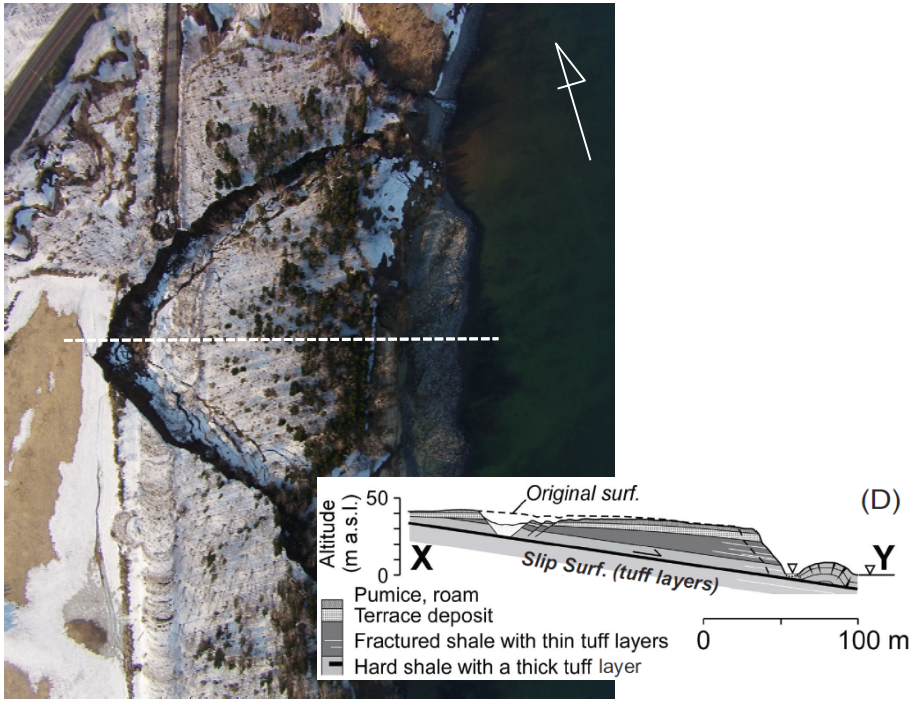
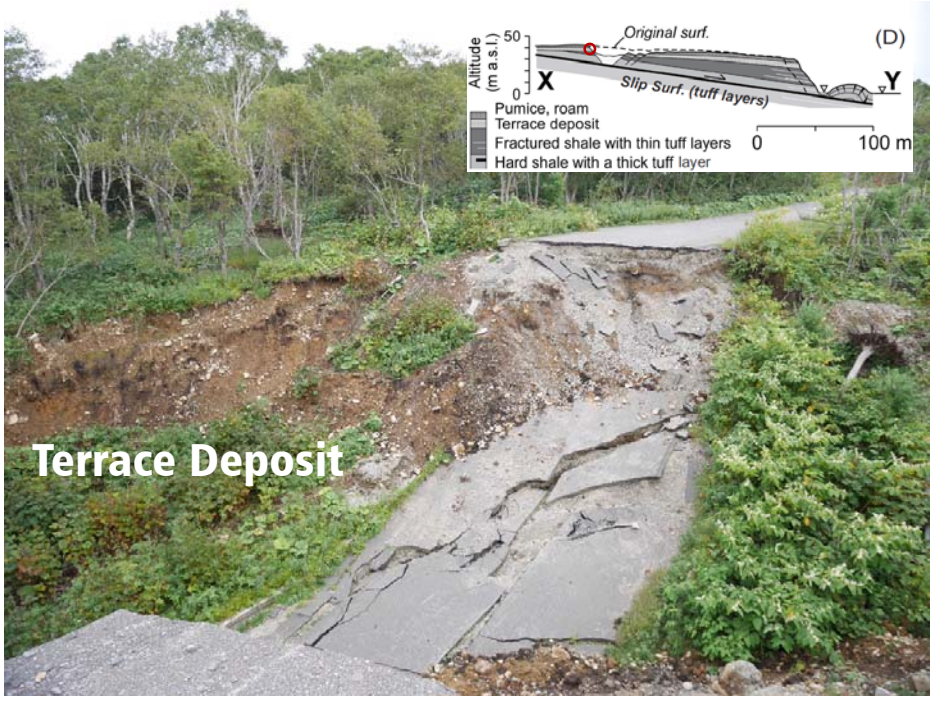
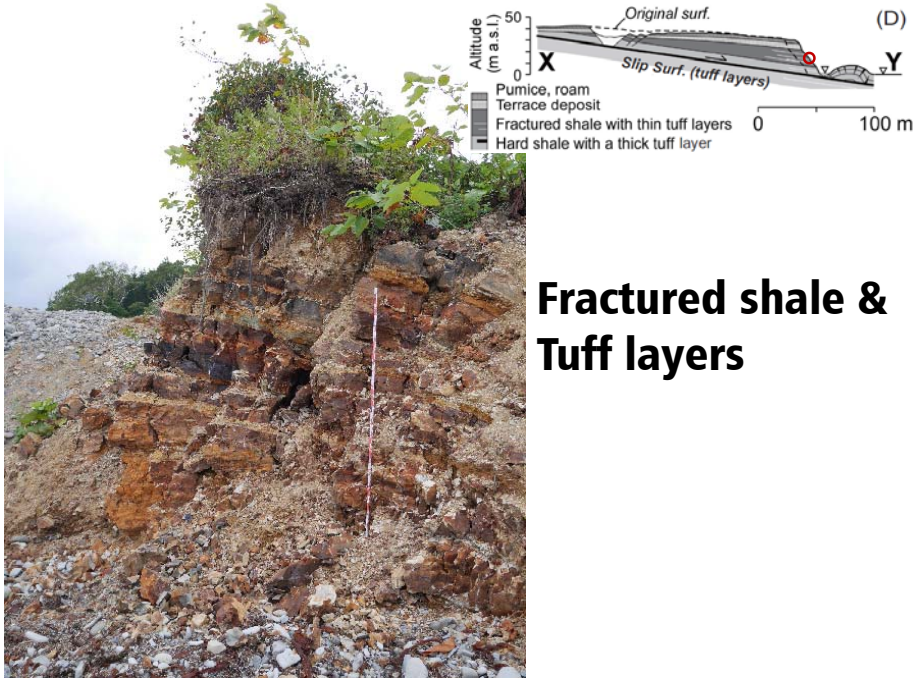
Repeating Seismic Events Indicate Stick-slip Behavior Before a Landslide

