On Repeating Earthquakes in the Northern Chilean Subduction Zone

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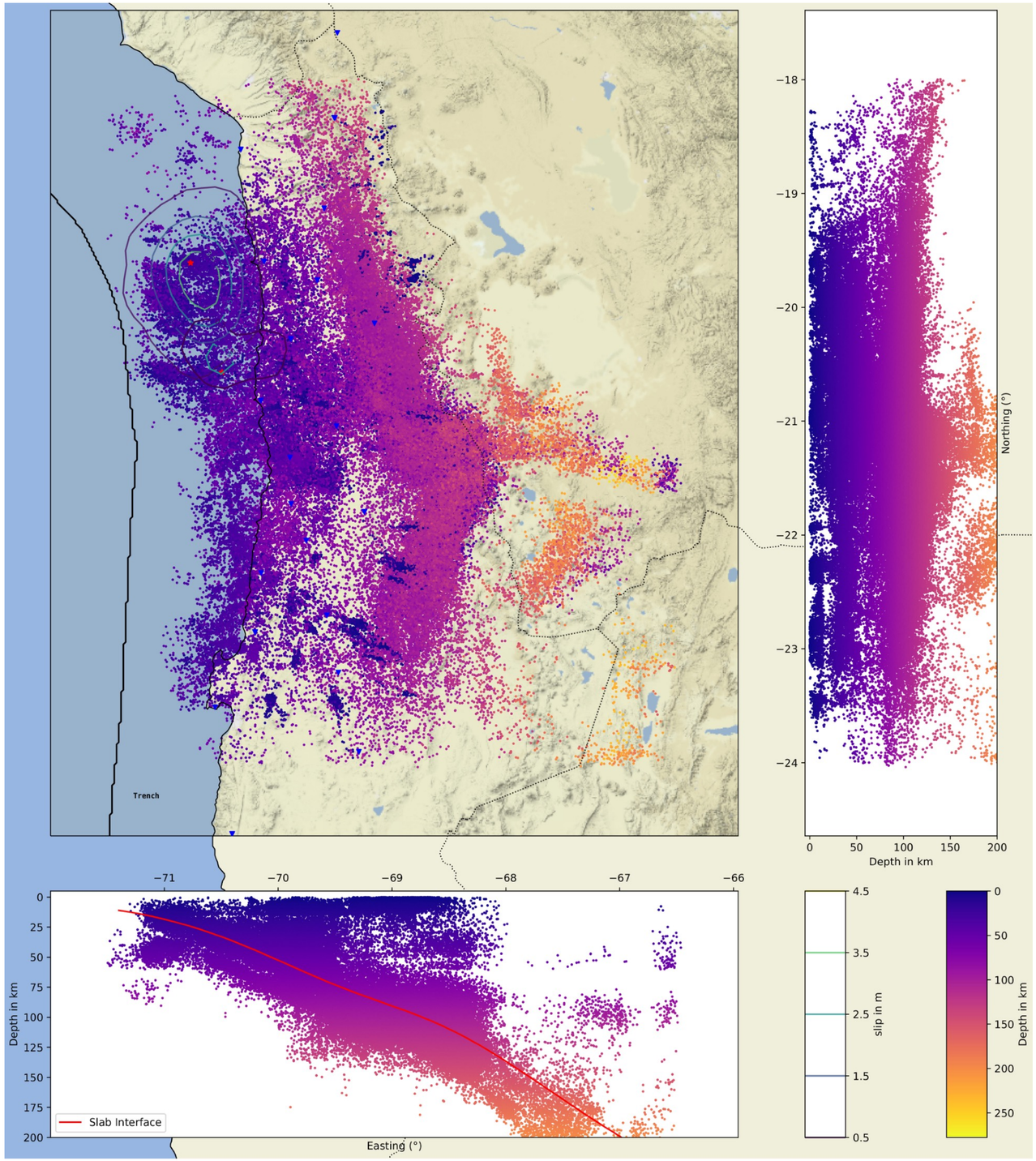
Search for Repeating Earthquakes (REs) in Northern Chile

Data Base

- IPOC network is monitoring seismicity since 2006
- Data Base is an extended version of the catalog by Sippl et al., 2018
- ~ 200.000 seismic events
- 2007 - 2021
- 2014 MW8.1 Iquique event included with fore- and aftershock series



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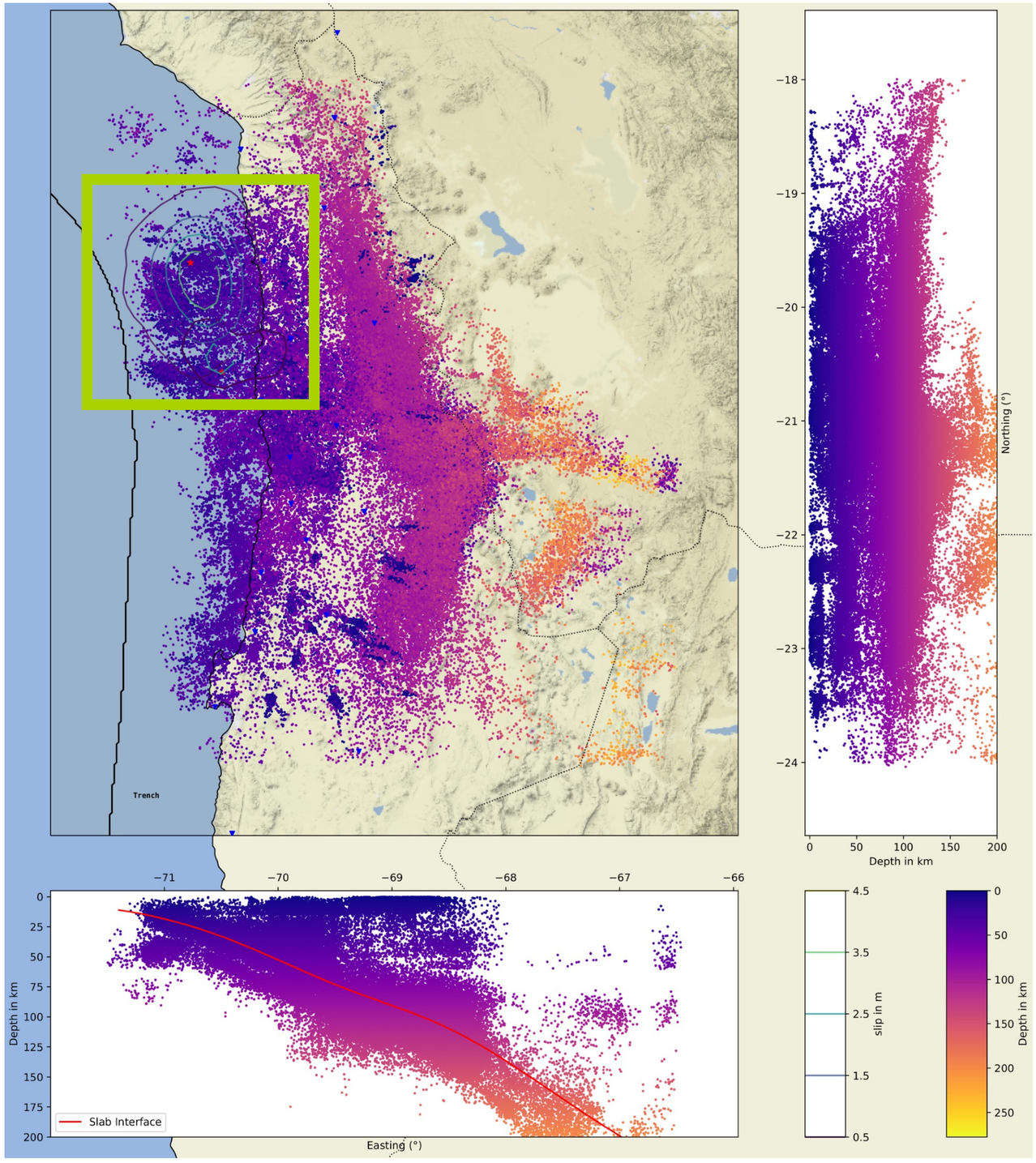
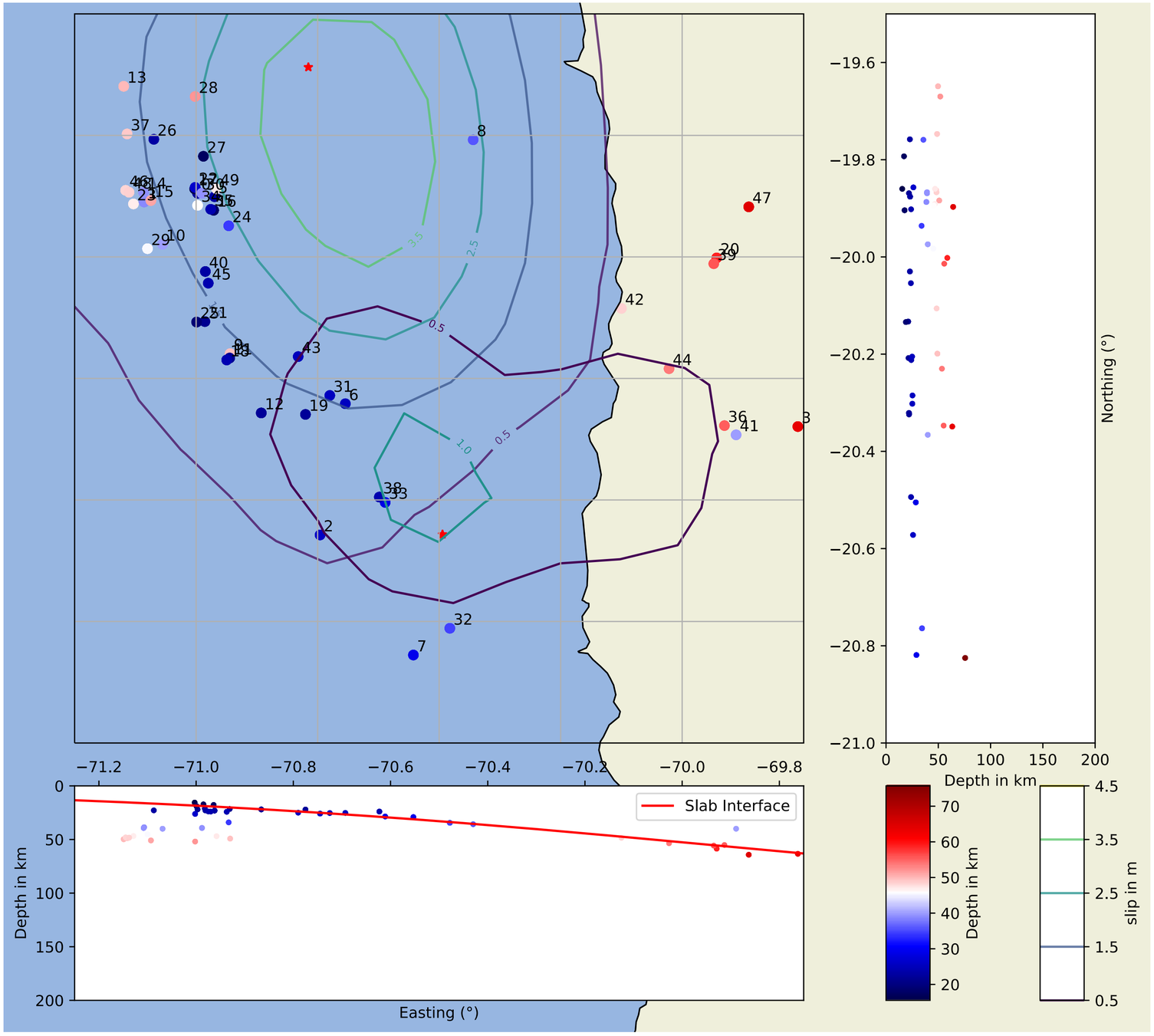
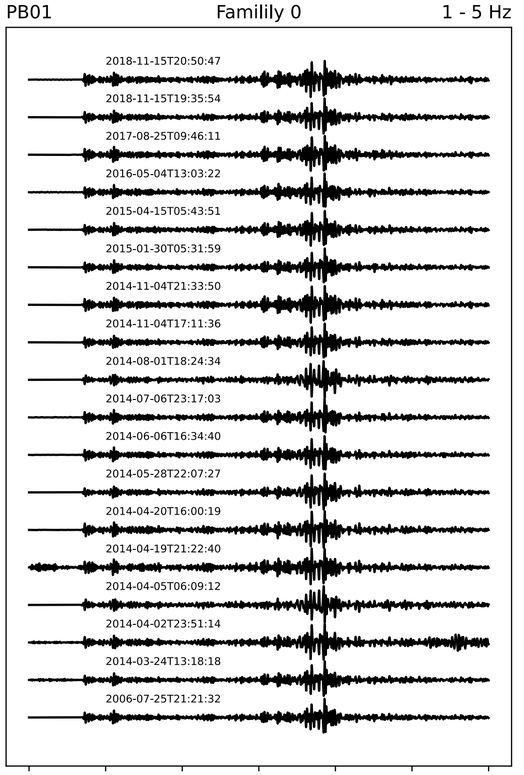
Repeating Earthquakes

