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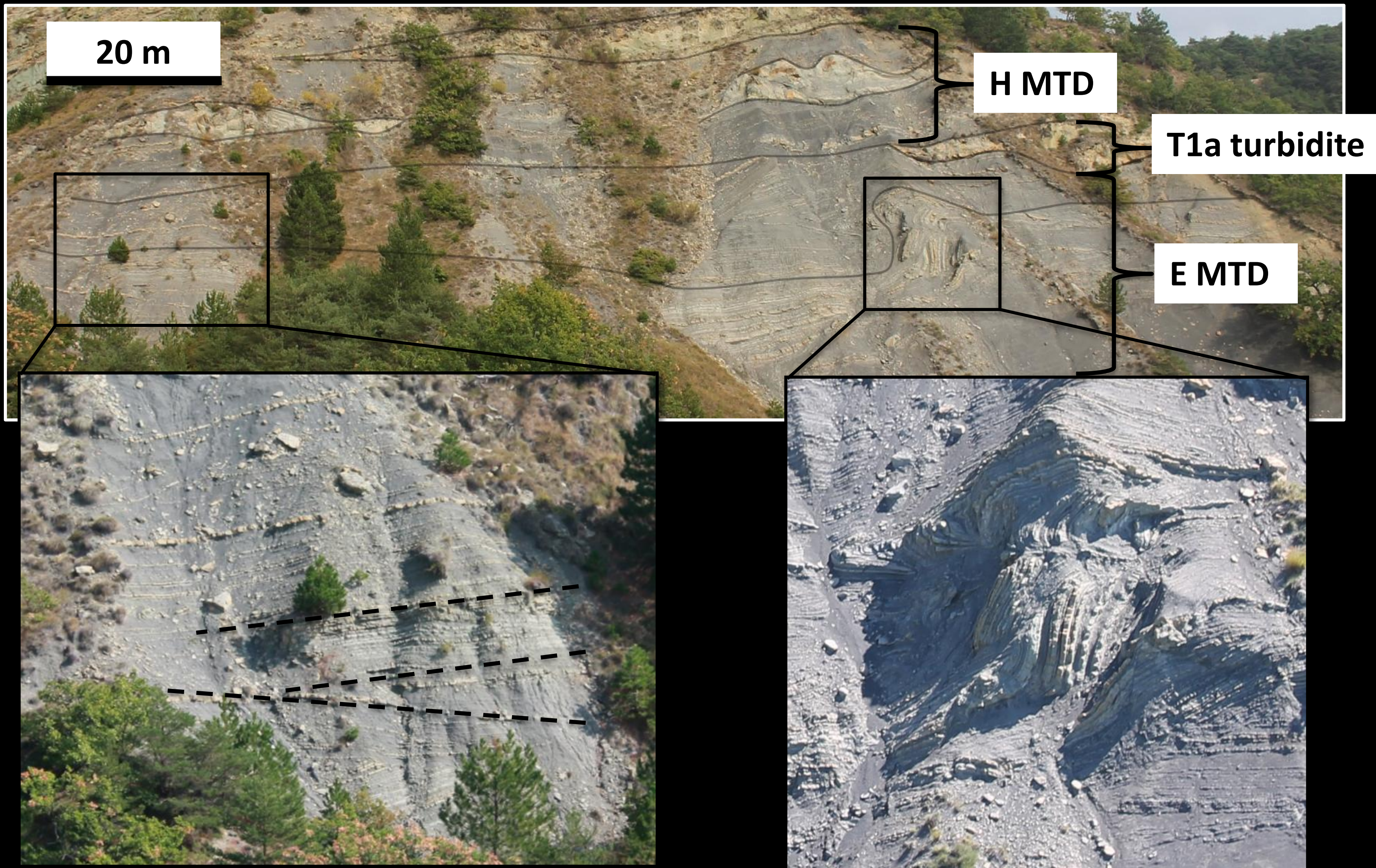
Single grains, dense suspensions (and disperse grainsize distributions) in turbidity currents; a geologist's perspective.

Modern environments

Rock Record (Aptian ~120 Ma)

Relation turbidite sand with underlying MTD; Les Cosmes

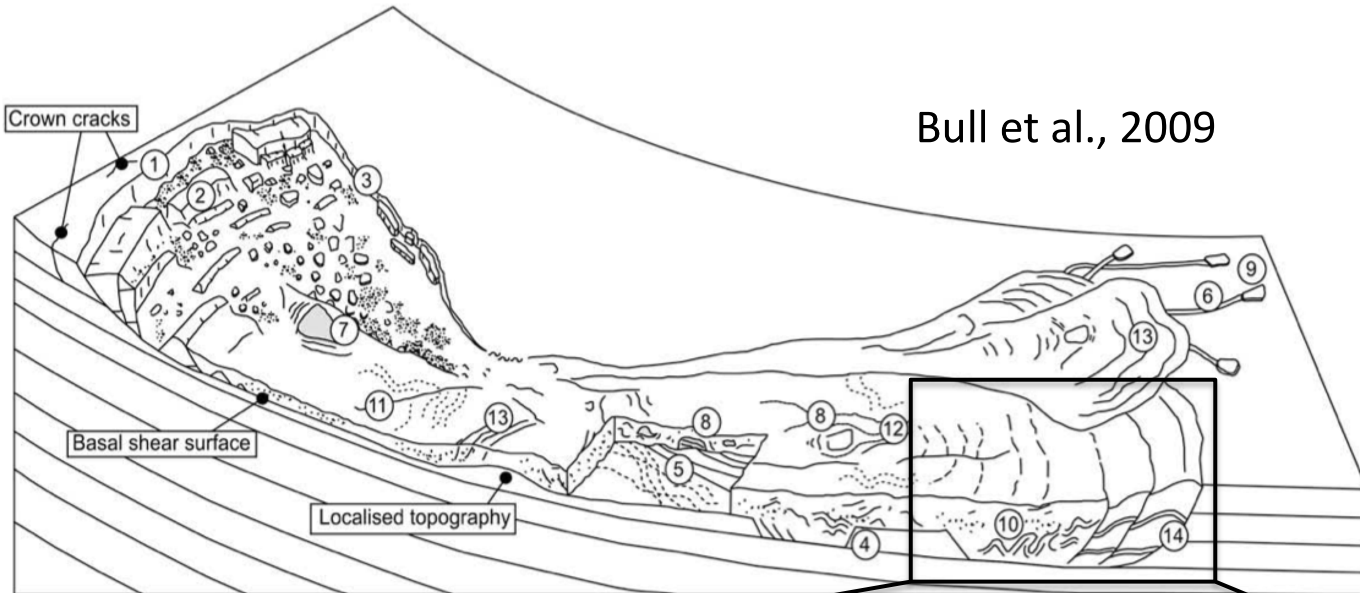


Rock Record (Aptian ~120 Ma)

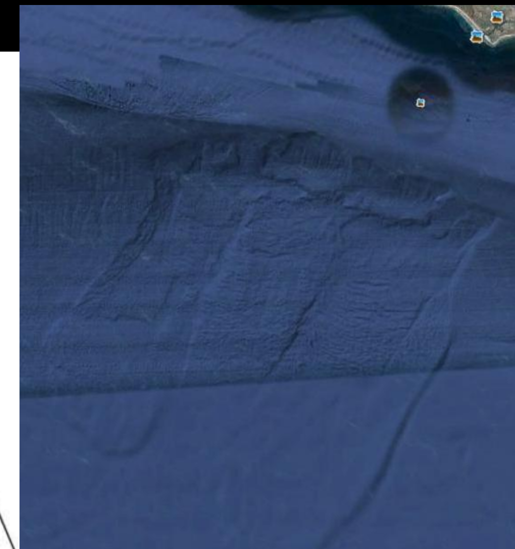
Relation turbidite sand with underlying MTD; Les Cosmes

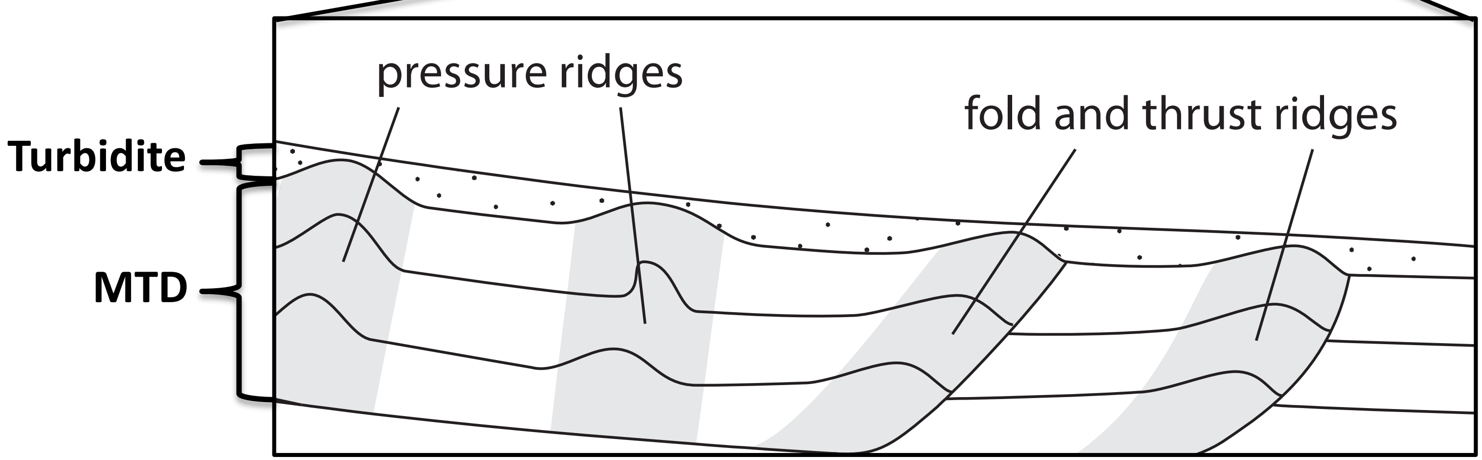
Rock Record (Aptian ~120 Ma)

Interpretation of sand-MTD relation



Bull et al., 2009

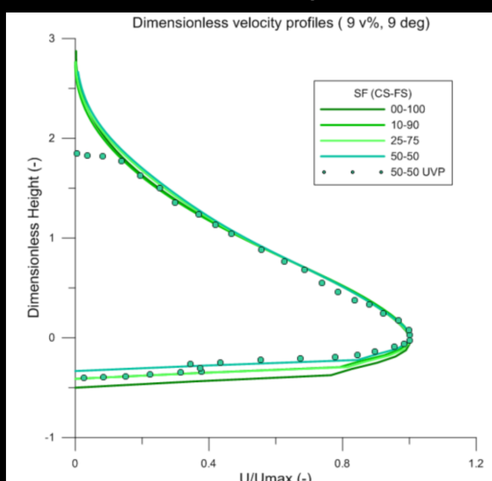




Modern Environments

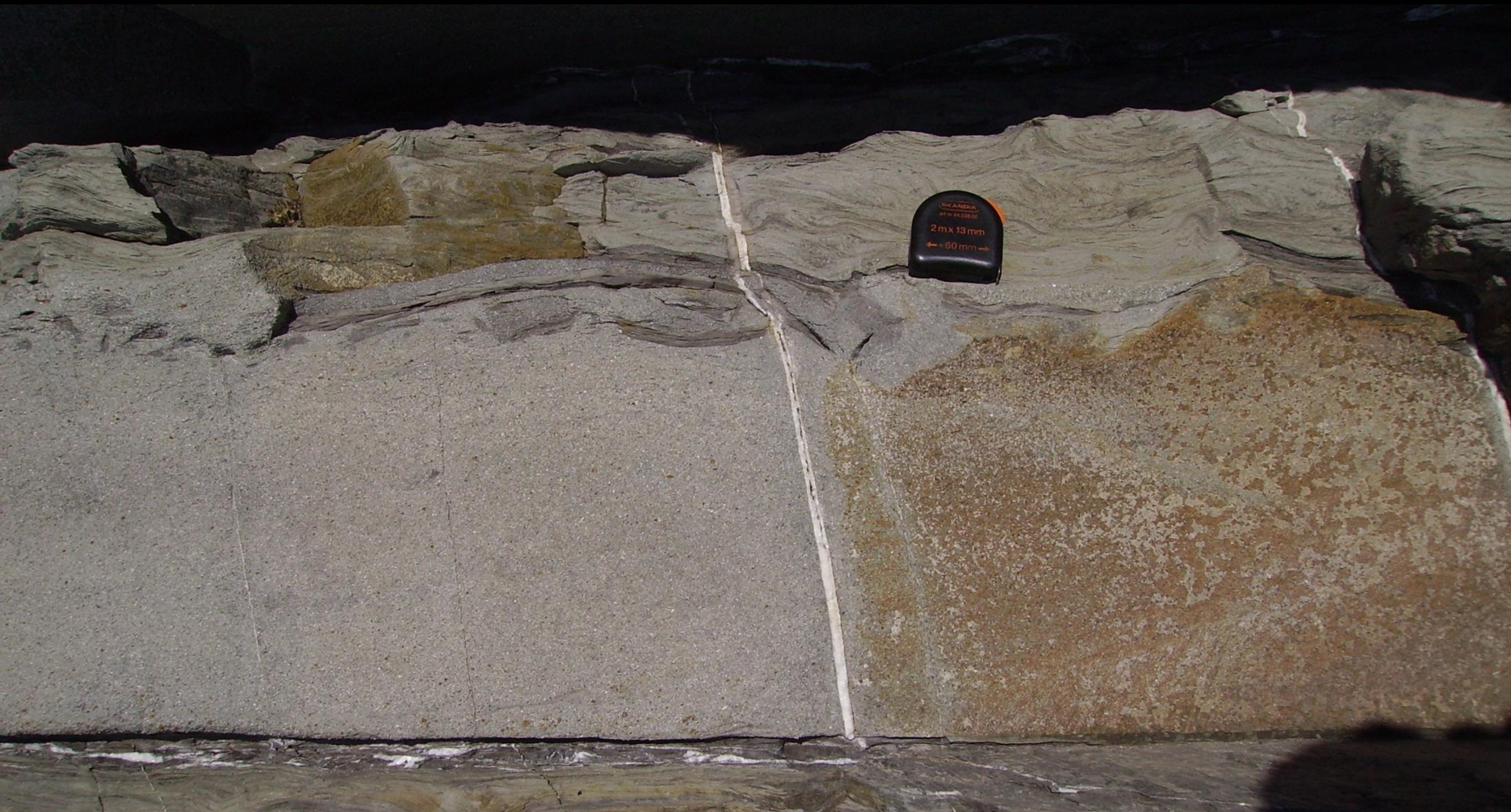
Rock Record

Numerical Experiment



Physical Experiment

Problem Definition



Problem Definition

?

Process Understanding

Empowers **Prediction**

?

?

?

Parameter ranges: Grainsize Distribution [mud-8000 micron]; Grain shape: number of spheres = 0

