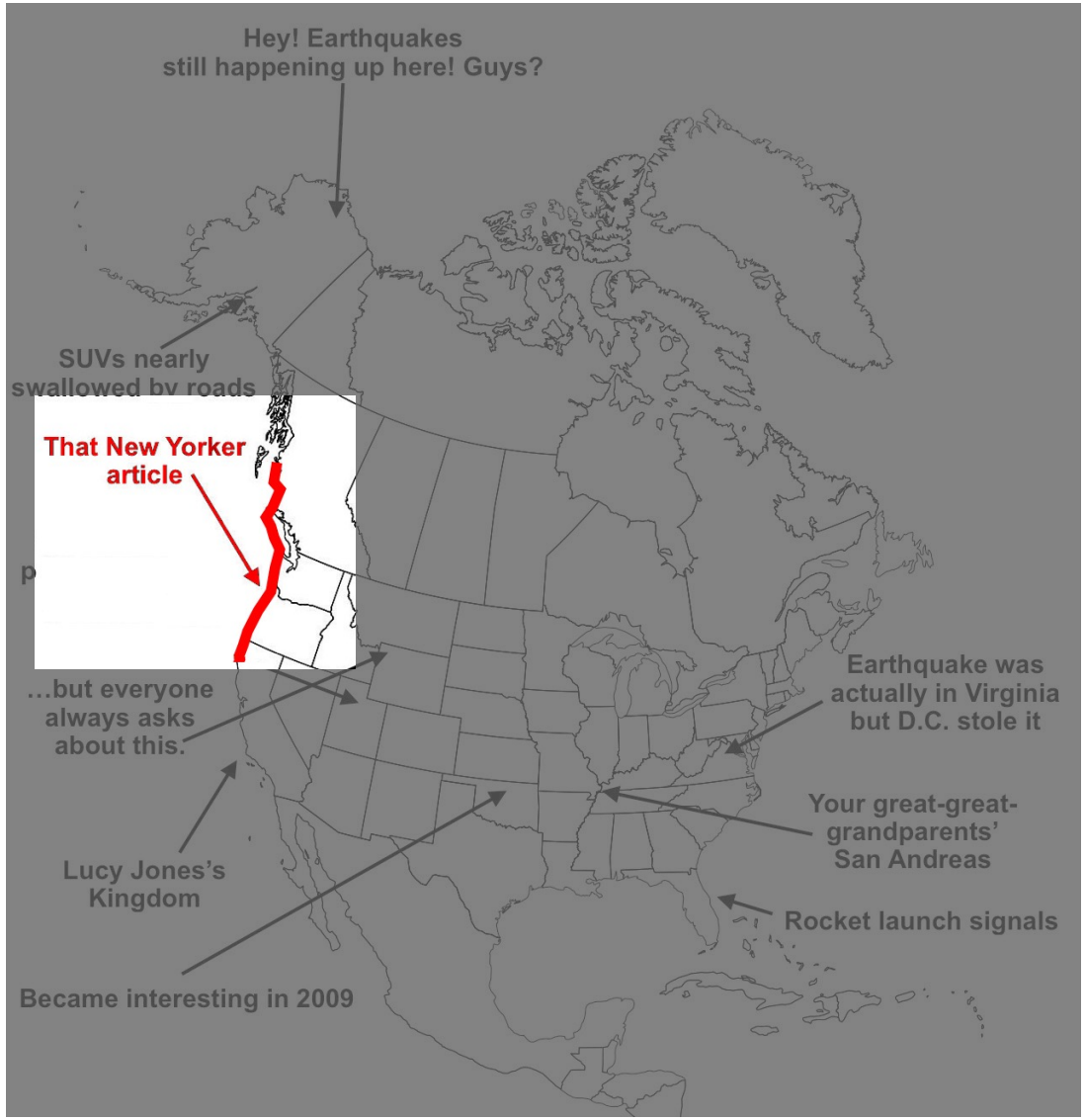
(Source: Twitterverse)

Cascadia Tsunamis: Segmented Earthquake Ruptures

Amir Salaree

GTS Seminar

January 17, 2020



(Source: Twitterverse)

Cascadia Tsunamis: Segmented Earthquake Ruptures

Amir Salaree

GTS Seminar

January 17, 2020

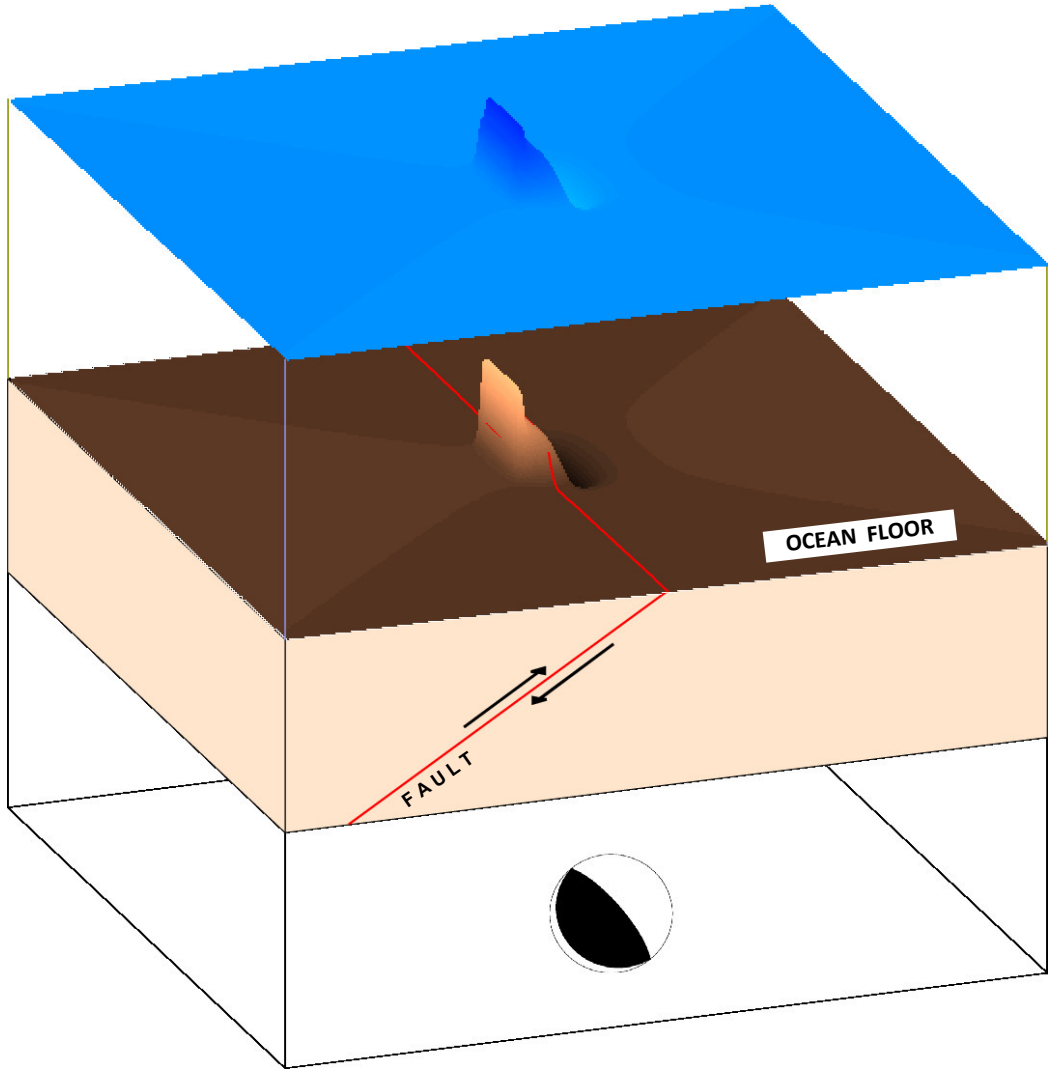
Introduction:

Tsunamis

How Tsunamis Work: *General Perspective*

How do we model tsunamis?

1) **Earthquakes**
2) Landslides
3) Volcanic Eruptions
4) Atmospheric Pressure Changes

