

What are the key elements that control the seismic signature of highly concentrated sediment flows?

Marco Piantini

Florent Gimbert

Evangelos Korkolis

Romain Rousseau

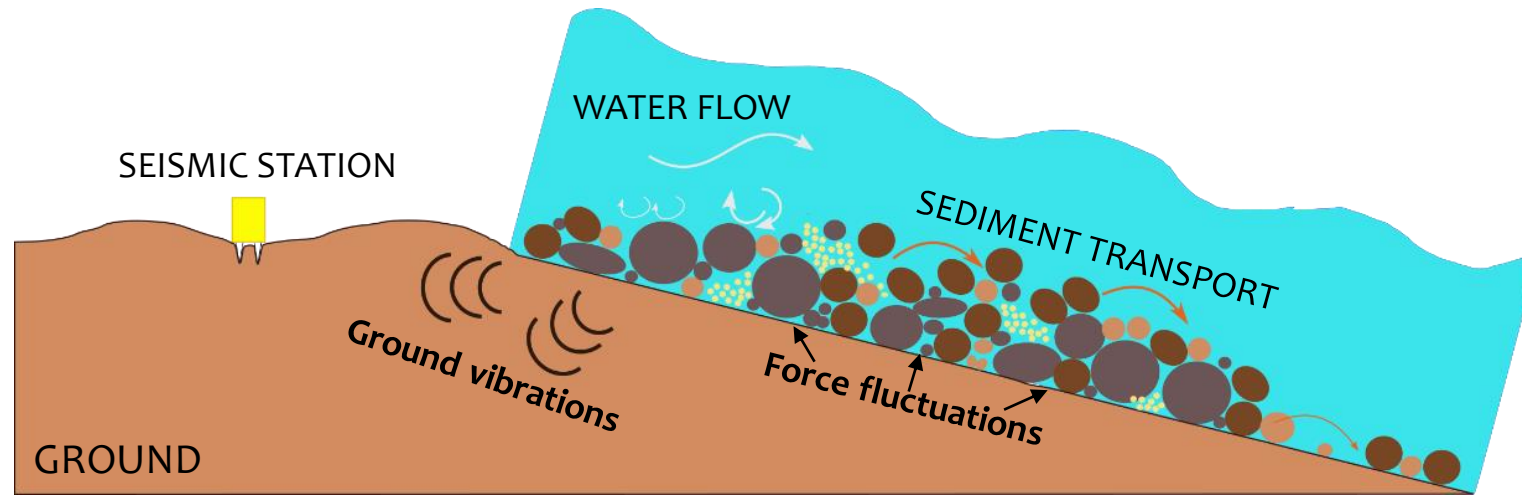
Hervé Bellot

Alain Recking



Introduction

Seismic monitoring of fluvial processes



Why seismic methods ?

- 👍 Non-invasive
- 👍 Continuous
- 👍 Cost-effective

Ground vibrations



Estimation of flow properties

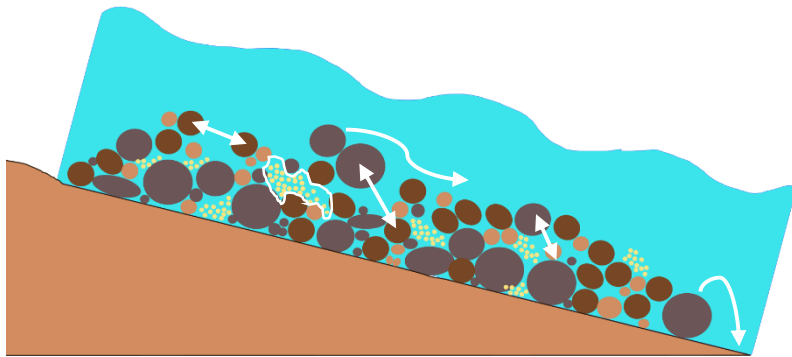
Bedload transport

Highly concentrated
sediment flows

Introduction

Highly concentrated sediment flows

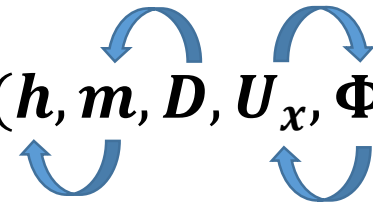
Flow properties  Basal force fluctuations (F')



