POLITECNICO
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PROPAGATION OF PRECIPITATION MEASUREMENT BIASES INTO HYDROLOGICAL SIMULATION: A CASE STUDY

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3 WMO/CIMO LEAD CENTRE "B. CASTELLI" ON PRECIPITATION INTENSITY
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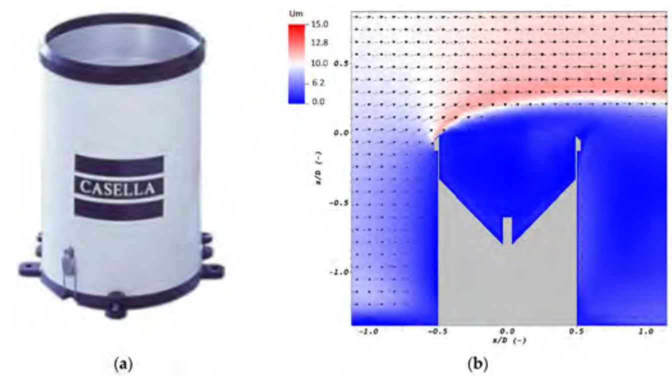
Objectives

Investigate precipitation bias due to **instrumental issues** and **environmental factors** (wind) and their propagation into hydrological simulation

PRIN-2015 *Reconciling precipitation with runoff: the role of understated measurement biases in the modelling of hydrological processes*



Source: Cauteruccio, A. and Lanza, L. *Water* **2020**, https://doi.org/10.3390/w12123431

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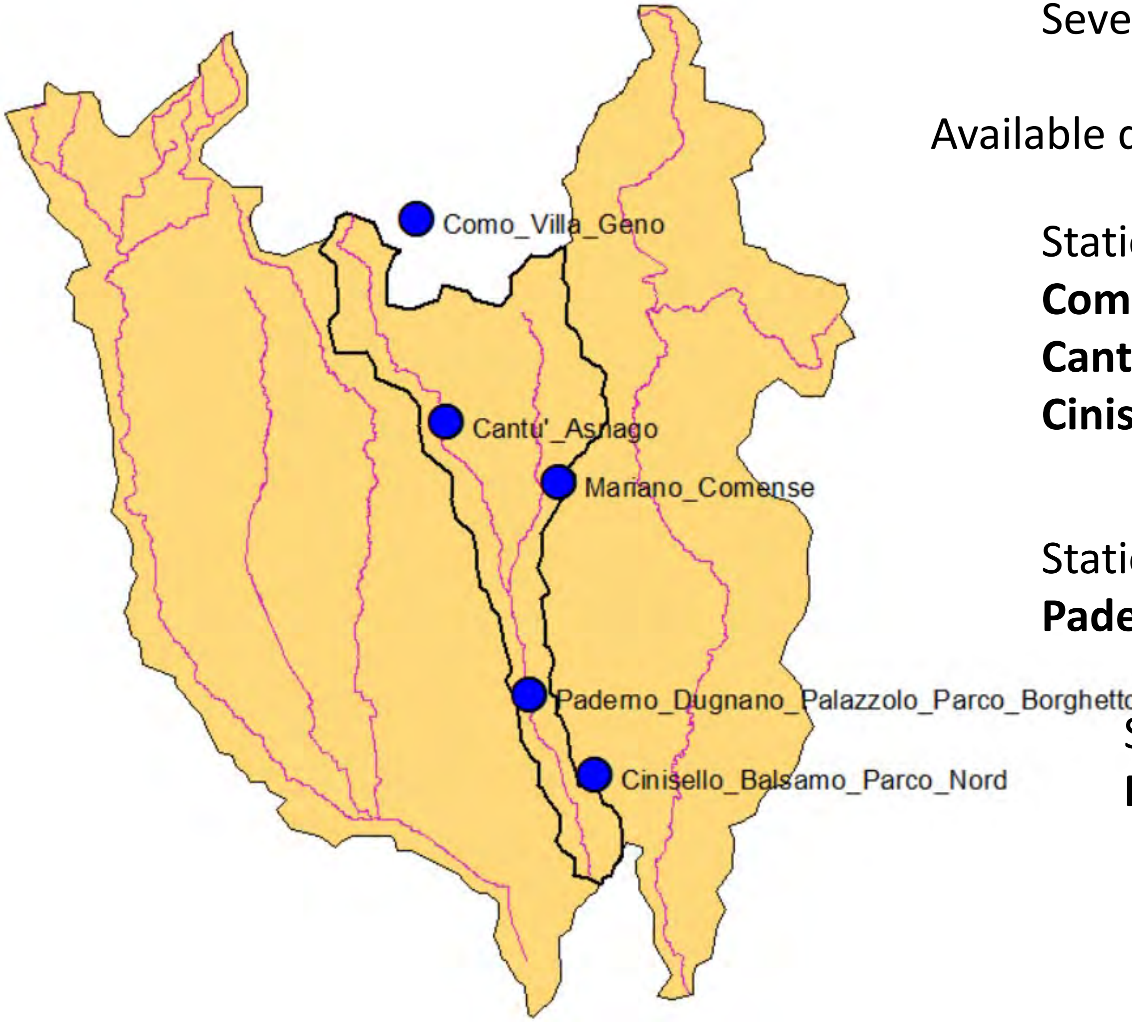
Case study: Seveso river



