POLITECNICO DI MILANO

ICSE6

Paris – August 27-31, 2012





INSIGHT ON HOW BED CONFIGURATION AFFECTS PROPERTIES OF BED LOAD MOTION

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Definition of the objective of the study

RESEARCH PROPOSAL:

Study of how **different kinds of bed** affect some **properties of sediments,** moving as bed load, within their **intermediate trajectories.**

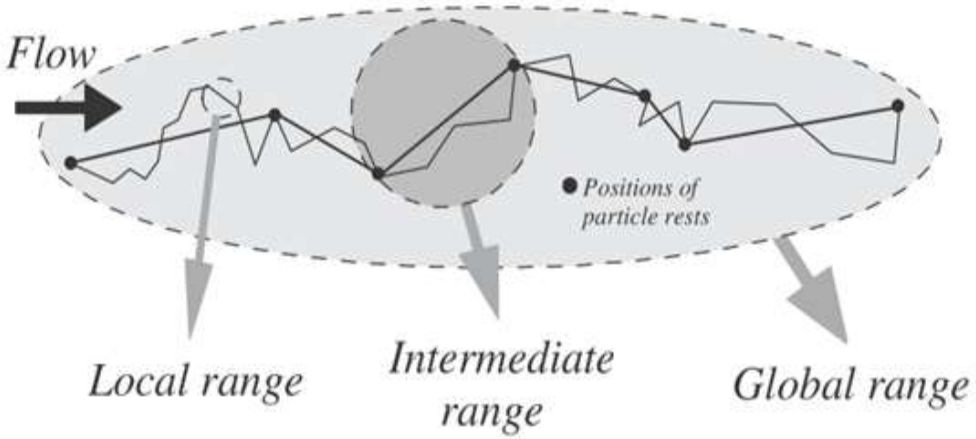

Figure 1. Conceptual representation of a bed particle trajectory consisting of three distinct ranges of scales: local, intermediate and global (Nikora et al. 2002).

Definition of the objective of the study

1) KINEMATICAL PROPERTIES

Variables: T_t , $\mathscr{L}$, L, L_x, L_y, V_x, V_y

Analysis:

- *min, max, μ, σ*, cv, S_k, K_u
- *PDF*
- *EPD*

2) TRAJECTORY STRUCTURE

Variables: $\mathscr{L}$, L

Analysis:

Tortuosity ($\mathscr{L} / L$)

Fractal dimension D ($\mathscr{L} \approx L^{D}$)

3) DIFFUSION PROPERTIES

Variables: $x(t)$, $y(t)$

Analysis:

Diffusion exponent ($\sigma^2 = t^{2\gamma}$)

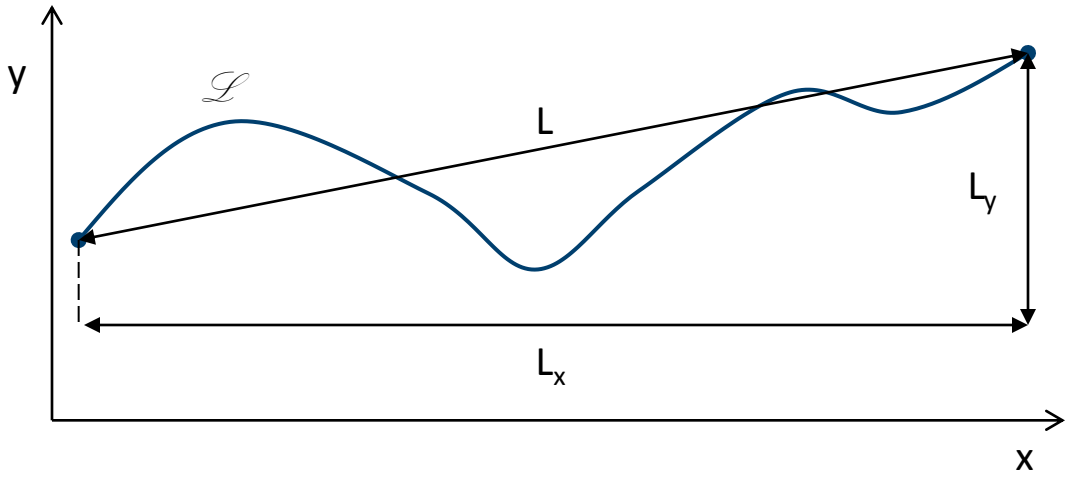

Figure 2. Definition sketch of some variables used to characterize intermediate particle trajectory.

