

The Role of Science and Technology in Earthquake Hazard Characterization: A Chilean Experience

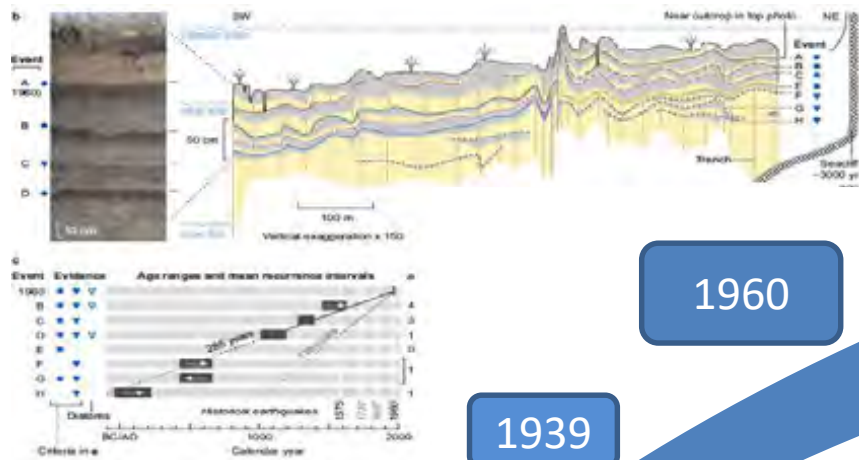


*STI Contribution to Policy Making on Natural Disaster Resilience
APEC – Workshop, 1-2 August 2018
Santiago - Chile*

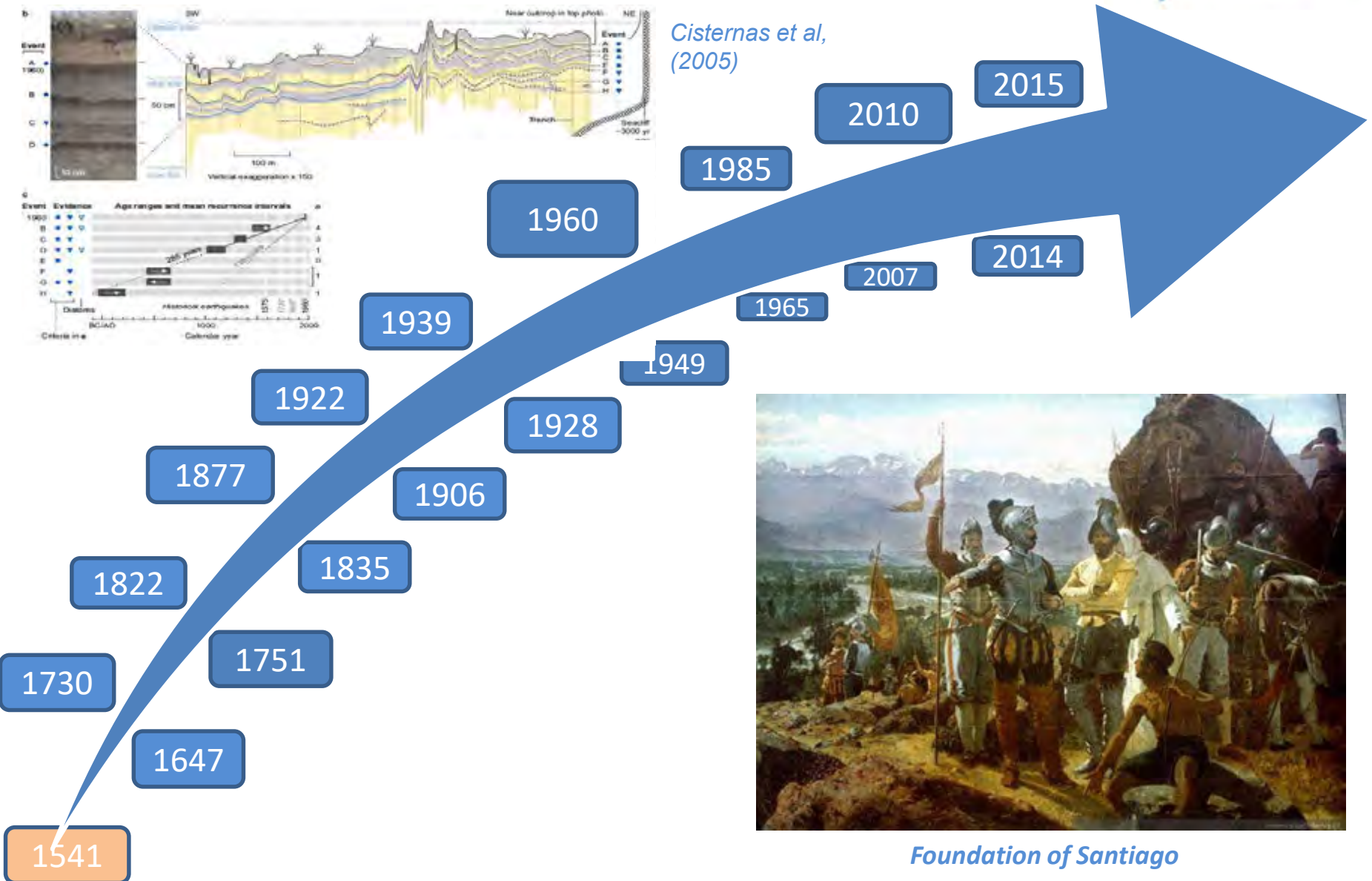
*Sergio Barrientos
Director
Centro Sismológico Nacional
Universidad de Chile*



Some Significant Earthquakes in Chile



Cisternas et al, (2005)

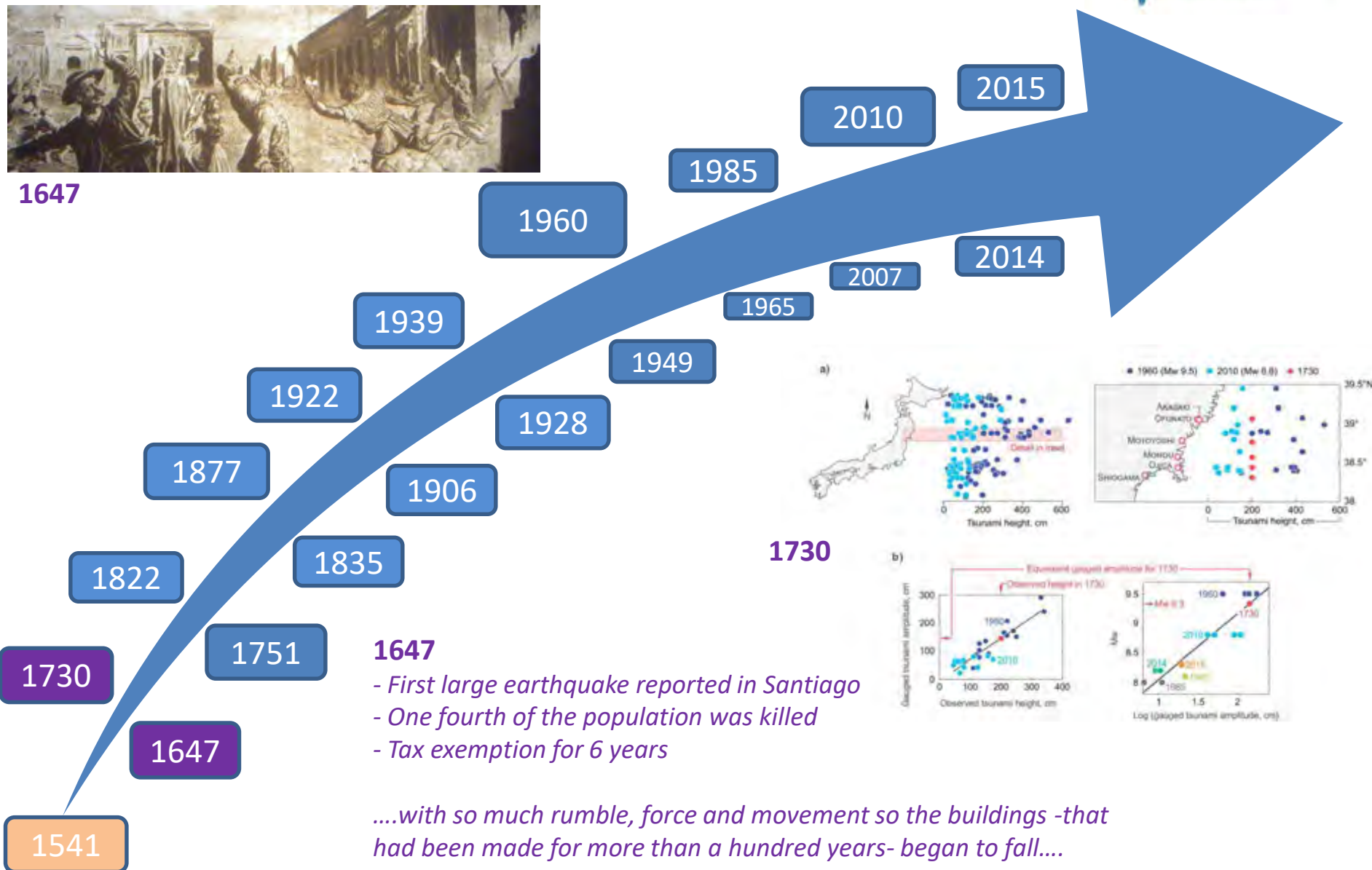


Foundation of Santiago

Some Significant Earthquakes in Chile



1647

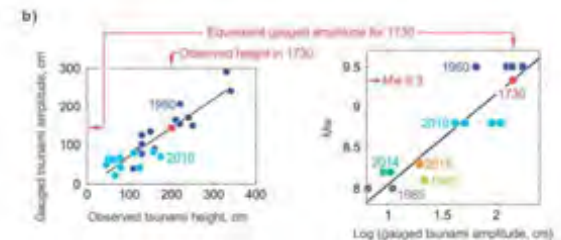
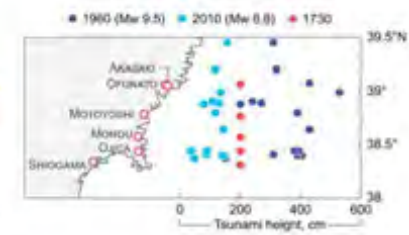
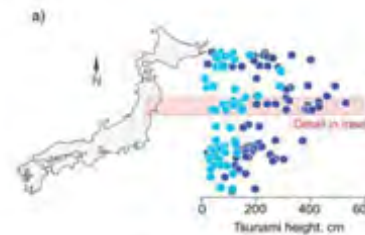


1647

- First large earthquake reported in Santiago
- One fourth of the population was killed
- Tax exemption for 6 years

1730

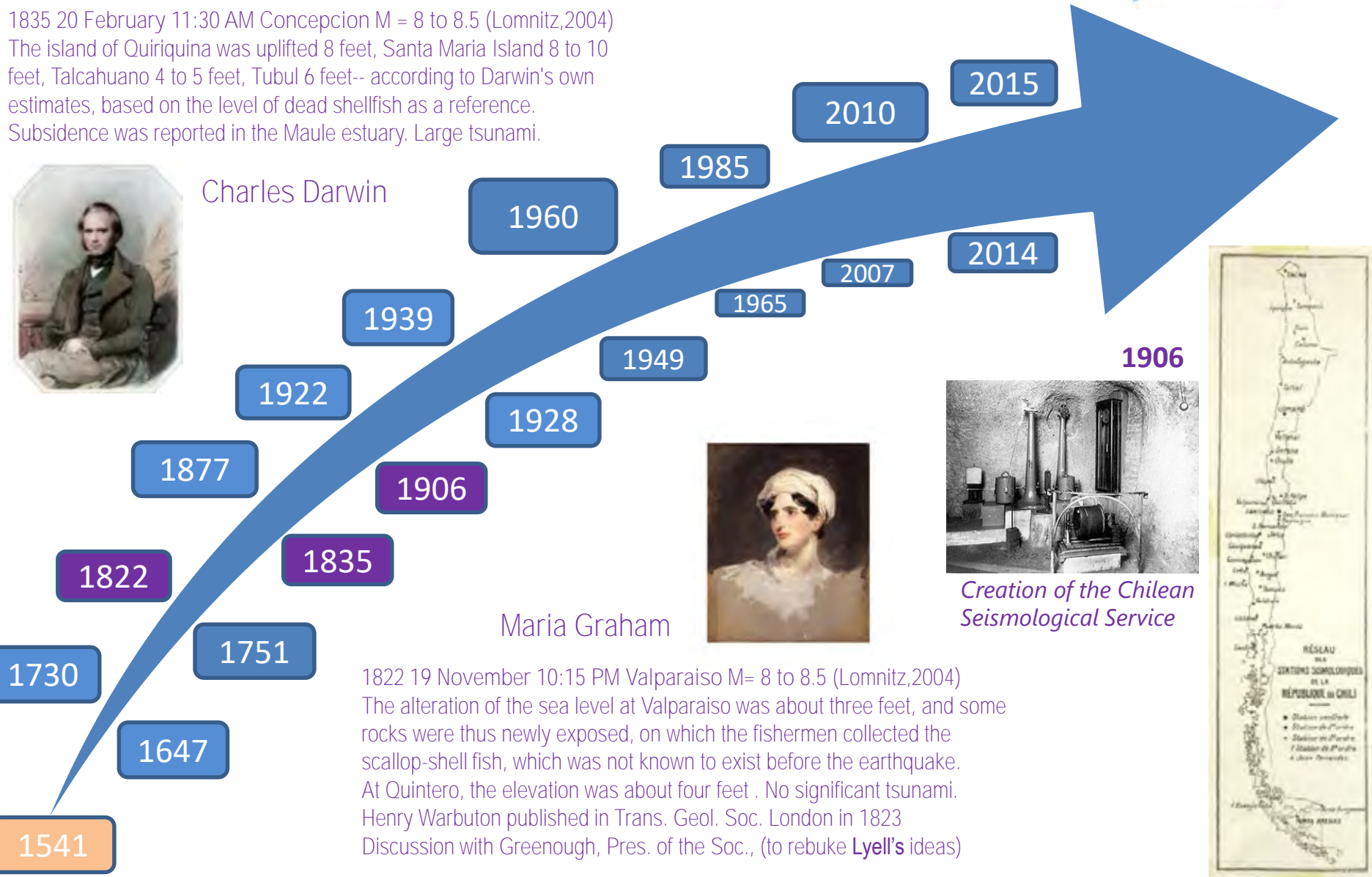
....with so much rumble, force and movement so the buildings -that had been made for more than a hundred years- began to fall....



