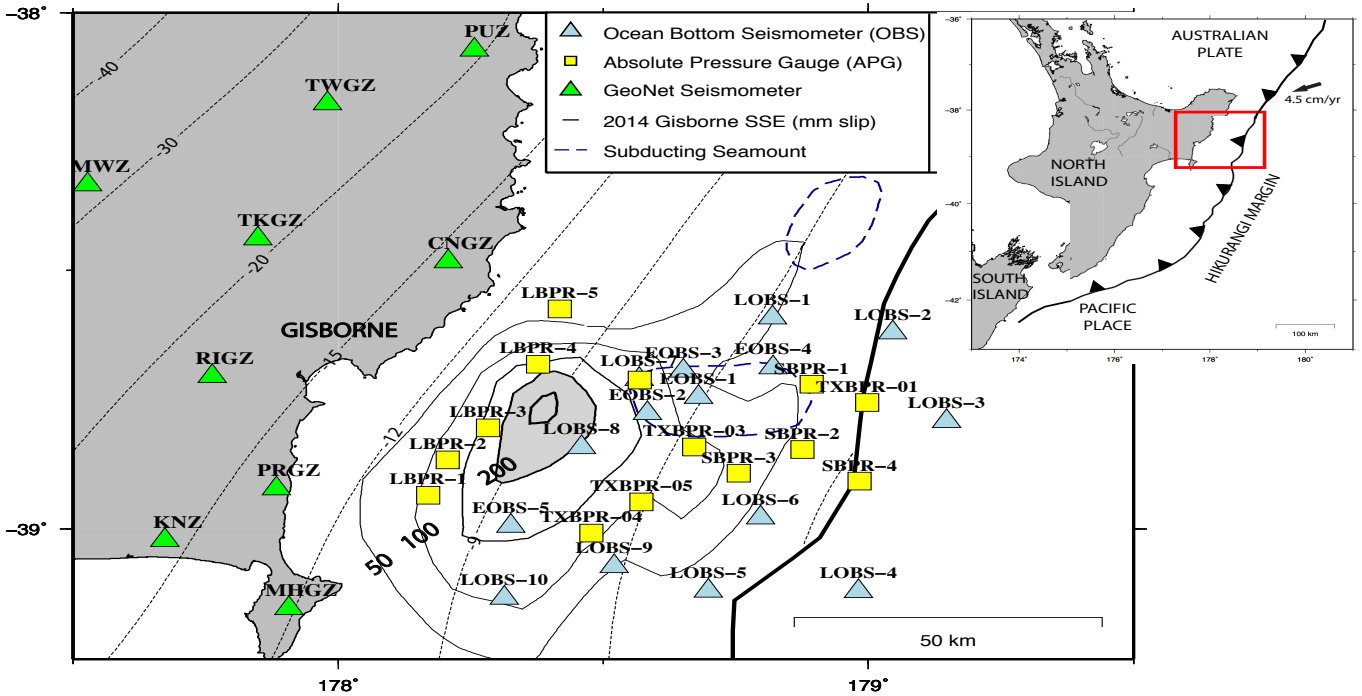
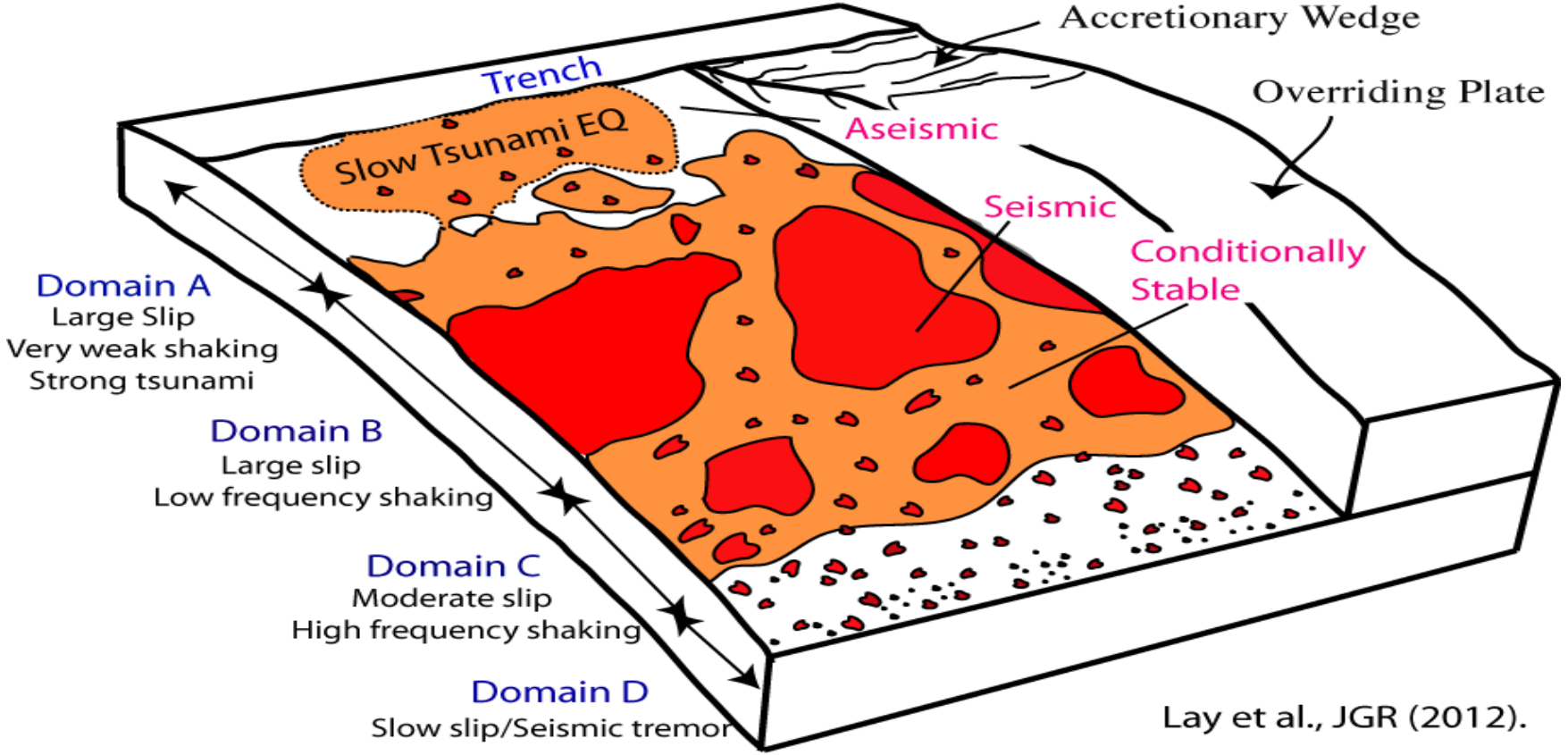
The Slip Behavior of the Shallow Megathrust from Seafloor Observations