Recent literature

(Cole et al., 2009; Tsai et al., 2012; McCoy et al., 2013; Hsu et al., 2014; Farin et al., 2019; Allstadt et al., 2020; Haas et al., 2021; Zhang et al., 2021)



$$F' = f(h, m, D, U_x, \Phi, \dots)$$


h = flow surface elevation
 m = flow mass
 D = particle diameter
 U_x = flow velocity
 Φ = volumetric solid concentration

- 1) Complex physics
- 2) Divergent approaches for modelling

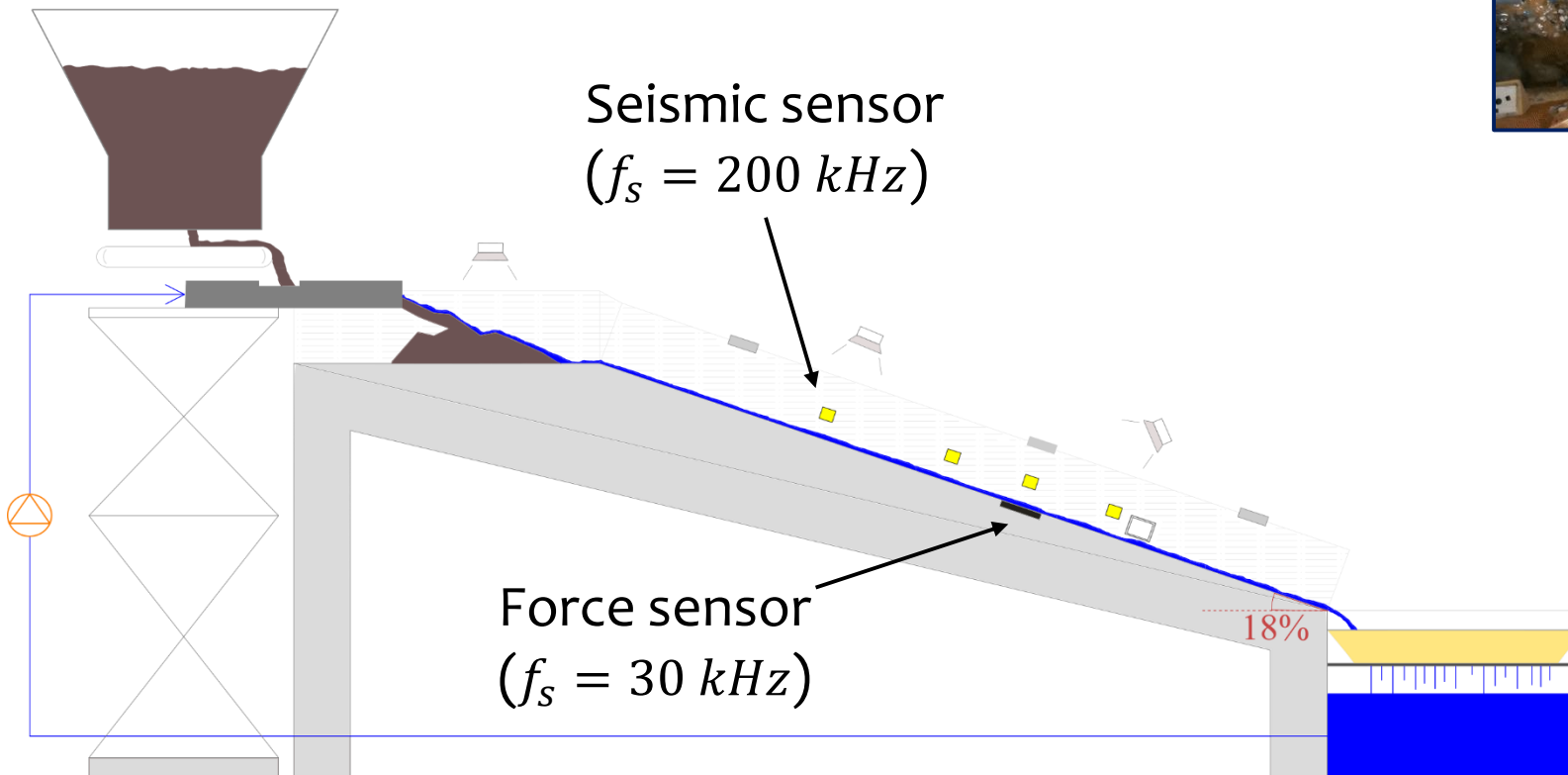
- ➡ How can we investigate such a complex physics?
- ➡ How can we properly interpret force fluctuations?