Experimental campaign

TEST CONDITIONS

Flow discharge	Q (l/s)	8.0	11.1	11.8	12.2	12.6	13.0
Mobile uniform bed	MB		■	■	■	■	■
Fixed Rough bed	FB		■	■	■	■	■
FB with macro-roughness elements - low density	FBLD		■	■	■	■	■
FB with macro-roughness elements - high density	FBHD		■	■	■	■	■
Smooth bed	SB		■				■
SB with macro-roughness elements - low density	SBLD	■	■				■
SB with macro-roughness elements- high density	SBHD	■	■				■

■ Carried out □ Not carried out

NOTE: $Q_{cr,Mobile\ Bed}$=10l/s;

Experimental set-up

EXPERIMETAL TOOLS		
Tool	**Description**	**Note/Function**
Duct	Length x width x height : 5.6m x 0.4m x 0.11m	-Recess section for MB experiments, length x height: 2m x 0.04m
Feeder	Location: close to the inlet	-Impulsive feeding
Ultrasonic Doppler Profiler	N of probes: 2 Location: upstream and downstream the measurement window	-Measurements of the instantaneous velocity profiles -Identification of bed height
Videocamera	Filmed area length x width: 0.4m x 0.25m Frame rate:26 fps	-Fixed above the duct
Magnetic flowmeter	Location: delivery pipe	-Measurements of flow discharge

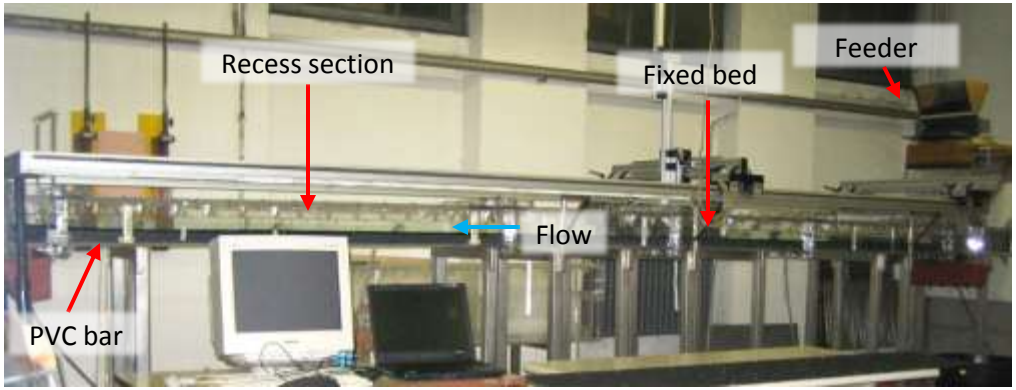

Figure 3. Pictures of the experimental set-up. dx) Duct and feeder; sx) Videocamera.

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SEDIMENTS	
Description	**Note/Function**
Shape: : uniform quasi-spherical Equivalent diameter: 3mm Density: 1270 kg/m^3 (PBT-plastic) Color: black/white (95% / 5% respectively)	-The mixture of BW sediments make easier particle tracking

Figure 4. Sediment mixture.

