Complexity of low-frequency earthquakes activity in western Shikoku

Natalia Poiata[1], Jean-Pierre Vilotte[1], Nikolai Shapiro[1,2], Mariano Supino[1], and Kazushige Obara[3]
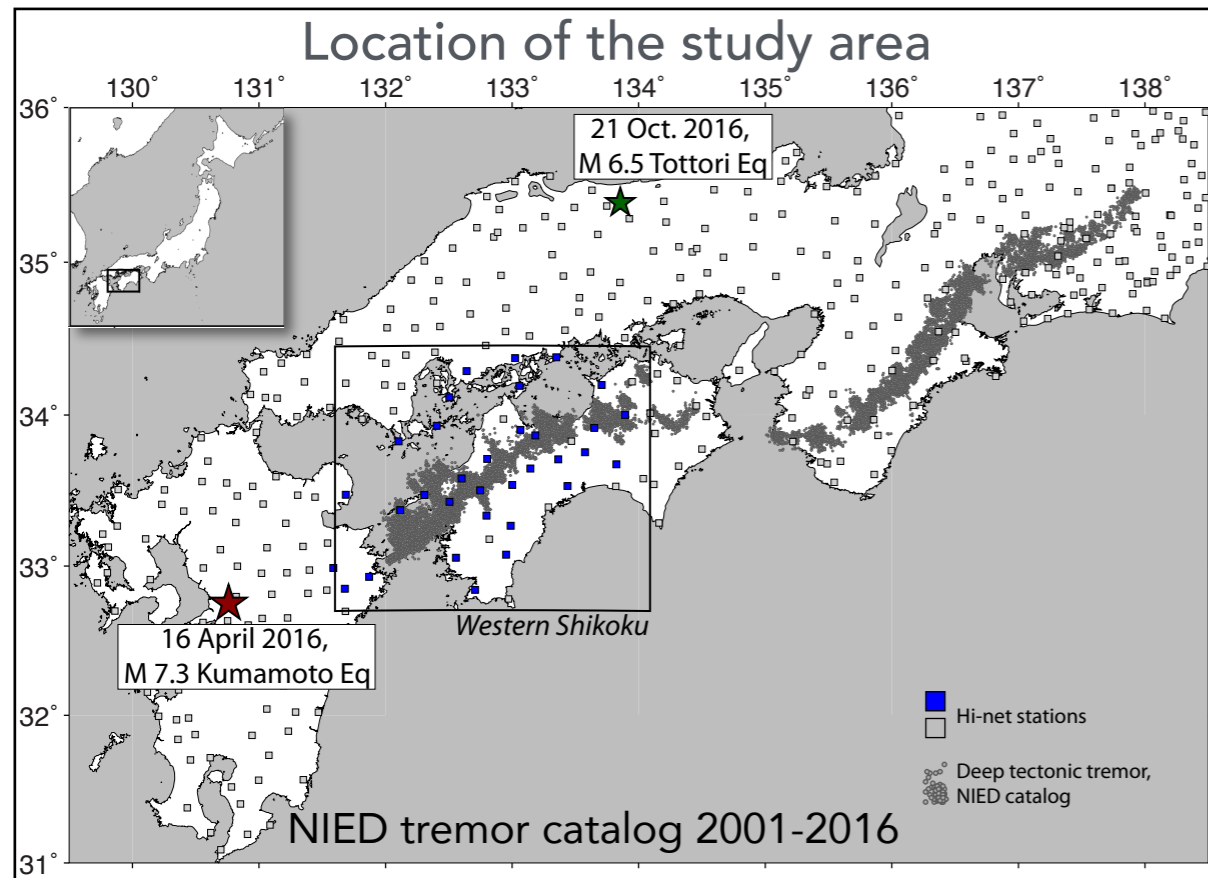
[1] Institut de Physique du Globe de Paris
[2] Institut des Sciences de la Terre, Université Grenoble Alpes
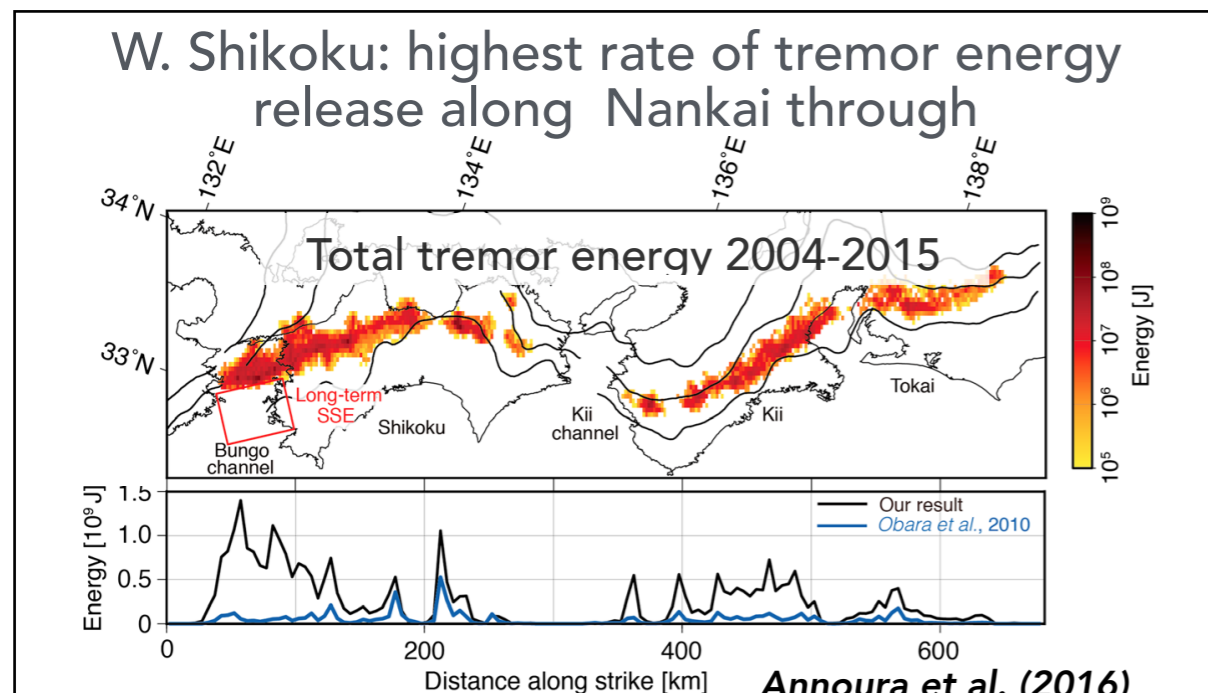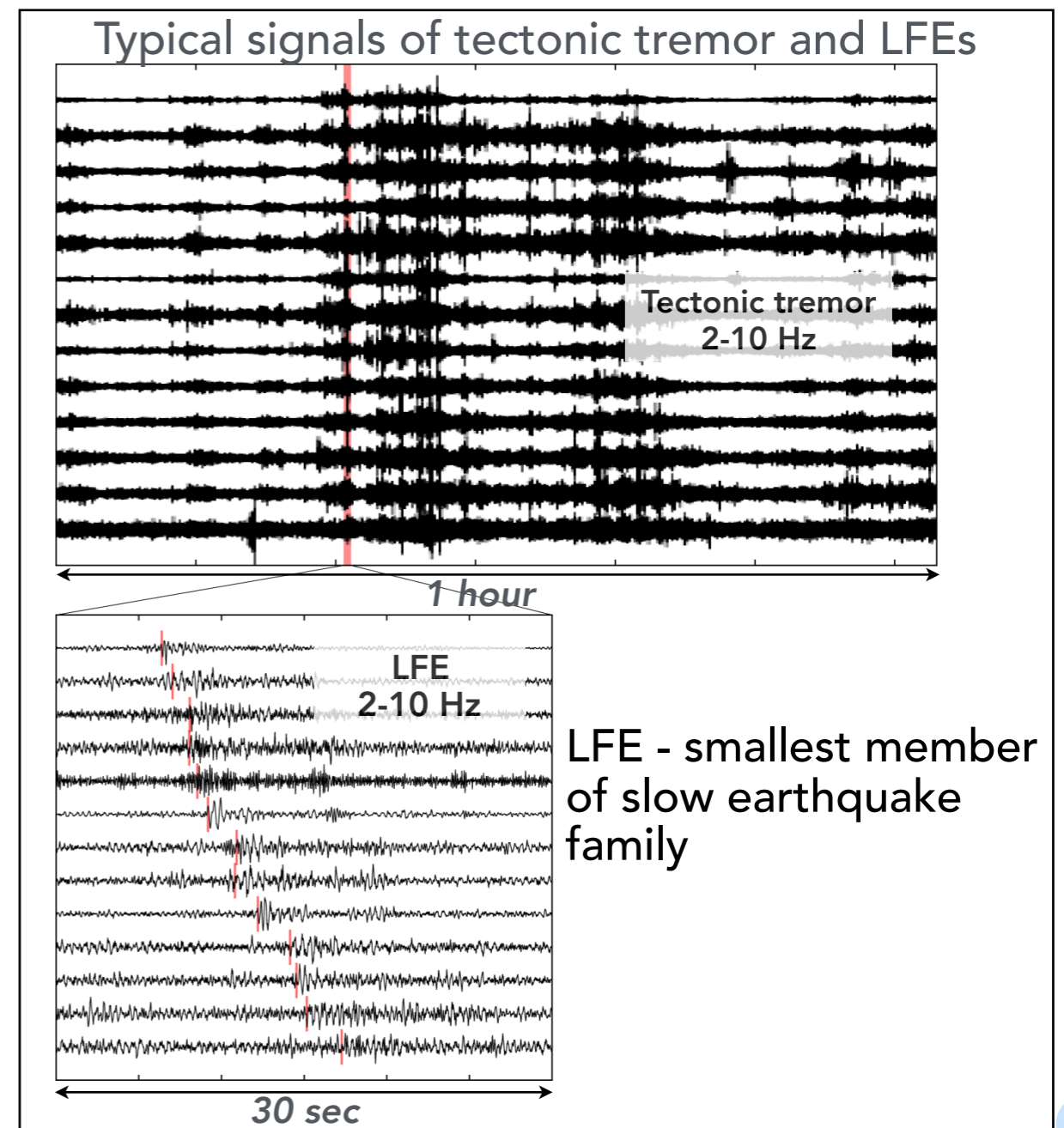[3] Earthquake Research Institute, The University of Tokyo

