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ICSE-6 2012

HYDREOS
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Evaluation of a High Resolution Profiler for Hydraulic Erosion Studies

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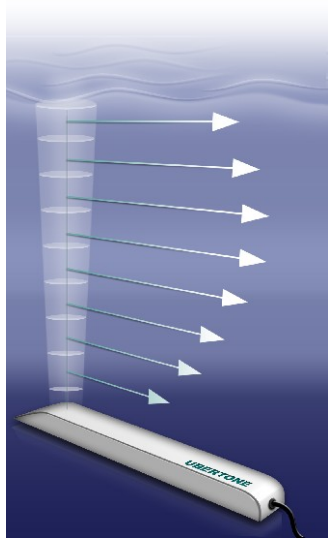
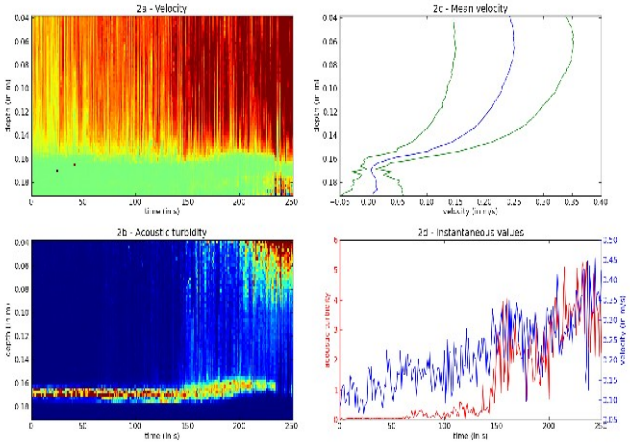
Outline of the presentation

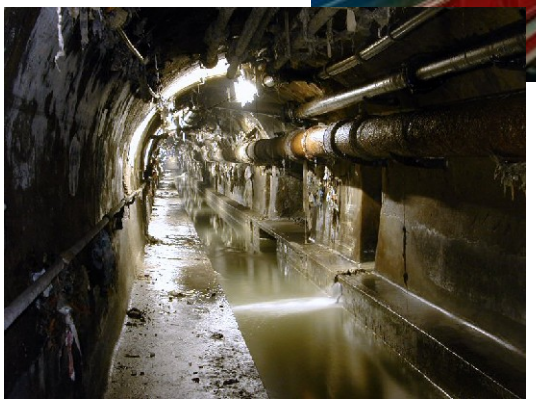
- Pulsed Doppler Technology
- **Velocity** measurement
- **Acoustic turbidity** measurement
- Combined measurements





A Tool for Erosion Studies

- Applications :
  - River bench and bed interface tracking
  - Normal velocity, shear stress, turbulent intensity → grabbing
  - Acoustic turbidity measurement → sediment transport



