Near-term probability of a Great earthquake on the Cascadia Subduction zone

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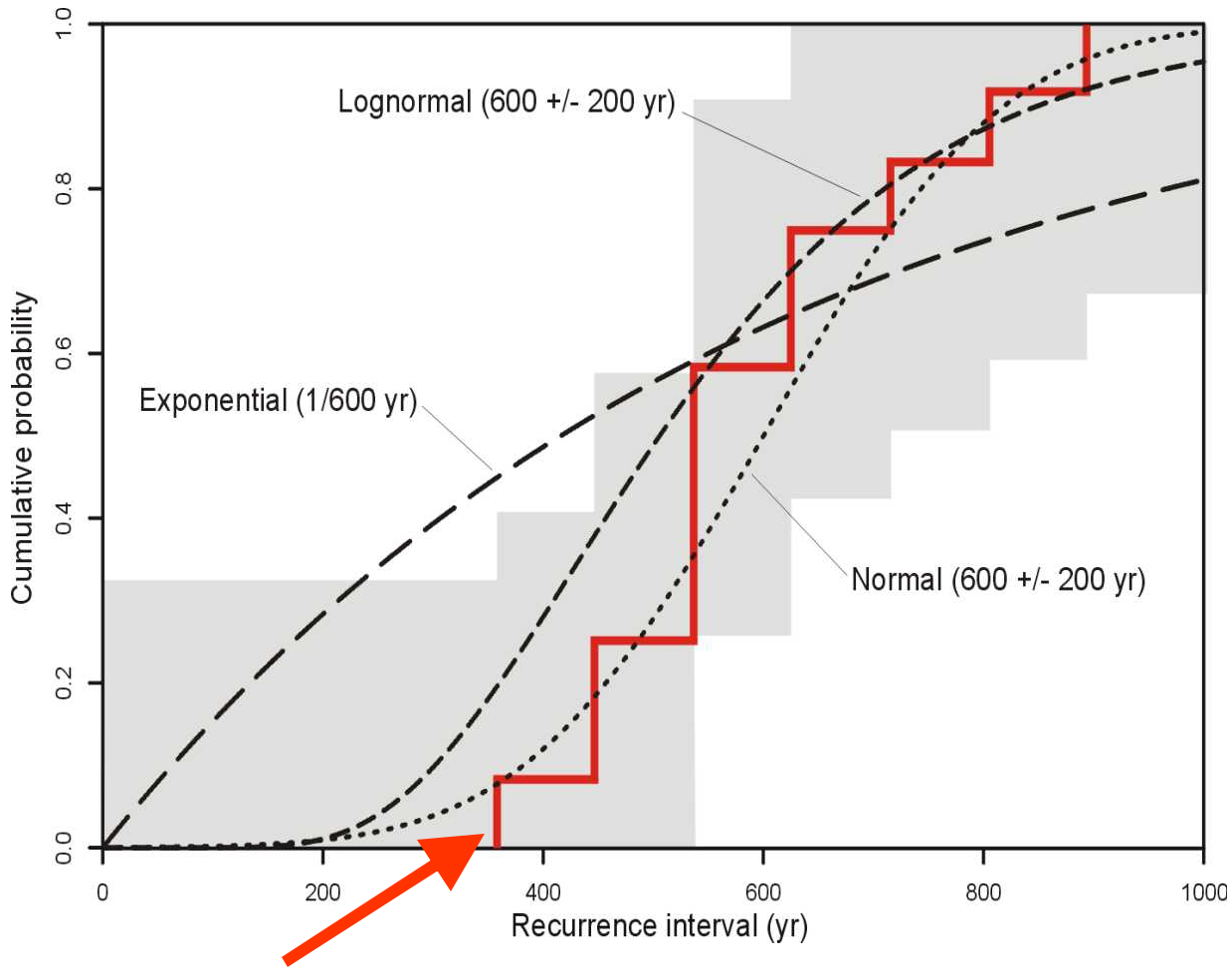
Distribution of recurrence intervals

Distributions
- normal
- lognormal
- Weibull
- exponential

Mean = 600

SD =180 years

(Adams, 1990)

