

# Dam-break su pendii collinari e superfici afforestate

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**Politecnico di  
Torino**

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**WP4.2** *L'évaluation des conséquences de l'onde de crue suite à la rupture d'un barrage dans la région de montagne, collinaires et de plaine. / Valutazione delle conseguenze dell'onda di dam-break in regioni montane, collinari e di pianura*

- **WP4.2.1** : Evaluation des conséquences de l'onde de crue dans l'eau sans charge / Studio della vulnerabilità dovuta all'onda di dam-break in assenza di trasporto solido
- **WP4.2.3** Propagation des ondes de crues dans le lit des rivières rugueuses ou des surfaces très boisés / Propagazione dell'onda di dam-break su pendii in presenza di vegetazione ad alto fusto
- **WP4.2.4** Modélisation de l'onde de crue sur les lits des rivières / Propagazione dell'onda di dam-break su pendii collinari

$$R = P * V * Dp$$

Probabilità di collasso  
dello sbarramento

Vulnerabilità

Danno potenziale

Intensità dell'onda

- Velocità del flusso
- Altezza d'acqua

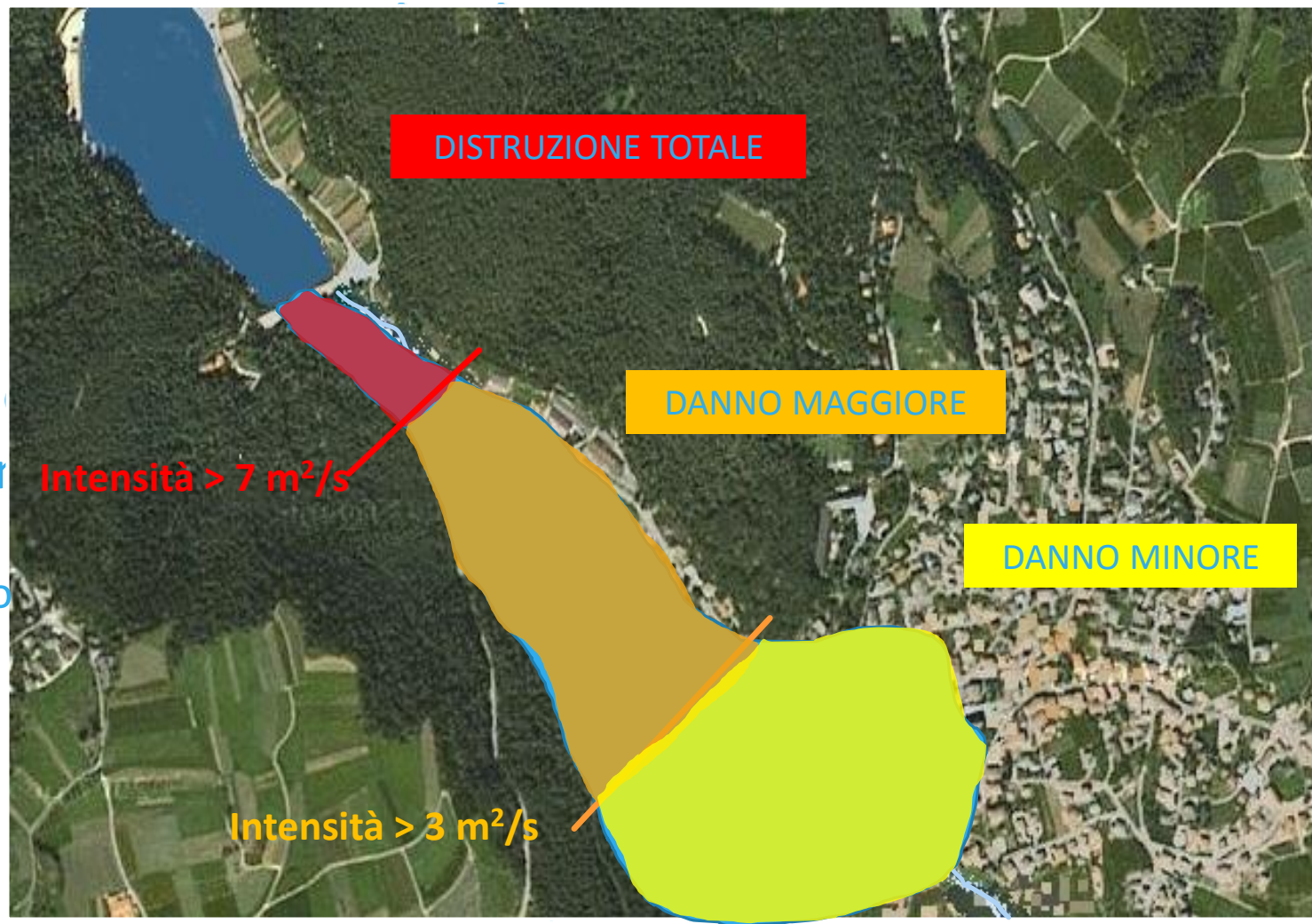
Area

potenzialmente  
allagata

$$V=U(x,y,t)\times h(x,y,t) \text{ (m}^2/\text{s)}$$

Probabilità di  
dello sbarramento  
Intensità Area  
Area  
potenzialmente  
allagata

- Velocità del flusso
- Altezza d'acqua

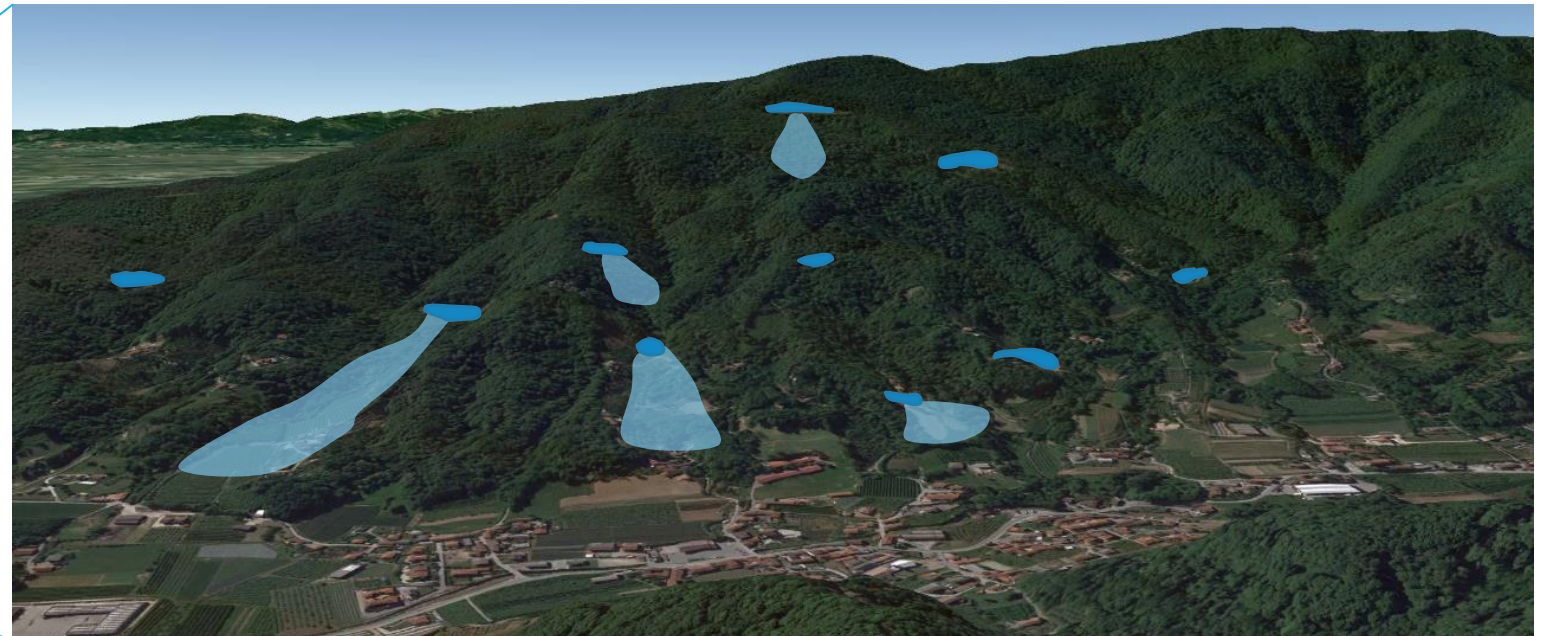
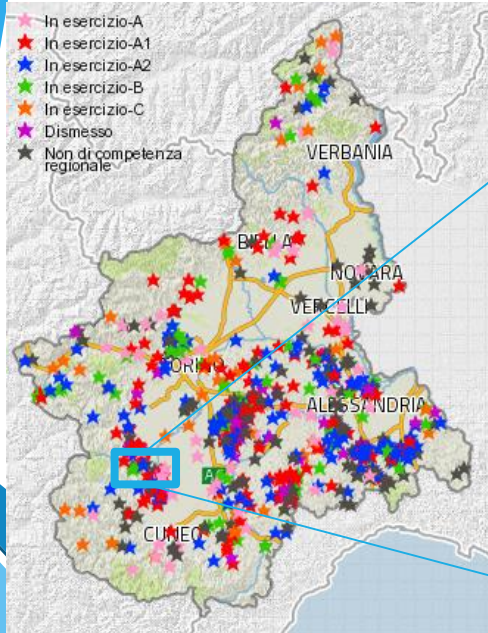




## Piccole dighe

- Assenza di immissario ed emissario (alvei non incisi)
- Superfici fortemente scabre (boschi, vigneti, piantagioni)
- Area colpita limitata ma elevata diffusione

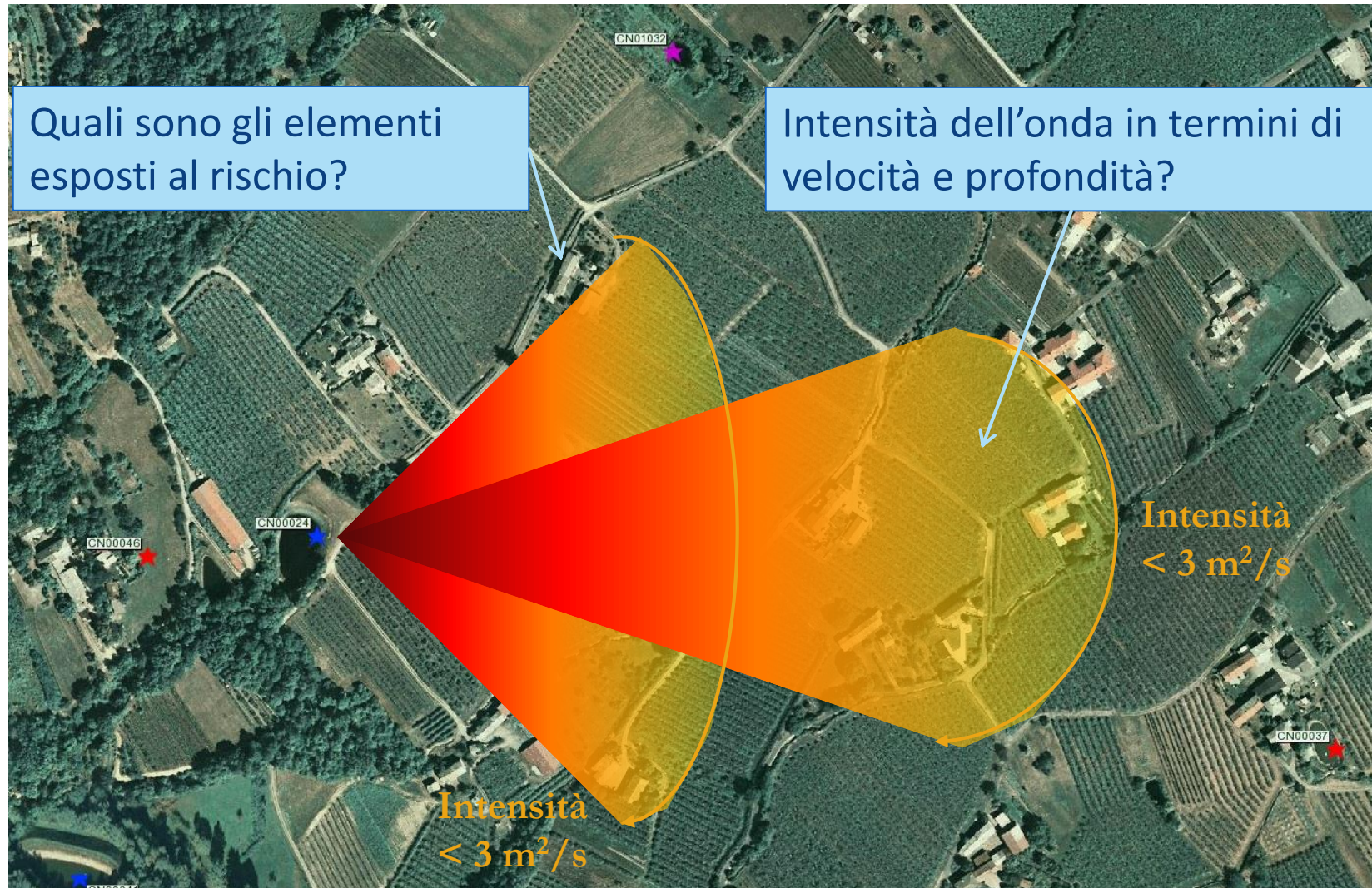
>15.000 in Italia , >1000 solo in Piemonte



