The Mw8.8 27-Feb-2010 Maule Earthquake: Researching pre-, co- and post-seismic deformation

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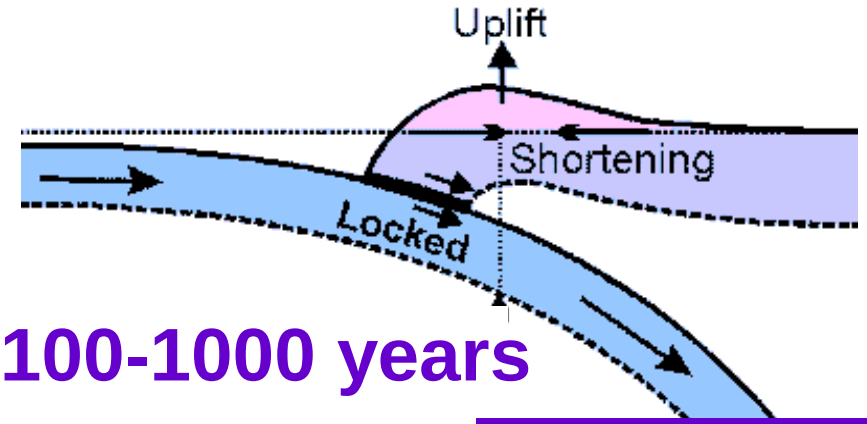
UDEC

M. Moreno, D. Melnick

GFZ-Potsdam

Seismic Cycle at Subduction Zones

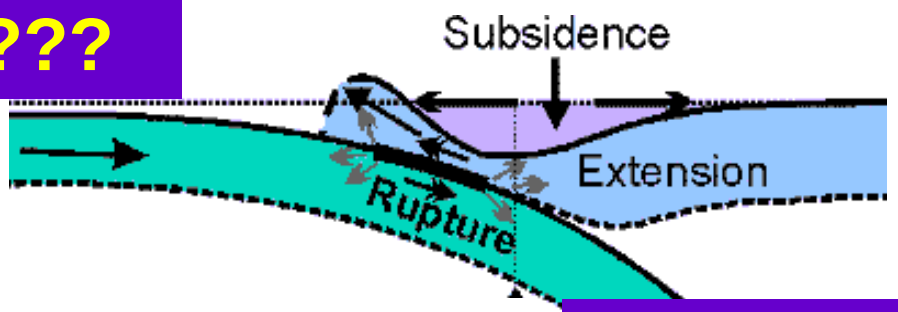
INTER-SEISMIC



100-1000 years

PRE-SEISMIC???

CO-SEISMIC

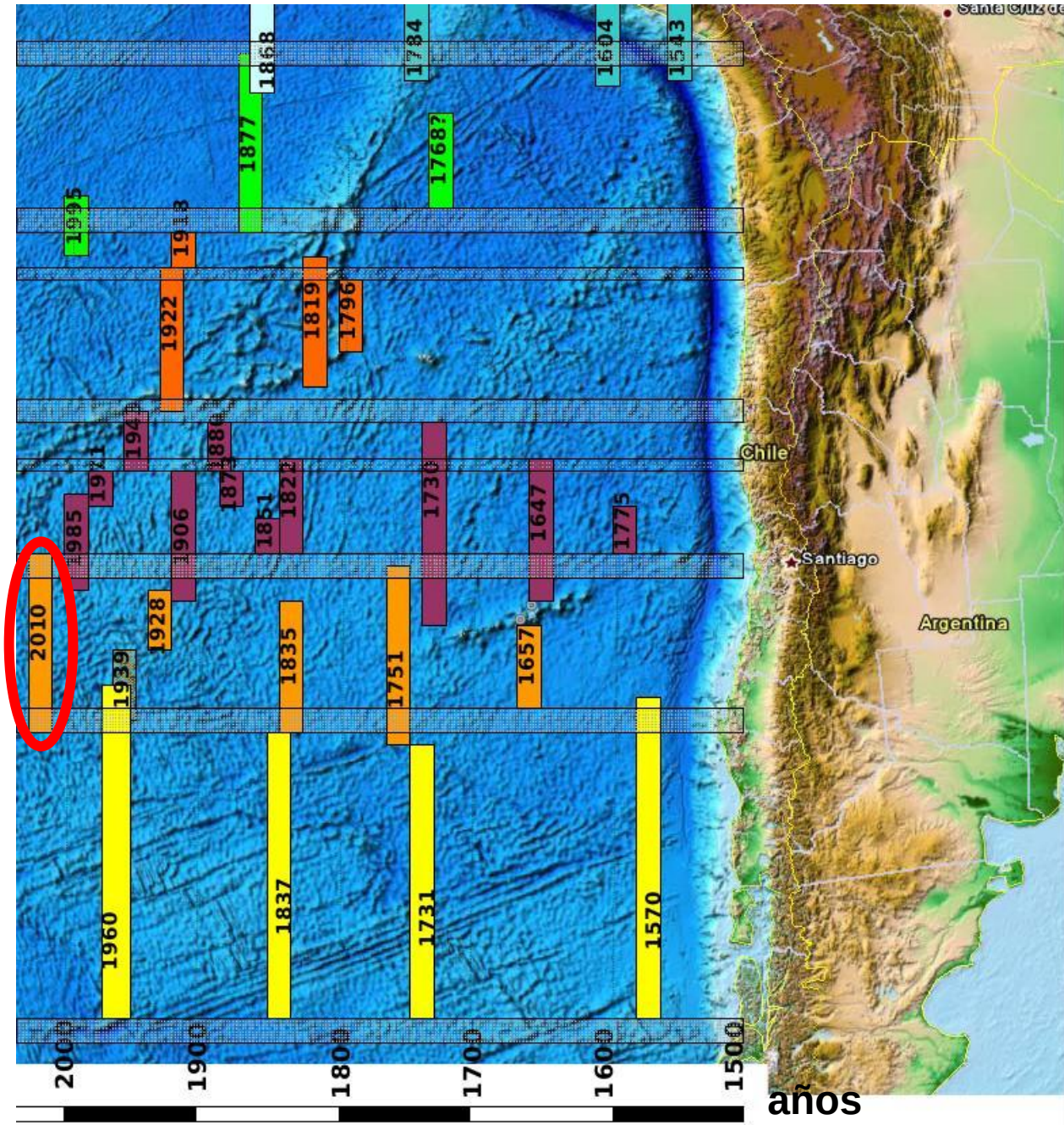


1-10 minutes

POST-SEISMIC!!!

INTER- TO PRE-SEISMIC PHASE OF THE MAULE EARTHQUAKE

Rupture Length of Great Historical Earthquakes (M>7.5)



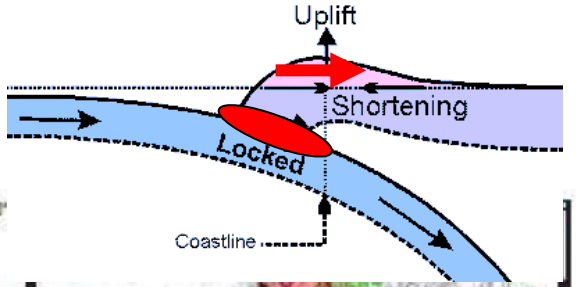
Pichilemu-Concepción Seismic Gap (175 Years)

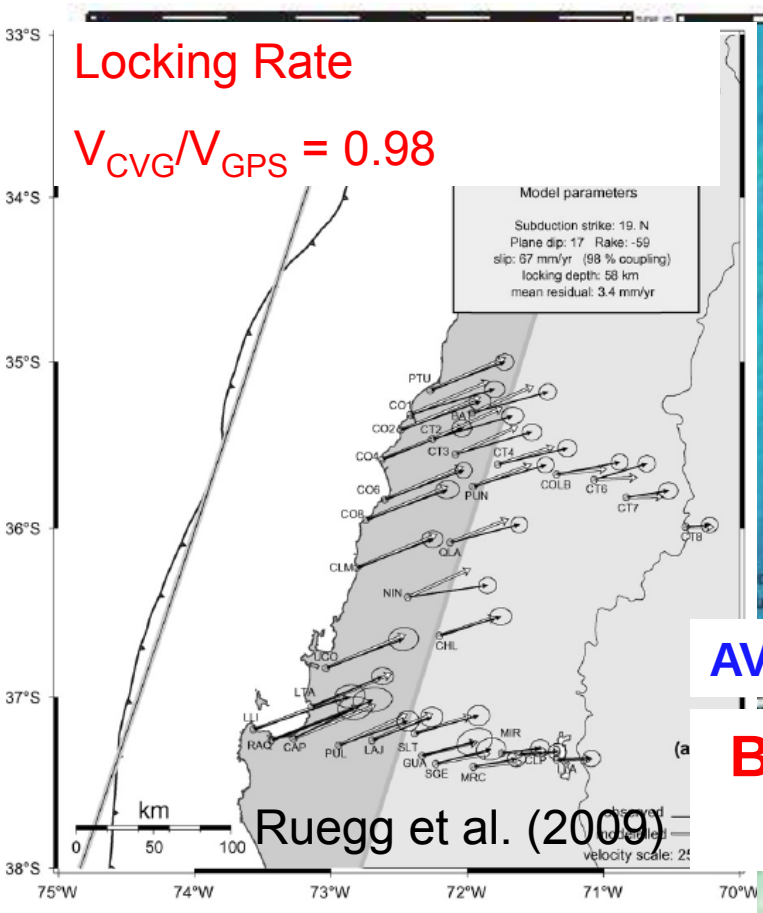
Seismogeneic Segmentation of Chilean Margin

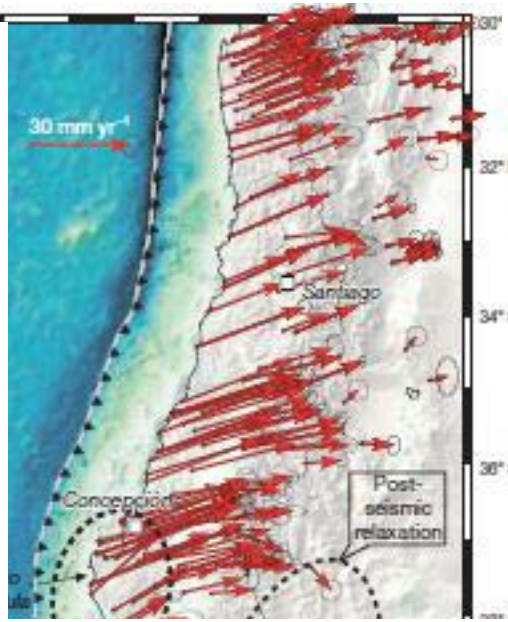
2010 Maule earthquake slip correlates with pre-seismic locking of Andean subduction zone

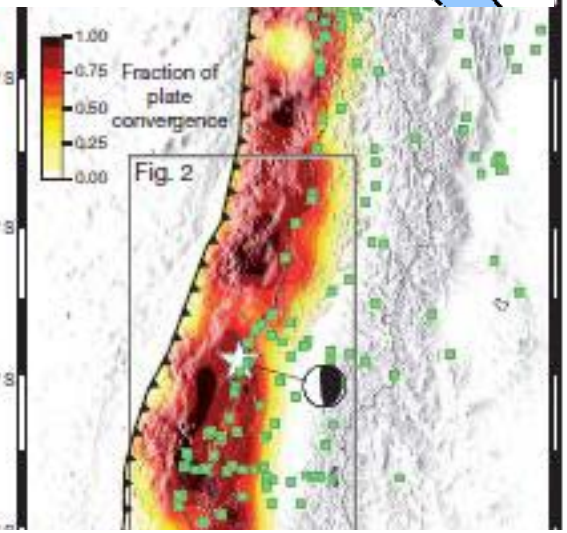
Marcos Moreno[1], Matthias Rosenau[1] & Onno Oncken[1]

1) GFZ-Potsdam, Germany









AVERAGE 5-10 YEARS BEFORE THE EARTHQUAKE

BUT, CAN WE KNOW WHEN DID ELASTIC STRAIN START ACCUMULATING???

THREE APPROACHES FOR ANALAZING COASTAL DEFORMATION AT SCALES OF DECADES

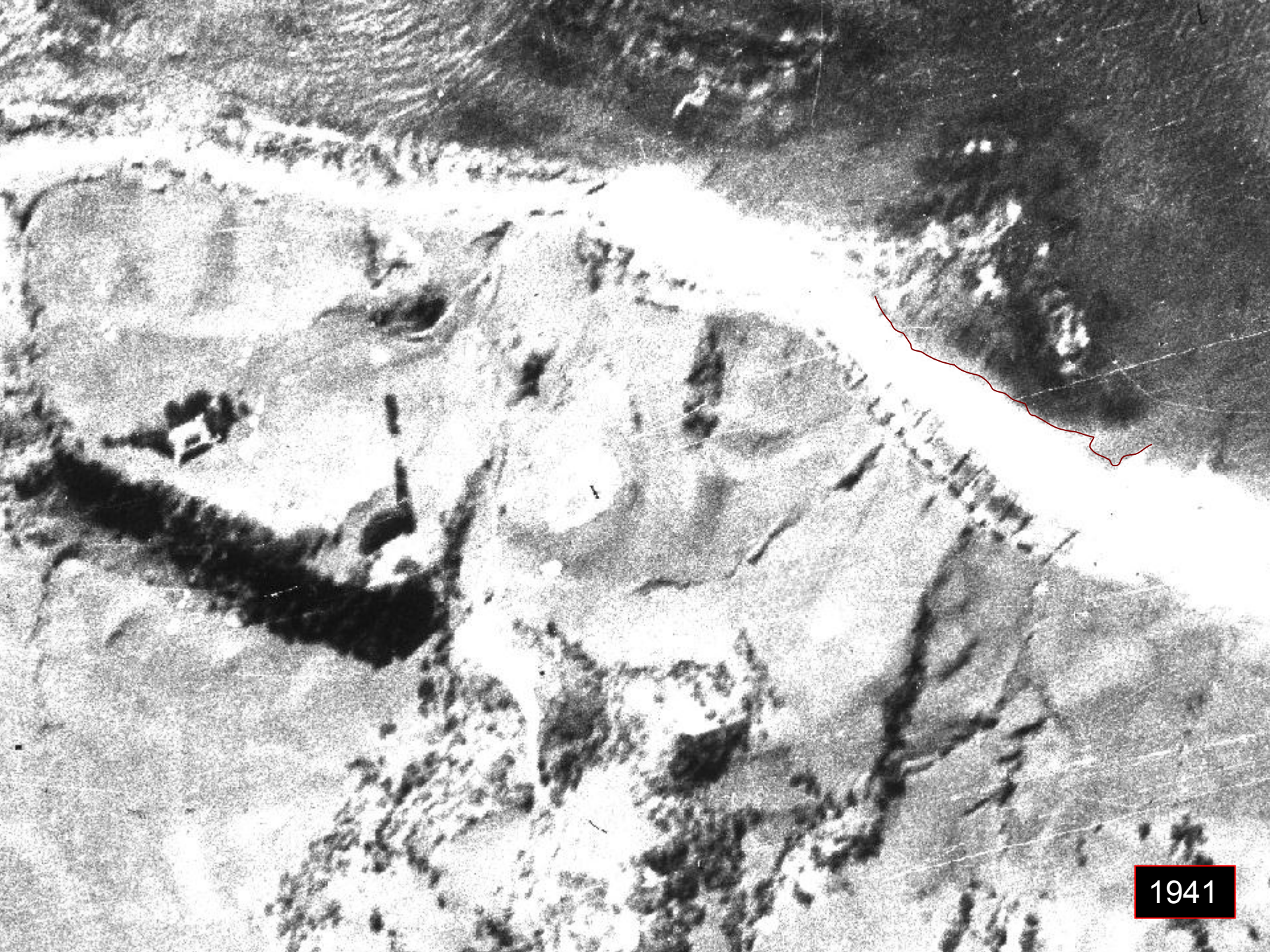
- VERTICAL MOVEMENT OF COASTAL PLATFORMS
- ANALYSIS OF TIDE-GAUGE TIME SERIES
- SPATIO-TEMPORAL EVOLUTION OF SEISMICITY

