Down-dip edge of rupture zones of CSZ great earthquakes

Ground-motion prediction equations for subduction-zone earthquakes use nearest distance between rupture surface and site

- Based on aftershock zones and, in some cases, modeling of strong-motion records
- Tohoku earthquake illustrates that high-frequency energy may be generated in areas closer to coast than areas of high slip
- What amount of slip correlates with “edge” of rupture for use in GMPE’s?

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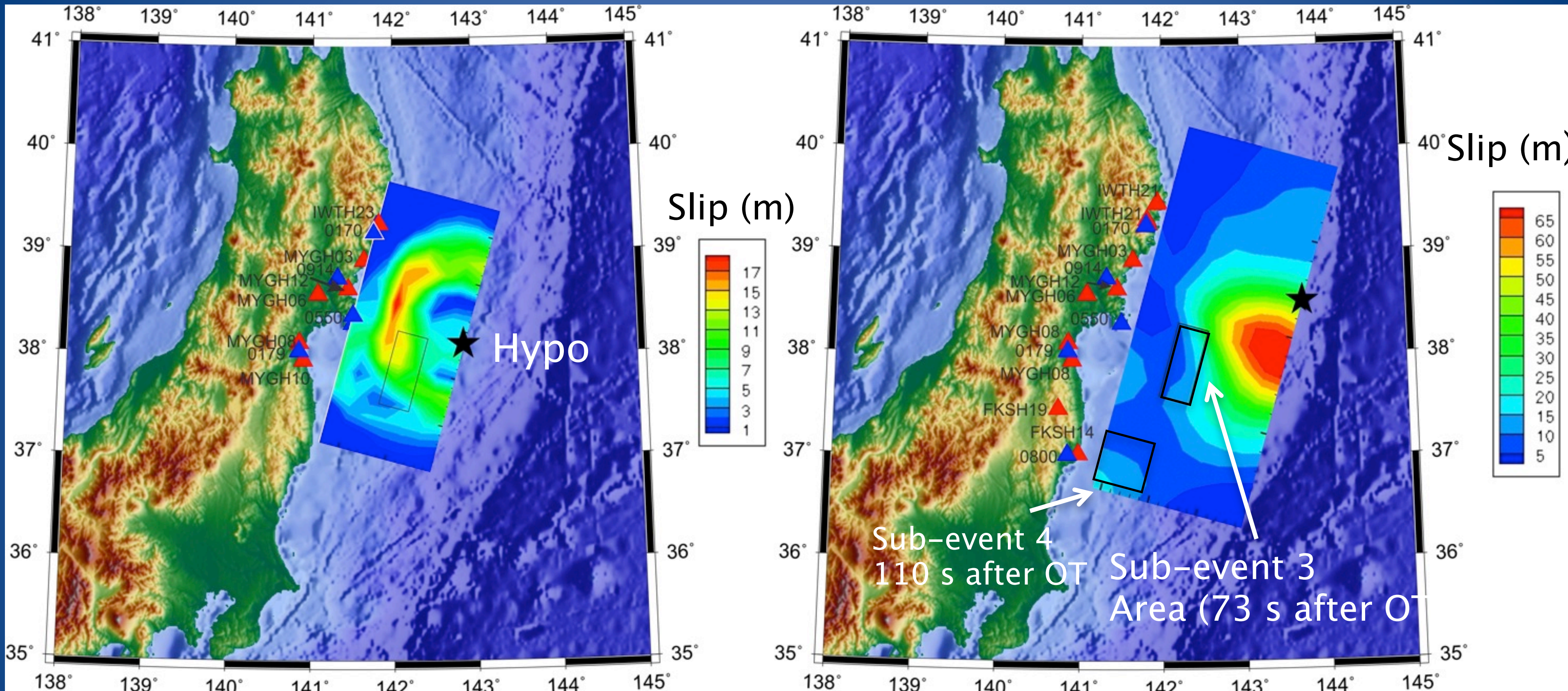
Results of inversions of velocity waveforms from strong-motion records (0-0.2 Hz) and 1 sps GPS displacement waveforms

Sub-event 1; Mw 8.5 Sub-event 2; Mw 9.05, starts 35 s later



Sub-event 1 ruptures downdip and to north; generates low (< 0.2 Hz) and high frequency ground motions

As sub-event 2 ruptures down dip and to south, high-frequency sub-events 3 and 4 occur (d=40 km). Sub-event 2 only generates low frequencies (< 0.2 Hz) at shallow depths (< 30 km), has rise time of slip of about 40 sec.