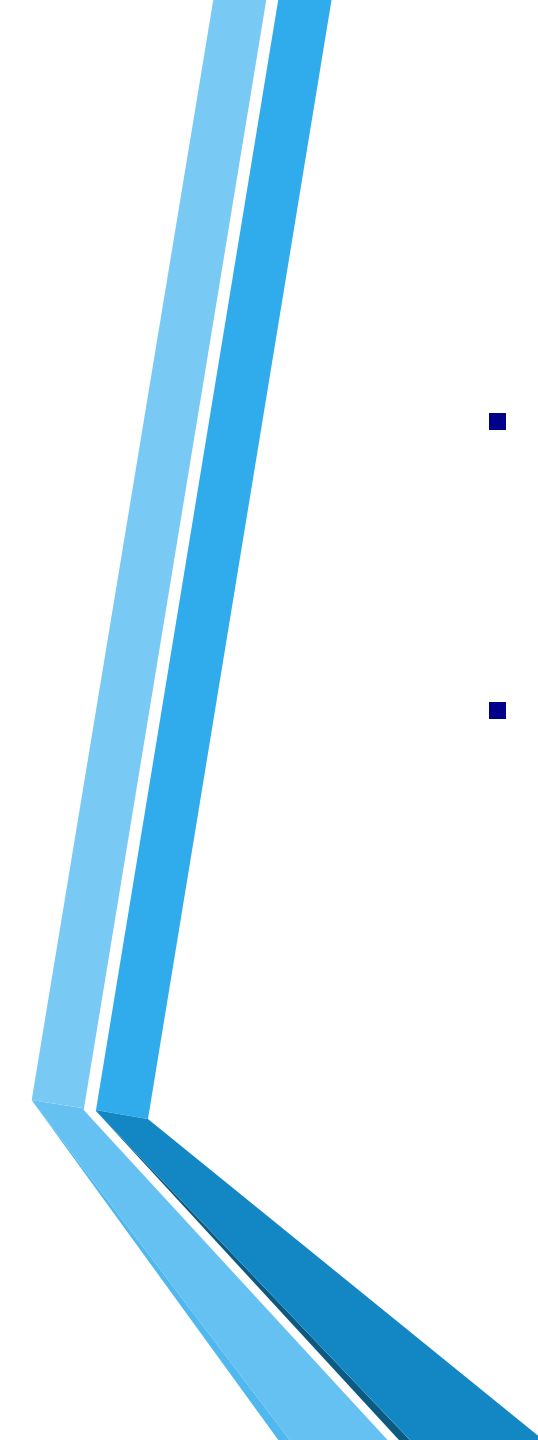


## Invaso su versante

...metodologia speditiva di indagine della vulnerabilità...



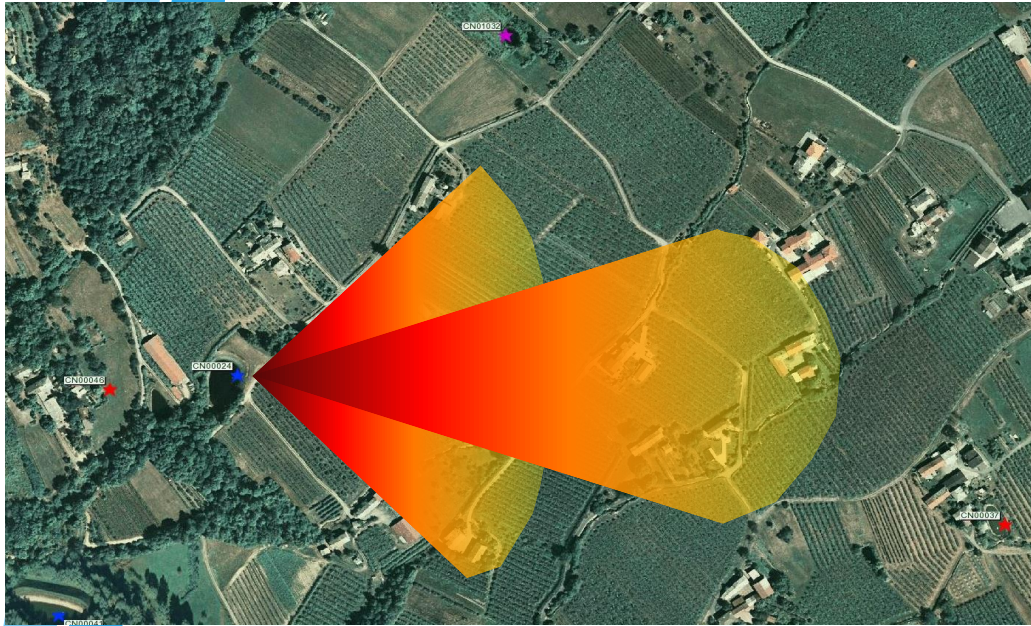
Invaso "CN00024" :  
 $V=17000 \text{ m}^3$   $H_{sb}=10\text{m}$



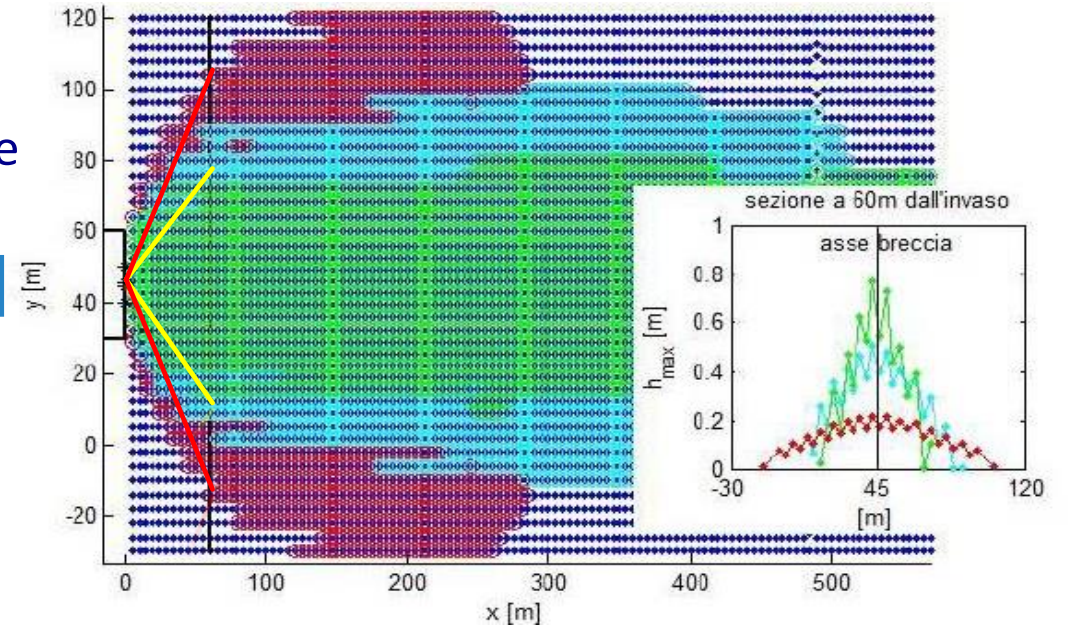
Invaso su versante  
...metodologia speditiva di indagine della vulnerabilità...  
METODOLOGIA SEGUITA

- Analisi numeriche
  - Brezo, modellistica di frontiera
  - Hec-Ras, modellistica di “uso comune”
- Modelli fisici
  - 1D, 2D di casi idealizzati
  - Casi reali

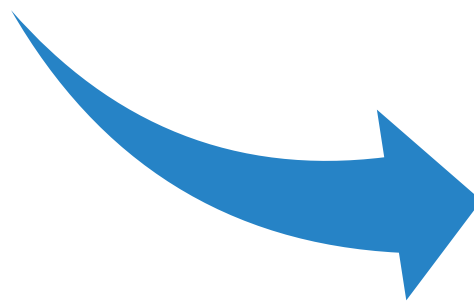




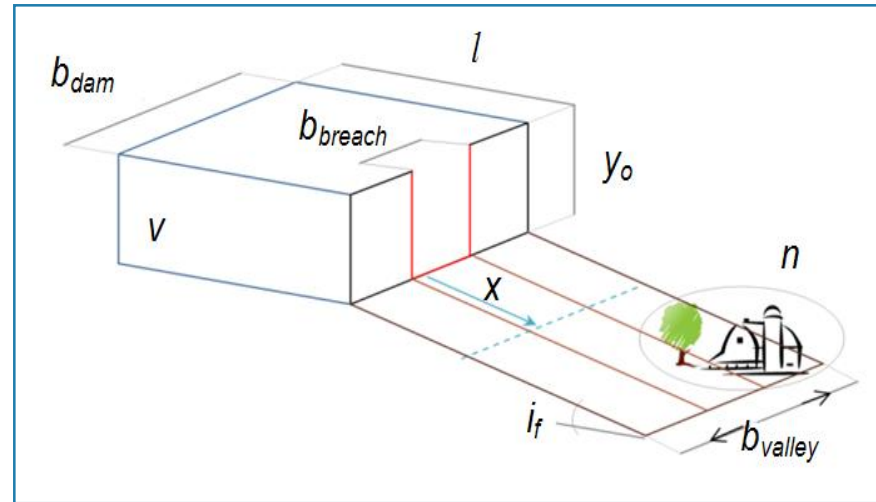
Validazione



Analisi statistica invasi reali



Modello sintetico

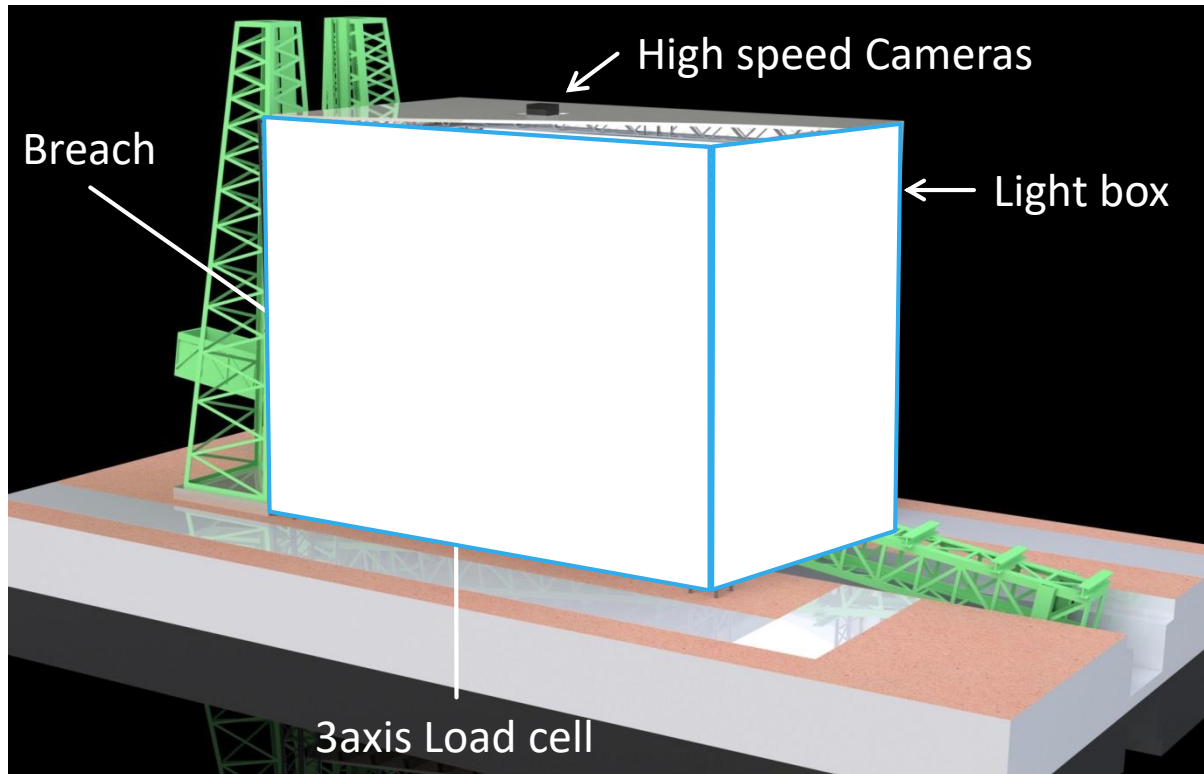


Modello numerico - Brezo



$i_f = 2\% \div 10\%$   
 $n = 0.035 \text{ m}^{-1/3}\text{s} \div 0.110 \text{ m}^{-1/3}\text{s}$