Methods

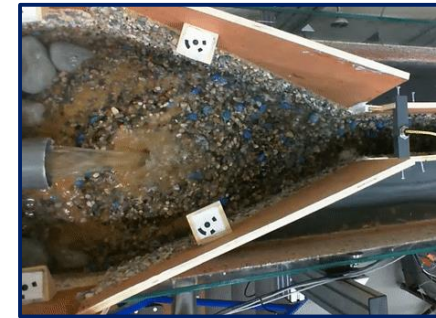
Downscaled flume experiments

Main goal: preserve the complexity of natural processes

- ➡ Self-triggering and propagation of sediment flows
- ➡ Wide bimodal grain size distribution



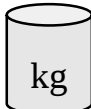
Upstream
storage area
(0,5x1,0 m)



Channel
(0,1x4,9 m)

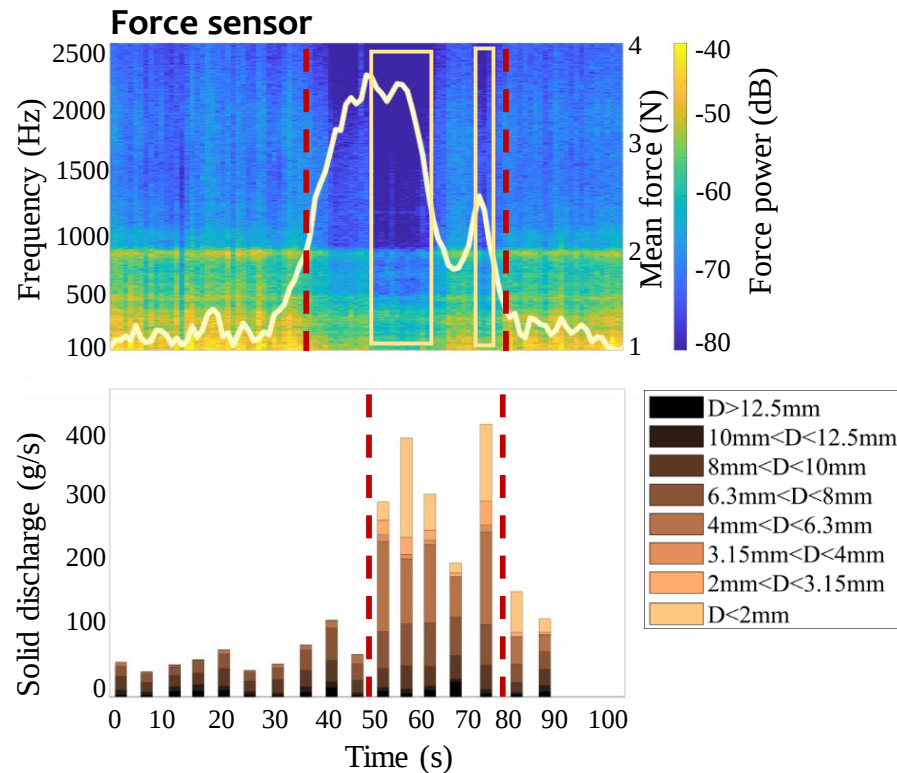
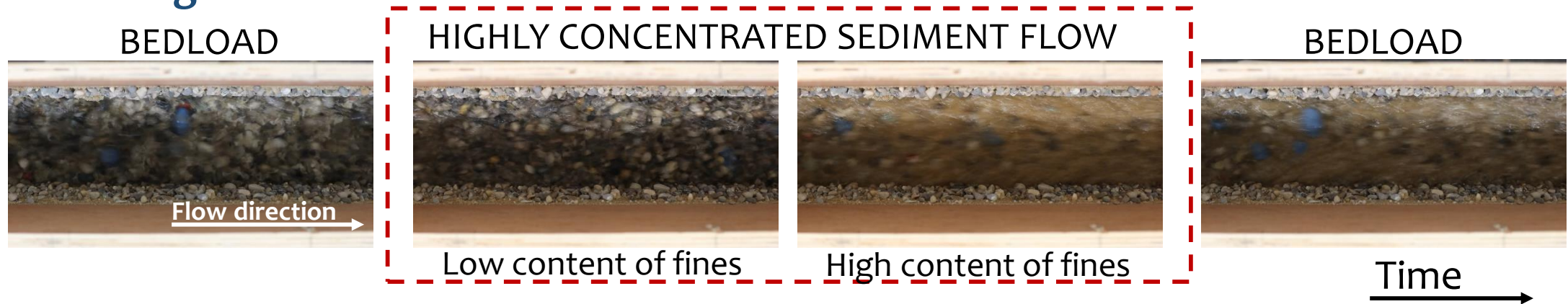


