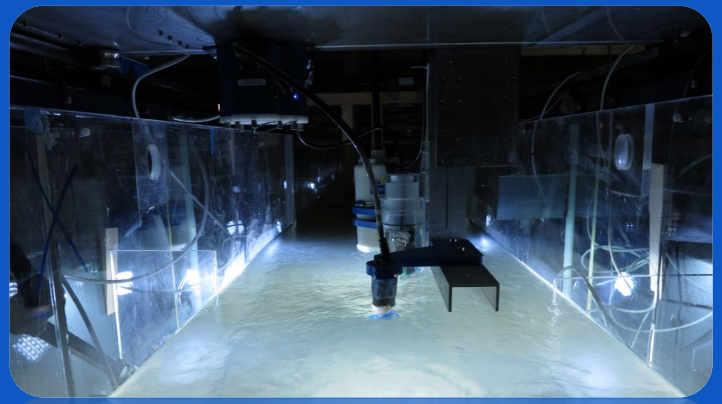
EGU General Assembly 2019

Bedload transport monitoring by means of hydro-acoustic techniques (ADCPs)



SEDIPASS

NTNU
Norwegian University of Science and Technology

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA
DIPARTIMENTO DI INGEGNERIA CIVILE, CHIMICA, AMBIENTALE E DEI MATERIALI

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Colin Rennie, UOttawa

Completion

METHODOLOGY

CONCEPT

Conevski et al. 2019
Conevski et al. 2019 (in submission)

Gaeuman et al 2006

Rennie et al. 2004

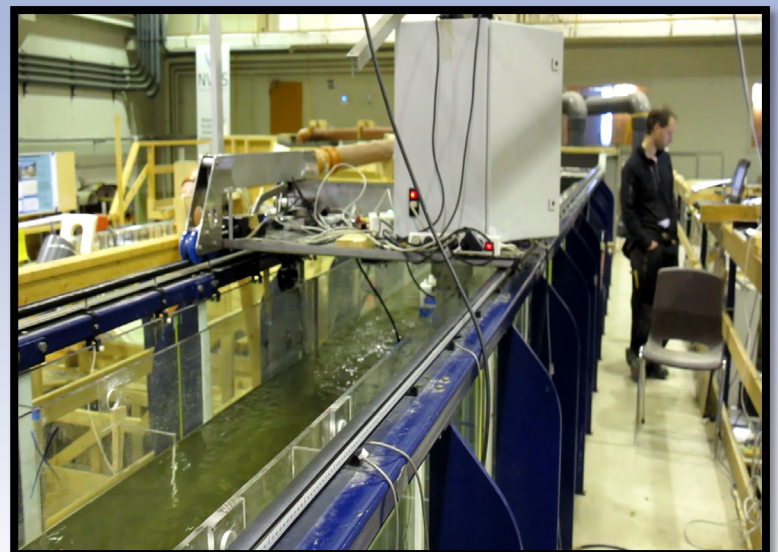
Rennie et al. 2002
BOTTOM TRACK BIAS

GOAL

Develop a technique based on the ADCP data to estimate the bedload transport rates in riverine environment.

- Techniques
- Outputs
- Limitations

Laboratory Measurements



Field Measurements

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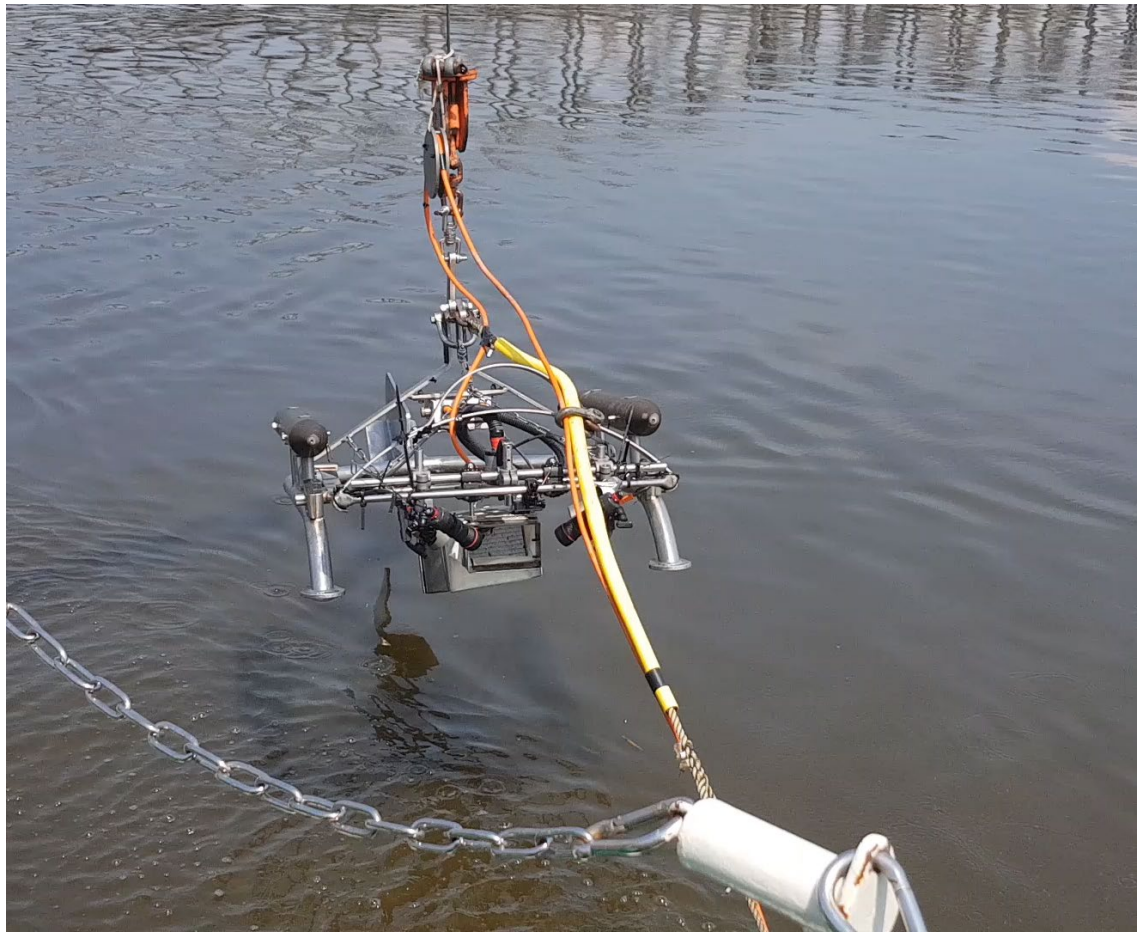
WHY?



