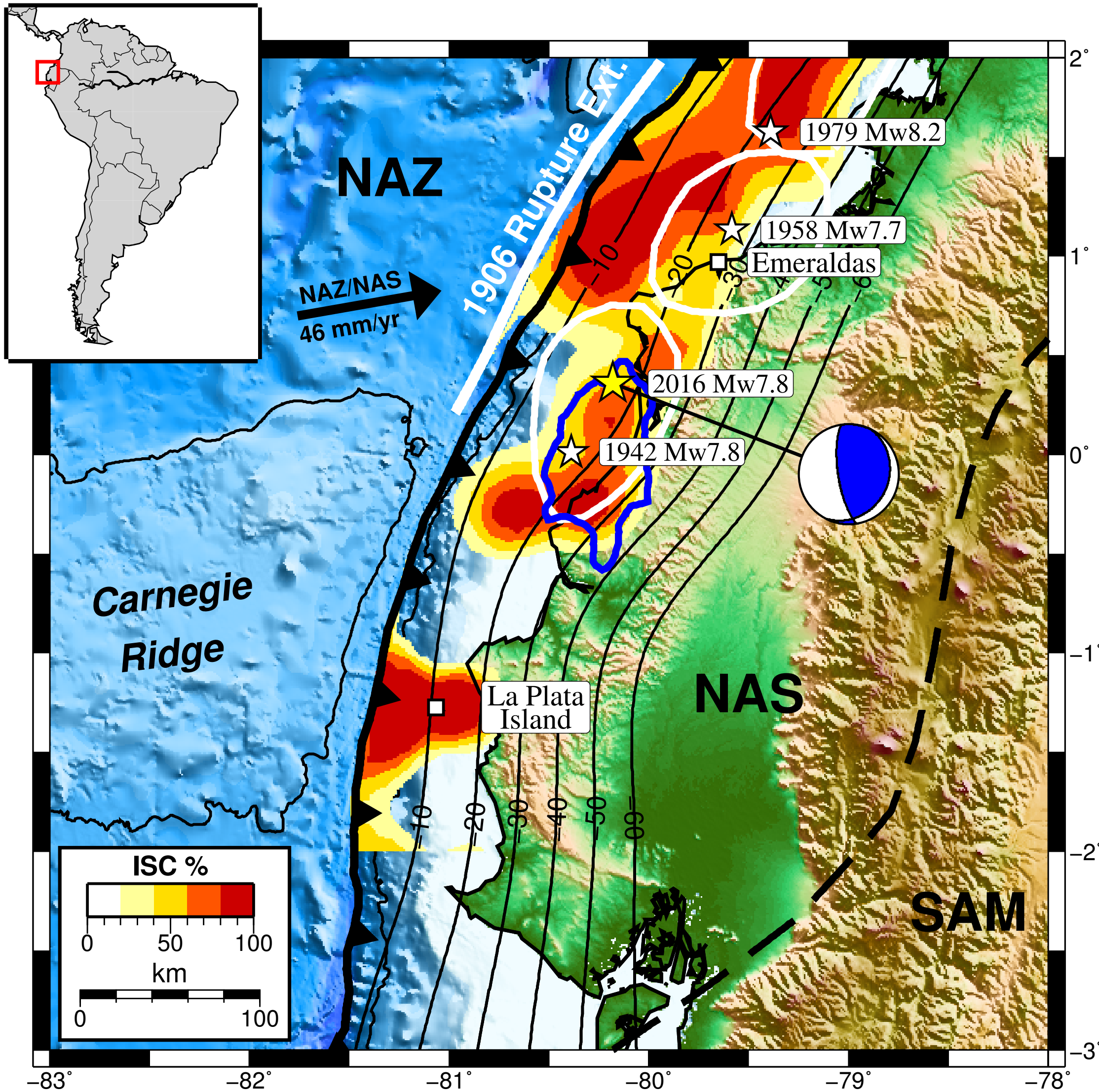
Aftershocks of the 2016 Mw 7.8 Ecuador earthquake reveal earthquake cycle is controlled by long-lived structures

H. Agurto-Detzel – Geoazur, Nice, France

Y. Font, P. Charvis, D. Ambrois,
J-M. Nocquet, F. Rolandone — Geoazur, Nice, France
A. Alvarado — IG-EPN, Quito, Ecuador
A. Rietbrock, S. Leon-Rios — KIT, Karlsruhe, Germany
A. Meltzer — Lehigh University, Bethlehem, USA
S. Beck — Arizona University, Tucson, USA

19th General Assembly of WEGENER - Grenoble, 12 September 2018

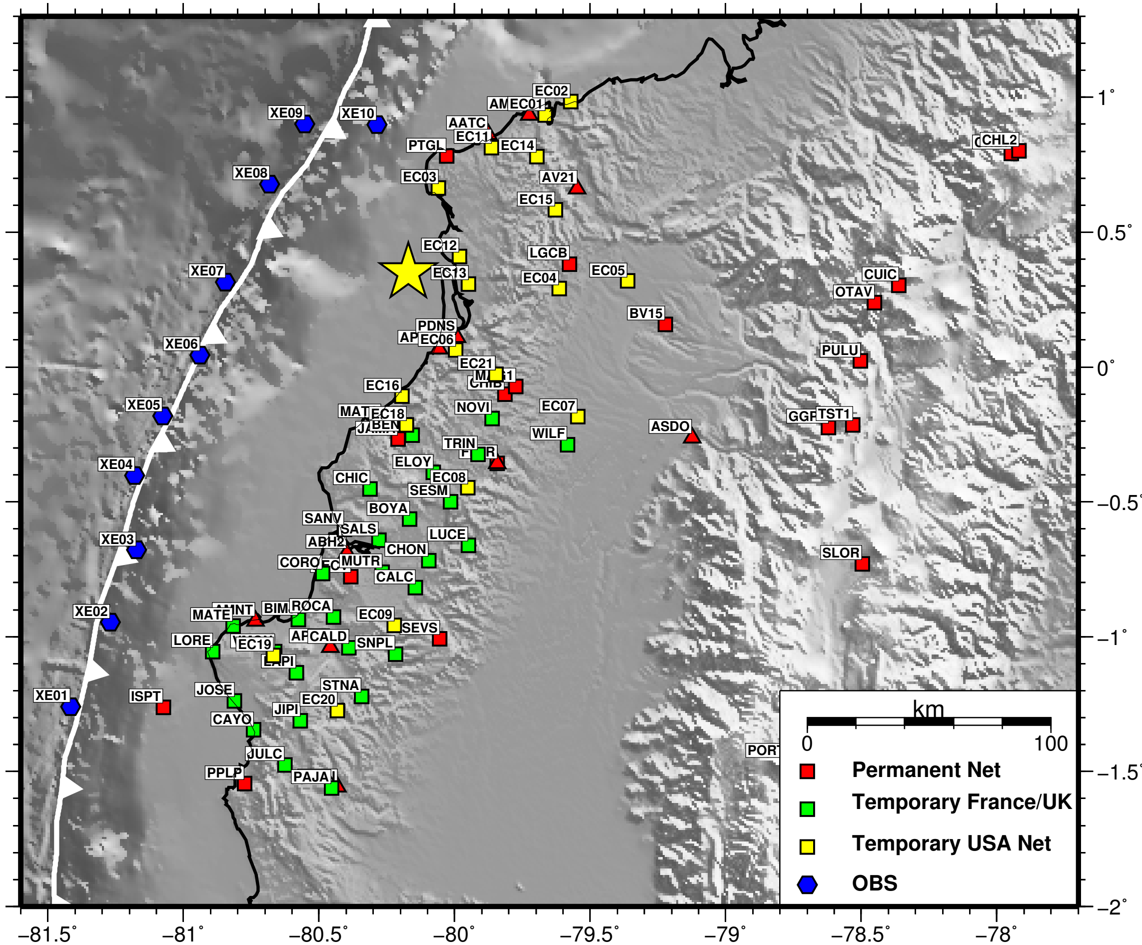
Seismotectonic Context



Interseismic coupling (Nocquet et al., 2014)
Coseismic rupture (Nocquet et al., 2016)
Rupture areas of past earthquakes (Kanamori and McNally, 1982; Mendoza and Dewey, 1984)

