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Regional analysis of sub-hourly rainfall in Calabria by means of the Partial Duration Series approach

Antonella Bodini[1], Stefano Luigi Gariano[2], Oreste Terranova[2]

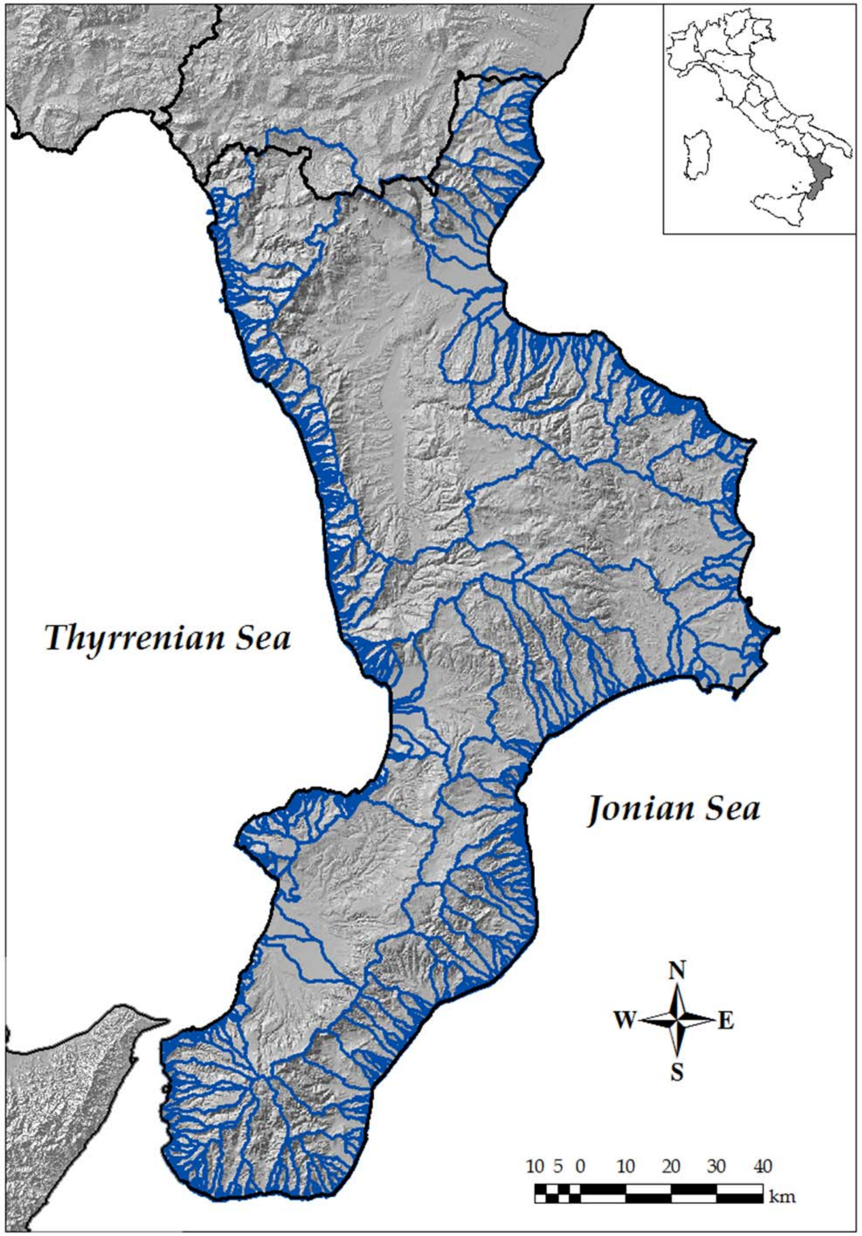
[1] CNR-IMATI, Milano; [2] CNR-IRPI, Rende-Cosenza, e-mail: terranova@irpi.cnr.it

Calabria

- large number of small drainage basins;
- very steep slopes and river beds;
- low permeability outcrops;
- very short lag times.

Hydrometric regime is strictly correlated with rainfall.

Intensity-Duration functions (IDf) are rarely known with adequate accuracy at sub-hourly duration.
They are commonly obtained by extrapolation from the >1h *IDf*.

