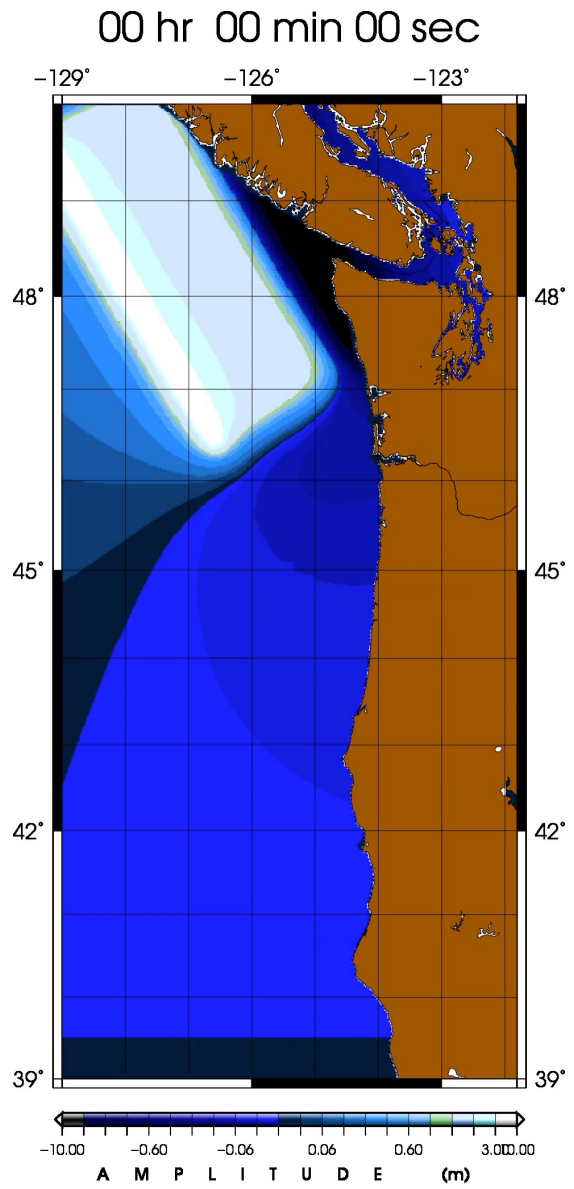
Cascadia Tsunami Scenarios: An Overview

Amir Salaree

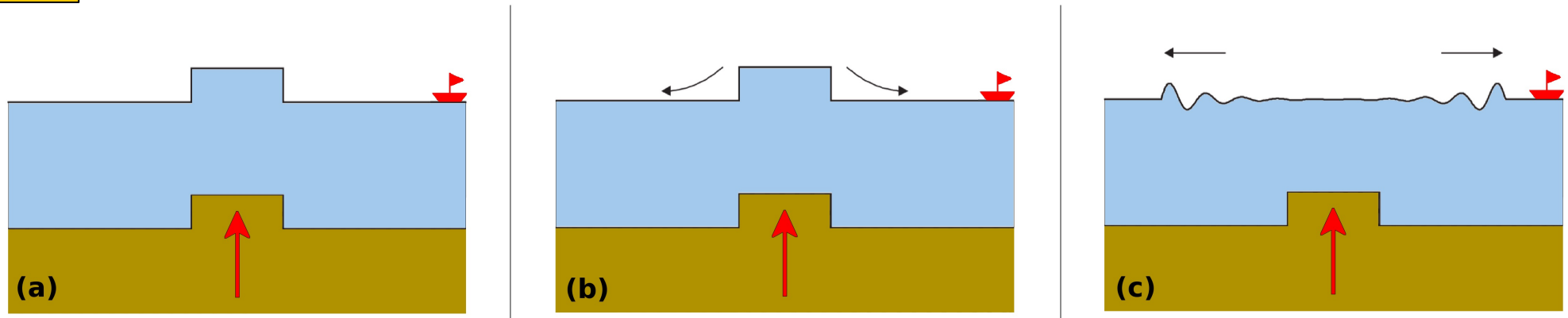
October 27, 2019

UM-MSU
Solid Earth Mini-workshop