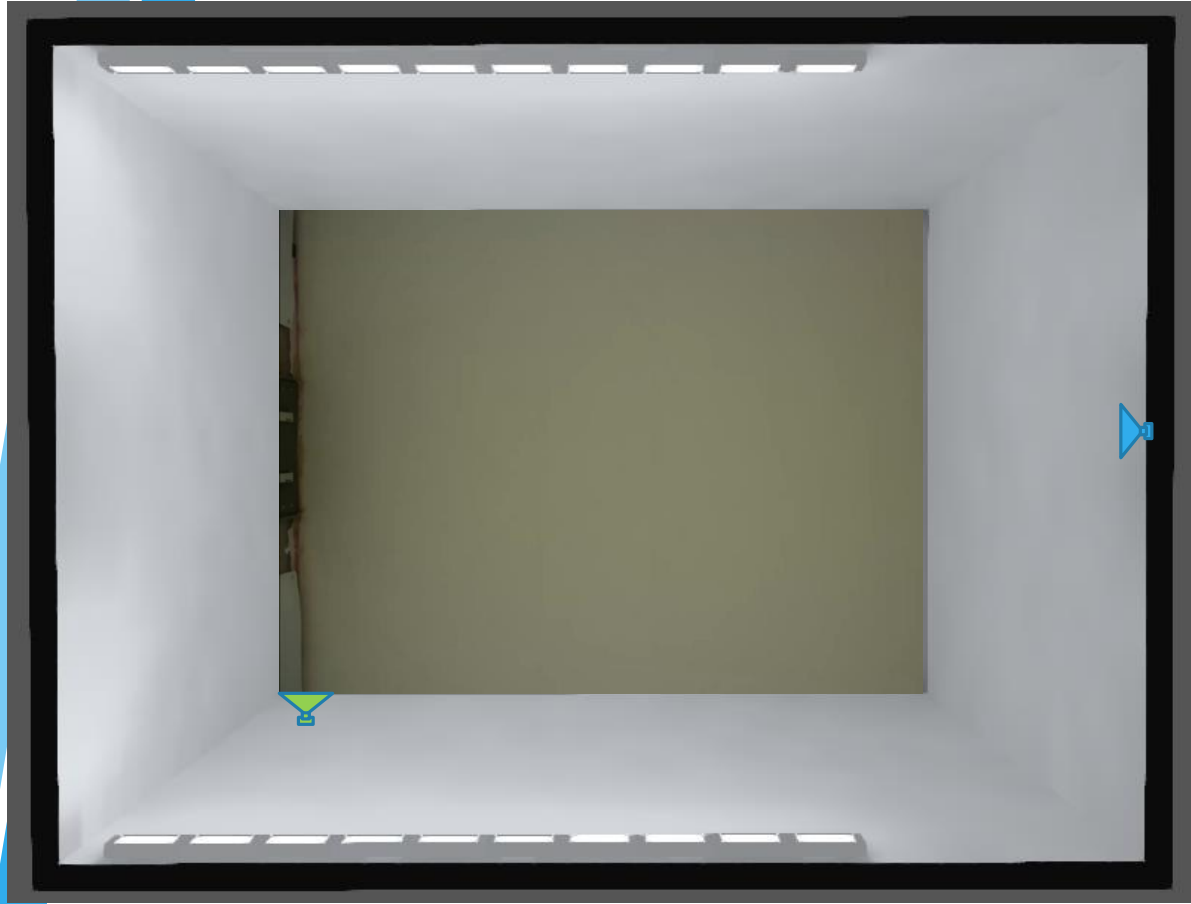
## Modelli fisici di laboratorio



### Dam break on vegetated surfaces

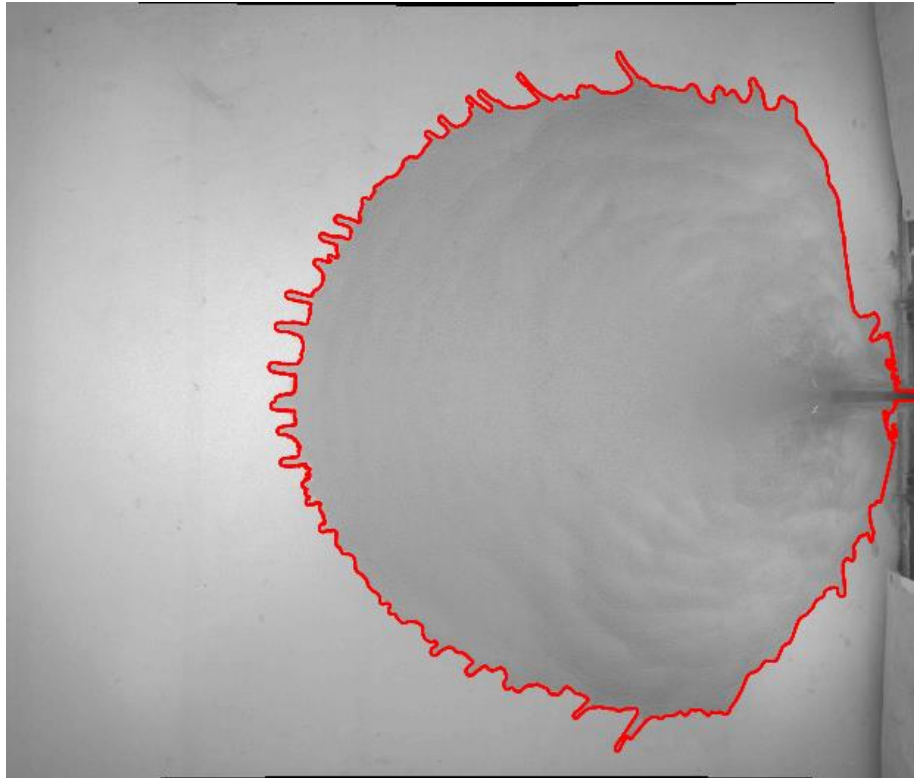
- Controllable variables
  - Surface slope
  - Roughness density, typology and arrangement
  - Reservoir dimensions
  - Breach size and opening time
- Variable to measure
  - Wave shape and propagation velocity
  - Impact (**forces**) on objects (buildings, etc)