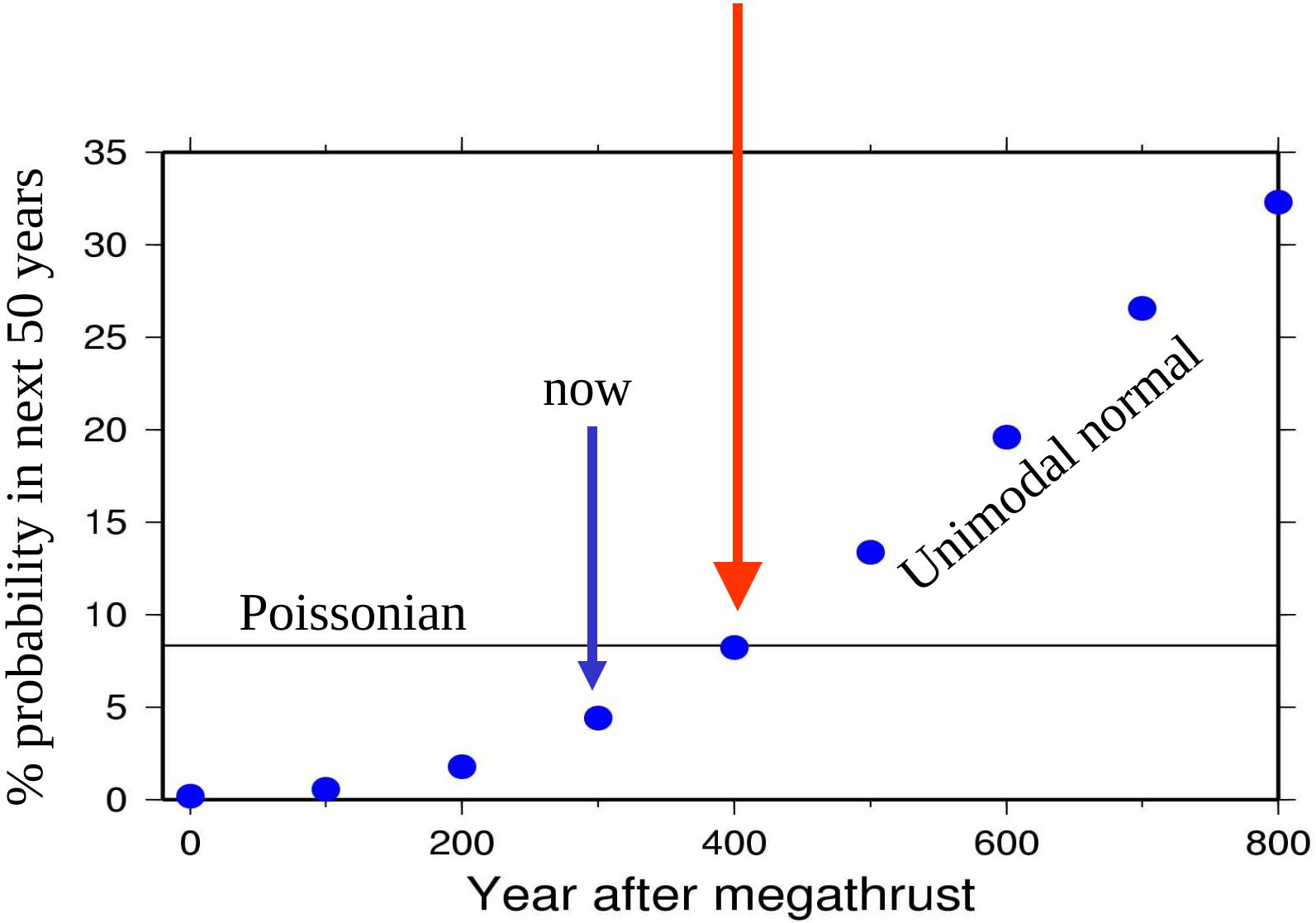


Intervals (red) from inter-turbidites

Unimodal Conclusions

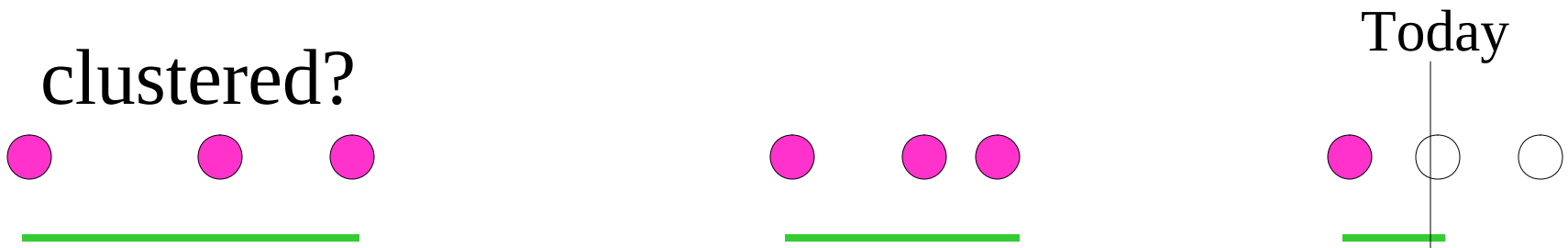
- 50-year conditional probability 4.5%
- Confirms estimates of Adams (1990) and Adams & Weichert (1994)
- 90% confidence interval: 1.5% - 14% probability (relatively tight)

