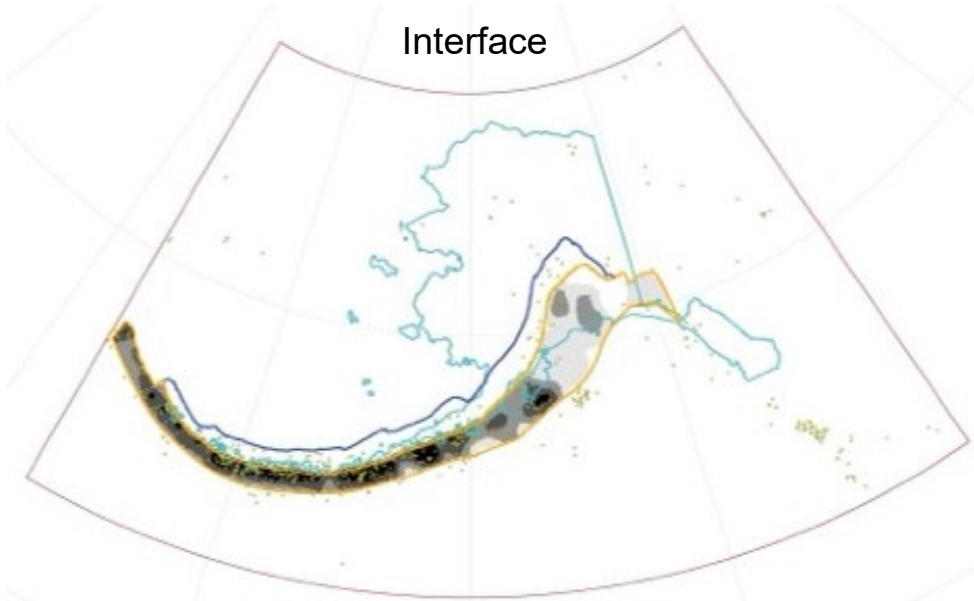


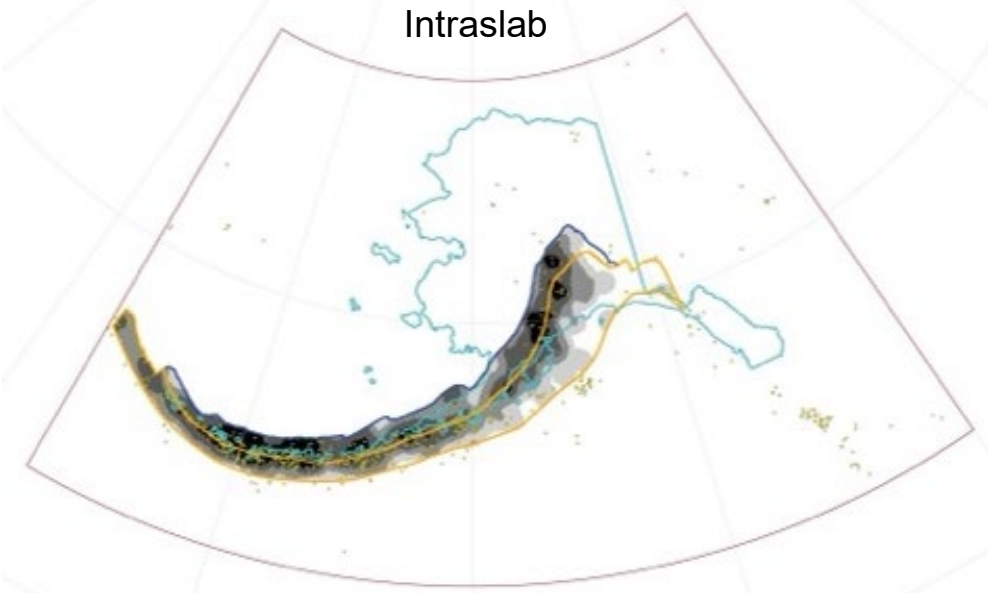
Alaska NSHM: Earthquake Catalogs & Gridded Seismicity Sources

2023:

- SLAB2 Probabilistic EQ Associator







(J. Herrick)