Masumi Yamada, Jim Mori, Yuki Matsushi
DPRI, Kyoto University

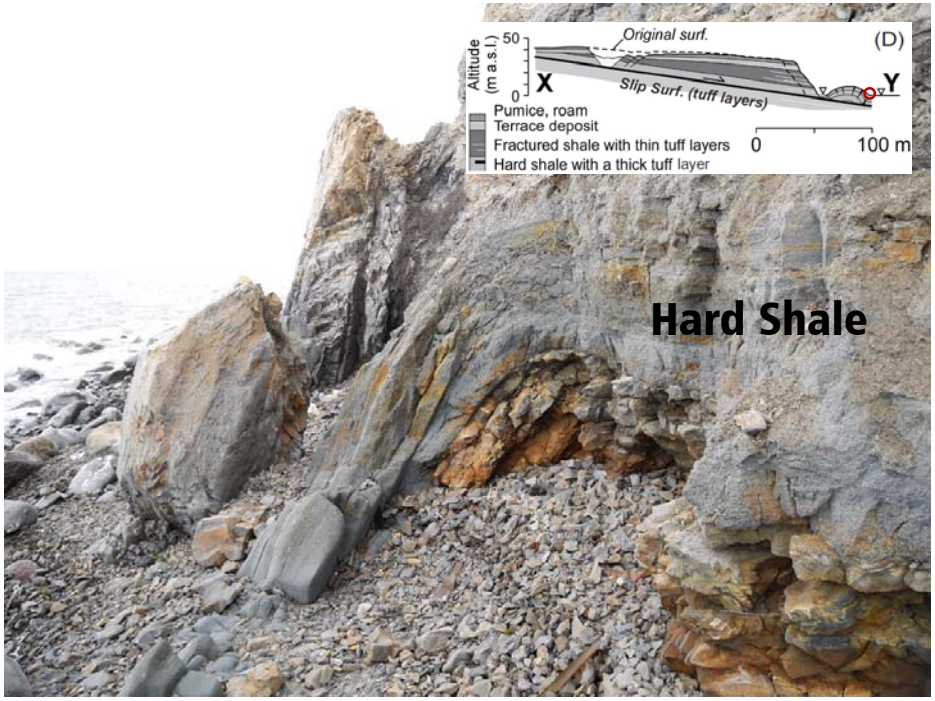
https://www.rt.com/news/253229-landslide-rise-eastern-hokkaido/ (Russia Today)