- **2016 Mw 7.8 Earthquake**
- **Interseismic Coupling**
- **Past Ruptures:**
  - **1906 M~8.6**
  - **1942 M7.8**
  - **1958 M7.7**
  - **1979 M8.2**
- **Diversity of Slip Processes SSE, Repeating Eqs., Swarms**

Processing



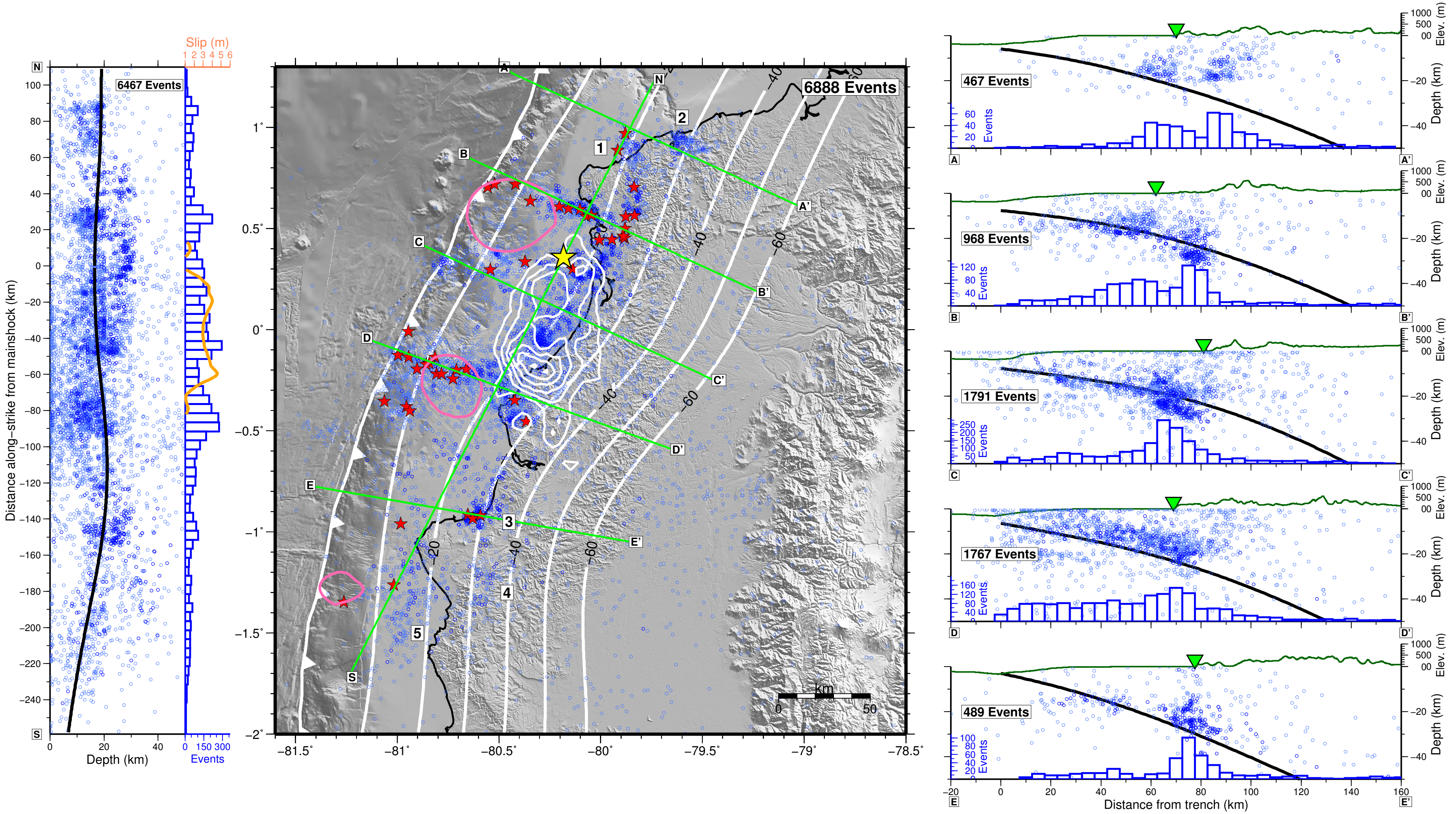
1-year Aftershock Deployment
60 Temporary Stations +
Permanent Ecuadorian Network

Processing in Seiscomp3
STA/LTA + DBSCAN

Relocation in NonLinLoc

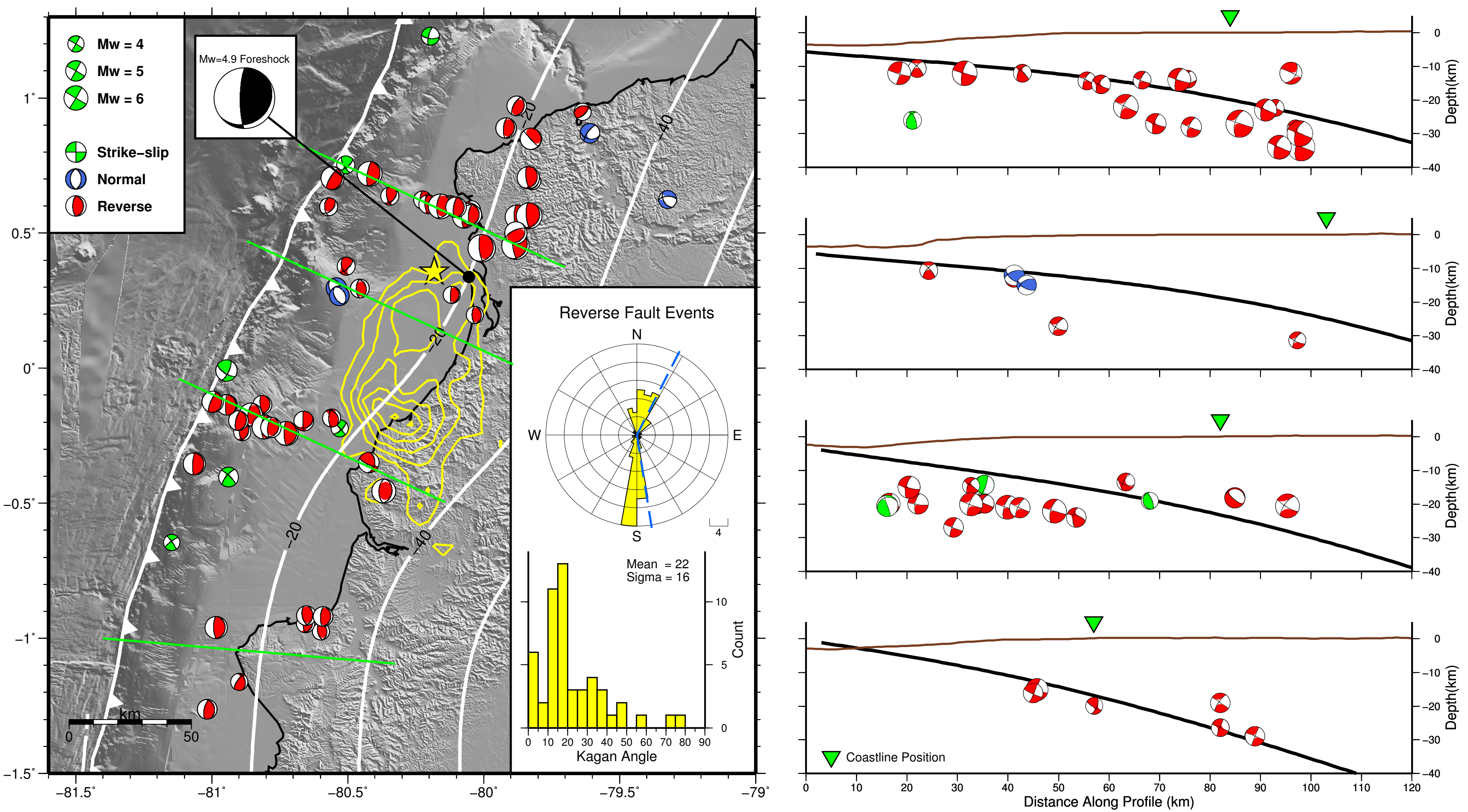
10k aftershocks
Local Magnitude (M_L)
0.7 – 6.9   Mc=2.5

