→ MEASUREMENTS AND OBSERVATIONS IN THE 21st CENTURY CONFERENCE

Measuring and modeling runoff discharges at the feet of a rocky channel incised on the Dimai Peak (Venetian Dolomites, Northeast Italy)

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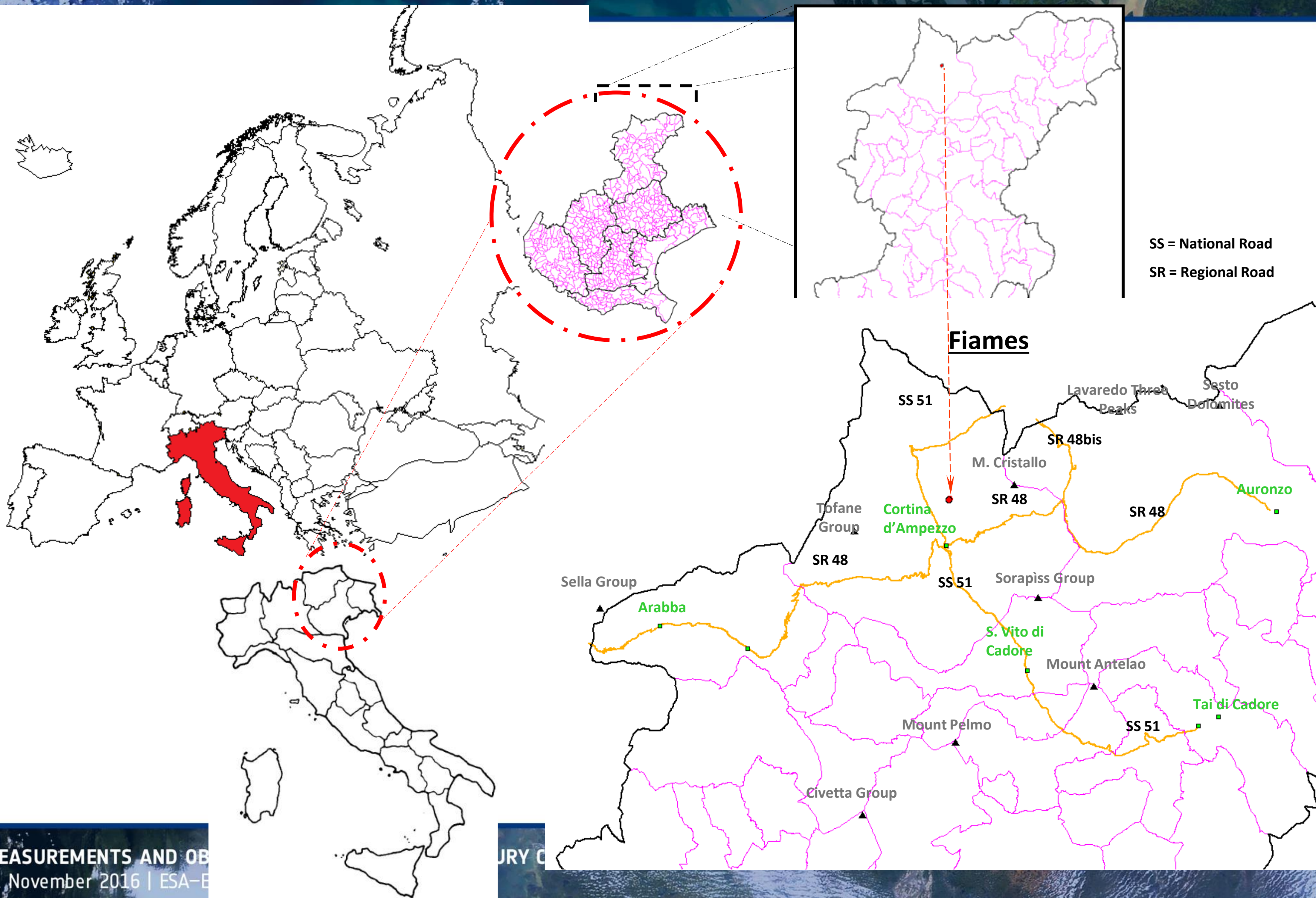
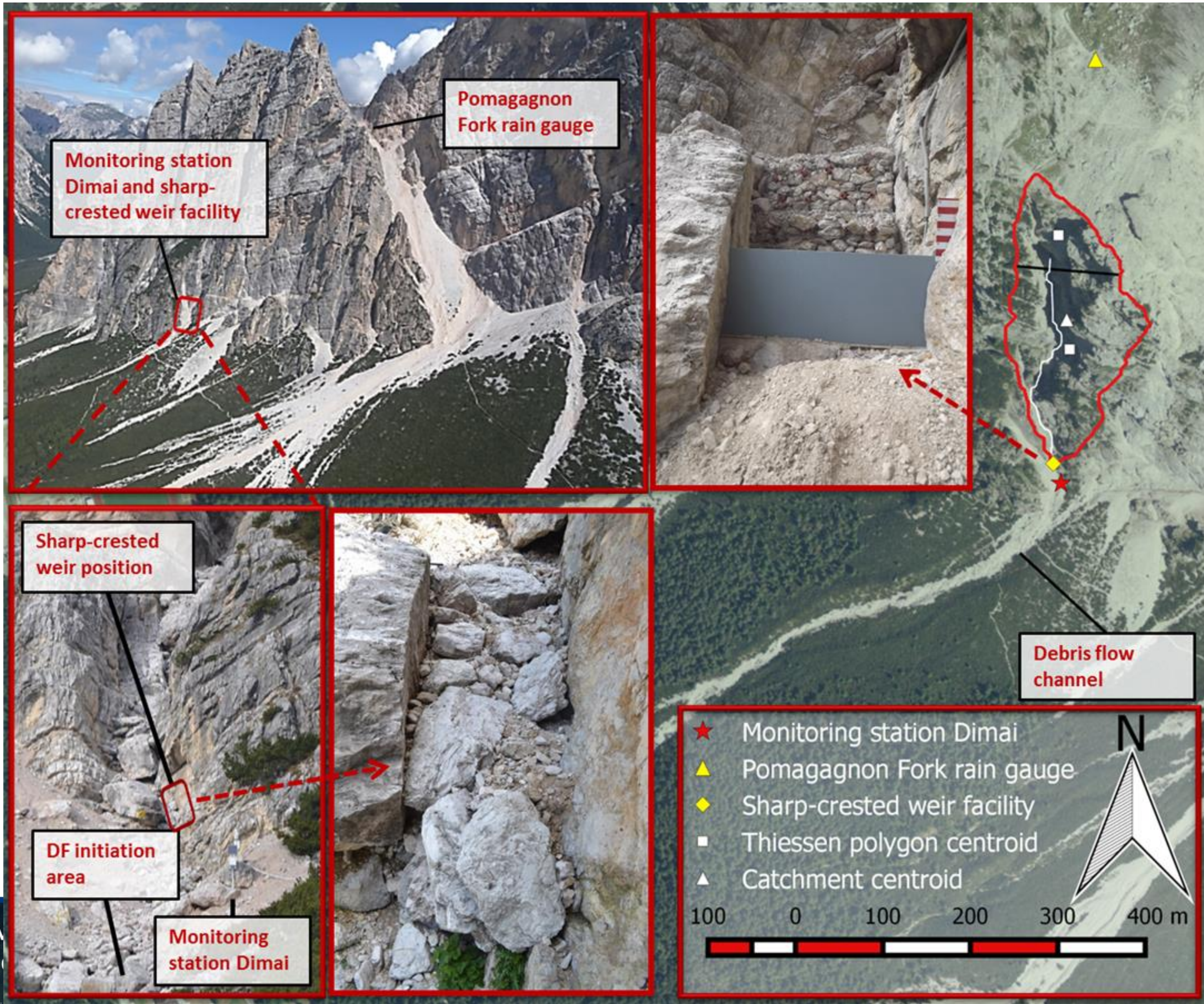