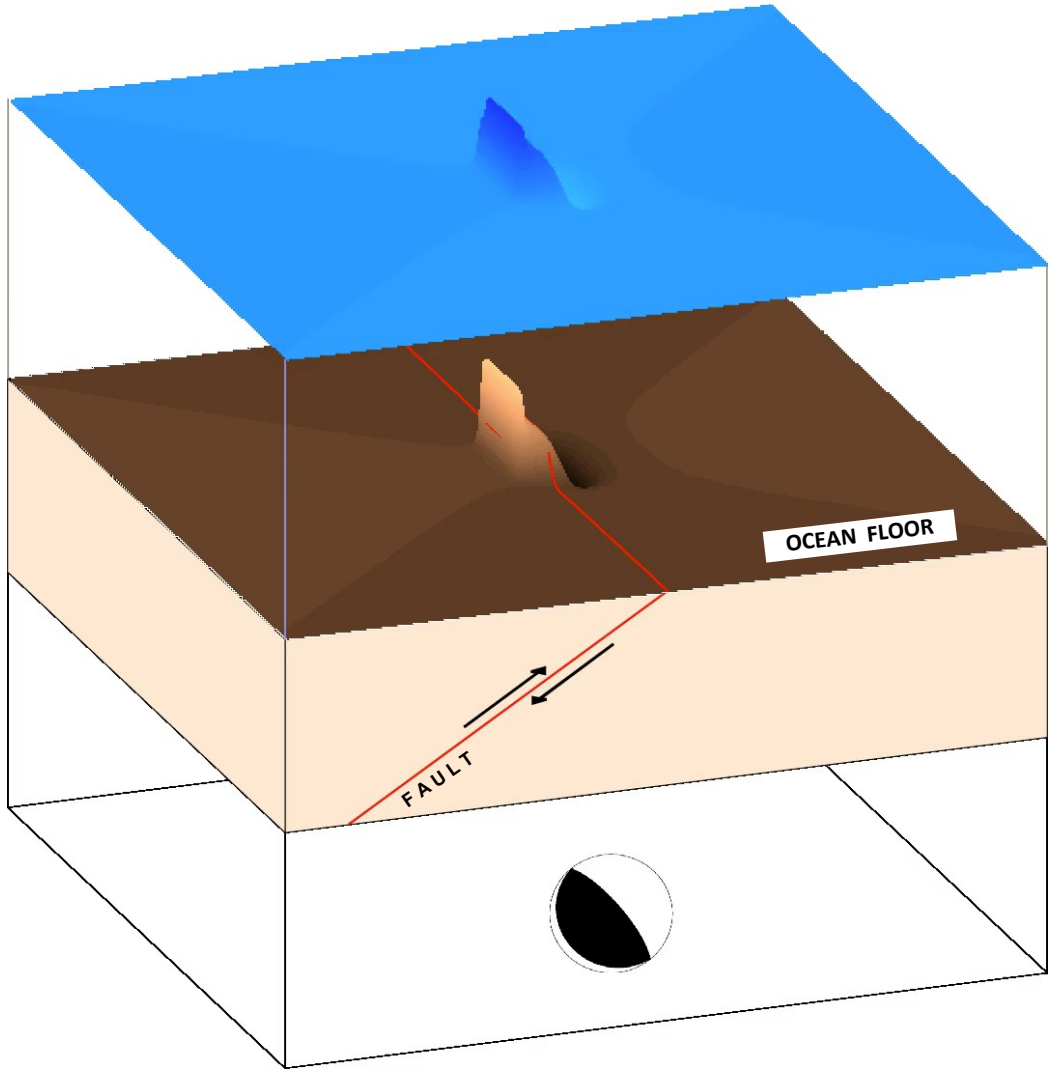


How Tsunamis Work: *General Perspective*

How do we model tsunamis?

1) **Earthquakes**
2) Landslides
3) Volcanic Eruptions
4) Atmospheric Pressure Changes

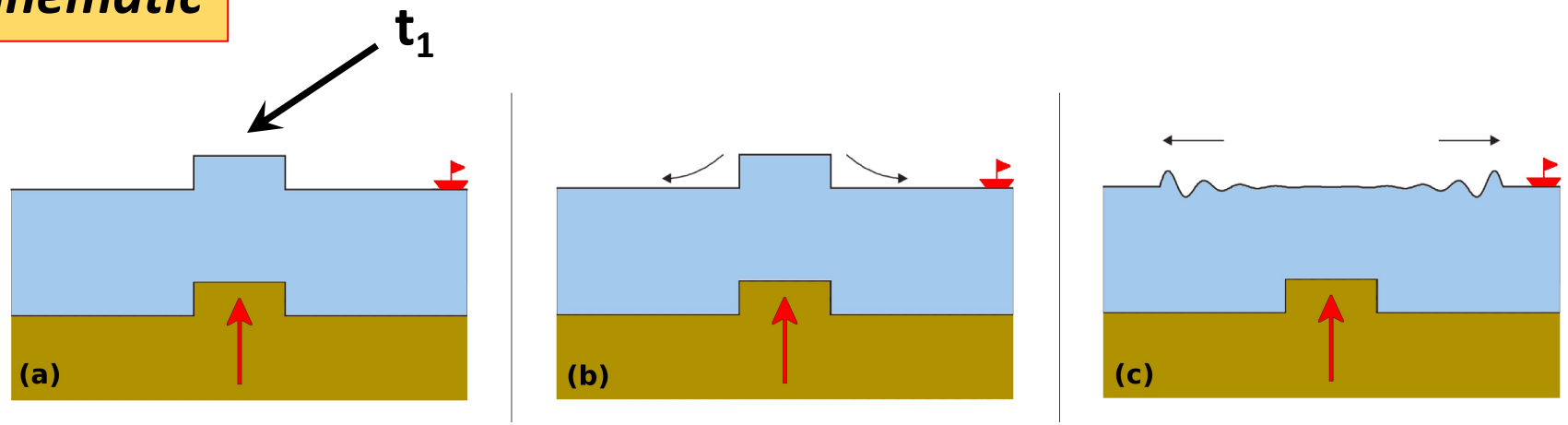
Source & Propagation



How Tsunamis Work: *Source*

Source: ***Static vs. Kinematic***

Static:



How Tsunamis Work: *Propagation*

Propagation: ***Gravity Waves***

Navier-Stokes Equation

Typical Values:

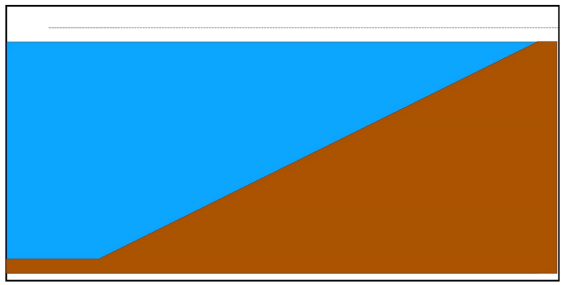
$g = 9.8$ m/s^2

$h = 4$ km

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

$\approx$ 440 mi/h

Speed of a jet plane!



How Tsunamis Work: *Propagation*

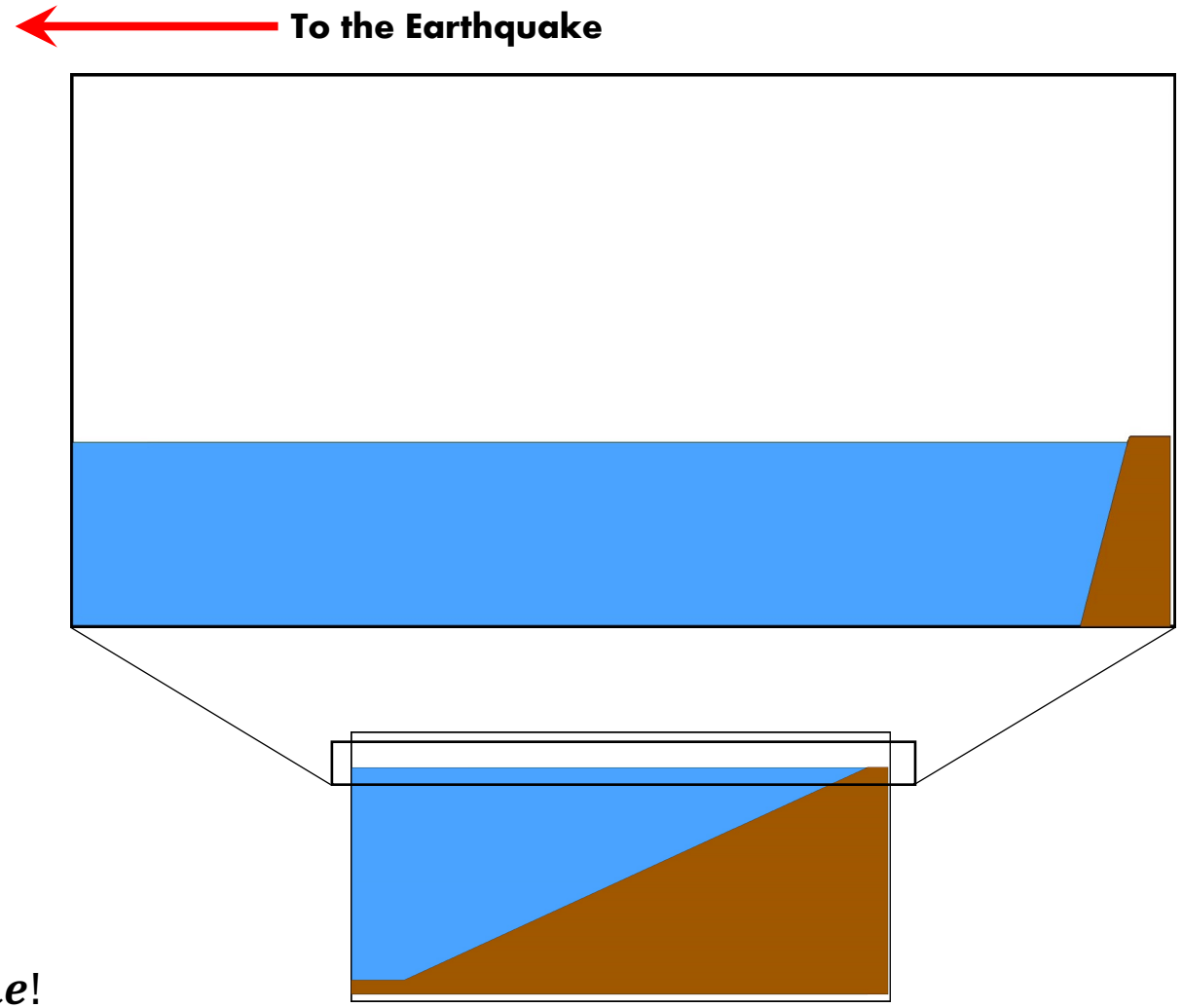
Propagation: *Gravity Waves*

Navier-Stokes Equation

Shallow water approximation

$$C = \sqrt{gh}$$

speed — ocean depth



Typical Values:

$g = 9.8$ m/s^2

$h = 4$ km

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

$\approx$ 440 mi/h

Speed of a jet plane!