Image processing

STREAMS (NOKES, 2012) :
PARTICLE IDENTIFICATION AN PARTICLE TRACKING

INPUT:
Sequences of images of moving sediments

↓

Identification

↓

Tracking

↓

OUTPUT:
x(t), y(t) partial global trajectories

POSTPROCESS_PTV:
IDENTIFICATION OF THE INTERMEDIATE TRAJECTORIES

INPUT:
x(t), y(t) partial global trajectories

↓

Labeling motion/stillness

↓

Validation

↓

OUTPUT:
x(t), y(t) intermediate trajectories

Criterion of labeling

$x_{t+\Delta t} > x_t \; \forall \; \Delta t > 0$ within the global trajectory

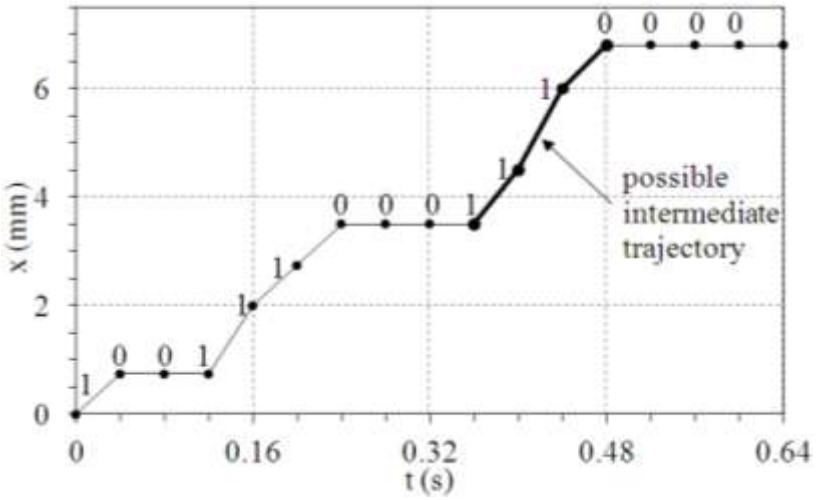

Figure 5. Sketch of the labeling procedure of a part of a global trajectory.
The tags "0/1" mean "stillness/motion".

Experimental campaign

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Carried out Not carried out Analyzed

NOTE: $Q_{cr,Mobile\ Bed}$=10l/s;