SS = National Road
SR = Regional Road
Fiames
SS 51
Lavaredo Three Peaks
Sesto Dolomites
SR 48bis
M. Cristallo
SR 48
Auronzo
Tofane Group
Cortina d'Ampezzo
SR 48
SR 48
Sella Group
Arabba
SS 51
Sorapìss Group
S. Vito di Cadore
Mount Antelao
Tai di Cadore
SS 51
Mount Pelmo
Civetta Group

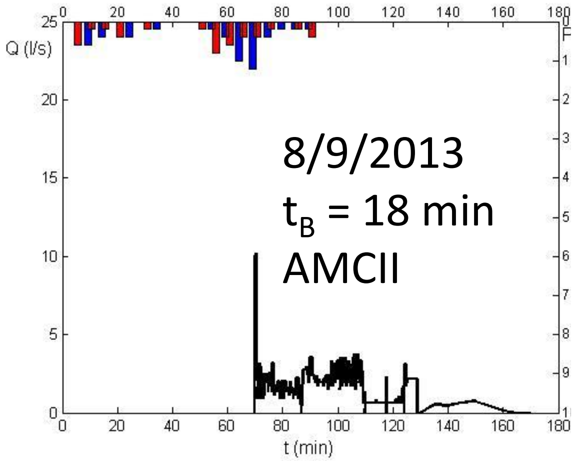
Field site

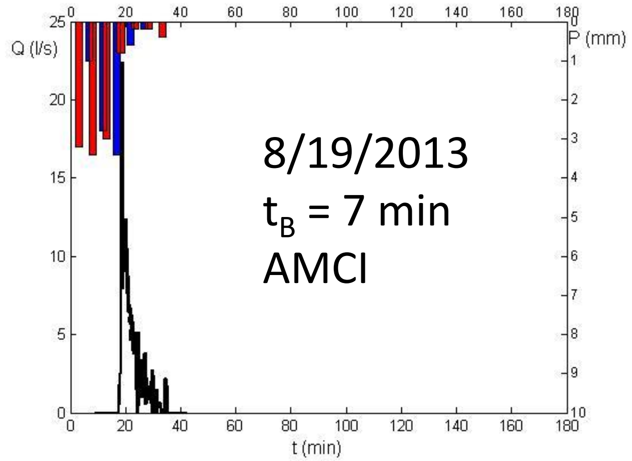


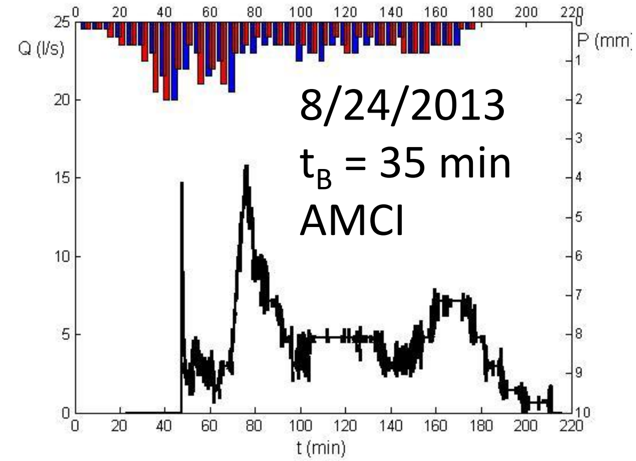
Pomagagnon Fork rain gauge
Monitoring station Dimai and sharp-crested weir facility
Sharp-crested weir position
DF initiation area
Monitoring station Dimai
Debris flow channel
Monitoring station Dimai
Pomagagnon Fork rain gauge
Sharp-crested weir facility
Thiessen polygon centroid
Catchment centroid
N
100 0 100 200 300 400 m

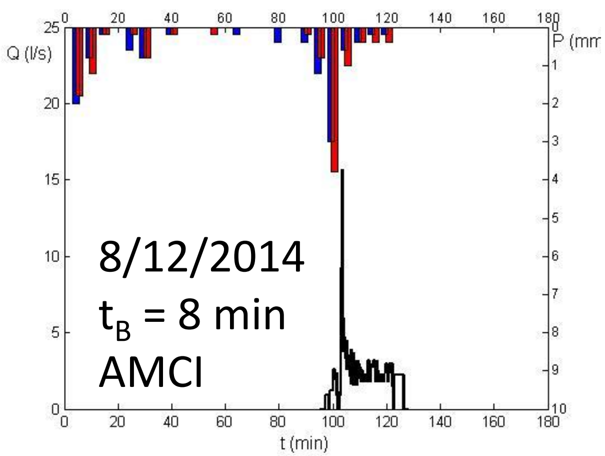
A challenging use of a classic experimental facility for measuring discharge

