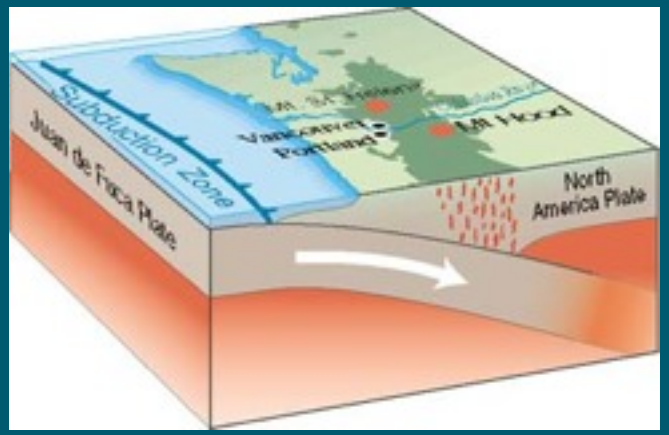
West Coast Earthquake Early Warning: Issues and imperatives

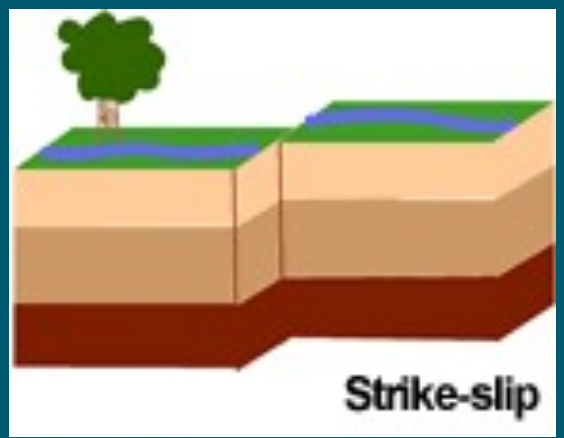
John Vidale PNSN Director
Paul Bodin PNSN Manager

Two kinds of faults along Western U.S.