Aftershocks Distribution

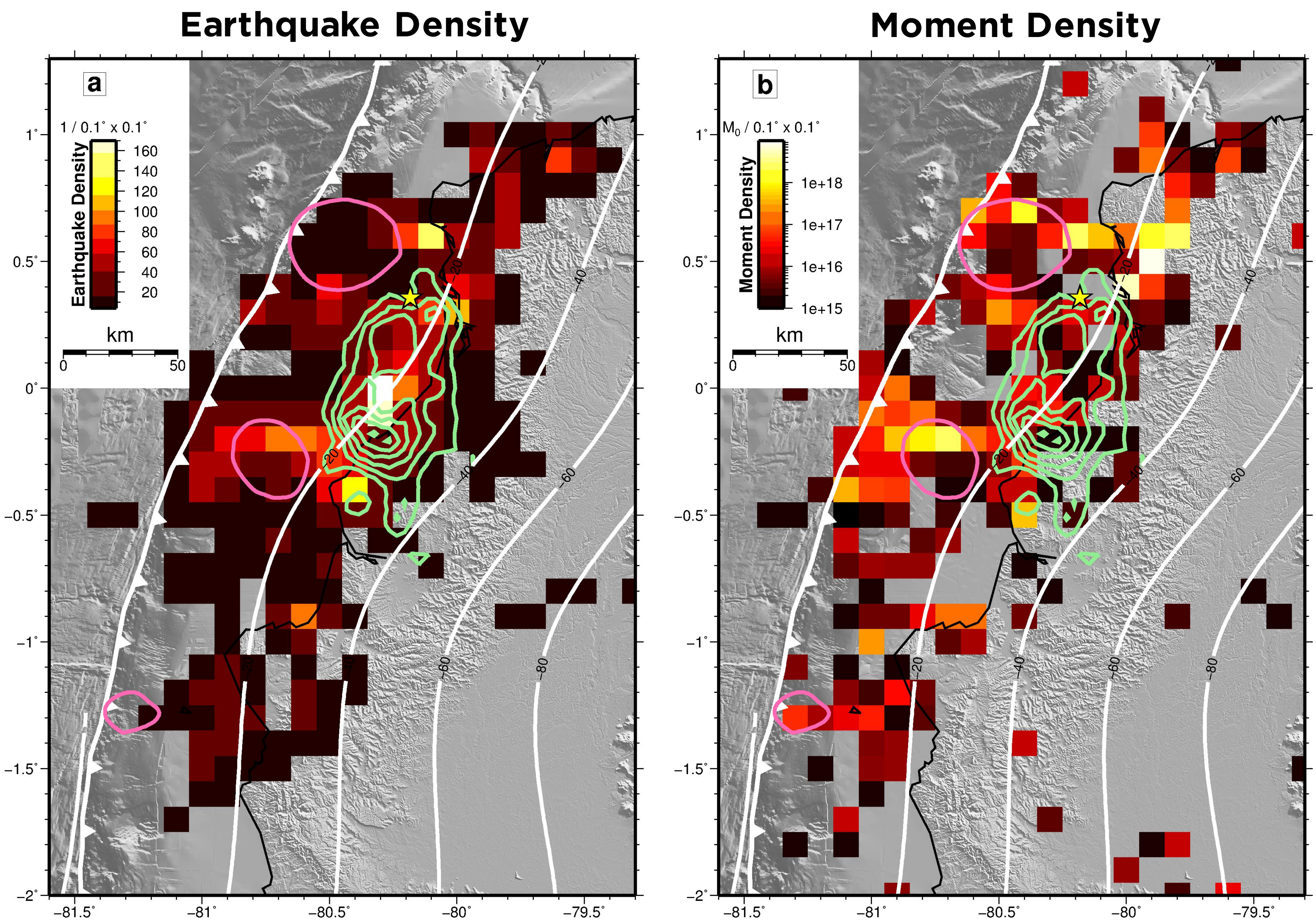


Coseismic rupture (Nocquet et al., 2016)
40 cm afterlip patches (Rolandone et al., 2018)

Seismotectonics and Moment Tensors

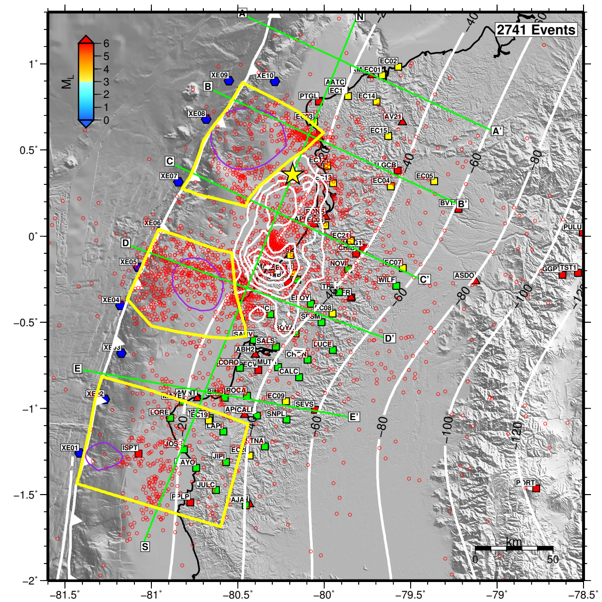


Earthquake Density

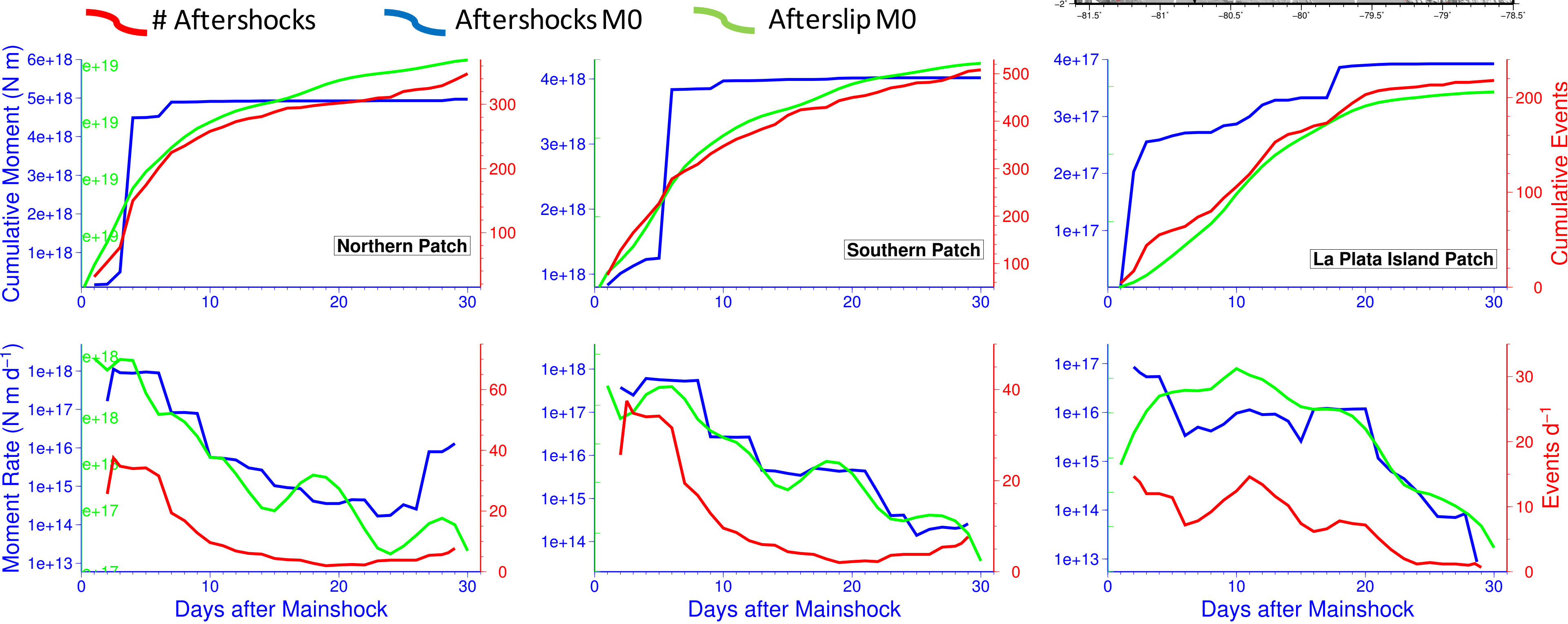


Coseismic rupture (Nocquet et al., 2016)
40 cm afterlip patches (Rolandone et al., 2018)