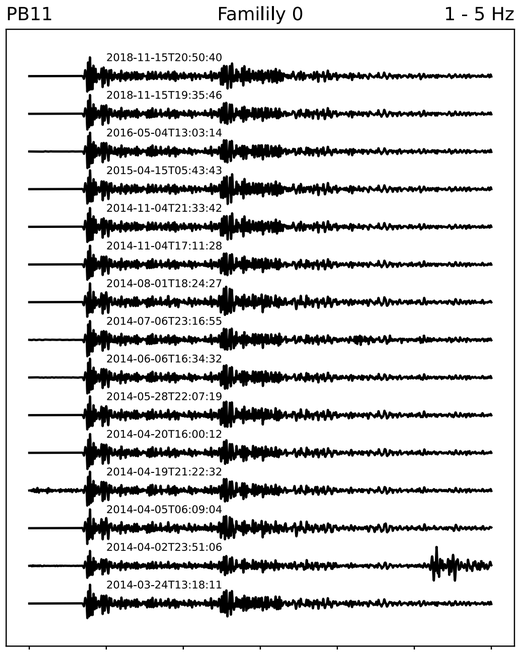
- RE selection in limited area of the mega-thrust event in 2014
- RE are identified by cc - values
- ~9100 Template events were correlated with continuous seismic data over the entire available time span
- cc > 0.95, at 3 stations, 1-4Hz bandpass, 35s time window
- We found 50 series (not counting doublets) containing 673 single events
- Magnitude range is 1.7 ≤ ml ≤ 4.8