EGU online

Target of the study: low-frequency earthquakes (LFE) activity in western Shikoku

Main goal: high-resolution catalog of LFEs and space-time characteristics of activity

Location of the study area

21 Oct. 2016, M 6.5 Tottori Eq

16 April 2016, M 7.3 Kumamoto Eq

Western Shikoku

Hi-net stations

Deep tectonic tremor, NIED catalog

NIED tremor catalog 2001-2016

W. Shikoku: highest rate of tremor energy release along Nankai through

Total tremor energy 2004-2015

Long-term SSE

Bungo channel

Shikoku

Kii channel

Kii

Tokai

Energy [J]

Our result
Obara et al., 2010

Energy [10⁹ J]

Distance along strike [km]

Annoura et al. (2016)

Typical signals of tectonic tremor and LFEs

Tectonic tremor
2-10 Hz

1 hour

LFE
2-10 Hz

LFE - smallest member of slow earthquake family

30 sec

2

4-year LFE catalog for western Shikoku from continuous Hi-net data

Method:

BackTrackBB detections and location algorithm
Multi-band statistical coherence-based method
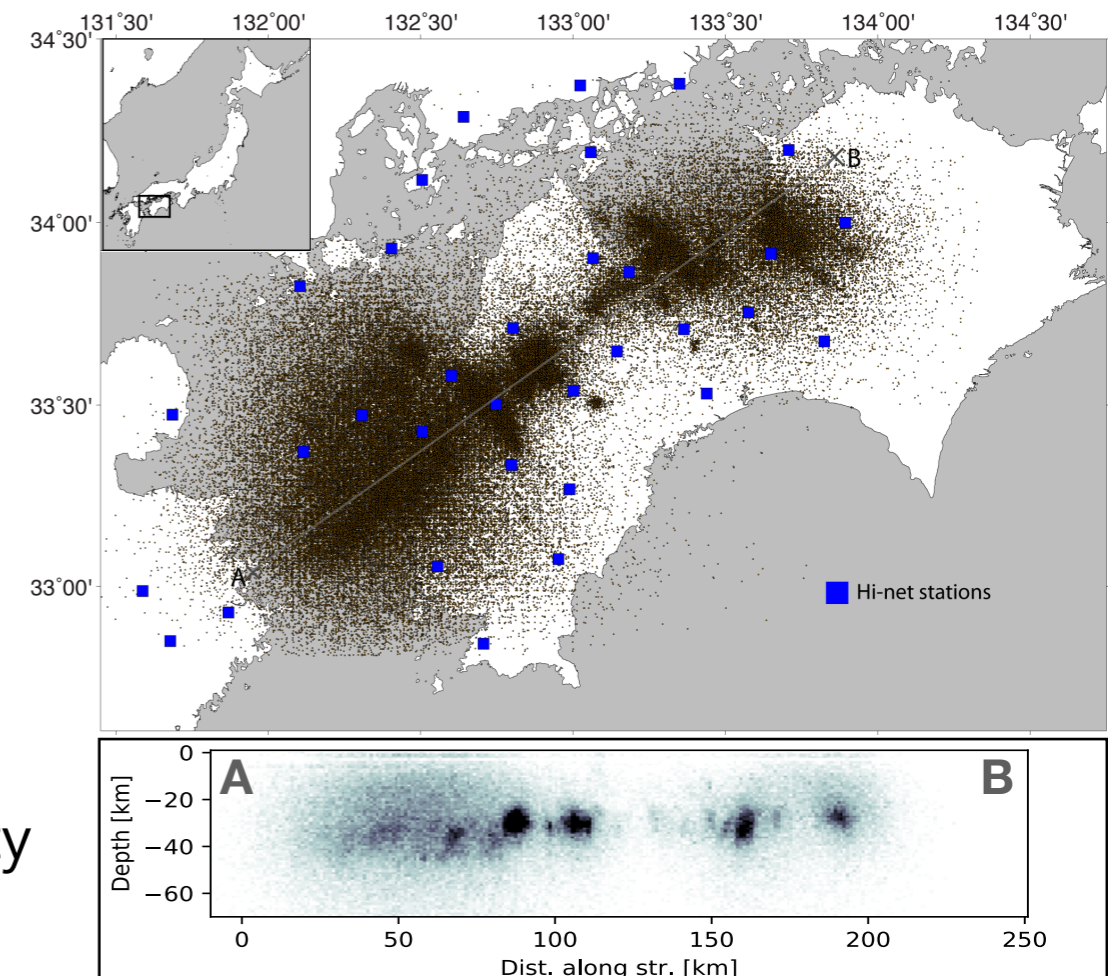(*Poiata et al., 2016; 2018; Supino et al., 2020*)

Using 3-component continuous data
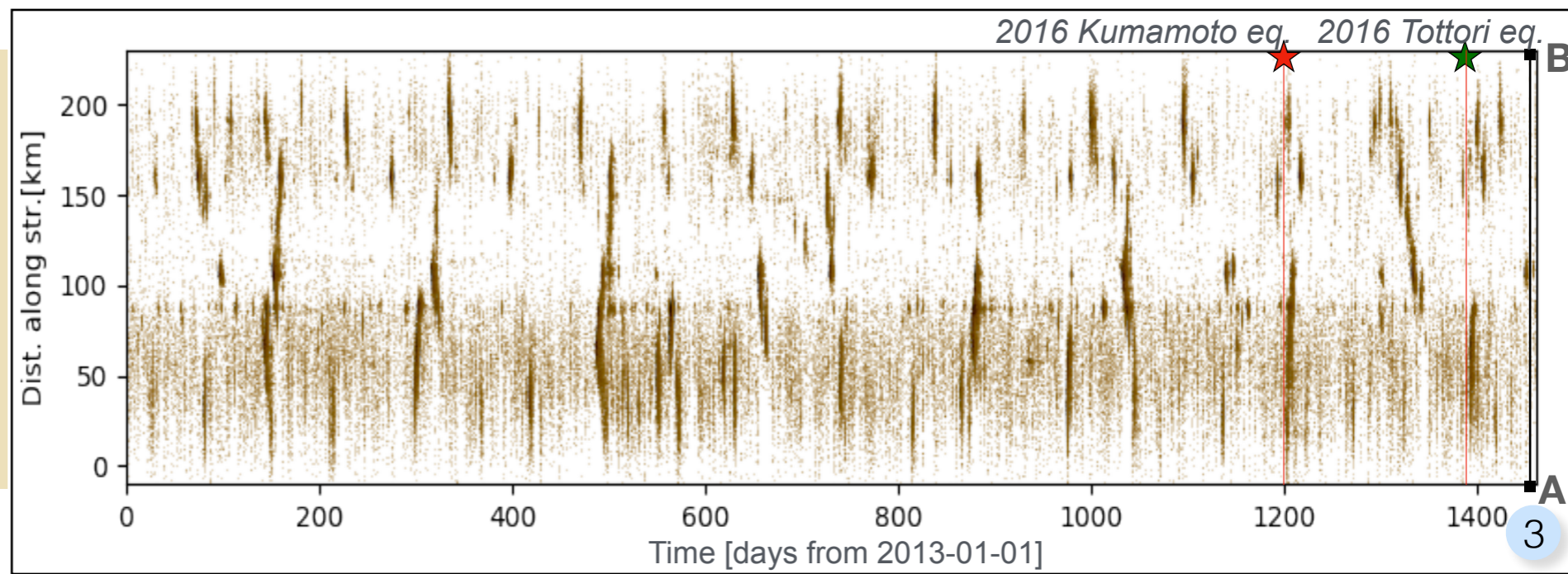
Results: ~176,800 detected and located LFEs