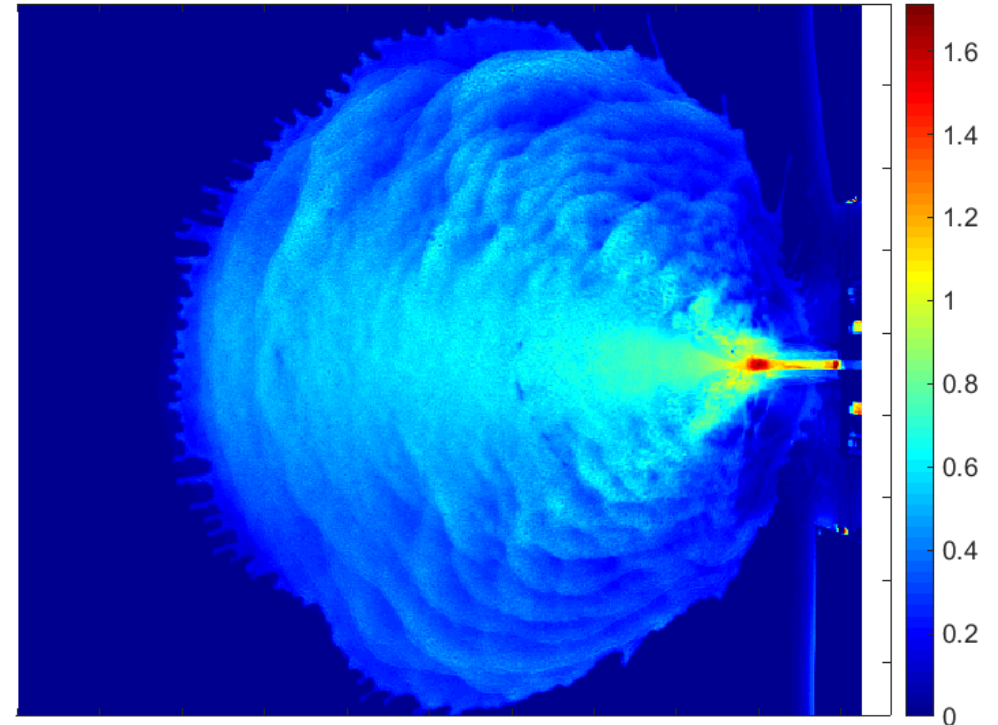
## ANALISI QUANTITATIVA - AVANZAMENTO DEL FRONTE

Avanzamento del fronte nel tempo



Profondità d'acqua iniziale nel serbatoio: 20 cm, 30 cm, 40 cm

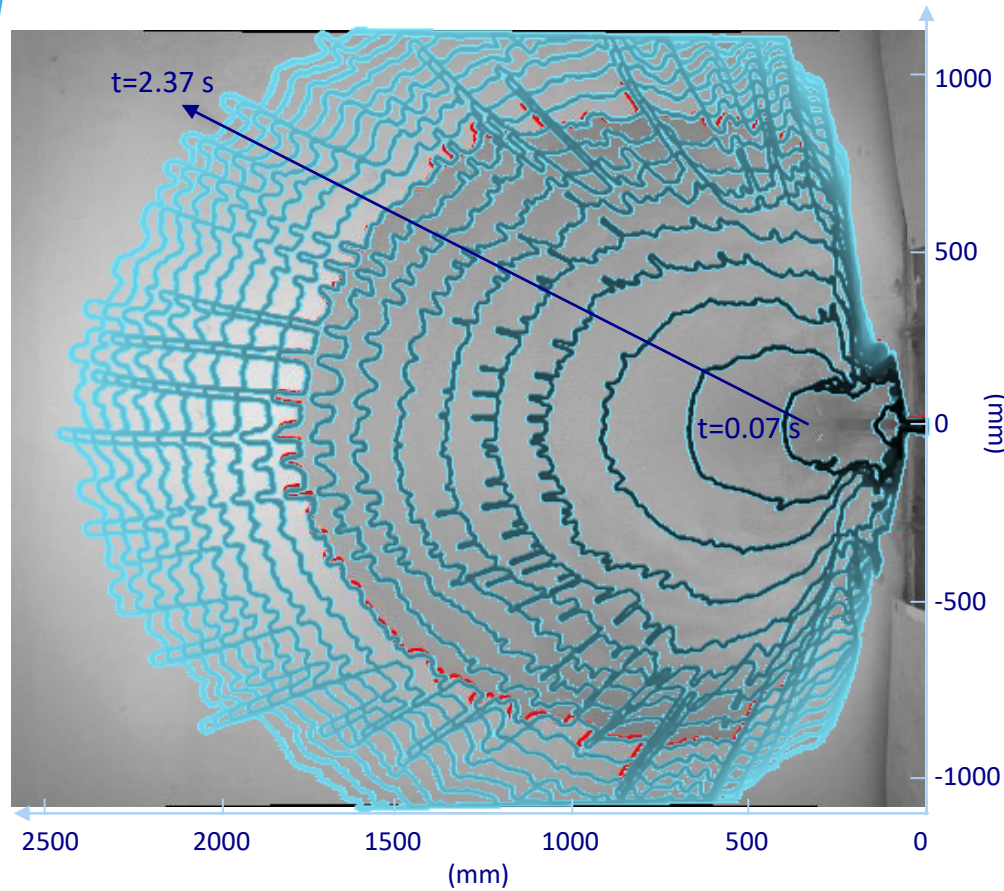
CAMPO DI ALTEZZE PER DAM BREAK LISCIO A 40 CM  
VALORI IN CM



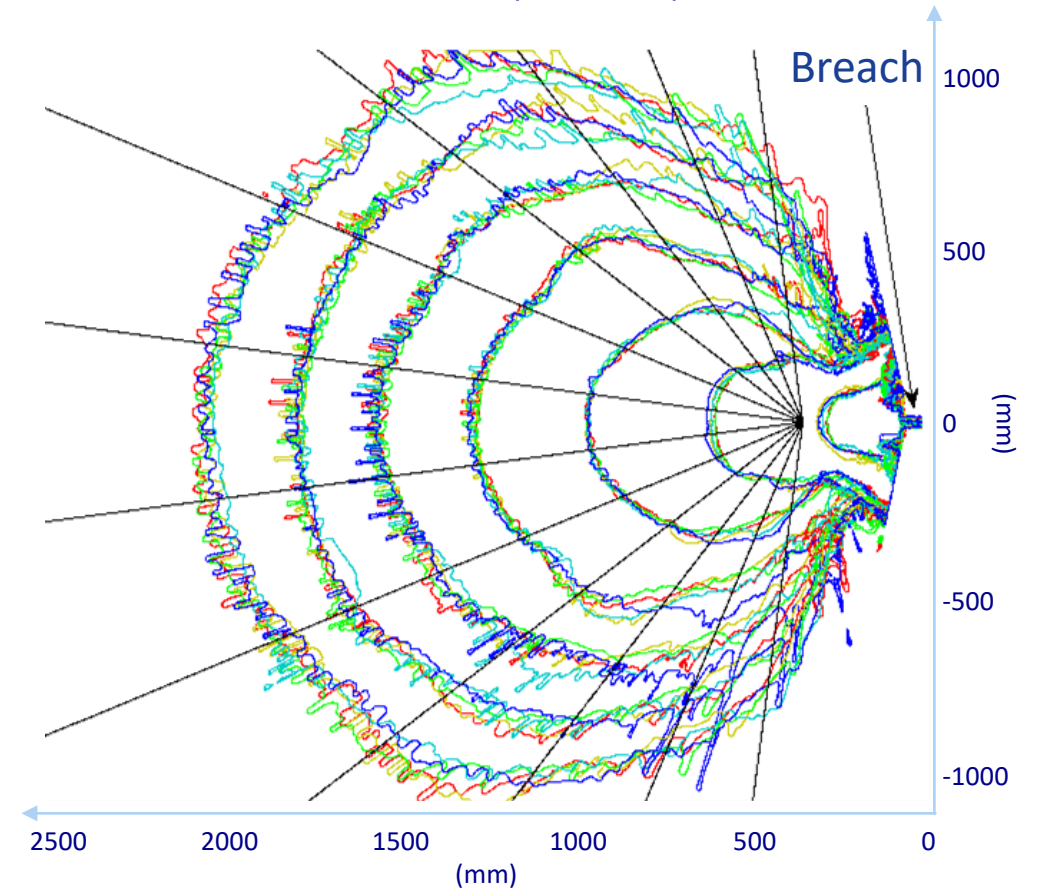
Ripetibilità: 5 esperimenti ciascuno

# ANALISI QUANTITATIVA - AVANZAMENTO DEL FRONTE PROFONDITA'

Avanzamento del fronte nel tempo



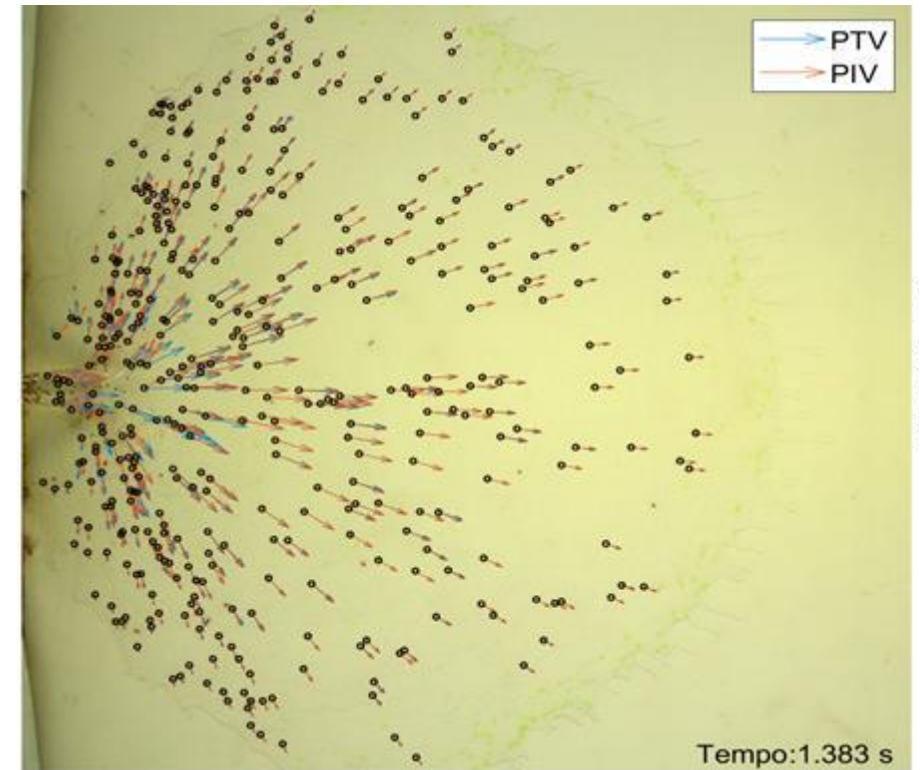
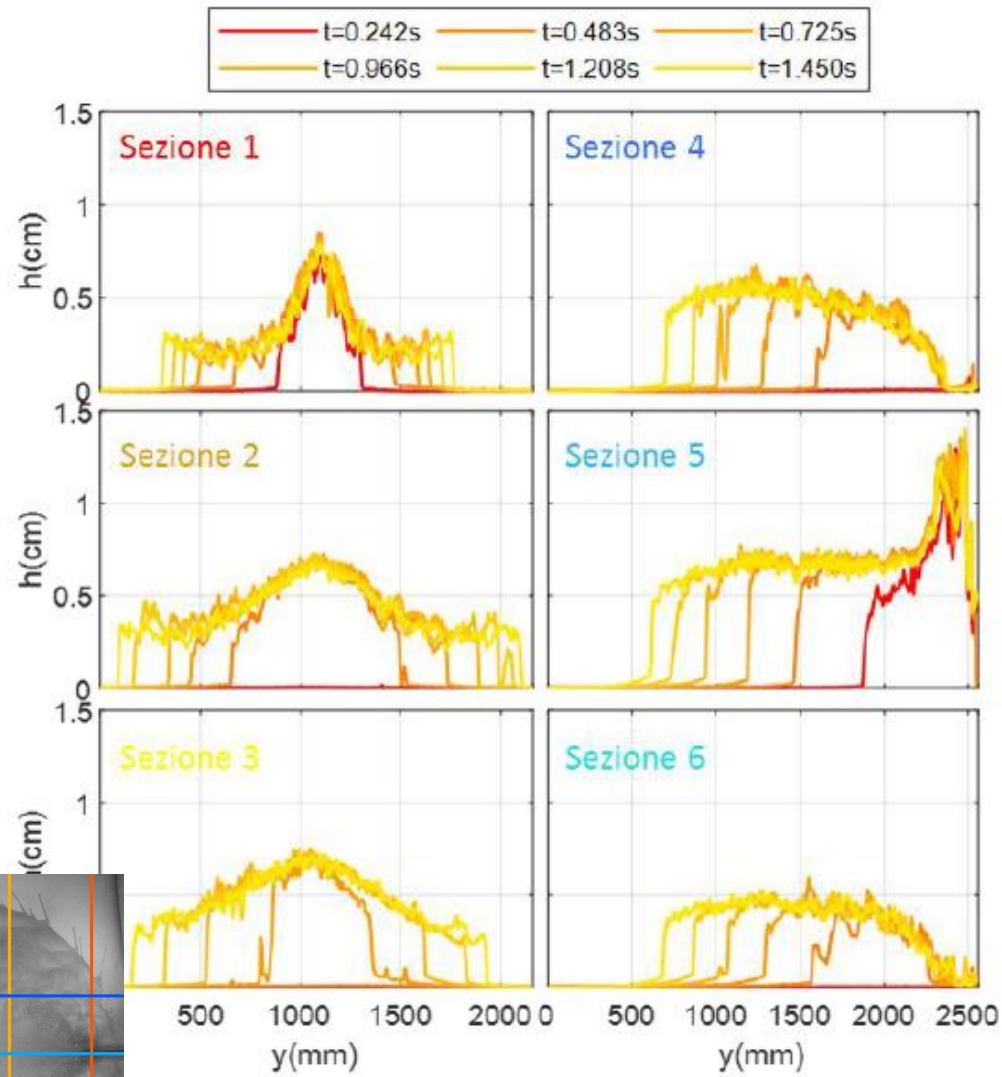
Profondità d'acqua iniziale nel serbatoio: 20 cm, 30 cm, 40 cm



Ripetibilità: 5 esperimenti ciascuno

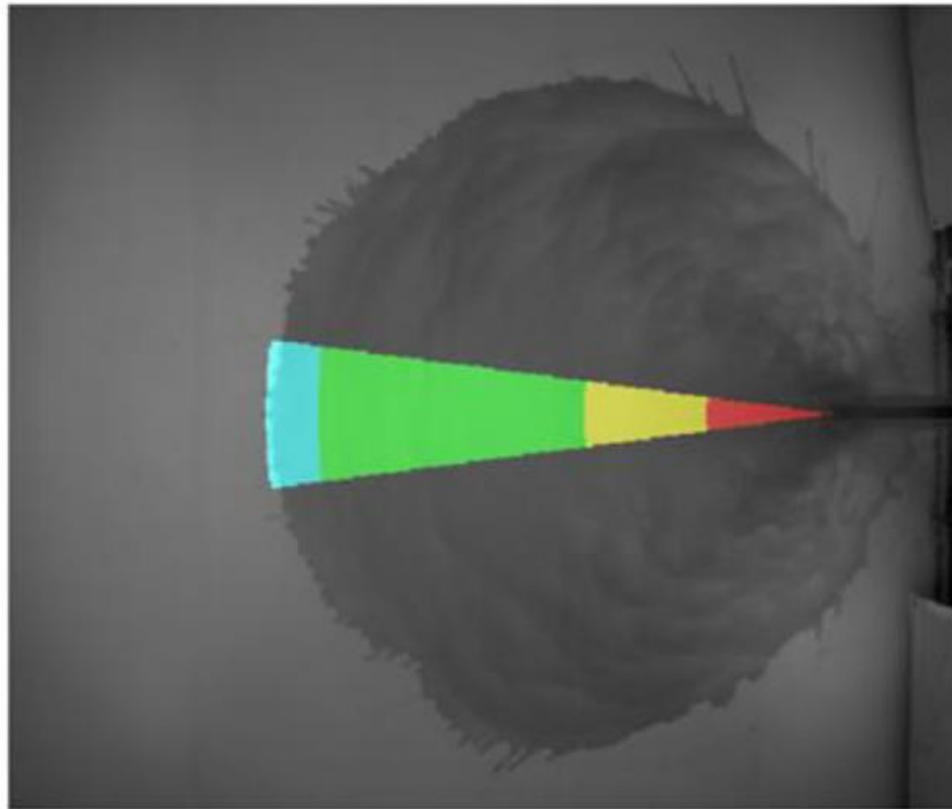


# ANALISI QUANTITATIVA - AVANZAMENTO DEL FRONTE VELOCITA'

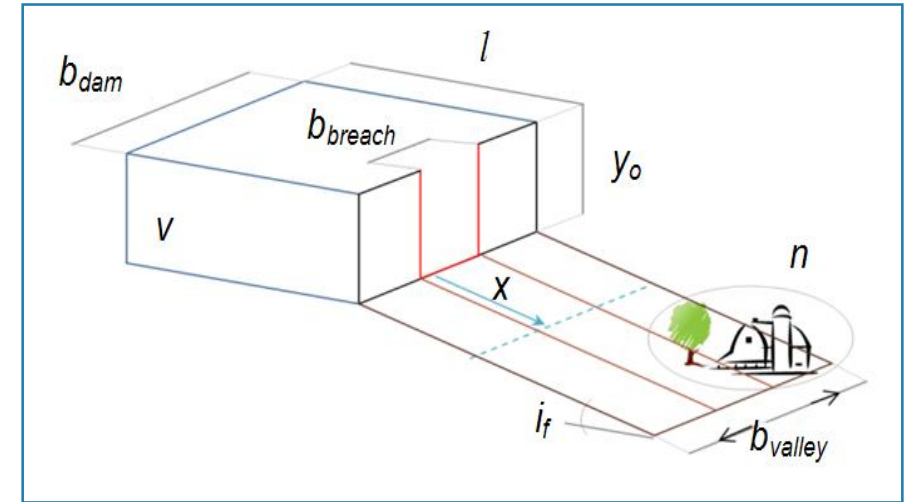


Particle Tracking Velocimetry

## VULNERABILITÀ



## ANALISI SINTETICA PER IL CASO IDEALIZZATO



La distanza delle soglie di Vulnerabilità è una funzione di:

- 1) altezza di ritenuta,  $y_0$ ,
- 2) pendenza del fondo  $i_f$
- 3) tipologia di apertura della breccia.