Experimental campaign

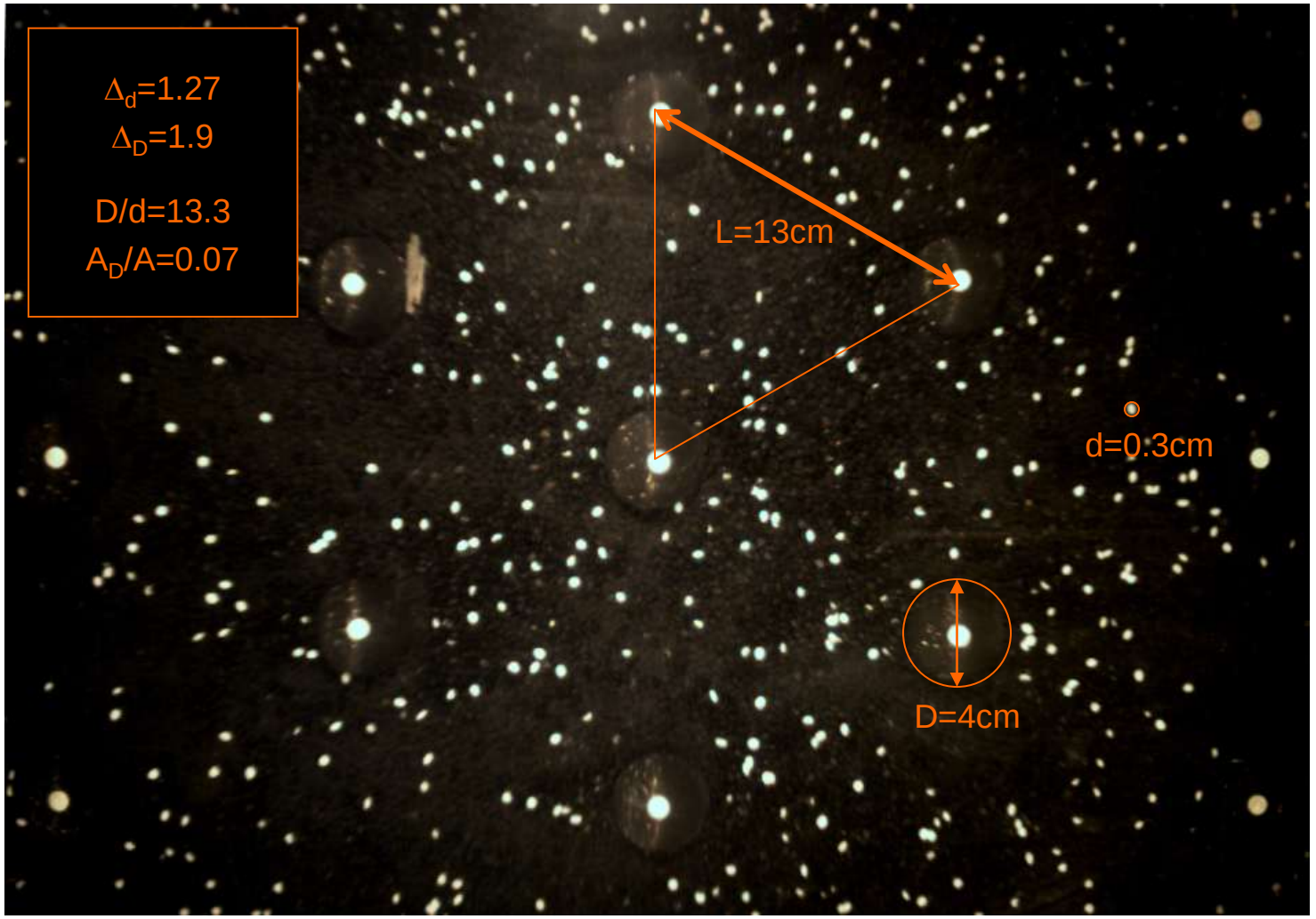


Figure 6. Path of macro-roughness elements in RBLD configuration.

Results: analysis of the statistical moments

Table 1. Parameters of the experimental tests and statistics of first and second order of the analyzed variables.

Test description		Momenta											
		T_t		L		L_x		L_y		V_x		V_y	
Test	Q (m^3/s)	μ (s)	σ (s)	μ (mm)	σ (mm)	μ (s)	σ (mm)	μ (mm)	σ (mm)	μ (mm/s)	σ (mm/s)	μ (mm/s)	σ (mm/s)
MB1	0.011	0.52	0.39	19.17	22.24	18.56	22.22	-0.20	4.89	28.25	17.17	-0.56	9.63
MB2	0.013	0.44	0.38	16.62	22.37	16.08	22.25	0.27	4.77	27.94	18.71	0.77	10.07
FB1	0.011	0.55	0.42	20.81	23.93	20.15	23.9	0.33	5.35	29.38	16.6	0.73	9.89
FB2	0.013	0.53	0.42	22.75	28.05	22.15	28.01	0.27	5.39	32.61	20.54	0.55	9.96
FBLD1	0.011	0.47	0.37	16.73	20.36	15.78	20.13	-0.23	6.31	26.92	16.82	-0.37	12.17

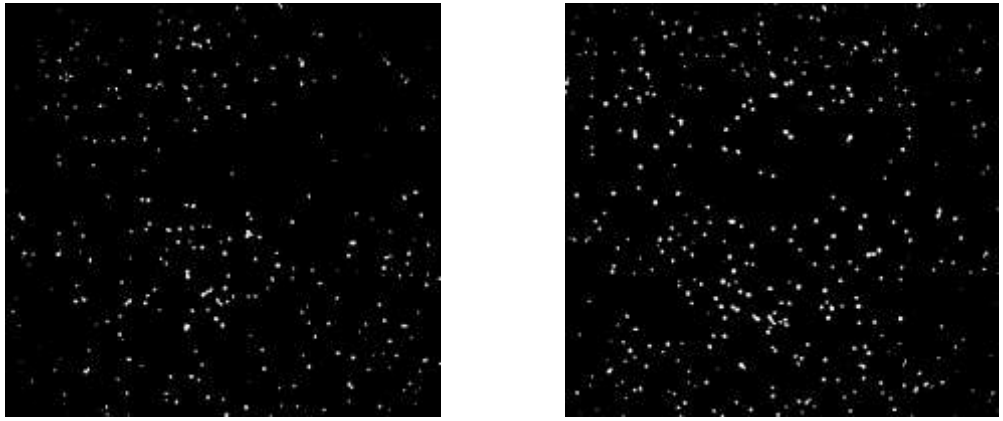


Figure 7. Images of the flume bed during the tests FB1 (lower *Q*, left side) and FB2 (larger *Q*, right side).

