A Canadian Pilot Project for a GPS-Augmented Tsunami Warning System

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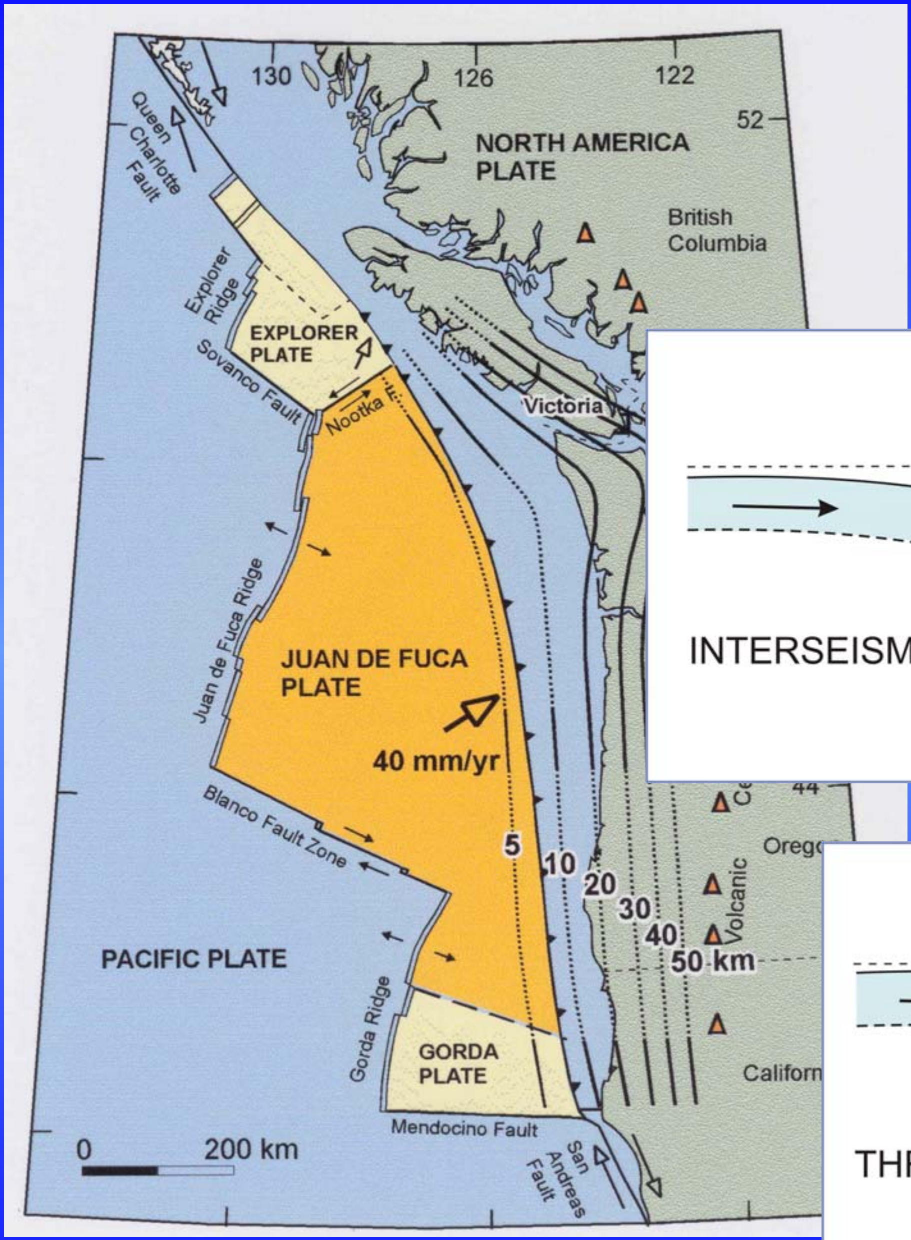
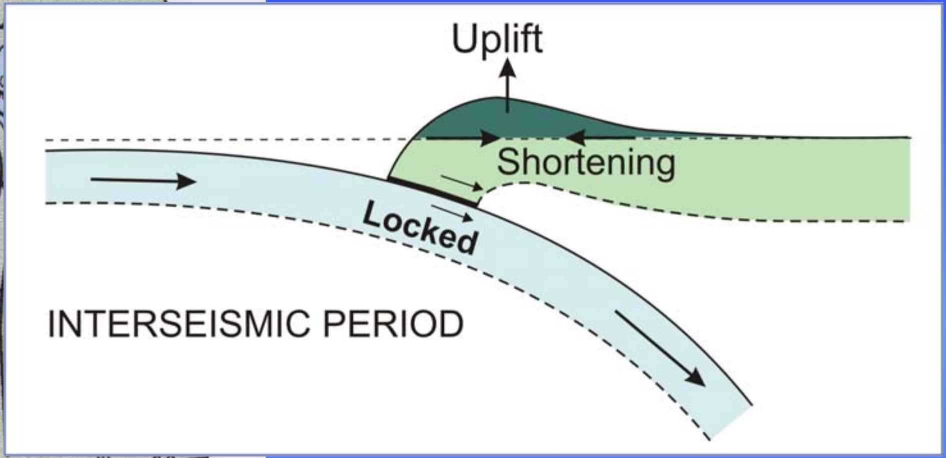
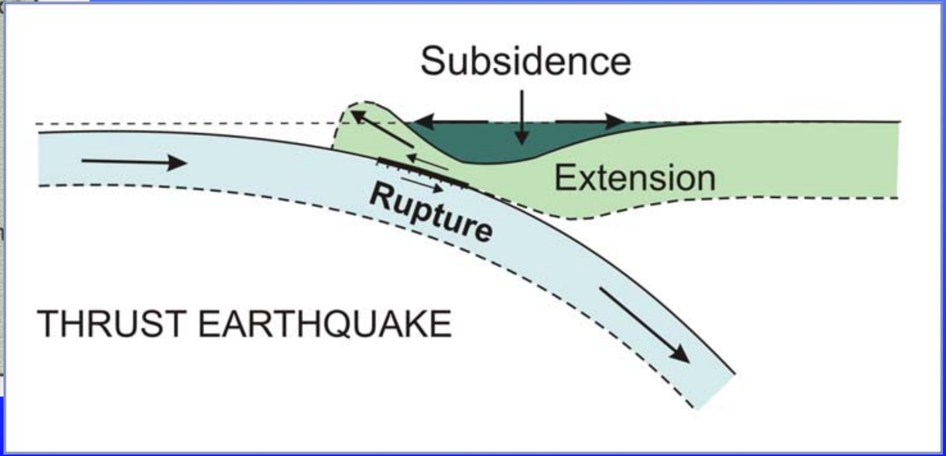
The Cascadia Subduction Zone