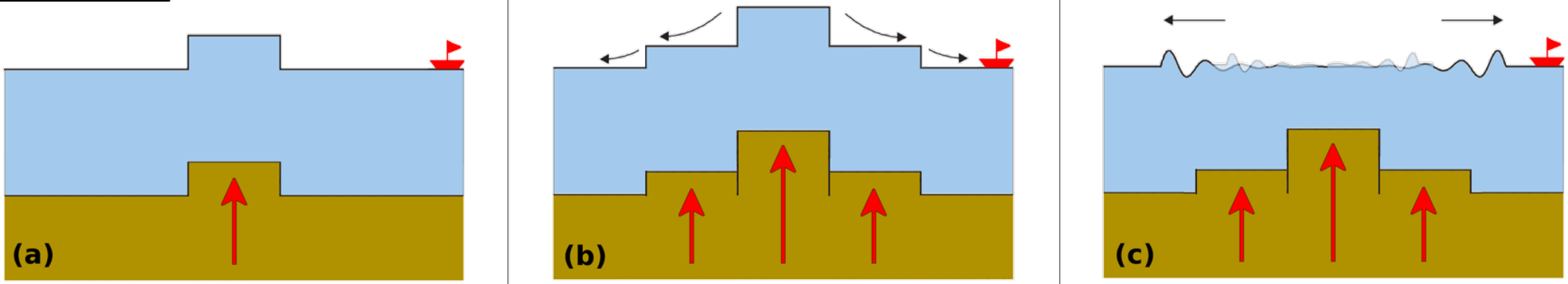


Intro: *What Is a Tsunami?*

Static Source:



Kinematic Source:

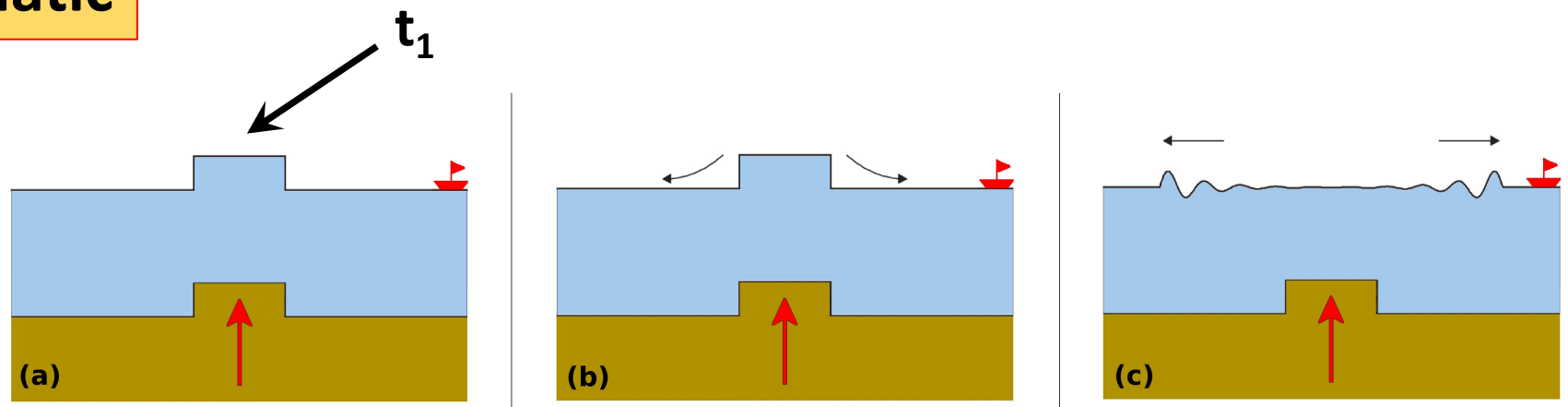


Modified from Okal & Synolakis (2003)