Clear clustering and segmentation of LFEs along strike of subducting slab

Strong spatial and temporal heterogeneity of activity

Sequences of intense LFE activity

Temporal view of LFE activity projected along strike of subducting slab

3

Partial catalog of LFEs during periods of energetic tremor sequences

Source characteristics analysed in Supino *et al.* (2020)

SCIENTIFIC REPORTS
natureresearch

https://doi.org/10.1038/s41598-020-63584-6

OPEN

Self-similarity of low-frequency earthquakes

M. Supino[1,2*], N. Poiata[1,3], G. Festa[2], J. P. Vilotte[1], C. Satriano[1] & K. Obara[4]

Low-frequency earthquakes are a particular class of slow earthquakes that provide a unique source of information on the physical processes along a subduction zone during the preparation of large earthquakes. Despite increasing detection of these events in recent years, their source mechanisms are still poorly characterised, and the relation between their magnitude and size remains controversial.
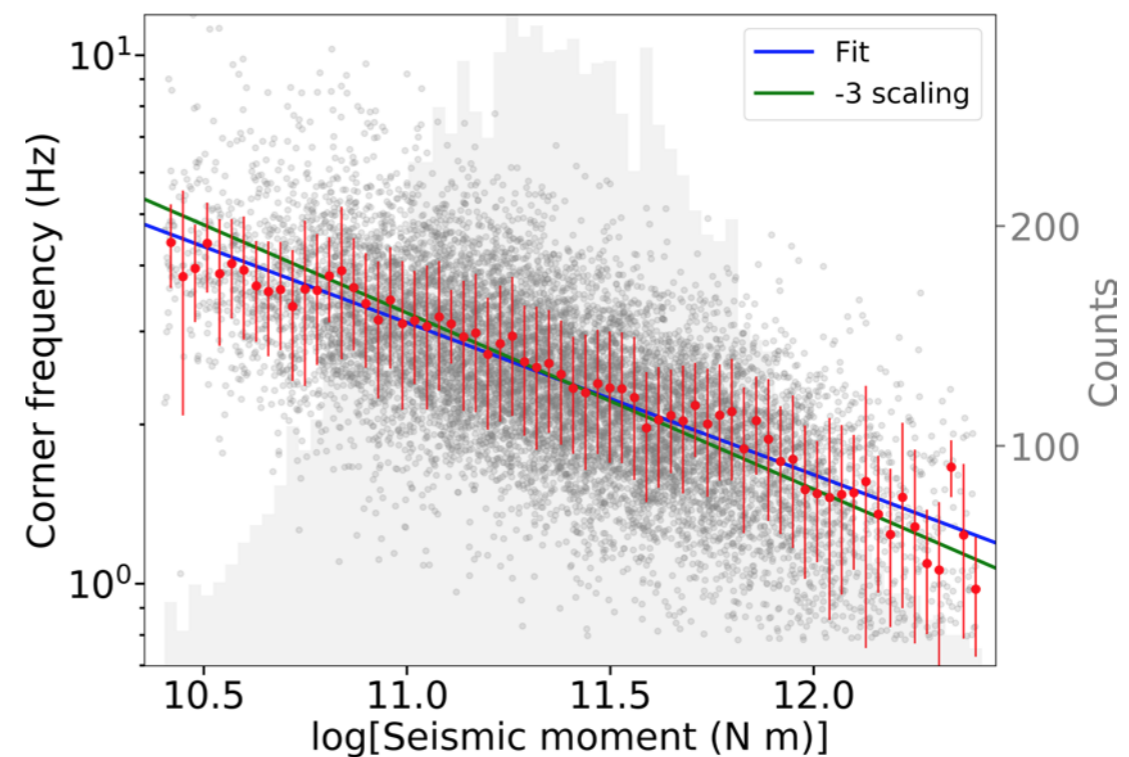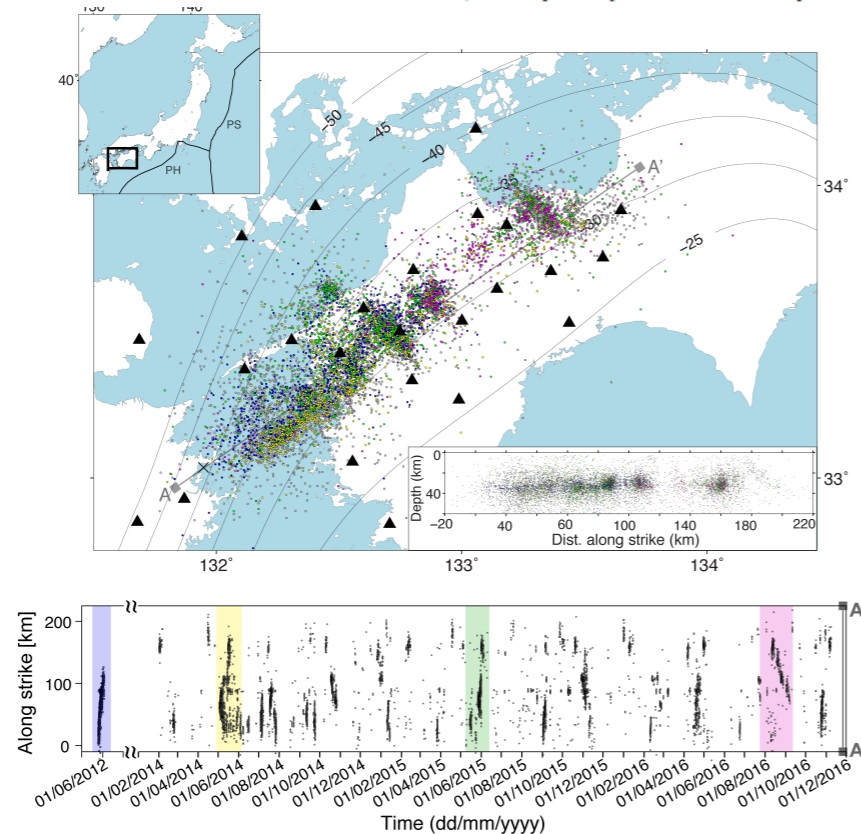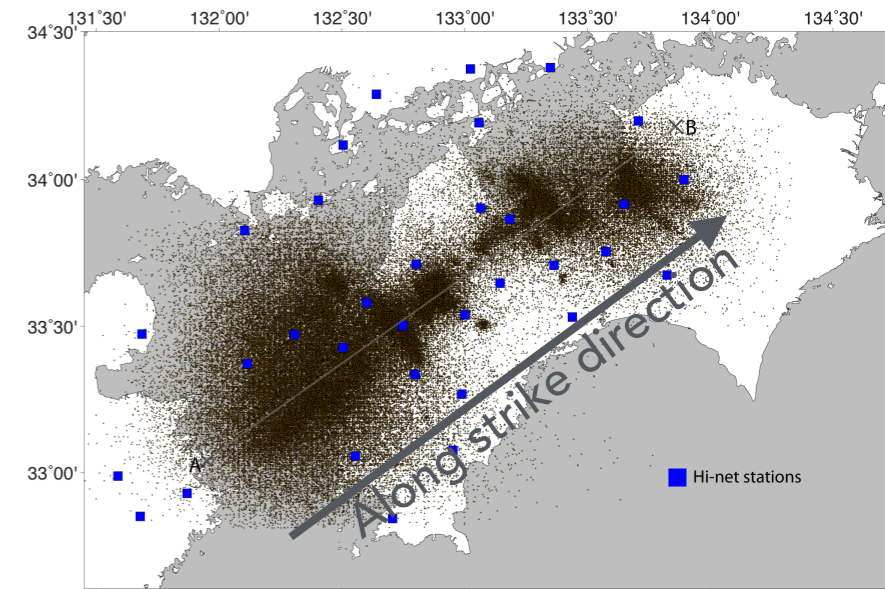

