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HYTECH Aquatic Interfaces

POLITECNICO DI MILANO

An analysis of entrainment and deposition rate fluctuations in weak bed load transport

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HYTECH
Hydrodynamic Transport in Ecologically Critical Heterogeneous Interfaces

Host Institution: Politecnico di Milano (ITA)

***I... ent kinematics* at small *temporal* and *spatial* scales**

PROCEDURE

1. Measurement

Approach

- **Lagrangian** → $T_{m\text{(time of motion)}}$, $V_{\text{(velocity)}}$, $L_{\text{(trajectory length)}}$, $t_{r\text{ (time of rest)}}$
- **Eulerian** → C concentration, q_s sediment flux, $t_{\text{inter-arrival}}$, E Entrainment, D Deposition

2. Merging the approaches

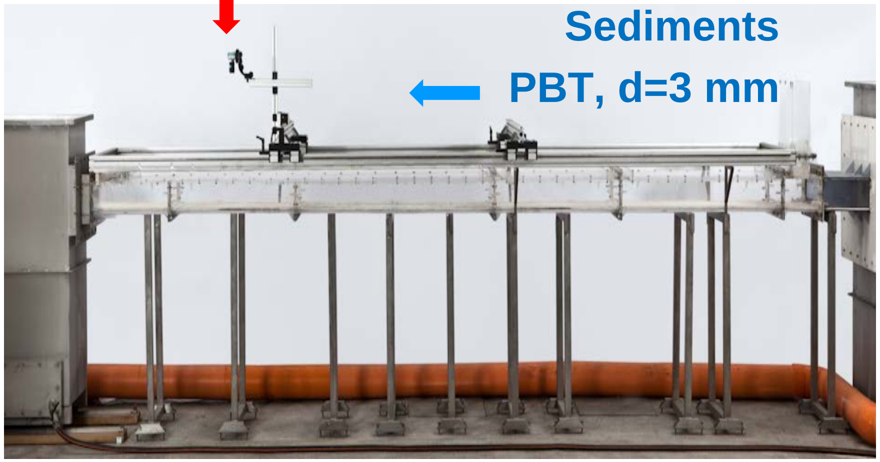
3. Data analysis and result interpretation