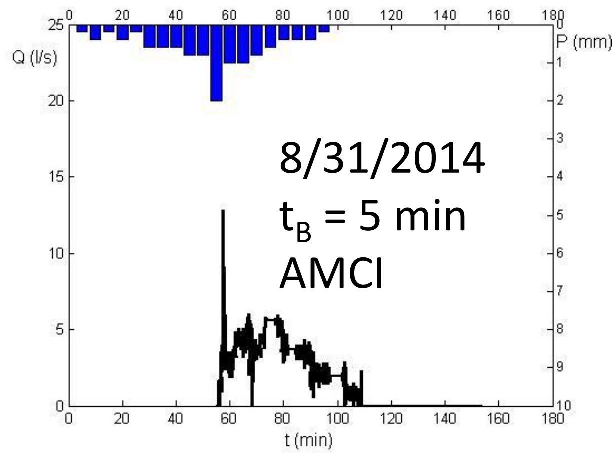
Measured runoff discharges

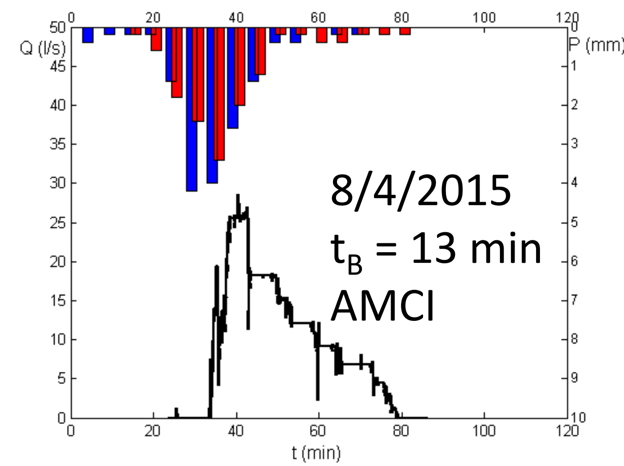












Blue: upstream rainfall; Red: downstream rainfall; t_B = response basin time

Times to peak between 20 and 70 seconds.

Hydrological modeling: rainfall excess

- Combination of the SCS-CN method with an Horton law, CNH (approach analogous to that of Grimaldi et al., 2013)

$$P_e(t) = \begin{cases} 0 & t \le t_{Ia} \\ \dfrac{\left(P(t) - Ia\right)^2}{P(t) - Ia + S} & t > t_{Ia} \;\&\; I < f_c \\ P_e(t-\Delta t) + \left[P(t) - P(t-\Delta t)\right] - f_c \Delta t & t > t_{Ia} \;\&\; I > f_c \end{cases}$$

P(t) = precipitation at time *t*; $P_e(t)$ = excess precipitation at time *t*

f_C = infiltration rate; *I* = rainfall intensity; *Ia* = initial abstractions

t_{Ia} = ending time of initial abstractions

Grimaldi S., A. Petroselli, and R. Romano (2013), Green-Ampt Curve-Number procedure as an empirical tool for rainfall-runoff modelling in small and ungauged basins, Hydrological Processes, 27, 1253-1264.

Hydrological modeling: routing

Runoff routing along the steepest direction

Slope paths: travel times computed as the ratio between flow path lengths and time invariant runoff velocities depending on land use

