



arpav

Tecniche innovative di misura dei livelli delle portate

Zasso Marco

Arpav – U.O. Supporto alla Protezione Civile

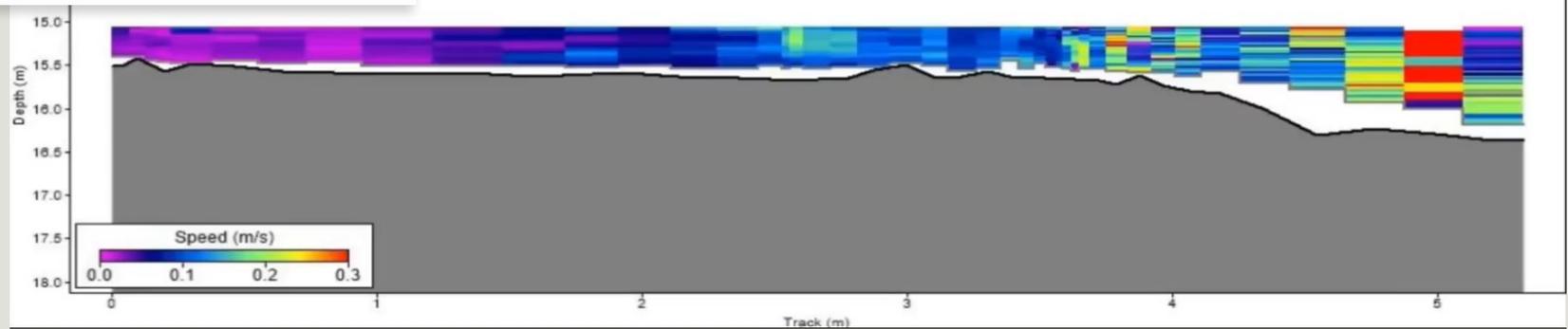
Padova, 30 maggio 2024

-
- Importanza delle misure idrologiche livello - portata;
 - Misure puntuali di portata:
 - sistemi Doppler: profilatori e misure puntuali radar;
 - tecniche di analisi video;
 - Applicazioni per misure di livello-portata in continuo: esempi di recenti installazioni;

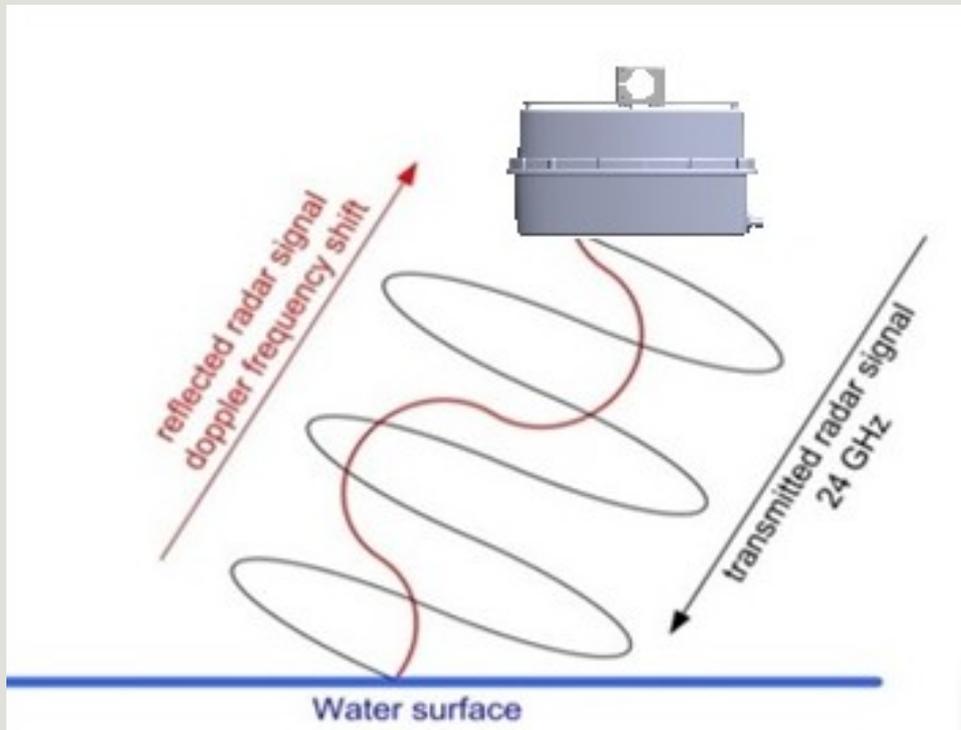
Misure con profilatori Doppler



Misure con profilatori Doppler



Misuratori radar Doppler non a contatto



Sfruttano il principio Doppler per la misura della velocità superficiale.

