CENTRO DE GEOCIENCIAS
UNIVERSIDAD NACIONAL AUTÓNOMA DE MÉXICO

HYDROLOGICAL CHARACTERIZATION AND INSTRUMENTAL DETECTION OF LAHARS ON ACTIVE VOLCANOES IN MEXICO.

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CONACYT
CENAPRED MÉXICO

Lahar monitoring in Mexico

Lahar: a volcanic debris flow

Lahar monitoring since 2011

1 monitoring station since 2019

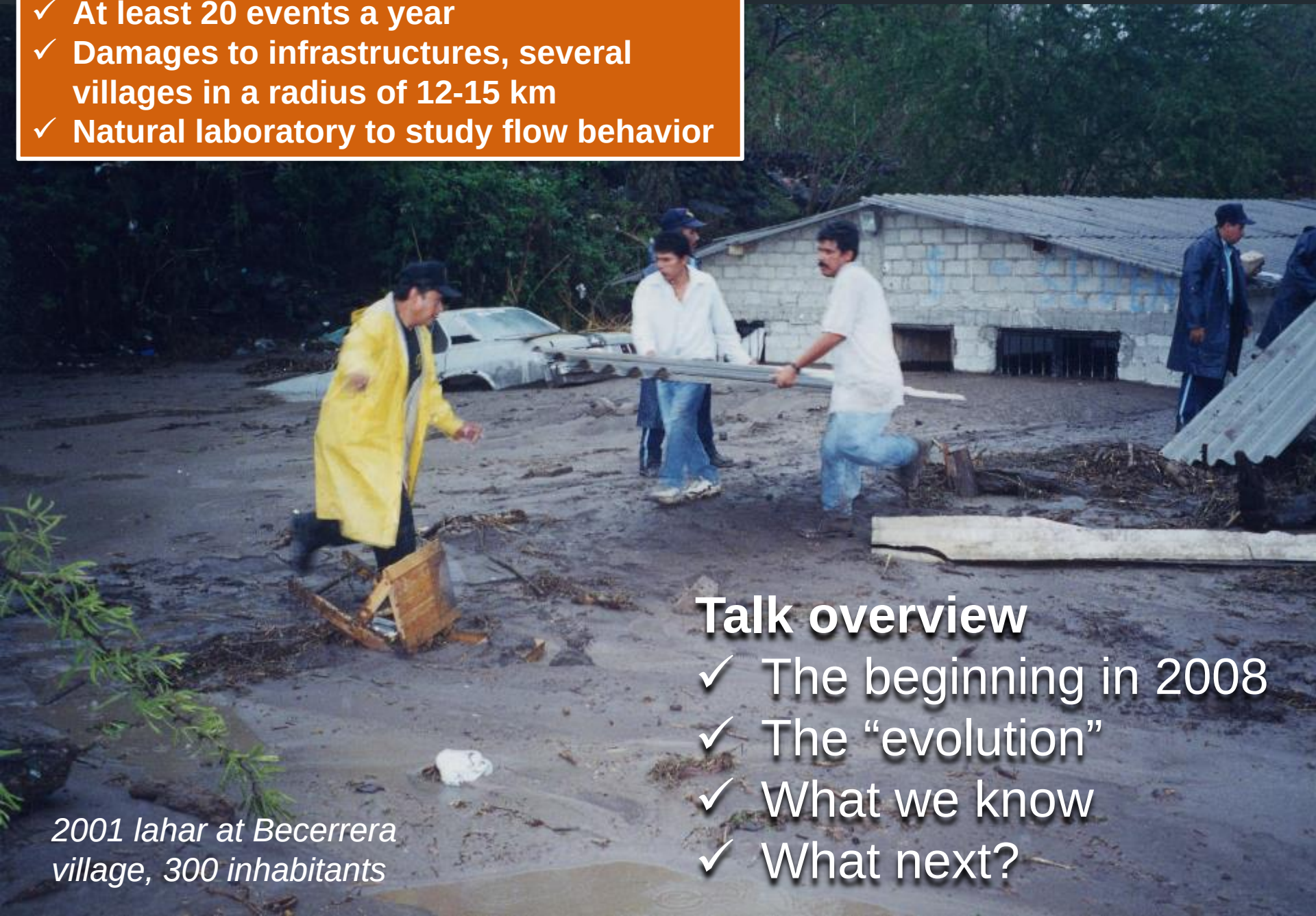
Popocatépetl volcano

Popocatépetl: Vulcanian activity, fine ash on the main cone. The glacier disappeared in 2003.

*Colima: Dome collapse, with emplacement of m-thick pyroclastic flow deposits on main ravine **up to 6 km** from the crater*

MOTIVATION:

- ✓ **At least 20 events a year**
- ✓ **Damages to infrastructures, several villages in a radius of 12-15 km**
- ✓ **Natural laboratory to study flow behavior**



2001 lahar at Becerrera village, 300 inhabitants

Talk overview

- ✓ The beginning in 2008
- ✓ The “evolution”
- ✓ What we know
- ✓ What next?

Common damages to infrastructure

2008, THE BEGINNING…….

Transducer pressure

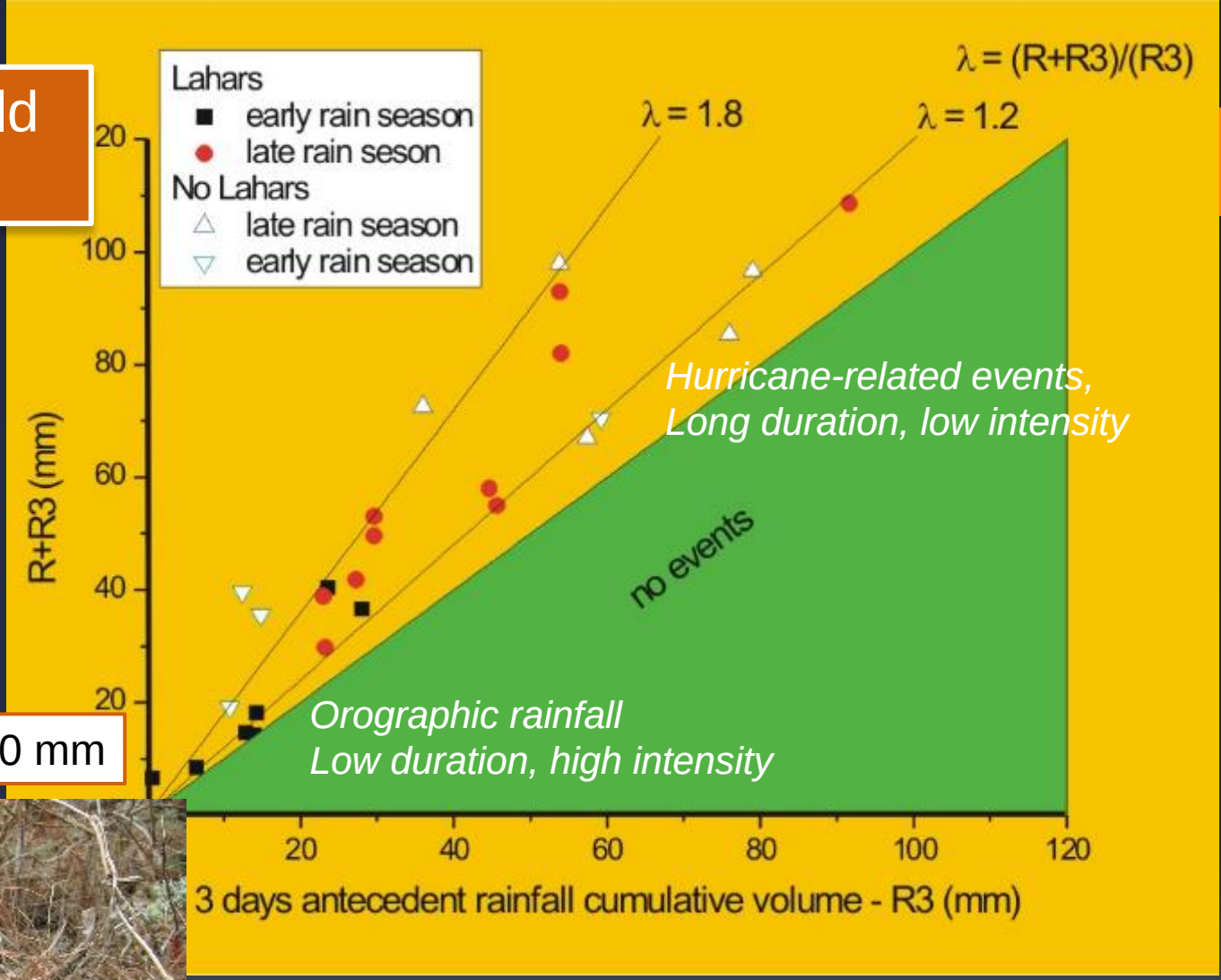
Channel erosion after the 2011 Jove hurricane

Events detected by the seismic network of the volcano observatory, no images available, only one station on the channel side.