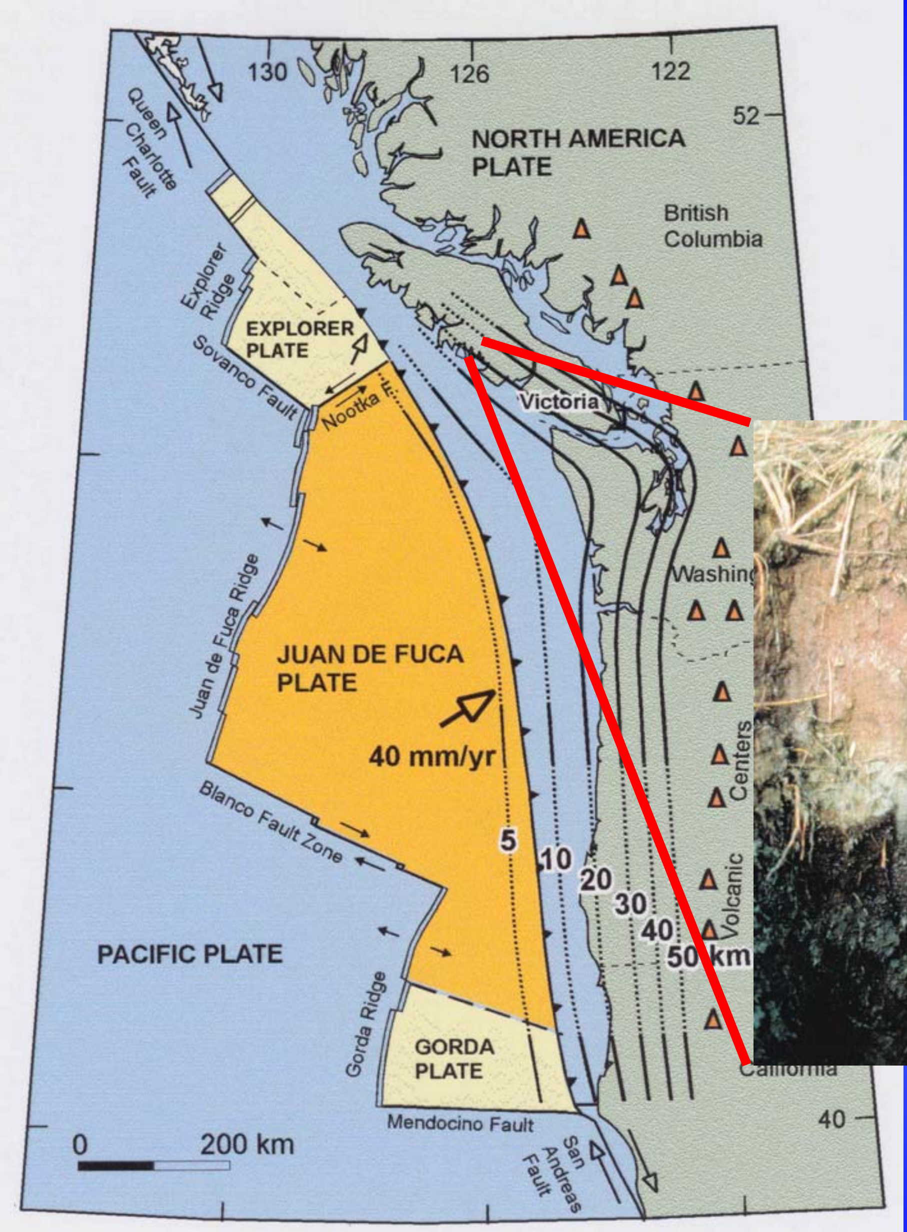






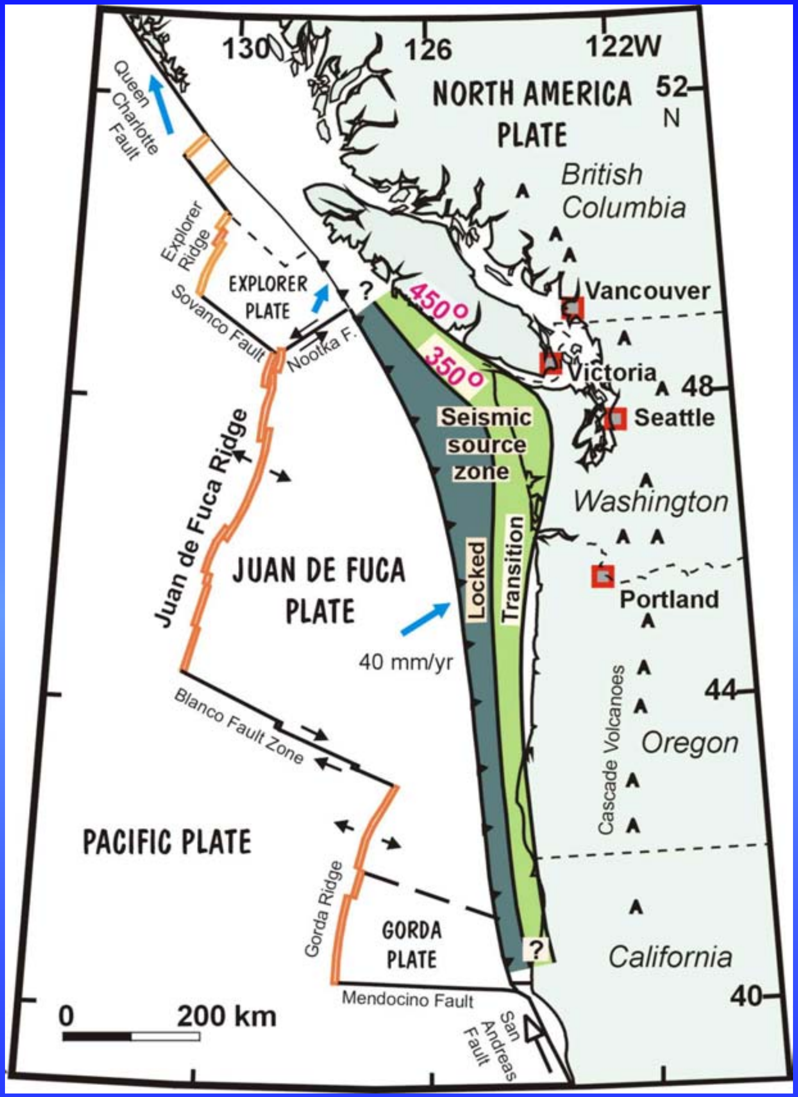
The Cascadia Subduction Zone

Evidence for past tsunamis

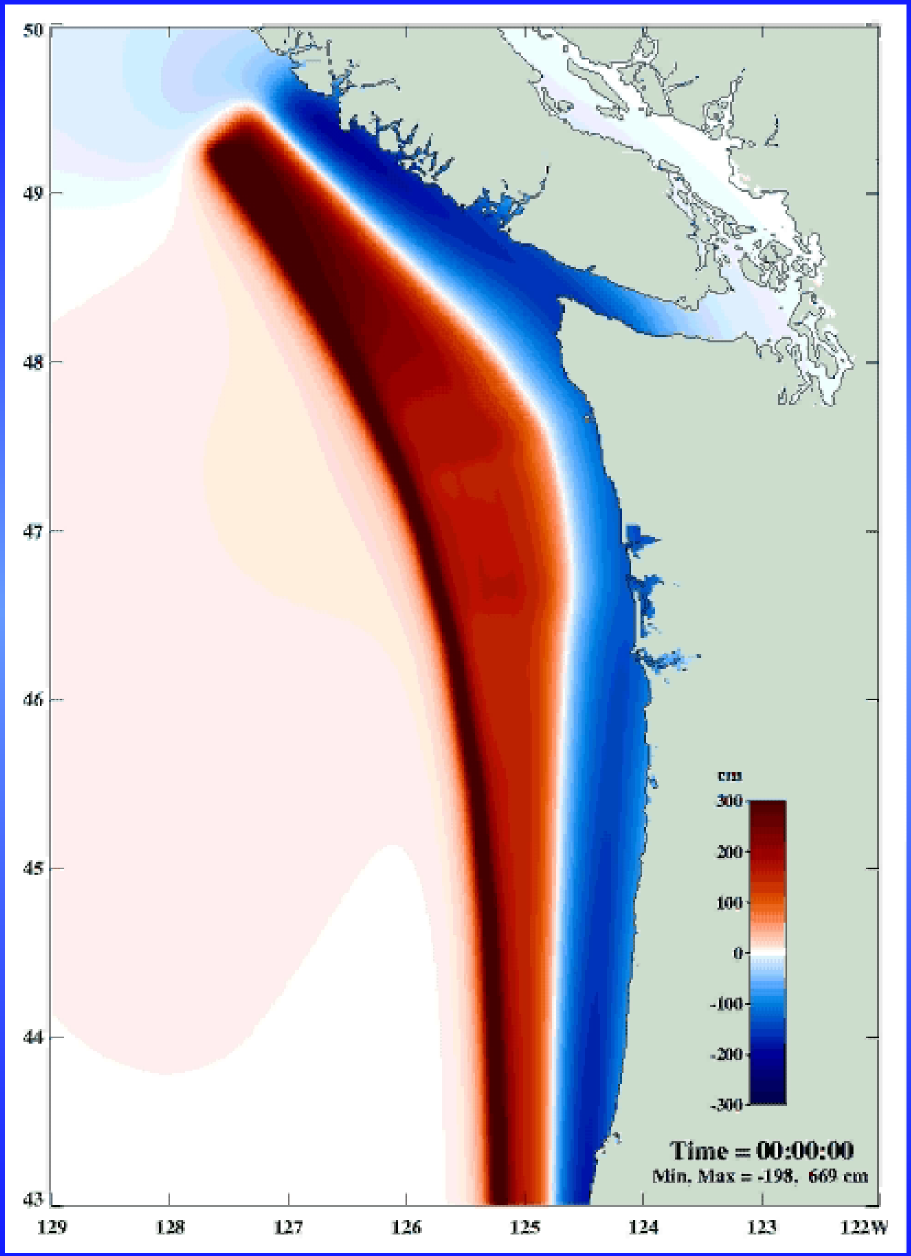


Clague & Bobrowsky

Present-day Crustal Deformation

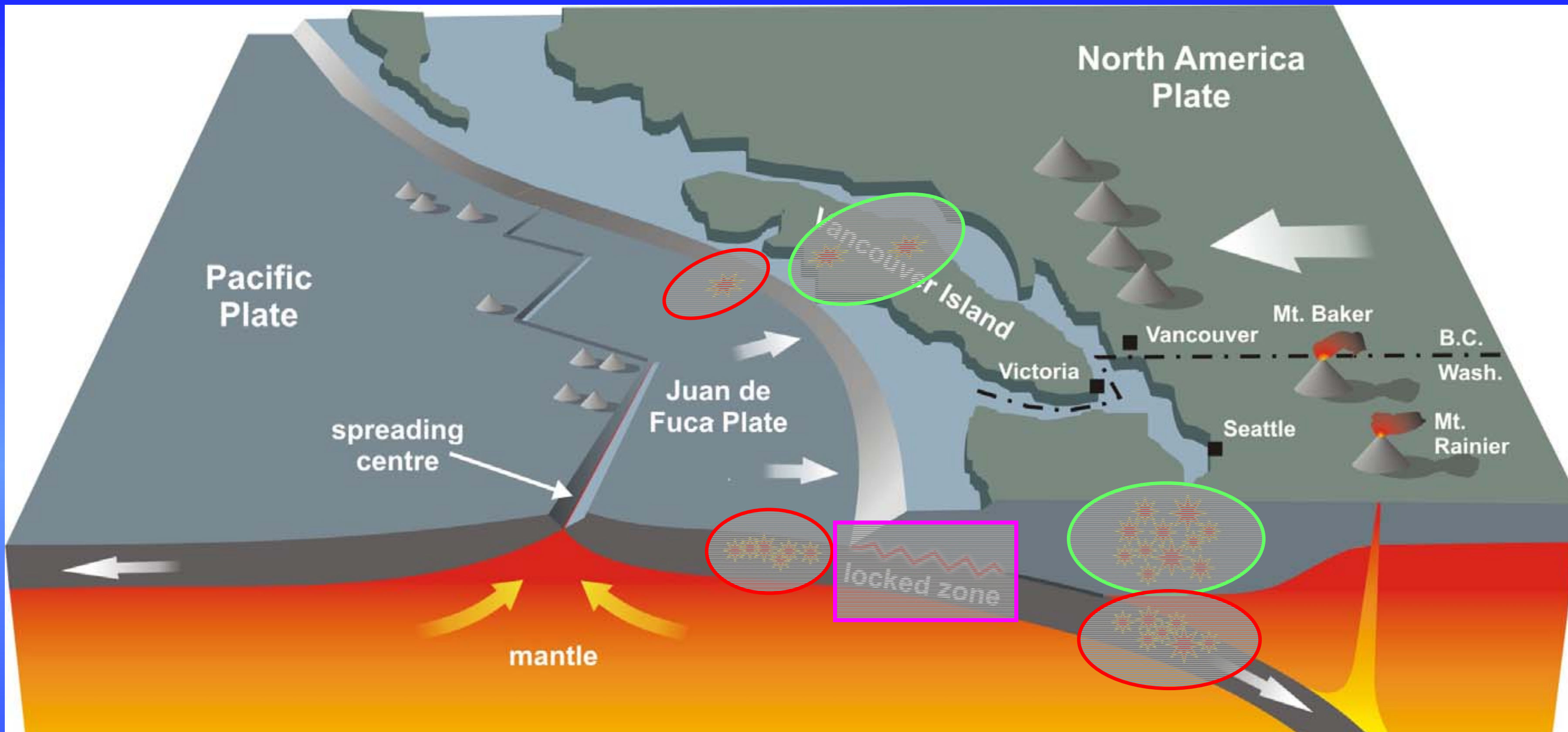


Flueck et al., JGR, 1997



Cherniawsky et al., PAGEOPH, 2006

Large Earthquakes on the Cascadia Subduction Zone



Megathrust Earthquakes