Altezza onda 0.3-0.5 cm

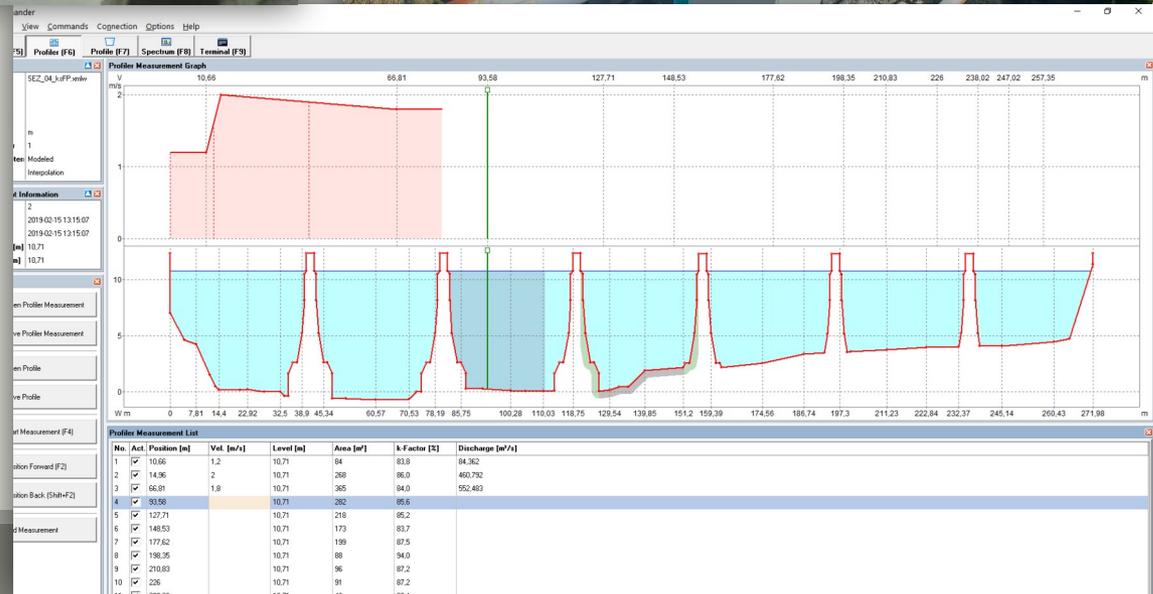
Inclinometro



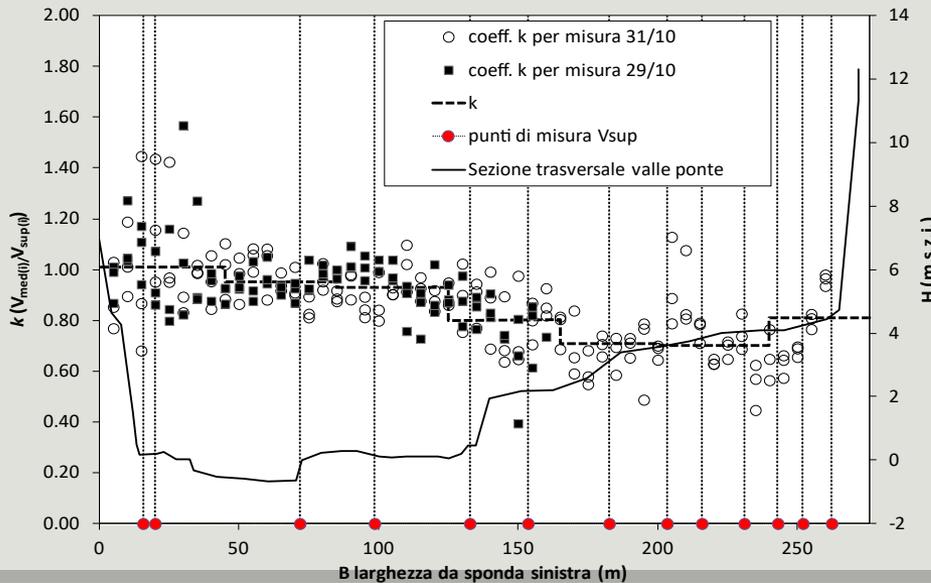
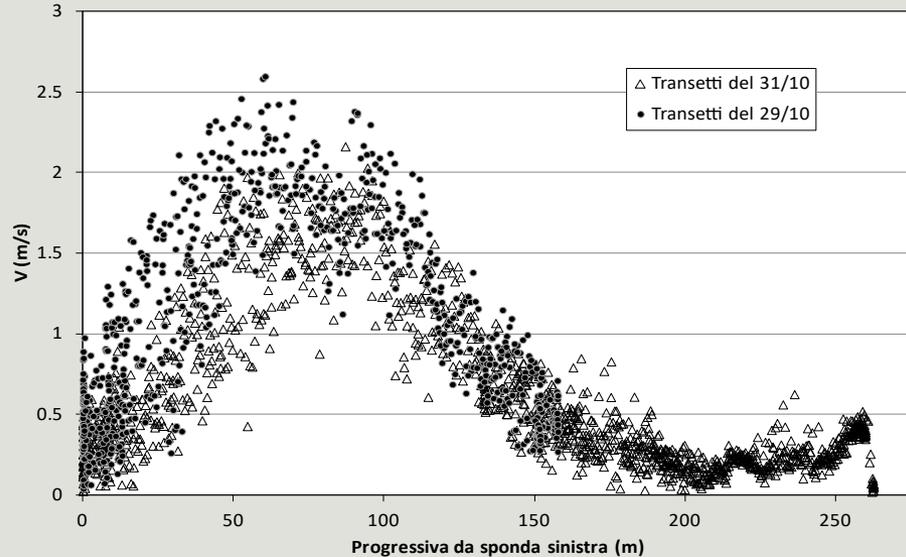
Misure con sensori radar Doppler



$$V_{med} = k * V_{sup}$$



Integrazione di metodologie diverse



ADCP:

1. Estrazione da dati ADCP di valori velocità superficiali e medie sulle verticali;
2. Stima e valutazione variabilità trasversale del rapporto v_{sup}/v_{med} .

RADAR:

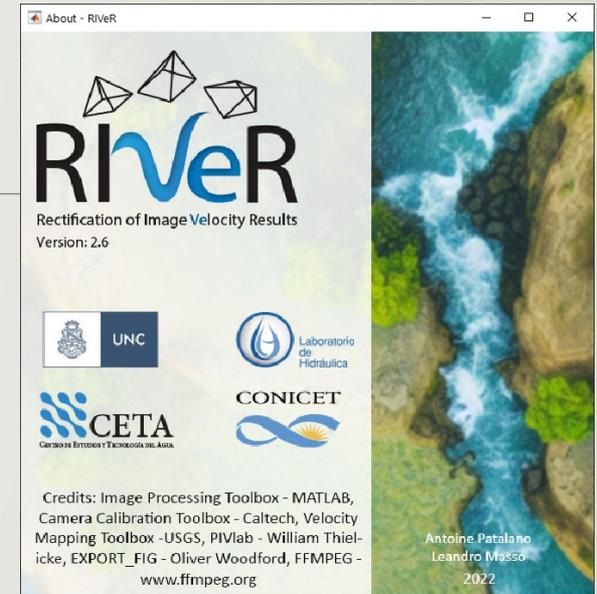
3. Utilizzo di un coefficiente di proporzionalità tra v_{sup}/v_{med} sito specifico.

Tecniche di analisi video

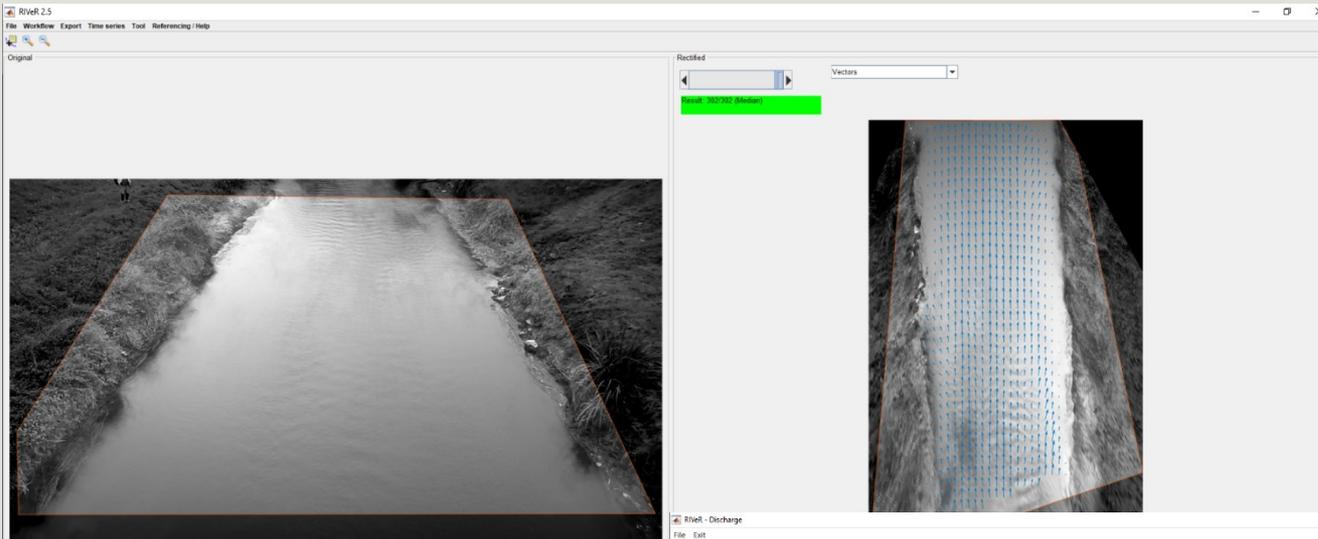
DOI: [10.1016/j.cageo.2017.07.009](https://doi.org/10.1016/j.cageo.2017.07.009) Computers & Geosciences (2017)

LSPIV (Large Scale Particle Image Velocimetry)

LSPTV (Large Scale Particle Tracking Velocimetry)



Tecniche di analisi video



Log Window

```

07/02/2022 17:57:55
Choose Section: CS 0
Real coordinates [Left bank Right bank]
x=[1420.4655 694.60497]
y=[246.2216 194.88904]
Real World coordinates [Left bank Right bank]
x=[0 0]
y=[0 11.16]
total length (Real World): 11.16
number of samples: 20
distance between samples: 0.55737
07/02/2022 17:59:13
Choose Section 'CS 0' has been deleted
    
```