Supplementary measurements

-  Video recording
-  Flow surface elevation
-  Outlet solid discharge
+ sieve measurements

Results

General findings

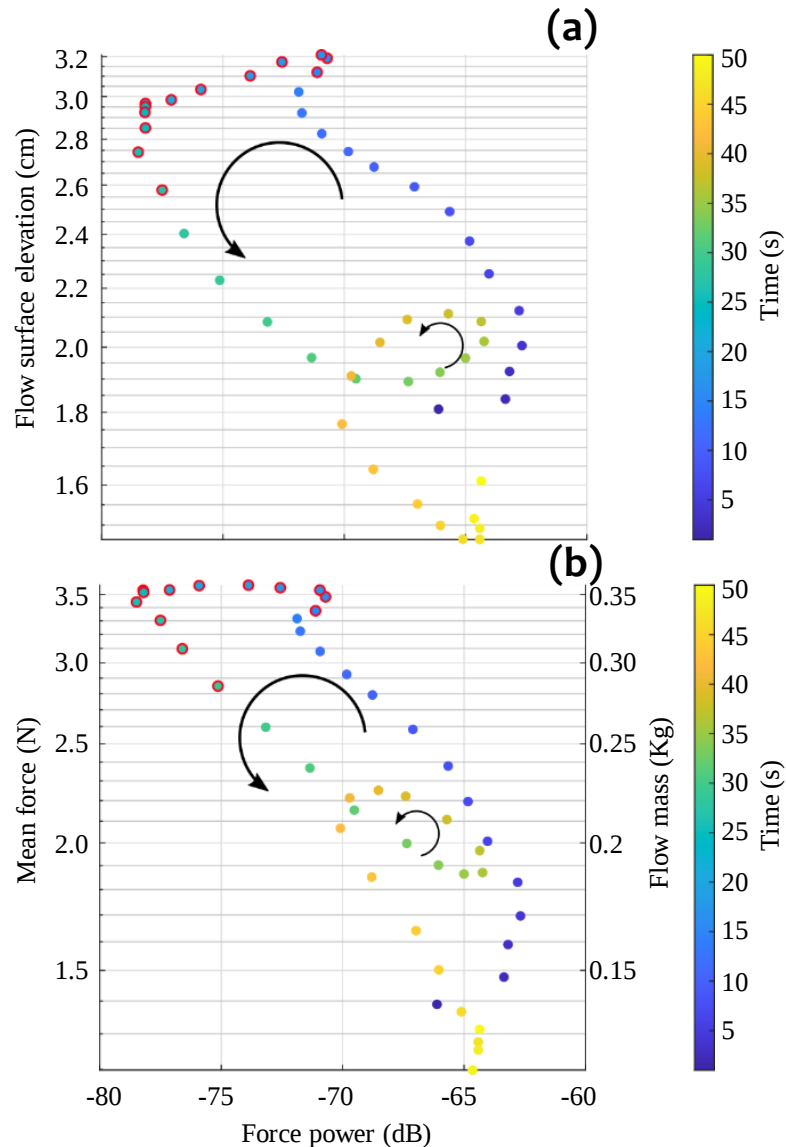


Main observations

- Varying force power
- Strong reduction when fines arrive ()

➡ What is the link with flow properties variations?