Crustal Earthquakes

In-Slab (Ocean Plate) Earthquakes

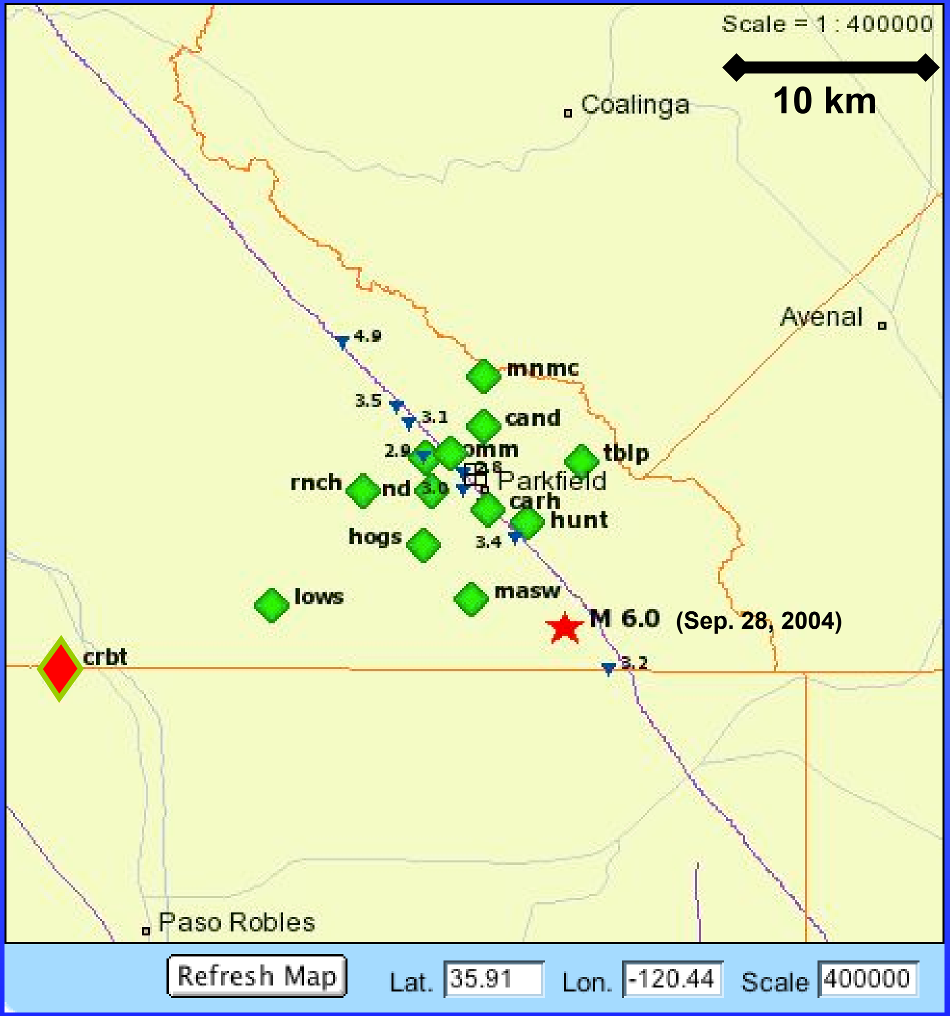
GIVEN:

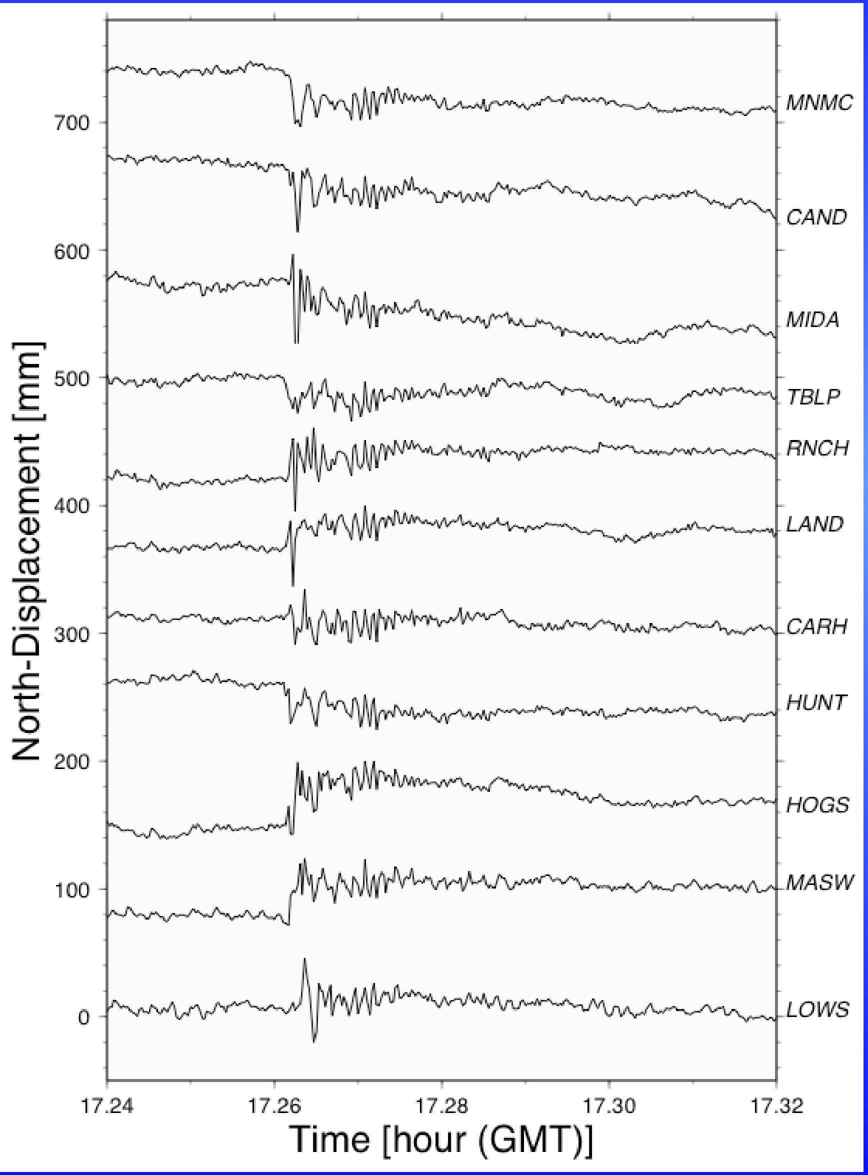
- large offshore earthquakes can occur
- a Cascadia megathrust earthquake will occur
- a tsunami will impact in ~15 min

The Challenge:

- Can we measure displacements in real time with sufficient accuracy?
- Can we constrain the likely type of rupture within 1 or 2 minutes?