RiVeR - Discharge

File Exit

Stage Profile (from AreaComp2 V1.07 - Lant and Mueller)

Station and Stage Table

Station	Stage (Dist. from left bank)
1	0
2	0.9868 -0.2388
3	1.3000 -0.4500
4	2.5500 -0.9200
5	3.3600 -1.0700
6	4.6100 -1.0100
7	5.2400 -0.9800
8	6.7000 -0.9100
9	8.1500 -0.7600
10	8.2000 -0.7400
11	8.7000 -0.6900
12	9.4300 -0.6200
13	10.1000 -0.5600
14	10.2600 -0.5800
15	11.0000 -0.4000
16	11.6200 -0.2800
17	11.9200 -0.1200
18	12.6300 0

ADCP: File: Starting Station: 0

CSV: File: Sezione_Q2.csv Starting Station: 0

Discharge Computation

Interp. Halfs

Mean Velocity coefficient: 0.87

Mean Section Method

Mid Section Method

Compute

Estimated discharge Q: 7.29

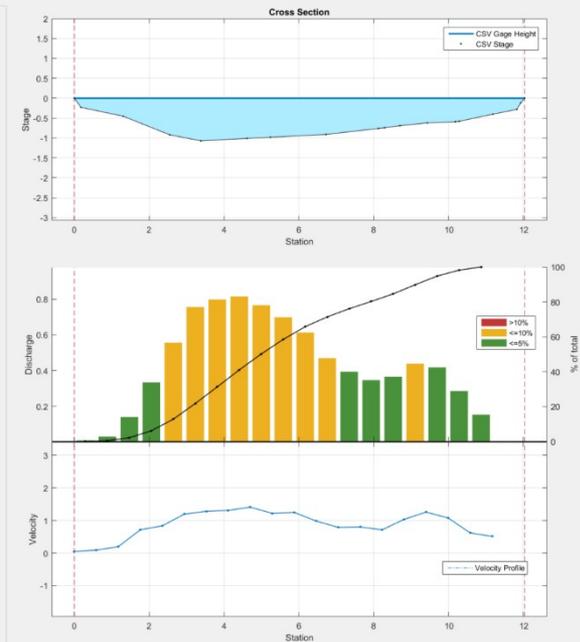
Measured: 100%

Interpolated: 0%

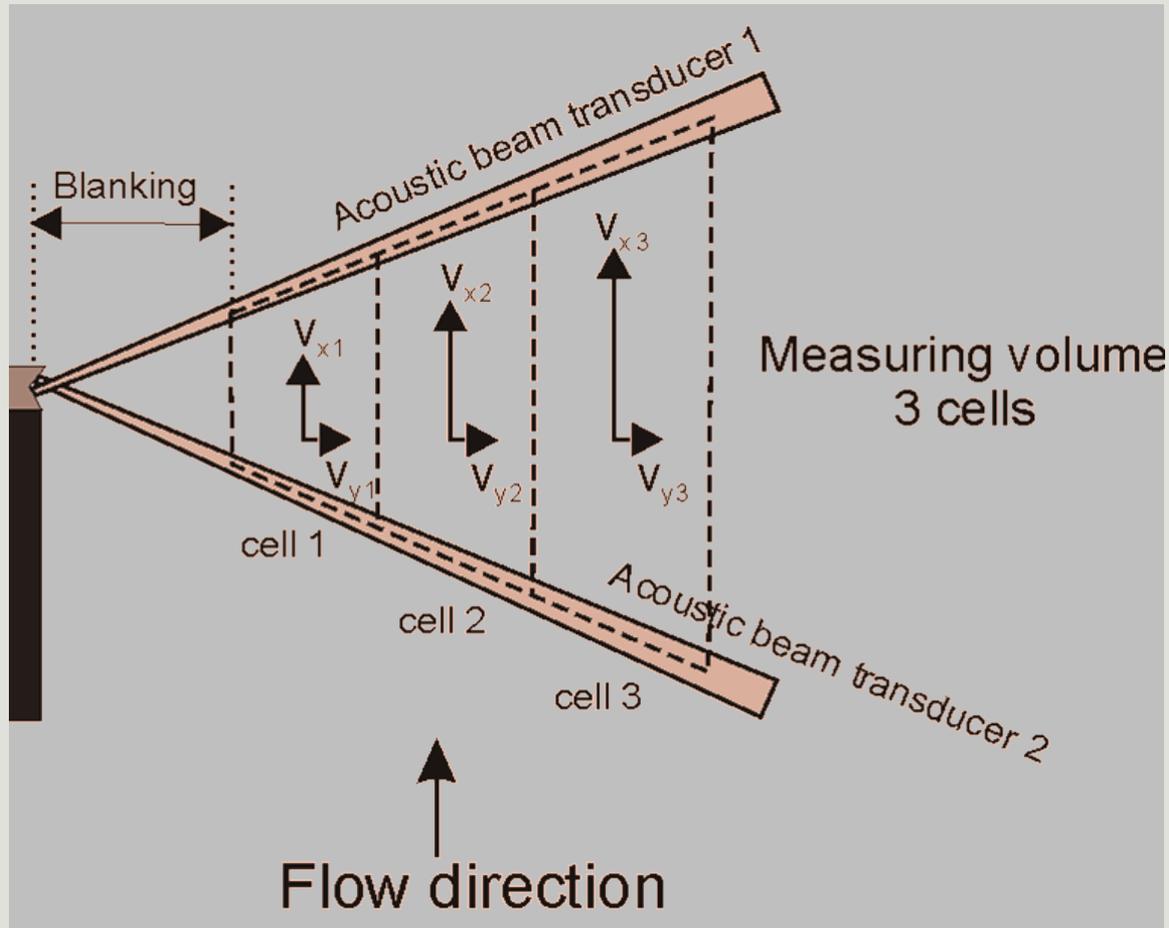
Velocity Profile

Station and Velocity Table

Station	Velocity
1	0
2	0.0874 0.0885
3	1.1747 0.1545
4	1.7621 0.1732
5	2.3495 0.8361
6	2.3368 1.1058
7	3.5242 1.2820
8	4.1116 1.3093
9	4.6989 1.4096
10	5.2863 1.2188
11	6.8737 1.2481
12	6.4611 0.9813
13	7.0484 0.7185
14	7.6358 0.7996
15	8.2232 0.7138
16	8.8105 1.0543
17	9.3979 1.0270
18	9.9853 1.0752
19	10.5726 0.6188