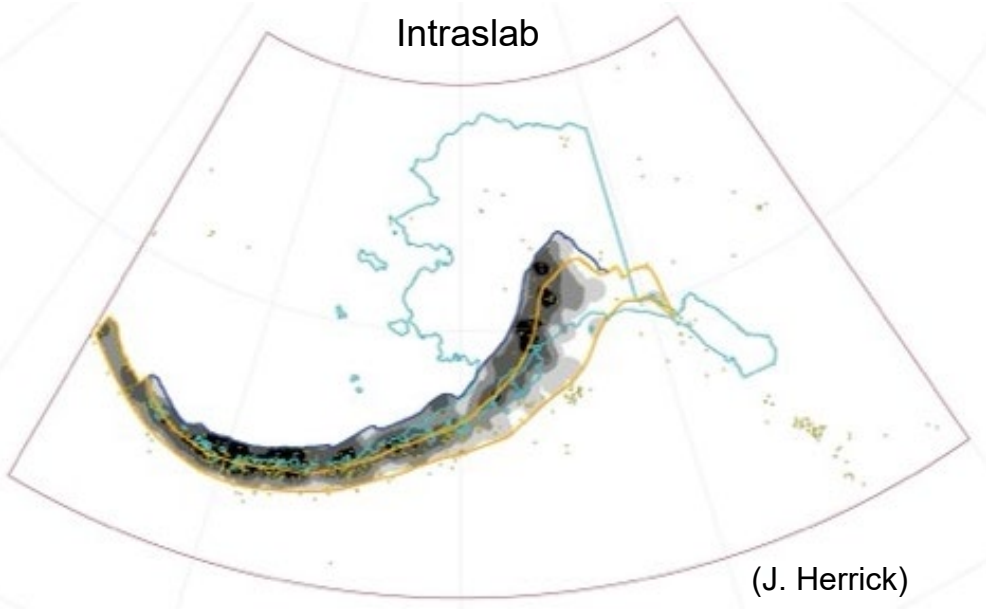
Alaska NSHM: Gridded seismicity and Intraslab sources

2007: Depth slices

- @ 60 km (50 - 80 km)
- @ 90 km (80 - 120 km)

2023: Intraslab and Interface Sources

- Point sources located at depths from SLAB2 model



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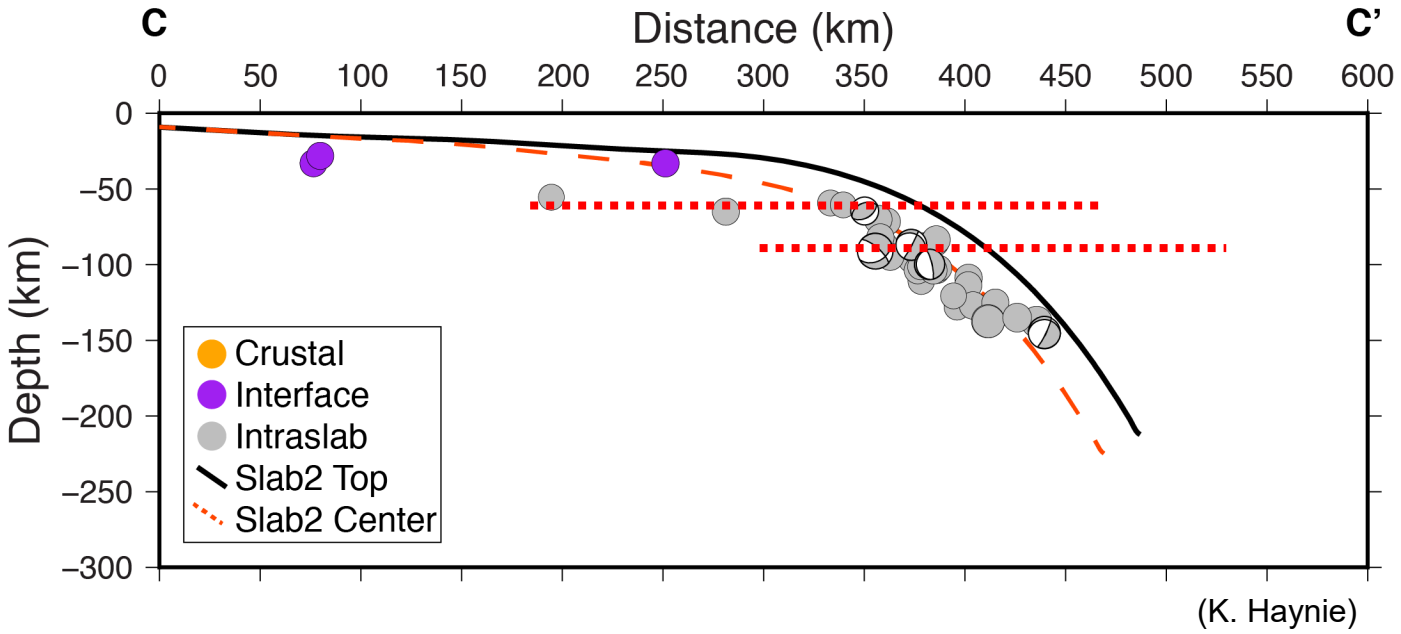
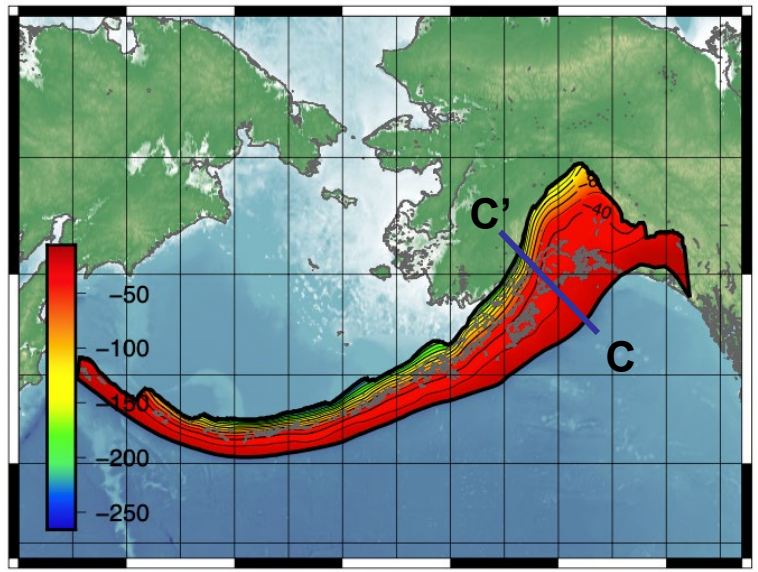