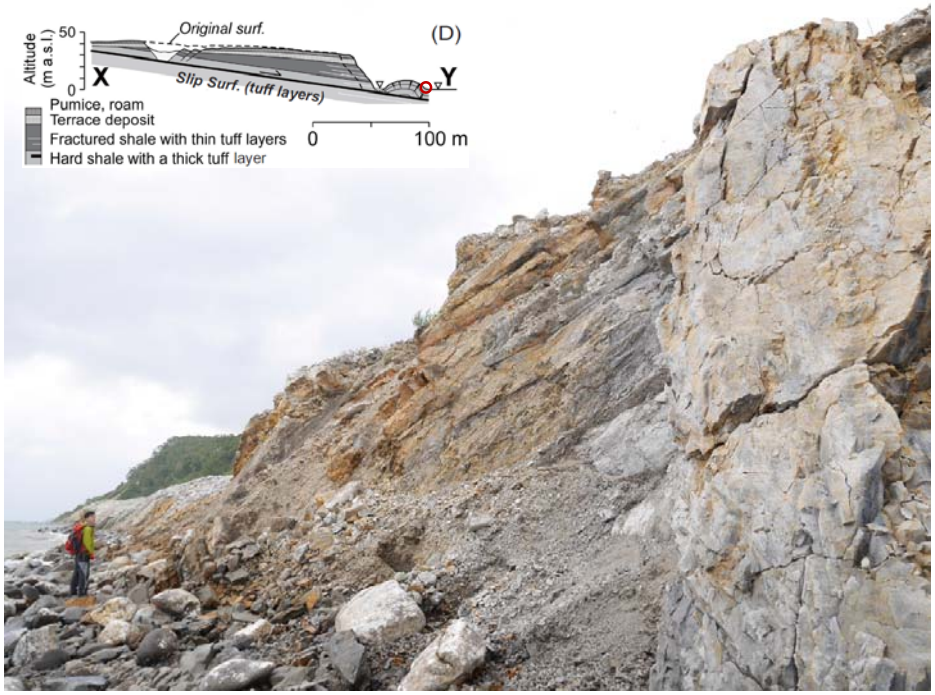




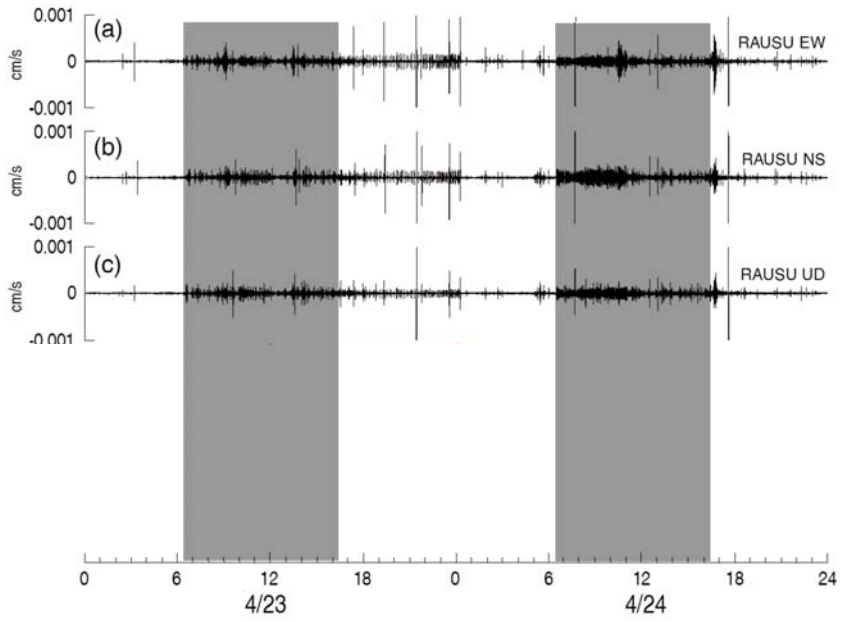


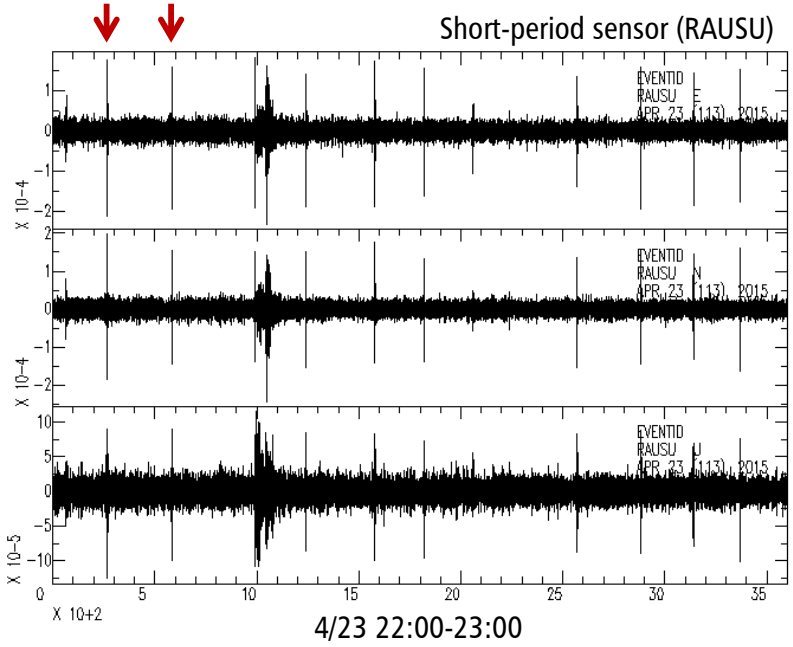
Fractured shale & Tuff layers


Original surf.
(D)
Altitude (m a.s.l.)
50
0
X
Y
Slip Surf. (tuff layers)
Pumice, roam
Terrace deposit
Fractured shale with thin tuff layers
Hard shale with a thick tuff layer
0
100 m
Hard Shale

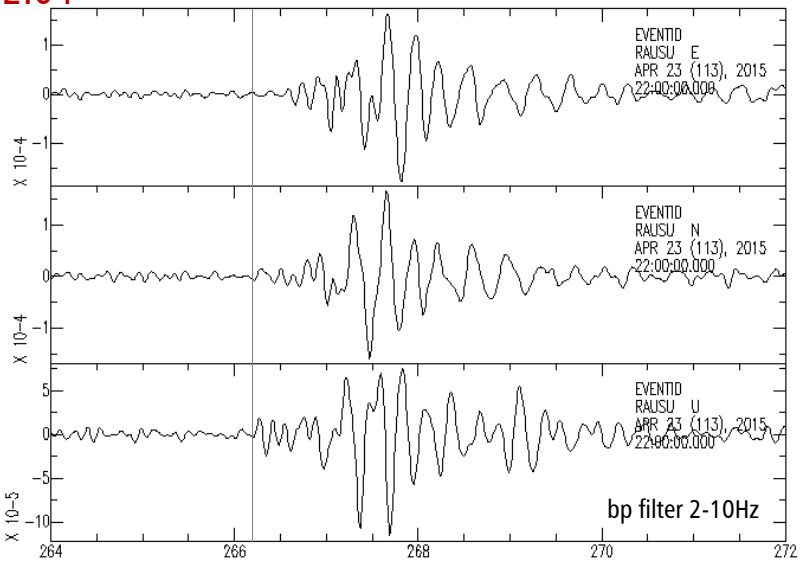

Original surf.
(D)
Altitude (m a.s.l.)
50
0
X
Y
Slip Surf. (tuff layers)
Pumice, roam
Terrace deposit
Fractured shale with thin tuff layers
Hard shale with a thick tuff layer
0
100 m


Seismometer
850m

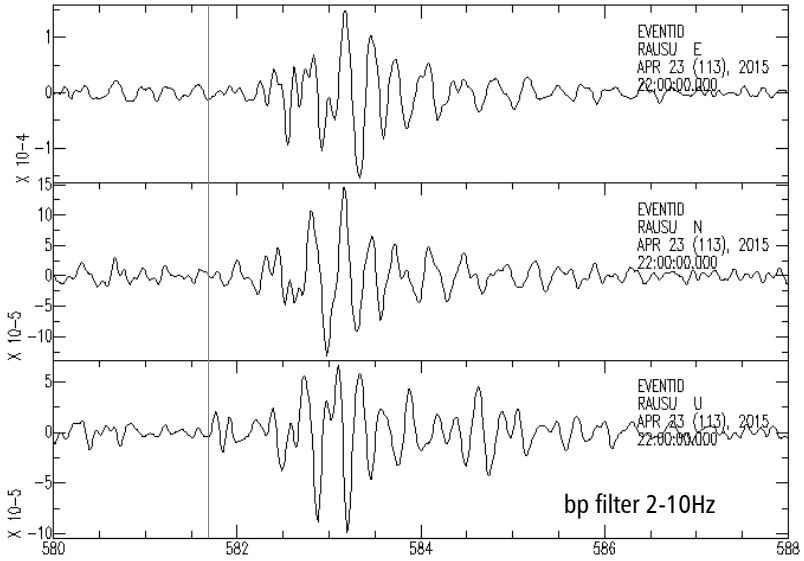

(a)
RAUSU EW
(b)
RAUSU NS
(c)
RAUSU UD
cm/s
0.001
0
-0.001
0
6
12
18
0
6
12
18
24
4/23
4/24

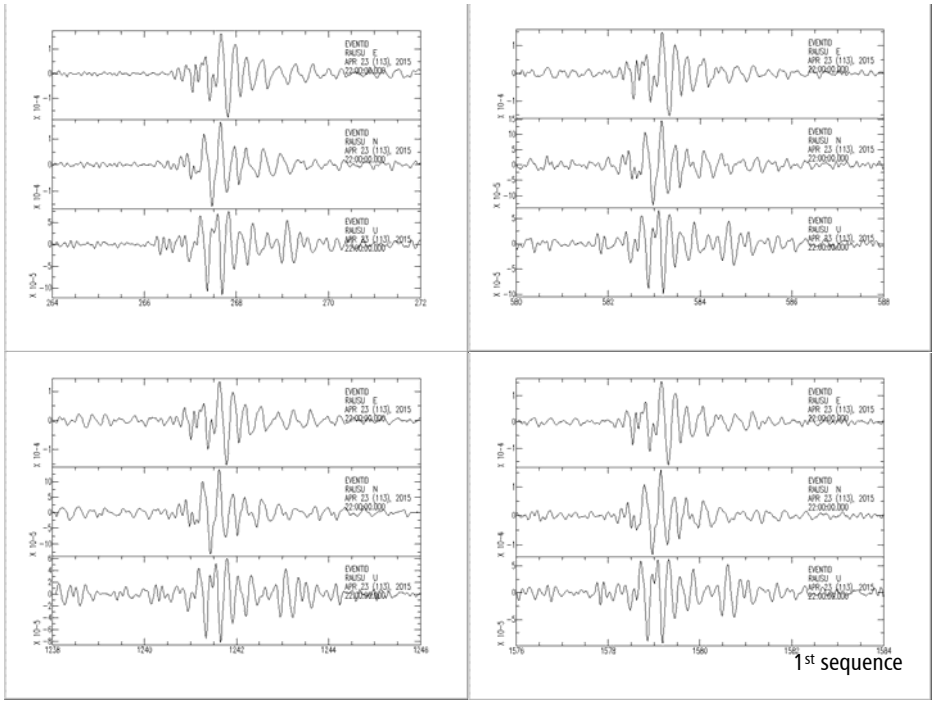

Short-period sensor (RAUSU)
EVENTID
RAUSU E
APR 23 (113), 2015
EVENTID
RAUSU N
APR 23 (113), 2015
EVENTID
RAUSU U
APR 23 (113), 2015
X 10−4
X 10−4
X 10−5
X 10+2
4/23 22:00-23:00