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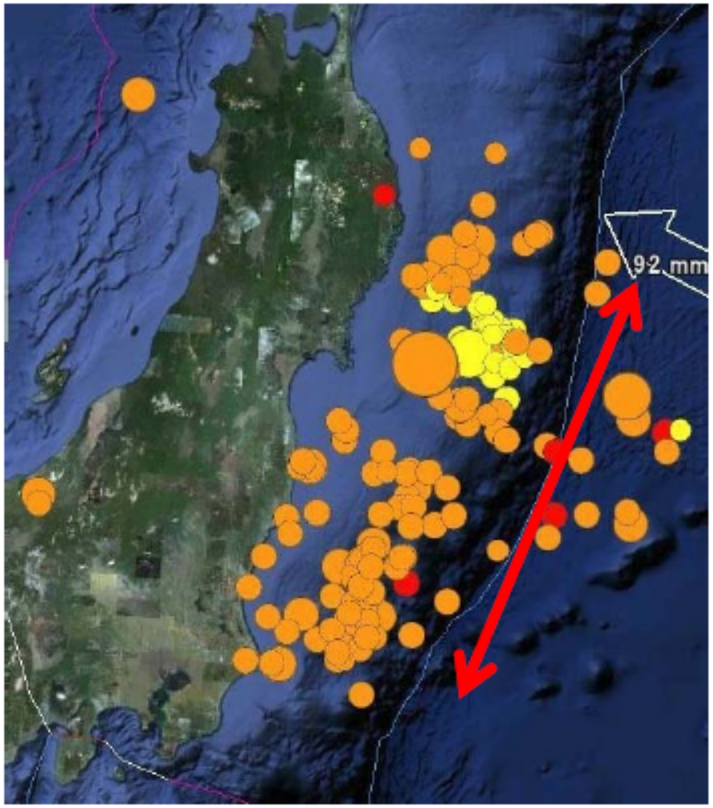
Slide from Jim Mori, Kyoto University

Earthquake much bigger than expected !

Expected earthquake sources
50 to 150 km segments
M7.5 to 8.2
(Headquarters for Earthquake Research Promotion)



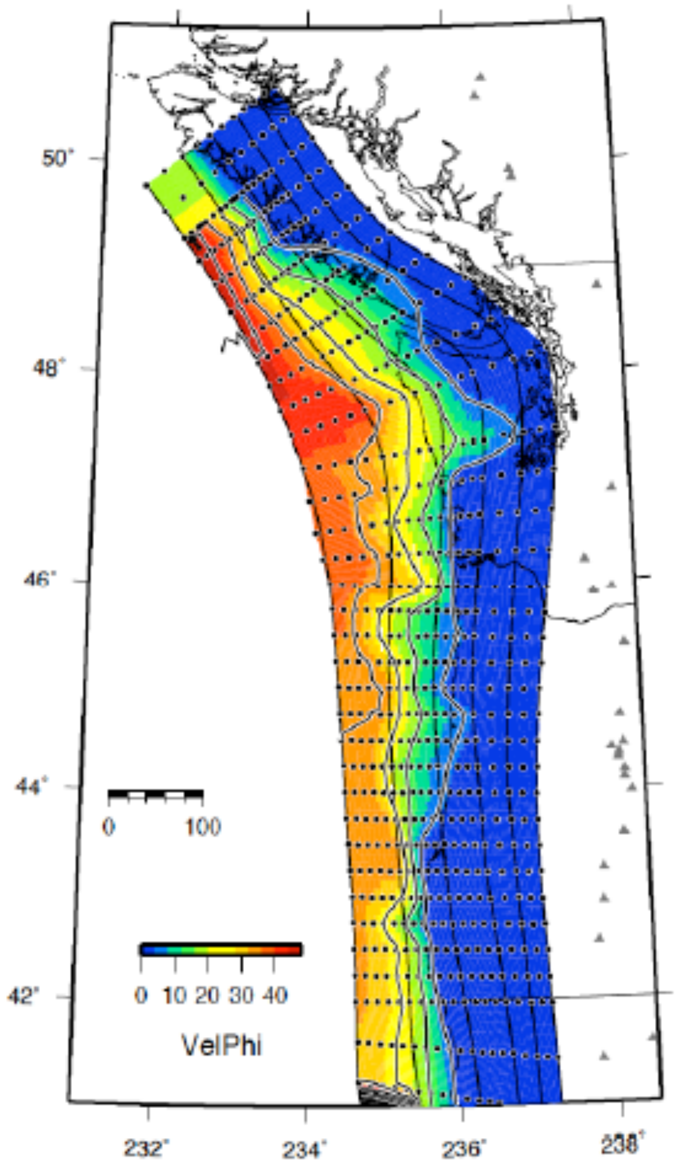
2011 Tohoku Earthquake
500 km long fault, M 9.0

(Aftershock map from USGS)

Preferences of Workshop participants (Eugene, Dec 15, 2011)