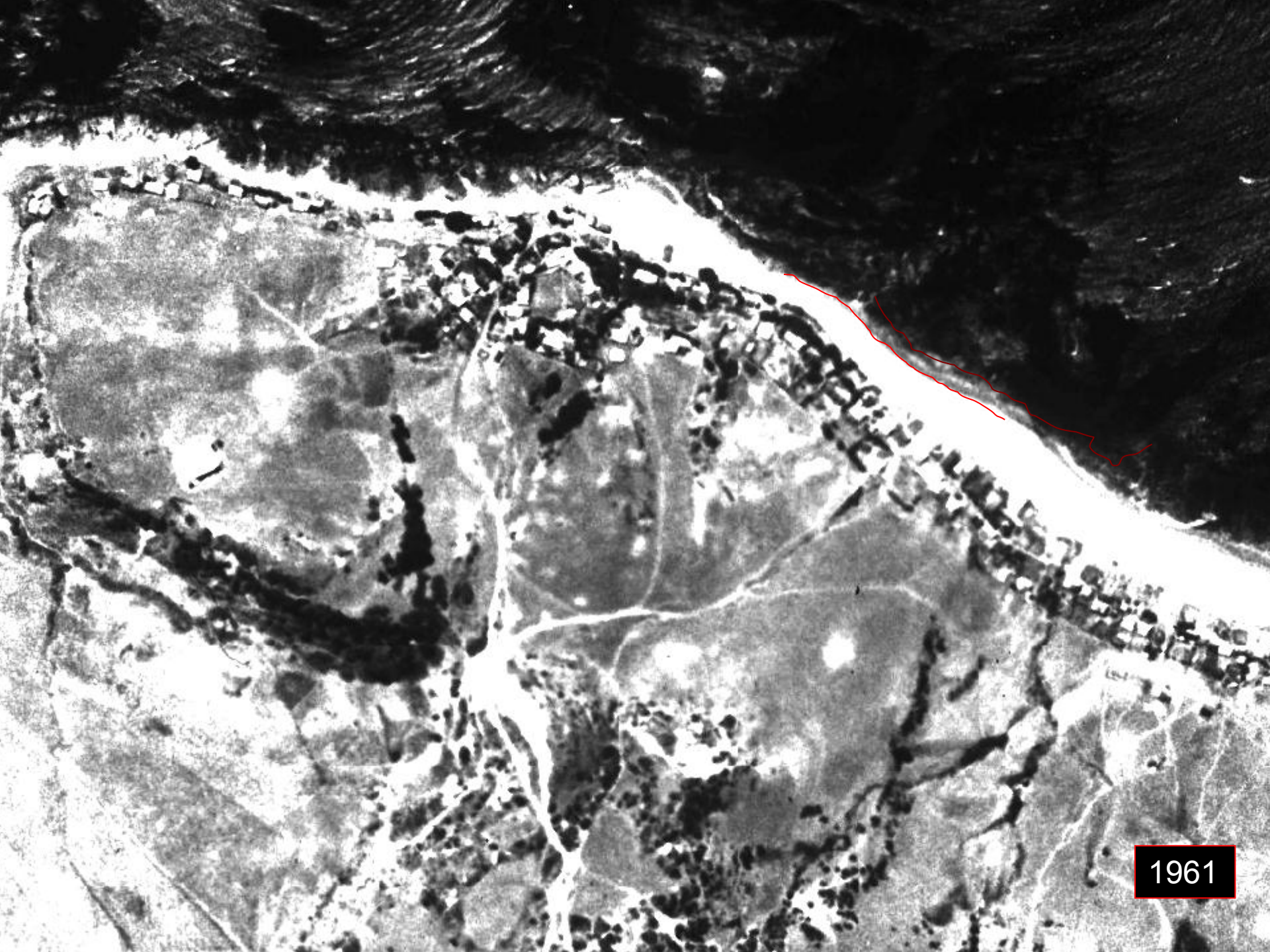
VERTICAL MOVEMENT OF COASTAL PLATFORMS

Punta Lavapie

VERTICAL MOVEMENT OF COASTAL PLATFORMS

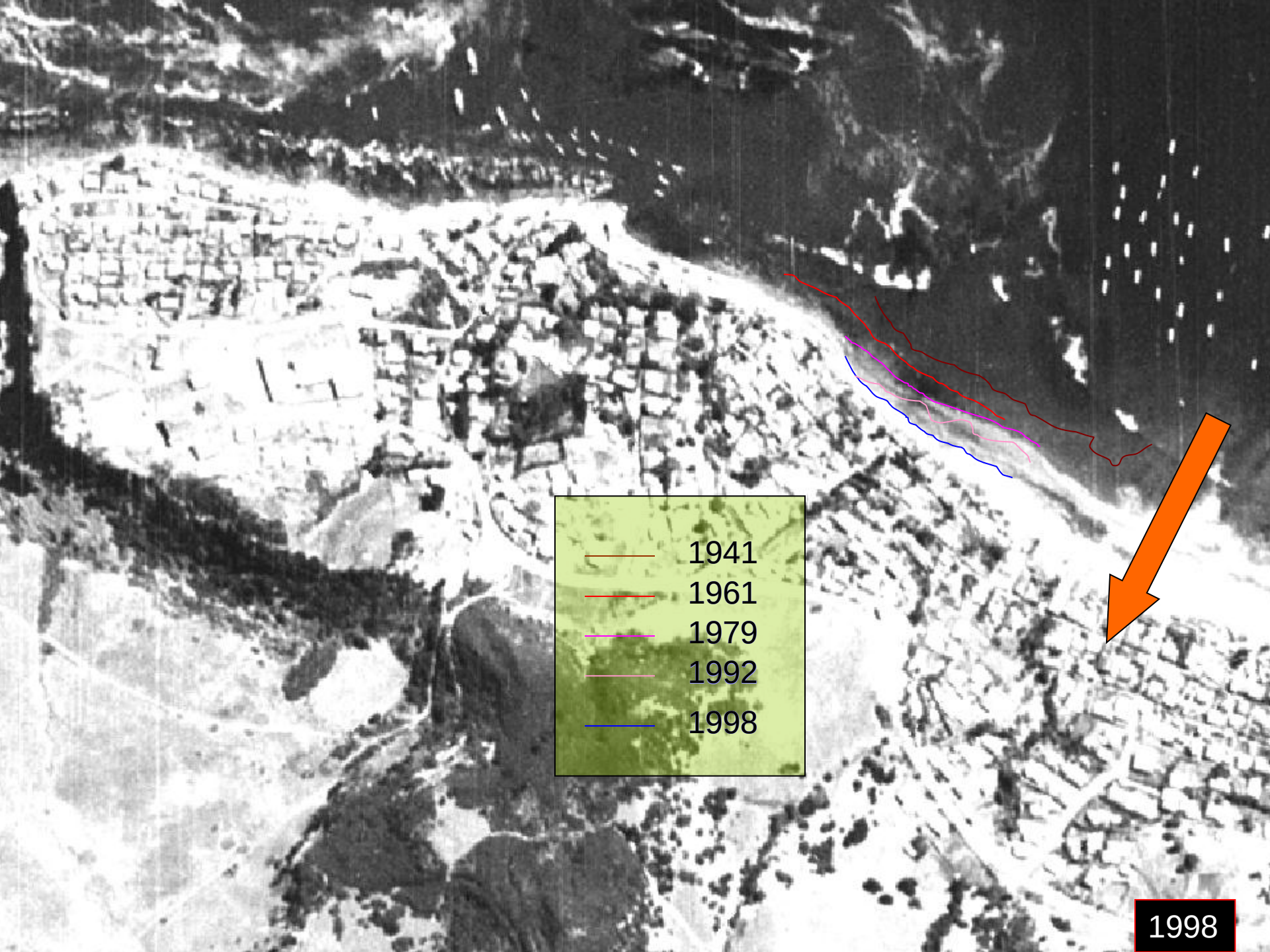
Punta Lavapié II, S-Ansicht; DGM-Raster=5 cm