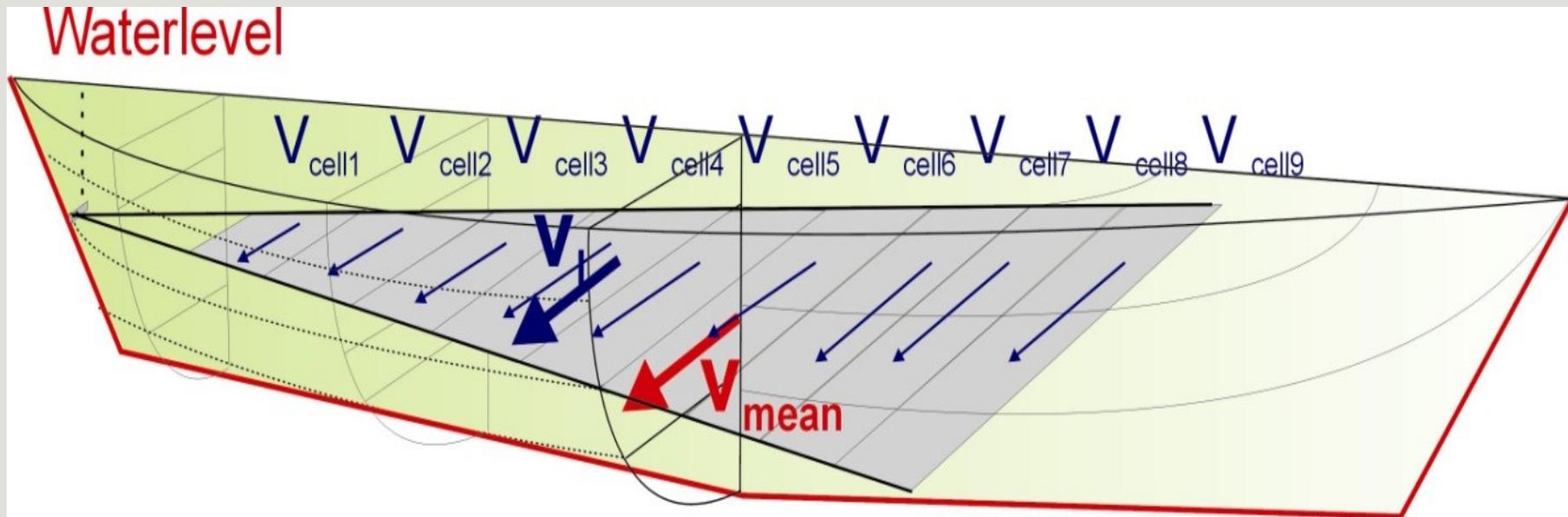
Misure di livello-portata in continuo profilatori Doppler



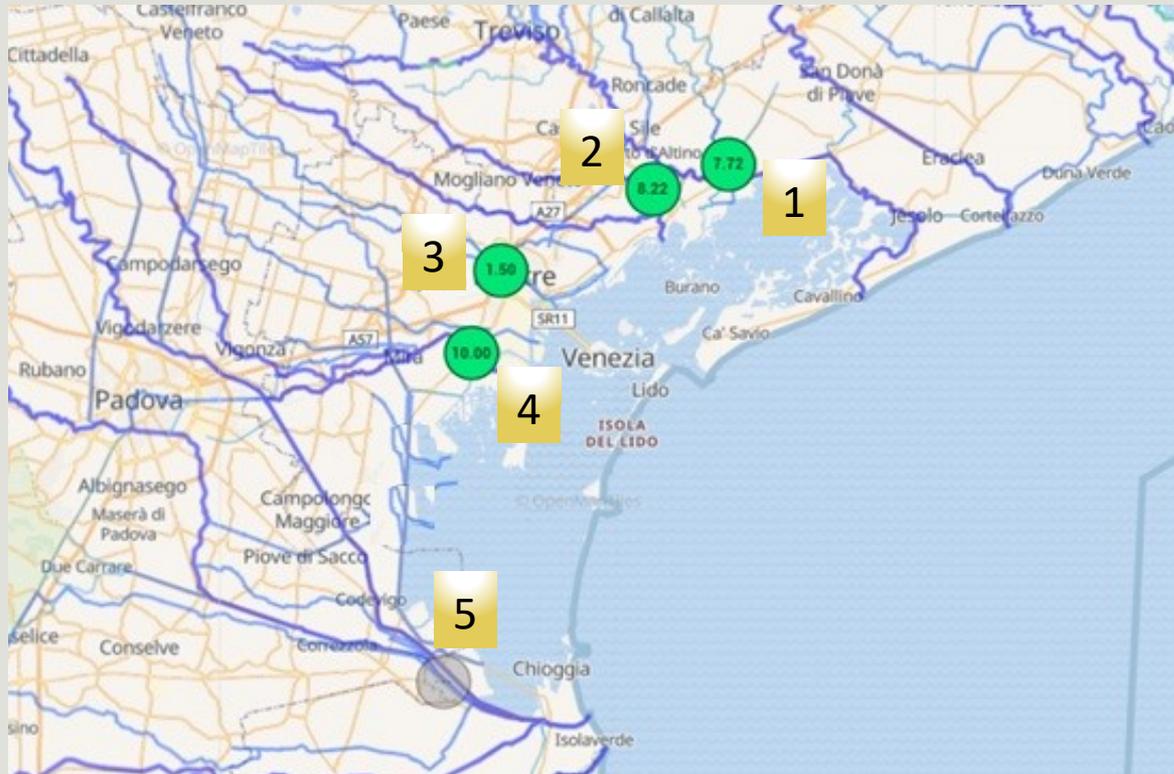
Misure di livello-portata in continuo profilatori Doppler

In una determinata sezione viene effettuata contemporaneamente:

- **Misura del Livello**
- **Misura della Velocità** di 9 celle orizzontali

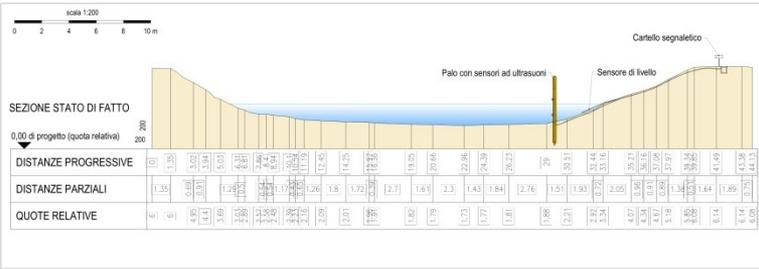


Misure di livello-portata in continuo profilatori Doppler



1. Canale Vela a Ponte Vela
2. Zero a Carmason
3. Marzenego a Mestre
4. Naviglio Brenta a Malcontenta
5. Canal Morto a Sostegno Priula

Misure in continuo - profilatori Doppler



Misure in continuo - profilatori Doppler

FASE DI CALIBRAZIONE:

Misure dirette di portata $\rightarrow V_{med}$

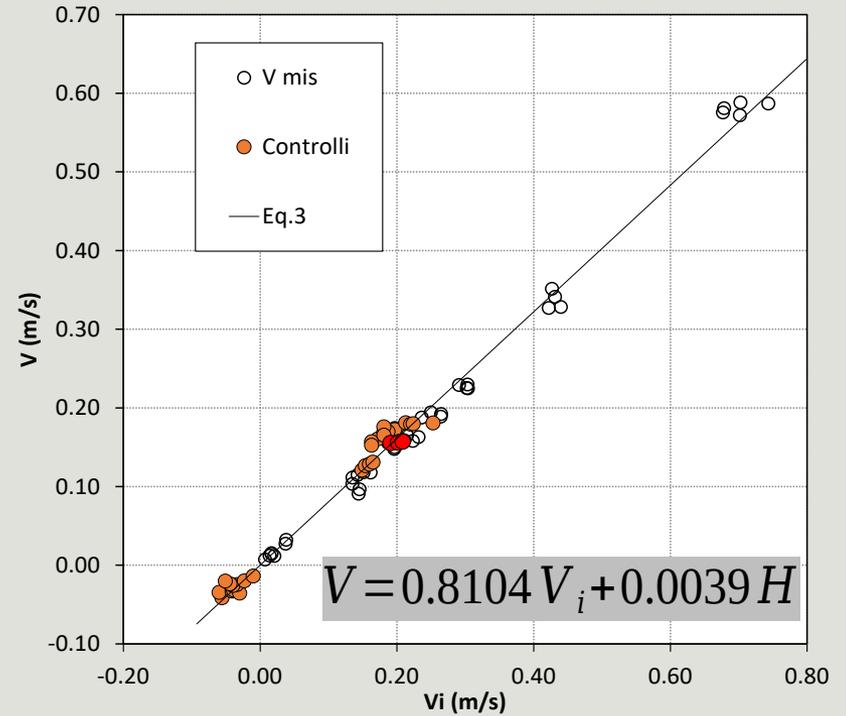
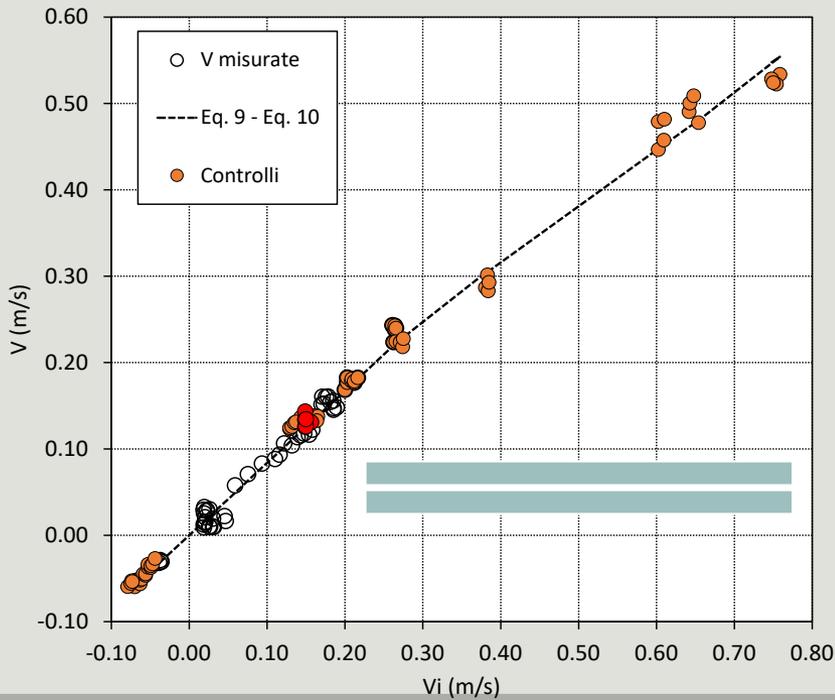
Dati stazioni $\rightarrow V_i, H$

