GPS Constraints on Earthquake Hazard in the Puget Lowland 2006 Update; In Progress

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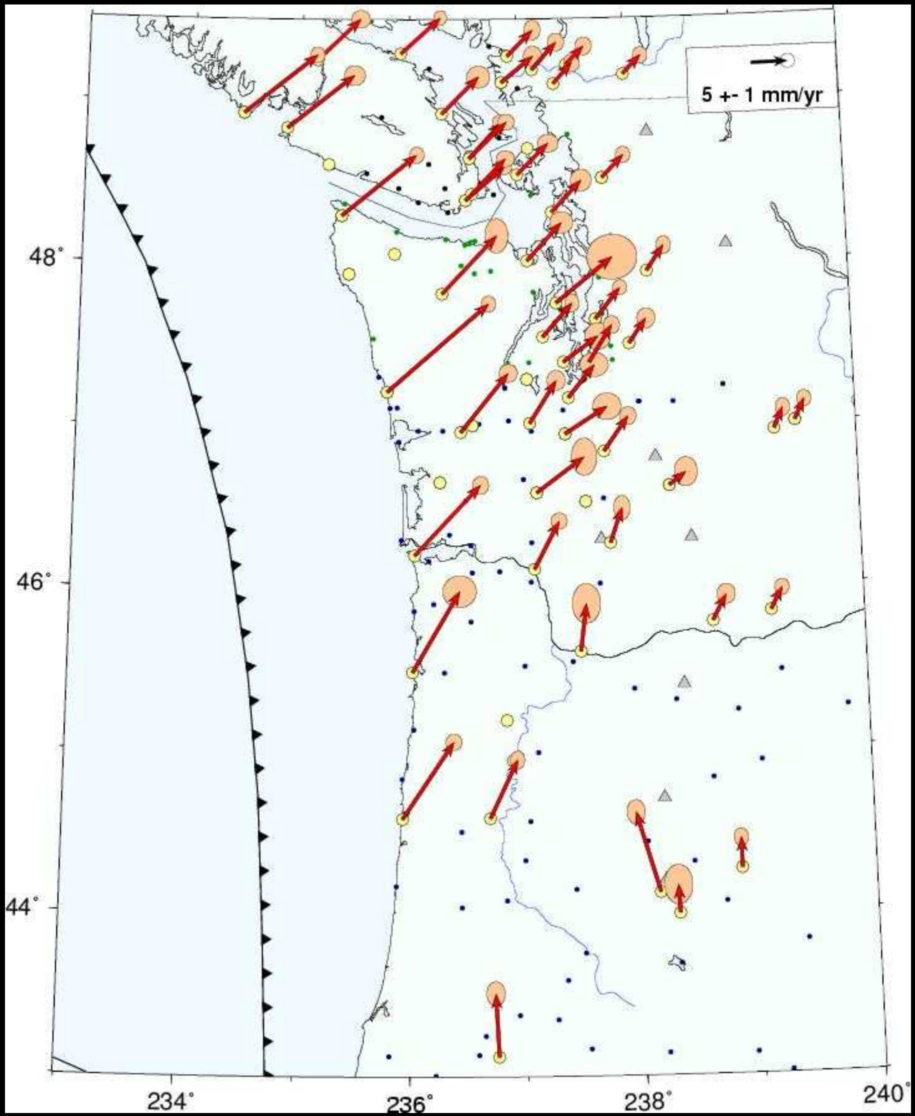
Content:

- Cascadia setting, forearc motion
- Puget Lowland N-S shortening from GPS
- Frequency-Magnitude of large earthquakes
- Tantalizing hints for the Seattle and Leech River Faults