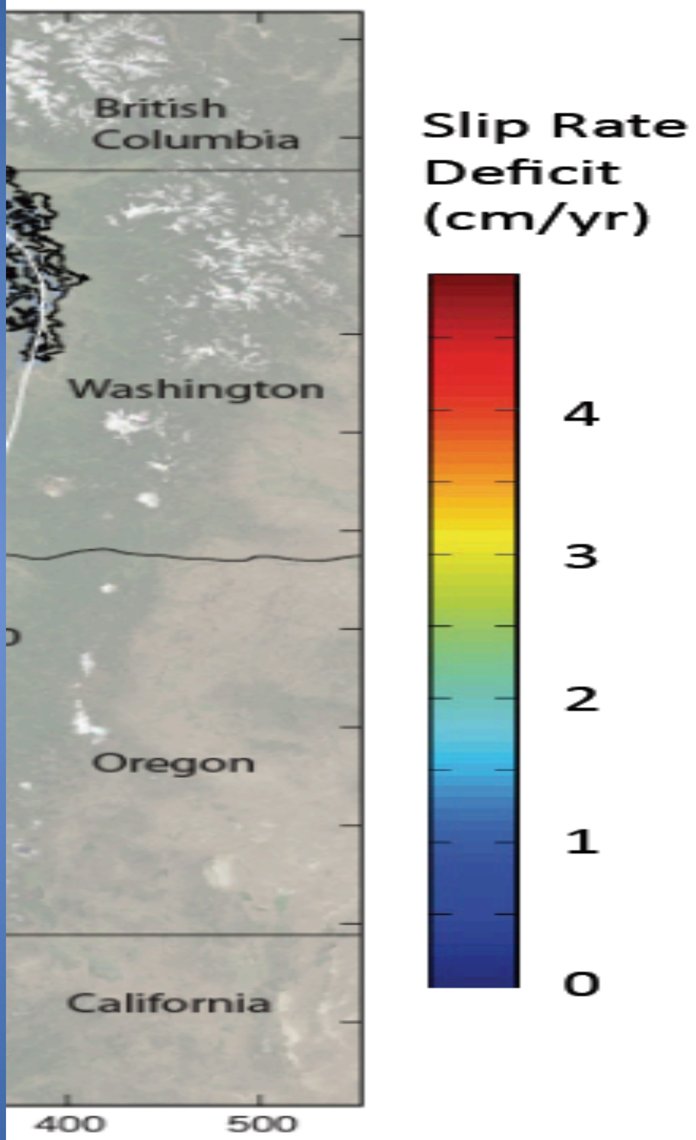
- Higher weight should be given to methods based on modeling GPS and uplift data. Note that M9 rupture may only have 1-2m slip at point defining nearest distance to station for GMPE's. So what coupling should be used to define edge of rupture zone?
- The top of tremor zone should be given significant weight as base of rupture zone (also considered some weight for base of tremor zone)
- Less weight for thermal models and other approaches

McCaffrey and King (2011)