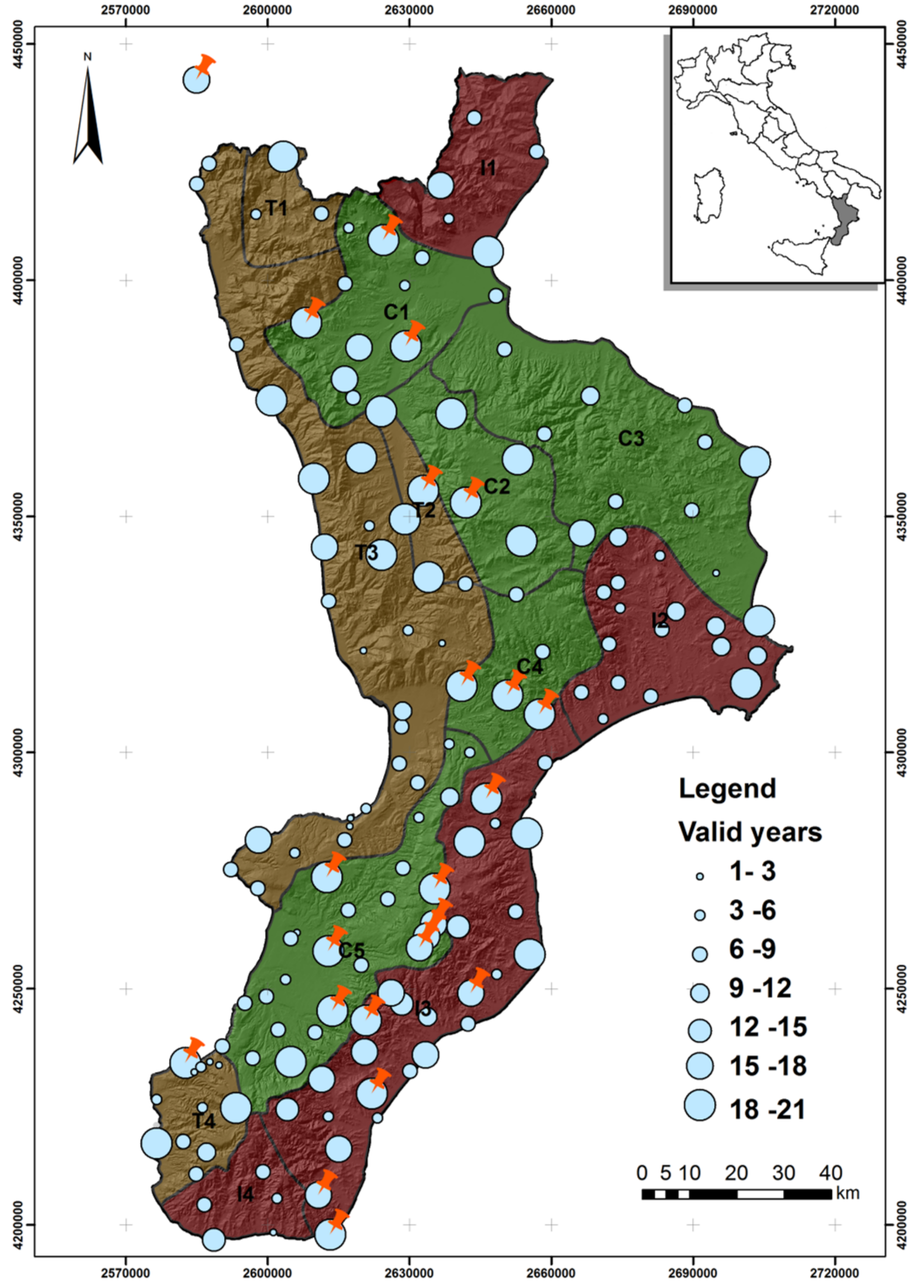


n.148 rain gauges with time resolution of 5 minutes.

Full years of events

n.23 stations with at least 10 years of observation were selected.

Hydrological variables analyzed for each rainfall event :
maximum intensity in 5, 10, 15, 20, 30, 60 minutes.



Analysis of extreme events

Generalized Pareto Distribution (GPD)

$z(p) = \alpha \{1-(1-p)^k\} / k$	$k \neq 0$
$z(p) = -\alpha \log (1-p)$	$k = 0$

- Derivable from the generalized extreme value distribution (GEV);
- Models daily rainfall data exceeding a “sufficiently-high” threshold;
- Estimates of return periods of a given event or quantile z_T (return level) at a fixed time interval T;

- In case of limited length series, estimates of quantiles obtained with GPD are better than those obtained with GEV (as they’re computed based on a greater data set).

Analysis of *partial duration series* (PDS)

- GPD is used for modeling erosive events assuming that their occurrence follows a homogeneous Poisson process with constant intensity λ (average number of events per year).

Regional frequency analysis

- Opposed to ***at site*** analysis;
- Data from all the gauges of a given homogeneous region are employed;
- It makes up for the lack of data, typical of rare events;
- Except for the site specific scale factor (***index flood***), observations made at different locations are assumed as pertaining to a single common process;
- a common probability distribution is obtained from such observations.

Analysis conducted according to the Hosking & Wallis (1993) approach based on L-moments, which produces robust and accurate estimates of the quantiles of a probability distribution.

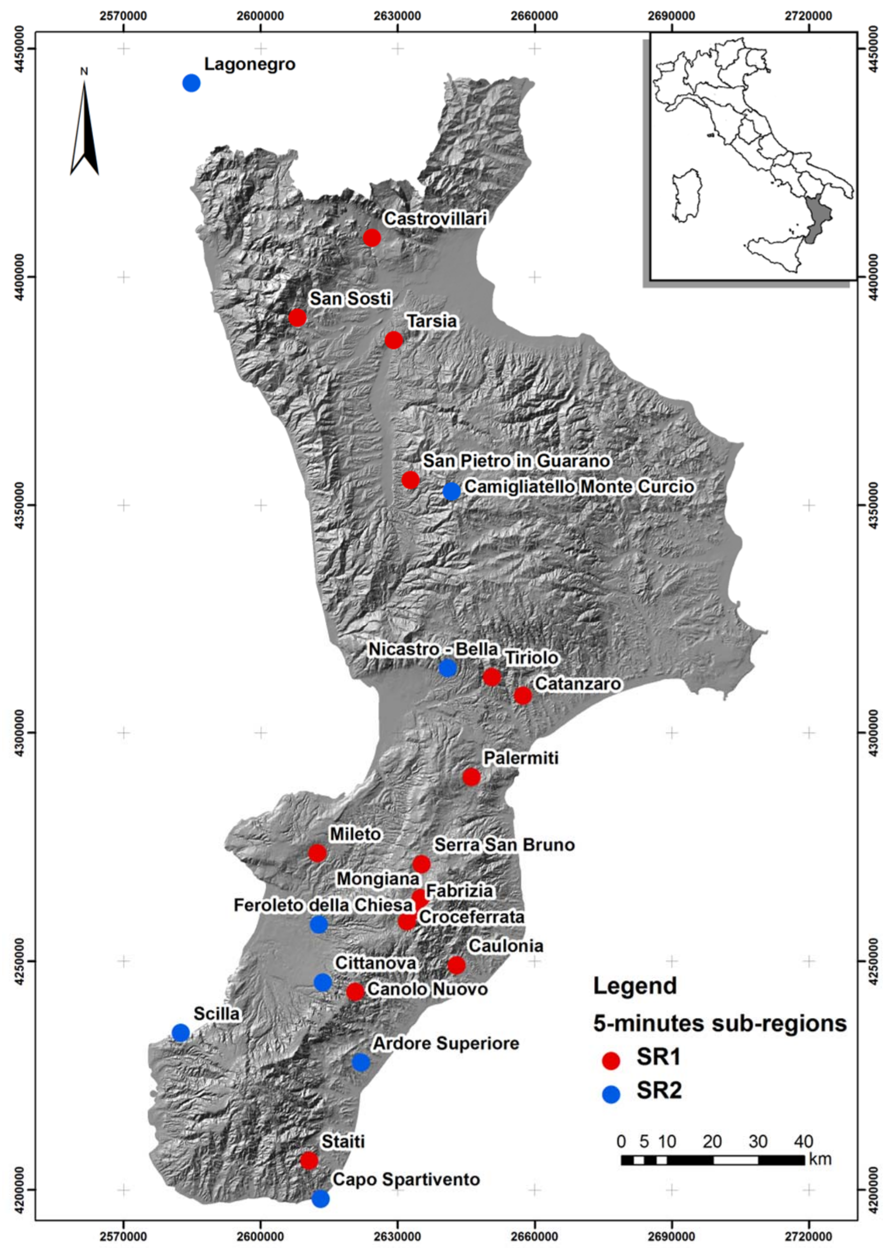
Use of both *GPD* and *regional frequency analysis* allows to analyze rare events, by improving the estimate of quantiles thanks to the high number of data.
The greater number of data, if compared to the annual maximum series approach, derives from the time-scale (cf. *GPD*) and the spatial-scale (cf. regional approach).