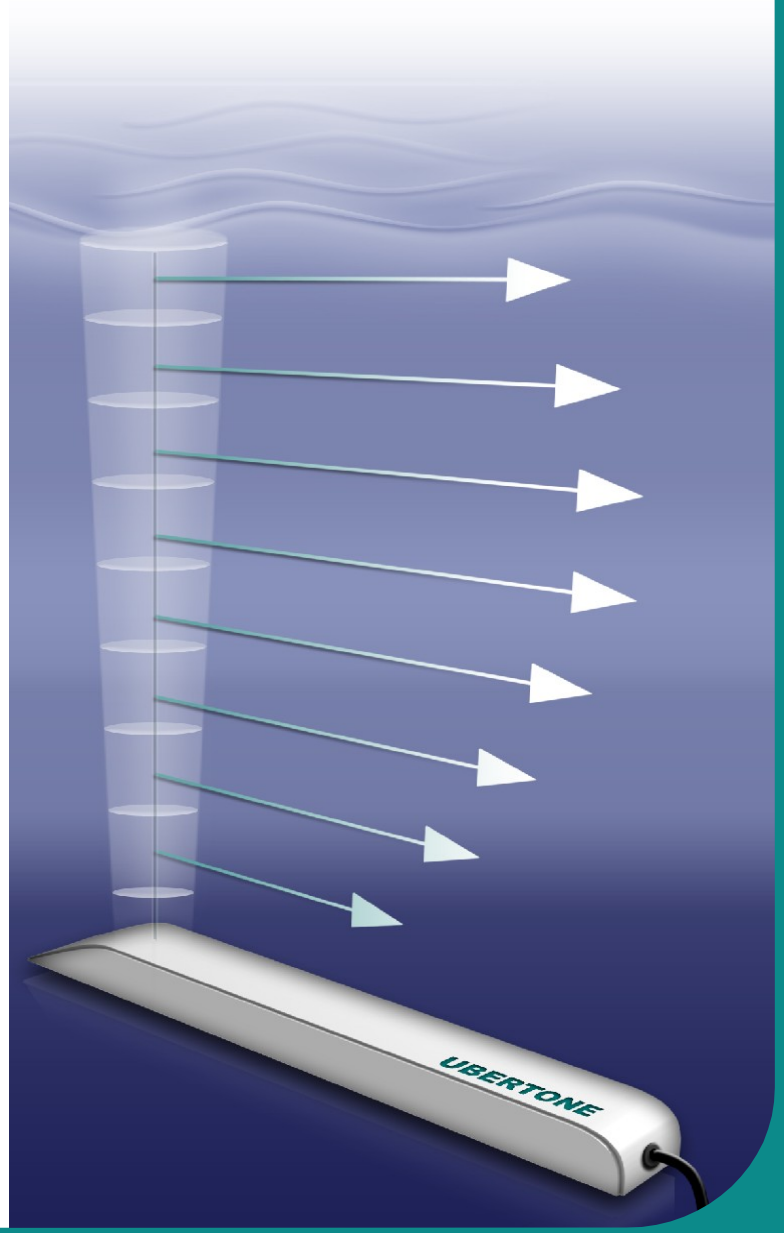
- UB-flow key points :
  - **Accurate** measurement
  - Install **Everywhere**

Acoustic Profiler : UB-Flow

- Measurements :
  - **Velocity** profiles
  - Acoustic **turbidity** profiles
  - Water **level**
- Technical advantages :
  - Spatial **resolution** (2.5 mm)
  - **Precision** (<1%)
  - **Outdoor** and **Laboratory** measurements
- Characteristics :
  - One fully immersed device (**low noise** electronic and logger)
  - 2 wideband transducers (**0.7** to **7.5 MHz**)

Pulsed Doppler Technology

- Close to medical Doppler sonography and sonar oceanography
- **Profiling** technique :
  - Burst emission
  - Echo delay ↔ cell position (sound propagation celerity)
  - Measurement in many narrow cells along the ultrasonic beam
- Performances :
  - **Accuracy** and **high resolution**
  - Range-velocity limit



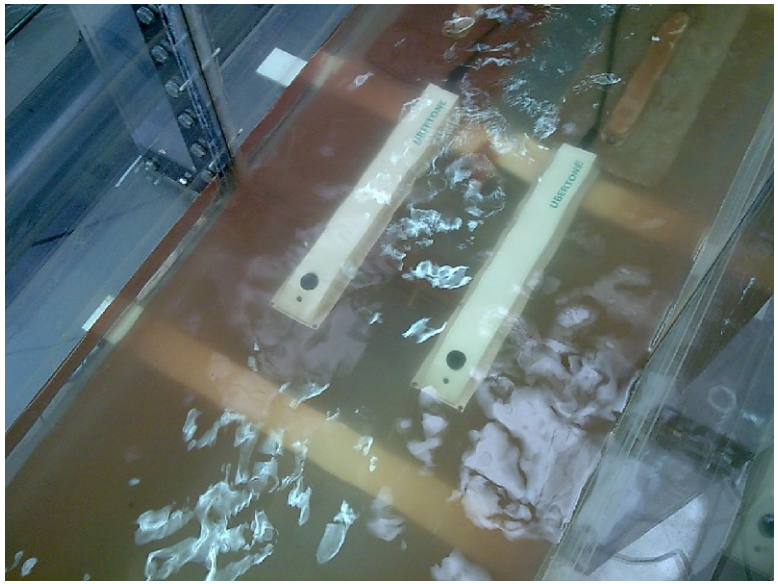
Velocity Estimation

$$v = \frac{c \cdot f_D}{2 f_0 \cdot \cos\beta}$$

v : flow velocity in one cell,
c : speed of sound,
f_0 : carrier frequency,
β : beam angle,
f_D : Doppler frequency.

