

Slow deformation event between large intraslab earthquakes at the Tonga Trench inferred from geodetic and seismological data

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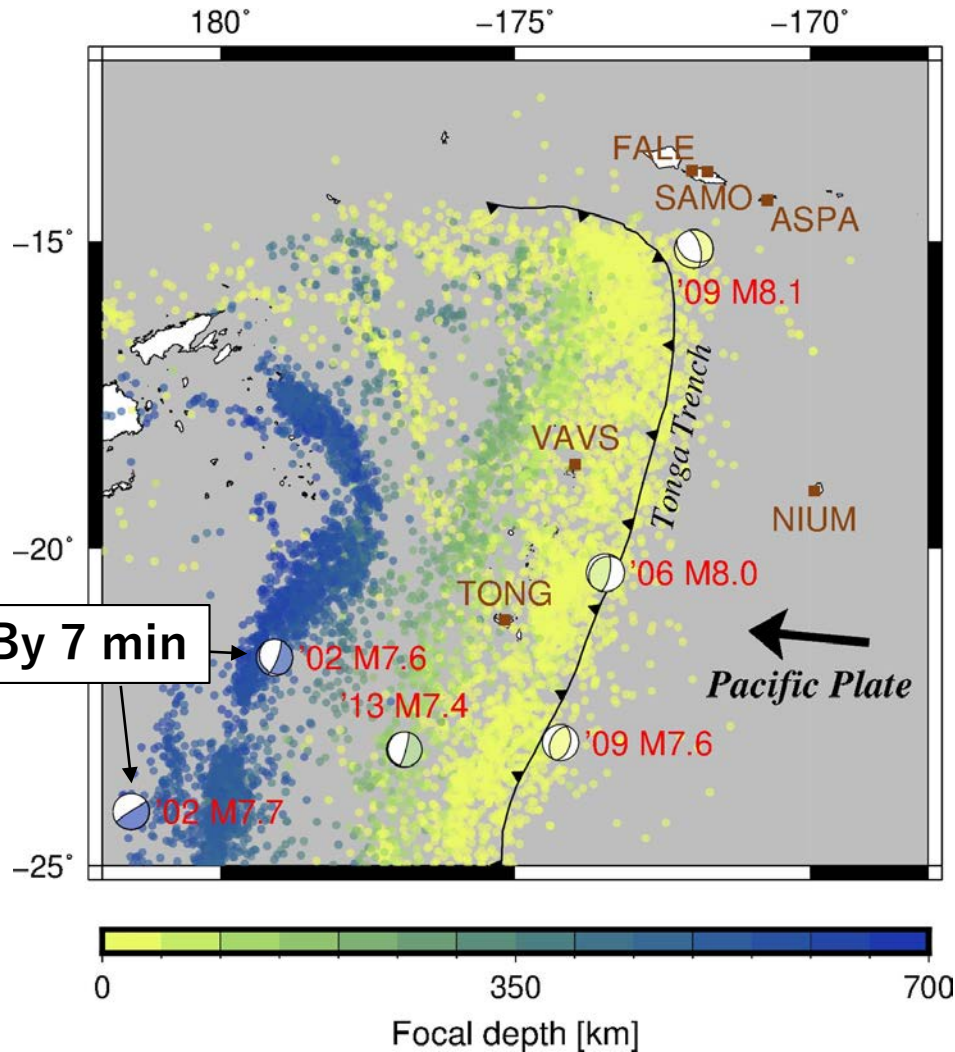
Slow deformation event between large intraslab earthquakes at the Tonga Trench

Yuta Mitsui¹, Hinako Muramatsu¹ & Yusaku Tanaka²

Slow deformations associated with a subducting slab can affect quasi-static displacements and seismicity over a wide range of depths. Here, we analyse the seismotectonic activities in the Tonga subduction zone, which is the world's most active area with regard to deep earthquakes. In our study, we combine data from global navigation satellite systems with an earthquake catalogue. We focus on the deep earthquakes that are below 400 km at the lower part of the Wadati–Benioff zone. We find that trenchward transient displacements and quiescence of deep earthquakes, in terms of background seismicity, were bounded in time by large intraslab earthquakes in 2009 and 2013. This “slow deformation event” between 2009 and 2013 may have been triggered by a distant and shallow M8.1 earthquake, which implies a slow slip event at the plate interface or a temporal acceleration of the subduction of the Pacific Plate. These findings provide new insights into the relationship between shallow and deep earthquakes in the subduction zone.