RESULTS OF REGIONAL ANALYSIS

*Maximum rainfall intensity in **5 minutes***

Data from the 23 raingauges resulted heterogeneous, based on the Hosking & Wallis (1993) test.

Two sub-regions resulted homogeneous (according to the Hosking & Wallis test):
- **positive shape parameter**
- **negative shape parameter**



RESULTS

Maximum rainfall intensity in ***5 minutes***

The threshold was set based on visual inspection of the mean excess plot and, therefore, was adopted an initial threshold of 35 mm/h .

Estimated intensity for some relevant return time

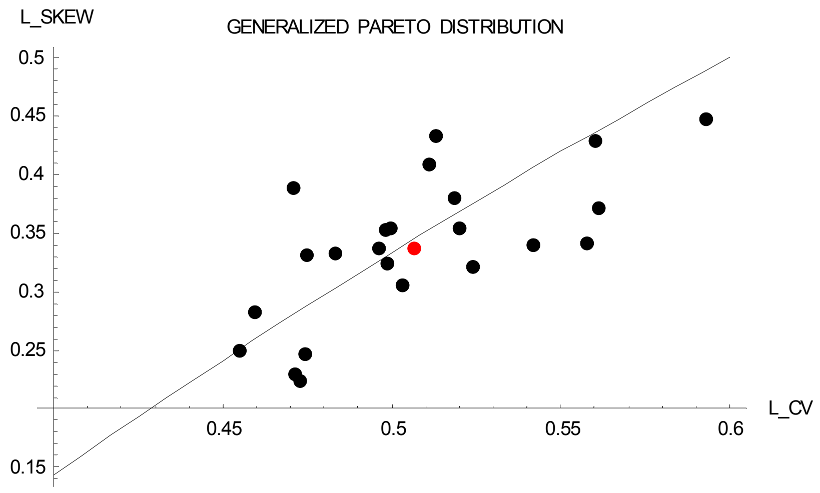
Raingauge	T=10	T=20	T=50	T=100
1030	146.8	171.4	208.0	239.1
1092	117.9	129.1	143.3	153.7
1140	163.9	192.3	234.4	270.3
1180	132.3	153.7	185.6	212.6
1230	134.5	156.4	189.0	216.7
1850	172.7	203.0	248.0	286.3
1940	190.2	224.4	275.1	318.3
1980	151.9	177.7	215.9	248.4
2086	180.4	212.4	260.0	300.5
2090	181.4	213.6	261.5	302.3
2120	194.8	230.0	282.3	326.8
2150	191.0	225.3	276.4	319.8
2180	182.2	214.6	262.7	303.7
2210	142.7	157.2	175.7	189.1
2290	203.4	240.4	295.5	342.4
2310	126.5	138.8	154.5	165.9
2510	138.7	152.7	170.5	183.5
2600	118.5	129.8	144.1	154.6
2690	128.2	140.8	156.8	168.5
2730	169.9	199.5	243.7	281.2
2890	178.9	210.5	257.6	297.6
2940	125.8	138.0	153.6	165.0
3210	131.1	144.0	160.5	172.5

RESULTS

Maximum rainfall intensity in ***10 minutes***

Treshold: 35 mm/h

One homogeneous region



Estimated intensity for some relevant return time

Raingauge	T=10	T=20	T=50	T=100
1030	126.5	143.0	165.4	182.7
1092	99.8	111.6	127.5	139.7
1140	123.3	139.3	160.9	177.5
1180	107.7	120.9	138.7	152.5
1230	107.0	120.0	137.7	151.2
1850	134.7	152.7	177.1	195.9
1940	129.0	146.1	169.1	186.8
1980	113.4	127.6	146.7	161.5
2086	145.9	166.0	193.2	214.1
2090	146.4	166.6	193.8	214.8
2120	149.7	170.5	198.5	220.2
2150	133.5	151.4	175.5	194.1
2180	137.1	155.6	180.6	199.8
2210	122.2	138.0	159.3	175.8
2290	142.2	161.7	187.9	208.2
2310	116.0	130.7	150.5	165.8
2510	113.8	128.1	147.4	162.3
2600	100.6	112.5	128.5	140.9
2690	107.4	120.6	138.3	152.0
2730	123.7	139.8	161.5	178.2
2890	142.3	161.7	187.9	208.2
2940	110.8	124.5	143.1	157.4
3210	116.3	131.0	150.9	166.3

