UNIVERSITÉ Grenoble Alpes

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ISTerre
Institut des Sciences de la Terre

Long-term deformation transients and their possible relation with subduction earthquakes

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David Marsan, Mathilde Radiguet, Michel Bouchon

Two end-member models for the nucleation of earthquakes

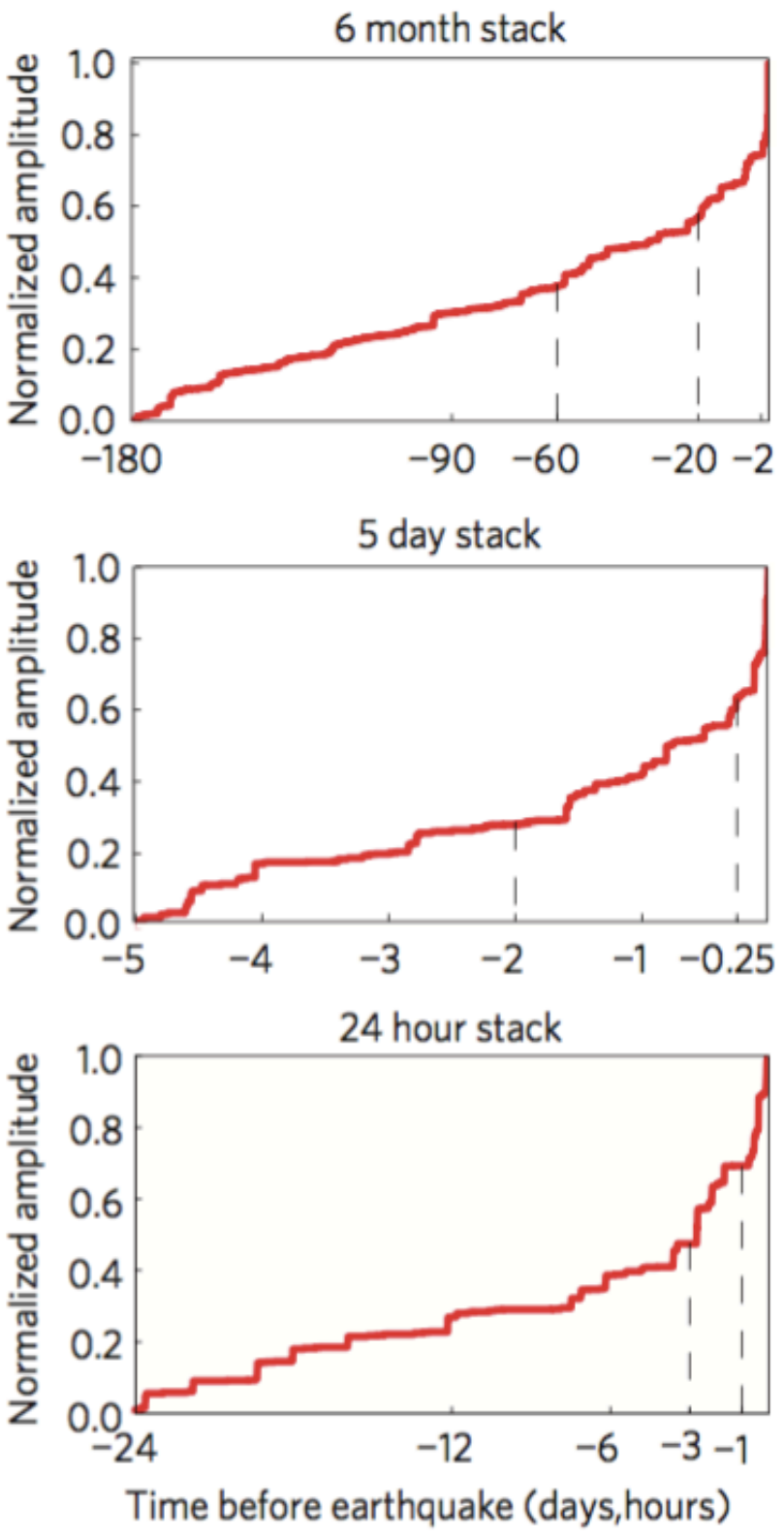
Slow cascade
or
Preslip triggering ?

Ellsworth & Beroza, 1995; Dodge et al., 1996

Most large interplate earthquakes have a long precursory phase

Normalized stacks of the cumulative seismic moments of 25 interplate sequences

Bouchon et al., 2013



1- Is this systematic?
Visible on the deformation ?

Mw8.1 2014 Iquique earthquake was preceeded by intense foreshock activity

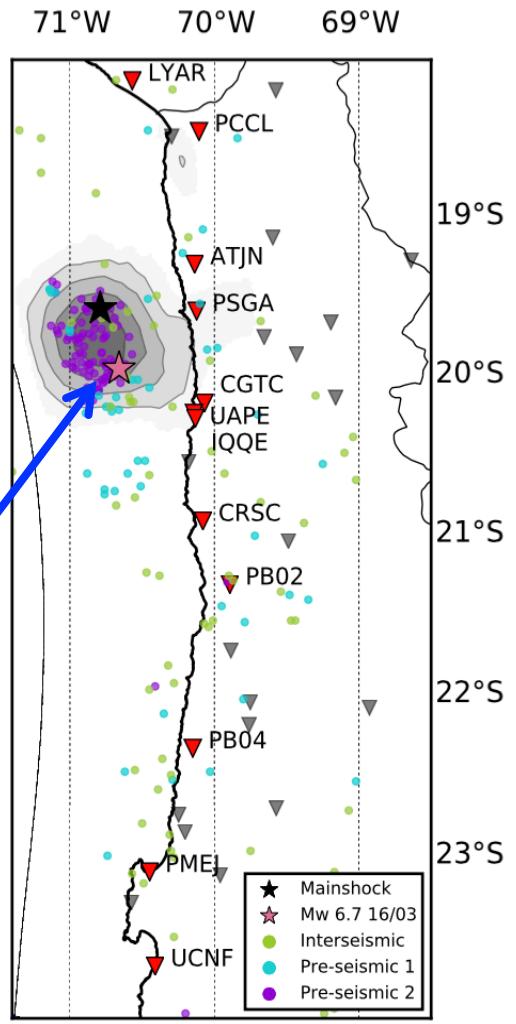
Most of the studies focused
on the 15-days preceding the mainshock
(after largest foreshock Mw6.7, March 16th, 2014)

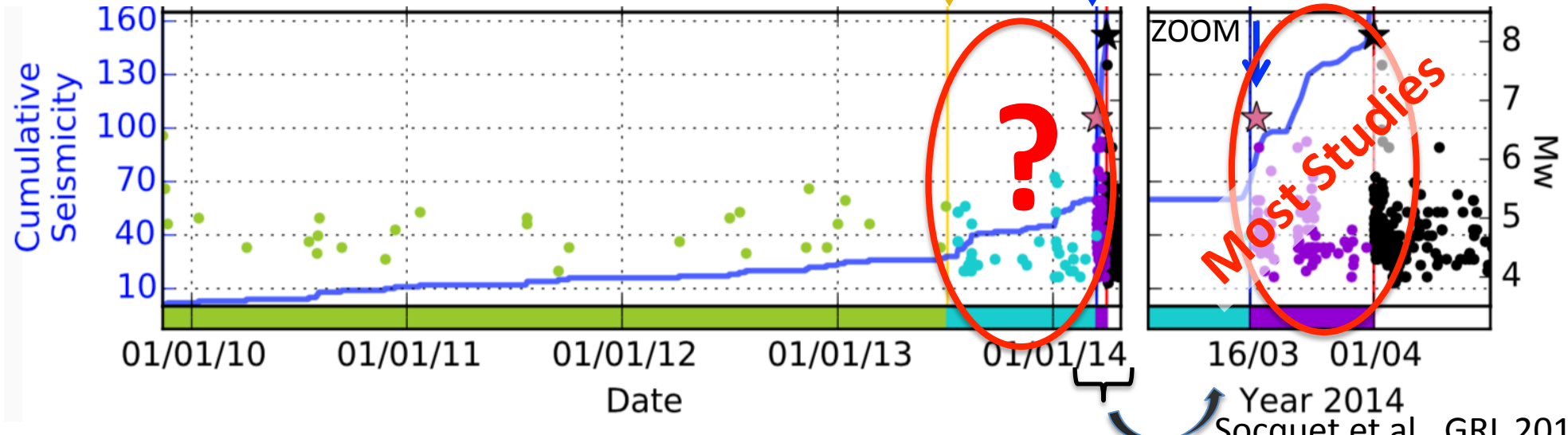
March 16th 2014
Largest foreshock Mw6.7

What about a potential long-term precursor ?

→ Combination of geodesy & seismology
at the **monthly, yearly, decadal** timescales