Repeating Earthquake Series (REQS) Map

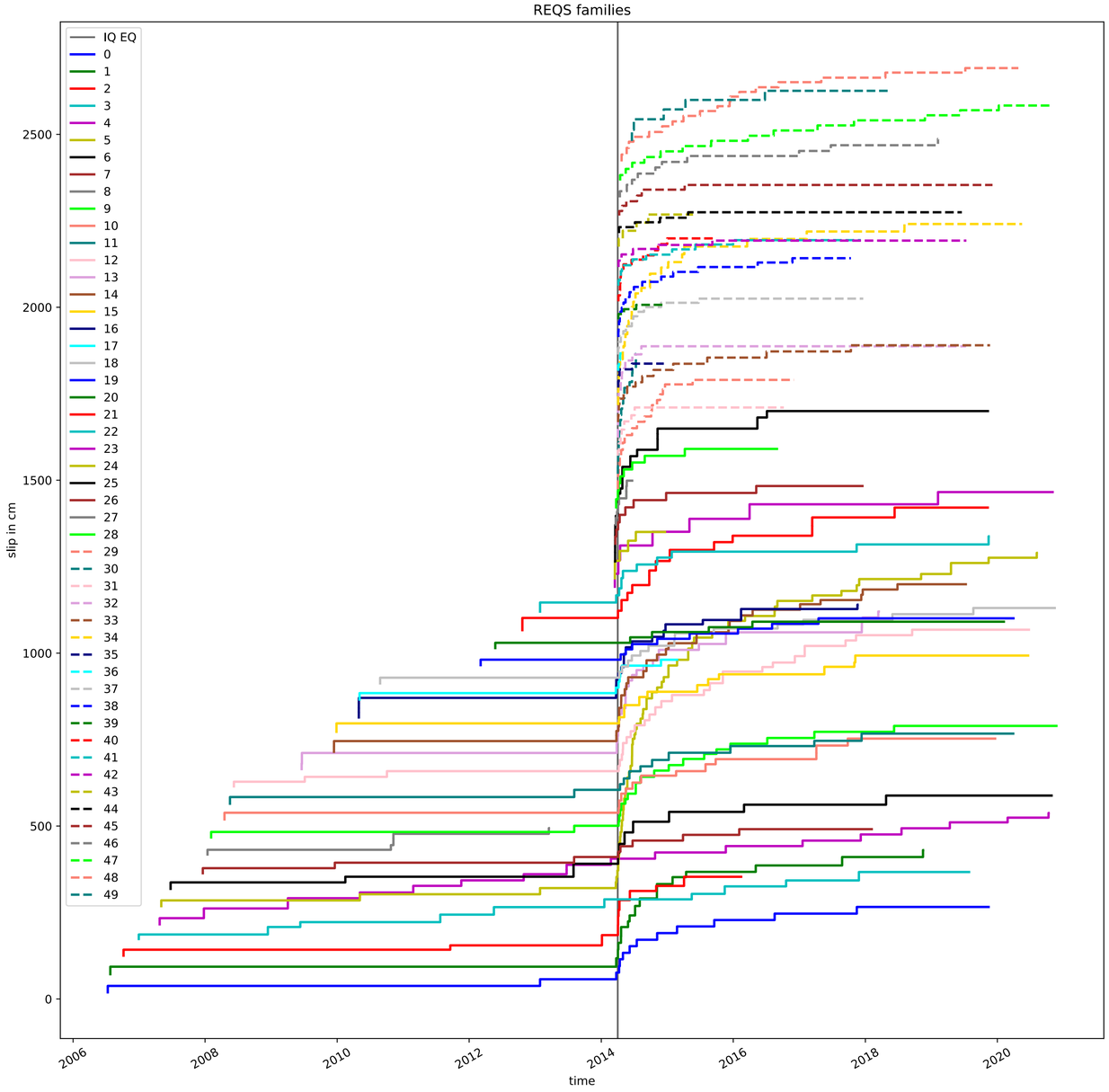




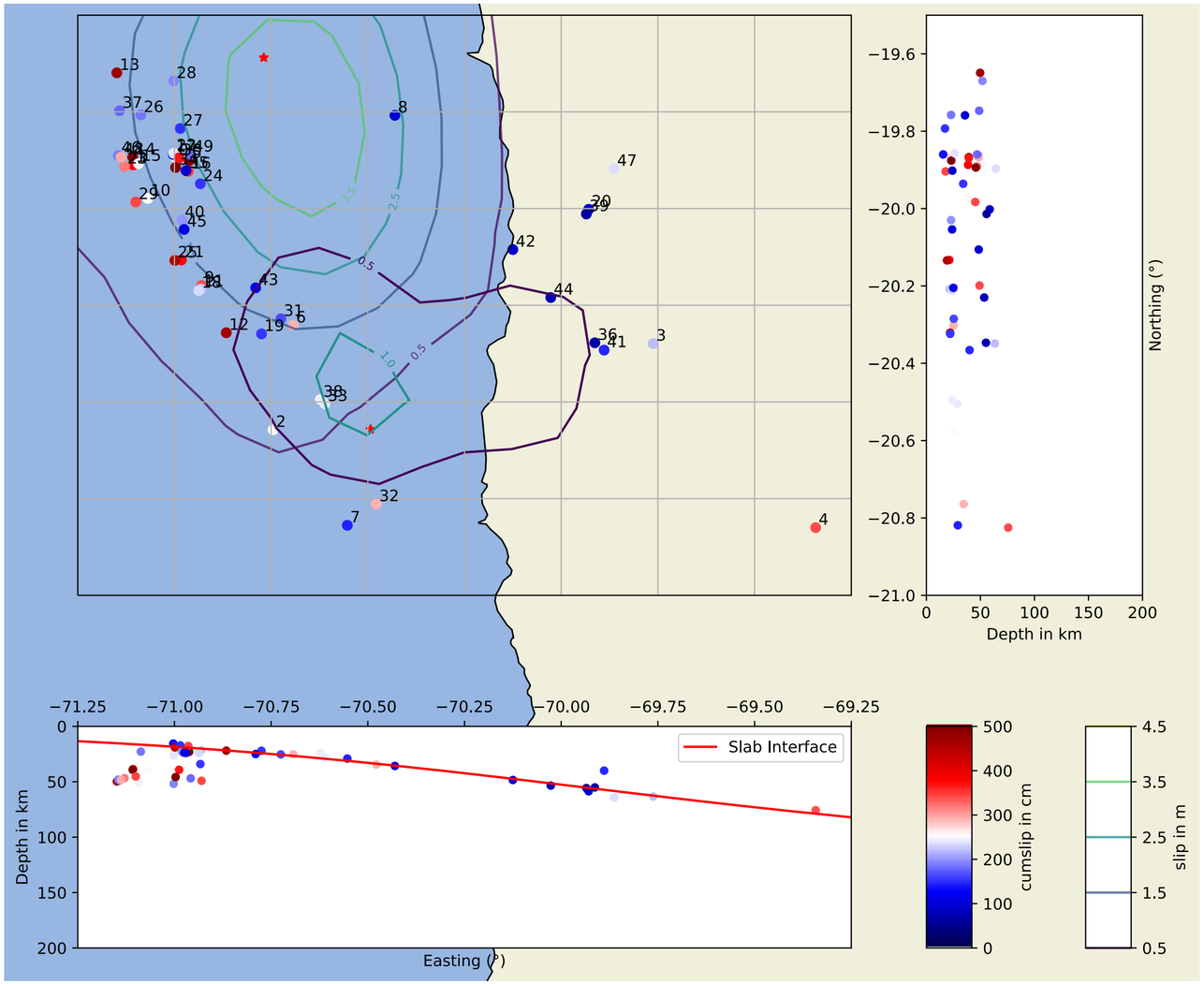


- Depth resolution offshore is worse, so it is likely that most series lie on the interface
- Slip distribution of the M_W8.1 & M_W7.6 Iquique event and aftershock from Schurr et al., 2014
- We compute slip from moments using Nadeau & Johnson, 1998, empirical relation

Slip Distribution of REQSs



slip vs occurrence time



- cumulative slip of all REs in each series

- Why is the cumslip (slip rate, too) so heterogenous?

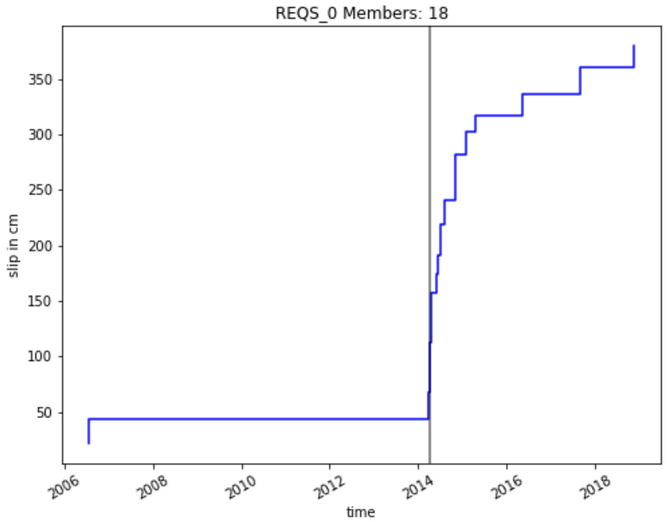
-> Let's have a more detailed look at the individual REQSs