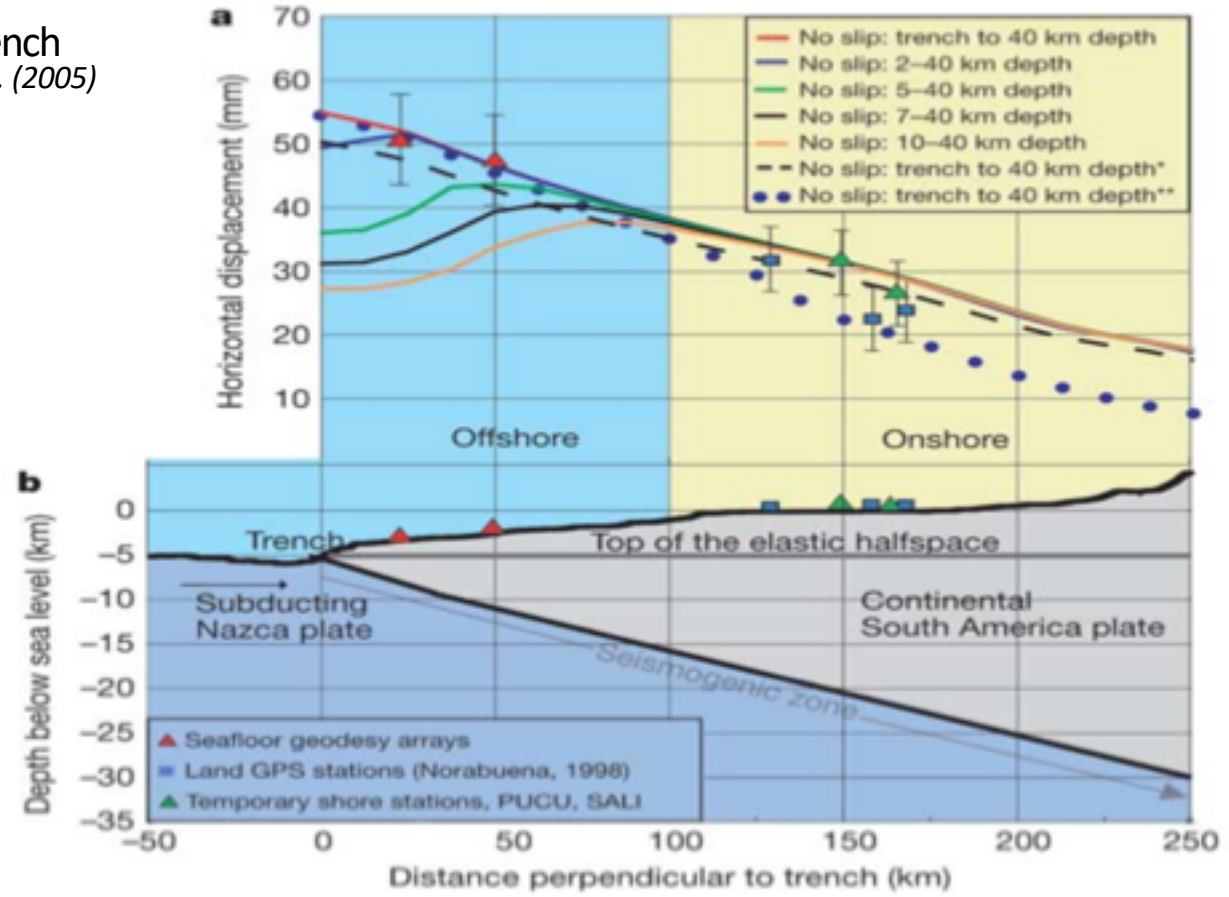
Susan Y. Schwartz- UC Santa Cruz




Accretionary Wedge
Trench
Overriding Plate
Slow Tsunami EQ
Aseismic
Seismic
Conditionally
Stable
Domain A
Large Slip
Very weak shaking
Strong tsunami
Domain B
Large slip
Low frequency shaking
Domain C
Moderate slip
High frequency shaking
Domain D
Slow slip/Seismic tremor
Lay et al., JGR (2012).

Is the Shallow Megathrust Locked?

Peru Trench
Gagnon et al. (2005)



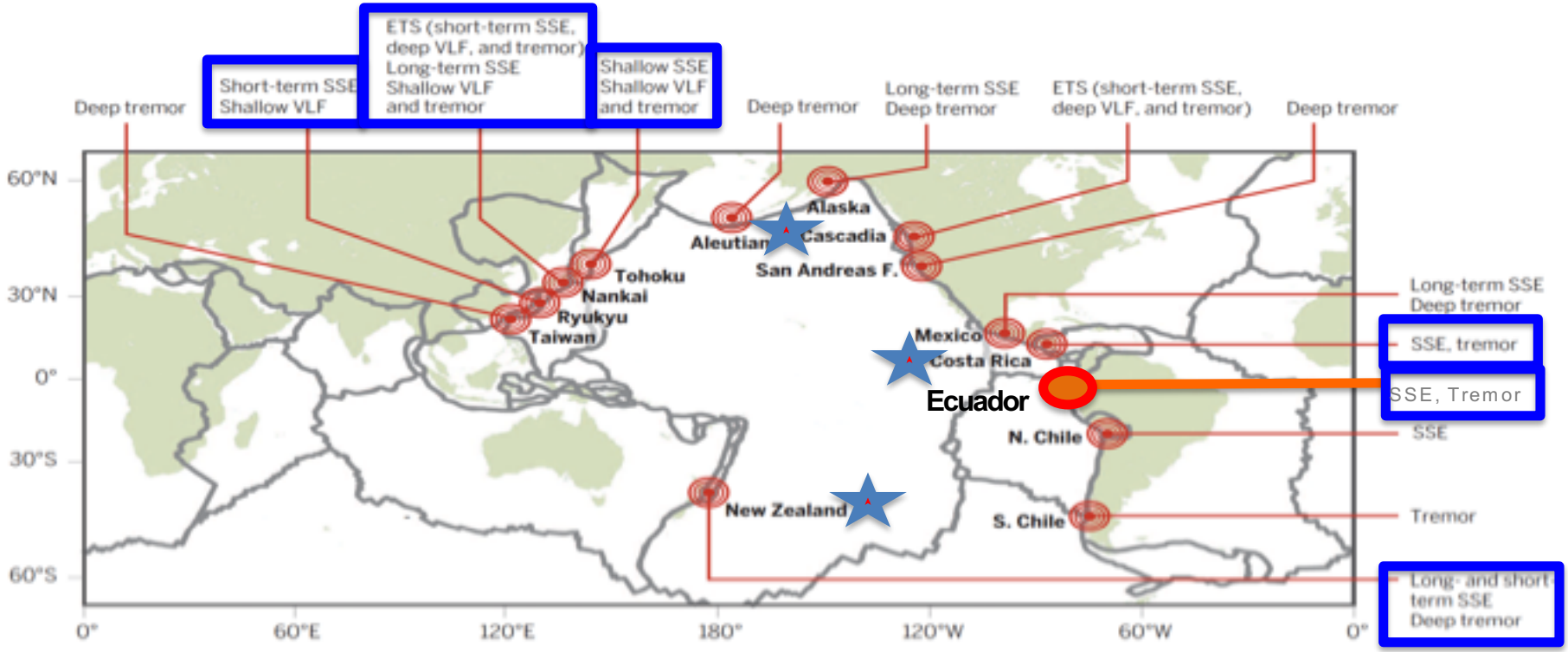
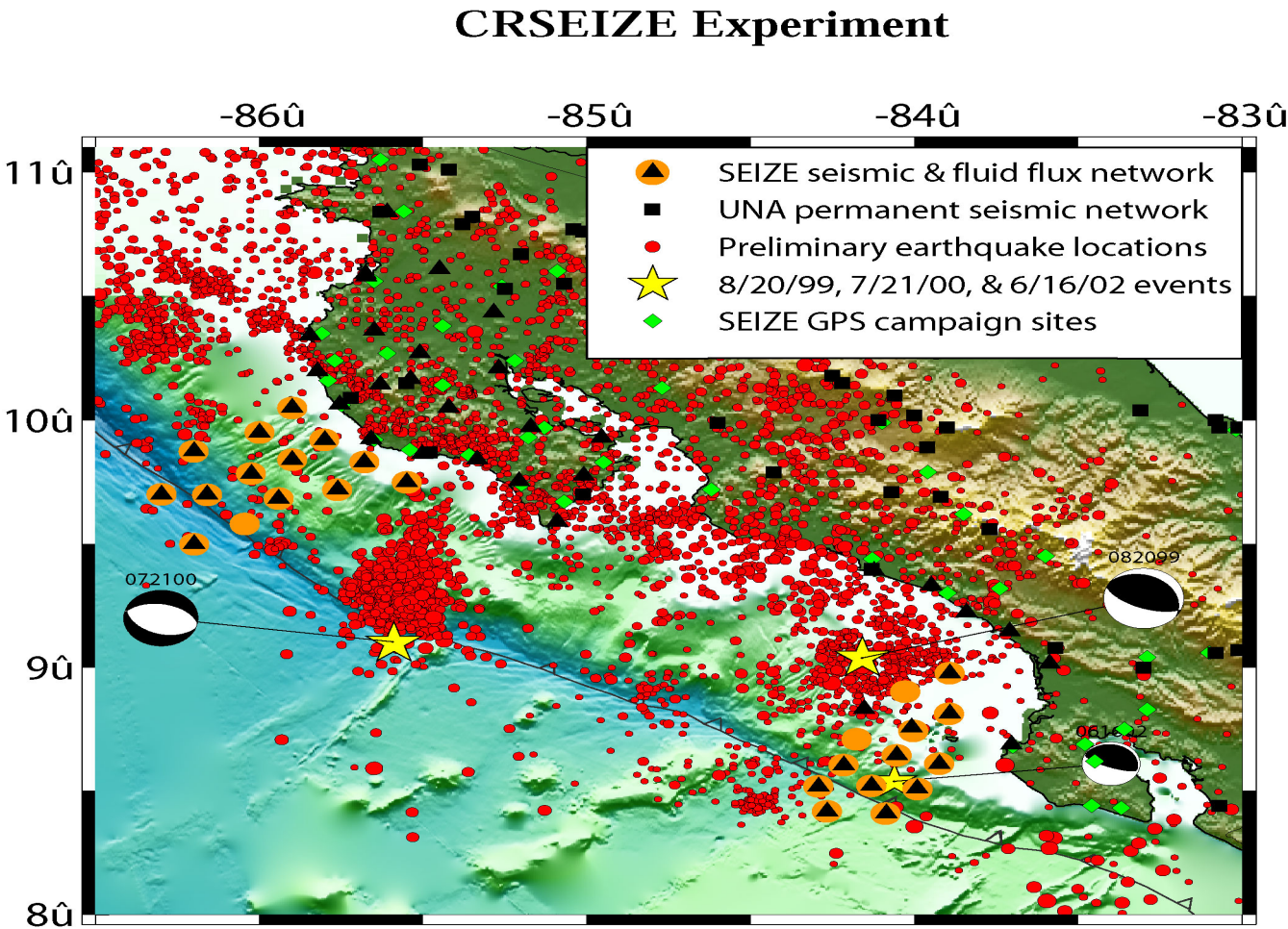


Fig. 3. Global distribution of slow earthquakes.