Relation to Afterslip

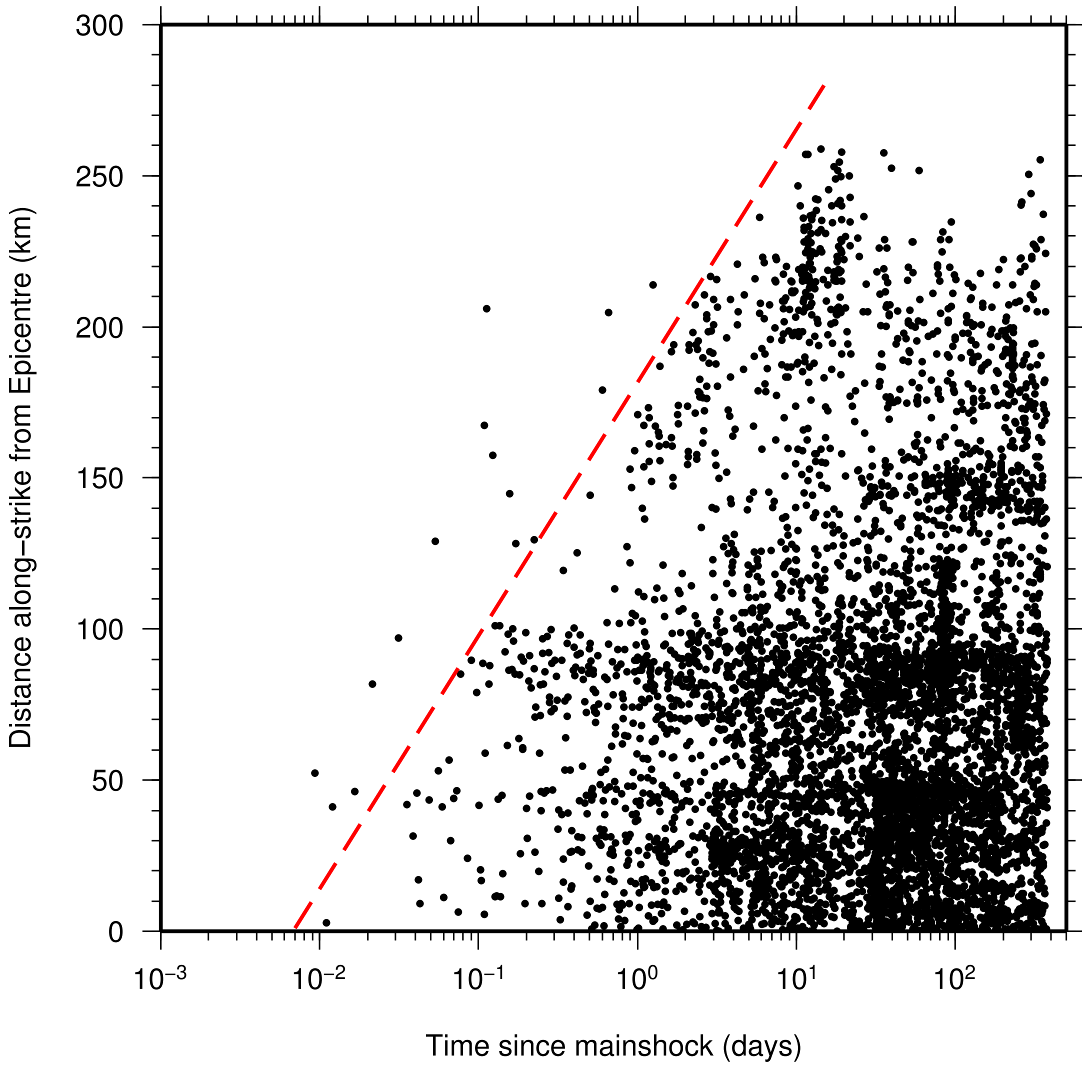


Close linear temporal dependency between afterslip and aftershocks



30 days afterlip from Rolandone et al. (2018)

Relation to Afterslip



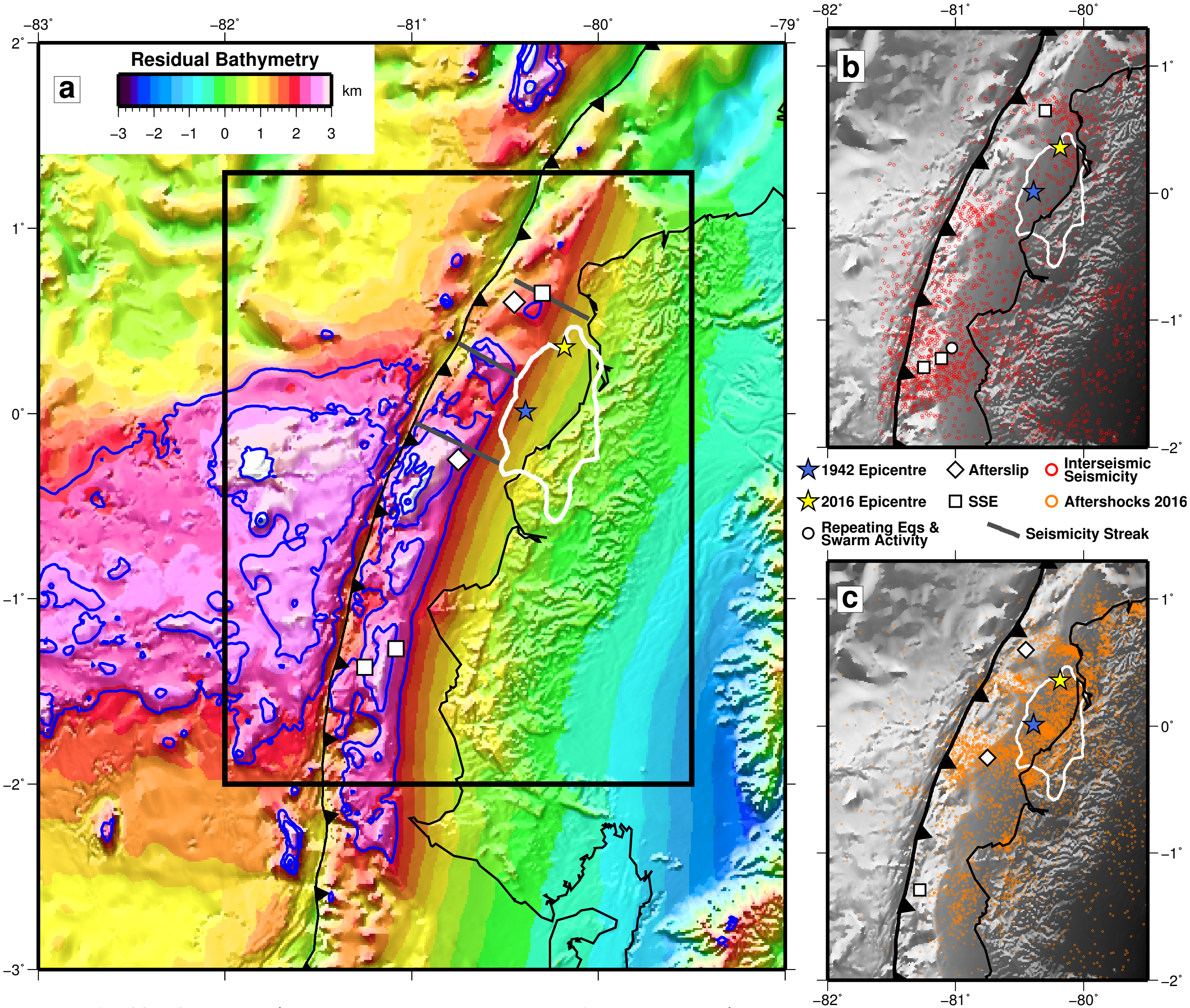
Log-time expansion of aftershocks along-strike