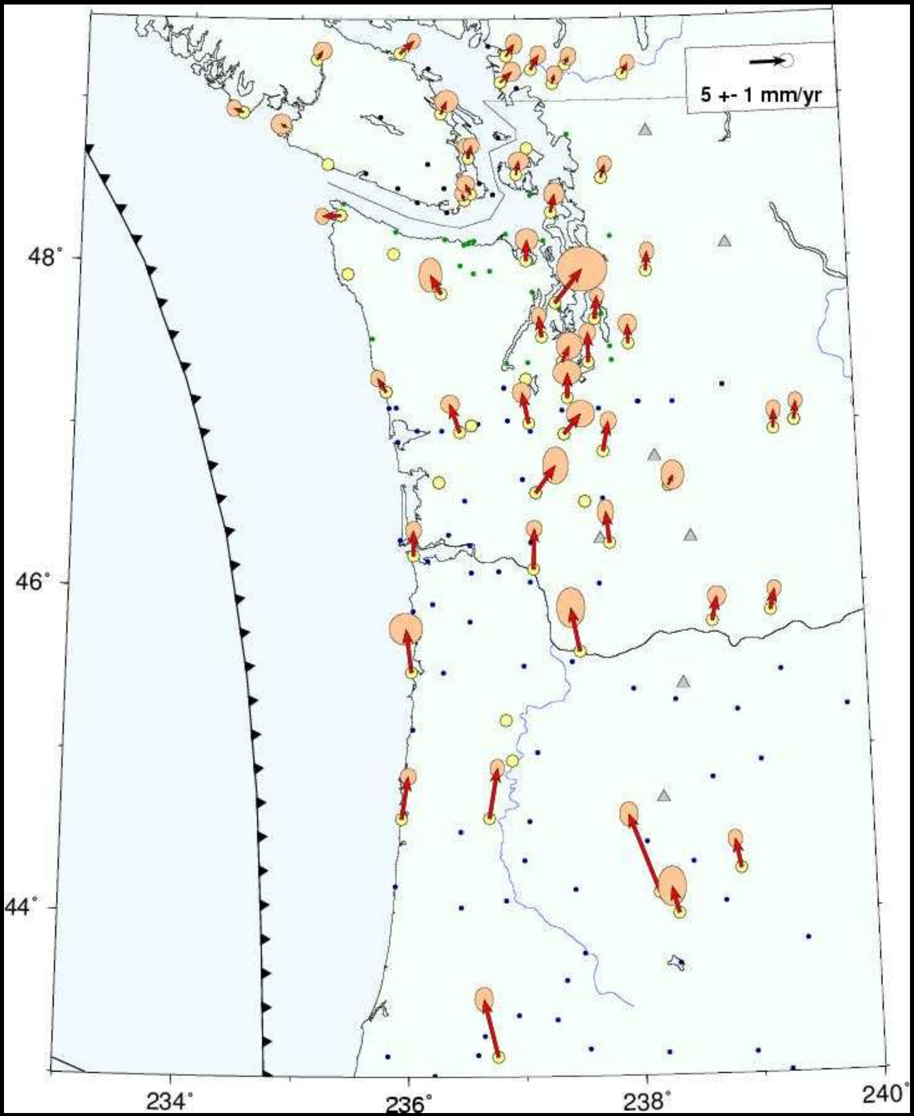
PGC 2006 solution for Cascadia margin

Clear subduction loading signal



ITRF2000, wrt. North America

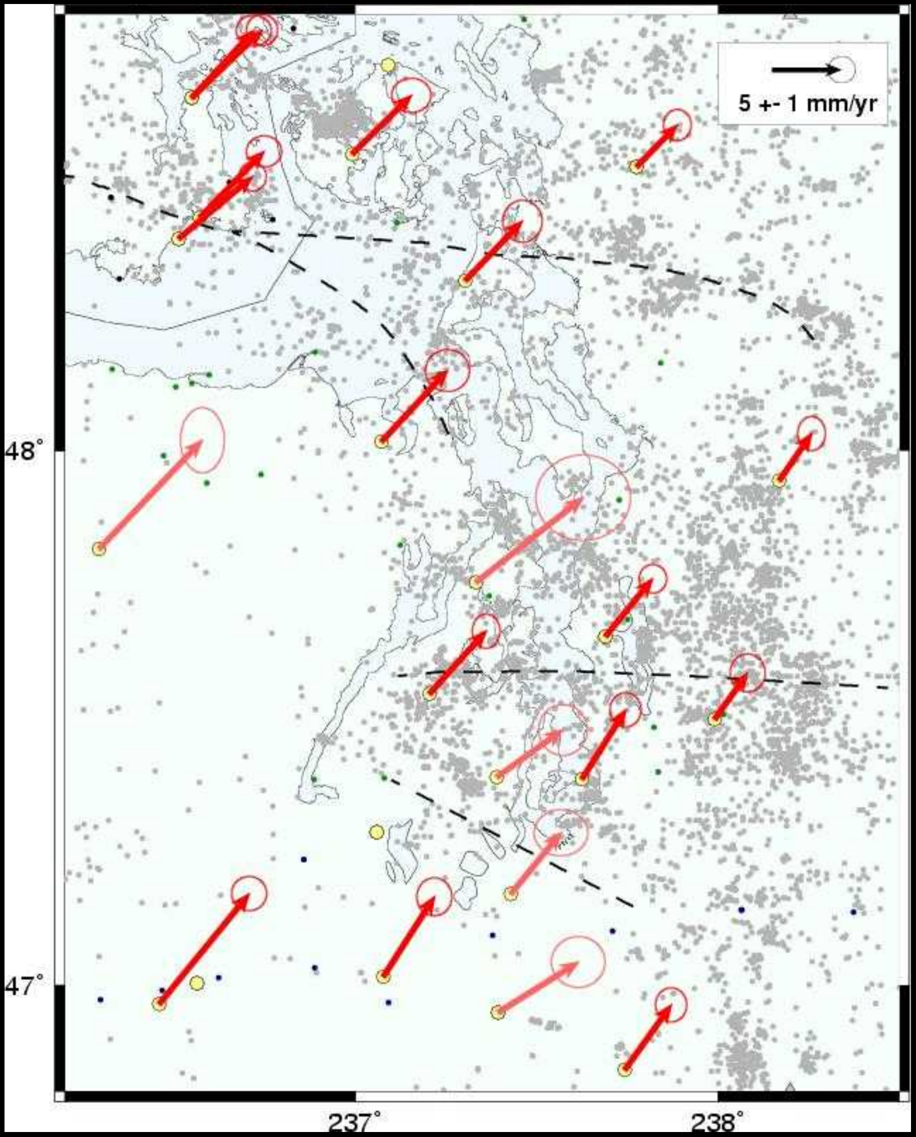
Residuals show forearc motion



After subduction loading correction

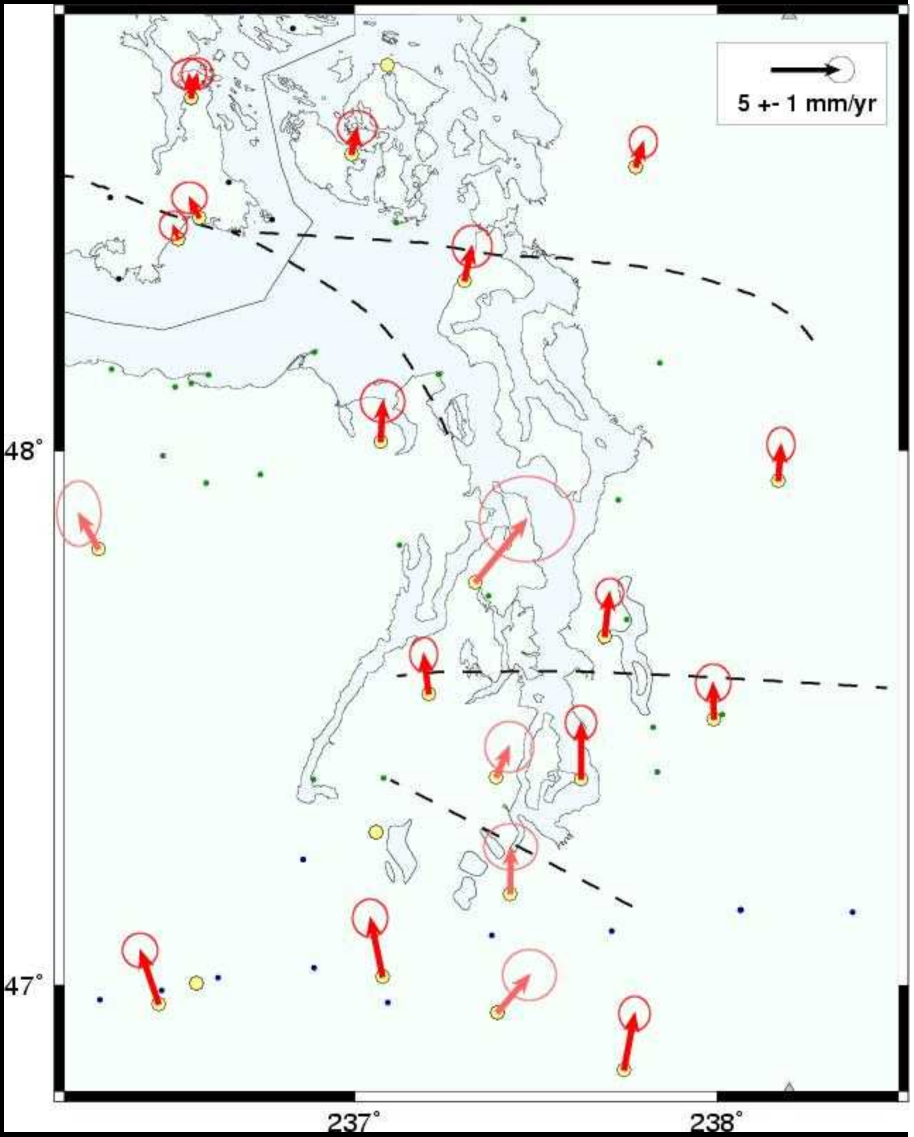
Puget Lowland GPS velocities

Clear subduction loading signal



ITRF2000, wrt. North America

Residuals show N-S shortening

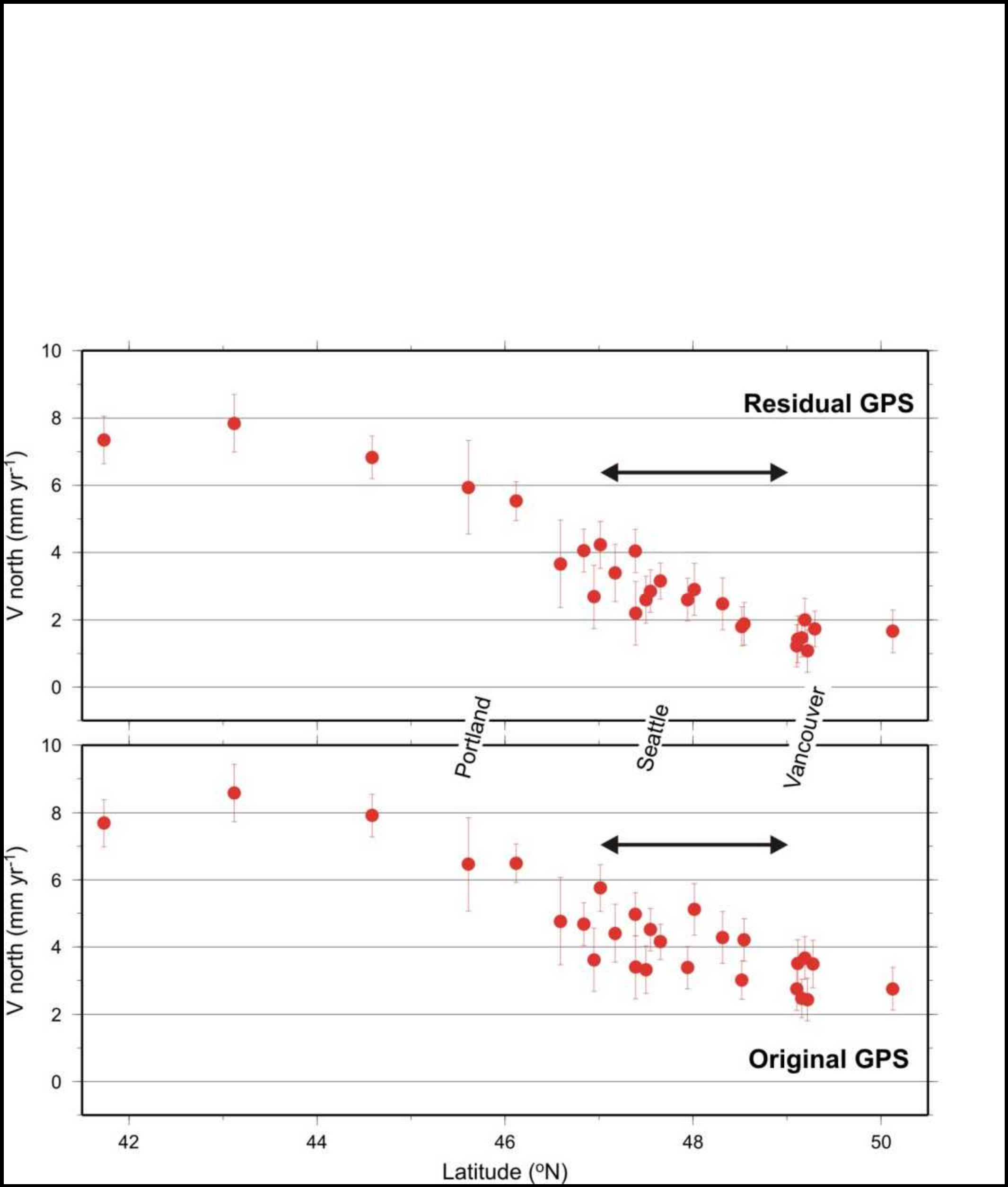


After subduction loading correction