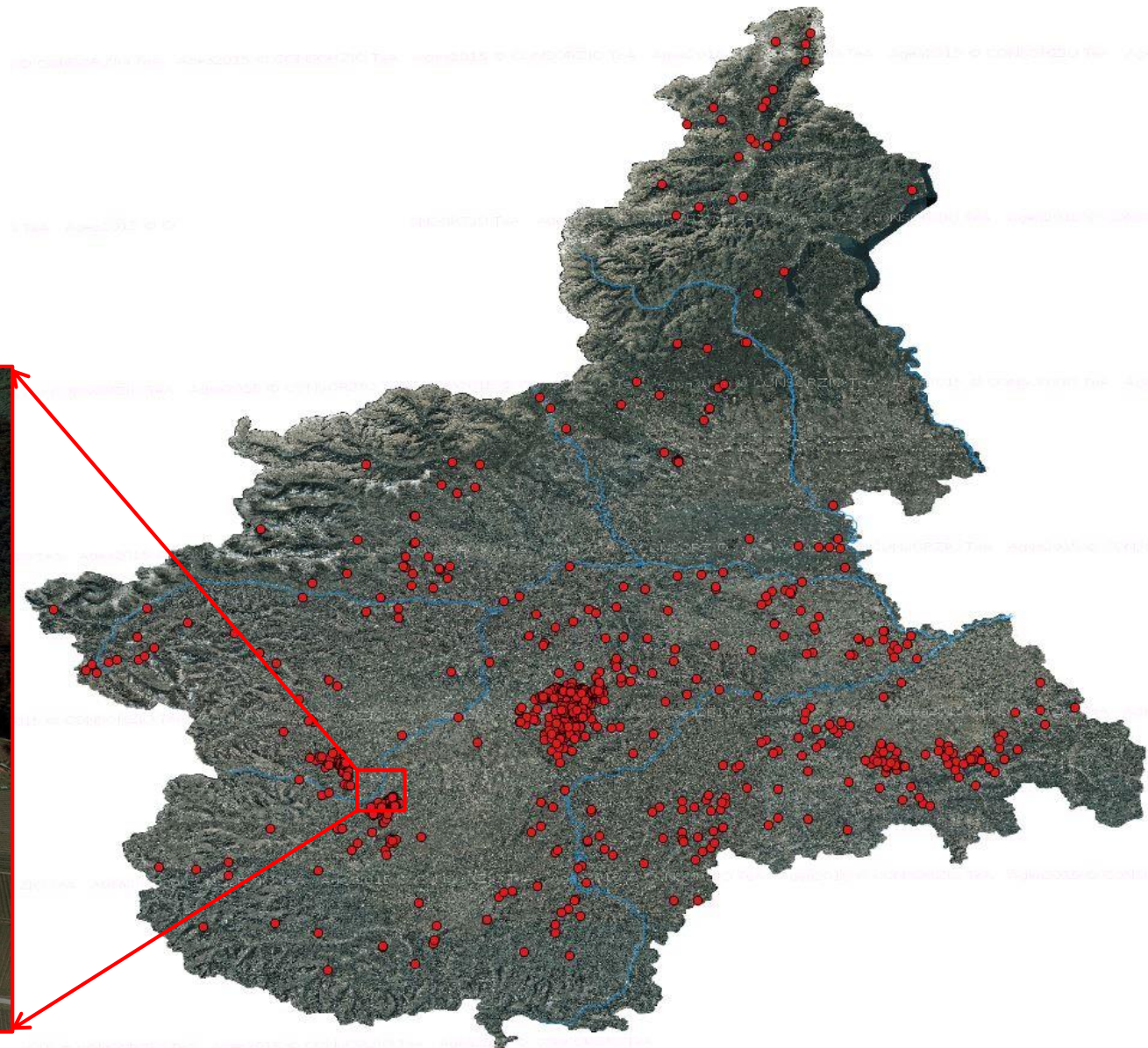
**...PROBLEMI...**



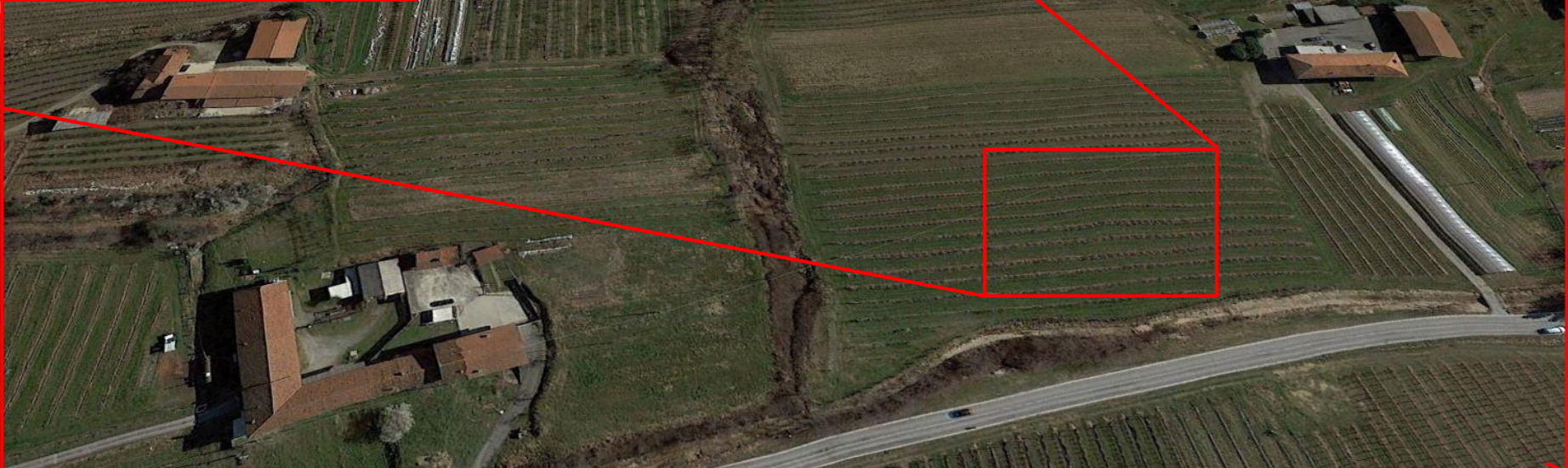
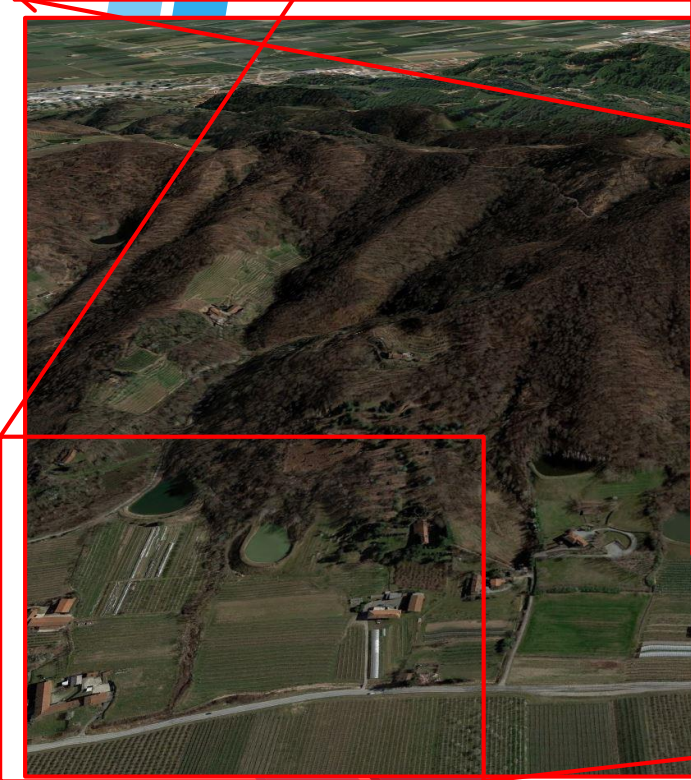
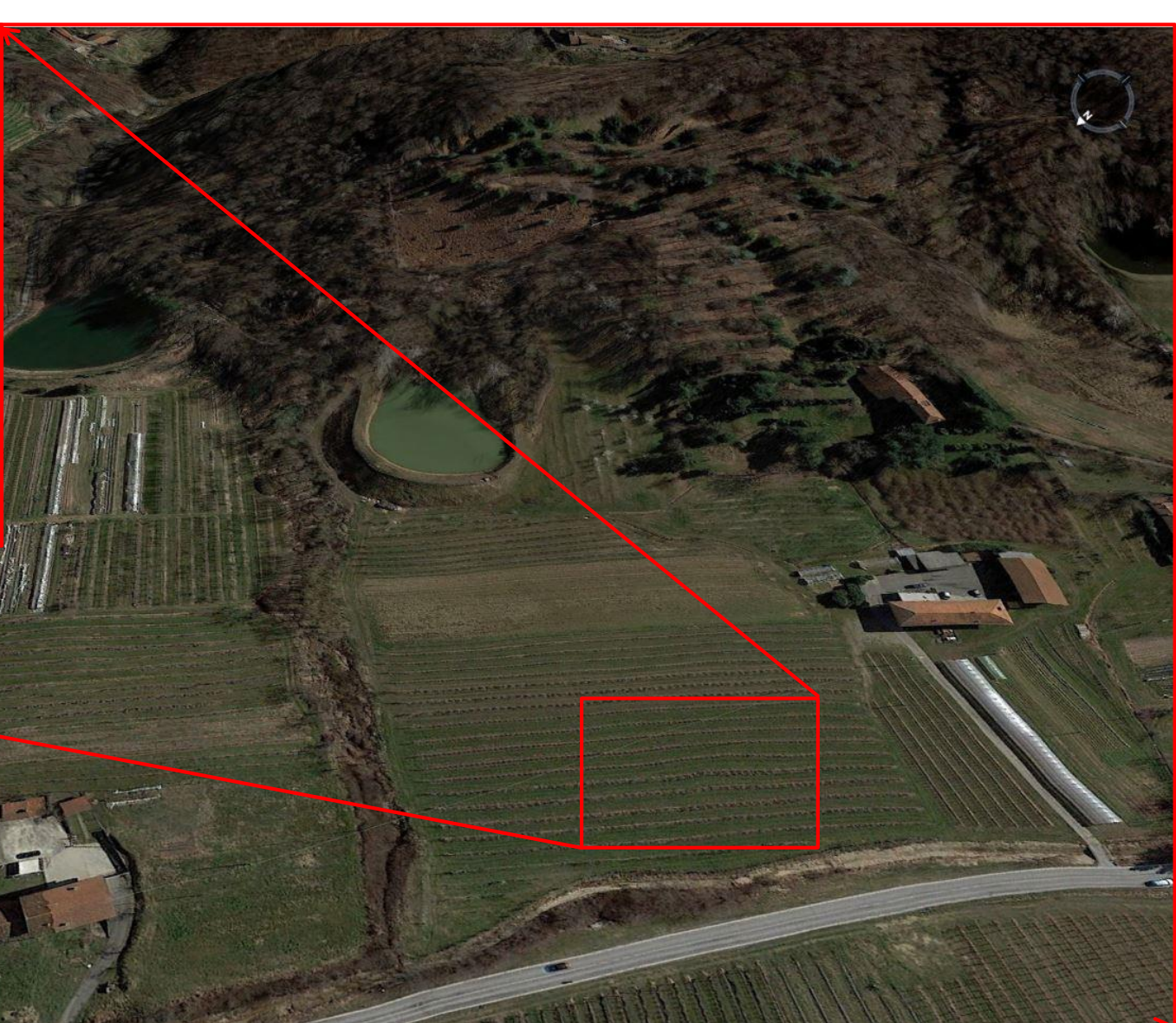
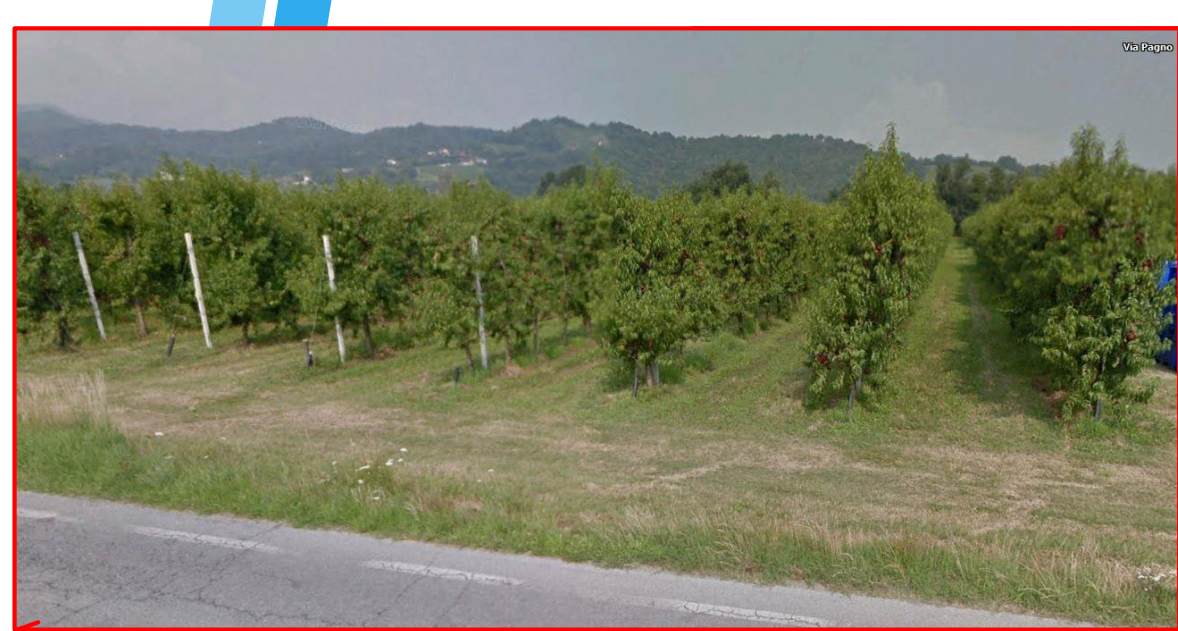
# INVASI REALI

## Scabrezza non “alla Manning”

Valgono ancora i modelli?









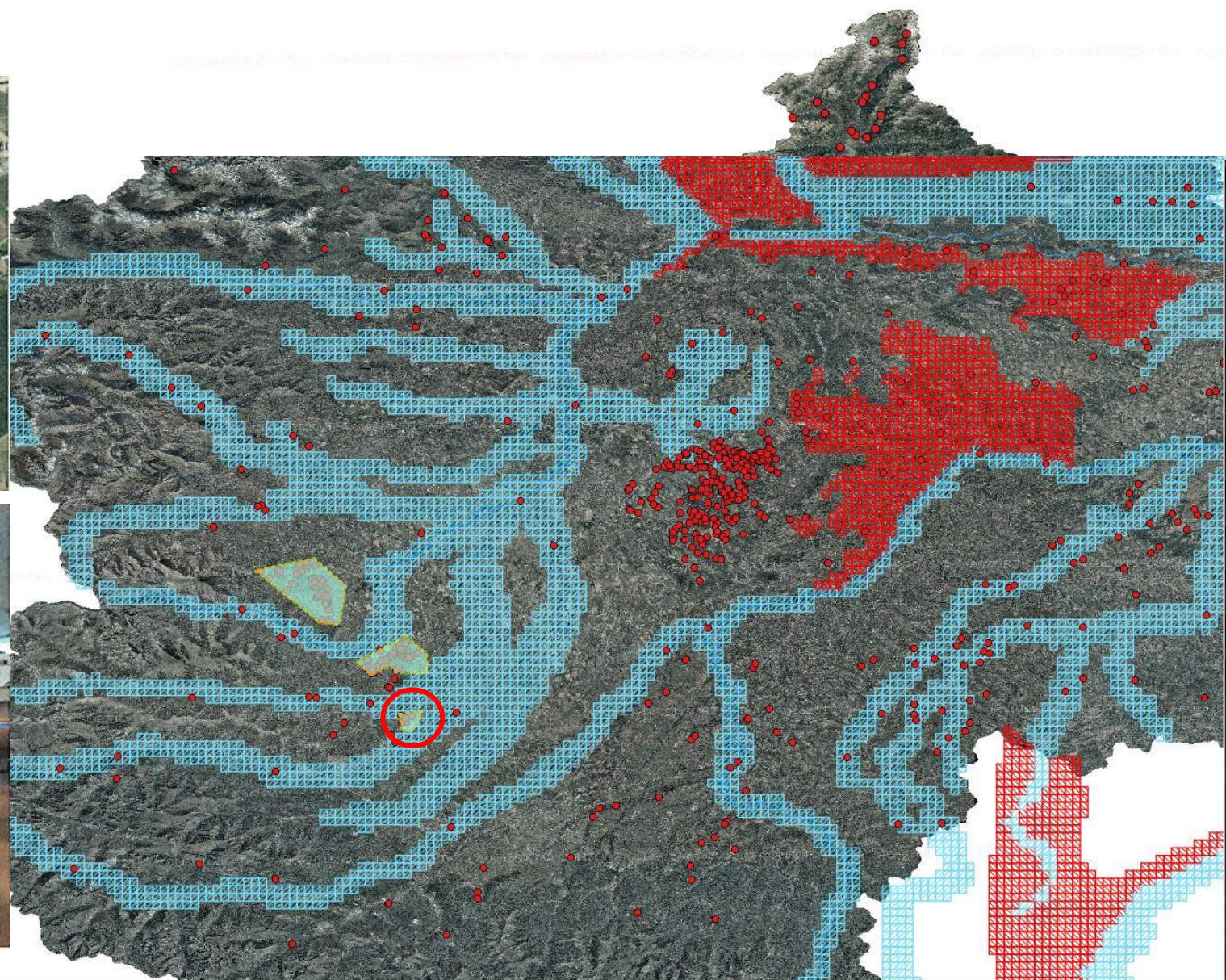
## Caratteristiche:

- 6 punti/m<sup>2</sup>
- 120 Km<sup>2</sup>
- Circa 150 invasi campionati



## CAMPAGNA LIDAR

Attività di rilevamento con sensore LiDAR  
aerotrasmontato



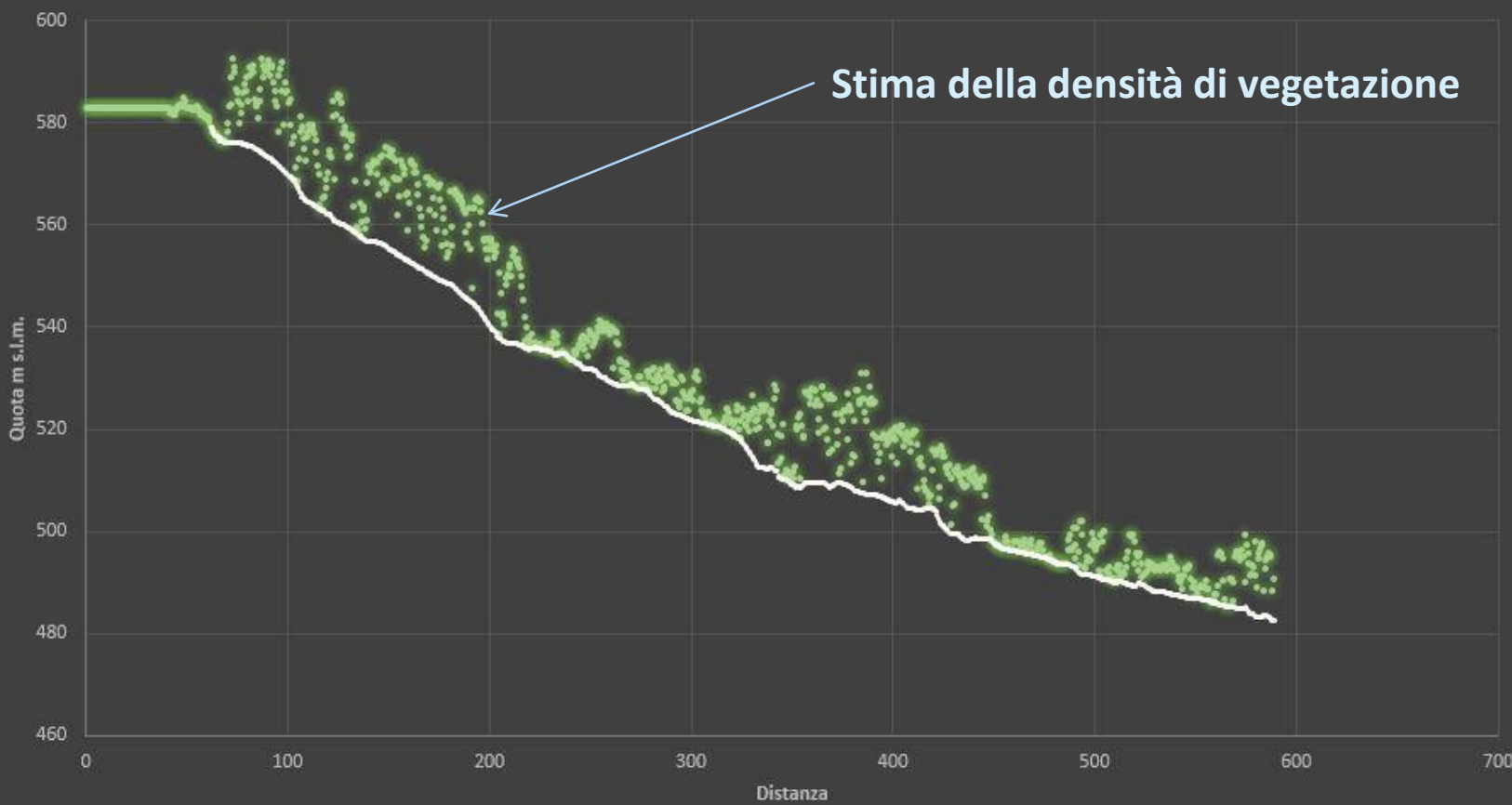
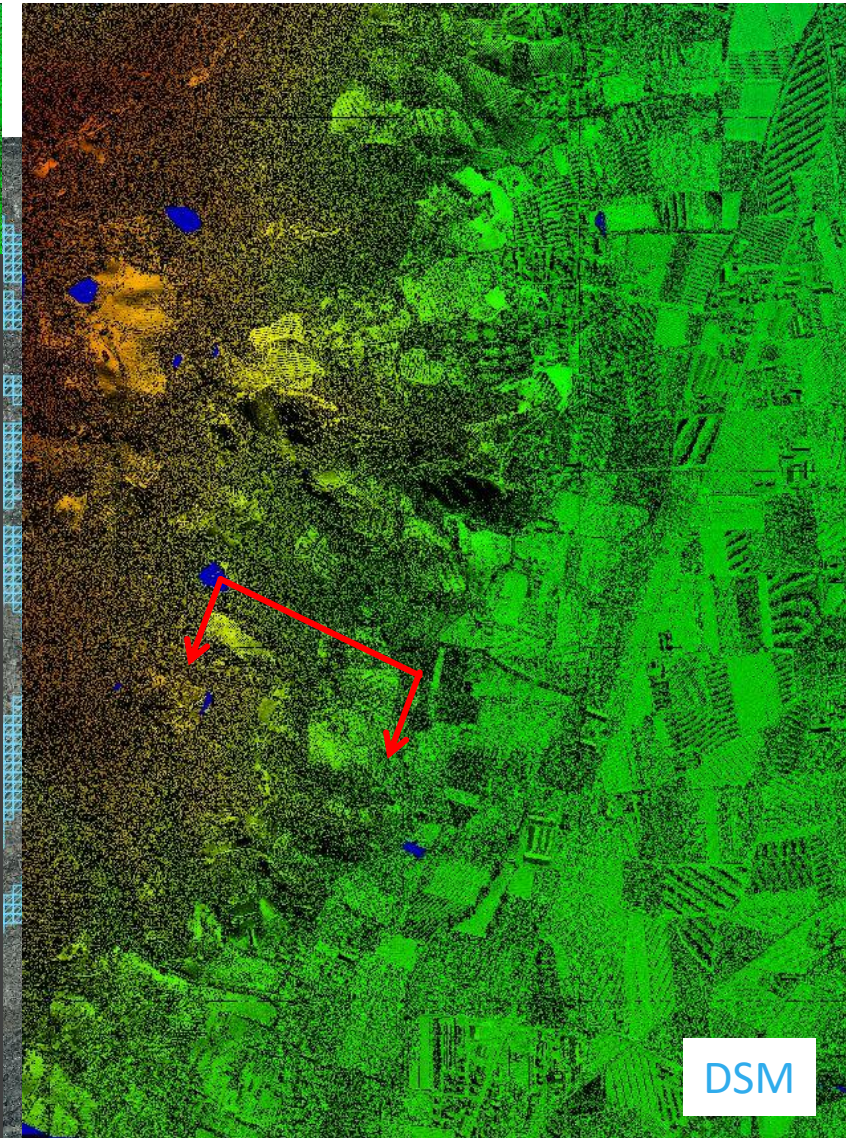
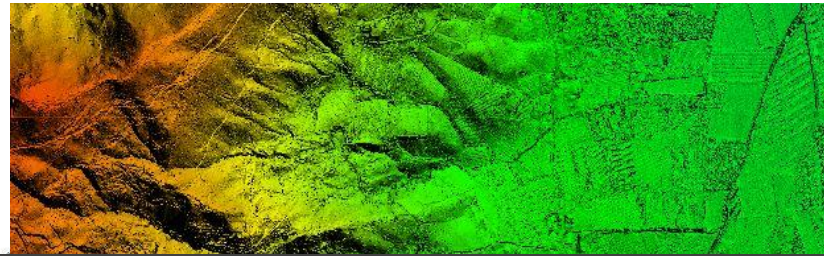


## Caratteristiche:

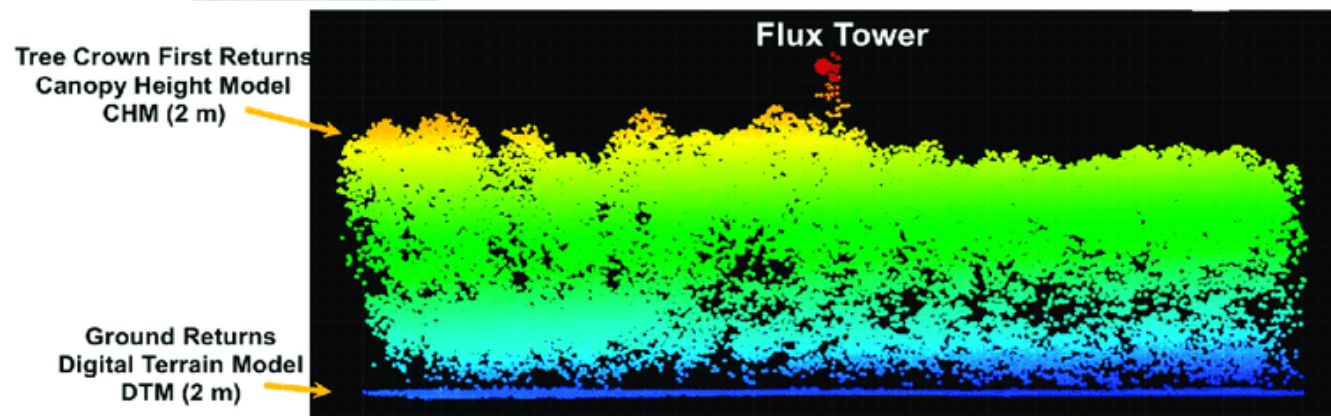
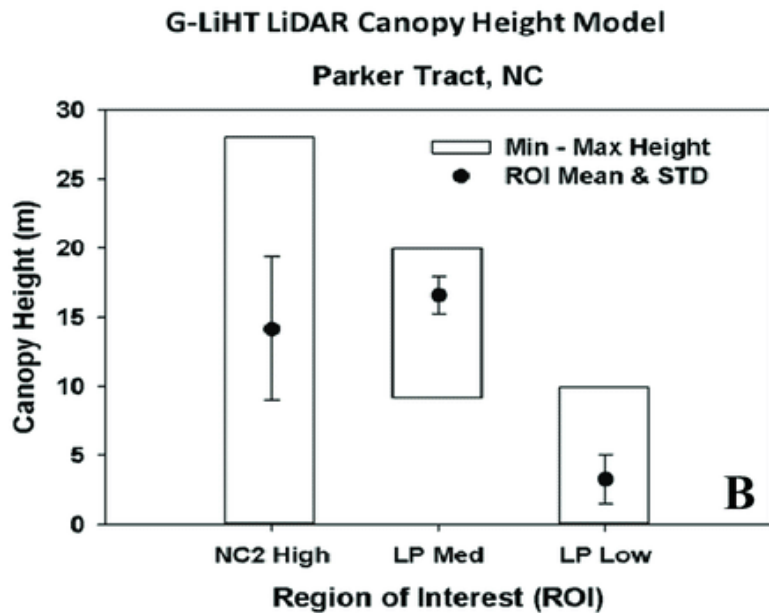
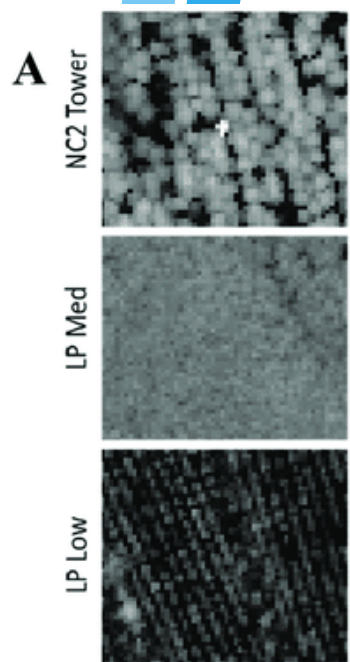
- 6 punti/m<sup>2</sup>
- 120 Km<sup>2</sup>
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## CAMPAGNA LIDAR