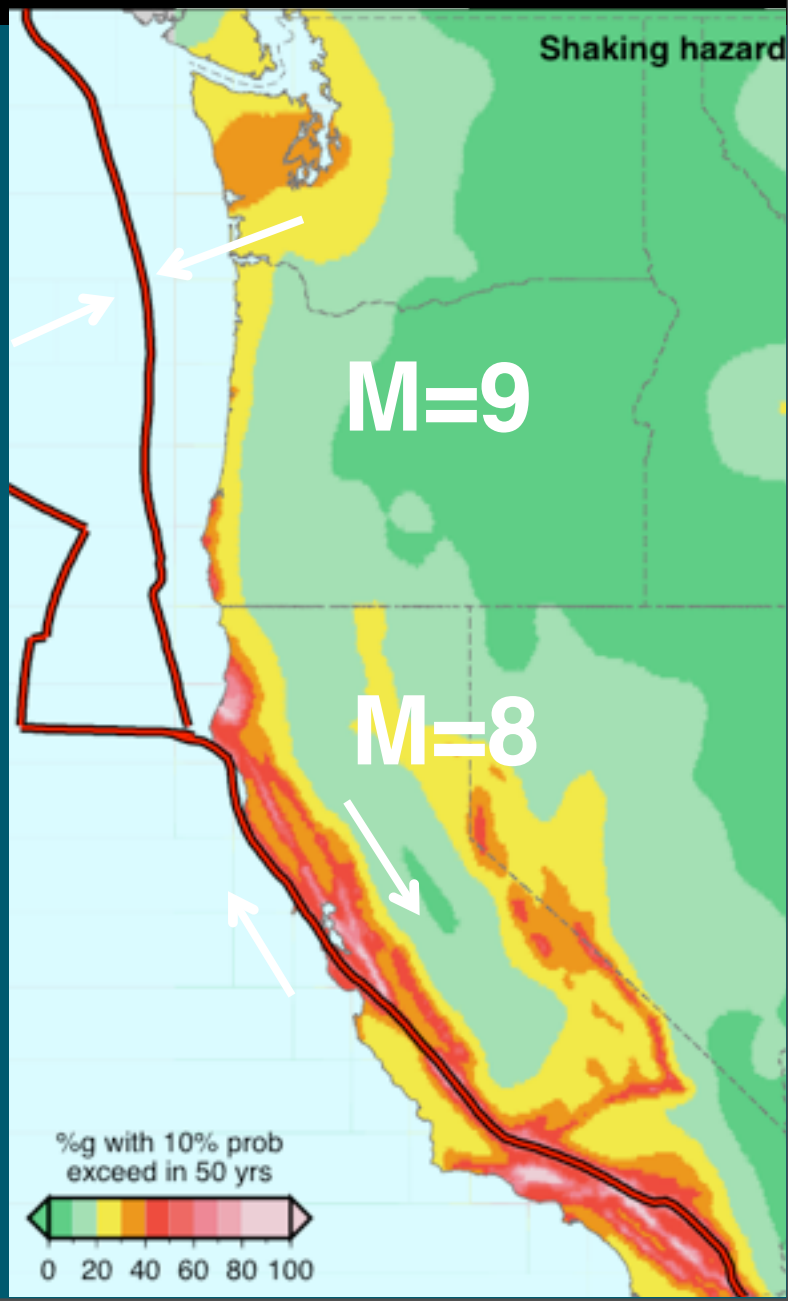


Cascadia: Subduction

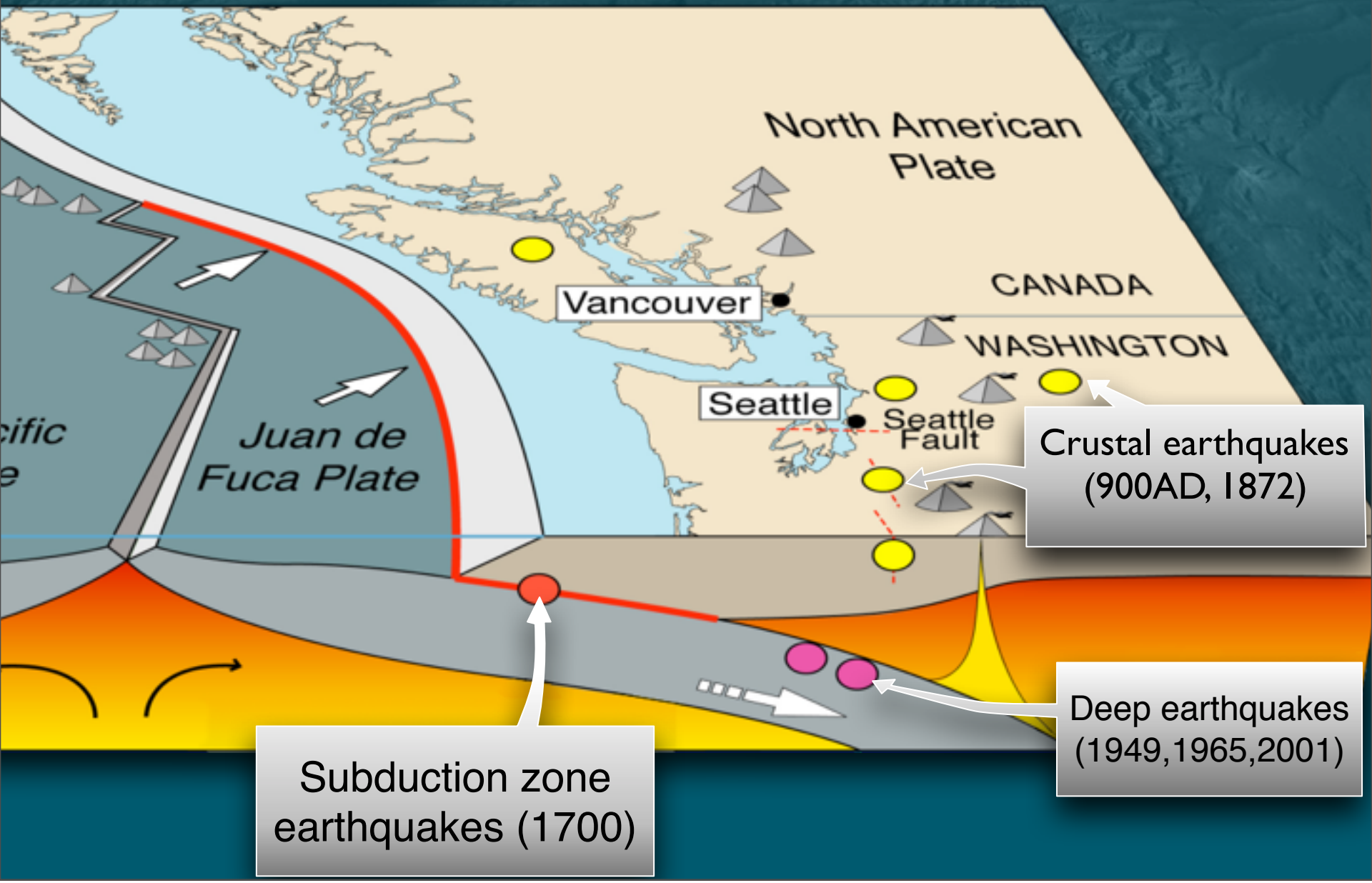
40ºN



San Andreas: Strike-Slip



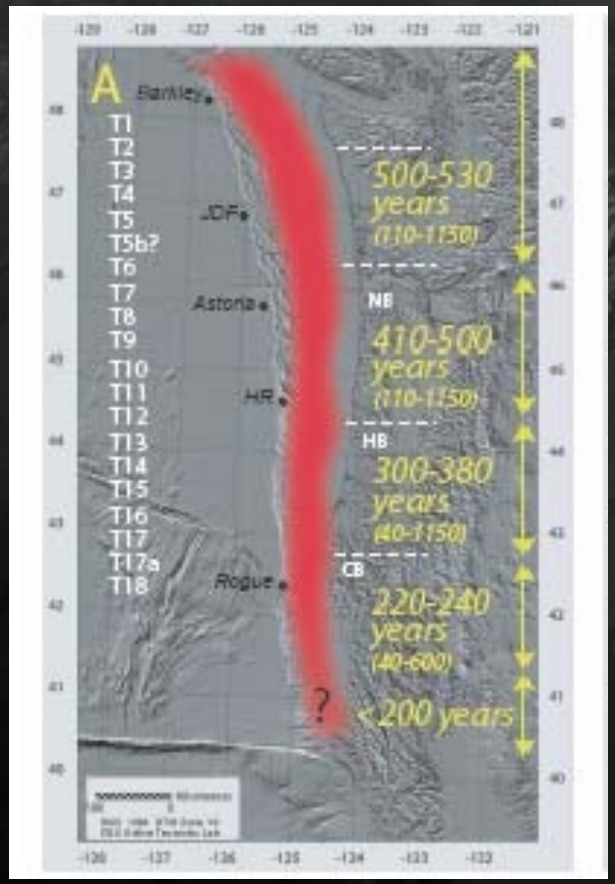
Cascadia: 3 kinds of quakes

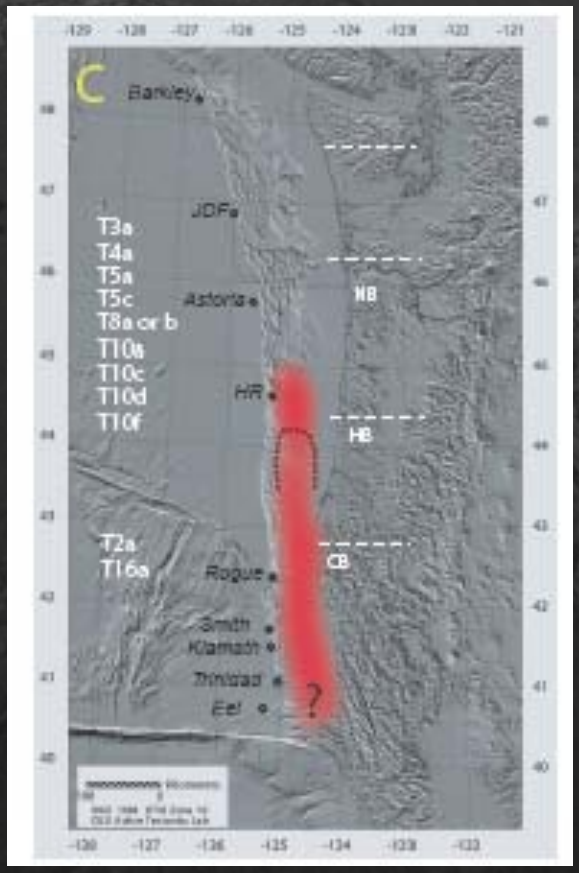


How often does Cascadia break?

- 500-year recurrence for **M9** ruptures
  - that breaks whole CSZ
- 500- to 1000-year recurrence for **M8.0-8.7**
  - that only ruptures southern CSZ
  - so for southern portion of Cascadia subduction zone: 250- to 340-year recurrence time for M8.0 or larger earthquakes
- How many **M6s** and **M7s**? Not clear.