Some Significant Earthquakes in Chile

1835 20 February 11:30 AM Concepcion M = 8 to 8.5 (Lomnitz,2004)
The island of Quiriquina was uplifted 8 feet, Santa Maria Island 8 to 10 feet, Talcahuano 4 to 5 feet, Tubul 6 feet-- according to Darwin's own estimates, based on the level of dead shellfish as a reference. Subsidence was reported in the Maule estuary. Large tsunami.

Charles Darwin



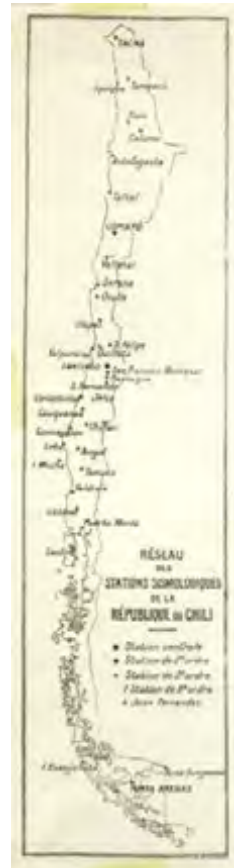
Maria Graham



1822 19 November 10:15 PM Valparaiso M= 8 to 8.5 (Lomnitz,2004)
The alteration of the sea level at Valparaiso was about three feet, and some rocks were thus newly exposed, on which the fishermen collected the scallop-shell fish, which was not known to exist before the earthquake. At Quintero, the elevation was about four feet. No significant tsunami. Henry Warbuton published in Trans. Geol. Soc. London in 1823 Discussion with Greenough, Pres. of the Soc., (to rebuke **Lyell's** ideas)



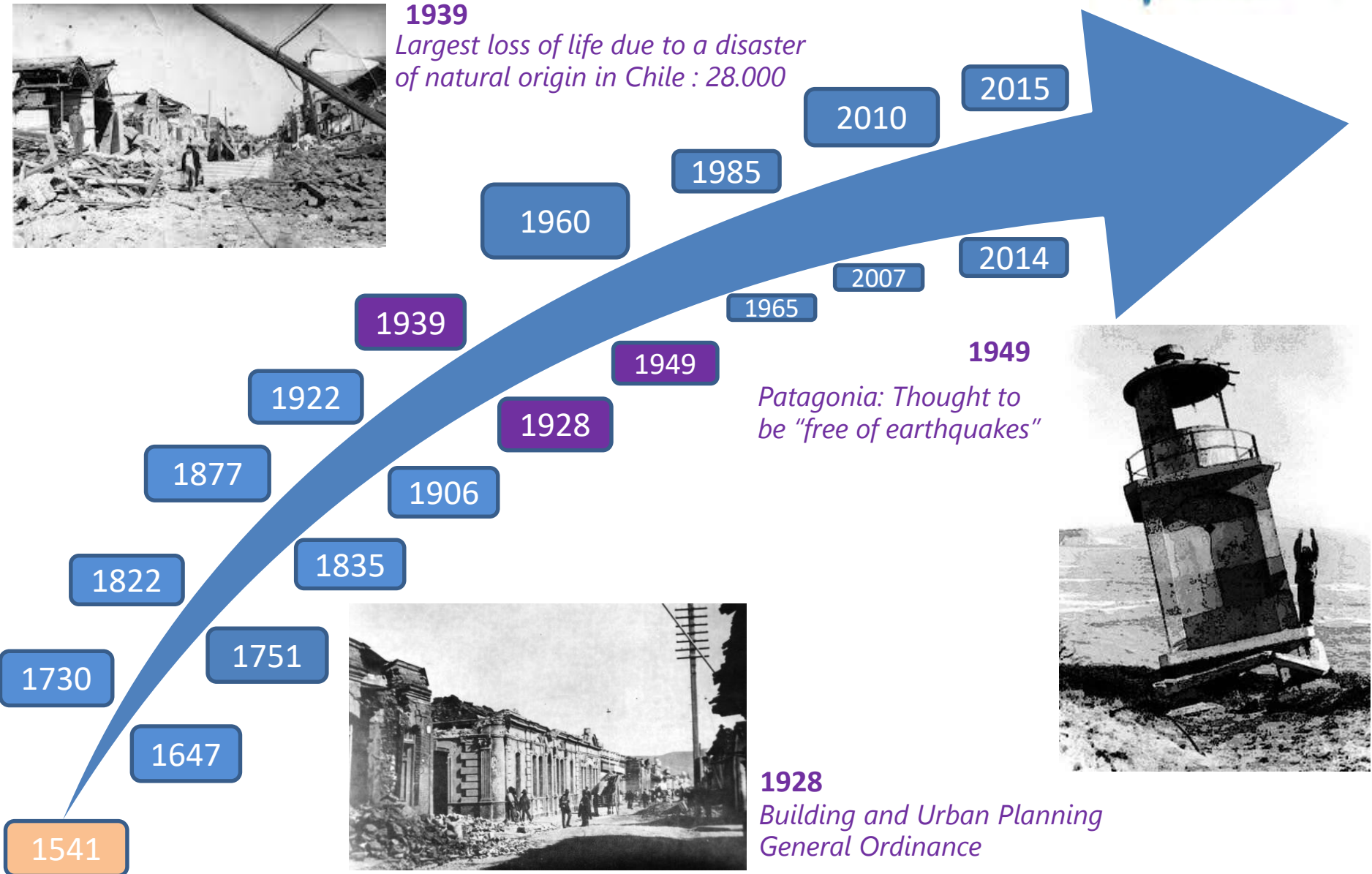
Creation of the Chilean Seismological Service



Some Significant Earthquakes in Chile



1939
Largest loss of life due to a disaster of natural origin in Chile : 28.000



Some Significant Earthquakes in Chile



*Largest event in historical instrumental seismology:
1000-km-long rupture. Estimated toll:
between 2000 and 5000.*

1960

1960

1985

2010

2015

2014

2007

1965

1949

1928

1906

1939

1922

1877

1822

1835

1751

1647

1730

1541

1965

*Failed tailing-dam; unknown number
deaths probably more than 200
Intermediate depth, normal fault
Precursor of Onemi created*



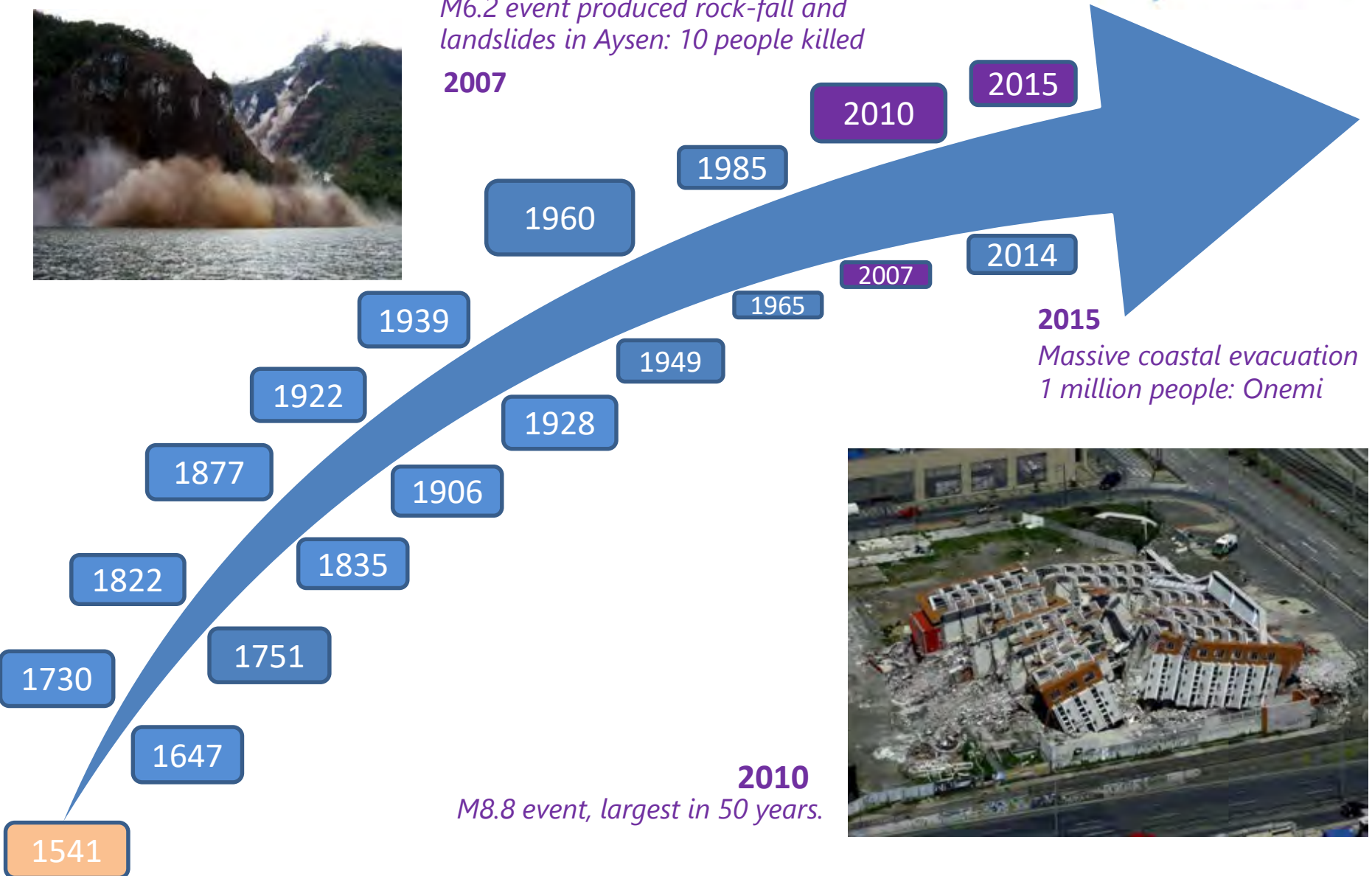
1985

*Largest event in central Chile
since 1906*

Some Significant Earthquakes in Chile



*M6.2 event produced rock-fall and
landslides in Aysen: 10 people killed*
2007

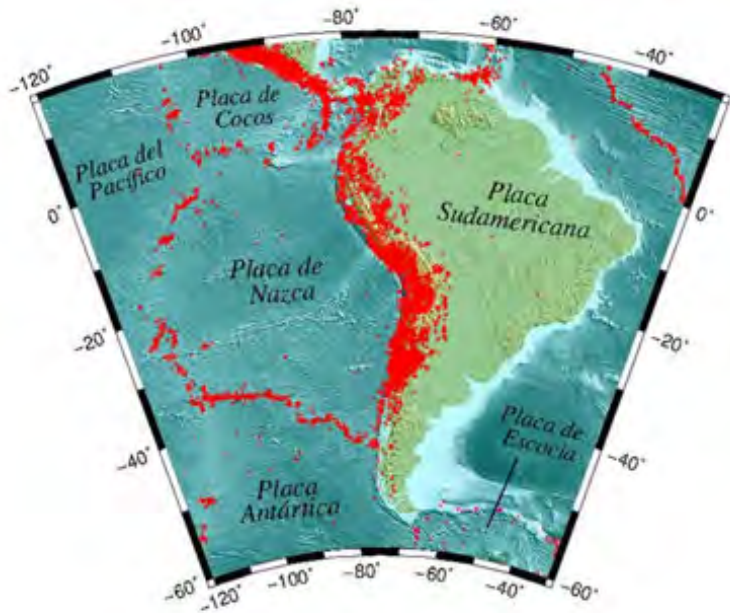


2015
*Massive coastal evacuation
1 million people: Onemi*



2010
M8.8 event, largest in 50 years.

Seismicity of Chile



- High rates of seismic productivity
 - Number of events per unit time
 - Giant earthquakes
- Approx. one magnitude 8 earthquake every decade
- Different types of faults and seismogenic regions
- Significant number of events followed by tsunamis
- Shallow seismicity
- Active tectonics close to urban centers and infrastructure

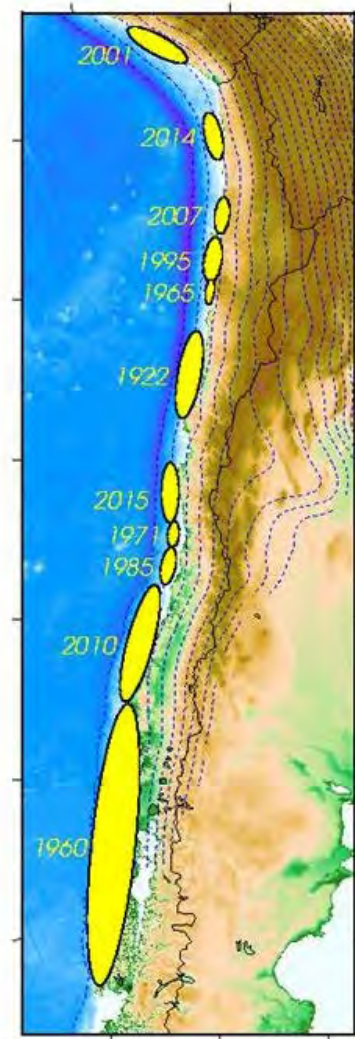
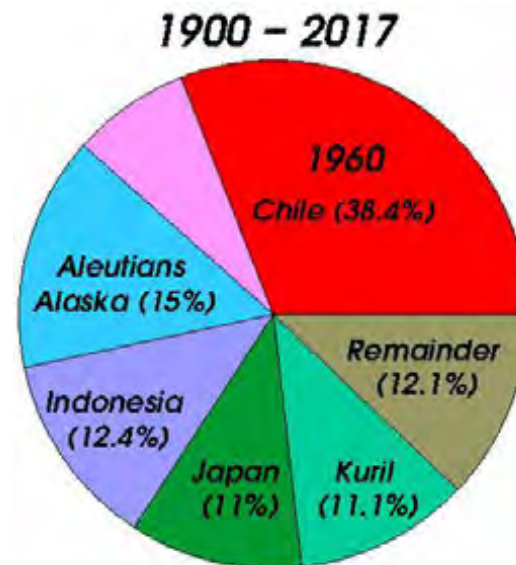
In Chile, since 1900, in terms of Disasters of Natural Origin:

- 99% fatalities due to earthquakes and tsunamis
- 98% economic loss due to earthquakes and tsunamis

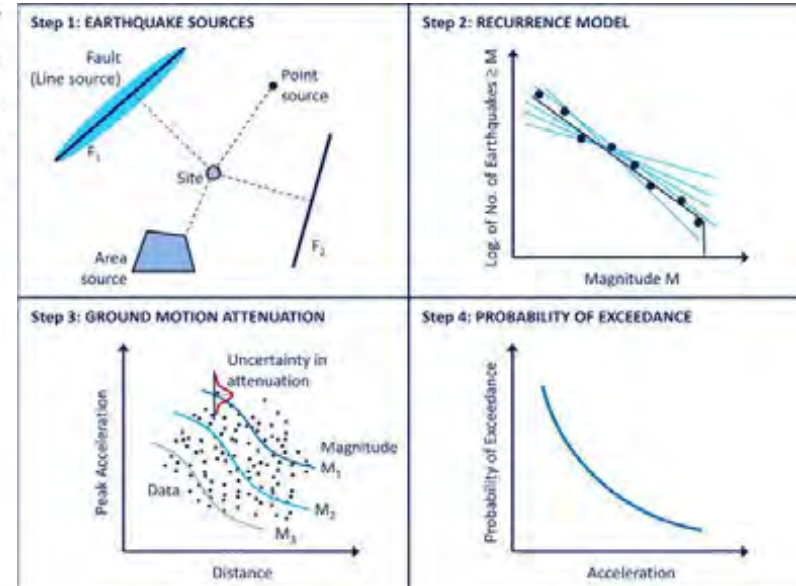
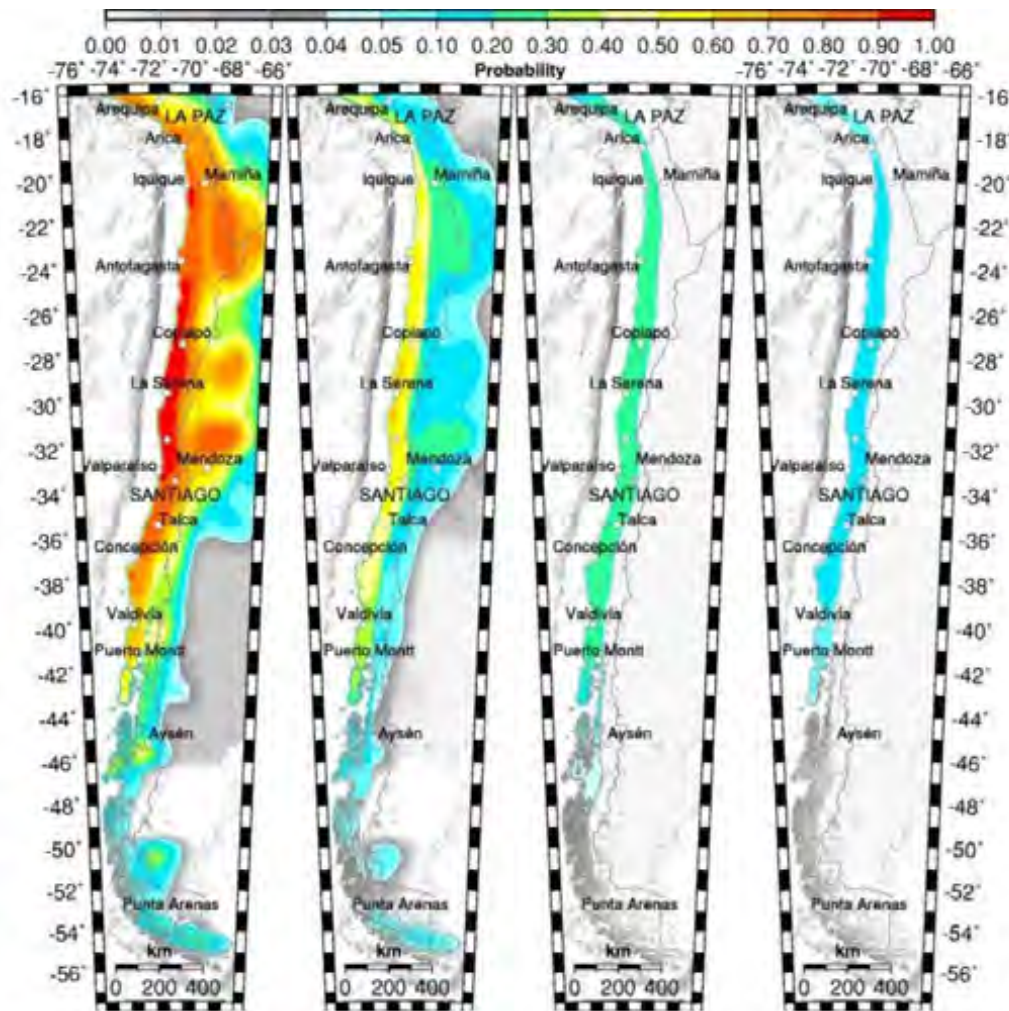
Tsunamis:

Runups 4 m or more: ≈ 25 yr

Runups 10 m or more: ≈ 45 – 50 yr



Interplate events



Probabilistic Approach, Cornell, (1968)

Probability of occurrence of earthquakes with magnitude $M(6,7,8,9)$ within 50 km in a random period of 30 yr.

Medina et al.

Observation System

Broad-band

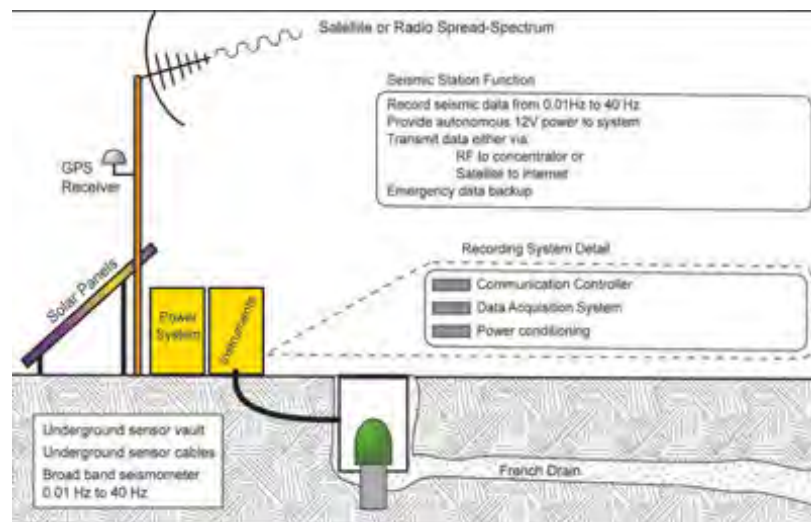
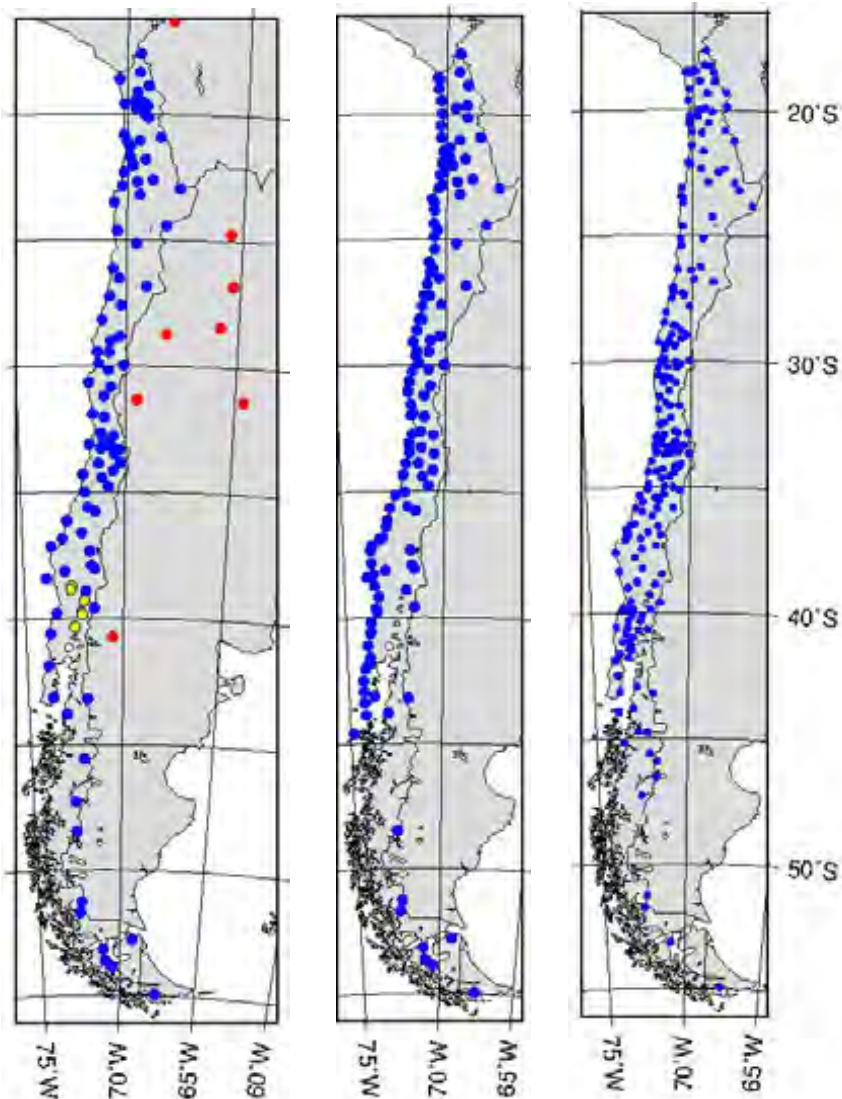
107

GPS

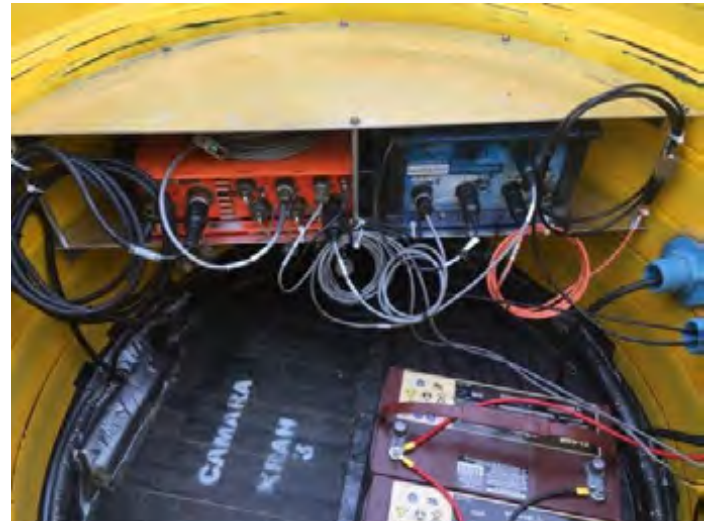
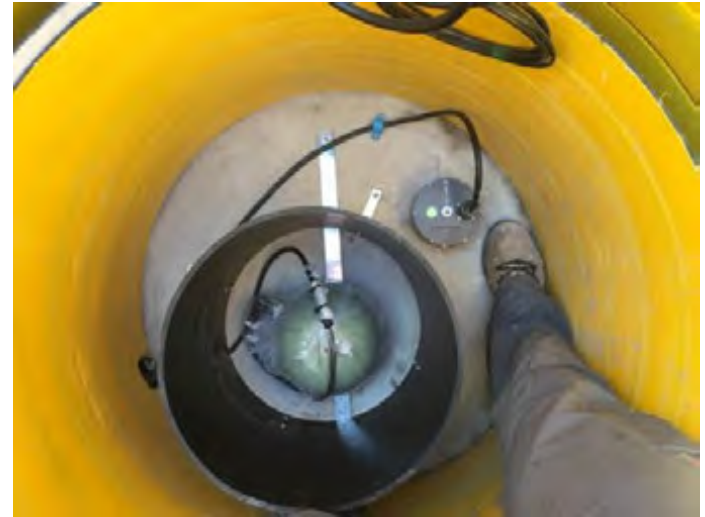
130

Strong Motion

297

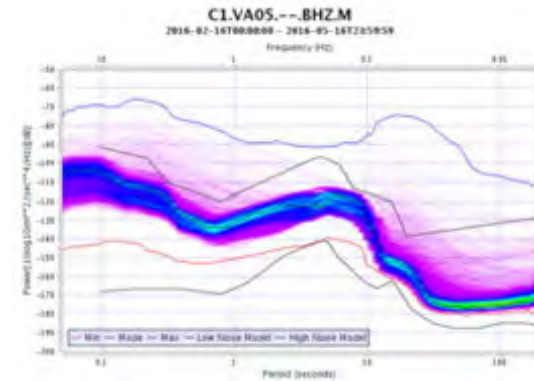
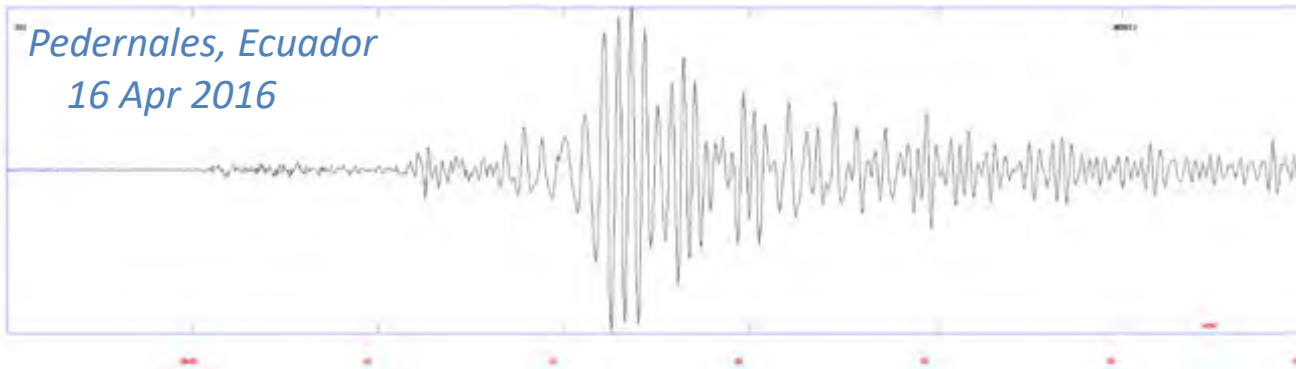