Cumulative Slip for Individual Series - Different Classes of REQSs

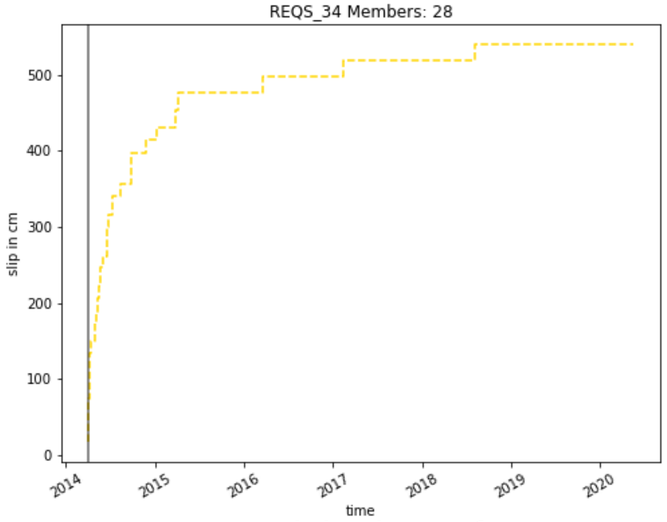
Hole time span

Zoom to IQ event OT ± 2 weeks

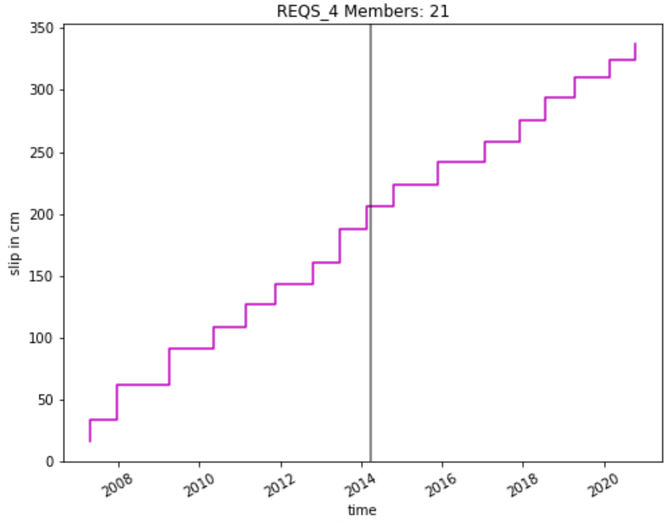
Continuous with Burst Characteristics



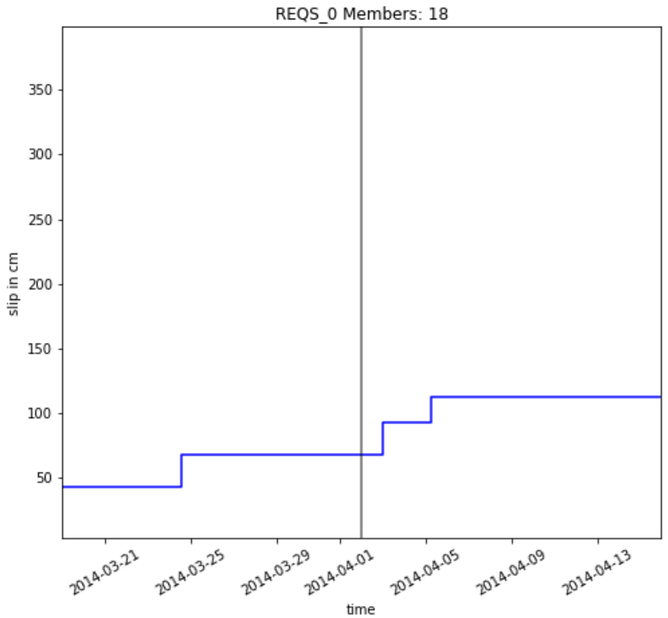
Burst



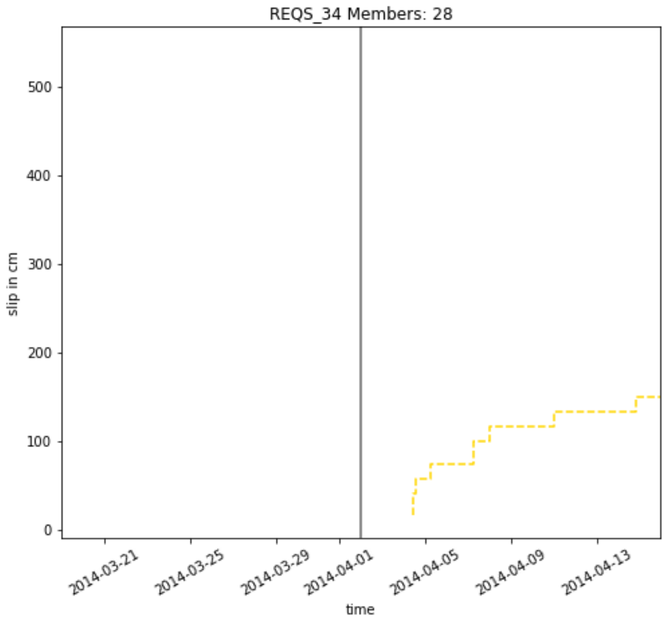
Continuous, Periodic



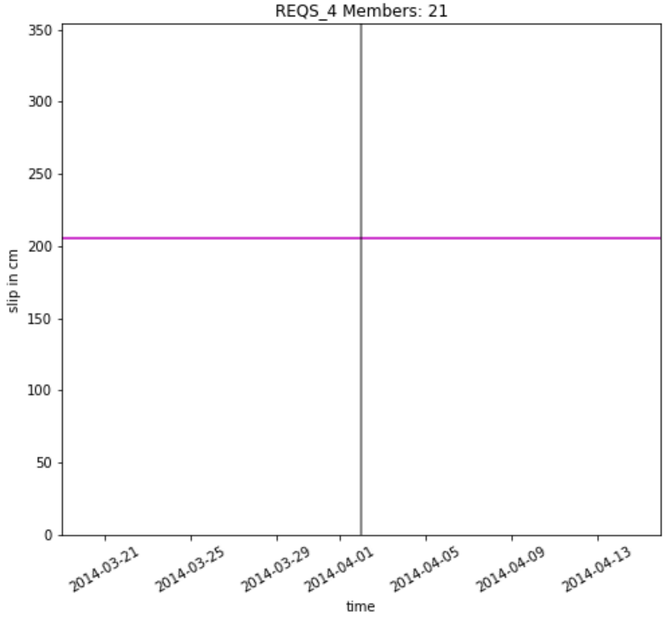
Activity just before, and after



activity just after

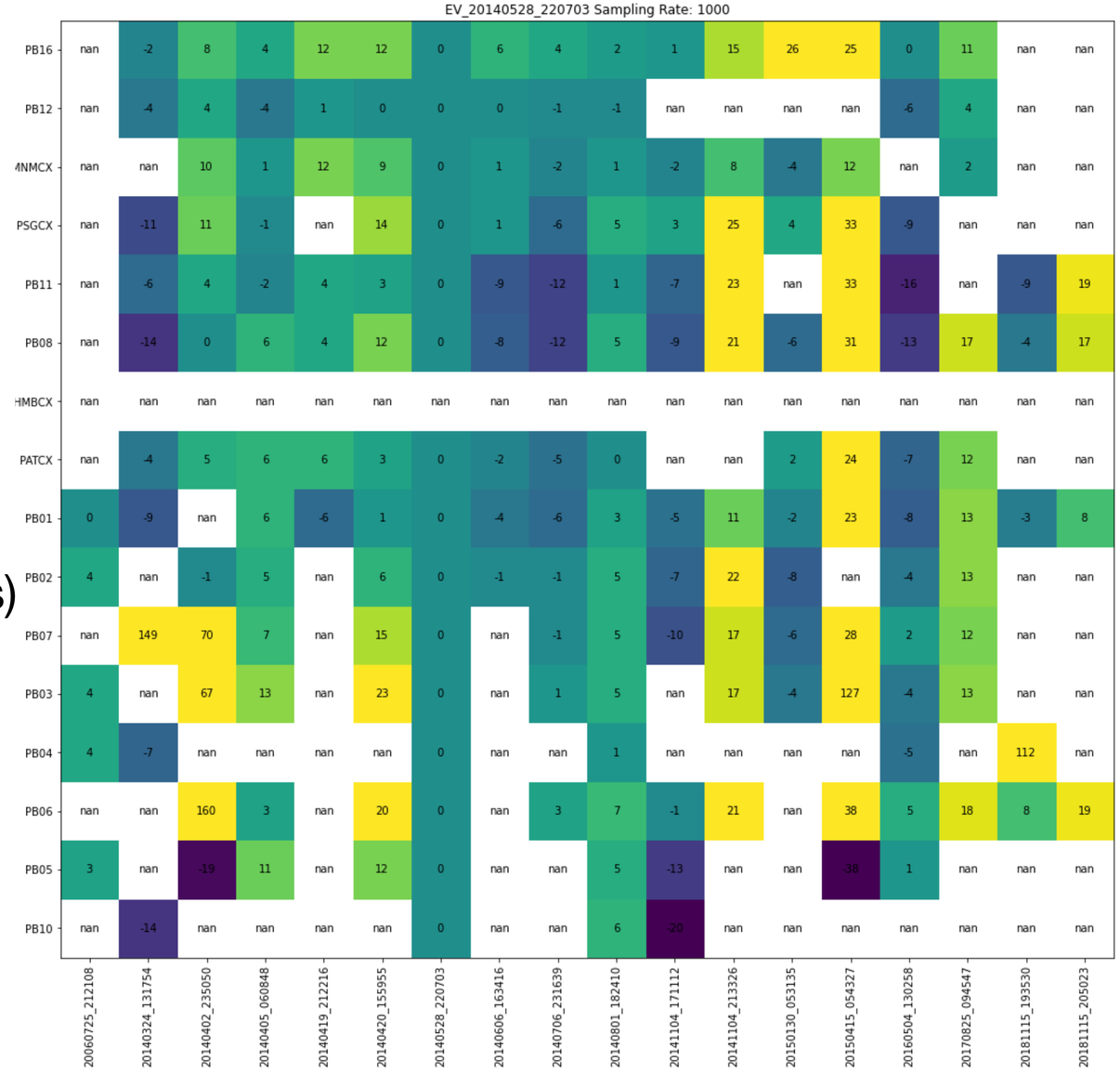


not affected



Look into Greater Detail - Are these REs truly part of one family?

- We examine RE Families by a precise relative relocalization approach
  - For one Family member we handpick P and S phases at all available stations
  - We perform cross correlation with the other REs for each phase over all stations, and measure cc time lag differences called differential S - P differential times (S-P diffdiffs)
  - Iterate for all events in family
  - Precise relative event location from cross-correlation based on those S-P diffdiffs, using a modification of the approach by Got & Okube, 2003.



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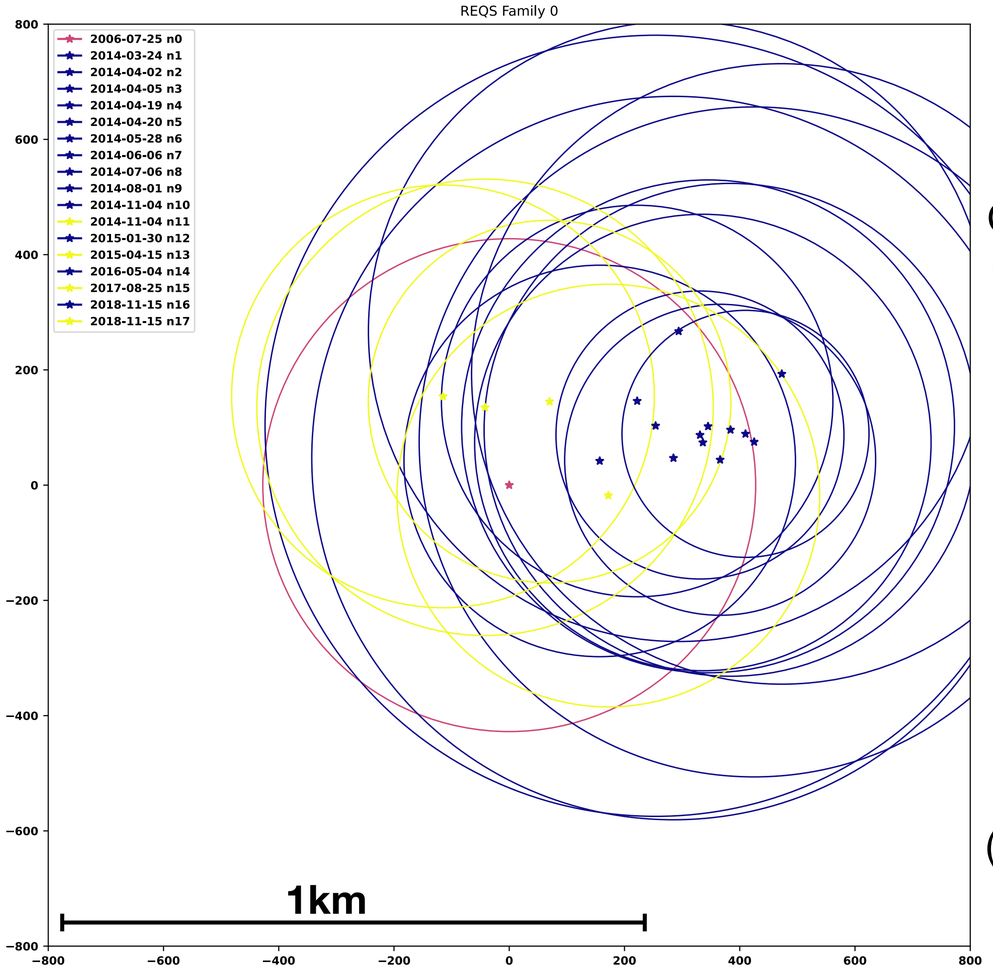