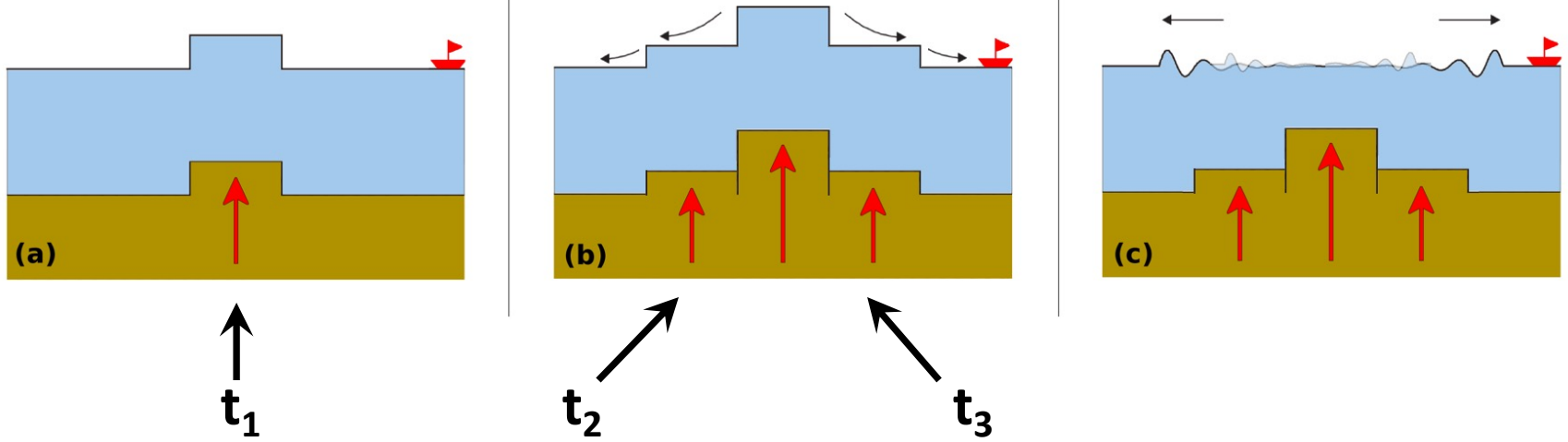
How Tsunamis Work: *Source*

Static vs. Kinematic

Static:



Kinematic:



How Tsunamis Work: *Bathymetry*

Gravity Waves

Navier-Stokes Equation

Typical Values:

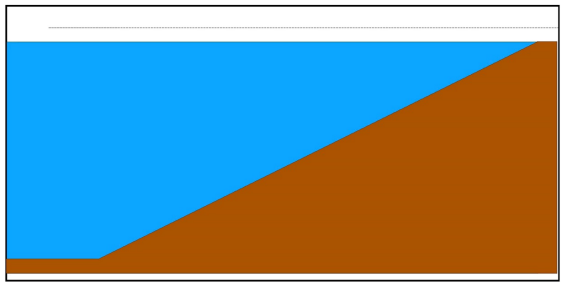
$g = 9.8$ m/s^2

$h = 4$ km

$\Rightarrow$ $C \approx 710$ km/h

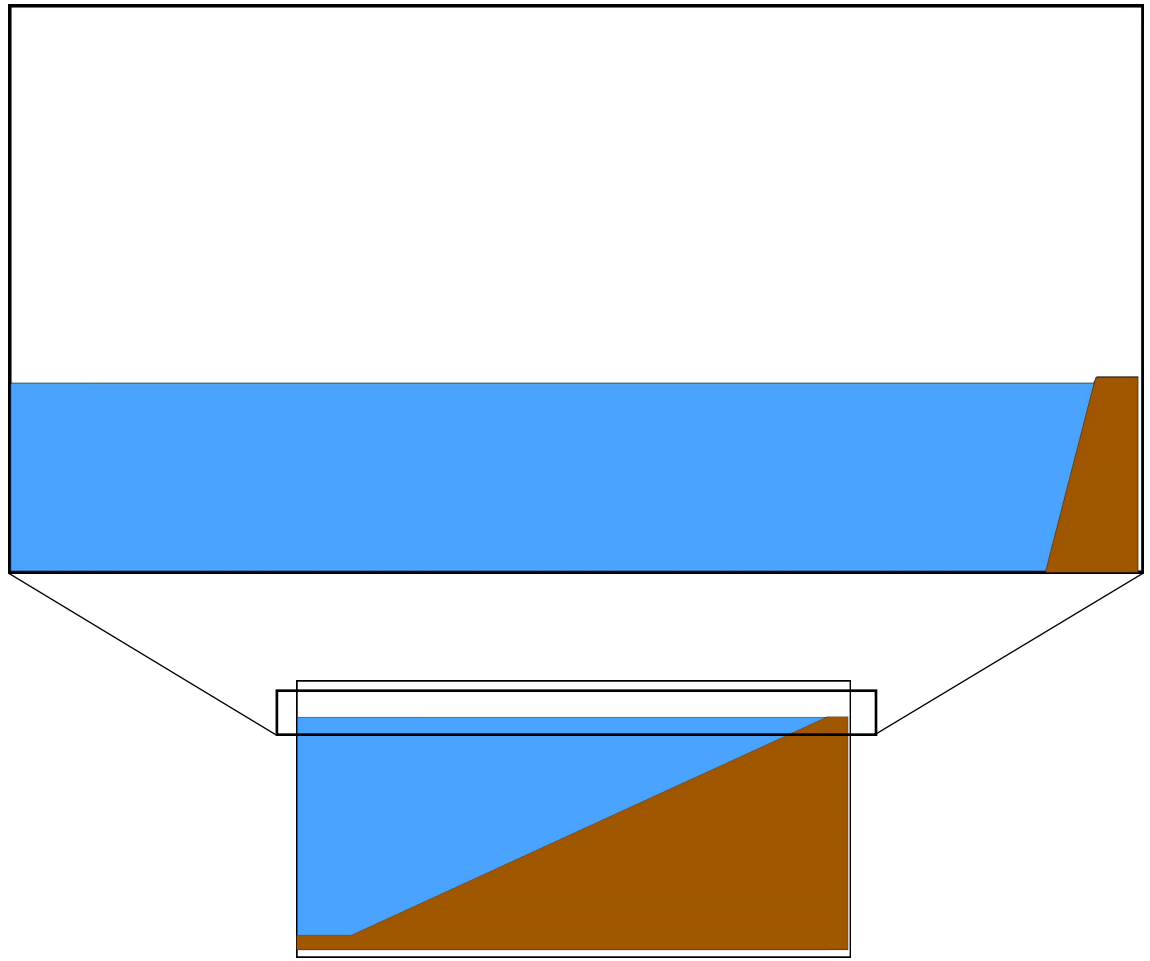
≈ 440 mi/h

Speed of a jet plane!



How Tsunamis Work: *Bathymetry*

Gravity Waves ← To the Earthquake



Navier-Stokes Equation

Shallow water approximation

$$C = \sqrt{gh}$$

speed — ocean depth

Typical Values:

$g = 9.8$ m/s^2

$h = 4$ km

→ $C \approx 710$ km/h

$\approx$ 440 mi/h

Speed of a jet plane!

Cascadia Tsunamis

Cascadia Tsunamis: *What Do We Know?*

Bit of History:

- **Heaton & Snavely (1985)**

Bulletin of the Seismological Society of America, Vol. 75, No. 5, pp. 1455–1460, October 1985

POSSIBLE TSUNAMI ALONG THE NORTHWESTERN COAST OF THE UNITED STATES INFERRED FROM INDIAN TRADITIONS

BY THOMAS H. HEATON AND PARKE D. SNAVELY, JR.

Subduction of the Juan de Fuca and Gorda plates beneath western North America presents a paradox; despite the fact that there is good evidence of 3 to 4 cm/yr of ongoing convergence, there is a remarkable paucity of either historic or instrumentally recorded shallow subduction earthquakes. Steady aseismic slip along the entire Cascadia subduction zone provides one explanation for this seismic quiescence. However, the Cascadia subduction zone shares many features, including temporal quiescence, with other subduction zones that have experienced very large shallow subduction earthquakes (Heaton and Kanamori, 1984). Yet, there is no direct geologic or historical evidence presently available to confirm that great shallow subduction earthquakes have occurred along the coast of Washington, Oregon, and northern California. However, there are reports describing Indian

Cascadia Tsunamis: *What Do We Know?*

Bit of History:

- Heaton & Snavely (1985)
- **Atwater (1987)**

Reports

Evidence for Great Holocene Earthquakes Along the Outer Coast of Washington State

BRIAN F. ATWATER

Intertidal mud has buried extensive, well-vegetated lowlands in westernmost Washington at least six times in the past 7000 years. Each burial was probably occasioned by rapid tectonic subsidence in the range of 0.5 to 2.0 meters. Anomalous sheets of sand atop at least three of the buried lowlands suggest that tsunamis resulted from the same events that caused the subsidence. These events may have been great earthquakes from the subduction zone between the Juan de Fuca and North America plates.

Cascadia Tsunamis: *What Do We Know?*

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Reports

Evidence for Great Holocene Earthquakes Along the Outer Coast of Wa

BRIAN F. ATWATER

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coastwise extent of individual episodes of coseismic subsidence. Another testable corollary is that shaking during the postulated earthquakes should have caused the liquefaction of Holocene coastal-lowland sand (*22*). If buried lowlands prove coeval for coastwise distances greater than 100 km, and if sand proves to have vented onto some of these lowlands at the start of burial, then the chronology of jerky submergence could be used to constrain the current probability of a great subduction earthquake in the Pacific Northwest.