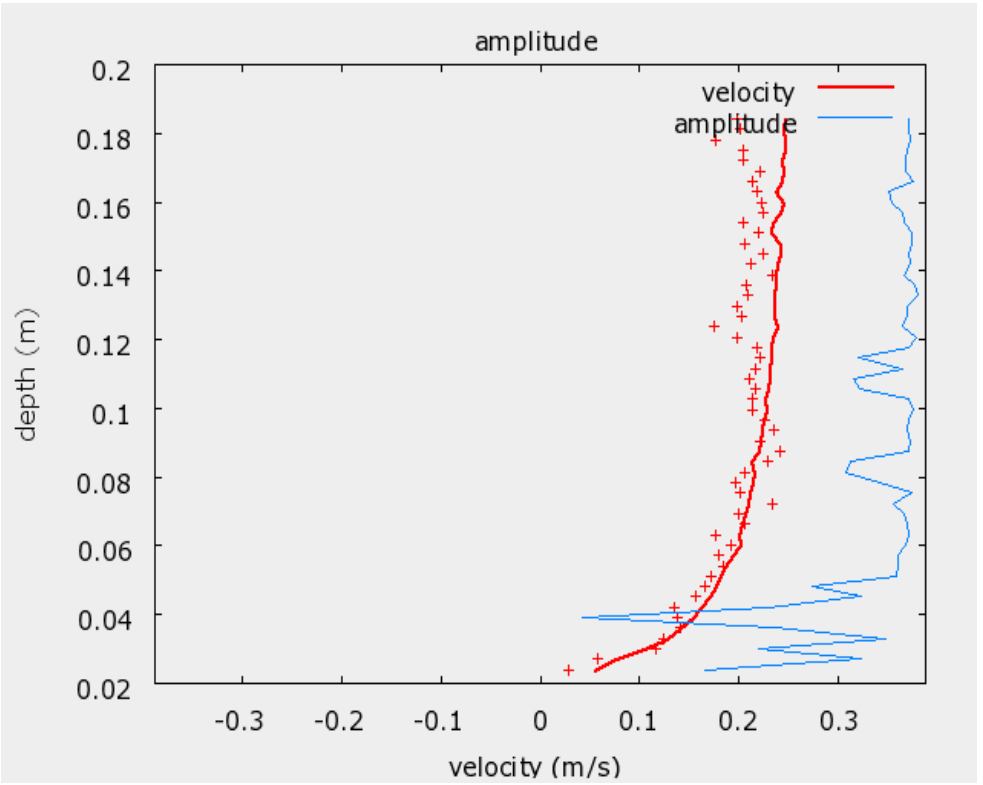
- Direct measurement
- Good accuracy
- Maximum likelihood estimator

Velocity Profile Measurement



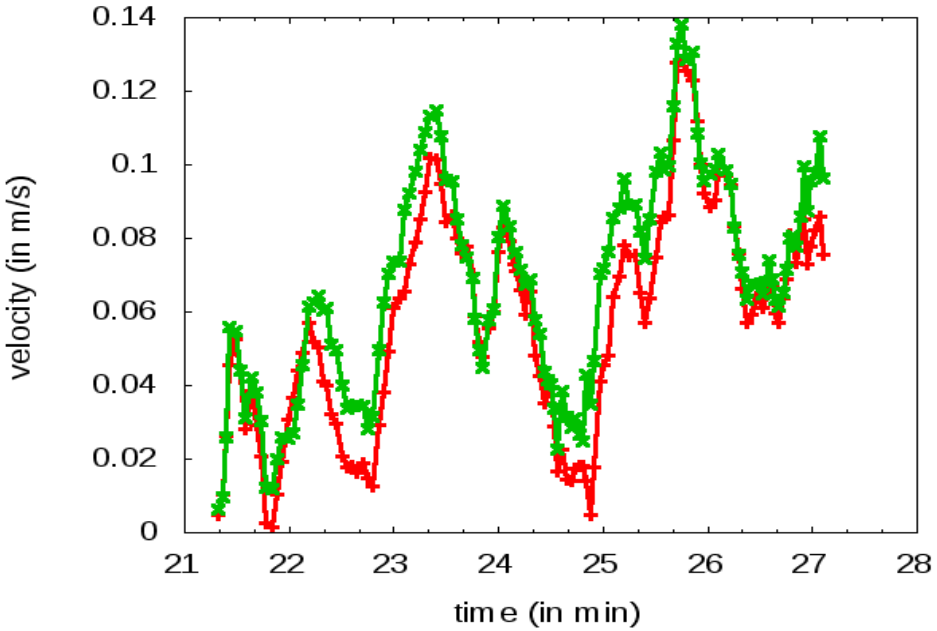
- In an experimental flume :
  - 60 cm large
  - 15 m long
  - Water high : 45 cm