Puget Lowland N-S shortening section

North velocity vs. latitude

Shortening distributed across Washington & northern Oregon



Puget Lowland N-S shortening section

North velocity vs. latitude

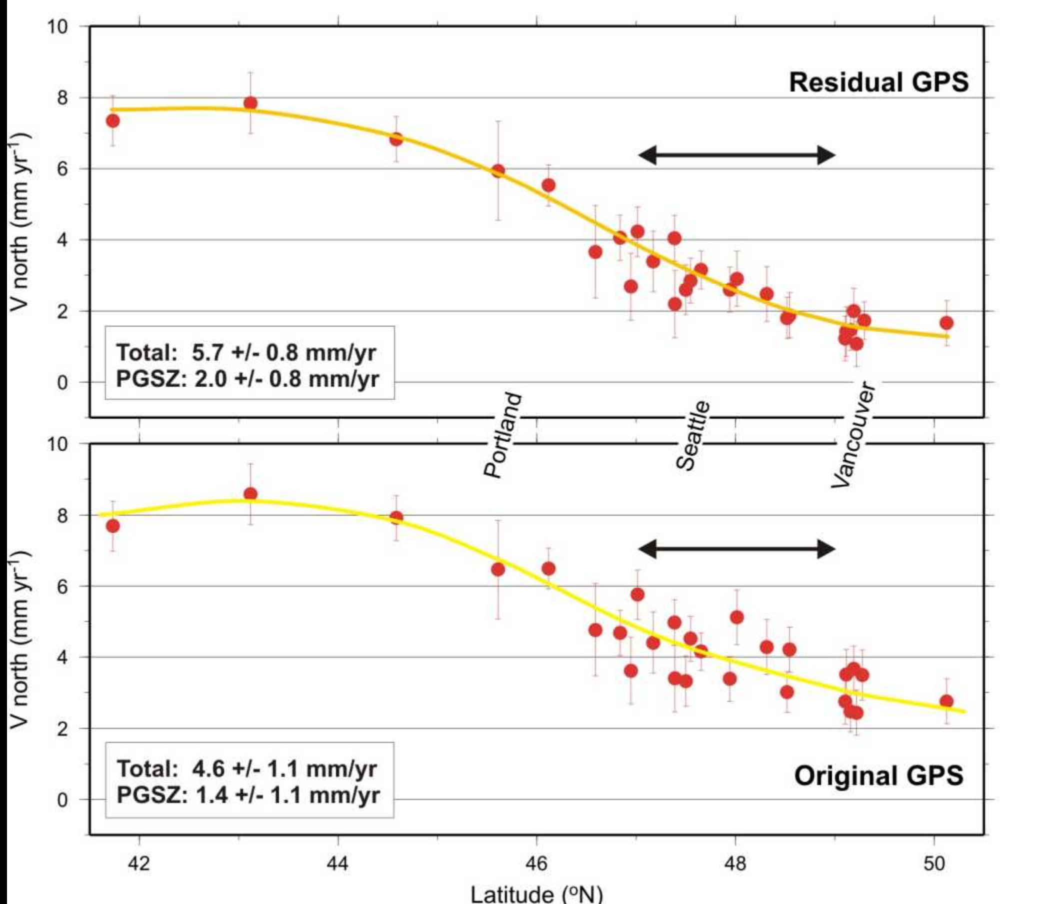
Shortening distributed across Washington & northern Oregon

Puget Seismic Zone:

Current: 1.4 +/- 1.1 mm/yr

Residual: 2.0 +/- 0.8 mm/yr

Only ~1/3 of total shortening



Puget Lowland N-S shortening section

Seismicity (ANSS, M>2 & M>4)