d= 1.1 mm

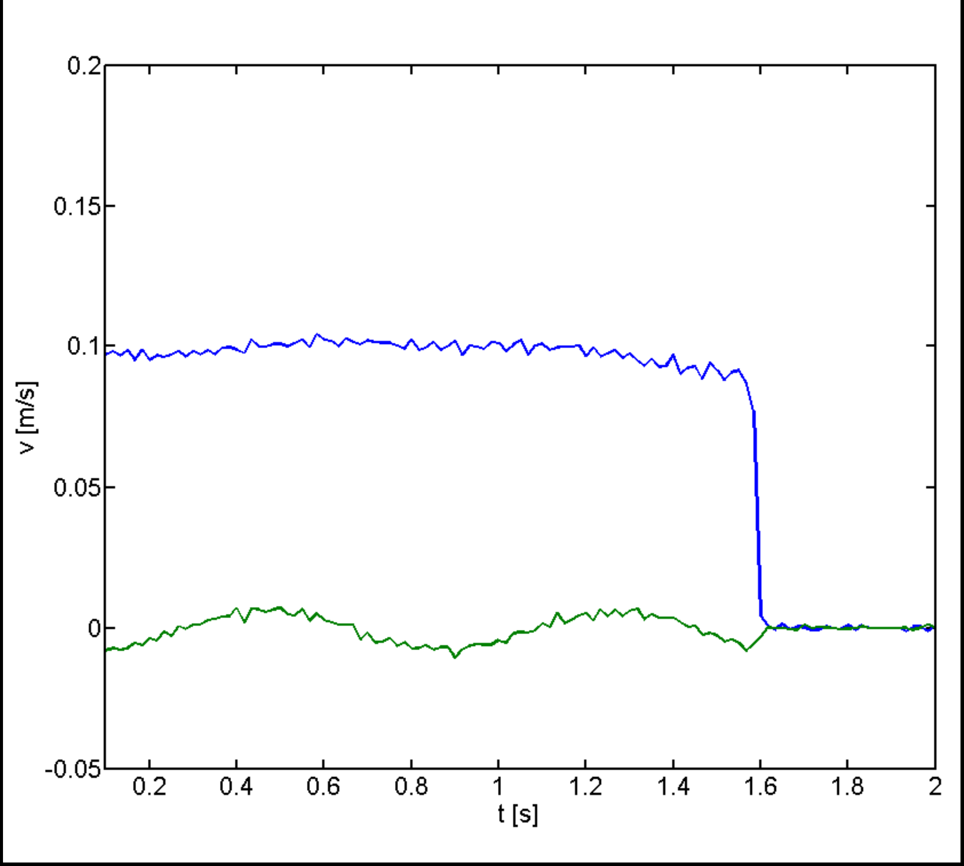
v_s= 0.098 m/s

v_{spred} (Ferguson&Church, 2004)= 0.13 m/s

$St = m_p v_s / 6\pi \mu r^2 = 32$

$Re_p = r v_s / \nu = 54$

Time to rest = 0.05 s



d= 1.1 mm

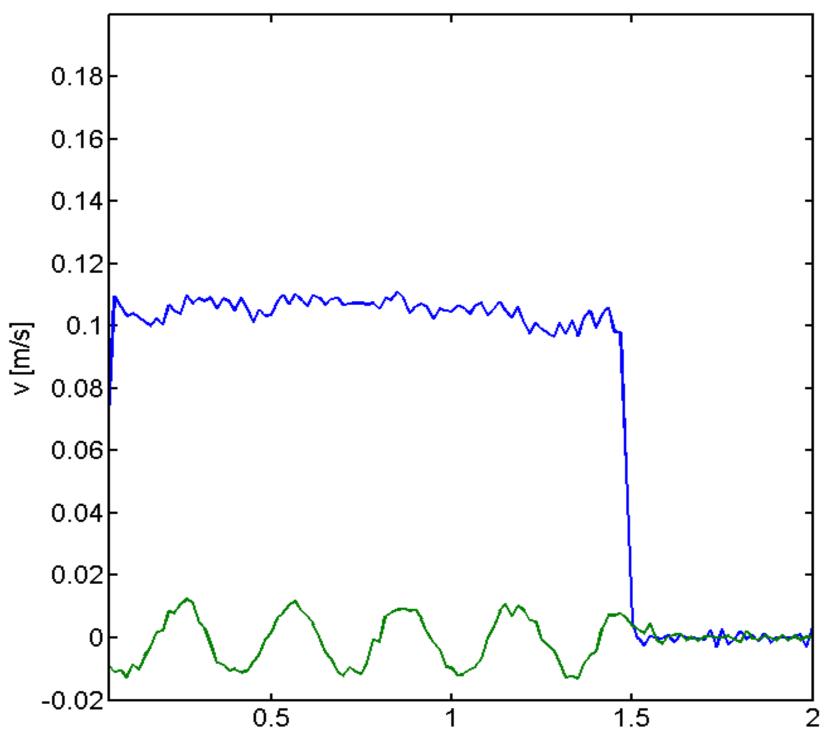
v_s= 0.10 m/s

v_{spred} = 0.13 m/s

St = 36

Re_p 60

Time to rest = 0.1 s



d= 2.0 mm

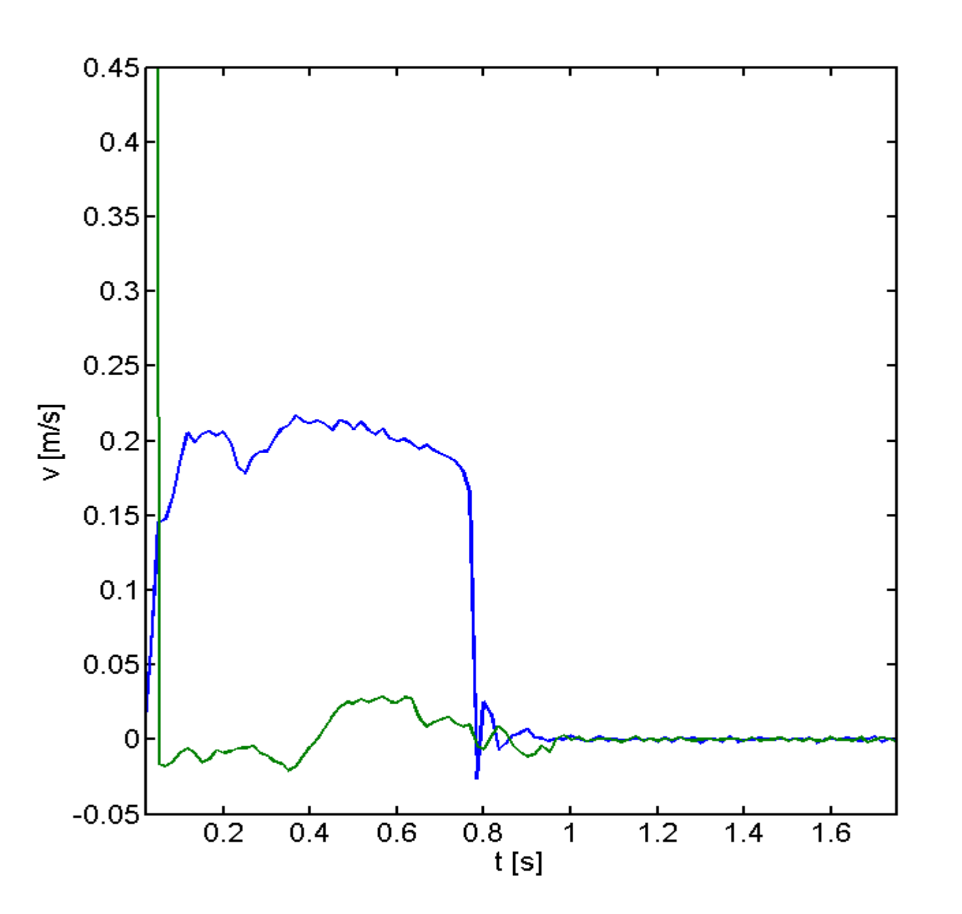
v_s= 0.21 m/s

v_{spred} = 0.19 m/s

St = 118

Re_p 201

Time to rest = 0.22 s



d= 3.1 mm

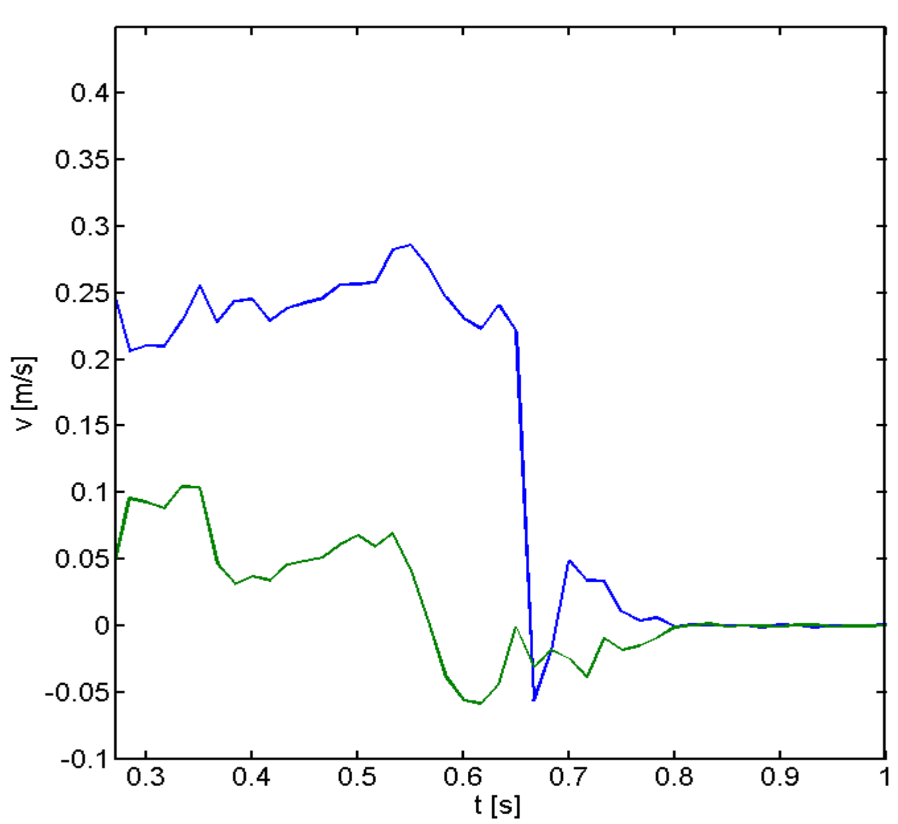
v_s= 0.24 m/s

v_{spred} = 0.25 m/s

St = 222

Re_p 377

Time to rest = 0.15 s



$d =$ 4.4 mm

$v_s =$ 0.29 m/s

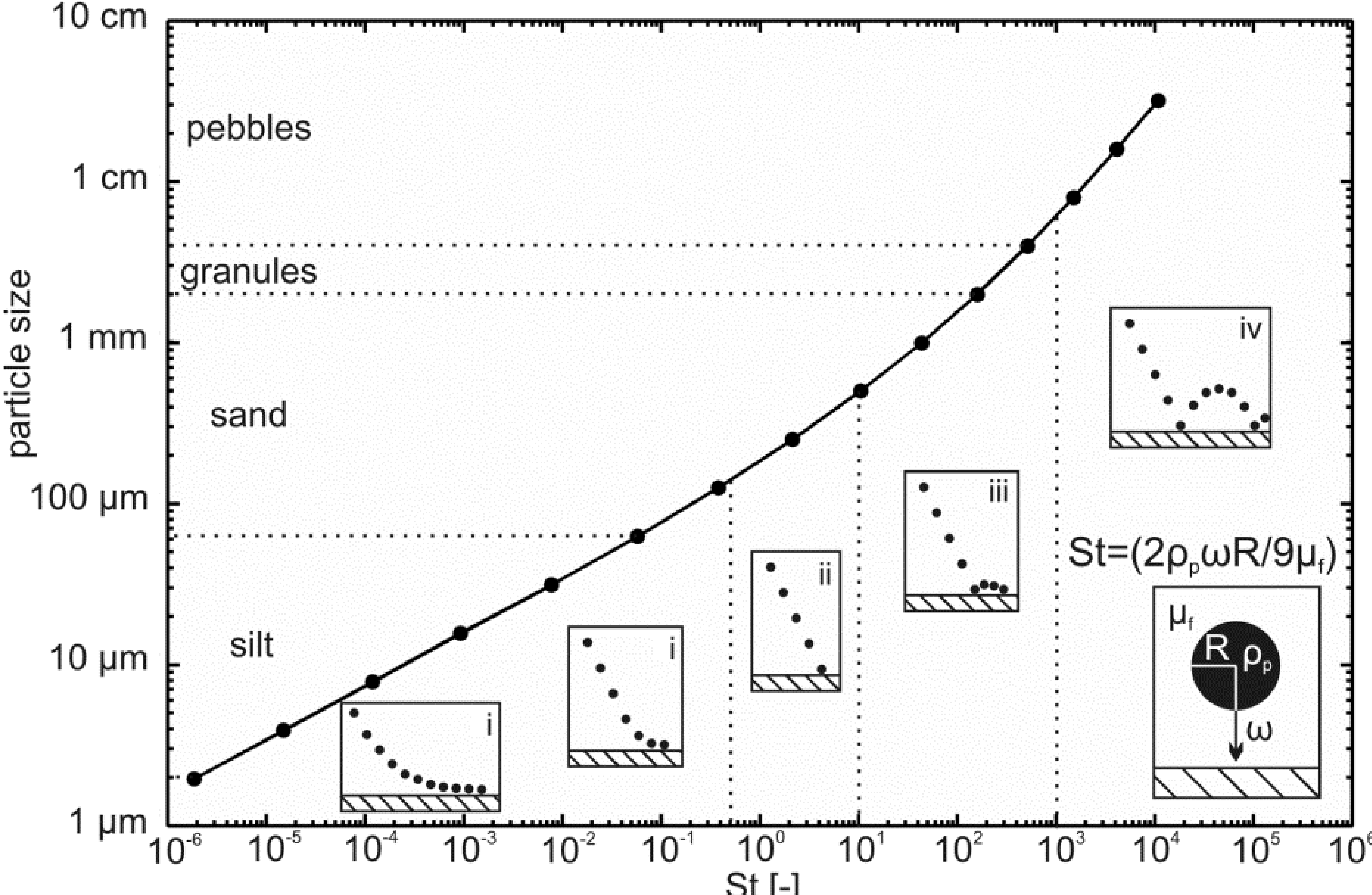
v_{spred} = 0.30 m/s

St = 375

Re_p 640

Time to rest = 0.23 s

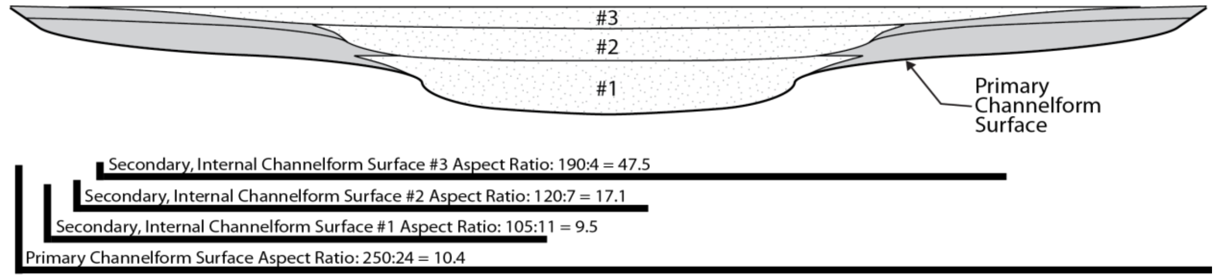
Figure 4. Settling behaviour of particles approaching a boundary



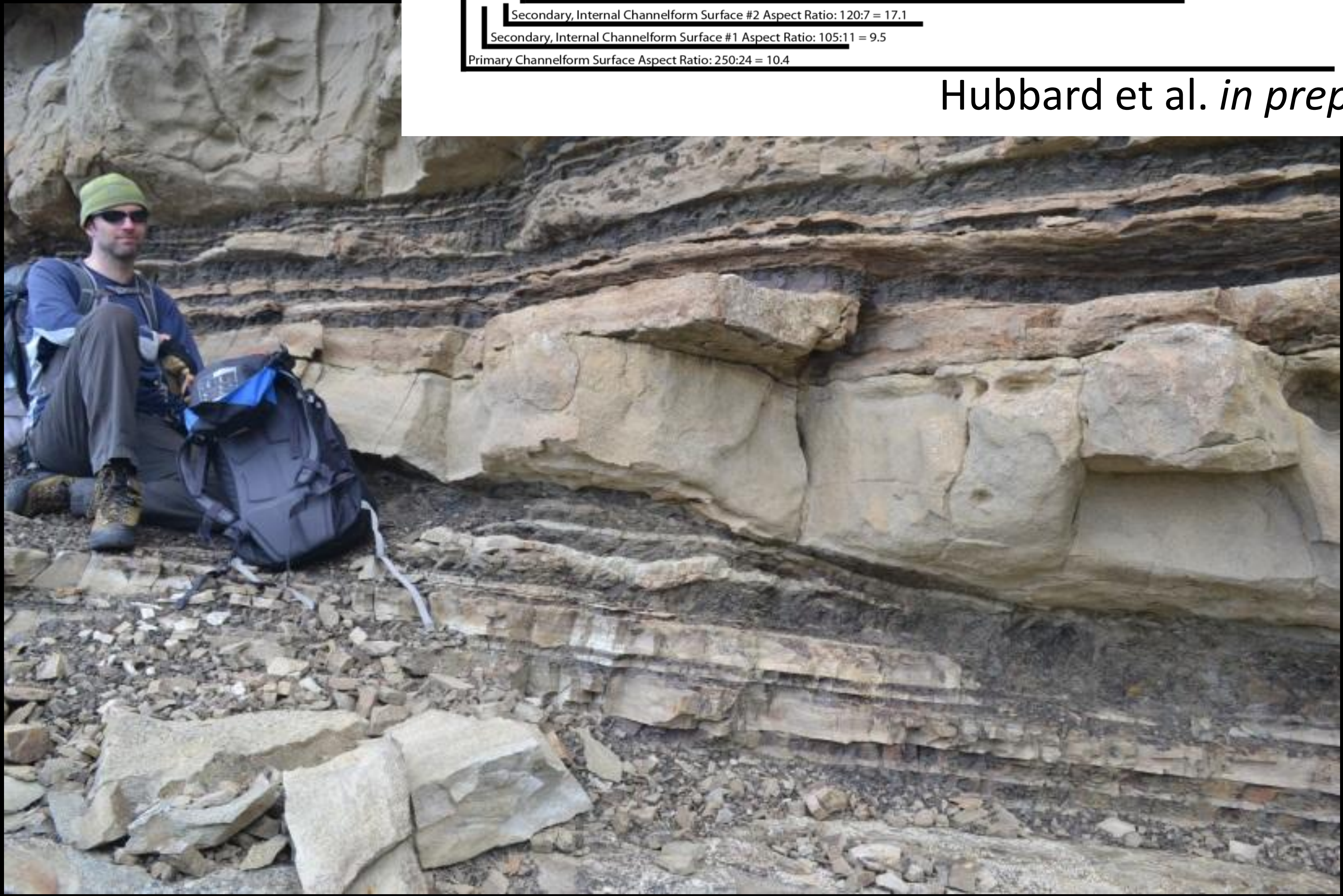
Some observations and remarks

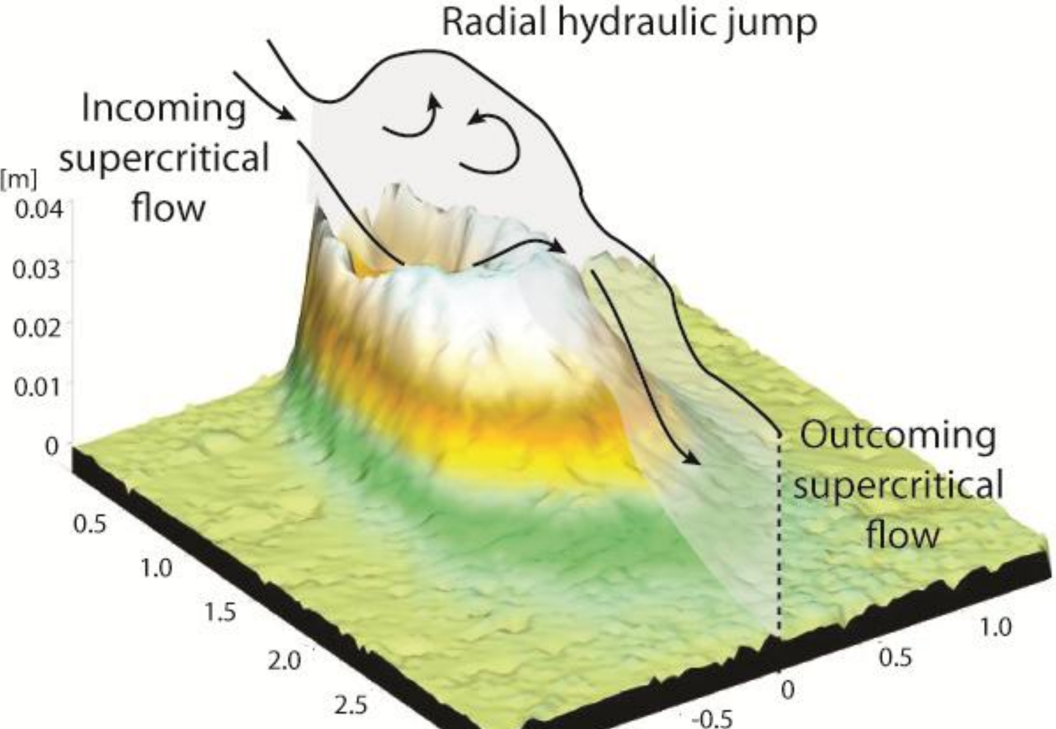
- Cd is periodic for intermediate grains (St 30)
- Restitution has rotational & lateral components when grains are irregular ; [all natural grains are irregular]; therefore all natural grains have rotational and lateral components to restitution.
- Splash mobilisation only occurs for large grains (>2 mm) in water
- For large grains, the wake-jet has resuspension potential
- The dampened and floating regime are also relevant for tutbidity currents [1-8000 micron]