Seismicity at the Tonga Trench



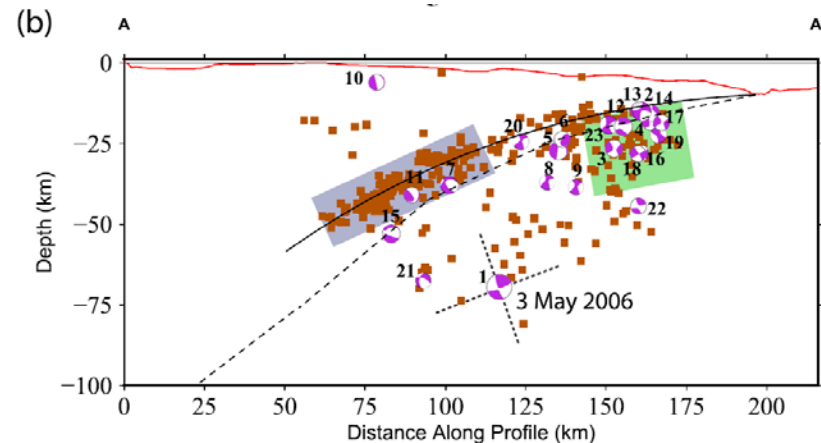
Hypocenter

ANSS catalog
1998~2018, >M4.5

Focal sphere

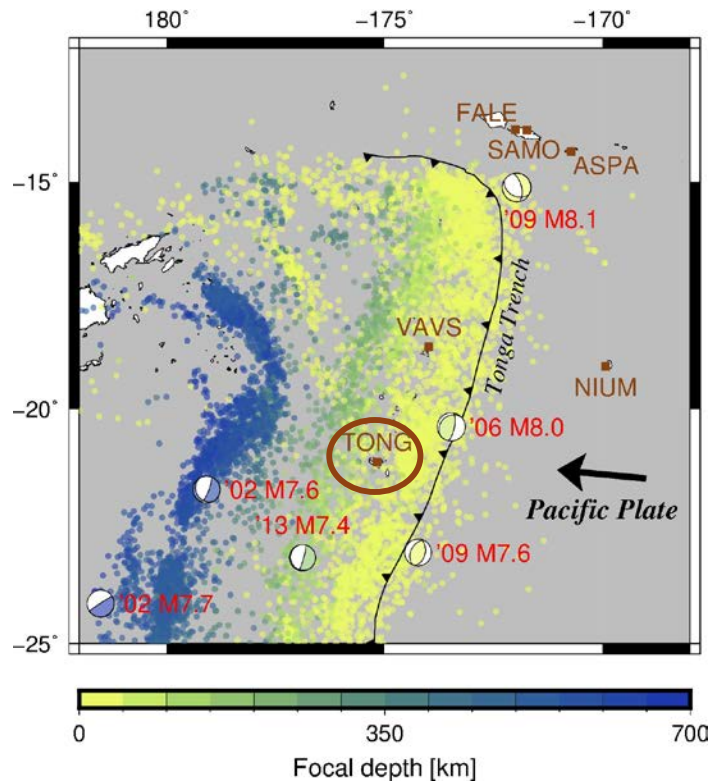
Global CMT solution
(Ekström et al., 2012)

- World's highest number of deep earthquakes
- Frequent occurrence of large intraslab earthquakes