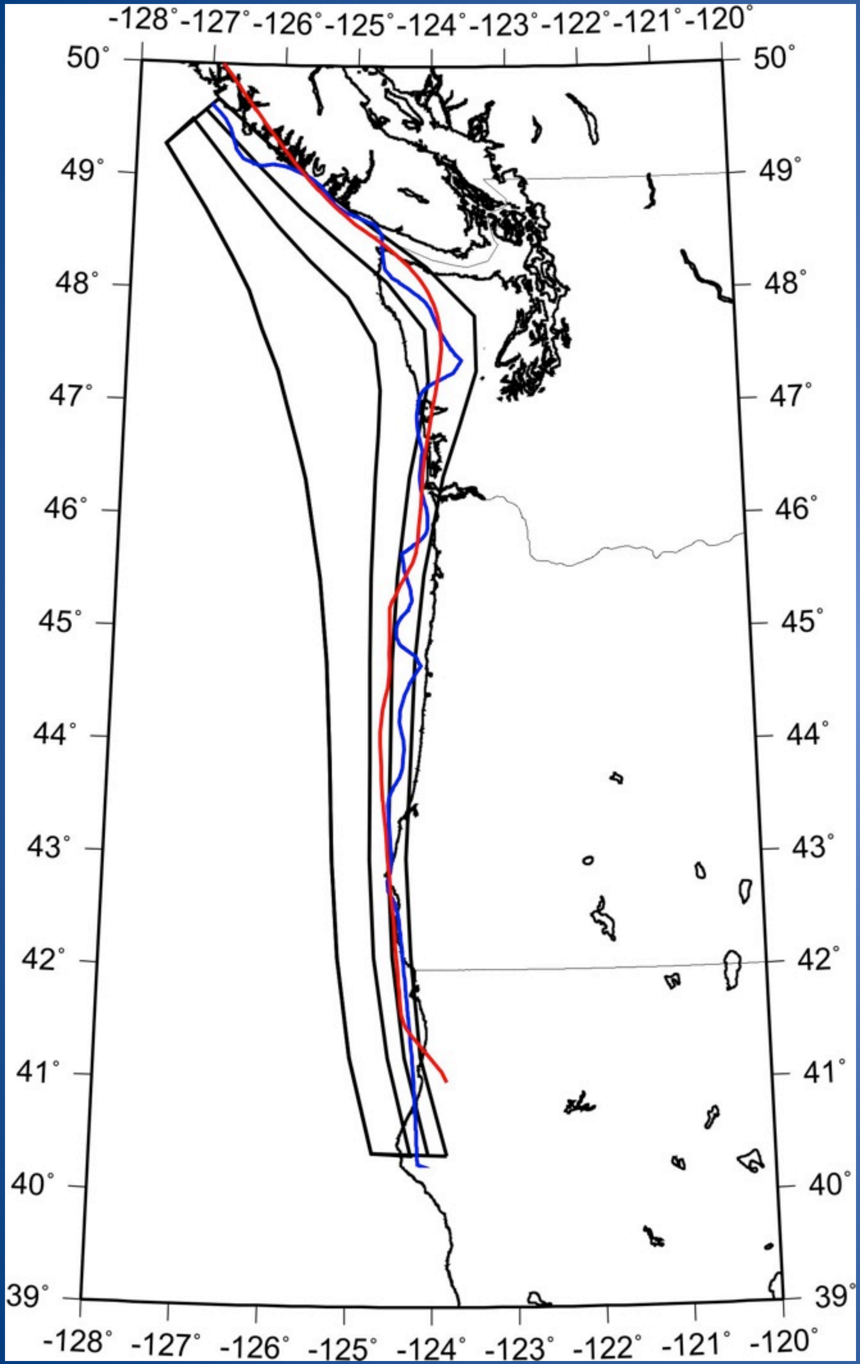


Uses Wang tapering function

Schmidt et al. (2011)