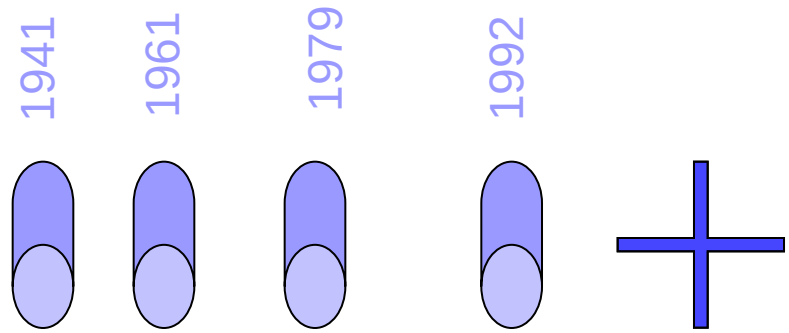

1941

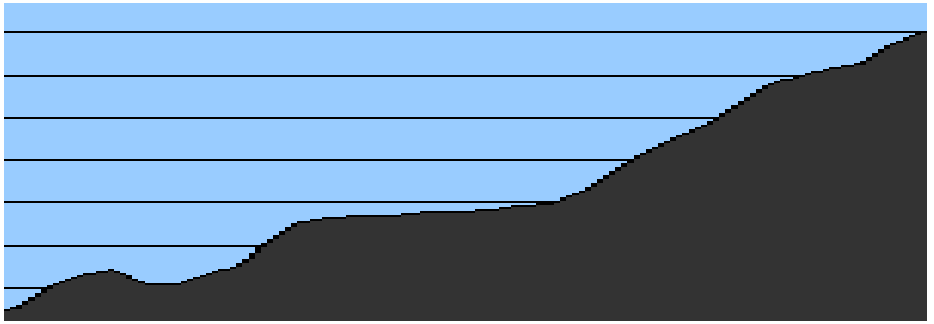

1961

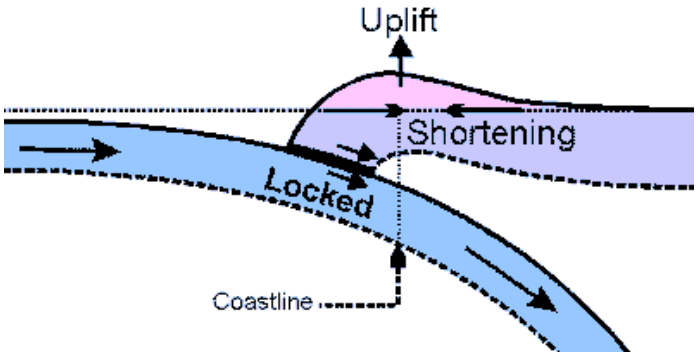

1979

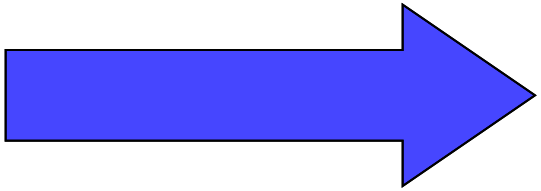

13,5 m
1992

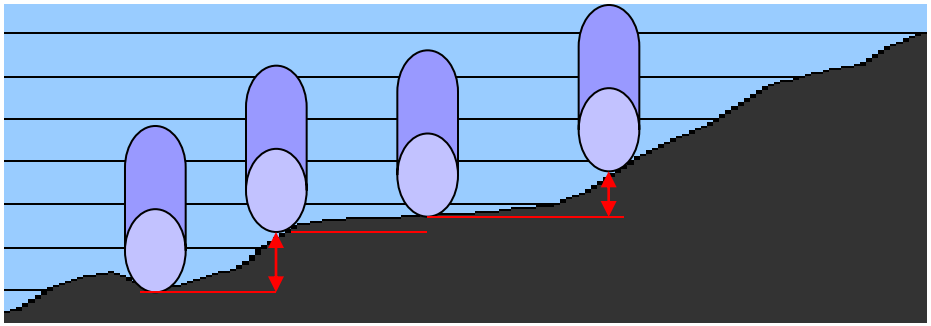

1941
1961
1979
1992
1998
1998


1941
1961
1979
1992

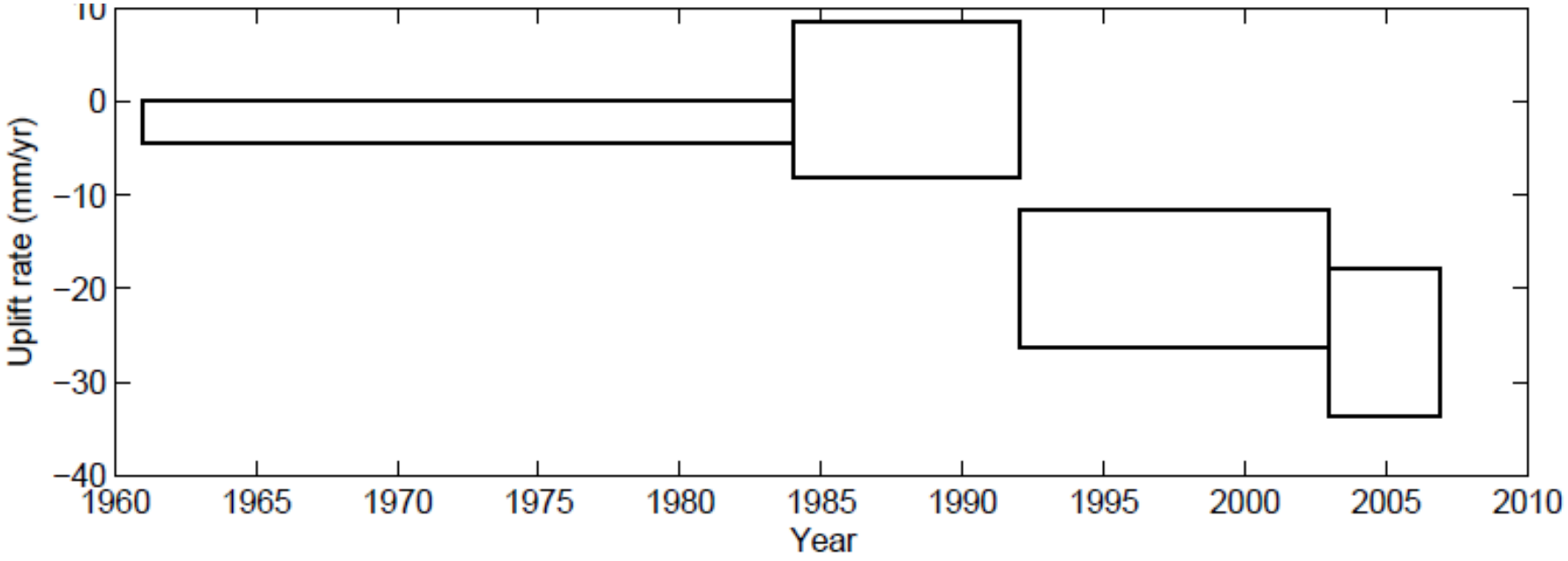



Uplift
Shortening
Locked
Coastline



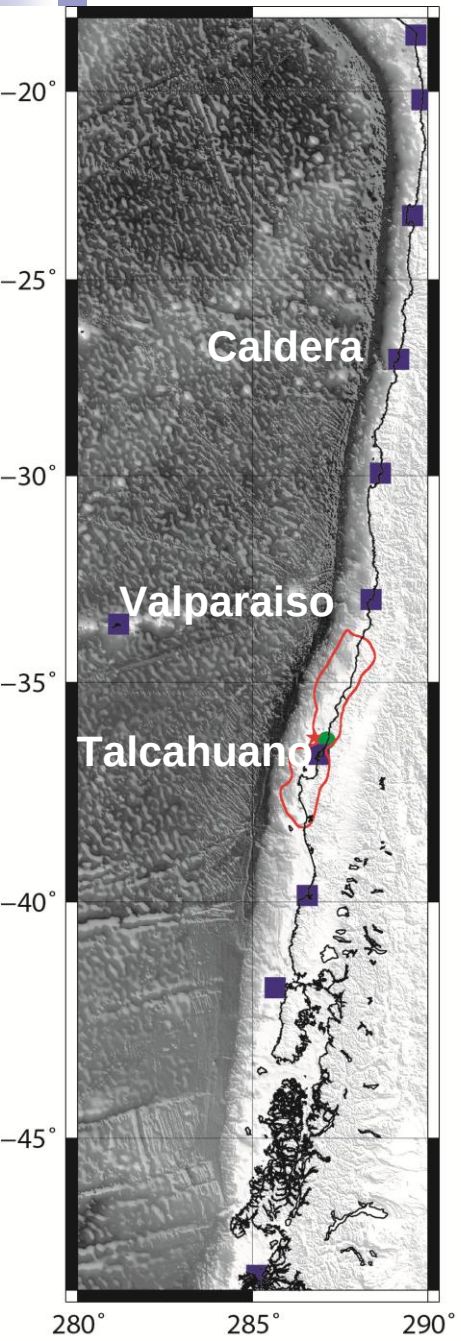


VERTICAL MOVEMENT OF COASTAL PLATFORMS

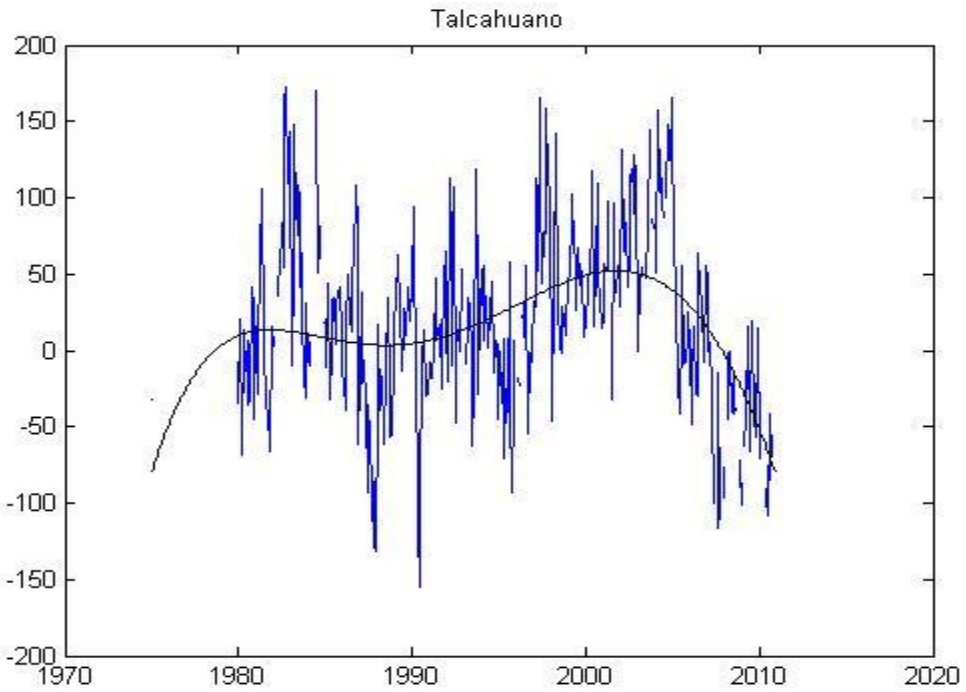


Preliminary results showing rapid subsidence since mid 90`s (10 times larger than global sea-level rise)

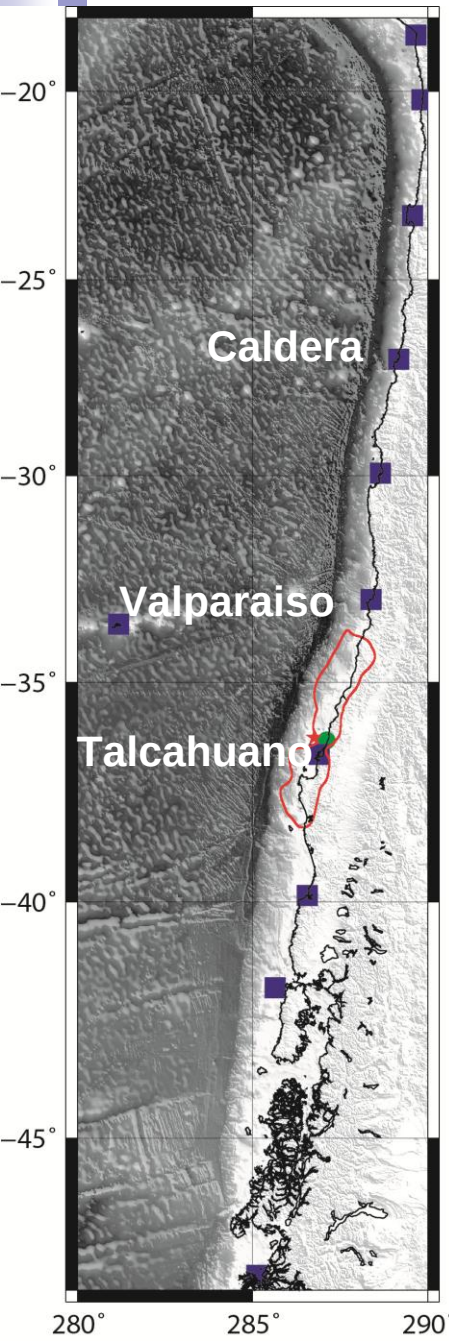
ANALYSIS OF TIDE-GAUGE TIME SERIES

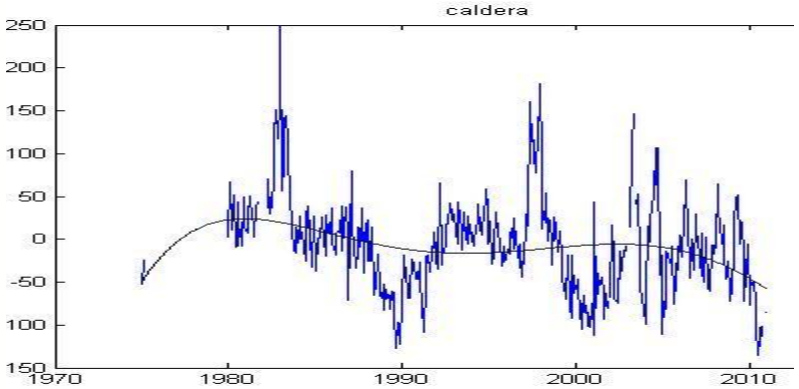


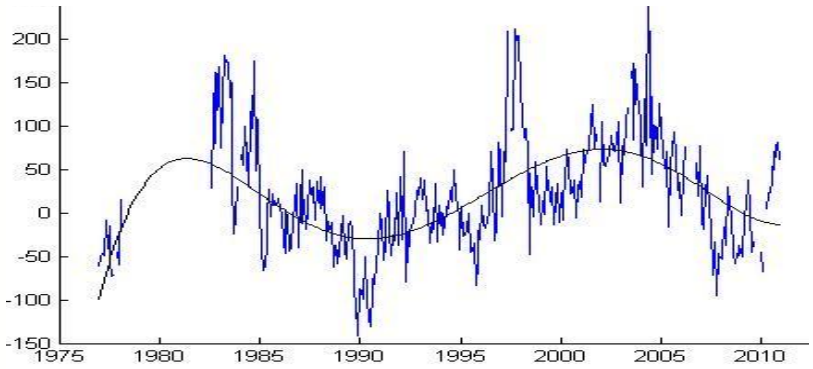
Mareograms record sea-level variations due to a combination of ocean-atmospheric phenomena and land-level vertical movement of tectonic origin