4

Along-strike space clustering and correlation of LFE activity
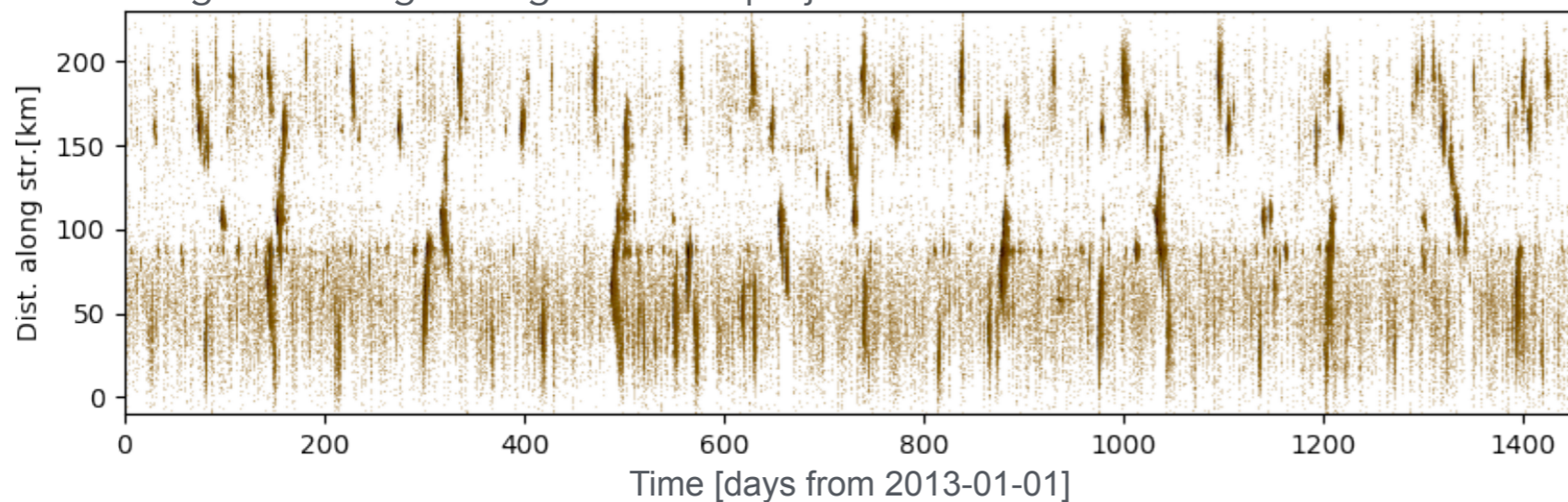
- Space LFE activity functions - along-strike variation of activity in time

$$\Delta \overline{\rho}_l(\zeta, t; \Delta\zeta) = \frac{\rho(\zeta, t; \Delta\zeta) - \overline{\rho}(\zeta)}{\overline{\rho}(\zeta)} \qquad \text{space-localised fluctuation}$$

with $\rho(\zeta, t; \Delta\zeta) -$ binned event probability density function
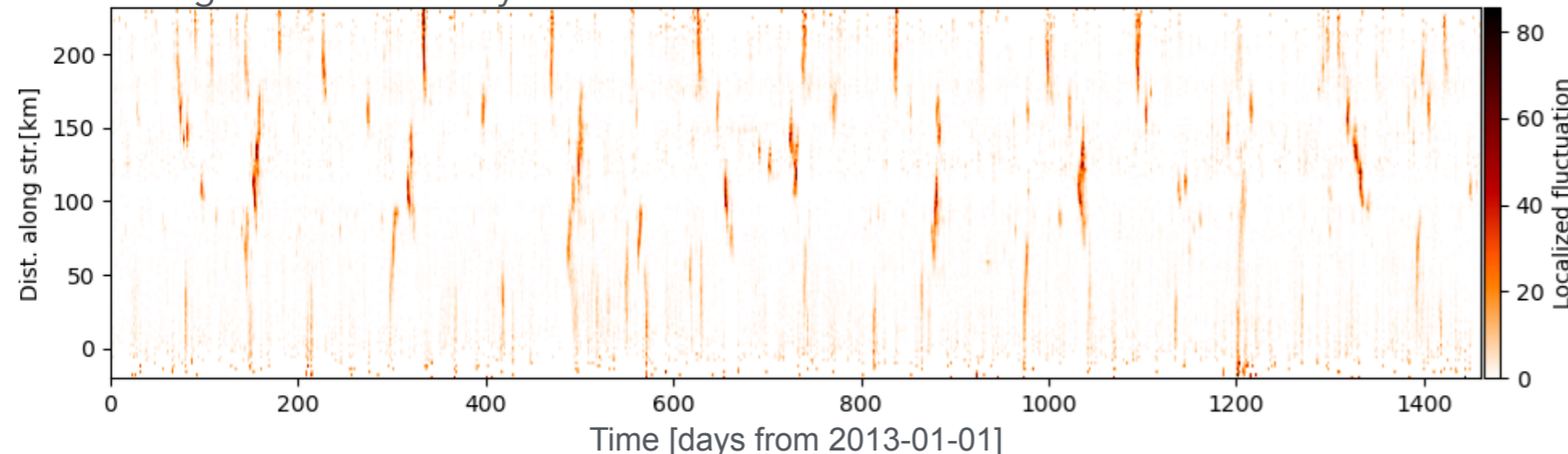*$\overline{\rho}(\zeta) -$ mean probability of event occurence in space bin*

Original catalog - along strike LFE projection

Original LFE catalog projected along subduction strike direction

binning in space, $\Delta\zeta = 2km$

Along-strike LFE activity functions

LFE activity function - localised fluctuation

$\overline{\rho}(\zeta)$ bin-dependent estimation

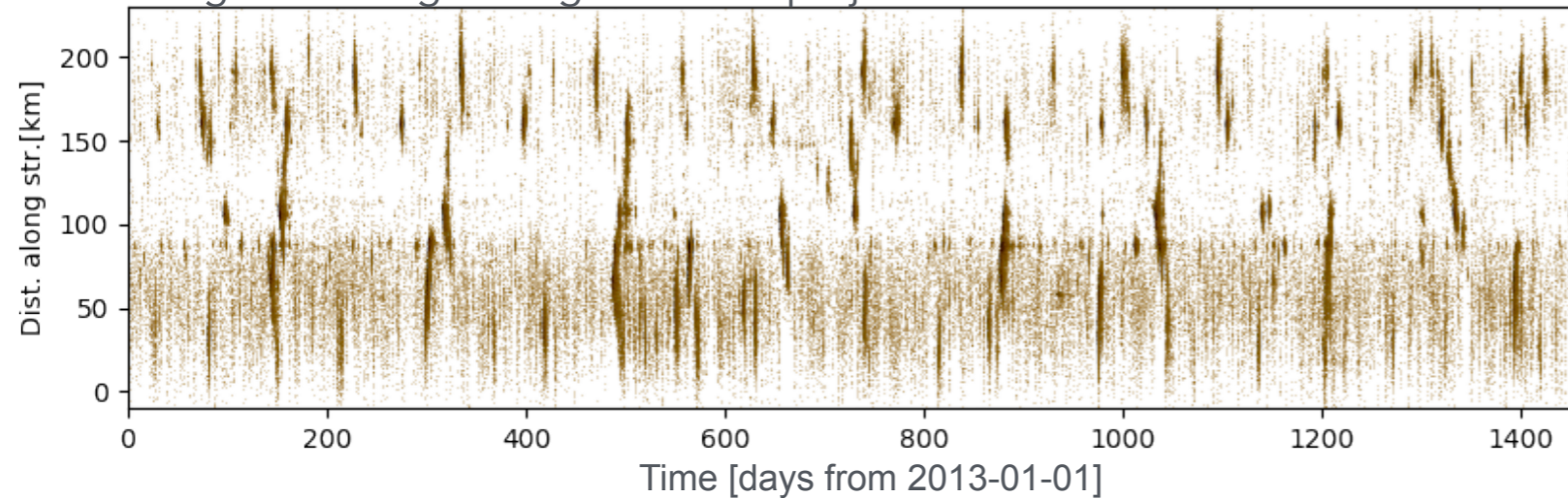$\Delta \overline{\rho}_l(\zeta, t; \Delta\zeta)$ bin-dependent fluctuation estimation