Seveso basin area: 200 km^2

Available data period: 2015-2018

Stations with 1 minute resolution:
Como villa Geno
Cantù
Cinisello Balsamo

Station with 5 minutes resolution :
Paderno Dugnano Palazzolo

Station with 10 minutes resolution :
Mariano Comense

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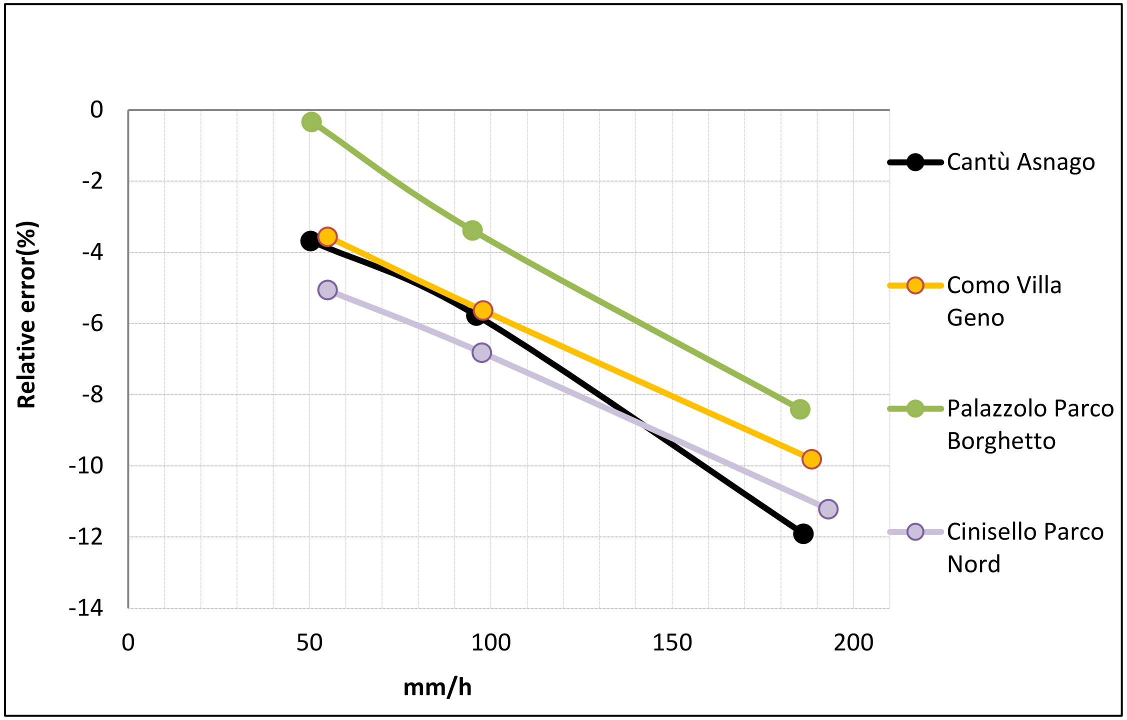
Field campaigns