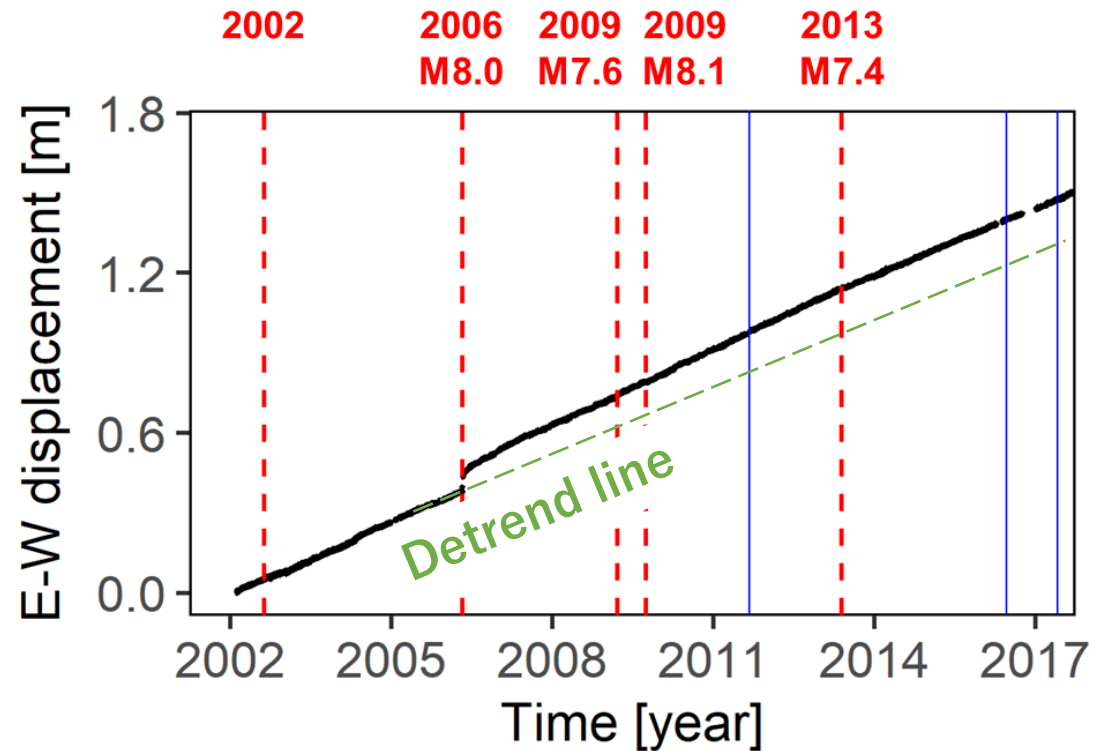


Meng et al. (2015)

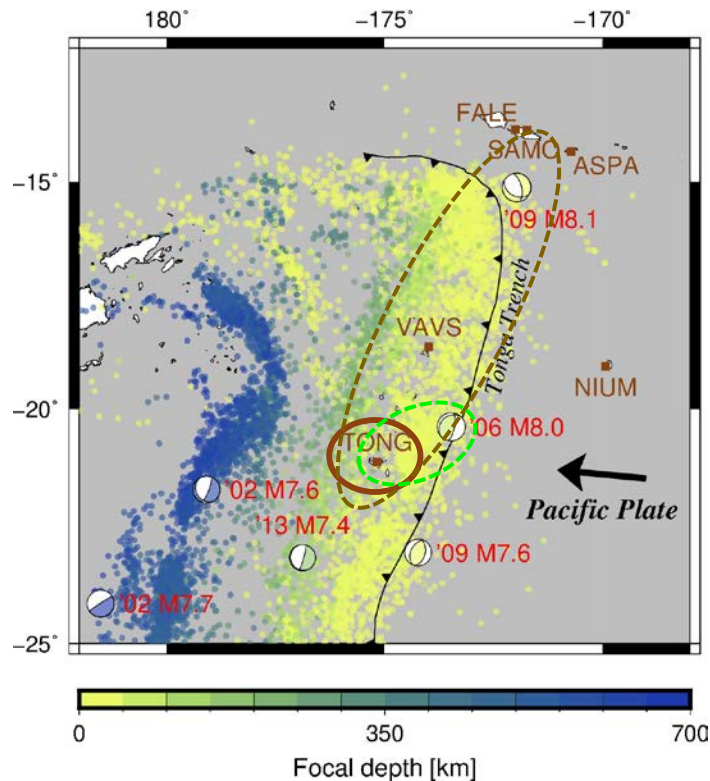
Large intraslab earthquakes and GNSS displacement