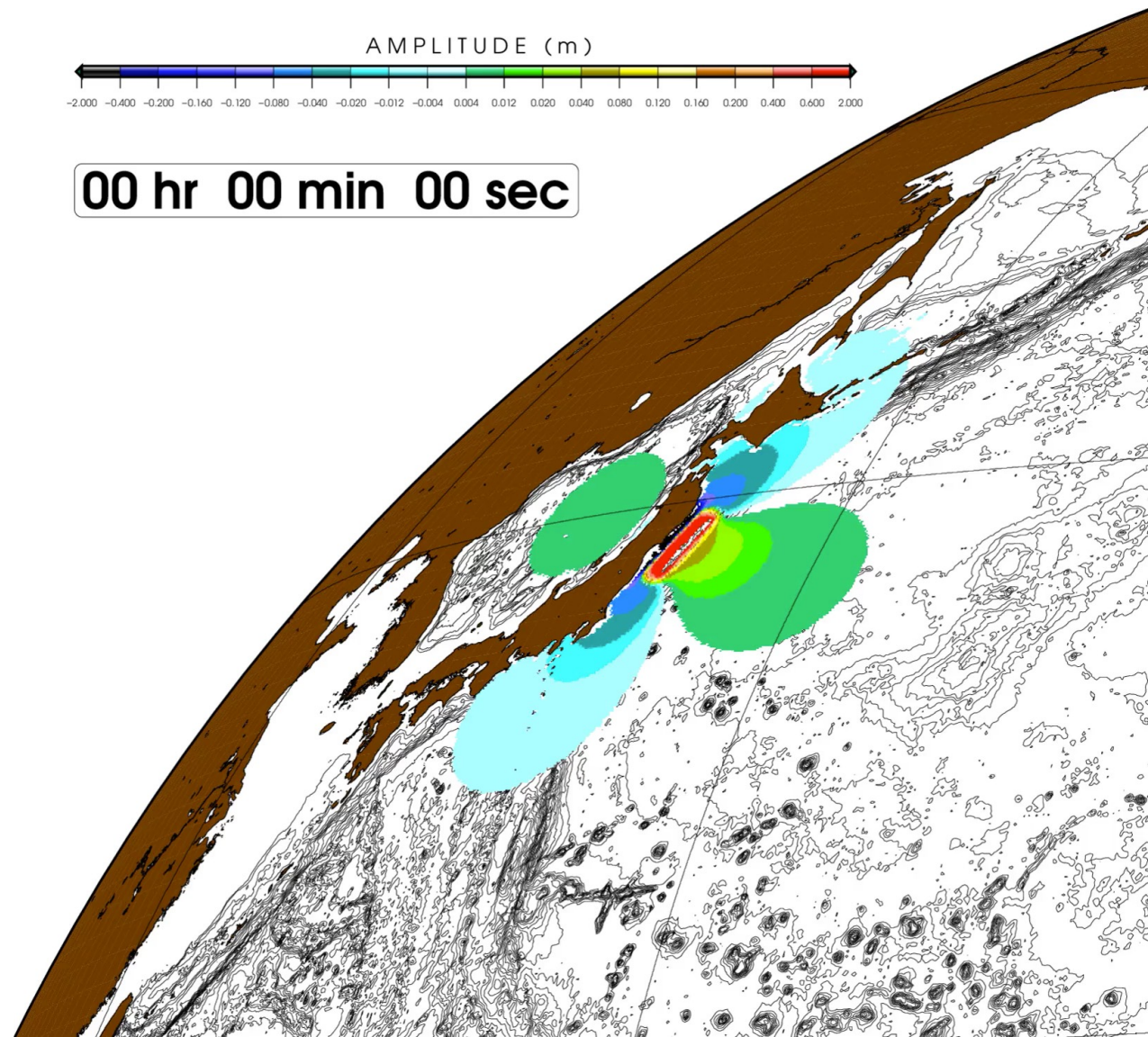
Tsunami Modeling

Near-Field

vs.

Far-Field

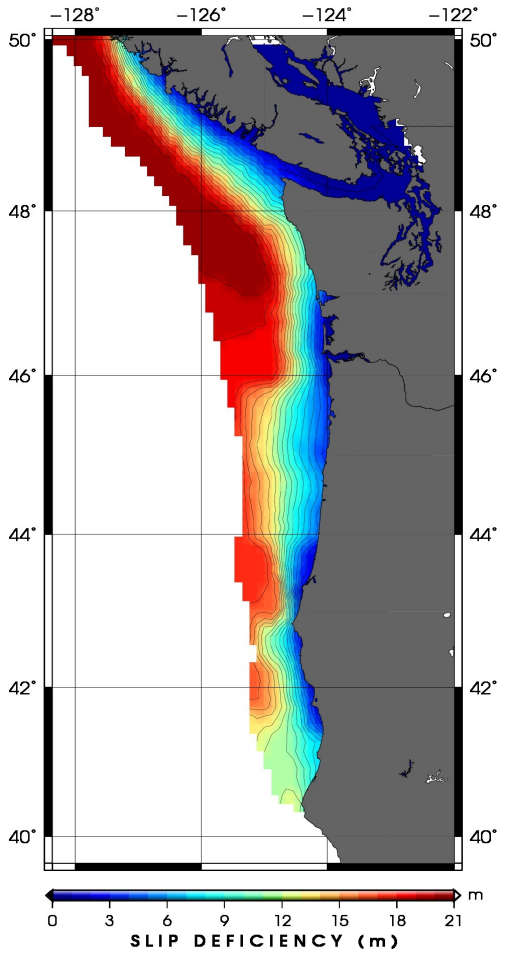
Data, Data, Data!

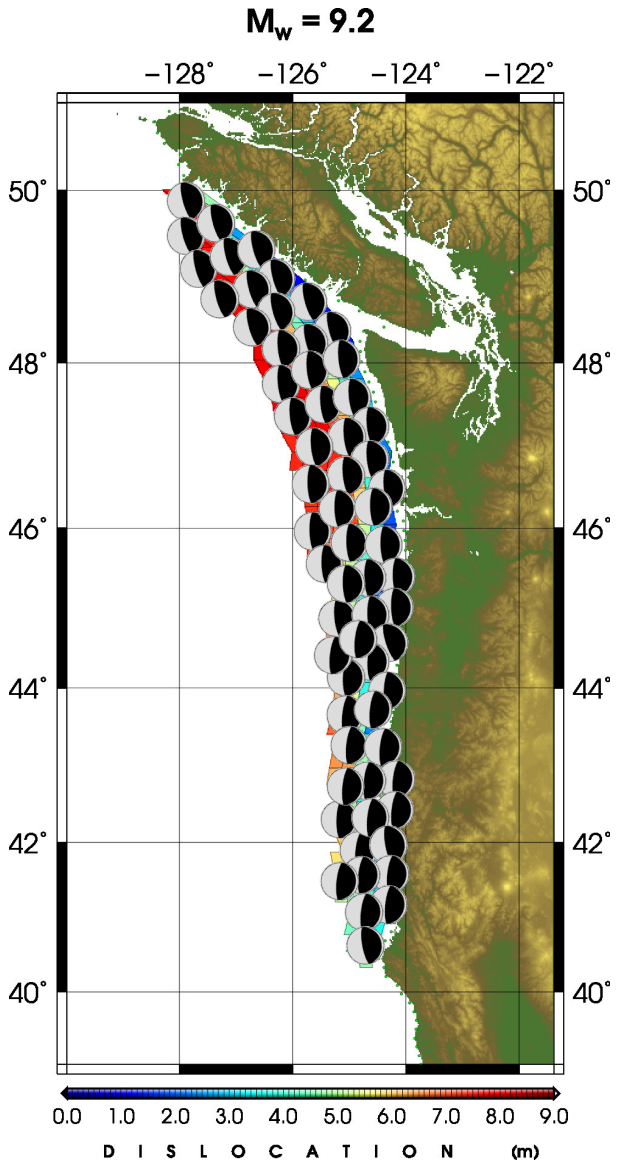


Tsunami Modeling:
Cascadia

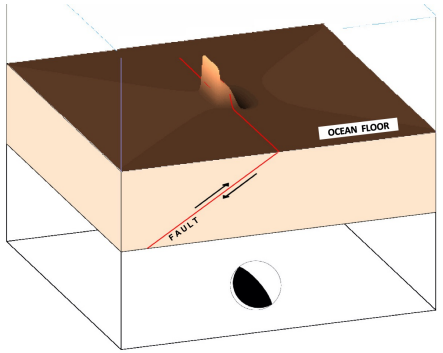
Tsunami Modeling: Cascadia

Locking Model





Point Source:



Finite Source:

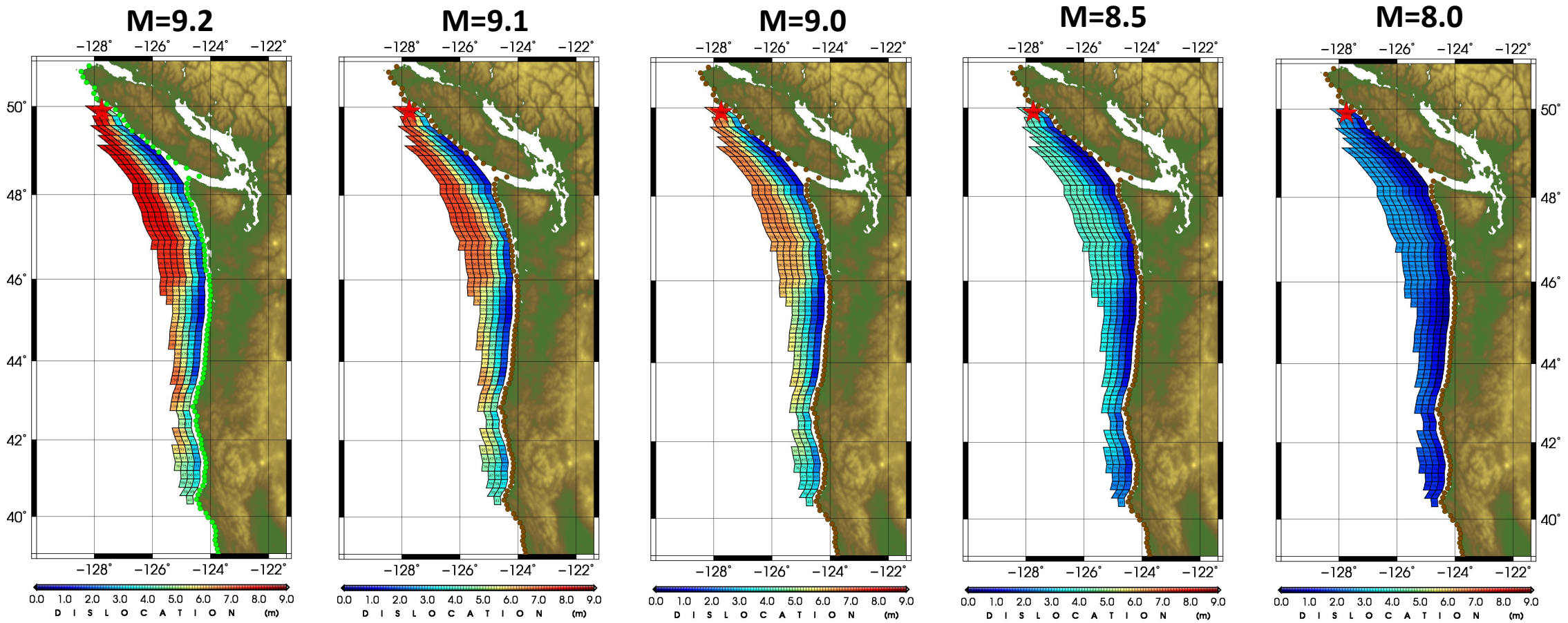
Kinematic vs. Static

Contribution of "Segments" → **Various Magnitudes**

Tsunami Modeling: Cascadia

Realistic Rupture & Real Bathymetry

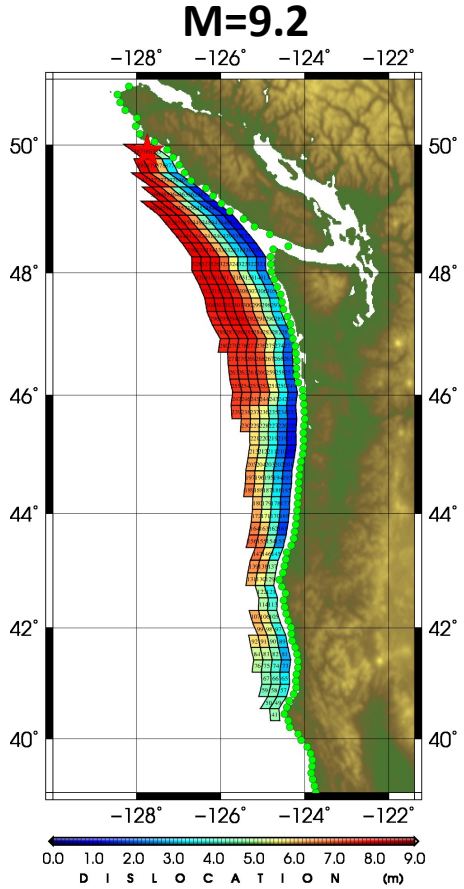
Maximum Slip Field for Each Magnitude Pool