In 2100 AD the normal distribution and Poissonian distributions will give equal conditional probabilities

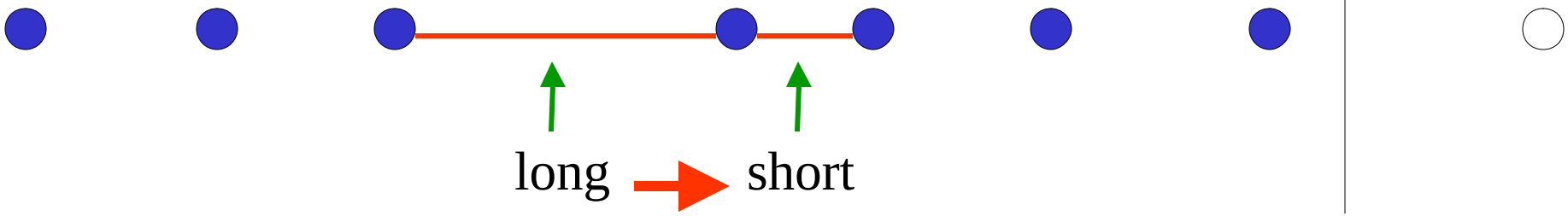


Interpretation –

clustered?

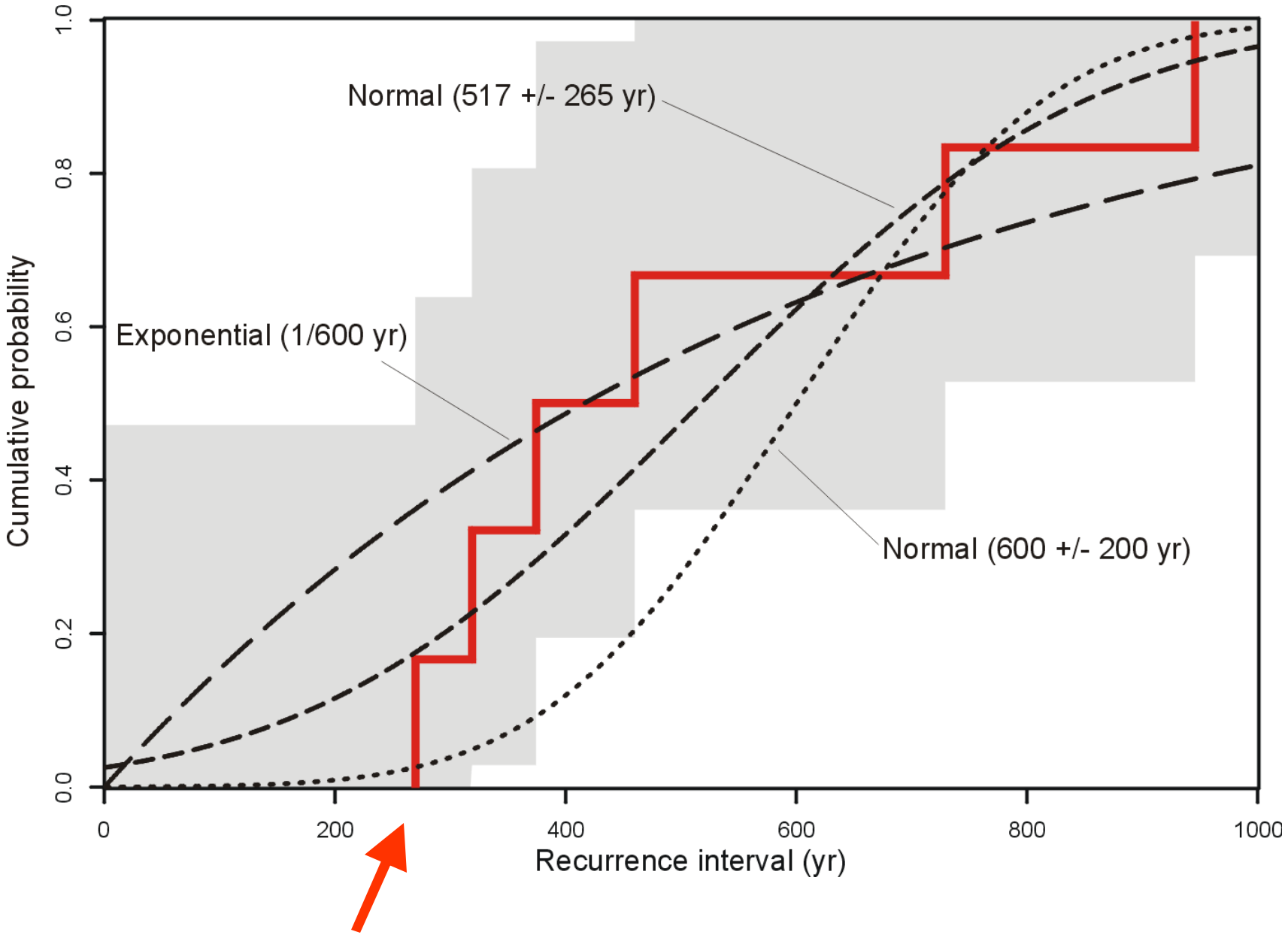


bimodal?



unimodal?

data not distinguishable from unimodal



Intervals (red) from coastal subsidence