EXPERIMENTS

Bed

Camera 32 fps, 960 x 630 pixels

65 x 40 cm^2, duration 50s

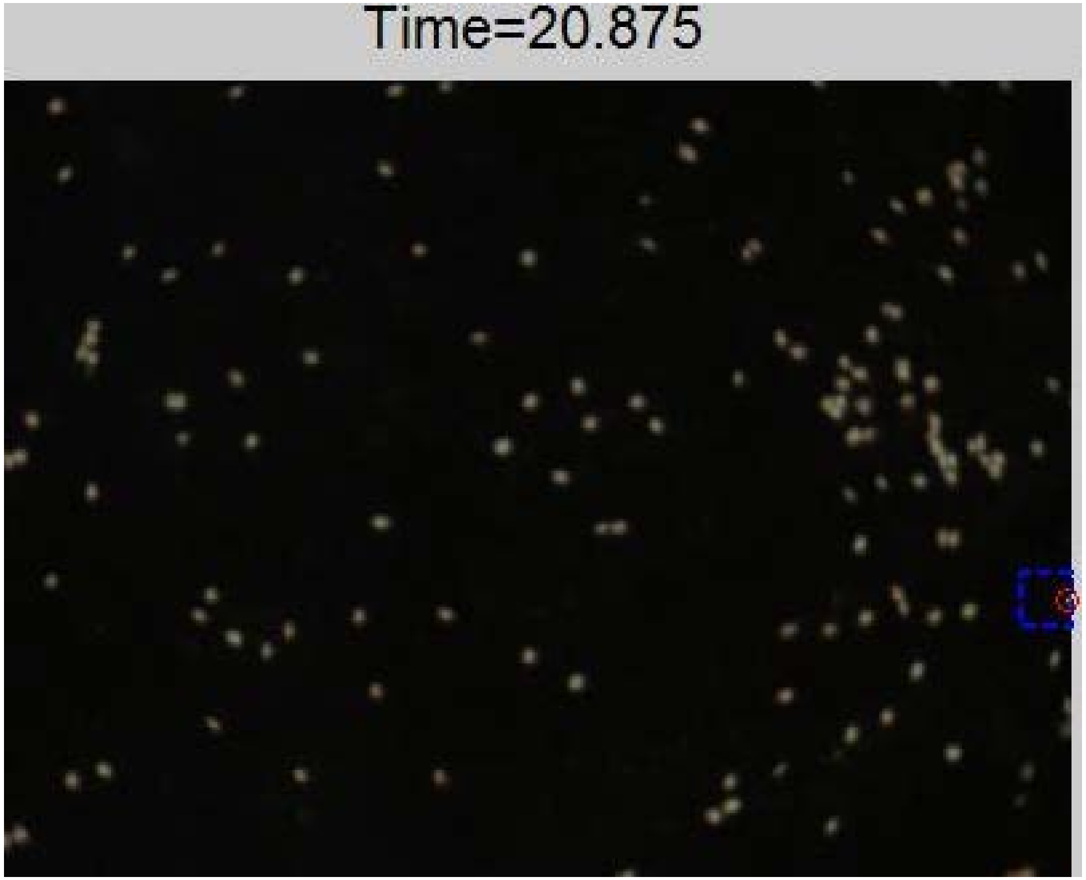


Experimental flume, Politecnico di Milano

Controls

- *Discharge*
- *Feeding rate*

Choice of fixed rough bed → ***system naturally in equilibrium if you feed equal or less than transport capacity***