RESULTS

Maximum rainfall intensity in ***15 minutes***

Threshold lowered to 25 mm/h.
23 stations form a homogeneous region

Maximum rainfall intensity in ***20 minutes***

Threshold: 35 mm/h.
22 stations form a homogeneous region

Maximum rainfall intensity in ***30minutes***

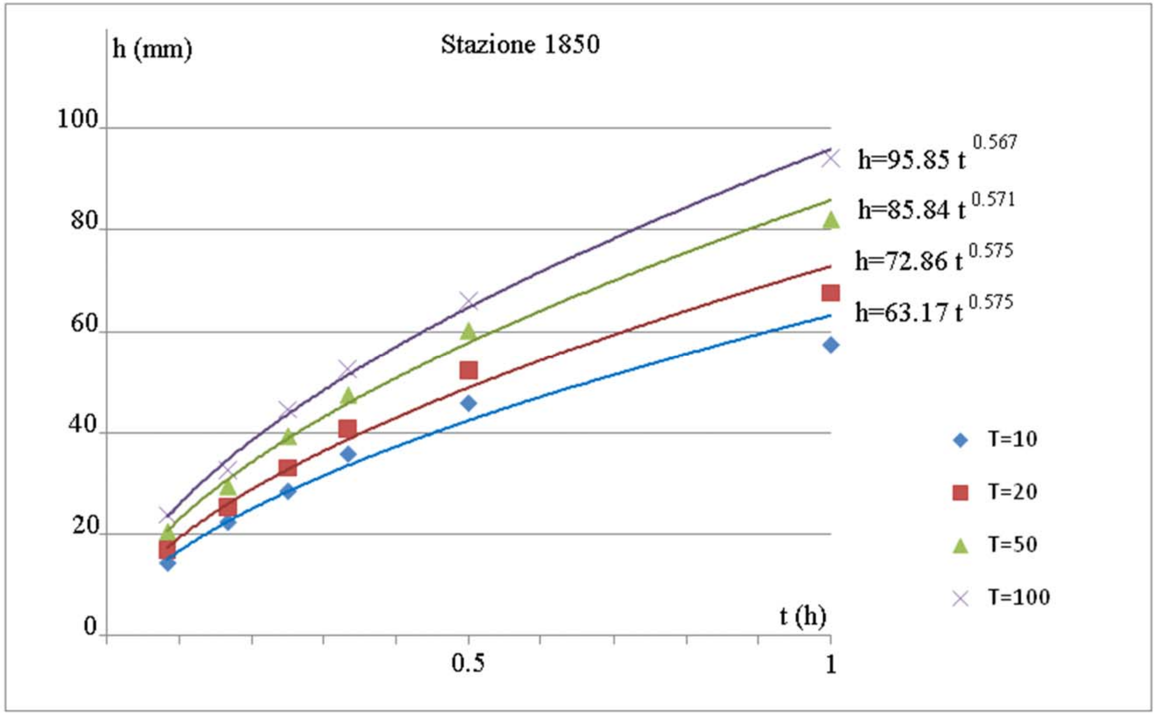
Threshold: 35 mm/h.
23 stations form a homogeneous region