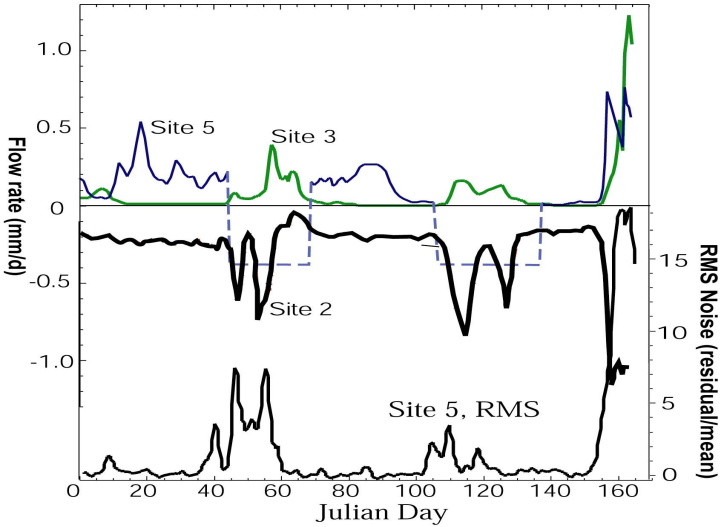
Obara & Kato, 2016

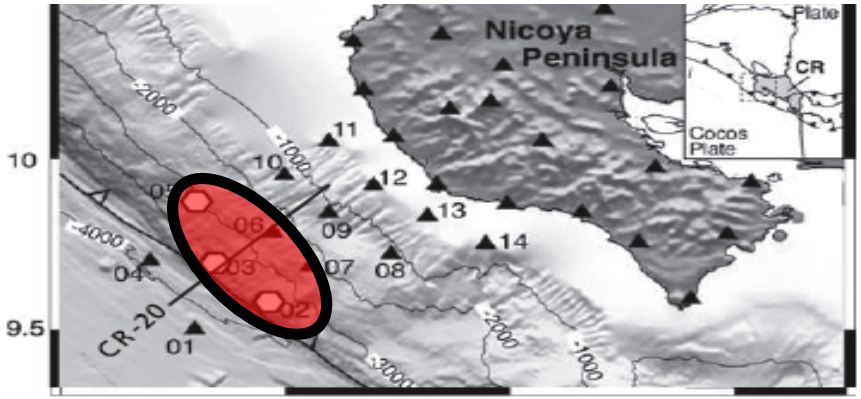
CRSEIZE: Costa Rica Subduction Zone Experiment- Instrumenting the Plate Boundary with a Seismic, GPS and Fluid Flow Network

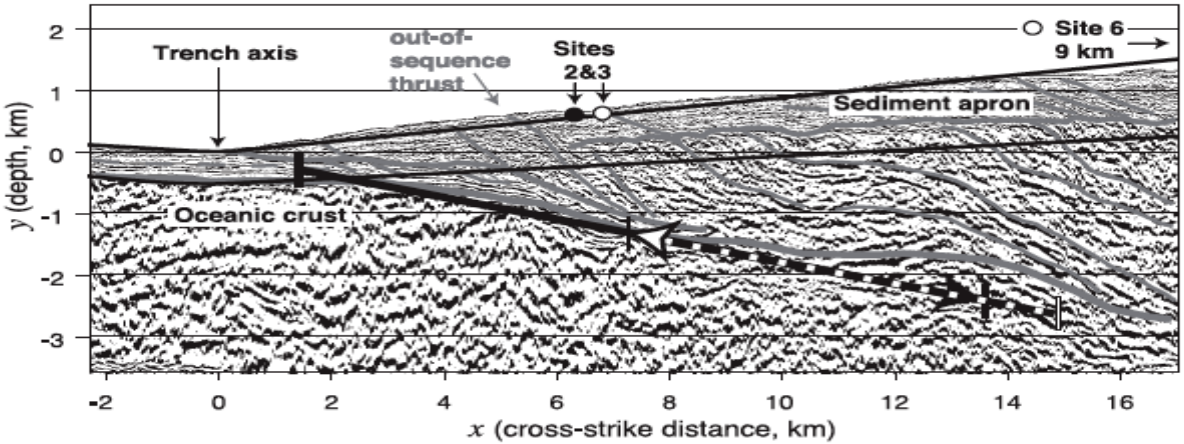
Collaborators: Tim Dixon, Marino Protti, Victor Gonzalez, LeRoy Dorman, Kevin Brown, Heather DeShon, Edmundo Norabuena, Andy Newman, Sue Bilek, Ernst Flueh