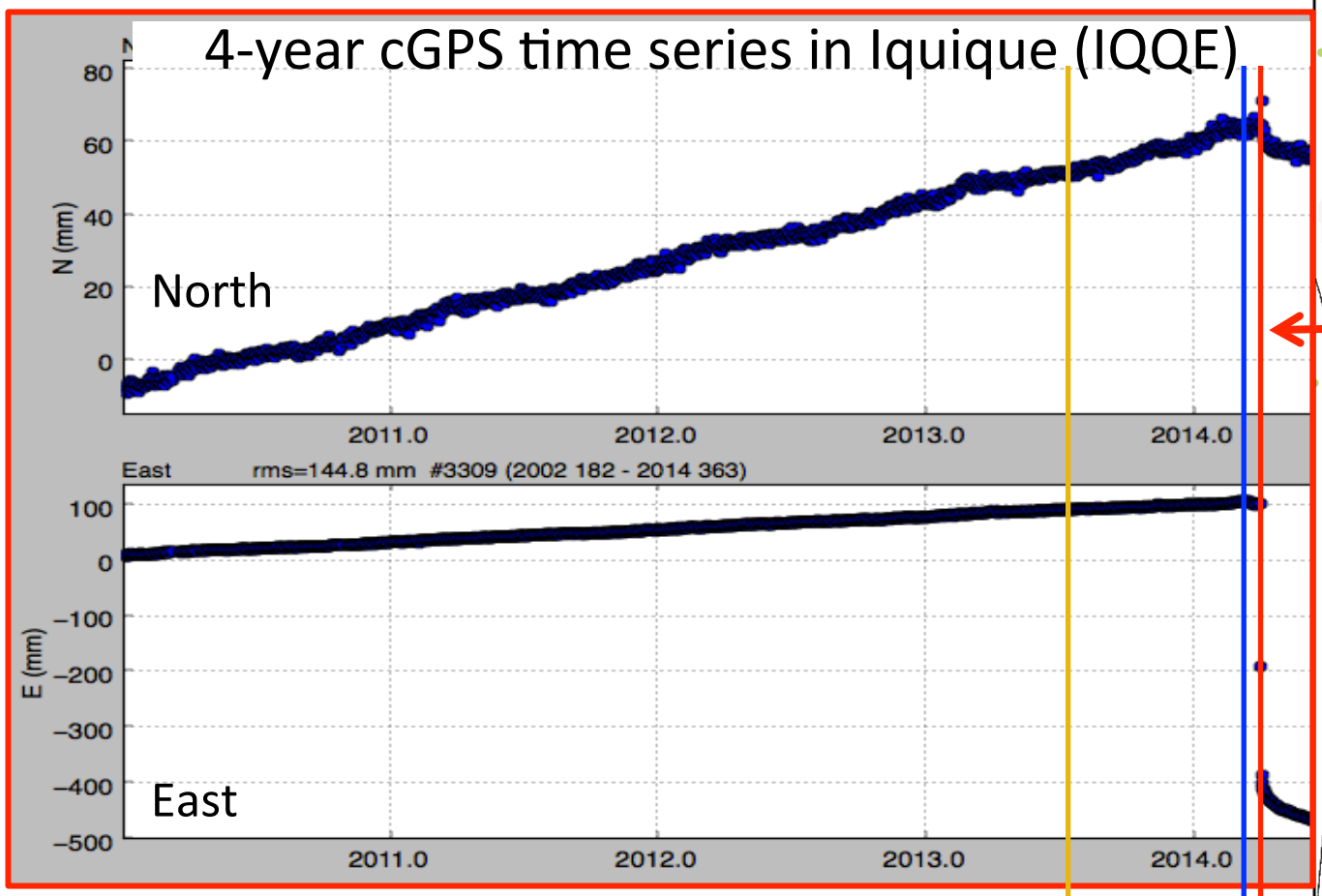
July 2013

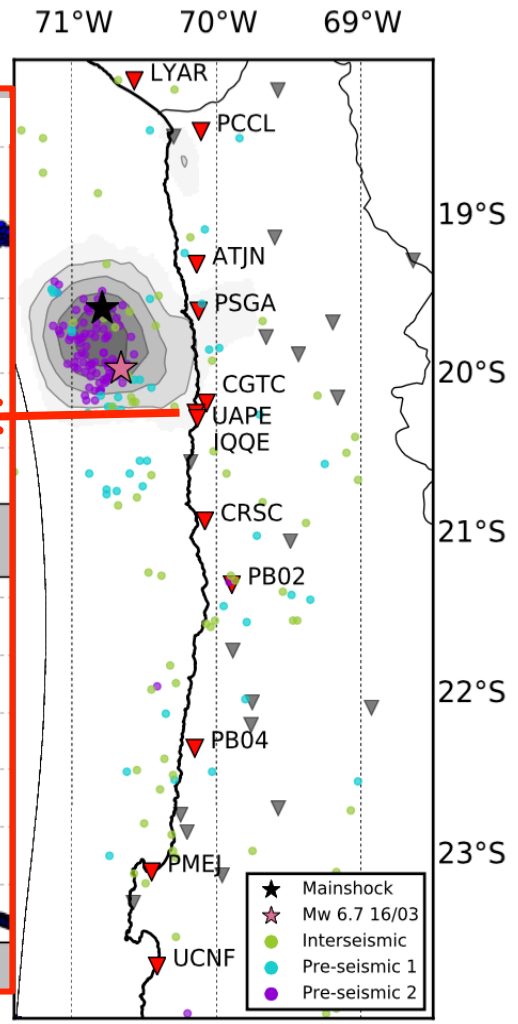


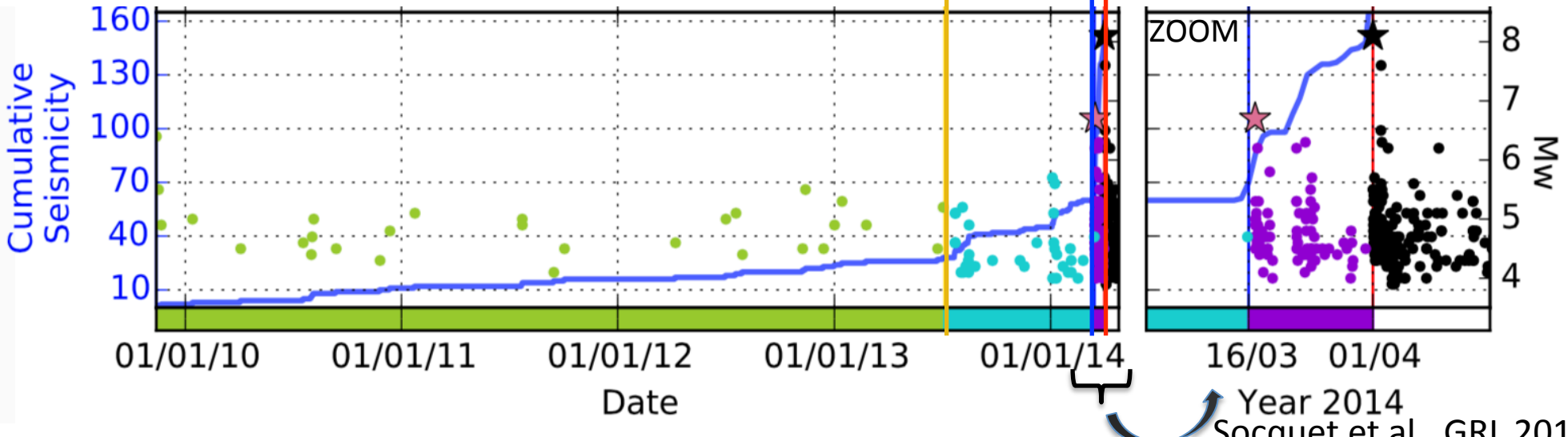


Socquet et al., GRL 2017

At the timescale of a few months, years…







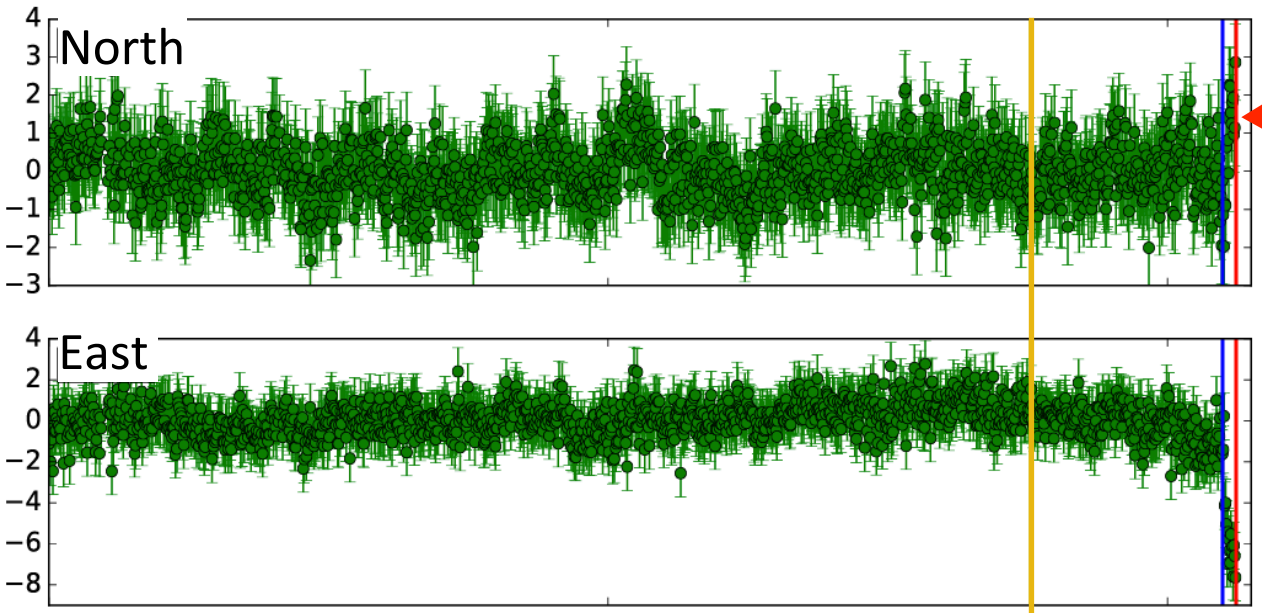
Socquet et al., GRL 2017

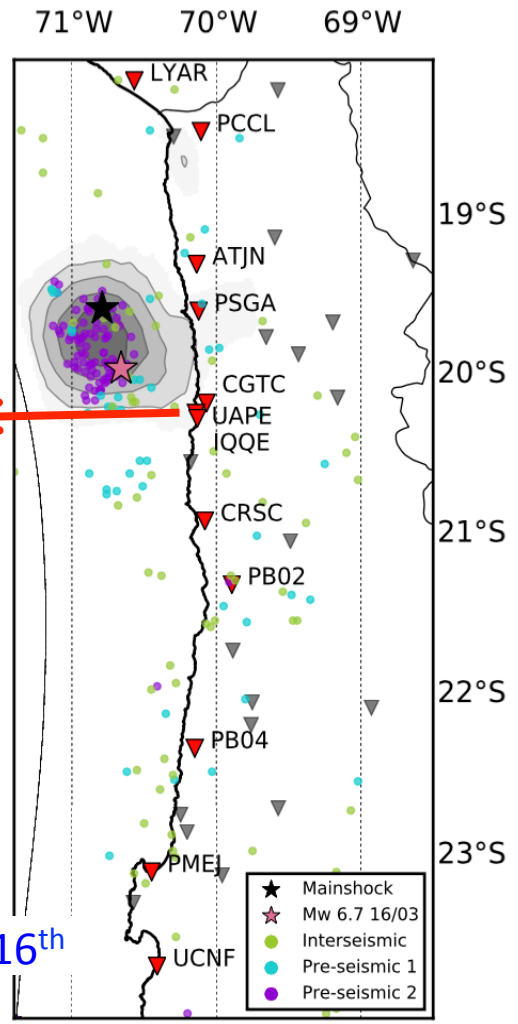
At the timescale of a few months, years…

