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On the characterisation of open-flow seeding conditions for image velocimetry techniques using UASs

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HydroLAB

Motivations & Objectives

Nowadays the implementation of optical methods in hydrological monitoring suffers the influence of seeding characteristics and environmental conditions

- ✓ Priori quantification of seeding characteristics in terms of seeding density, spatial distribution of tracers and coefficient of variation of area in the ROI
- ✓ Statistical evaluation of the influence of seeding characteristics on PTV and LSPIV technique accuracy based on field experiments

Assess the uncertainty of computed surface velocities and remote river flow estimates

Seeding and Image velocimetry

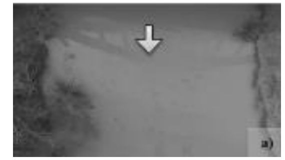
REAL SEEDING

NATURAL FEATURES

ARTIFICIAL TRACERS

ENVIRONMENTAL NOISE

FIELD SURVEY



PRE-PROCESSING

Filter 1

IMAGE ENHANCEMENT

SEEDING QUANTIFICATION

DENSITY

DISTRIBUTION

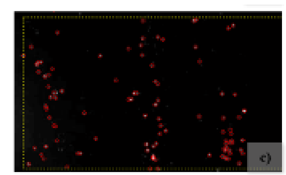
DIMENSION

SHAPE

PROCESSING

Filter 2

DETECTION CROSS-CORRELATION

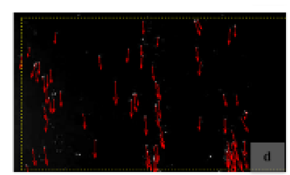


EFFECTIVE SEEDING

POST-PROCESSING

Filter 3

VALIDATION

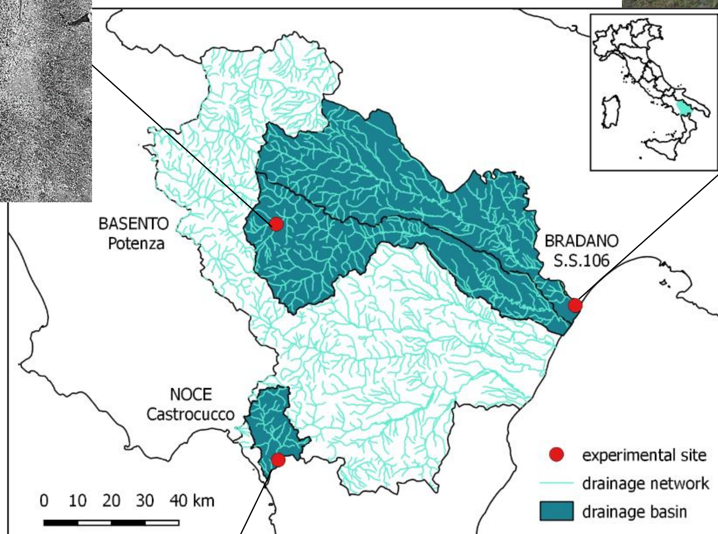


Field experiments

Bradano river

Equipment

Basento river



Noce river

- Artificial tracers deployments
- FHD videos captured at 24 frames DJI Phantom 3 Pro Quadcopter
- Benchmarking velocities estimated using current meters Seba F1

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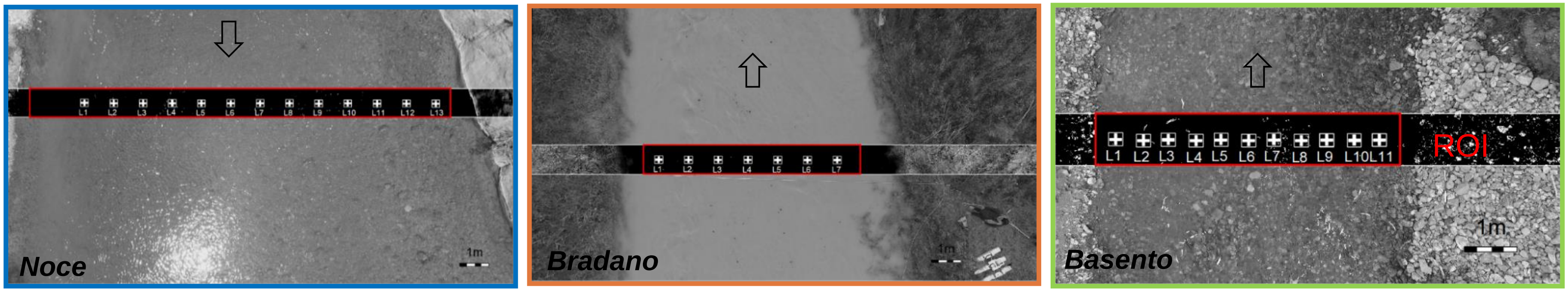
Seeding characterisation