Database of of accurately tracked particles ⇨ ***Measuring Kinematics***

Entrainment rate

Deposition rate

Definition of Motion *(Campagnol et al. 2013)*

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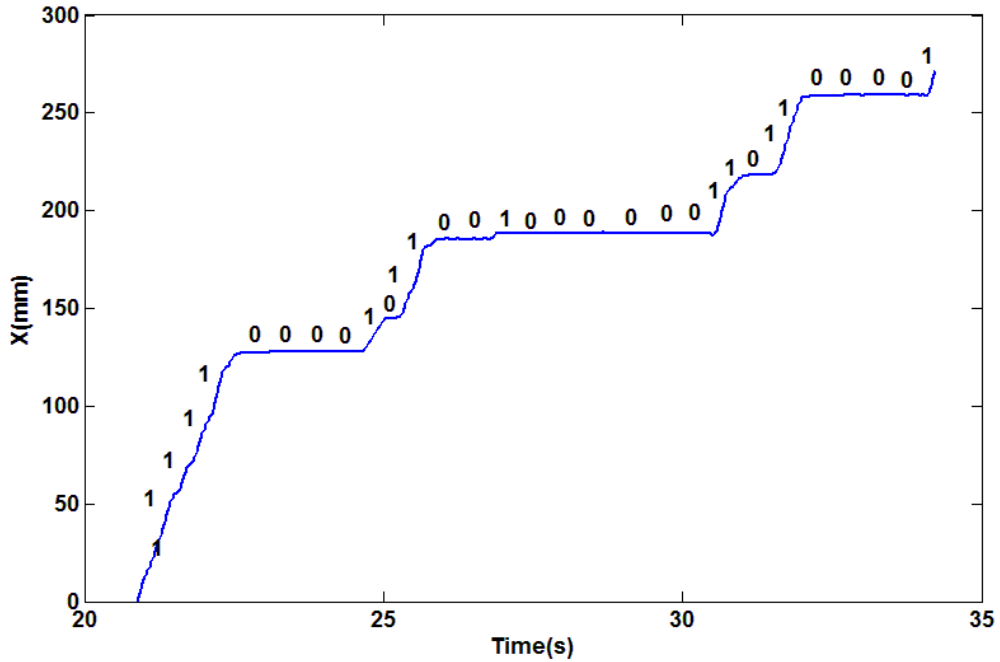
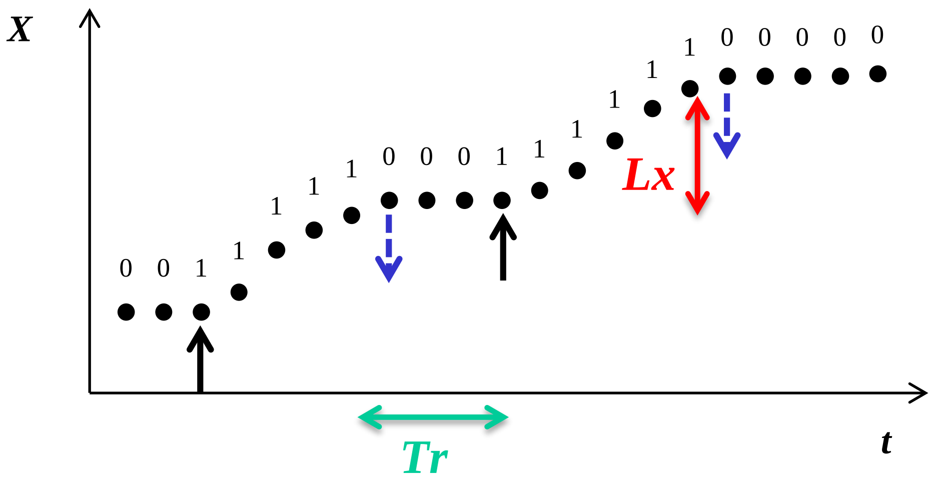