Problem Definition



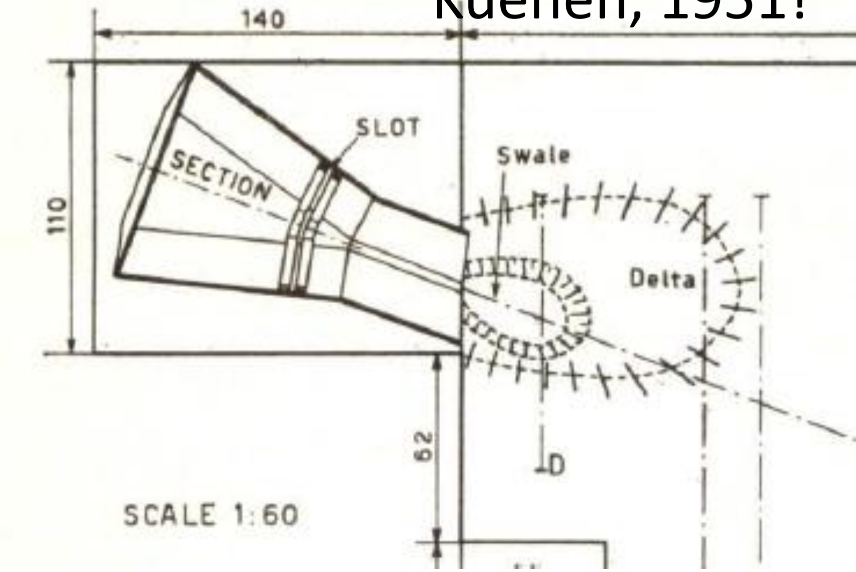
Hubbard et al. *in prep.*



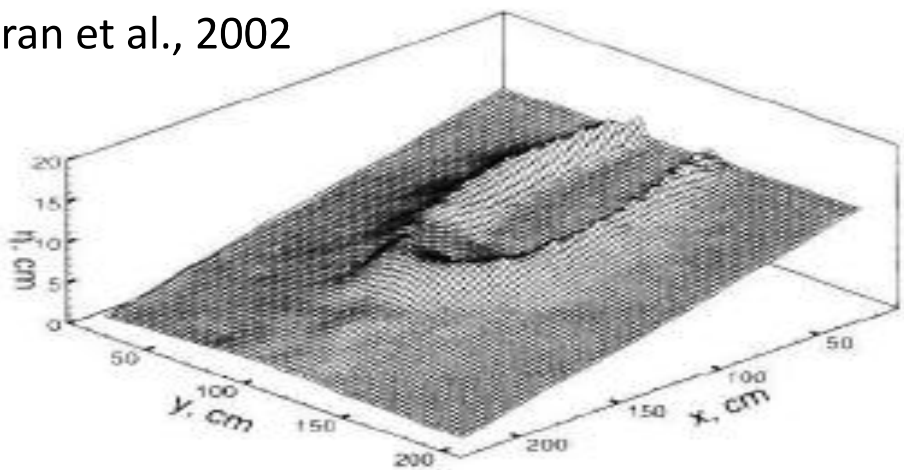


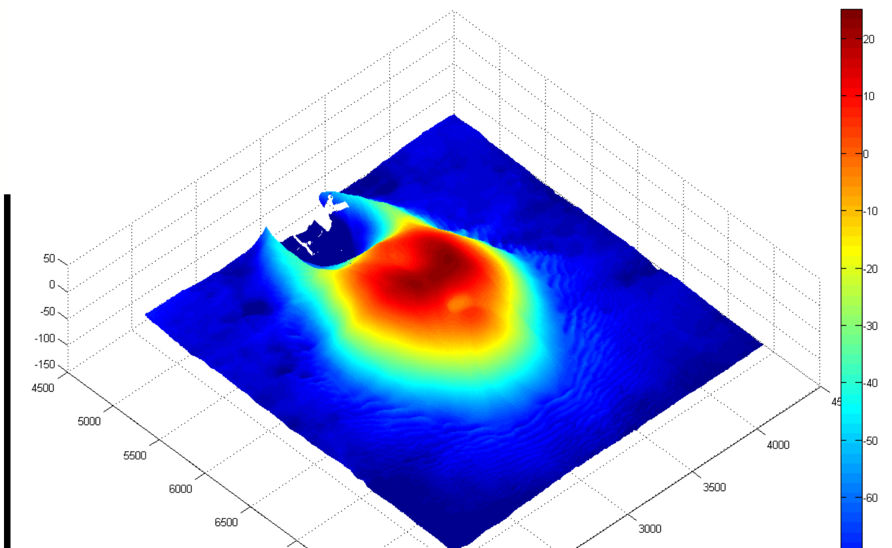
after Baas *et al*. (2004)

Kuenen, 1951!



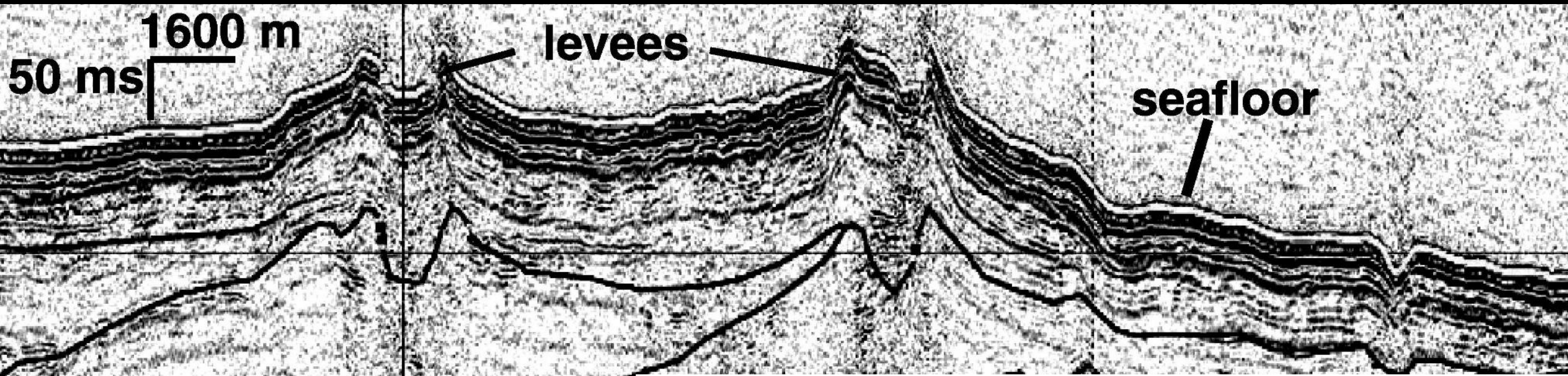
Imran et al., 2002



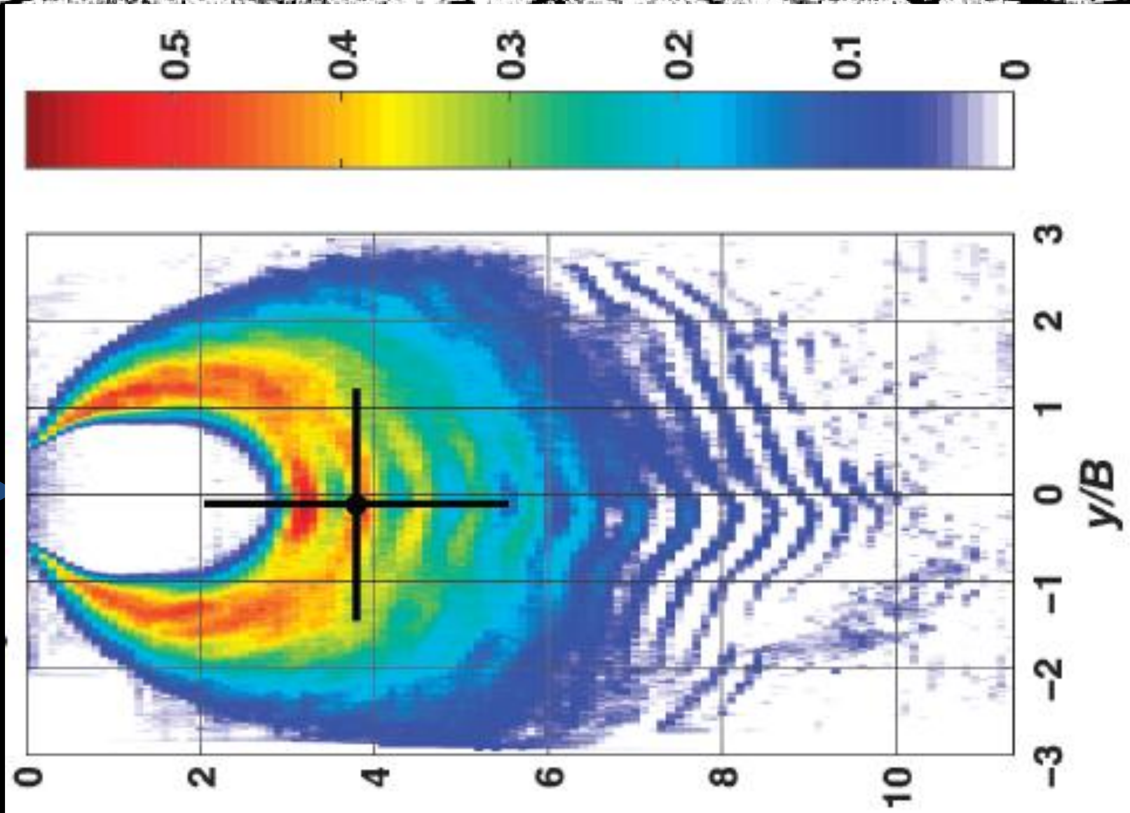


EUROTANK Classic
Expansion Lobe Run #1

Rowland et al. 2010: “This is a levee confined channel”

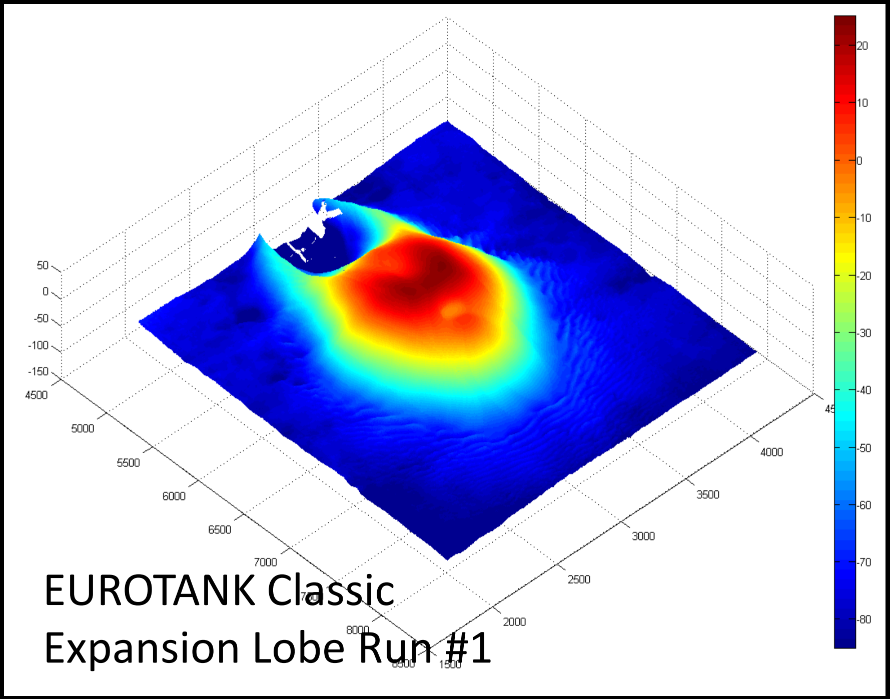


“This is not a levee confined channel”

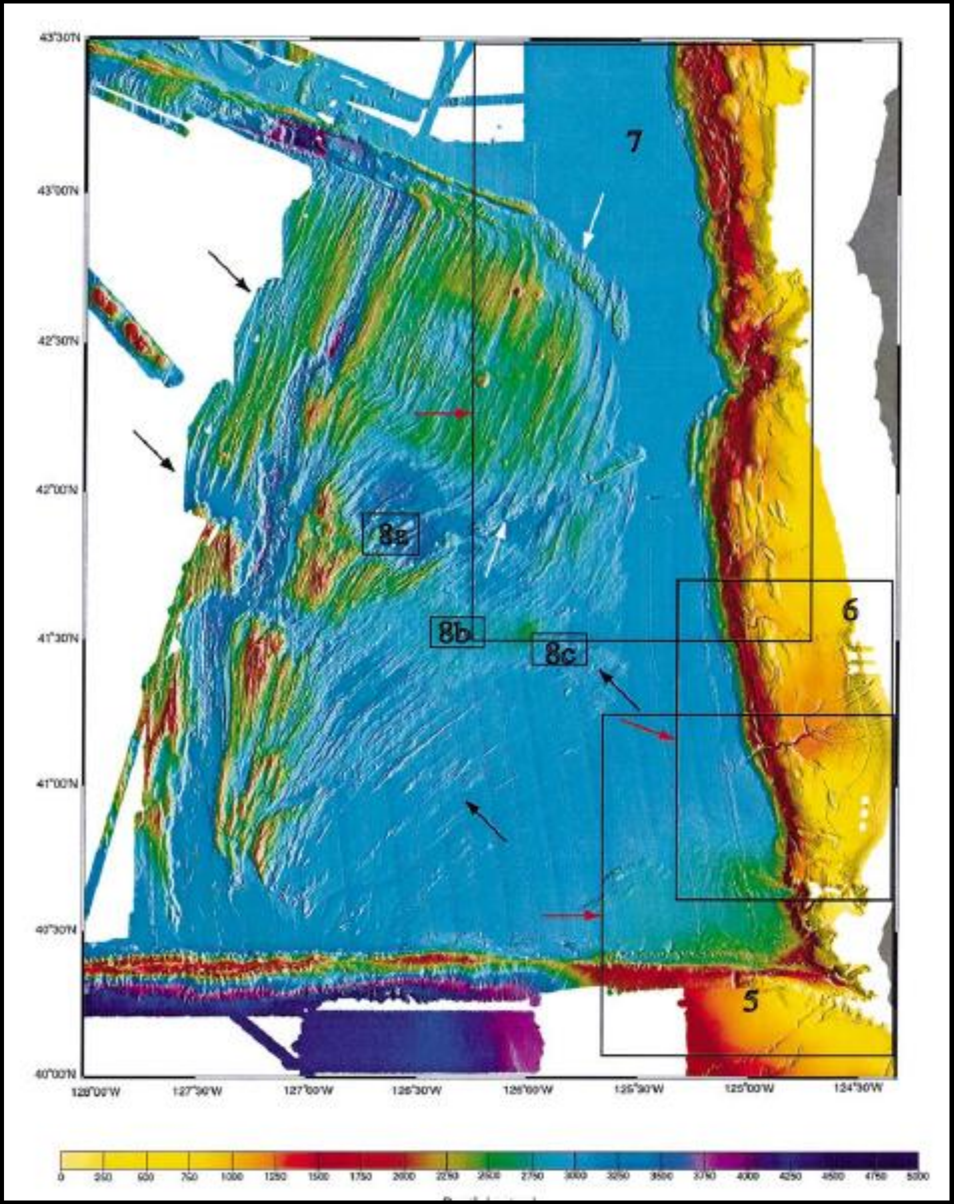


Rowland et al. 2010

This architecture *is* an analogue to some natural systems:

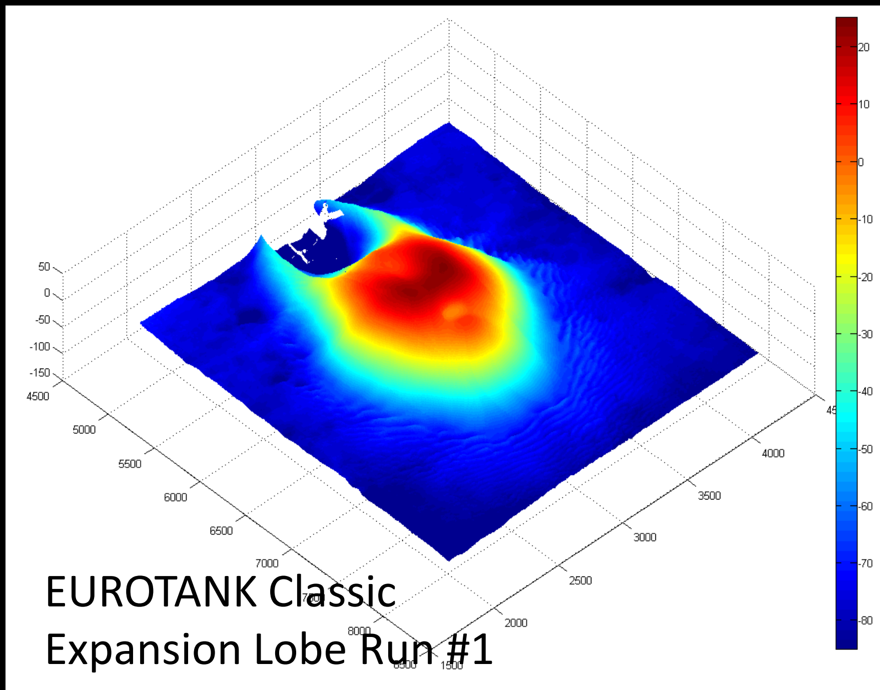


Plunge pools at canyon-fan transitions at the toes of steep active margins (Pacific; Indian Ocean)



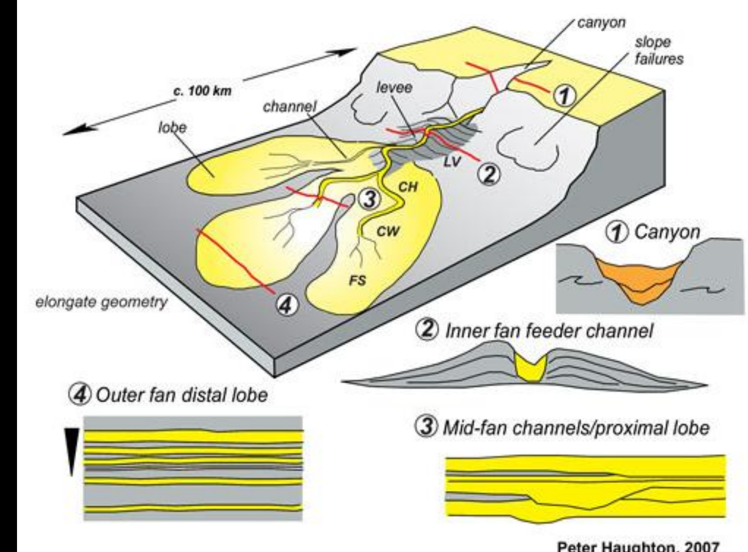
Dziak et al., 2001

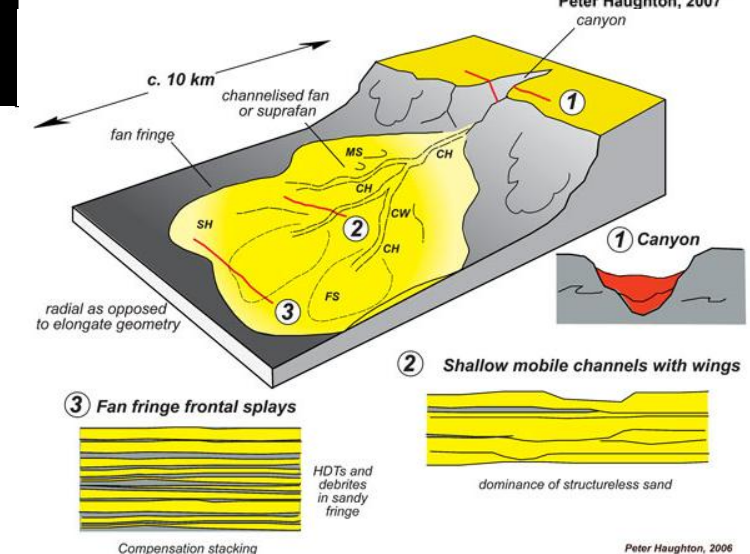
But this experimental architecture is not analogue to these types of systems