Results: Pdf and Edp

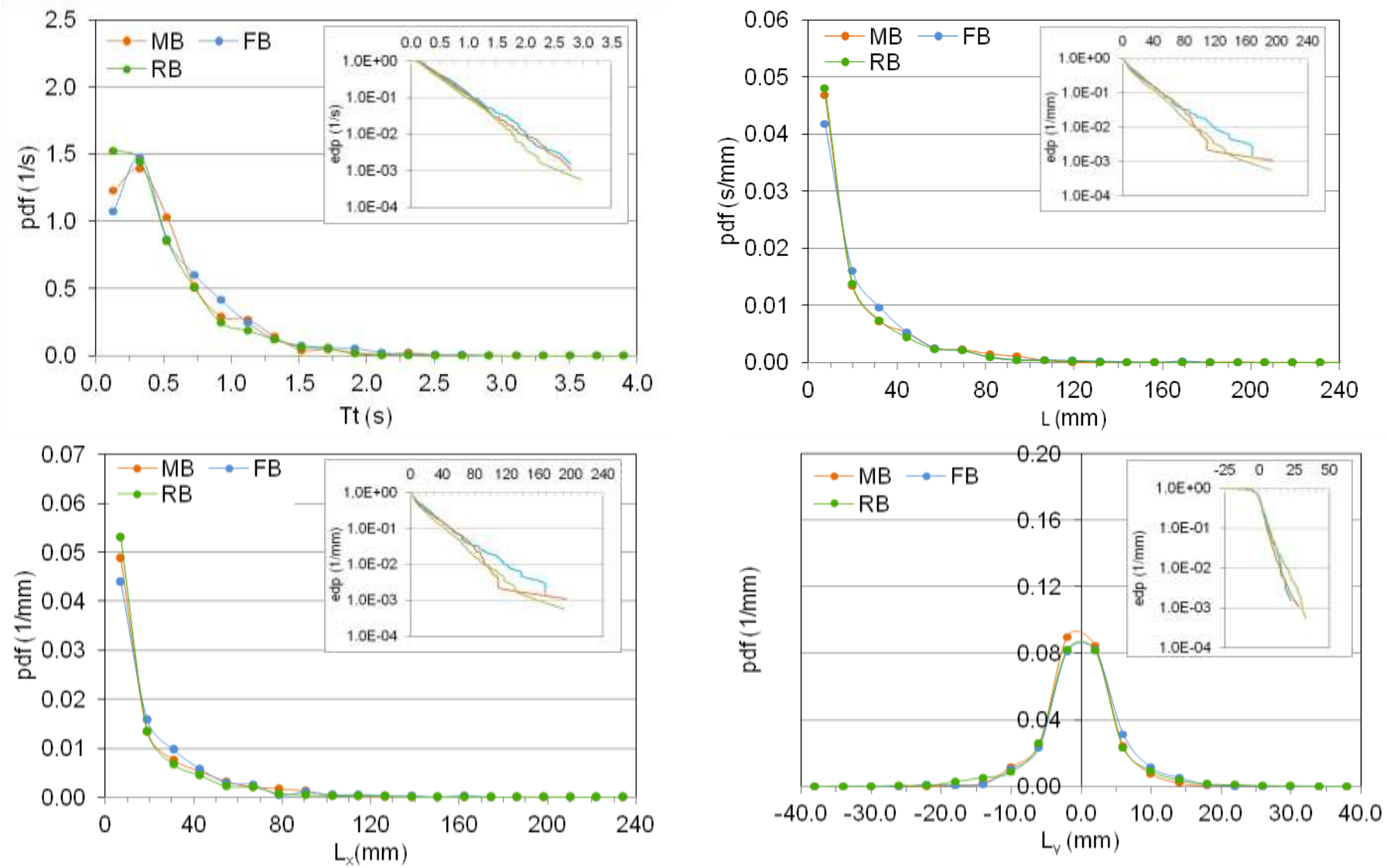
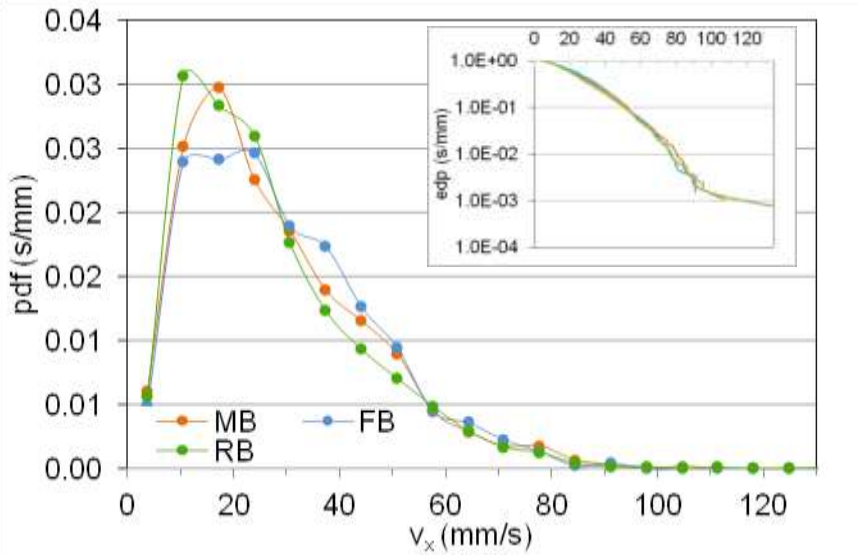