- Typical turbulent log-law velocity profile



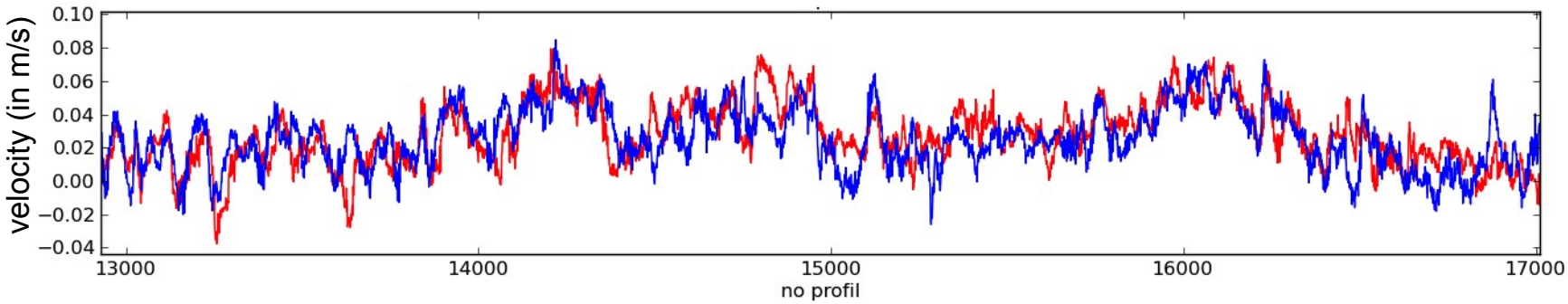
Turbulence Study

- Measurement at 0.25 Hz in river:



- correlation between two adjacent cells
- Injection frequency ~0.01 Hz
- Good signal-to-noise ratio

- Measurement at 100 Hz in a mixing tank :



Acoustic Turbidity Estimation

$$T_r = \frac{v_r^2}{v_e^2 \cdot \Delta t_p \cdot G_t(z)} \left(\frac{z}{R_t} \right)^2$$

v_r : reception voltage,

v_e : emission voltage,

Δt_p : pulse emission duration,

$G_t(z)$: electro-acoustic gain,

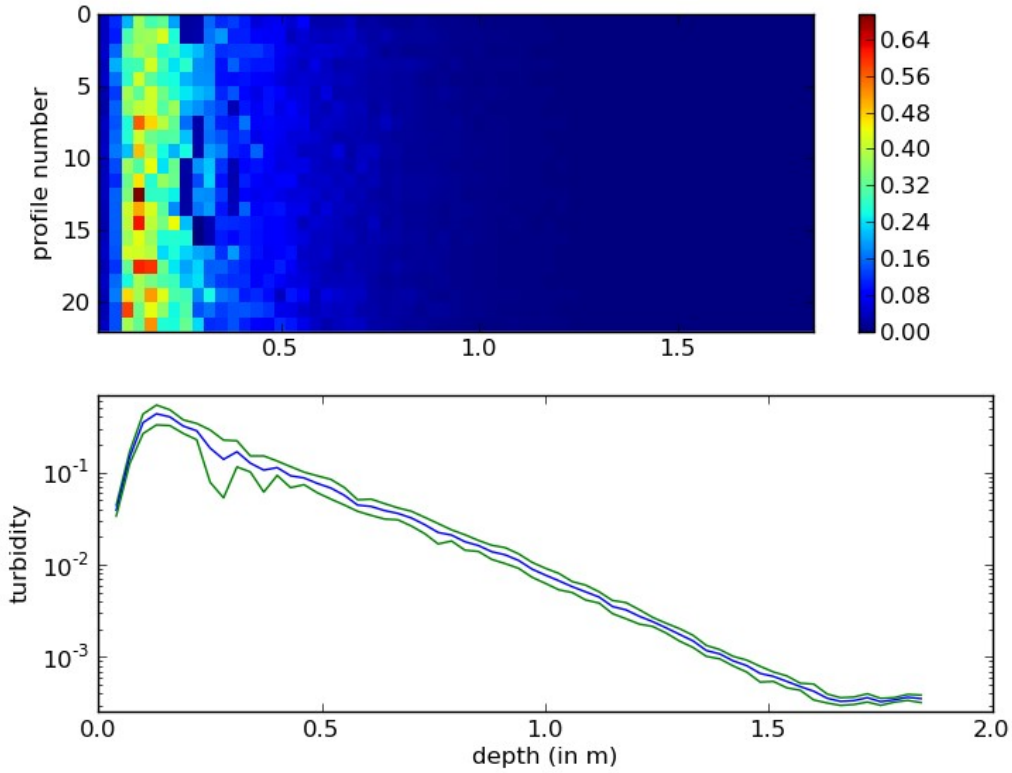
z : distance to the transducer,

R_t : transducer's radius.