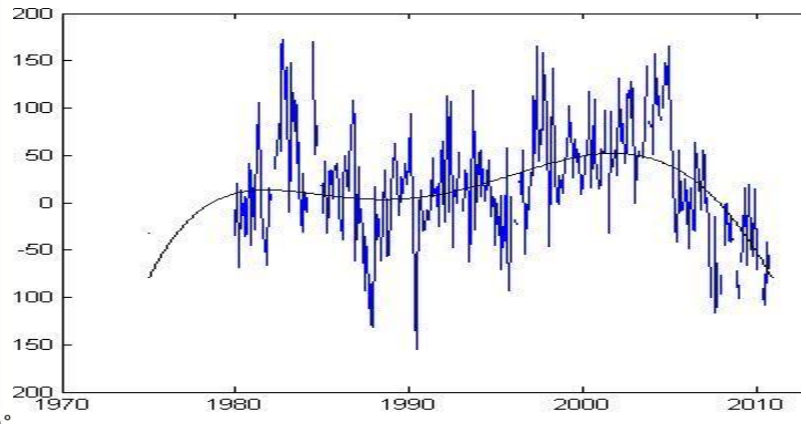


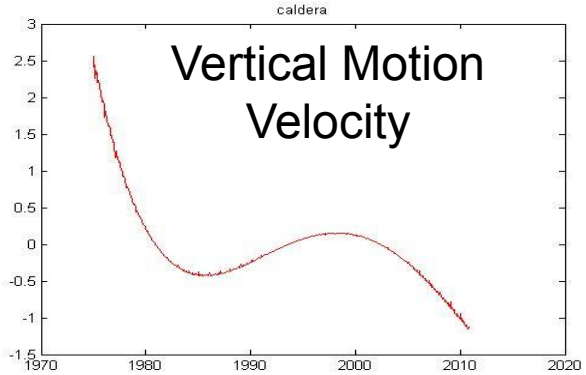
ANALYSIS OF TIDE-GAUGE TIME SERIES

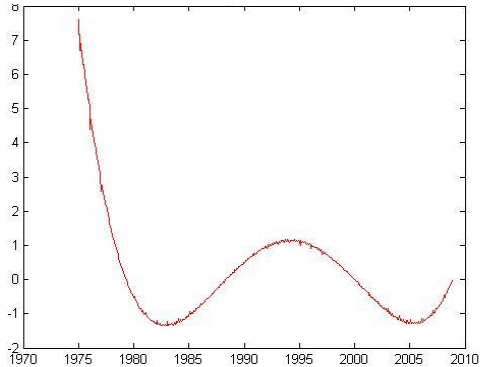


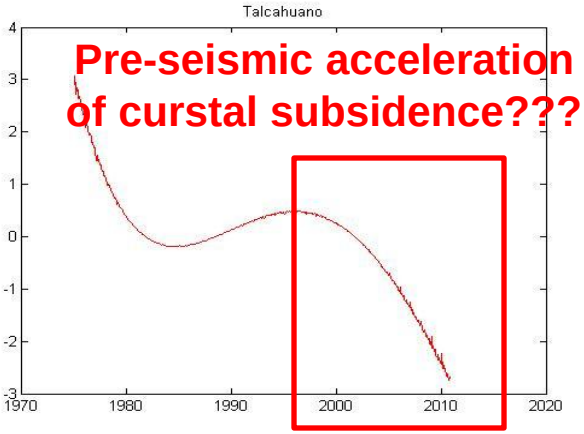








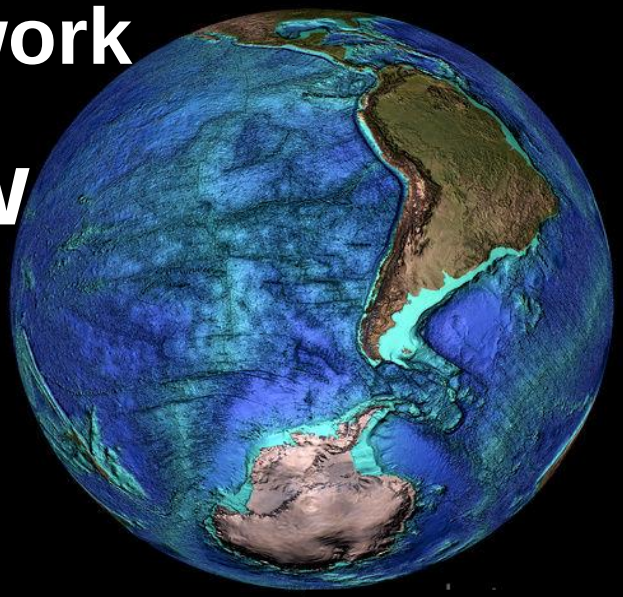




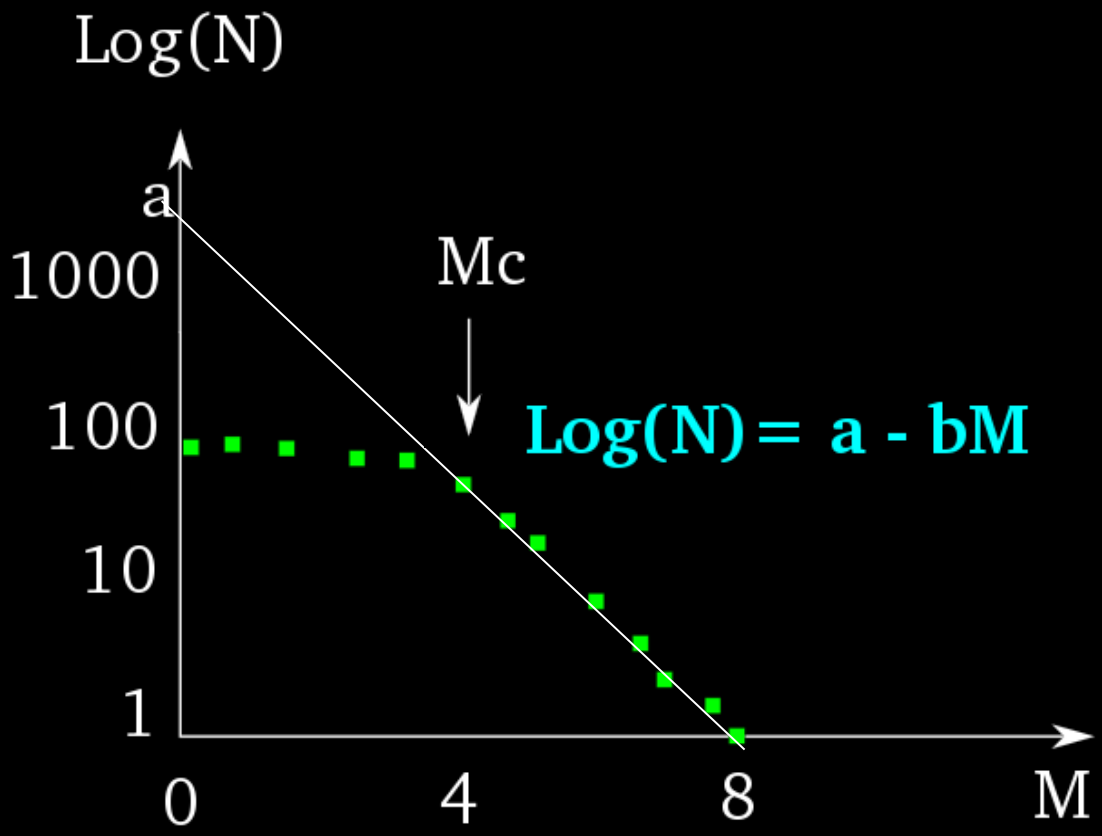
SPATIO-TEMPORAL EVOLUTION OF SEISMICITY

Hugo Soto and Daniel Morales work

Gutenberg-Richter Law



- *Frecuencia-magnitug* relationship for a set of earthquakes in a given time and volume



N: Number of earthquakes with magnitude > M

M: Magnitude

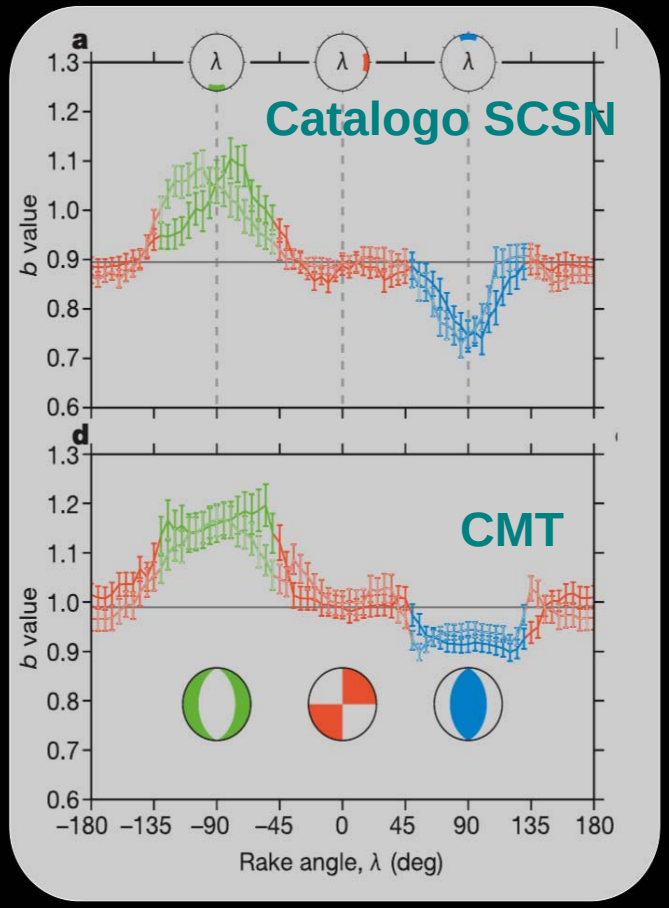
a: Rate of Seismicity

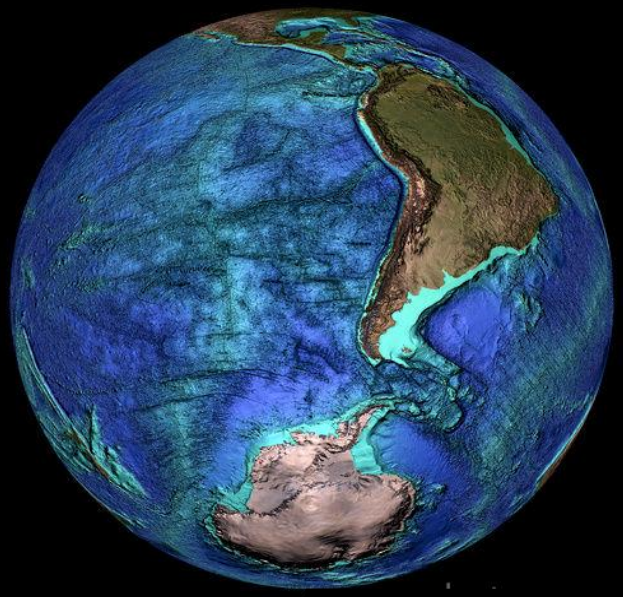
b: Slope of linear relationship

Mc: Magnitude of completness

b-value and degree of Coupling

- Schorlemmer et al (NATURE 2005)



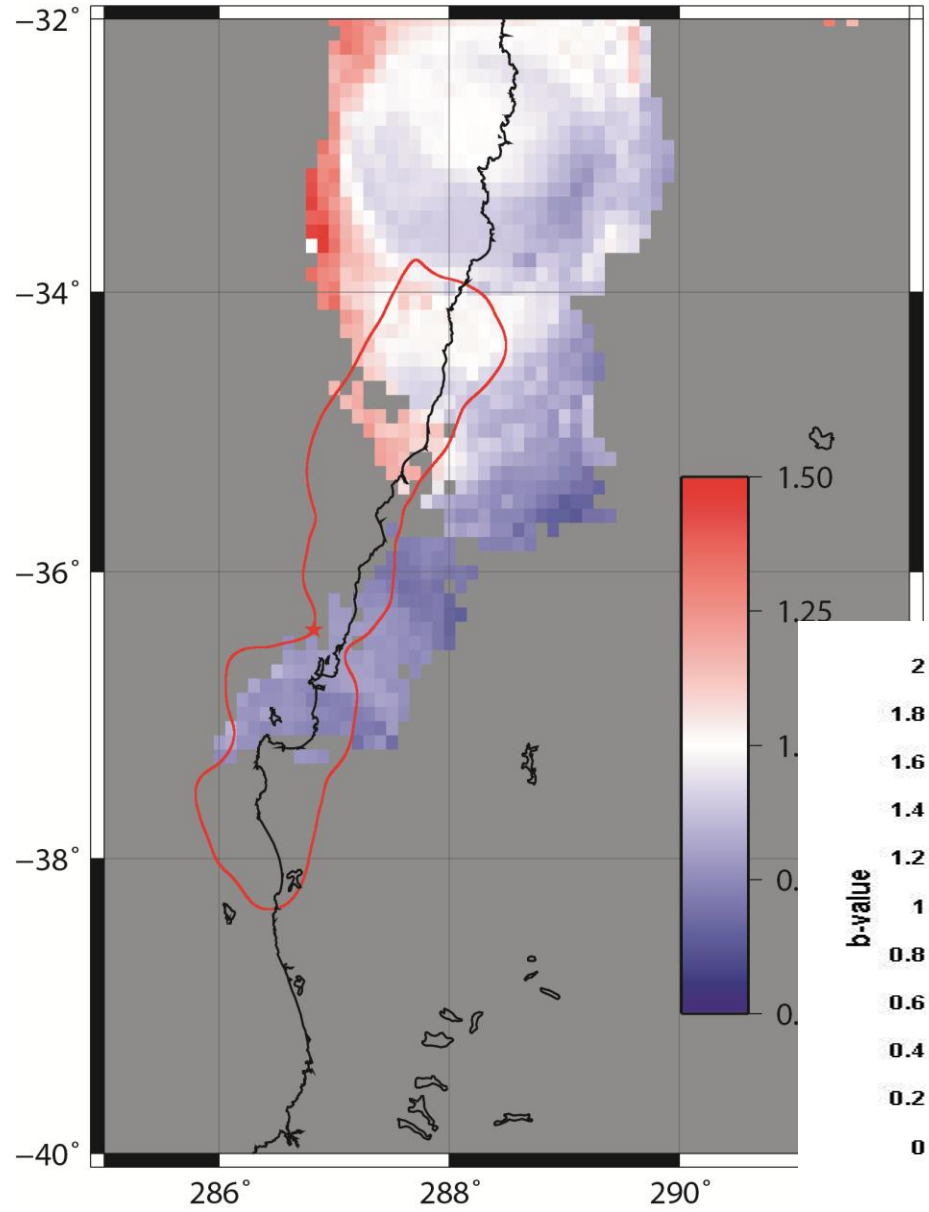


Normal **Low Stress**

Shear

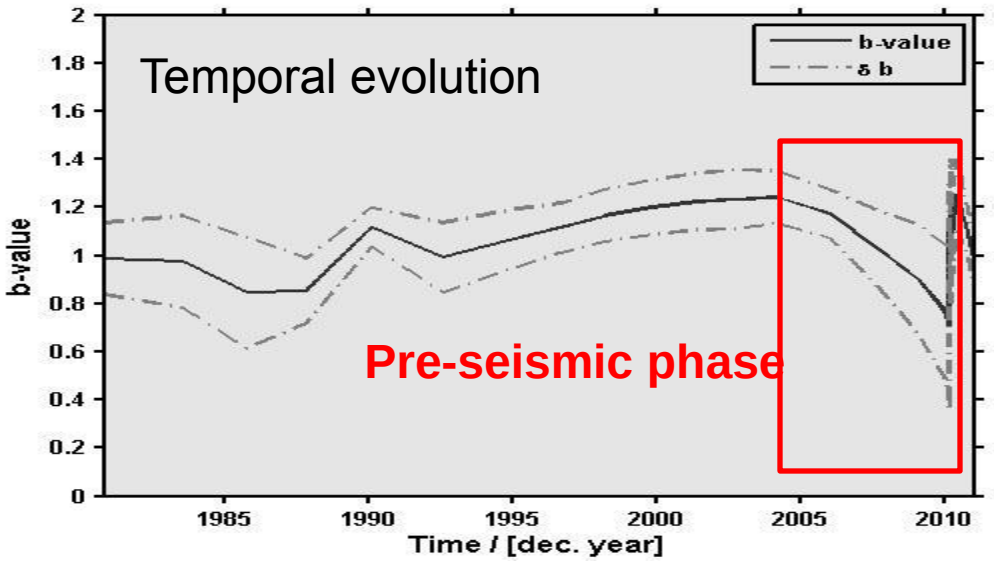
Reverse **High Stress**

SPATIO-TEMPORAL EVOLUTION OF SEISMICITY



b-value computed from NEIC seismicity (1973-2009) 15 km around the megathrust.