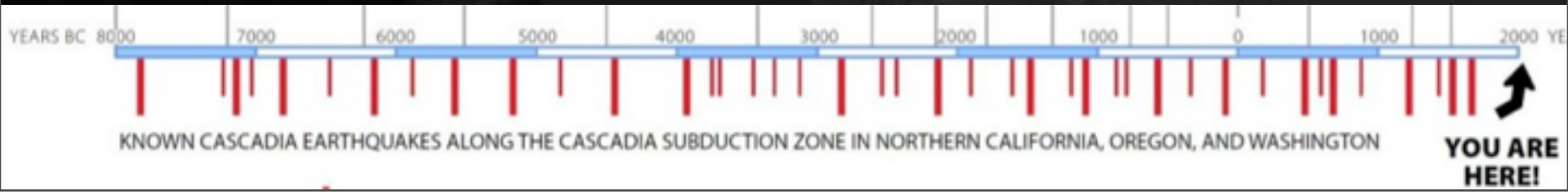
Last 10,000 years of big earthquakes from offshore geology





20 ~M9 events, 20 ~M8 to M8.5 events

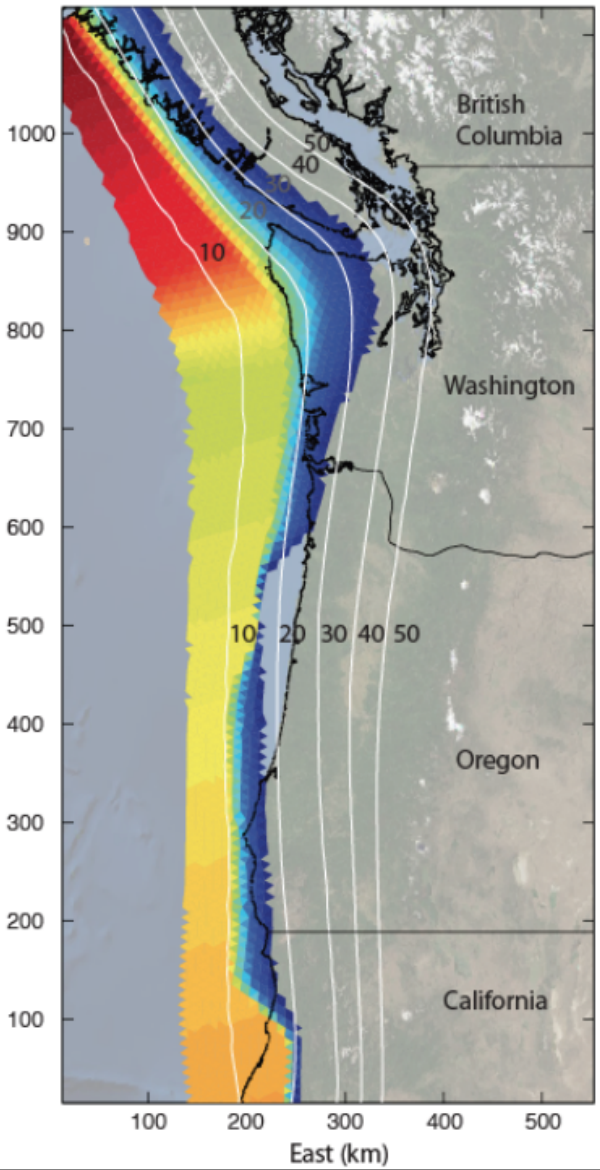
(Goldfinger et al., 2008, Bull, Seis. Soc. Amer)



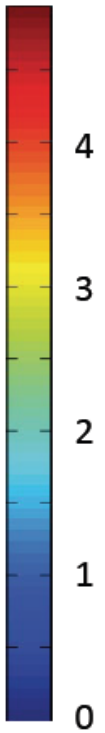
Approximate 50-year probabilities

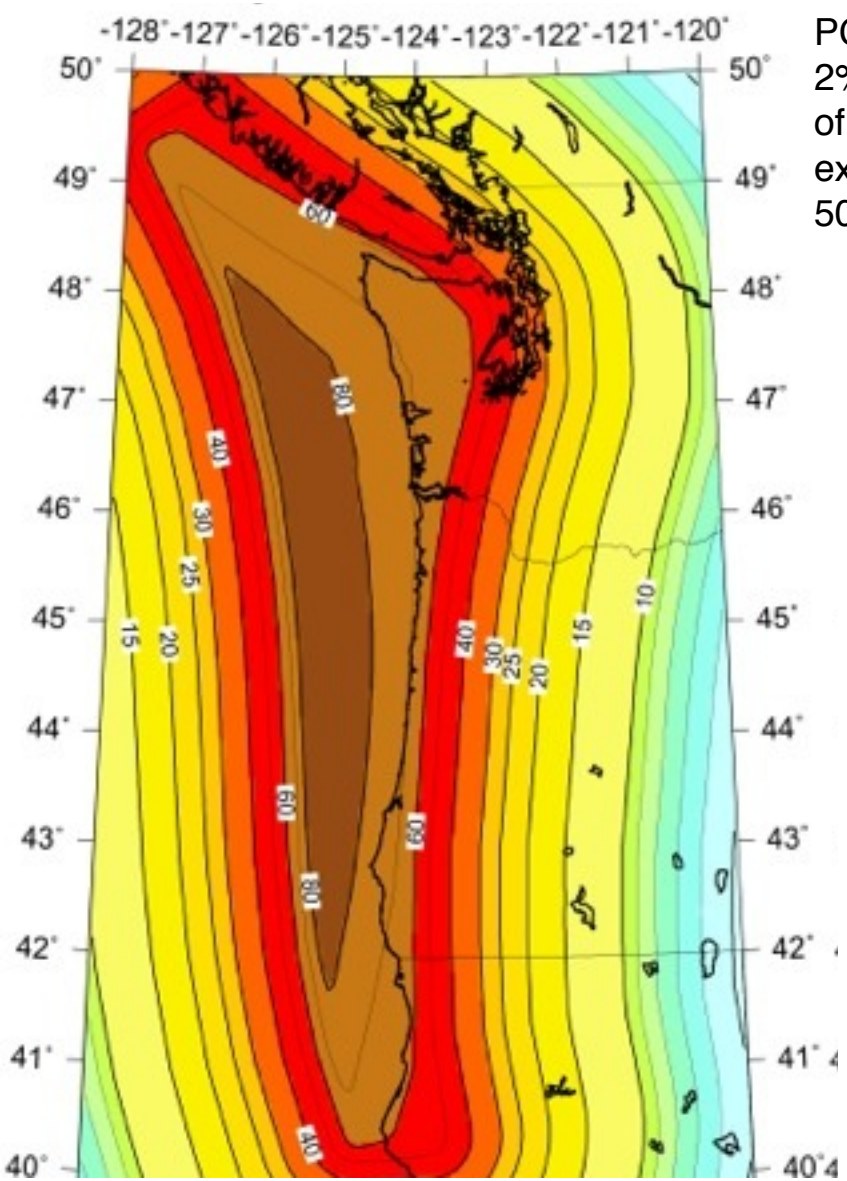
- This year's target:
  - Cascadia M9: 14%
  - Southern Cascadia M8-9: 25-40%
- Later, with denser, better instrumentation
  - Shallow Seattle Fault M ≥ 6.5: 5%
  - Shallow M ≥ 6.5 in entire Puget Sound area: 15%
  - Deep M ≥ 6.5: 84% (1949, 1965, 2001)