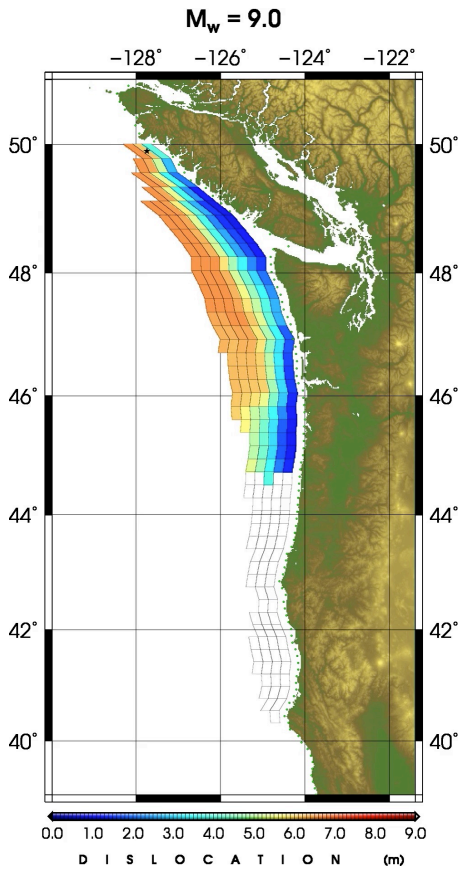


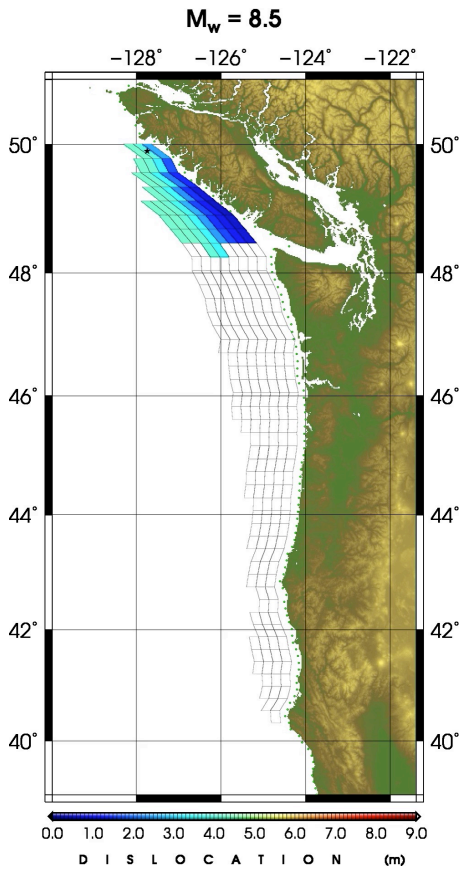
Tsunami Modeling: Cascadia

Realistic Rupture & Real Bathymetry

Rupture Scenarios



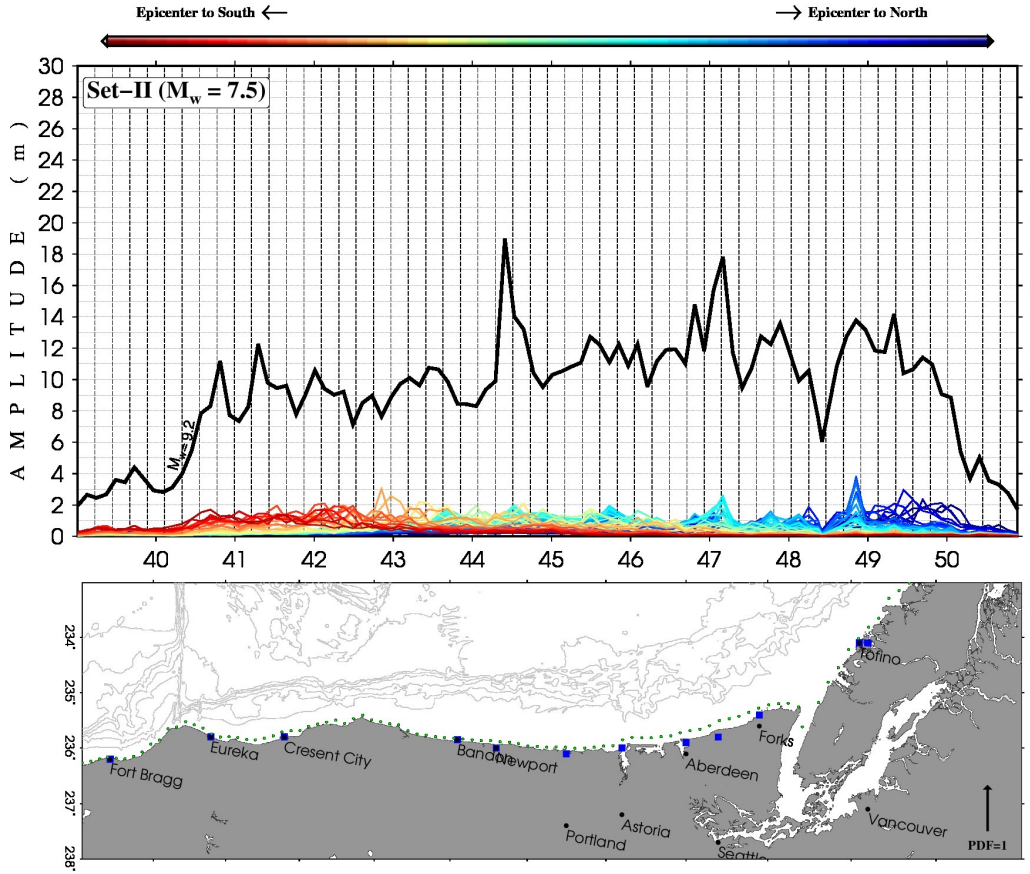




Tsunami Modeling: Cascadia

Realistic Rupture & Real Bathymetry

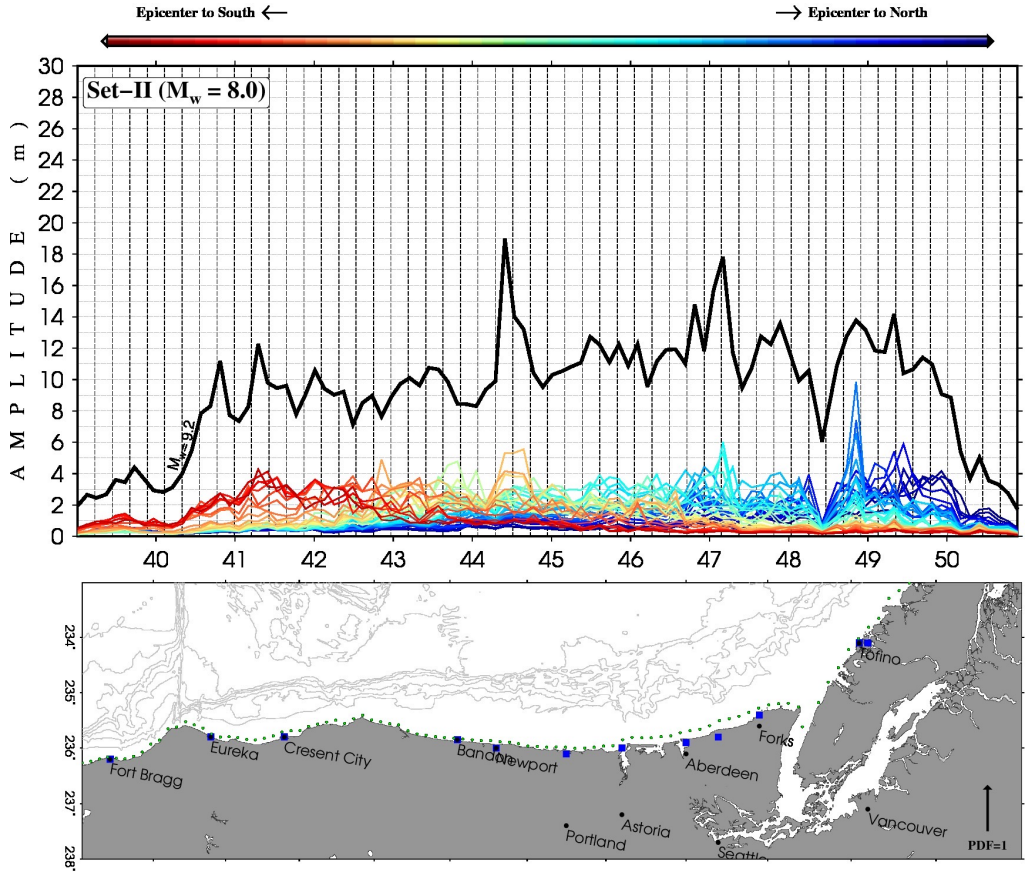
M=7.5



Tsunami Modeling: Cascadia

Realistic Rupture & Real Bathymetry

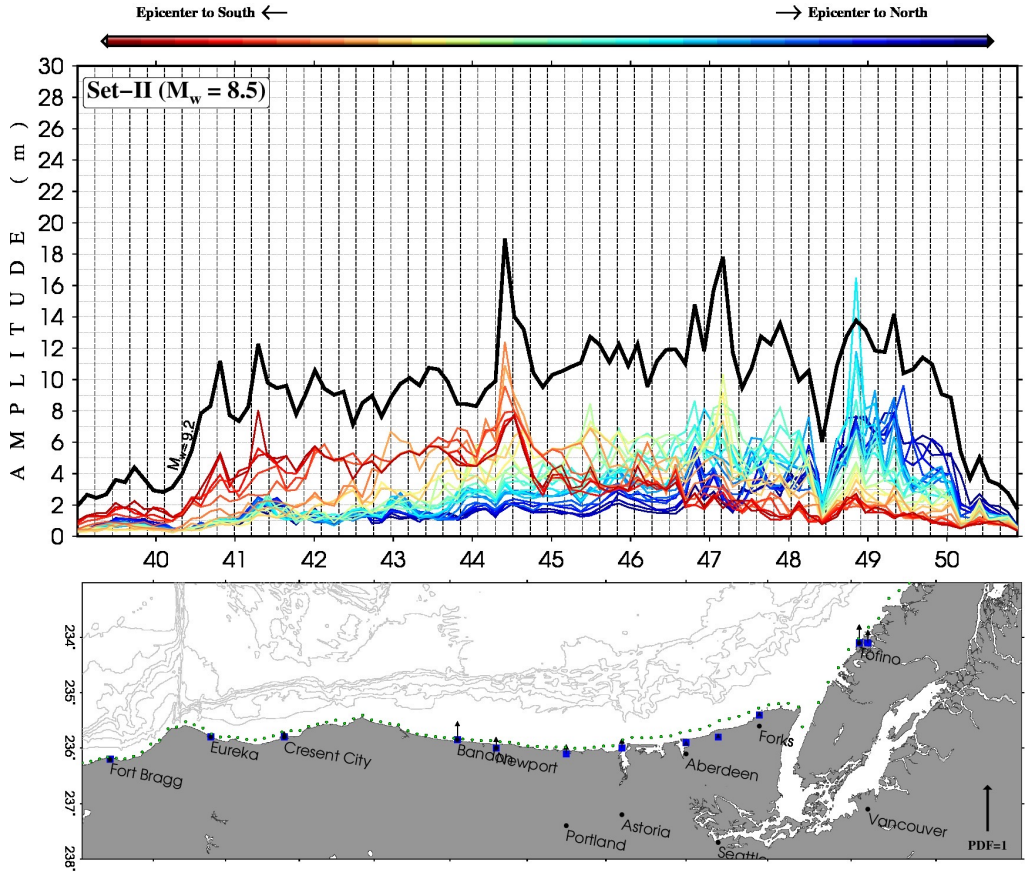
M=8.0



Tsunami Modeling: Cascadia

Realistic Rupture & Real Bathymetry

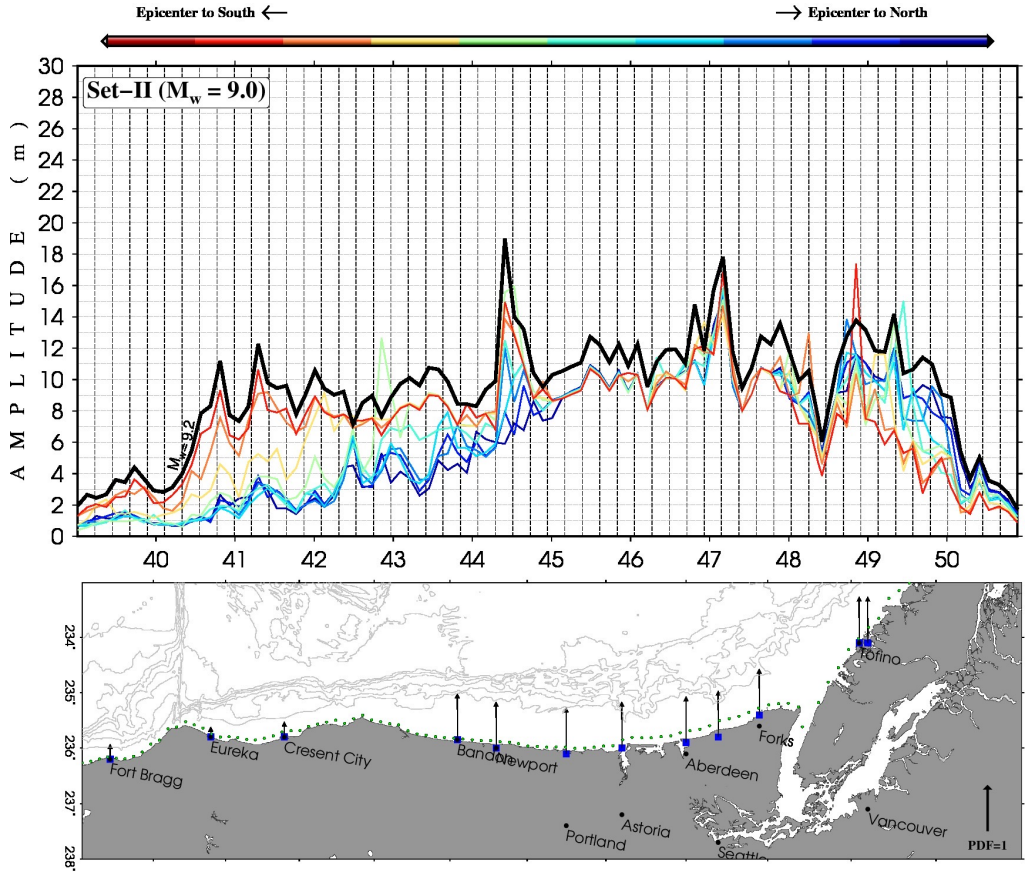
M=8.5



Tsunami Modeling: Cascadia

Realistic Rupture & Real Bathymetry

