Observations of rapid large-scale slip/deformation of the slab before some large subduction earthquakes

Michel Bouchon, David Marsan, Virginie Durand, Jorge Jara, Anne Socquet, Michel Campillo, Hugo Perfettini, Blandine Gardonio
All the M≥6.5 (interplate and intraplate) earthquakes which occurred in these two densely instrumented zones between 01/01/1999 and 01/01/2011
Deep and shallow seismic activity before Tohoku earthquake

- Deep seismicity background
  - M > 1

- Shallow foreshocks
  - M > 4
Time series of the gravity signals at different stages of their analysis. Blue dots: December 2010 and February 2011 values; pink dots: March 2011 value.

Panet et al. 2018
“We show that this earthquake is the extreme expression of initially silent deformation migrating from depth to the surface [ ] starting a few months before March 2011.”

Panet et al. 2018
The 2014 M8.2 Iquique, Chile, earthquake

“Accelerations in seismicity started around 270 days before the mainshock”

Kato et al., 2016
Normalized cumulative number/moment of events

time before Iquique (days)

-450 -400 -350 -300 -250 -200 -150 -100 -50

M>4
Shallow (depth<40km)
Deep (80km<depth<125km)
From 1/1/2013 to 15/3/2014

July-August 2013
January-March 2014
Deep and shallow seismic activity before 2014 $M_{\text{8.2}}$ Iquique earthquake

- Shallow ($<40\text{km}$) $M_{\geq4}$ foreshocks
- Deep ($>80\text{km}$) seismic moment release
M 8.8 Maule
(Feb 27 2010)

epicentral area (M>4)
down-dip in slab (M>3.2)

Start of foreshocks (January 14)
10 hours apart

January 21
January 22

normalized cumulative number of events

time before earthquake (days)
$\Delta(lat)=1^\circ$

eastern extent=$70^\circ$

$70\text{km}<\text{depth}<120\text{km}$
correlation window = 1 day

Moment correlation between all shallow and deep events located within 2° of Tohoku epicenter
1 day correlation

$\Delta(\text{lat}) = 500\text{km}$
Seismic activity increases deep (~100km) in the slab before several giant subduction earthquakes.

This moderate activity is spread over a broad range of the slab and is synchronized with bursts of activity in the seismogenic zone.

Some characteristics of this activity are reminiscent of those of SSE’s: Small deformation/slip occurring over a broad spatial range over a period of a few months.
18 shocks are visible in the 6 triggered windows:
The 150km-long Izmit rupture and the closest stations to the epicenter