Big earthquakes and shaking hazard



Slip Rate Deficit (cm/yr)

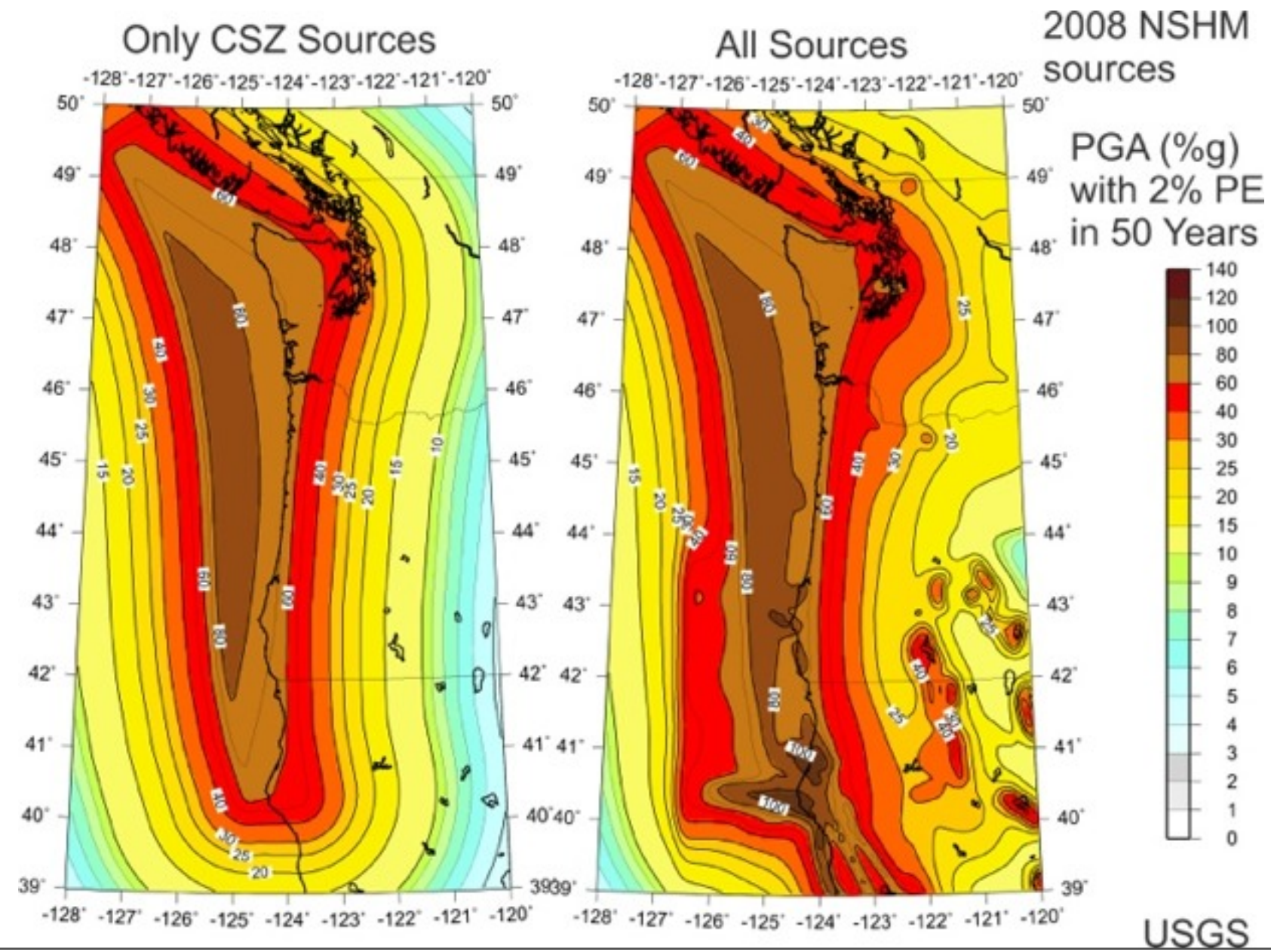




PGA (%g)
2% chance of being exceeded in 50 years

USGS science for a changing world