1st order correlation with GPS strain rate but local differences

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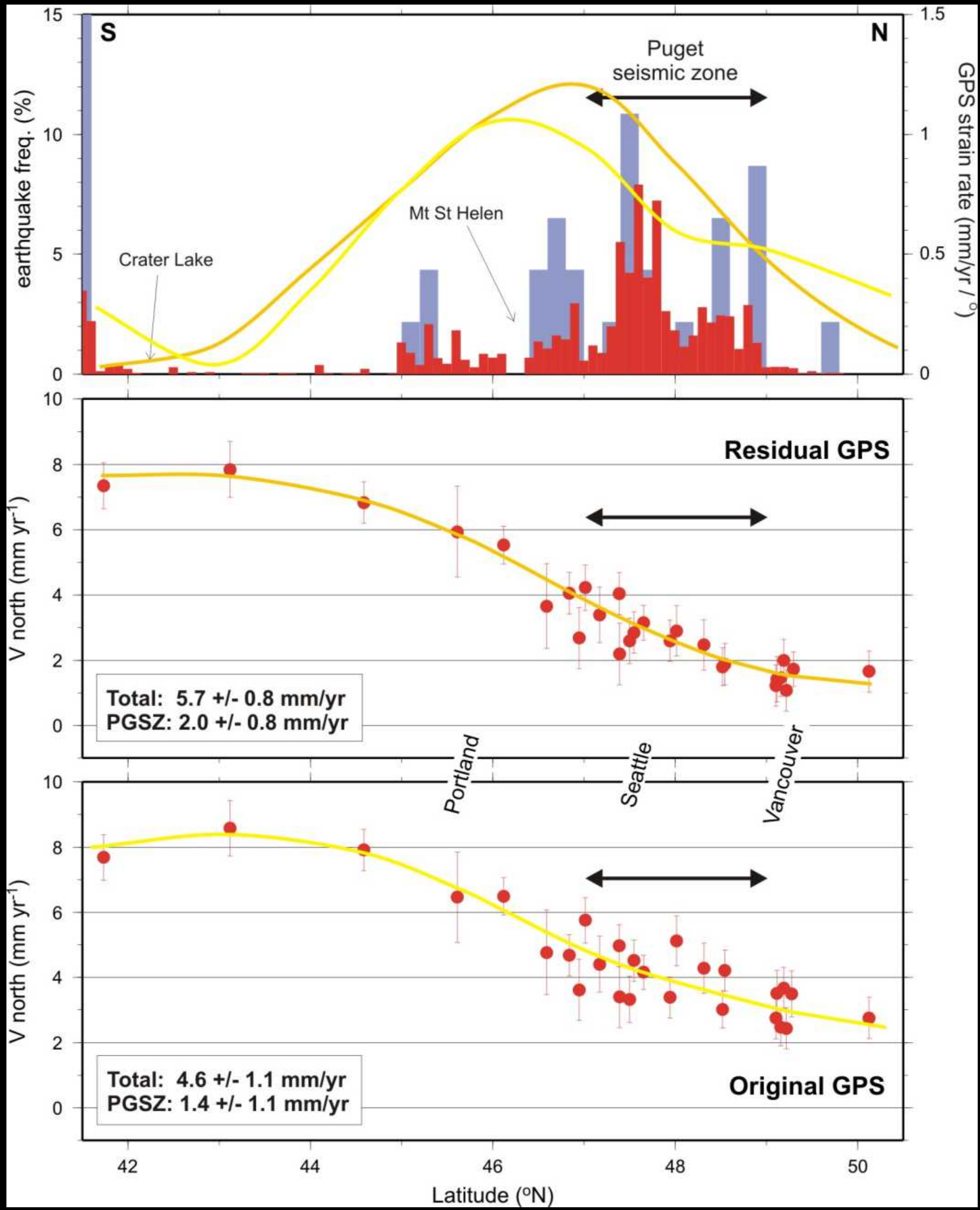
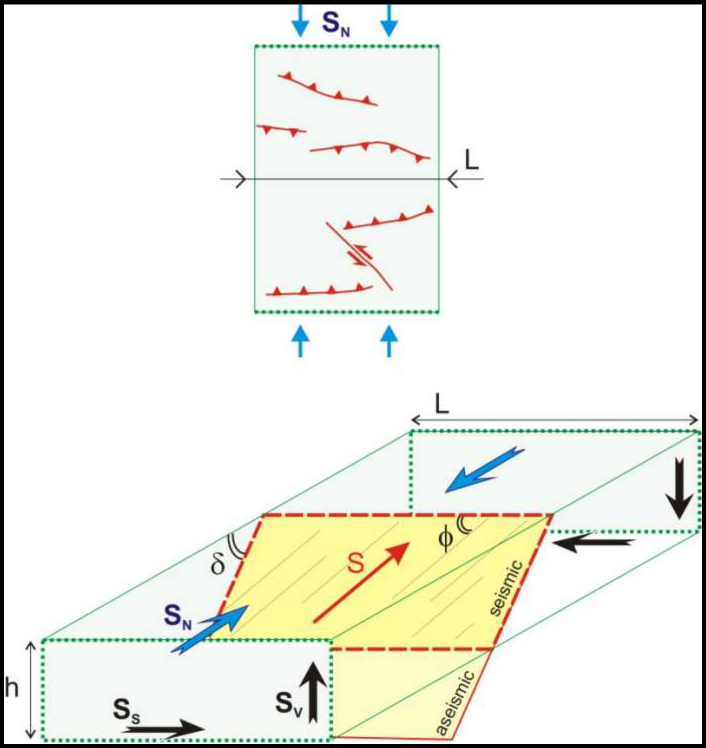


From GPS to seismic moment & frequency – magnitude of large earthquakes

GPS to seismic moment rate

$$\dot{M}_0^{GPS} = \frac{\mu L h}{\sin\delta} \frac{\dot{s}_N}{\sin\phi \cos\delta}$$

* Requires: characteristic width (L), seismic thickness (h), fault style (ϕ, δ)
* Assume 100% "seismic efficiency"



Moment rate to frequency – magnitude:

(1) Characteristic earthquake recurrence

$$T_C = \frac{10^{(1.5M_C + 9.05)}}{\dot{M}_0^{GPS}}$$

(2) GR distribution based on local catalogue (*a* and *b* values)

=> **Catalogue Mx**

$$M_X = \frac{1}{c-b}\left[Log_{10}\left(\frac{\dot{M}_0^{GPS}}{\varphi}\frac{c-b}{b}\right) - a - d\right]$$