Palazzolo

Field campaigns

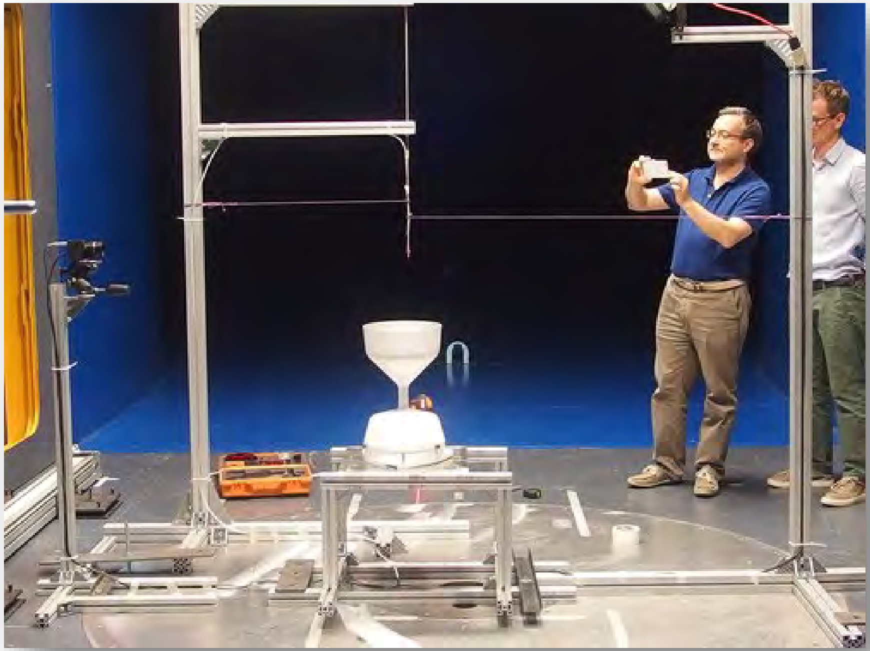
Palazzolo

Experimental Bias



$$e\ (\%) = \frac{(RI_{mis-}\ RI_{ref})}{RI_{ref}}\ 100$$

Wind tunnel experiments



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Wind tunnel experiments: simulation results

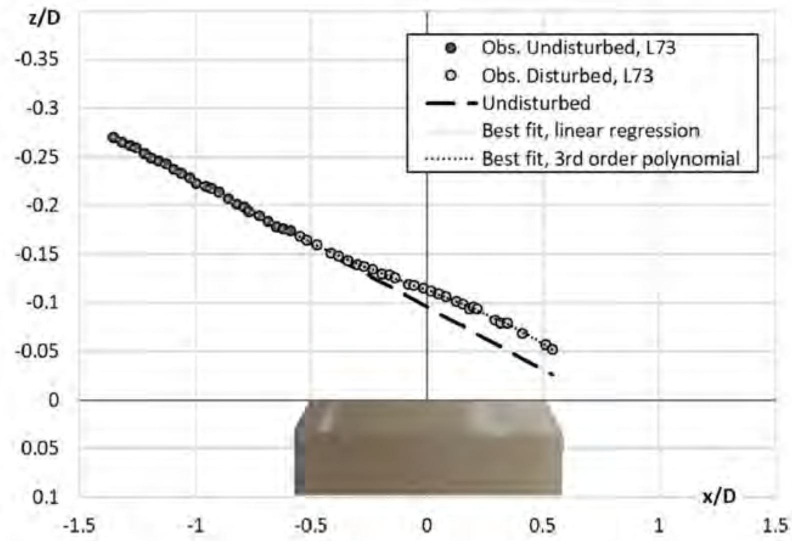


Figure 7. Observed (circles) and undisturbed (dashed line) drop trajectory above the collector of the cylindrical gauge at Uref = 12.5 m s−1.

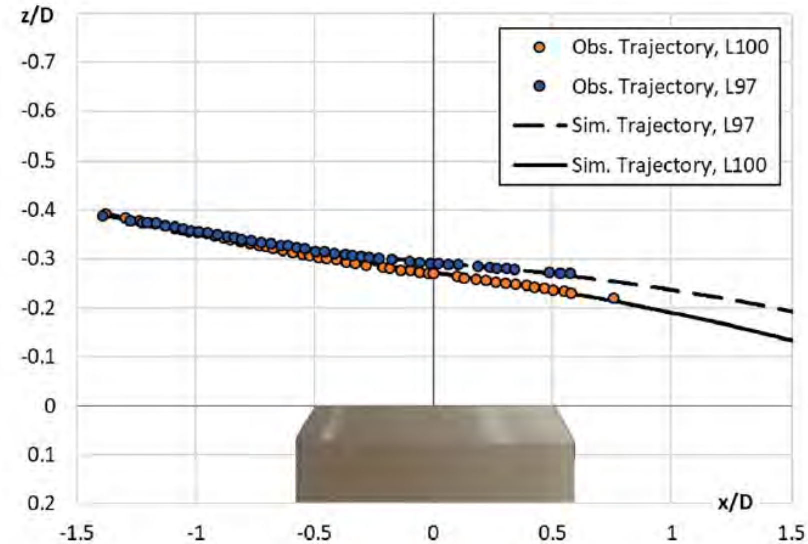


Figure 12. Observed (circles) and simulated (lines) drop trajectories for two drops of different size, released at the same initial position and traveling above the collector of the cylindrical gauge at Uref = 13.1 m s−1.