(K. Haynie)

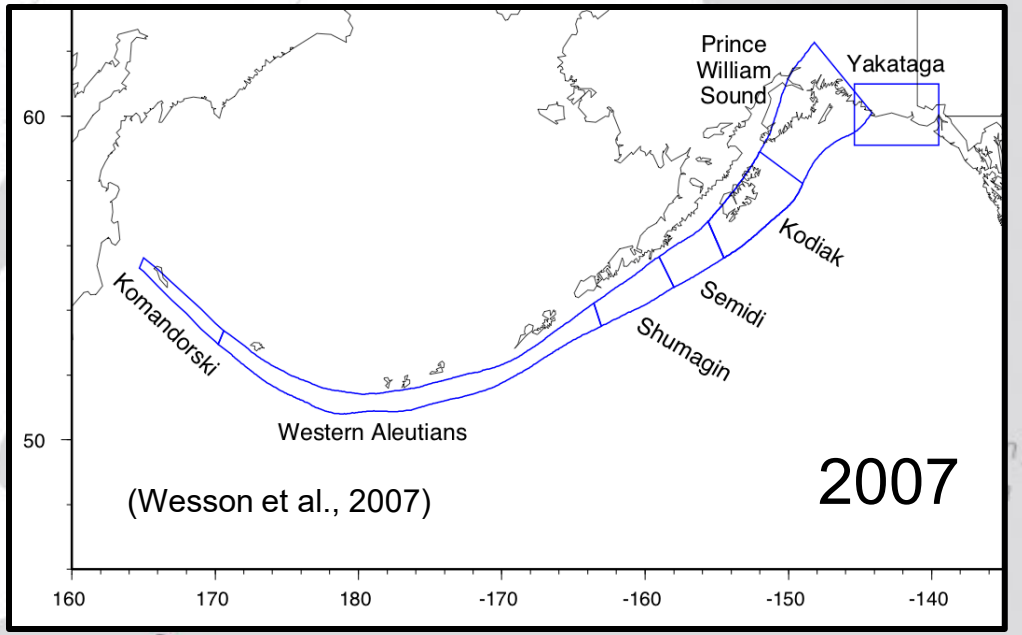


(K. Haynie)

Alaska NSHM: Evolution of a subduction zone model

2007: 7 sections, single down-dip width

2023: SLAB2, 15 sections, multiple down-dip widths



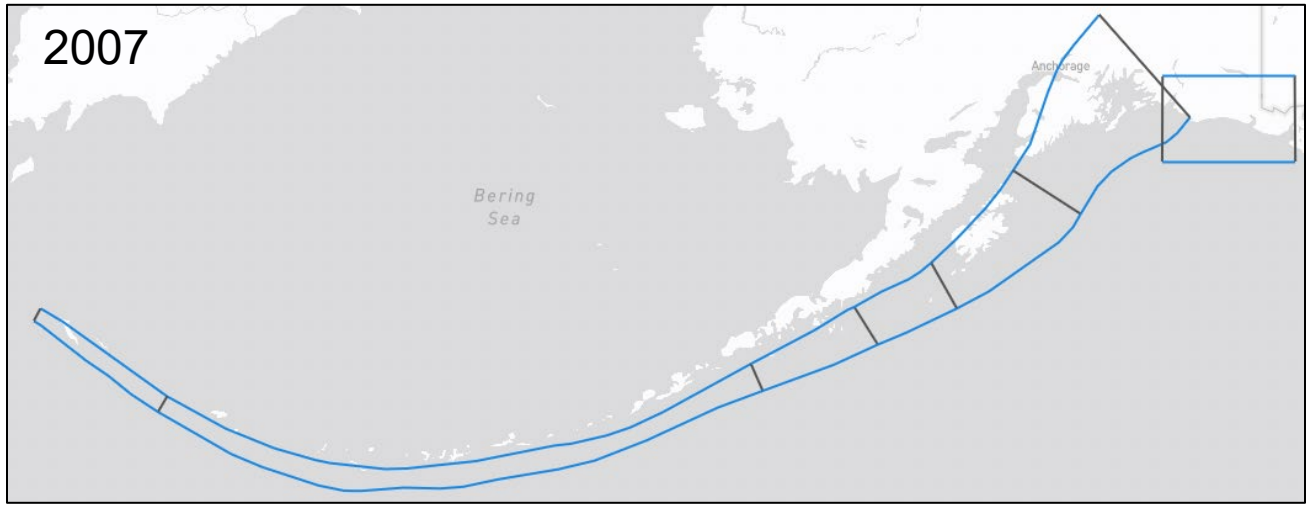
Alaska NSHM: Subduction Interface Magnitudes and Recurrence