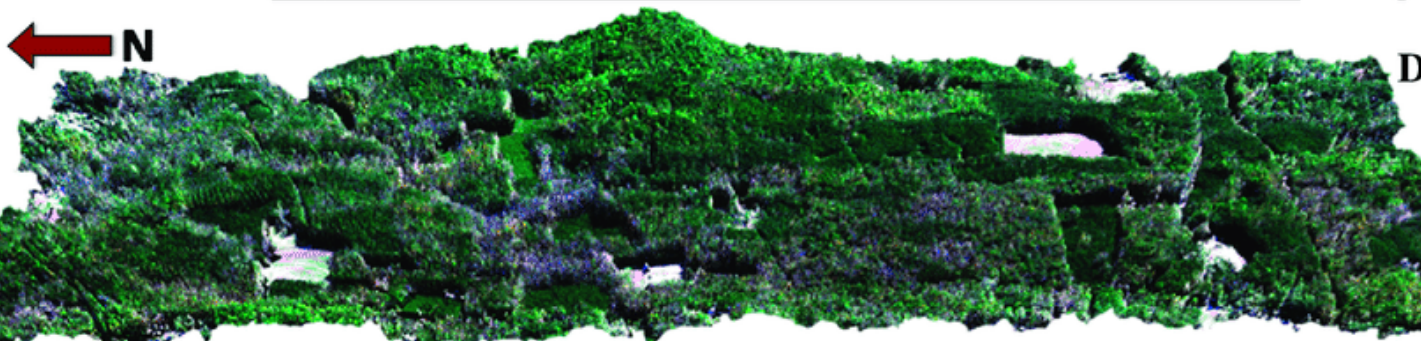
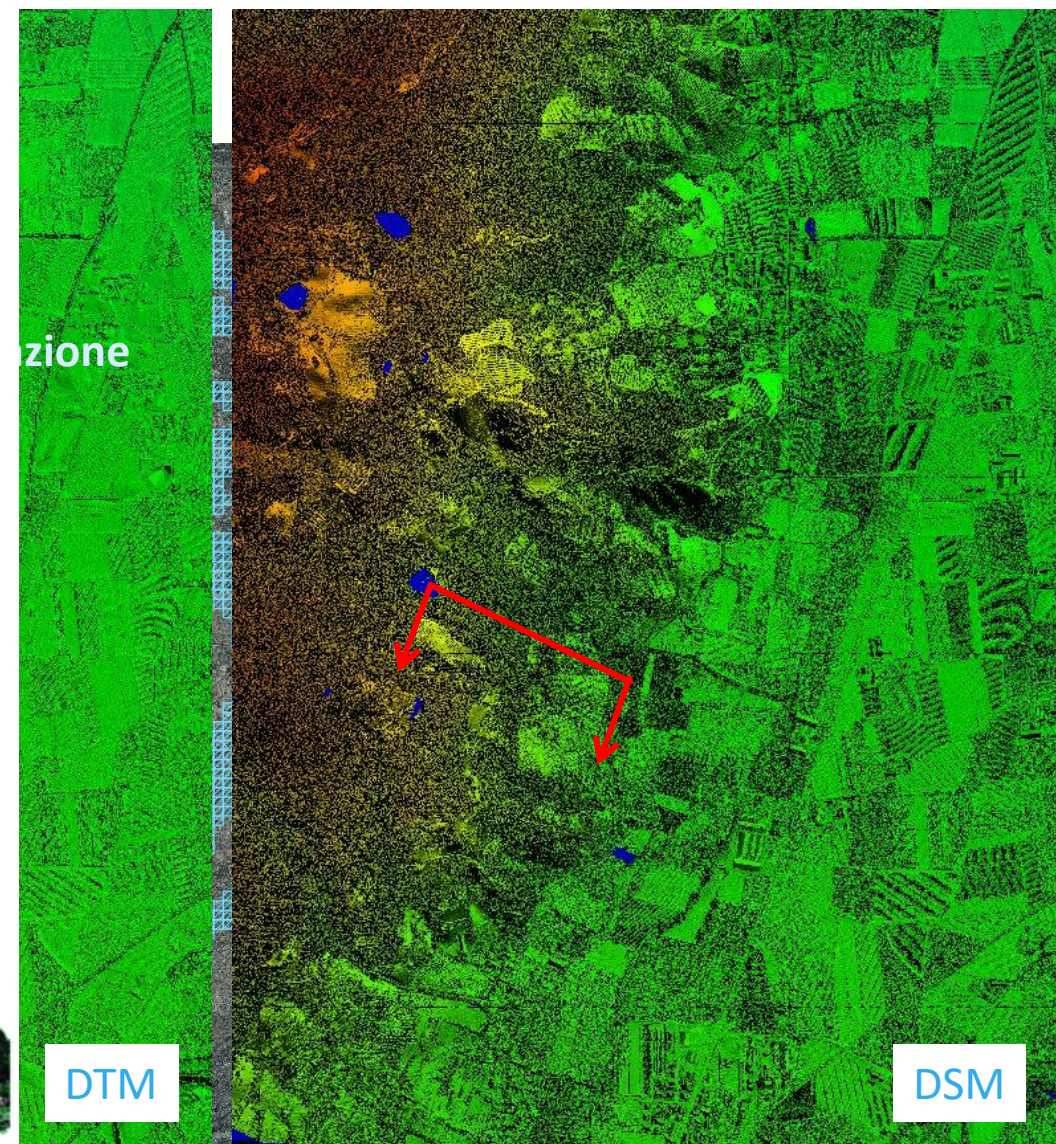
Attività di rilevamento con sensore LiDAR  
aerotrasmontato







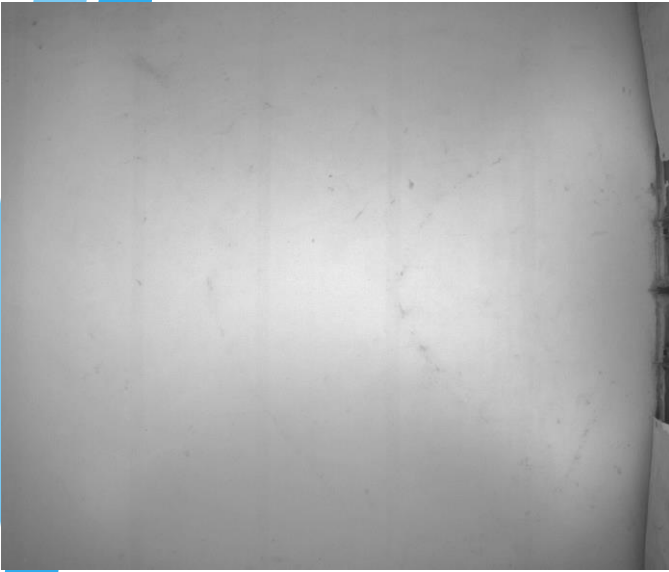
**C**



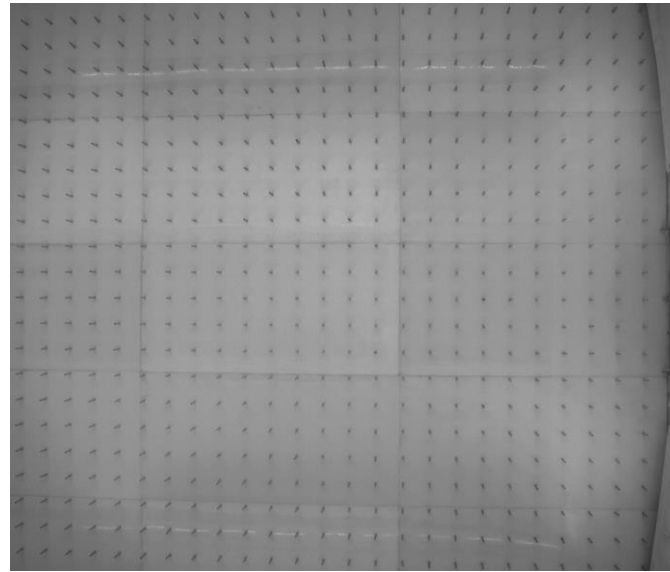


# INFLUENZA DELLA VEGETAZIONE SULLA FORMA DELL'ONDA DI PIENA

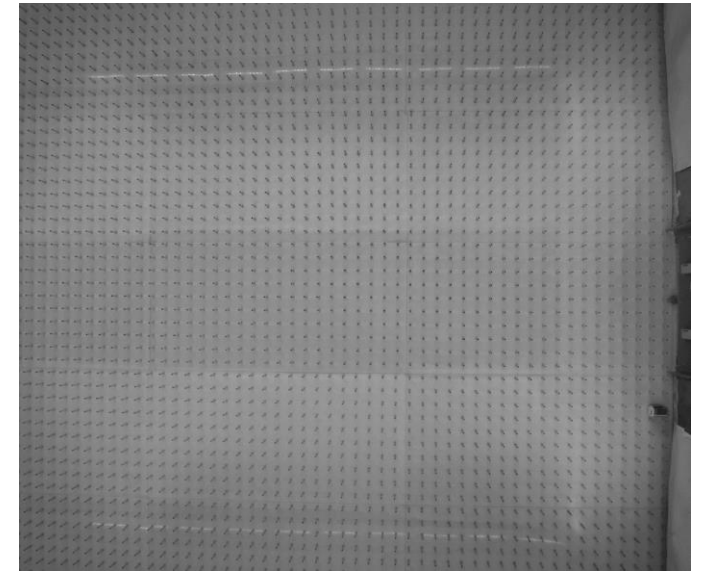
Fondo liscio



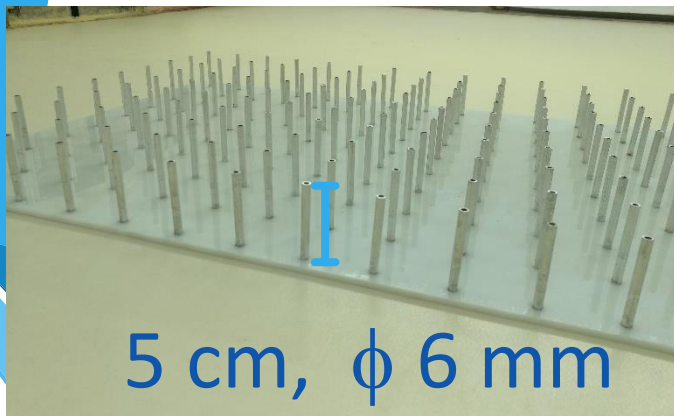
Maglia 10 x 10 cm



Maglia 5 x 5 cm

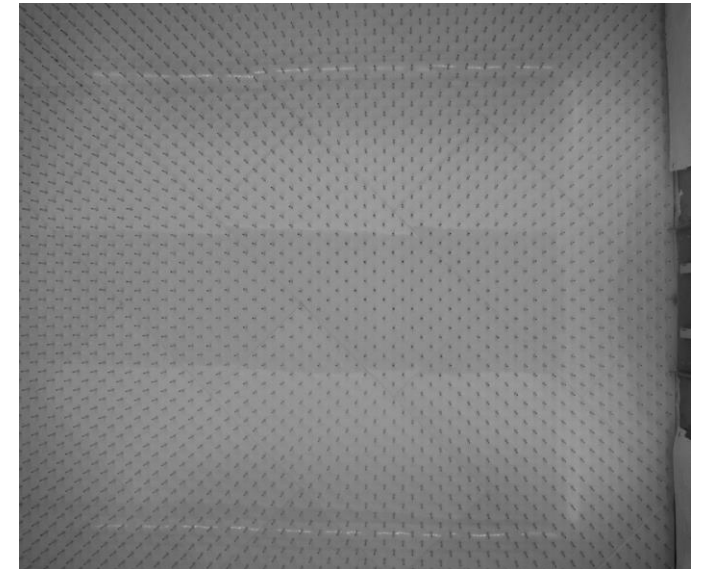
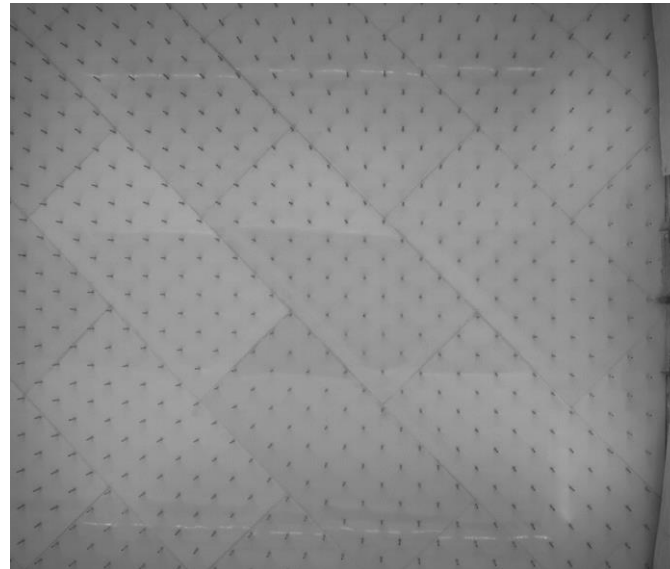