Cauteruccio, A., Brambilla, E., Stagnaro, M., Lanza, L. G., & Rocchi, D. (2021). Wind tunnel validation of a particle tracking model to evaluate the wind-induced bias of precipitation measurements. Water Resources Research, 57, e2020WR028766. https://doi.org/10.1029/2020WR028766

Collection Efficiency

Collection efficiency curve (CE), for wind speed (Uref [m/s]) and rainfall intensity (RI [mm/h]) till 18 m/s and 25 mm/h:

$$CE(U_{ref}) = y_0(RI_c) + \frac{a(RI_c)}{1 + e^{-\frac{(U_{ref} - x_0(RI_c))}{b(RI_c)}}}$$

$X_0 = 0.5222 \ln(RI_c) + 4.4164$

$Y_0 = 0.0166 \ln(RI_c) + 0.8645$

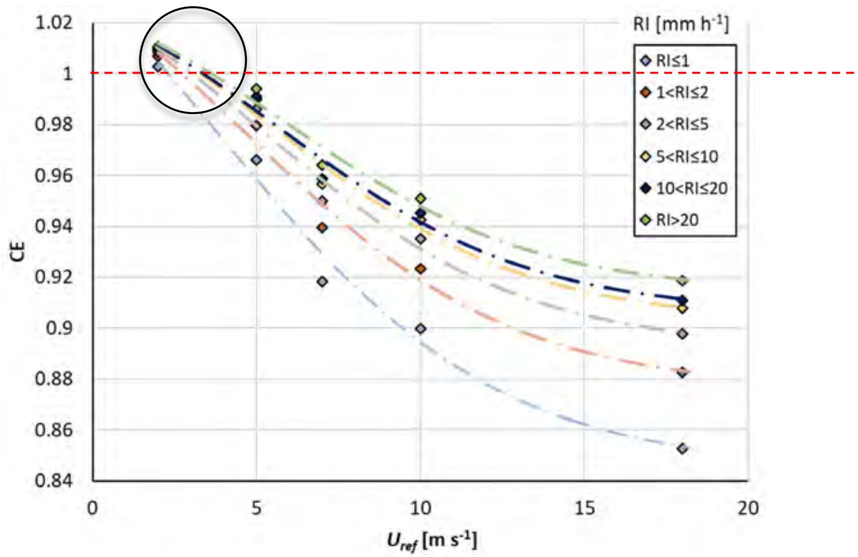
$a = 0.2213\, RI_c^{-0.17}$

$b = 0.1191 \ln(RI_c) - 4.1365$

$$CE = \frac{RI}{RI_{corretta}}$$

↓

$$RI_{corretta} = \frac{RI}{CE}$$



$RI_{corretta} < RI$

$RI_{corretta} > RI$

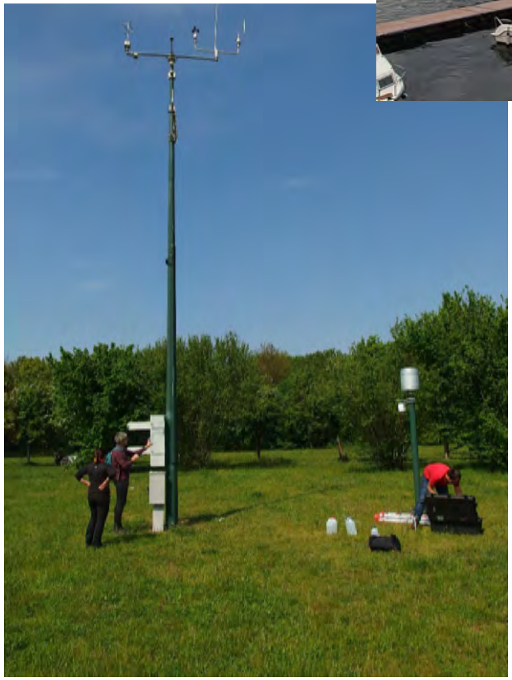
Cauteruccio and Lanza, 2020

Flood event analysis

Como Villa Geno

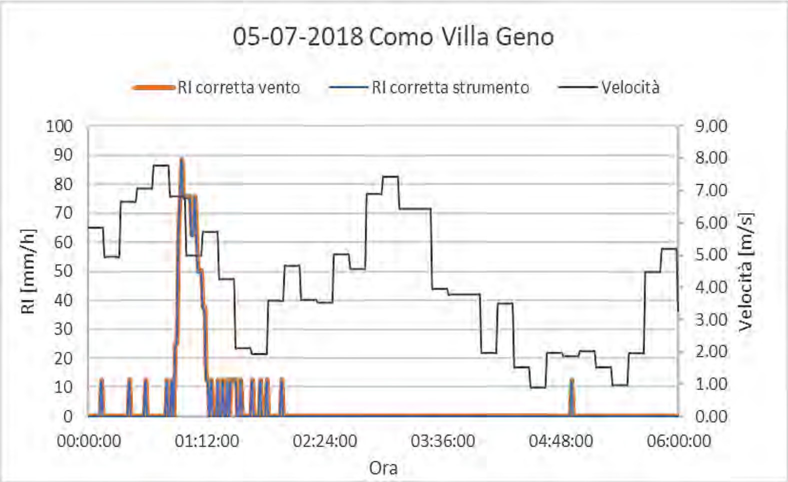
Flood events:

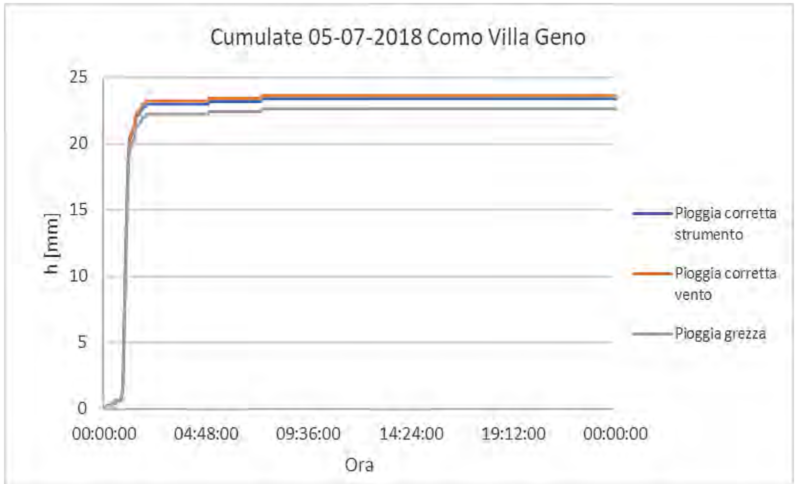
- ☐ 11 May 2017
- ☐ 28 June 2017
- ☐ 5 November 2017
- ■ 5 July 2018
- ■ 27-29 October 2018