GNSS time series@TONG station
(Blewitt et al., 2018)



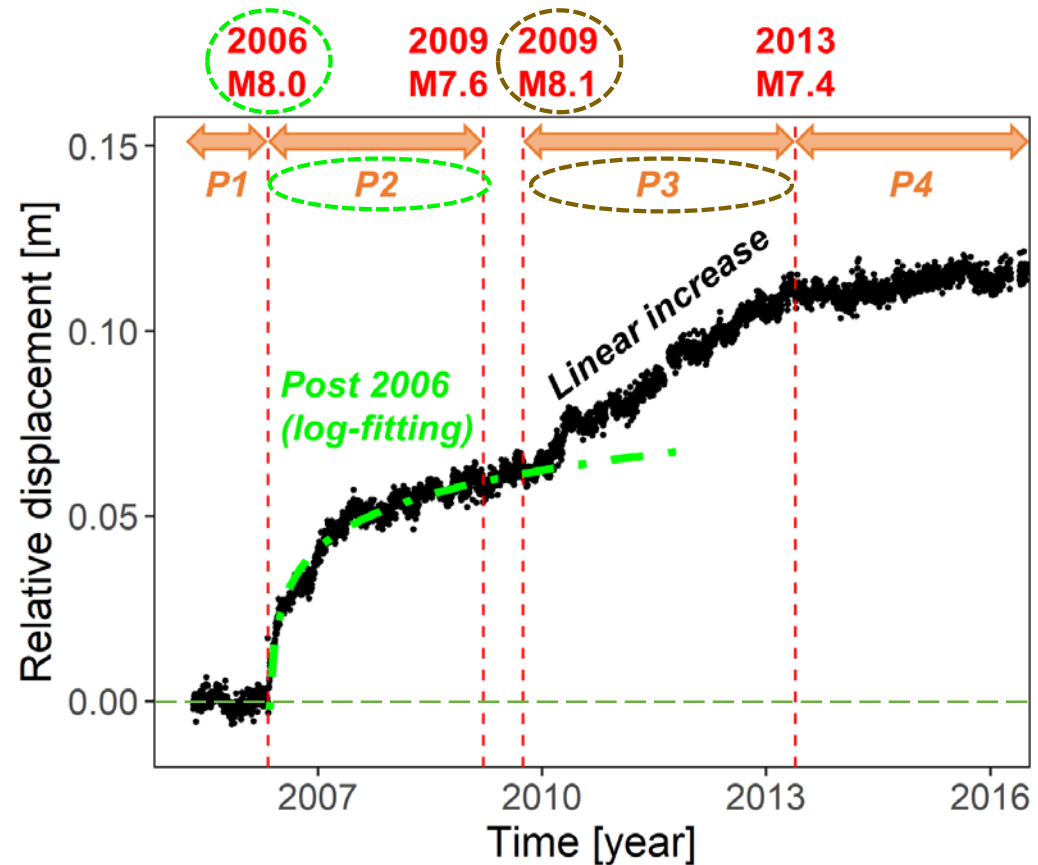
Large intraslab earthquakes and GNSS displacement



Post-2006:
Logarithmic decay
(Burgers rheology or RSF afterslip)

Post-2009:
Strange linear disp.