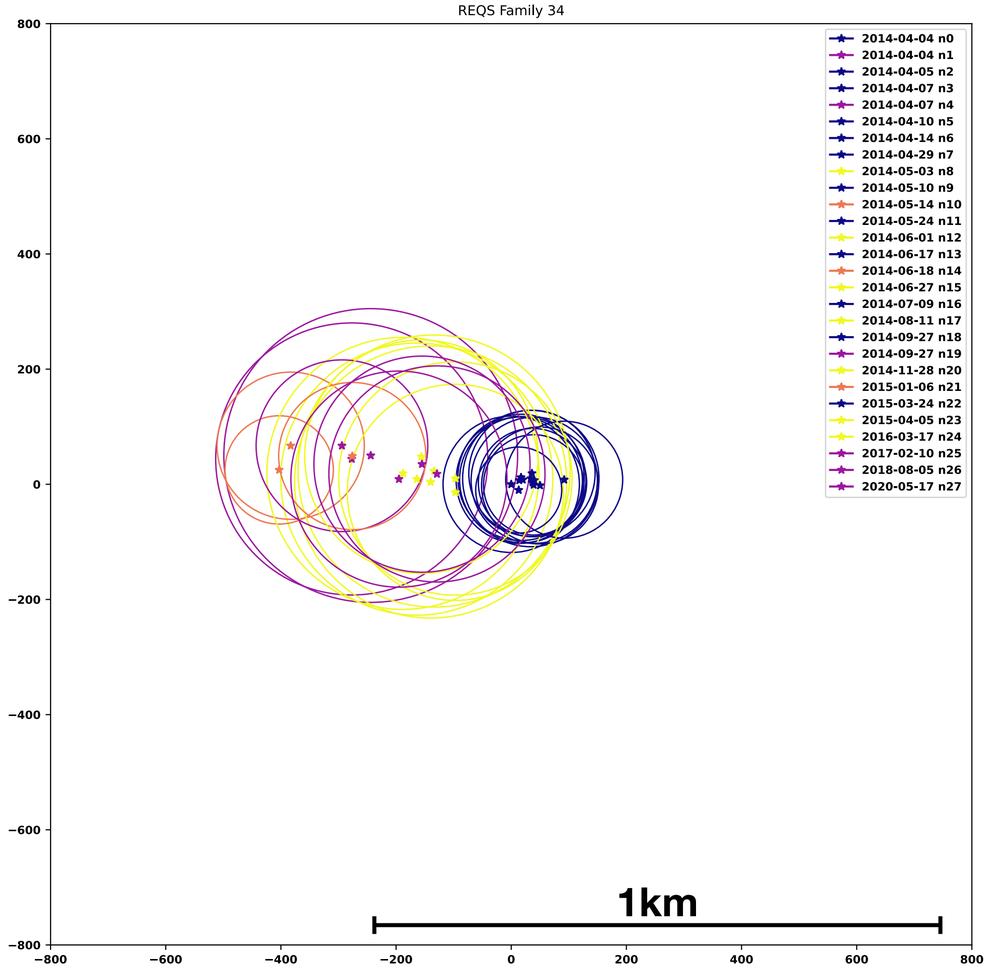
REQS 0 - true RE
all rupture planes overlap

Map view

Colors according to Cluster association

Clusterization by Using the average inter event cc values as association matrix

Radii computed from stress drop and moment (Folesky et al, 2021)



REQS 34 - complex RE family
not all rupture planes overlap

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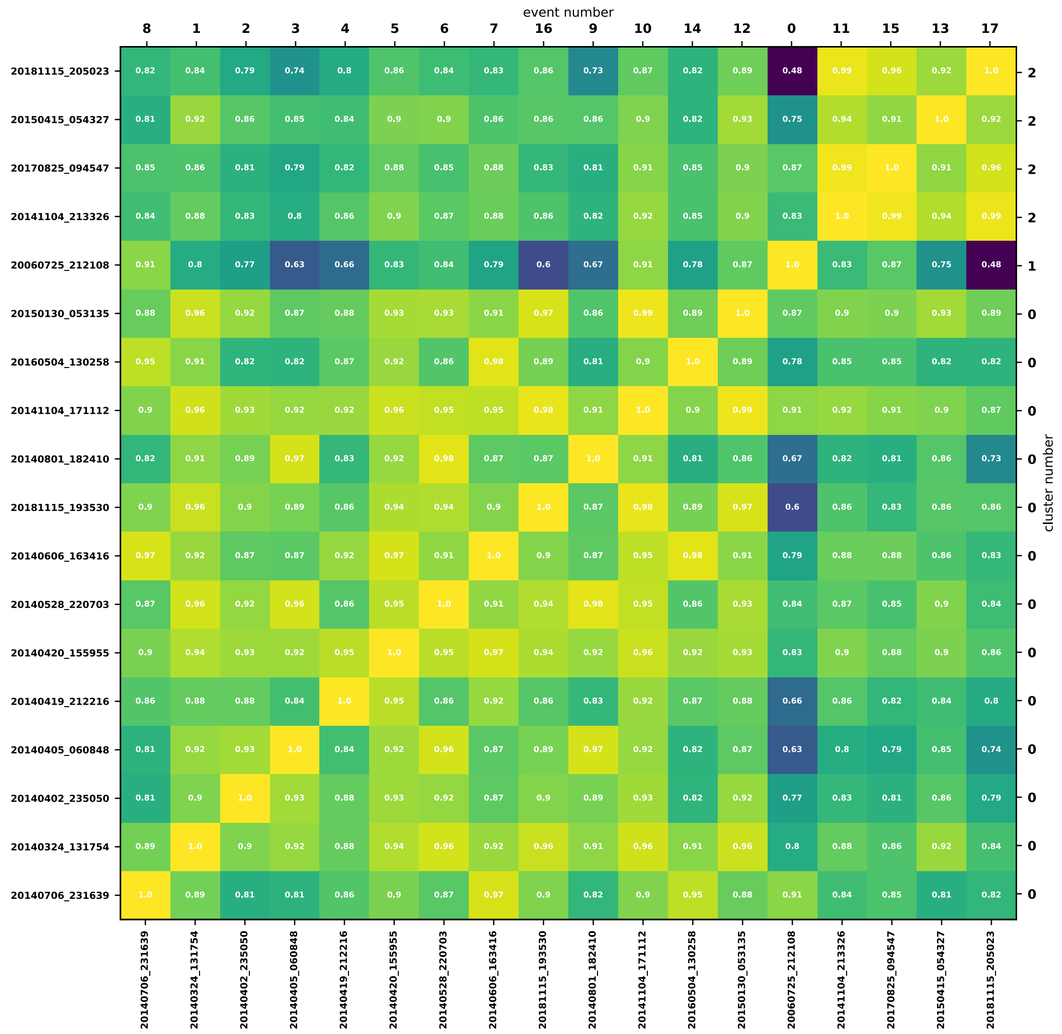

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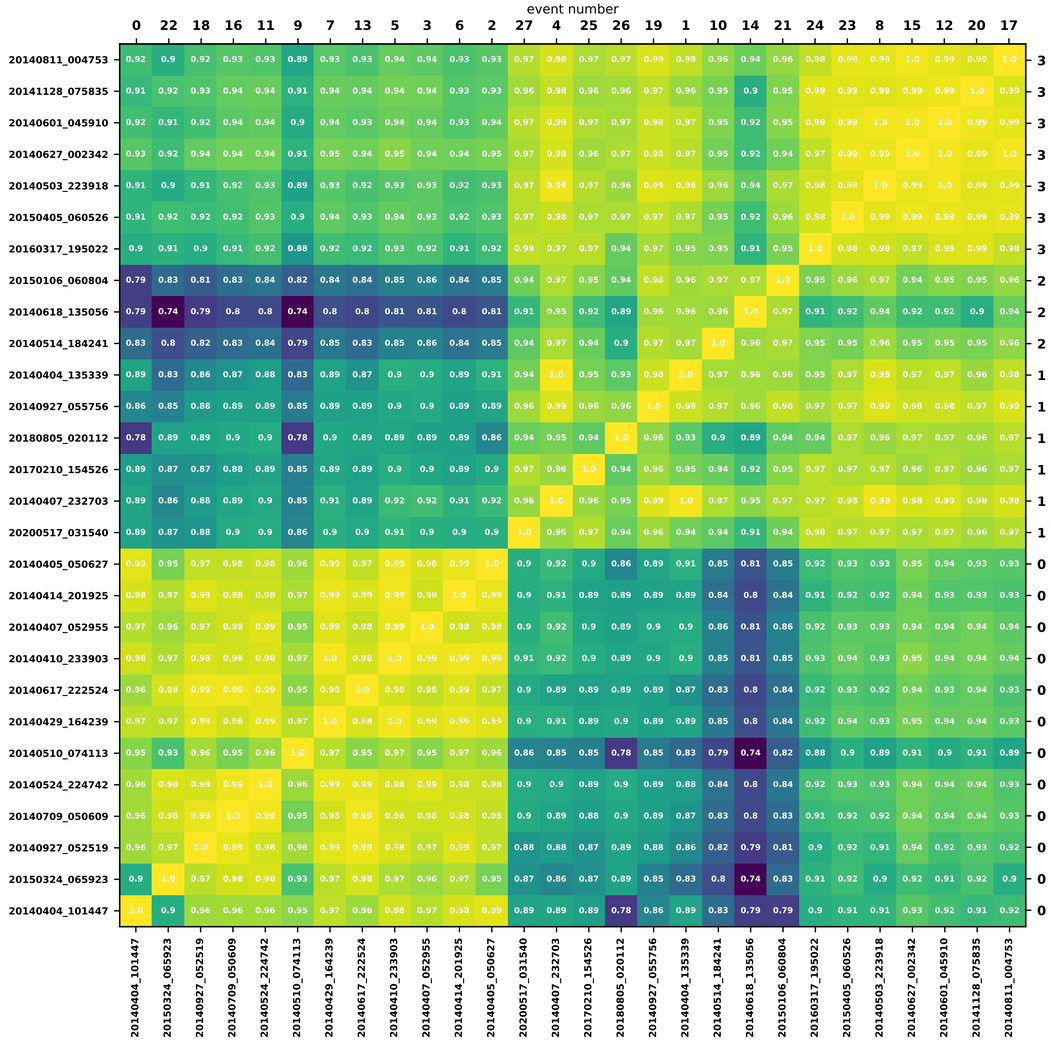