Results

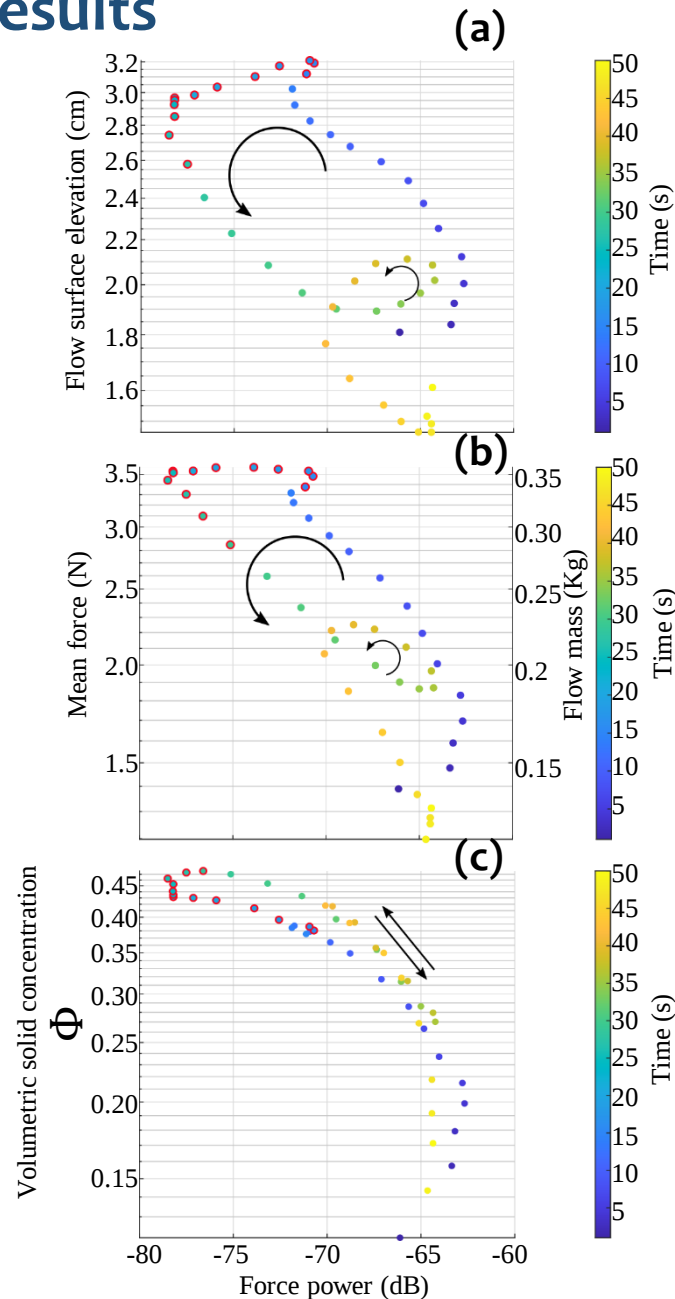


Main observations

h-F' and m-F'

- Overall negative correlations
- ➔ Not consistent with many studies
(*Hsu et al., 2009; Allstadt et al., 2020; Zhang et al., 2021*)
- Wide counterclockwise hysteresis and loops
- ➔ Not a primary control on F'

Results



Main observations

h - F' and m - F'