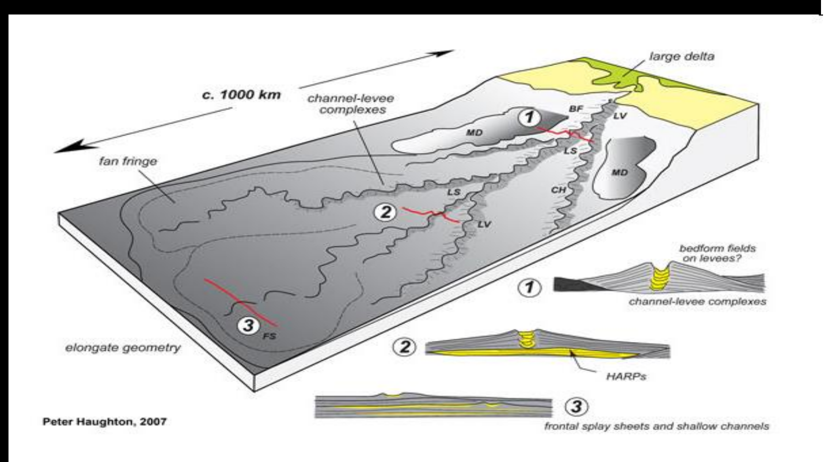


EUROTANK Classic Expansion Lobe Run #1

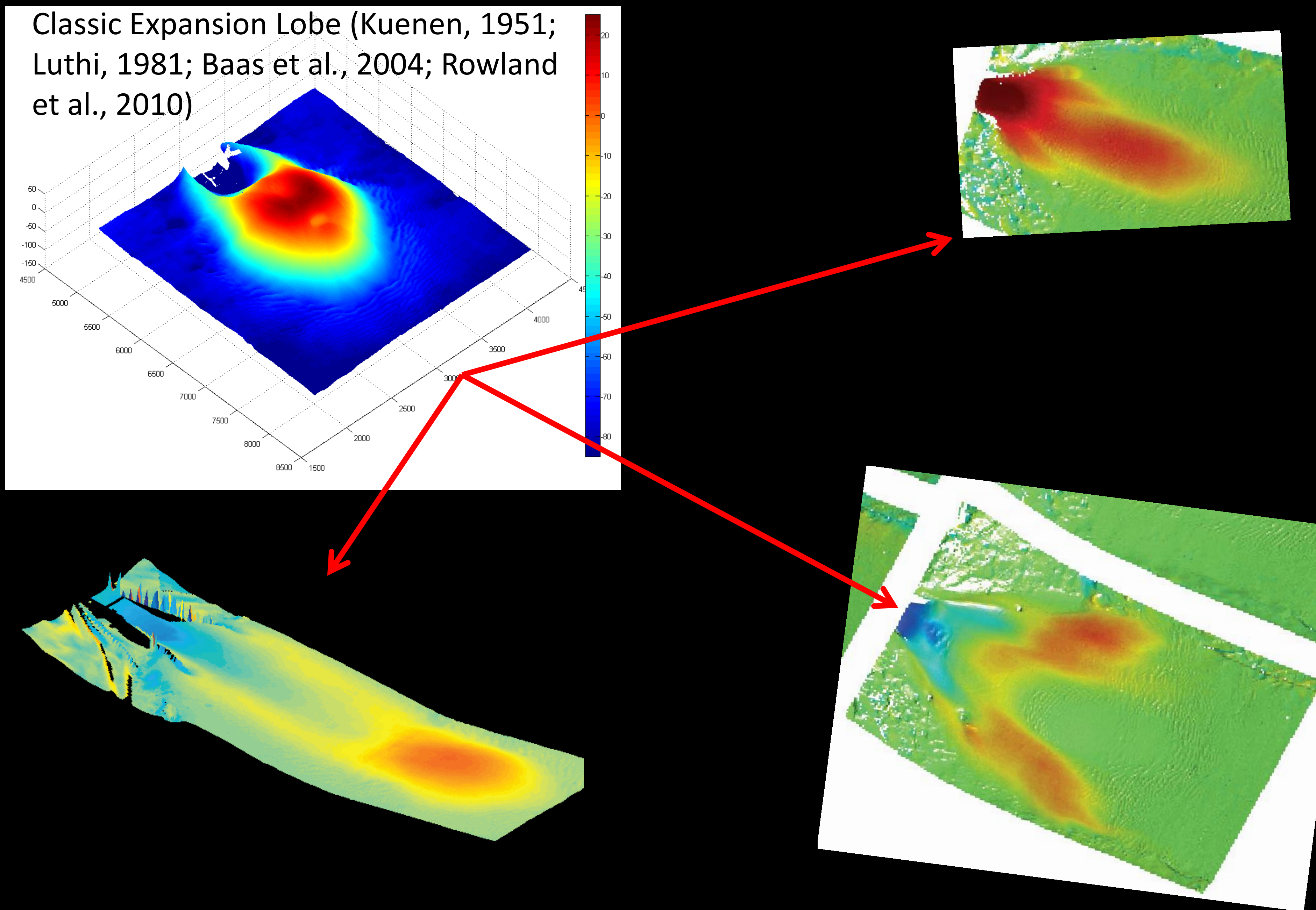
Drawings by Peter Haughton
http://sepmstrata.org



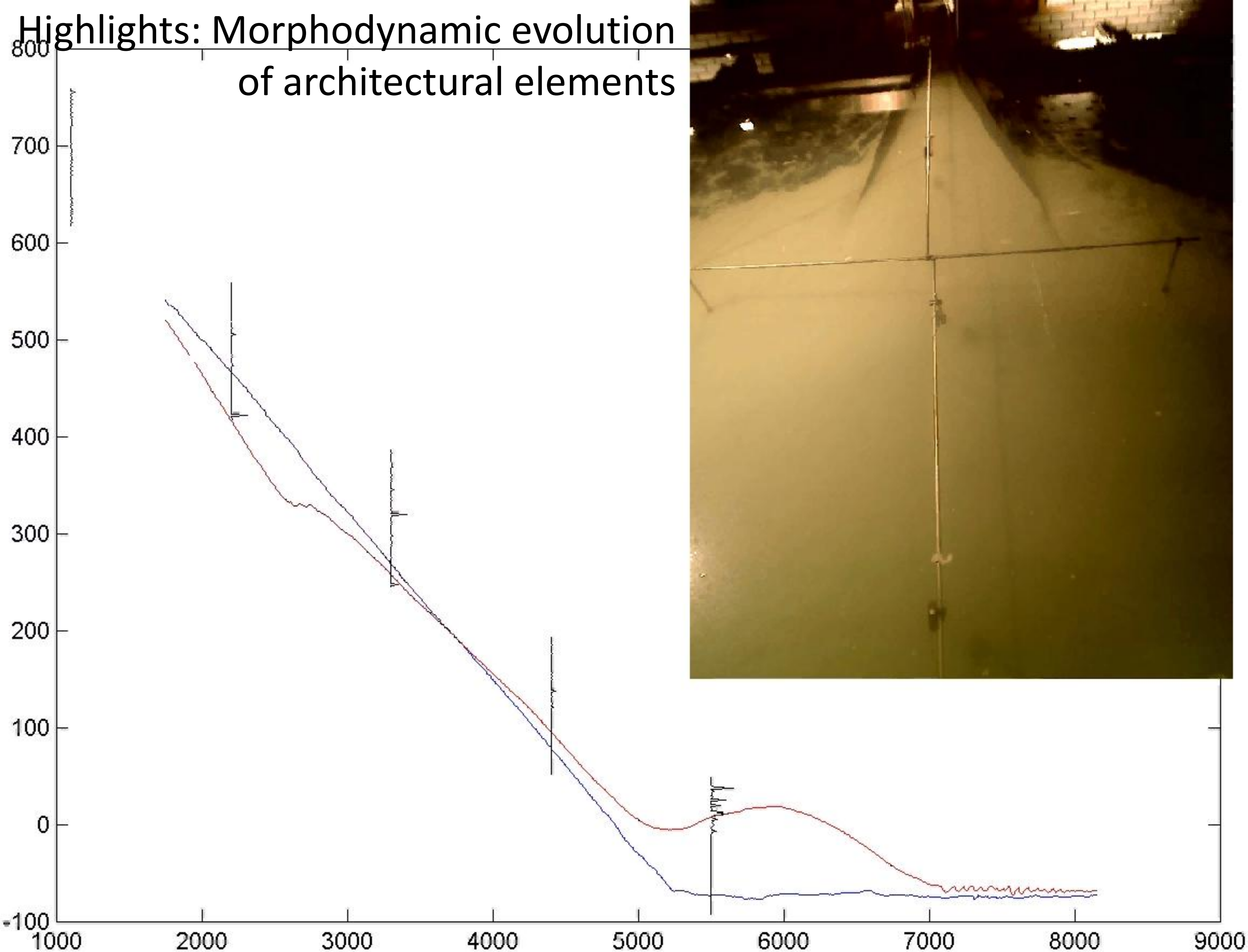


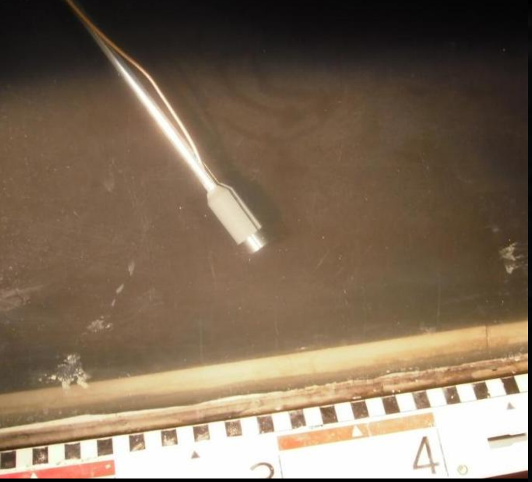


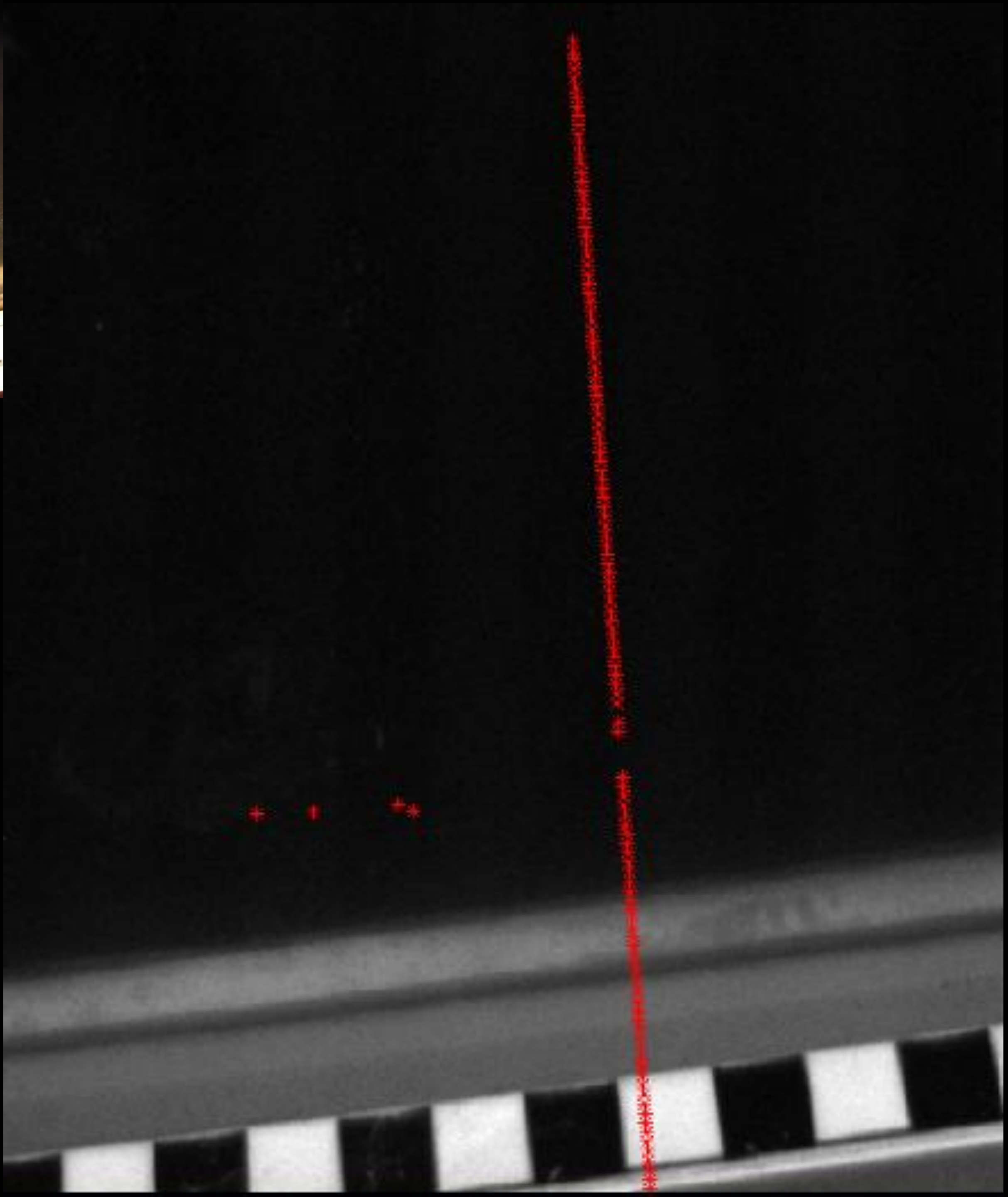
Diverse morphodynamic evolution of architectural elements

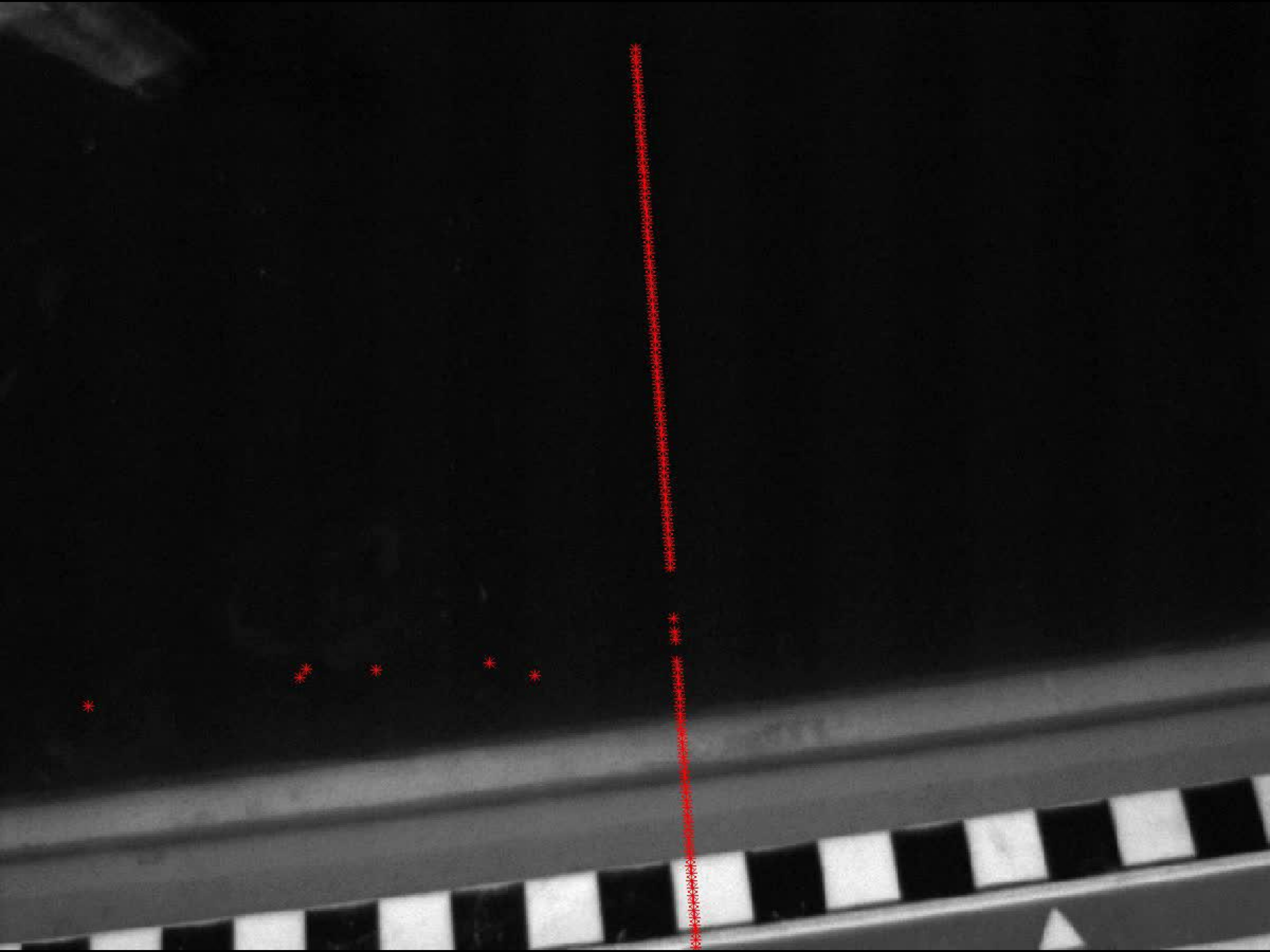


Highlights: Morphodynamic evolution of architectural elements



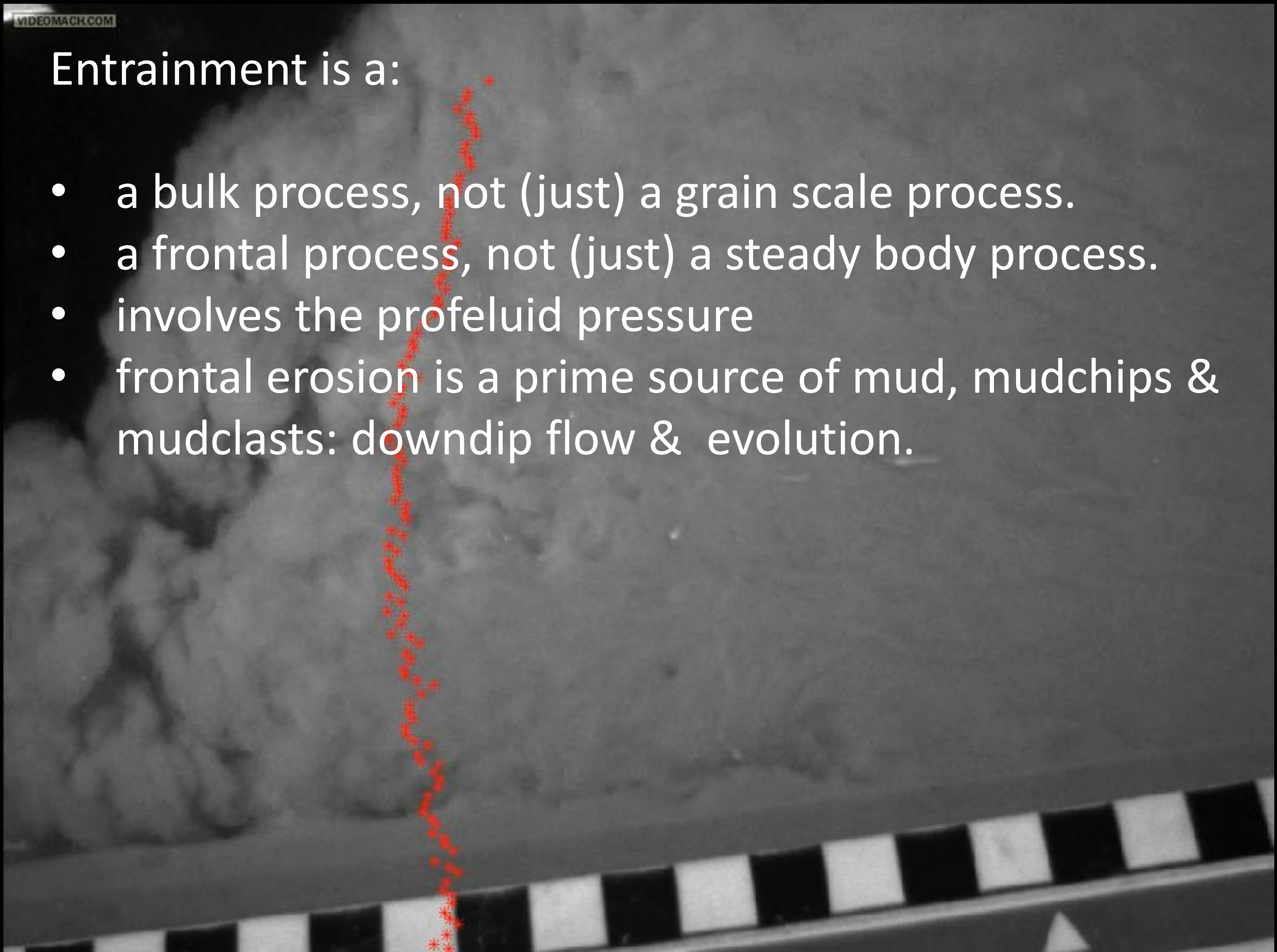




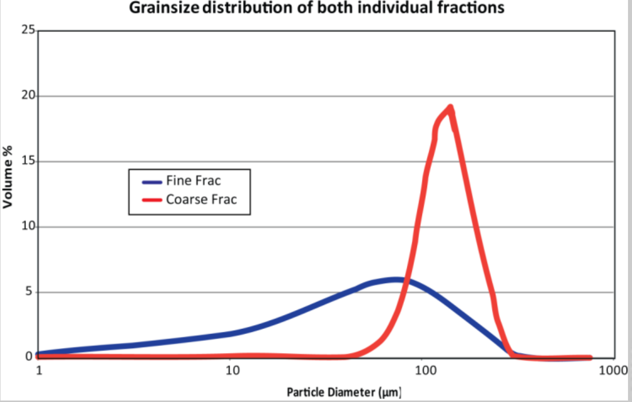


Entrainment is a:

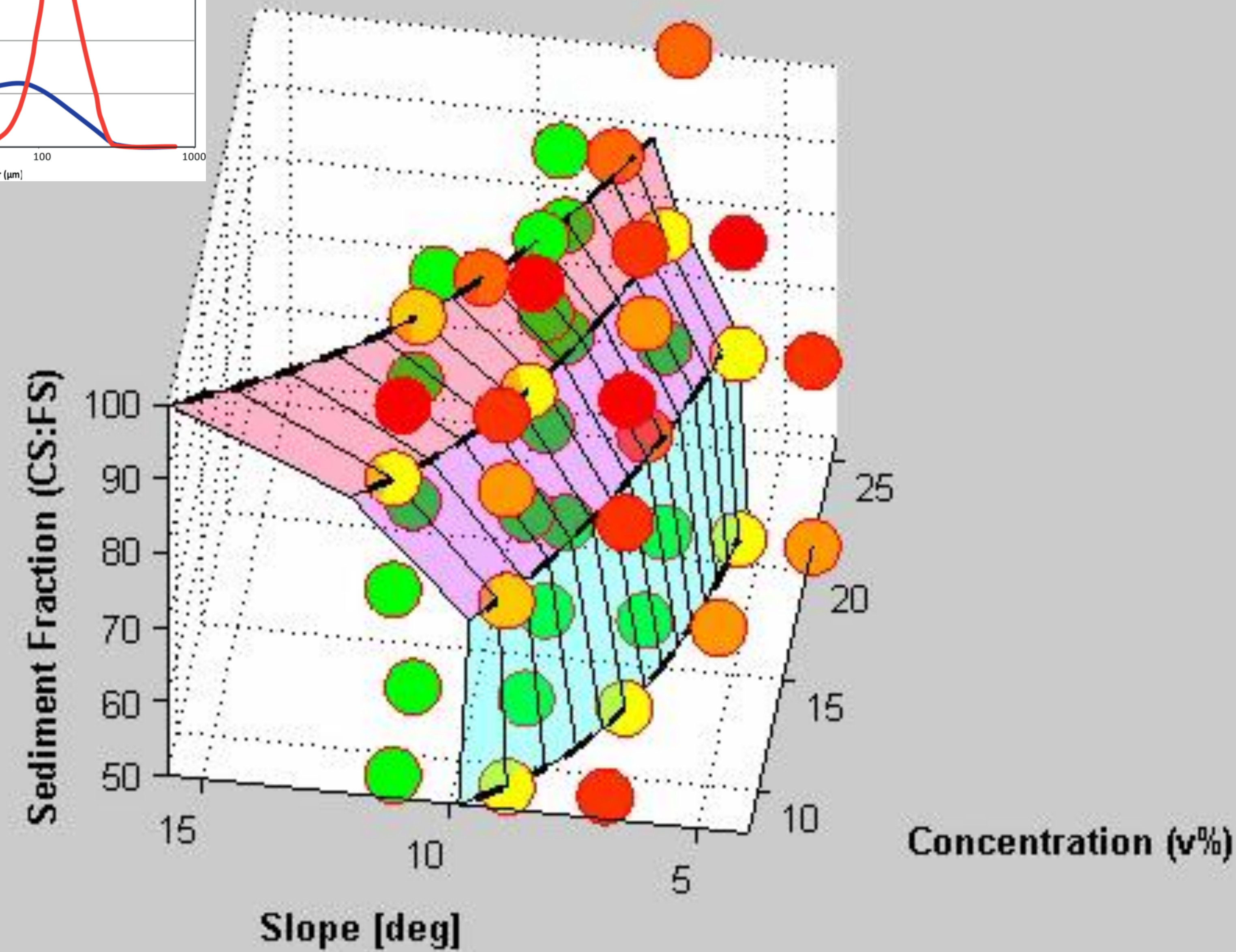
- a bulk process, not (just) a grain scale process.
- a frontal process, not (just) a steady body process.
- involves the profeluid pressure
- frontal erosion is a prime source of mud, mudchips & mudclasts: downdip flow & evolution.



Problem Definition: Gratuitous fieldsite picture



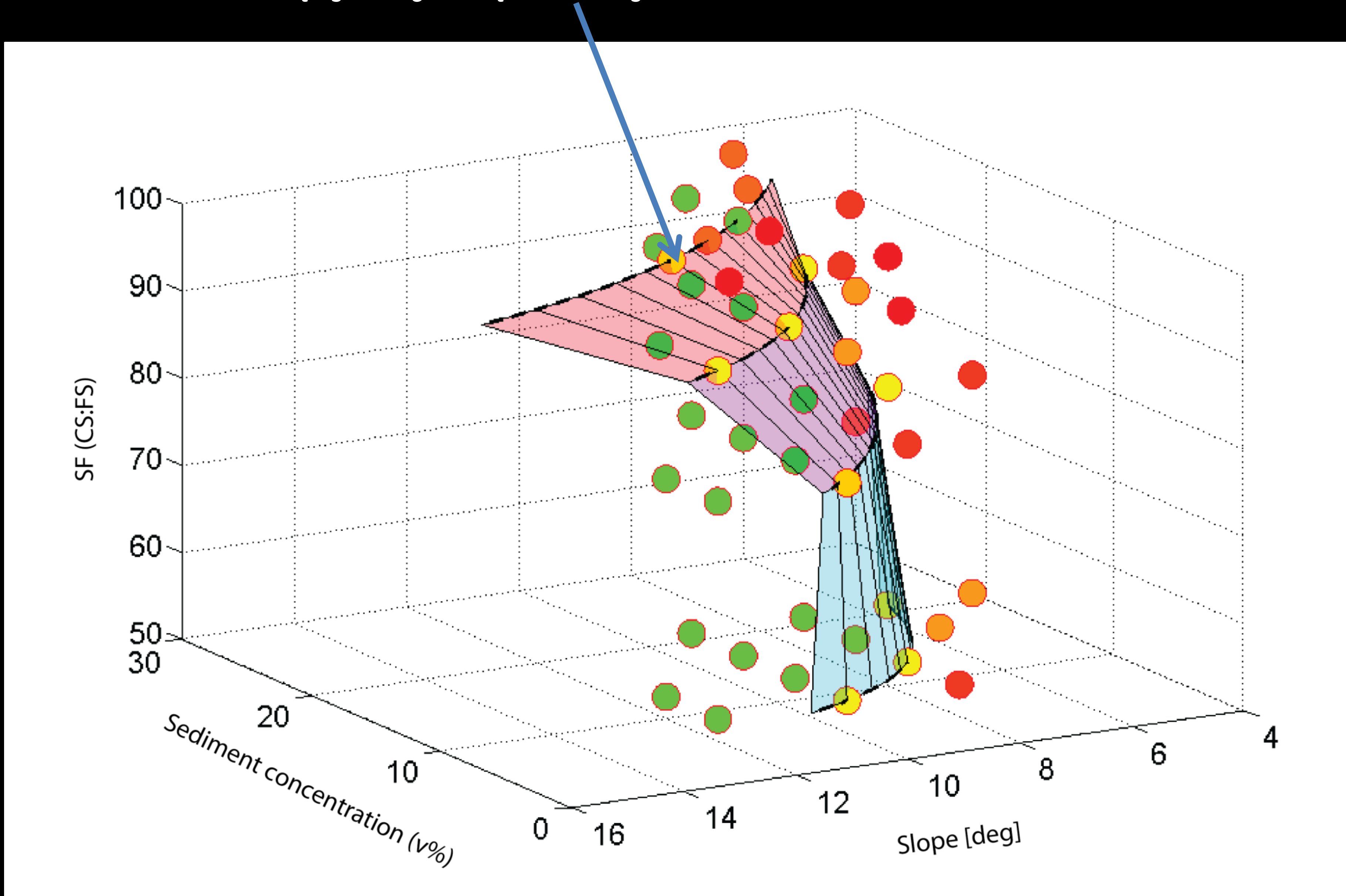
Grainsize distribution of both individual fractions
25
20
15
10
5
0
Volume %
Fine Frac
Coarse Frac
1
10
100
1000
Particle Diameter (μm)



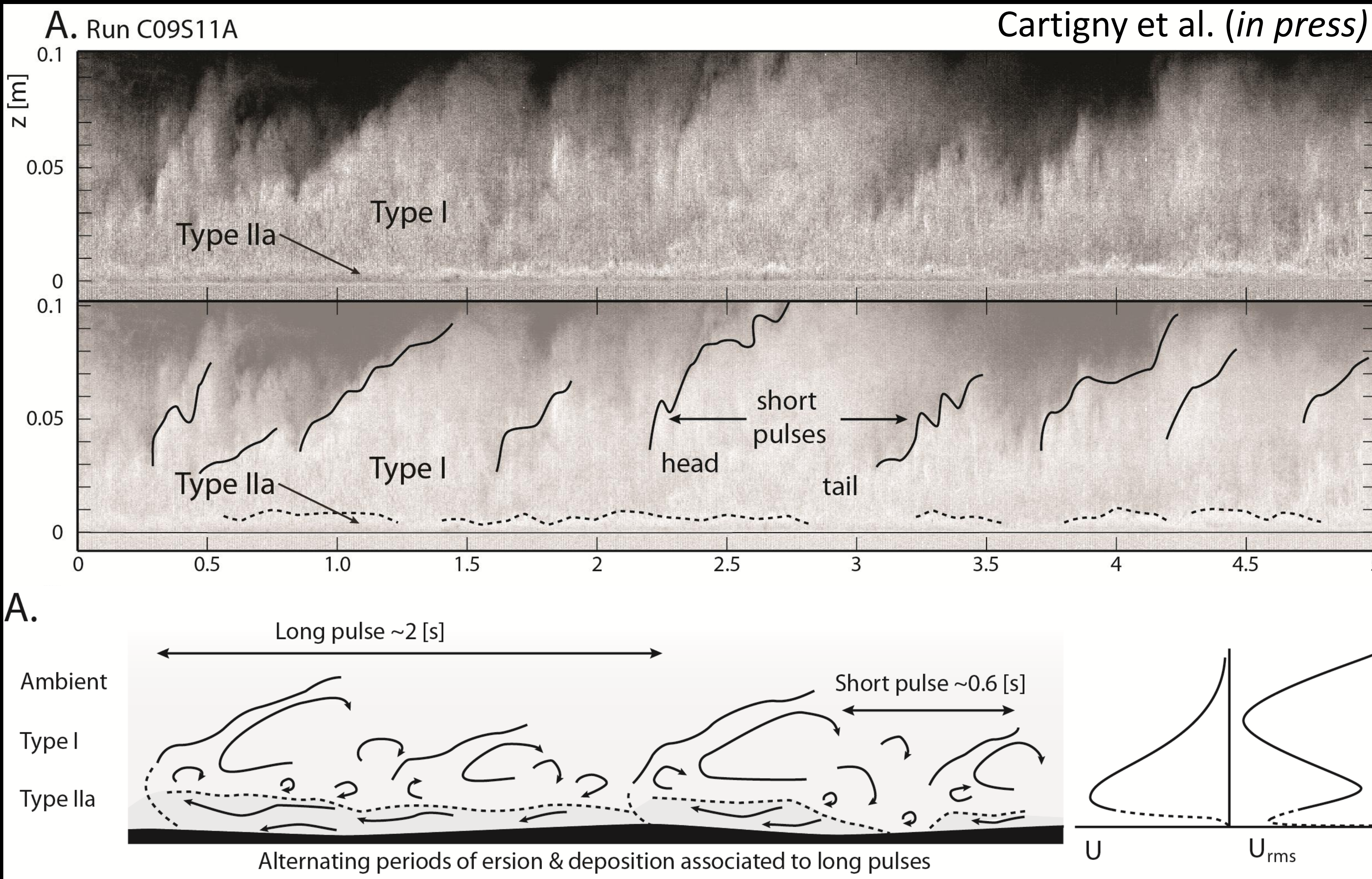
Sediment Fraction (CS:FS)
100
90
80
70
60
50
15
10
5
Slope [deg]
25
20
15
10
Concentration (v%)

What is the function for the bypass condition?

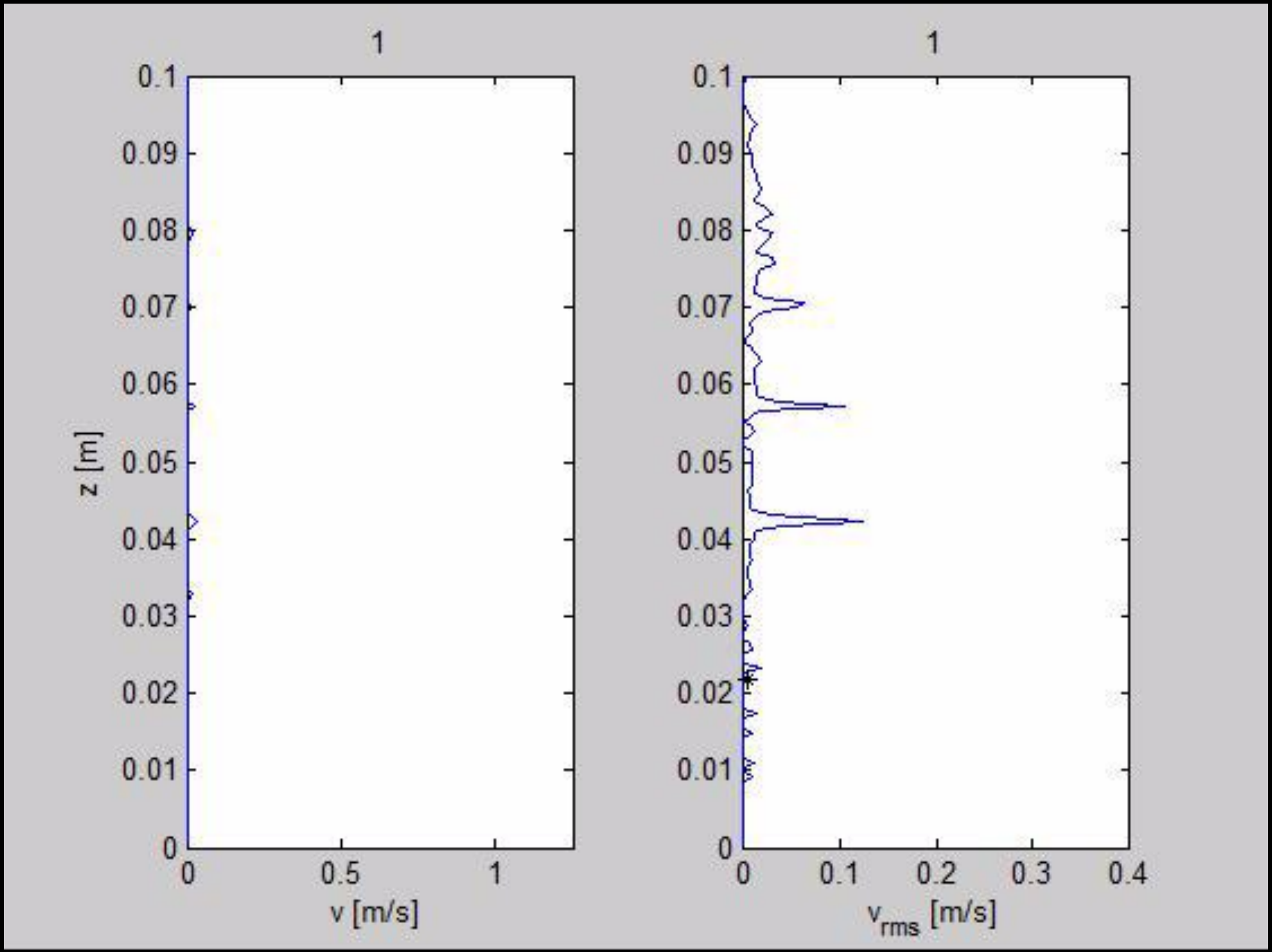
Bypass= F{ $Ri_{\tau}v_s = \kappa_c (Re_{\tau})$; $u^*/v_s = 1$; k^*; Fr'; S; Q; d; c; composition}



What are the flow conditions and phenomena near the bed at deposition?



Flow conditions; u*?



Location of the bed?