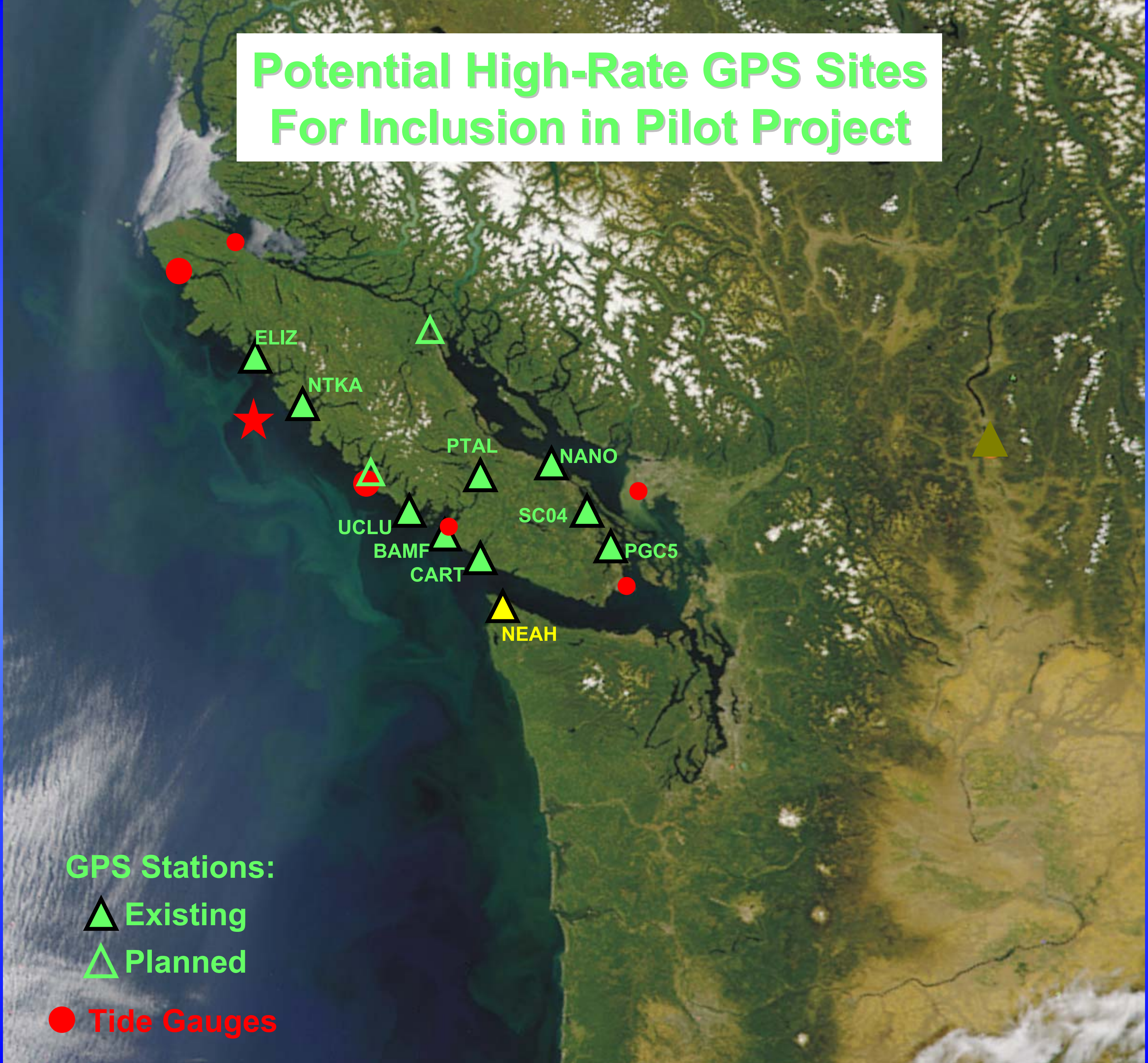
Instantaneous Positions: Mw 6.0 Parkfield EQ





Y. Bock, CSRC Fall Meeting, October 20, 2005, SIO

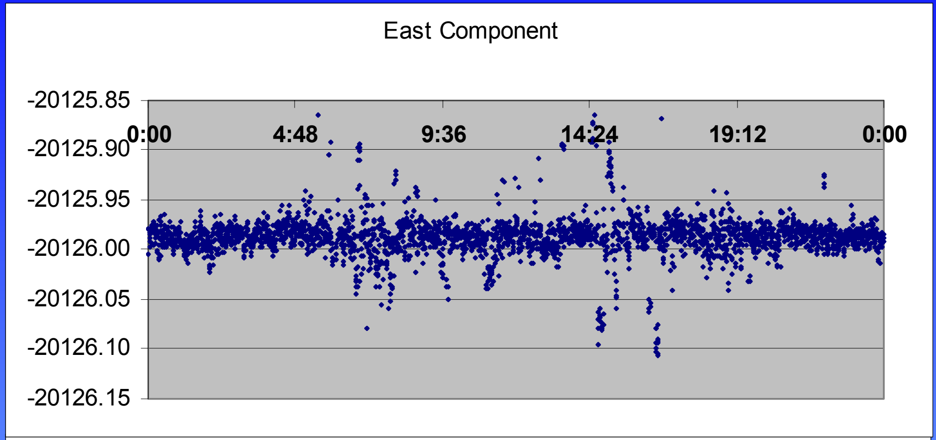
Potential High-Rate GPS Sites For Inclusion in Pilot Project



Nominal Noise Levels for Cascadia Pilot GPS –Tsunami Network

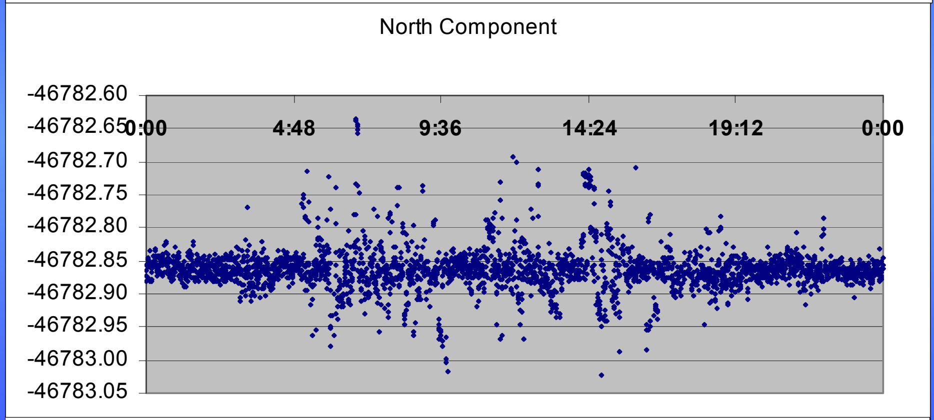
30 sec RTD Positions of BAMF vs PTAL over 24h