Wildlife camera!

….testing the camera

Rainfall threshold 2008-2010

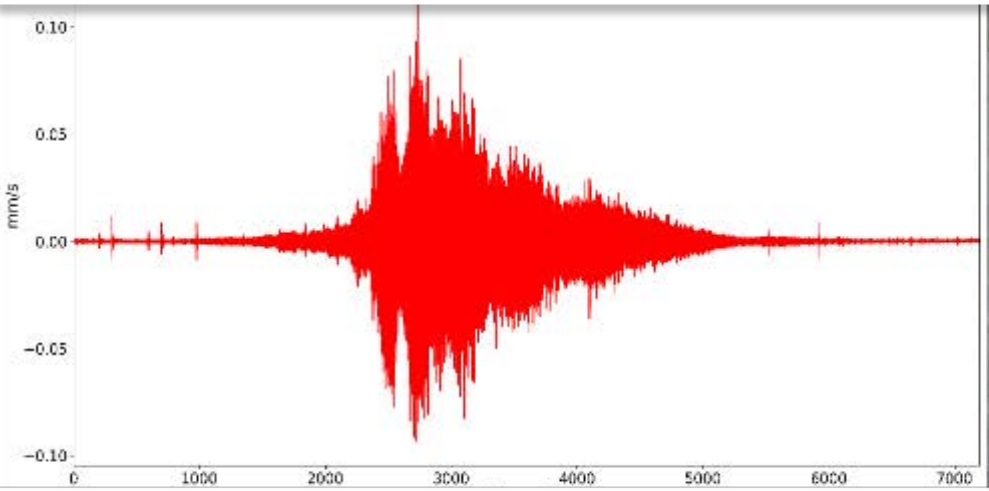


10 mm

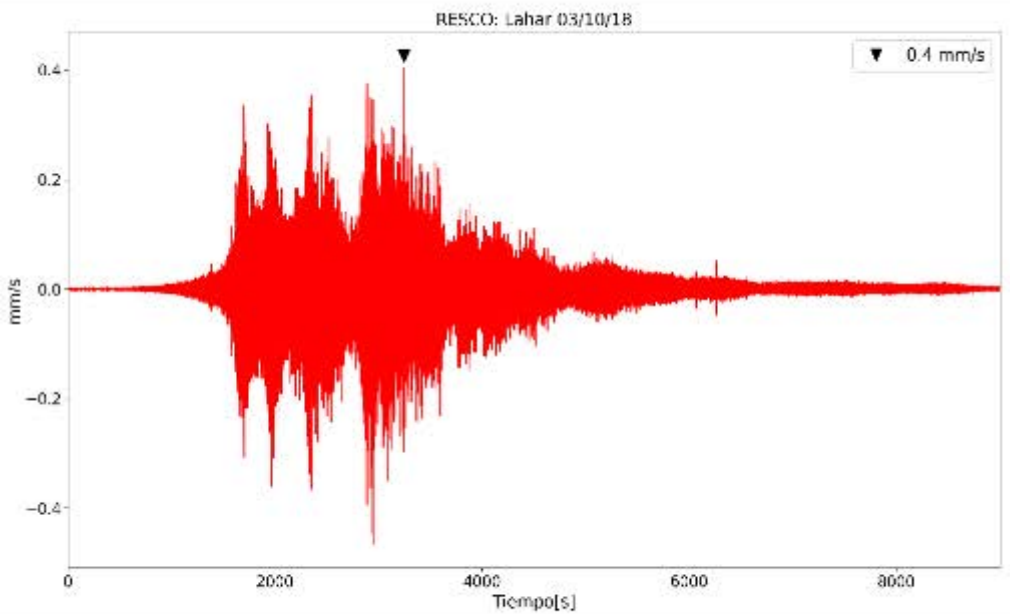
Capra et al 2010.

Hydrophobic soils under dry conditions, at the beginning of the rainfall season

Rainfall threshold: Very difficult **at the beginning of the rainy season (orographic rainfalls)**, no rain detected at the monitoring station

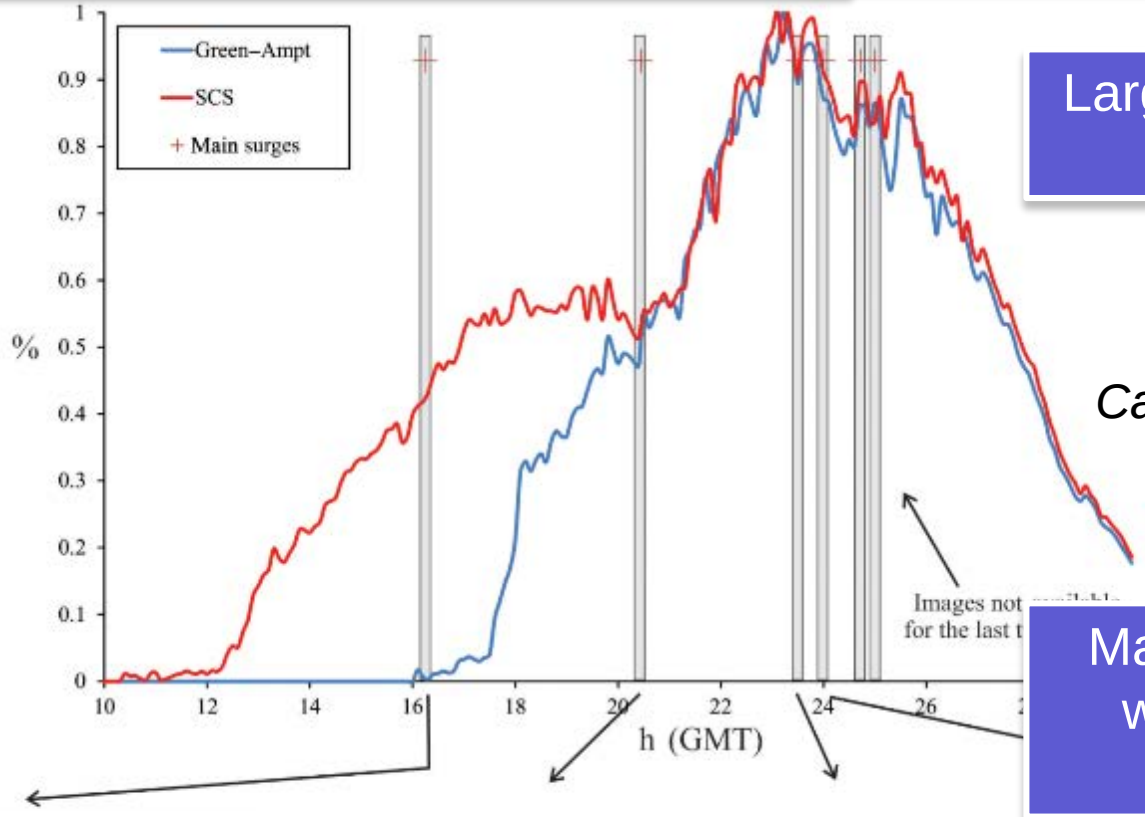


Dry block-rich fronts



Catchment's peak discharge vs. flow-peak discharge

2015 Hurricane Patricia, rainfall-runoff simulation



Largest lahars triggered by hurricanes.