2000 Slow Slip Events- Postulated from Fluid Flow

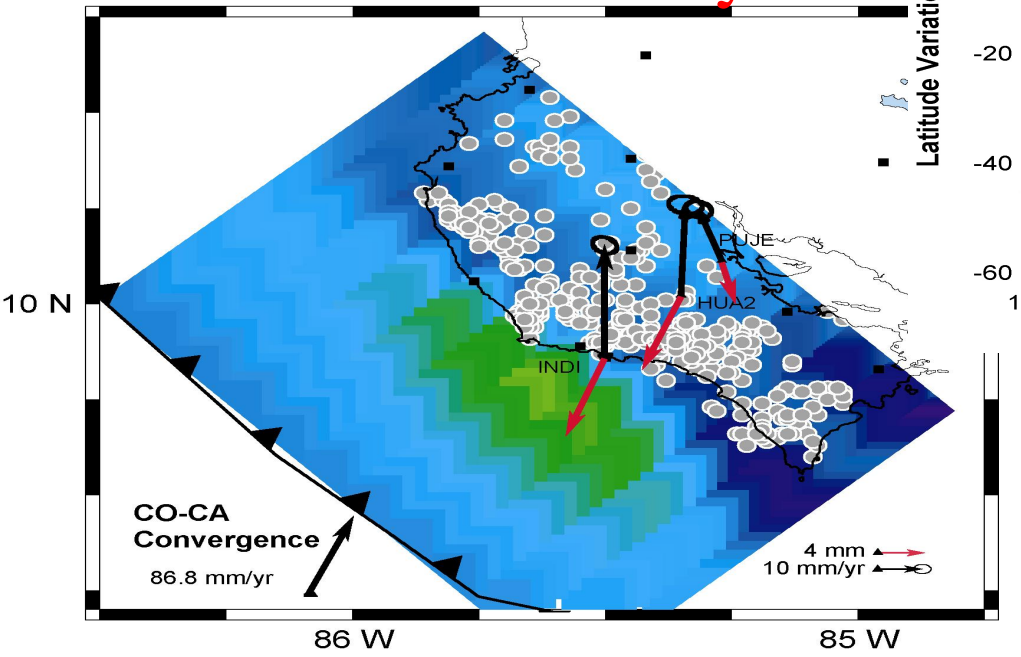


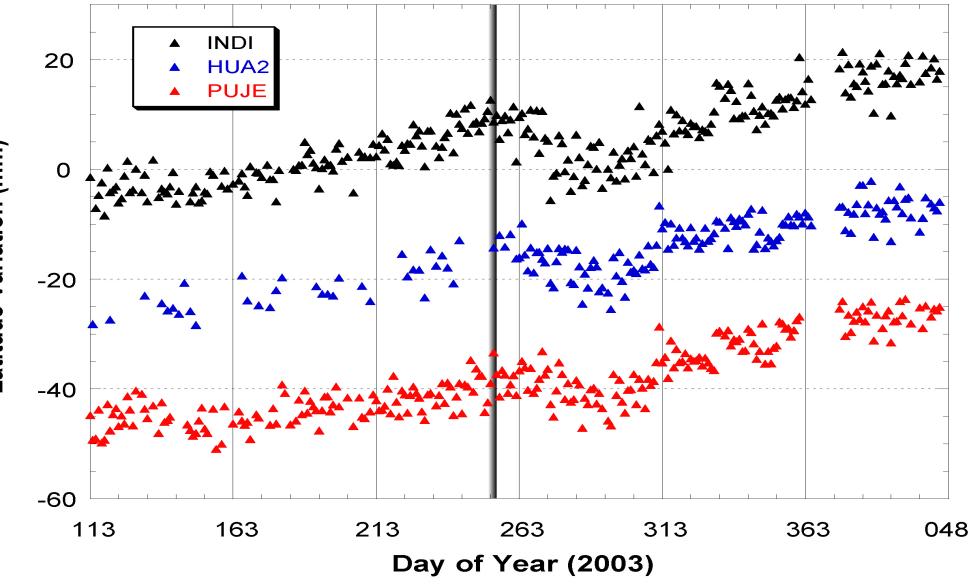


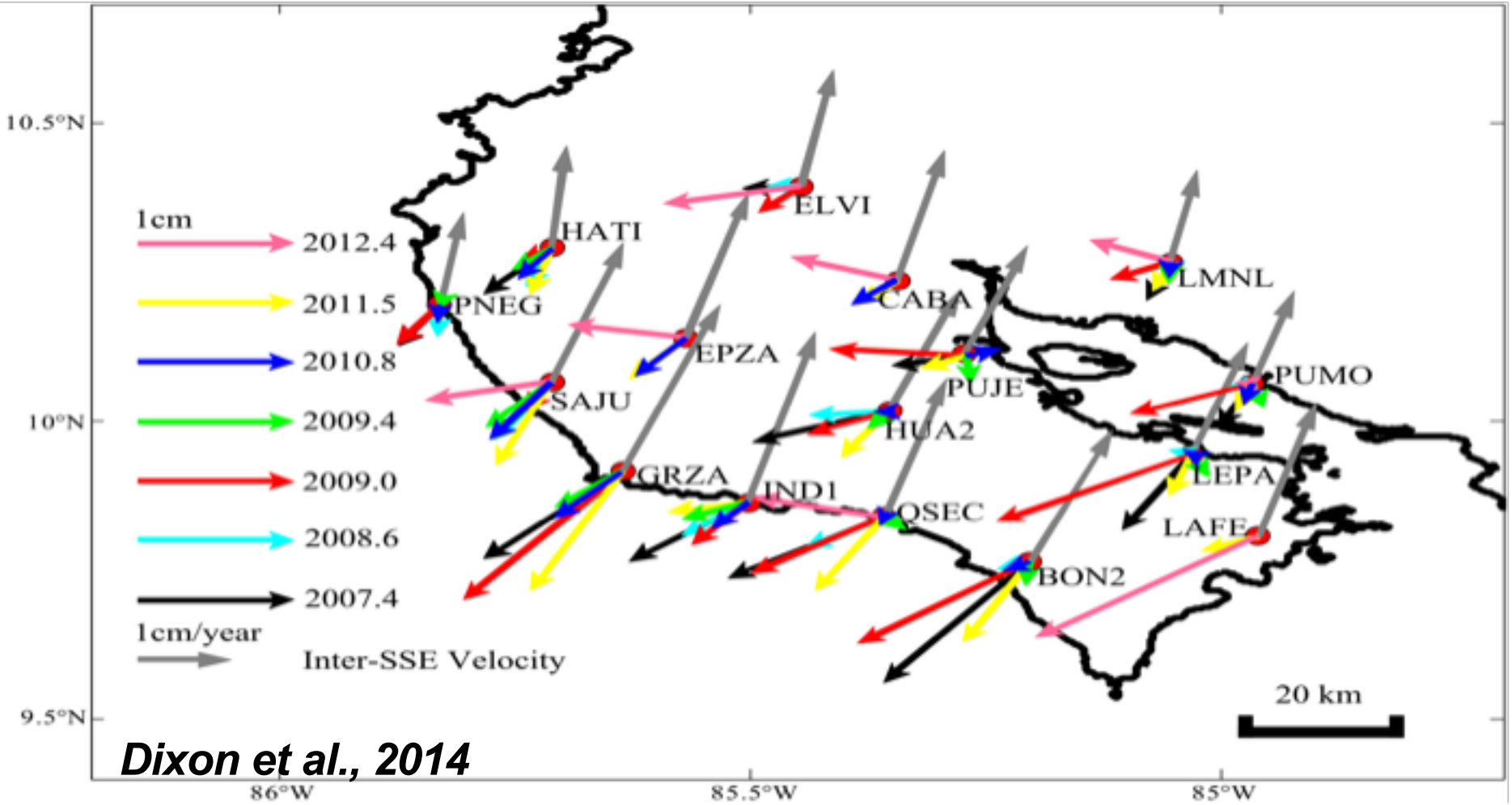


Brown et al., 2005
LaBonte et al., 2009

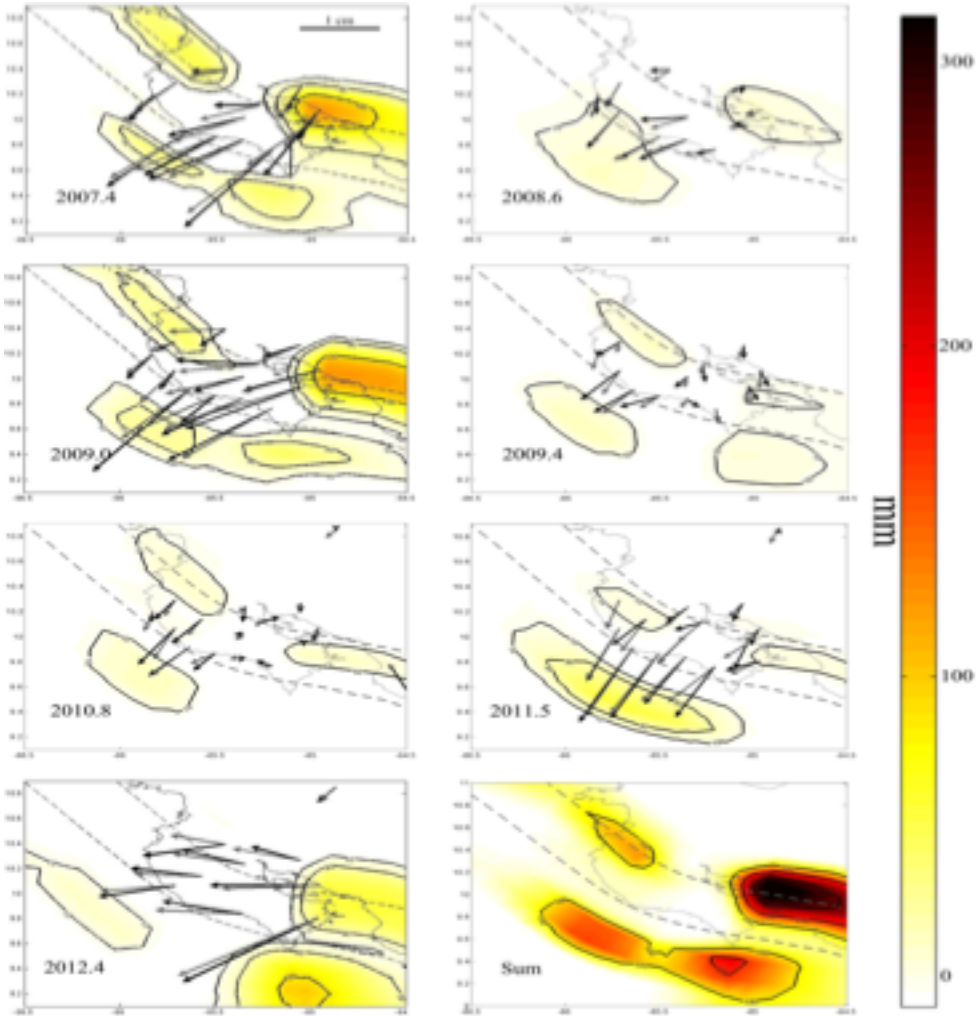
2003 Slow Slip Event- Observed Geodetically







Dixon et al., 2014

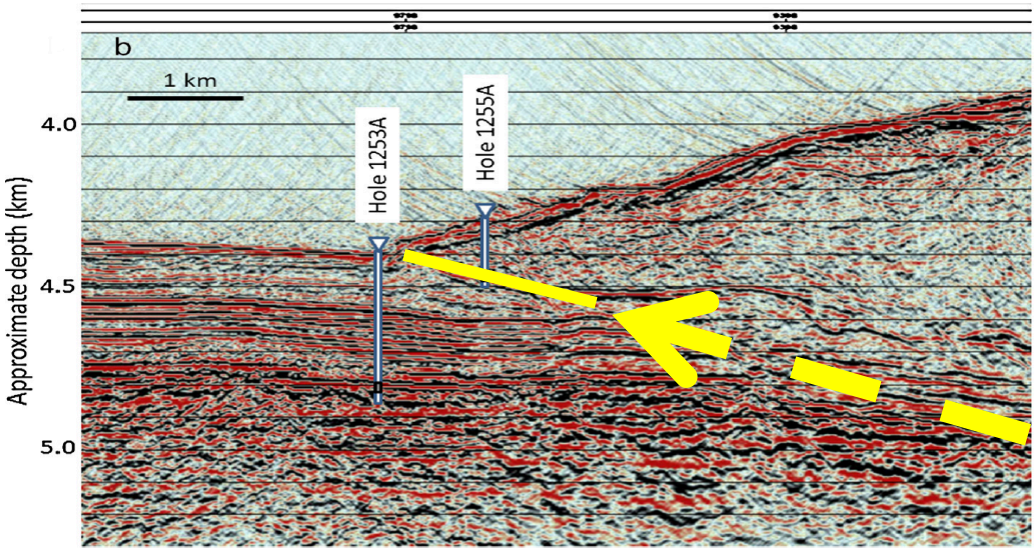


Slow slip occurs both up- and down-dip of the seismogenic zone.

Up-dip slow slip ***may*** extend to very close to the trench. ***Not well resolved***

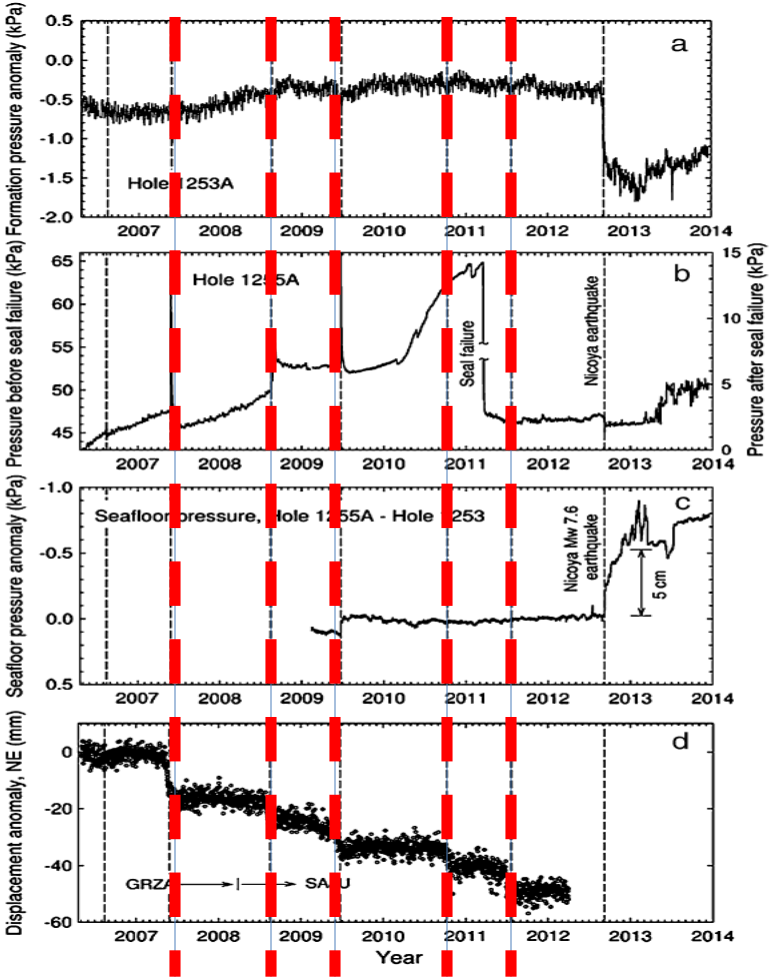
If the present rate of shallow slow slip exists, all interseismic strain accumulation is released in slow slip.