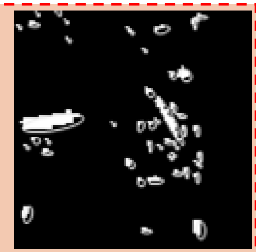


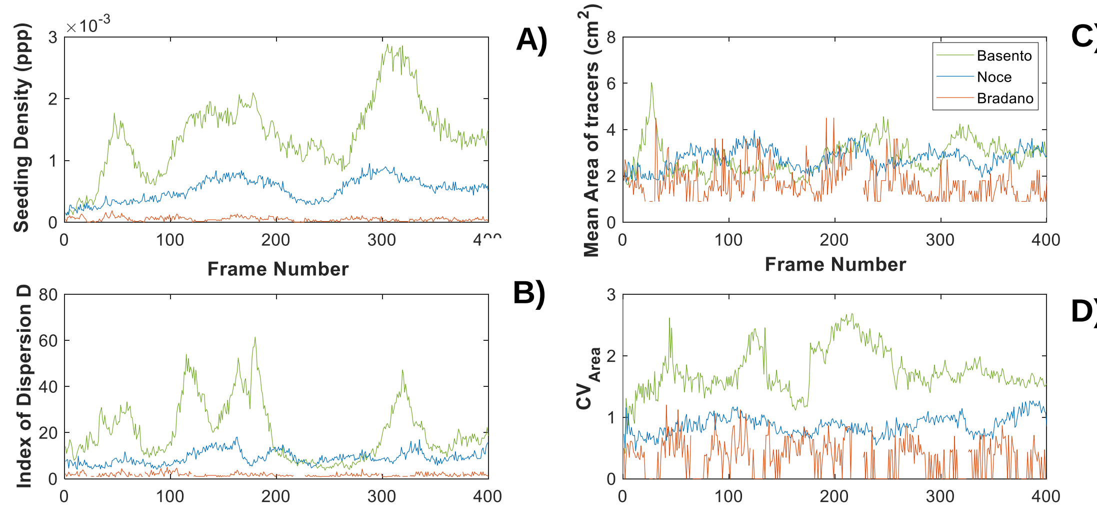
A) Seeding density (particles per pixel)

B) Index of dispersion: $D = \sigma^2/\mu$

C) Mean area of tracers (cm^2)

D) Coefficient of variation of tracers' area





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Methodology

- For each case study, PTV and LSPIV techniques were applied considering five different sets of images (FWs).

Frame windows	FW1	FW2	FW3	FW4	FW5
Frames	1-100	26-125	51-150	76-175	101-200

- For each FW, the average of absolute errors calculated for the different measurement locations was computed and correlated.

$$\varepsilon = ((U_c - U_m)/U_m)100$$

- Multiple linear regression analysis was performed to statistically evaluate the significance of the investigated seeding parameters.

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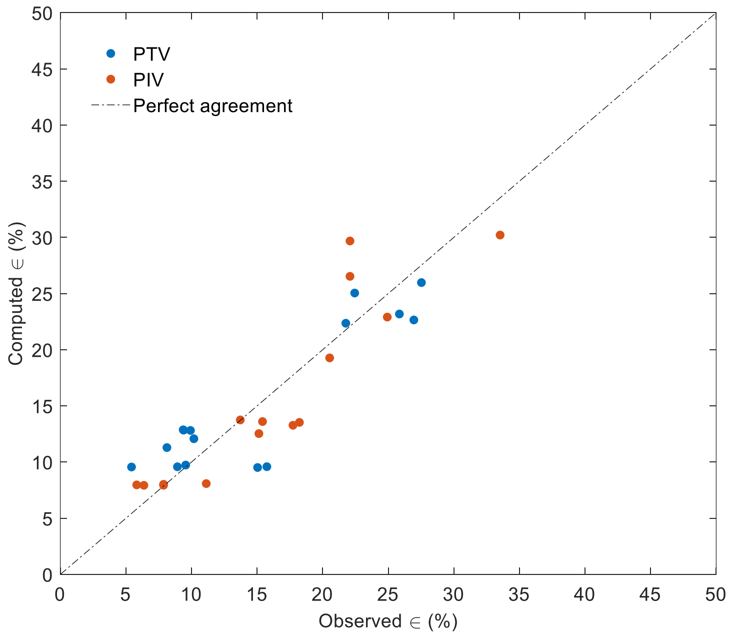
Results and discussion

$$e = c_1(\rho/\max(\rho)) + c_2(\nu/\max(\nu)) + c_3(CV_{area}/\max(CV_{area}))$$

	c_1	c_2	c_3	R^2	p-value
PTV	-14.6932	2.9118	35.7002	0.8001	0.0001
LSPIV	-18.5738	21.0869	26.0480	0.8083	0.0000

- The three metrics have a similar statistical significance (Table). It can be observed the negative correlation between the absolute error and the seeding density and the positive correlation with the index of dispersion and coefficient of variation of tracers' area.

- The Figure shows the error predicted by the multiple regression analysis vs error observed with the PTV and LSPIV techniques.



Conclusions

- ✓ In this work three metrics based on seeding density, index of dispersion, and spatial variance of tracers’ were adopted for the characterization of seeding in the field.

- ✓ Statistical analysis of field results show that the these metrics have a significant contribution to the velocity estimation accuracy.

- ✓ A priori evaluation of flow seeding conditions can allow to choose the best frame footage for the image velocimetry analysis.

- ✓ Further investigation are necessary along with the application of these ideas to case studies with very different field conditions.

References

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