Theoretical and numerical simulations
(e.g. Perfettini and Avouac, 2004; Ariyoshi et al., 2007, Kato et al., 2007; Perfettini et al., 2018)

Observational Studies
(e.g. Peng and Zhao, 2009; Franck et al., 2017)

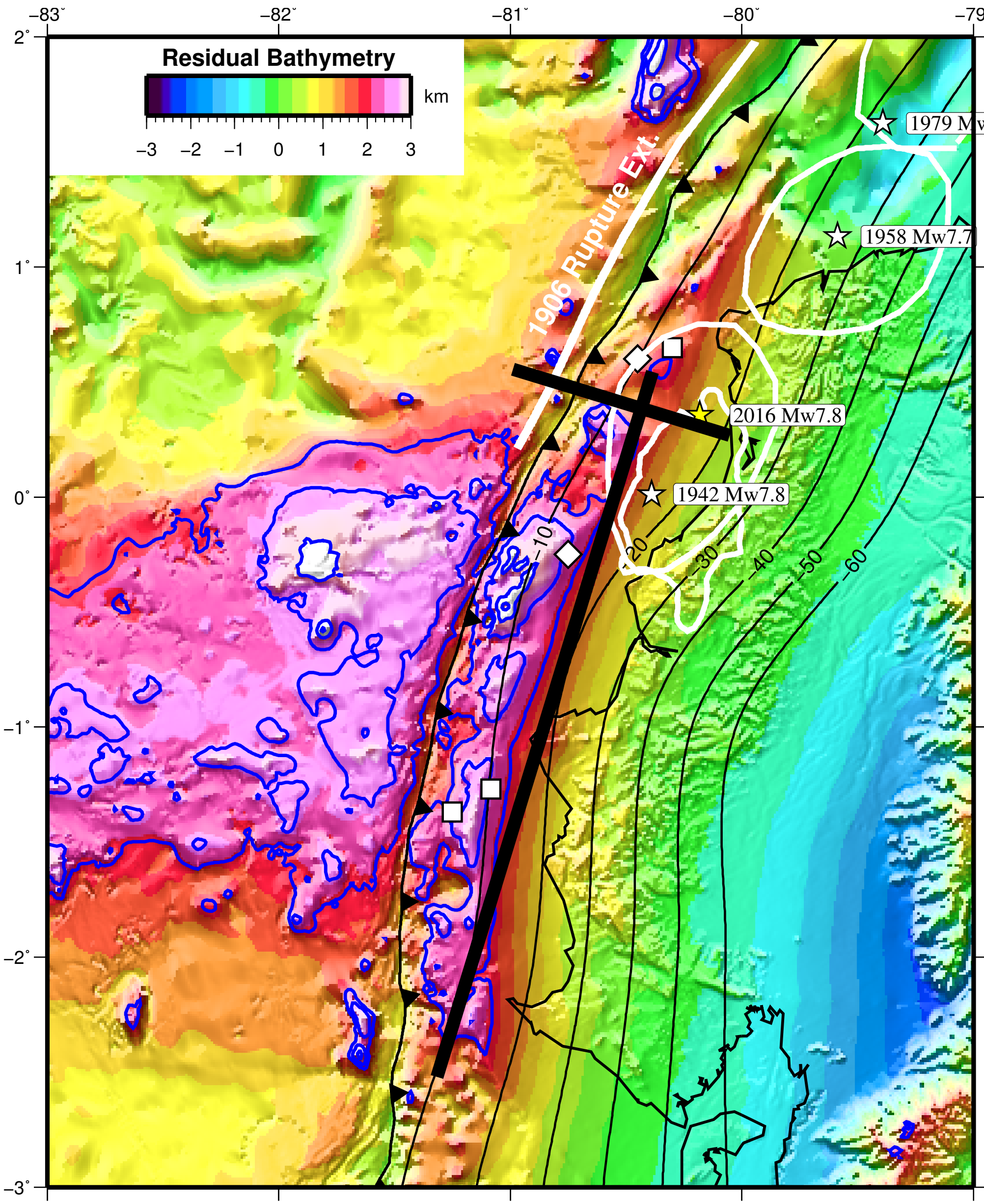
➔ Afterslip drives aftershock activity

The Big Picture



Residual bathymetry (Oniangue, 2016; Basset and Watts, 2015)

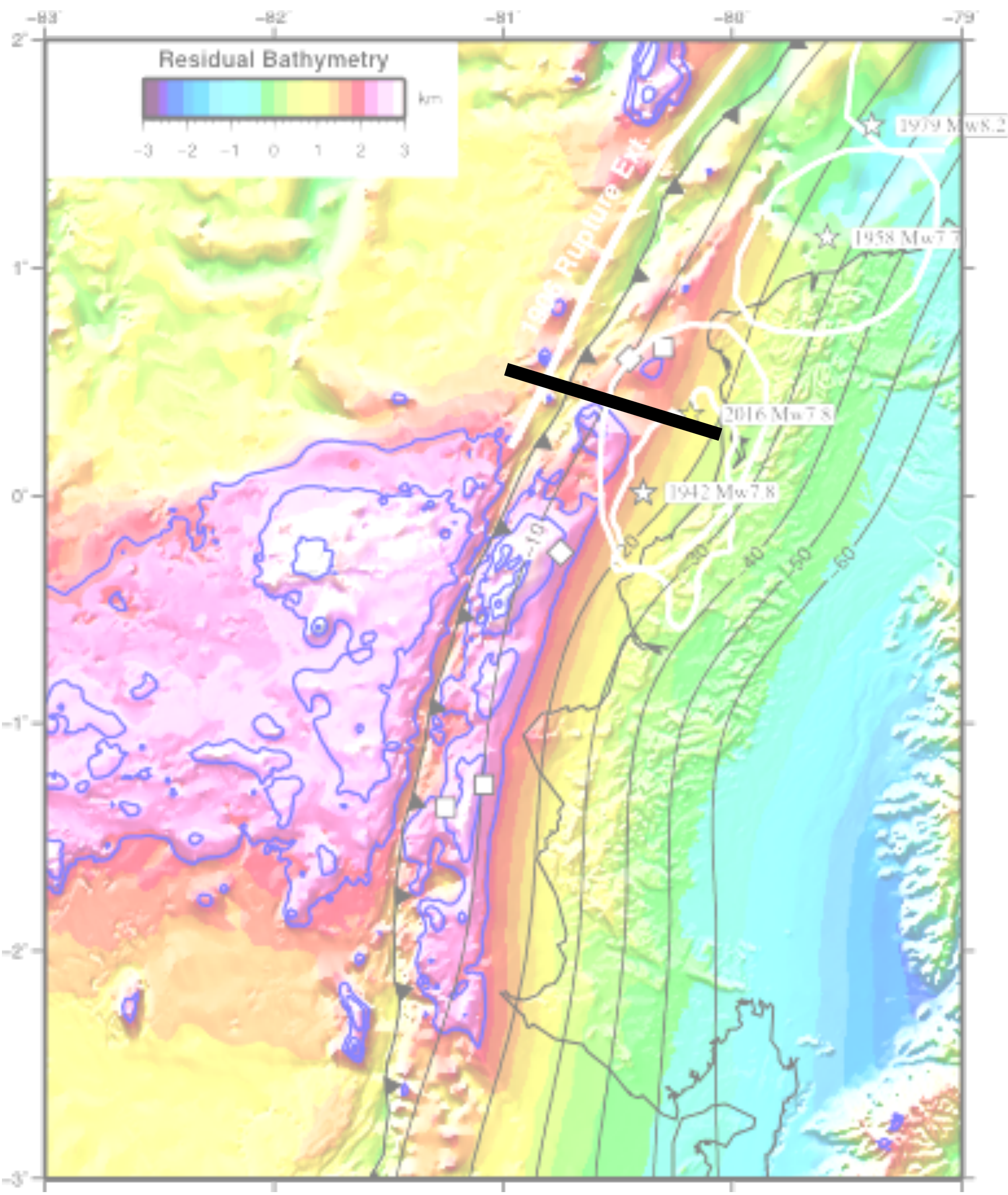
The Big Picture



Interaction between seismic and aseismic processes along the earthquake cycle

Bimodal slip segmentation both along-strike and along-dip, controlled by structural features such as incoming oceanic relief