VA06 Catapilco



VA06 Catapilco

Pedernales, Ecuador
16 Apr 2016



Data Center



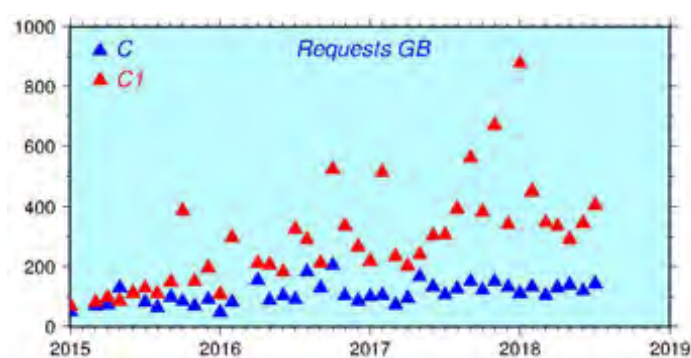
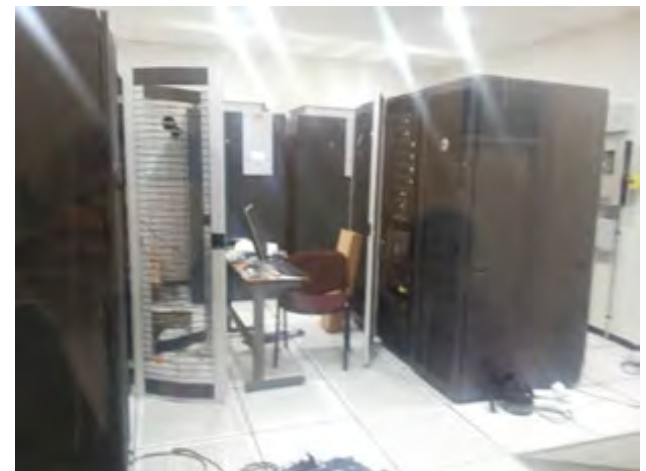
Early Bird



*Similar systems installed at
ONEMI and SHOA*



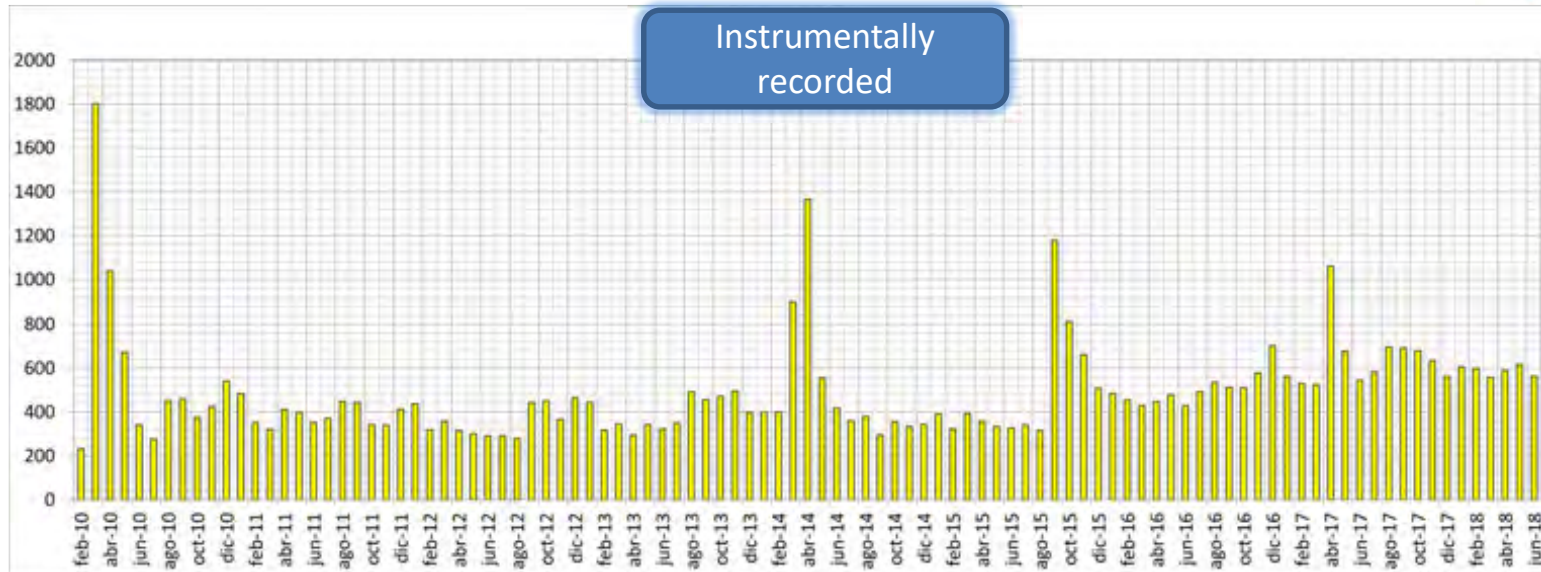
SeisComP Antelope, Early Bird



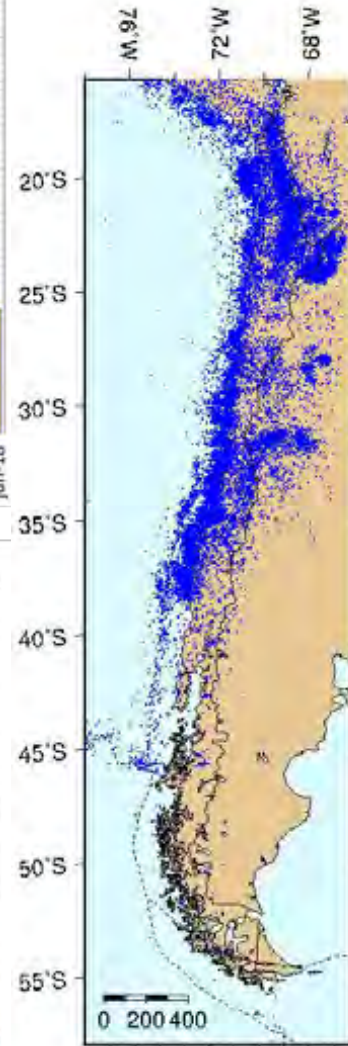
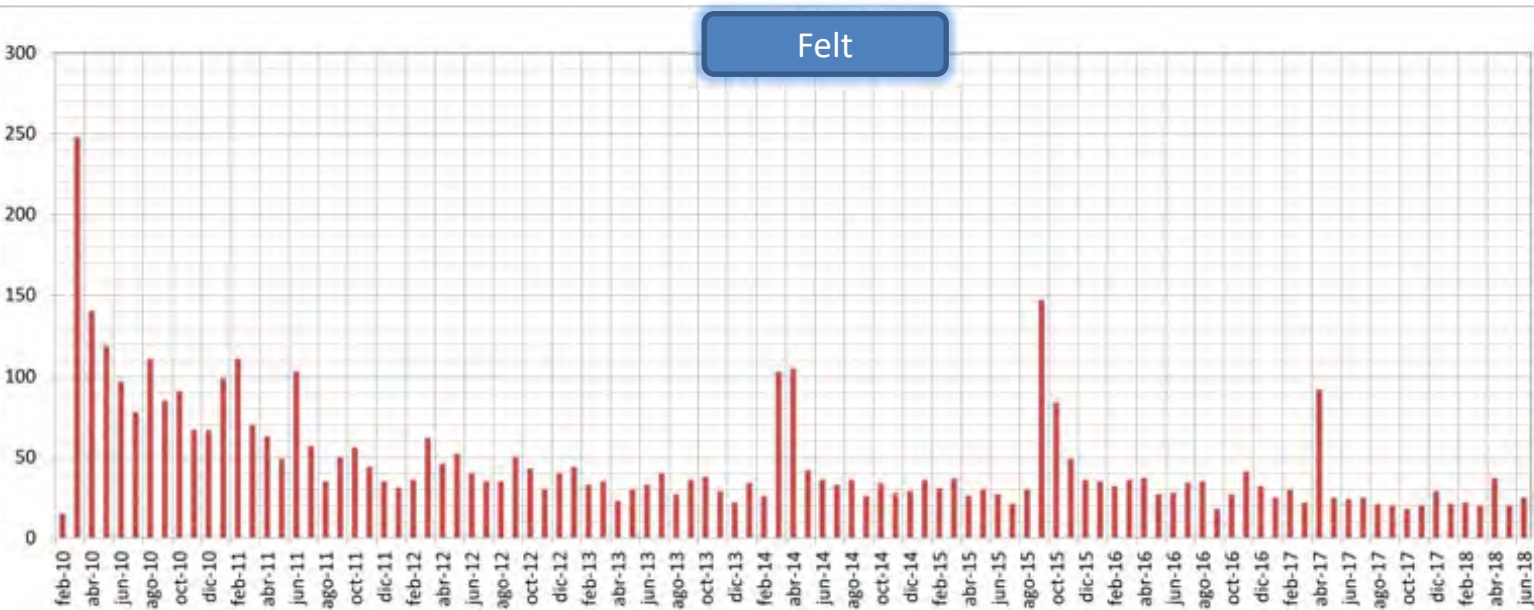
Seismicity of Chile

Feb 2010 – Jun 2018

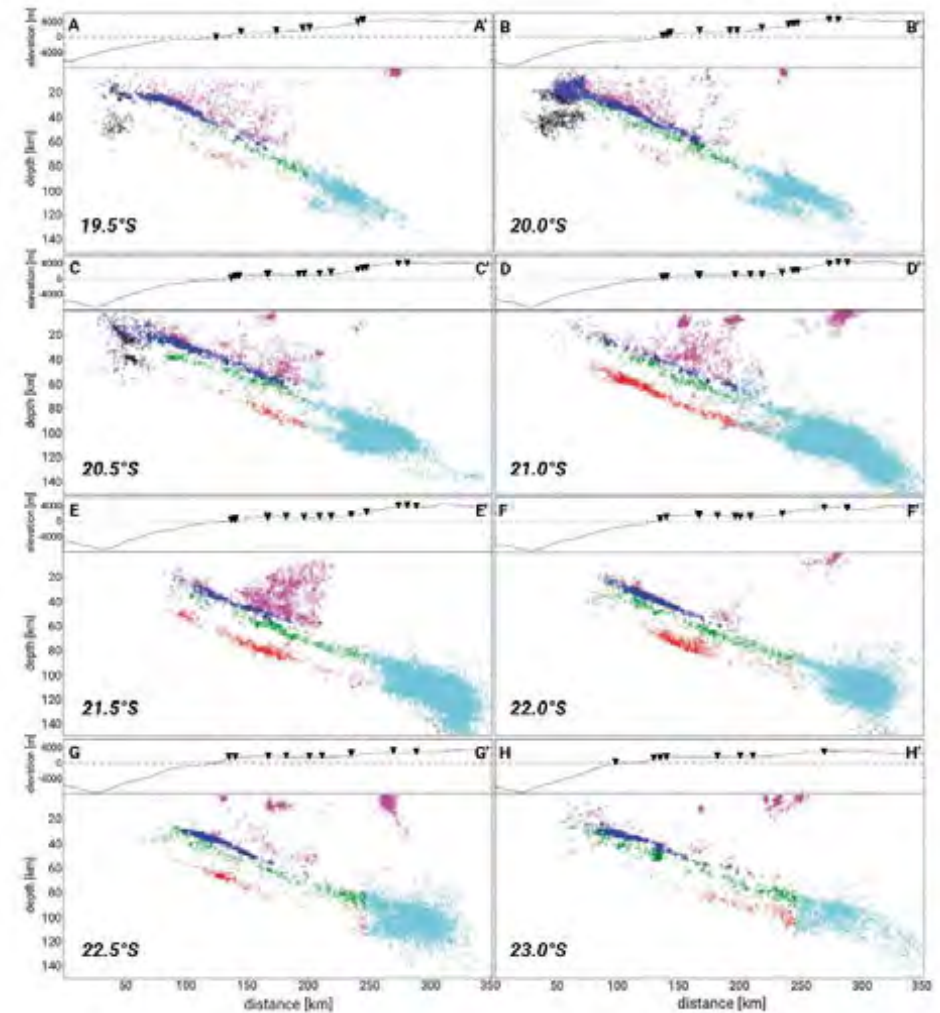
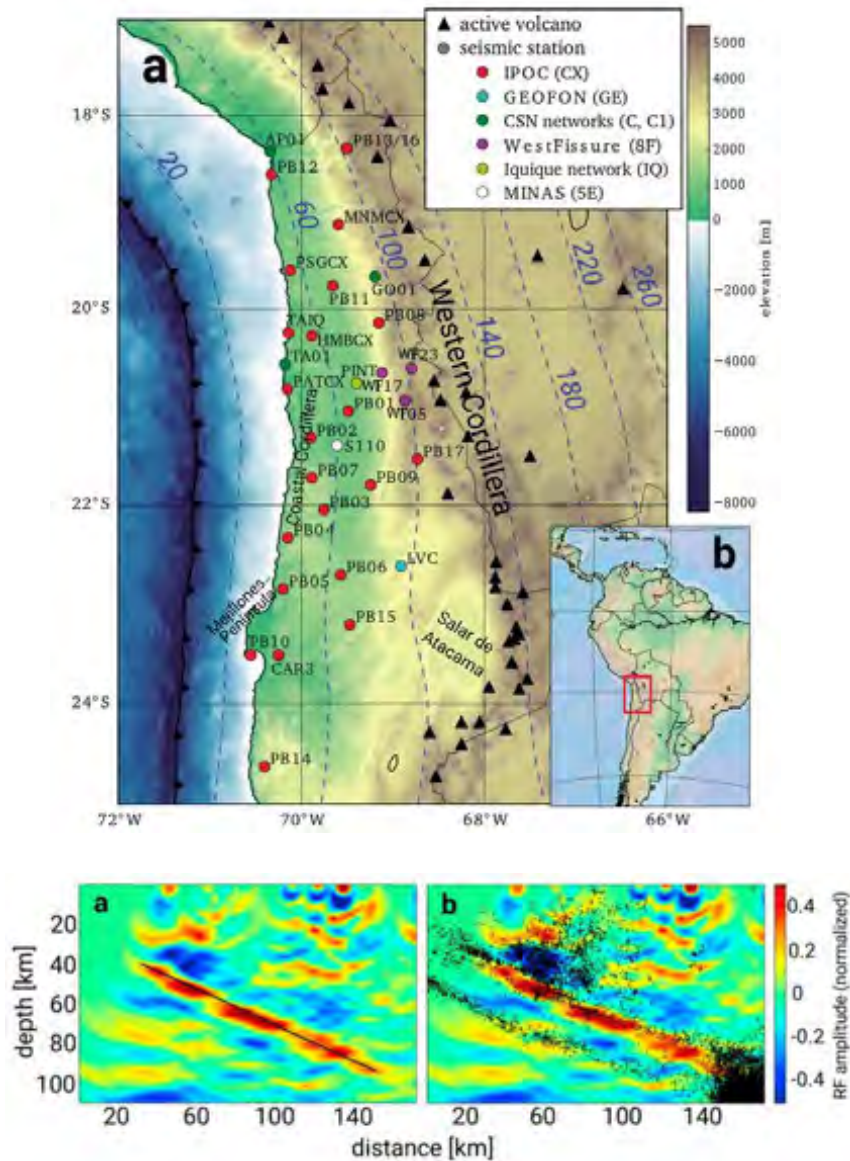
Instrumentally
recorded