Red start and line are epicenter (Vigny et al. 2011) and 4-m slip contour (Lorito et al. 2010) of Maule earthquake



COSEISMIC PHASE OF THE MAULE EARTHQUAKE

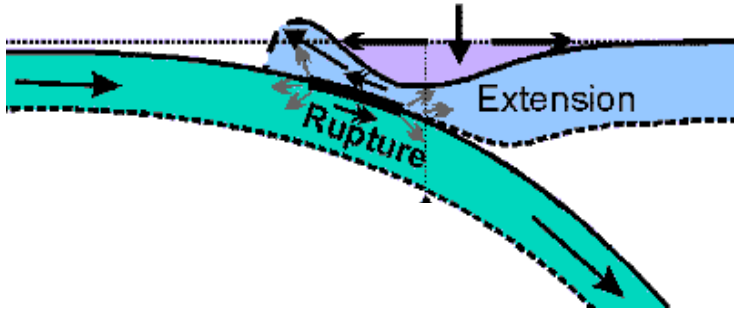
Sciencexpress Brevia

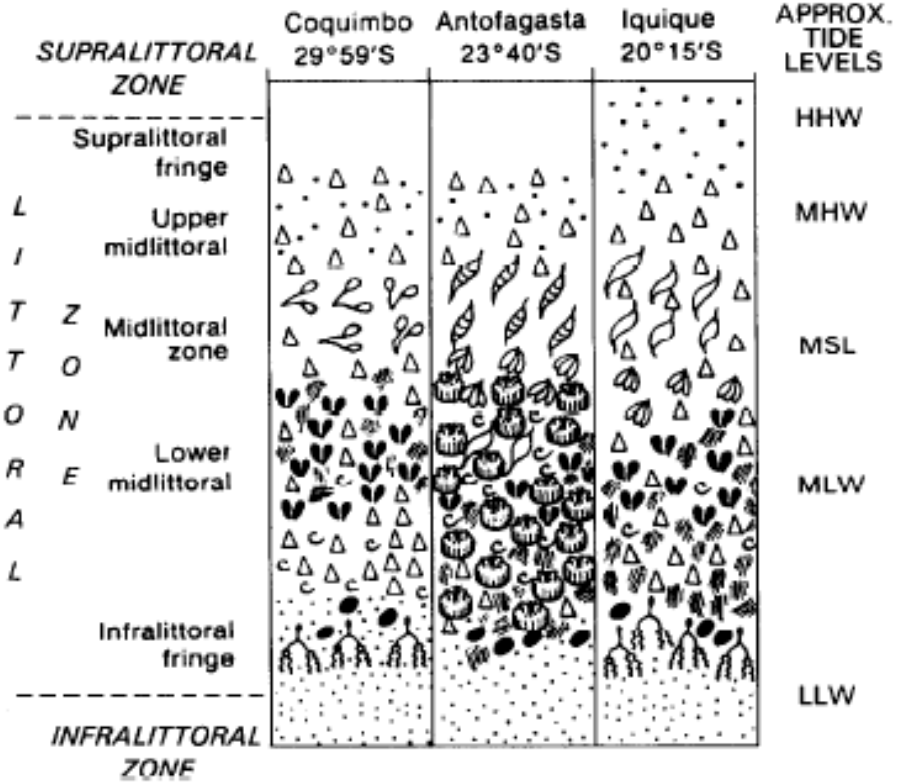
Land-Level Changes Produced by the M_w 8.8 2010 Chilean Earthquake

Marcelo Farías,[1]* Gabriel Vargas,[1] Andrés Tassara,[2] Sébastien Carretier,[3] Stéphane Baize,[4] Daniel Melnick,[5] Klaus Bataille[2]

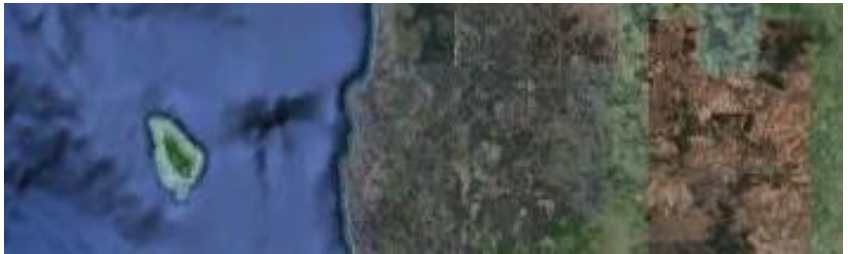
[1]Departamento de Geología, Universidad de Chile, Plaza Ercilla 803, Santiago, Chile. [2]Departamento de Ciencias de la Tierra, Universidad de Concepción, Casilla 160-C, Concepción, Chile. [3]IRD, LMTG, UPS (OMP), Université de Toulouse, 14, Av. Belin, Toulouse 31400, France. [4]Institut de Radioprotection et de Sûrete Nucléaire (IRSN), BP 17, 92262 Fontenay-aux-Roses, France. [5]Institut für Erd- und Umweltwissenschaften, Univesität Potsdam, Haus 27, Zi. 2.26, Karl-Liebknecht-Str. 24, 14476 Golm, Germany.

Litoral organisms dead and dried at 1.5-2 m above sea-level!!!!





Ortlieb et al. (1996)