(3) GR distribution based on empirical *Mx* & *b* values

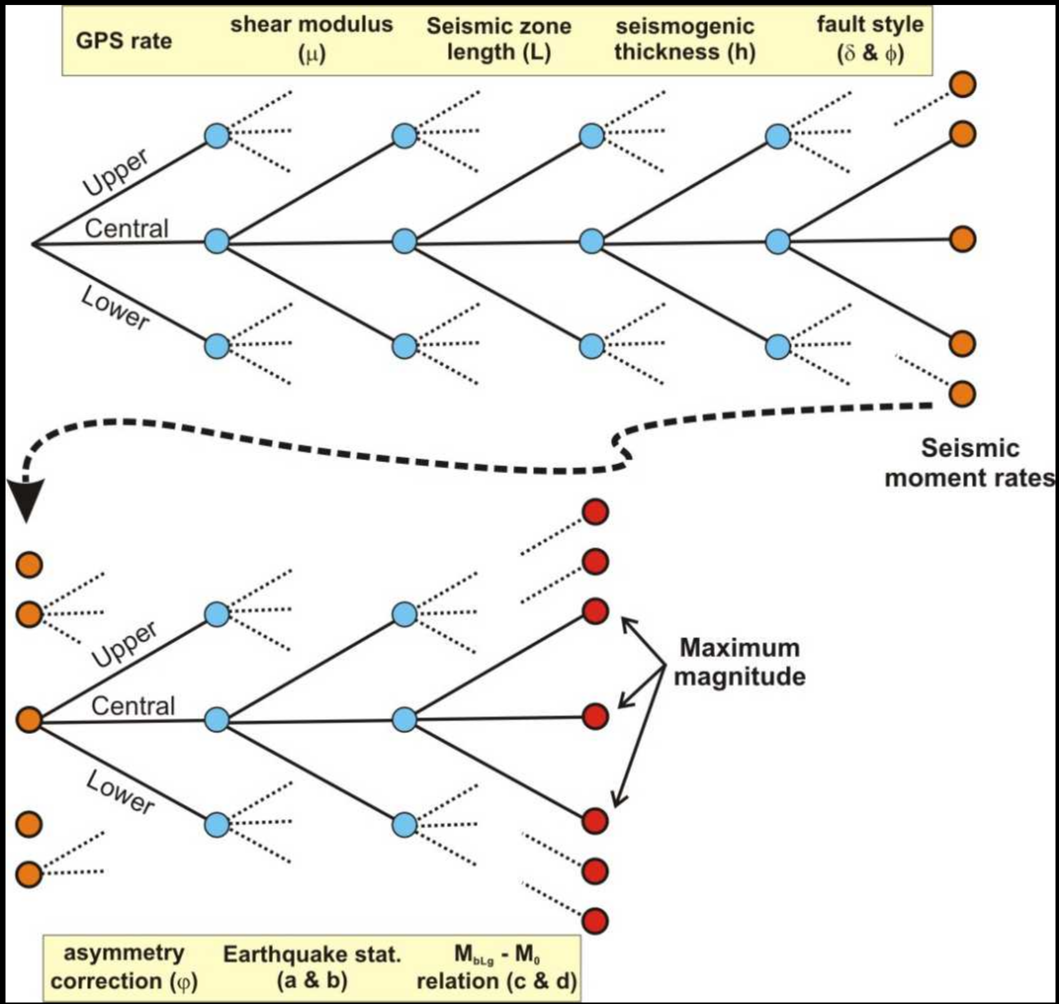
=> **Empirical a value**

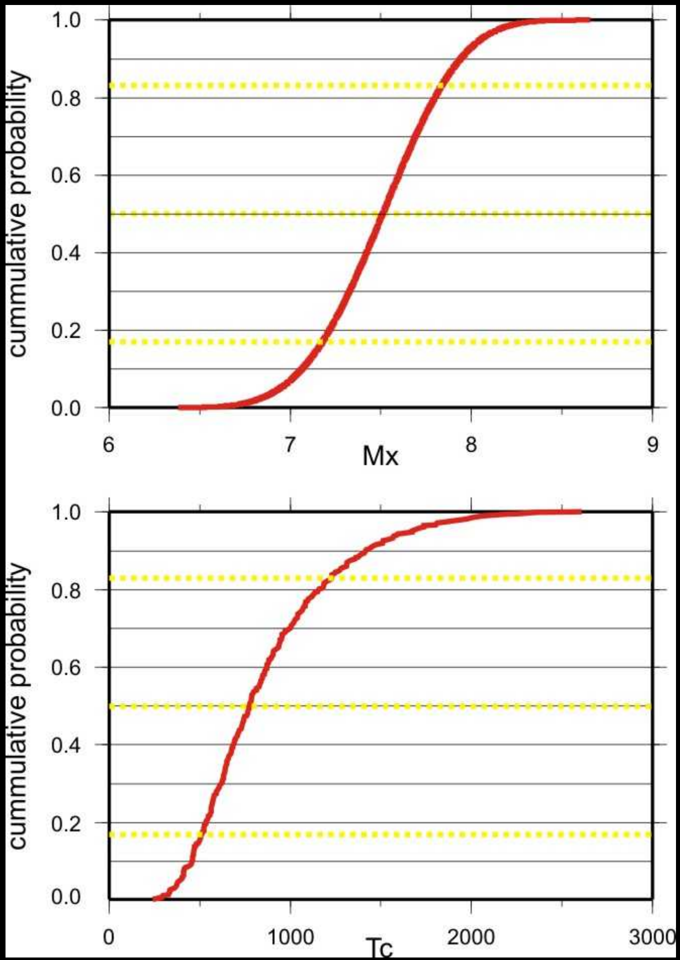
$$a_E = Log_{10}\left(\frac{\dot{M}_0^{GPS}}{\varphi}\frac{c-b_E}{b_E}\right) - (c-b_E)M_X^E - d$$

Logic Tree & Uncertainties

Uncertainties estimated using a logic tree (discrete distribution for each parameter)

cdf defines median and 66CI, 95 CI, …



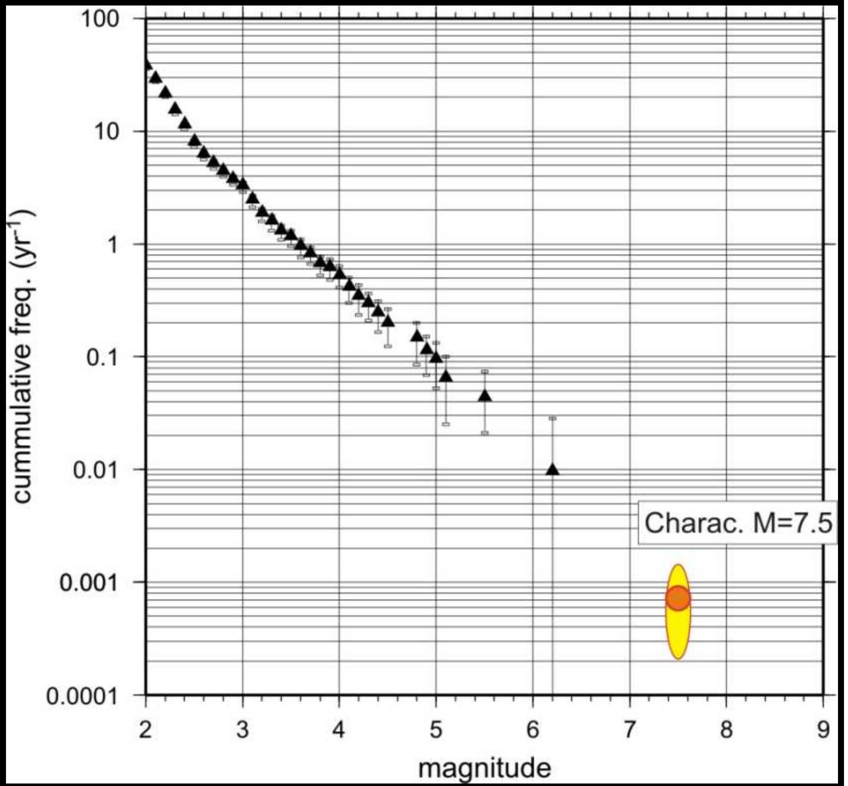


Frequency - magnitude for Puget Lowland current

Present-day GPS shortening: 1.4 +/- 1.1 mm/yr

M_W=7.5 characteristic earthquakes:

T_C = 1390 yr (66CI: 660 – 4490 yr)