The Big Picture

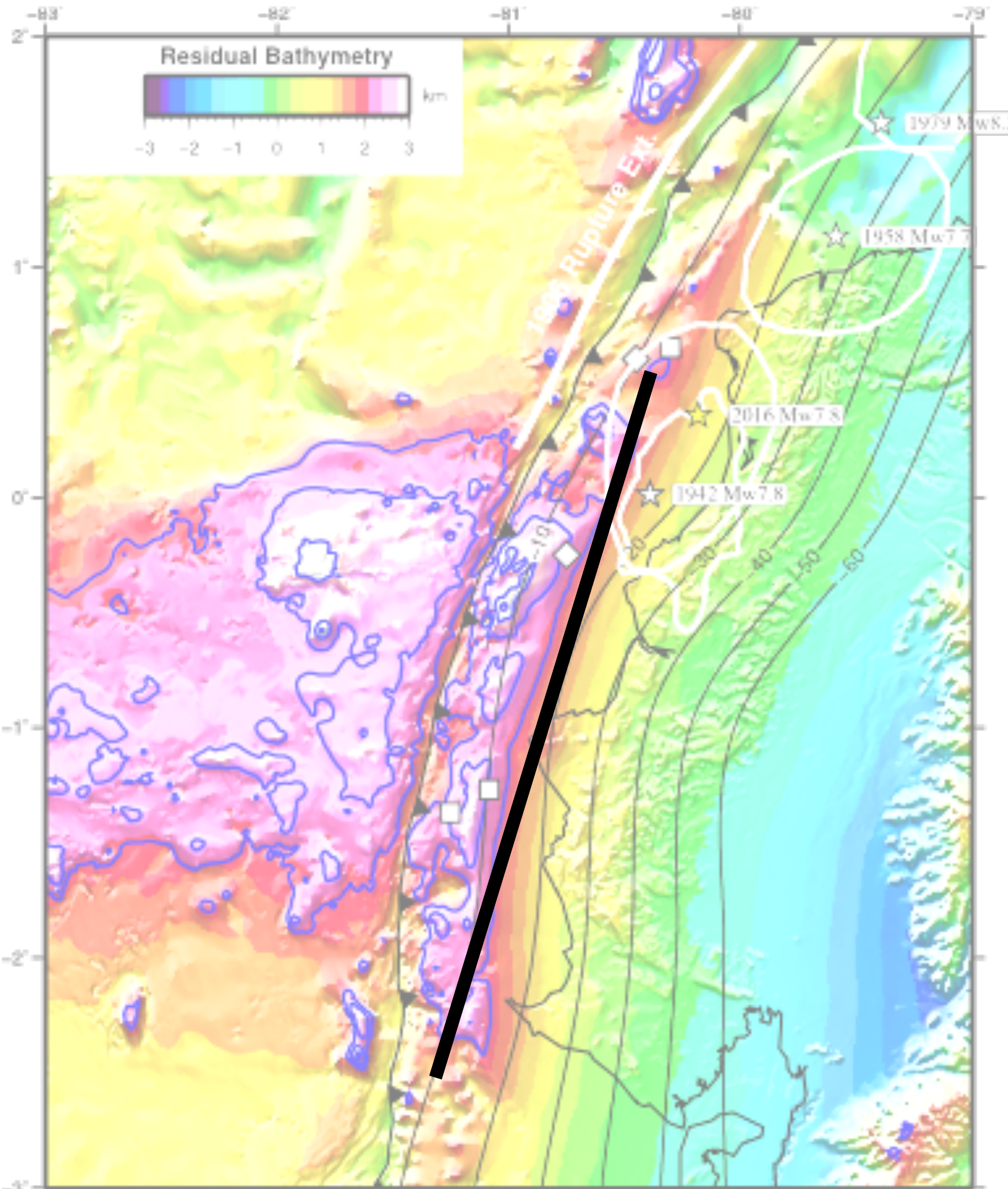


Along-strike

Large megathrust earthquakes that can rupture up to the trench.

No large megathrust earthquakes that can rupture up to the trench. Presence of aseismic slip processes.

The Big Picture



Along-dip

No large megathrust rupture, or if any, contained between ~15 to 35 km depth.

No large earthquakes. Aseismic slip, repeating earthquakes, swarms

Conclusion

1 year postseismic activity, +10,000 events, M<6.9

Aftershocks constrained within coseismic rupture and up-dip

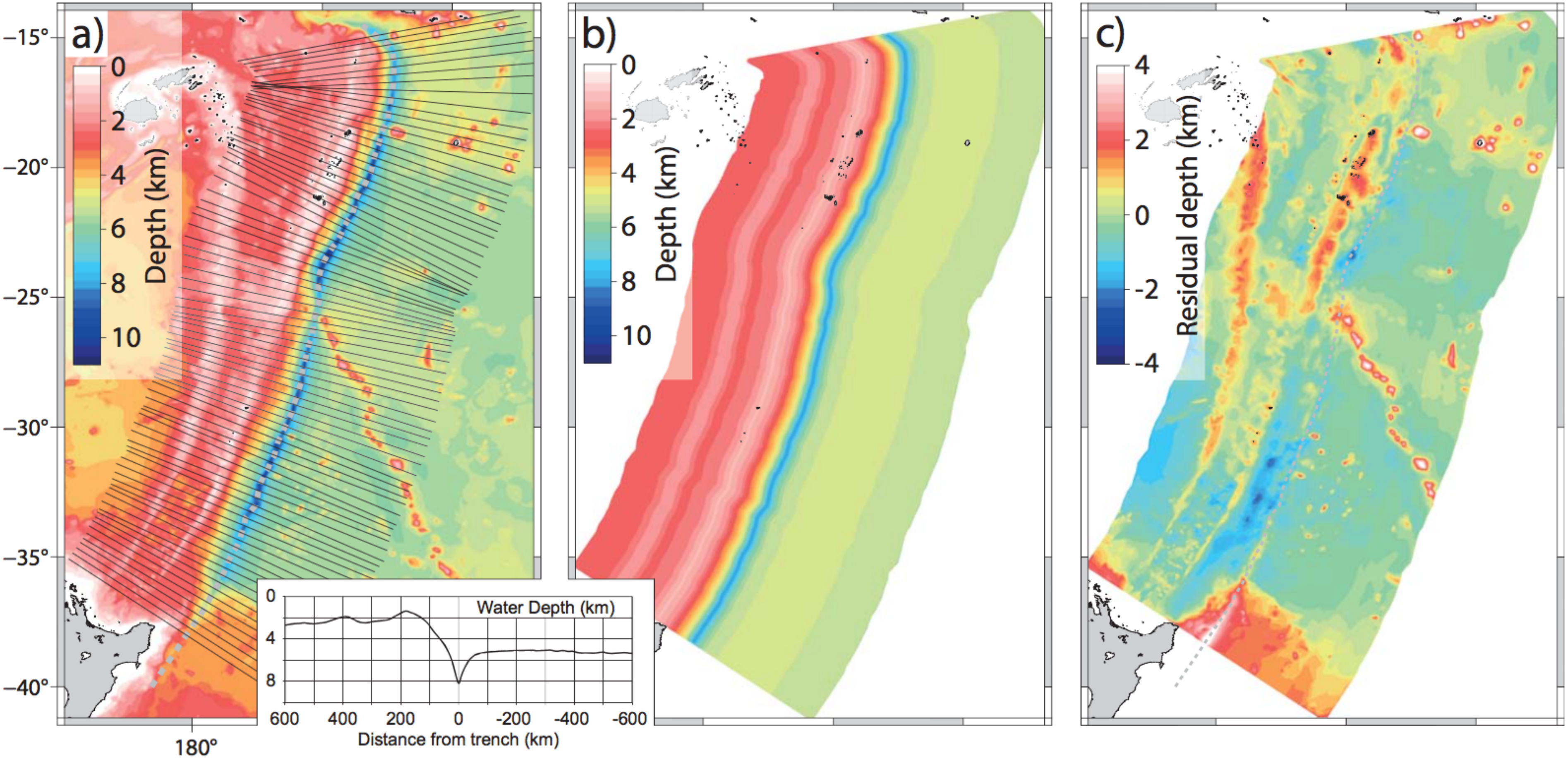
Persistent seismicity patterns over the earthquake cycle (IS & PS)