$$Hillslope\ Routing\ time = \frac{L_{s1}}{v_{s1}} + \frac{L_{s2}}{v_{s2}}$$

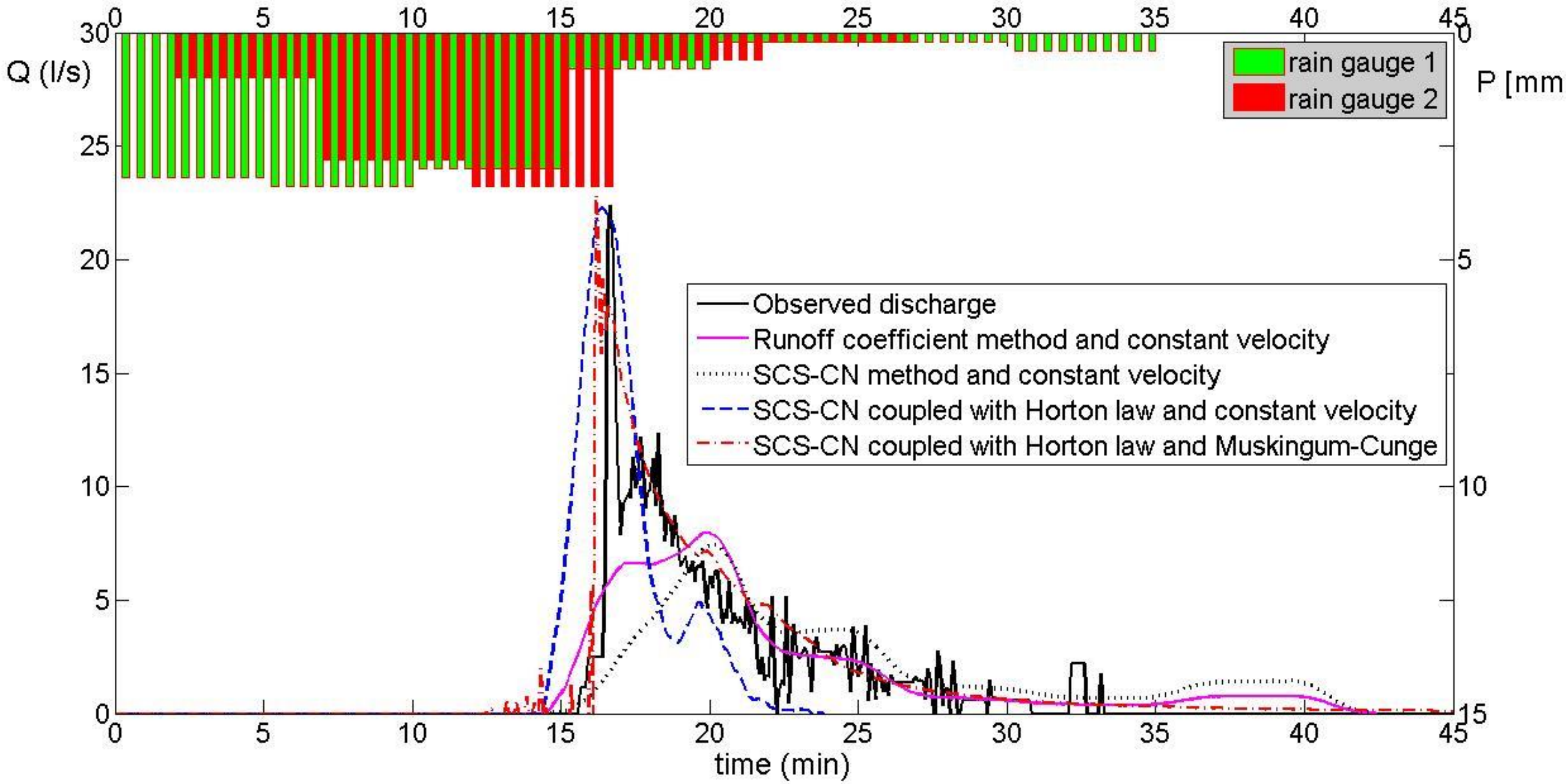
L_{s1} = *path length along land use 1*
L_{s2} = *path length along land use 2*
v_{s1} = *velocity along land use 1*
v_{s2} = *velocity along land use 2*

Channel network: matched diffusivity kinematic-wave model (Orlandini and Rosso, 1996) based on the Muskingum-Cunge scheme

$$\mathrm{Q_{i+1}}^{\mathrm{j+1}} = C_1 \mathrm{Q_i}^{\mathrm{j+1}} + C_2 \mathrm{Q_i}^{\mathrm{j}} + + C_3 \mathrm{Q_{i+1}}^{\mathrm{j}} + C_4 \mathrm{q_{L_{i+1}}}^{\mathrm{j+1}}$$