REFERENCES AND NOTES

1. T. H. Heaton and S. H. Hartzell, *Science* **236**, 162 (1987).

Cascadia Tsunamis: *What Do We Know?*

Bit of History:

- Heaton & Snavely (1985)
- Atwater (1987)
- **Satake (1996)**

LETTERS TO NATURE

Time and size of a giant earthquake in Cascadia inferred from Japanese tsunami records of January 1700

Kenji Satake*, Kunihiko Shimazaki†, Yoshinobu Tsuji† & Kazue Ueda†

* Seismotectonics Section, Geological Survey of Japan, Tsukuba 305, Japan
† Earthquake Research Institute, University of Tokyo, Tokyo 113, Japan

GEOLOGICAL evidence shows that great earthquakes have occurred in the recent prehistoric past in the Cascadia subduction zone, off the Pacific coast of North America. The most recent event (or series of events) is dated at about 300 years ago[1–4], but the precise date and magnitude have not been determined. Geological inves-

Cascadia Tsunamis: *What Do We Know?*

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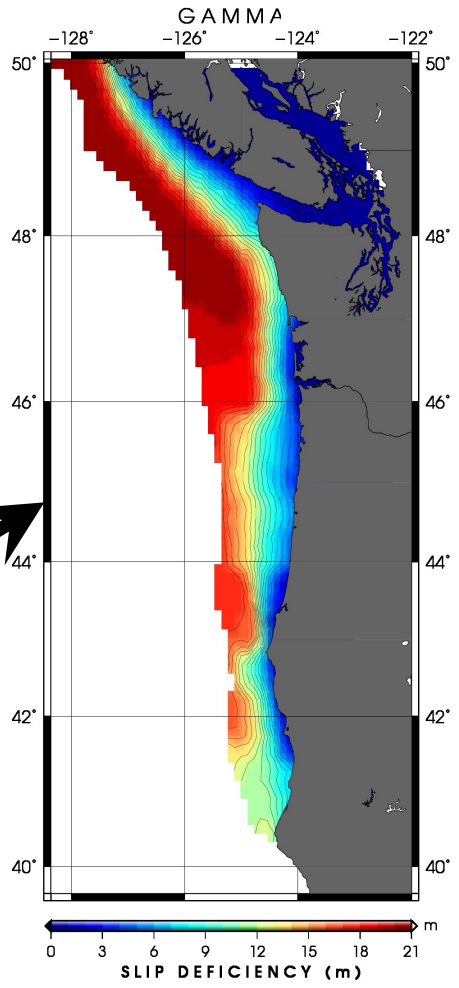
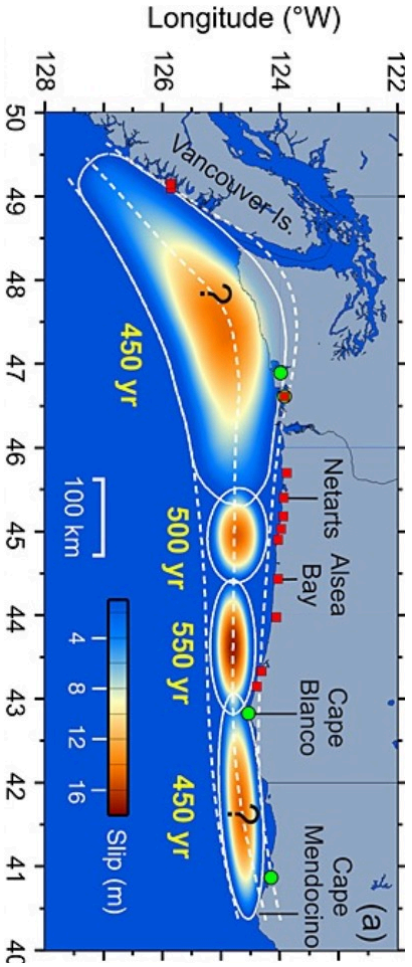
of a local cause. Historical earthquake records and palaeoseismic evidence indicate the absence of a large earthquake in 1700 in South America, Alaska or Kamchatka, leaving Cascadia as the most likely source of this tsunami. The estimated time of the earthquake is the evening (about 21:00 local time) of 26 January 1700. The magnitude is estimated as 9 from the tsunami heights, in which case the earthquake ruptured the entire length of the Cascadia subduction zone[2]. These estimates are consistent with