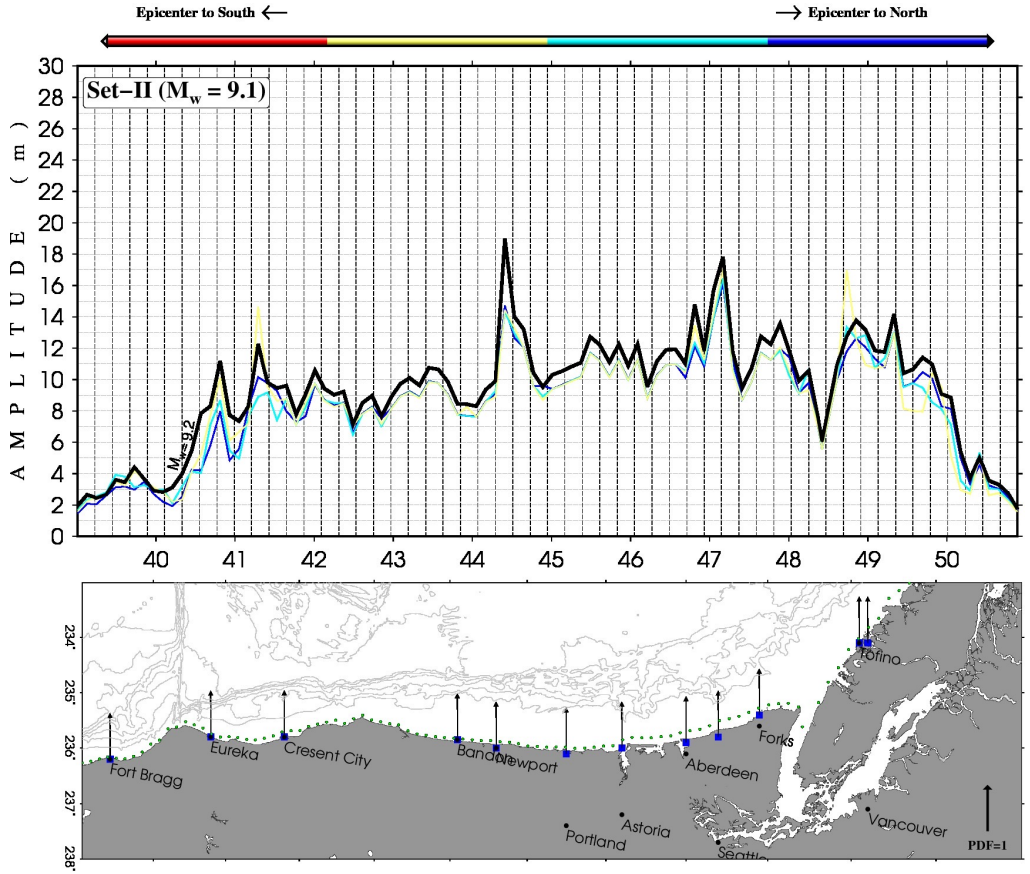
M=9.0



Tsunami Modeling: Cascadia

Realistic Rupture & Real Bathymetry

M=9.1



Tsunami Modeling: Cascadia

Realistic Rupture & Real Bathymetry

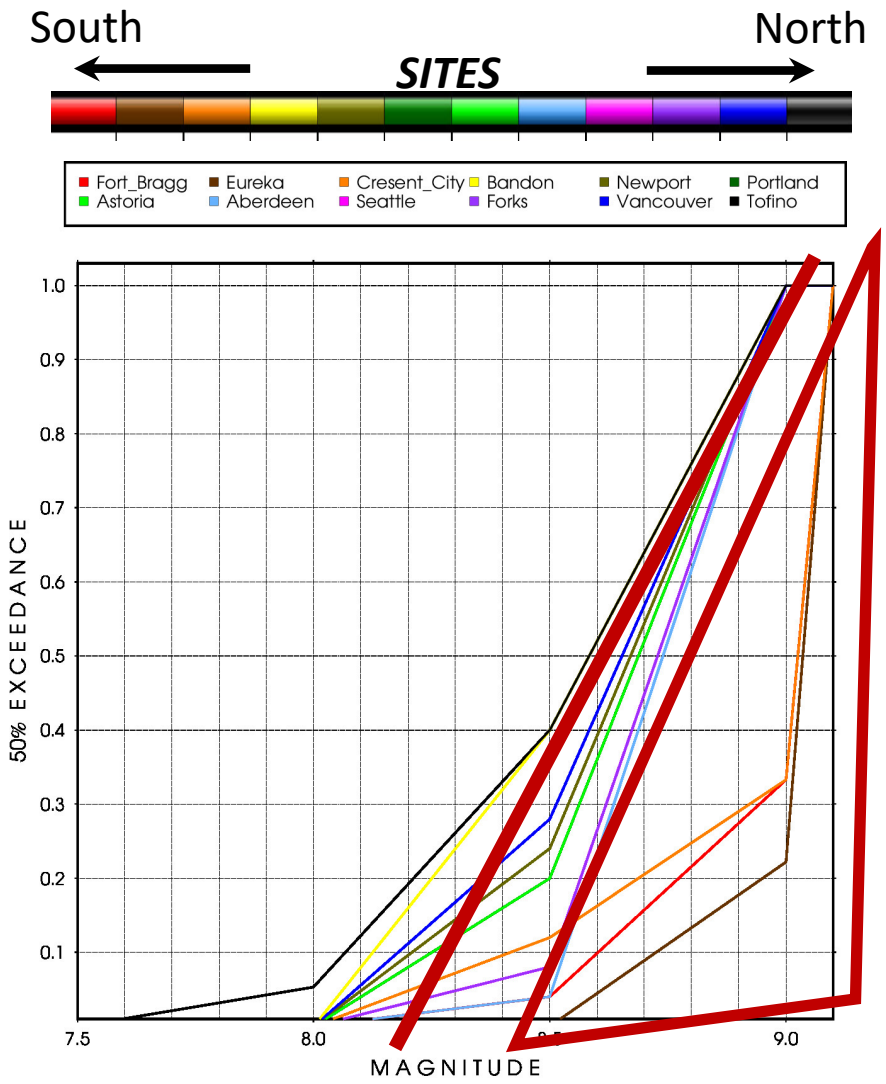
Summary

1) General increase in coastal amplitudes *from South to North*.

2) Mid-latitude sites show anomalously large amplitudes.

3) There is a groups of outliers to this trend:

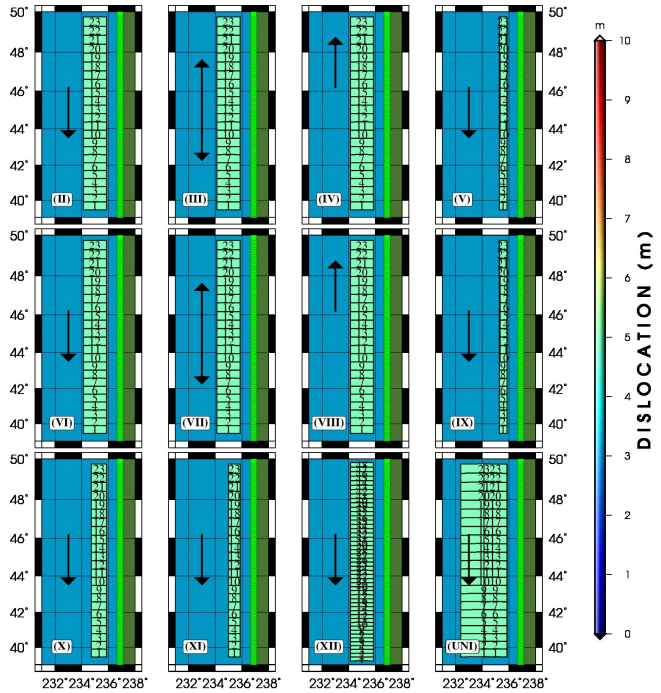
Fort Bragg, Eureka & Crescent City



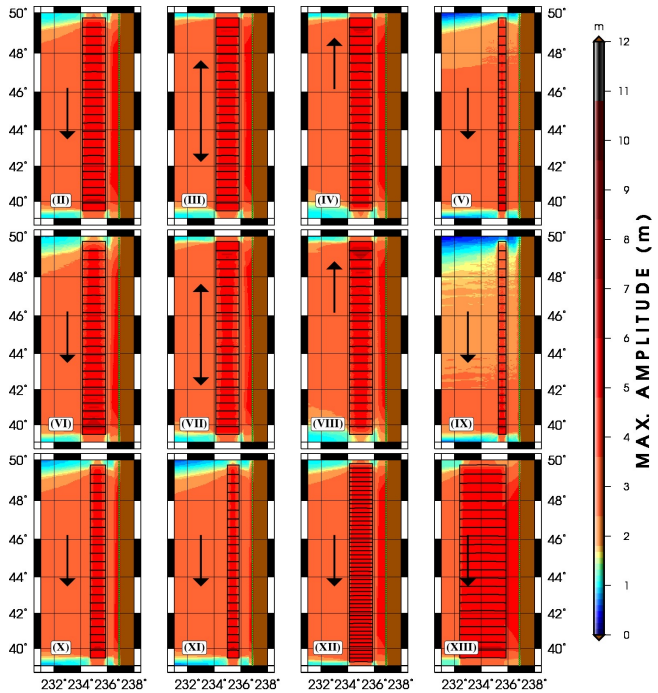
Tsunami Modeling: Cascadia

TEST 1: Linear Rupture (flat ocean)