Regressione lineare multipla

$V_{med} = f(H, V_{ind})$

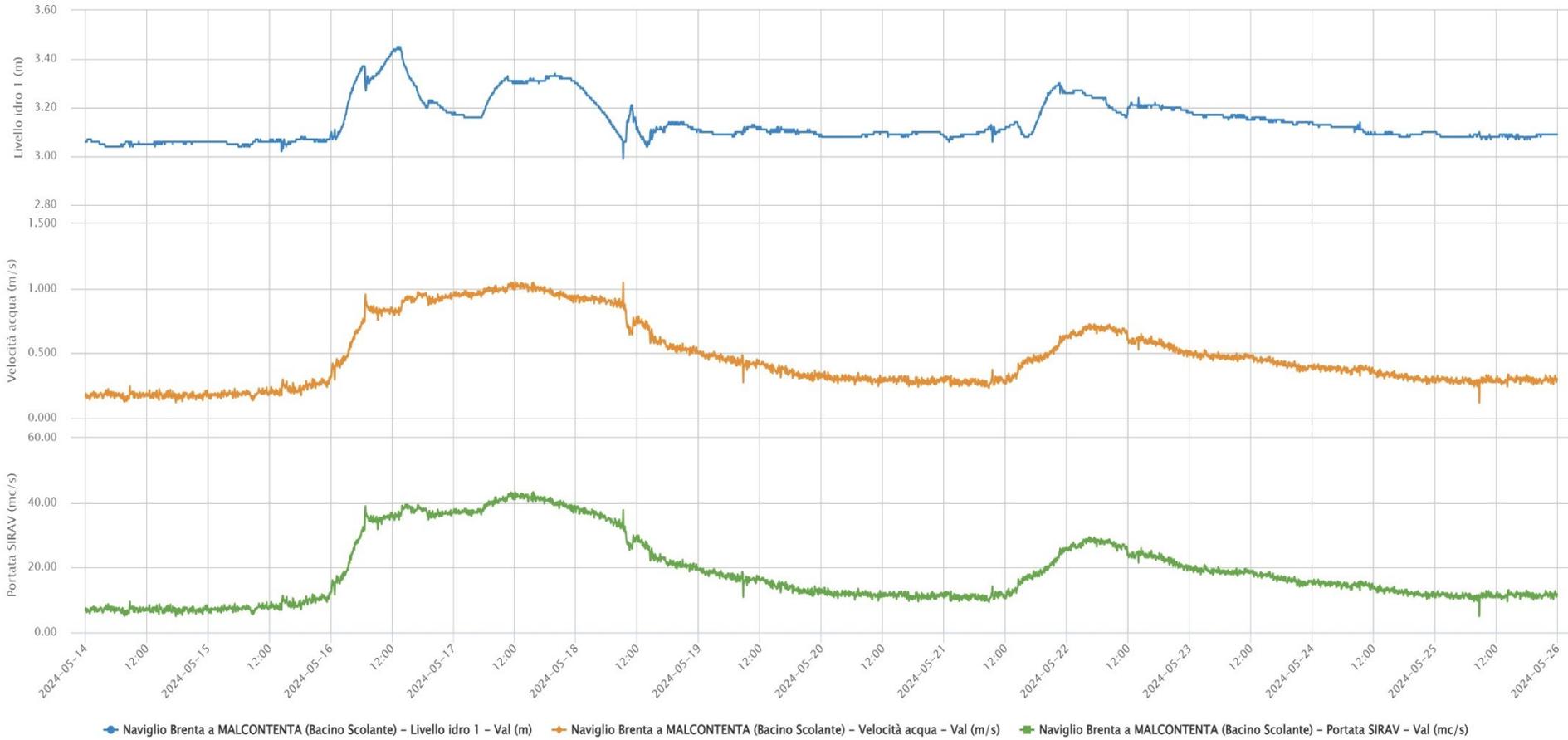
$Y = V_{med}$

$X = (H, V_{ind})$



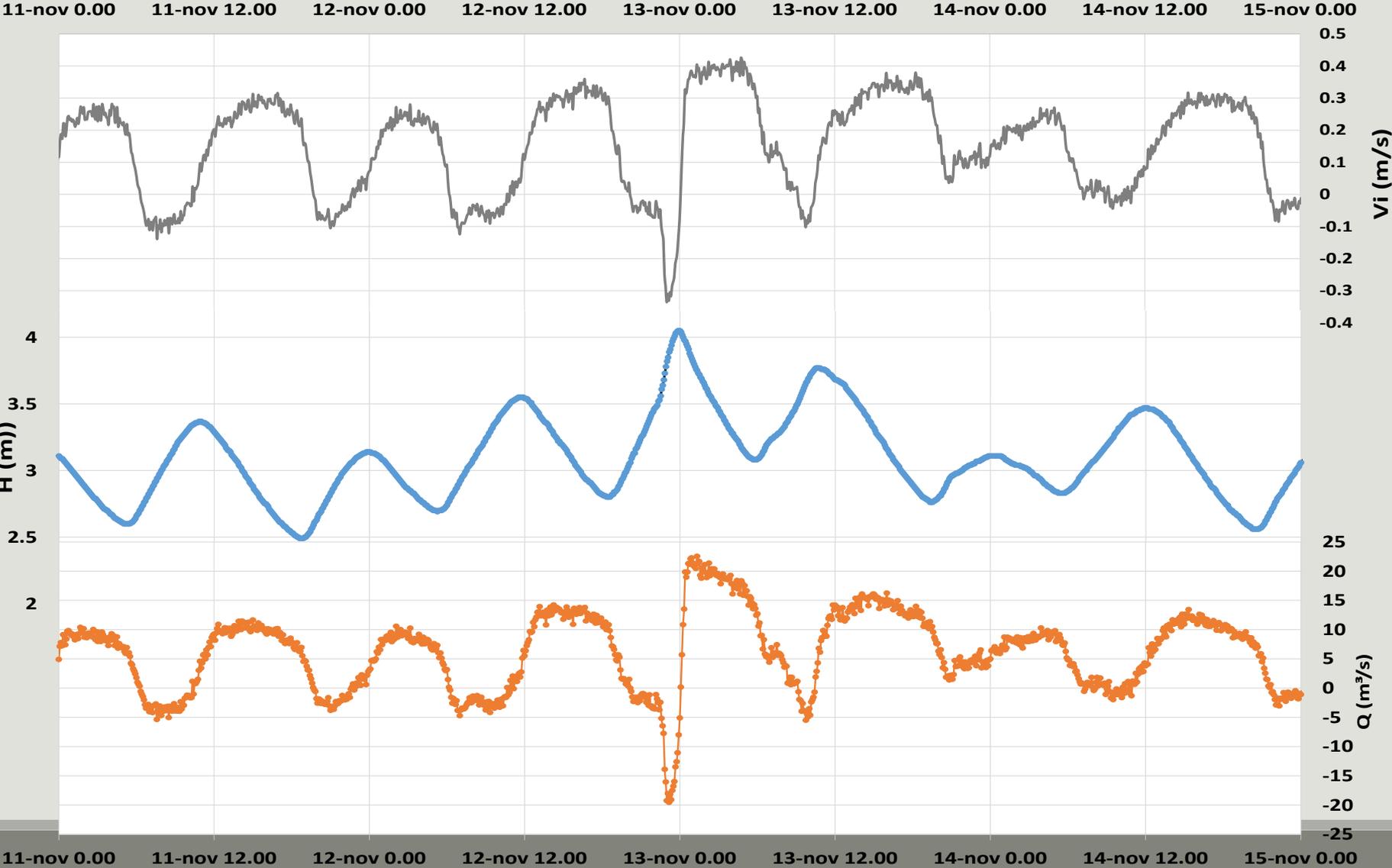
Misure in continuo - profilatori Doppler

Naviglio Brenta a Malcontenta – maggio 2024



Misure in continuo - profilatori Doppler

Zero a Carmason- novembre 2019

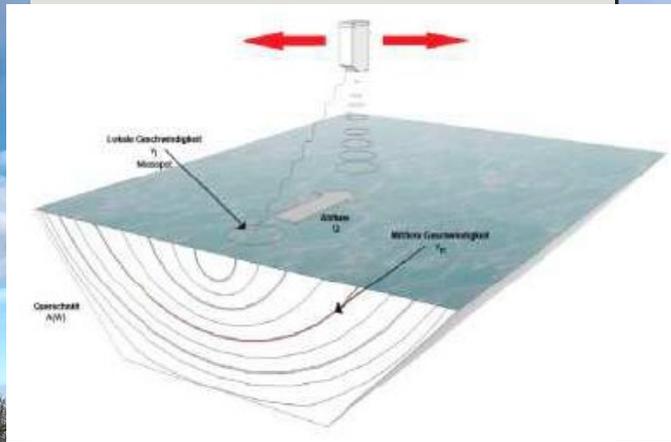


Misure in continuo - radar Doppler

V sup + H + topografia \longrightarrow Vmed + A \longrightarrow Q



Cagnola a Bovolenta



Livenza a Portobuffolè

Misure in continuo - radar Doppler

Boite a Cancia



Brenta a Primolano



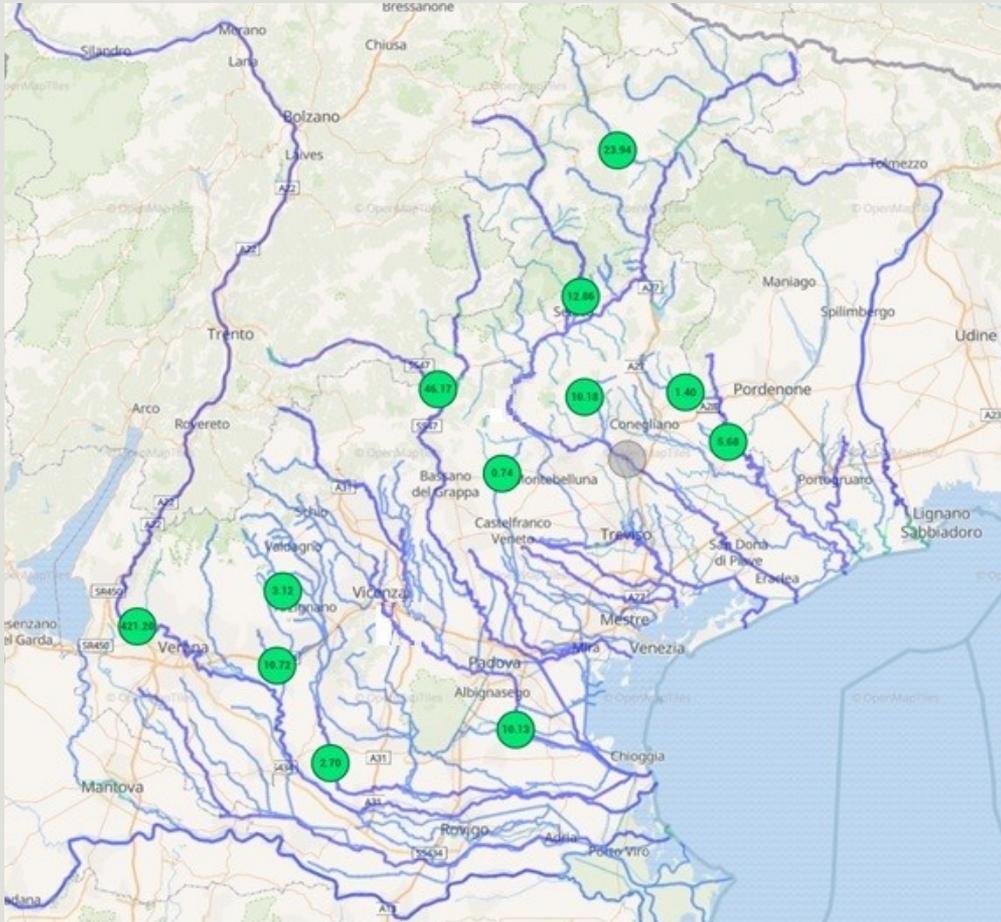
Meschio a Cordignano



Alpone a San Bonifacio



Misure in continuo - radar Doppler



1. Boite a Cancia
2. Cordevole a Sass Muss
3. Brenta a Primolano
4. Soligo a Pramaor
5. Muson a Asolo
6. Meschio a Cordignano
7. Livenza a Portobuffolè
8. Chiampo a Chiampo
9. Alpone a San Bonifacio
10. Adige a Pescantina
11. Fratta a San Salvaro
12. Cagnola a Bovolenta
13. Piave a Ponte della Priula??

Variabilità di condizioni!!