Traditional Methods

- *Expensive*
- *Long*
- *Labor Intensive*
- *Statistically invalid*

Laboratory filed data post-processing

Tmin~1 month

A value

XX g/s/m

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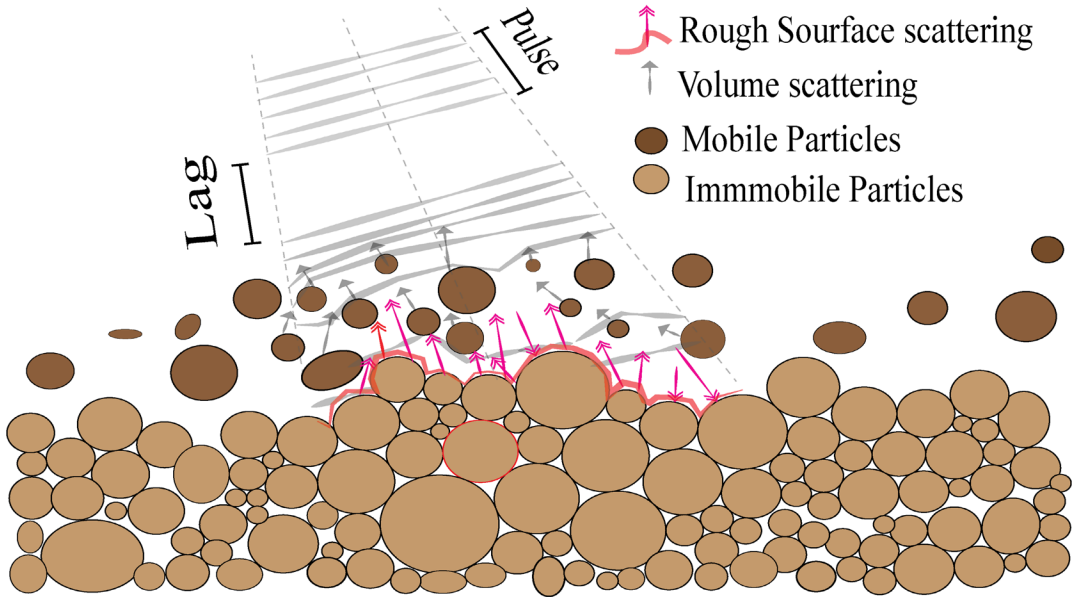
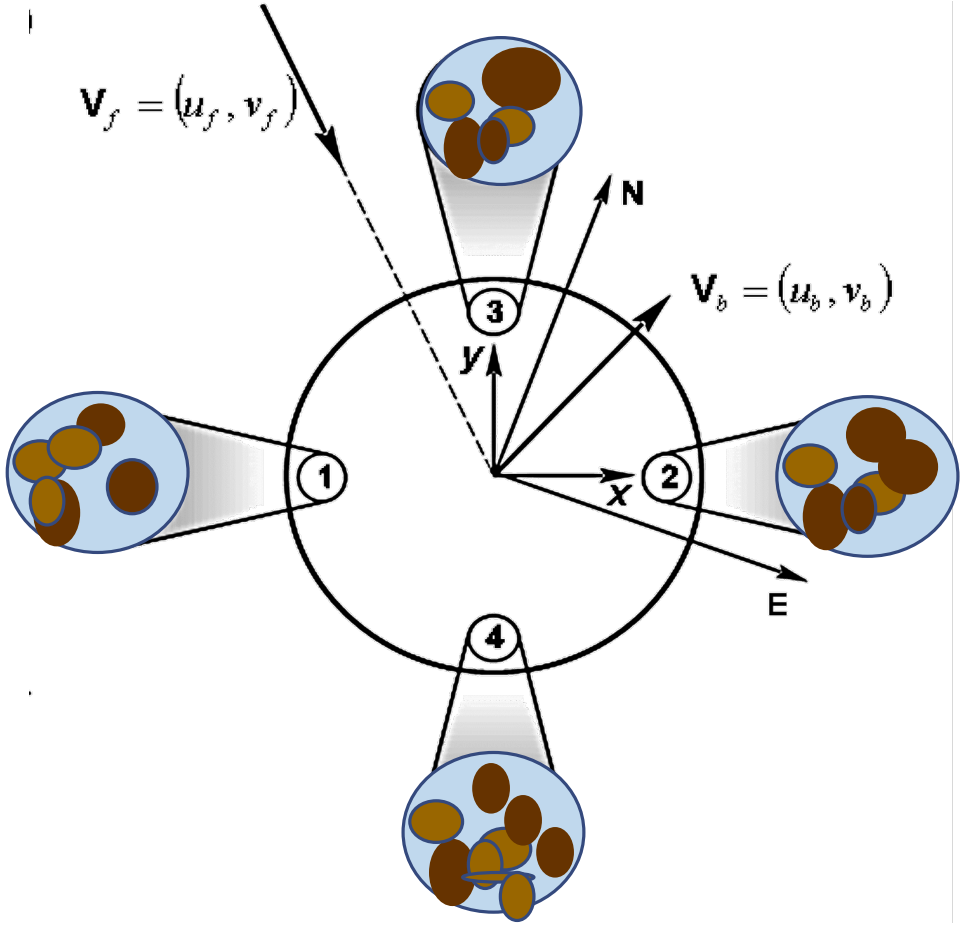
State of art



Main hypothesis for stationary measurements

$$v_a = v_{BT}$$

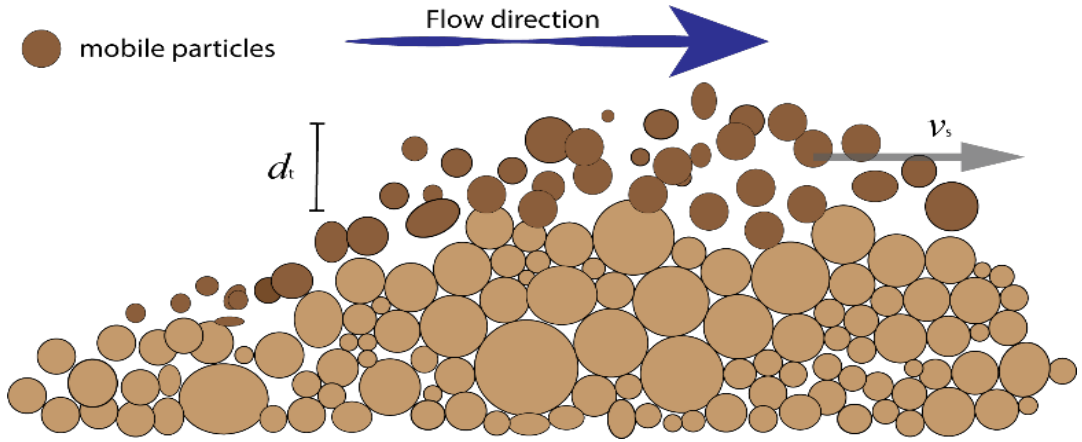
Four beams homogeneity



What does the apparent velocity measure?

General Approach

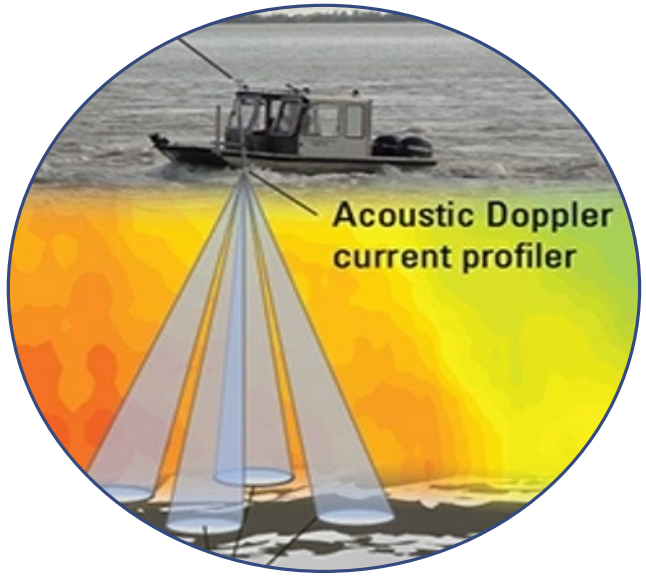
Kinematic theory



$$q_s = \sum_{i=1}^{n} \boldsymbol{v_{af}} d_t (1-\lambda)\, \rho_s$$

Bedload concentration and active layer

$C_b = f(u*)$ *(Van Rijn 1984)*
$C_b = f(Sv)$



Spatially average bedload velocity

v_a - apparent velocity

Local Shear Stress and water velocity profiles

- *Reynolds stress (Stacey et al. 1999)*
- *Bulk-full shear stress*
- *Log-Law fitting*
- *Log-Law semi empirical*

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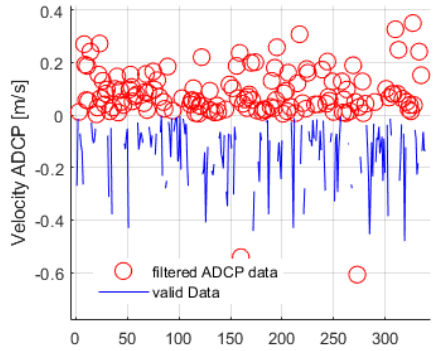
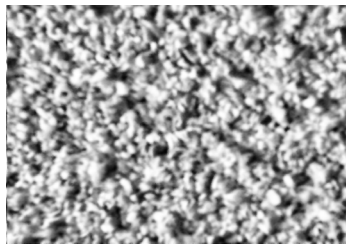
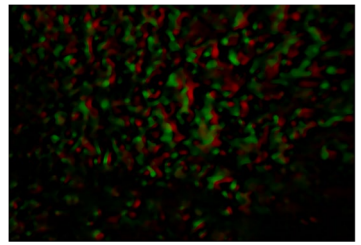
Methods and Data processing

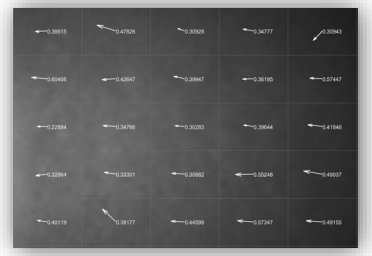
- ADCP velocity data de-spiking and vector filtering
- Image processing and image velocity (*lab comparison techniques*)
  - Bedload surface camera velocity (v_c)
  - Bedload surface concentration
  - Particle Size Distribution
  - Active layer thickness
- Bedload physical sampling
- Acoustic velocimetry (ADVs, UVPs)
- Backscattering Correction and acoustic parameters