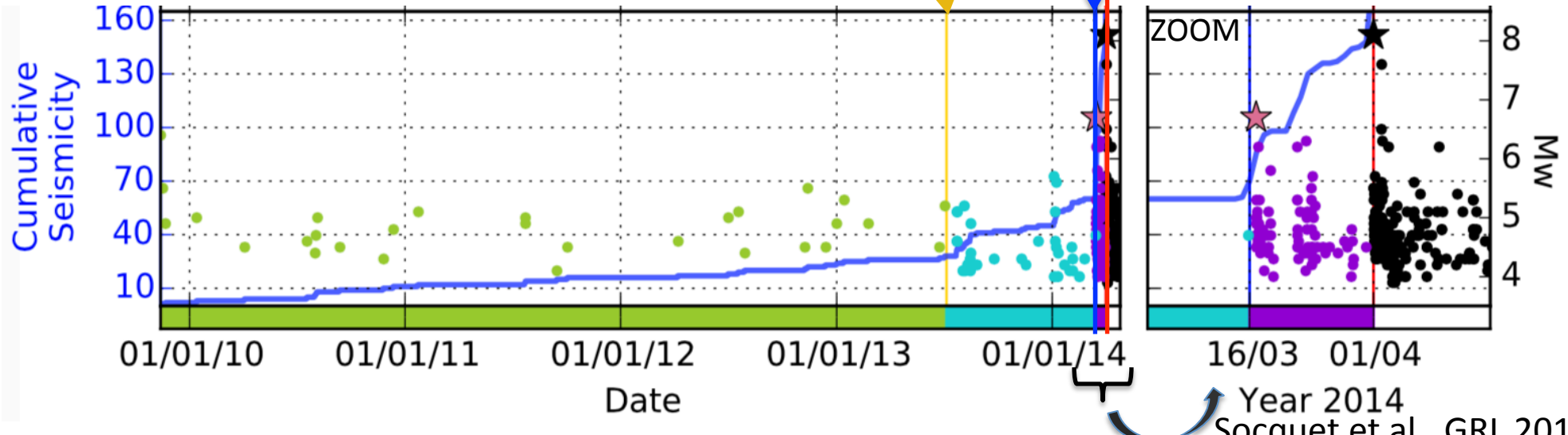
4-year cGPS time series in Iquique (IQQE) → detrended

→Large signal after Mw 6.7 foreshock

→ Variations in trend 8-months before mainshock







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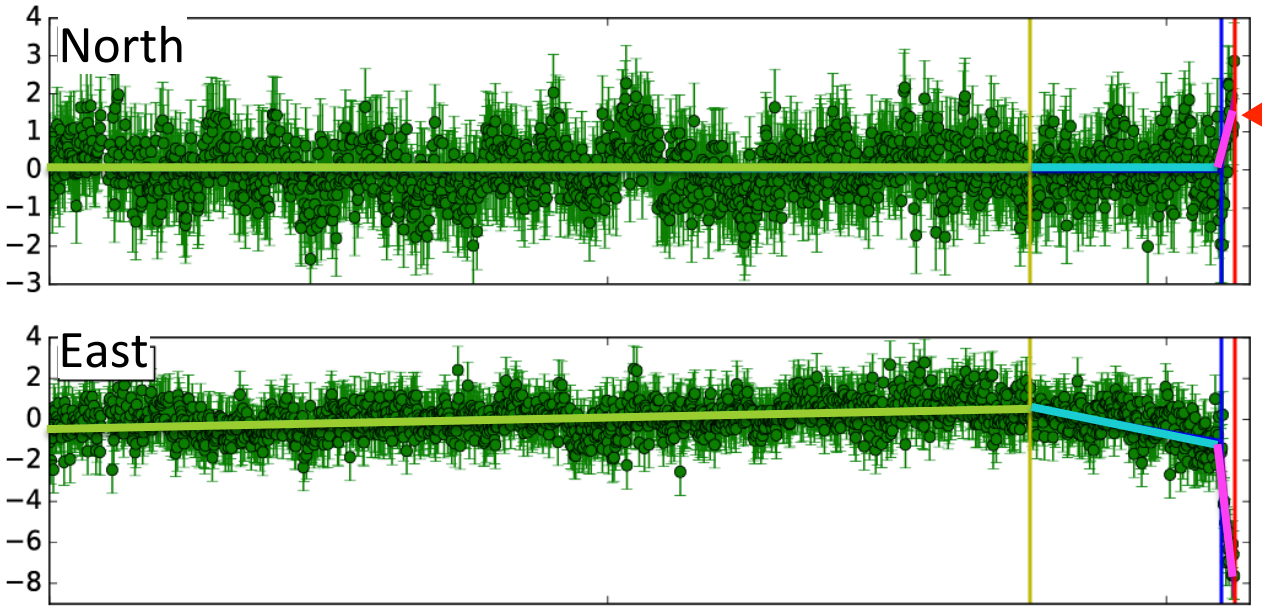