Dixon et al., 2014



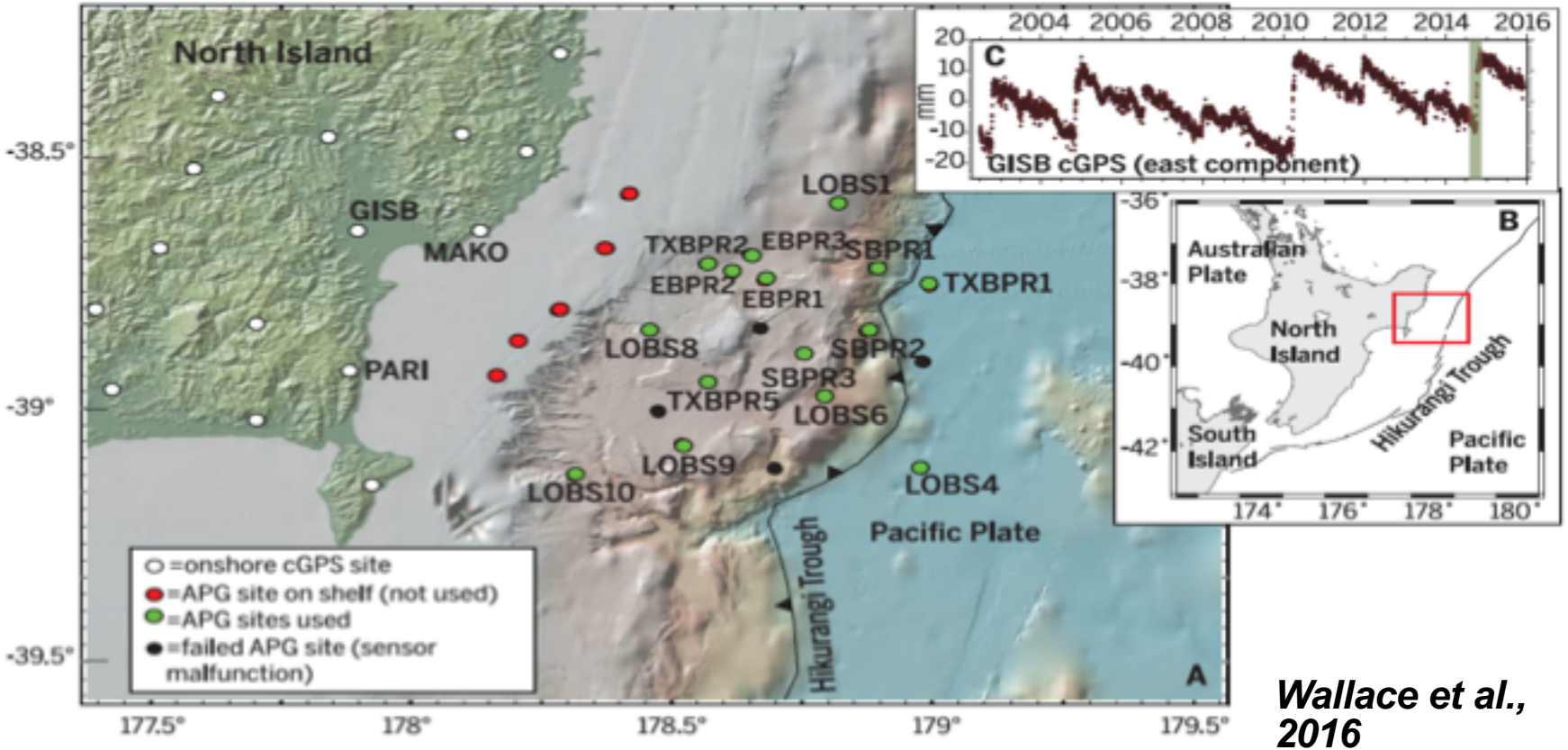
Davis et al., 2015

Slow slip initiates offshore and propagates to the trench



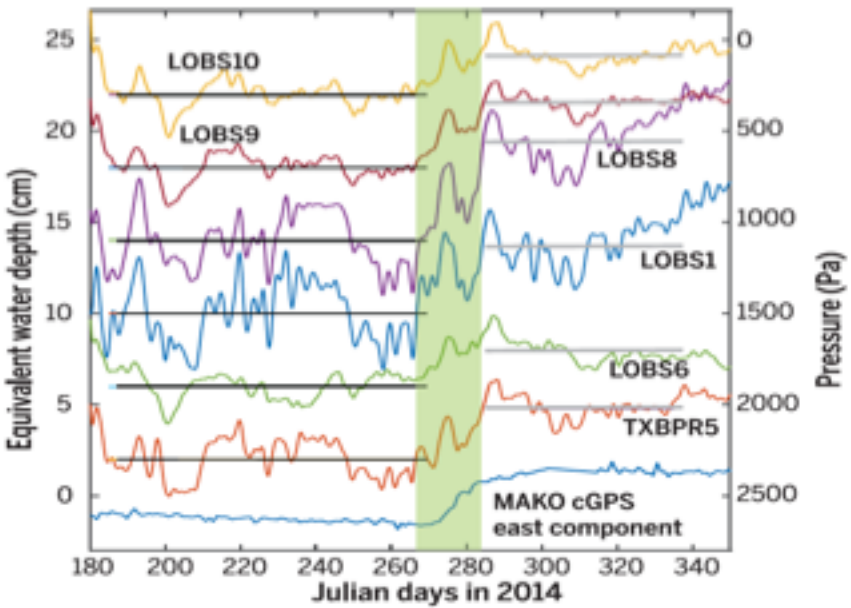
Hikurangi Ocean Bottom Investigation of Tremor and Slow Slip