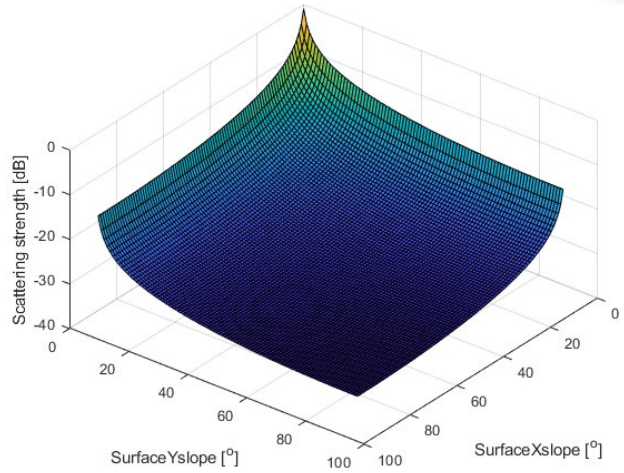
$$Sv + K = -SL + R\cos(\theta) + EI - Af + 2TL$$











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First Laboratory Campaign

2MHz

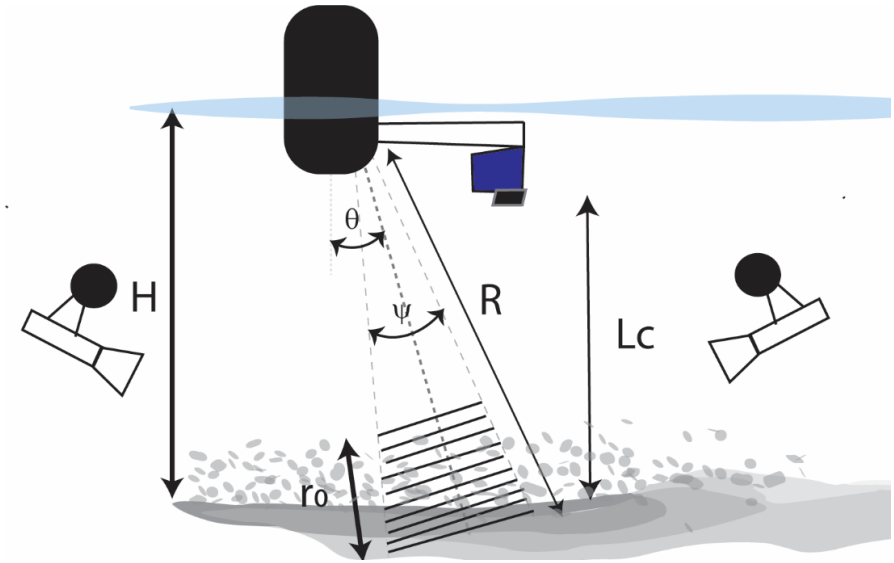
3MHz

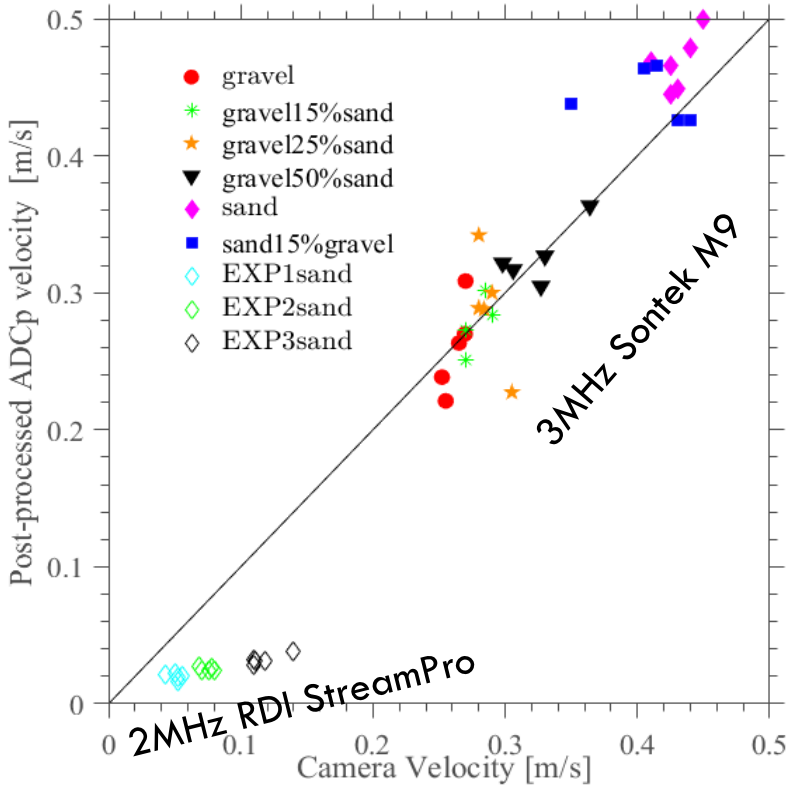
SIX mixtures

$D50_{sand}$ = 1mm

$D50_{gravel}$= 4mm

Laboratories in UniBo and UOttawa





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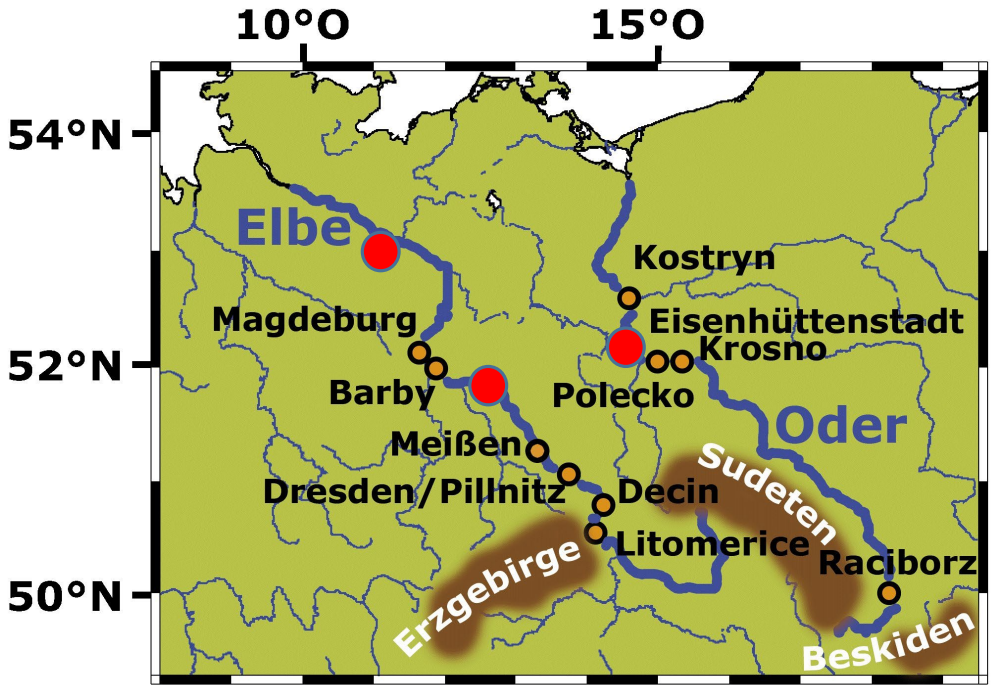
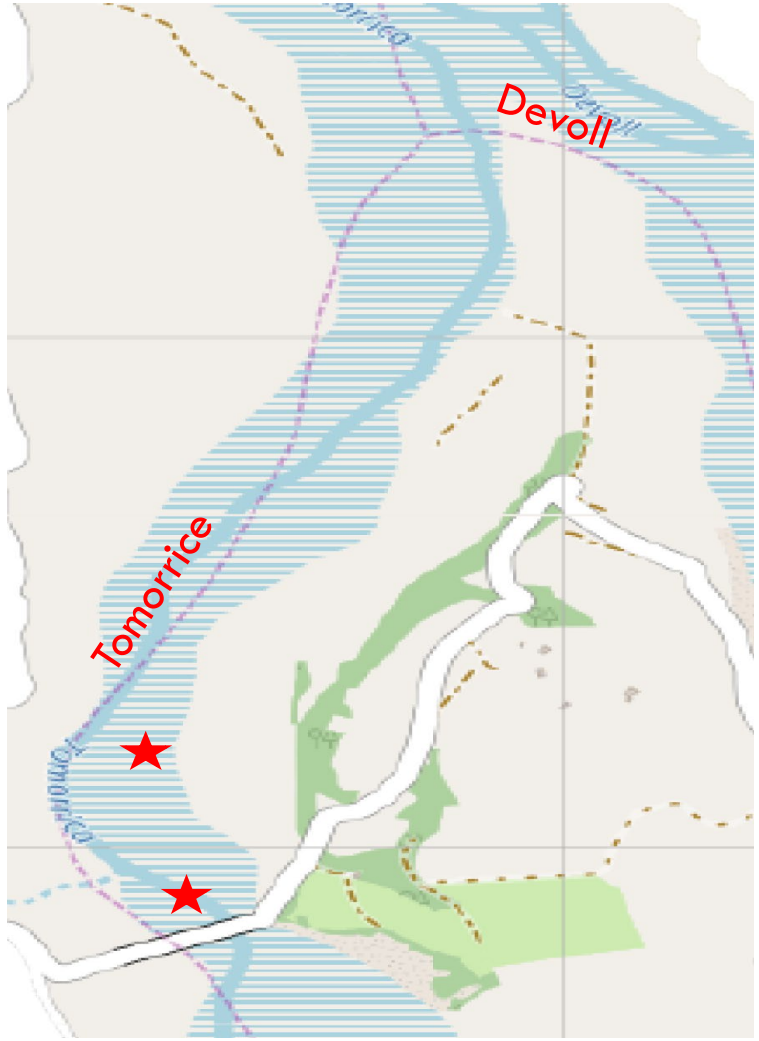
Field Sutdy