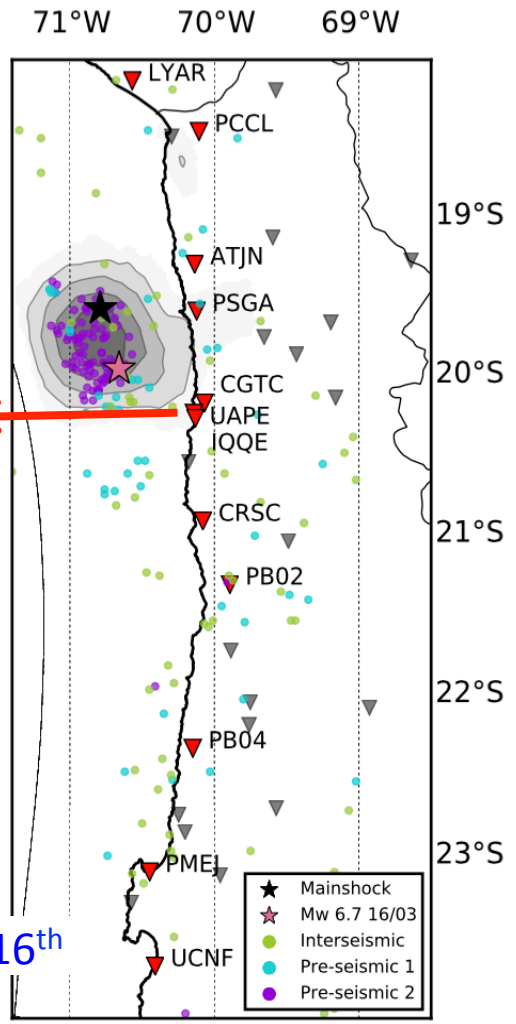

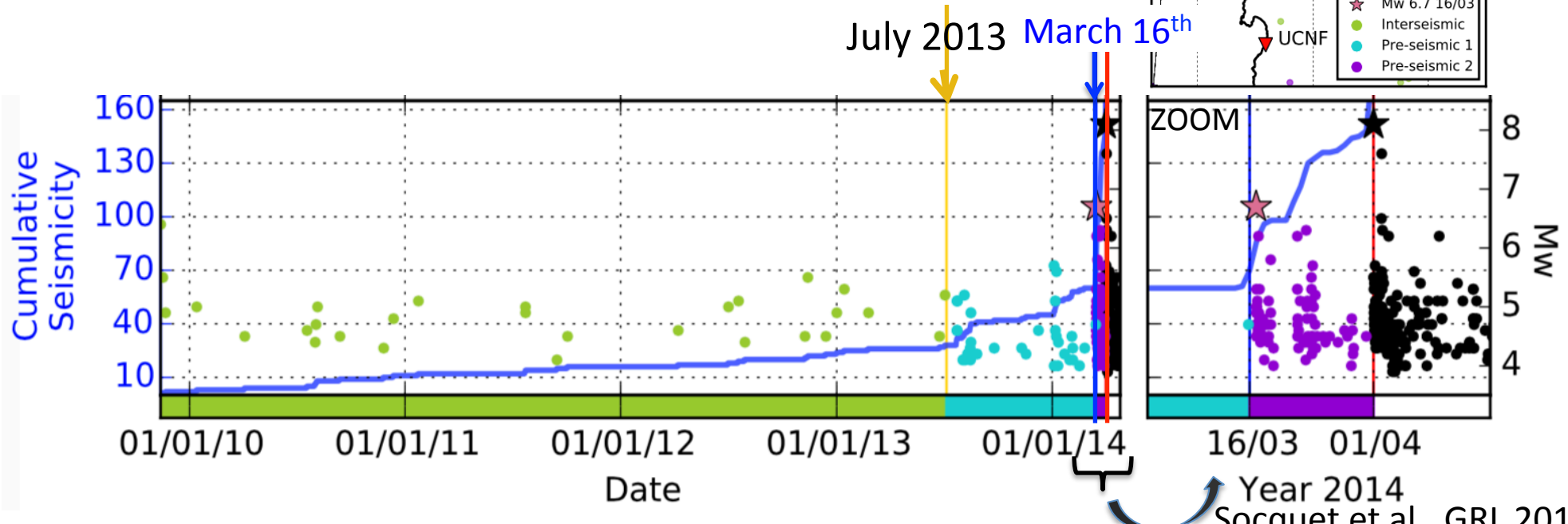

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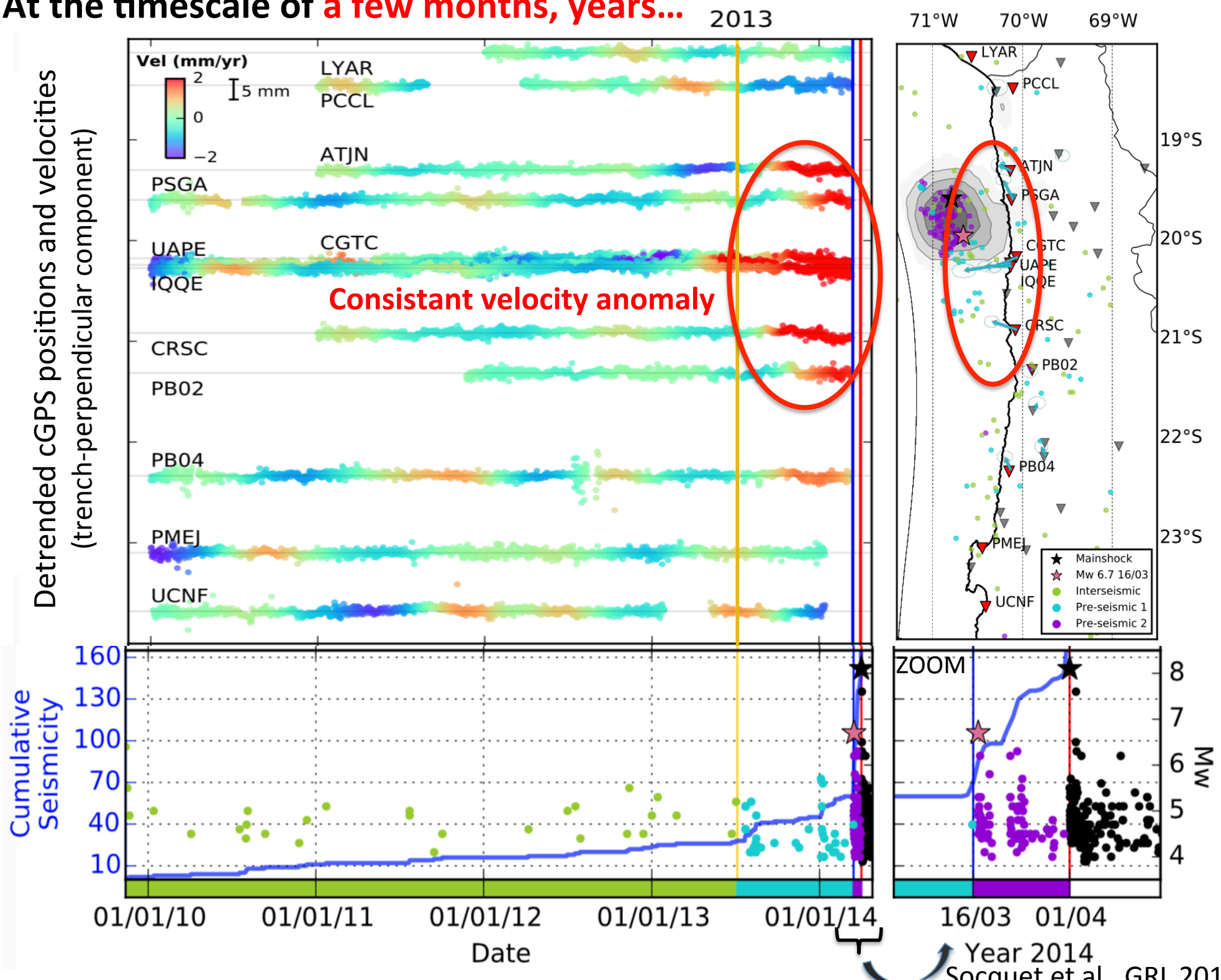
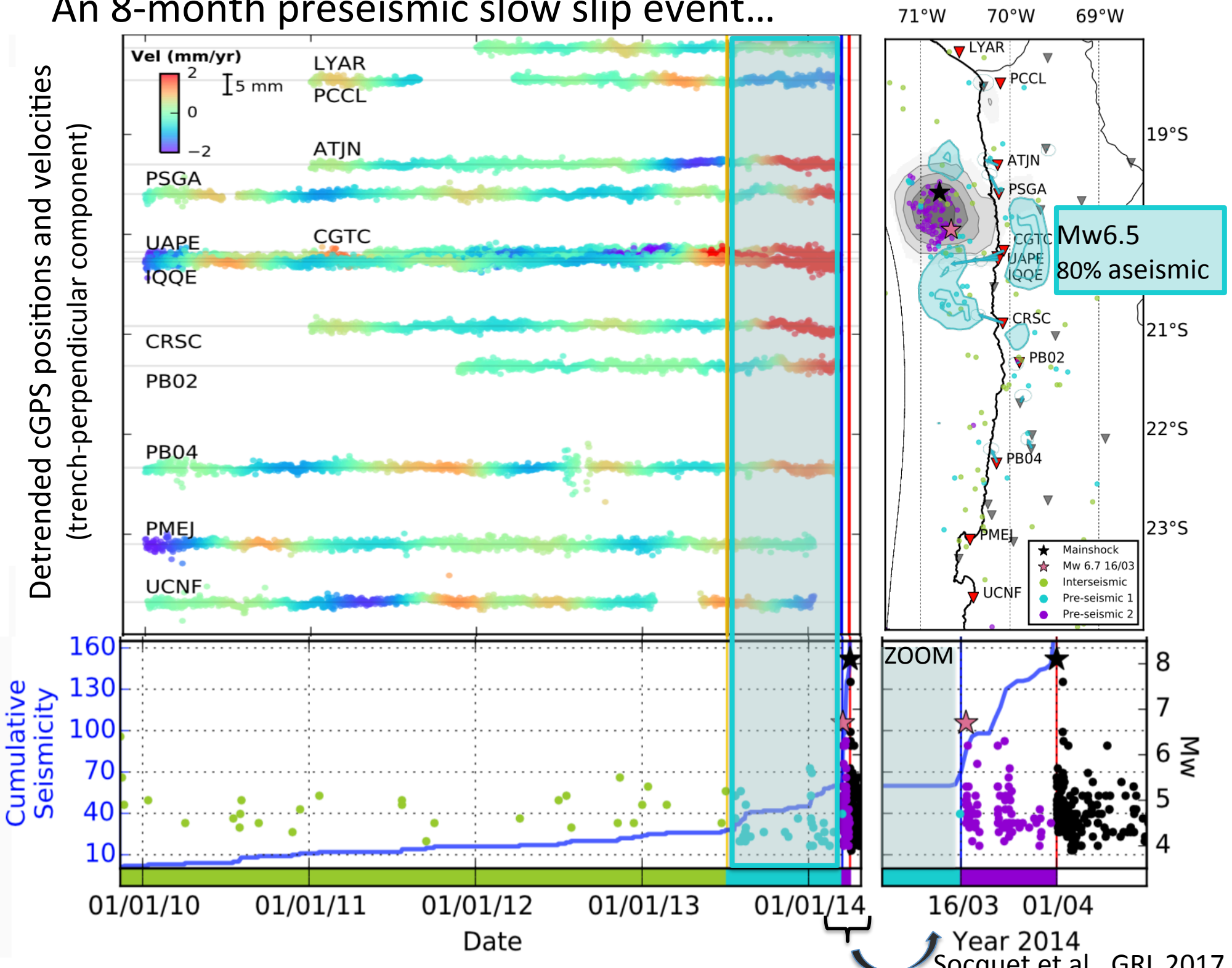