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More Characteristics can be Computed

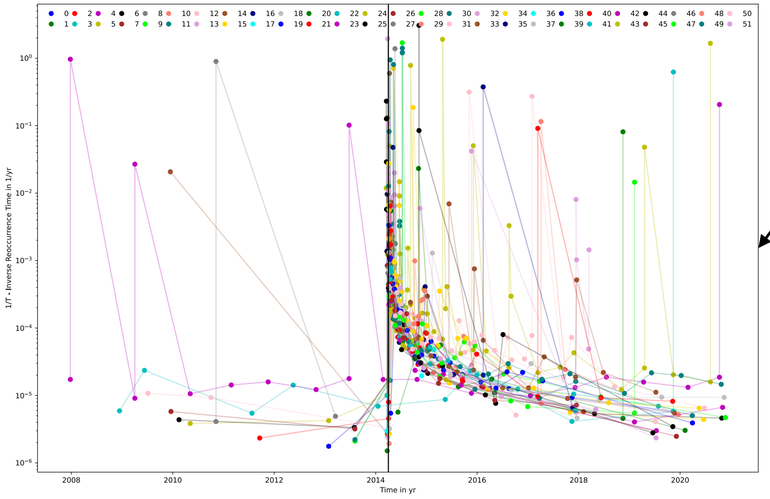
Event reoccurrence time decay rates

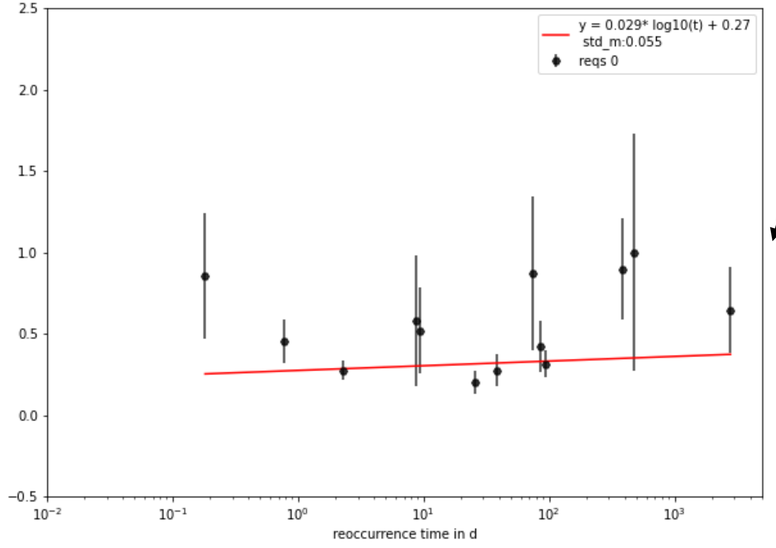
Spectral variability/depletion over time

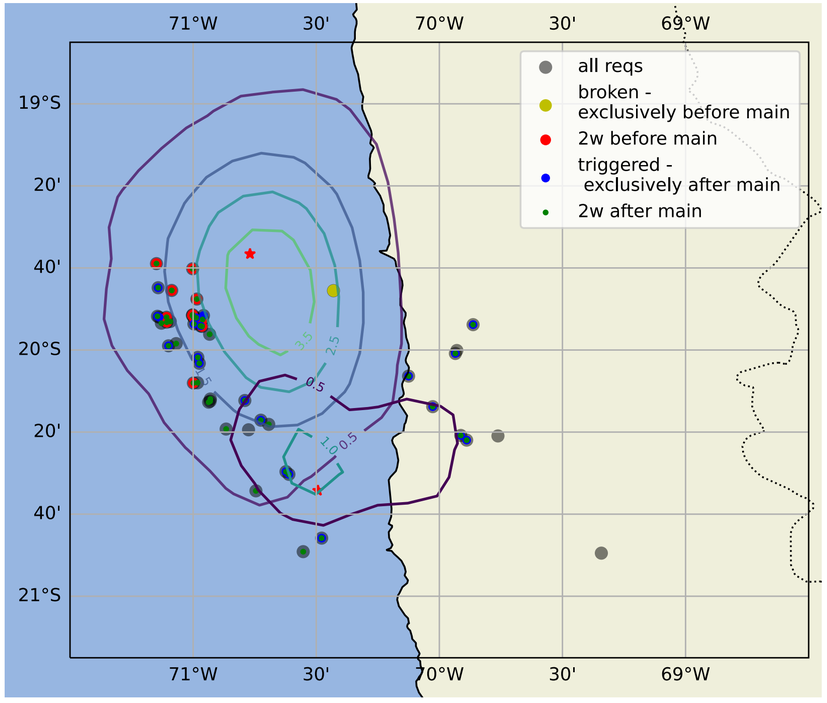
Average cumulative slip

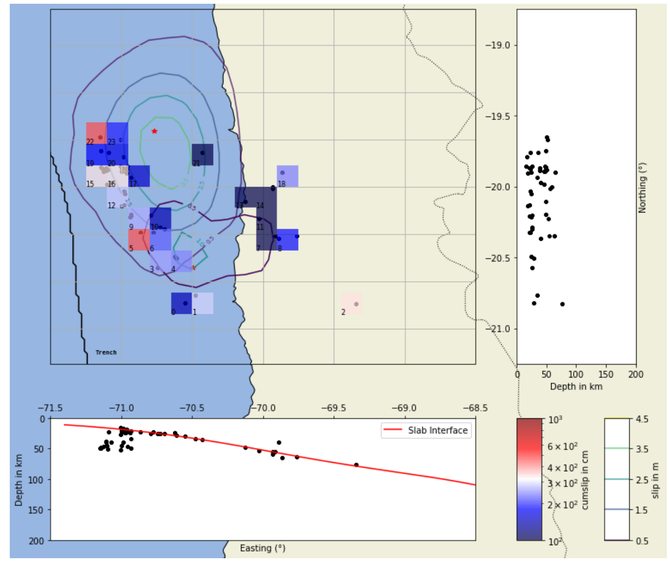
Average slip rate

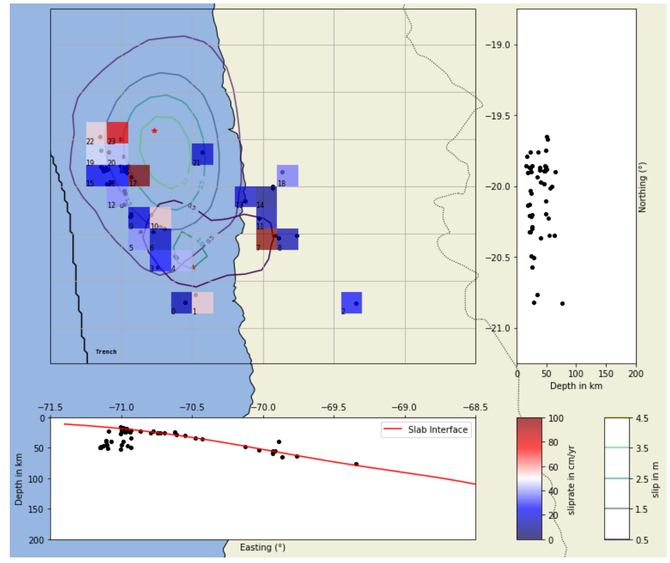
RE activity relative to IQ event











Summary & Outlook
The challenge is to combine the small with the big picture!

- Many parameters may be analyzed using REs, such as cumulative slip, slip rates, RE type, occurrence time decay rates, spectral variation, and more

- False association of events, however, can lead to significant bias in singular parameters and disturb the bigger picture

- Intra-family cluster analysis can help to find subclusters. For this, we can use a S -P diffdiff based relative relocalization procedures or cc - matrix based clustering.

Outlook

- Ideally, all RE families should be analyzed for true and false members.

- Recently, we have completed a template matching procedure for the entire catalog, without spatial restriction. This will allow analysis of **RE**s throughout the **entire subduction zone**.

- This presentation did not cover the interpretation of the shown parameters nor comparison to others such as locking or stress drop distributions, mechanism or magnitudes

Thank you for your attention!