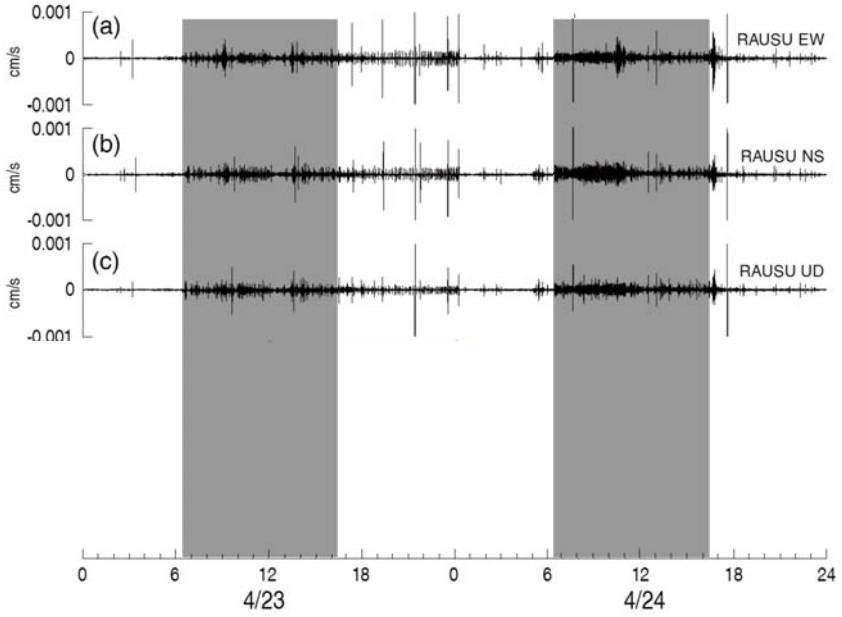
22:04


EVENTID
RAUSU E
APR 23 (113), 2015
22:00:00.000
EVENTID
RAUSU N
APR 23 (113), 2015
22:00:00.000
EVENTID
RAUSU U
APR 23 (113), 2015
22:00:00.000
X 10−4
X 10−4
X 10−5
bp filter 2-10Hz

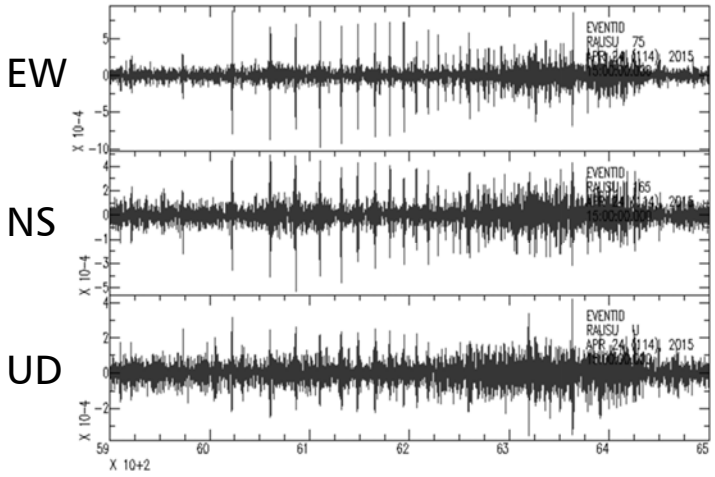
22:09

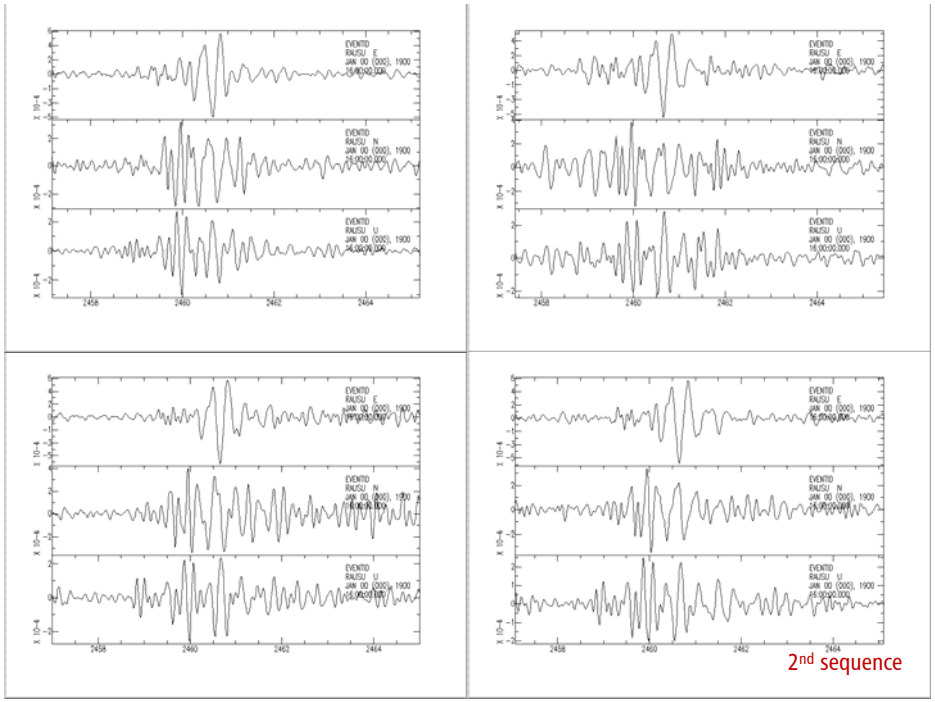

EVENTID
RAUSU E
APR 23 (113), 2015
22:00:00.000
EVENTID
RAUSU N
APR 23 (113), 2015
22:00:00.000
EVENTID
RAUSU U
APR 23 (113), 2015
22:00:00.000
X 10−4
X 10−5
bp filter 2-10Hz