$V \sim 1$ m/s

- Stationary measurements, Germany
  Three campaigns, Oder and Elbe River
  The procedure followed pre-defined program by BfG:
  - D50= 0.4-2mm, Dstd~ 1mm
  - 5 – 8 points per cross-section , 10 cross- sections
  - 57 (x 3 samples per point) sampled

★ Stationary measurements, Albania
Two campaigns
D50= 0.5-4mm, Dstd~ 5mm



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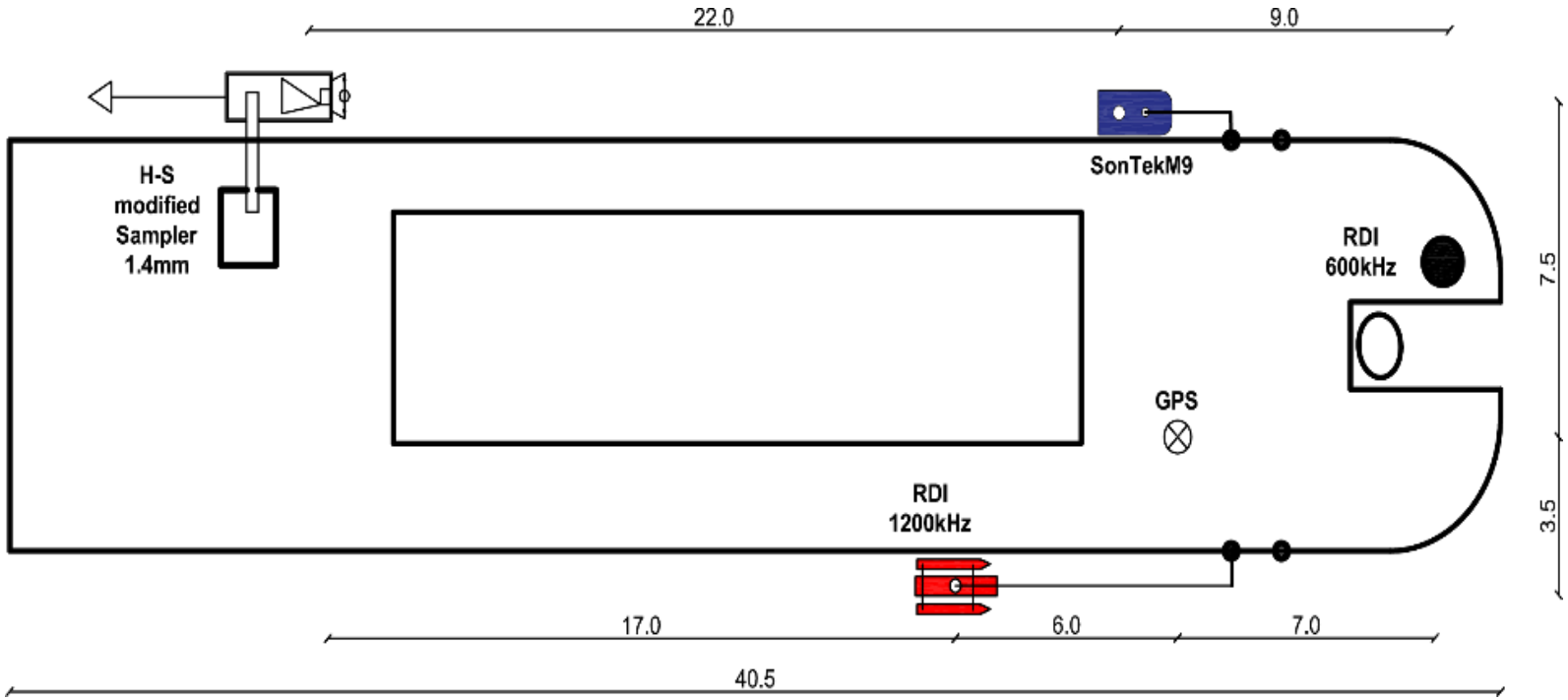
Field Study

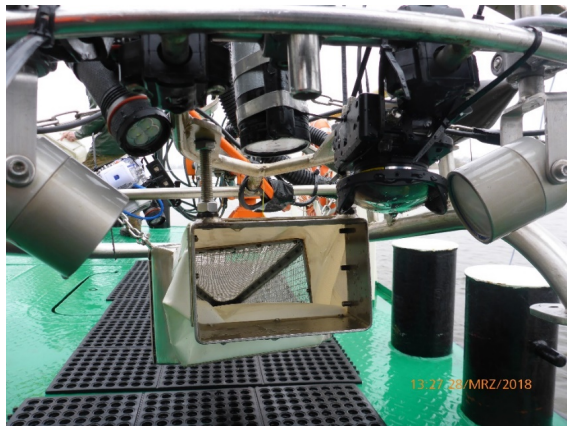
Stationary Measurements

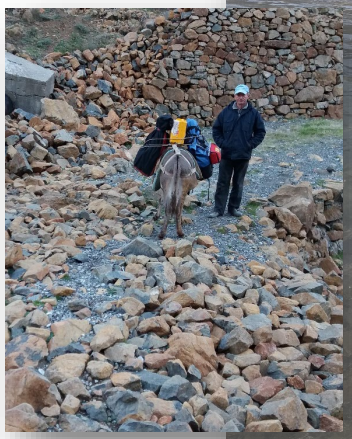


ADPCs on filed:

- RDI 0.6 MHz
- RDI 1.2 MHz
- Sontek 1MHz/3MHz

FOUR different signal modulations (IC, PC, BB)