Felt



Northern Chile

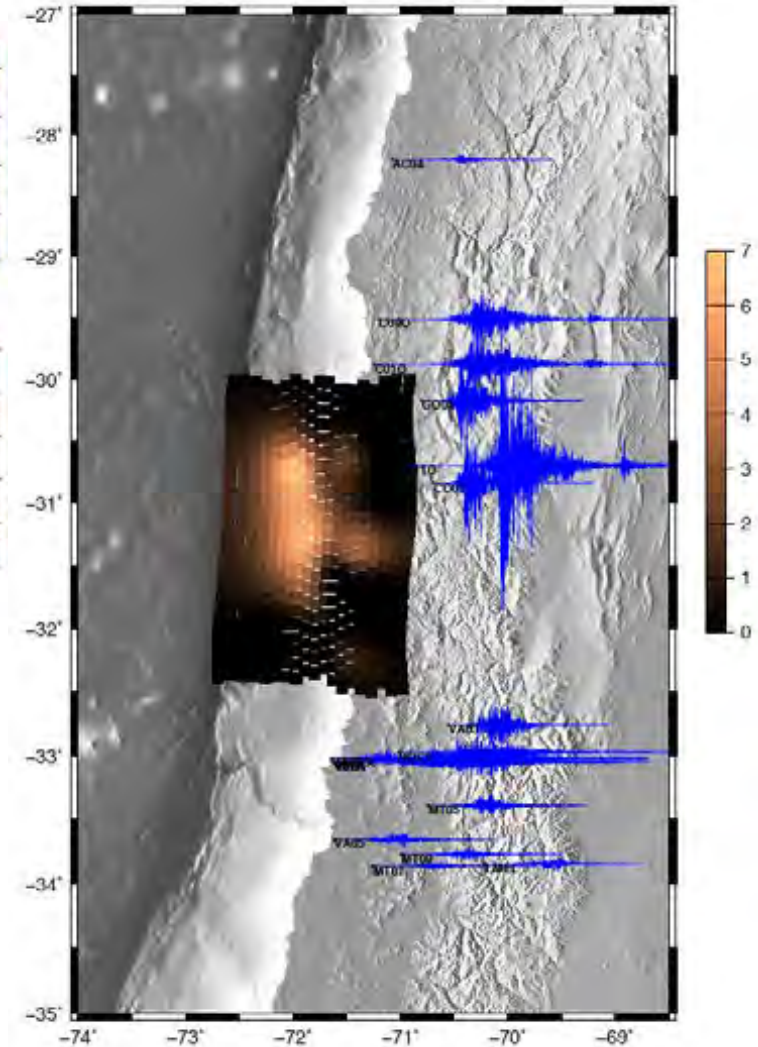
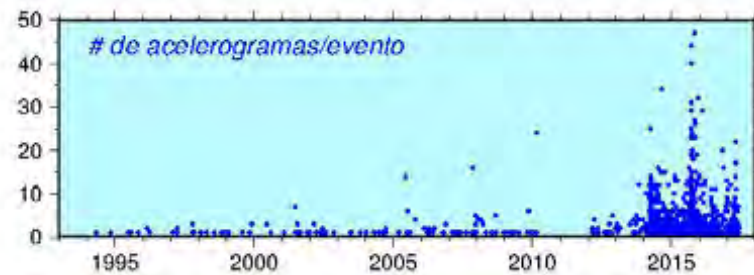
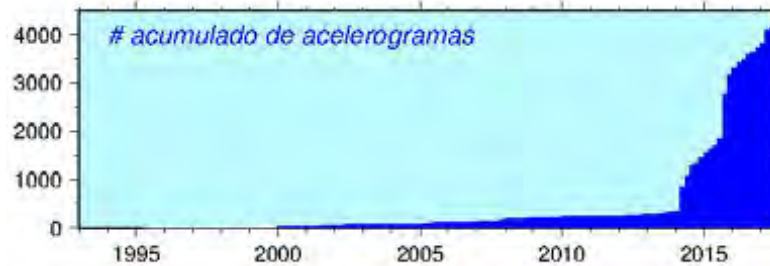
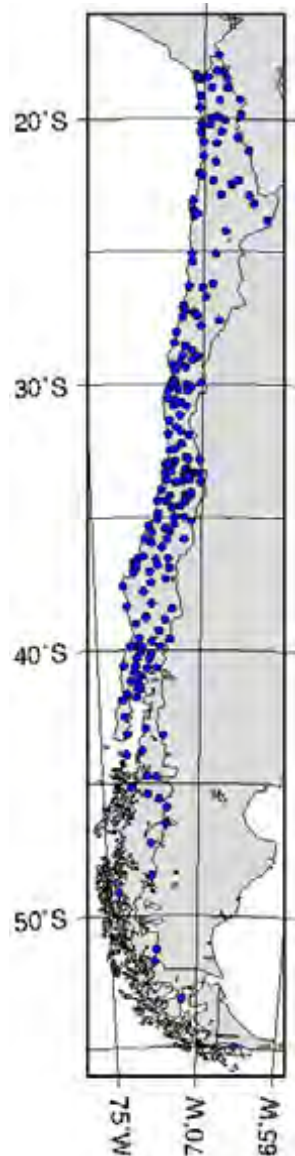


Sippl et al. (2018)

Illapel 2015, Acceleration records

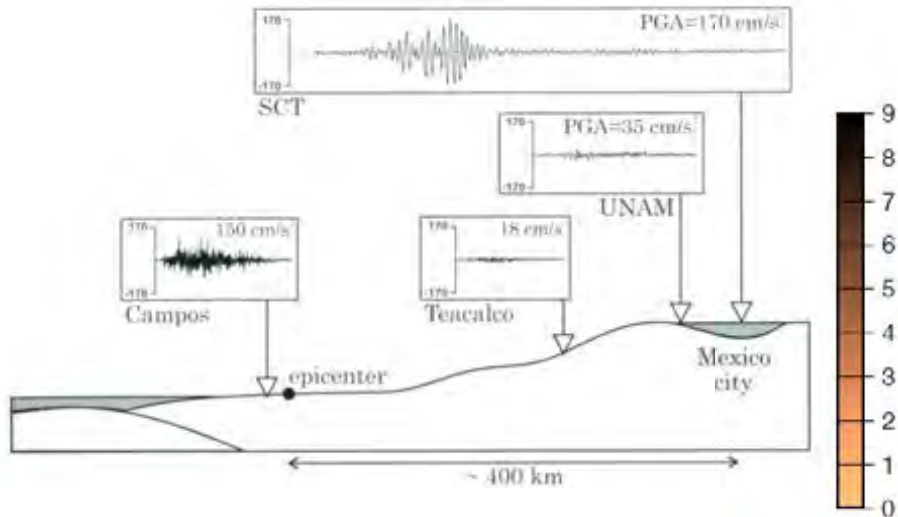
297

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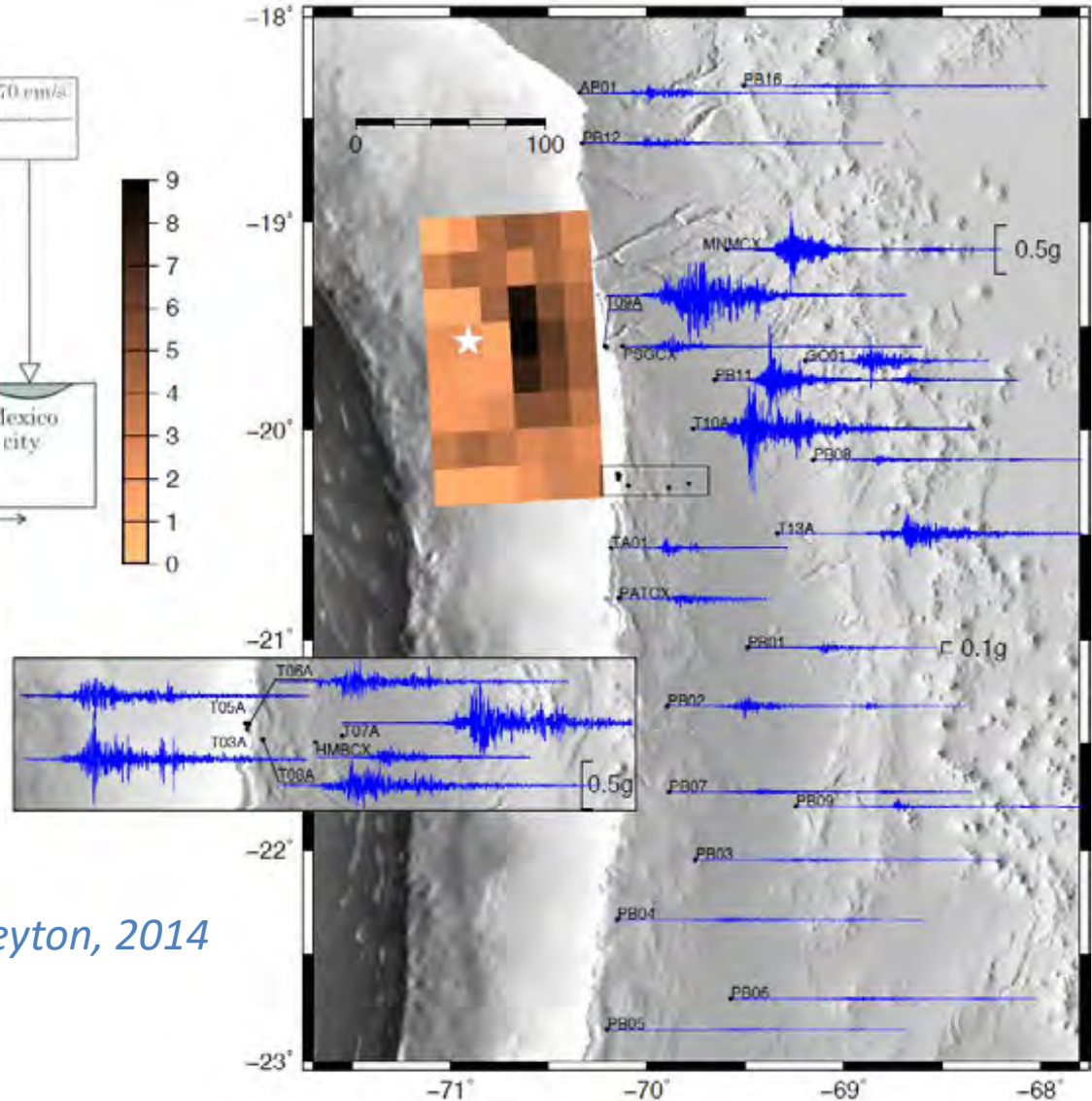


Leyton (2015)