$$if\ x_{ti} < x_{ti+\Delta t}\ for\ all\ \Delta ts \rightarrow motion \rightarrow \text{labeled } 1$$

$$\text{Else rest} \rightarrow \text{labeled } 0$$

ENTRAINMENT, DEPOSITION



1: Particle at motion
0: Particle at rest

Entrainment 0 → 1
Deposition 1 → 0

Validate an Entrainment

- ***Removing short displacements due to shaking***

particle was at a decent motion prior to stop

If Lx > d ⇨ Validated

d: particle size

(following Drake et al. 1988)

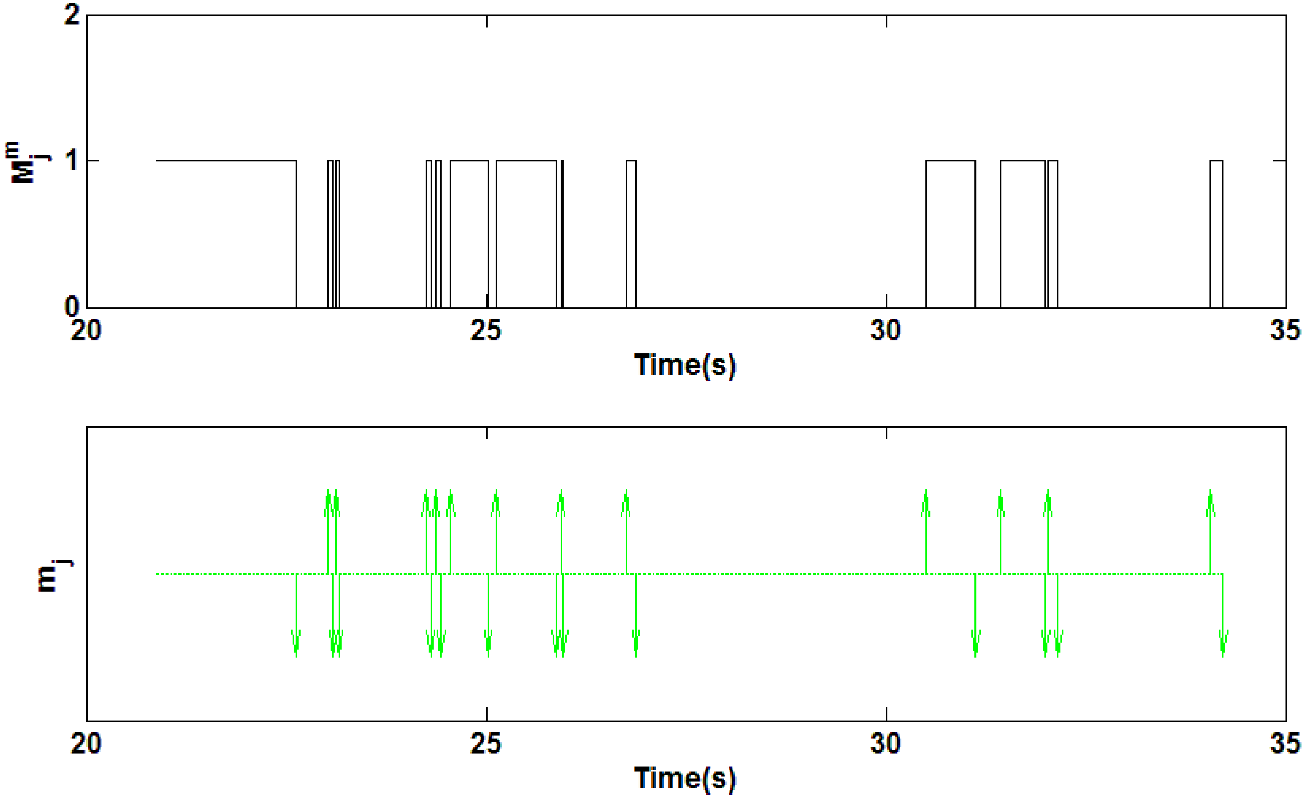
Validate a deposition

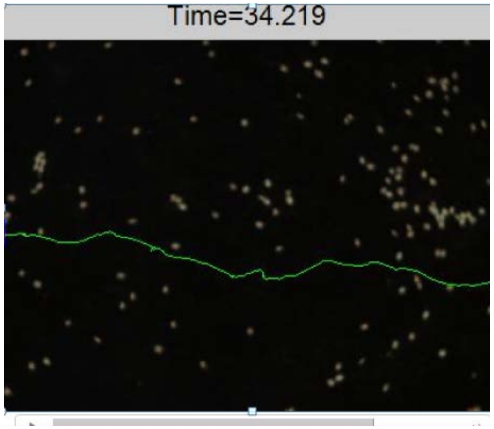
- ***Removing short stops***

particle is at a decent rest time

If $T_r > T_{threshold}$ ⇨ Validated

$T_{threshold}$: required time for a particle to travel a distance of one particle size





A sample of Entrainment and deposition instants for a global trajectory

Entrainment, Deposition rates (E, D)

$$E(mm/s) = \frac{N_E W_g}{A\Delta t} \qquad D(mm/s) = \frac{N_D W_g}{A\Delta t}$$