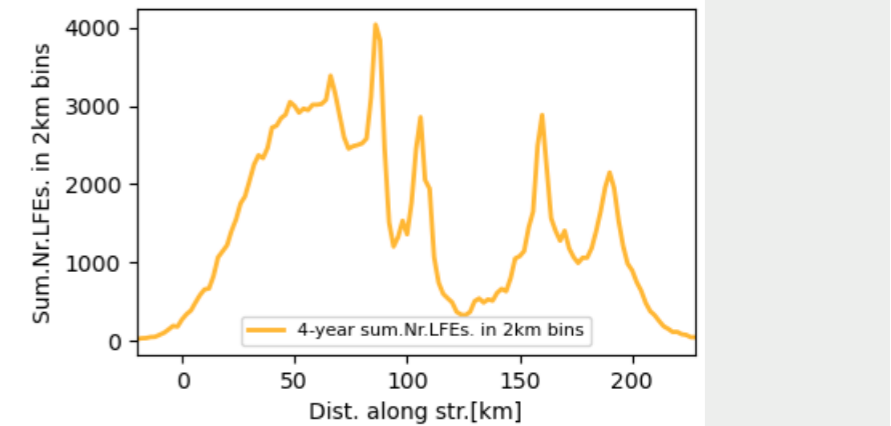$\Delta \overline{\rho}_l(\zeta, t; \Delta\zeta)^+$ retaining positive part

5

Along-strike space clustering and correlation of LFE activity

- Statistical characteristics of along-strike LFE activity over 4-year time period
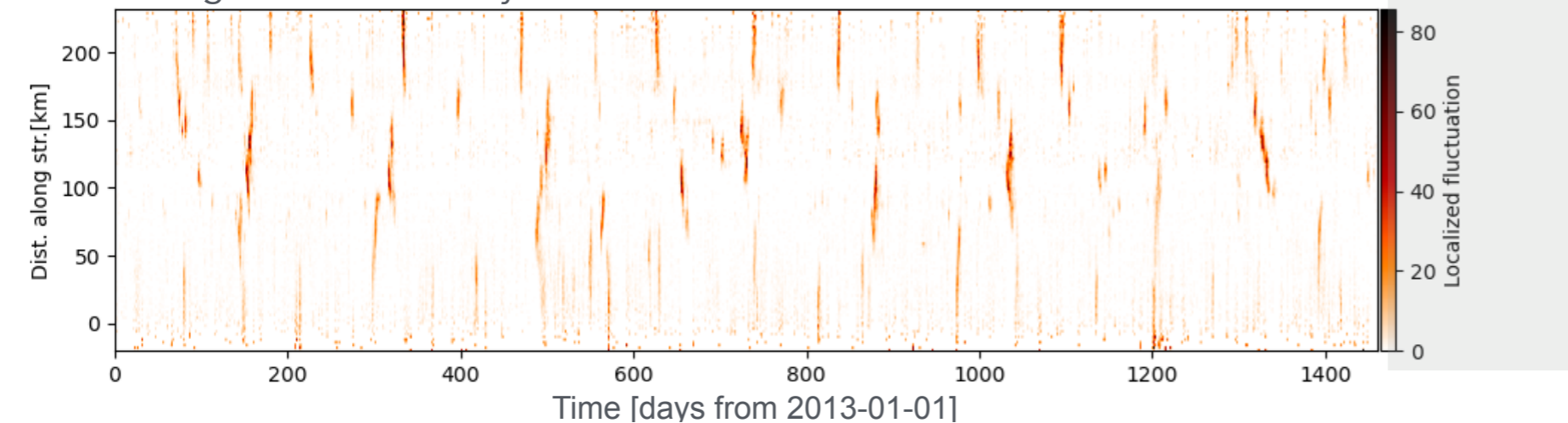

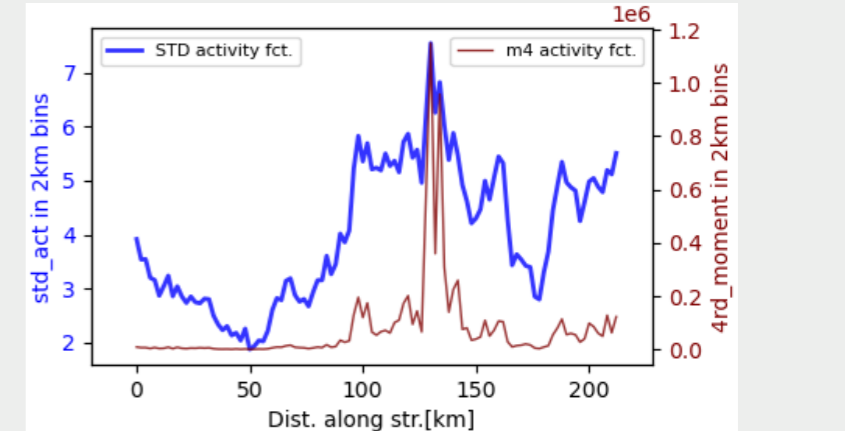Original catalog - along strike LFE projection

4-year summary along-strike activity

Along-strike LFE activity functions
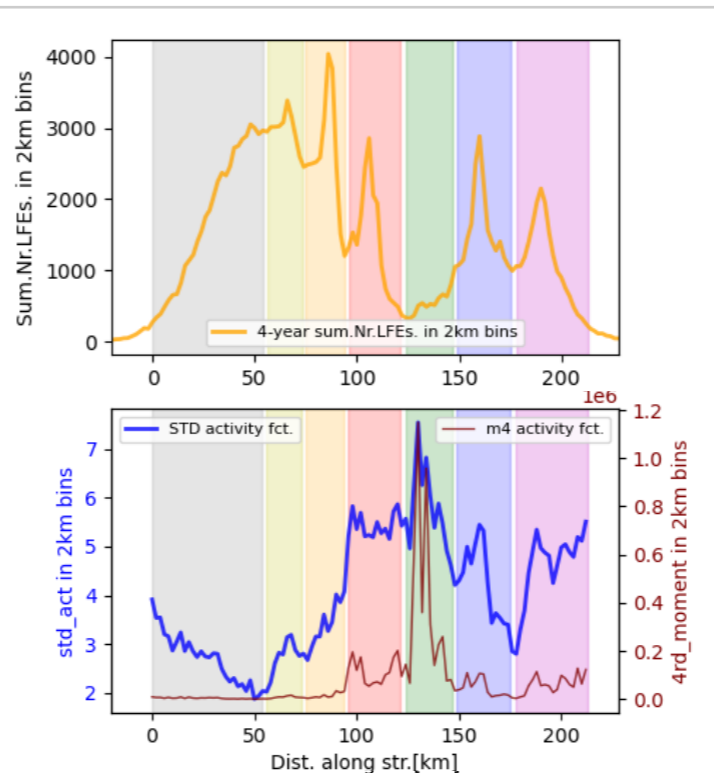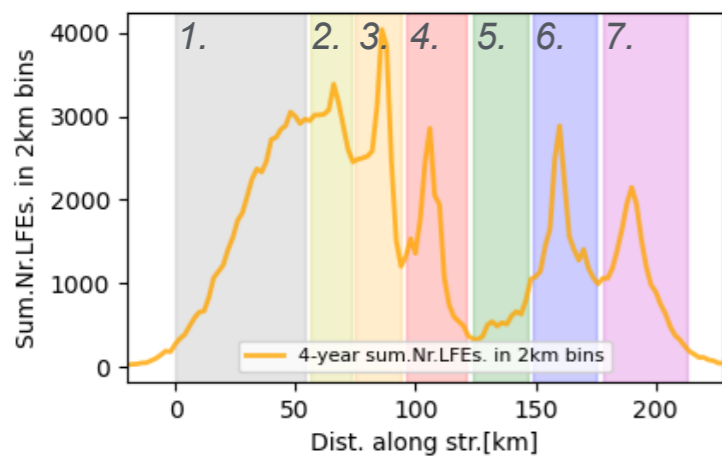
Standard deviation and 4th moment

Information on variation of along-strike LFE occurrence patterns over 4-year period