Linear temporal dependency between afterslip and aftershocks
Log-time expansion of aftershocks
➔ aftershocks evolution governed by afterslip

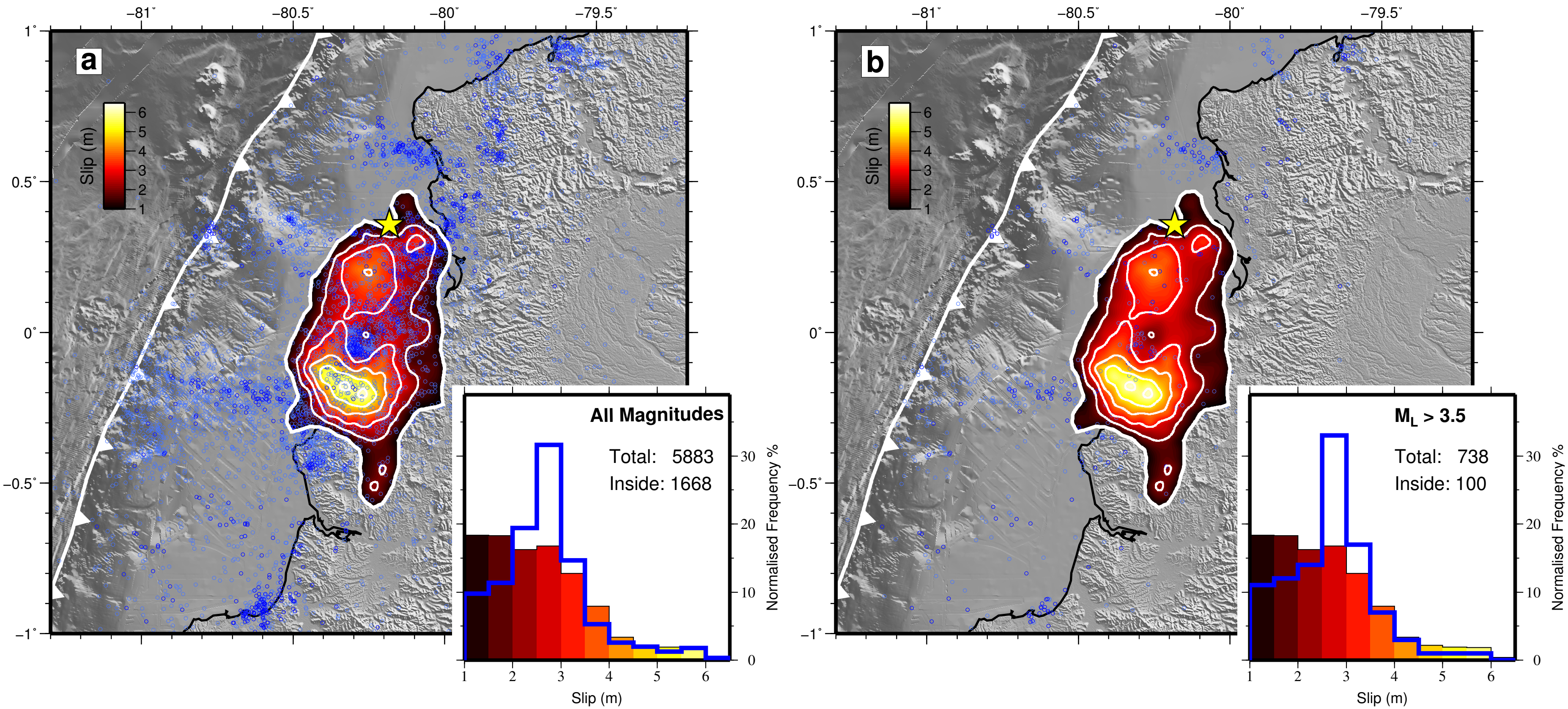
Interaction of seismic and aseismic processes along the earthquake cycle

Variability of slip modes controlled by subducted oceanic relief

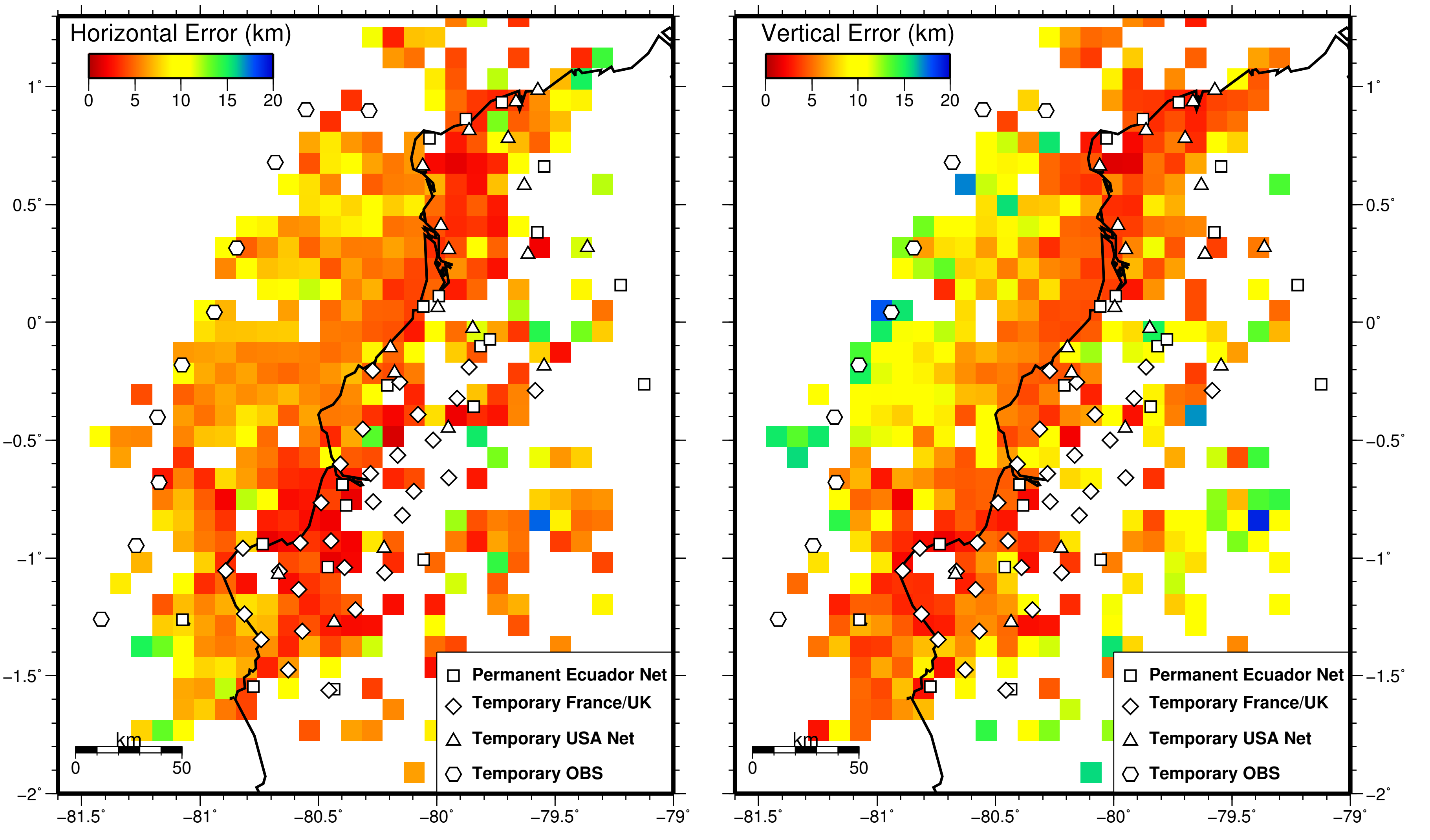
Bimodal slip segmentation along-strike and along-dip


a)
b)
c)
Depth (km)
0
2
4
6
8
10
Residual depth (km)
4
2
0
-2
-4
−15°
−20°
−25°
−30°
−35°
−40°
180°
Water Depth (km)
Distance from trench (km)
600
400
200
0
-200
-400
-600