Iquique 2014, Acceleration records

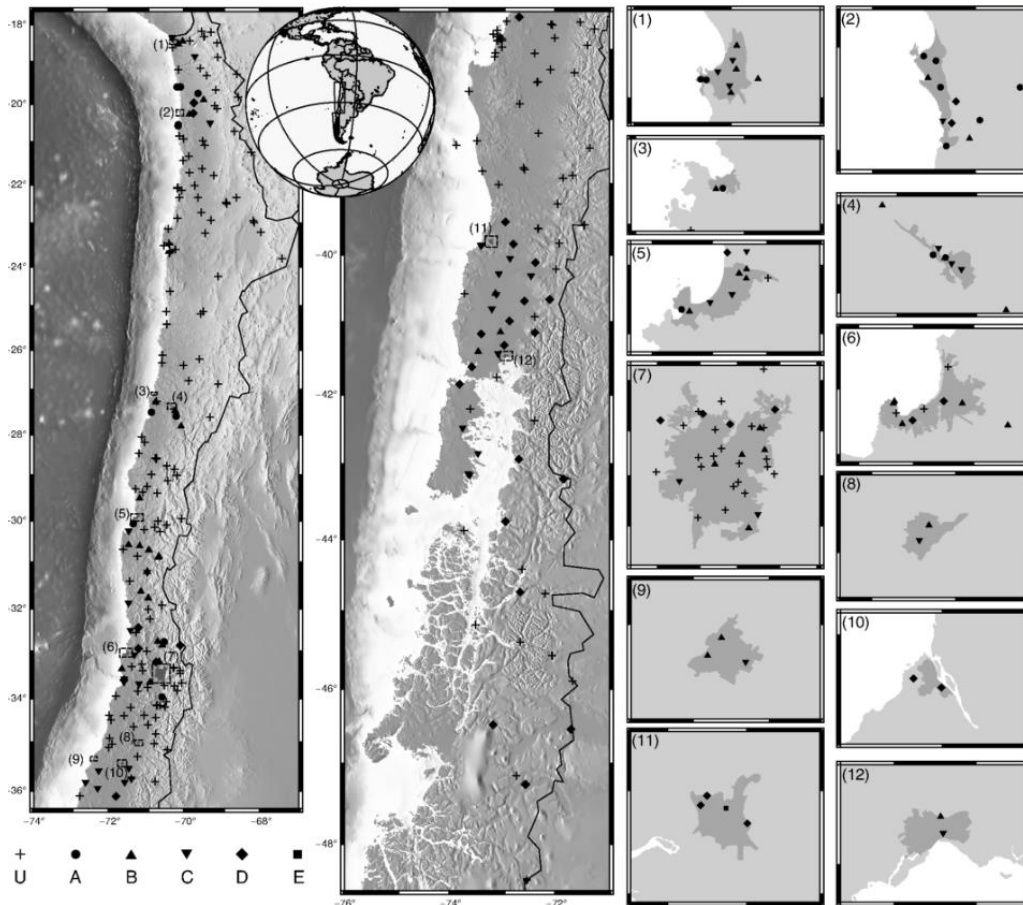


Mexico City, 1985

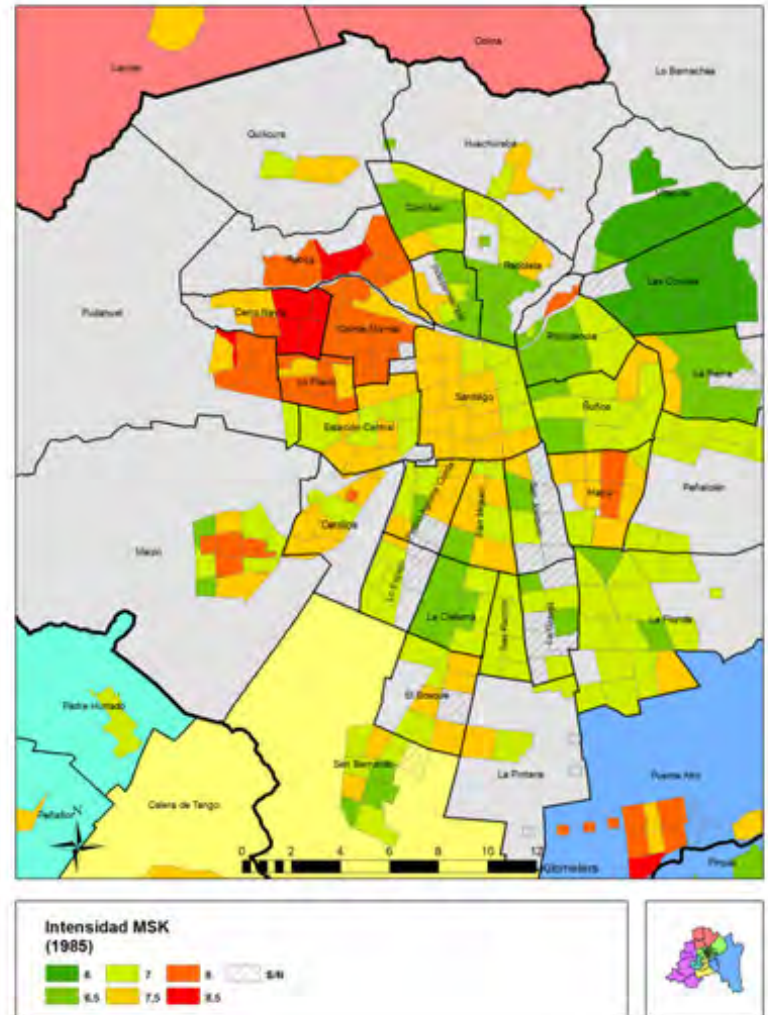


Leyton, 2014

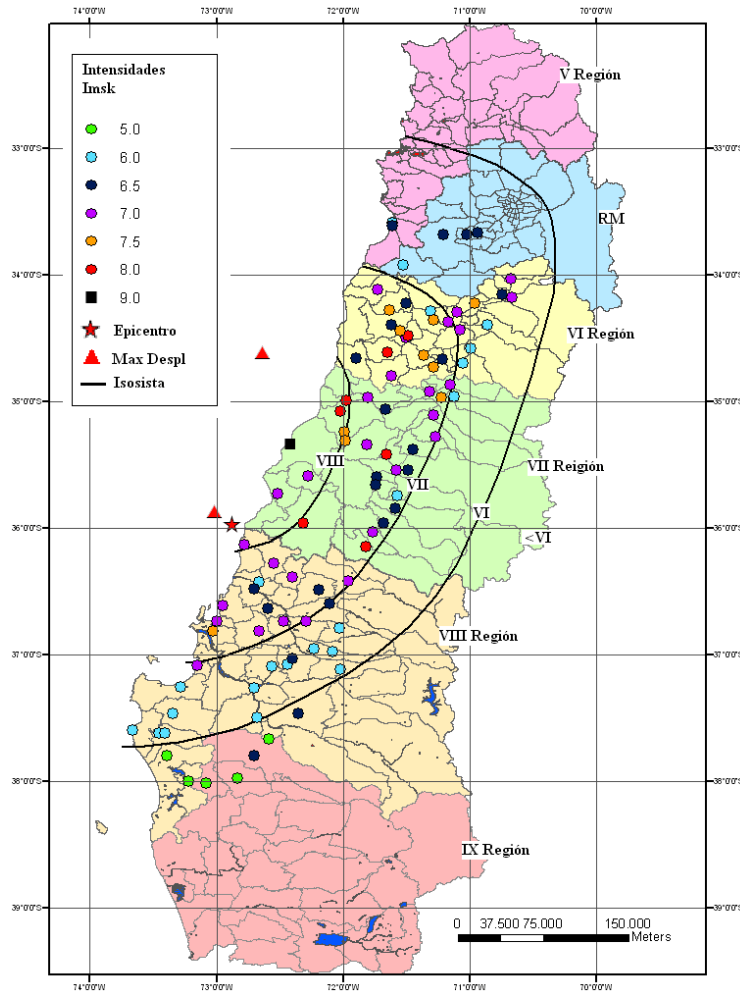
MSK Intensity in Santiago



Strong motion instruments

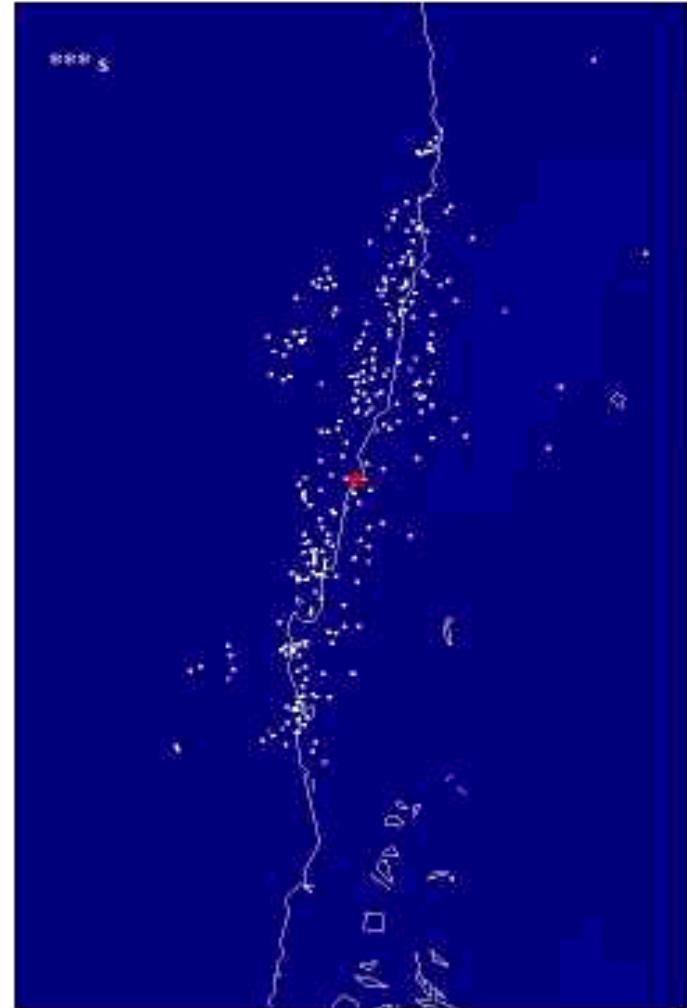


Significant Earthquakes in Chile



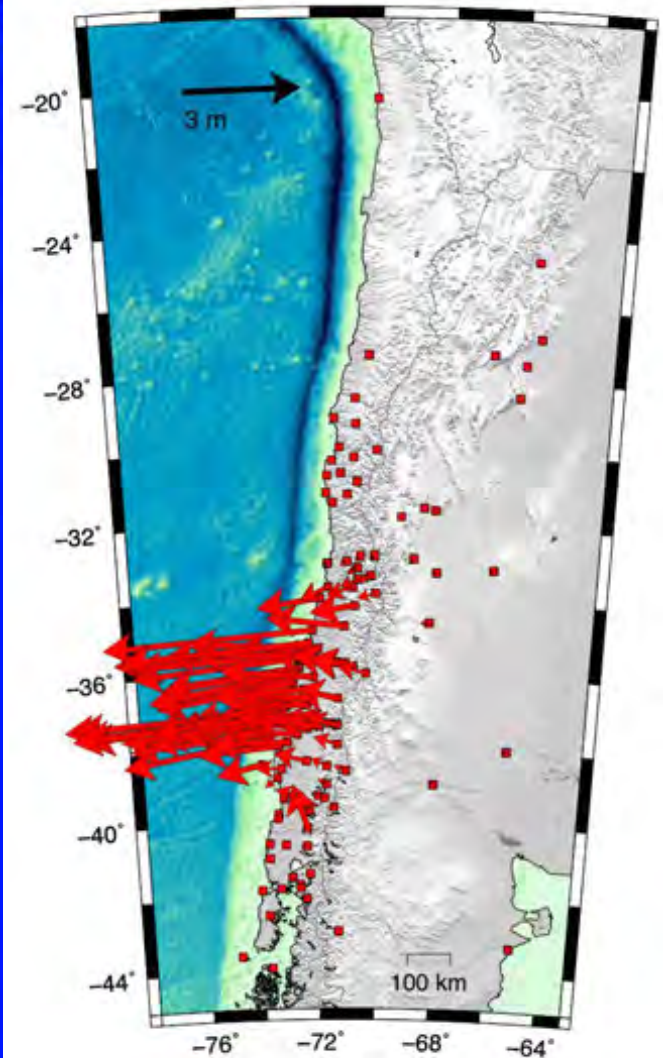
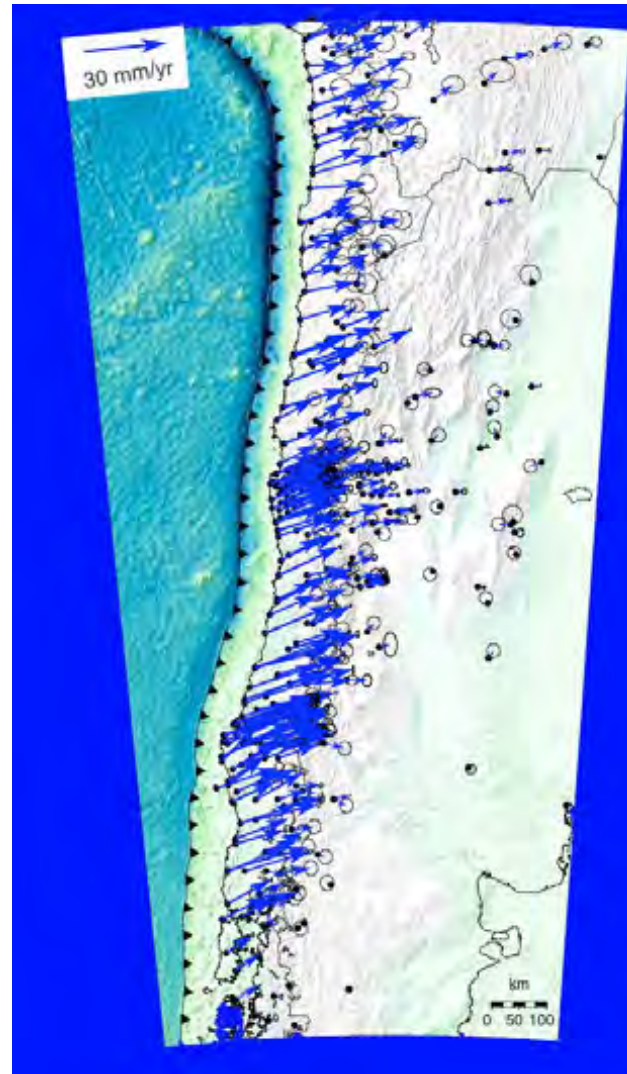
Universidad de Chile
M. Astroza - S. Ruiz