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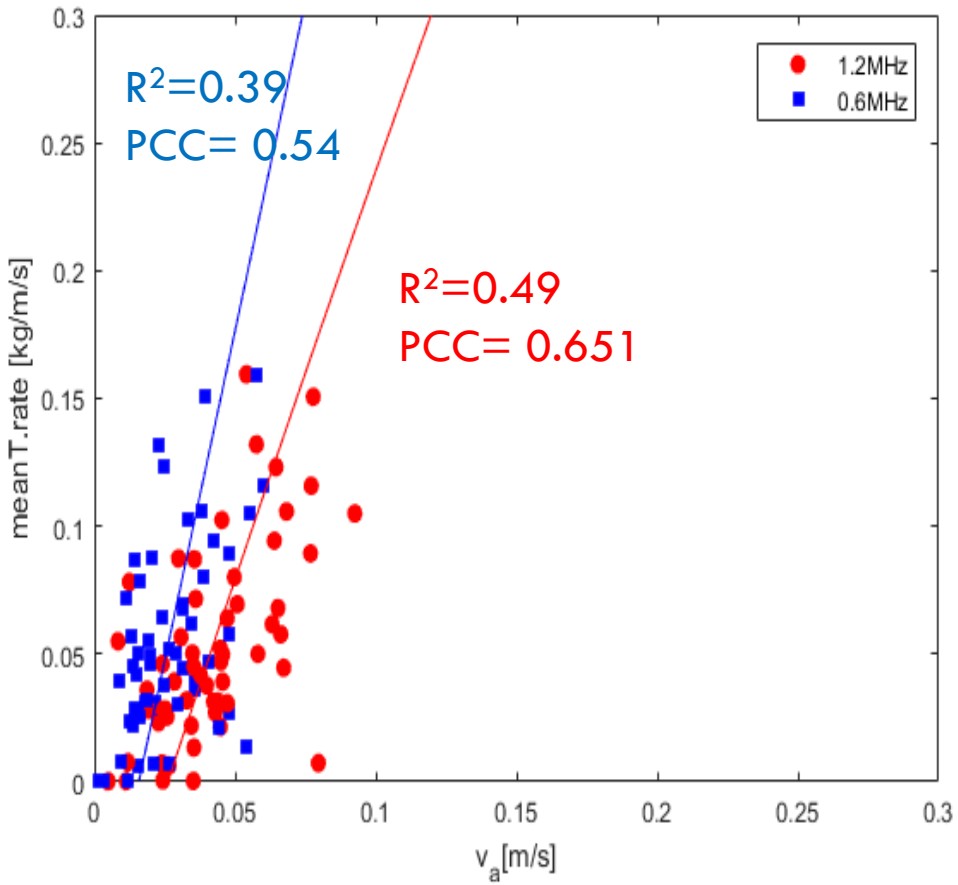
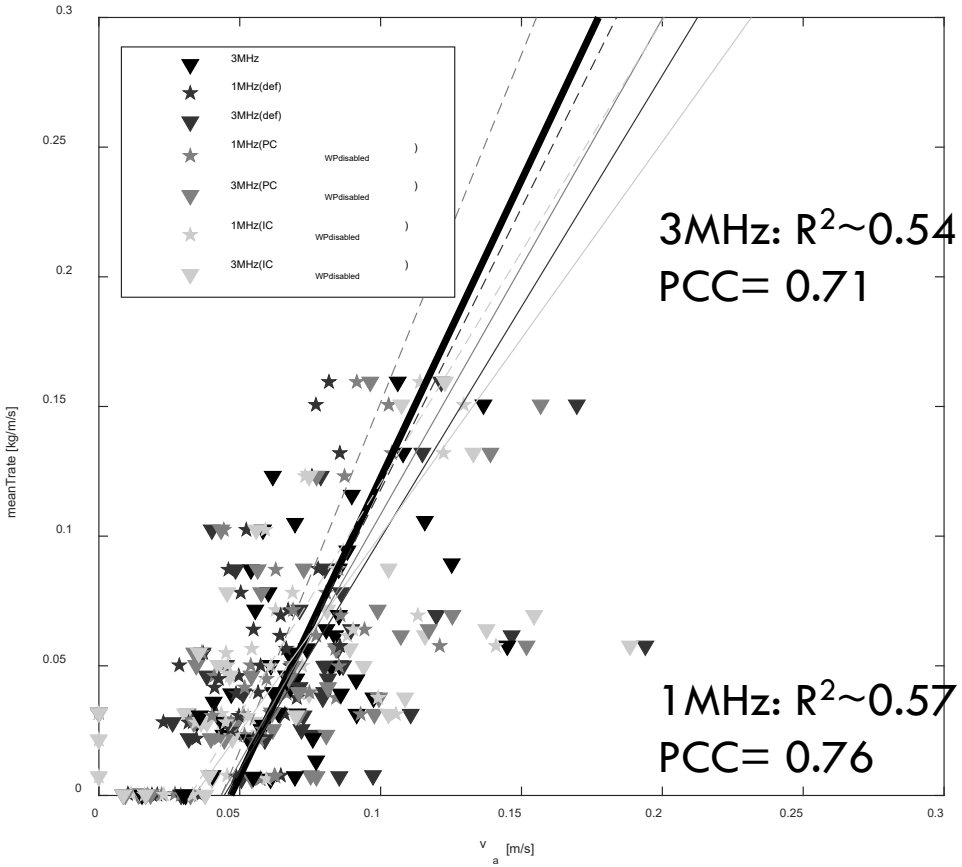
Field Sutdy

The Apparent Velocity

RDI



Sontek



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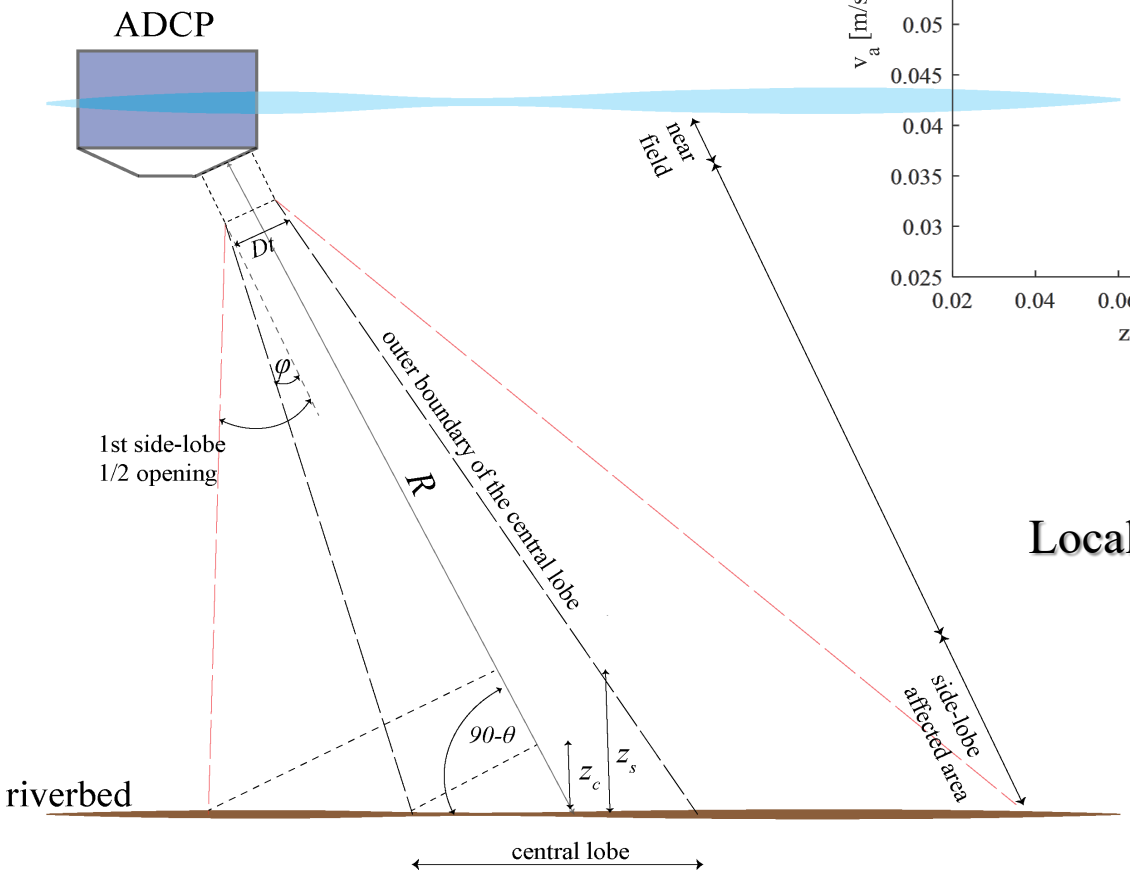
FIELD SUTDY