East



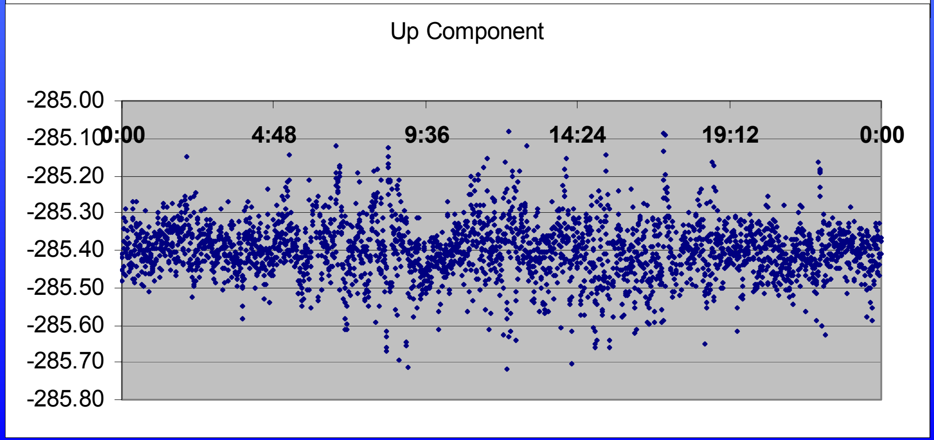
East IQR = 0.02 m

North



North IQR = 0.02 m

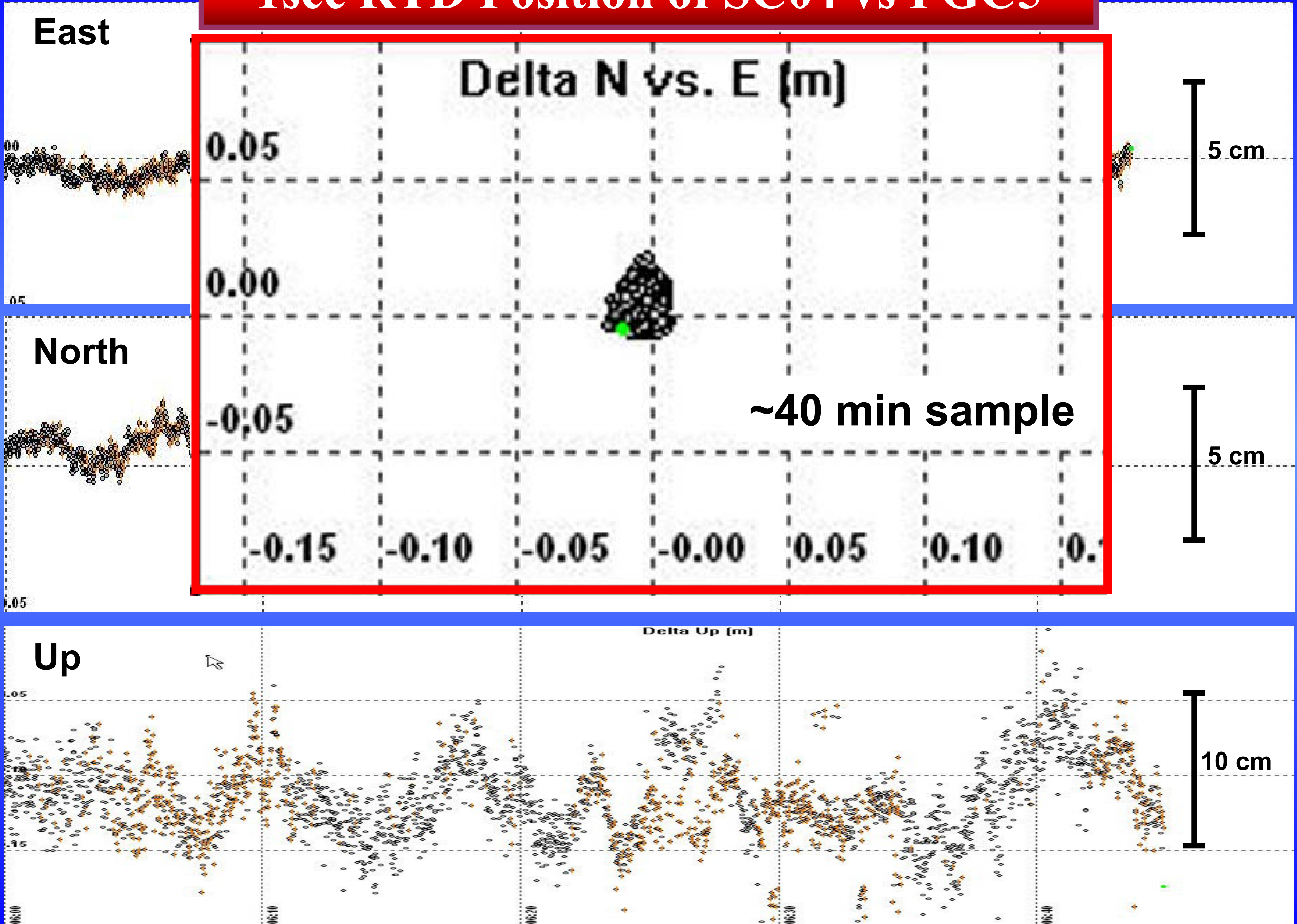
Up



Up IQR = 0.09 m

4% outliers (5 x IQR)