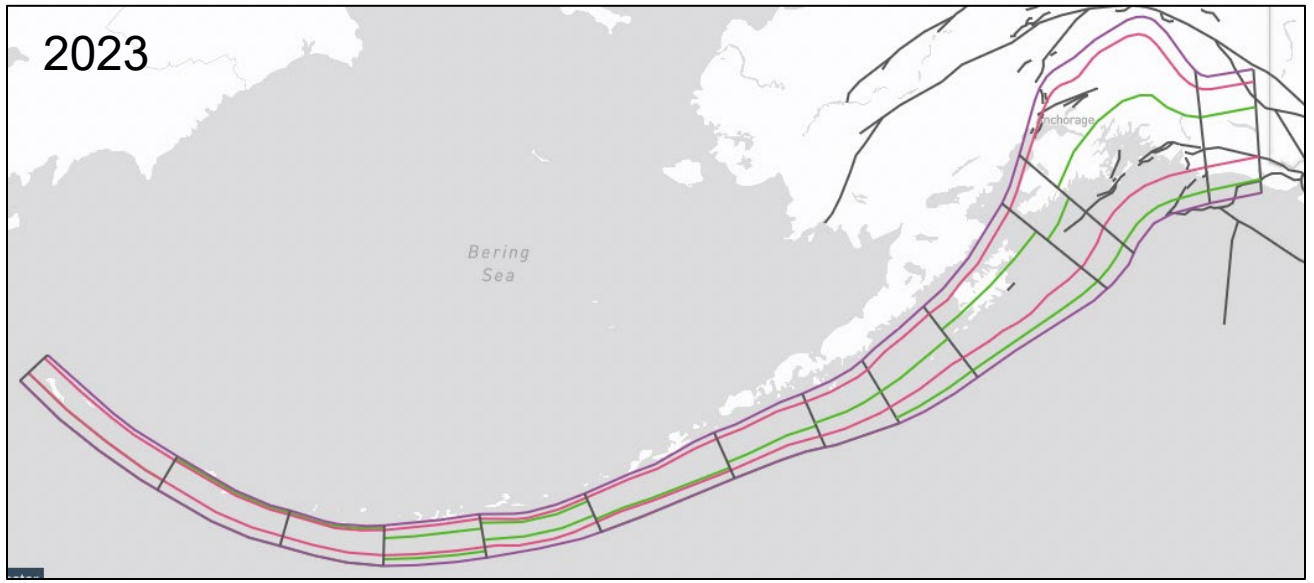
2007:

- Single down dip width
- M5 to M7: Zone source model
- M7 to M8: Floating rupture over entire arc
- M8+: Strict segmentation (7 sections)
  - Mix of ‘characteristic’ and GR MFDs

2023:

- 3 Down dip widths
  - Narrow, Wide
  - Geodetic (Briggs, Witter, Freymueller)
- M5 to M7: Spatial PDF model
- M7 to M8: Floating rupture over entire arc
- M8+: 15 sections
- Shaw (2023) 3-branch scaling relation
- Rate models (3)
  - Catalog, Geologic, Geodetic





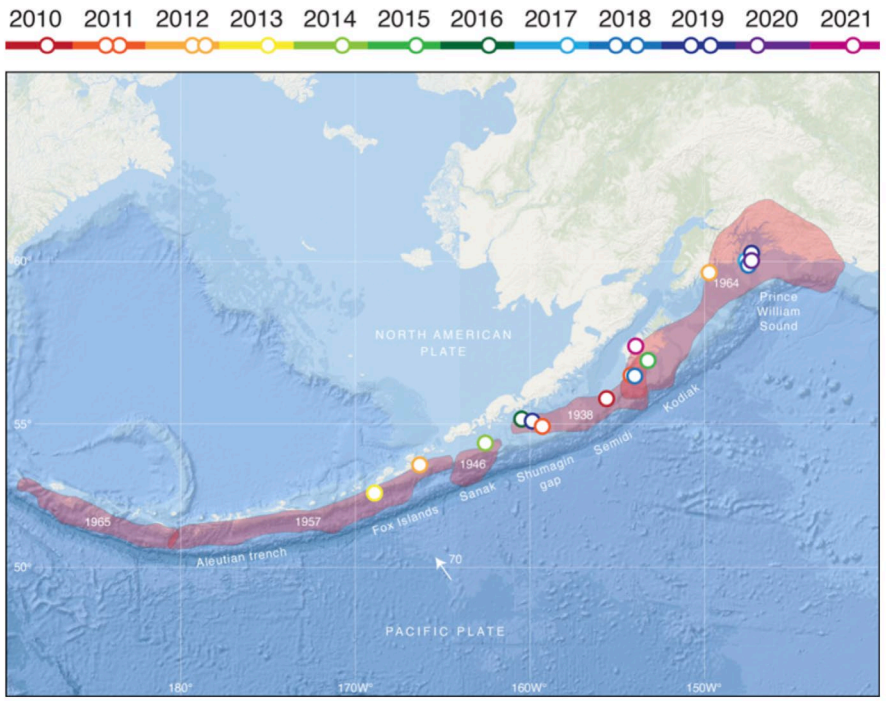
NSHM: Magnitude Scaling Relations (MSRs)