Socquet et al., GRL 2017

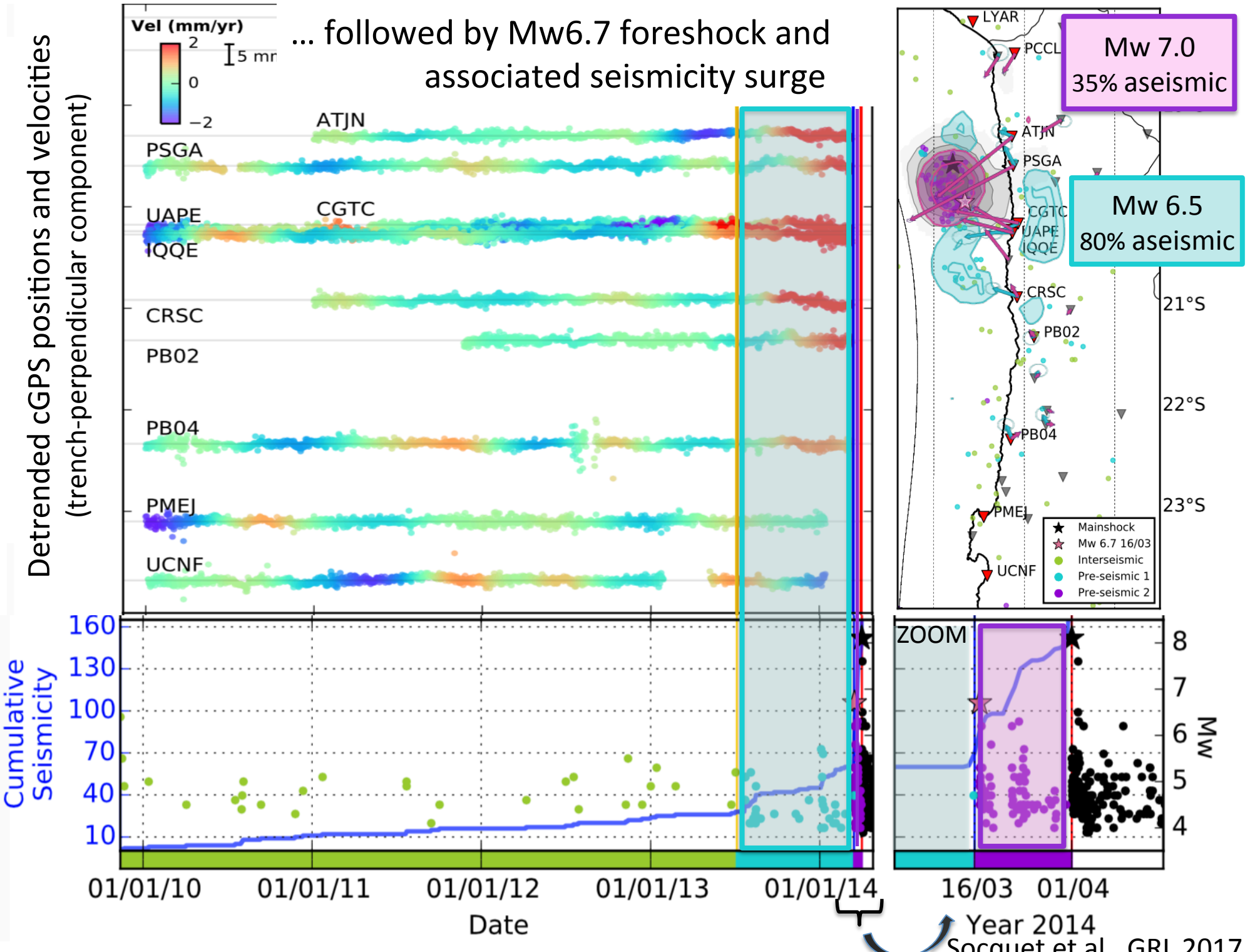
An 8-month preseismic slow slip event…



Socquet et al., GRL 2017

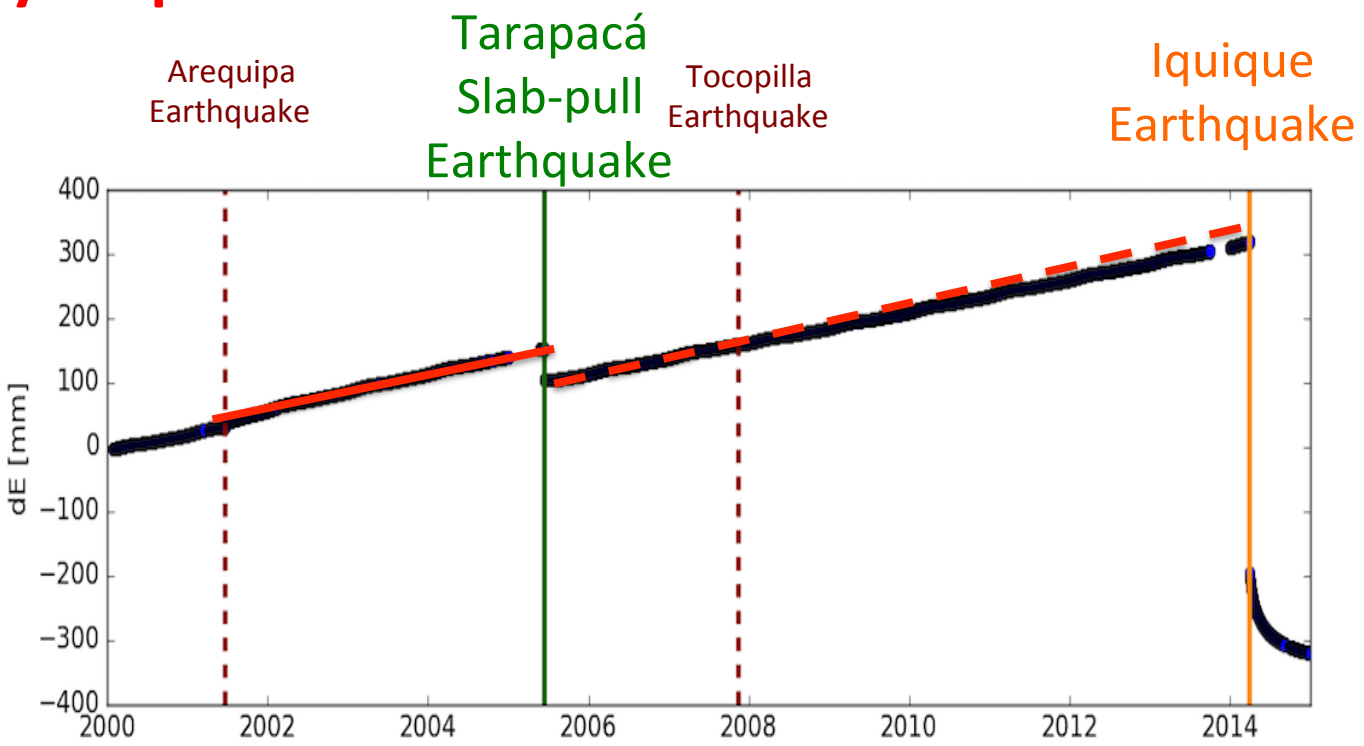
An 8-month preseismic slow slip event…

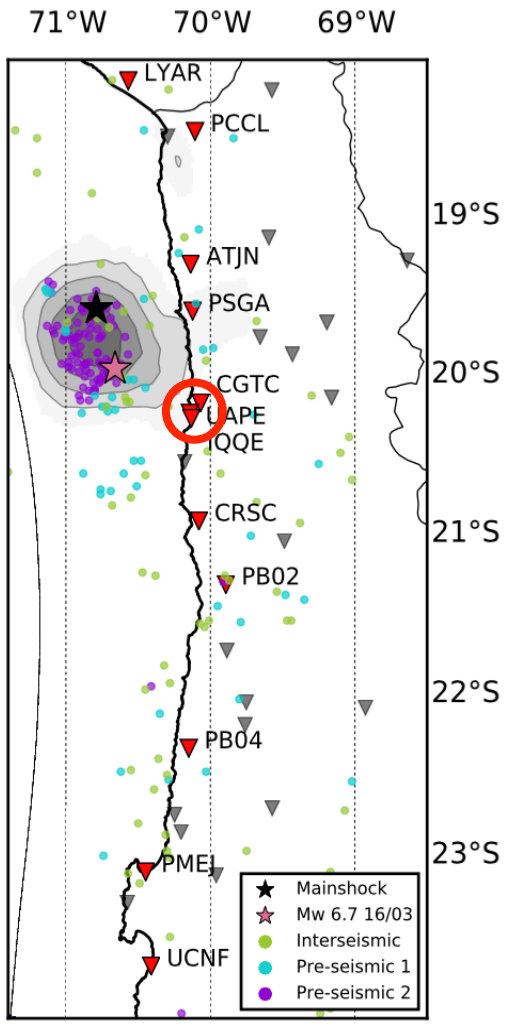
… followed by Mw6.7 foreshock and associated seismicity surge



Socquet et al., GRL 2017

15-year position time series of UAPE GPS station





Jara et al., GRL 2017

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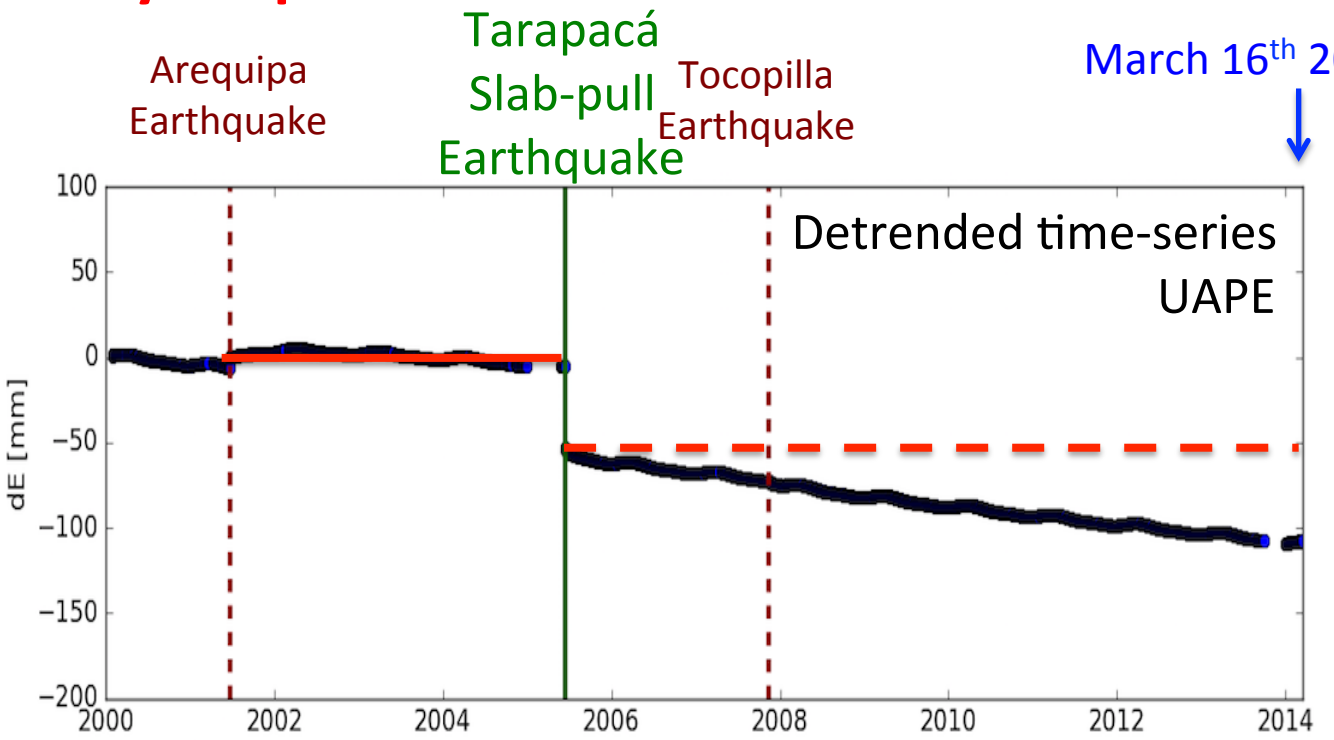
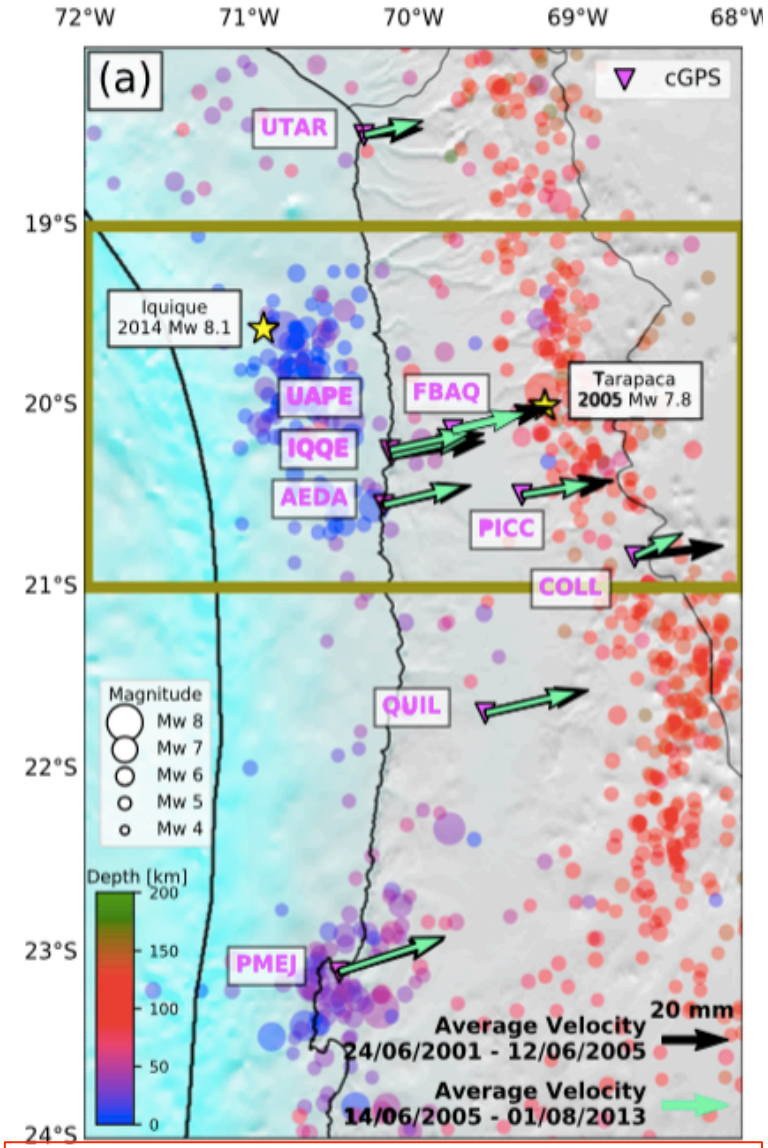




Significant velocity change between Tarapaca slab-pull and Iquique interface earthquake