1st sequence

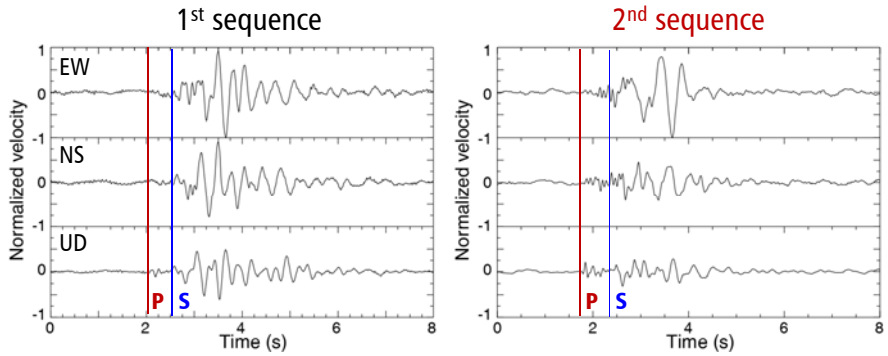


Waveforms of the 2nd sequence

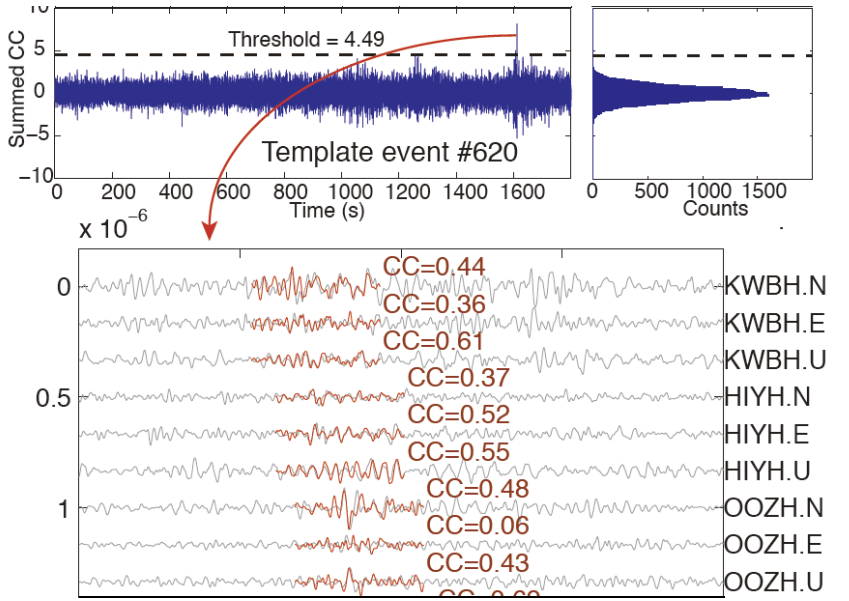




Template Waveforms



S-P time: ~0.5 sec (distance 850m)



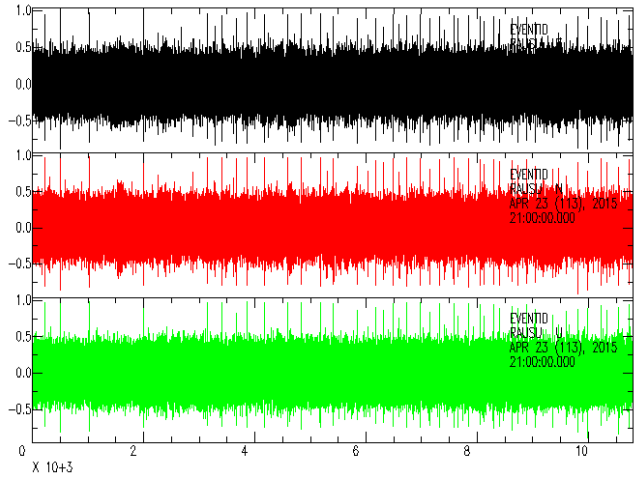
(Shelly et al., 2007)