UPLIFT

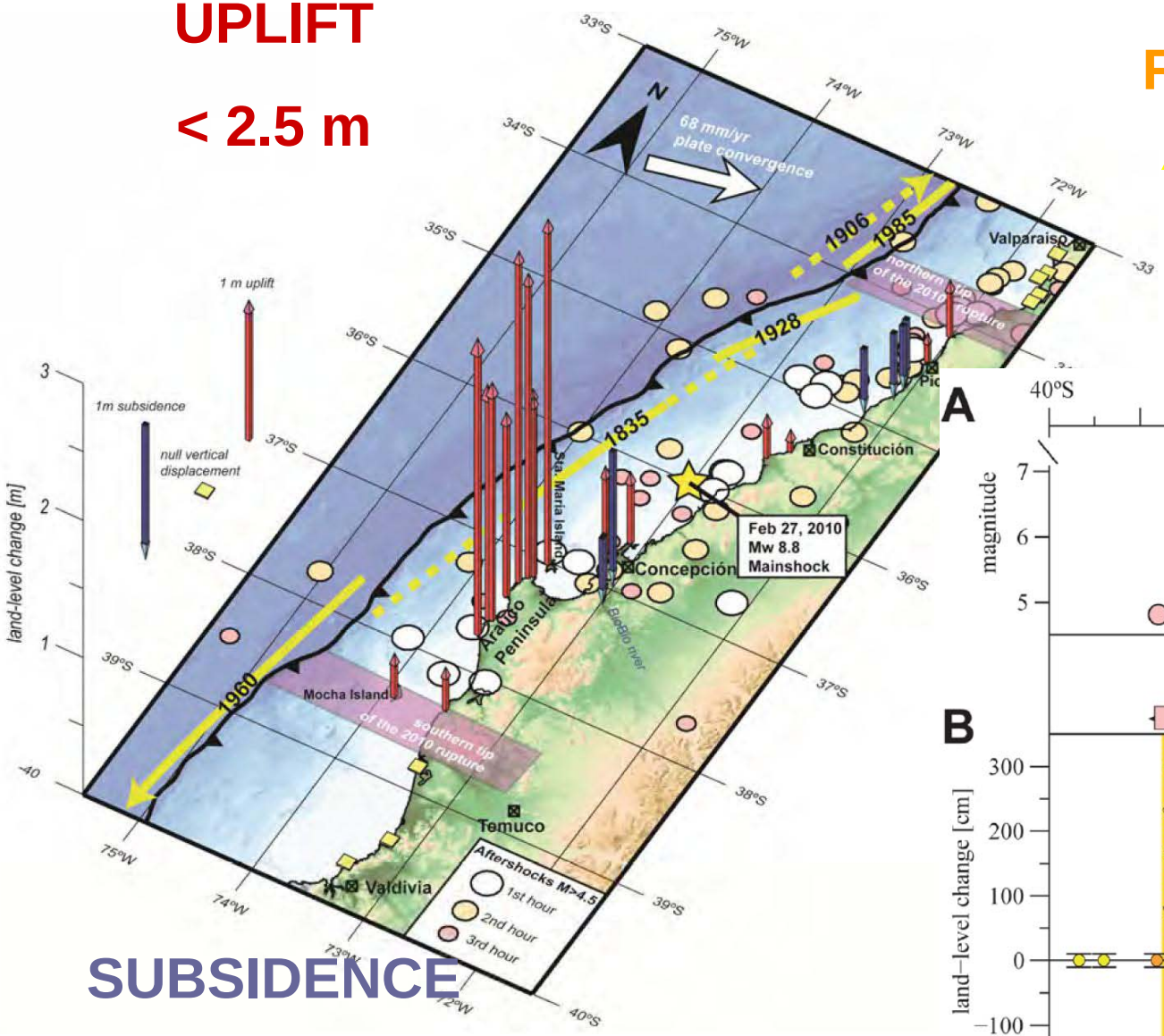
< 2.5 m

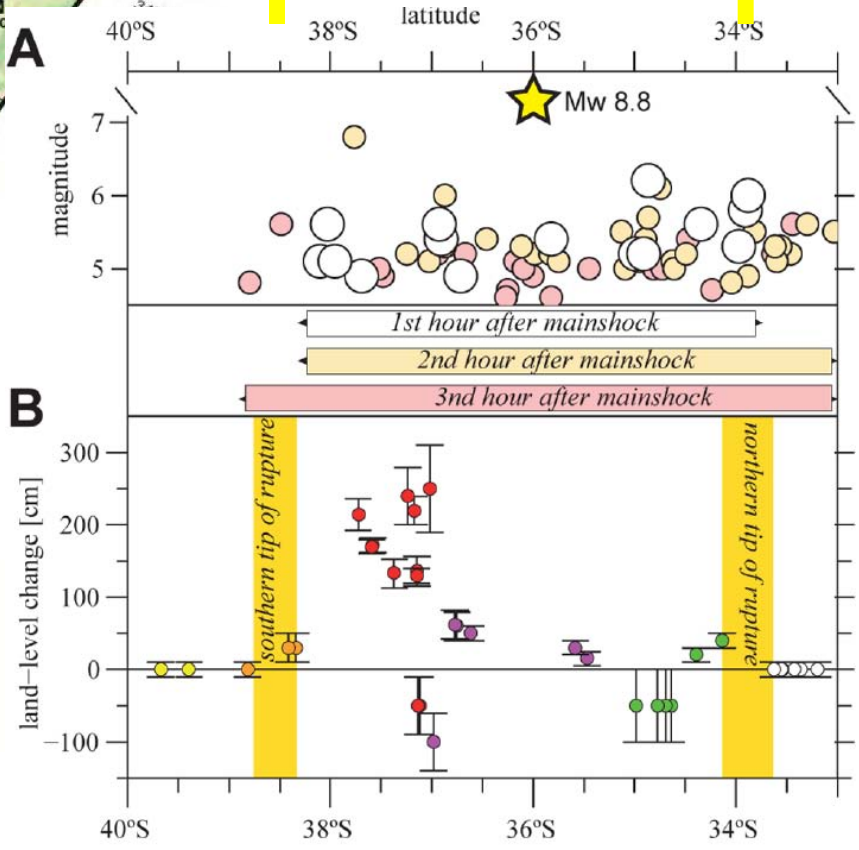
SUBSIDENCE

> - 1 m

RUPTURE LENGTH

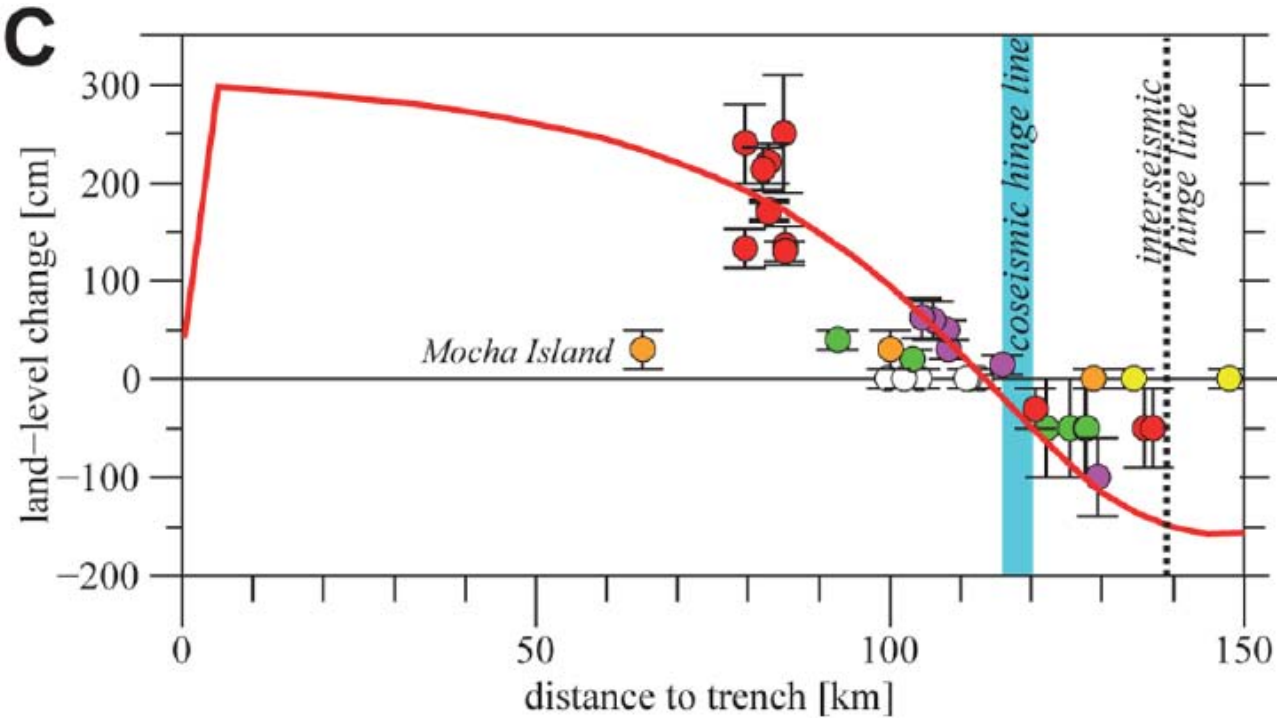
505 KM

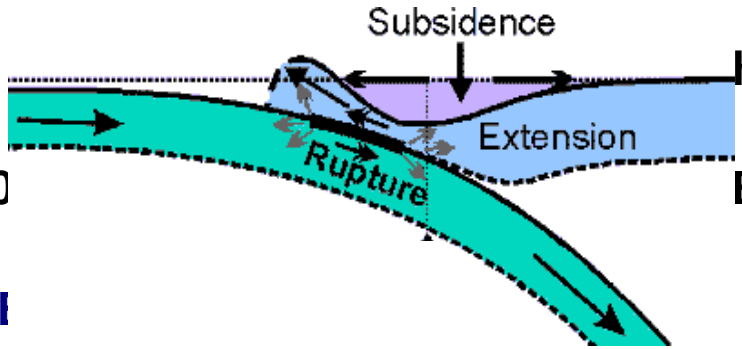




Preferred Elastic Dislocation Model

Updip = 0 km, downdip = 43 km, slip = 10 m



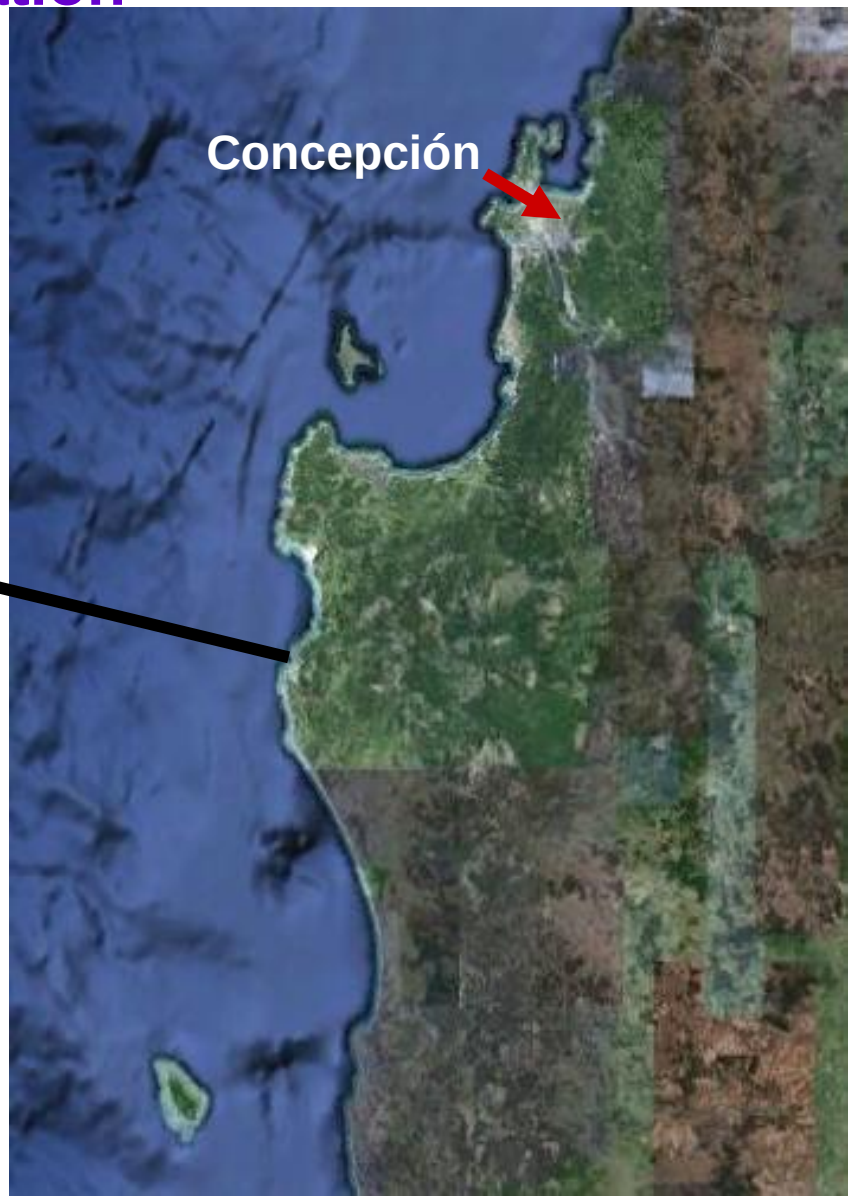


FAULT DIMENSIONS: **h (W)**

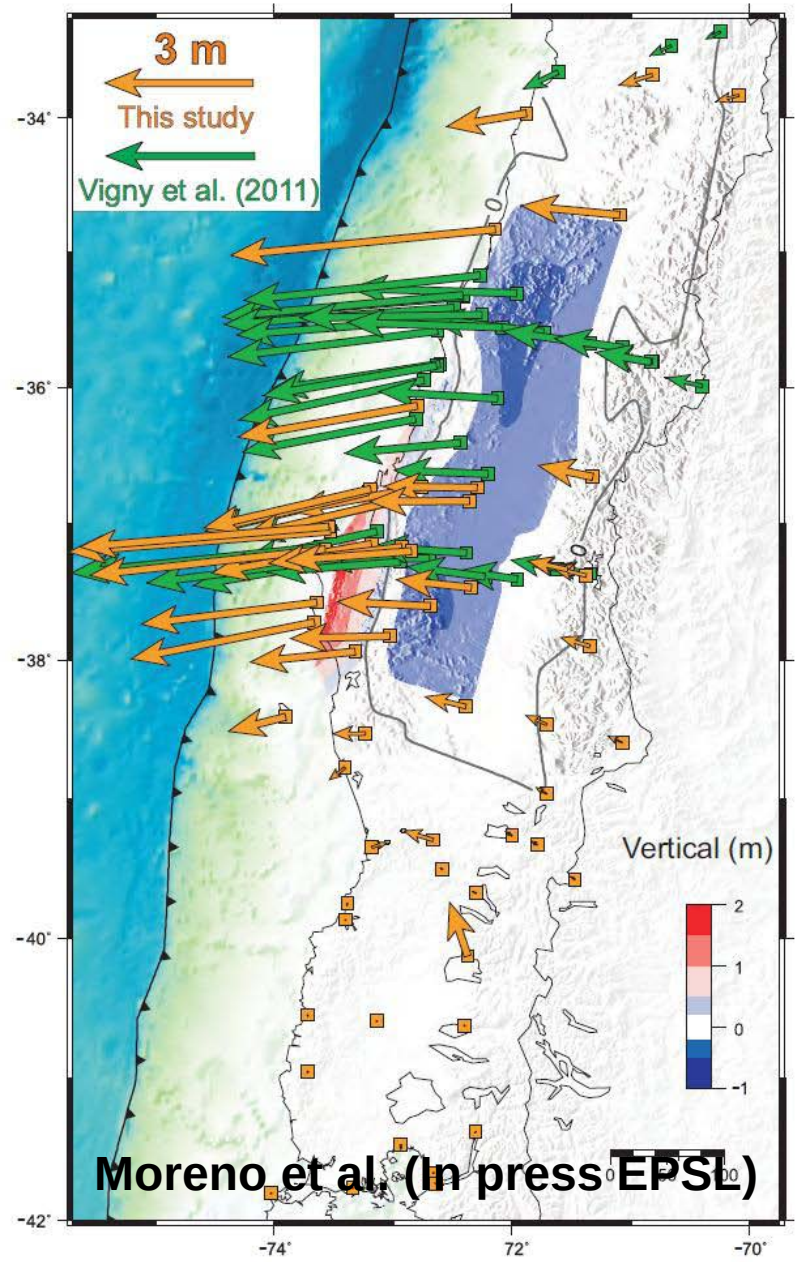
SEISMIC MOMENT: 30 **E22 Nm**

MOMENT MAGNITUDI

Re-measuring GPS campaign points for co-seismic deformation



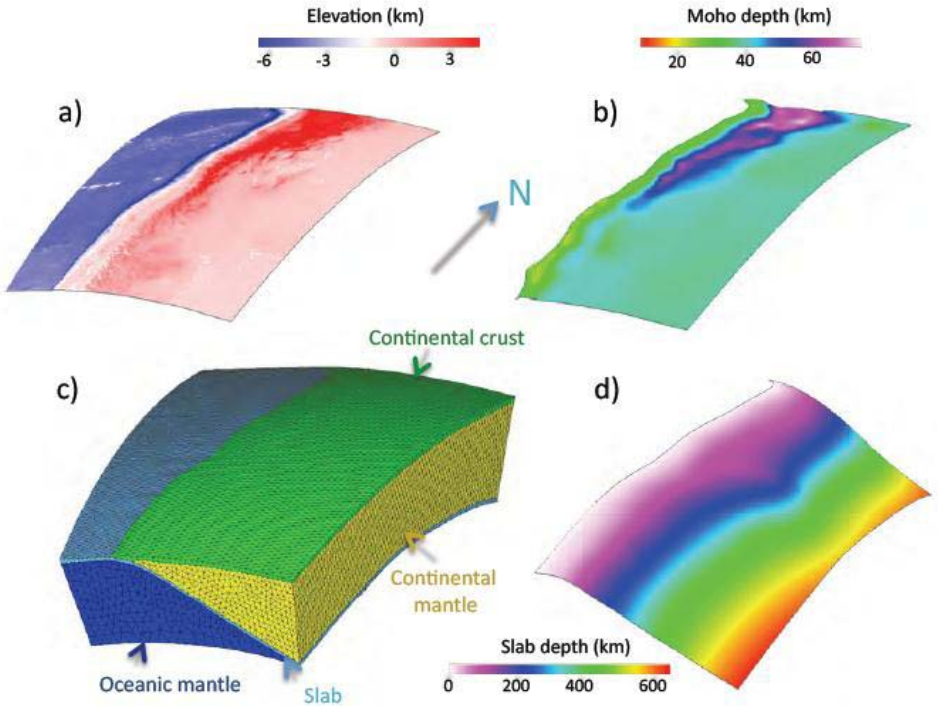
COSEISMIC HORIZONTAL DISPLACEMENT FROM CONTINUOUS AND CAMPAIGN GPS STATIONS



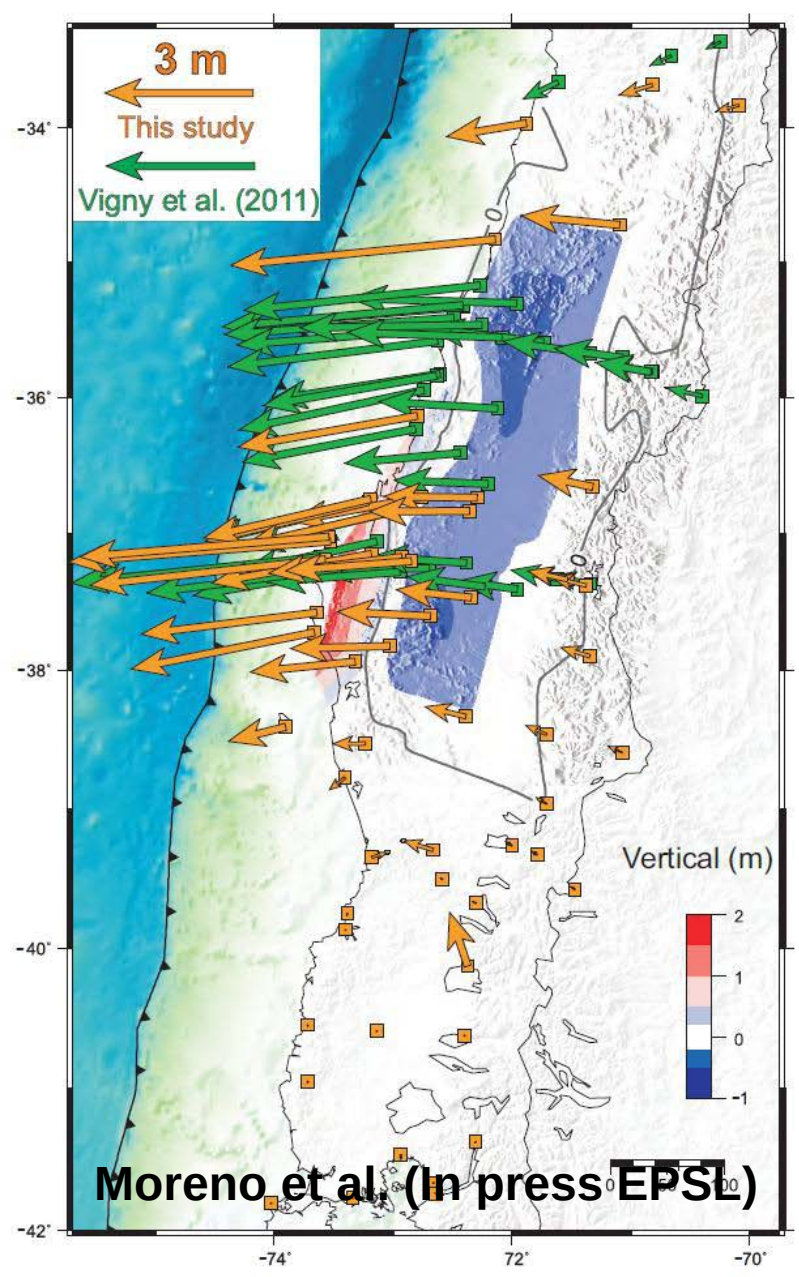
Moreno et al. (In press EPSL)