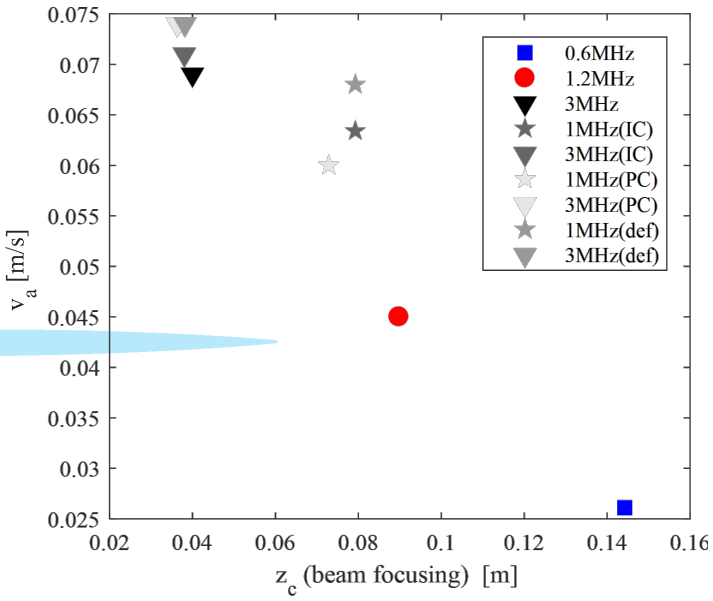
LIMITATIONS

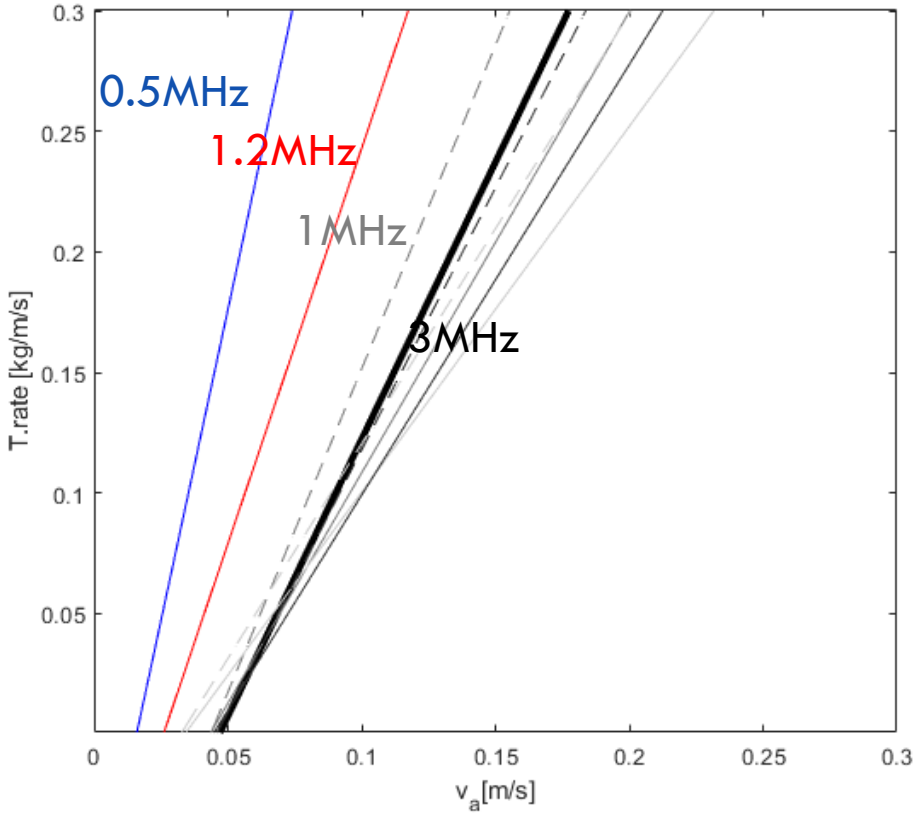
The acoustic geometry limitation

- pulse length
- central-lobe contaminated area

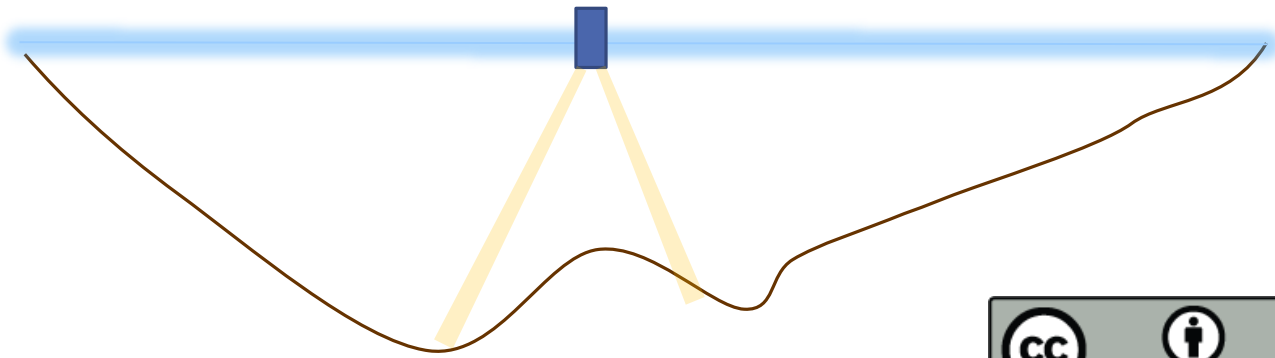


The frequency Limitation





Local riverbed deformations



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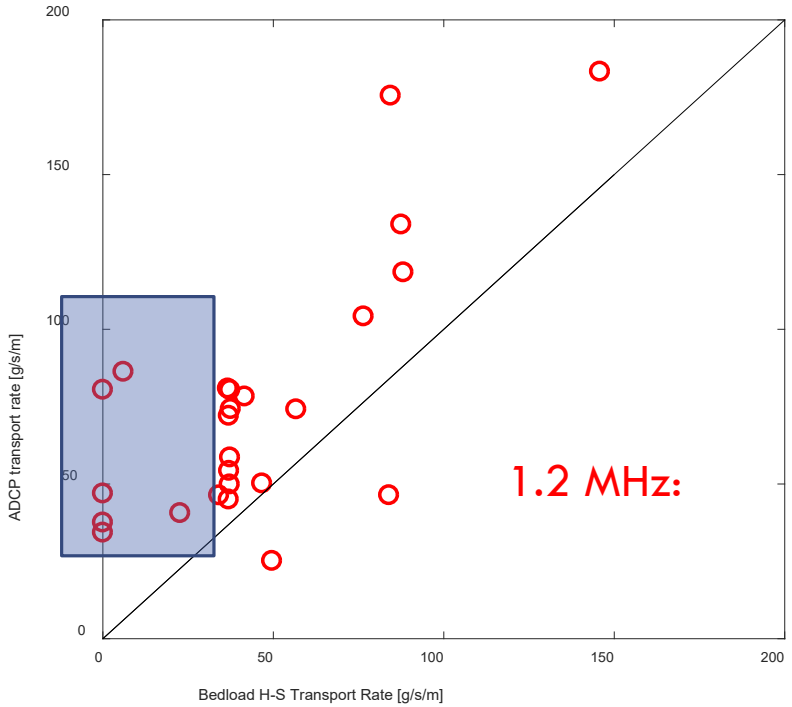
Field Sutdy

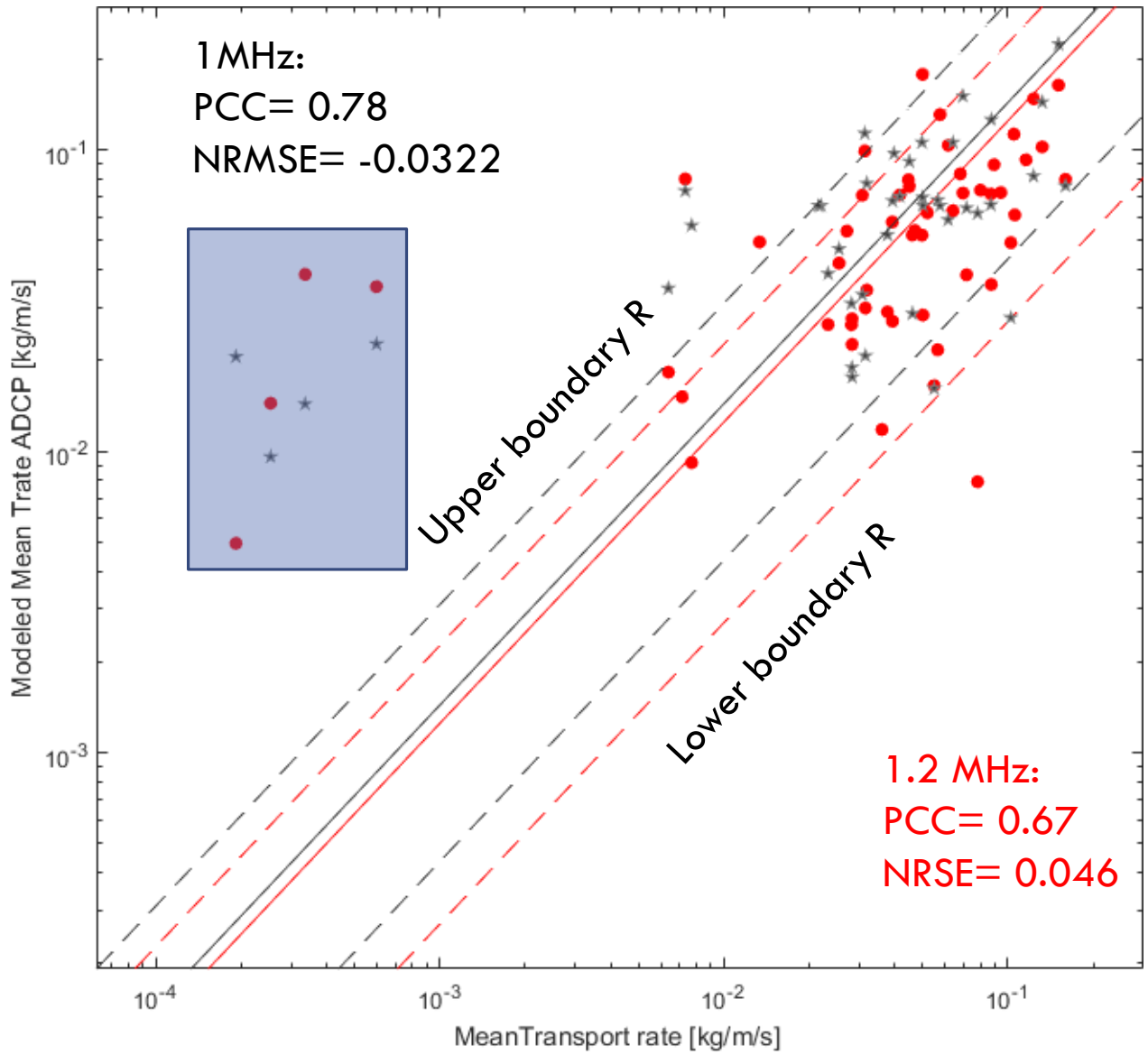
guidelines

- Optimum sampling frequencies in sand rivers (1MHz and 1.2 MHz)
- Bedload Concentration estimation, based on the shear stress calculations (the realistic values)