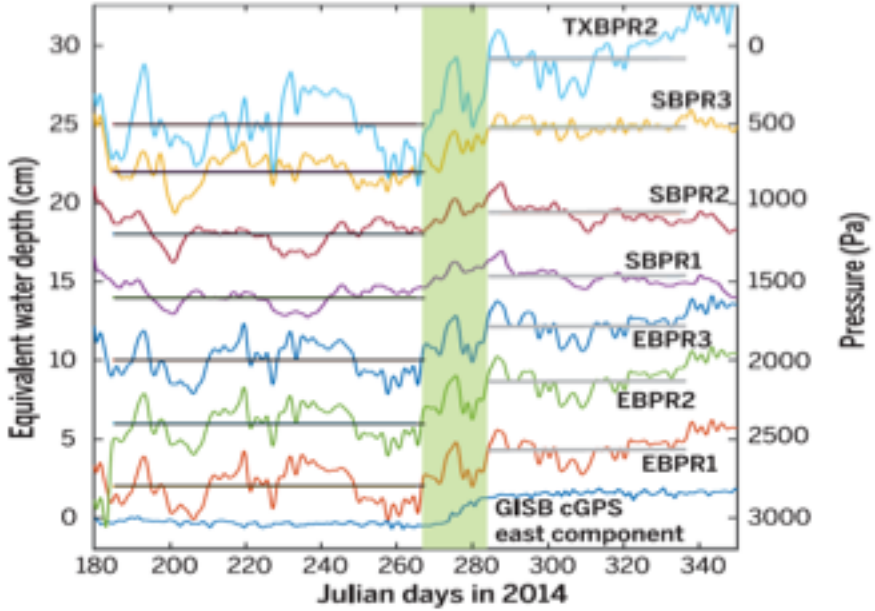
HOBITSS



Wallace et al., 2016

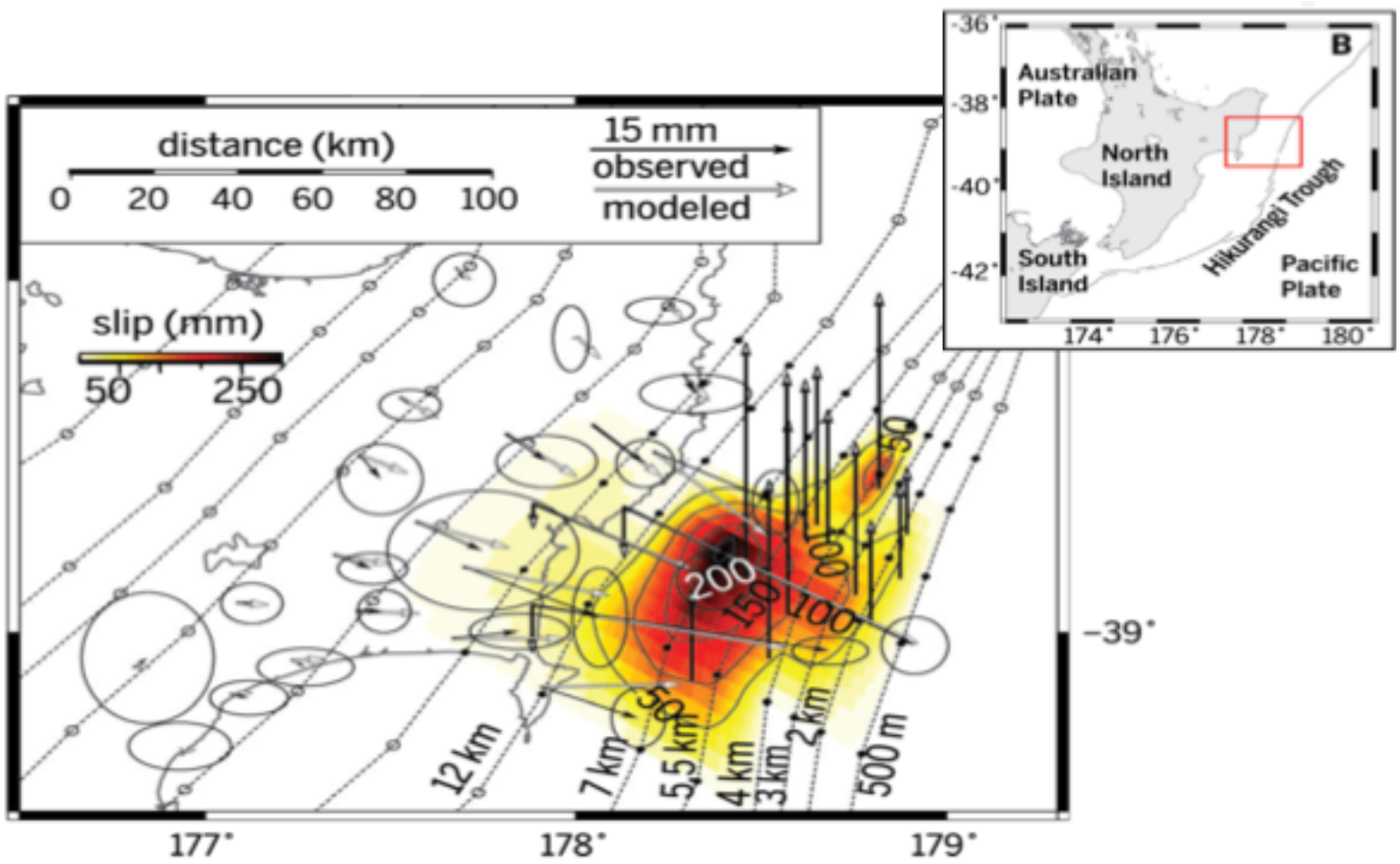
Ocean Bottom Pressure Data

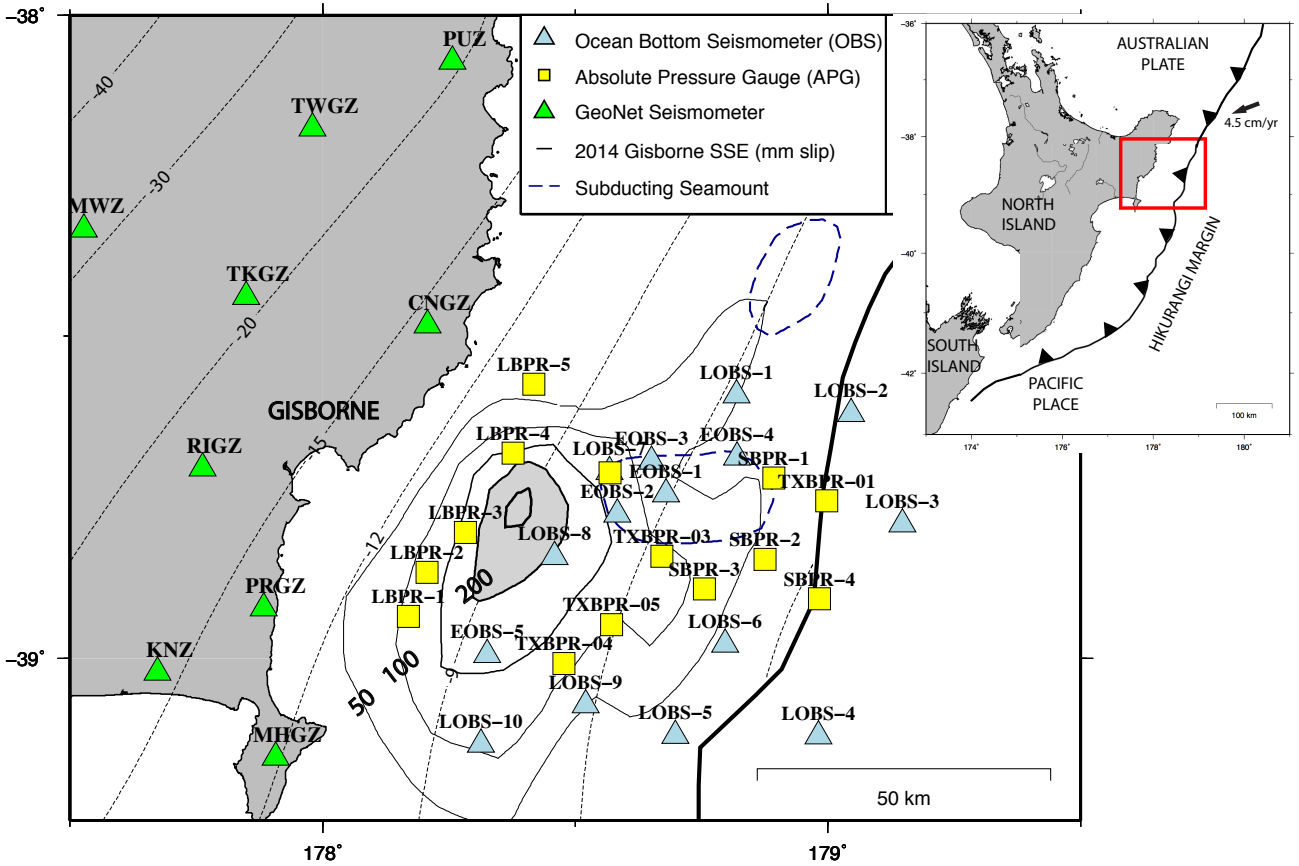


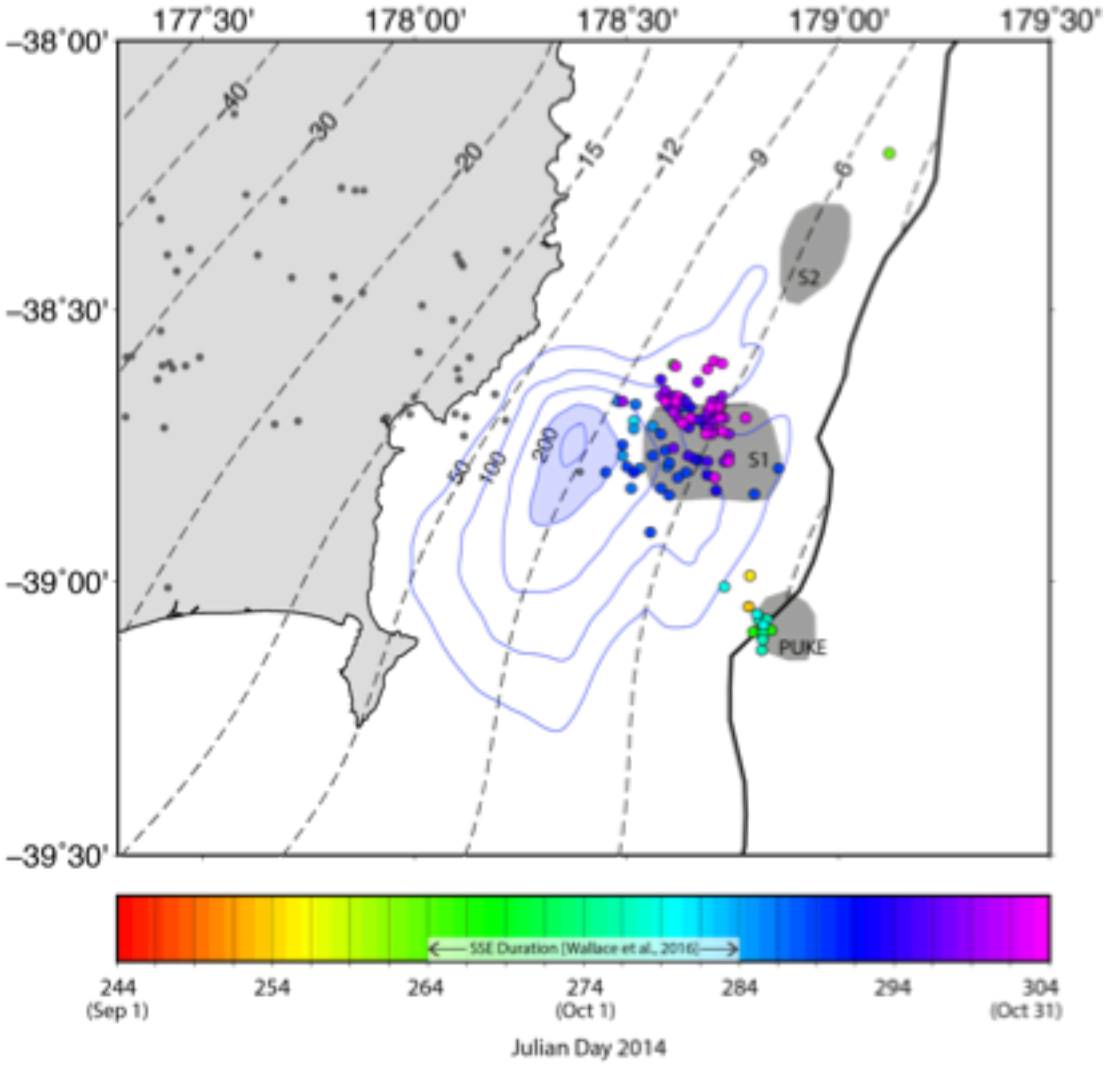


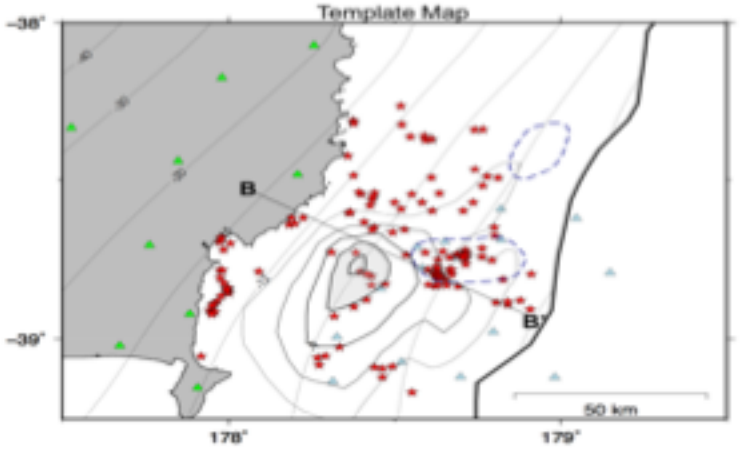
Seafloor moves up ~2-5 cm

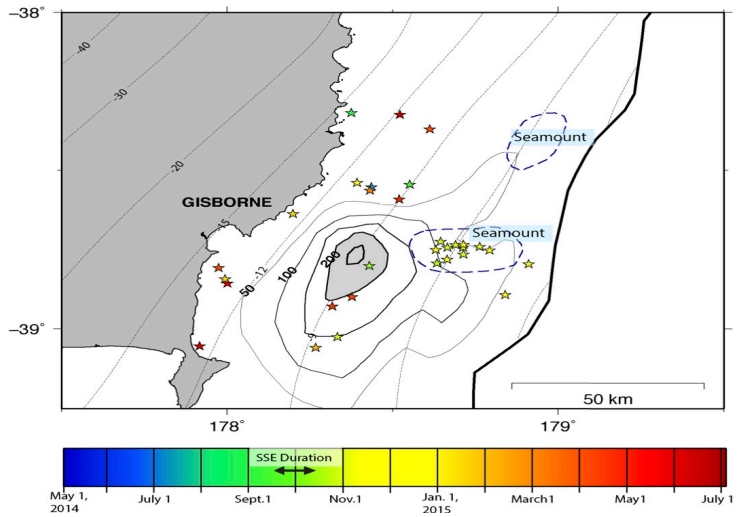
Wallace et al., 2016

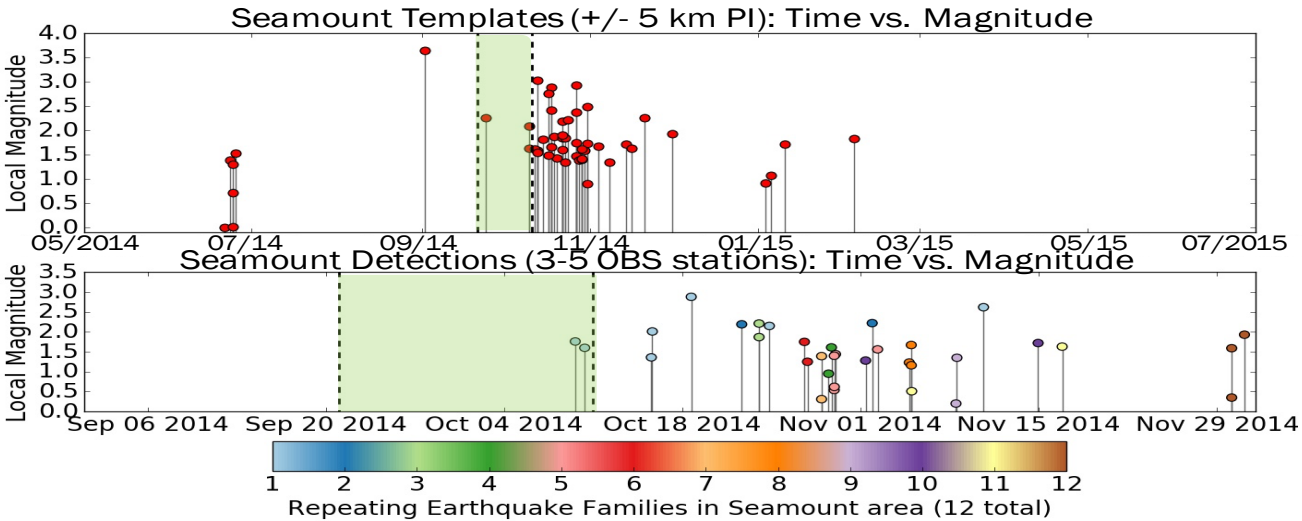

distance (km)
0 20 40 60 80 100
15 mm
observed
modeled
slip (mm)
50 250
200
150
100
50
12 km
7 km
5.5 km
4 km
3 km
2 km
500 m
177°
178°
179°
-39°
-36°
-38°
-40°
-42°
174°
176°
178°
180°
B
Australian Plate
North Island