- Independent from the sensor
- Related to Suspended Sediment Concentration and particle size

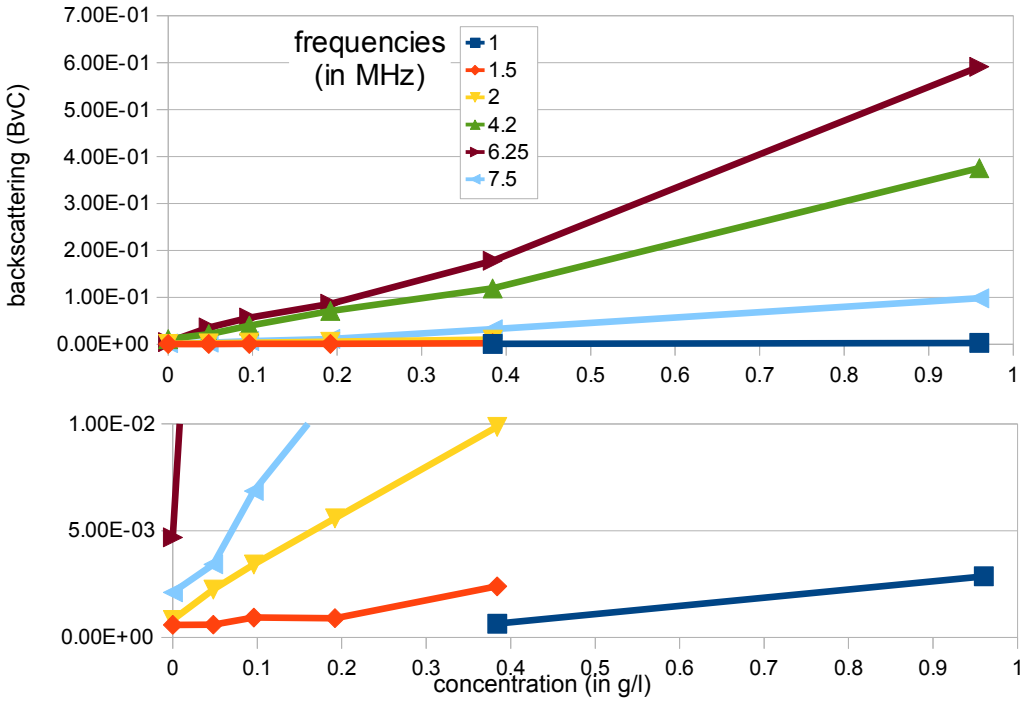
Acoustic Turbidity at High Concentration

- Aeration Tank (~6 g/l)
- Theoretical relation between acoustic turbidity ratio and concentration (homogeneous medium) : $T_r = \beta_v C \exp\left(-4\alpha_v C r\right)$