Normalized X-correlation

EW

NS

UD



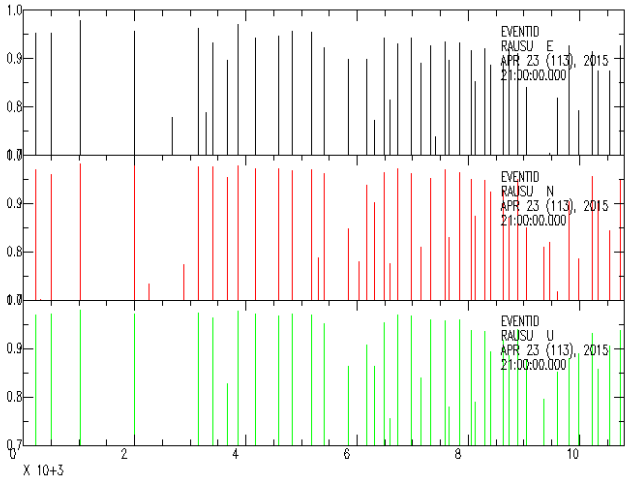
4/23 21:00-24:00

Normalized X-correlation

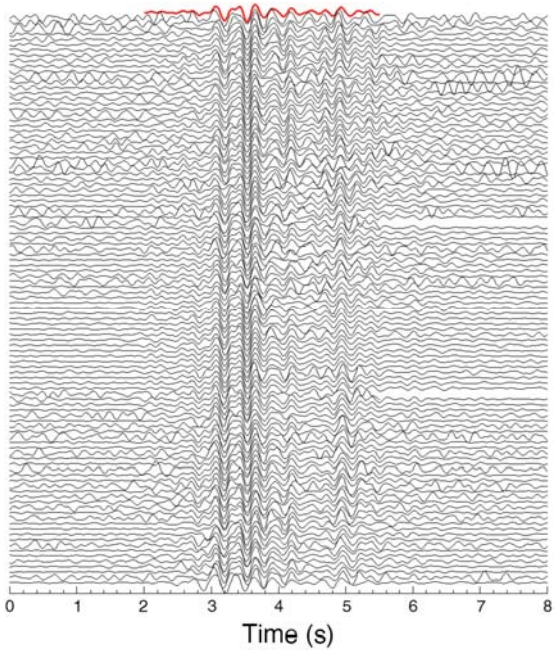
EW

NS

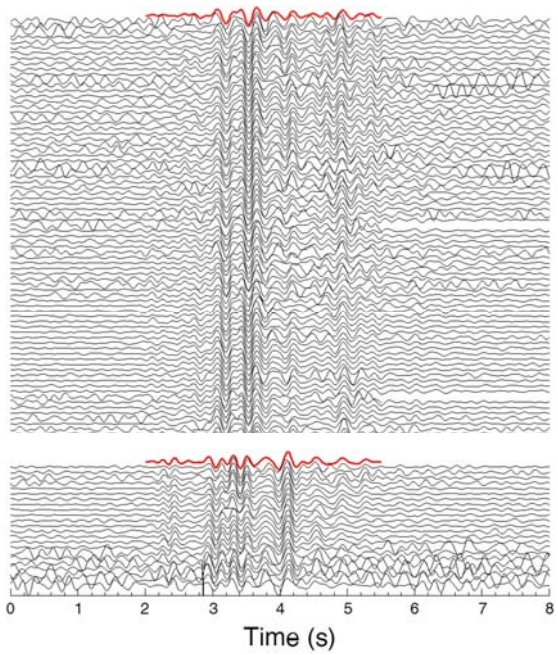
UD

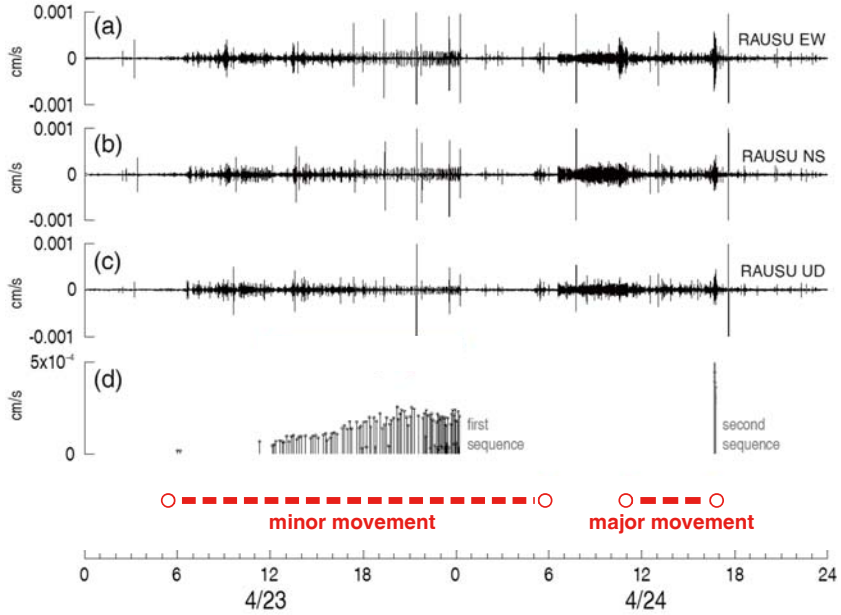


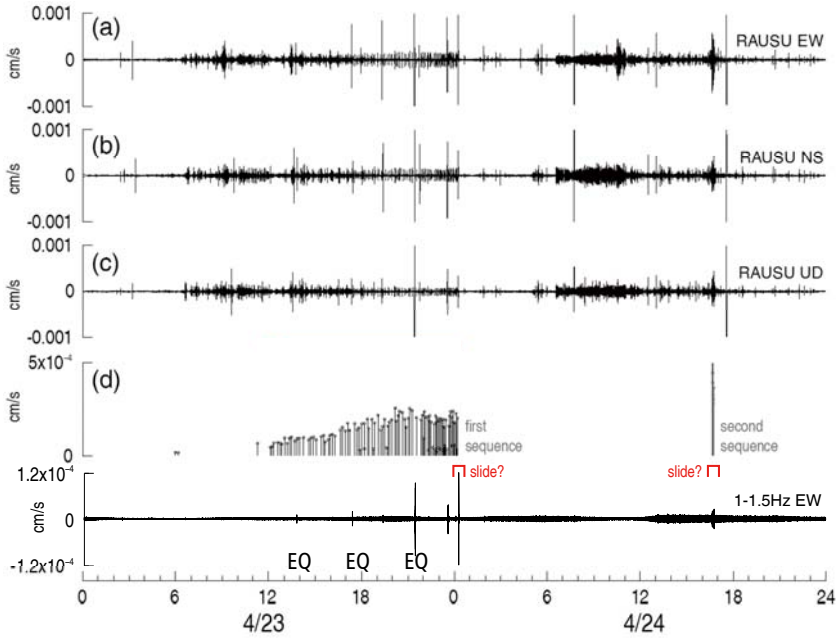
4/23 21:00-24:00



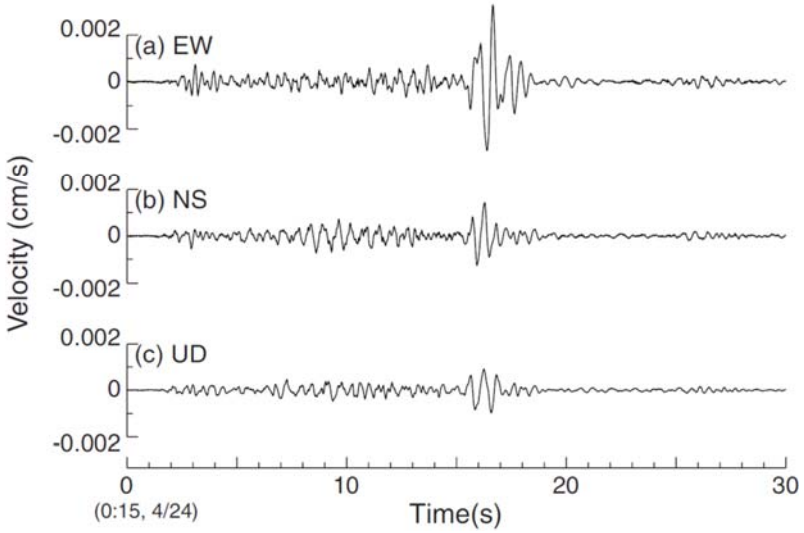
106 events

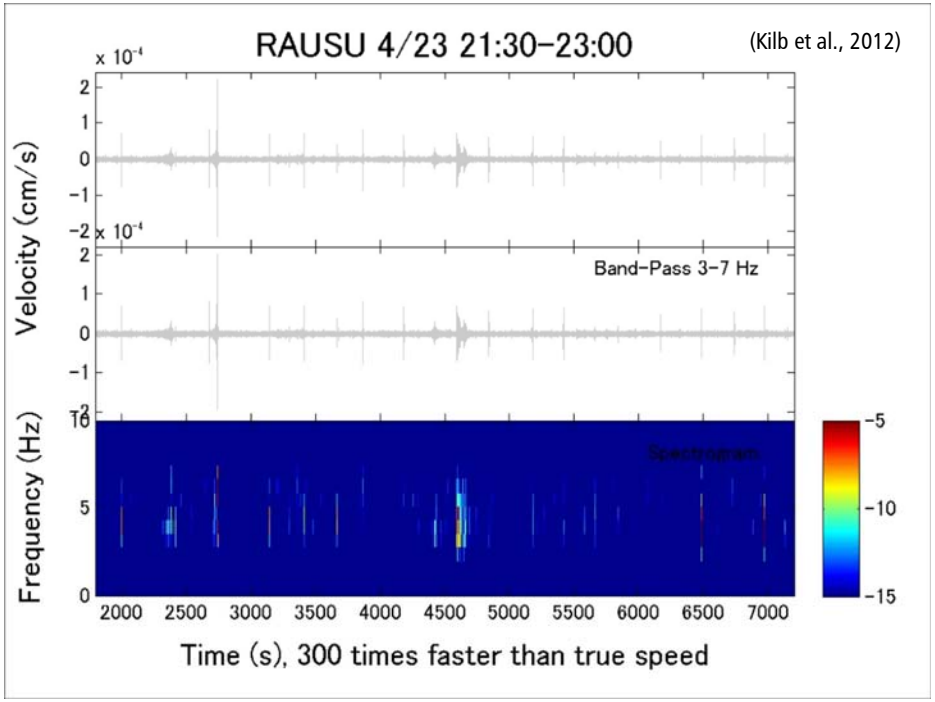