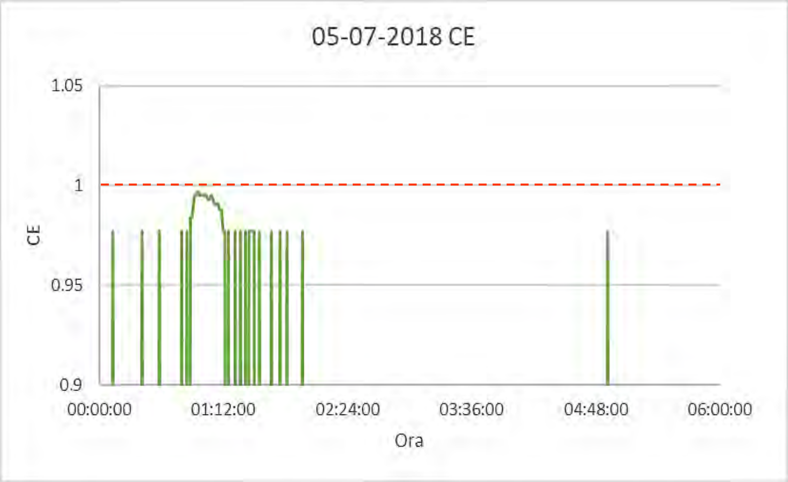


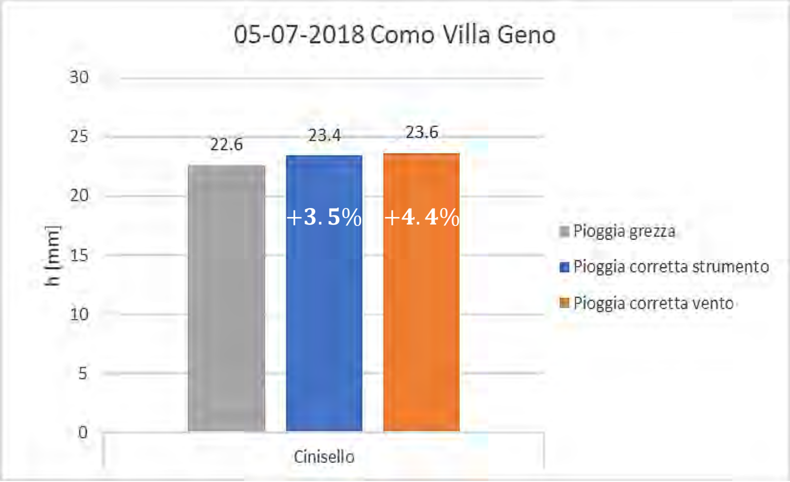
Cinisello Balsamo
Parco Nord

Precipitation at Como Villa Geno – Event 4









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