+ InSAR + Land-level changes from biomarkers

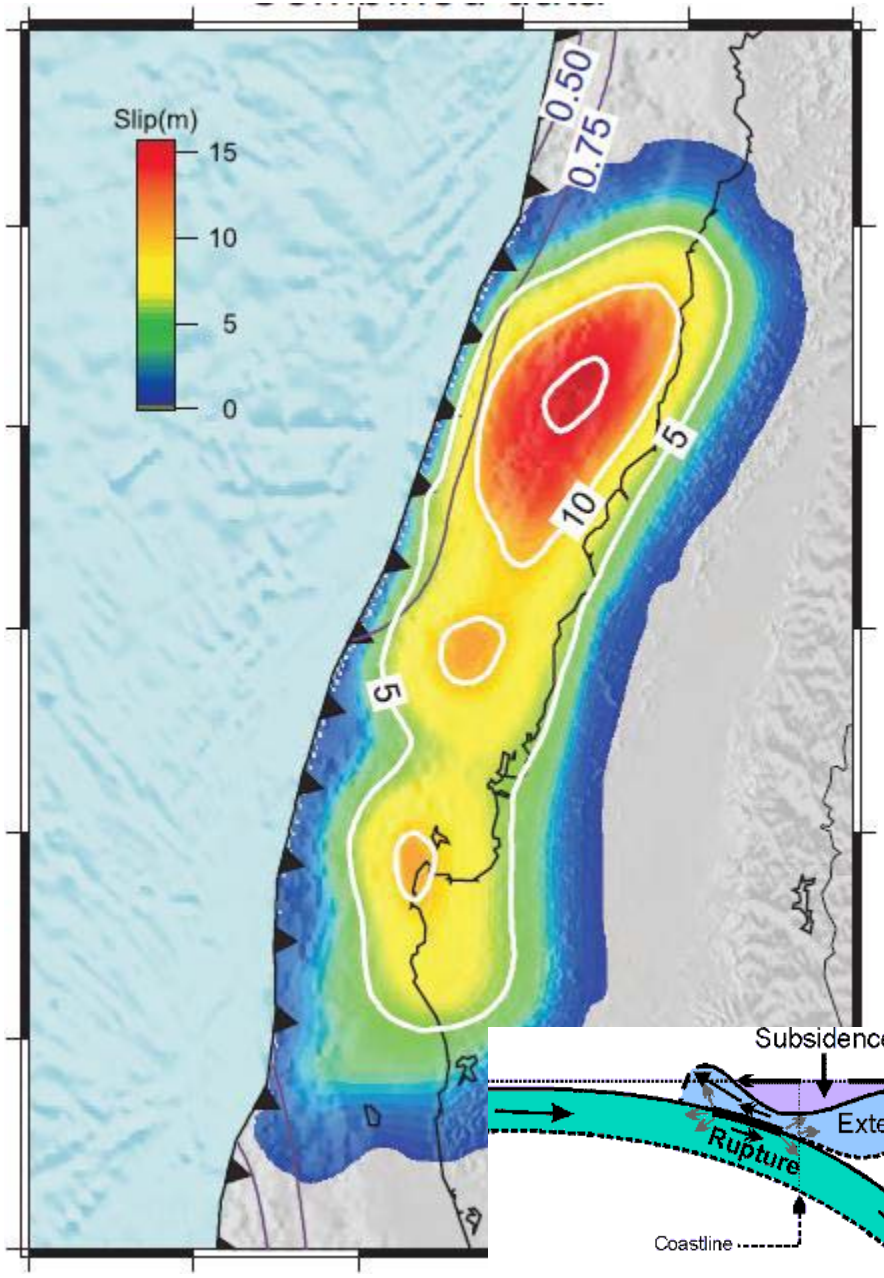
3D FEM with realistic geometries
(Tassara and Echaurren, accepted GJI)

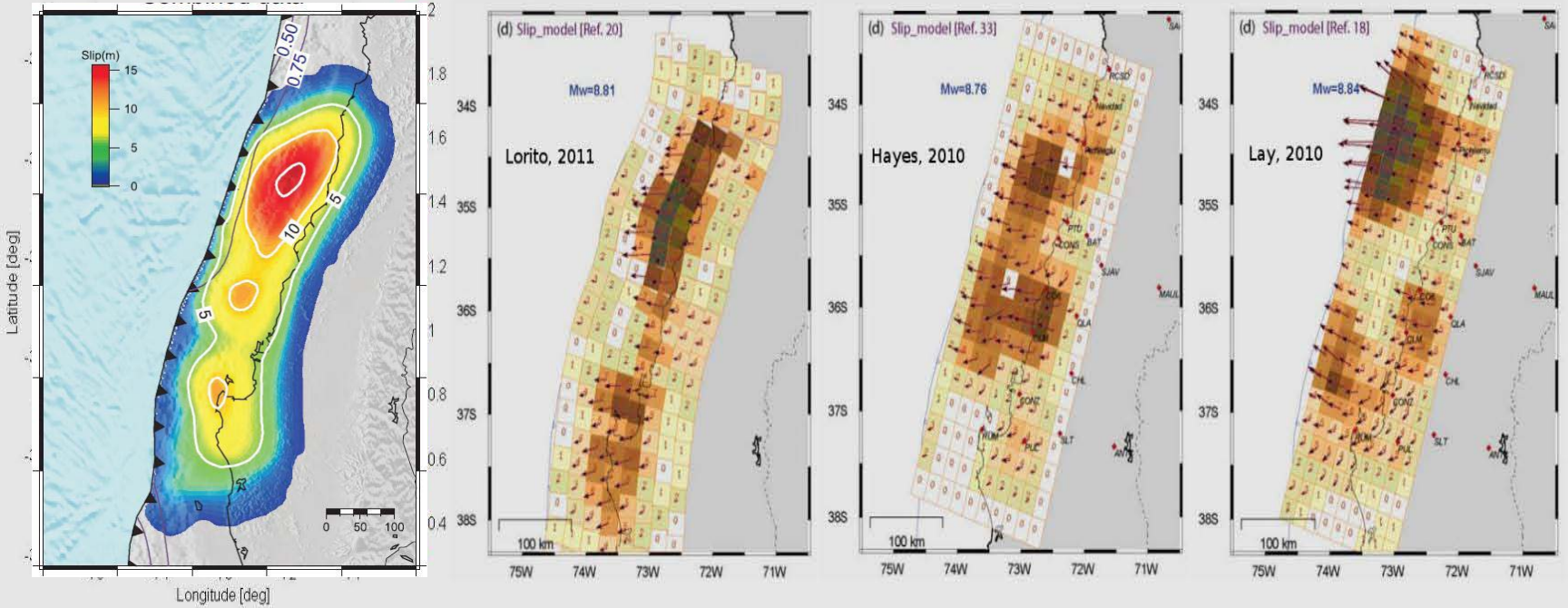


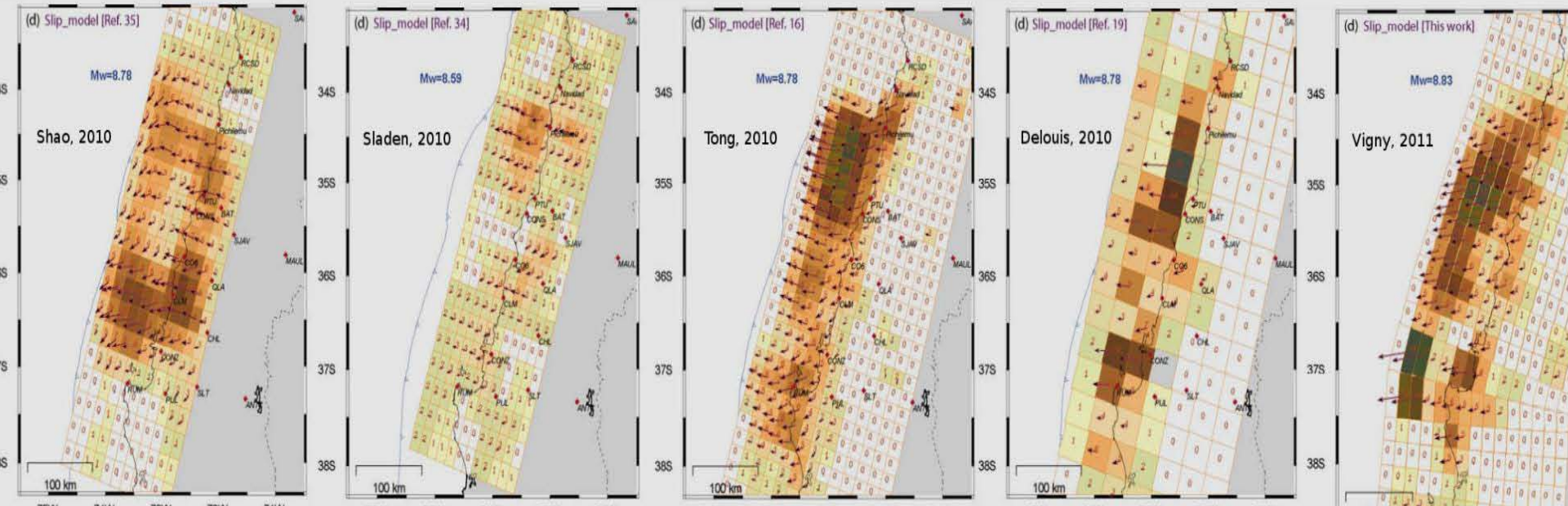
COSEISMIC SLIP MODEL



Moreno et al. (In press EPSL)

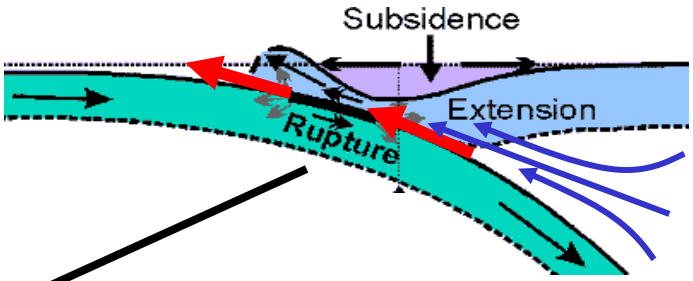



Slip(m)
15
10
5
0
0.50
0.75
5
10
5
0 50 100
Latitude [deg]
Longitude [deg]
(d) Slip_model [Ref. 20]
Mw=8.81
Lorito, 2011
(d) Slip_model [Ref. 33]
Mw=8.76
Hayes, 2010
(d) Slip_model [Ref. 18]
Mw=8.84
Lay, 2010
100 km
75W 74W 73W 72W 71W
34S 35S 36S 37S 38S


(d) Slip_model [Ref. 35]
Mw=8.78
Shao, 2010
(d) Slip_model [Ref. 34]
Mw=8.59
Sladen, 2010
(d) Slip_model [Ref. 16]
Mw=8.78
Tong, 2010
(d) Slip_model [Ref. 19]
Mw=8.78
Delouis, 2010
(d) Slip_model [This work]
Mw=8.83
Vigny, 2011
100 km
34S 35S 36S 37S 38S

POST-SEISMIC PHASE OF THE MAULE EARTHQUAKE

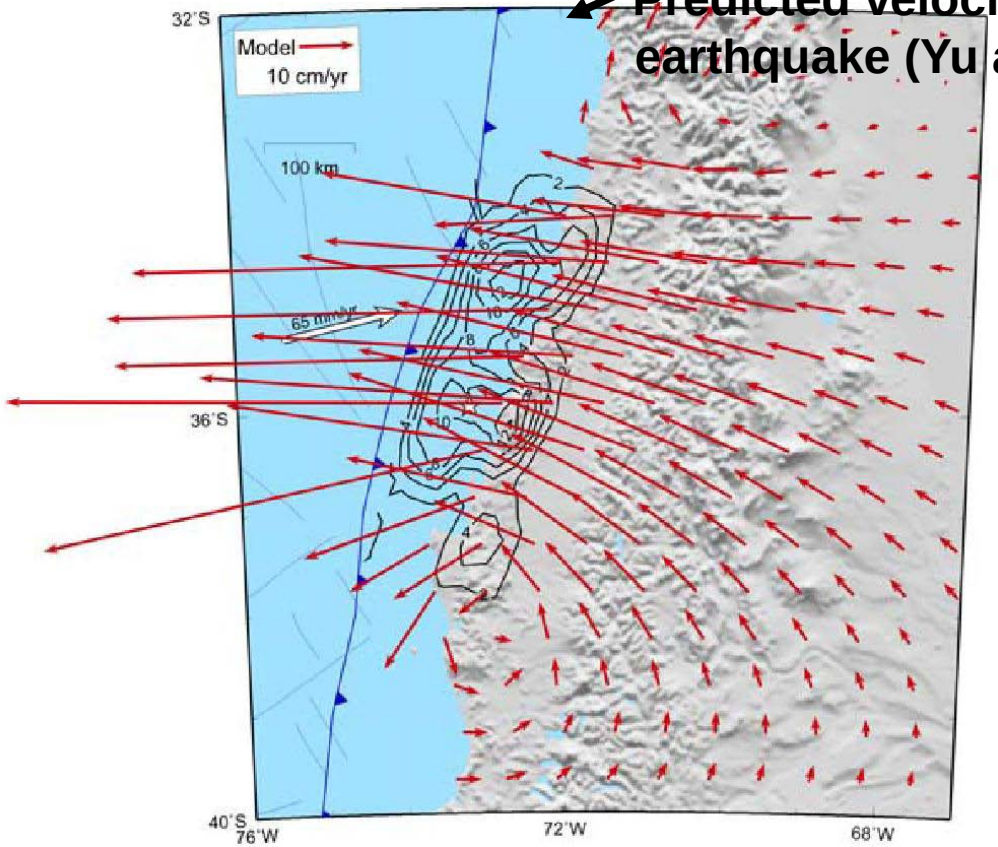
POSTSISMIC DEFORMATION

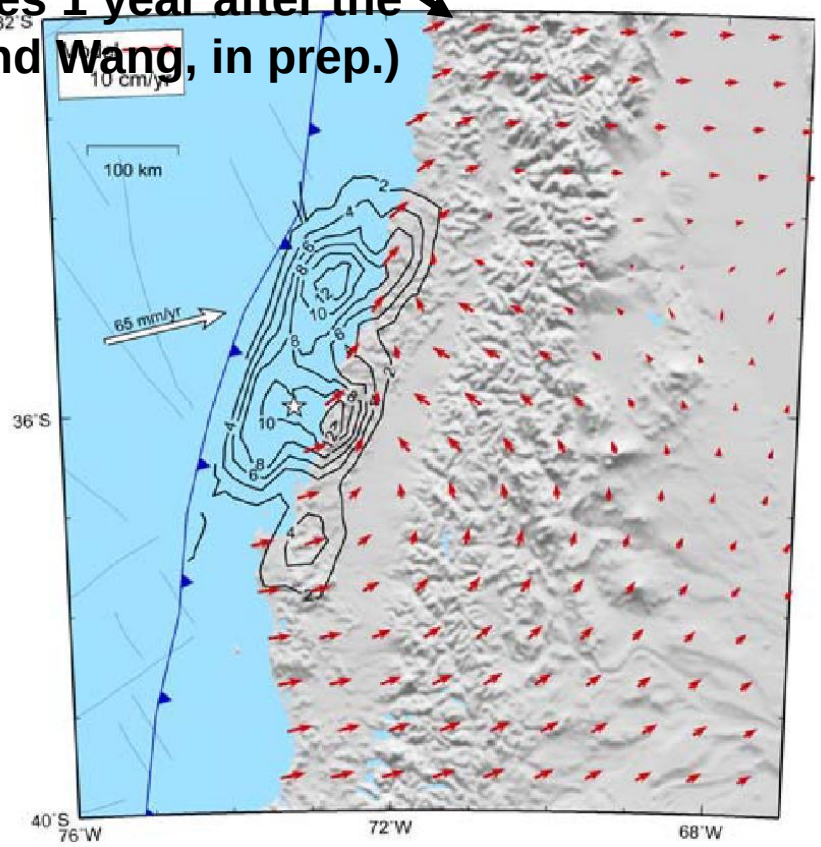


Rapid after-slip on the fault (0.1-2 años)