Physically not unreasonable that events could cluster, **but**

Coastal data:- 1700 AD marks beginning of new cluster

Turbidite data:- 1700 AD marks end of a cluster

Cluster Conclusions

If we are in a cluster,

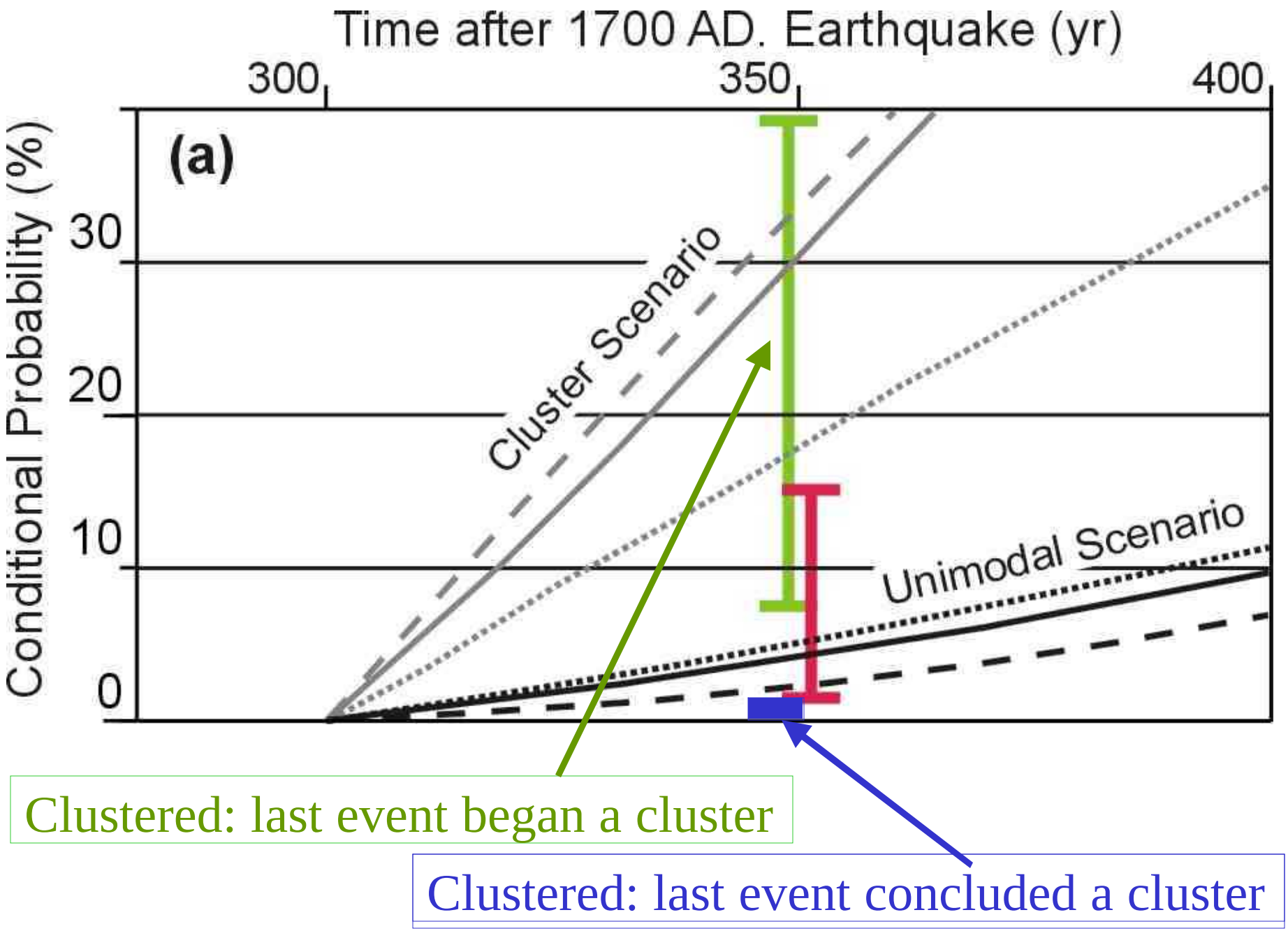
50 year conditional probability 21% (90% CI 7-39%)