→ Affects most stations in the area

Jara et al., GRL, 2017

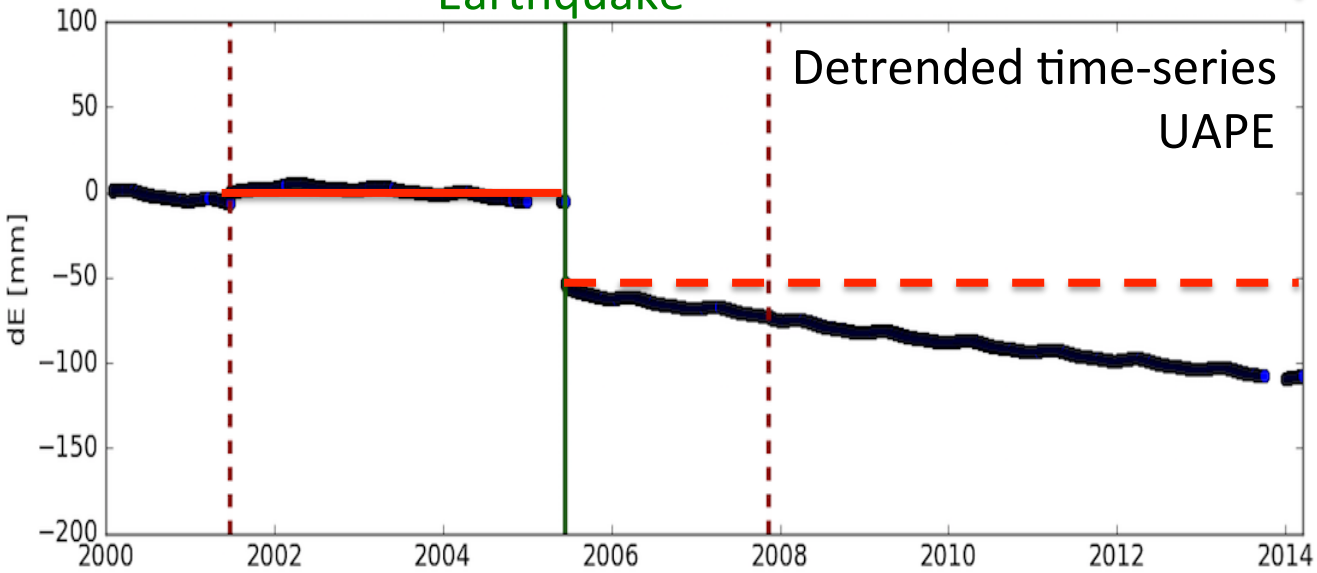
15-year position and seismicity time series

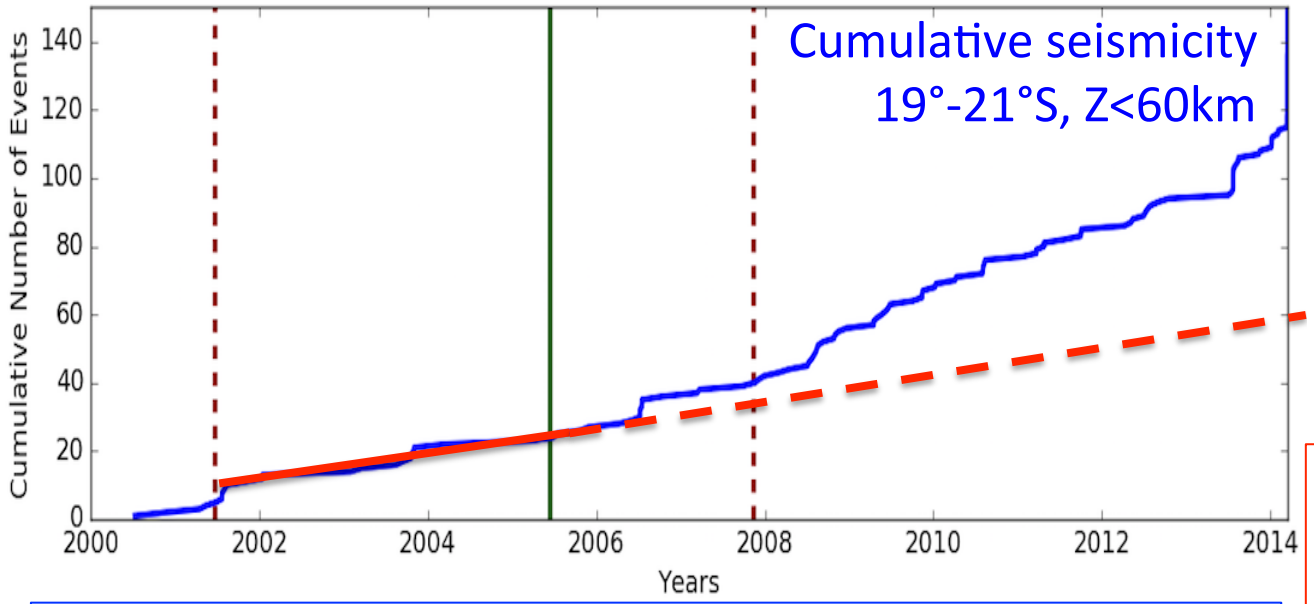
Arequipa Earthquake

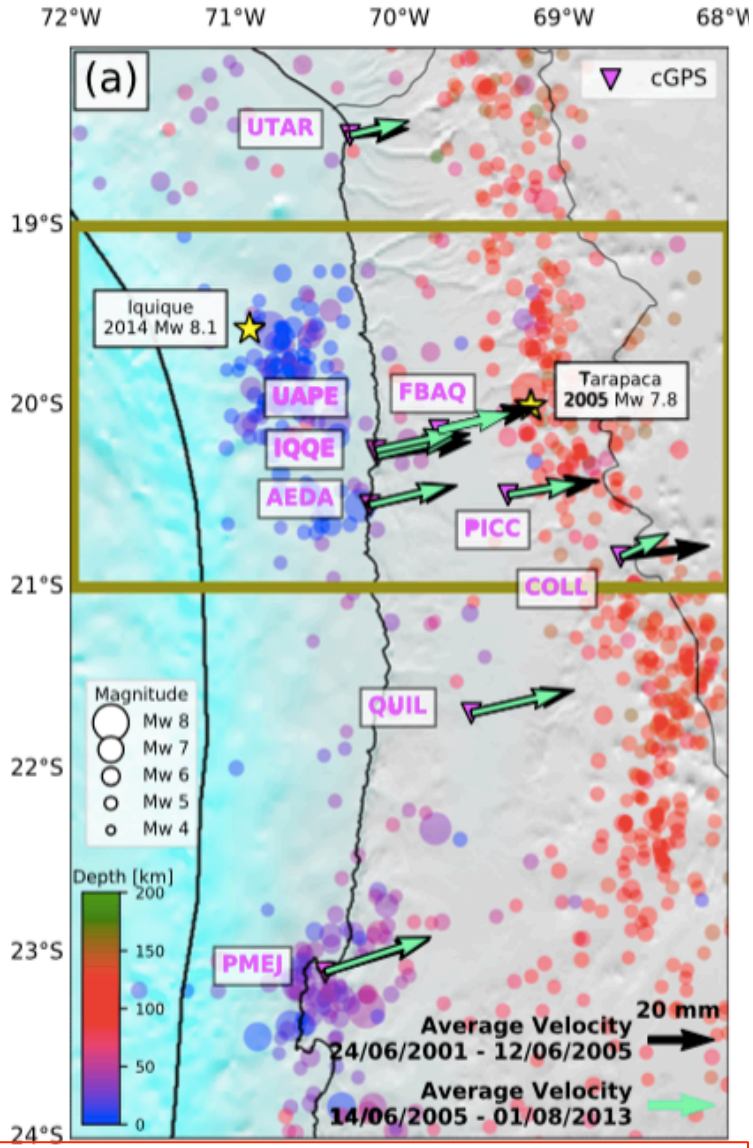
Tarapacá Slab-pull Earthquake

Tocopilla Earthquake

March 16th 2014





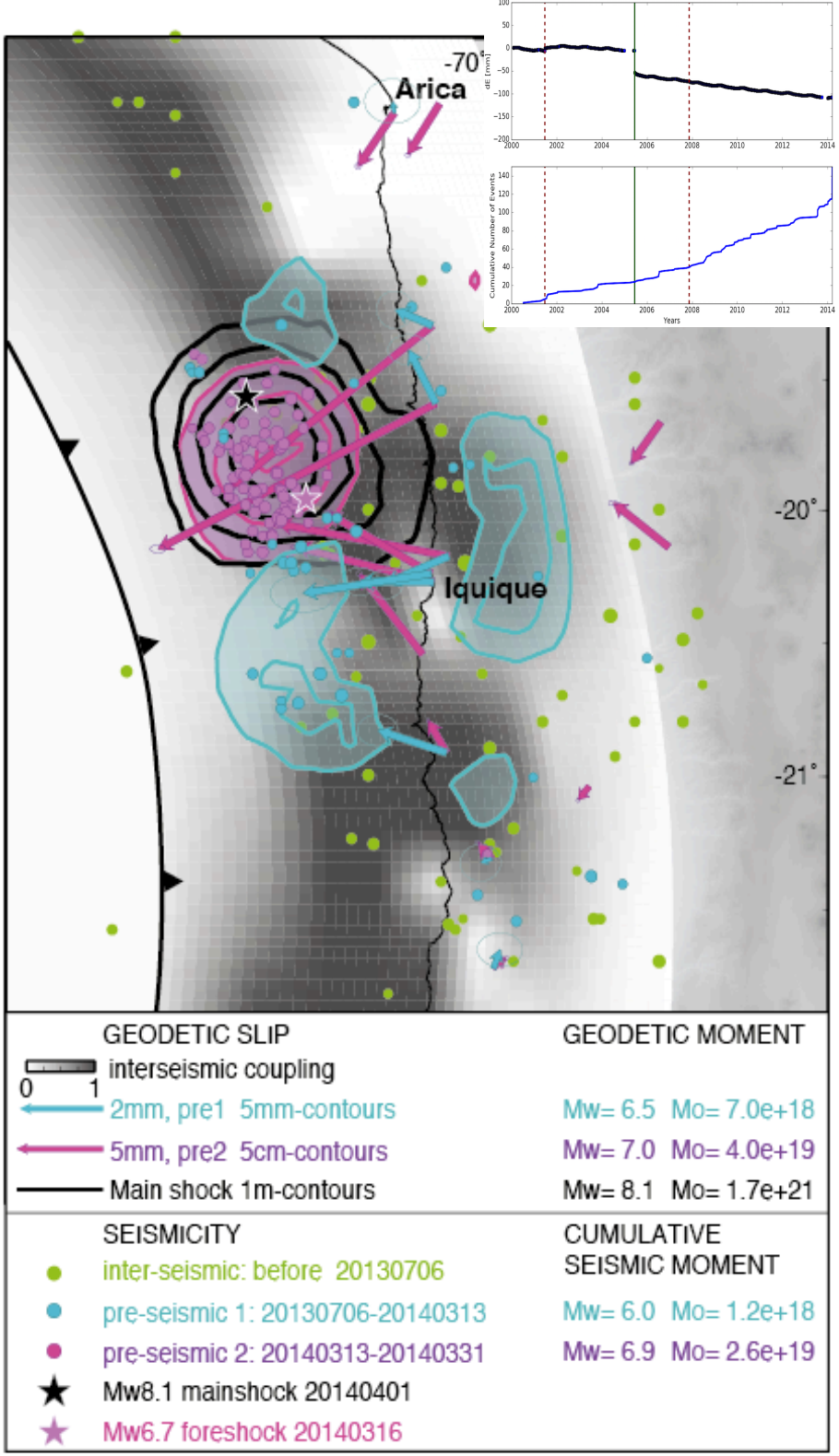


Shallow Seismicity increases after Tarapaca Earthquake

Significant velocity change between Tarapaca slab-pull and Iquique interface earthquake

→ Affects most stations in the area

Jara et al., GRL, 2017



Pre-Iquique in summary….