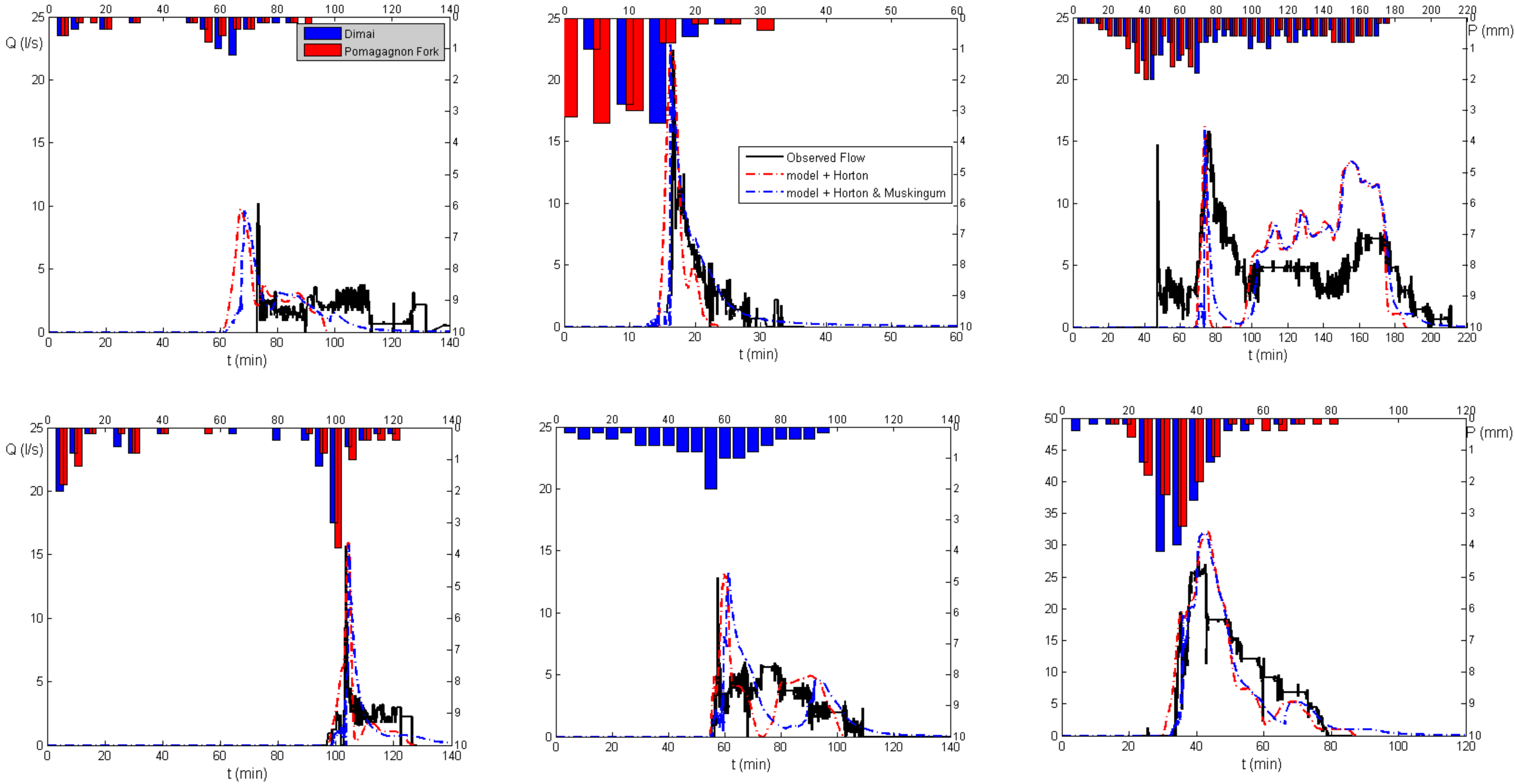
C_i = *routing coefficients depending on* kinematic flood wave celerity c_k and hydraulic diffusivity D_h
Q_{i+1}^{j+1} = *runoff at the cell (i+1)Δs and time (j+1)Δt*
$q_{L_{i+1}}^{j+1}$ = *lateral inflow at the cell (i+1)Δs and time (j+1)Δt*

Orlandini, S., & Rosso, R. (1996). Diffusion Wave Modeling of Distributed Catchment Dynamics. *Journal of Hydrologic Engineering*, *1*(3), 103–113. doi:10.1061/(ASCE)1084-0699(1996)1:3(103)



Usual methods for estimating excess rainfall as constant runoff coefficient and SCS-CN are not able to simulated the hydrological response of headwater rocky basins. In some cases, also the velocity constant approach, is not suitable for such simulations.