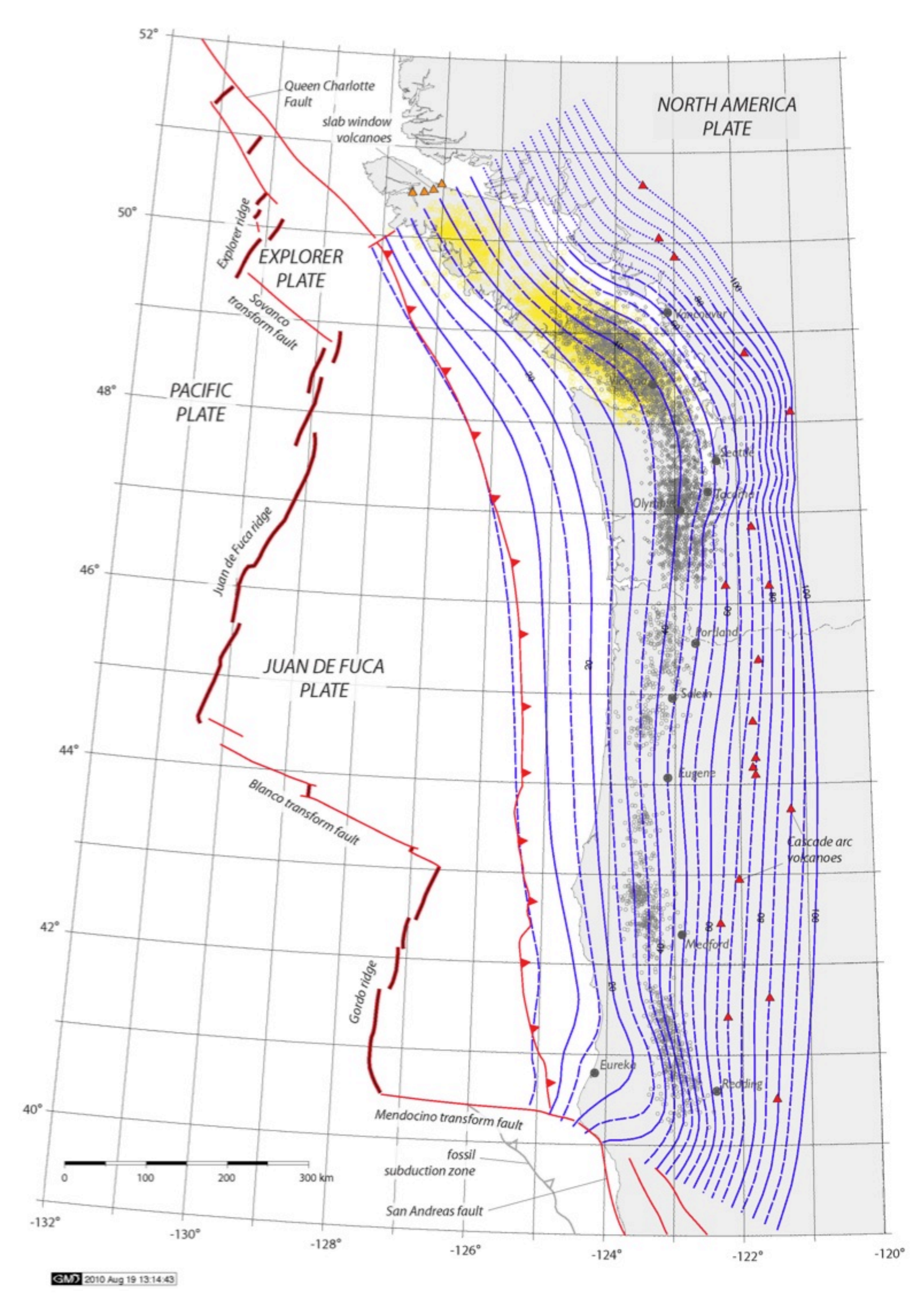


Uses Wang tapering function



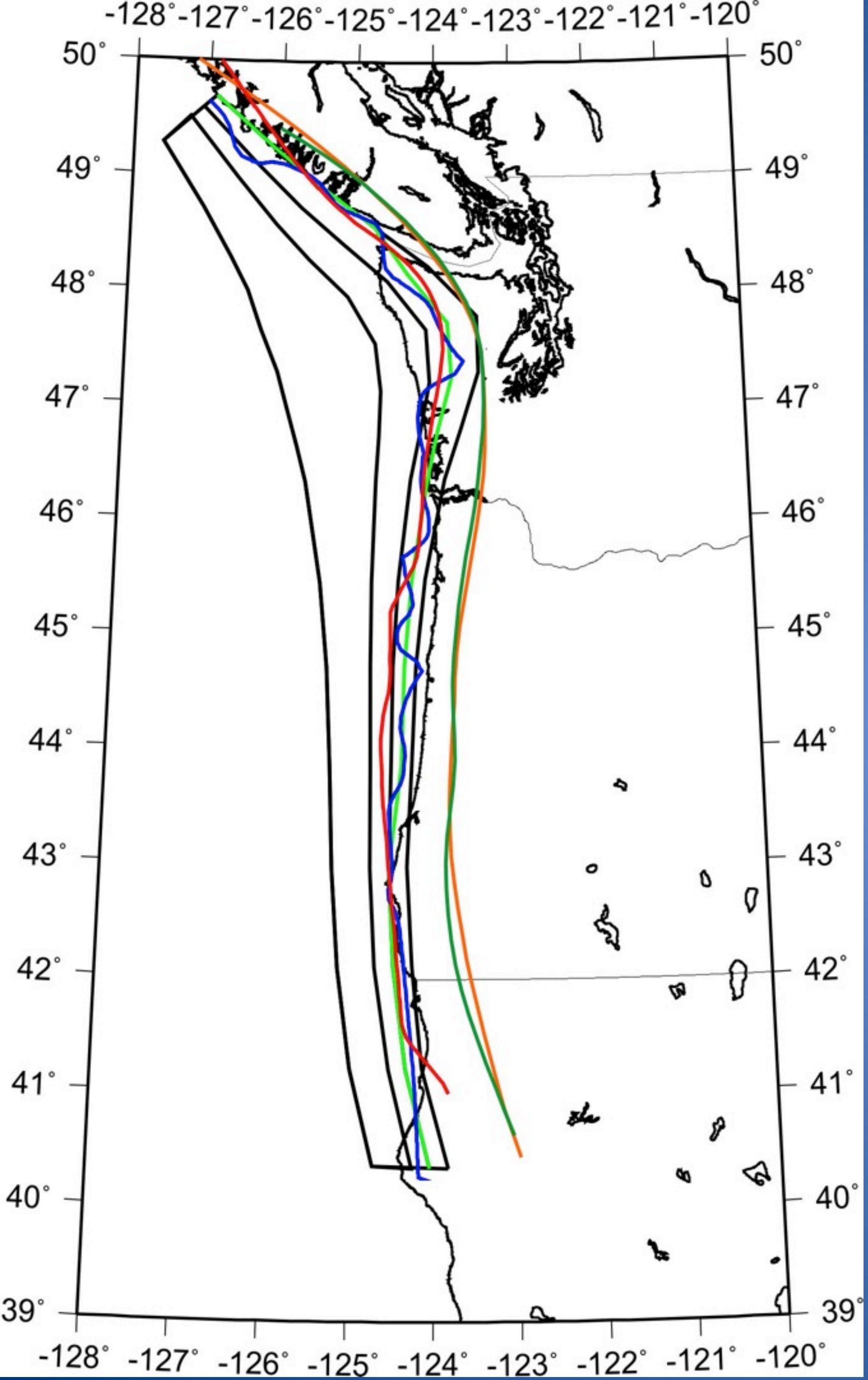
Blue: 1 cm/yr locking contour from McCaffrey and King

Red: 1 cm/yr locking contour from Schmidt et al.



Map prepared by Pat McCrory

Circles are non-volcanic tremor locations



Black: three of the models used in 2008 (From Flück, Hyndman and Wang, 1997) Base of locked zone, base of transition zone, midpoint between the two

Blue: McCaffrey and King 1 cm/yr locked

Red: Schmidt et al. 1 cm/yr locked

Green: approx. average

Dark Green: top of tremor zone from Gomberg et al. (2010)