N_E : *No.* of entrainments within every single time interval

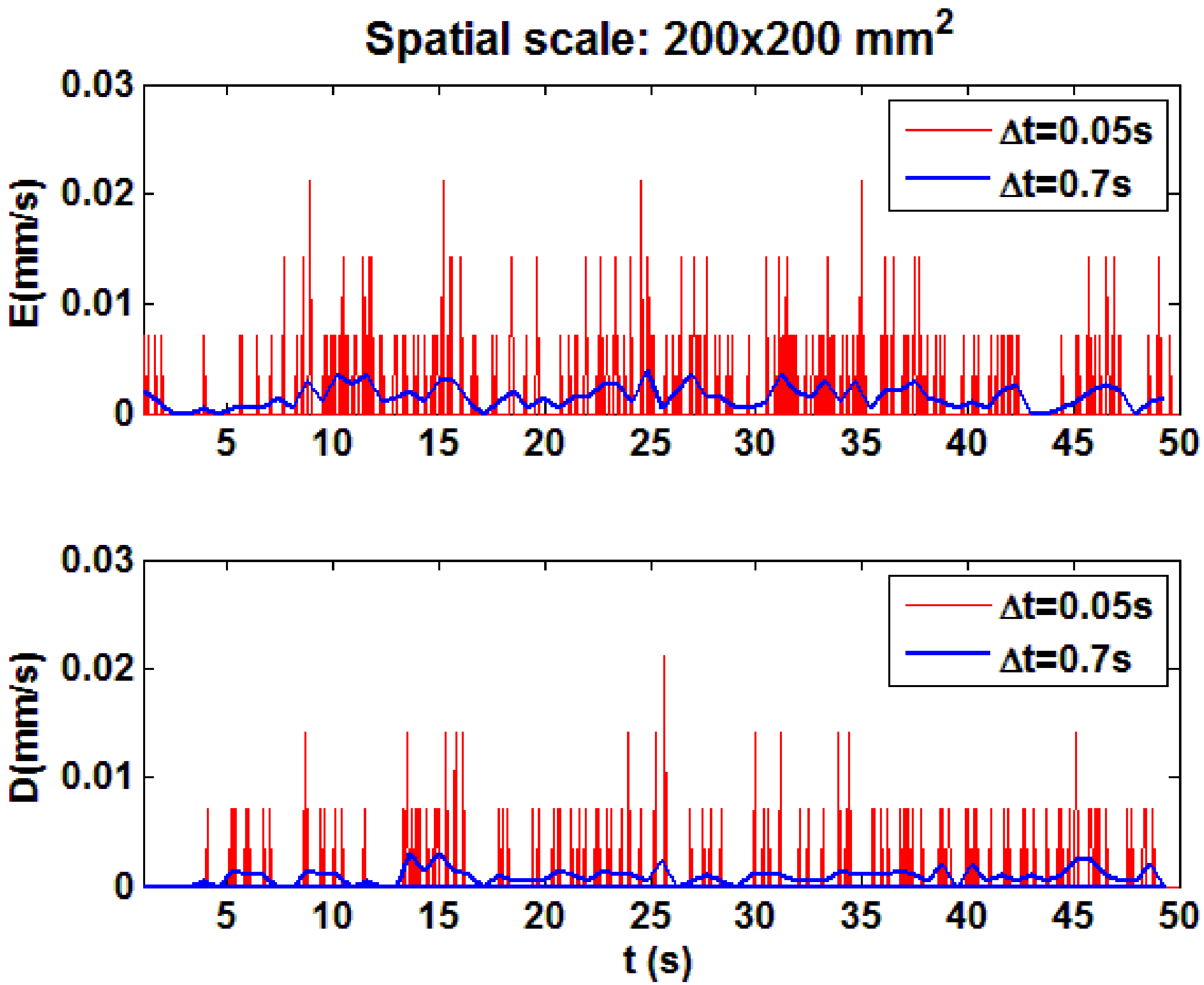
N_D : *No.* of depositions within every single time interval