Capra et al., 2018

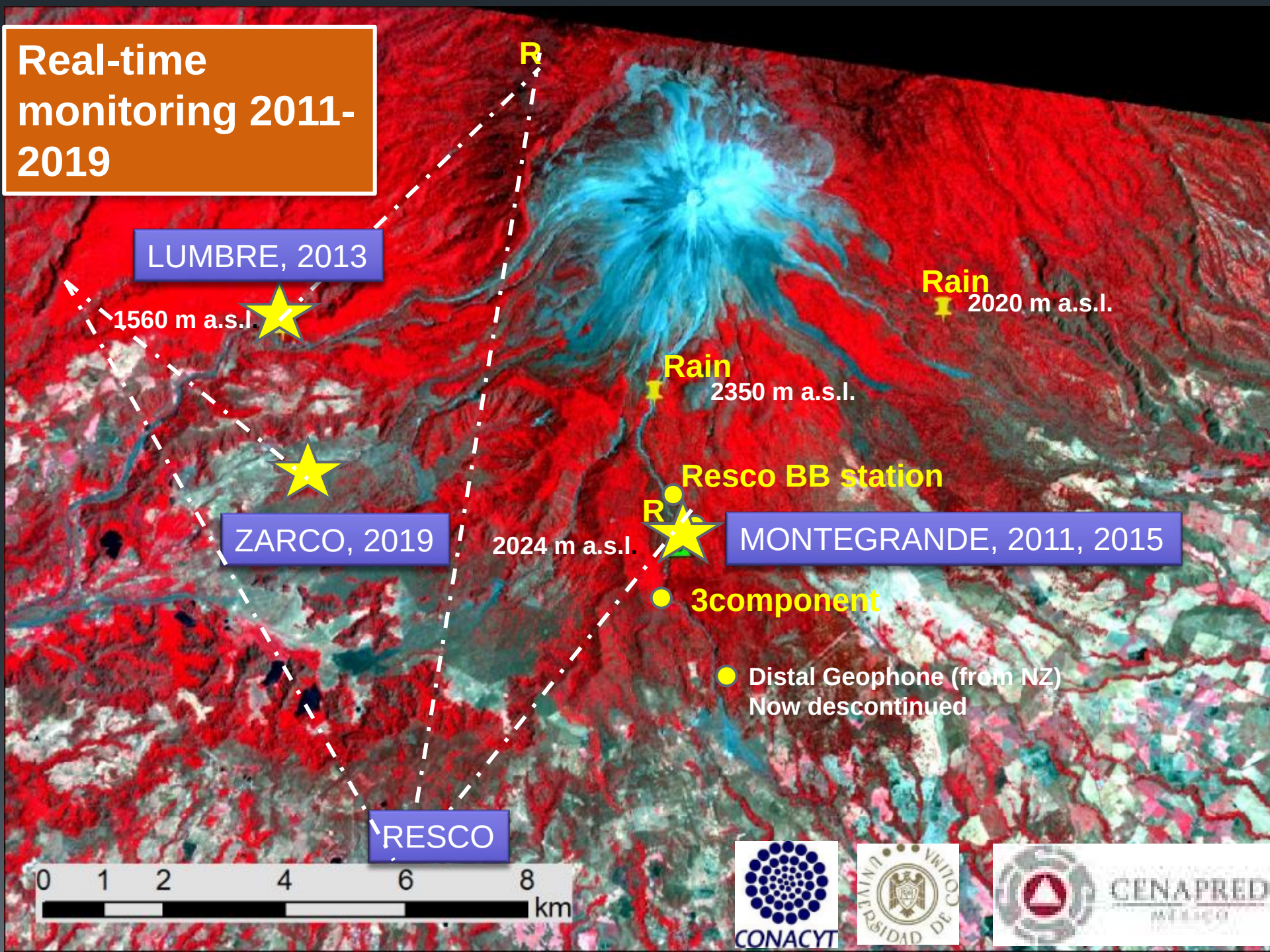
Main surges correlate with the watershed discharge


Initial water runoff


First hyperconcentrated flow detected in the seismic record


First main pulse


Second main pulse


Real-time monitoring 2011-2019
R
LUMBRE, 2013
1560 m a.s.l.
Rain
2020 m a.s.l.
Rain
2350 m a.s.l.
Resco BB station
R
ZARCO, 2019
2024 m a.s.l.
MONTEGRANDE, 2011, 2015
3component
Distal Geophone (from NZ)
Now descontinued
RESCO
0 1 2 4 6 8
km
CONACYT
CENAPRED

2011, Montegrande ravine

We started with:

- Video camera (capturing each 2 sec.)
- Rain gauge station (1 min, 0.2 mm)
- Moisture soil sensor
- 10 Hz Geophone
- Real-time data transmission

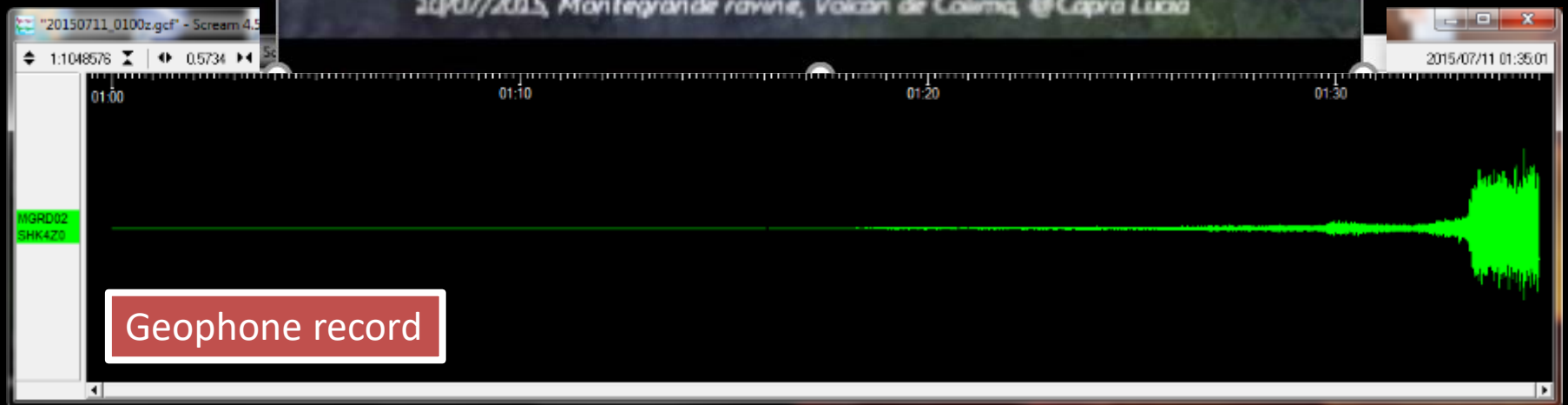
2011, First monitoring station at Montegrande ravine

11 june 2013
300 mm of rain

Second main pulse
The lahar lasted more than 2 hours

At 6.5 km from the crater
outside the BAF inundation area..