Albania



Germany



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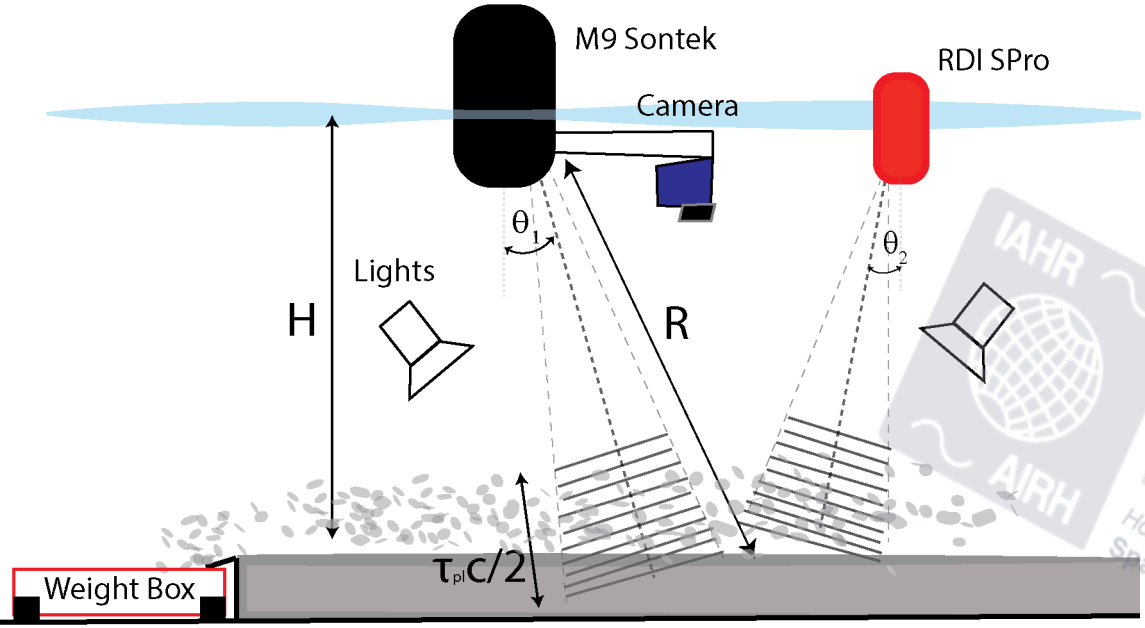
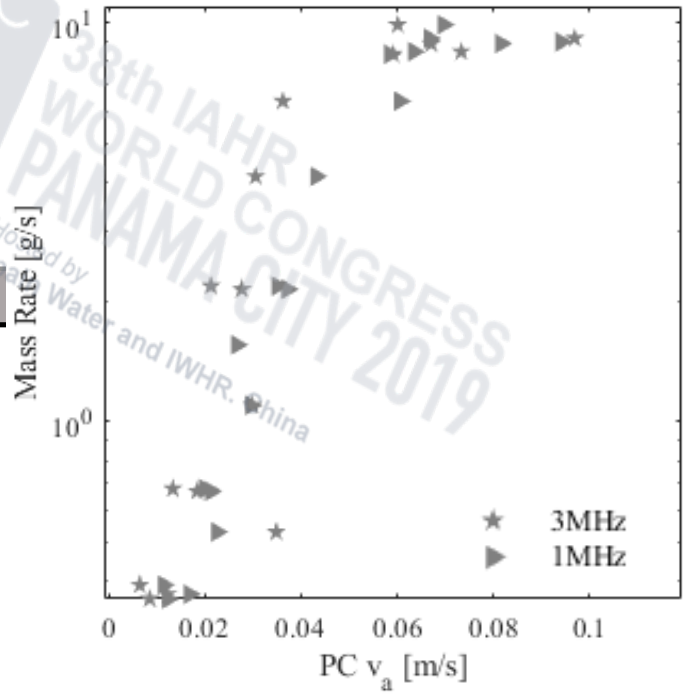
Second Laboratory Campaign

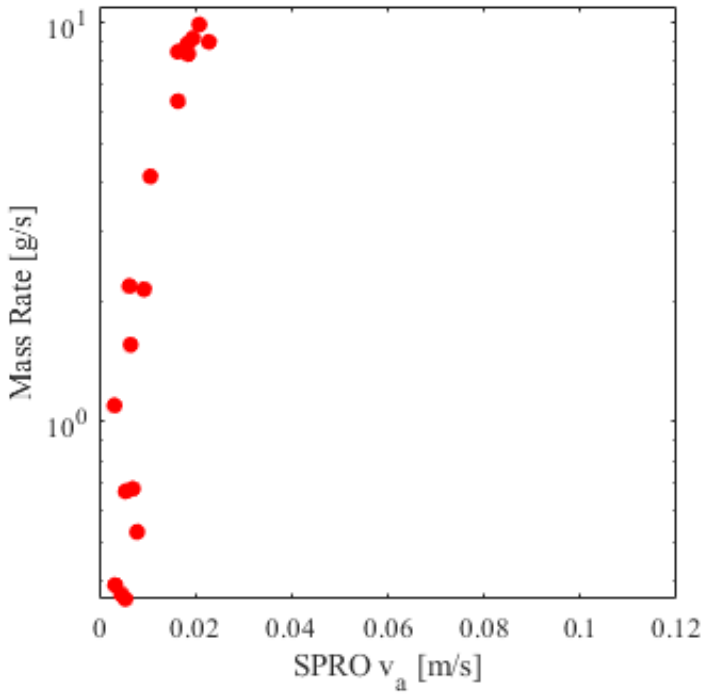
Proof of concept

Fine sand **D50~0.32mm** (Rayleigh Scattering)



The Transport rate is in strong correlation with the apparent velocity !