GNSS time series@TONG station
(Blewitt et al., 2018)



Post-2009 (M8.1 EQ) displacement

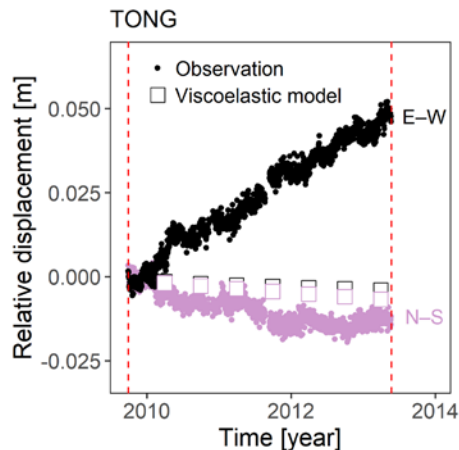
Separate slow event, possibly triggered by M8.1 EQ

(~ 5 cm during 4 yr)

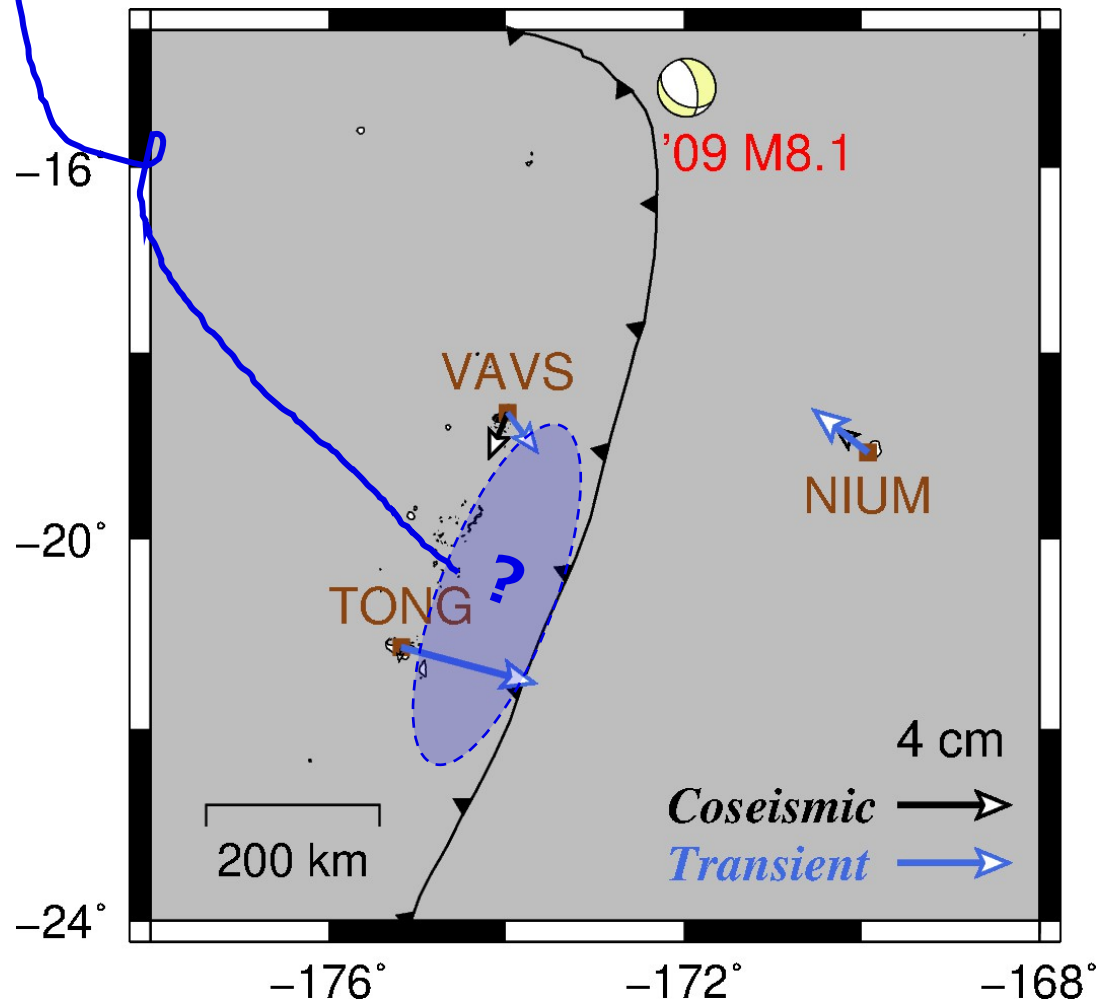
@upper-plate stations
(TONG, VAVS):

Strange linear disp.