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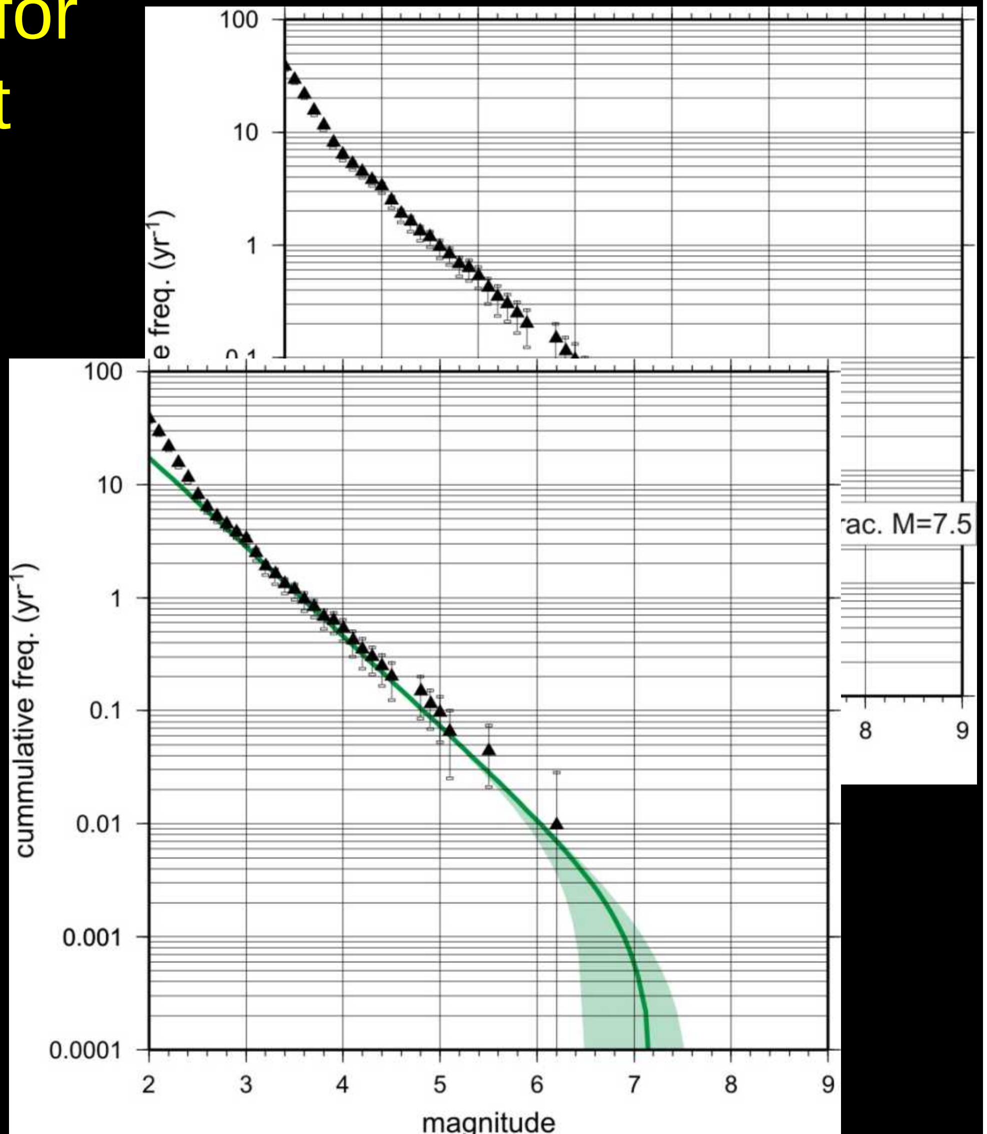
GR with PGSZ catalogue:

M_X = 7.2 (66CI: 6.5 – 7.6)



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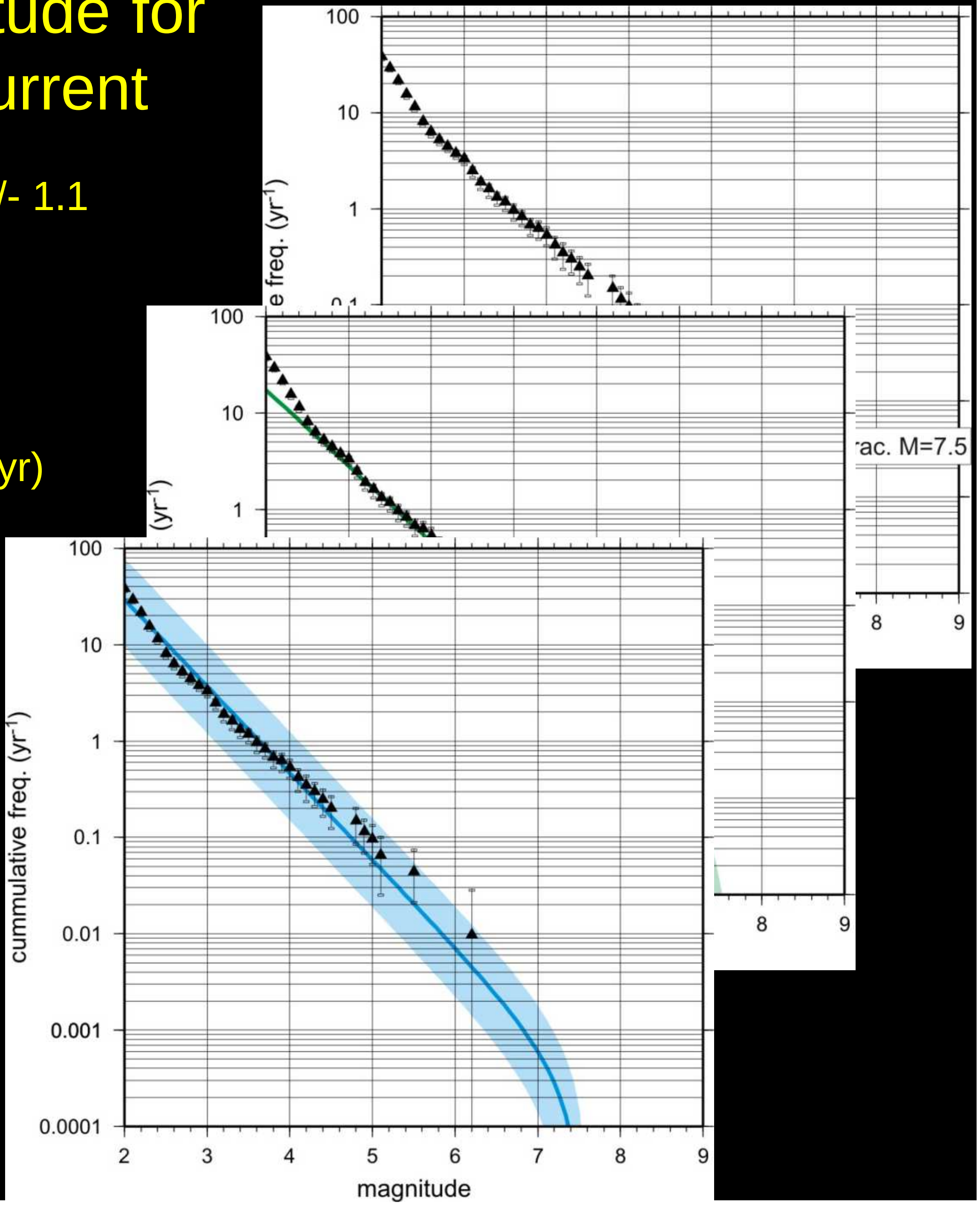
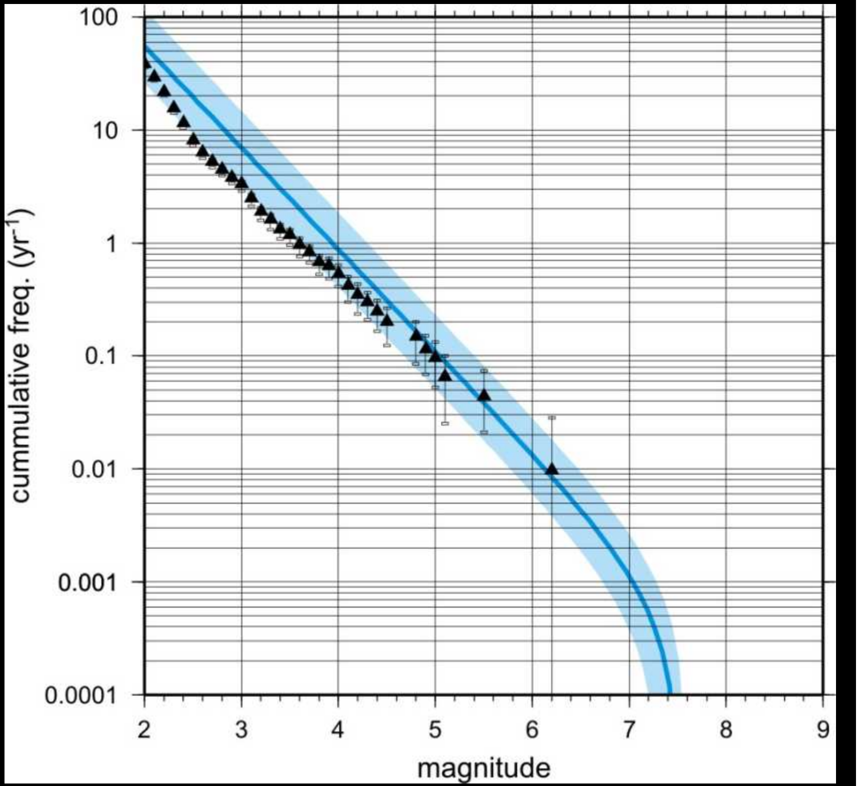
GR with empirical Mx & b:
M = 7 per 1460 yr
(66CI: 570 – 4960 yr)