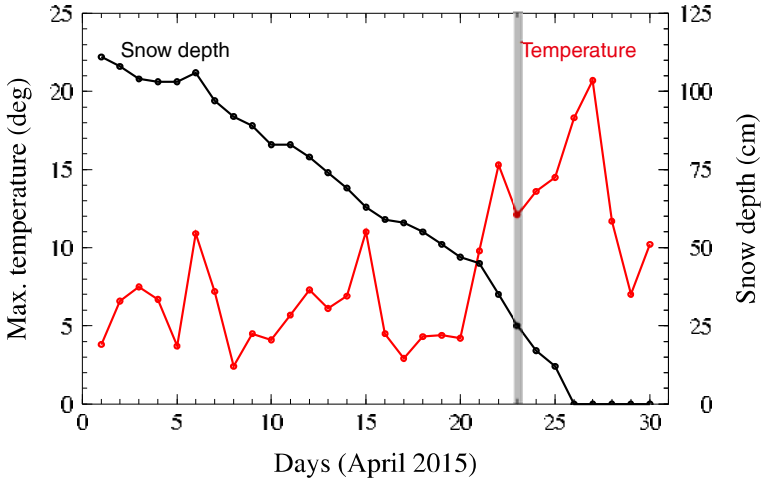


Velocity at the end of 1st sequence

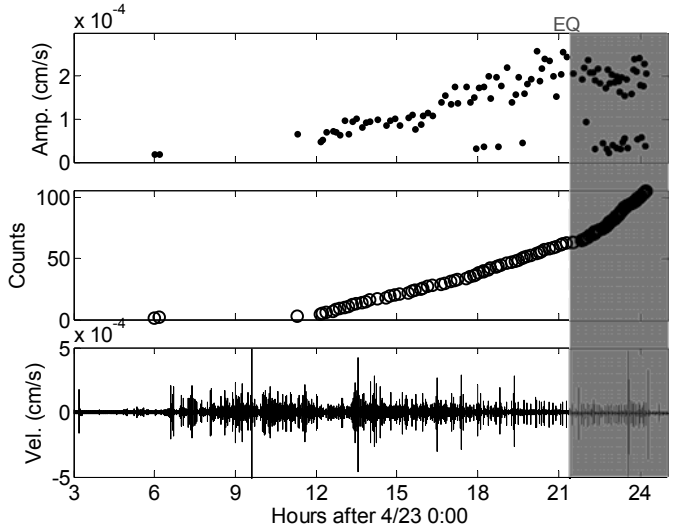




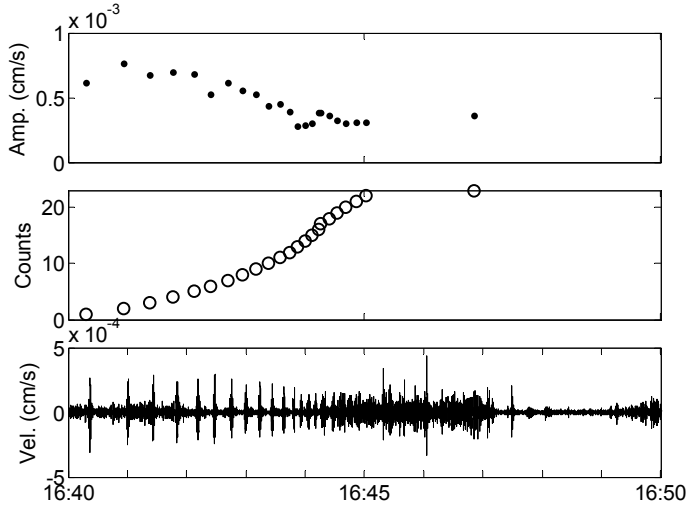
Weather Condition

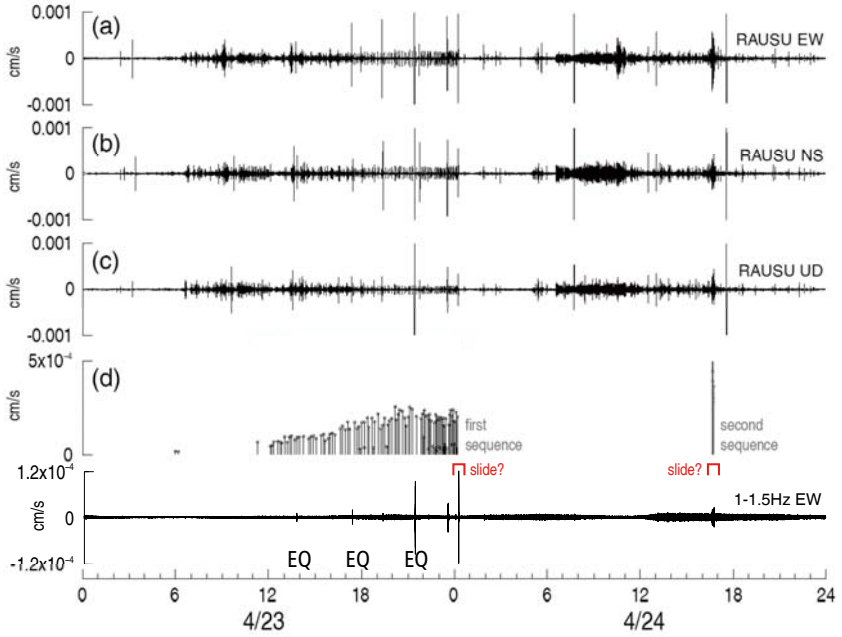


Timing and Amplitude



Timing and Amplitude 2





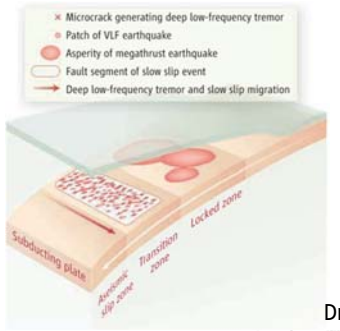
Interpretation

Identical waveforms → the same source (small)