Astroza et al., 2010

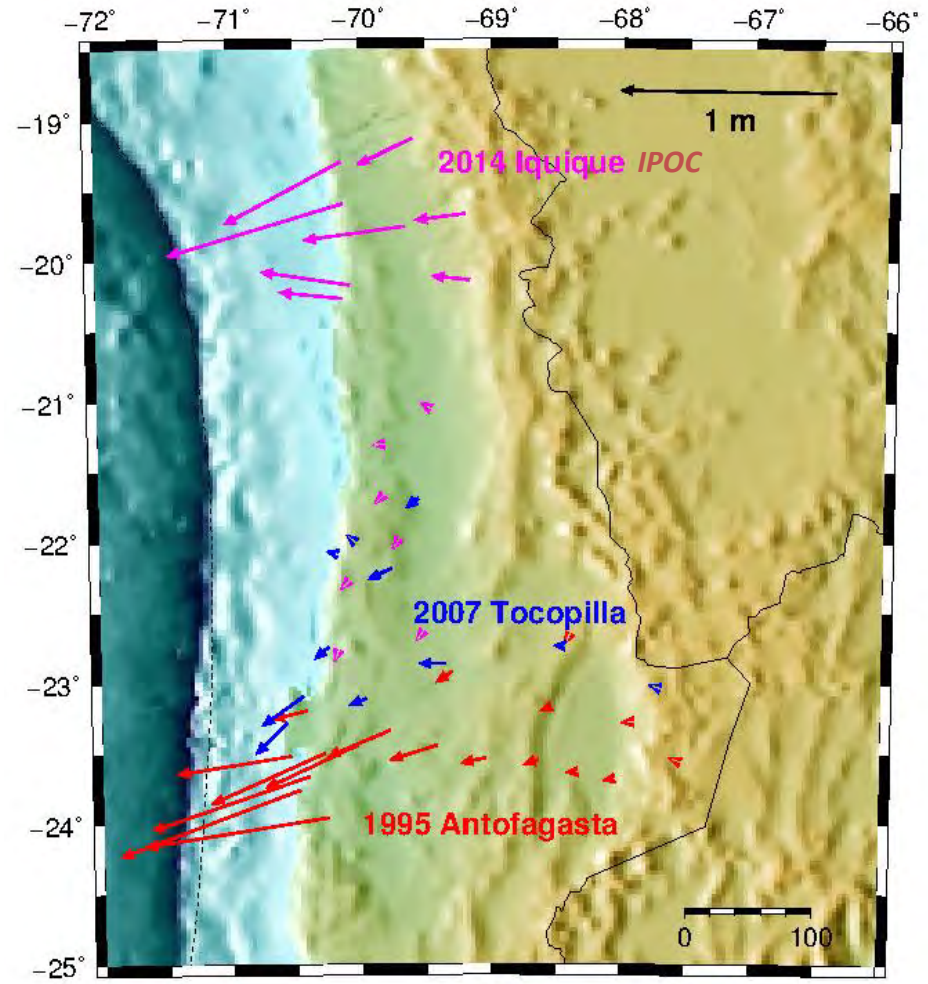
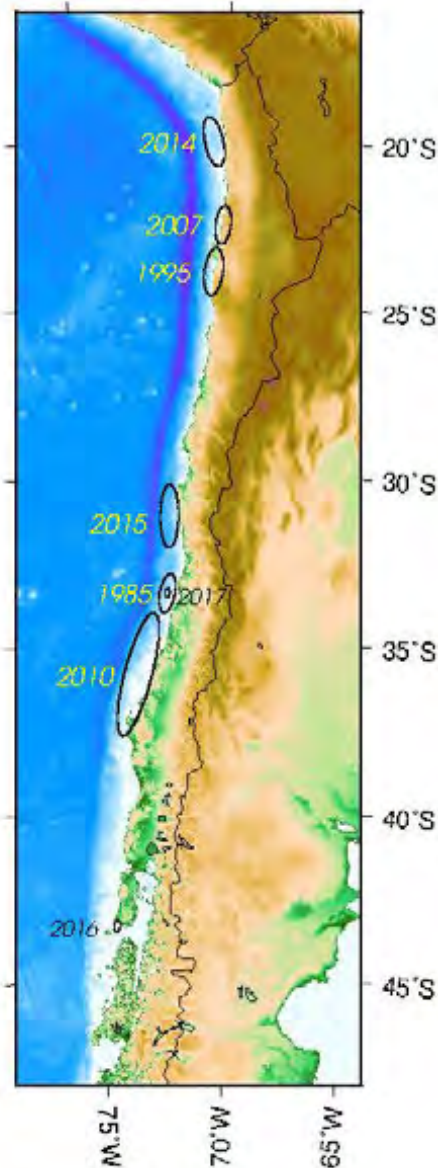
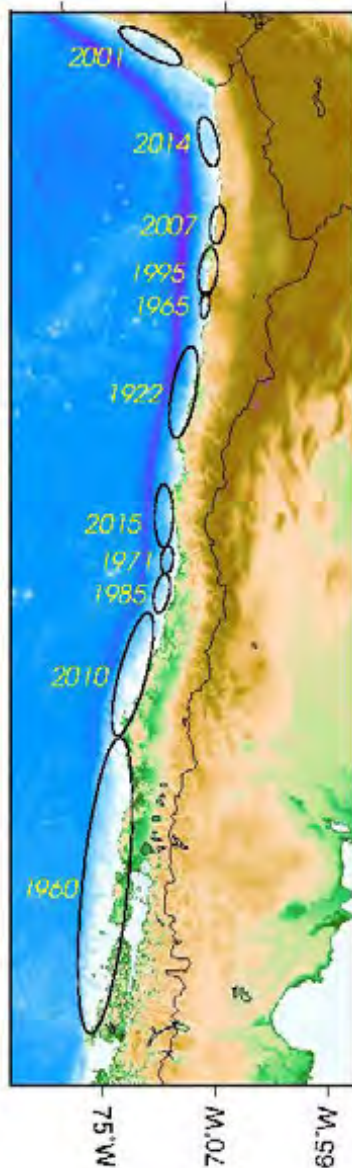


Kiser and Ishi (2011)

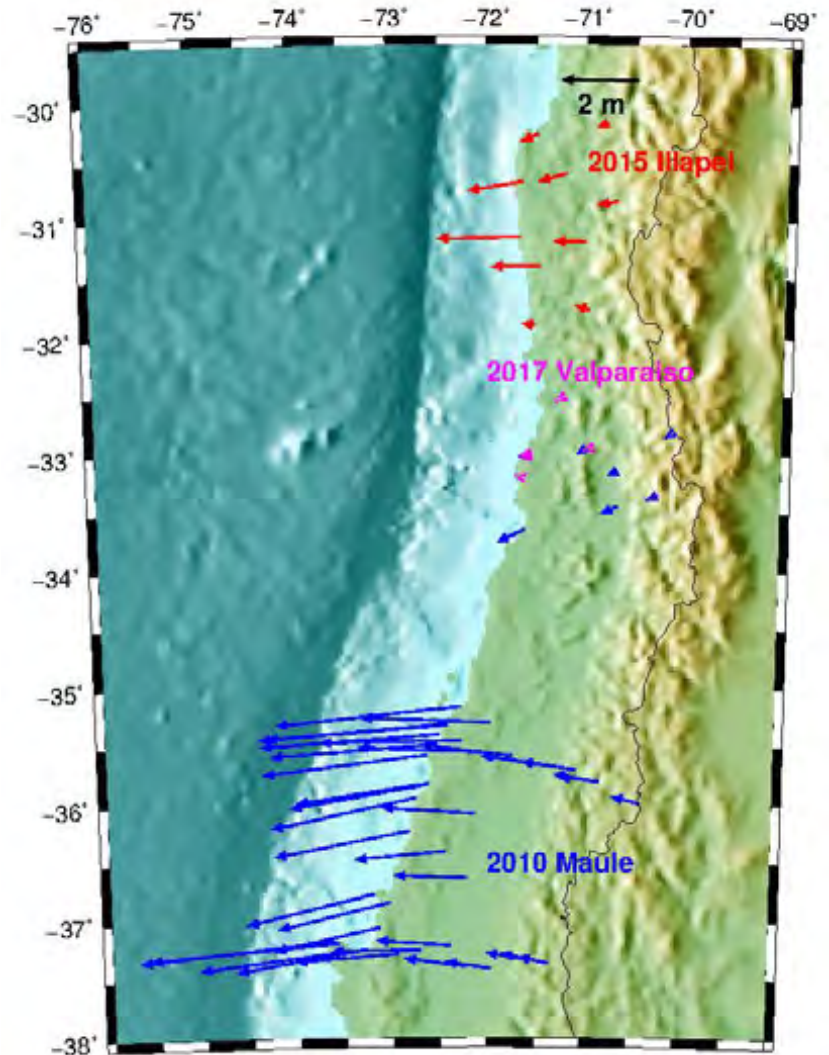
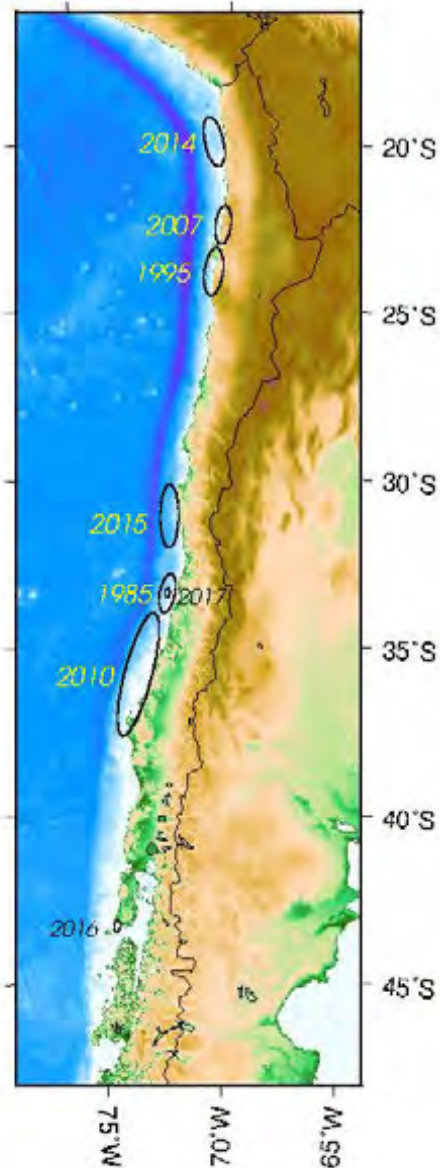
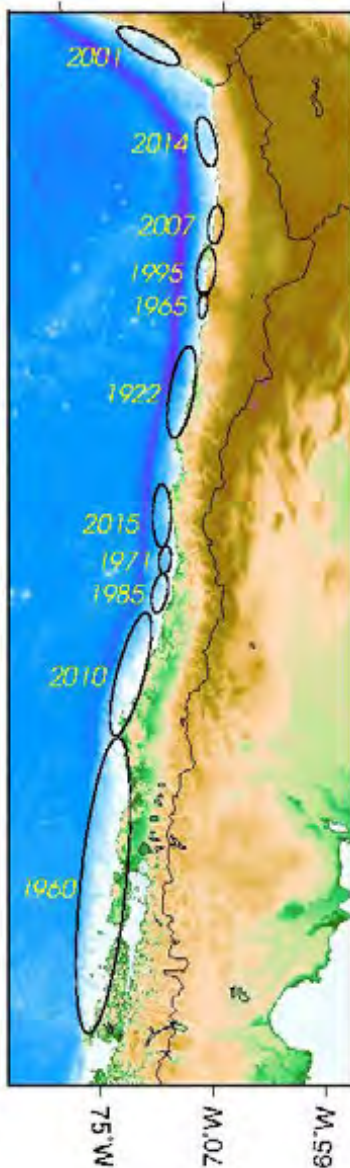
DIPLOMA DE POSTITULO EN SISMOLOGIA



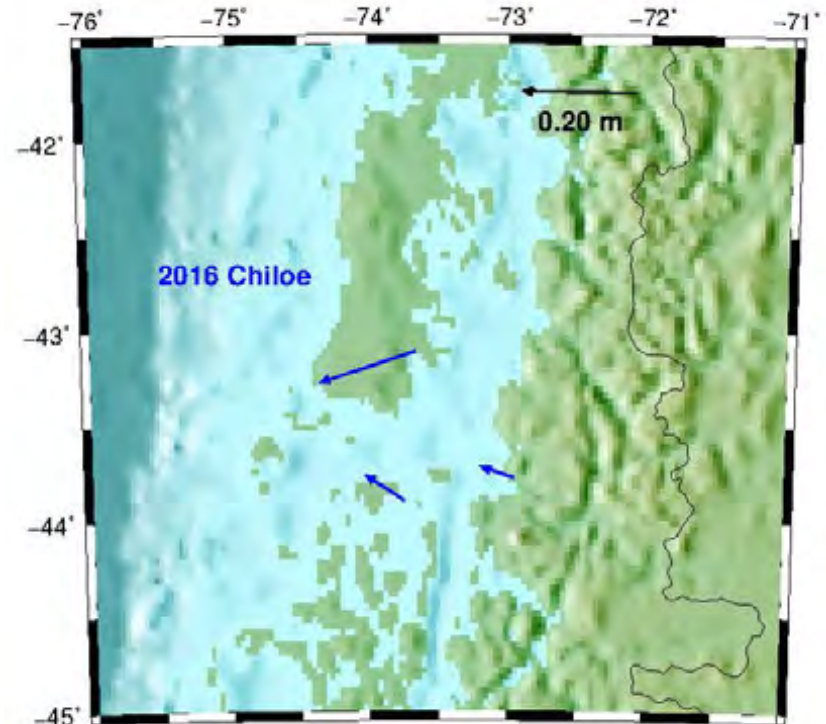
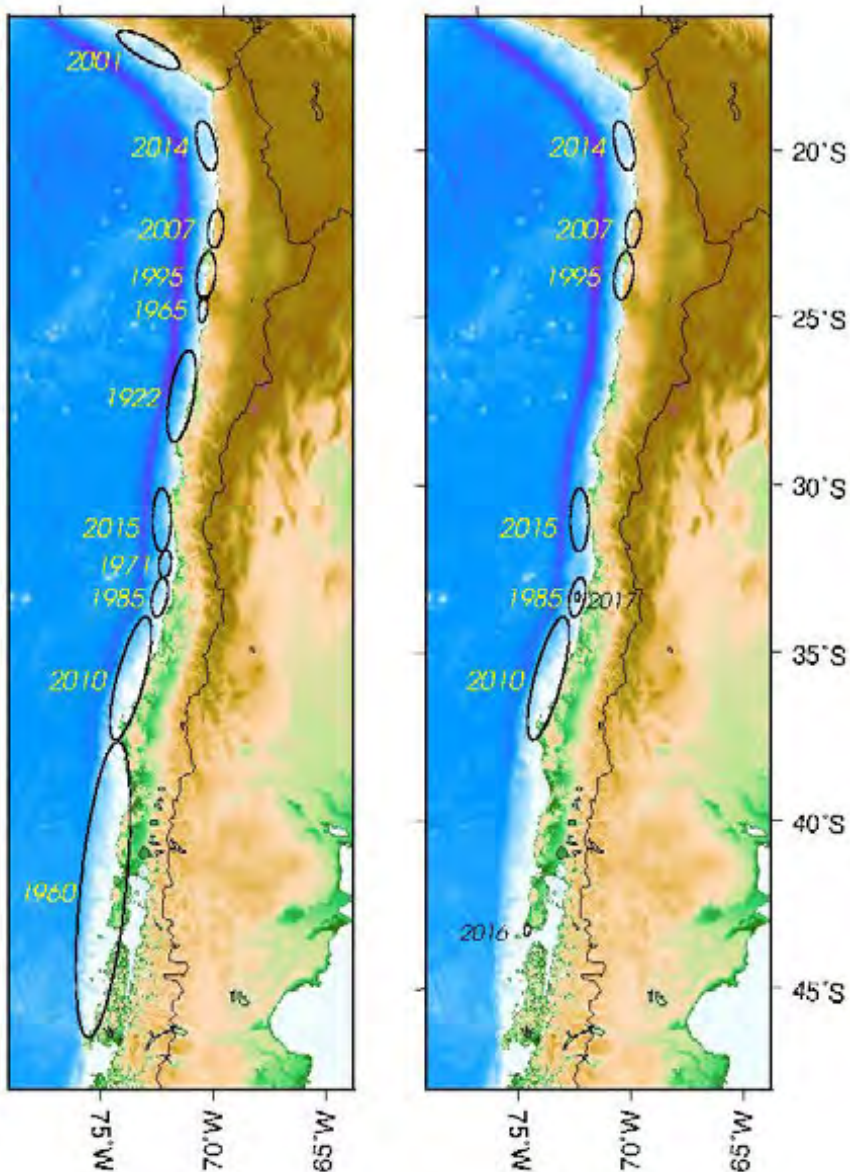
Large earthquakes in Chile