1sec RTD Position of SC04 vs PGC5

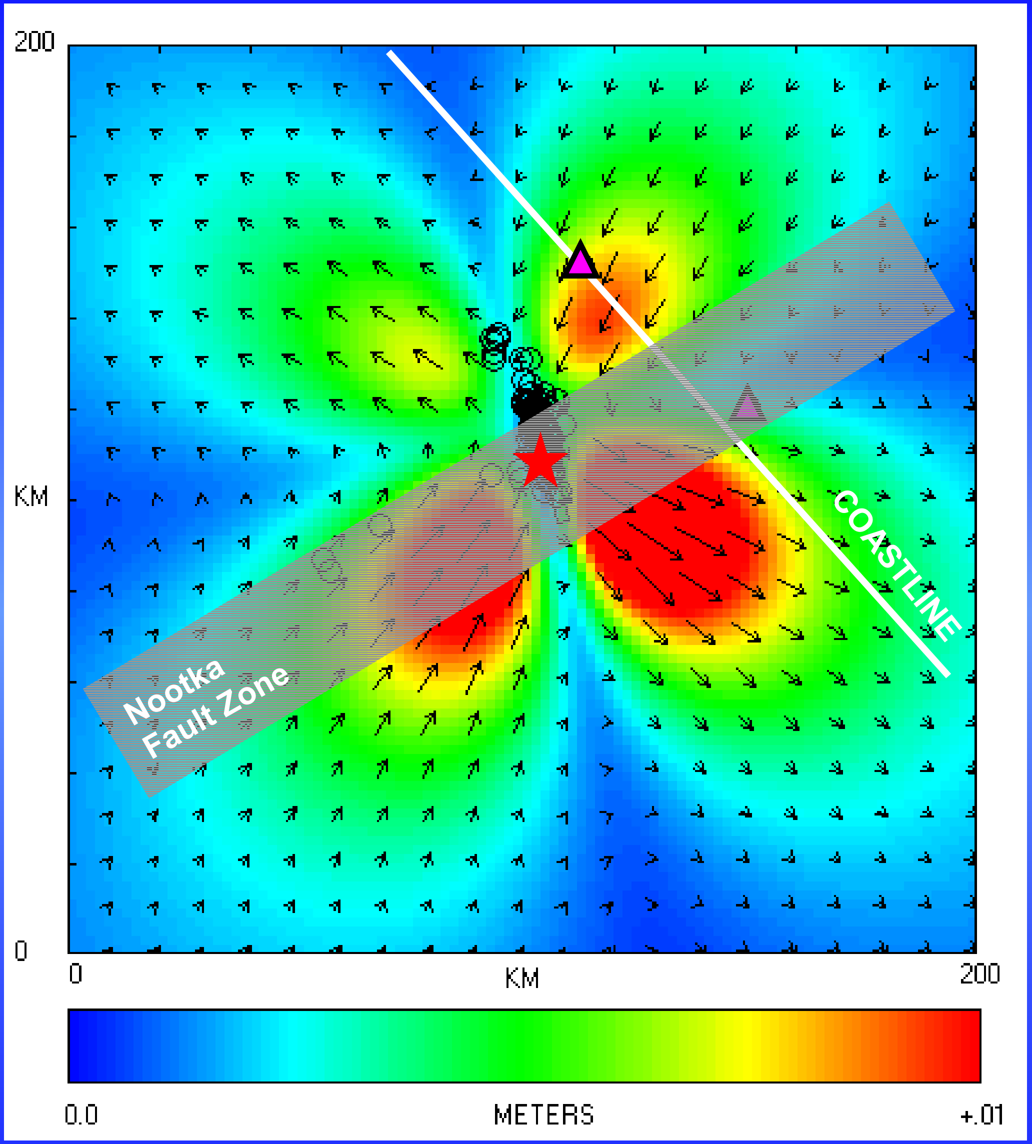


Model of Surface Horizontal Displacements for Jul.19, 2004 Nootka Earthquake

Mw: 6.4
Lat/Long:
49.50 -127.23
Depth: 23 km

NP1:
Strike: 166
Dip: 83
Rake: 165

Fault:
Length: 30 km
Width: 20 km
Top: 15 km
Slip: ~25 cm

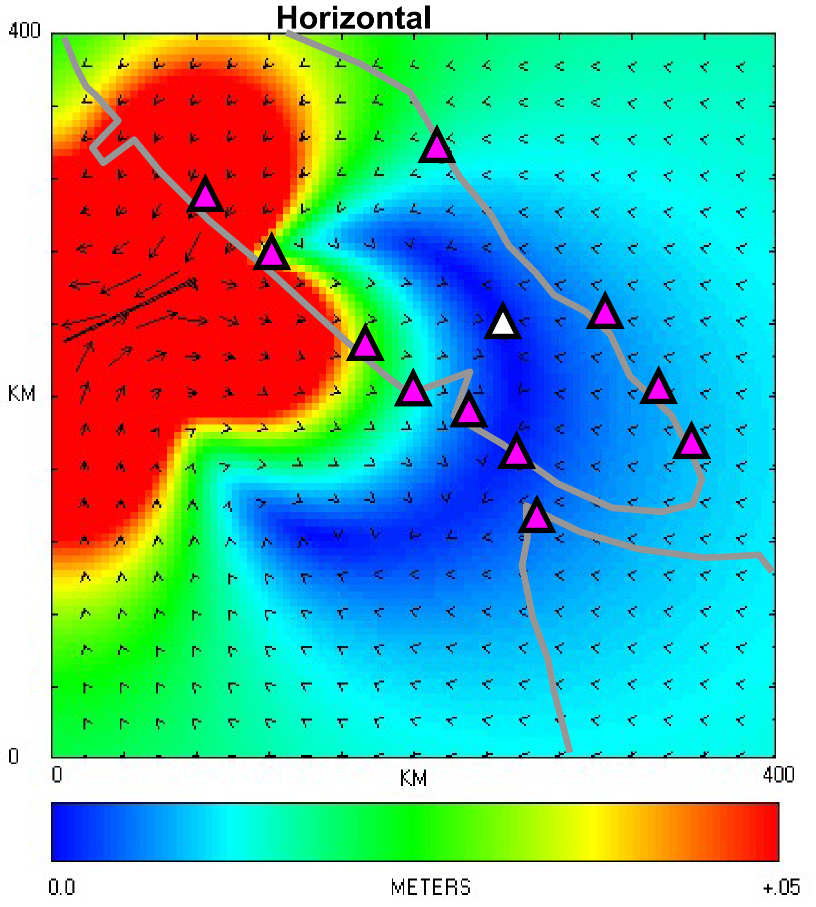


Observed Coseismic Displacements:

ELIZ: ~7mm

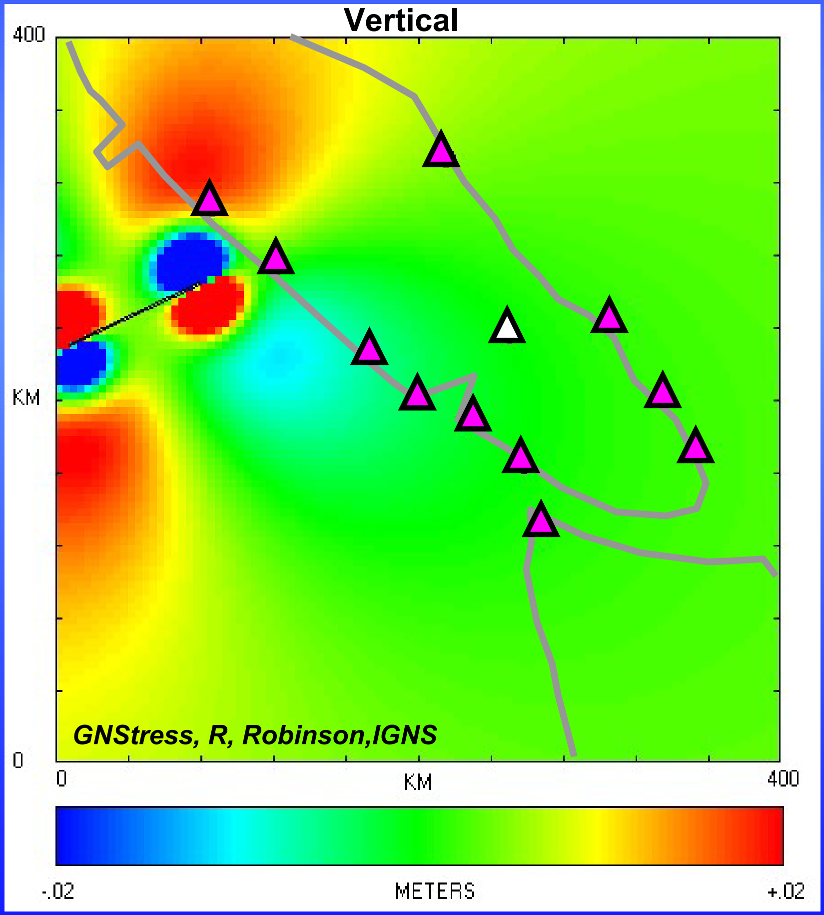
NTKA: ~2mm

Relative Displacements from a Large Offshore Strike-slip Rupture



ELIZ: 20.9 cm @ -154° ; 1.0 cm up

NTKA: 3.8 cm @ +126° ; 0.1 cm up



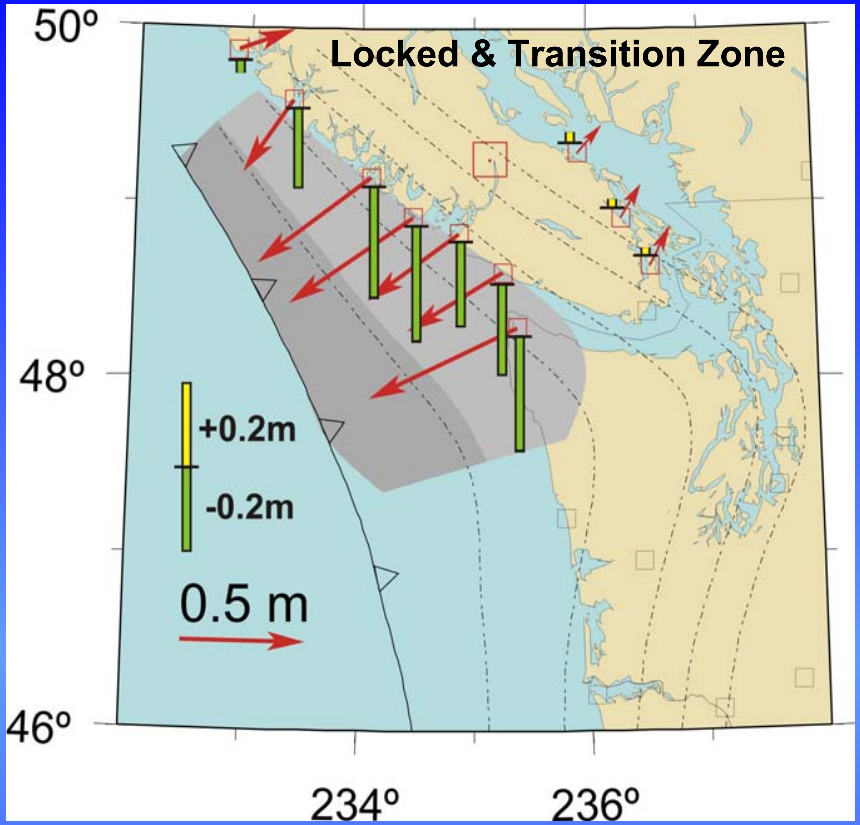
Mw: 7.3
Lat/Long:
49.33 -127.70
Depth: 5 km