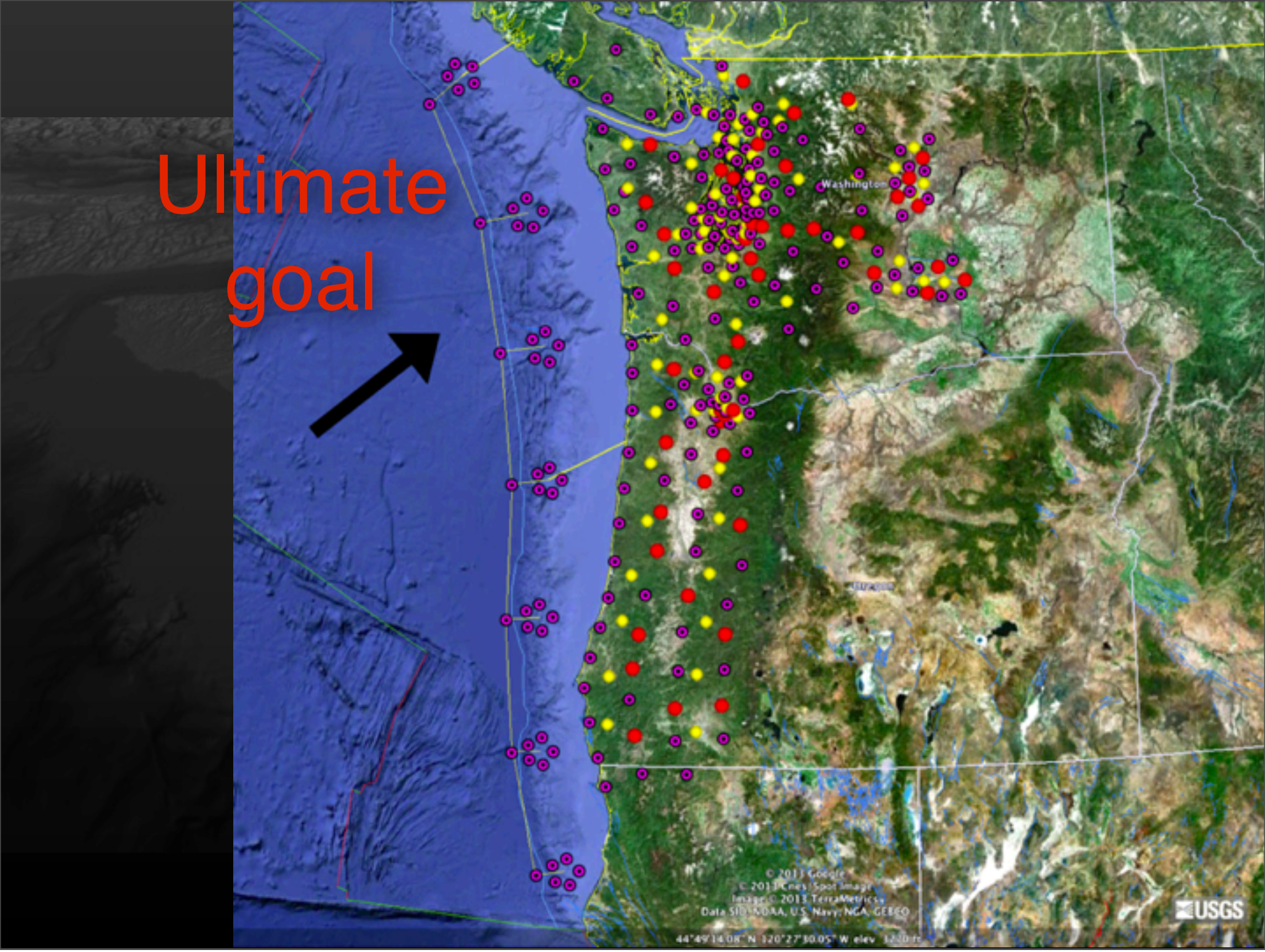
Coastal vs overall shaking hazard



Sumatra 2004,

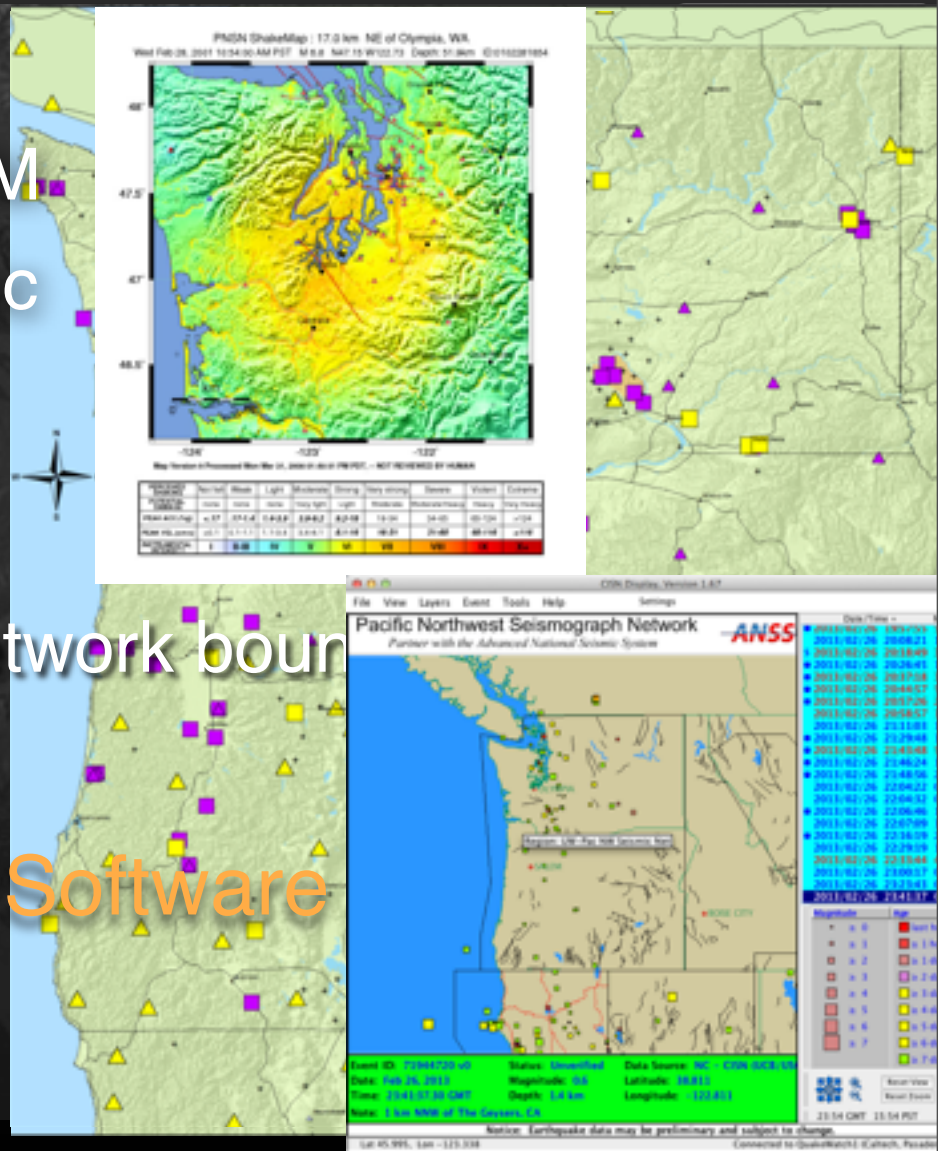
similar to expected Cascadia M9 earthquake