- Trench-ward
- Larger disp. far from the epicenter



Co- and post-seismic displacement



ETAS parameter estimation for the Tonga Trench

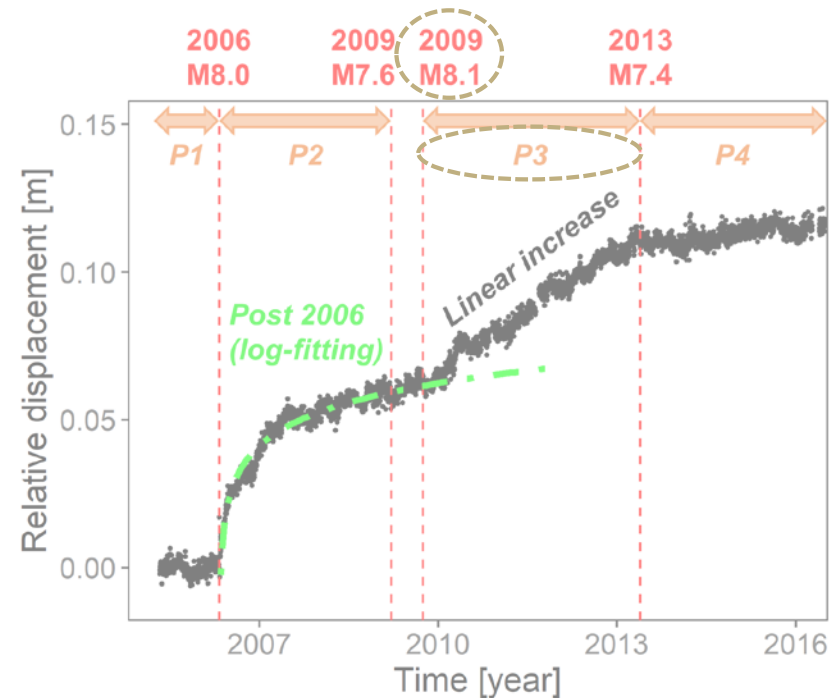
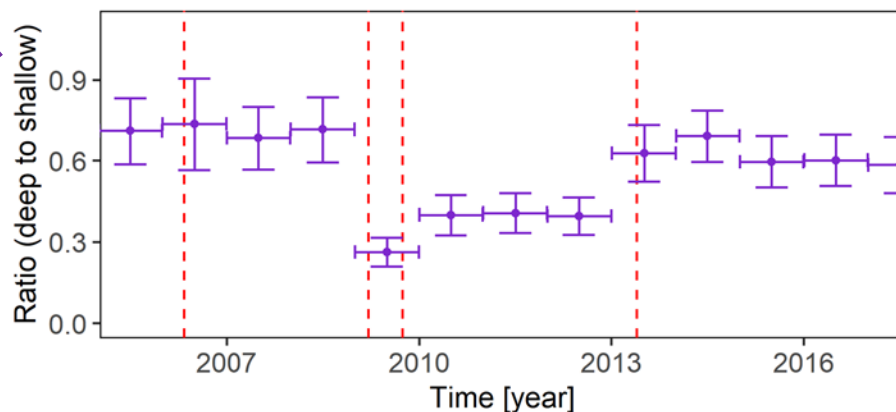
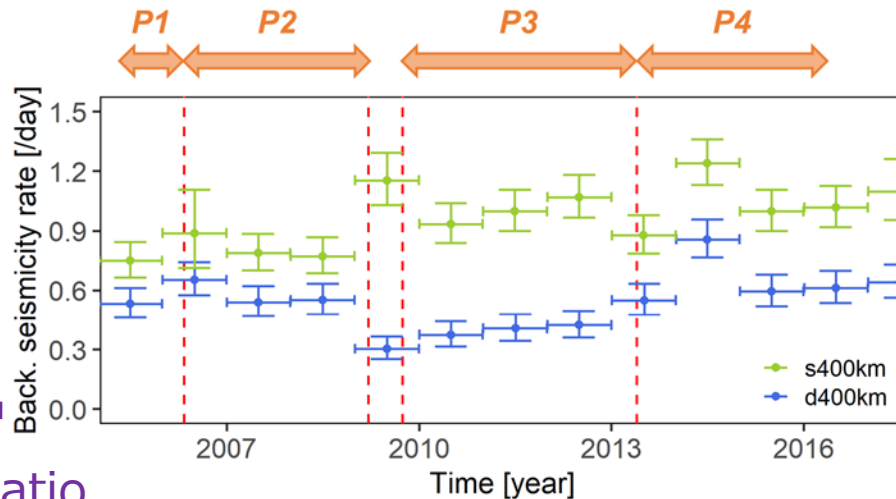
$$\lambda(t) = \underbrace{\mu}_{\text{Background}} + \sum_{t_i \leq t} \frac{K e^{\alpha(M_i - M_c)}}{(t - t_i + c)^p} \quad \text{Aftershocks}$$