Along-strike space clustering and correlation of LFE activity

- Defining main (along strike) regions of activity

Separating regions with similar characteristics of LFE activity

Along-strike activity correlation matrix -> spatial extent of regions
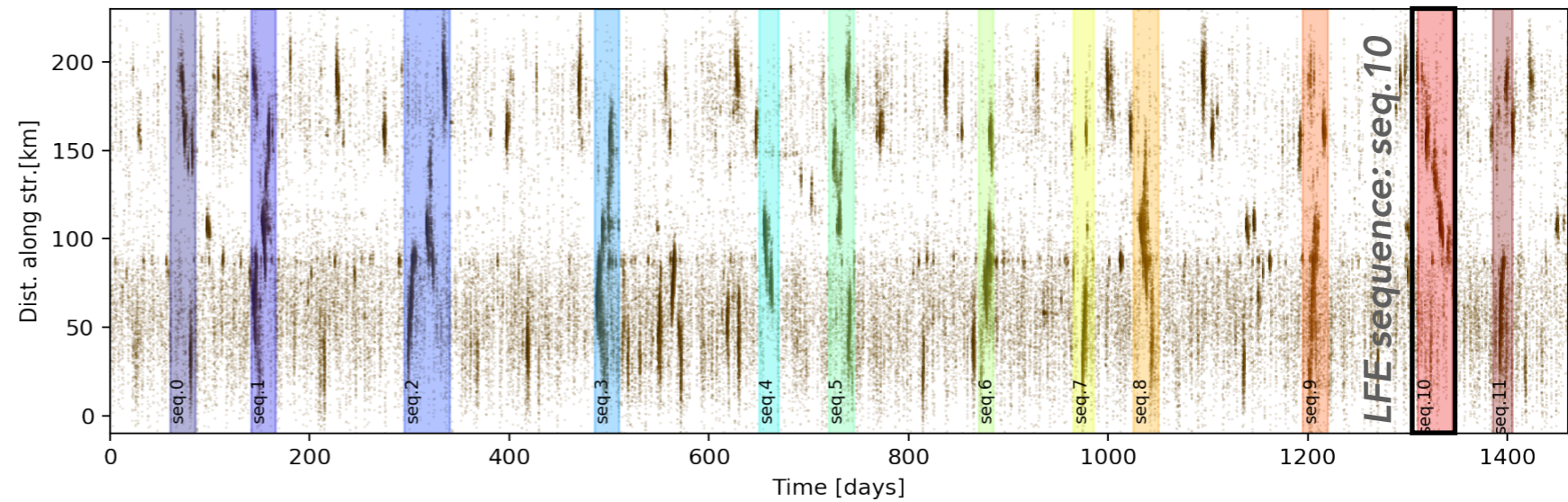
Defined 7 main regions
- different activity patterns
- distinct correlation features
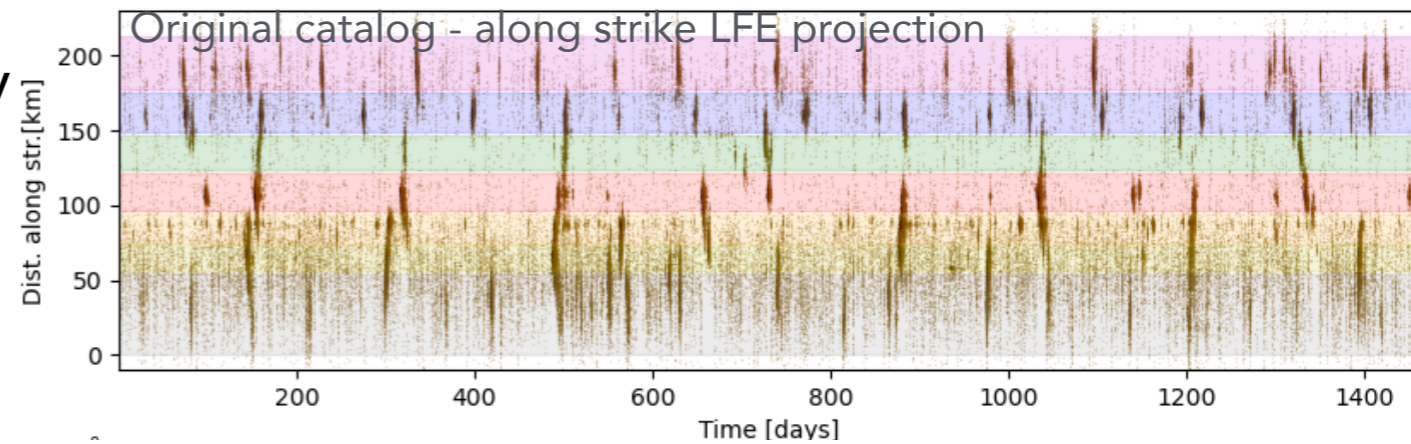
Along-strike activity CC matrix

2D binned LFE
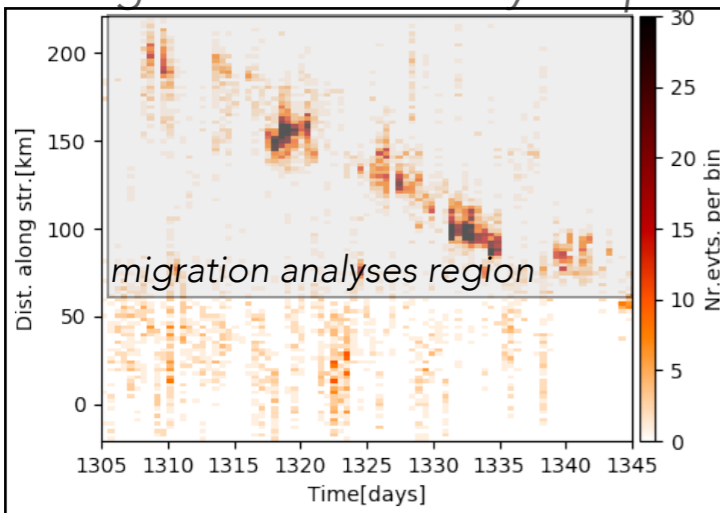
Migration of LFE activity during major sequences

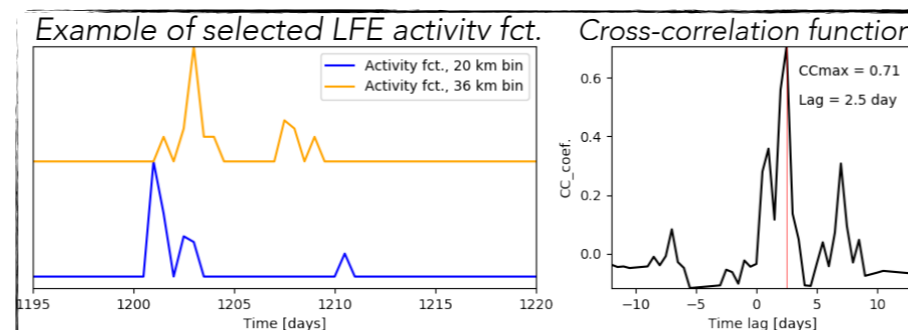Estimating LFE activity front migration speed along strike of subducting slab

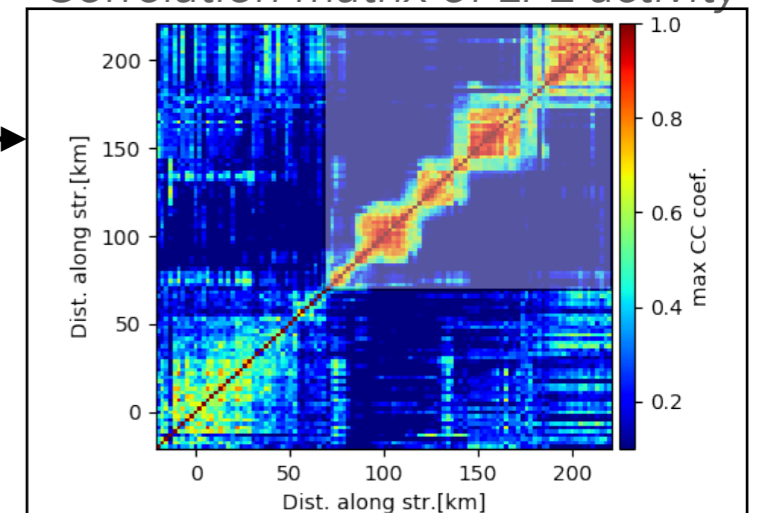Procedure:

Cross-Correlation of
binned LFE activity functions

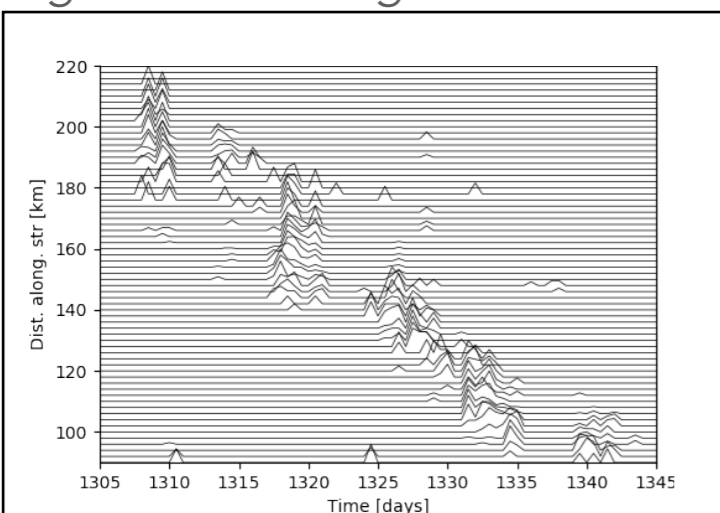*Along-strike LFE activity: seq. 10*

Correlation of along strike activity functions

Example of selected LFE activity fct.   *Cross-correlation function*
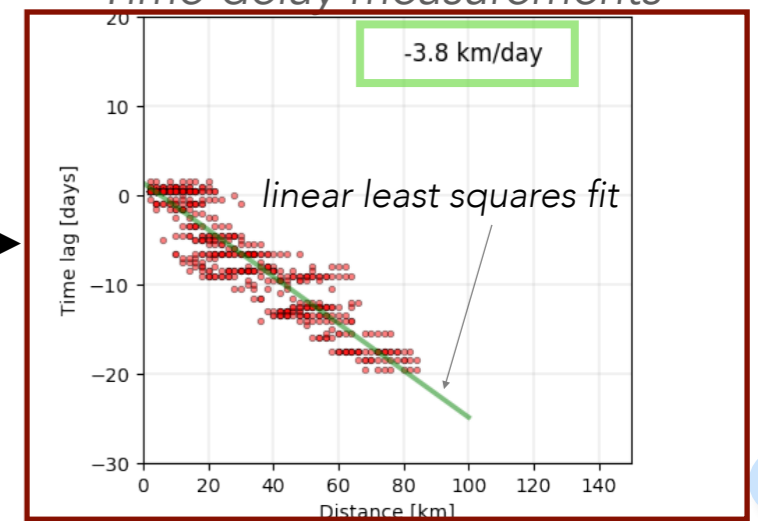

Correlation matrix of LFE activity

Region for time-lag measurement

Exploiting time-delay information from CC
for LFE activity migration speed estimation

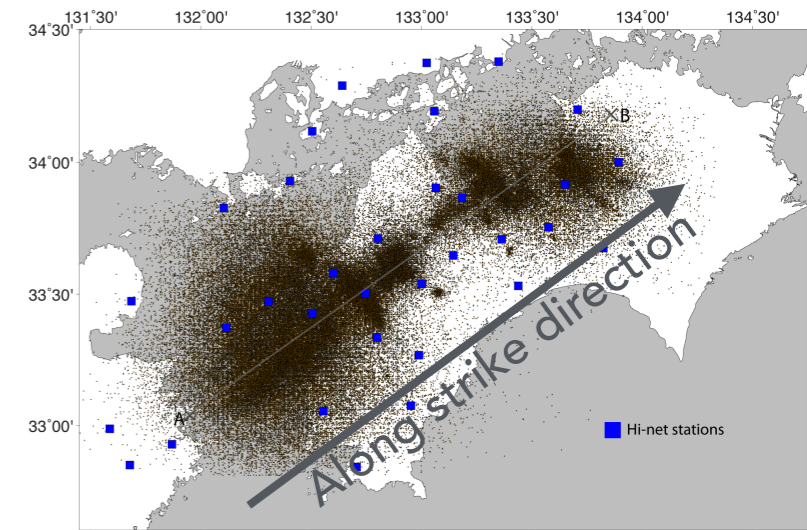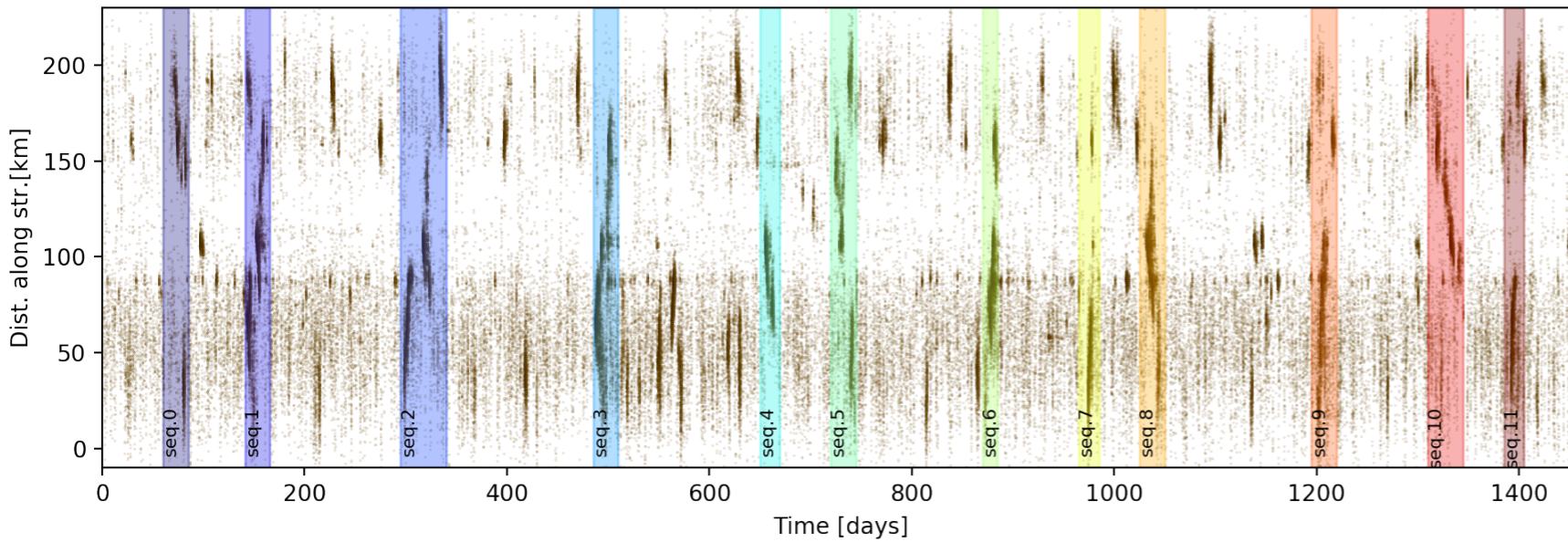Time-delay measurements for strike bin-pairs