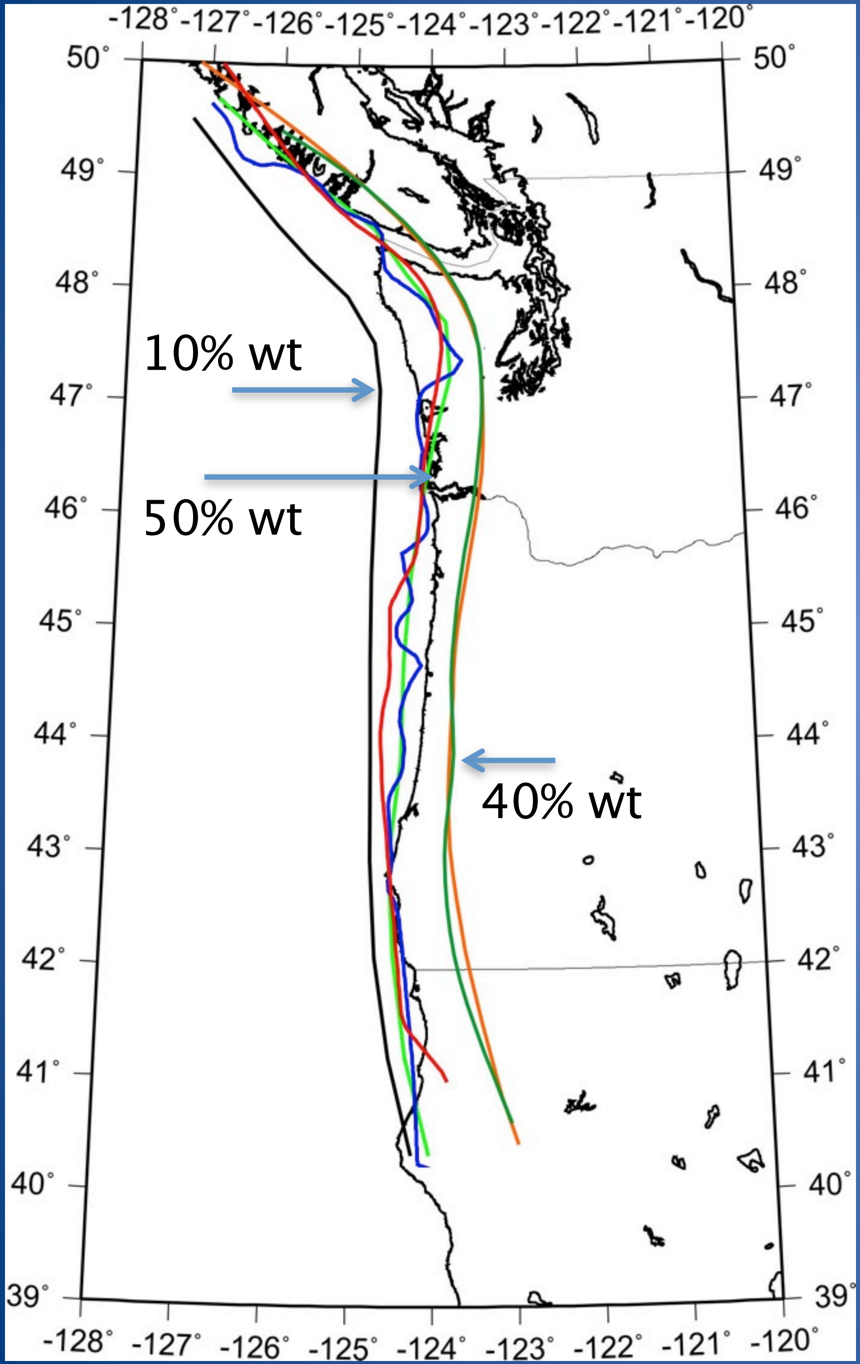
Orange: top of tremor zone from A. Wech

Thanks to Pat McCrory and Luke Blair for providing coords for top of tremor

Strawman logic tree for down-dip edge

- 10% weight: base of locked zone from Flück, Hyndman, and Wang (1997), based on thermal model and uplift modeling (same as used in 2008)
- 50% weight: average of 1 cm/yr locked contours from McCaffrey and King; and Schmidt et al.
- 40% weight: top of tremor