Few mm's of uncertainty…

u*, z0, uncertain bed position

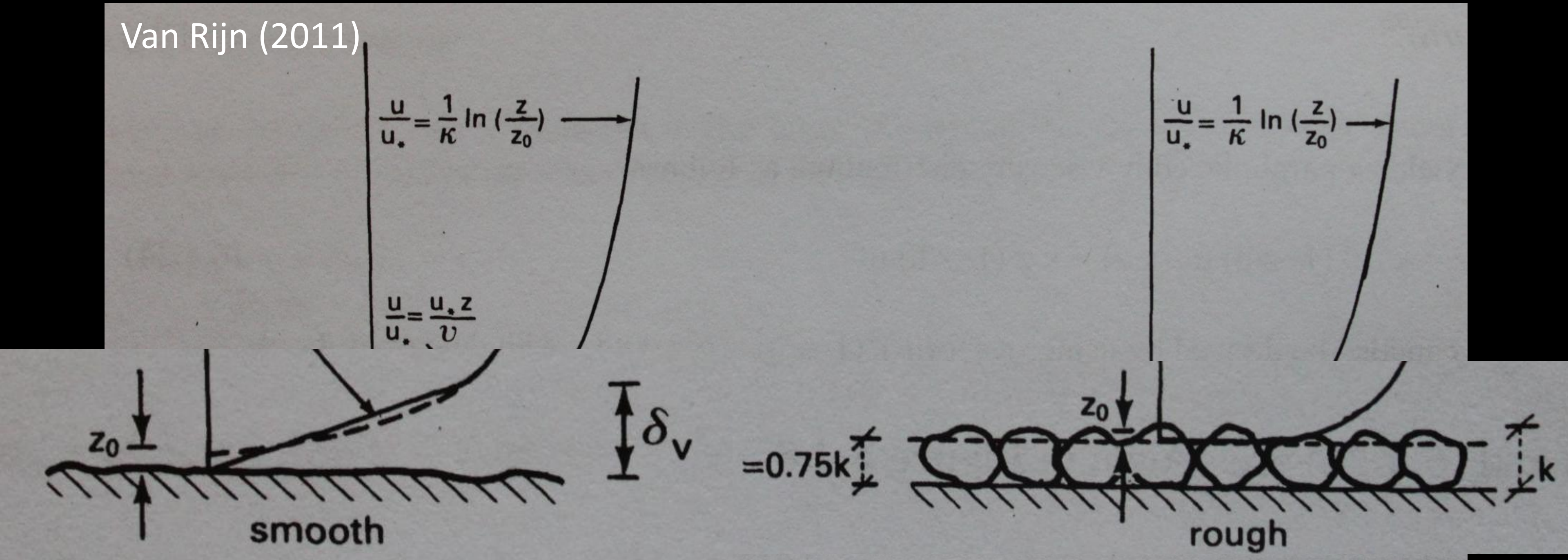
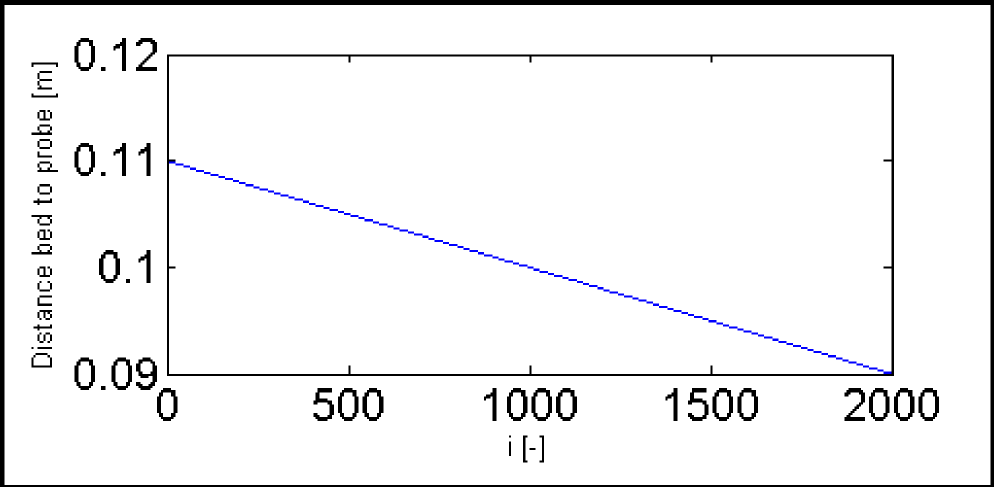
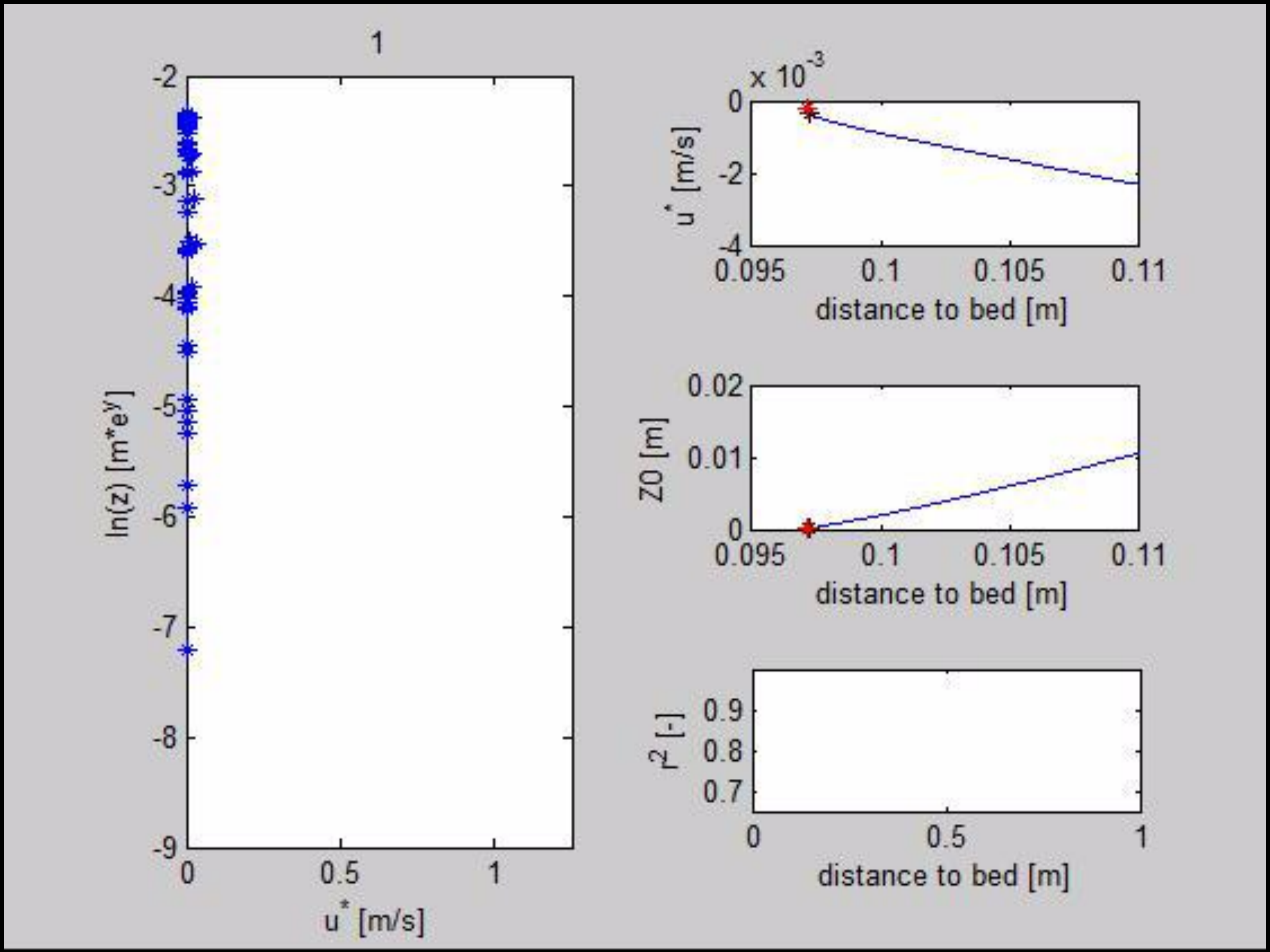


Figure 6.4.9 *Velocity distributions in hydraulically smooth and rough flow*

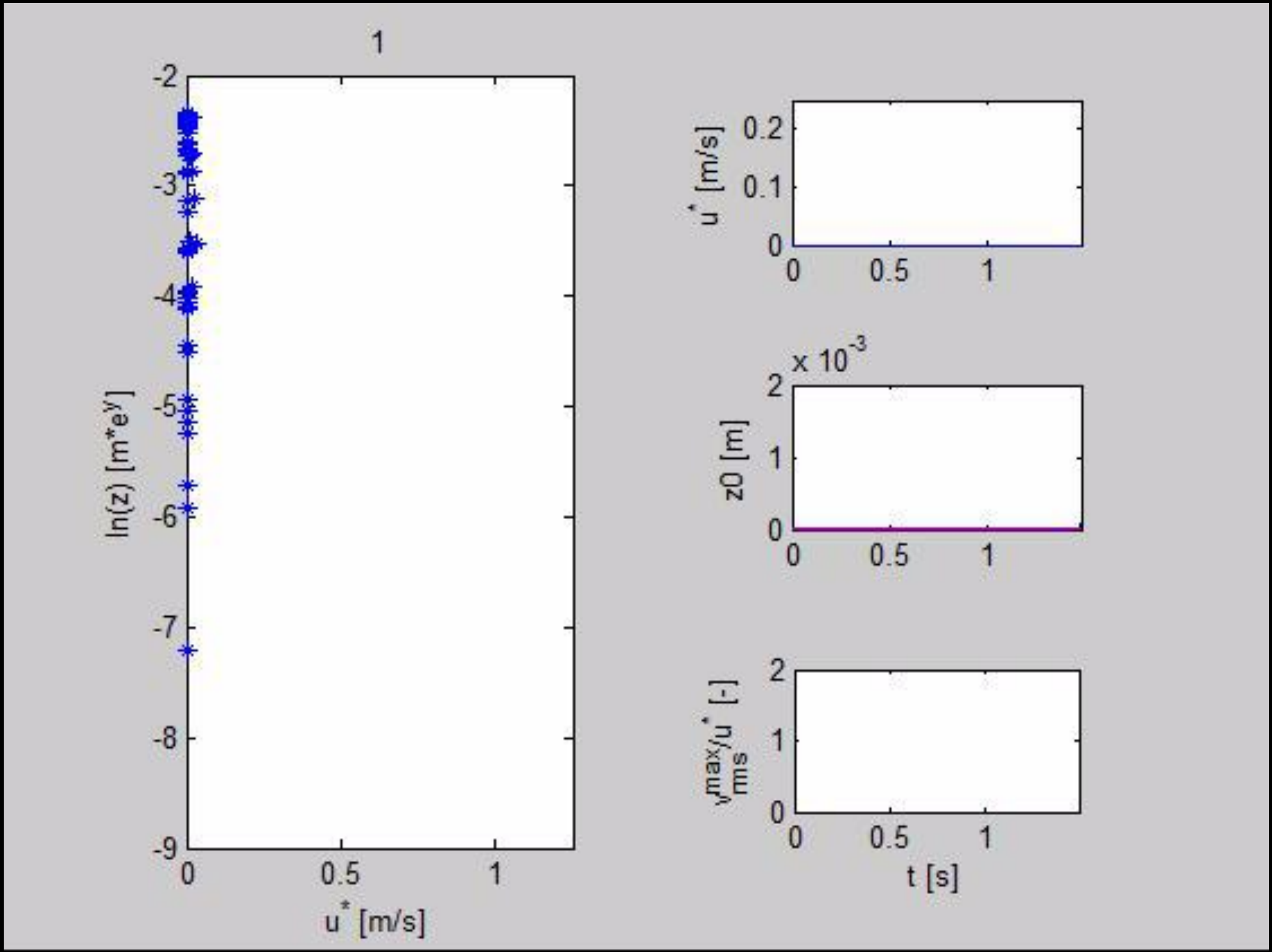
- Empeirical z0
- Best-fit for different bed locations

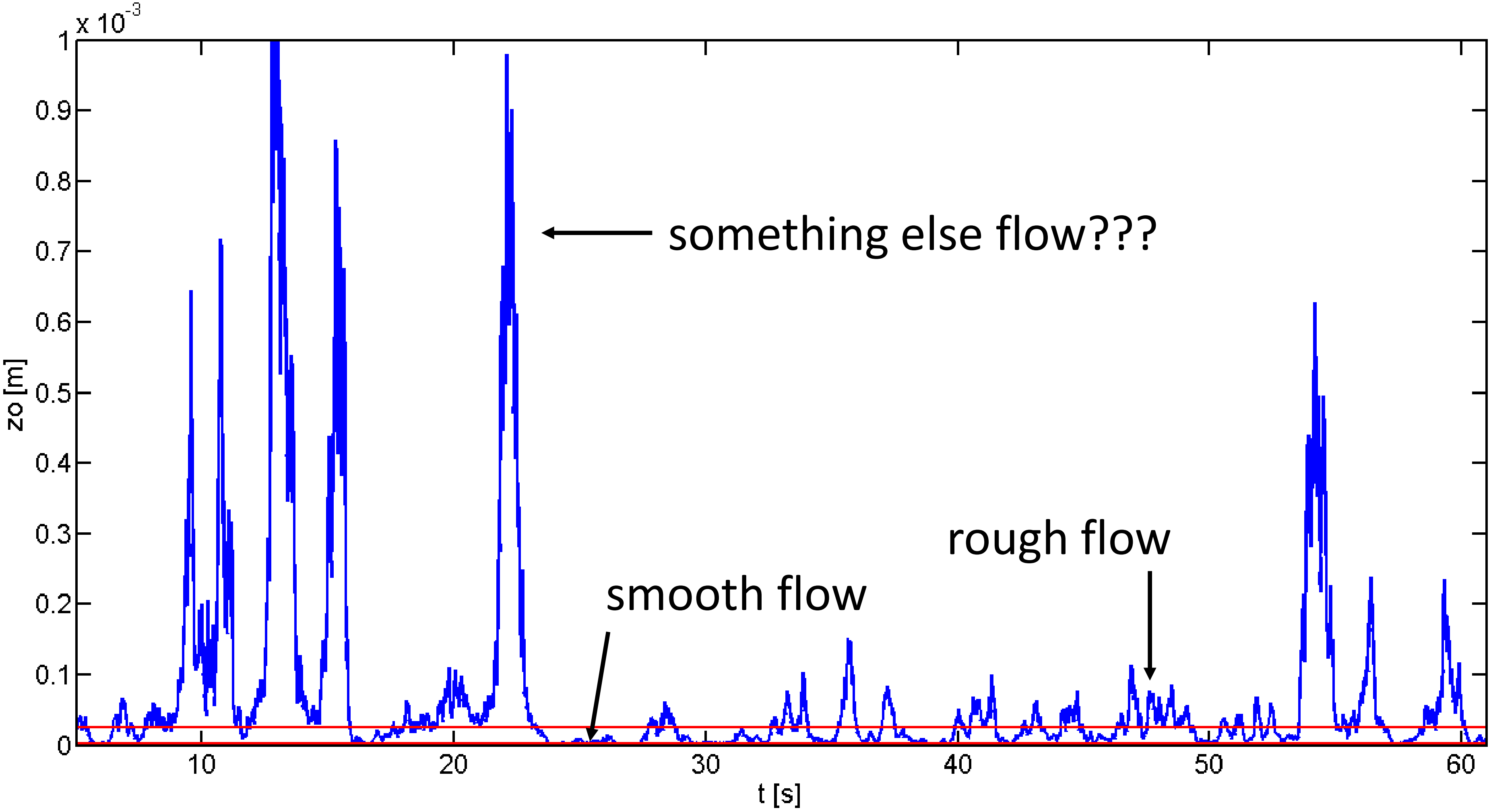


Fitting u* and z0 without pre-defining the bed location.



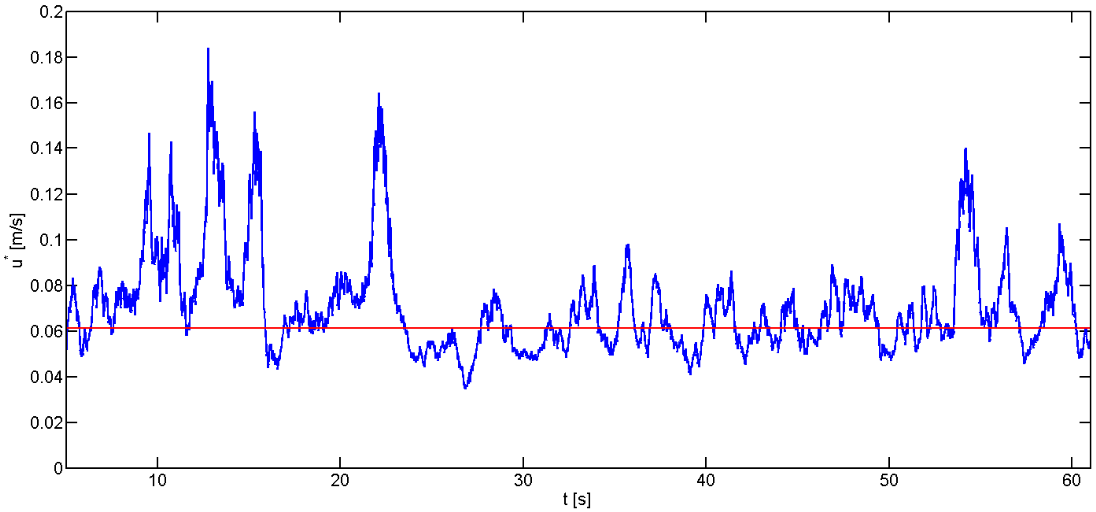
Evolution of u*, z0, and r^2 through time.





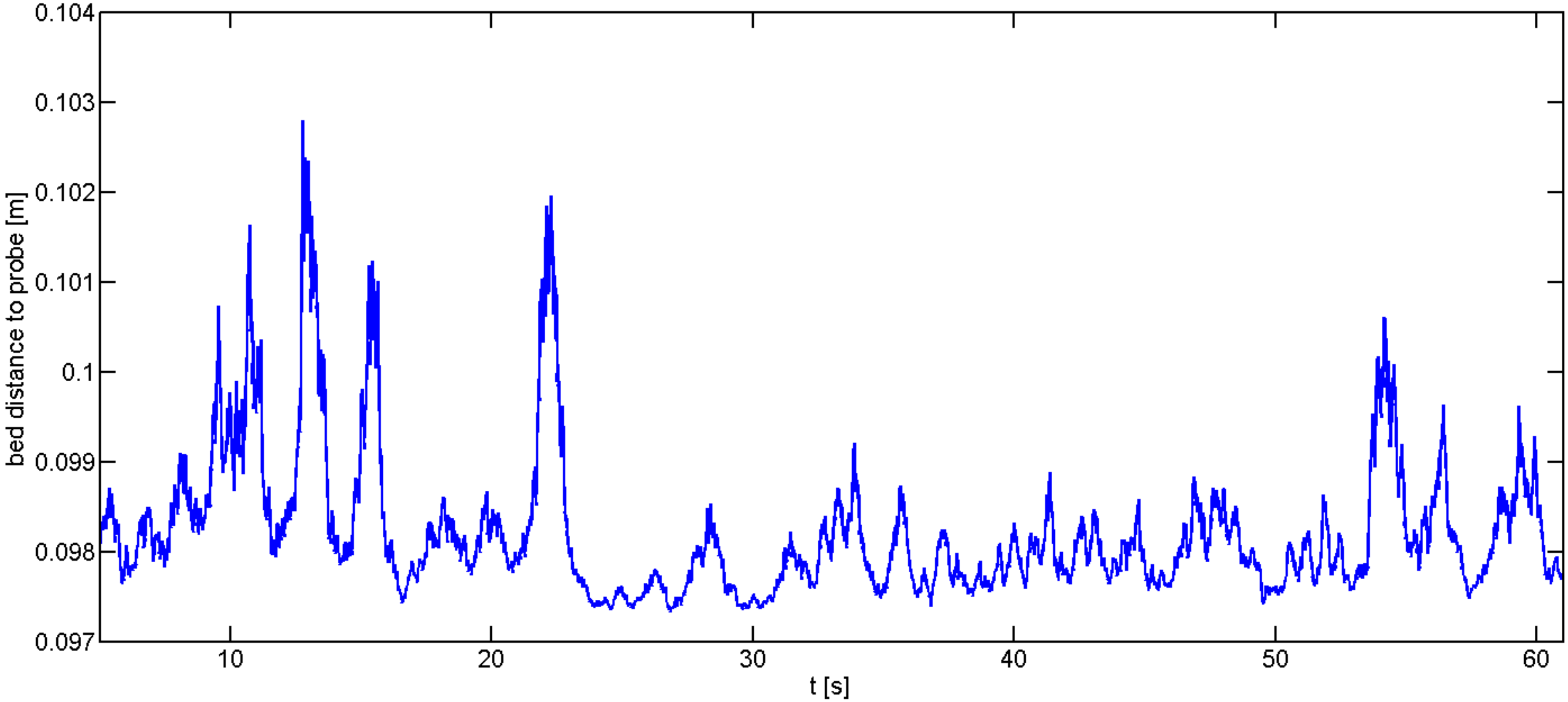
$k^* = u^* k_s / \nu = 46$ transitionally rough