Maximum rainfall intensity in ***60 minutes***

Threshold lowered to 20 mm/h.
22 stations form a homogeneous region

IDF CURVES

$$h_{t,T} = a \cdot t^n$$

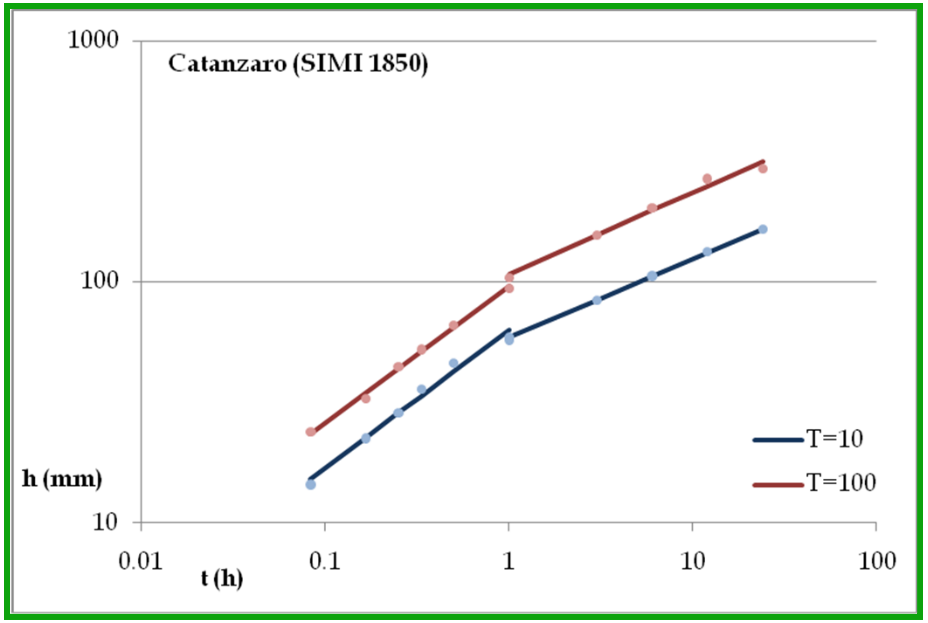


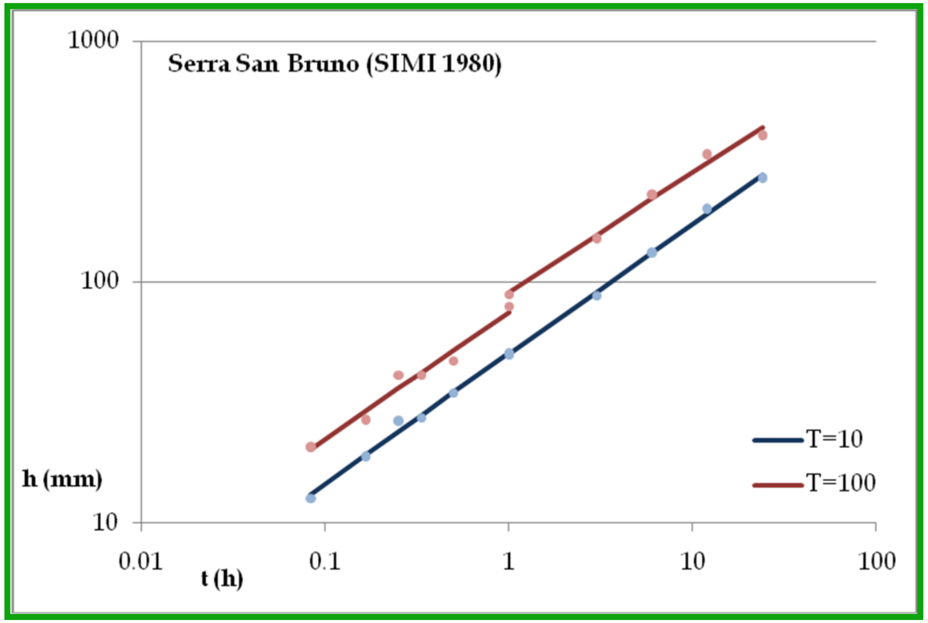
IDF CURVES

$$h_{t,T} = a \cdot t^n$$

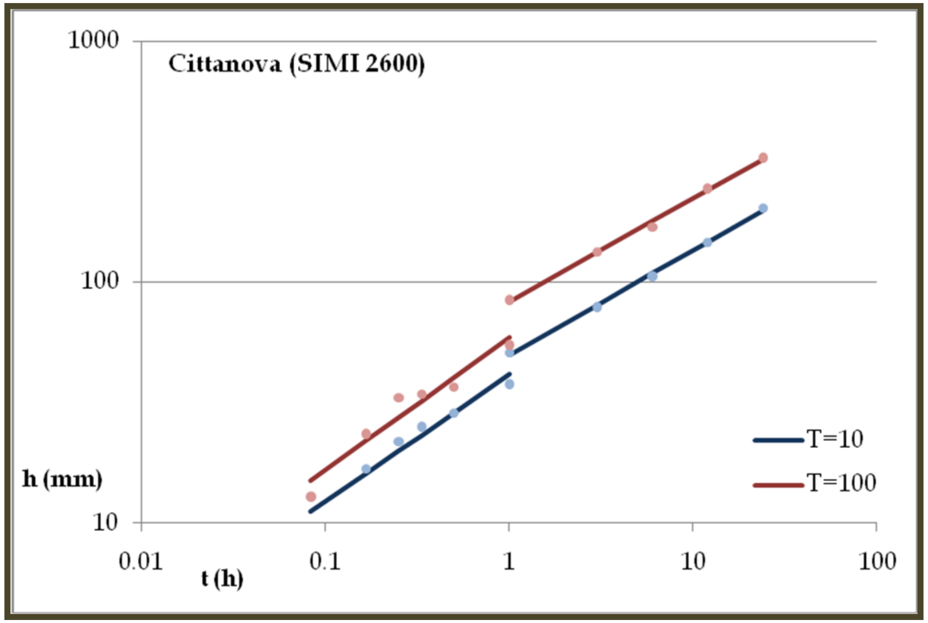
Raingauge	T=10				T=100			
	hourly		sub-hourly		hourly		sub-hourly	
	a	n	a	n	a	n	a	n
1230	40.978	0.491	53.416	0.608	60.273	0.523	77.751	0.593
1850	58.843	0.326	63.174	0.575	107.086	0.341	95.854	0.567
1980	50.343	0.538	51.066	0.547	90.589	0.498	75.106	0.528
2090	52.719	0.390	62.504	0.554	100.152	0.268	94.814	0.544
2120	49.942	0.372	59.831	0.506	93.737	0.393	89.993	0.490
2180	58.192	0.415	49.989	0.447	77.839	0.460	72.065	0.412
2210	70.936	0.353	83.242	0.774	126.147	0.471	138.625	0.862
2600	49.678	0.435	41.502	0.530	82.981	0.428	58.829	0.549
2690	46.475	0.279	63.559	0.713	81.964	0.244	100.993	0.786
2730	35.487	0.256	55.246	0.549	52.740	0.204	81.672	0.533
2890	48.483	0.406	82.624	0.682	79.130	0.385	130.951	0.693
3210	46.896	0.405	54.091	0.599	80.645	0.398	82.854	0.649