Trial logic tree

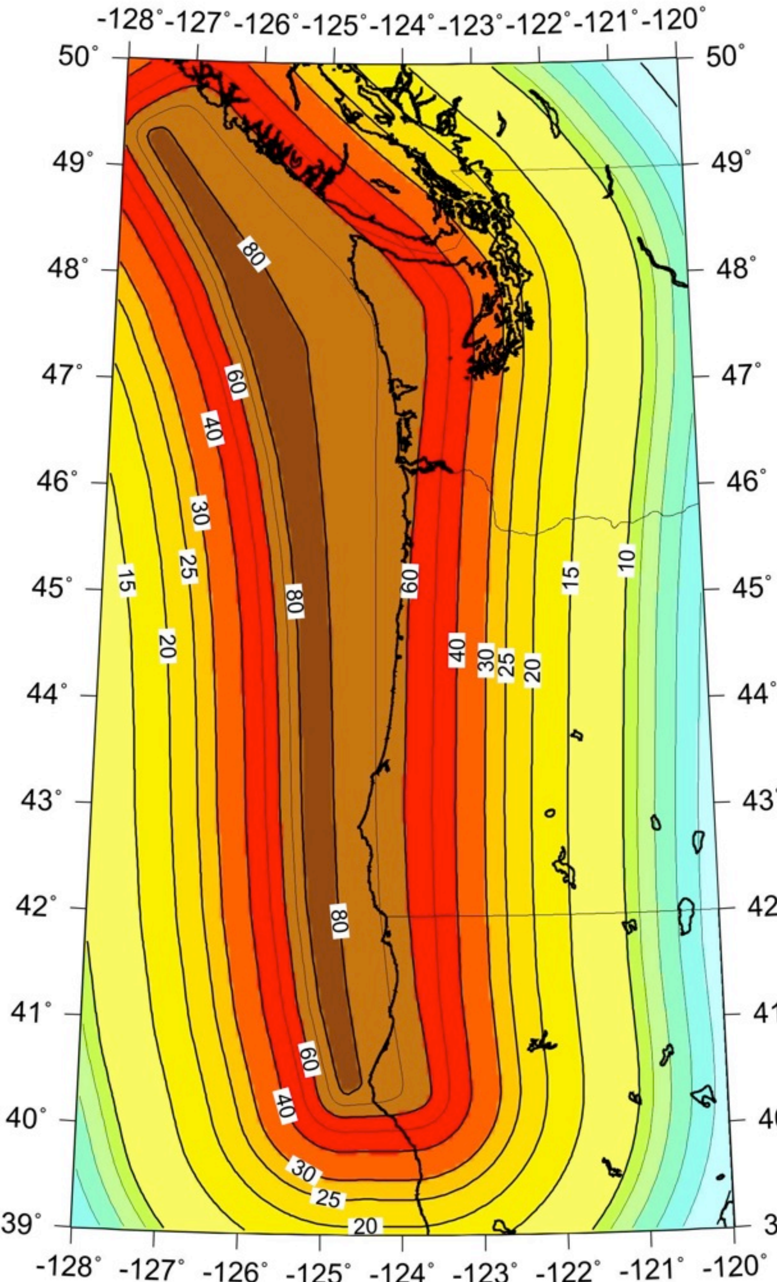


Black: base of locked zone from Flück, Hyndman, and Wang (1997)

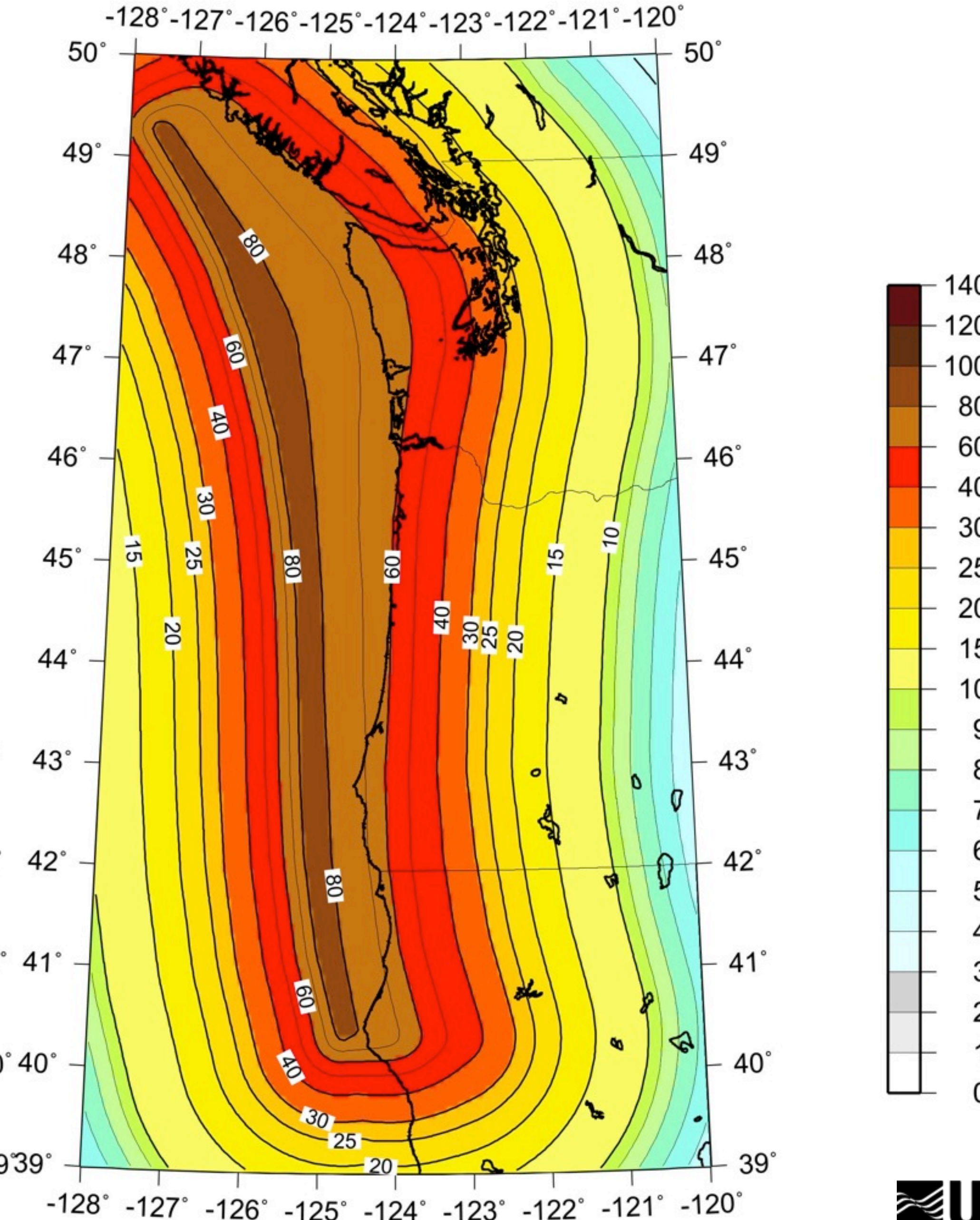
Light Green: average of McCaffrey and King (blue) and Schmidt et al. (red) contour for 1cm/yr locking