$k_s = 3\ d_{90}$ (van Rijn)

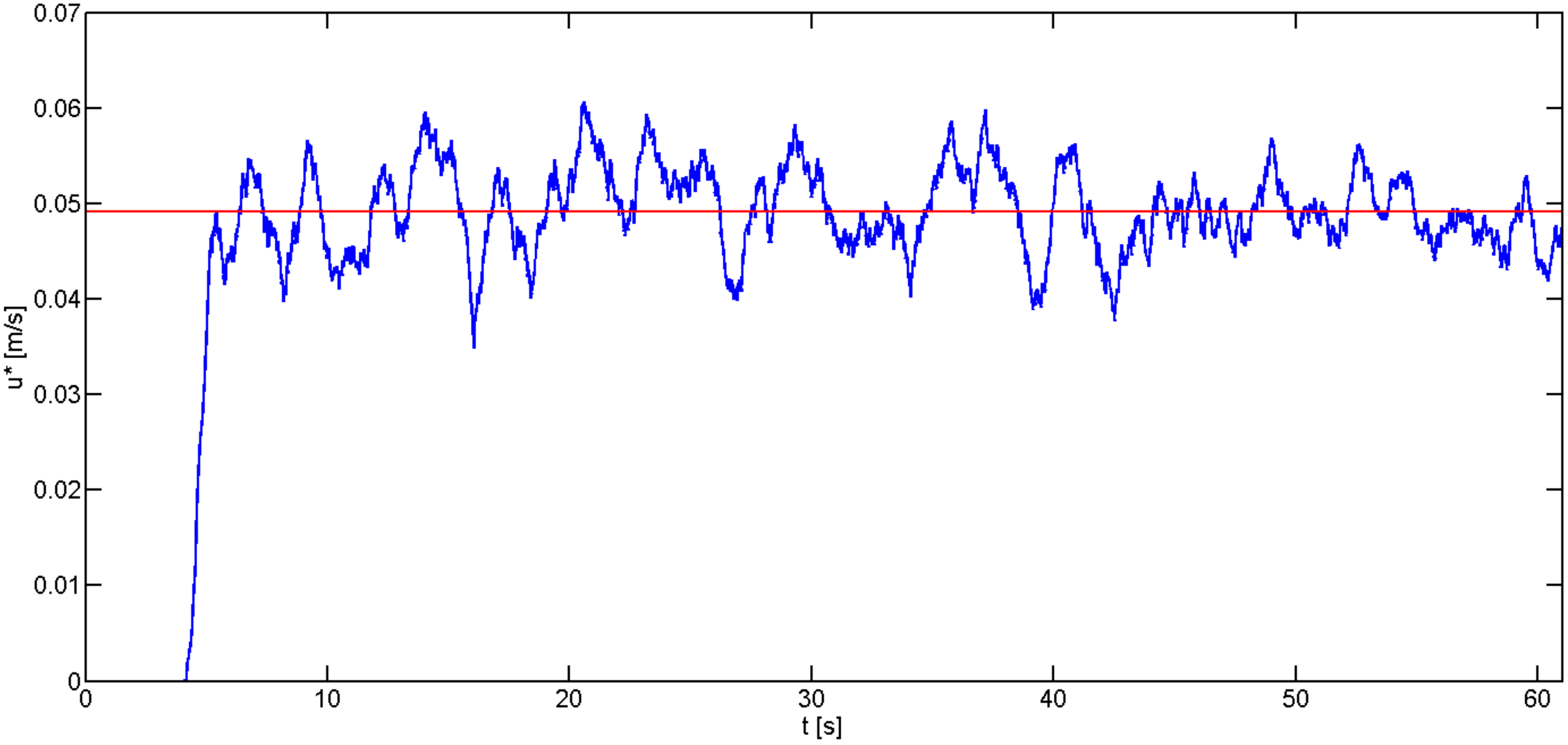


strong positive correlation between z0 and u*; negative with v_{rms}

Problematic, not physical

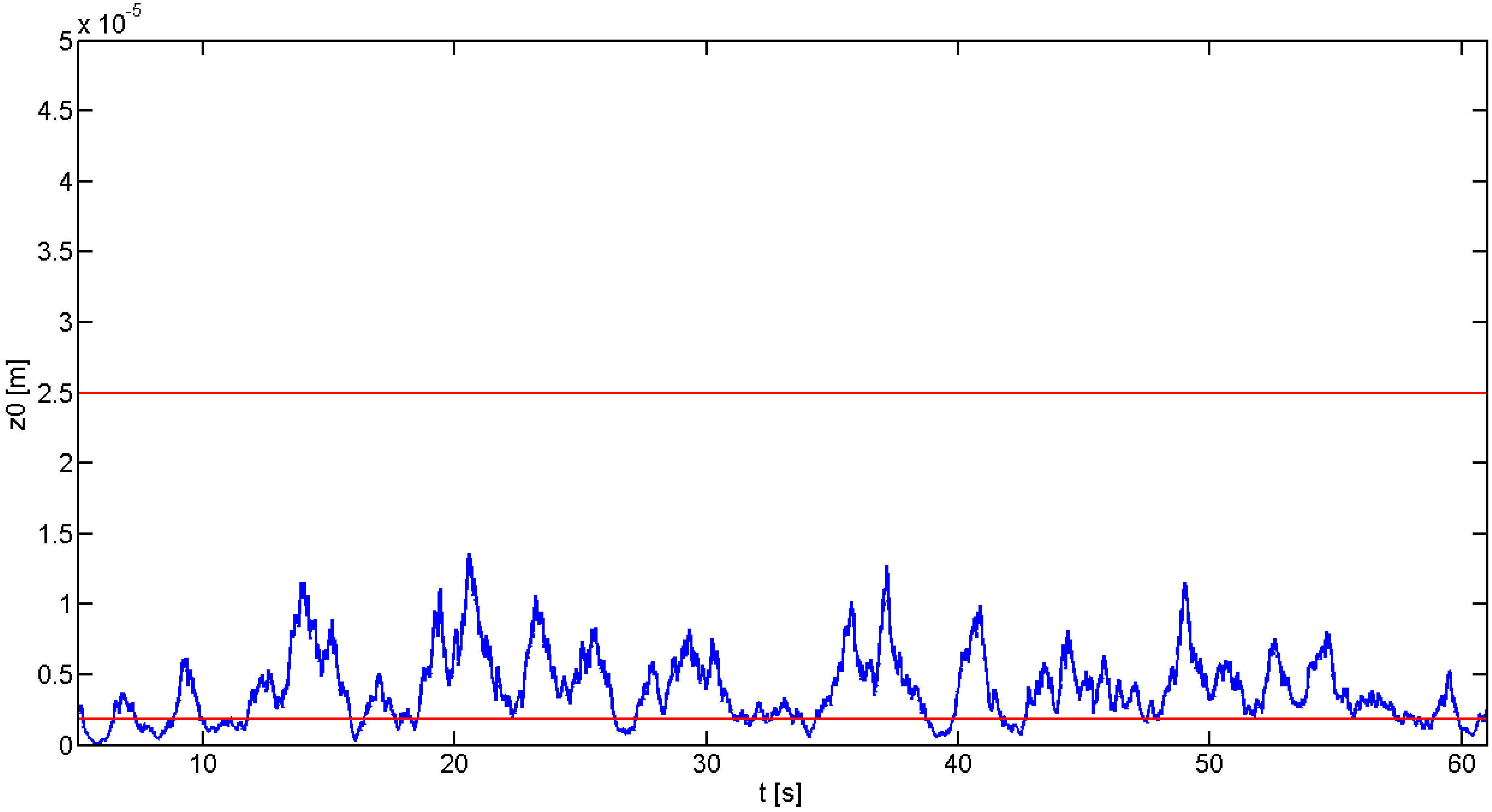


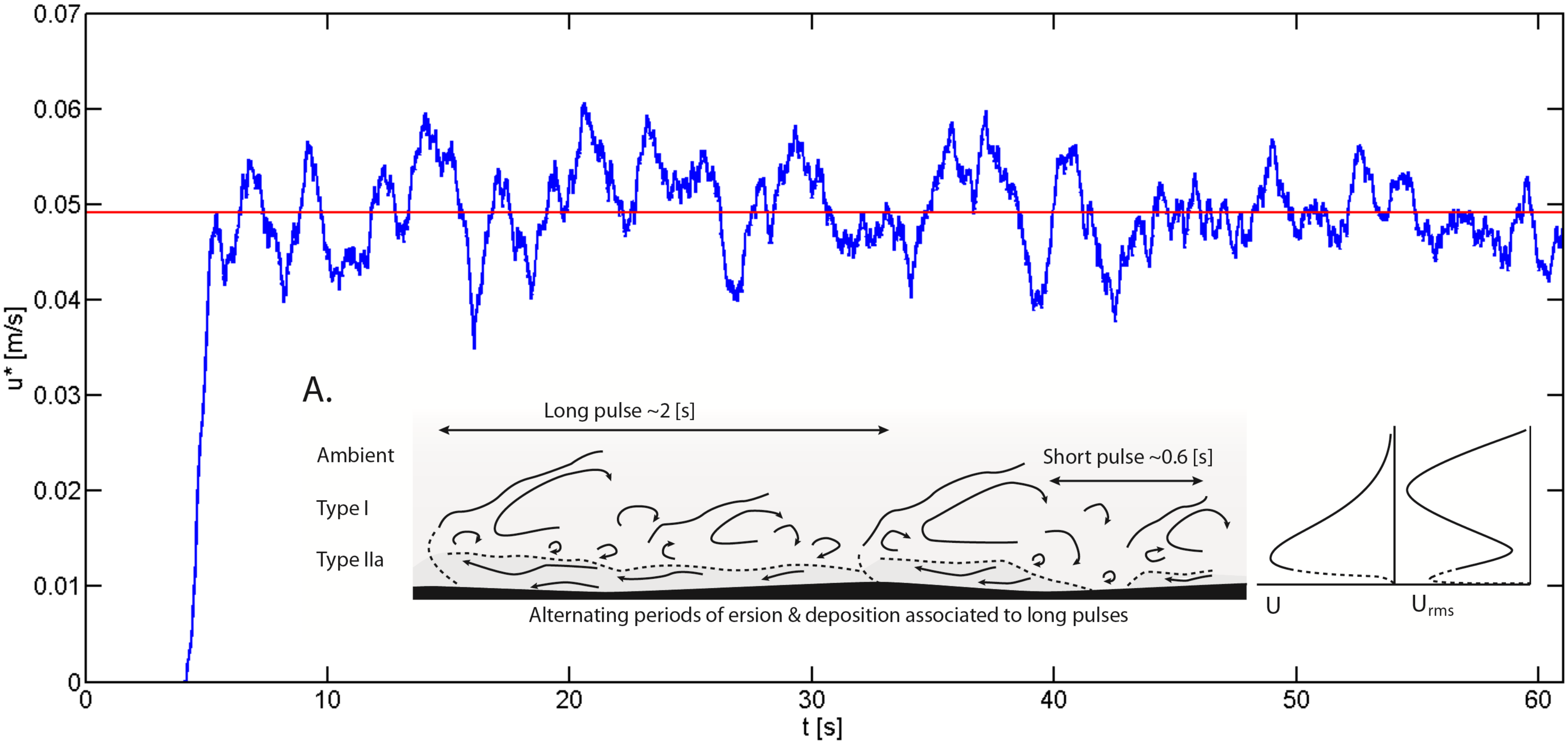
Fixing the bed at 0.0975 m

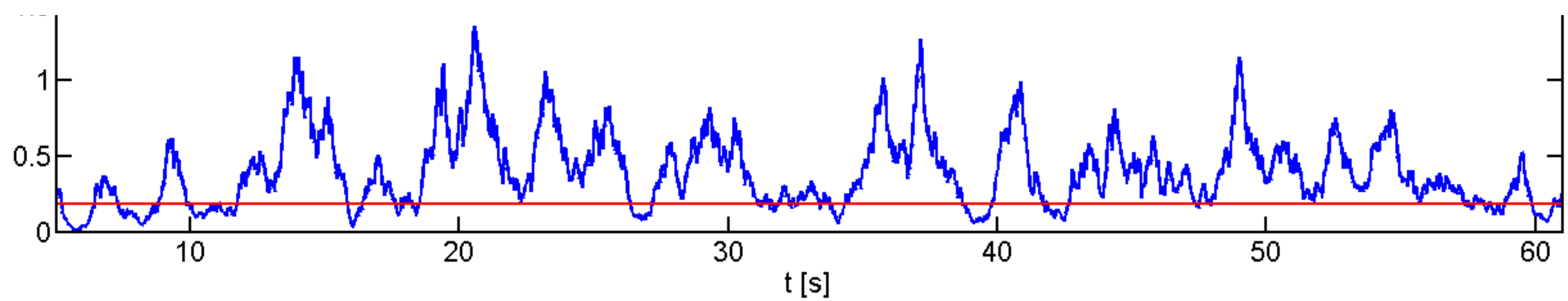


$u^* = 0.049$ m/s; $u^*_{rms} = 0.004$ m/s

Fixing the bed at 0.0975 m

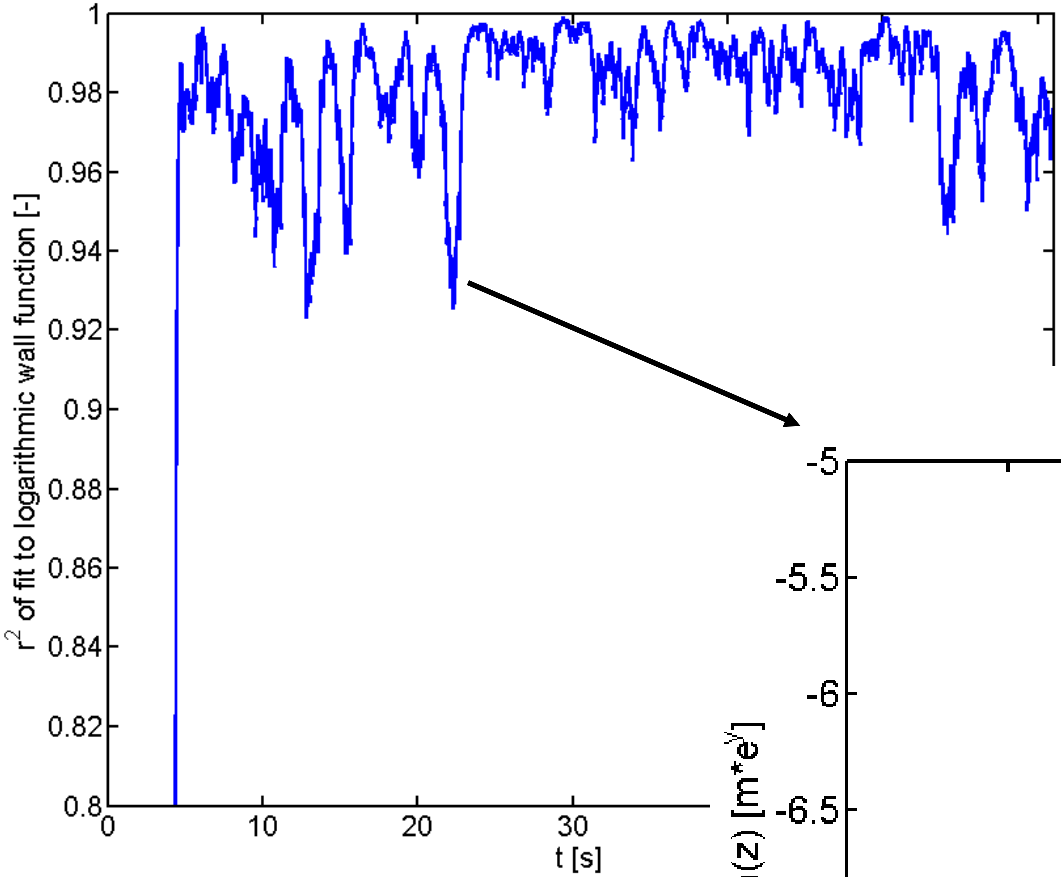




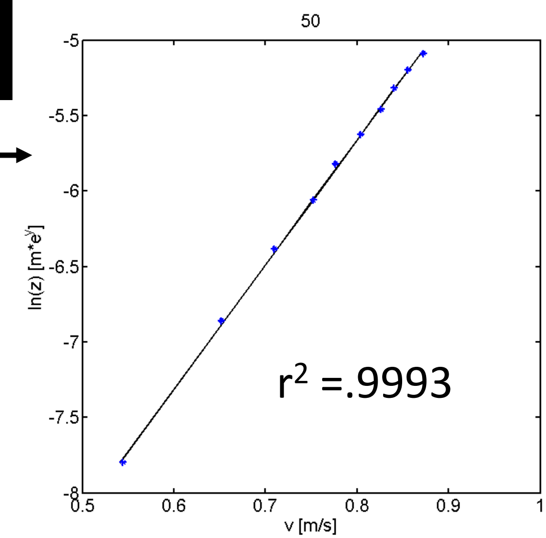


Positive correlation: k* = 30-45; u* = 0.04-0.06; z0 = small-rough

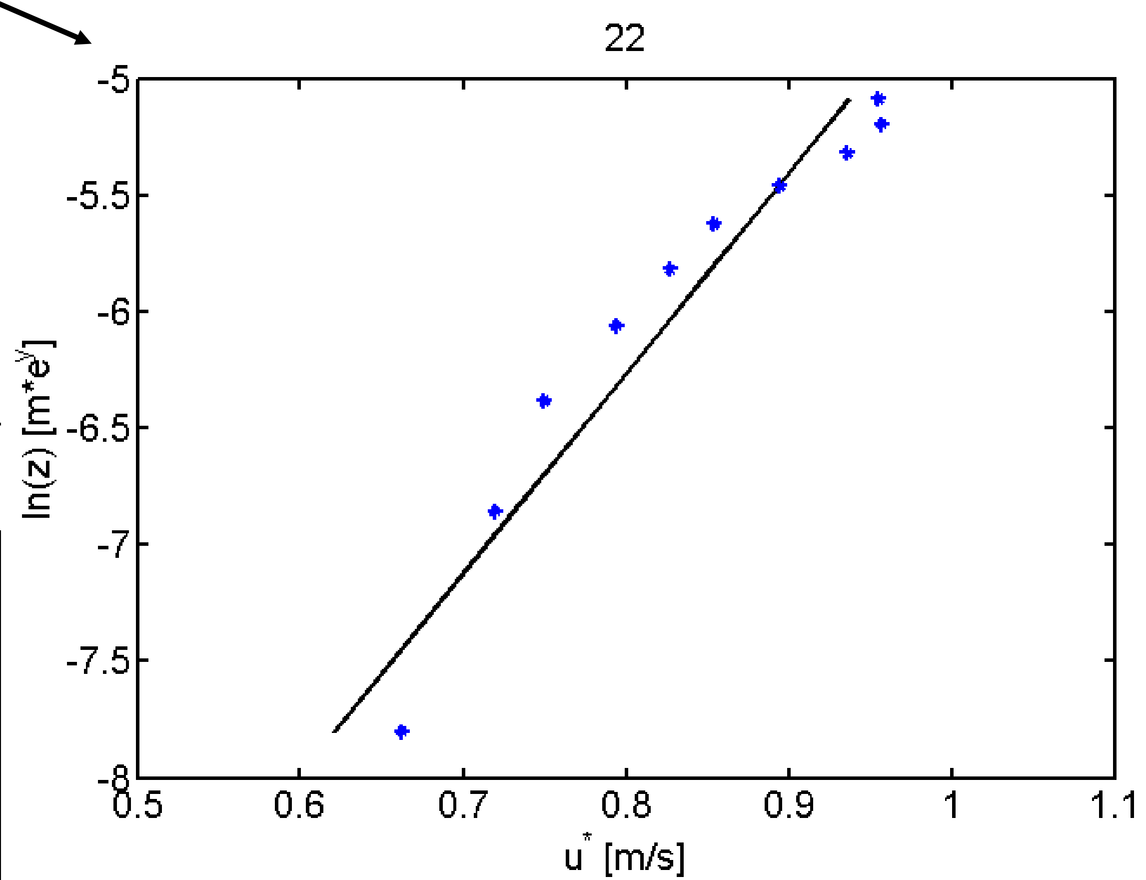
But…



r^2 of fit to logarithmic wall function [-]
t [s]
1
0.98
0.96
0.94
0.92
0.9
0.88
0.86
0.84
0.82
0.8
0
10
20
30