Misure in continuo - radar Doppler

FASE DI CALIBRAZIONE:

Misure dirette di portata \longrightarrow V_{med}

Dati stazioni \longrightarrow V_i, H

Regressione lineare multipla

$V_{med} = f(H, V_{ind})$

$Y = V_{med}$

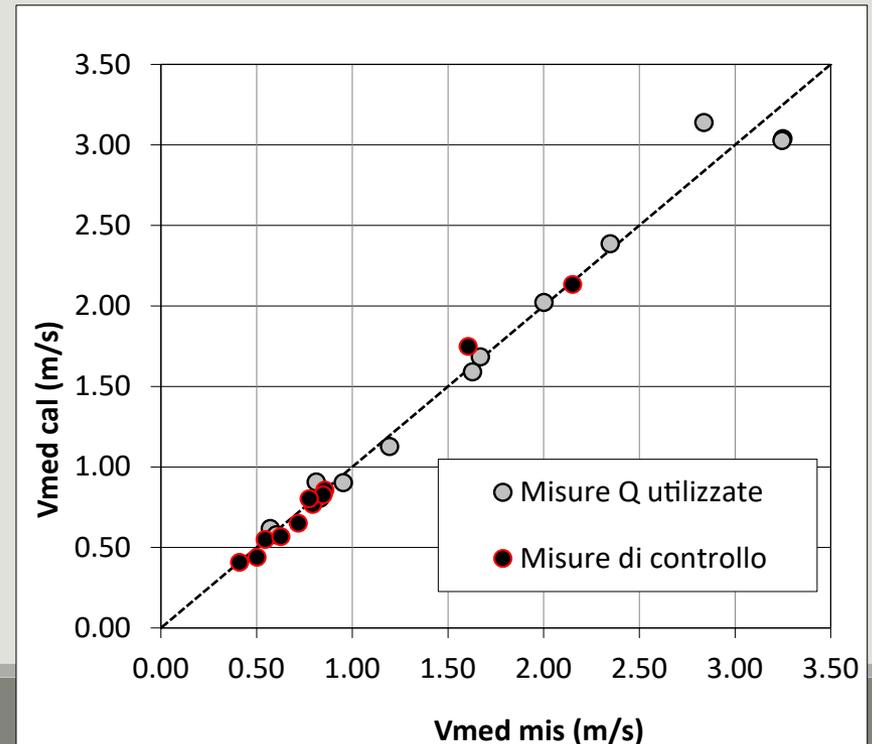
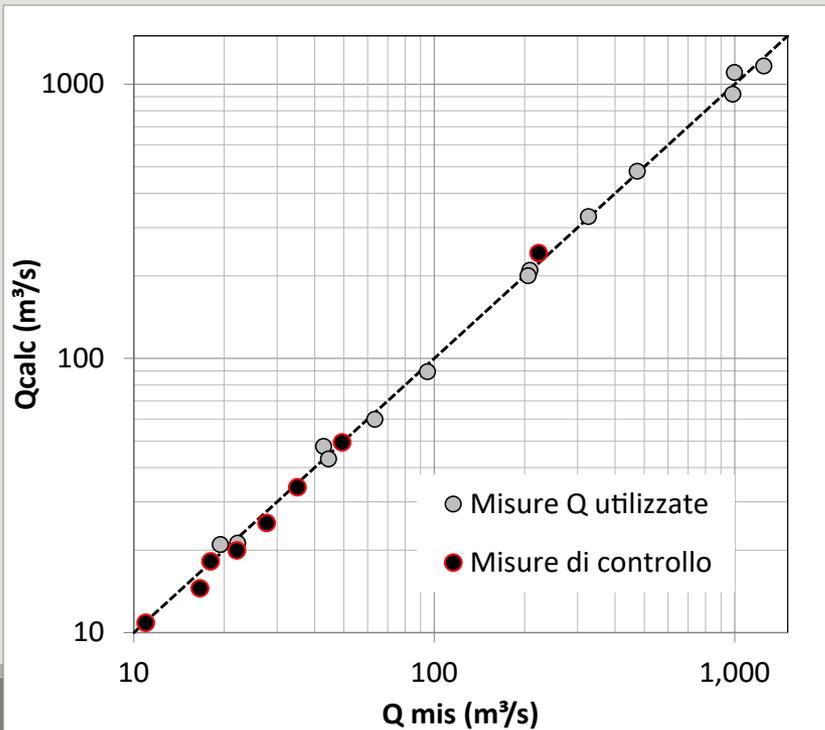
$X = (H, V_{ind})$

Adige a Pescantina (2019):

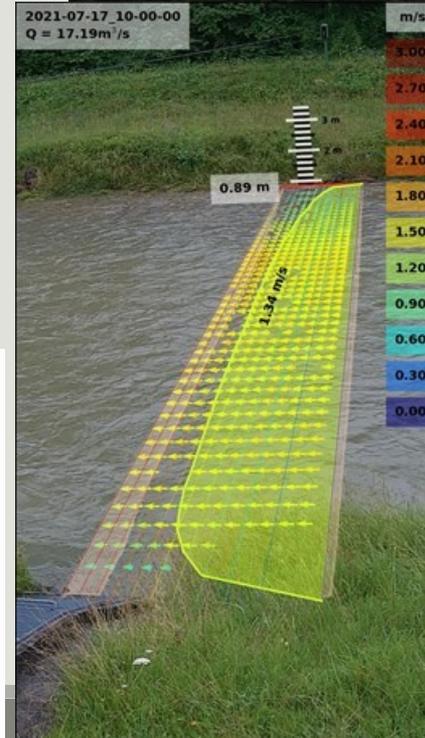
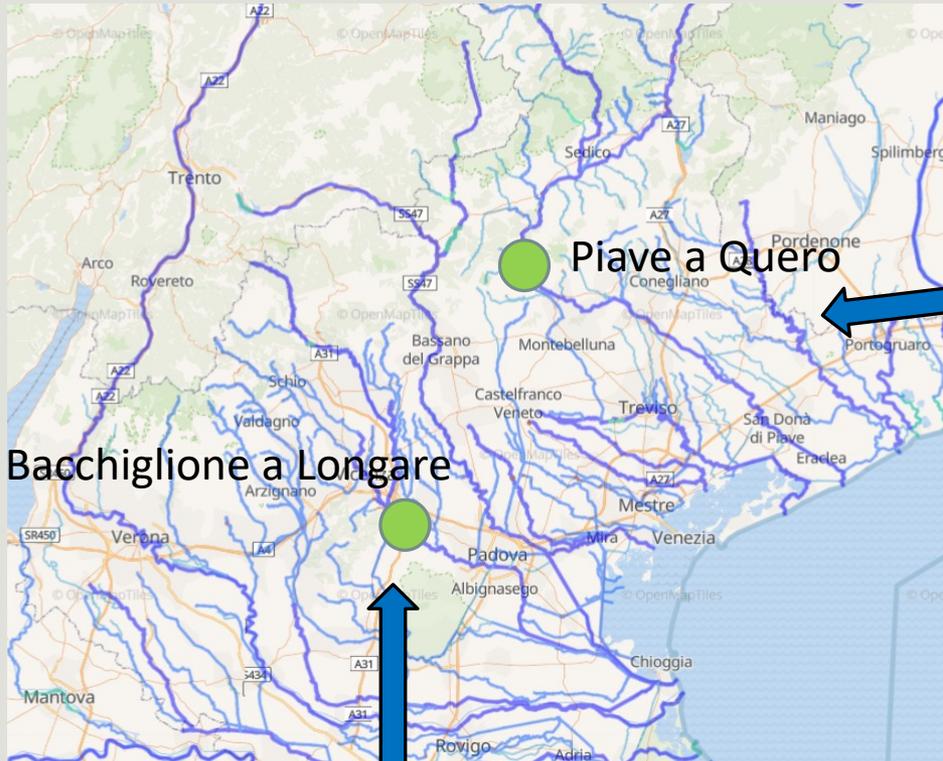
$$1. Q = A * (0.826 * V_i + 0.0912 * H)$$