MSRs for finite faults and interface:

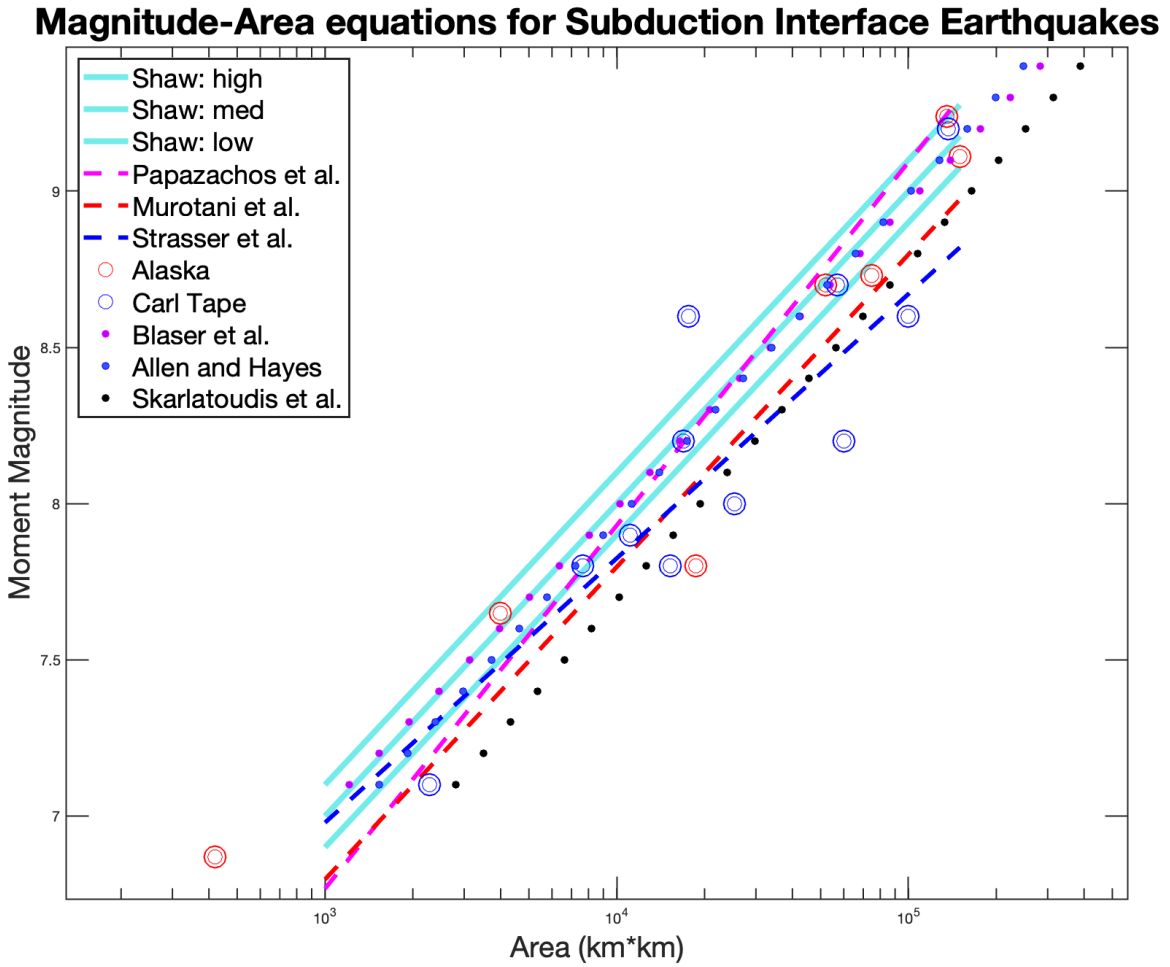
- Rupture magnitude from fault geometry (length or area)
- Rupture size from magnitude (e.g. for floating ruptures)

MSRs for gridded/smoothed seismicity sources:

- Point source pseudo-fault size



Witter et al. (2022)



Alaska and CONUS NSHMs: Subduction Ground Motion Models (GMMs)