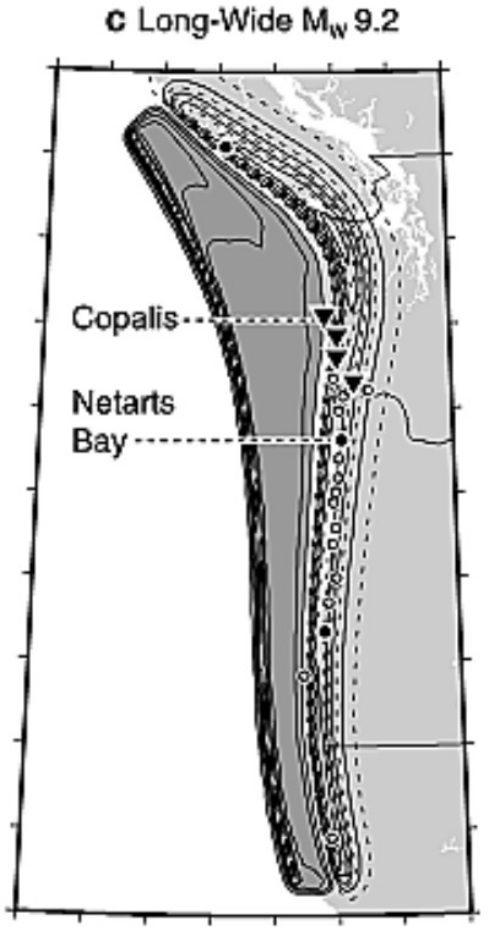
Cascadia Tsunamis: *Rupture Models*

Marlon Ramos

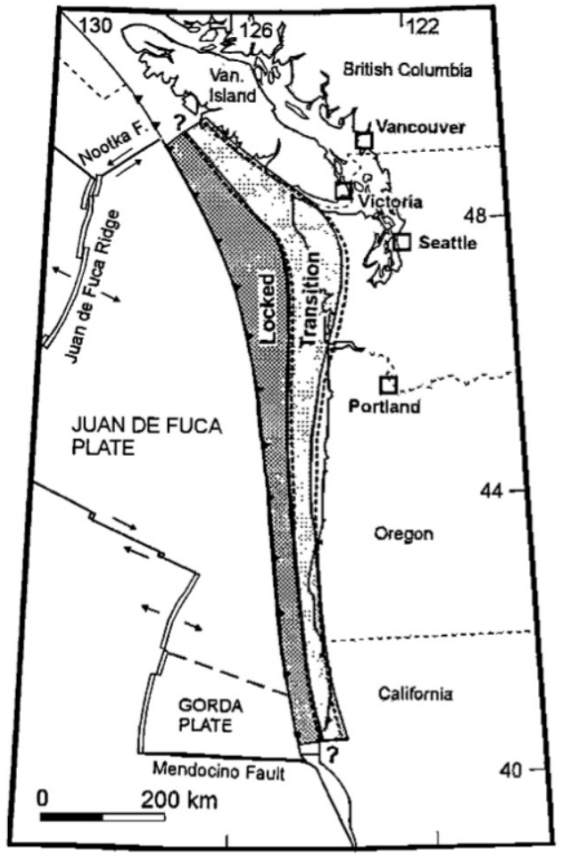




Wang *et al* (2013)



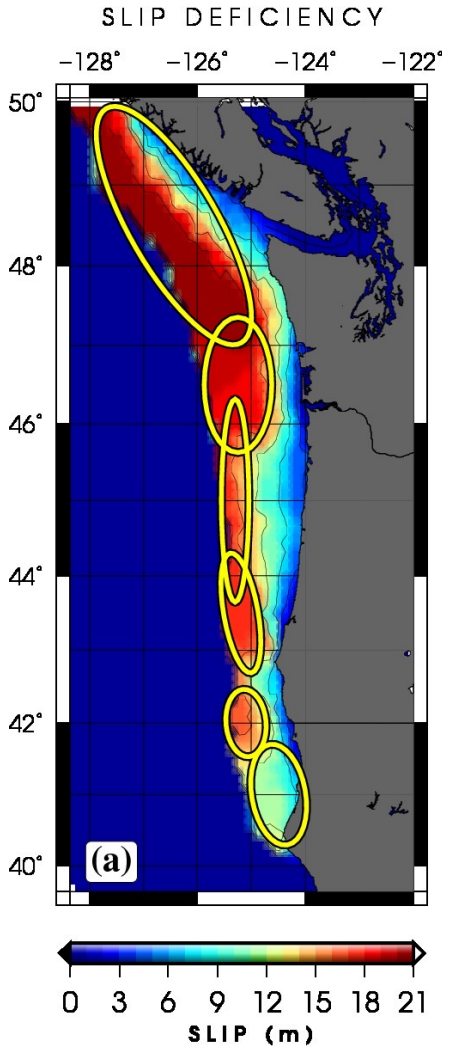
Satake *et al* (2003)