9 years before 2014 Iquique earthquake, 2005 slab pull earthquake triggers:

- Decrease of eastward GPS velocities
- Increase of seismicity rate

→ Decoupling of interface

8 months before 2014 Iquique earthquake:

- Decrease of coastal velocities
- Increase of seismicity

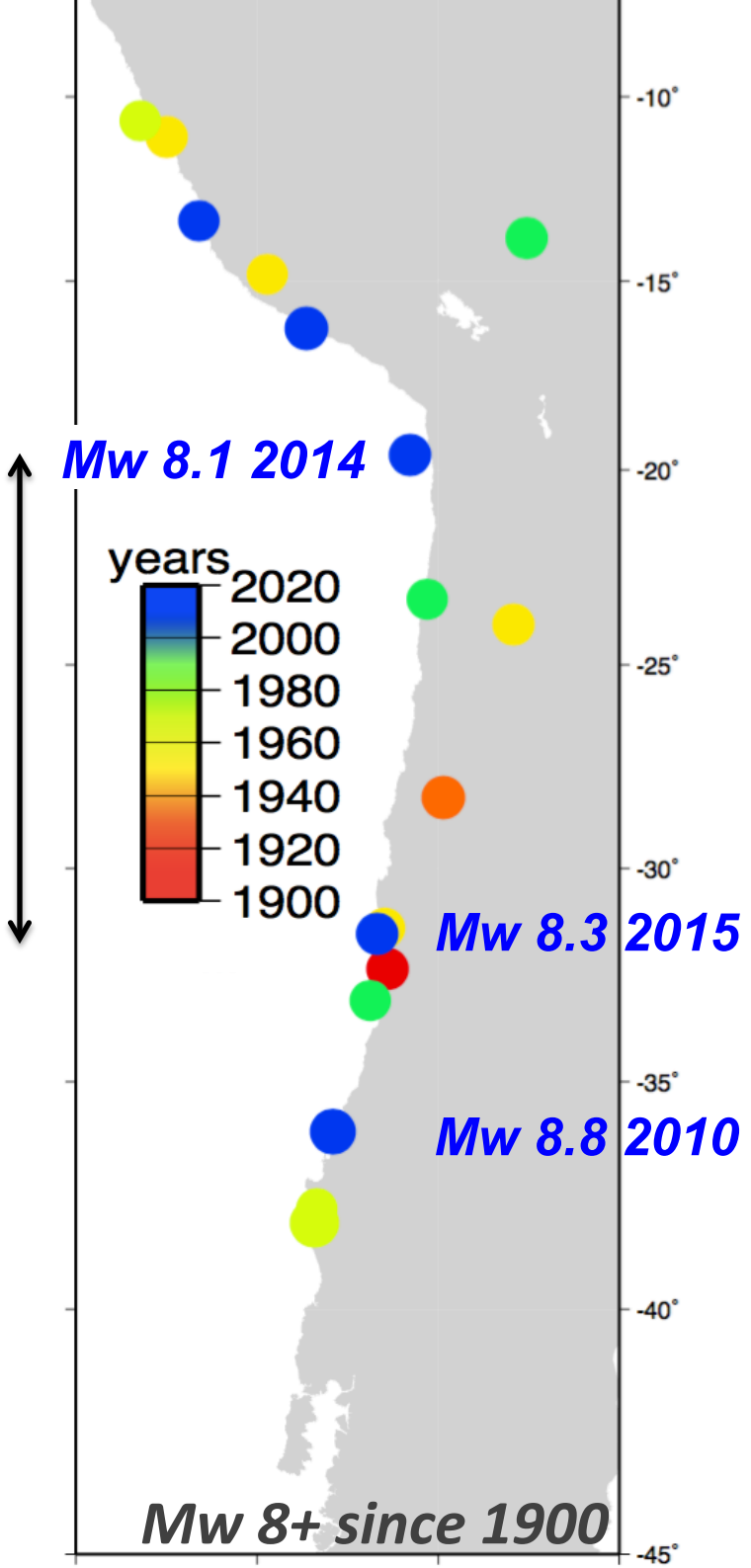
→ Mw6.5 slow slip, 80% aseismic

15 days before Iquique EQ (after Mw6.7 foreshock)

- Abrupt increase of seismic activity
- Strong deformation signal

→ Mw7.0 slow slip, 35% aseismic

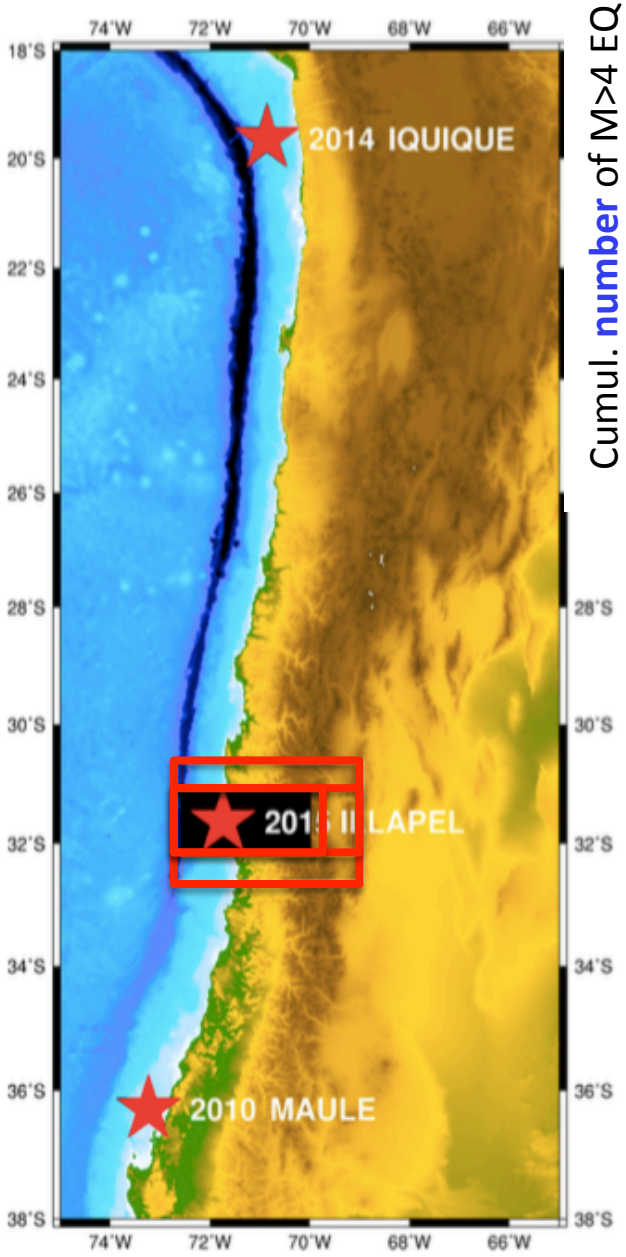
Subduction zones are ruptured by sequences of large earthquakes



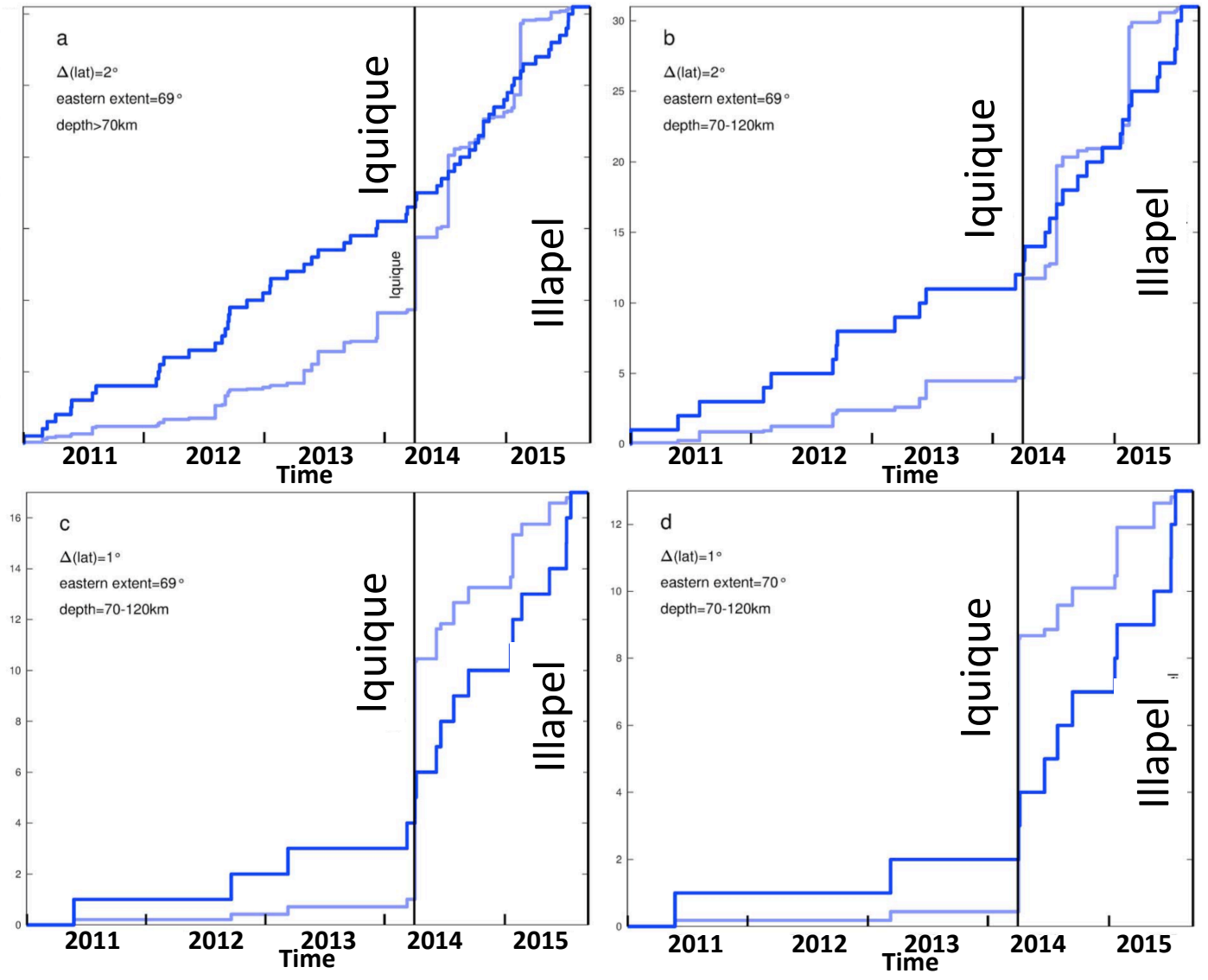
1200 km

2- Any link between distant earthquakes?