Bibliography

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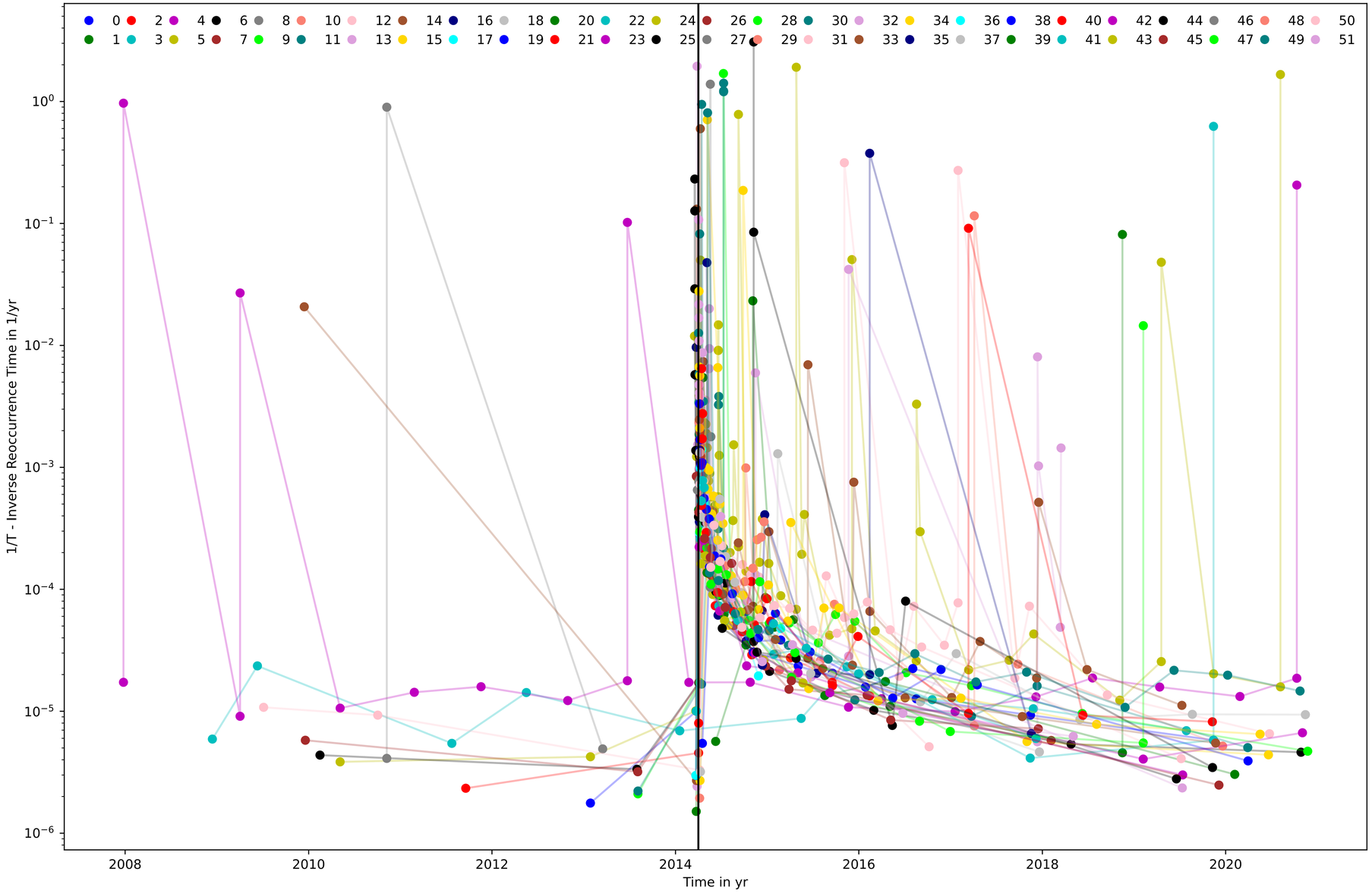
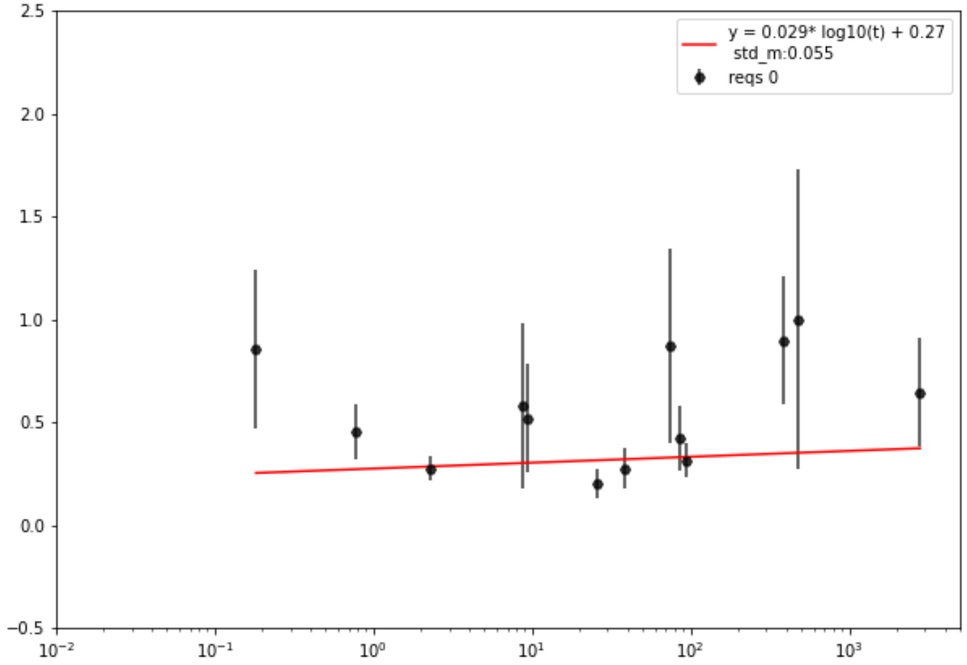
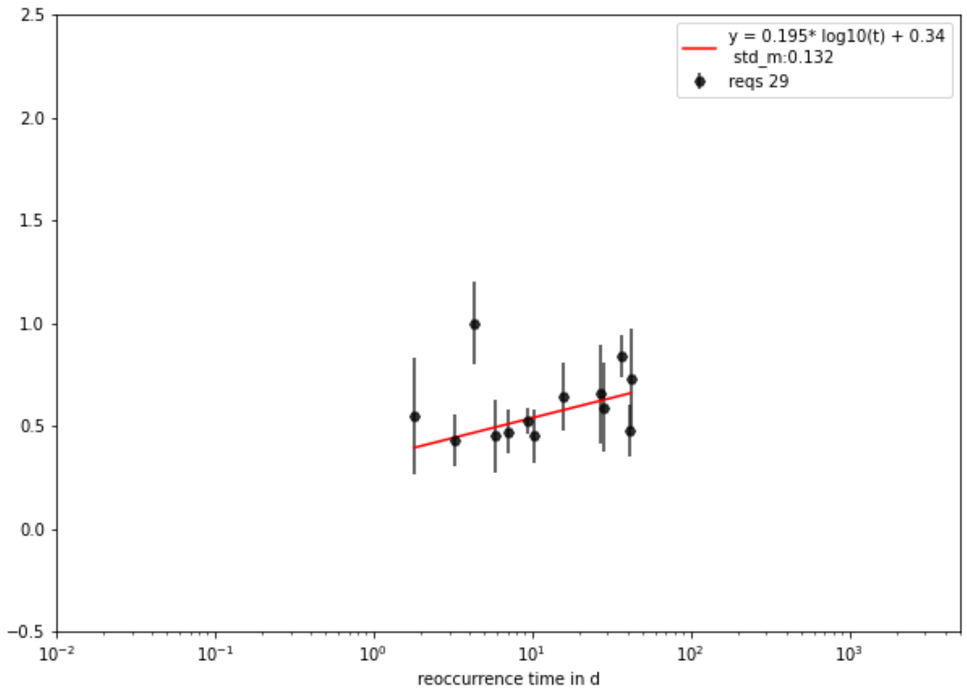
Appendix



Invers inter event times against occurrence times

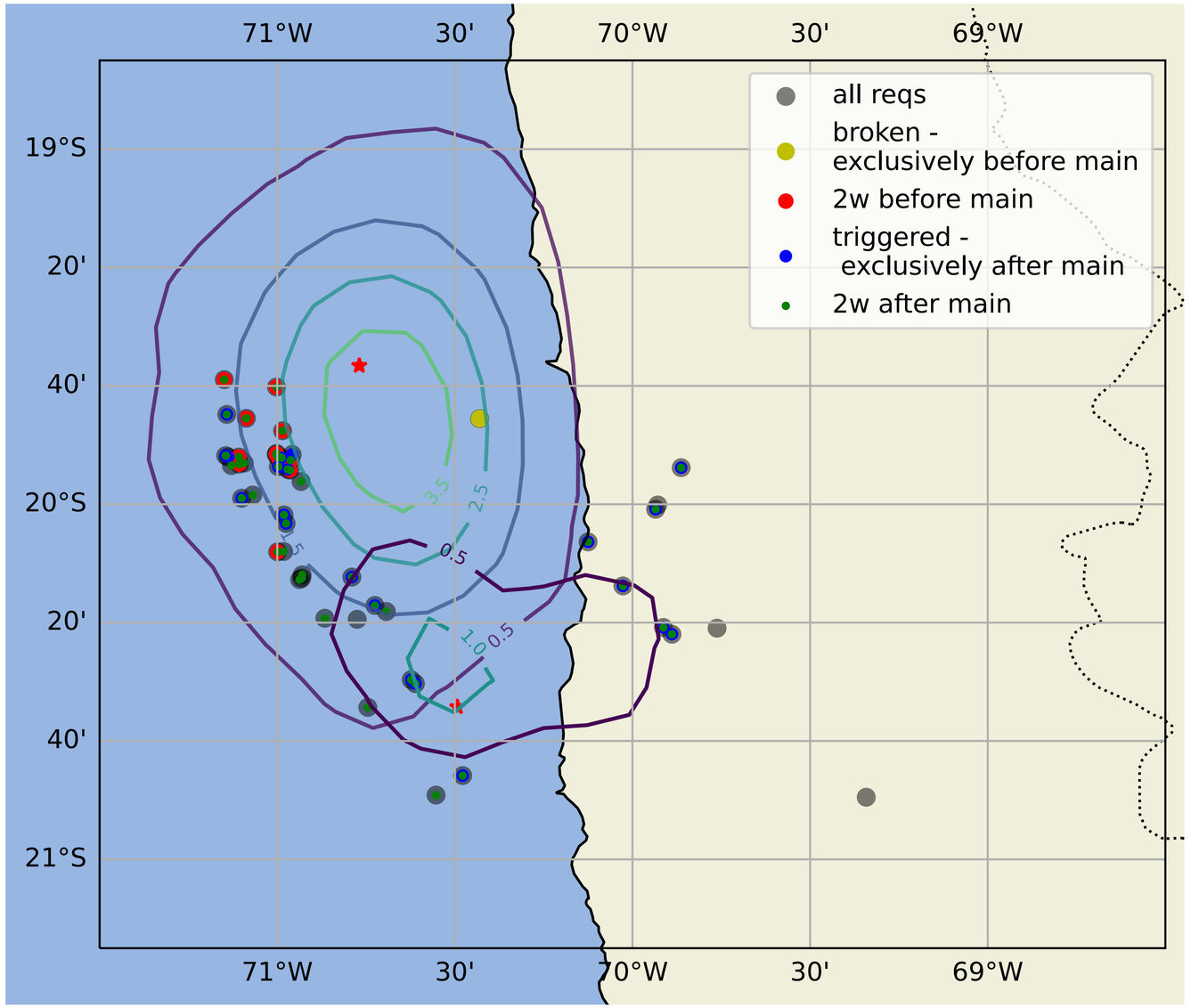
From such decay curves it is possible to estimate Omori type decay exponents (Schaff et al., 1998)