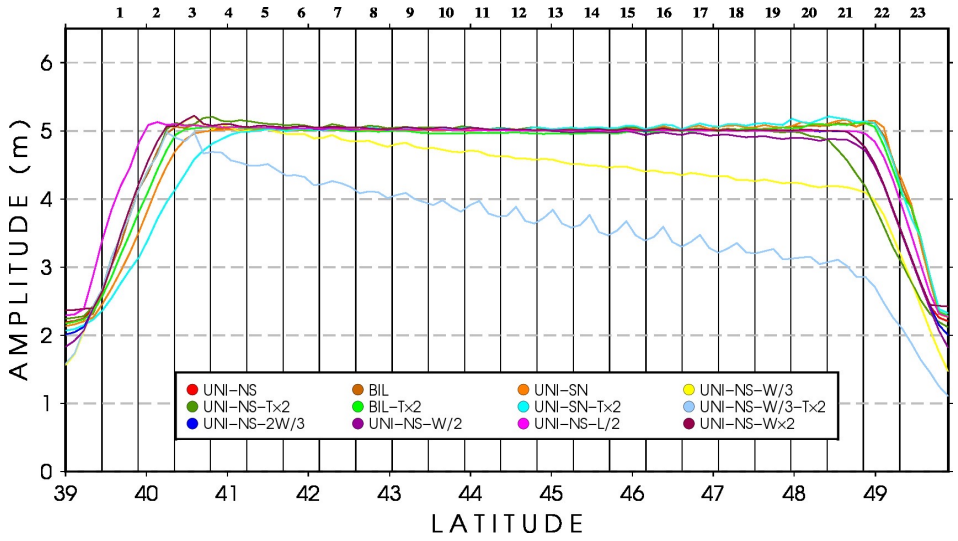
Rupture Model



Tsunami Model



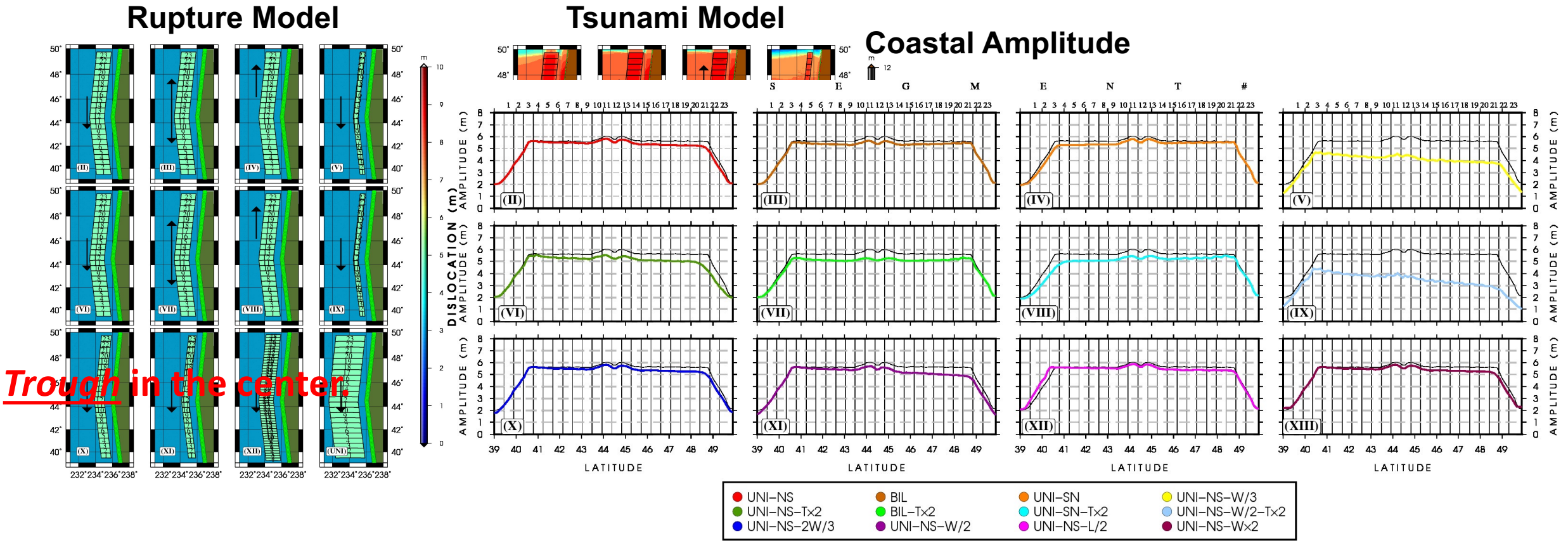
Coastal Amplitude



No significant near-field trend.

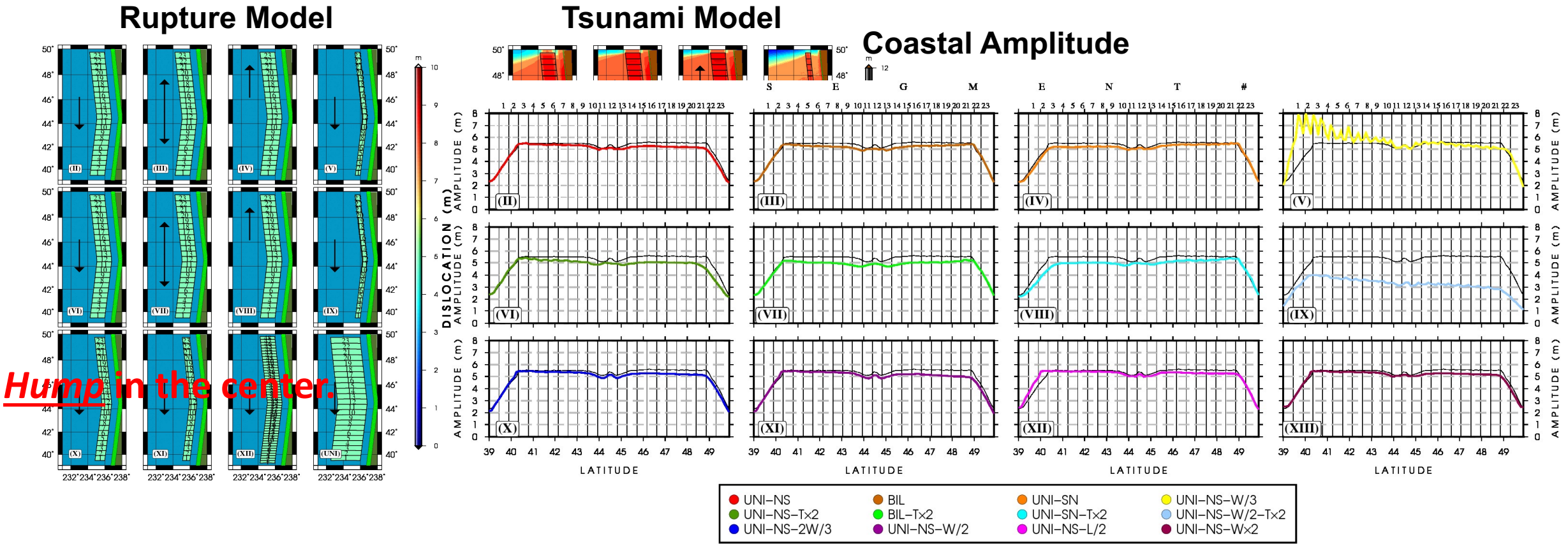
Tsunami Modeling: Cascadia

TEST 2: Convex Rupture (flat ocean)



Tsunami Modeling: Cascadia

TEST 3: Concave Rupture (flat ocean)



Tsunami Modeling: Cascadia

Summary

- *Worst-case* tsunami scenario is **NOT** unique to the largest rupture – especially in the south.
- Larger slip in the north, coastal morphology, as well as the JdF-Pac plate boundary dominate the propagation of Cascadia tsunamis.
- Tsunami hazard in southern Cascadia is mostly affected by southern segments (mostly irrelevant of the north).
- Tsunami hazard at the southern coastlines does not vary much by increasing rupture size, with the exception of M>9.1 earthquakes.

On-going Work

Tsunami Source Resolution

Tsunami Source Resolution

How Much Resoltion Do We Really Need?

Can *less* be *more*?

- How would removing source details affect the tsunami?
- *How would removing details from a picture affect our perception of what/who it is of?*

Tsunami Source Resolution

Question:

Is there a “sufficiency” threshold?

Simple Experiment: Fourier Filtering

Tsunami Source Resolution

Simple Experiment: Fourier Filtering

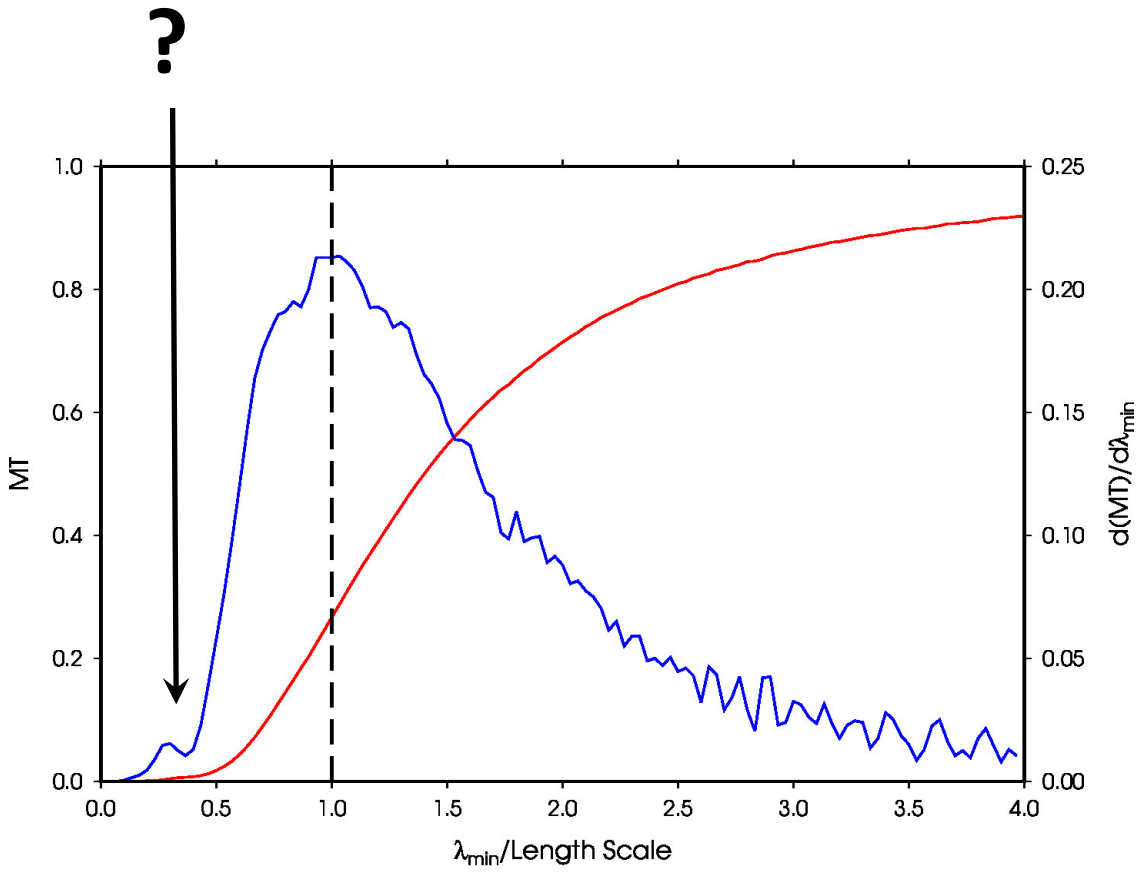
Question:

Is there a “sufficiency” threshold? ?