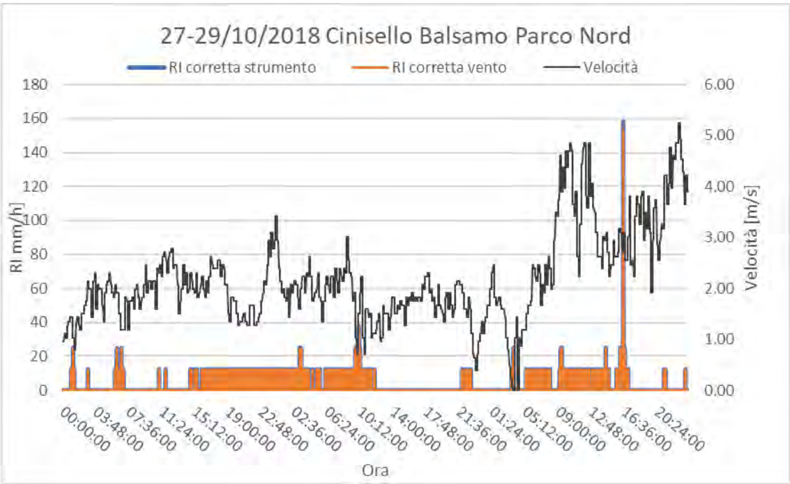
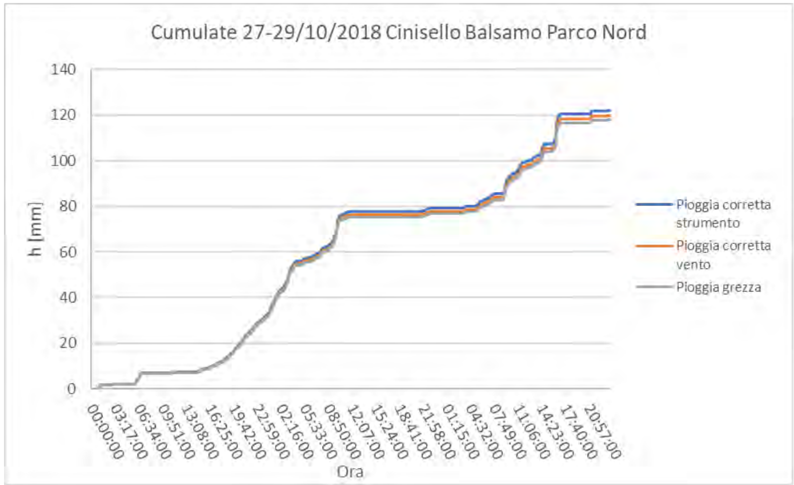
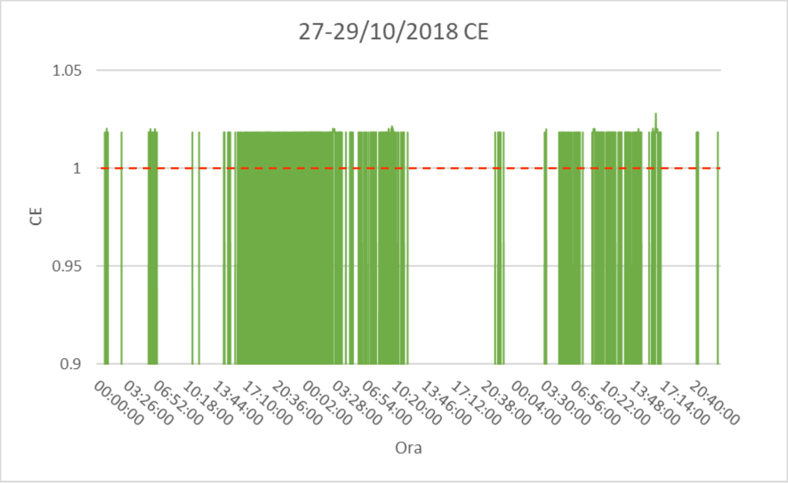
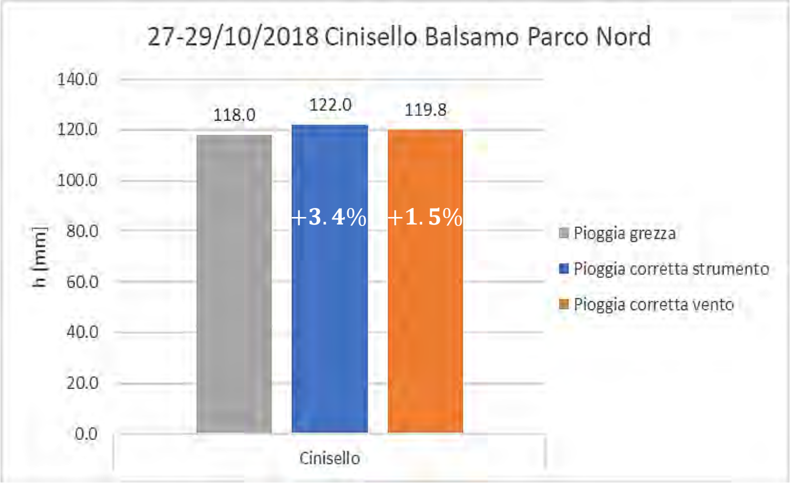
Precipitation Cinisello Balsamo – Event 5