Modelled runoff discharges



V_S (slope velocity) = 0.7 m/s

V_C (channel velocity) = 1 m/s

K_S = 9 $m^{1/3}$ s^{-1}

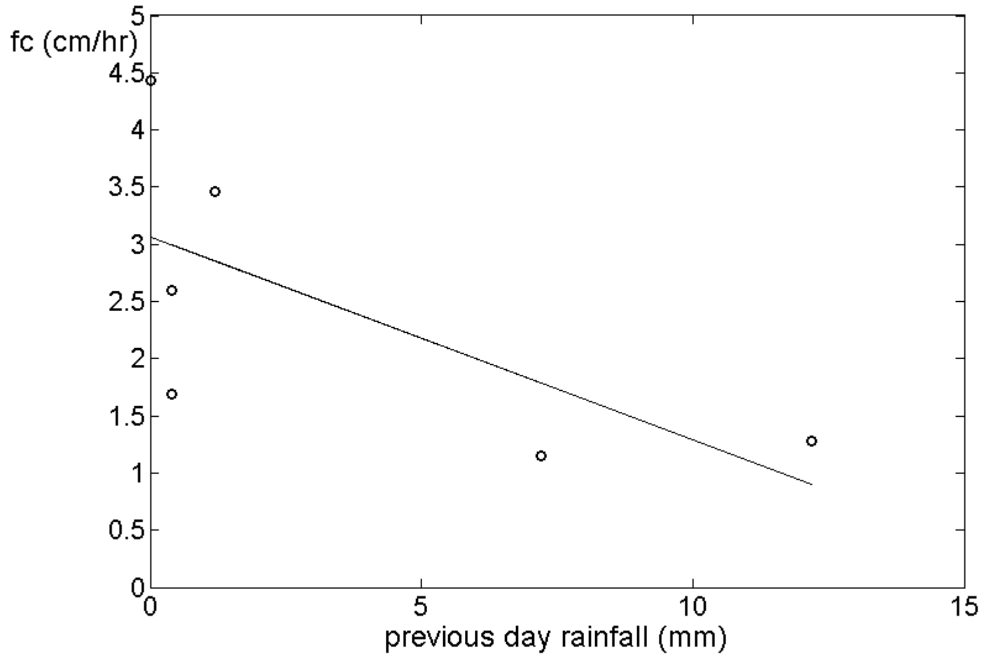
Model parameters

***Ia = 0.1 S** (estimated through rainfall events without runoff*

Event	AMC	Rainfall (mm)	Ia (CN = 90.4-83.3)
7/17/2013	I	5	6.4-12.3
7/29/2013	II	2.4	2.7-5.2
8/5/2013	II	2.6	2.7-5.2
8/23/2013	II	5.4	2.7-5.2
9/16/2013	III	2.8	1.2-2.7
7/14/2014	III	3	1.2-2.7
8/2/2014	III	3	1.2-2.7
8/5/2014	II	3	2.7-5.2
8/20/2014	I	5.2	6.4-12.3
8/30/2014	I	2.6	6.4-12.3
9/12/2014	II	2.4	2.7-5.2
9/9/2014	I	3.2	6.4-12.3

Calibration of infiltration rate f_c

Linear decreasing with the rainfall of the previous day



Slope routing U = 0.7 m/s

Channel routing K_s = 9 m$^{1/3}$/s

CONCLUSIONS

1) Hydrological response of headwater rocky basins to convective rainfalls is impulsive with times to peaks in the range 20-60 seconds.
2) Rainfall excess mechanism is dominated by an hortonian law.
3) Runoff routing along slope can be simulated through the constant velocity approach.
4) Runoff routing along channel cannot be simulated through the constant velocity approach but only by a matched diffusivity kinematic model or a more refined model.
5) A reasonable predictability of the model is guaranteed by the use of values of parameters except for the infiltration rate varying with the antecedent rainfalls.

More details in

Gregoretti C., Degetto M., Bernard M., Crucil, G., Pimazzoni A., De Vido G., Berti M., Simoni A. Lanzoni S. Runoff of small rocky headwater catchments: Field observations and hydrological modeling. *Water Resources Research. 52(10) 8138-8158*