If we are between clusters,

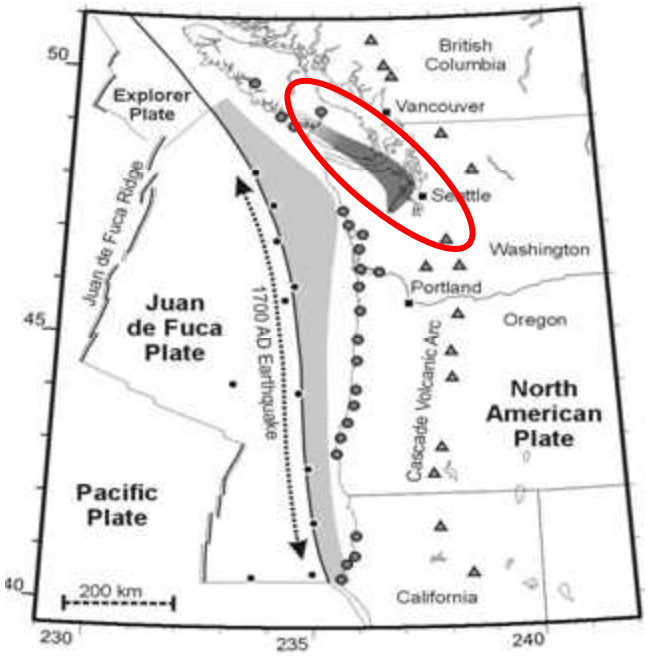
50 year conditional probability <1% (at 90% CI)

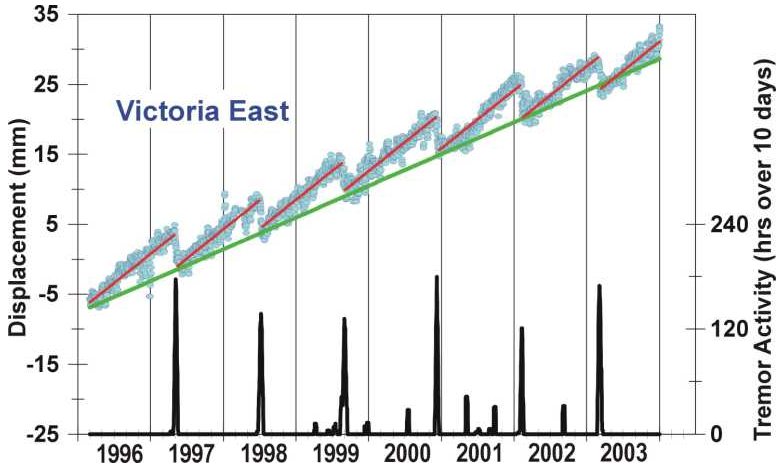
Either "fast approaching the next event"

or "no worries"


Time after 1700 AD. Earthquake (yr)
300
350
400
(a)
Conditional Probability (%)
30
20
10
0
Cluster Scenario
Unimodal Scenario
Clustered: last event began a cluster
Clustered: last event concluded a cluster

Episodic Tremor and Slip: Assumptions





- Every 14 +/- 1 months
- Duration 1-3 weeks

  (few days in any one place?)
- Slip 20-40 mm

  (~ 2/3 of subduction convergence)
- ETS loads locked zone
- Failure of locked zone partially dependent on loading rate
- Only Seattle - Vancouver I. ETS is important