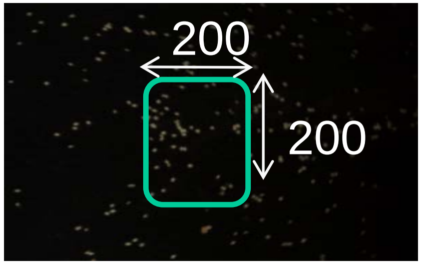
W_g : *Volume of the particle*

A : *Area* of spatial scales

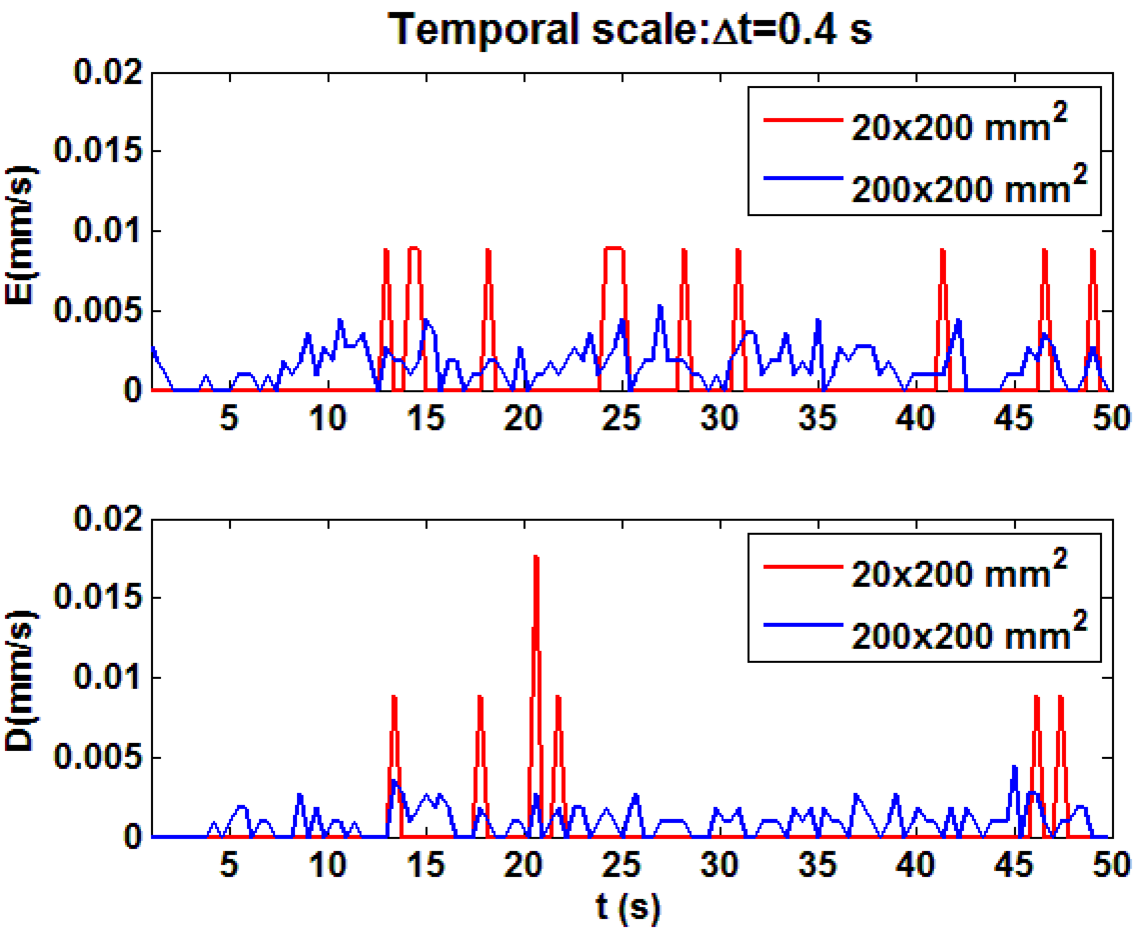
Δt : *tempral* scale

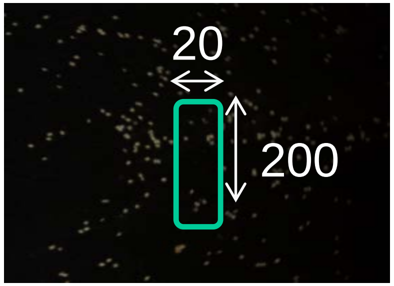
1. Temporal variation of E and D for fixed spatial scale and changing the time scale