Large earthquakes in Chile



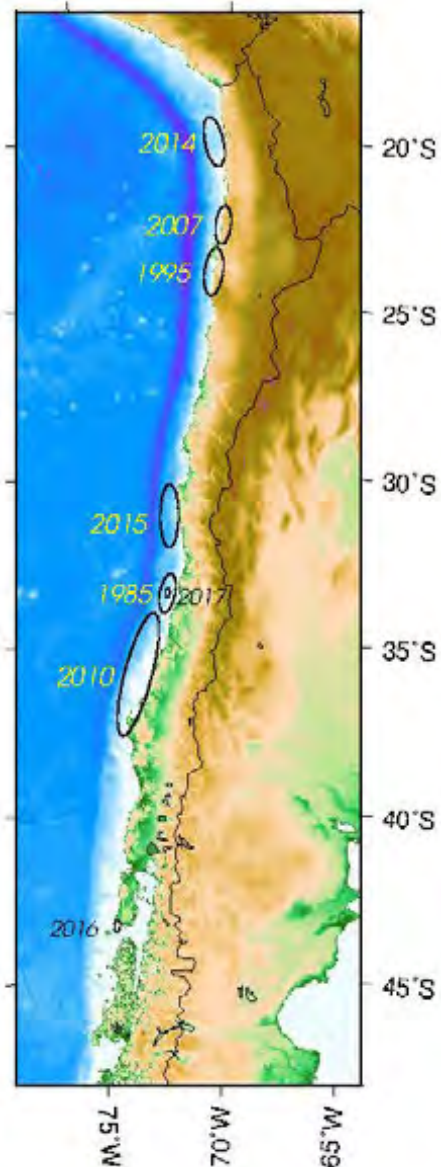
Large earthquakes in Chile



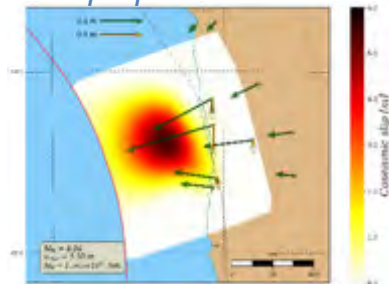
G-FAST, B. Crowell
Earthquake location input
PGD, Fault Mechanism, Centroid

In addition
Okada formulation
SLAB 1.0 contact Surface
Laplacian smoothing

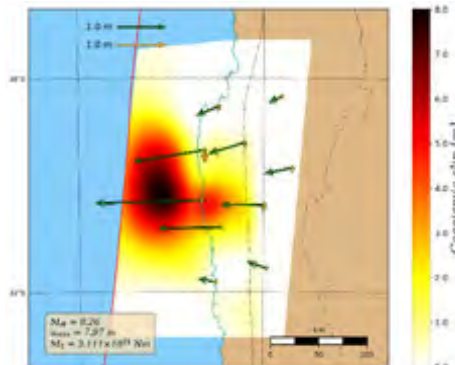
Large earthquakes in Chile



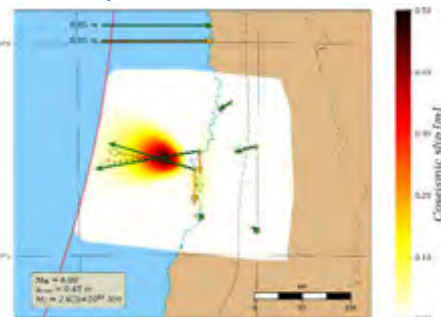
Iquique 2014



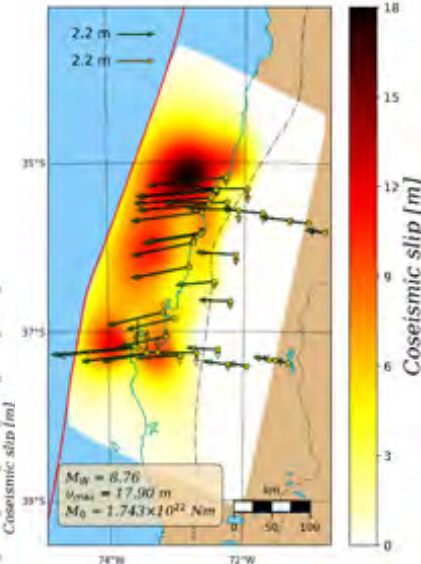
Illapel 2015



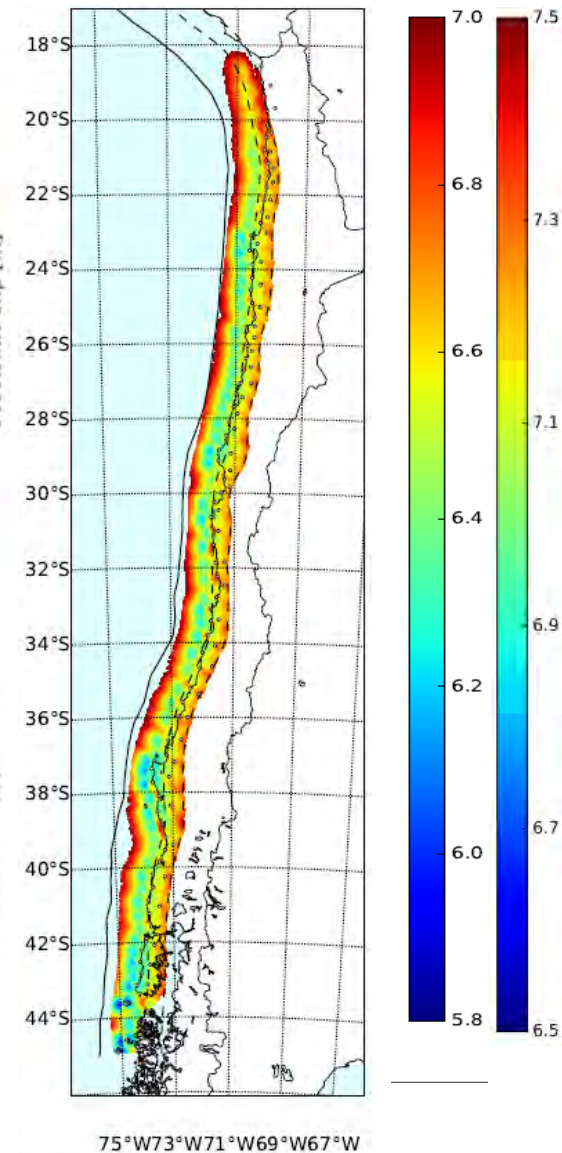
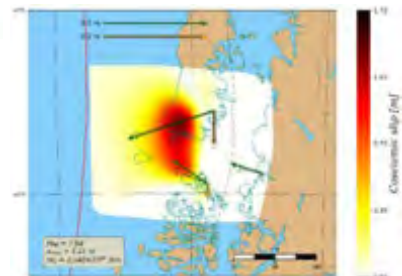
Valparaiso 2017



Maule 2010

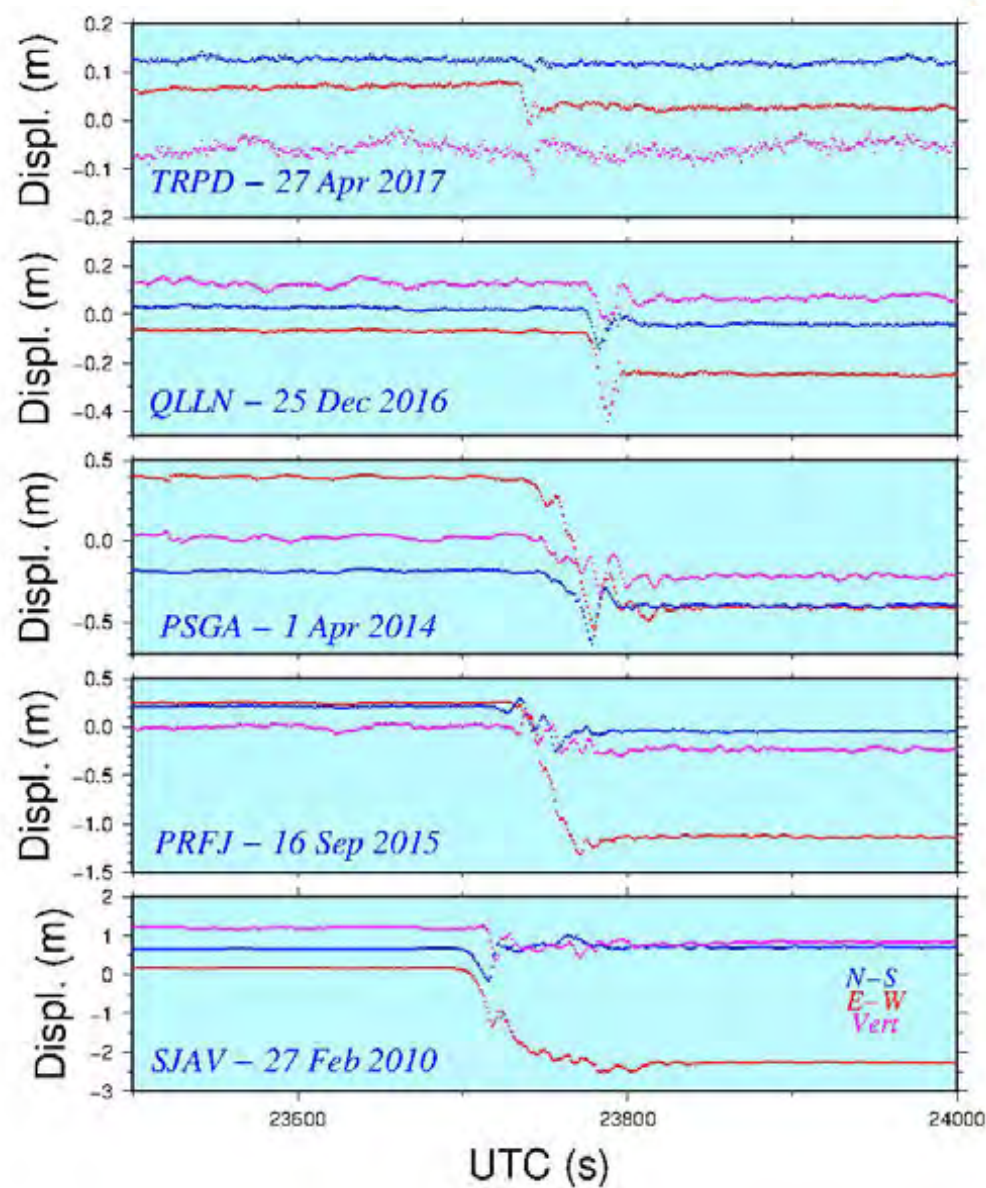
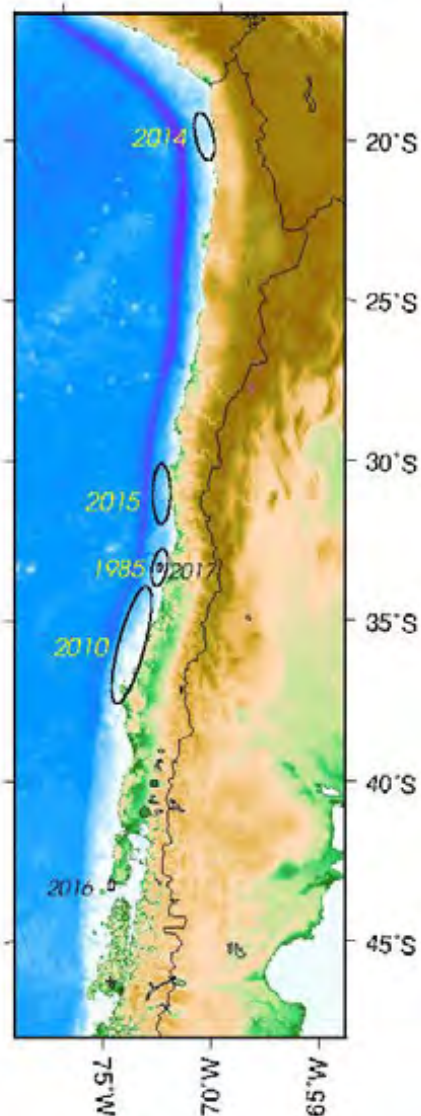


Chiloe 2016



Fault-slip estimates by F. Del Campo

GNSS records



$M=6.9$

$M=7.6$

$M=8.2$

$M=8.3$

$M=8.8$

J.C. Baez

Tsunami Warning System: GPS