Dynamic Stress Loading

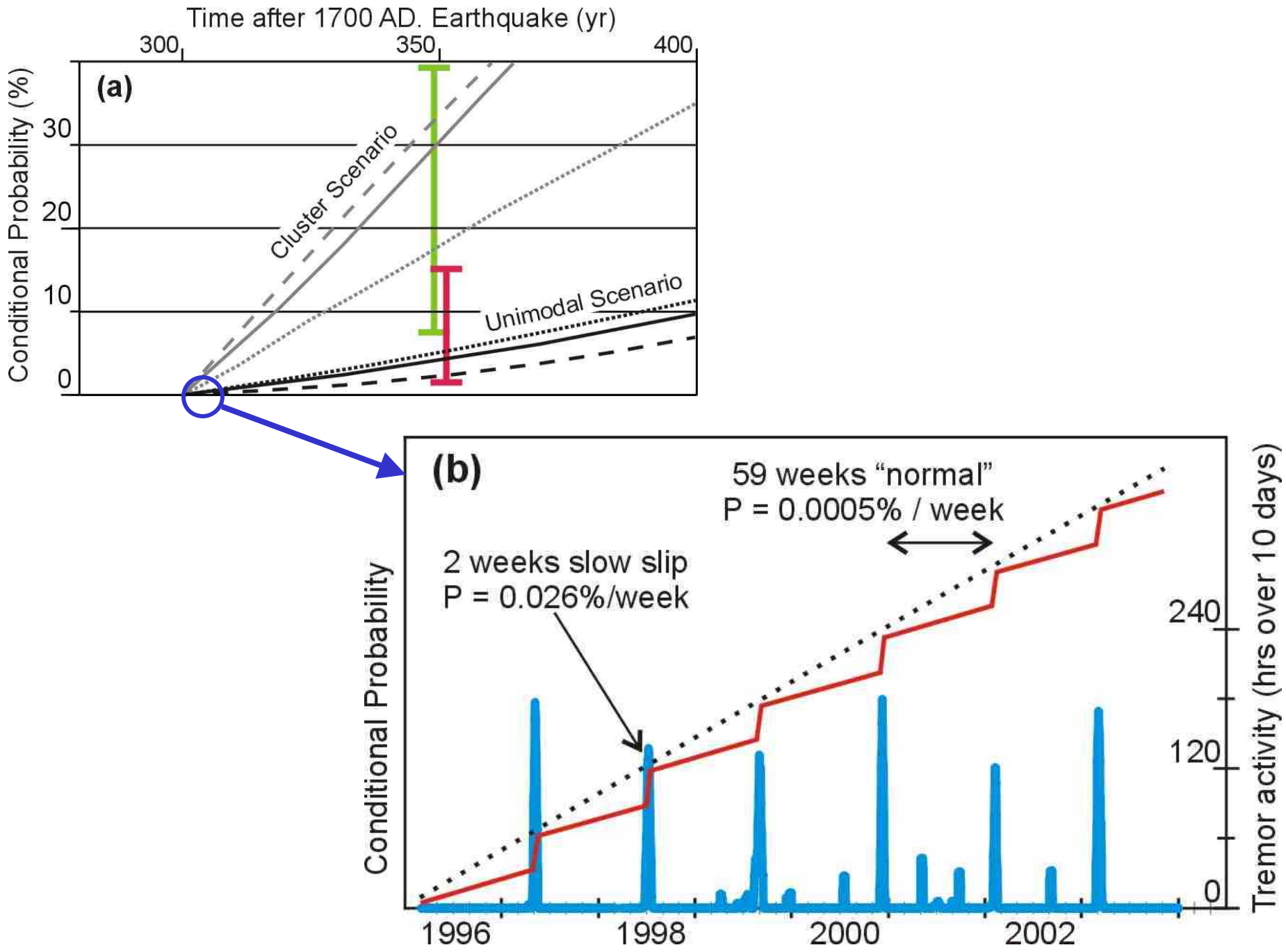
An ETS event increases shear stress on bottom part of locked zone by about 0.001-0.005 MPa/event.

Subduction earthquake stress drop ~0.2-5.0 MPa (Ruff, 1999), higher value at the base of the locked zone.

Shear stress loading rate averaged over 600 year cycle is 0.0003-0.008 MPa/year

So incremental shear stress loading during a 2-week ETS is about half of the total accumulation during the 60 week cycle.