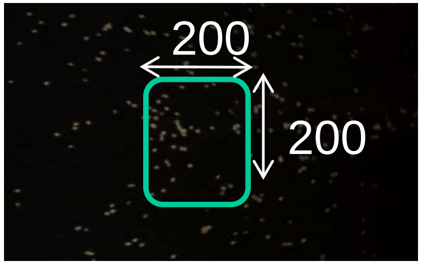




2. Temporal variation of E and D for fixed temporal scale and changing the spatial scale

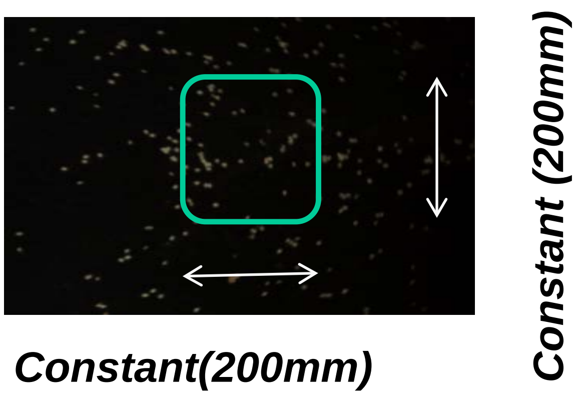


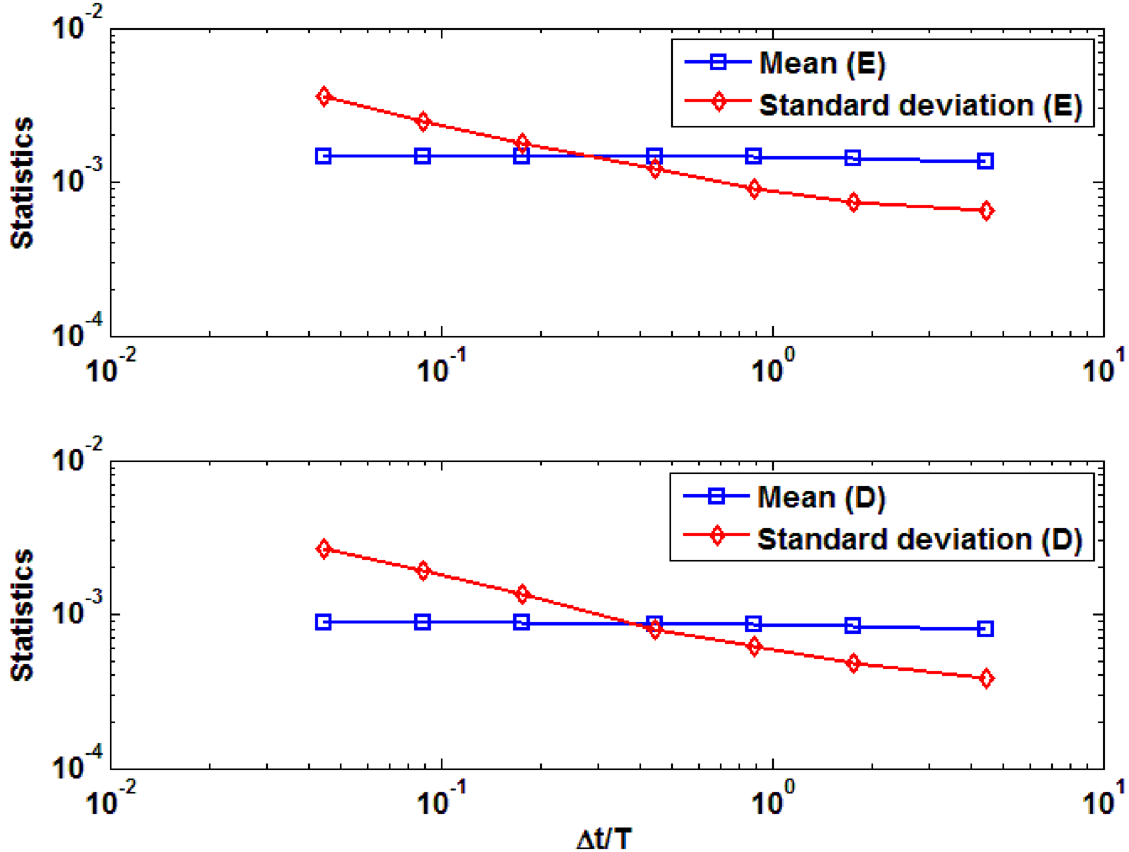




3. Temporal scale analysis (E, D)

Spatial scale constant (200x200)