8.27 PM first pyroclastic flow, Estimated flow velocity 7m/s

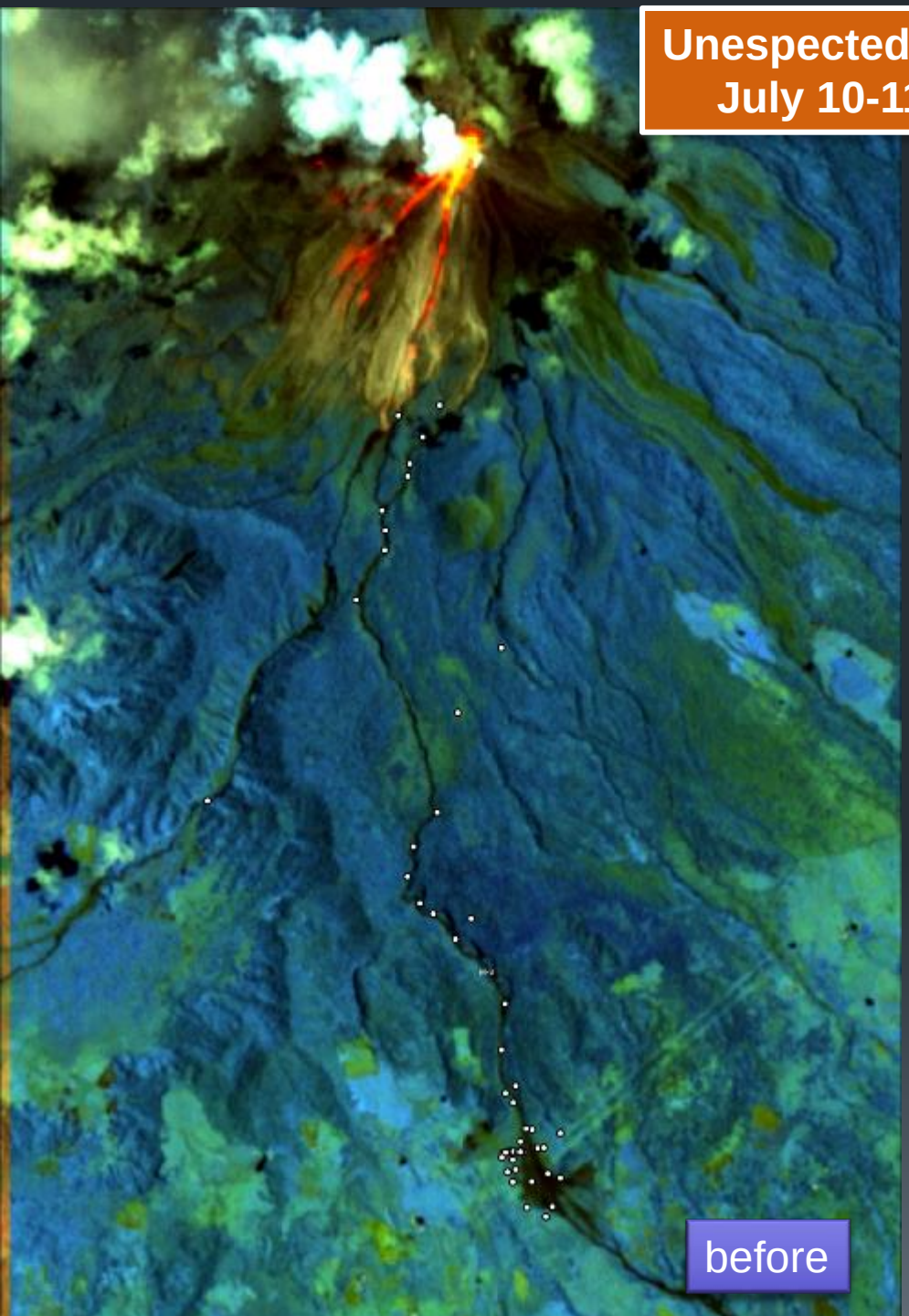


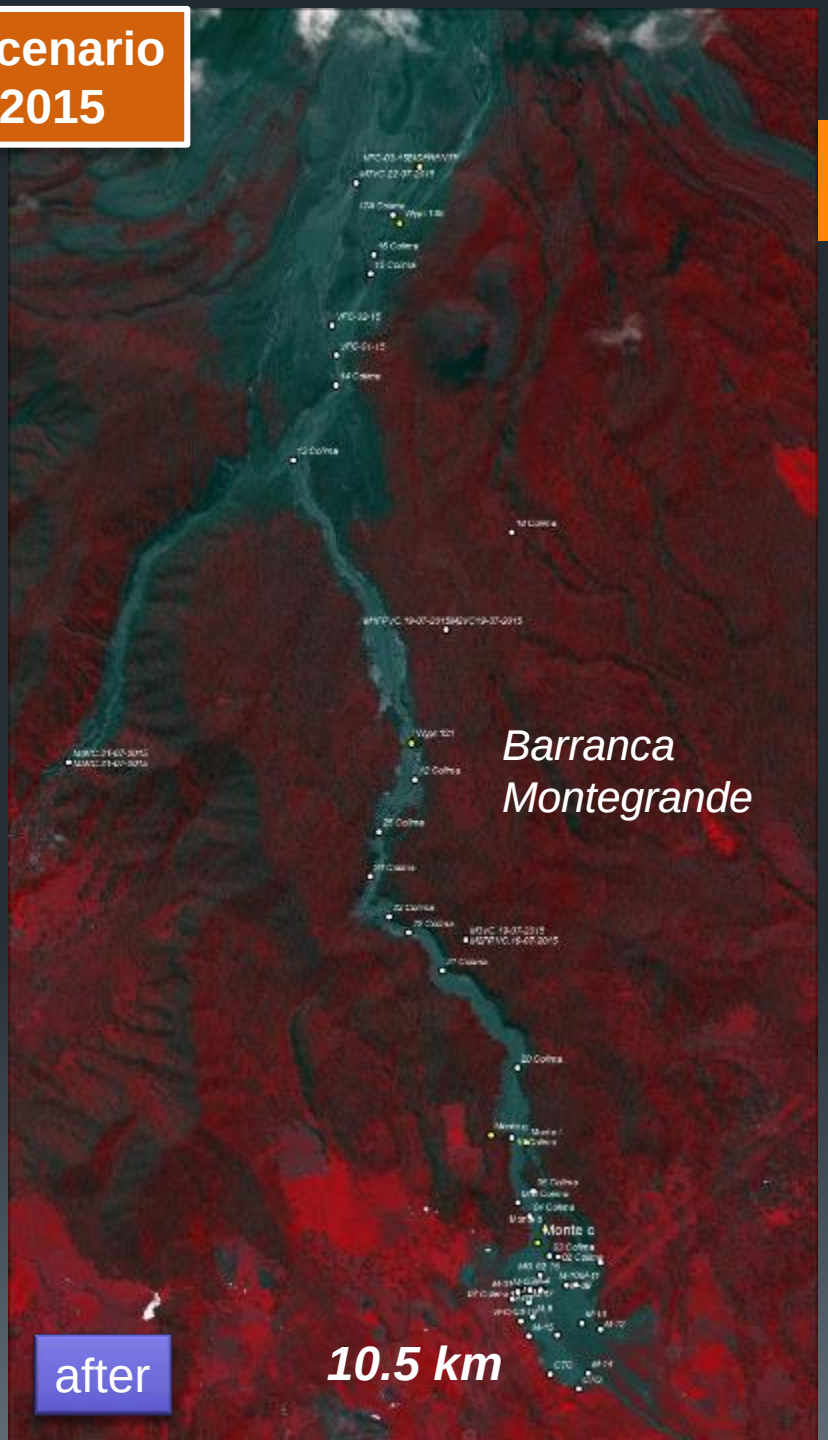
Geophone record

Before the 10-11 July eruption

… AND AFTER

Unespected scenario
July 10-11, 2015





2015 Block-and-ash flow deposits

Montegrande ravine, 2015

Improved with:

- Raspberry Shake 4D
- DataCube+Lennartz 3Dlite

<u>At 500m upflow</u>

- Broad band station
- *Infrasound Chaparrales*

<u>At 900 m downflow</u>

- *DataCube+Lennarrts 3Dlite*

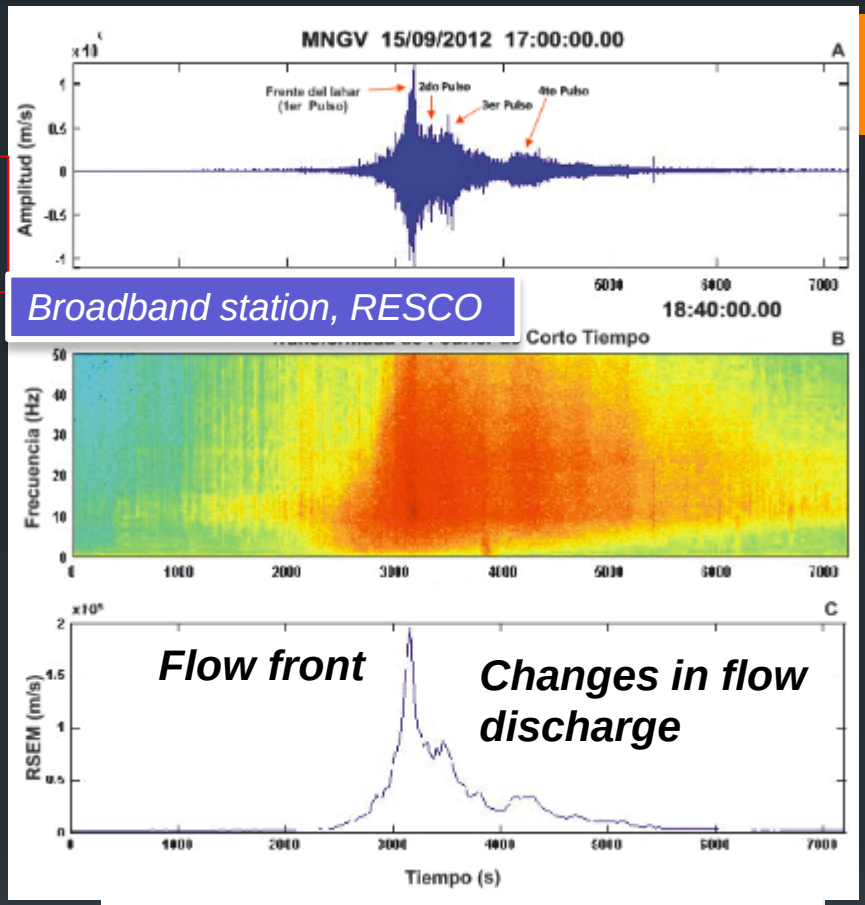
Lumbre ravine, 2013

- Geophone 10Hz
- Raspberry shake 4.5Hz (3D)
- Broadband station
- Accelerometer
- Flow stage