Figure 8. Pdf and Edp of the travelt time and lenght for Q=11.1 l/s.

Results: Pdf and Edp



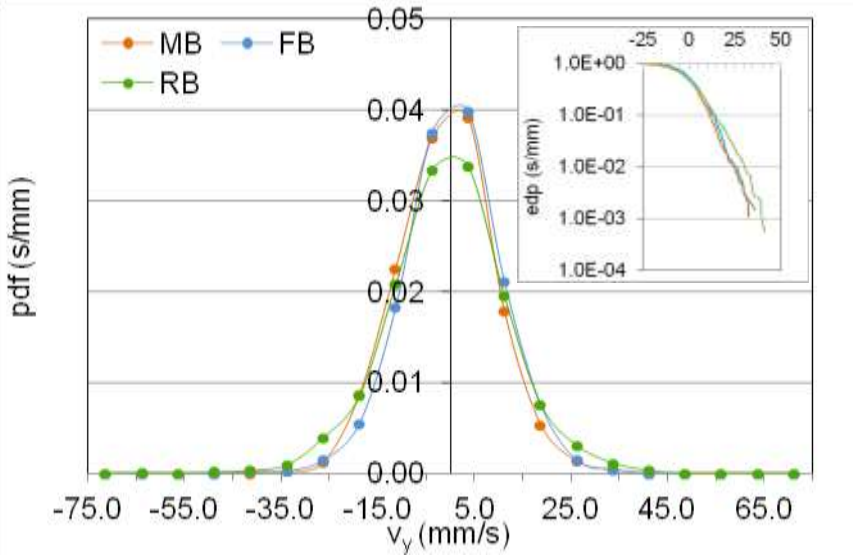


Figure 9. Pdf and Edp of the velocity components for Q=11.1 l/s.

Conclusion and further steps

MAIN FINDINGS:

1. The **comparison among data** of previous studies **have to done carefully**;

   → **FB** can **reproduce closely** but **not perfectly** the **MB**;

   → **Macro-roughness elements** change the characteristics of particle trajectories and the differences could depend on their **density** and **patchiness.**

2. The **relationship between the solid discharge and the length of the trajectory** is not straightforward and **involves the intermittent features of the process** (i.e., motion and stillness of particles);

3. **Under weak bed load condition, kinematic variables don't change significantly with the discharge.**

NEXT STEPS:

- Analysis of the trajectories in all different experimental sets-up;
- Analysis of the **geometrical structure** of intermediate trajectories
- Analysis of the **diffusion properties** of moving sediments within the intermediate range.

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THANKS FOR YOUR ATTENTION