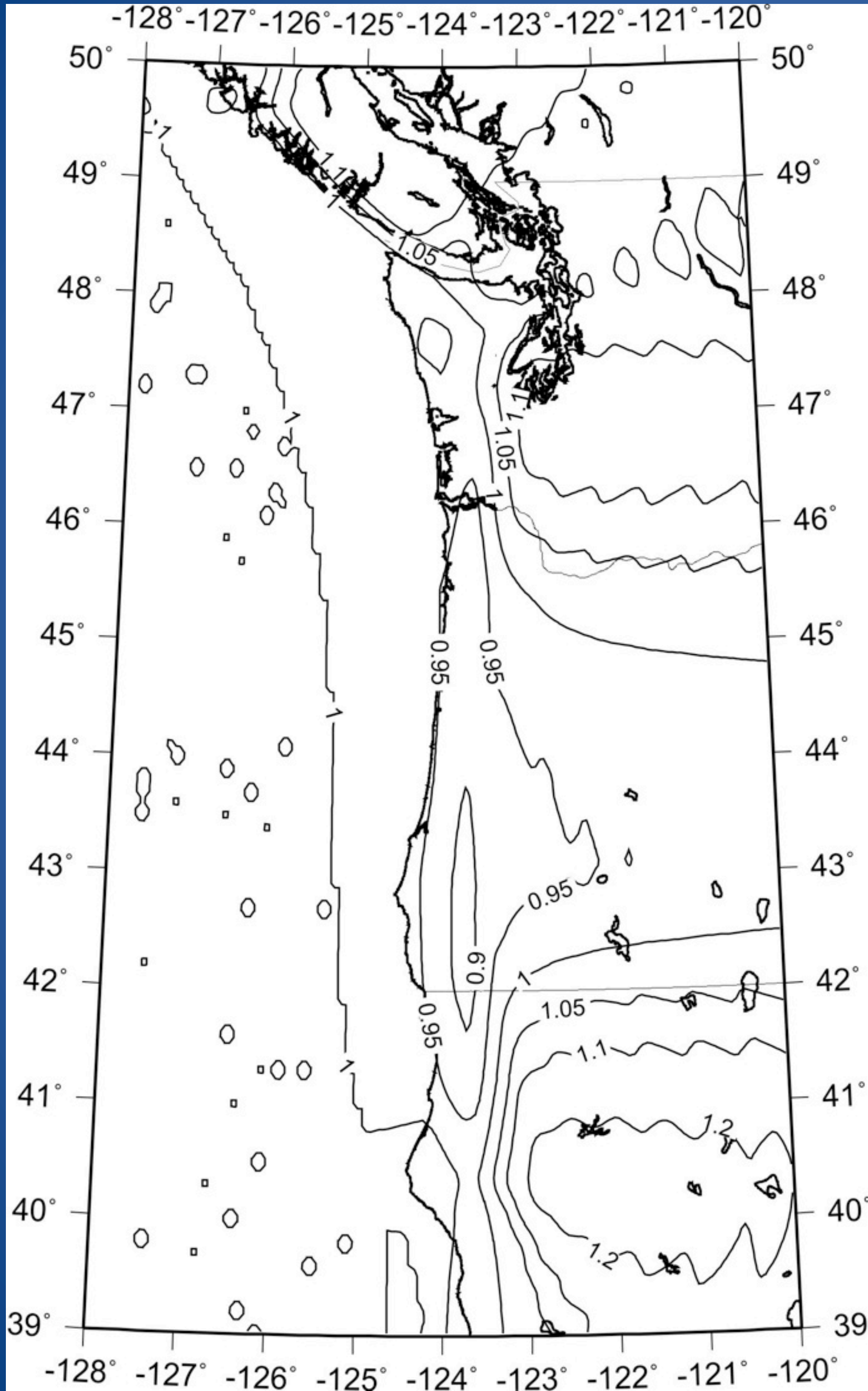
Use average of:
Dark Green: Top of tremor from Gomberg et al. (2010)
Orange: Top of tremor from A. Wech

M9 2008 logic tree for down-dip edge



using proposed logic tree for down-dip edge





Ratio of 2%/50 PGA between new down-dip edge logic tree and 2008 logic tree

Only for hazard from M9.0 Cascadia earthquakes

500 yr recurrence

- Maybe we should use contour of 2 cm/yr locking as seaward limit of downdip rupture
- Are there constraints from observations (or non-observations) of liquefaction or landslides in the Puget Sound area or other areas (Columbia River, Willamette Valley)?