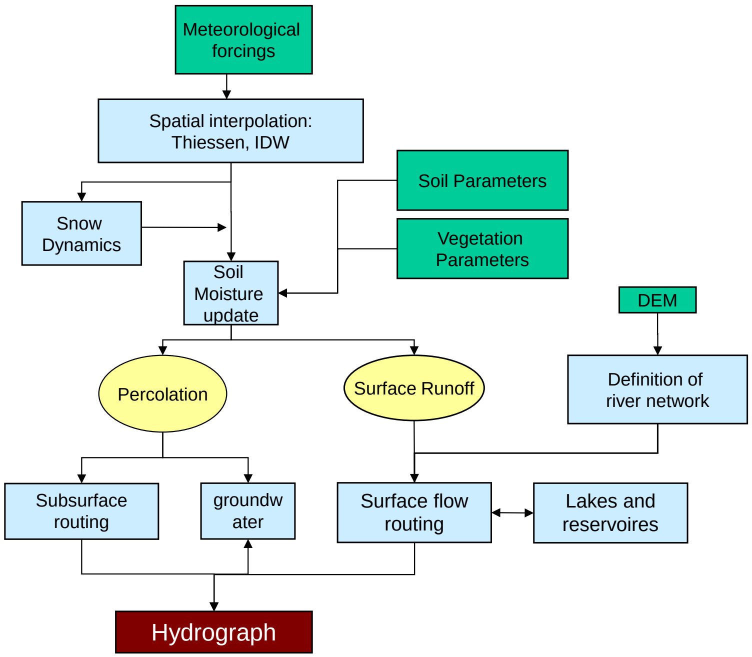






Hydrological modelling

FEST-WB: Flash – flood Event – based Spatially – distributed rainfall – runoff Transformation – including Water Balance



Precipitation input (mm):

- Precipitation corrected for instrumental bias
- As before plus correction for wind induced bias
- Original data as provided by ARPA Lombardia

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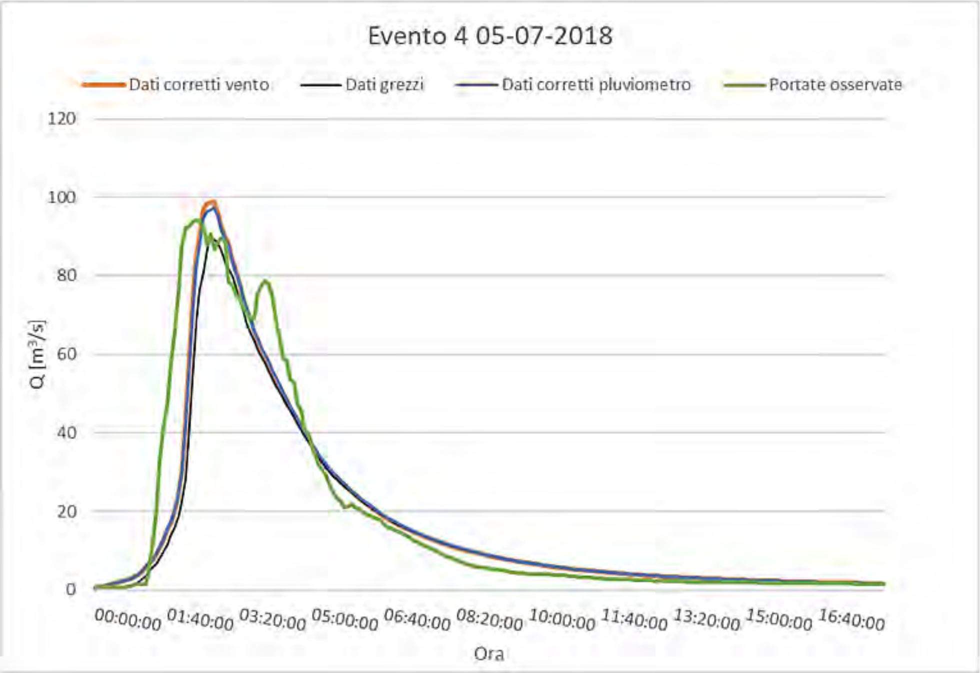
Flood simulation – event 4