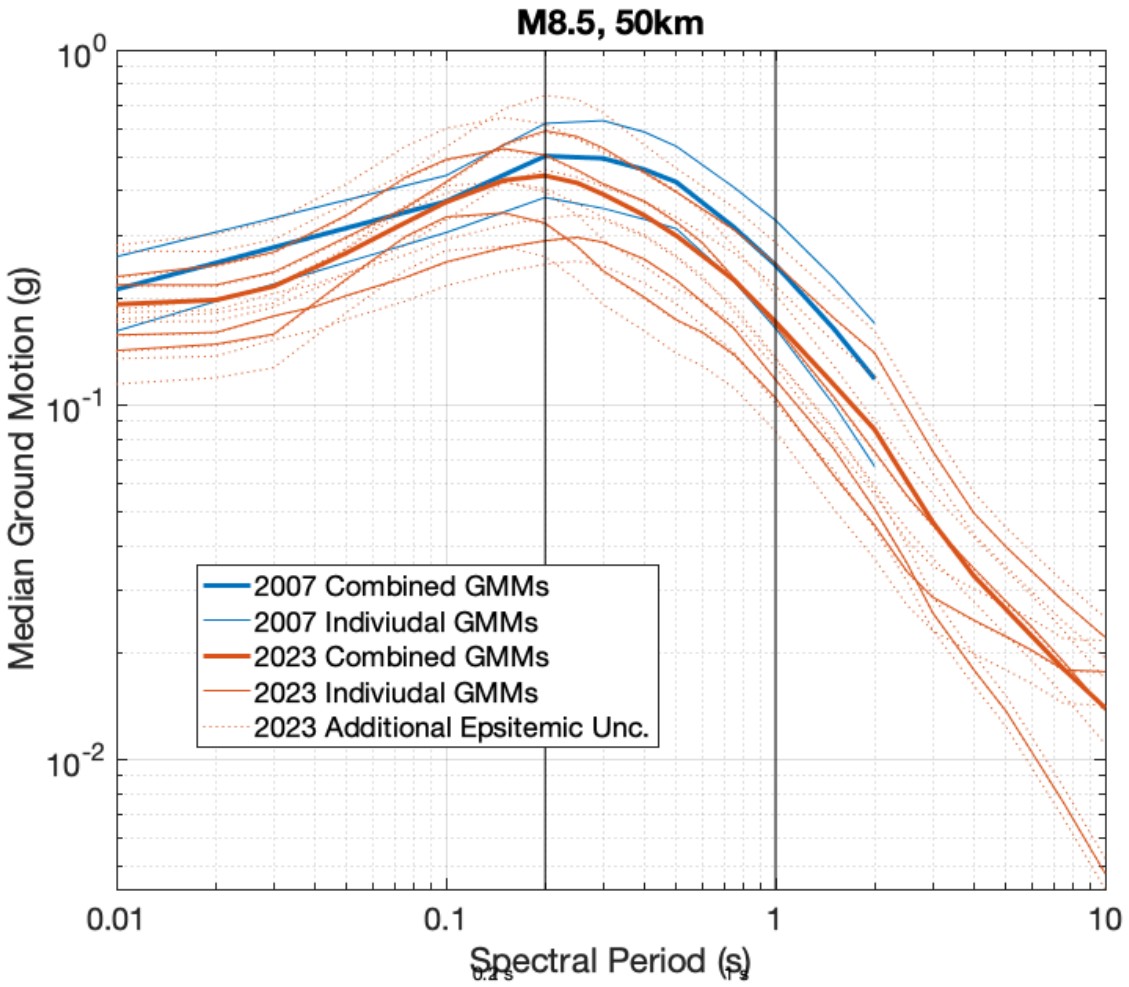
NGA-Subduction

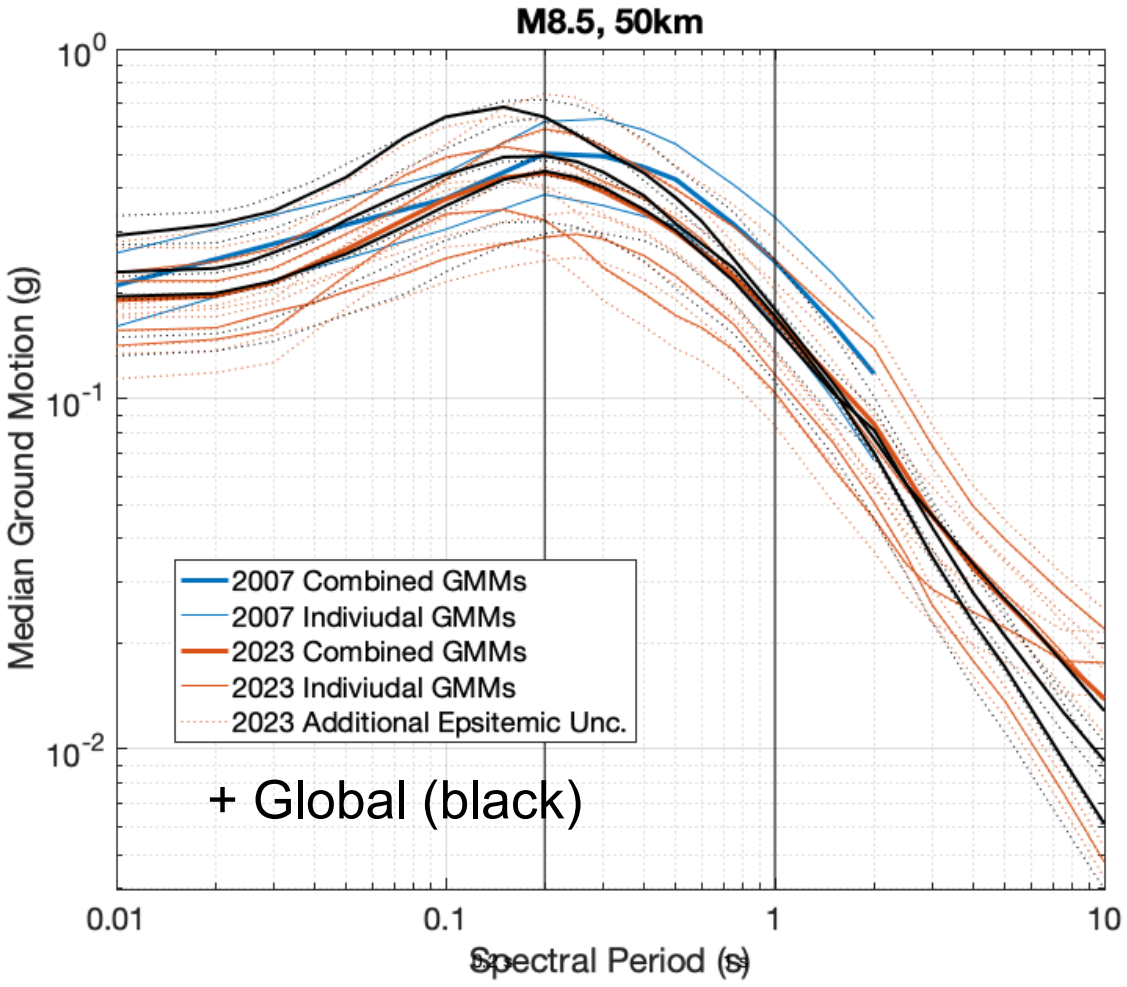
- Pacific Earthquake Engineering Research Center (PEER)
- Multi-period response spectra (MPRS):
  - 22 spectral periods
  - Site class V_{S30} [150..1500] m/s
- RotD50
- NGA-Sub GMMs include regionalized model for Alaska
- GMMs include basin effect terms
- Epistemic uncertainty (ε)