Lumbre station, radio repeater at Nevado de Colima, 2014

1) First seismological characterization, Vázquez et al., 2016

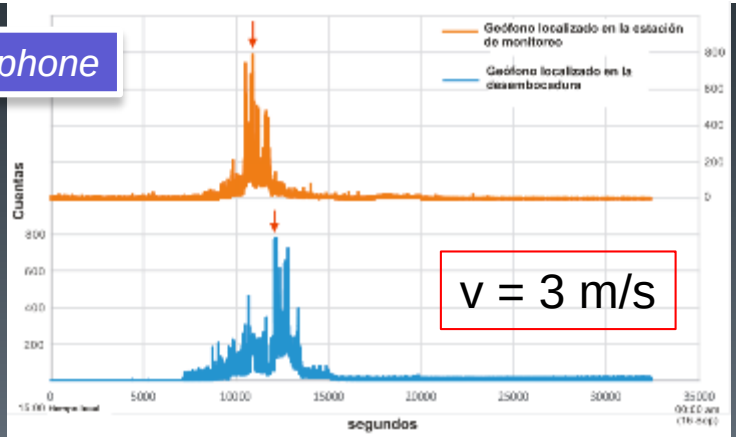
I = 95 mm/hr
20 mm



Broadband station, RESCO

Flow front

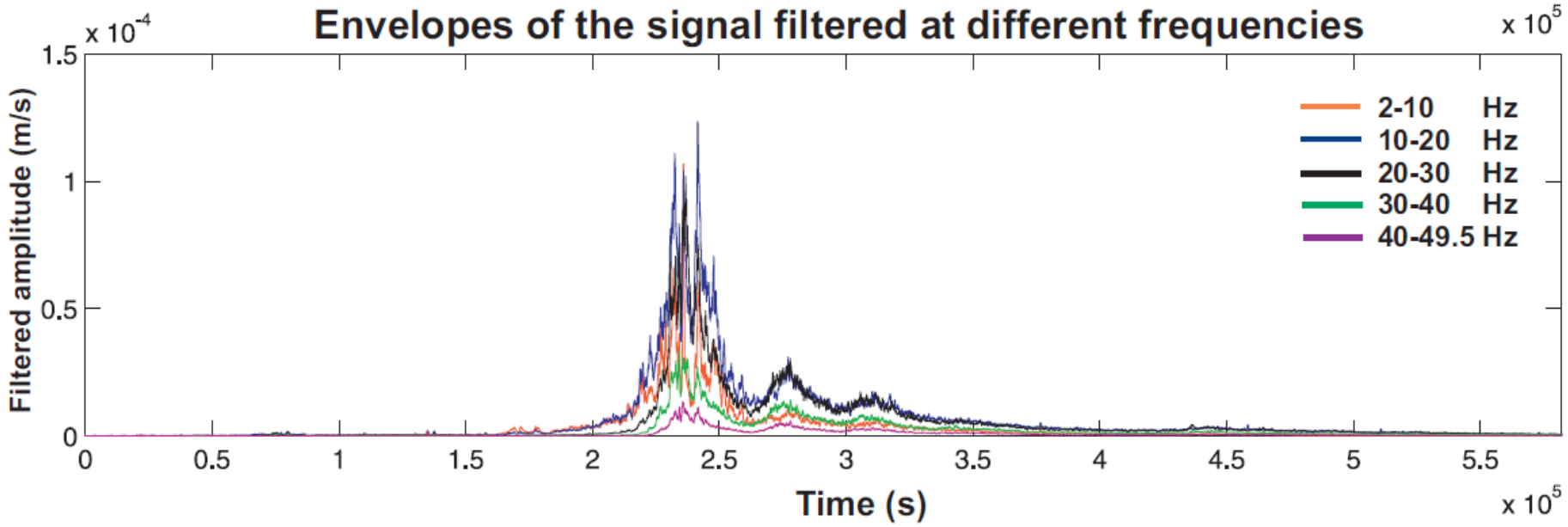
geophone



v = 3 m/s

1) Frequency content, Vázquez et al., 2016

- Blocky-front dominated by 10-20 Hz frequencies
- Main body 20-40 Hz



2) Transport and depositional processes, Vazquez et al., 2014

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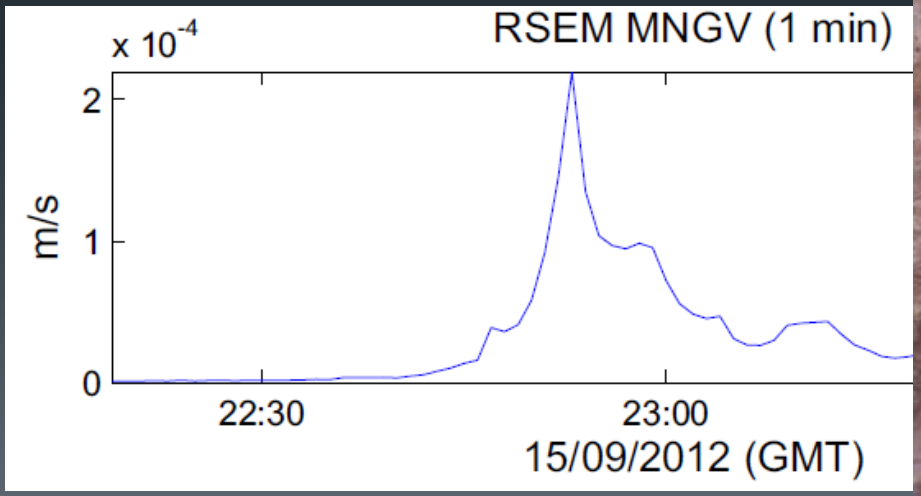
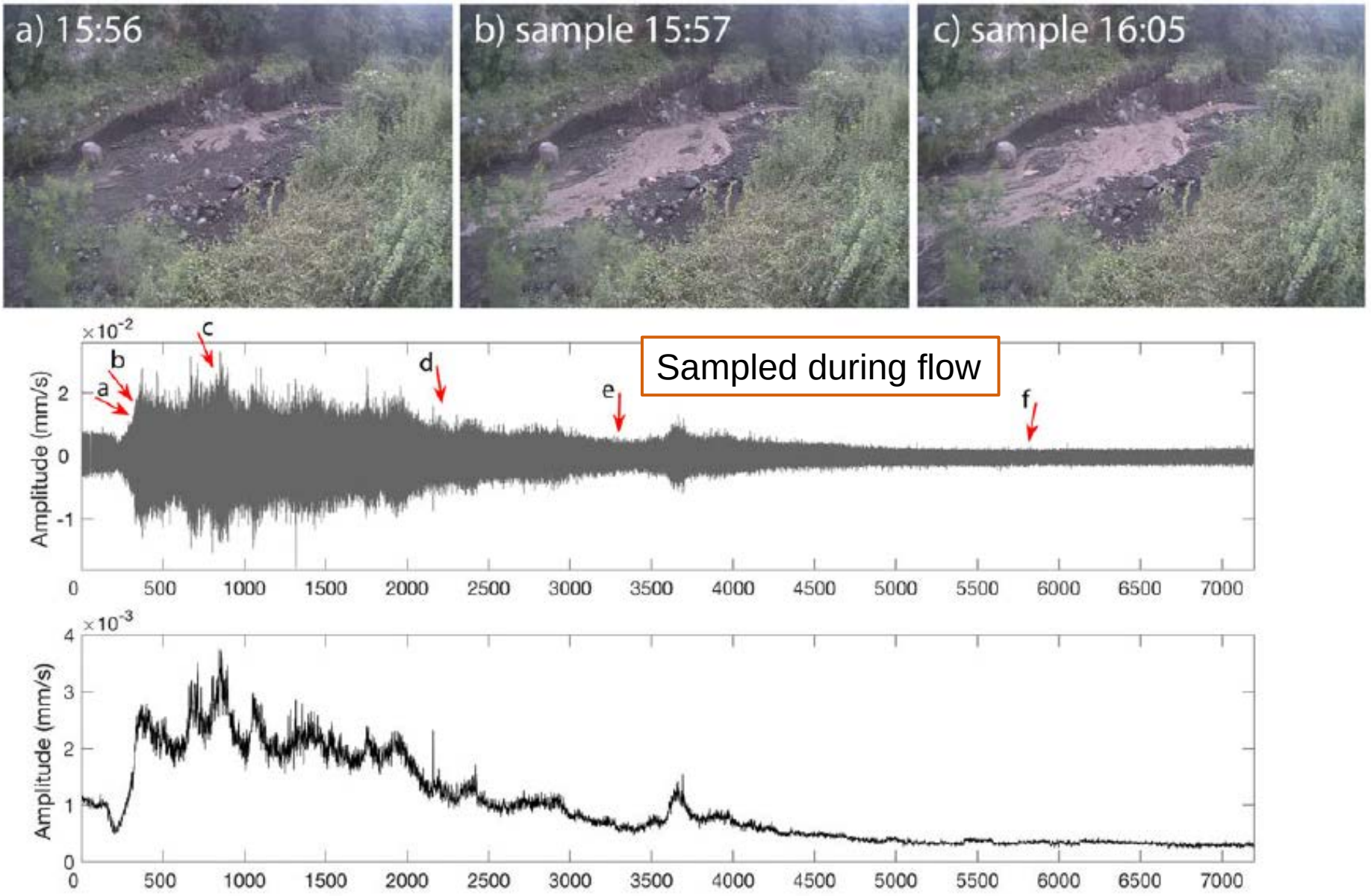
Sedimentation rate ~3 cm/min