- Parameter estimation of the ETAS model (Ogata, 1988) per year

- Two depth ranges:

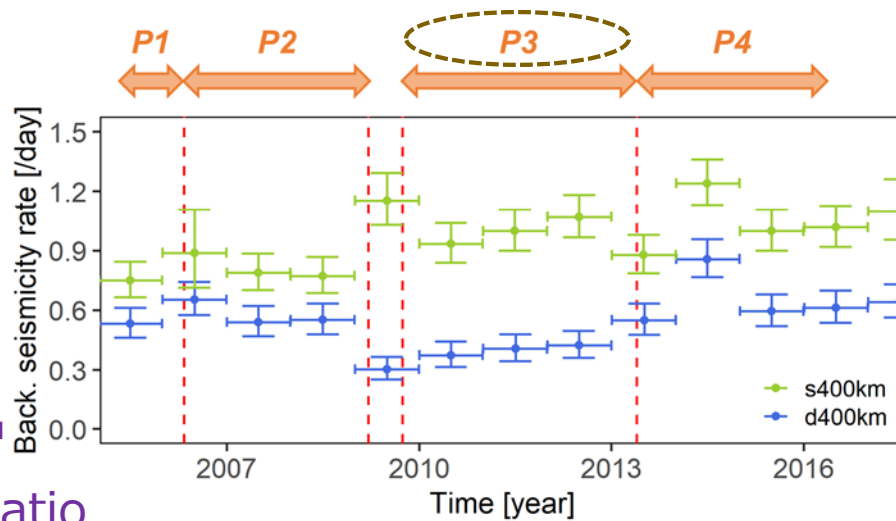
Shallower than 400 km (s400km)

Deeper than 400 km (d400km)

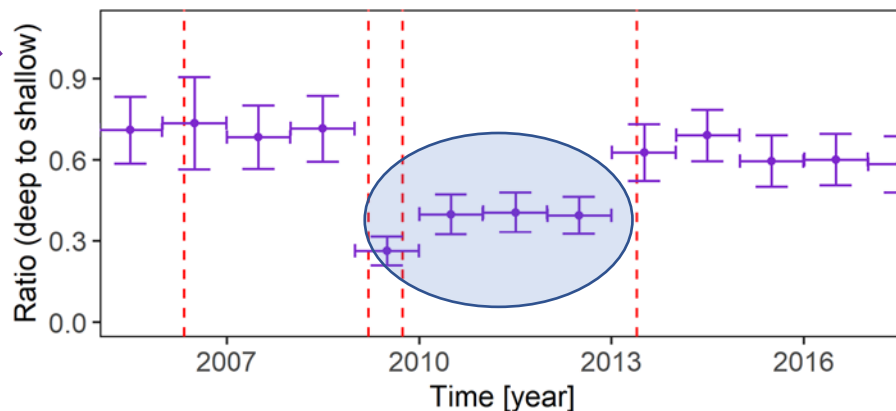


Synchronized deep and shallow events

- Temporary decrease in the seismicity of deep EQ in the **P3** period



Ratio



- Separate slow event, possibly triggered by the distant M8.1 EQ in the **P3** period