	CONUS 2018 (Cascadia)	CONUS 2023 (Cascadia)
Subduction Interface	- 34% Abrahamson et al. (2006) (BC Hydro) - 33% Atkinson & Macias (2006) - 33% Zhao et al. (2006)	**NGA-Subduction + older GMMs** - 25% Abrahamson & Gülerce (2021) - 25% Kuehn et al. (2020) - 25% Parker et al. (2021) - 12.5% Zhao et al (2006) - 12.5% Atkinson & Macias (2009)
Subduction Intraslab	- 50% Abrahamson et al. (2006) (BC Hydro) - 50% Zhao et al. (2006)	**NGA-Subduction** - 25% Abrahamson & Gülerce (2021) - 25% Kuehn et al. (2020) - 25% Parker et al. (2021) - 25% Zhao et al. (2006)

	Alaska 2007	Alaska 2023
Subduction Interface	**0 – 70 km:** - 50% Youngs et al. (1997) - 50% Sadigh et al. (1997) **70 – 1000 km:** - 100% Youngs et al. (1997)	**NGA-Subduction** - 34% Abrahamson & Gülerce (2021) - 33% Kuehn et al. (2020) - 33% Parker et al. (2021)
Subduction Intraslab	- 50% Youngs et al. (1997) - 50% Atkinson & Boore (2003)	**NGA-Subduction** - 34% Abrahamson & Gülerce (2021) - 33% Kuehn et al. (2020) - 33% Parker et al. (2021)