3 main surges: 3 depositional units



3) Sediment volume vs. seismic amplitude and frequency, Coviello et al., 2018, toward the warning system

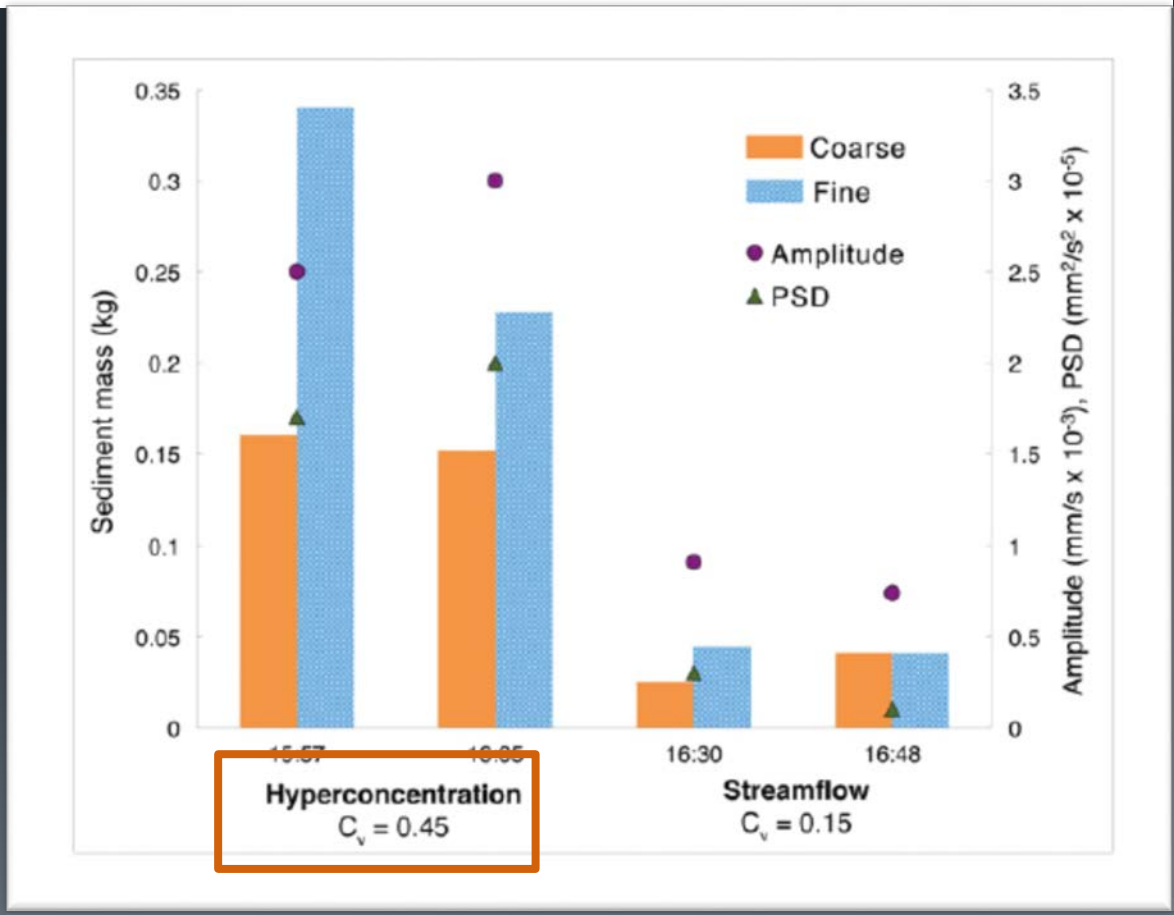


3) Sediment volume vs. seismic amplitude and frequency, Coviello et al., 2018

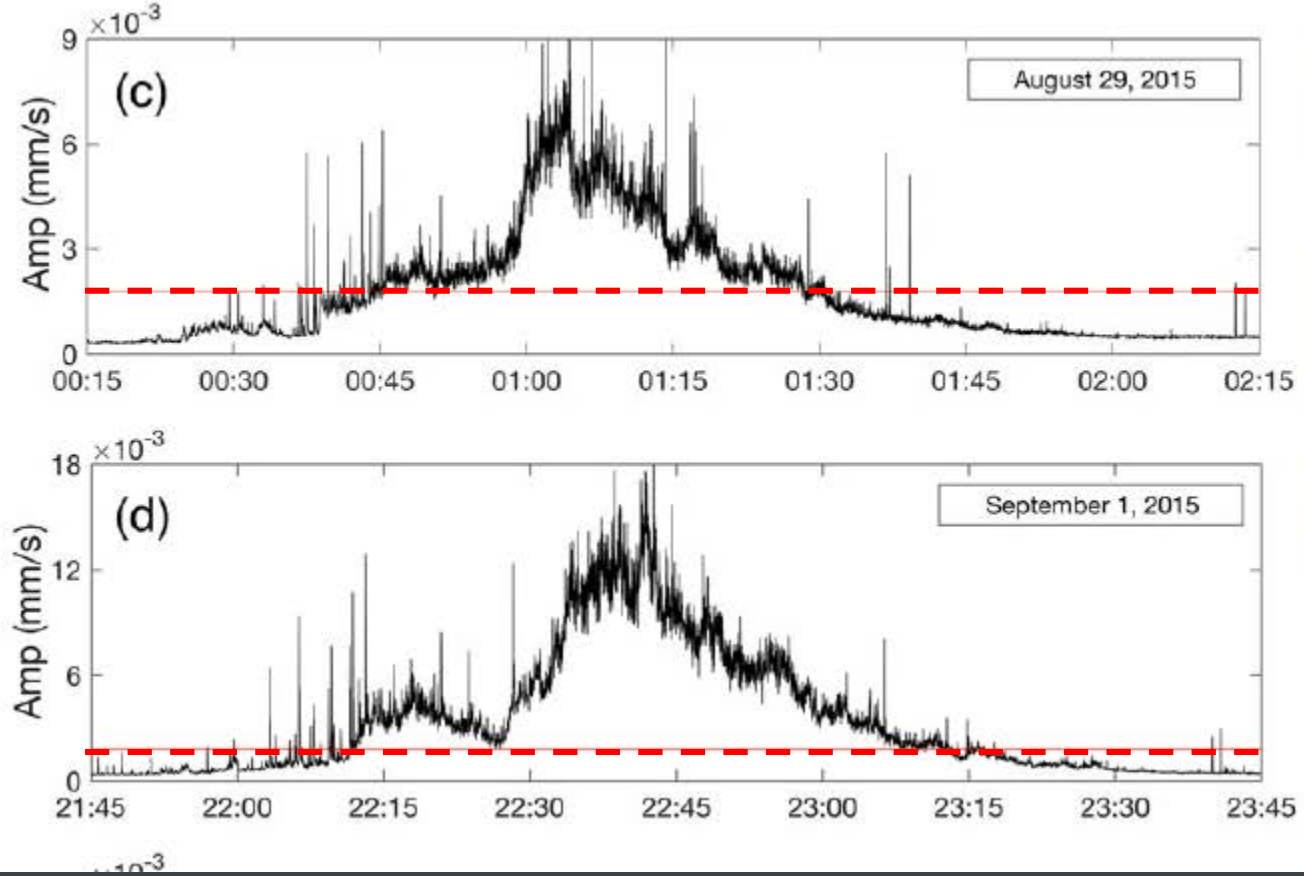
	Amplitude (mm/s)	PSD (mm^2/s^2)	ρ_m (kg/m^3)	μ_m (Ns/m^2)	τ_y (N/m^2)
Sample at 15:57	2.5×10^{-3}	1.7×10^{-5}	1710	2.75	8.39
Sample at 16:05	3×10^{-3}	2×10^{-5}	1759	4.79	14.09
Sample at 16:30	0.91×10^{-3}	0.3×10^{-4}	1297	0.03	0.11
Sample at 16:48	0.74×10^{-3}	0.1×10^{-4}	1248	0.02	0.07

Note: With the different value of volumetric sediment concentration C_v measured in laboratory, specific mass ρ_m, dynamic viscosity μ_m and yield stress τ_y of the four samples were calculated.