MT: Statistical similarity between two datasets:

MT=0 ⟹ Identical

MT: large ⟹ Not similar



Tsunami Source Resolution

Another Source of Complexity: *Surface Waves*

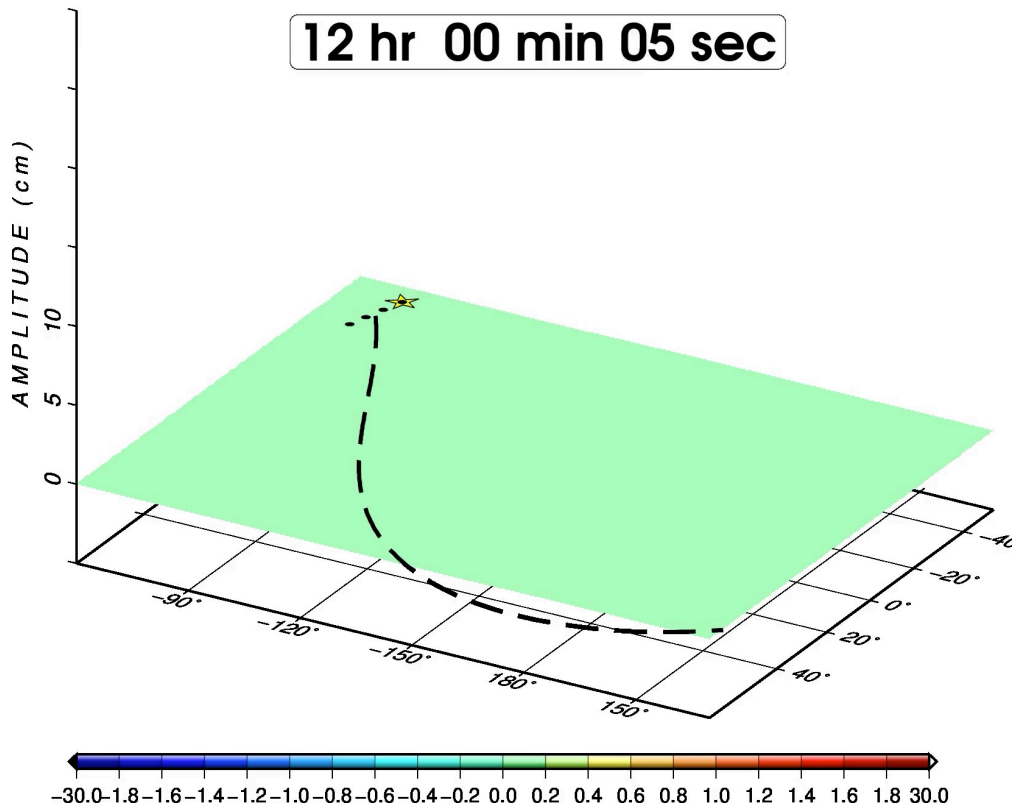
Question:

How much would synthetic Rayleigh waves perturb tsunami simulations?

Normal Modes of the Earth

Amplitude of ~6 cm over T~150 s

MUST BE CONSIDERED!

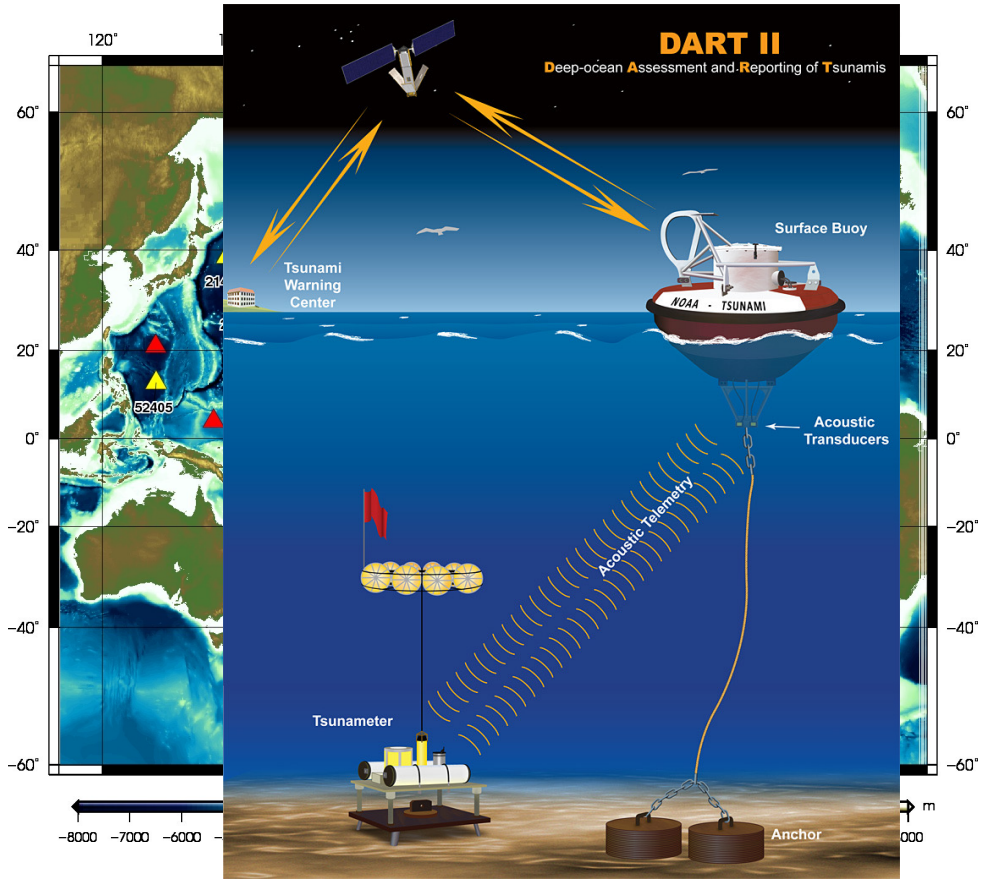


On-going Work

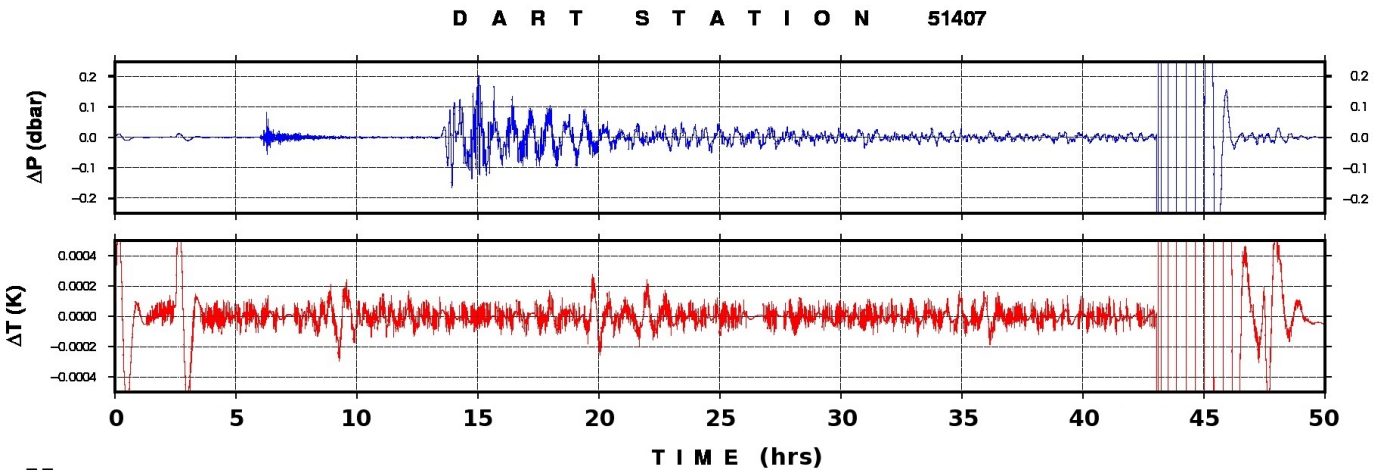
DART SITE SELECTION

DART SITE SELECTION

Deep-ocean Assessment and Reporting of Tsunamis (DART)



DART Record of 2011 Japan Tsunami



DART SITE SELECTION

Can we avoid repeating ourselves?