Flück *et al* (1997)

Cascadia Tsunamis: *What Have We Planned?*

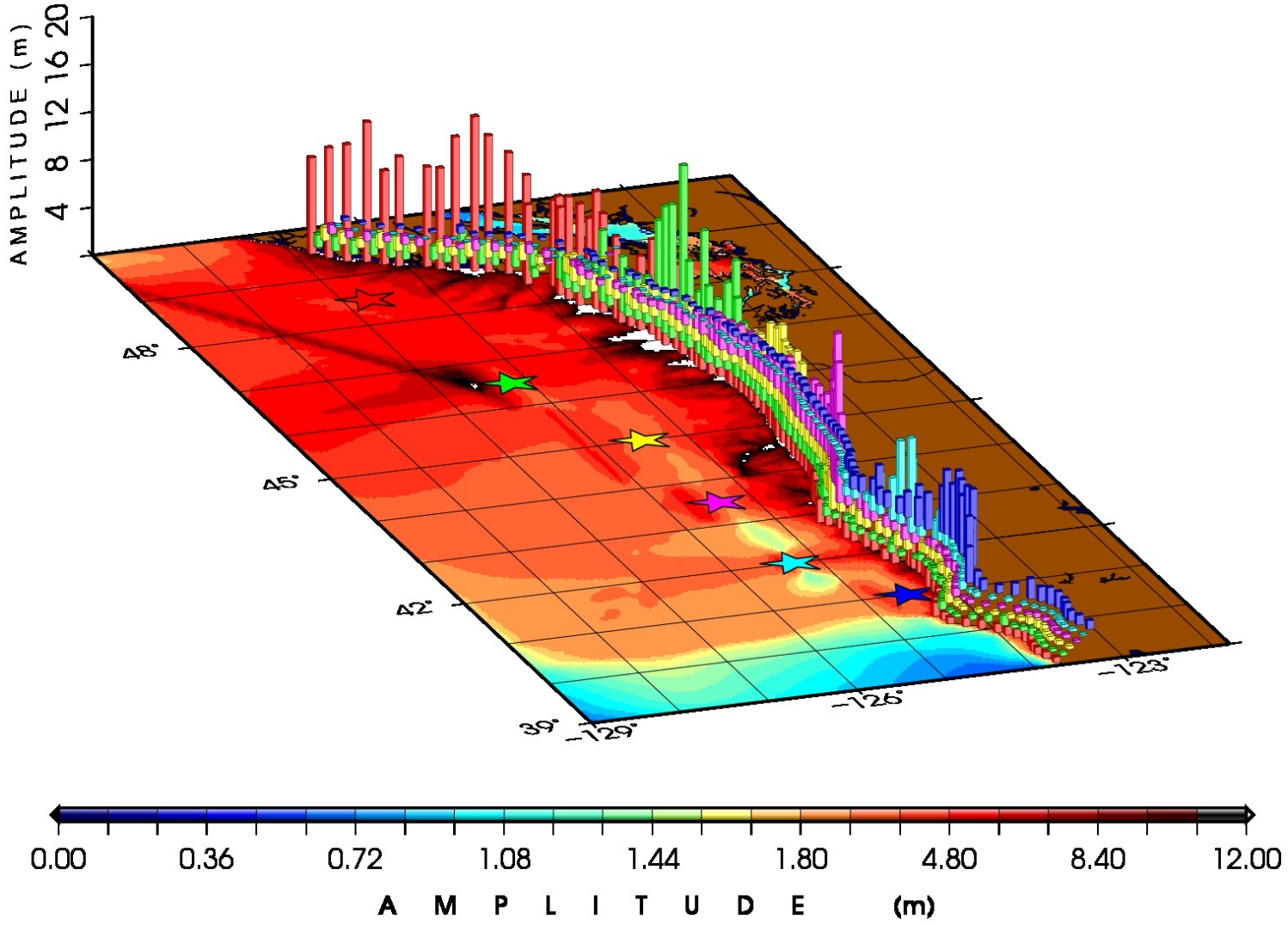
Tsunami Scenarios



Cascadia Tsunamis: *Our Work*

Tsunami Scenarios

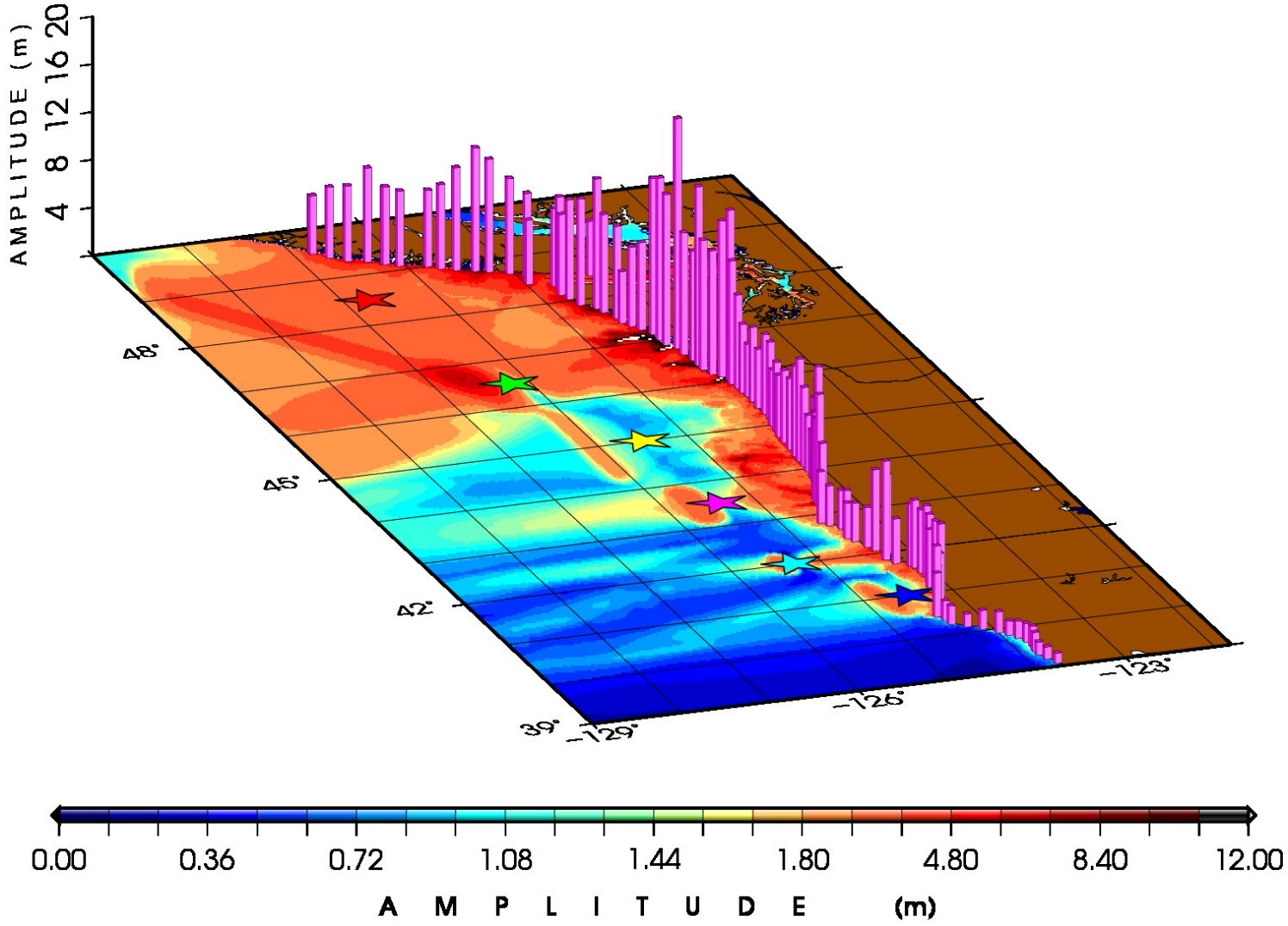
Individual "Subevents"



Cascadia Tsunamis: *Our Work*

Tsunami Scenarios

Kinematic-*ish* Rupture



Cascadia Tsunamis: *Our Work*

"Influential" Segments

Statistical analysis of contribution of each block.