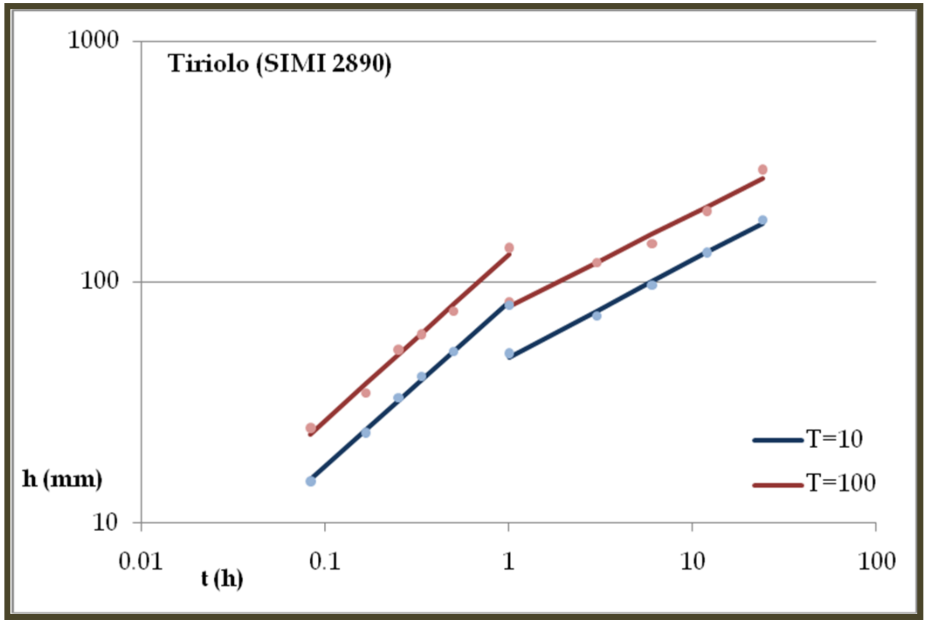
IDF CURVES


1000
Catanzaro (SIMI 1850)
100
h (mm)
10
0.01
0.1
1
10
100
t (h)
T=10
T=100


1000
Serra San Bruno (SIMI 1980)
100
h (mm)
10
0.01
0.1
1
10
100
t (h)
T=10
T=100

IDF CURVES

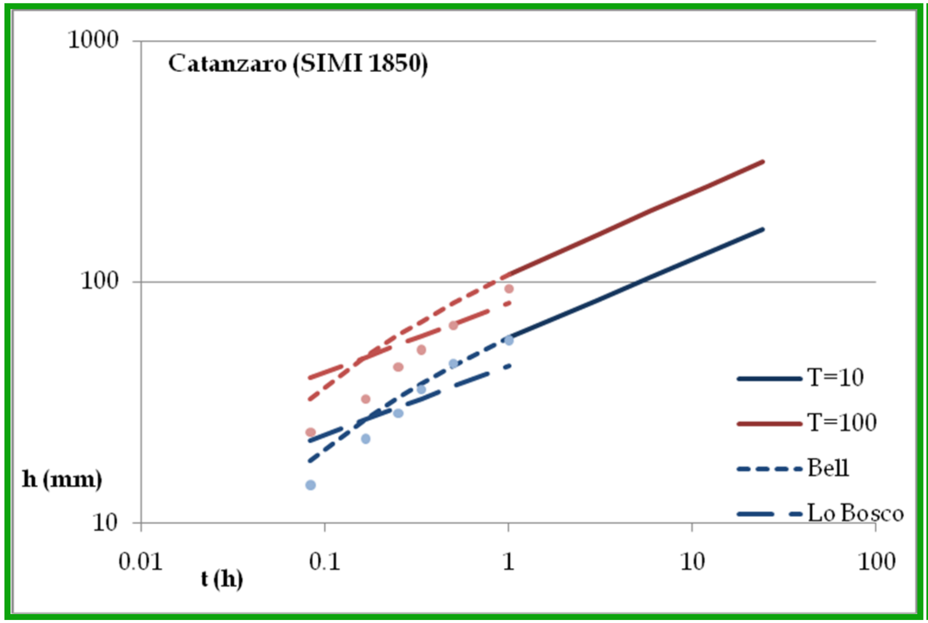

Cittanova (SIMI 2600)
1000
100
10
h (mm)
0.01
0.1
1
10
100
t (h)
T=10
T=100

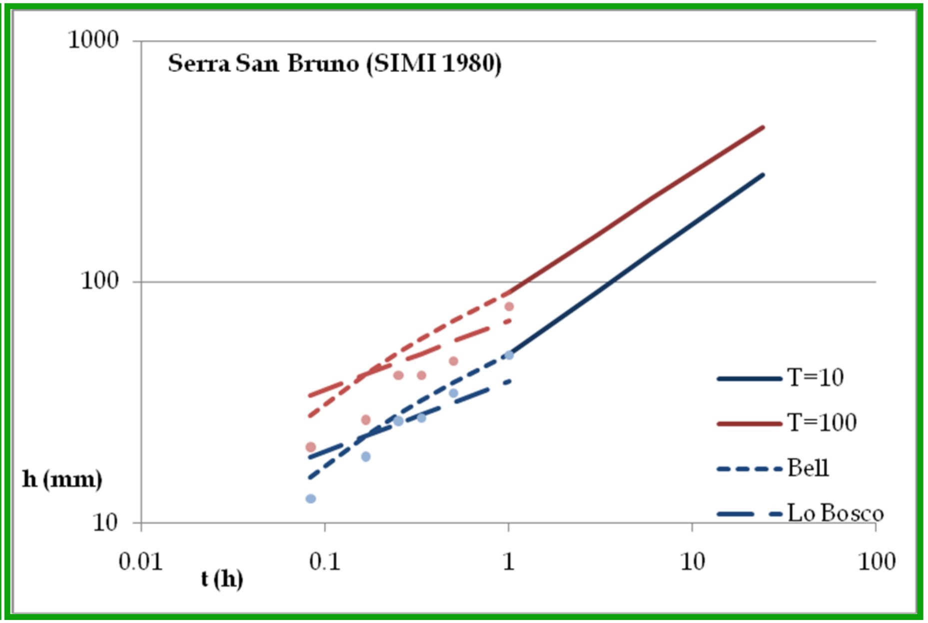

Tiriolo (SIMI 2890)
1000
100
10
h (mm)
0.01
0.1
1
10
100
t (h)
T=10
T=100

IDF CURVES

Lo Bosco (1987) $$\frac{h_{(d)}}{h_{(60)}} = 0.235 \cdot d^{0.289}$$