$$\text{Se } V_i \leq ((0.945 + 0.190 * H) / 0.314)$$

$$2. Q = A * (0.945 + 0.512 * V_i + 0.281 * H)$$



Misure in continuo - analisi video



V_{media} su
verticale

$$V_{medv} = k \cdot V_{sup}$$

$$V_{medv} = f(k_s, y)$$



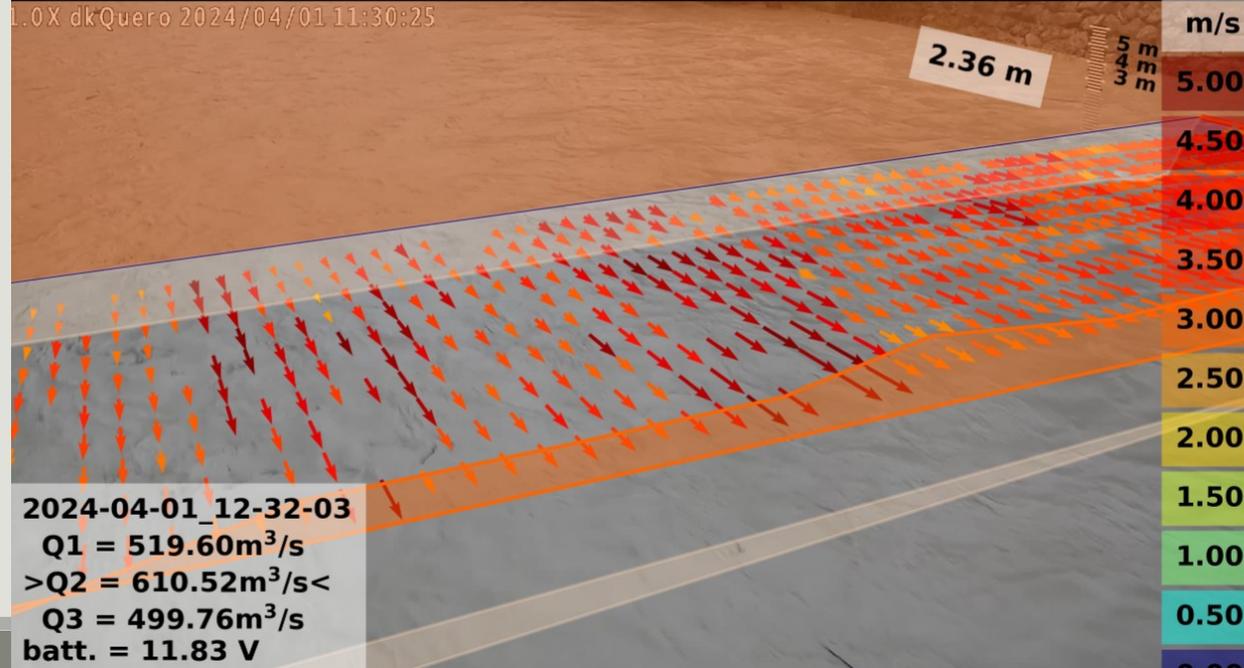
Misure in continuo - analisi video

Piave a Quero



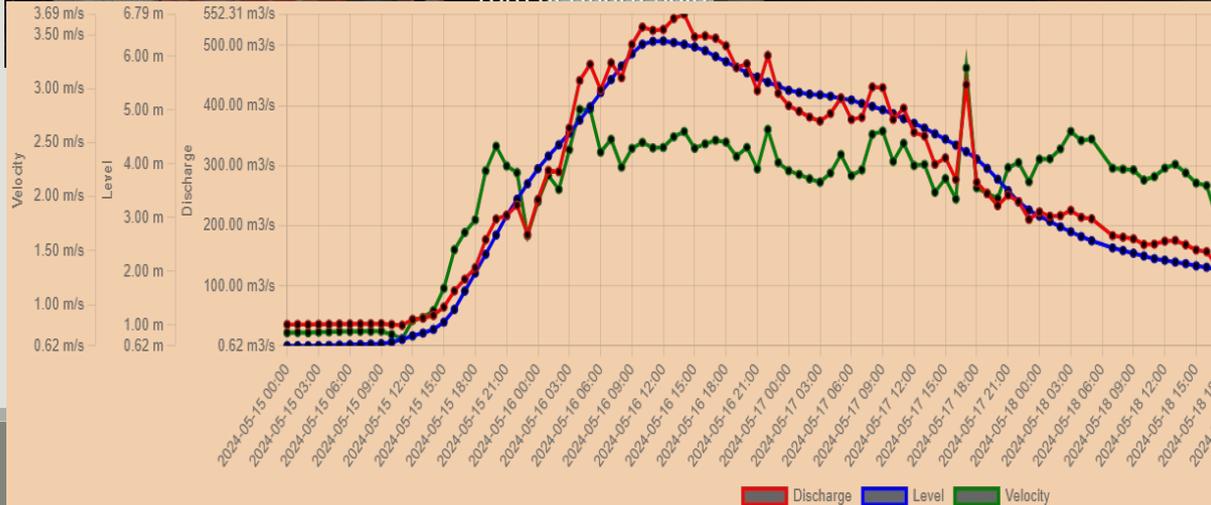
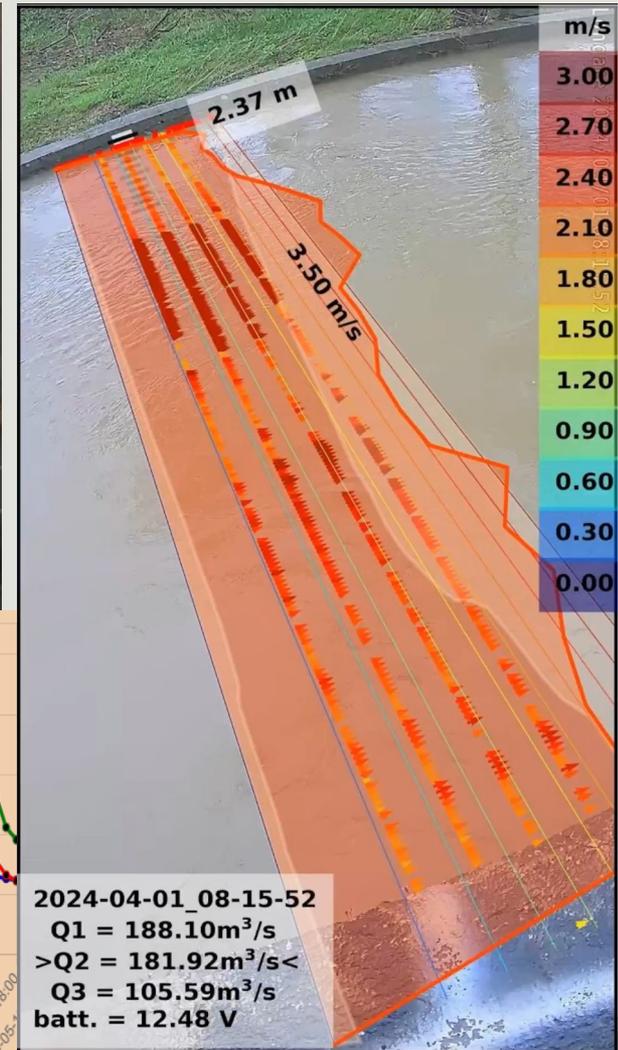
Measurement image

L.0X dkQuero 2024/04/01 11:30:25



Misure in continuo - analisi video

Bacchiglione a Longare



GRAZIE