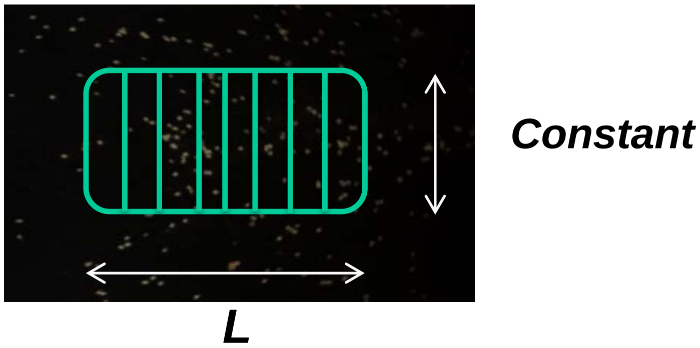


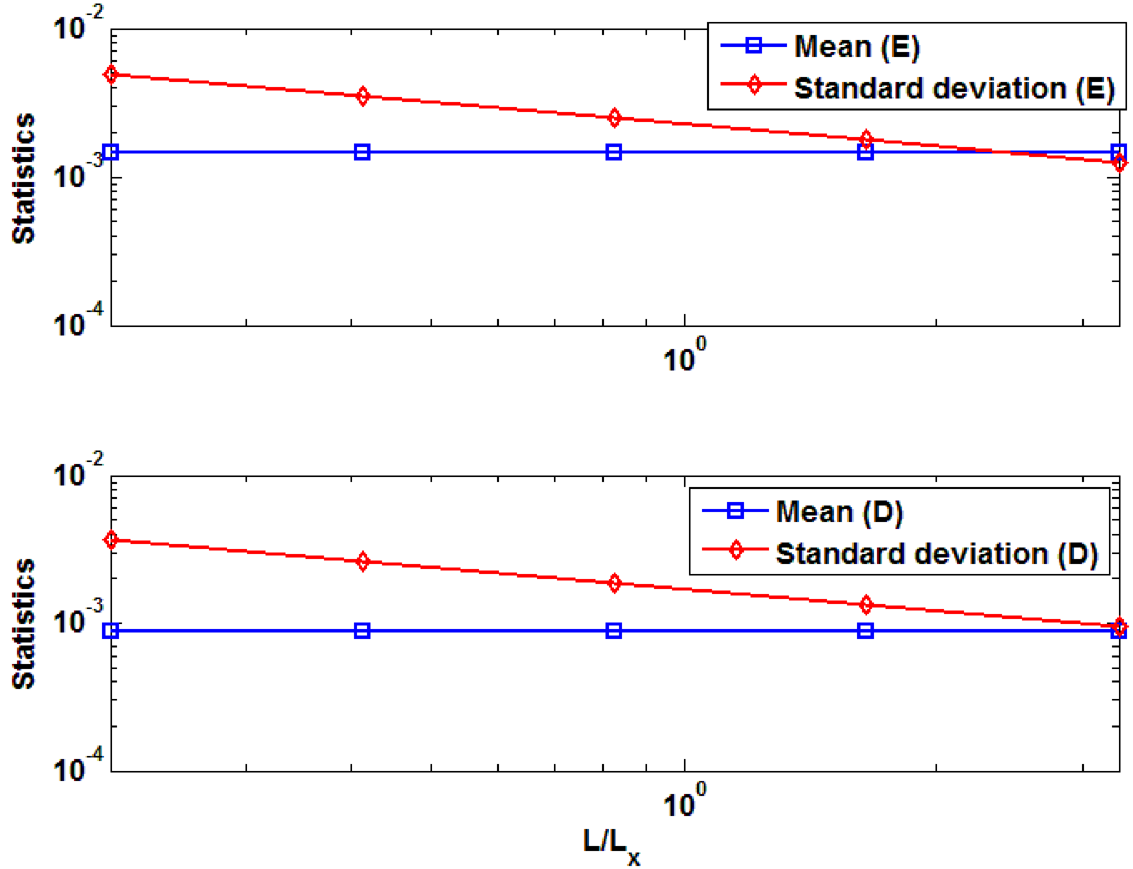
T: Average travel time of the trajectories

Δt: Temporal scales

4. Spatial scale analysis (E, D)

Temporal scale constant (dt=0.4s)
width constant (200 mm)





Lx: Average value of the trajectory lengths
L: Length of the special scale

The followings are key findings based on the preliminary results for E and D

1. ***The time series for E and D show that quantities are highly fluctuating for small support scales***

2. ***For increasing support scales, the fluctuation pattern becomes smoother***

3. ***The mean values of E and D are temporally and spatially scale independent whereas a scale dependency was observed for their standard deviations***

ACKNOWLEDGEMENT

HYTECH

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Technische Universität Braunschweig

The University Of Sheffield.

University of Aberdeen

cnrs

GHT Giotto High Technology

POLITECNICO DI MILANO

NIOZ Royal Netherlands Institute for Sea Research

European Commission

”my father had an early interest in sediment transport and river mechanics, but after careful thought opted for the simpler aspects of physics”

Professor H.A. Einstein (1904-1973)