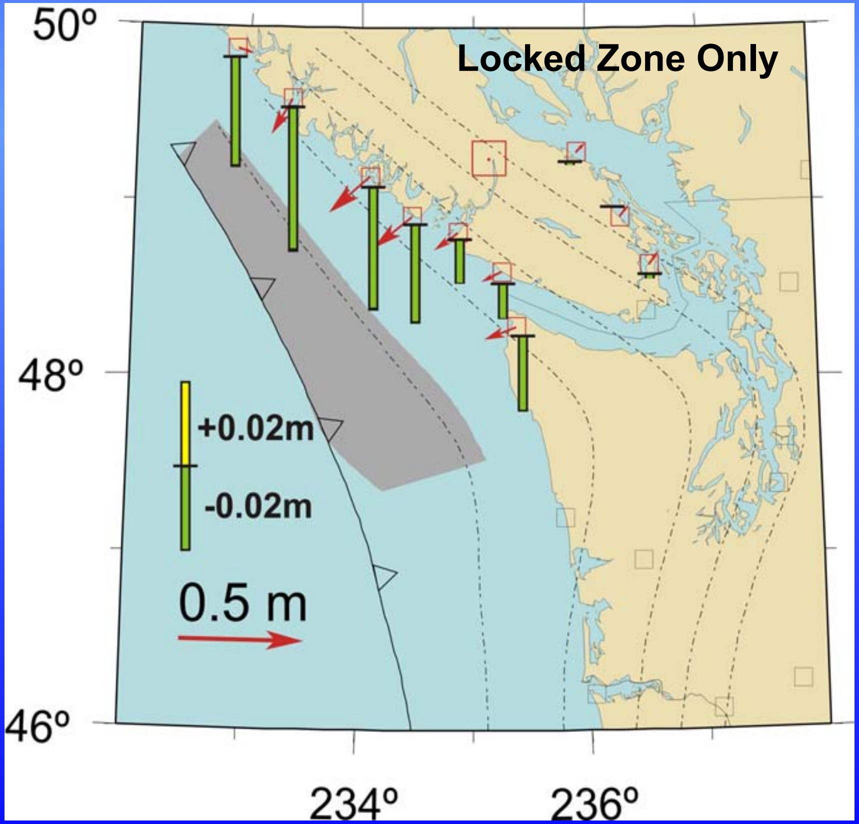
NP1:
Strike: 245
Dip: 86
Rake: 0

Fault:
Length: 80 km
Width: 15 km
Top: 5 km
Slip: ~ 3.5 m

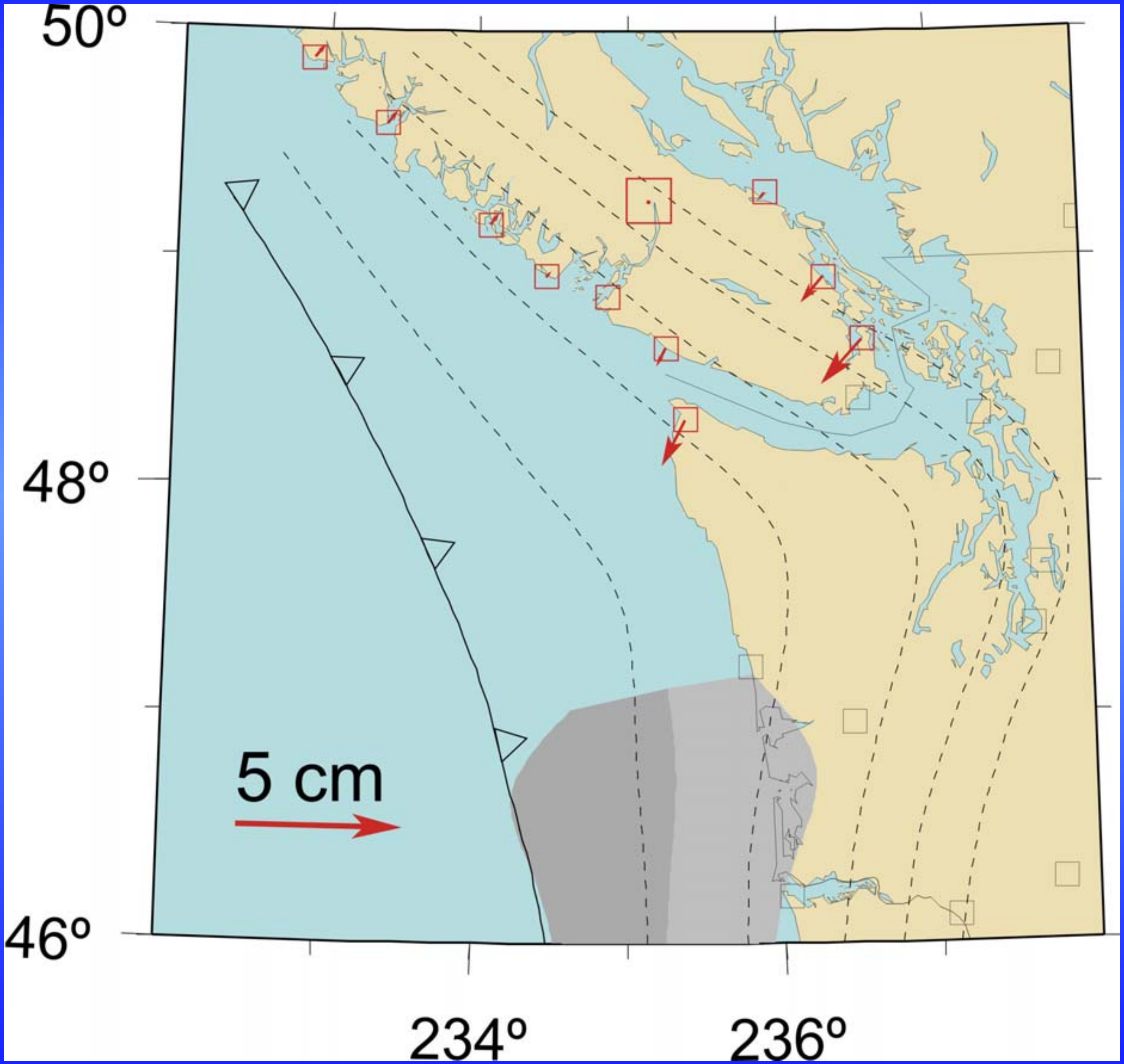
Scenario Megathrust Ruptures

- 100yr slip deficit accumulation
- rupture directly offshore Vancouver Is.
- “locked” coupling factor 1.0
- “transition” coupling varies: 1.0 to 0.0
- displacements relative to central site