From hyperconcentrated to stream flow

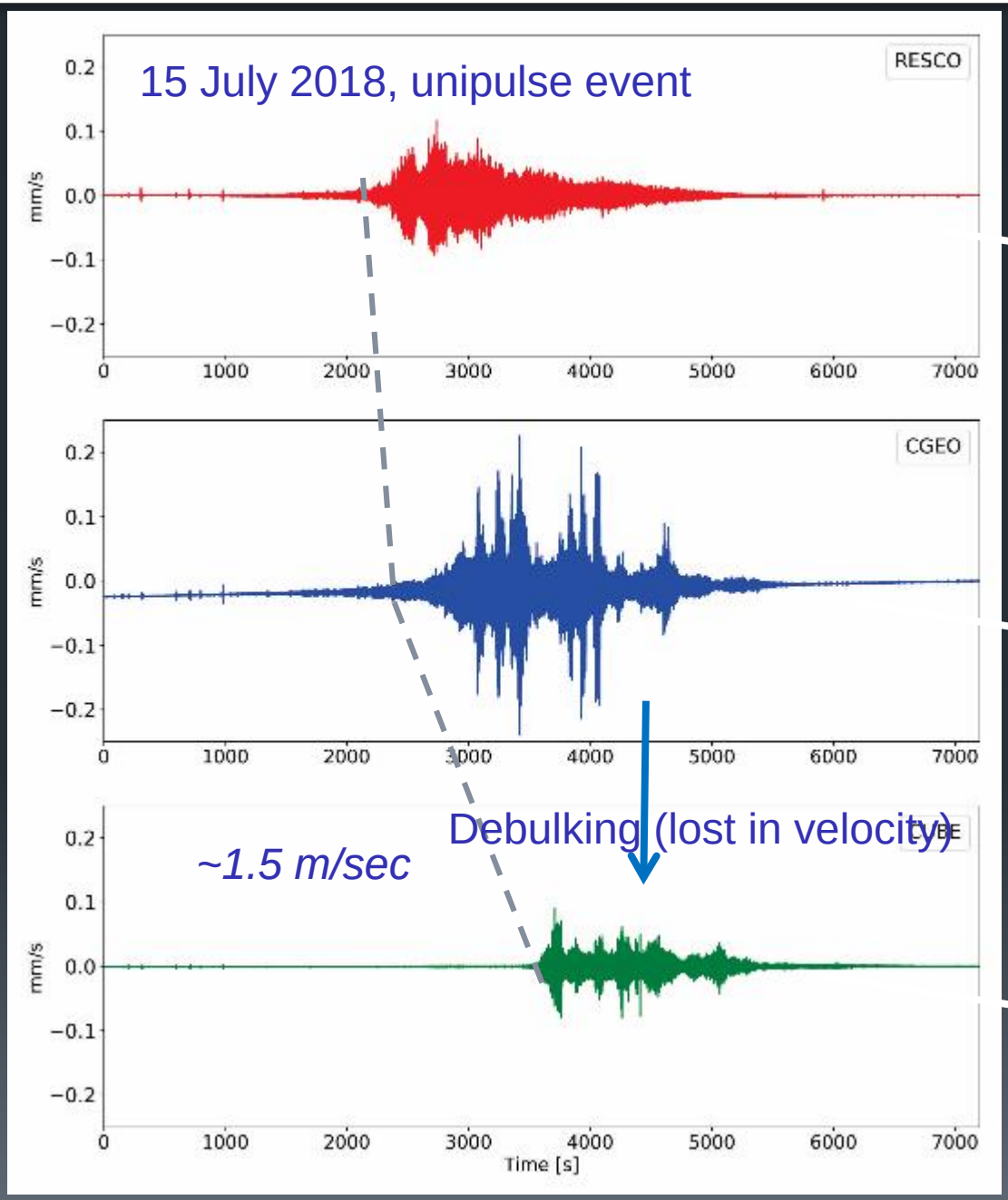


3) Sediment volume vs. seismic amplitude and frequency, Coviello et al., 2018



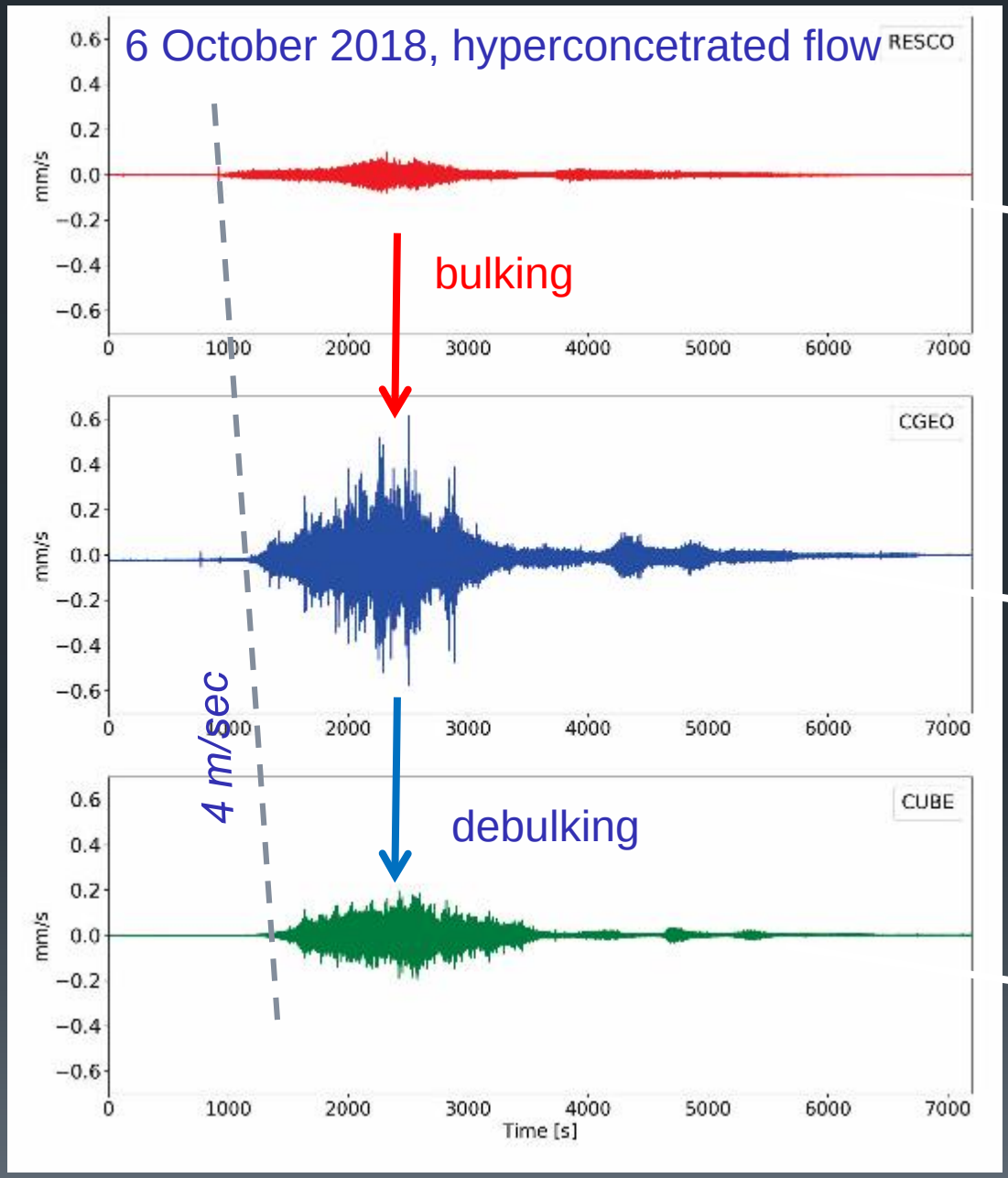
Warning system to detect hyperconcetrated flow
(Cv 0.45)
Amplitude threshold 10^{-3} mm/s

5) erosion: bulking-debulking (Ivonne Martínez poster)