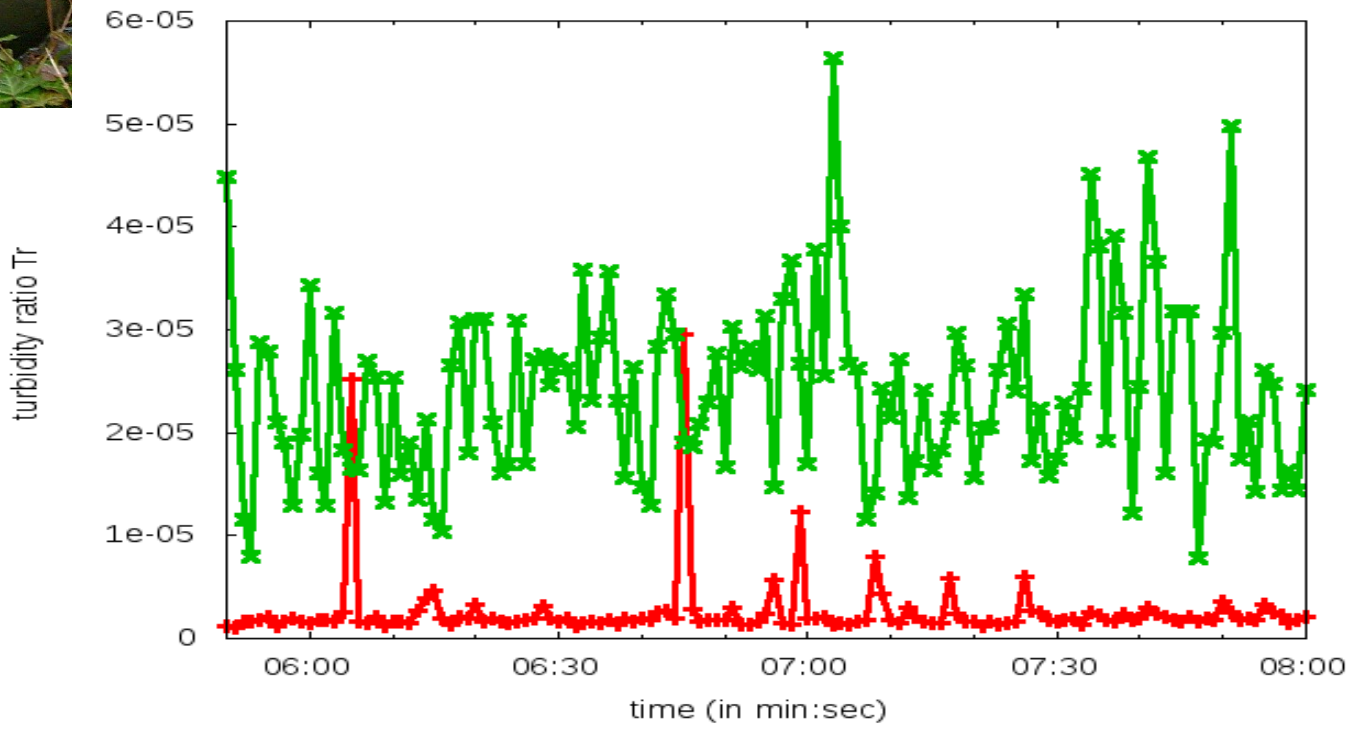
Concentration Measurement

- Paper paste from 0 to 1g/l in a mixing tank
- Backscattering coefficient (β_v) for different concentrations and frequencies



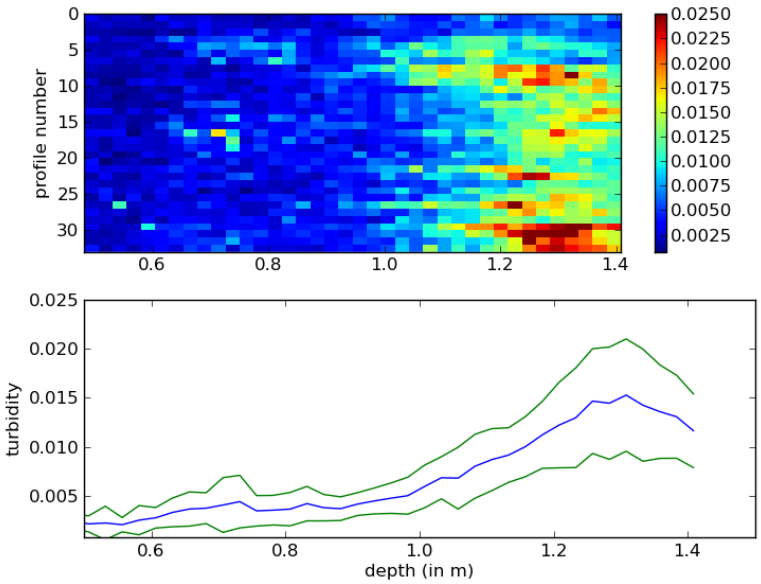
Turbidity in River

- Depends on suspended sediments **concentration** :
  - Rainy condition (in green line)
  - Low water condition (in red line)