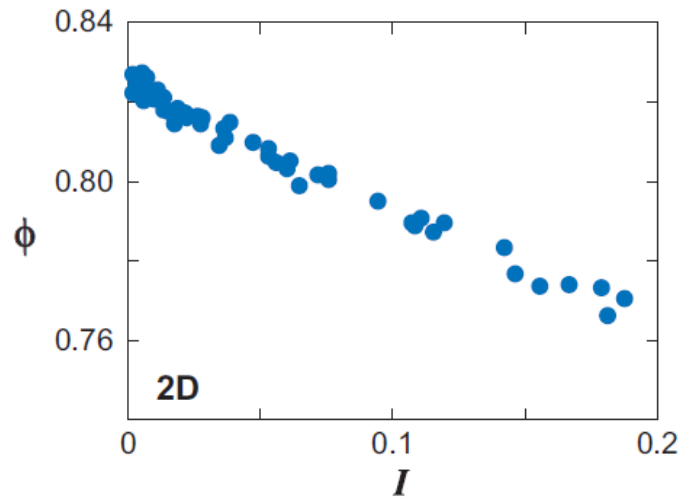
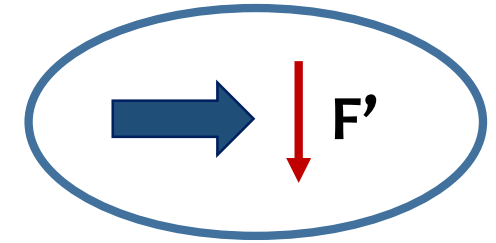
- Overall negative correlations
- ➔ Not consistent with many studies (*Hsu et al., 2009; Allstadt et al., 2020; Zhang et al., 2021*)
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- ➔ Not a primary control on F'

Φ - F'

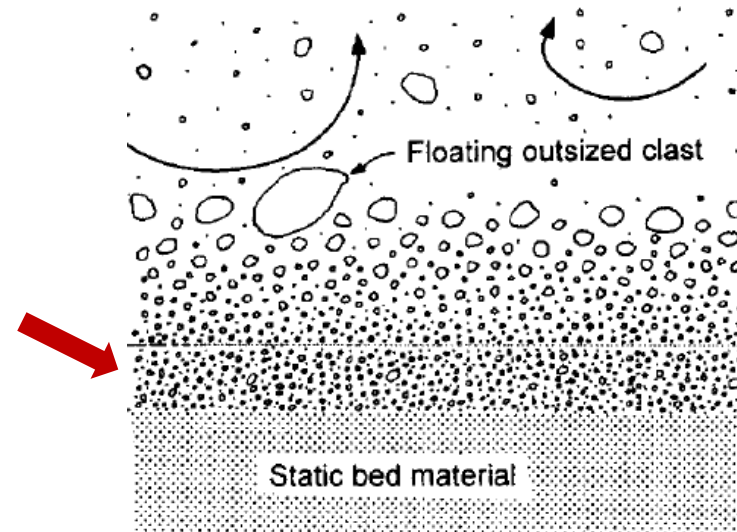
- Clear negative correlation in Φ - F'
- ➔ Consistent with recent studies (*Allstadt et al., 2020; Zhang et al., 2021*)
- Hysteresis and loops suppressed in Φ - F'
- ➔ Primary control on flow physics and F' !

Discussion and conclusions

$\uparrow \Phi$ = Particle agitation + $\uparrow$ Frictional enduring contacts



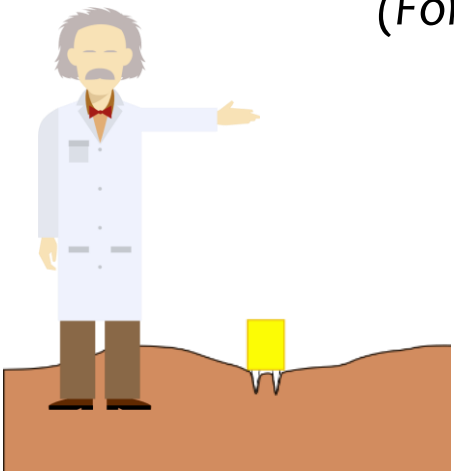
(Forterre & Pouliquen, 2008)



(Sohn, 1997)

Take-home message

Volumetric solid concentration controls the physics and the seismic signature of highly concentrated sediment flows



THANK YOU FOR YOUR ATTENTION AND... CONCENTRATION (Φ)!

Marco Piantini ¹

Florent Gimbert

Evangelos Korkolis

Romain Rousseau

Hervé Bellot

Alain Recking

(marco.piantini@univ-grenoble-alpes.fr)