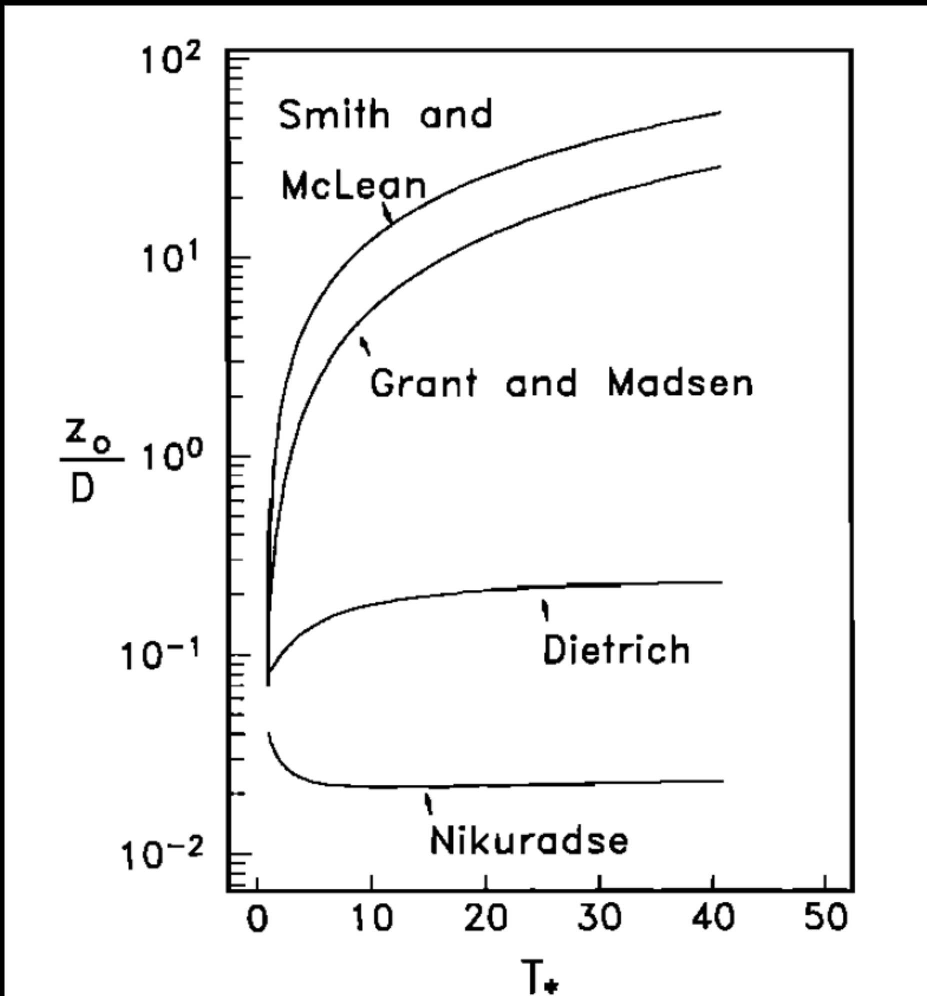
50
ln(z) [m*e^y]
v [m/s]
r^2 =.9993



22
ln(z) [m*e^y]
u* [m/s]
-5
-5.5
-6
-6.5
-7
-7.5
-8
0.5
0.6
0.7
0.8
0.9
1
1.1

Lesson learned (methodological):

u^*, τ_b, z0? When bed location & transport stage uncertainty: freedom, freedom, freedom (with misleading high r^2).

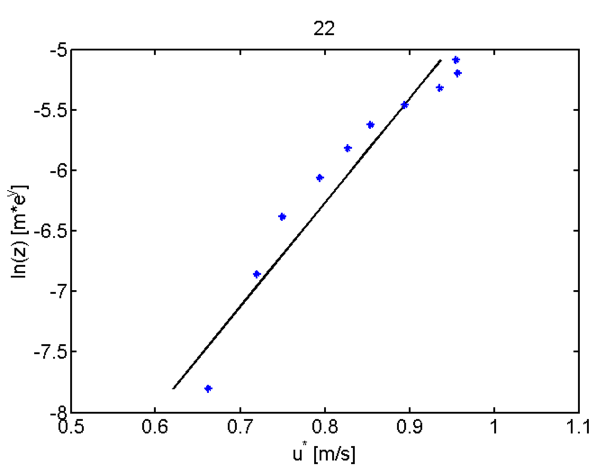


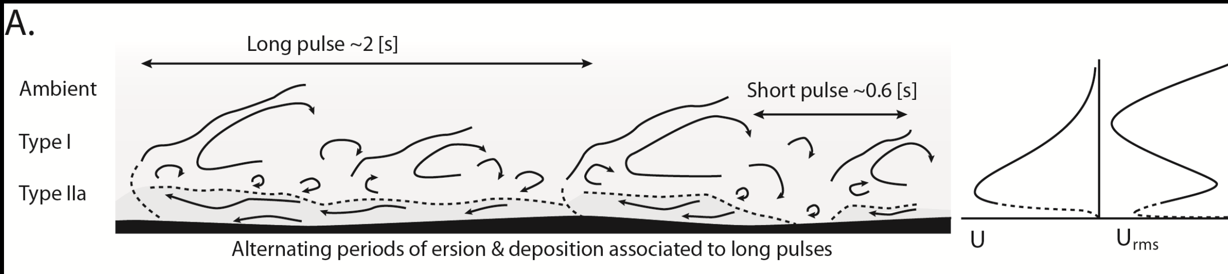
Wiberg & Rubin 1989 “Bed Roughness produced by saltating sediment”

Implication Hypothesis: standard methods of determining u* and z0 break down because the logarithmic law of the wall does not apply, applying it anyway results in “ghost roughness”

Nikuradse [1933]
Owen [1964]
Smith & McLean [1977]
Grant & Madsen [1982]
Dietrich [1982]
???

Lessons learned (phenomenological): The velocity structure periodically fluctuates away from logarithmic

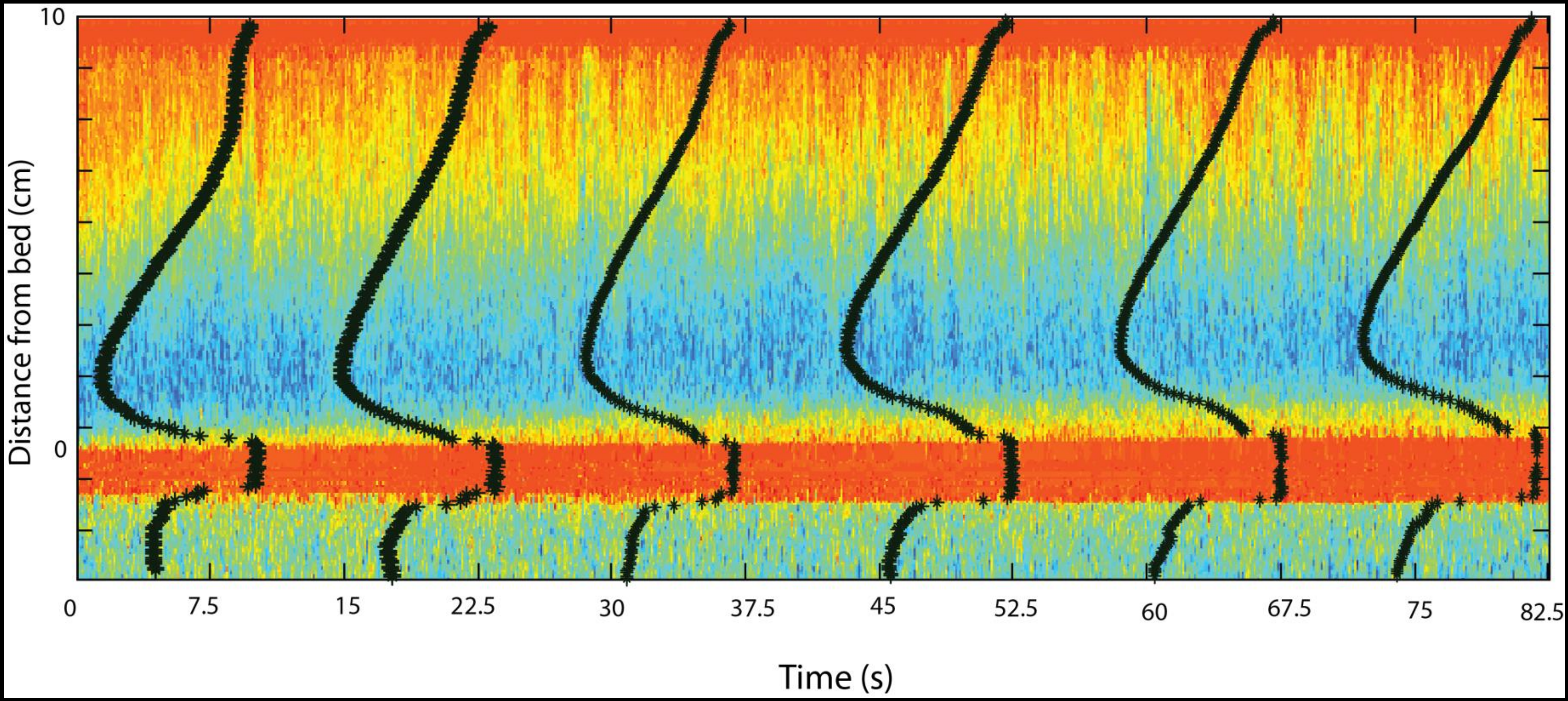




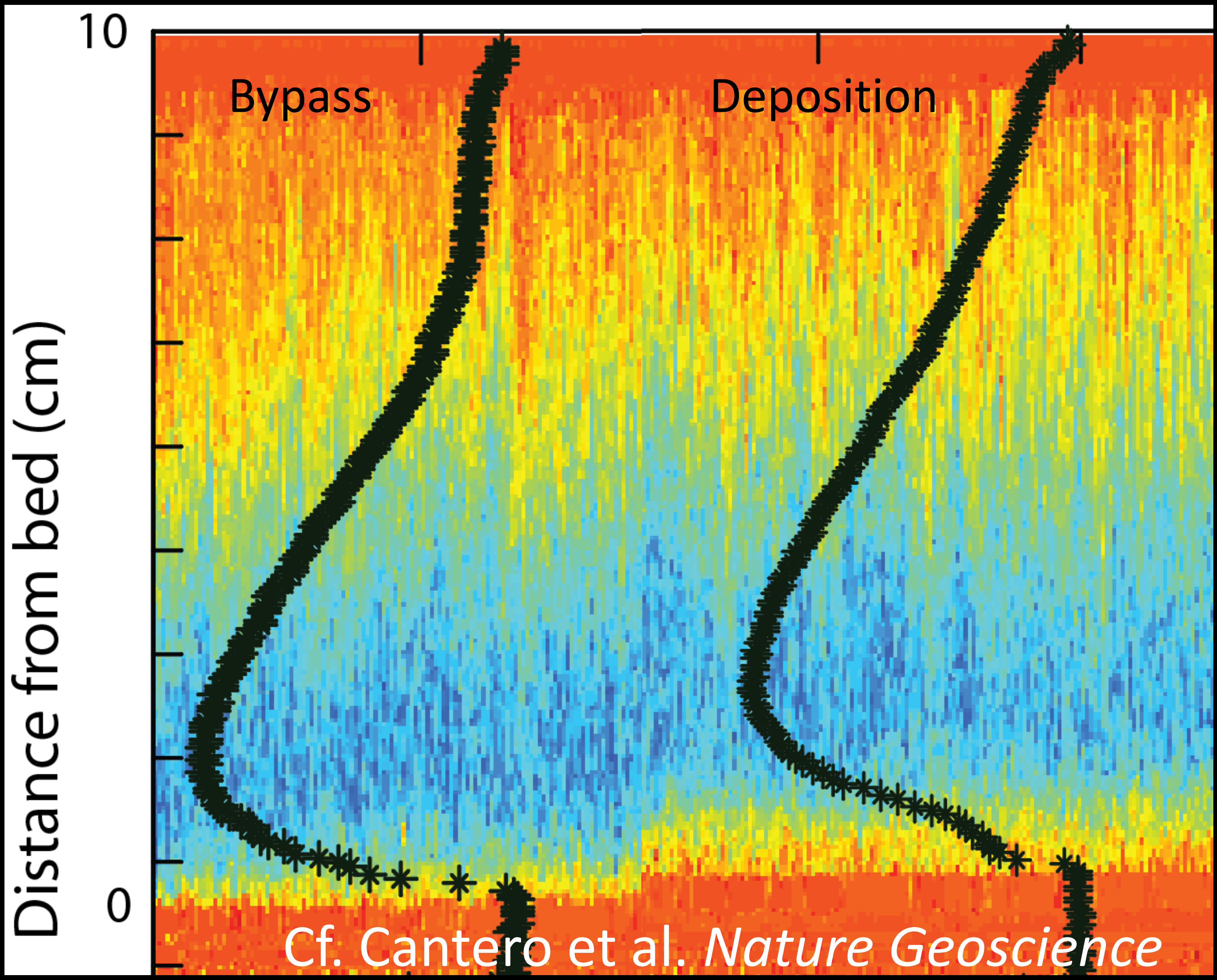
Hypothetic interpretations:

- Density stratification? $\tau(z)/\rho(z) = u^*(z)$
- Turbulence dampening *sensu* Bala? $Ri_\tau v_s > \kappa_c\,(Re_\tau)$
- Formation of a bed extracts energy from the flow?
- Transport of momentum by settling of high velocity grains?
- Extra energy sink from collisions of particles in high density region?
- …?
- Experimental methodological explanations? (Doppler; space-time averaging; density dependence of ultrasound velocity)

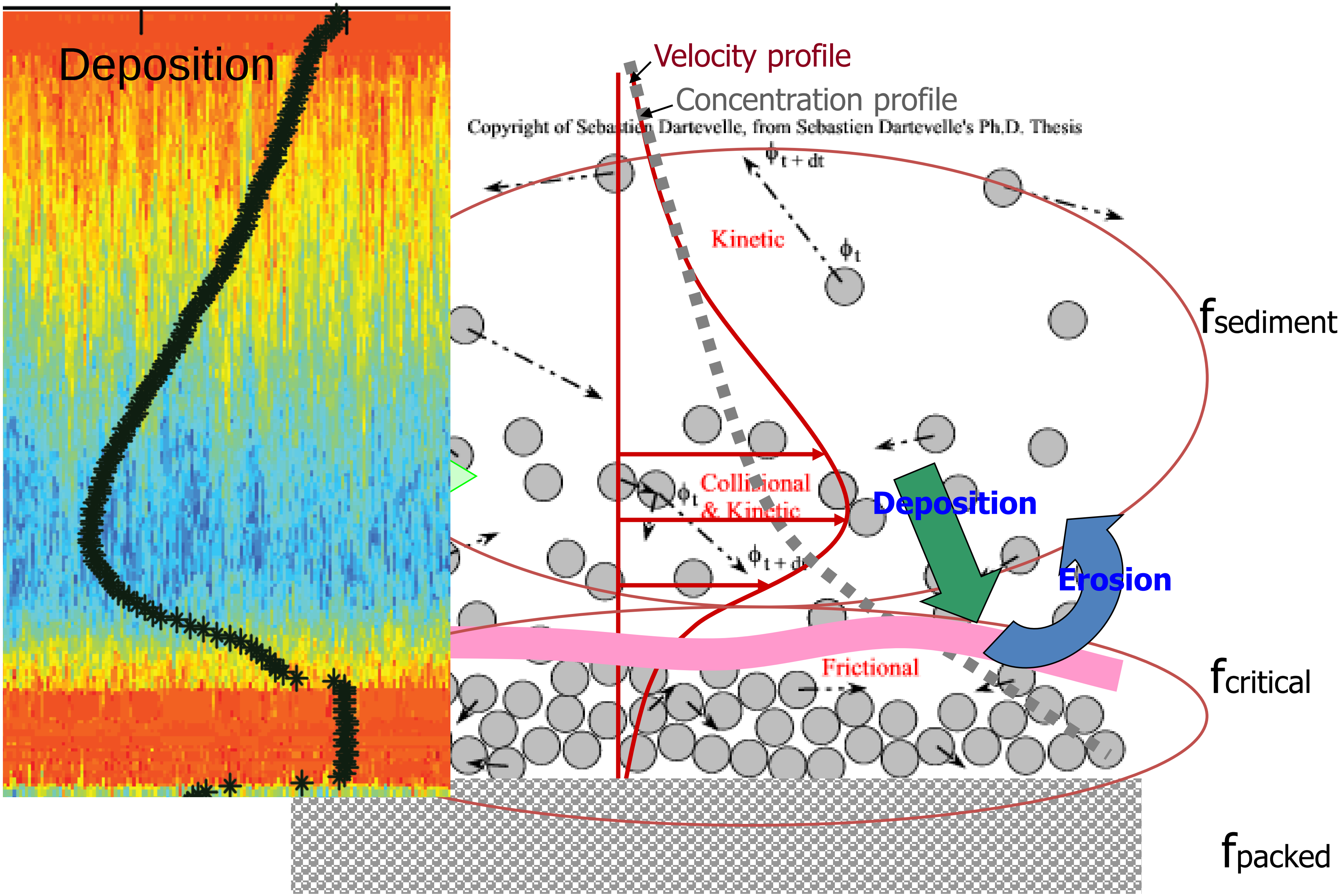
Application to flow over aggrading bed
Bypassing flow structure ≠ depositing flow structure



The rheology of this basal zone is different from Newtonian Turbulent Flow?



The deposit is formed in a modified basal rheological regime.



Deposition from turbidity currents is the transformation from turbulent suspension to fixed bed.

This “Depositional Transformation” is a difficult subject:

- What is the role of porefluid pressure gradients?
- Collisional& frictional vs. viscous lubrication?
- How does the evolution of this basal layer affect the over-riding flow dynamics?
- How to model?
  - DNS resolving grains & porefluid (*sensu* Eckart’s talk)?
  - Can a non-Newtonian continuum rheology be applied?


He Liz, how can these wave ripples be aggrading so consistently for 0.5 m?
I don't know Kyle, but I can wave my hand like a true field geologist.