Bell (1969) $$\frac{h_{(d)}}{h_{(60)}} = 0.54 \cdot d^{0.25} - 0.50$$

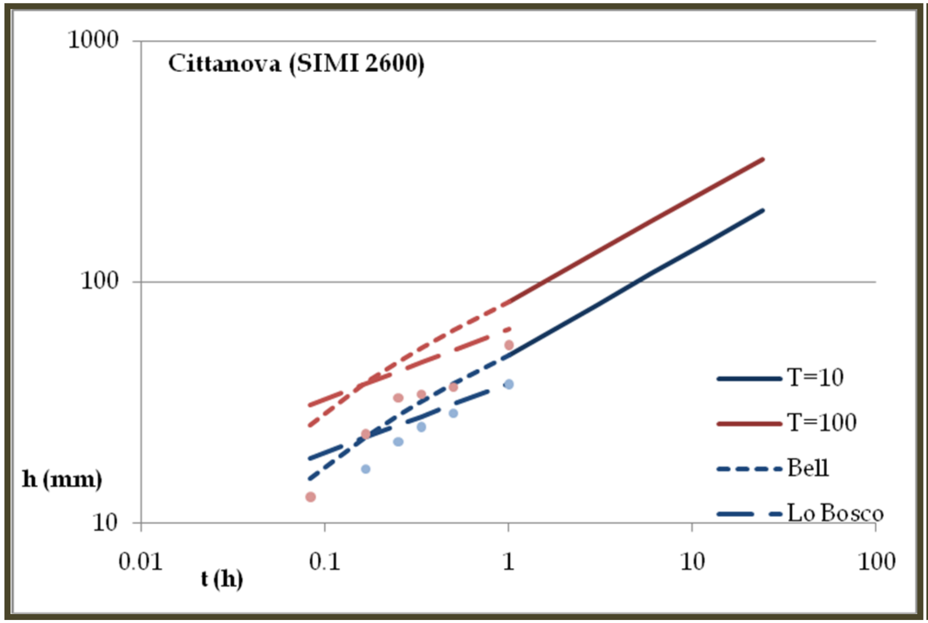


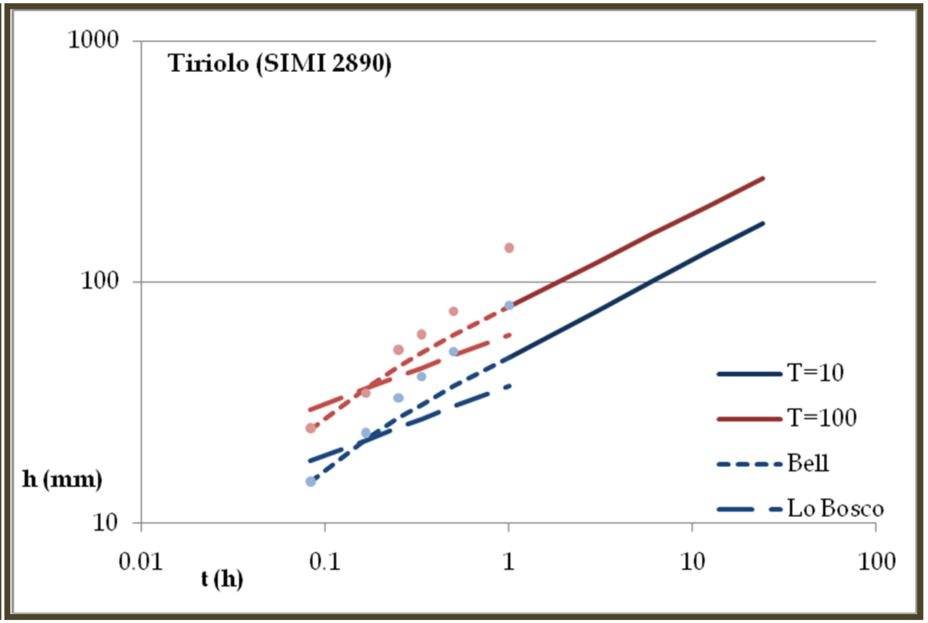


IDF CURVES

Lo Bosco (1987) $$\frac{h_{(d)}}{h_{(60)}} = 0.235 \cdot d^{0.289}$$

Bell (1969) $$\frac{h_{(d)}}{h_{(60)}} = 0.54 \cdot d^{0.25} - 0.50$$

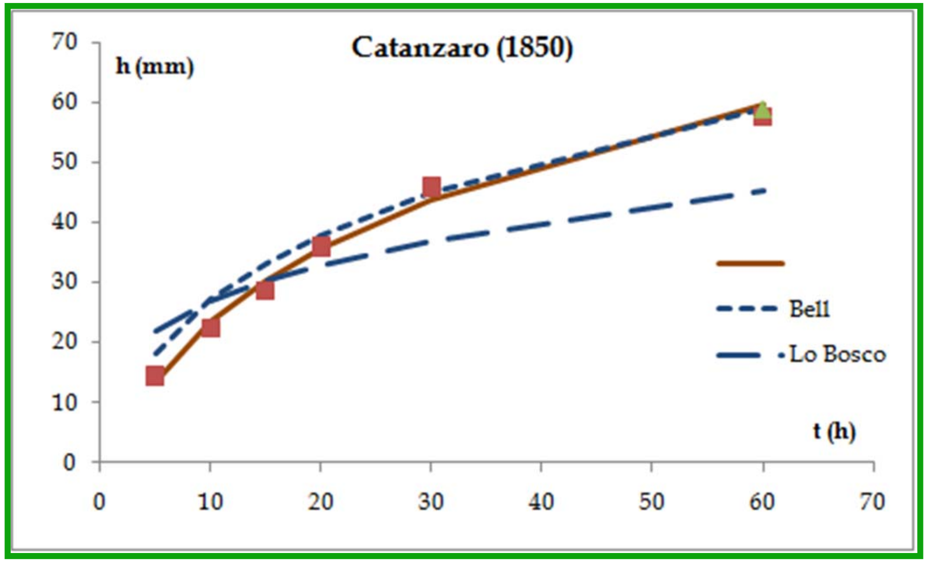


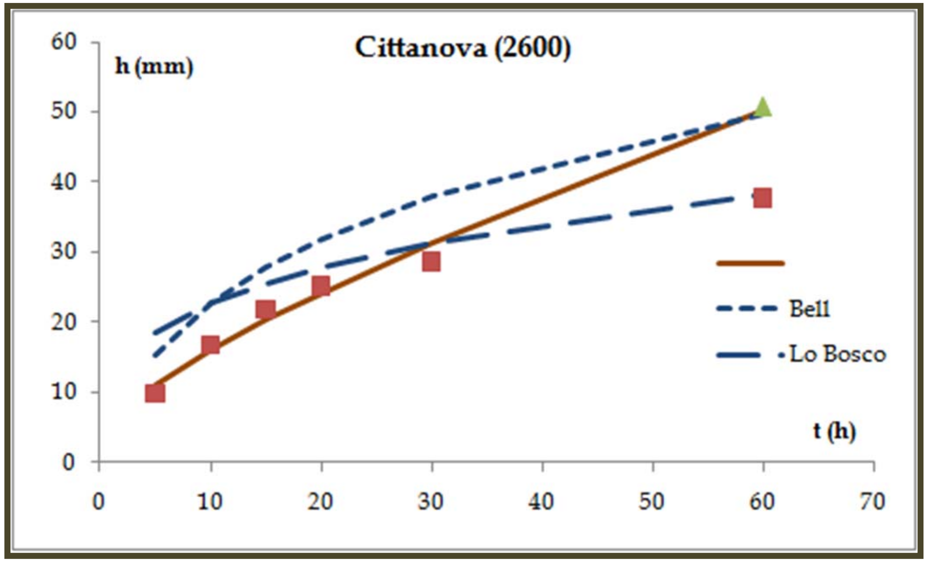


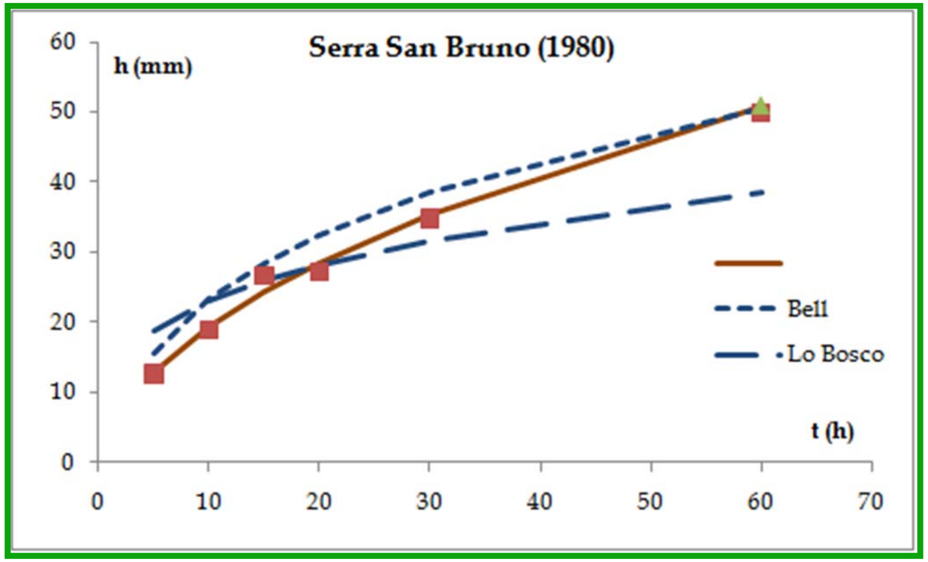
$$\frac{h_{(d)}}{h_{(60)}} = a \cdot d^{n} + b$$