Long-term frequency - magnitude

Puget Lowland long-term GPS shortening rate: 2.0 +/- 0.8 mm/yr

GR with empirical Mx & b:
M = 7 per 910 yr
(66CI: 430 – 1950 yr)



North Cascadia long-term GPS shortening rate: 5.7 +/- 0.8 mm/yr

GR with empirical Mx & b:
M = 7 per 310 yr
(66CI: 150 – 620 yr)

Closed up on Seattle Fault

Relative velocities across the Seattle Fault (differential time series with respect to SEAT)

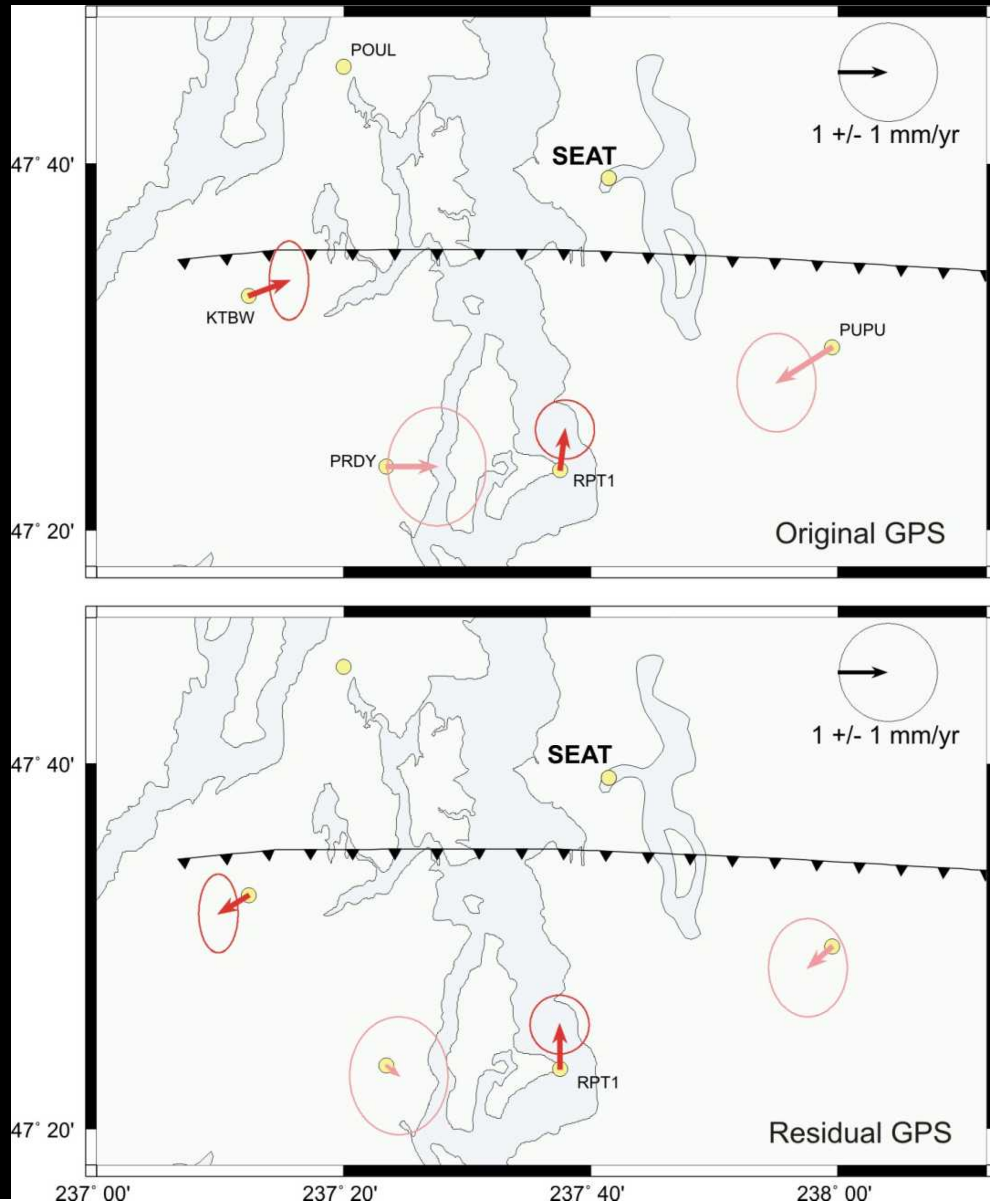
Significant reduction of common signal (noise, ETS, subduction)

RPT1 / SEAT (7 yrs):