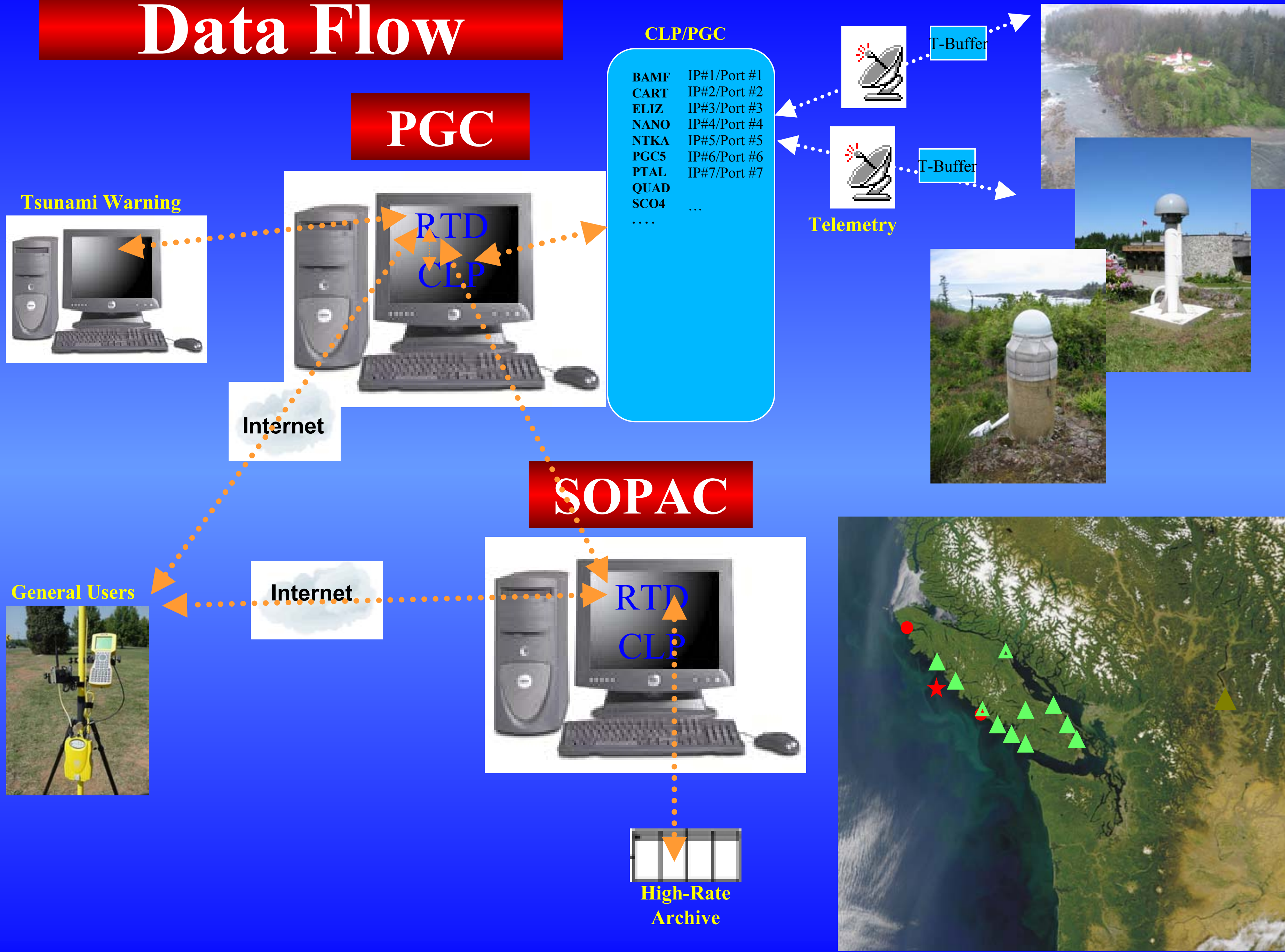




Array Sensitivity to Megathrust Rupture to the South

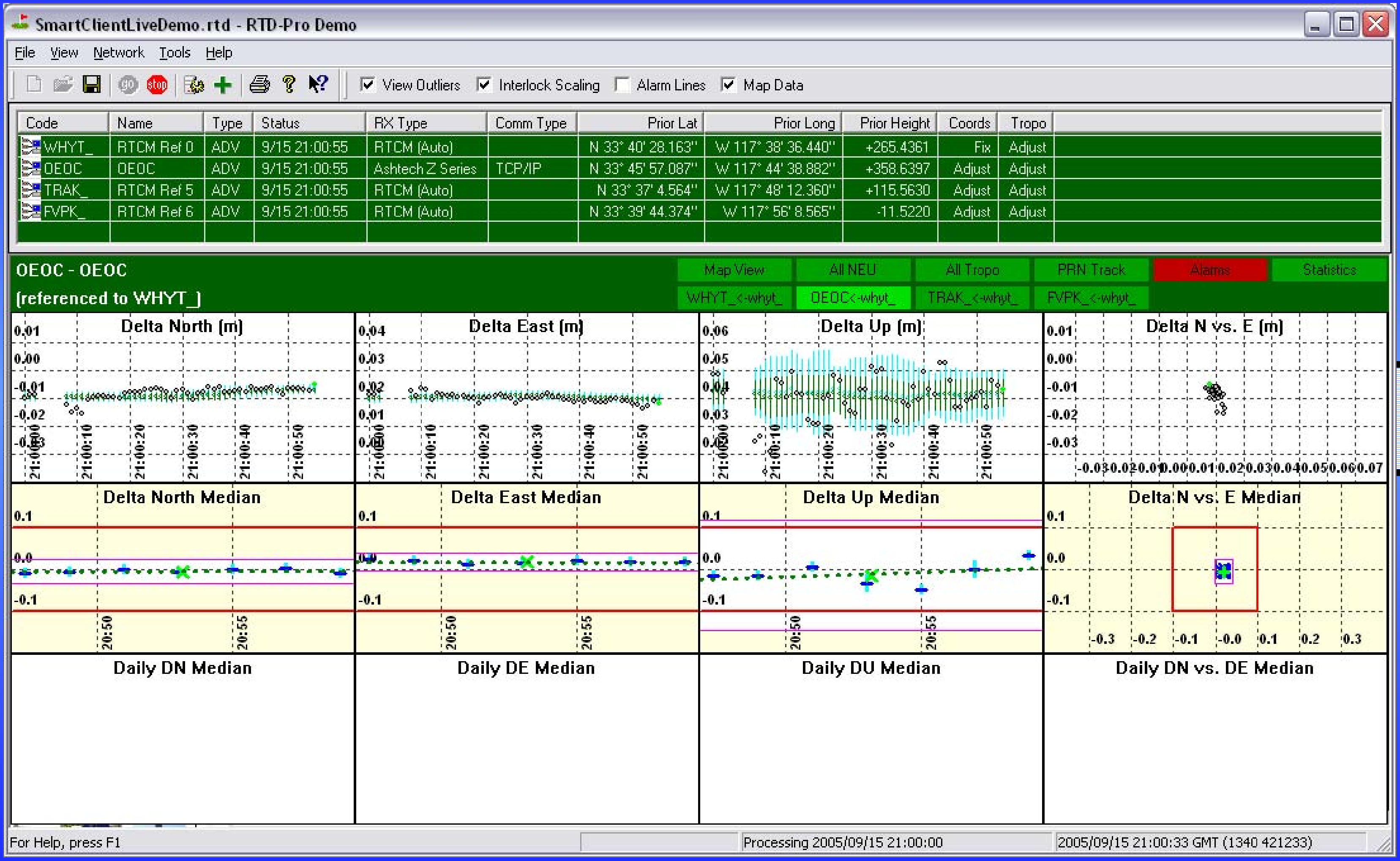


Data Flow



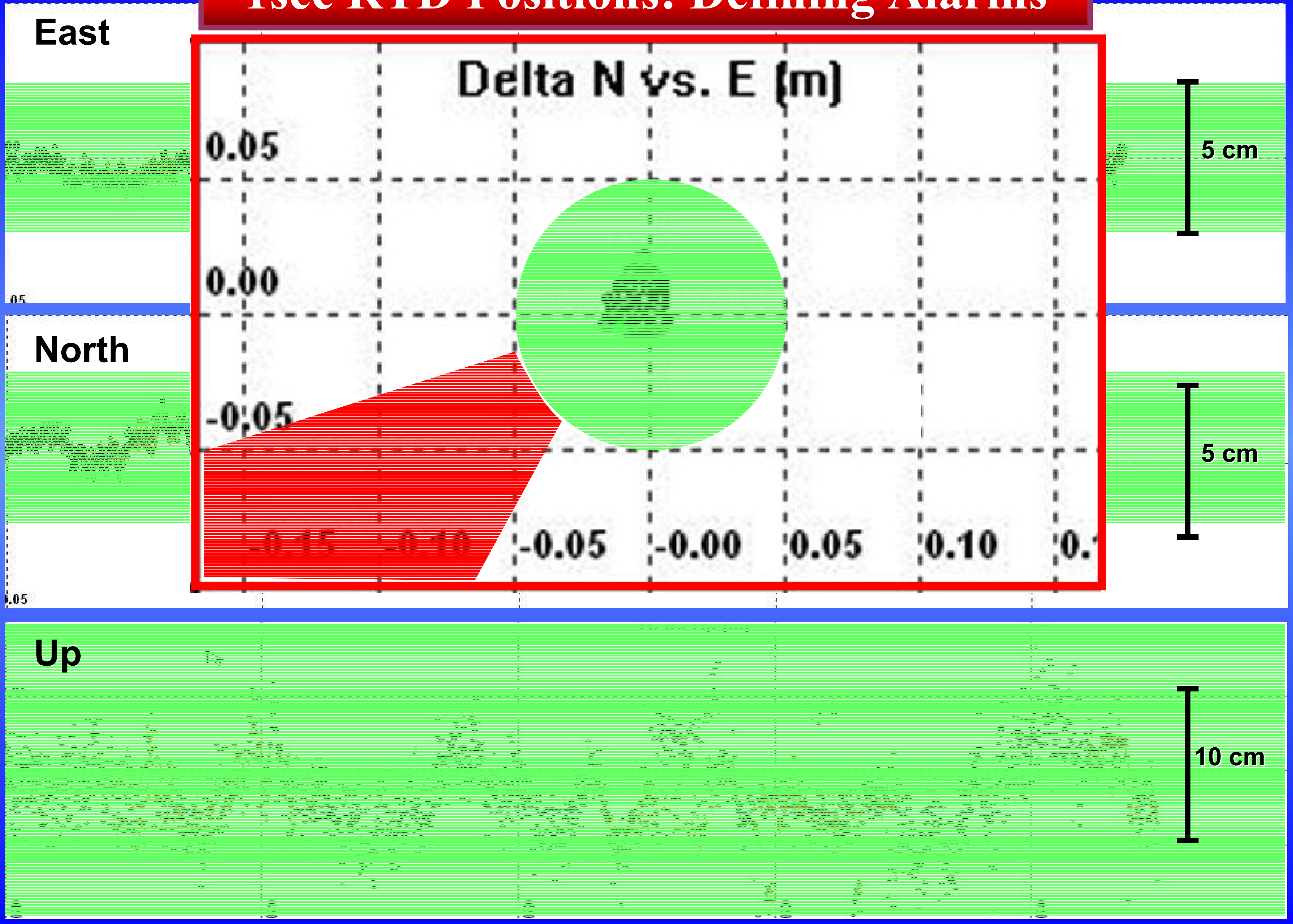
PGC
Tsunami Warning
RTD
CLP
Internet
CLP/PGC
BAMF IP#1/Port #1
CART IP#2/Port #2
ELIZ IP#3/Port #3
NANO IP#4/Port #4
NTKA IP#5/Port #5
PGC5 IP#6/Port #6
PTAL IP#7/Port #7
QUAD
SCO4 …
….
T-Buffer
T-Buffer
Telemetry
SOPAC
General Users
Internet
RTD
CLP
High-Rate Archive

Position Server



RYO Positions

1sec RTD Positions: Defining Alarms



SUMMARY

The technology exists to measure displacements in real time over 30 to 50 km baselines to a precision of 1–2 cm horizontally and 3-5 cm vertically.

We can use this capability to help constrain the magnitude and nature of rupture for offshore earthquakes within a few minutes after the event.

This information can be provided to tsunami warning networks in real-time to aid in rapid establishment of the appropriate tsunami advisory.

We are initiating a 2-year pilot project to determine the capabilities, effectiveness, and operational costs for such a GPS-enhanced tsunami warning network.


The End