Seismic data from
DataCube
Lennartz 3Dlite MkIII

5) erosion: bulking-debulking



Seismic data from
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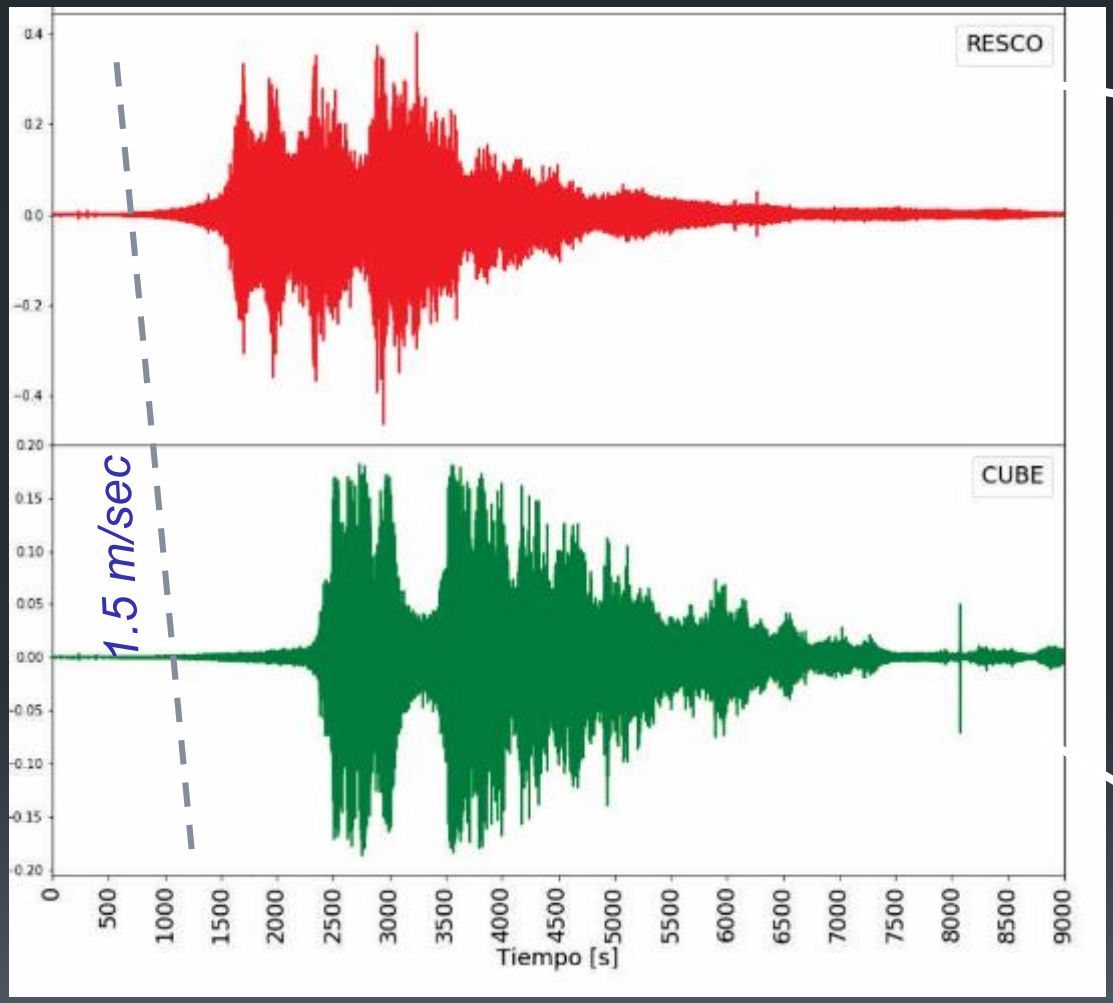
5) erosion: bulking-debulking

3 October 2018, multipulse event

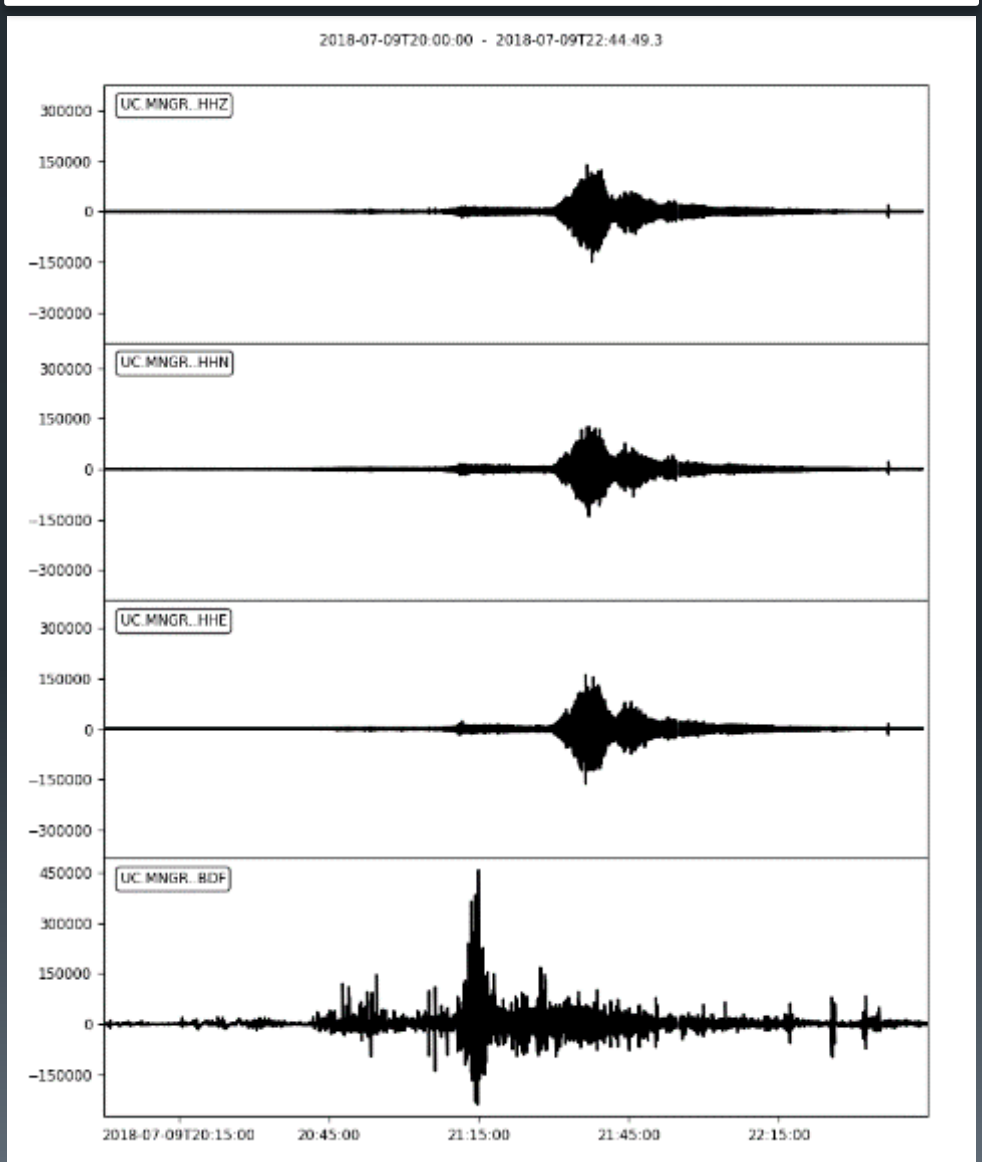
Seismic data from
DataCube
Lennartz 3Dlite MkIII




Geociencias UNAM
2018-10-03 GMT 23:53:55
00:51,72

WHAT NEXT?

Infrasound for warning system?

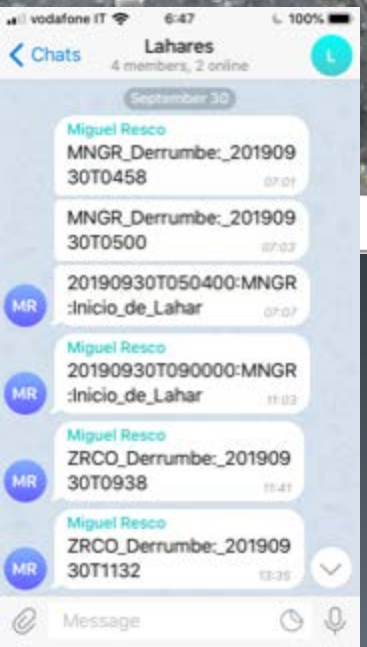


Analysis of the cross-channel seismic component
Braden Walsh

Data from accelerometer. Flow mass?
Braden Walsh

Numerical modeling to compare “synthetic” seismic signal with real signals

Web page
The Image refreshes each minute



Gracias por su atención!