South Island
Hikurangi Trough
Pacific Plate

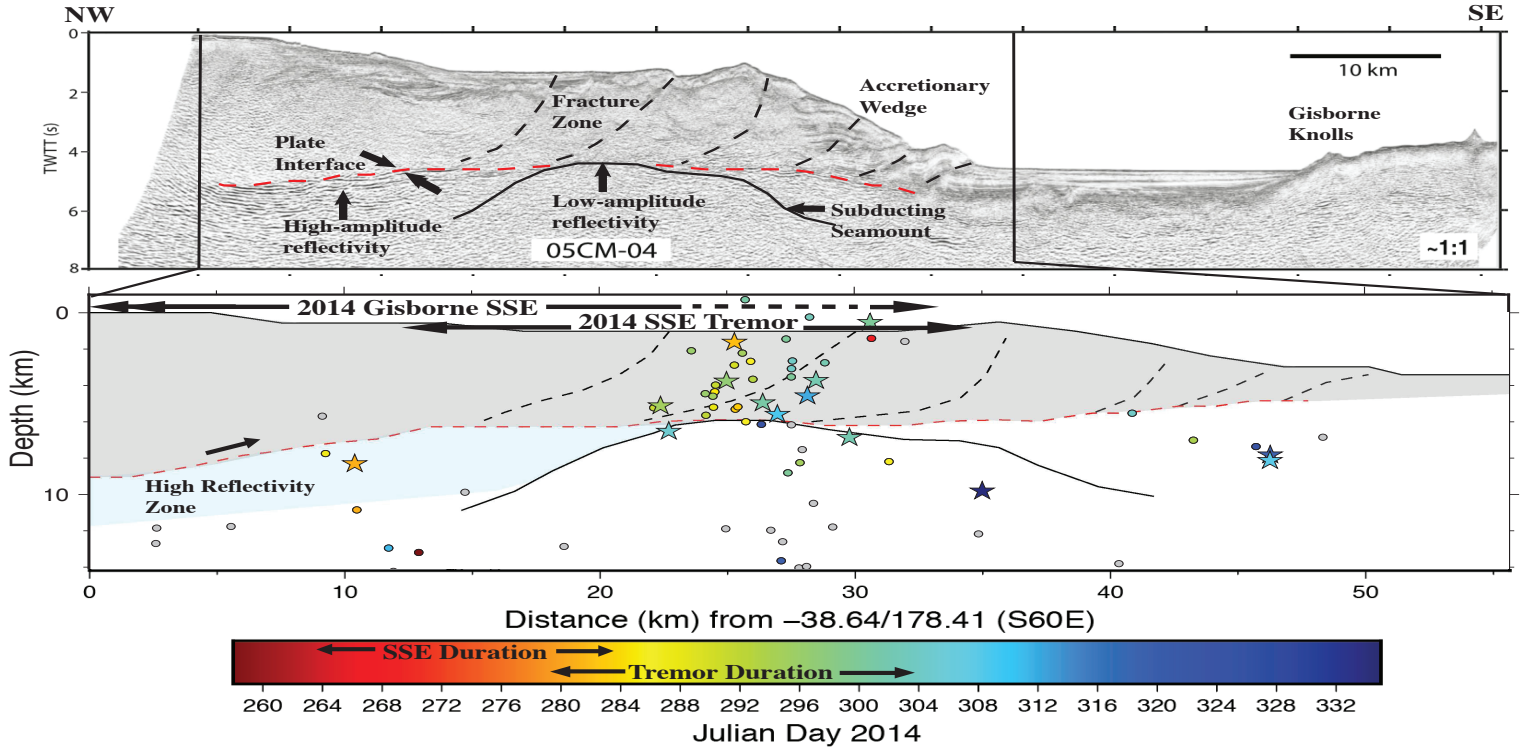

Ocean Bottom Seismometer (OBS)
Absolute Pressure Gauge (APG)
GeoNet Seismometer
2014 Gisborne SSE (mm slip)
Subducting Seamount
PUZ
TWGZ
MWZ
TKGZ
CNGZ
RIGZ
PRGZ
KNZ
MHGZ
GISBORNE
LBPR–5
LBPR–4
LBPR–3
LBPR–2
LBPR–1
EOBS–5
LOBS–10
LOBS–8
LOBS–9
TXBPR–04
TXBPR–05
TXBPR–03
EOBS–3
EOBS–4
EOBS–1
EOBS–2
LOBS–1
LOBS–2
LOBS–3
LOBS–6
LOBS–5
LOBS–4
SBPR–1
SBPR–2
SBPR–3
SBPR–4
TXBPR–01
40
30
20
15
12
9
200
100
50
–38°
–39°
178°
179°
50 km
AUSTRALIAN PLATE
4.5 cm/yr
NORTH ISLAND
SOUTH ISLAND
PACIFIC PLACE
HIKURANGI MARGIN
100 km