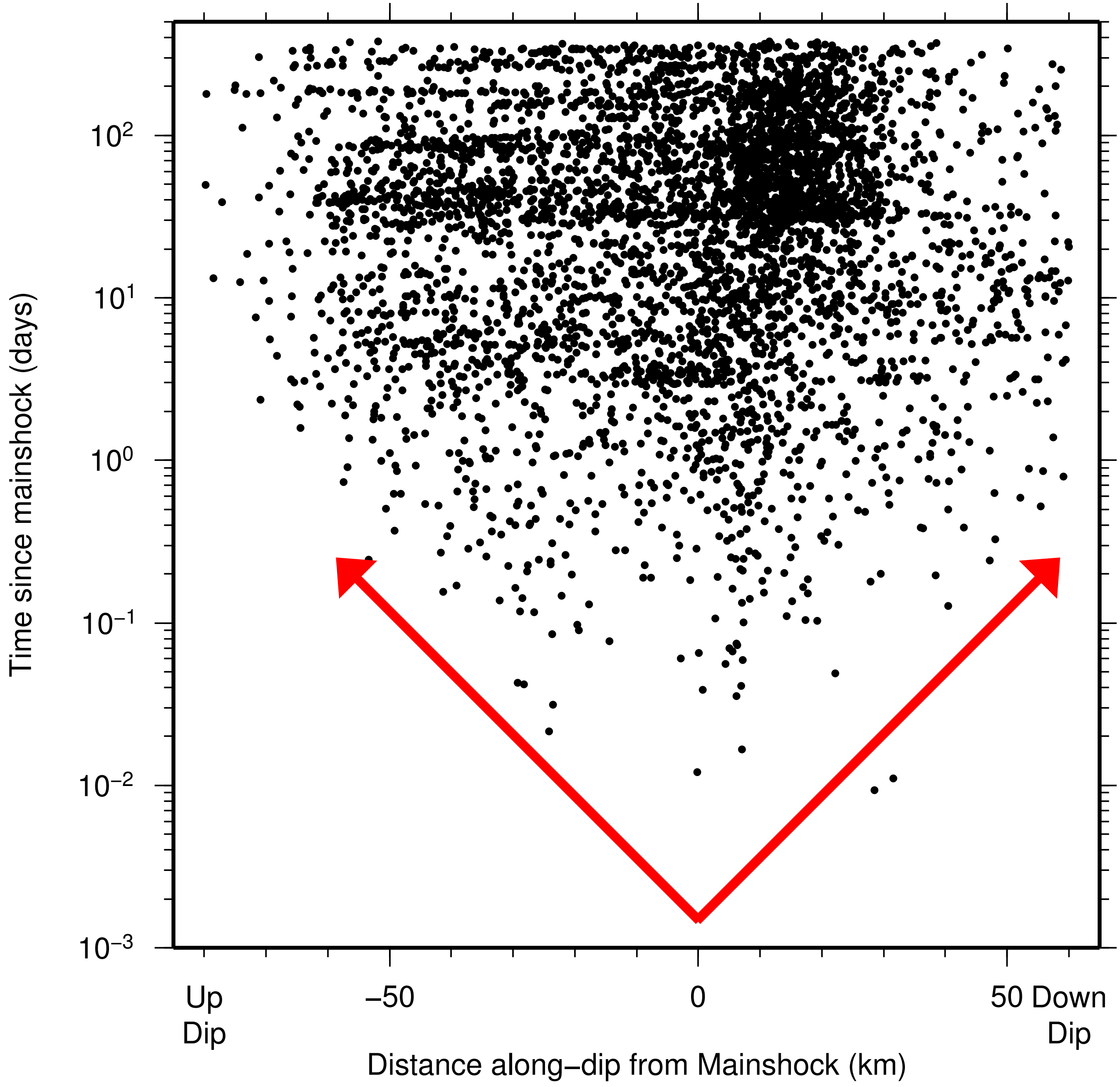
Relation to Coseismic Slip Distribution

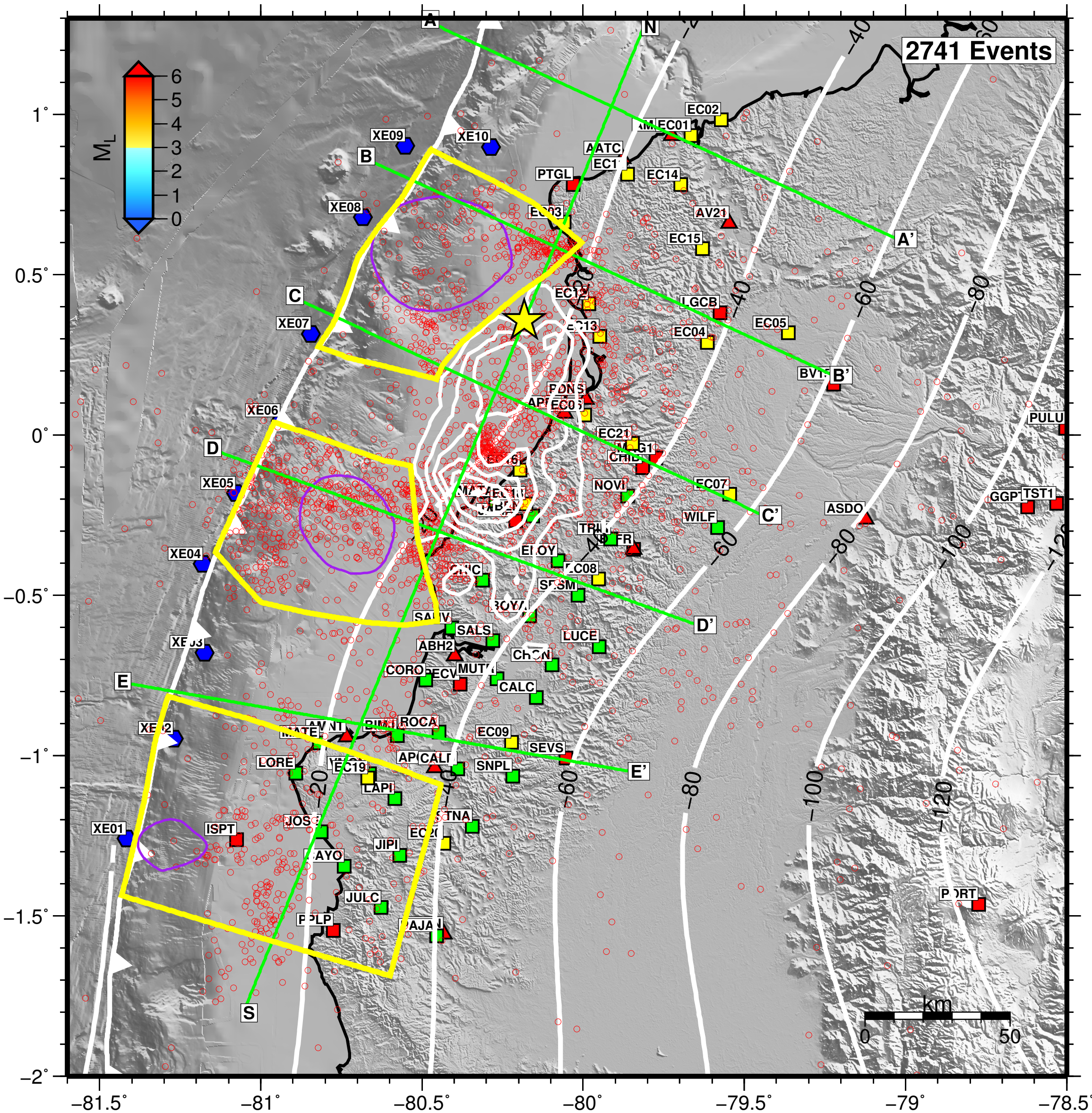


Coseismic rupture (Nocquet et al., 2016)



Horizontal Error (km)
0
5
10
15
20
Vertical Error (km)
Permanent Ecuador Net
Temporary France/UK
Temporary USA Net
Temporary OBS
km
0
50
1˚
0.5˚
0˚
−0.5˚
−1˚
−1.5˚
−2˚
−81.5˚
−81˚
−80.5˚
−80˚
−79.5˚
−79˚


Time since mainshock (days)
10^2
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
Up Dip
–50
0
50 Down Dip
Distance along–dip from Mainshock (km)



2741 Events
M_L
A
A'
B
B'
C
C'
D
D'
E
E'
N
S
km
0
50