0.8 +/- 0.3 mm/yr shortening

NB: Independent of subduction loading model

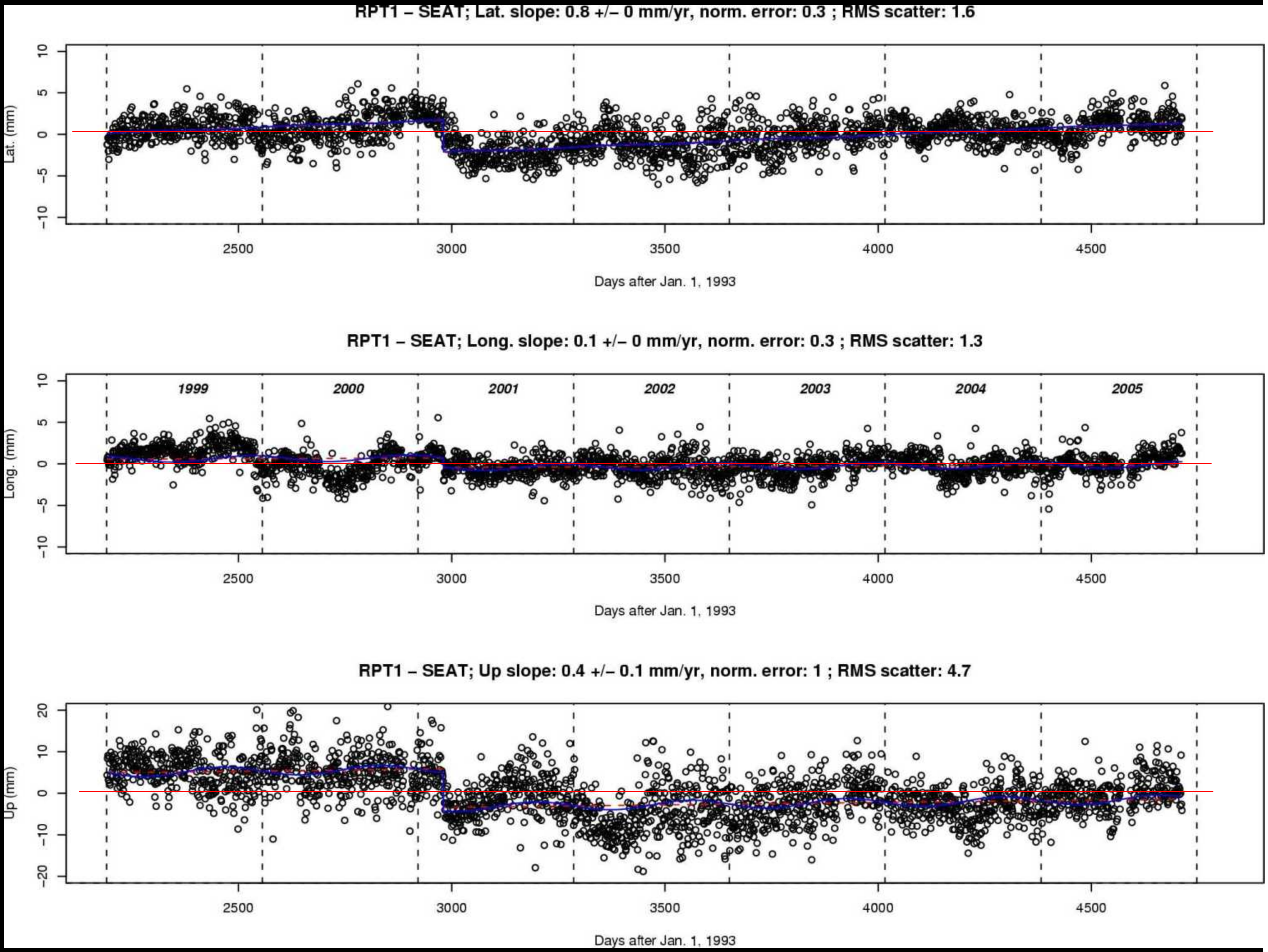
Other sites < 5 years and/or noisy



RPT1-SEAT time series

Differential time series

Typical daily horizontal RMS ~1.5 mm



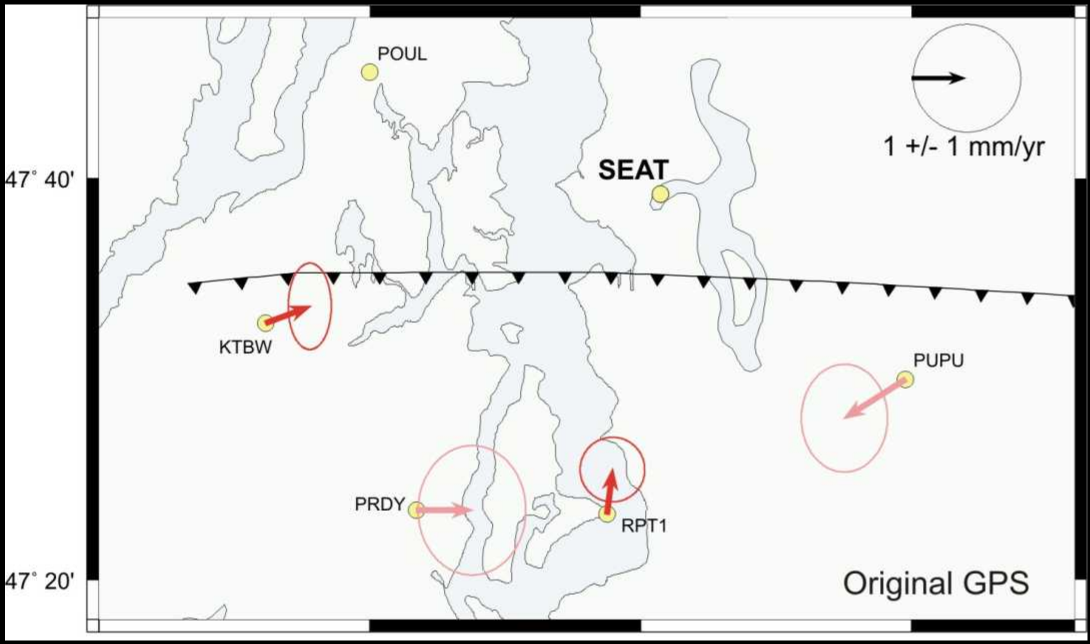
Closed up on Seattle Fault

Shortening across Seattle Fault:

0.8 +/- 0.3 mm/yr shortening

Predicted recurrence period for GR with empirical Mx & b:

M = 7 per 2260 yr
(66CI: 1080 – 4820 yr)



Preliminary Conclusions

(1) N-S shortening distributed across N Oregon, Washington (and southernmost BC ?)

(2) Rate of M=7.0 for Puget Sound from GPS

- Current: ~1/1500 yr (600 – 5000 yr)
- Long-term: ~1/900 yr (400 – 2000 yr)

(3) Slightly larger rates for S. Washington – N. Oregon

But much smaller background seismicity!

(4) Speculative rate of M=7.0 for Seattle Fault

~1/2200 yr (1100 – 4800 yr)

~1/2 of Puget Sound SZ, ~1/10 of total North Cascadia

Close up on Leech River / Devil Mountain Fault

Relative velocities across the Leech River/Devil Mountain Fault (with respect to ALBH)

Significant interference from subduction loading signal

PGC4 / ALBH (6.5 yrs):

0.1 +/- 0.2 mm/yr

ESQM / ALBH (5 yrs):

0.3 +/- 0.2 mm/yr

Other sites suggest possible problems with subduction model