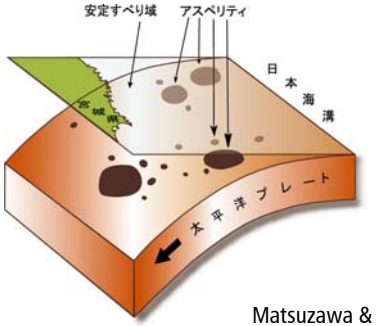
Increasing amplitudes → acceleration of sliding

Repeating sequence → stick-slip movement

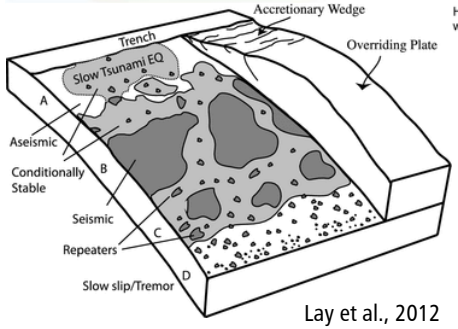
Disturbed by an EQ → delicate balance



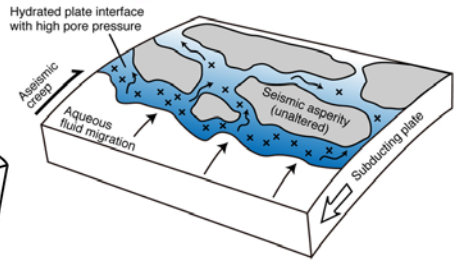
Dragert 2007



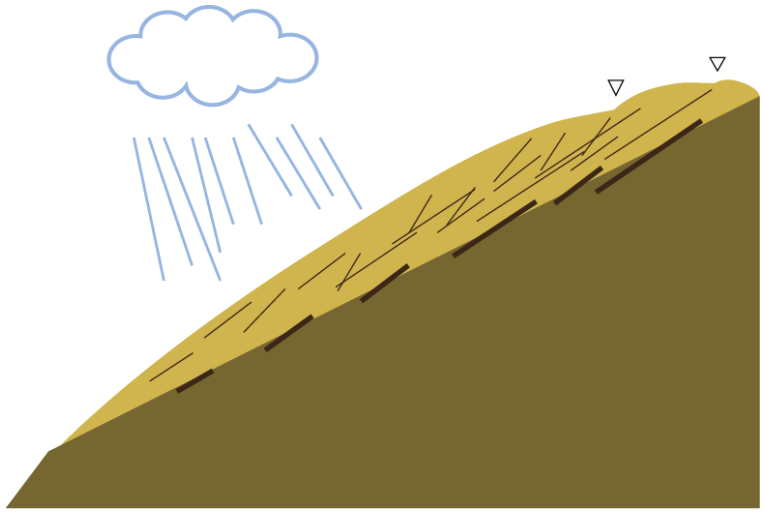
Matsuzawa & Uchida



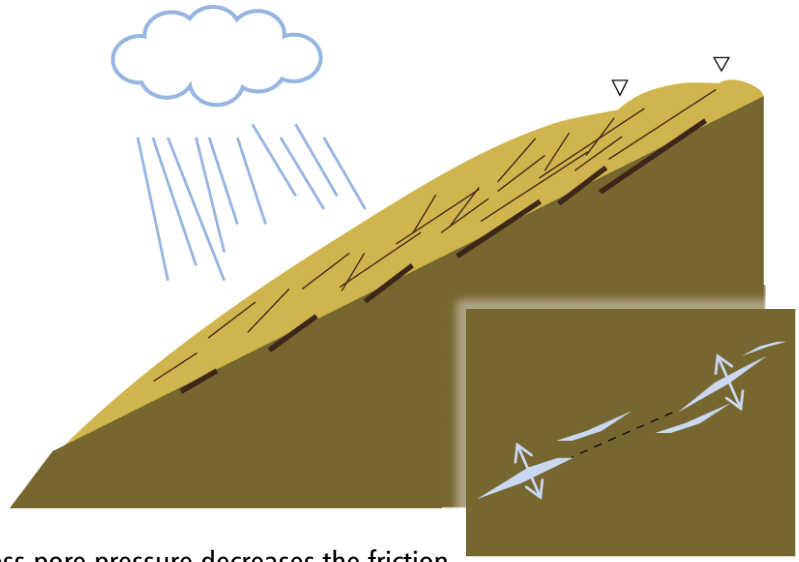
Lay et al., 2012



Katayama et al., 2013

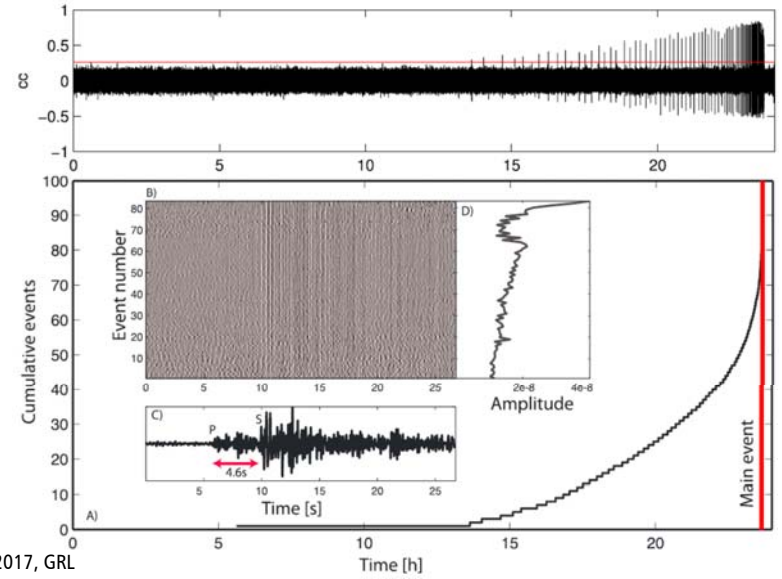


Heterogeneous structure (locked and unlocked sections)



Excess pore pressure decreases the friction

Greenland landslide in 2017



Poli 2017, GRL

Summary

Observation

Repeated earthquakes with similar waveforms before RAUSU landslide

Interpretation

Small scale stick-slip movement at a specific location on the landslide slip surface

Conclusion

Heterogeneous structure can play an important role in the initiation of landslides

Yamada, Mori, and Matsushi (2016) GRL