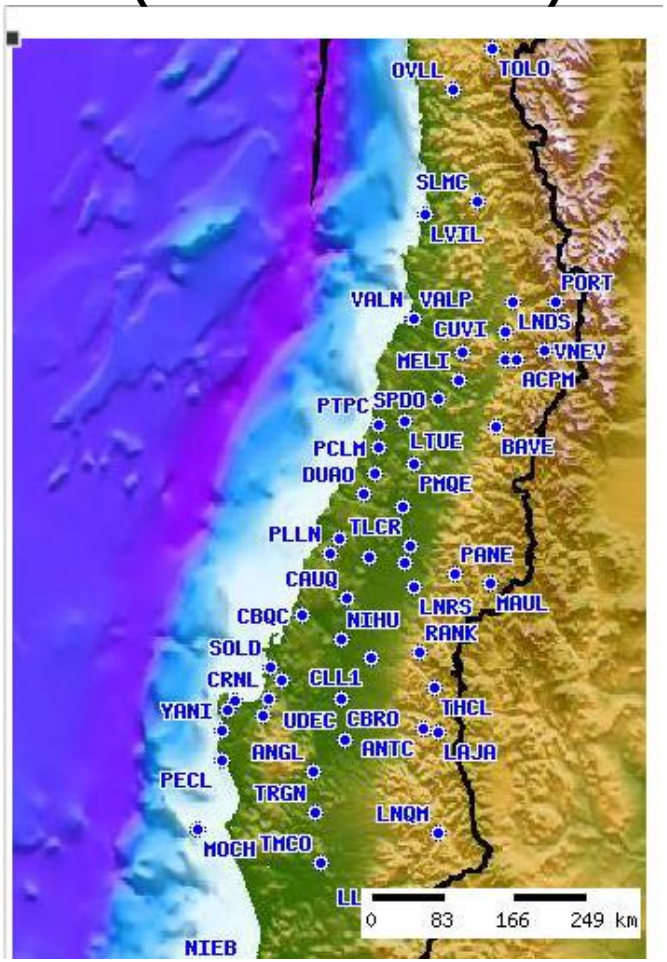
Slow viscous relaxation of mantle (10-50 años)

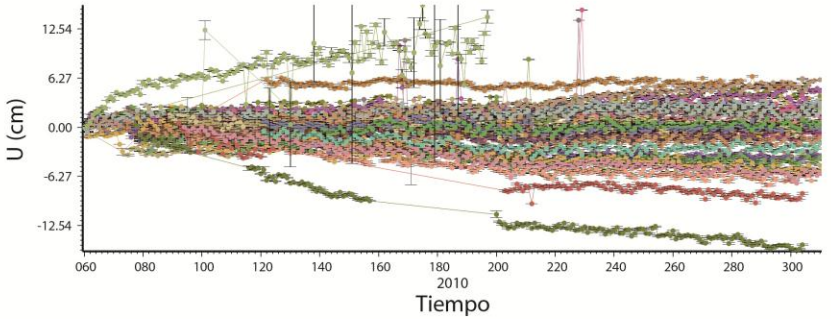
Predicted velocities 1 year after the earthquake (Yu and Wang, in prep.)



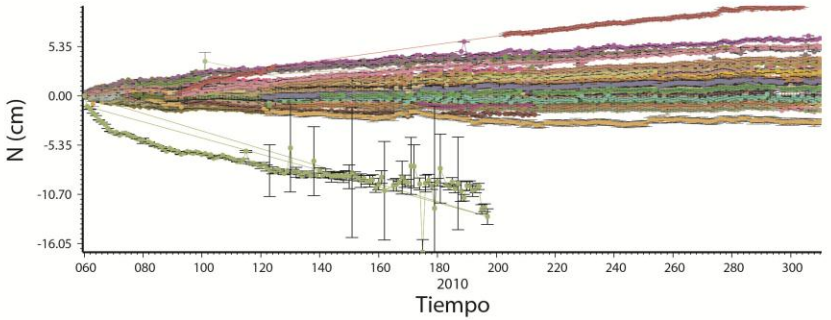


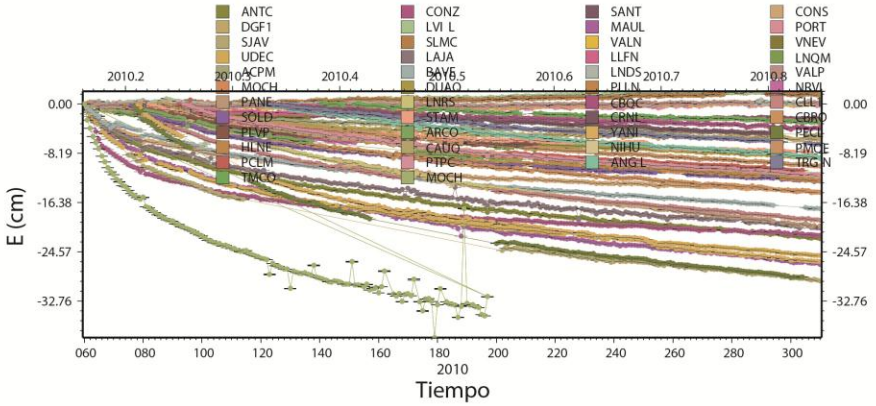
Continuous GPS stations being served and processed at UDEC (Juan Carlos Baez)



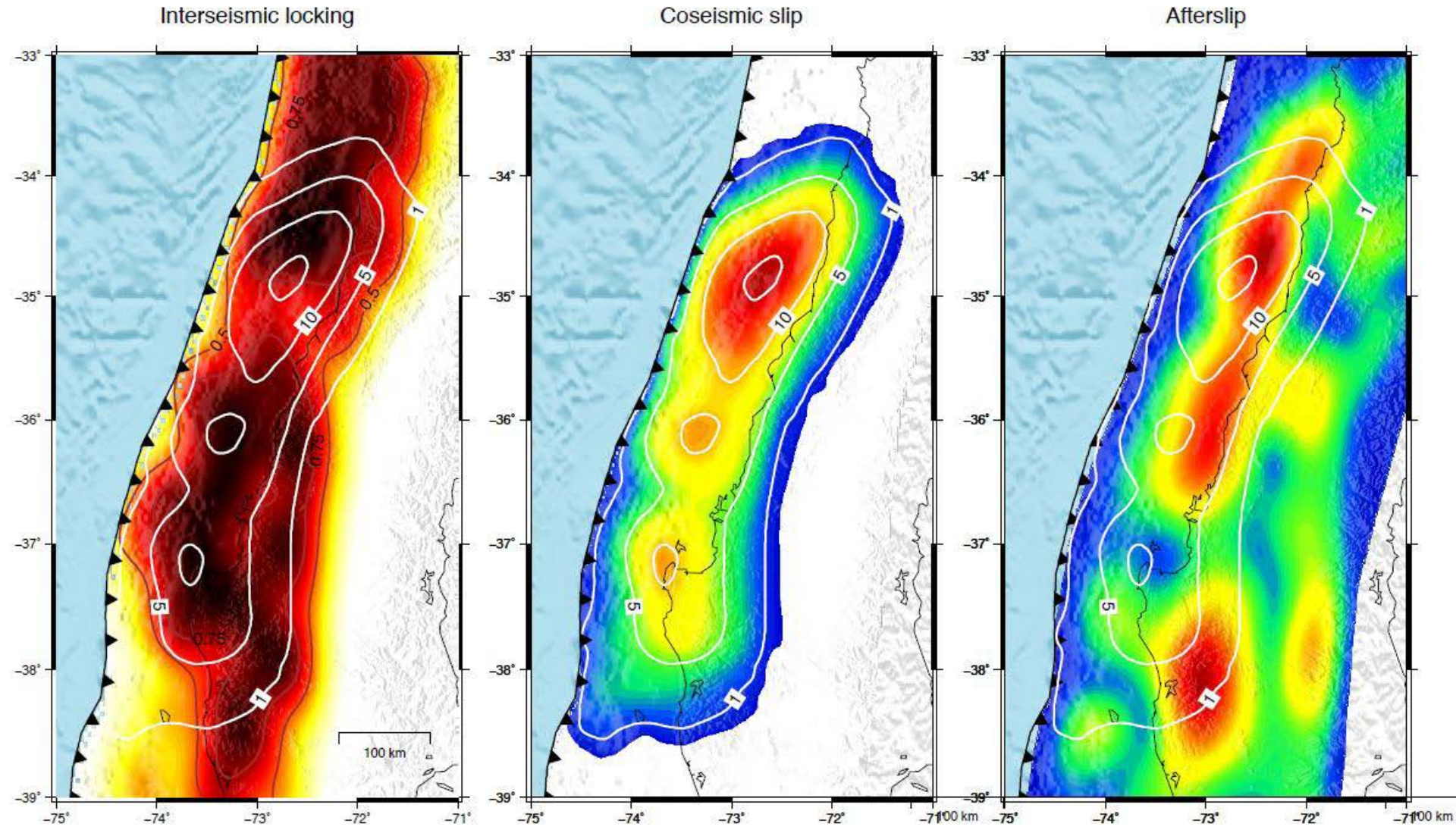


6 first month of post-seismic deformation

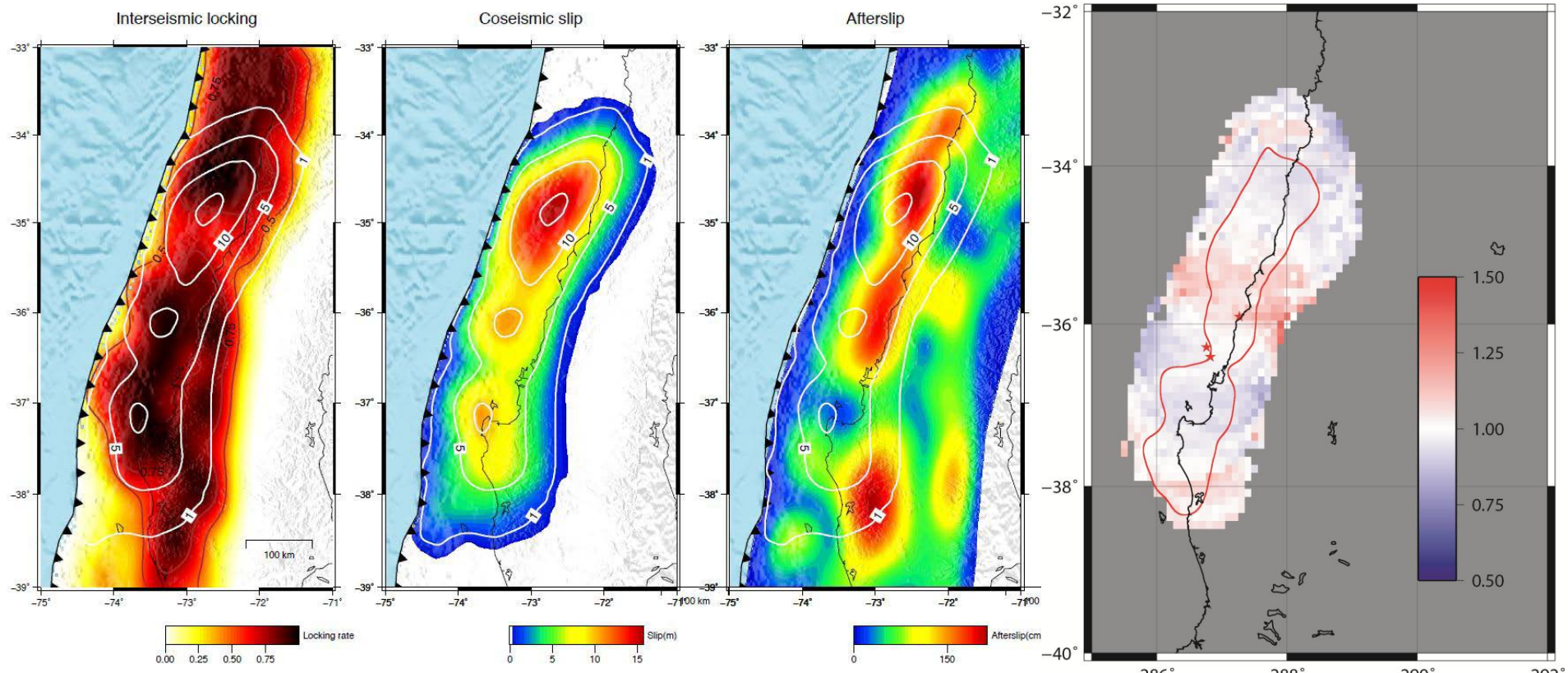




Interseismic locking, co- and post-seismic slip with the same 3D FEM (Moreno et al., in prep)



Interseismic locking, co- and post-seismic slip with the same 3D FEM (Moreno et al., in prep)



b-value 1 year after 27F

CONCLUSIONS

- **Preliminary results of relative sea-level change due to tectonic loading of the megathrust fault (from analysis of coast-line advance on coastal terraces and tide-gauge time) suggest acceleration of crustal deformation 10-5 years before the 2010 Maule earthquake.**
- **This is consistent with an accelerated decrease of b-value (increase in seismic coupling) 5 years before the earthquake.**
- **These possible pre-seismic signal of crustal deformation must be confirmed with other methods: integrated analysis of TIGO time-series and satellite geodesy and gravity.**
- **Geodetic data (GPS-GNSS, InSAR, GRACE) complemented with seismicity data allow a clear characterization of crustal deformation due to the seismic cycle of the megathrust.**
- **Rich characterization of CO- and POST-SEISMIC processes improved by 3D Finite Element Modeling.**
- **Still lot of work to do and lot of knowledge to acquire from the Maule earthquake**

MUCHAS GRACIAS!!!!

VIELEN DANK!!!!