Slab-Driven Deep Interaction and Triggering between megathrusts ?



Cumul. **number** of M>4 EQ and **normalized moment**



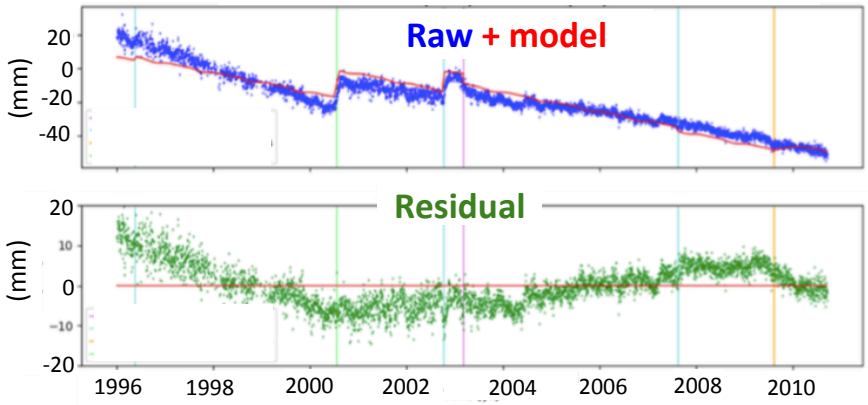
Evolution of deep seismicity below Illapel

Bouchon et al., GRL 2018

Long-term *(decades)* accelerated slip & seismicity before 2011 Japan earthquake

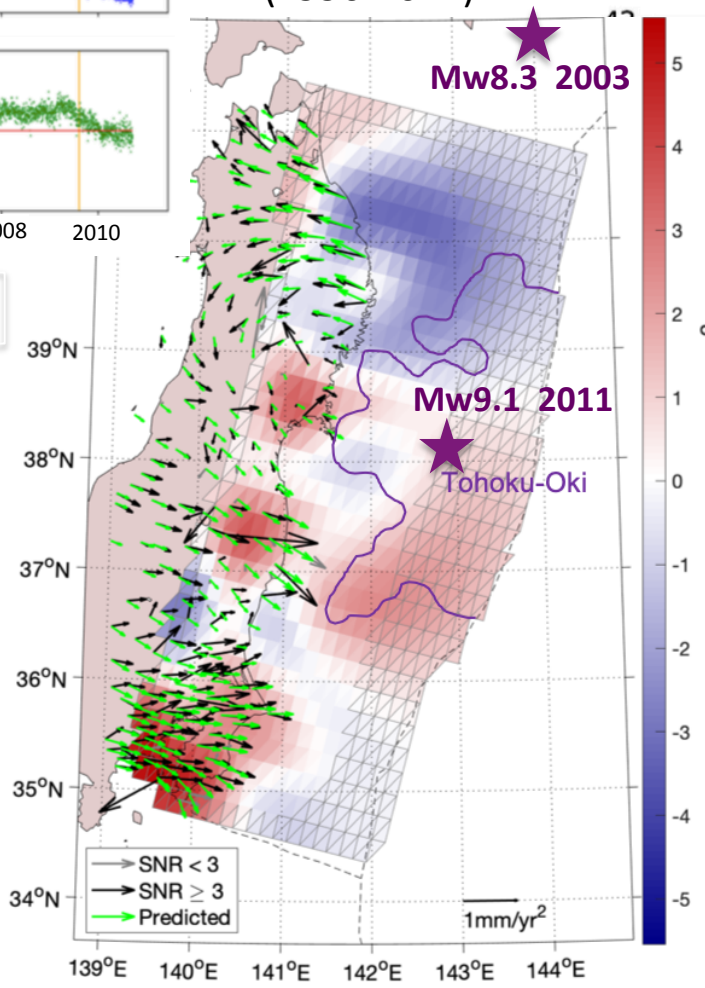
$$x(t) = x_R + v(t - t_R) + \frac{1}{2}a(t - t_R)^2 + \sum_{k=1}^{2}[s_k \sin(2k\pi(t - t_R)) + c_k \cos(2k\pi(t - t_R))] + \sum_{j=1}^{n_J} b_j \mathrm{H}(t - t_j) + \sum_{s=1}^{n_S} d_s \mathrm{J}(t - t_s) + \sum_{i=1}^{n_i} a_i \log\left(1 + \frac{t - t_i}{T_R}\right)$$

Position time series

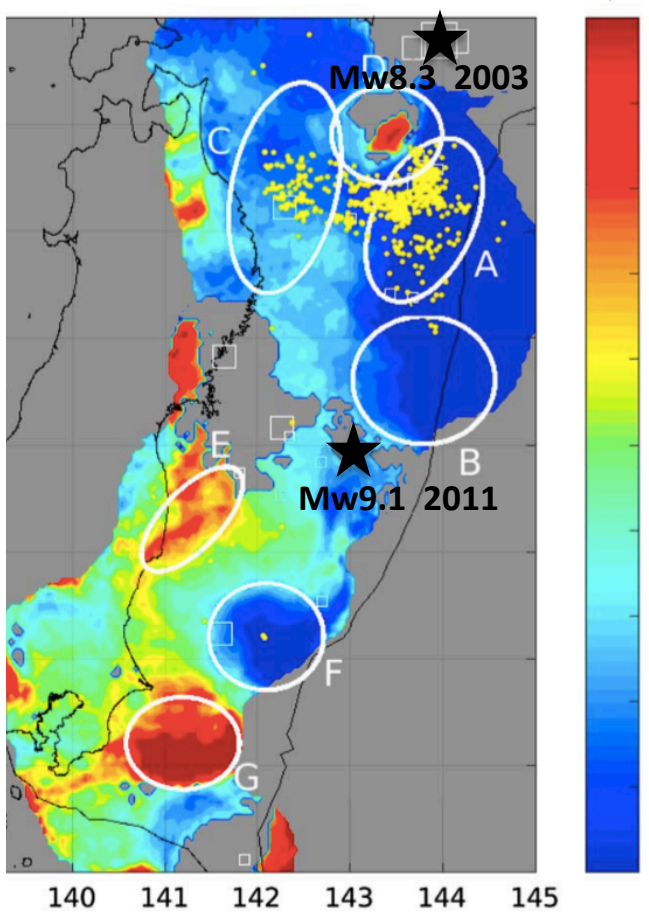


Marill et al., in prep

Slip acceleration (1996-2011)

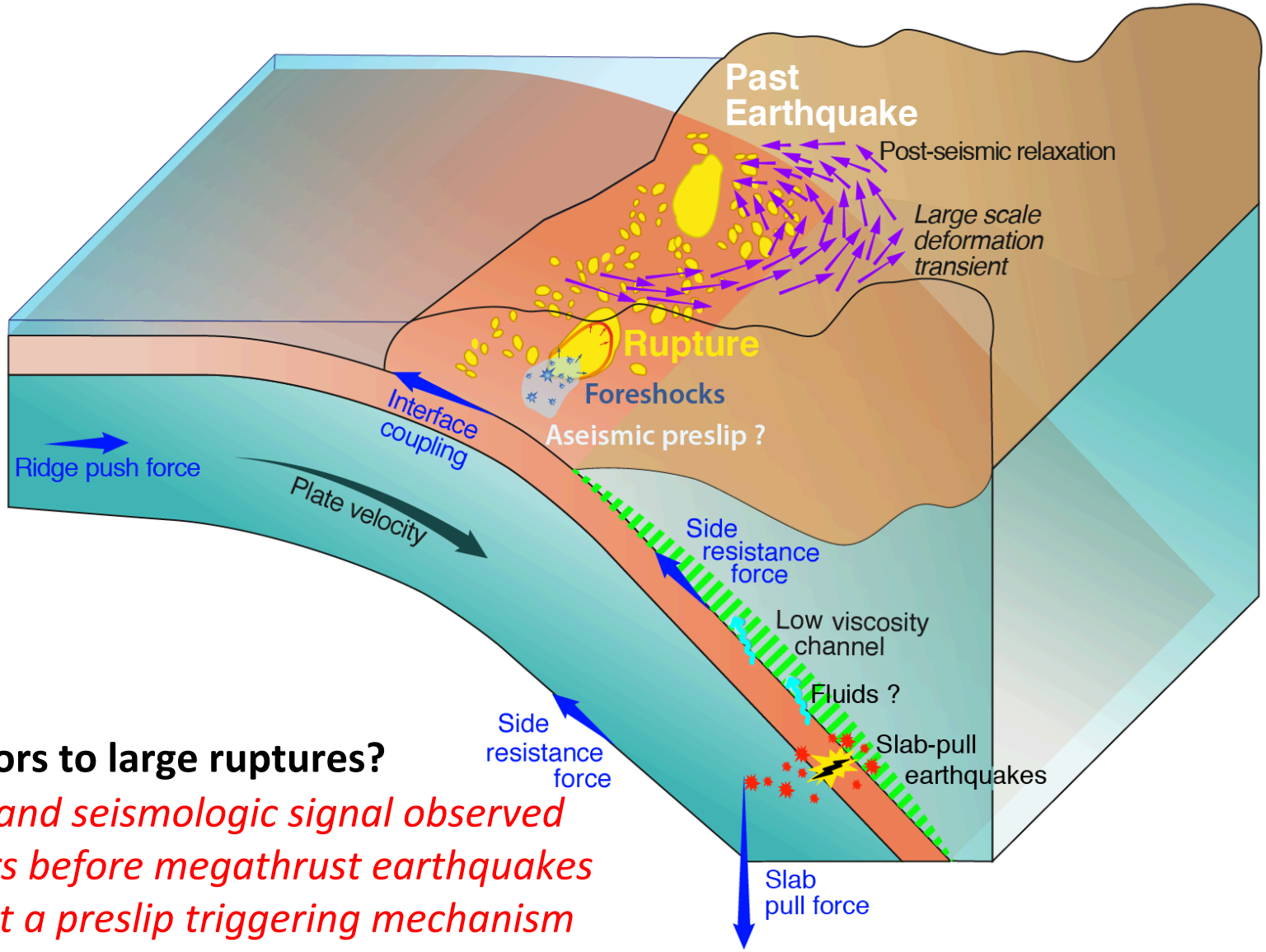


Acceleration of background seismicity (1990-2011)



Marsan et al., 2017

Long-lasting, large-scale precursor to megathrust earthquake?



- **Long-lasting precursors to large ruptures?**

→ *Precursory geodetic and seismologic signal observed days to months/years before megathrust earthquakes*

→ *Observations suggest a preslip triggering mechanism*

- **Any link between recent earthquakes during a sequence?**

→ *Large scale interactions exist (seen in deformation and seismicity)*

→ *The slab might may a a role that is underestimated so far*