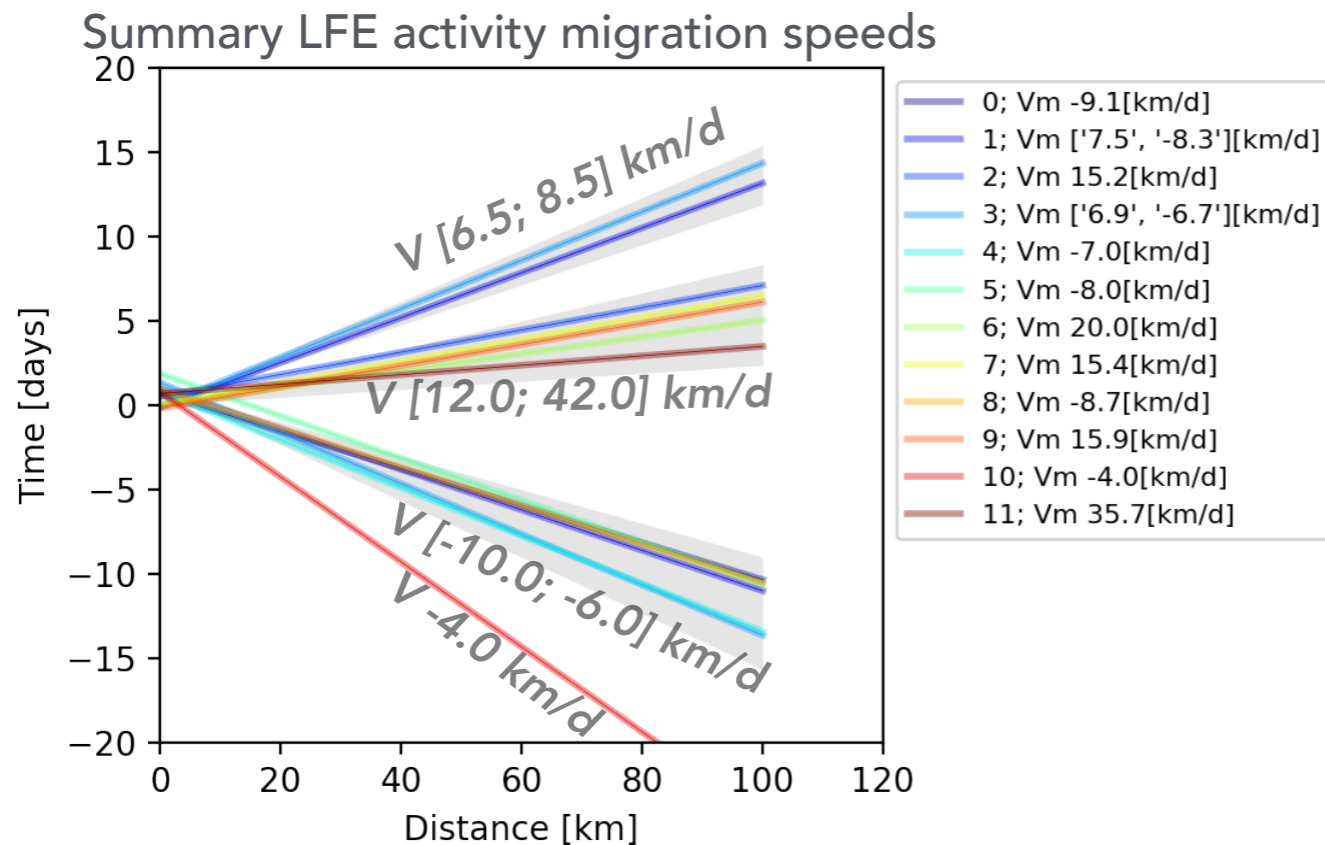*Time-delay measurements*

-3.8 km/day

linear least squares fit

Migration of LFE activity during major sequences

Estimating LFE activity front migration speed along strike of subducting slab
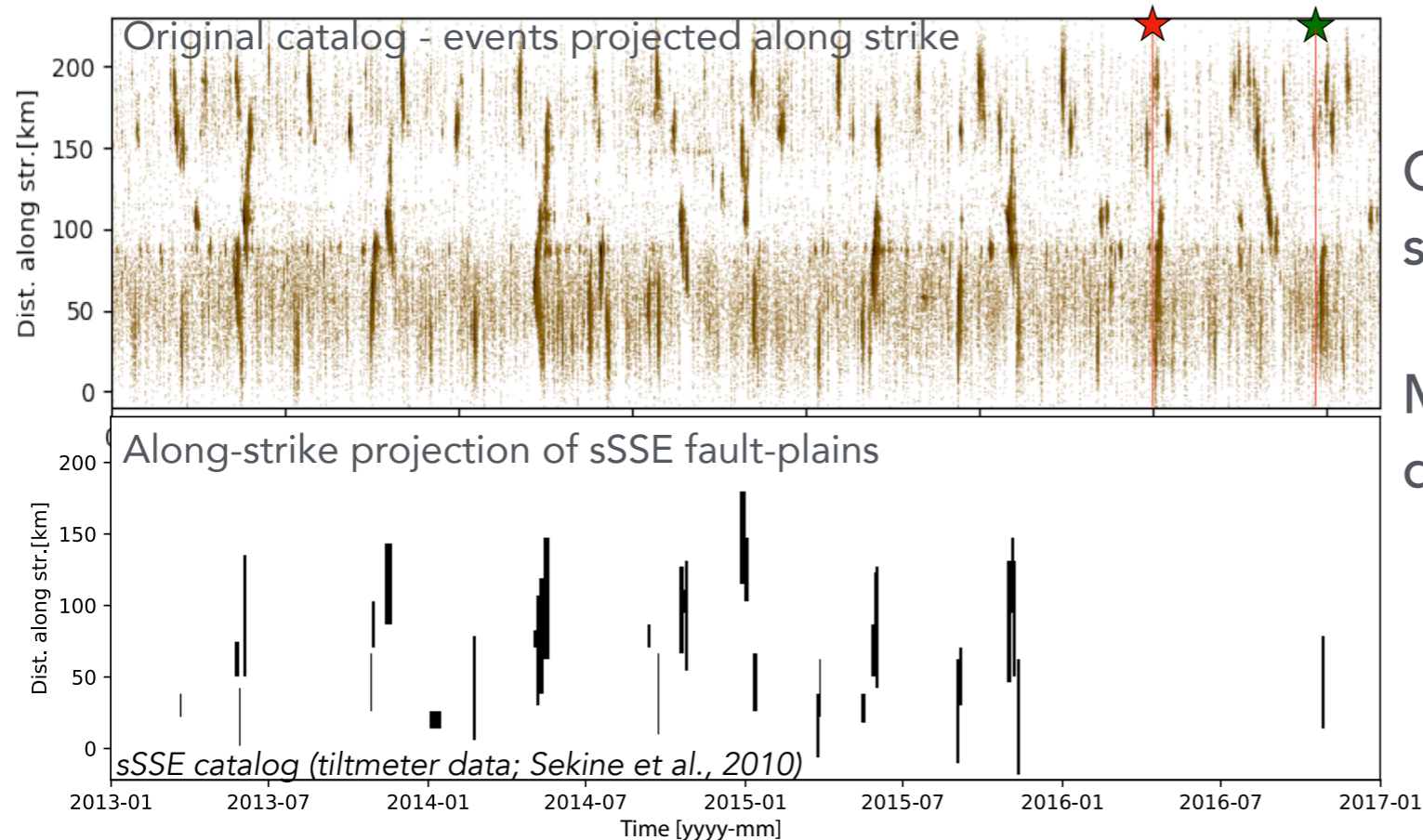

LFE migration front speeds consistent with those of tectonic tremor from previous studies
Patterns/directions of migration can vary significantly
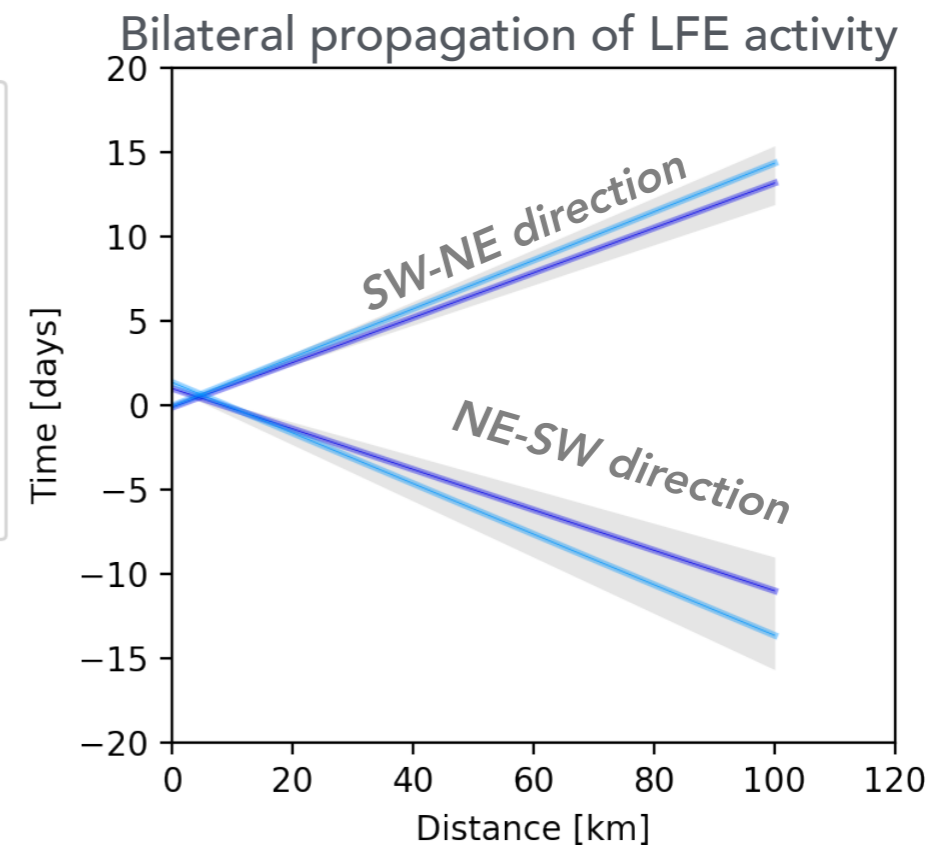
Concluding remarks

LFE activity and short-term slow-slip events (sSSE)

Correlation between major LFE sequences and SSEs

Migration of LFE activity among different regions during SSEs

Summary

Detailed LFE catalog for SW Shikoku subduction zone; period 2013-2016

Spatial and temporal heterogeneity of LFE activity during analysed 4 years

Major LFE sequences - periods of intense activity often involving hole region

Clear along-strike clustering and segmentation: potential structural factor

Defined 7 main regions of LFE activity - patches of LFE sources with similar occurrence patterns

LFE front migration speeds - significant variability with the limits of previous analysis