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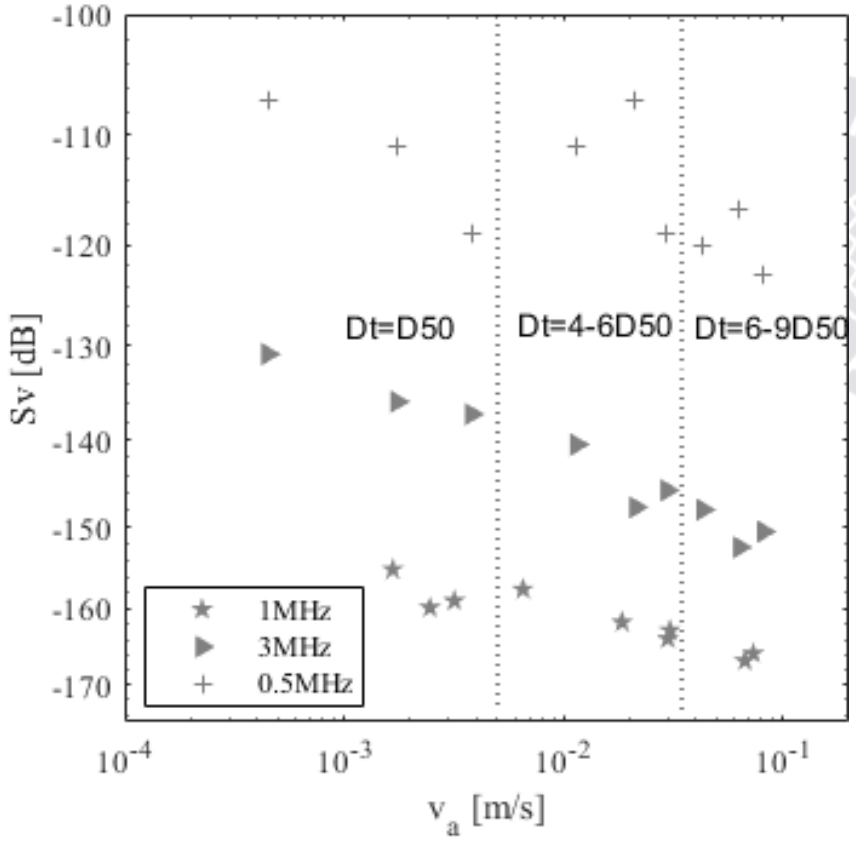
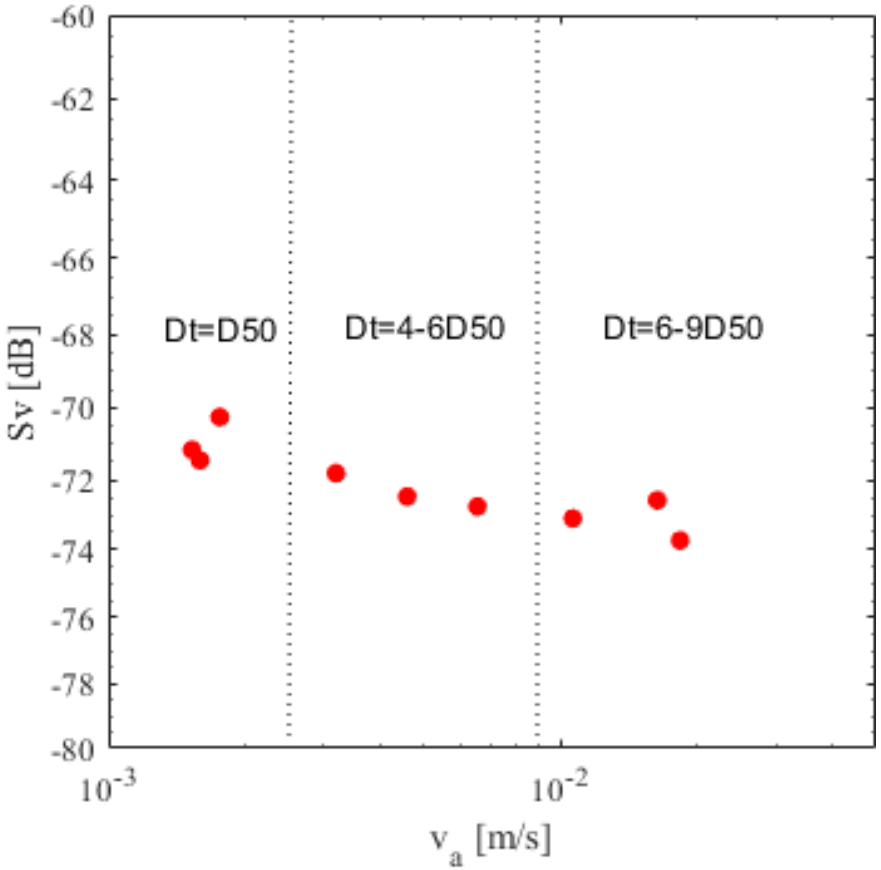
Towards bedload concentration

$$Sv + K = -SL + R\cos(\theta) + EI - Af + 2TL$$

SONTEK M9



StreamPro



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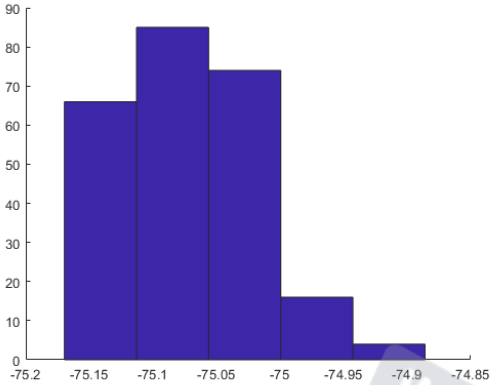
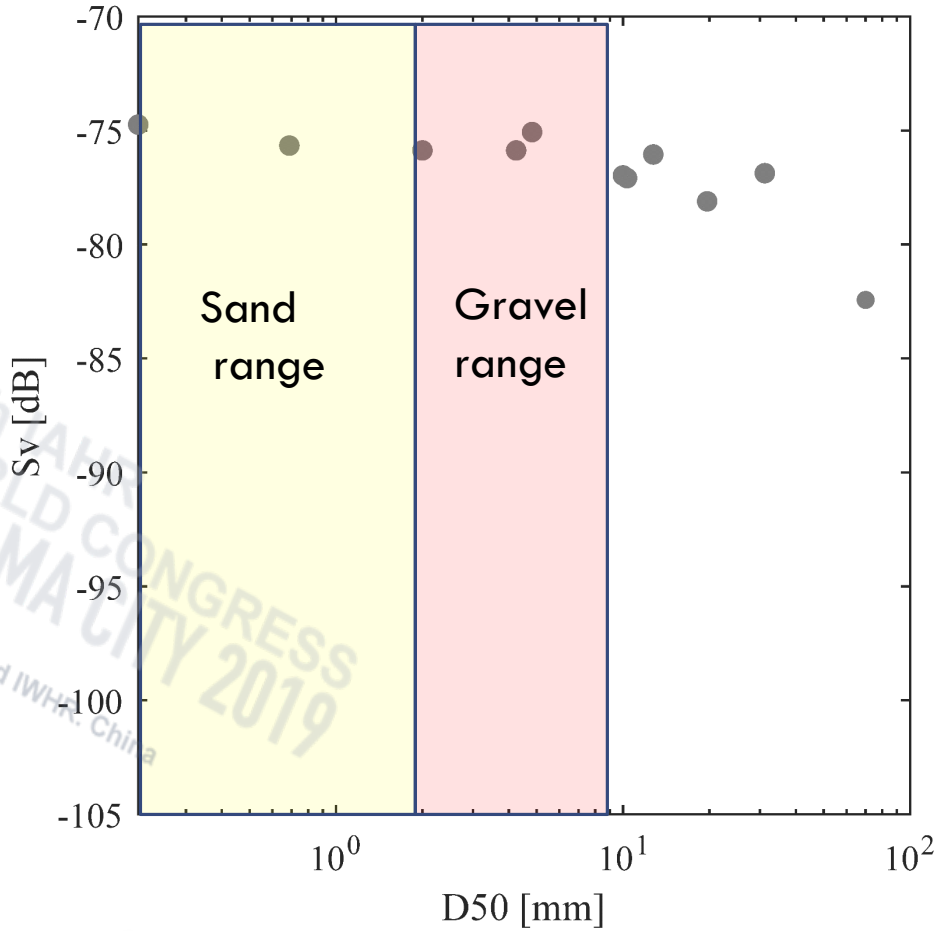
Towards D50

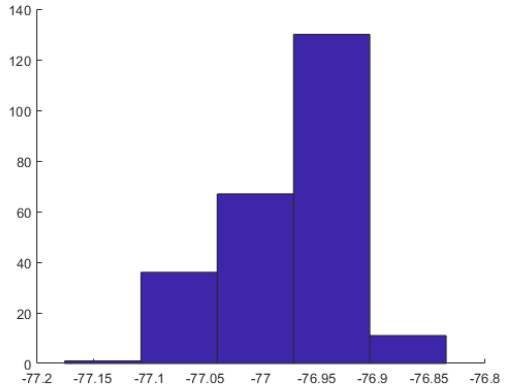


M9 vertical beam



- Statistical similarities

Additional experiment



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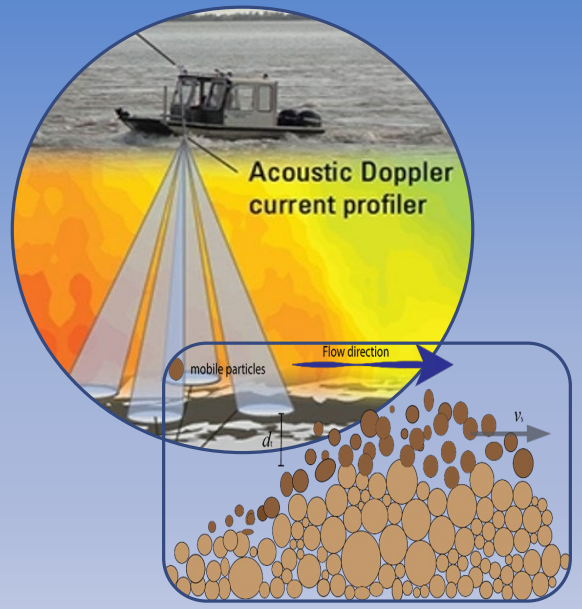
Bedload and ADCPs

Bedload concentration and active layer

Next final Step



Spatially average bedload velocity

Instrument Limitations

Guidelines for field application

Local Shear Stress and water velocity profiles

Thanks for the attention!

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To BeContinued