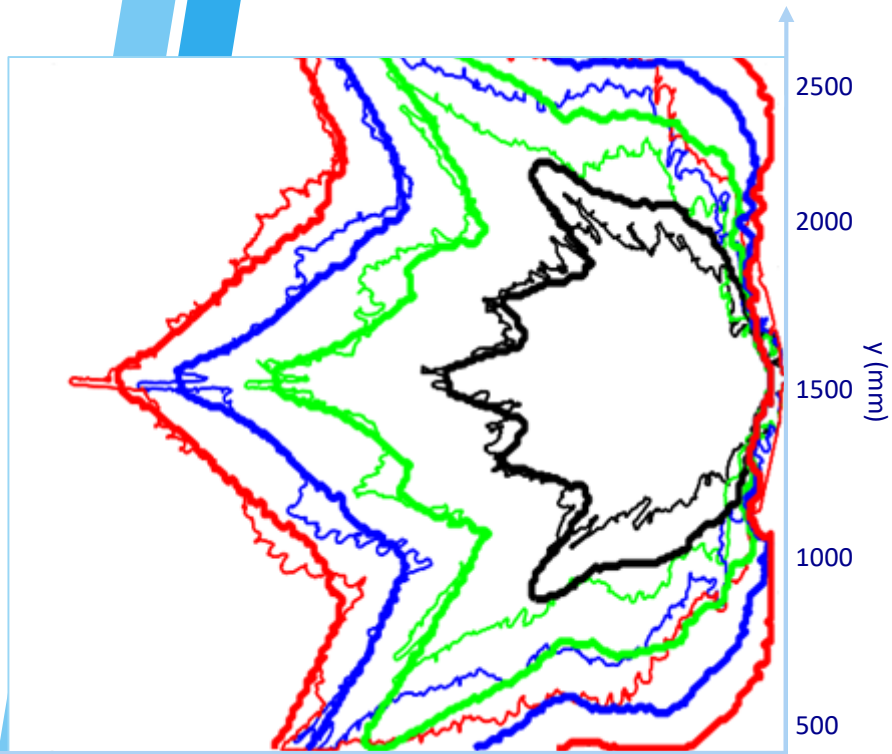
Angolo  
0°



5 cm,  $\phi$  6 mm

Angolo  
45°



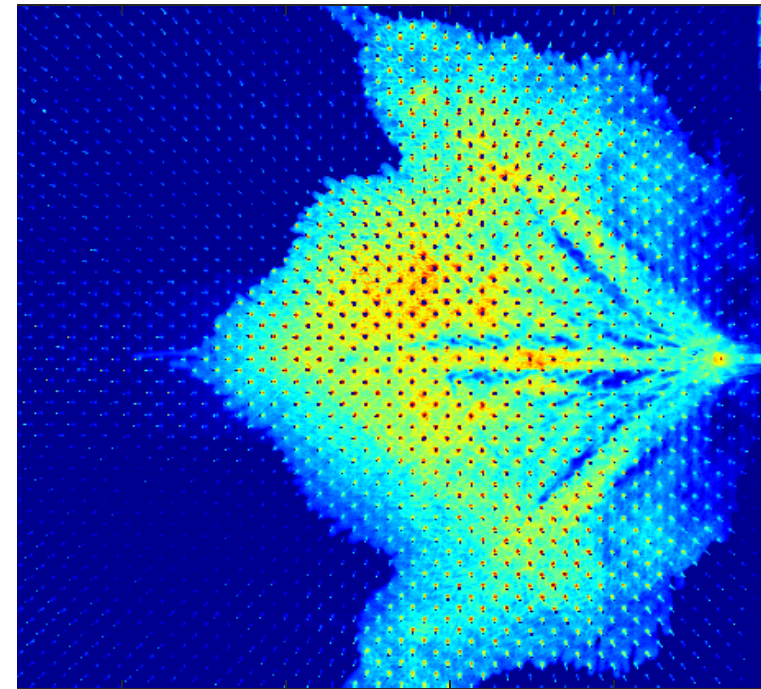
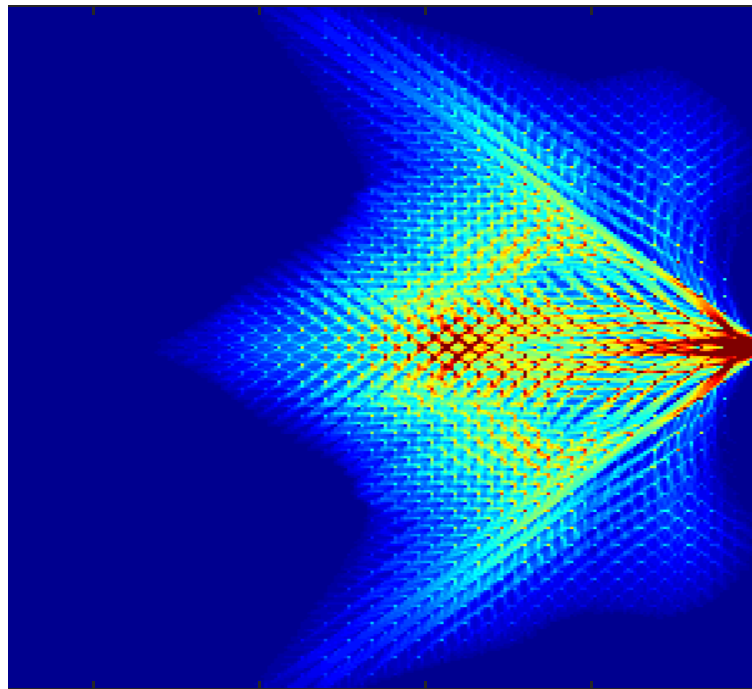


BreZo

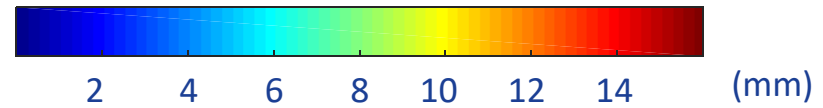


BreZo

Lab



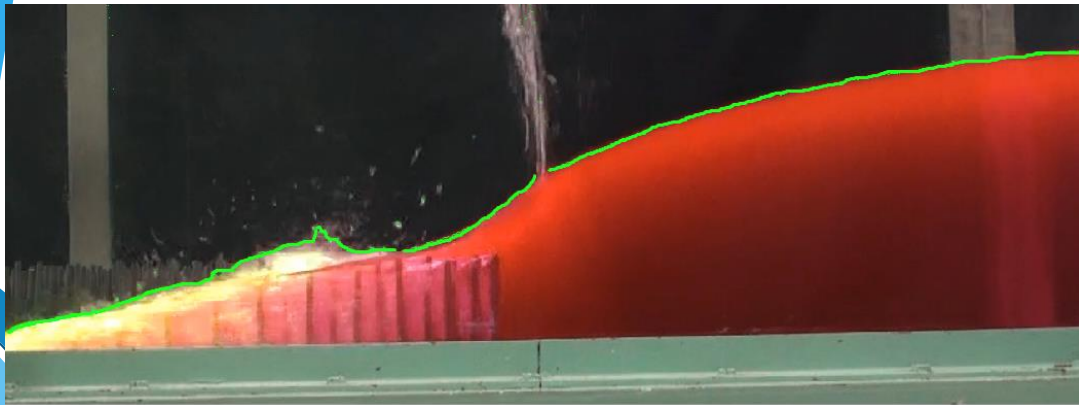
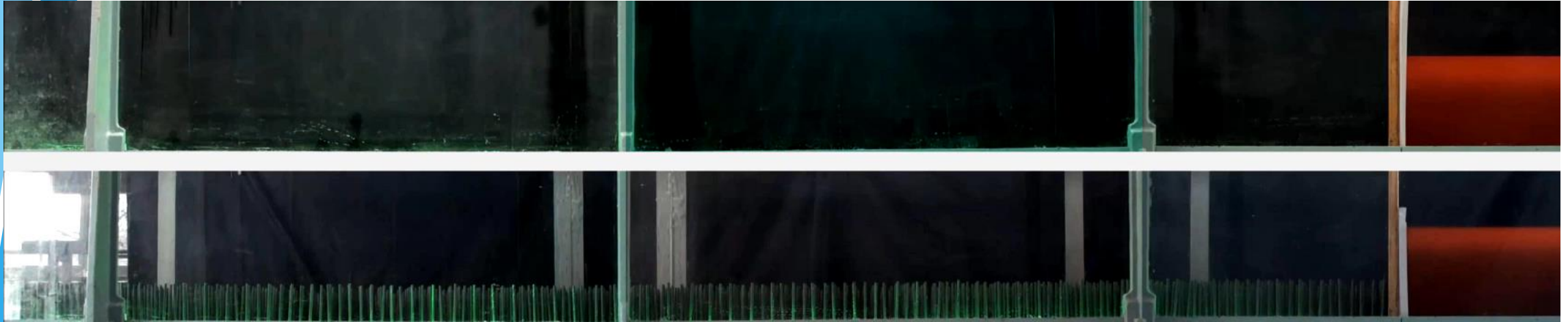
$t = 1.5$  s



**Modellazione della  
vegetazione come  
ostacoli!**



# Onda 1D, Calibrazione del Manning coefficient?



**Riconoscimento del  
fronte e del profilo**



**Misura drag**

# Unsteady Flow Computational Options

1D Flow Options | 2D Flow Options | Restart Options | Advanced Time Step Control

## 1D/2D Interface Computational Options

Maximum iterations between 1D/2D interface:

Water surface calculation tolerance:  (ft)

Flow calculation tolerance:  %

Minimum flow tolerance:  (cfs)

## 2D Flow Area Computational Parameters

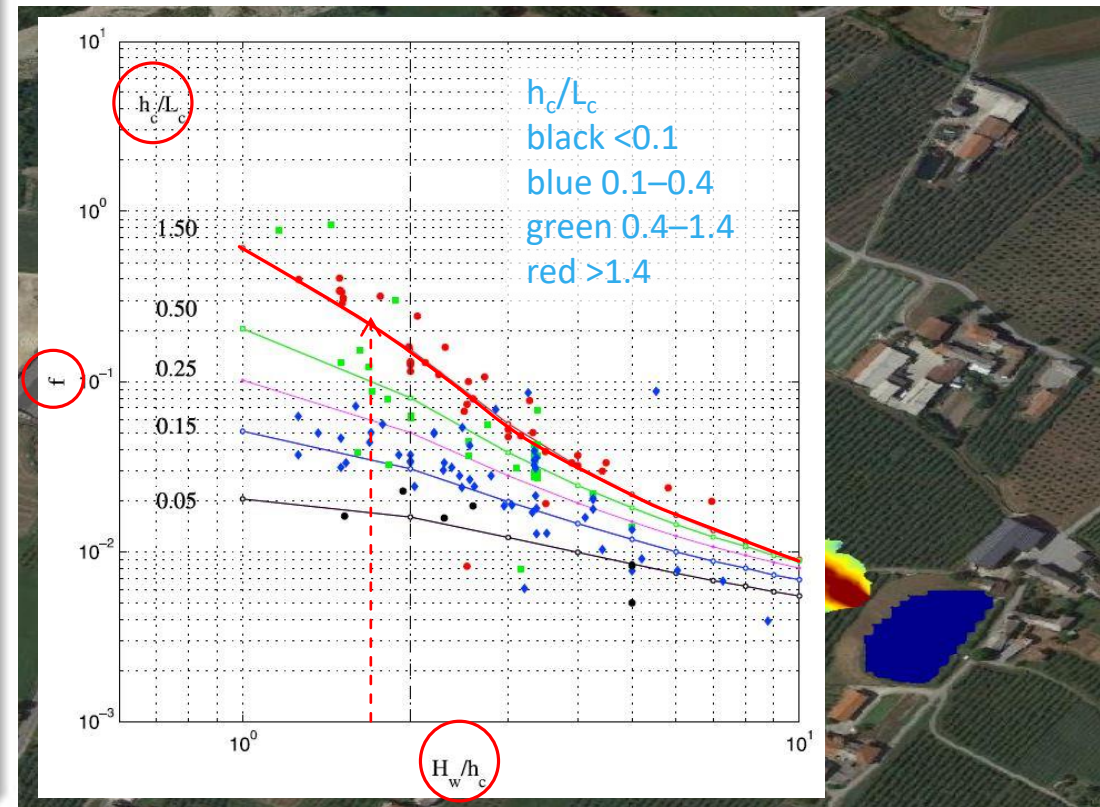
Parameter	Default	Cuyahoga River
Theta Implicit Weighting Factor (.6 to 1)	1	1
Warm Up Theta (.6 to 1)	1	1
Water Surface Calculation Tolerance (ft)	0.01	0.01
Volume Tolerance (ft)	0.01	0.01
Maximum Iterations	20	20
Computational Equation	Diffusion Wave	Diffusion Wave
Initial Conditions Time (hrs)	Diffusion Wave	1
Initial Conditions Ramp-up Fraction (0 to 1)	Full Momentum	0.1
Maximum Time Slices		1
Eddy Viscosity		
Boundary Condition Volume Check	<input type="checkbox"/>	<input type="checkbox"/>
Coriolis Effect Latitude (-90 to 90)		

Reset to Defaults

# Esempio HEC-RAS 5.07

$$Q_i = -DH_w \frac{\partial H_w}{\partial x_i},$$

$$Q_i \cong \sqrt{\frac{8}{f}} L H_w^{3/2} \left( \frac{\partial H_w}{\partial x_i} \right)^{1/2},$$



## LINEE GUIDA PER LA VALUTAZIONE DELL'ONDA DI PIENA DI 'PICCOLI' INVASI COLLINARI

### IN COSA INVESTIRE?

- Serve una buona modellazione della SUPERFICE e della VEGETAZIONE. I dati LiDAR sono ormai alla portata di tutti i professionisti!
- Non servono modelli sofisticati: HEC-RAS è OK! (formulazione diffusiva?)
  - Modellazione 3D con il mapper (almeno 1 punto al m<sup>2</sup>)
  - Ricerca dei parametri della vegetazione (da LiDAR)
  - Stima del Manning coefficient equivalente



**Grazie per l'attenzione**

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