Ishii, Shearer, Houston, and Vidale, Nature, 2005


Ultimate goal
Washington
USGS

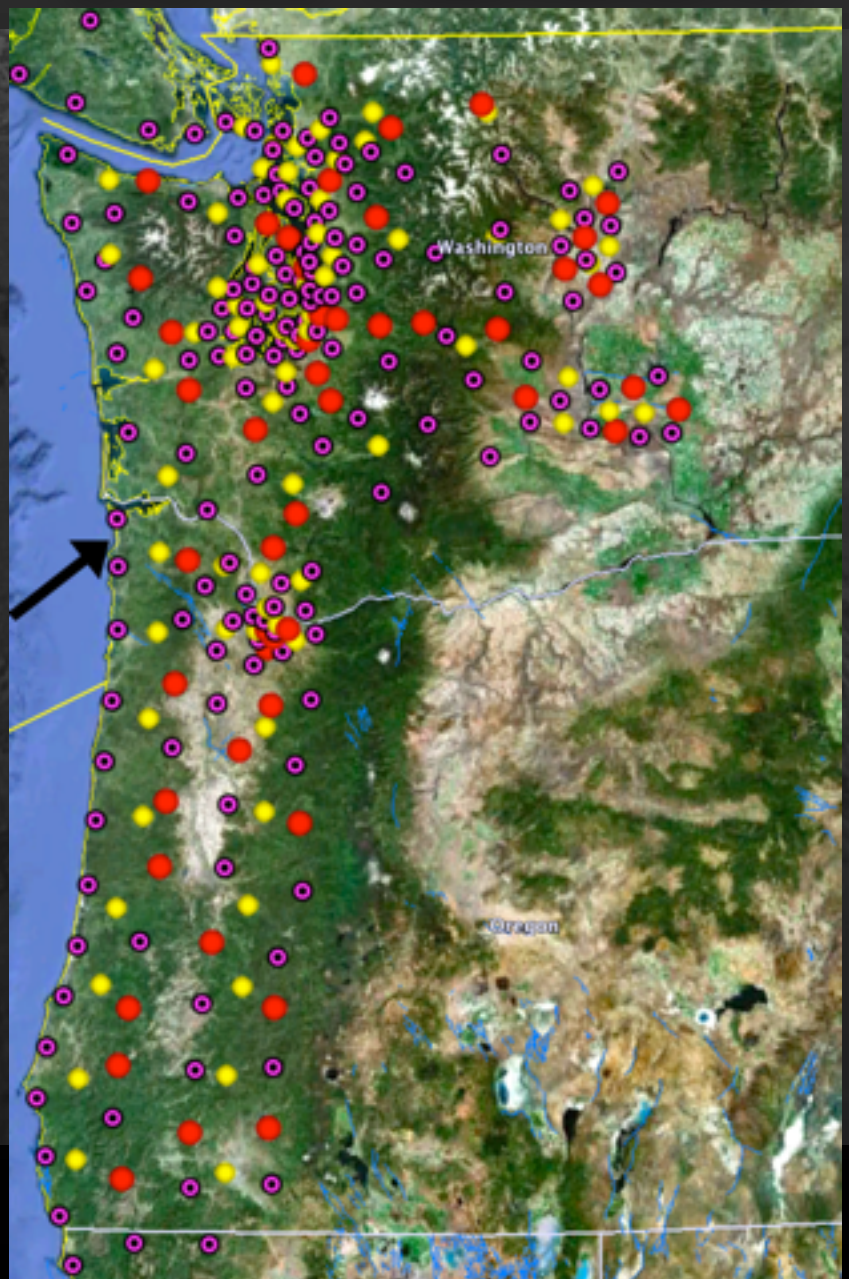
Current Network

- Stations we Operate
  - ~~120 SP~~, 50 BB, 200 SM
  - heterogeneous, historic
  - diverse telemetry
- Data we Import
  - data shared across network boun
  - we don't control these
- Acquisition/Processing Software
  - same as California
  - takes several minutes
  - notification, product distribution through EIDS.



EEW Network

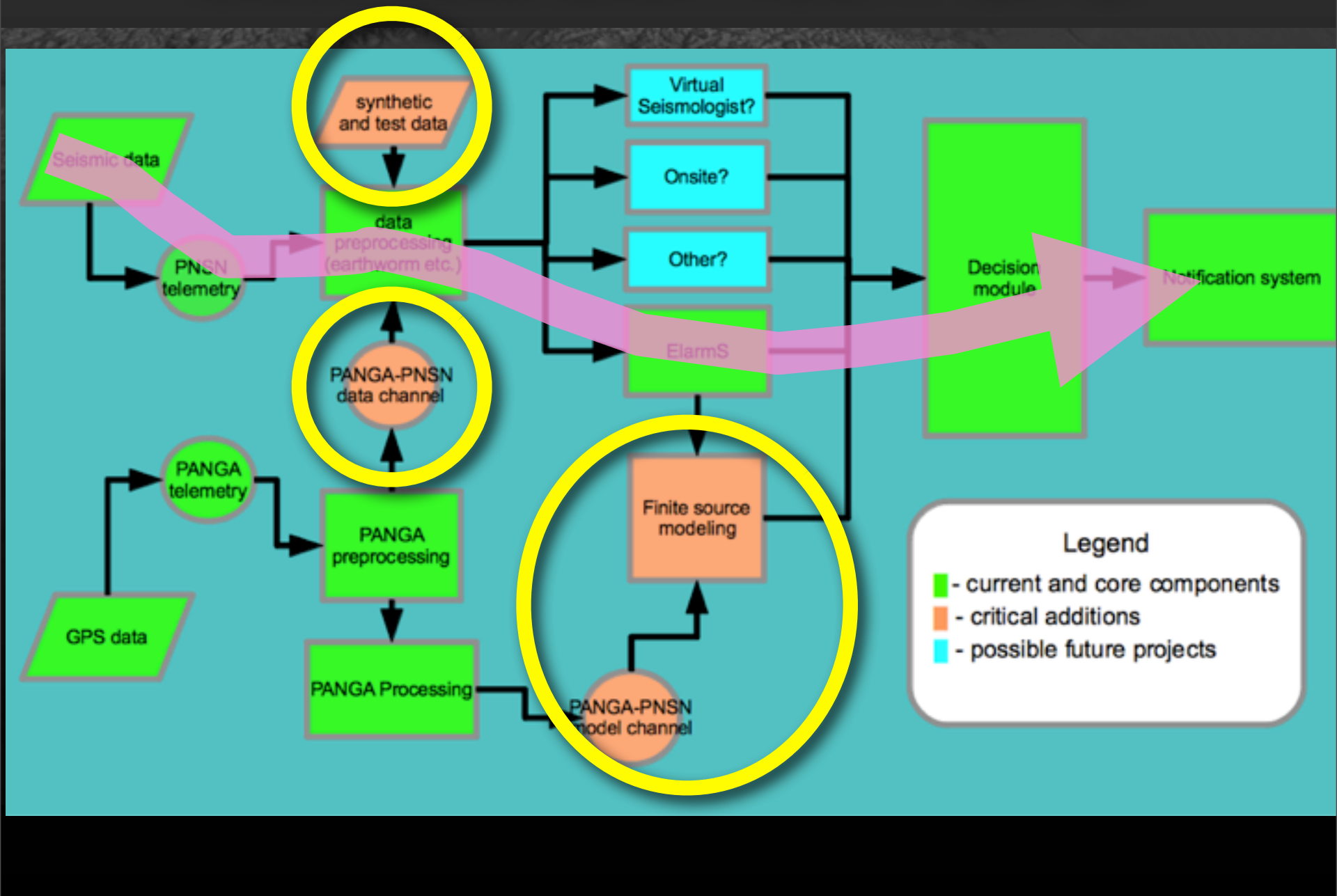
- Low-latency backbone
  - 66 BB, 150 GPS, 210 SM
  - uniform instrumentation
  - 6 field centers
- Processing at Seattle
  - backup across 3 West Coast system centers.
  - coordinated by USGS
- Warnings may be distributed in a variety of ways.