Furthermore this occurs at a loading rate about 30x the average value


Time after 1700 AD. Earthquake (yr)
300
350
400
(a)
Conditional Probability (%)
30
20
10
0
Cluster Scenario
Unimodal Scenario
(b)
59 weeks "normal"
P = 0.0005% / week
2 weeks slow slip
P = 0.026%/week
Conditional Probability
240
120
0
Tremor activity (hrs over 10 days)
1996
1998
2000
2002

Probability during ETS event 25-65 x higher than at other times

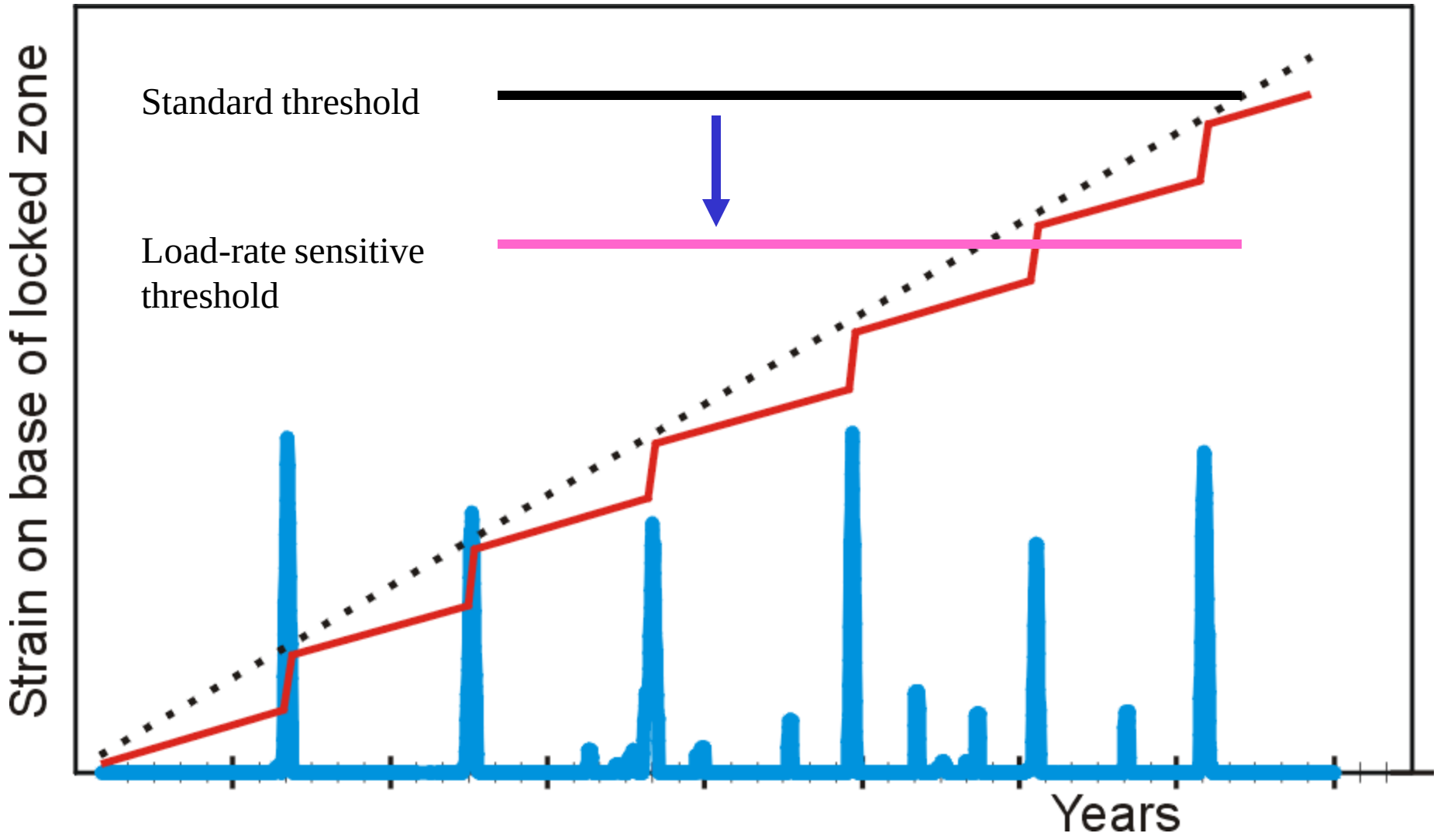
Estimate for unimodal model

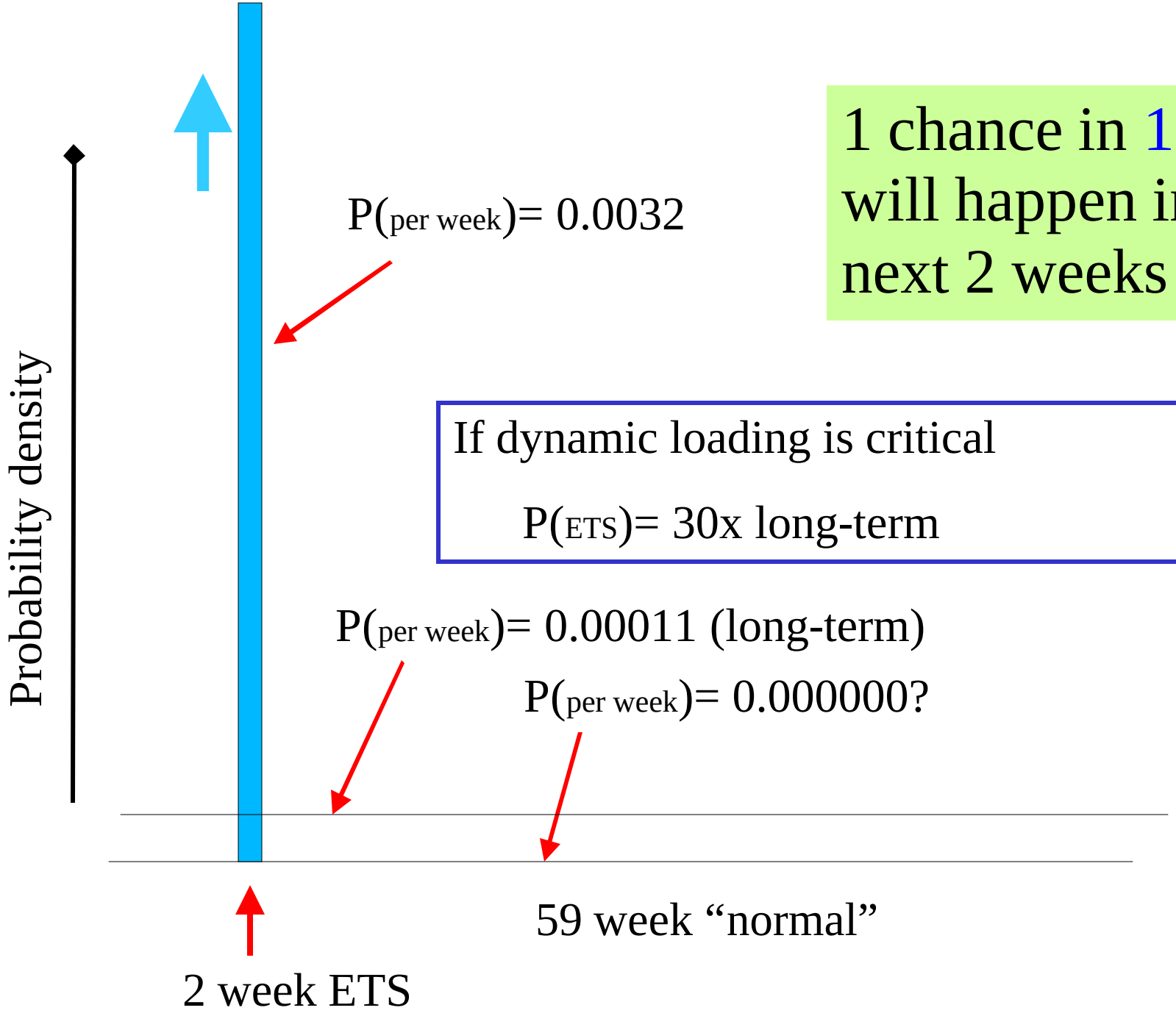
During slow slip	0.026% per week	1/4000
Outside slow-slip	0.0005% per week	1/200,000

Estimate for worst of the two cluster models

During slow slip	0.21% per week	1/500
Outside slow-slip	0.004% per week	1/25,000

If failure threshold is rate sensitive……




Probability density
P(per week)= 0.0032
1 chance in 150 it will happen in the next 2 weeks
If dynamic loading is critical
P(ETS)= 30x long-term
P(per week)= 0.00011 (long-term)
P(per week)= 0.000000?
59 week “normal”
2 week ETS

Conclusions

- P(50 yr) = 1-15% at 90% CI for a unimodal hypothesis
- P(50 yr) = <1% or 7-40% for a cluster hypothesis that needs to be looked at in more detail
- Slow-slip dramatically increases probabilities

- Need more research on
  - recurrence distribution & clustering
  - megathrust earthquake mechanics
- Need to ponder consequences of ETS-related forecasting to earthquake hazard preparedness & mitigation