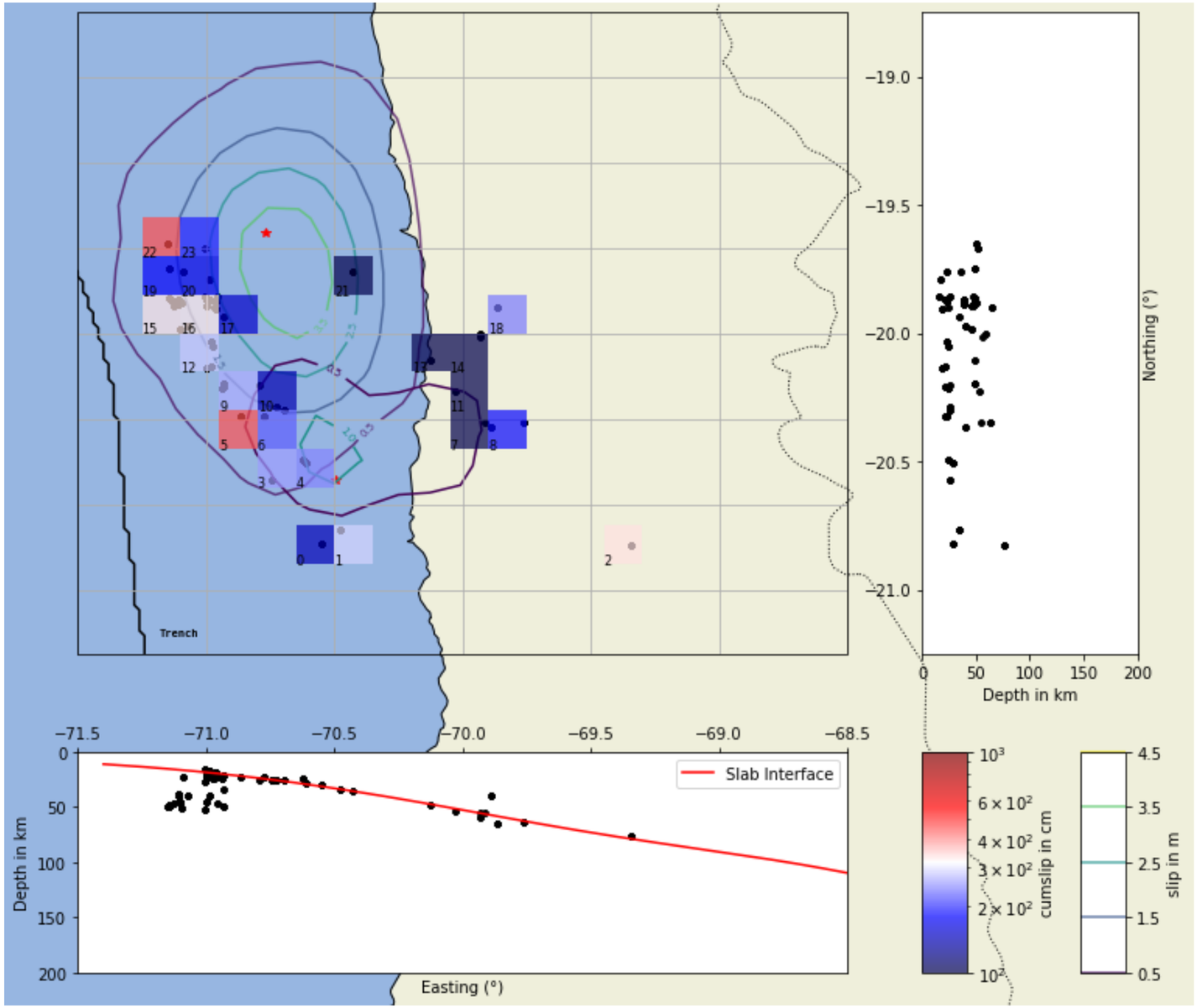
Spectral decay as proxy for fault healing after McLaskey et al., 2012

Shown is the dependence of the ratio of the displacement spectra of two frequency bands (1-5Hz, 35-40Hz) averaged over all stations in dependence of the reoccurrence time. Longer reoccurrence time should show increased high frequency content compared to shorter times, due to fault healing.



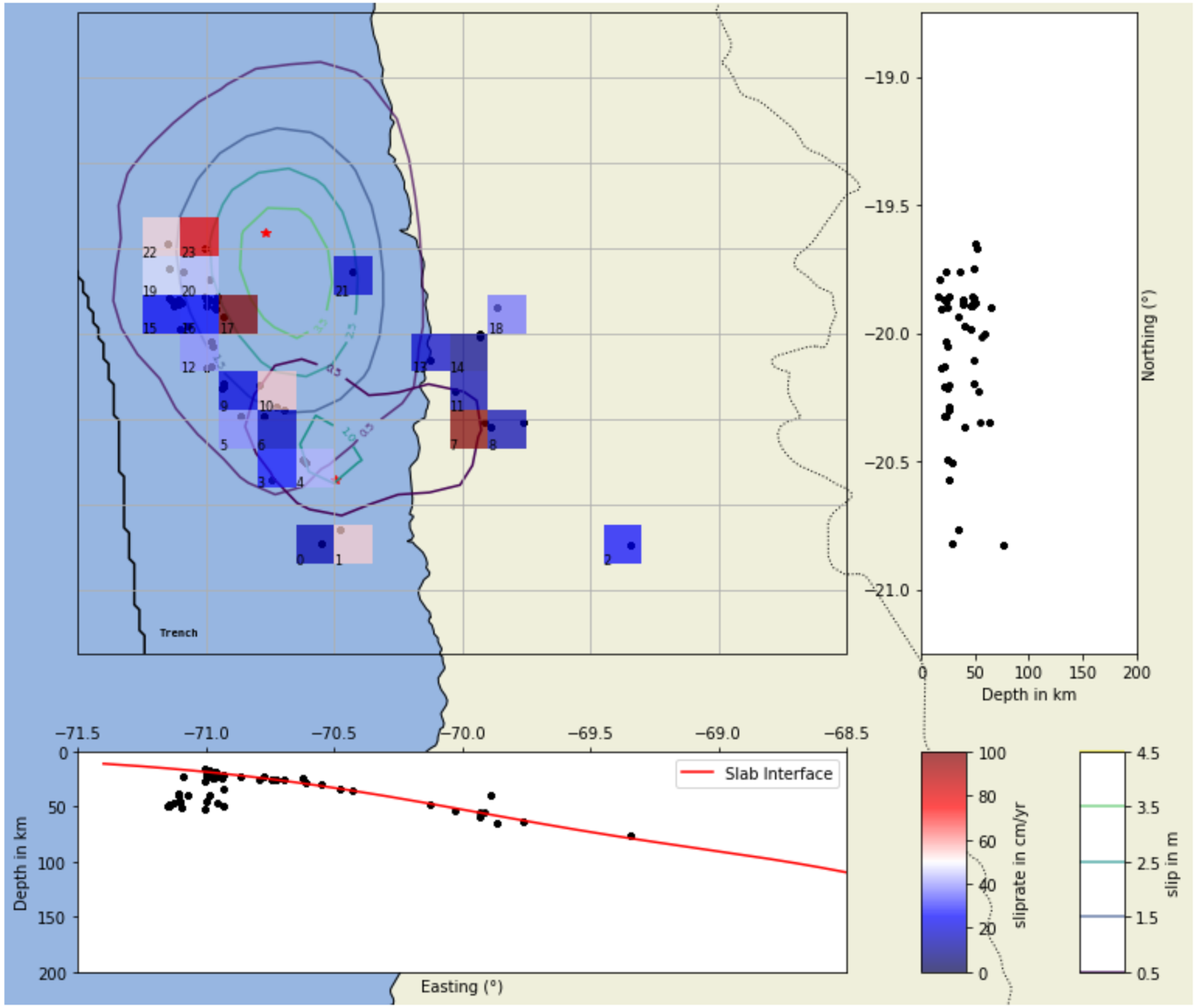
RE activity put in relation to the Iququie event occurrence

REQS are classified as broken, if only pre seismic events are contained, before main, if active in the 2 weeks before IQEQ, triggered, if only active after main event occurrence, after, if active within the 2weeks after the IQEQ



Cumulative slip averaged on a regular grid

High coseismic slip regions appear to correspond to less slip released by RE in corresponding regions.



Slip rate averaged on a regular grid

Note increased slip rates closer to high slip regions go the mega thrust event