IDF CURVES

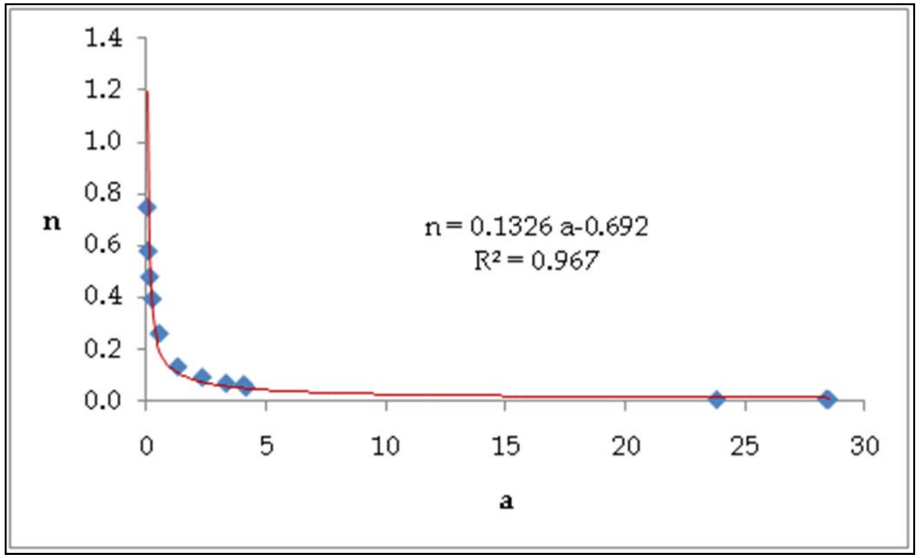
		a	n	b
1230	San Sosti	2.3472	0.0957	-2.4713
1850	Catanzaro	0.5509	0.2647	-0.6146
1940	Palermiti	4.1801	0.0570	-4.2597
1980	Serra San Bruno	0.1467	0.4834	-0.0665
2090	Fabrizia	3.3498	0.0726	-3.4853
2120	Caulonia	1.3267	0.1366	-1.3340
2180	Canolo Nuovo	0.0843	0.5829	0.0689
2210	Ardore Superiore	0.2630	0.3983	-0.3383
2600	Cittanova	0.0419	0.7515	0.0776
2690	Feroleto della Chiesa	4.0872	0.0671	-4.3413
2730	Mileto	23.8467	0.0096	-23.7974
2890	Tiriolo	28.5179	0.0097	-28.6527
3210	Lagonegro	28.4330	0.0111	-28.7375

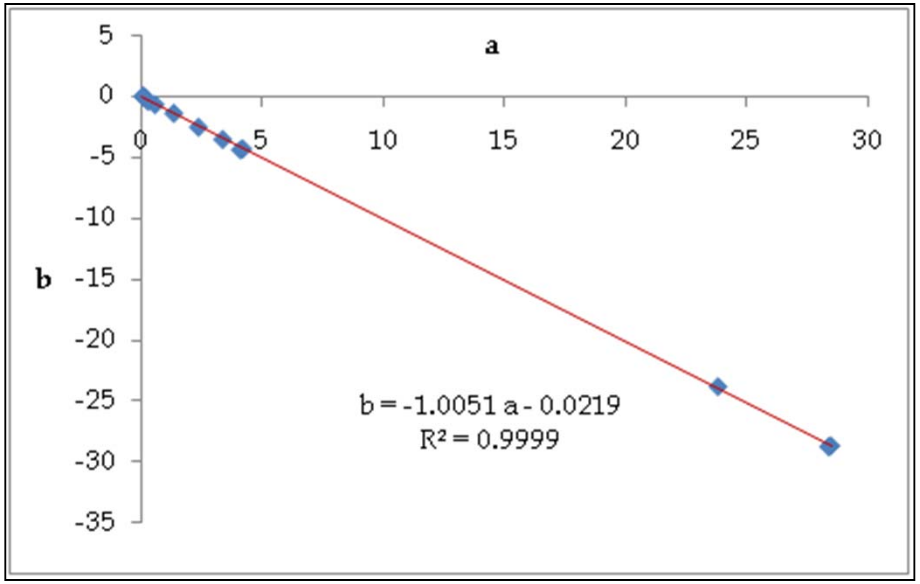






IDF CURVES





$$\frac{h_{(d)}}{h_{(60)}} = a \cdot d^n + b$$

		a
1230	San Sosti	2.3472
1850	Catanzaro	0.5509
1940	Palermiti	4.1801
1980	Serra San Bruno	0.1467
2090	Fabrizia	3.3498
2120	Caulonia	1.3267
2180	Canolo Nuovo	0.0843
2210	Ardore Superiore	0.2630
2600	Cittanova	0.0419
2690	Feroleto della Chiesa	4.0872
2730	Mileto	23.8467
2890	Tiriolo	28.5179
3210	Lagonegro	28.4330

$$n = 0.1326 \cdot a^{-0.692}$$

$$b = -1.005 \cdot a - 0.022$$

IDF CURVES

$$\frac{h_{(d)}}{h_{(60)}} = a \cdot d^{0.1326 \cdot a^{-0.692}} - 1.005 \cdot a - 0.022$$

Only one parameter

Preliminary results

Few raingauges and few data (short time series)

Thank you for your attention

Antonella Bodini[1], Stefano Luigi Gariano[2], Oreste Terranova[2]
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