3 Stages for EEW in Cascadia

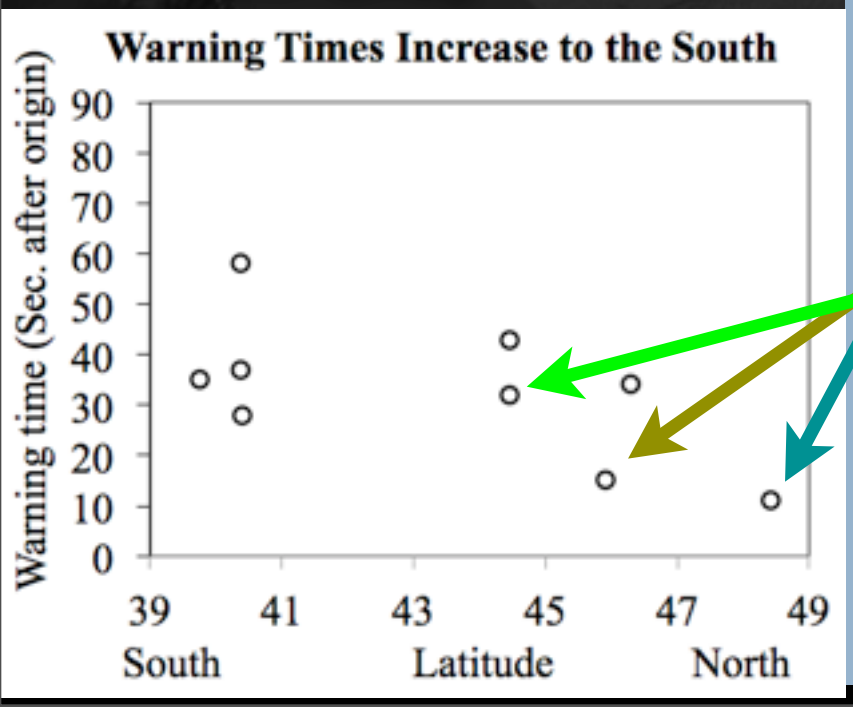
- 1 - Develop & deploy prototype EEW system based on current PNSN network (GBMF).
  - » Build on CISN-EEW efforts, adding (and testing) PNW-specific capabilities to target megathrust events.
  - » Beef up coastal stations where particularly thin.
- 2 - Solidify operations for robust megathrust earthquake EEW.
- 3 - Densify coverage and procedures to allow warnings for crustal and deep events.

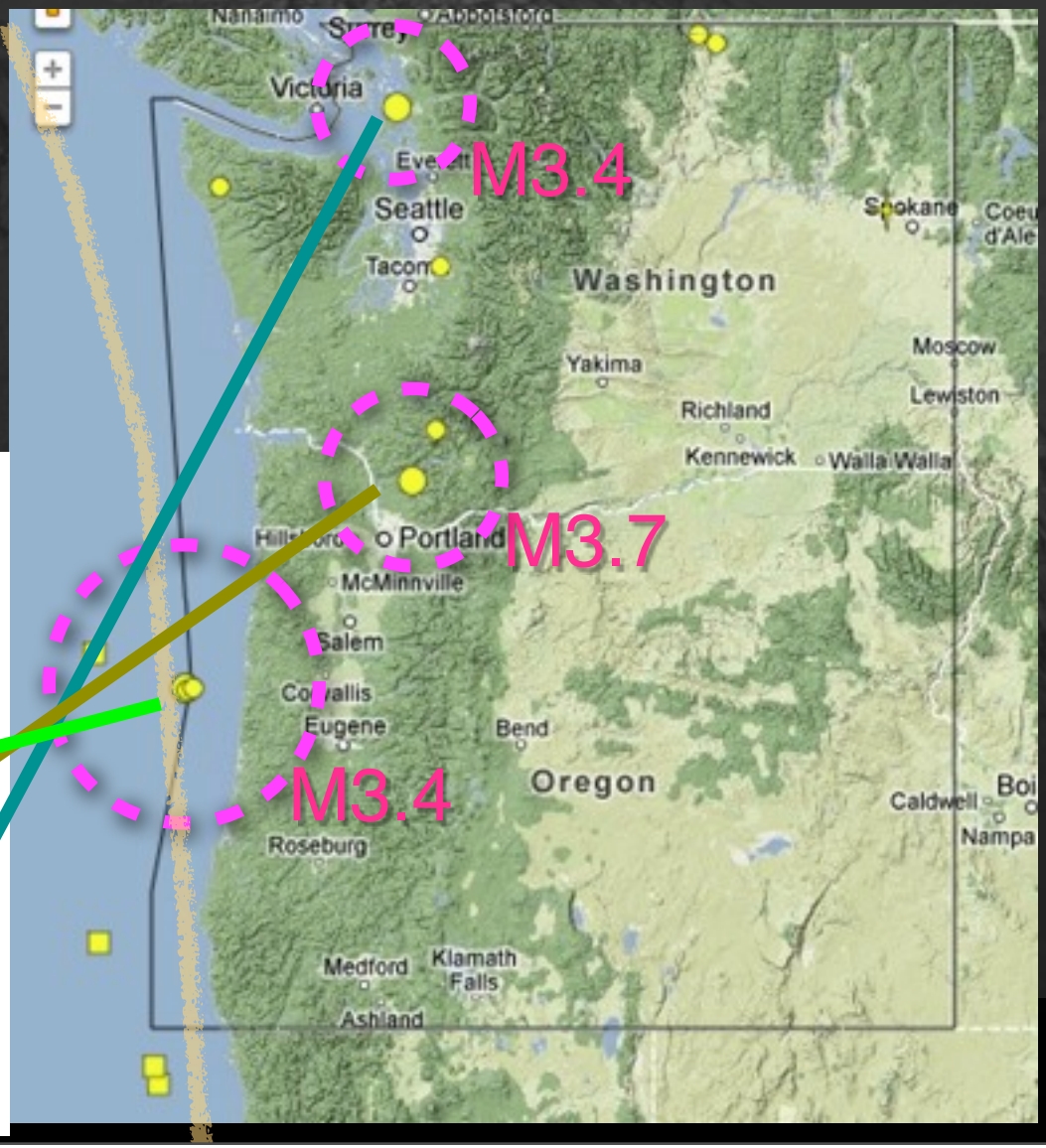
Cascadia ElarmS2 + GPS



Current ElarmS results

- Promising results from past month
- 34 Triggers
- 10 Real Alarms (M>2.5)





Cascadian Capabilities

- Megathrust Earthquakes
  - 1/2 minute to 5 minutes warning to urban centers (depending on quake starting point and location).
  - Can forecast chance of M7+ growing to M9.
  - Enhanced tsunami forecasts possible (w/ NOAA).
- Other Earthquakes (crustal, deep)
  - seconds to perhaps a minute of warning.
  - “Blind Zones” currently limit usefulness of proximate warnings.
  - Requires denser instrumentation.