NSHM GMMS: Epistemic Uncertainty

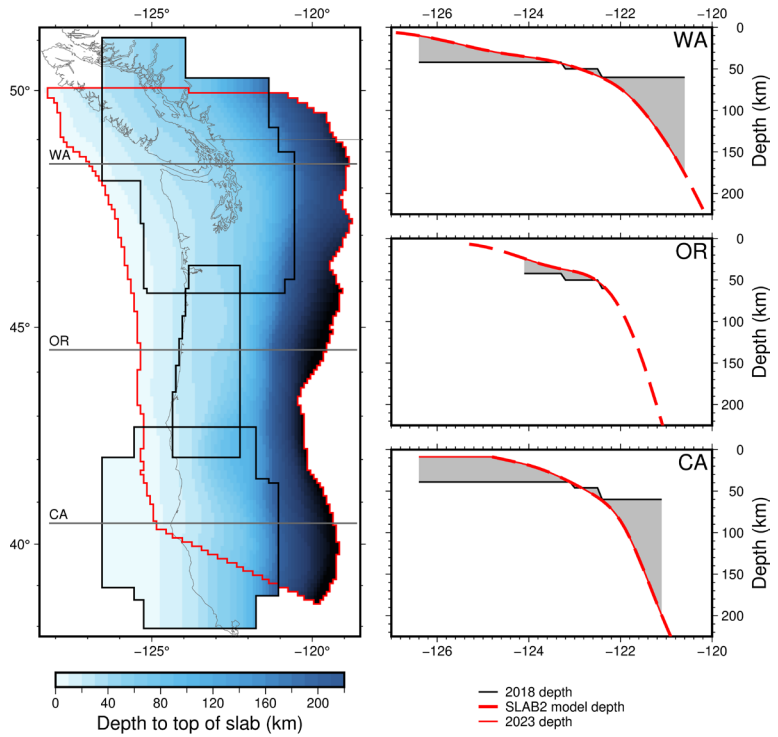




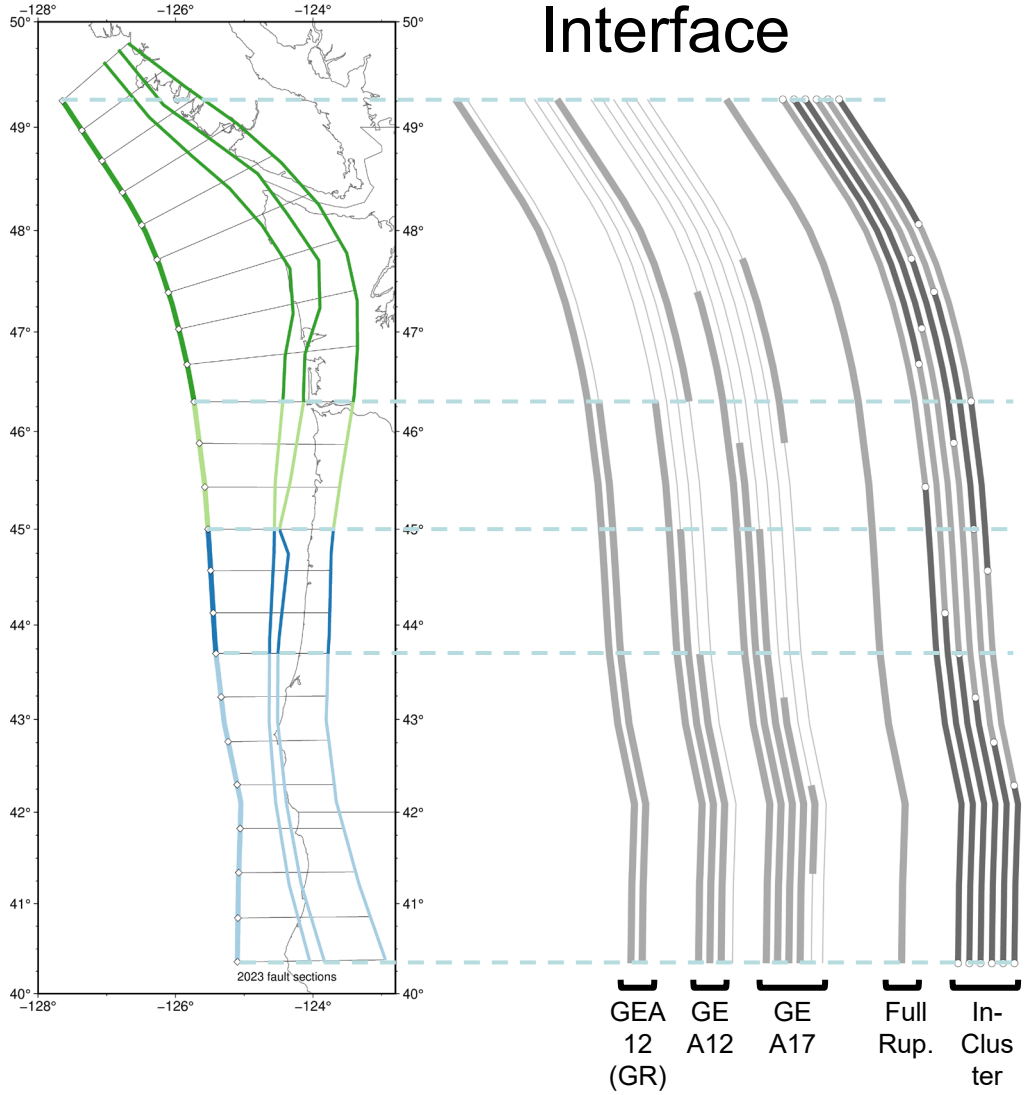
CONUS NSHM: Cascadia subduction zone geometry and segmentation

- Interface: Multiple segmentation models: Goldfinger et al. (2012, 2017)
- Interface: Adding cluster model for 2023
- Intraslab: using Slab 2 surface
- See J. Altekruse poster

Intraslab



Interface



NSHM Subduction Zones: Potential Improvements

- Adoption of inversion methodology (e.g. UCERF3)
- Subduction zone geometry
  - Any and all improvements to interface geometry (distance to rupture is critical parameter in hazard)
  - Slab 3.0? (intermediate point releases?)
  - Relocated catalogs?
- Rate constraints:
  - Improved network and catalogs (reduce depth uncertainty)
  - Geodesy: Improved GPS; offshore/OB? Improved afterslip and glacial isostatic rebound models; reconcile interseismic locked with coseismic rupture areas
  - Continued onshore and turbidite paleoseismology
  - Lake Paleoseismology (e.g. Eklutna Lake ~93yr RP over 2300 yr)
- GMM development:
  - Non-ergodic, regionalized models
  - Improved network and catalogs
  - Develop 'living' region-specific ground motion databases
  - Large magnitude scaling break, regionally varying
  - Separate median and aleatory variability models
  - Epistemic uncertainty (backbone models, polynomial chaos, Sammon's mapping)
- See also poster by Jason Altekruse