177°30'
178°00'
178°30'
179°00'
179°30'
-38°00'
-38°30'
-39°00'
-39°30'
40
30
20
15
12
9
6
50
100
200
S1
S2
PUKE
SSE Duration [Wallace et al., 2016]
244
(Sep 1)
254
264
274
(Oct 1)
284
294
304
(Oct 31)
Julian Day 2014


Template Map
-38°
-39°
B
B'
50 km
178°
179°

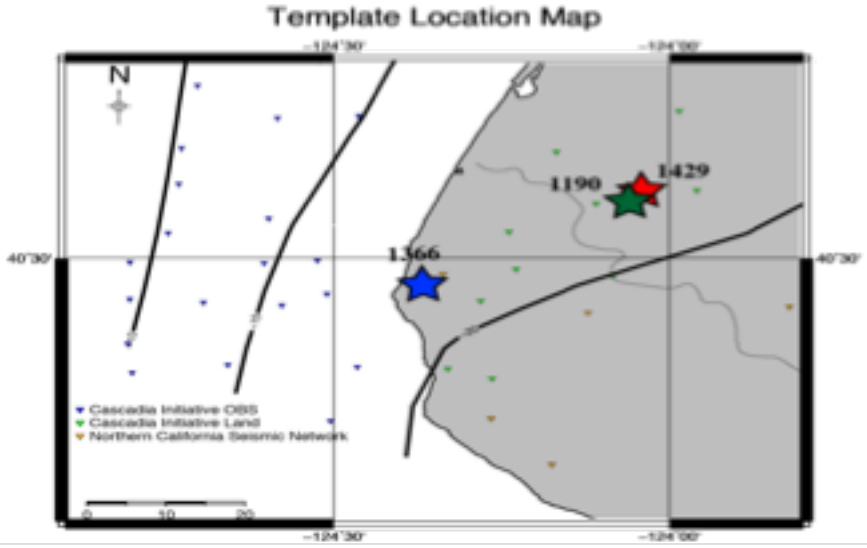

-38°
-39°
GISBORNE
Seamount
Seamount
50 km
178°
179°
SSE Duration
May 1, 2014
July 1
Sept.1
Nov.1
Jan. 1, 2015
March1
May1
July 1

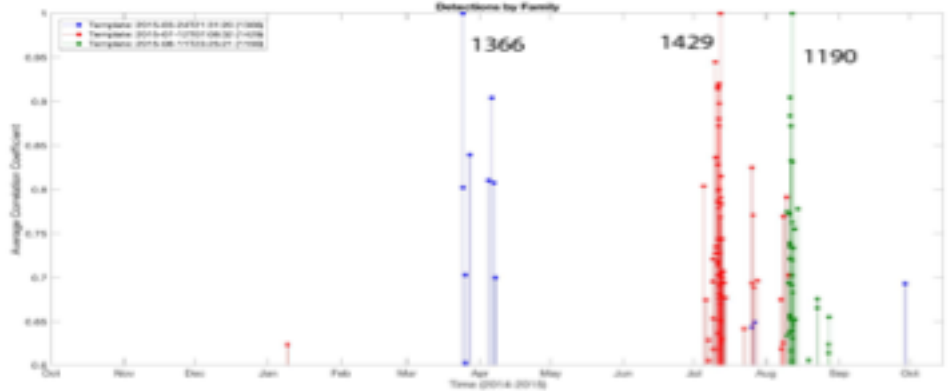

Seamount Templates (+/- 5 km PI): Time vs. Magnitude
Local Magnitude
05/2014
07/14
09/14
11/14
01/15
03/15
05/15
07/2015
Seamount Detections (3-5 OBS stations): Time vs. Magnitude
Local Magnitude
Sep 06 2014
Sep 20 2014
Oct 04 2014
Oct 18 2014
Nov 01 2014
Nov 15 2014
Nov 29 2014
Repeating Earthquake Families in Seamount area (12 total)


NW
SE
TWTT (s)
Plate Interface
Fracture Zone
Accretionary Wedge
High-amplitude reflectivity
Low-amplitude reflectivity
Subducting Seamount
05CM-04
10 km
Gisborne Knolls
~1:1
2014 Gisborne SSE
2014 SSE Tremor
Depth (km)
High Reflectivity Zone
Distance (km) from –38.64/178.41 (S60E)
SSE Duration
Tremor Duration
Julian Day 2014

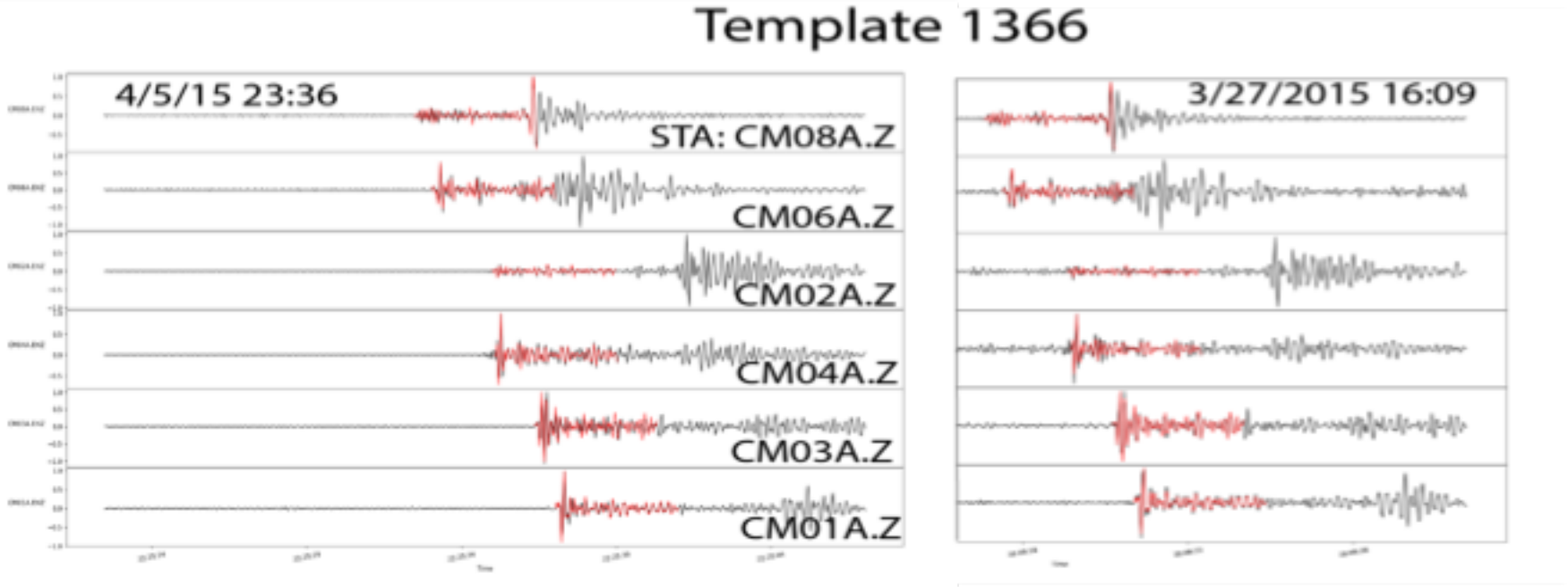
California Summer School for Mathematics and Science- Cluster 4
California Hazards: Earthquakes and Climate Change

COSMOS
UC Santa Cruz
California State Summer School for Mathematics and Science


Template Location Map
−124°30'
−124°00'
N
1190
1429
1366
40°30'
40°30'
Cascadia Initiative OBS
Cascadia Initiative Land
Northern California Seismic Network
0
10
20
−124°30'
−124°00'


Detections by Family
1366
1429
1190
Average Correlation Coefficient
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct

Template Matching with Seismic Data



CONTINUING WORK:

1. Pick P and S arrivals and locate new events.
2. Determine faulting geometry of earthquakes to establish which events are on the plate interface.
3. Perform template matching to identify repeating sequences.
4. Correlate our postulated shallow slow slip events with geodetic data (CI- APGs, borehole strain, GPS) and seismic tremor