Q max [m³/s]	**Gross**	**Mechanics correction**	**Wind correction**	**Observed**
	89.63	97.44 (+**8.71** %)	98.82 (+**10.25** %)	94.13

$U_{ref} = 4 \div 8 \text{ m/s}$

$CE < 1$

$h_{corretta\ vento} > h_{corretta\ pluviometro}$



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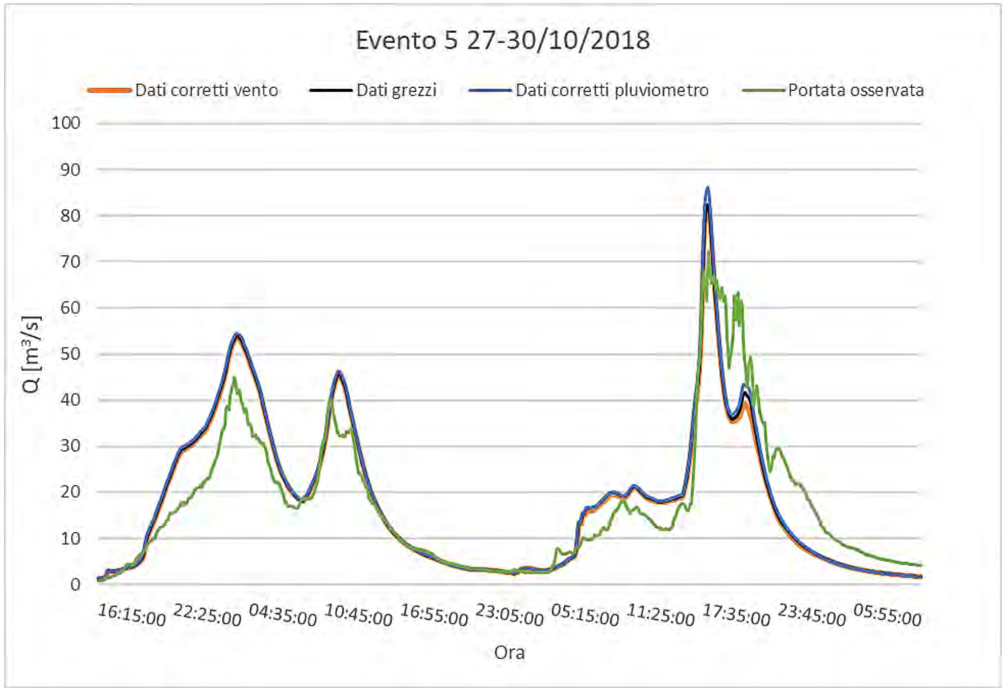
Flood simulation – event 5

Q max [m³/s]	Gross	Mechanics correction	Wind correction	Observed
	82.38	86.09 (+4.50 %)	81.19 (−1.45 %)	72.34

$U_{ref} < 4\ m/s$

$CE > 1$

$h_{corretta\ vento} < h_{corretta\ pluviometro}$



Flood simulation results

Q max [m³/s]	Gross	Mechanics correction		Wind correction		Observed
Event 1	**71.36**	73.98	**+3.67 %**	71.95	**+0.83 %**	49.53
Event 2	**65.07**	67.91	**+4.37 %**	63.56	**−2.32 %**	81.29
Event 3	**61.76**	62.50	**+1.20 %**	61.23	**−0.86 %**	57.95
Event 4	**89.63**	97.44	**+8.71 %**	98.82	**+10.25 %**	94.13
Event 5	**82.38**	86.09	**+4.50 %**	81.19	**−1.44 %**	72.34

Conclusions

1. Instrumental bias in investigated stations is > 10% for high precipitation intensity
2. Wind induced error becomes relevant and can be greater than instrumental bias for high values of wind speed
3. When wind speed is low, wind induced error compensates the instrumental bias
4. The maximum total precipitation bias, out of the five flood events considered, was 4.4% with a discharge bias of 10.25%

Thank you for your attention

Acknowledgements
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