EEW considerations

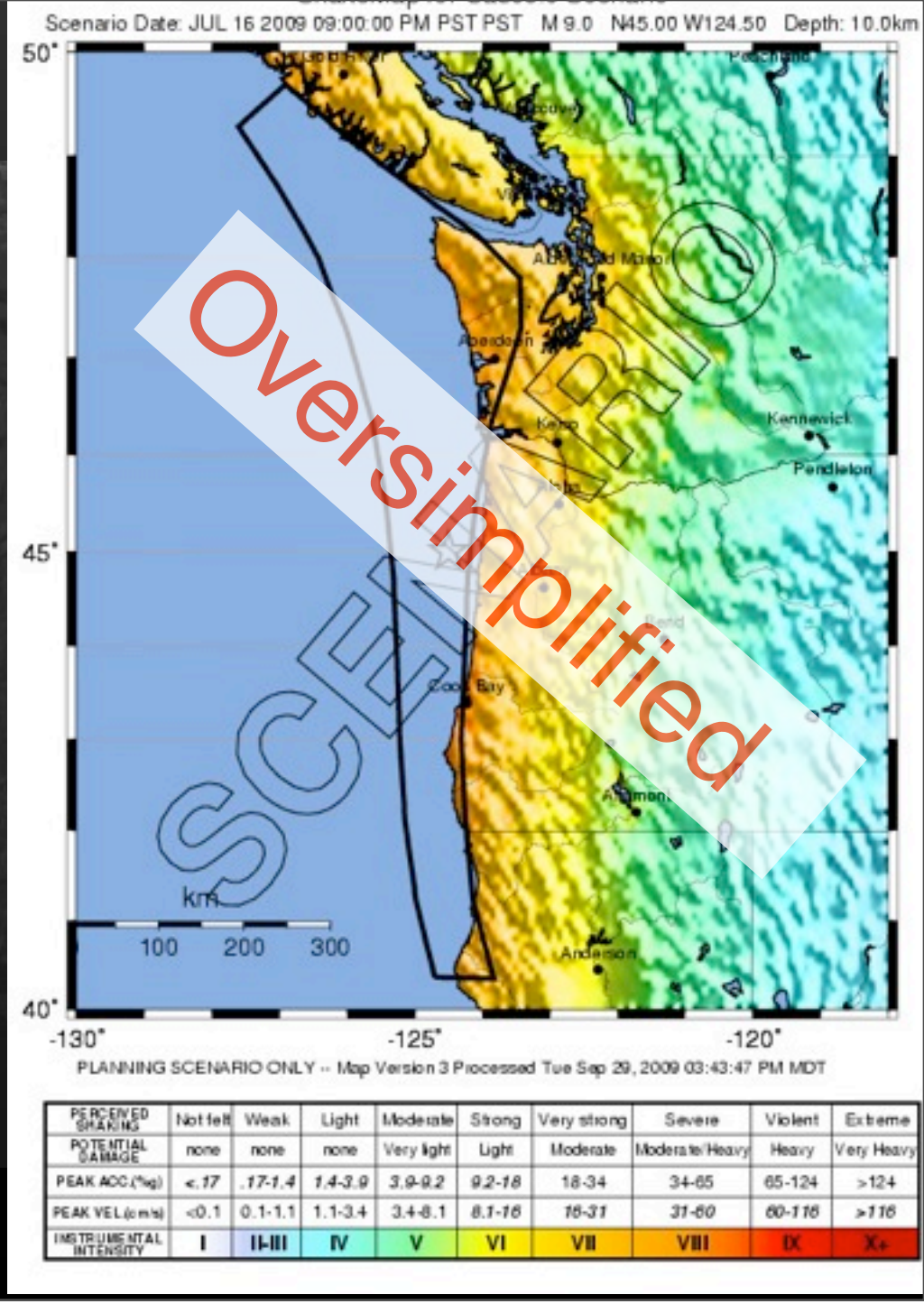
- Expense:
  - Full system ~$16M/yr for entire West Coast.
  - However, coverage and costs are fluid.
- Everybody that's anybody is doing it:
  - Japan (~$1B), China (~$300M+), Mexico, Korea, Romania, Taiwan, are doing it now.
- It's not hard:
  - Basic physics known for more than a century.
- It's a good way to improve all ANSS performance:
  - Accurate results before chaos sets in.
  - Much better performance during chaos.

Quantitative earthquake risk

- FEMA (2008, all quakes)
  - WA $400M/yr
  - OR $200M/yr, ~$1000/person/yr
- M9 estimates (minus California, Canada)
  - Cost in Oregon, 2013 report
    - $30B
  - Cost in Washington, 2012 WS-DNR HAZUS run
    - $15B+ (no tsunami, landslides, liquefaction)
- Comparisons
- Tohoku 2011 - $250B+, Chile 2010 $15-30B
- Sumatra 2004 - 230,000 killed

Risk to PNW

- Shaking uneven
- Building uneven
- Aftermath
  - big crustal aftershocks
  - landslides, volcanoes
- Costs more than just direct damage
  - current business climate, image
  - insurance expense
  - neighborhood recovery
  - business continuity



Current status of PNW EEW

- ~$80K/yr EEW funds from USGS
- $1.8M grant from Moore Foundation
  - 4-yr plan (2012-2015) to prototype
  - Fall Technical workshop - science, communications
  - End of year - M8-9s Warnings to a handful of entities
- $16M/yr for full implementation plan
  - For entire West Coast of US
  - Would take ten years to finish PNW
- Serious budget uncertainty in DC
- EEW seems inevitable (to us) eventually
  - could be full and centralized (USGS) could be partial and/or fragmented.

Short- and long-term issues

- Many benefits will be cumulative:
  - Building with specialized EEW equipment.
  - Linking in to networked operations.
  - People will learn to take better advantage of EEW with familiarity.
  - Growing pressure to provide awareness faster.
  - First step toward building out EEW to cover more risks, faster.
  - Building on other emergency warnings.

Next step - this workshop's focus

- We'll detect everything M > 3 in PNW.
  - set aside for now all but large events on the coast.
- Estimate probability that the ground rupture will spread across the length of Cascadia.
- Provide an estimate of shaking for specific sites in the case M > 7(?).
- We're offering to send these estimates to emergency managers that will work with us to improve their usefulness.
- Start of a process aimed at reaching full EEW capability 5-10 years.

Peace of mind in earthquake country?