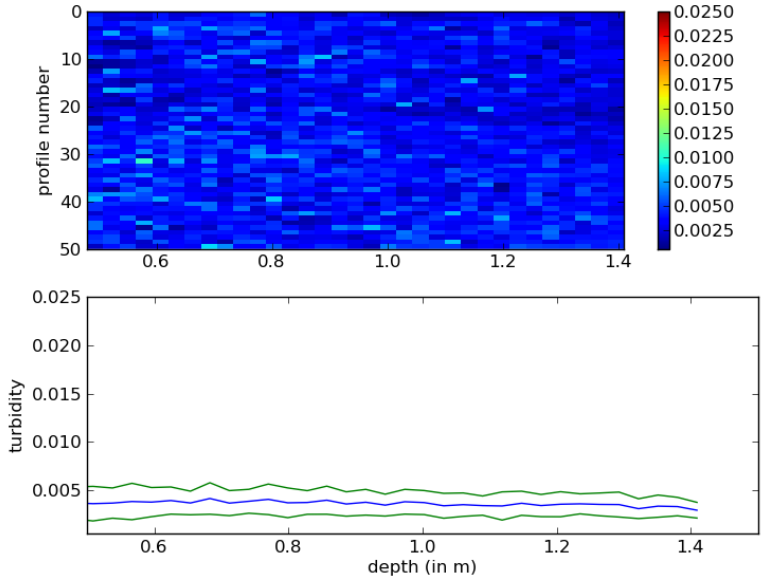


Sediment transport in a primary clarifier

- Inflow acoustic turbidity profile



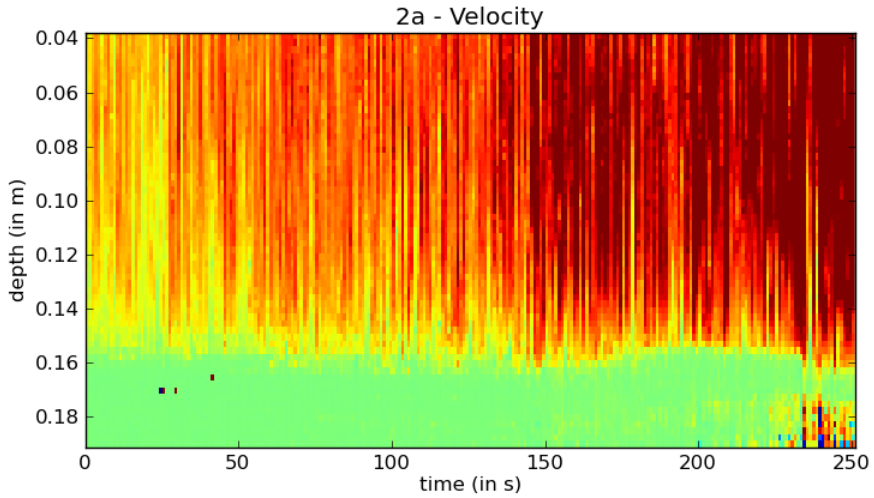
- Outflow

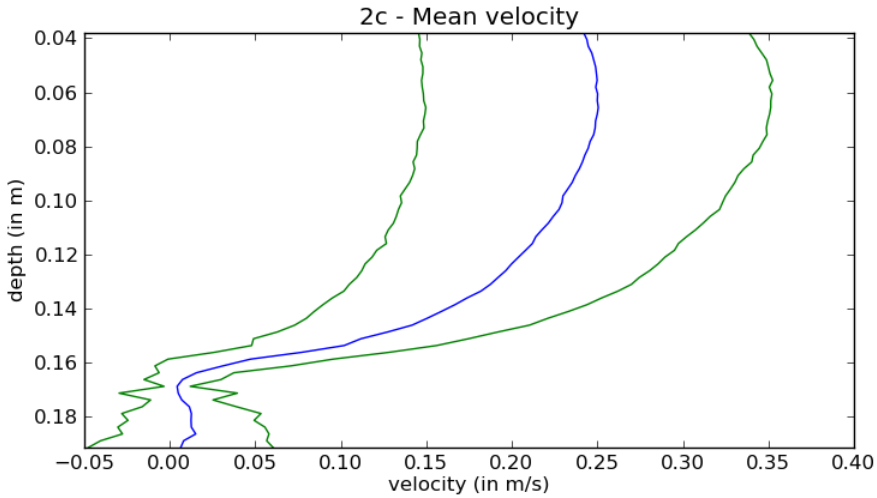


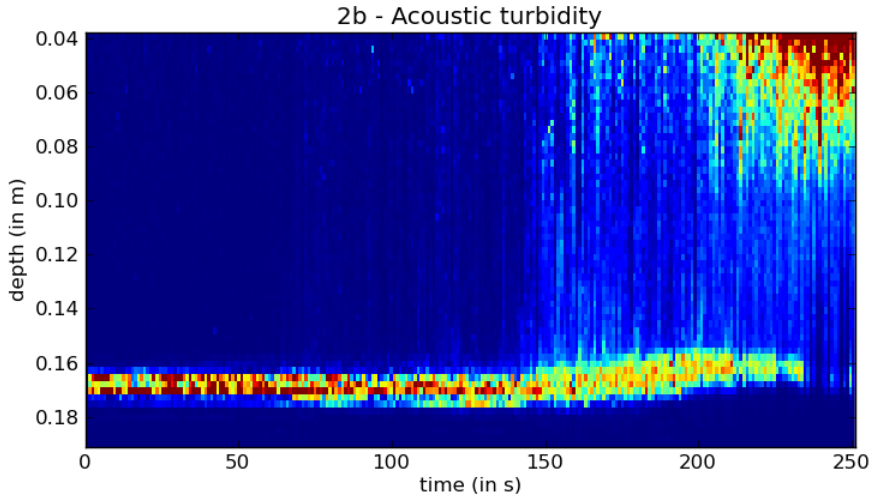
Sediment Transport in River

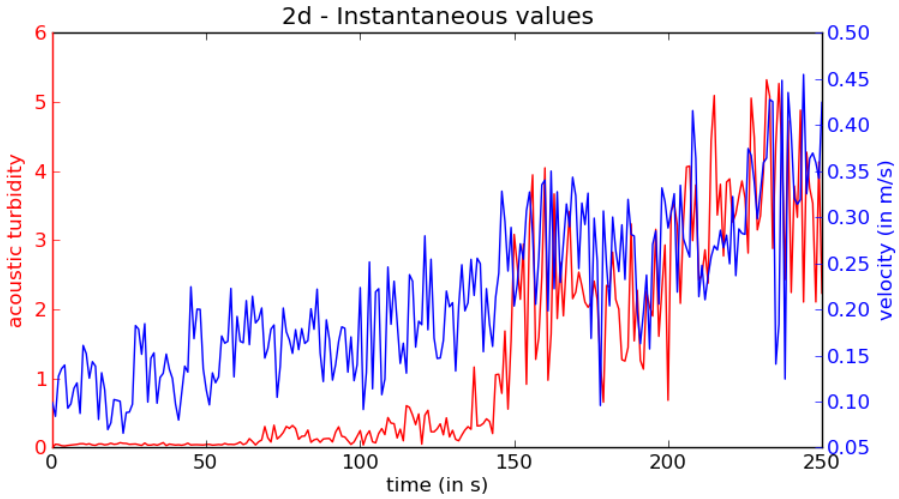
- *Couesnon* river flushed on a daily basis : remove the sediments around the *Mont St Michel*
- Observation of the profile near the bottom of the river at the flush beginning

Sediment Transport in River



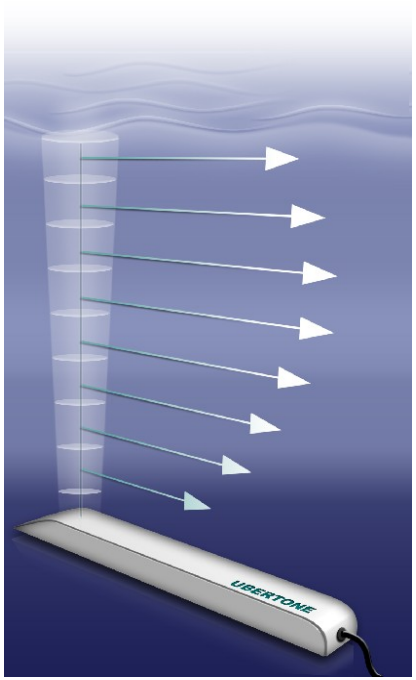






Conclusion

- New profiler for **outdoor** applications
- **Velocity** and acoustic **turbidity** measurements
- Wide frequency range for particle size selectivity
- Powerful tool for **erosion** and **sediment transport** studies



Discussion

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- “concours national d'aide à la création d'entreprise de technologie innovante” **Laureate** in 2008 and 2010
- 12 years of academic and industrial experience

- **Design**, manufacture and sale of ultrasonic measurement **instruments for liquids**
- **Services** and consulting (leasing, measurements campaigns, data analysis, metrology expertise)