

Analysis of EURO-CORDEX sub-daily rainfall simulations and derived event characteristics



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Image: NASA 2020



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- Intensive urbanization and related increase of impervious surfaces, causes negative impacts on the hydrological cycle, amplifying the risk of urban floods. These impacts can get even worse due to potential climate change impacts.
- It is of key importance to ascertain the quality of regional climate models (RCMs), which are commonly used for assessing at proper spatial resolutions future impacts of climate change on hydrological events.

**Analysis of
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sub-daily
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GOAL

- We aim to evaluate historical simulations of precipitation data from selected RCMs belonging to the Euro-CORDEX (Coordinated Regional Climate Downscaling Experiment for the Euro-Mediterranean area) with high temporal resolution (three-hourly), in order to understand how they compare to fine-resolution observations.
- We investigate the ability to reproduce event characteristics as well as the rainfall maxima annual at different durations.
- We aim to highlight the differences between RCMs, supporting the selection of the most suitable climate model to assess the impacts in the locations considered, and to understand which trends of intense precipitation are expected in the future.

METHODOLOGY

- We evaluated event characteristics with rainfall data at three-hour scale in the period 1990-2005.
- We evaluated the ability in reproducing rainfall annual maxima at 3h – 6h – 12h – 24h.
- We elaborated a ranking of the RCM models.

SELECTED RCM MODELS

CM5-ALAD
CM5-RACM22
ECE-HIRH
ECE-RACM22
ECE-RCA4
HAD-HIRH
HAD-RACM22
HAD-RCA4
MPI-RCA4
NOR-RCA4
NOR-REMO15

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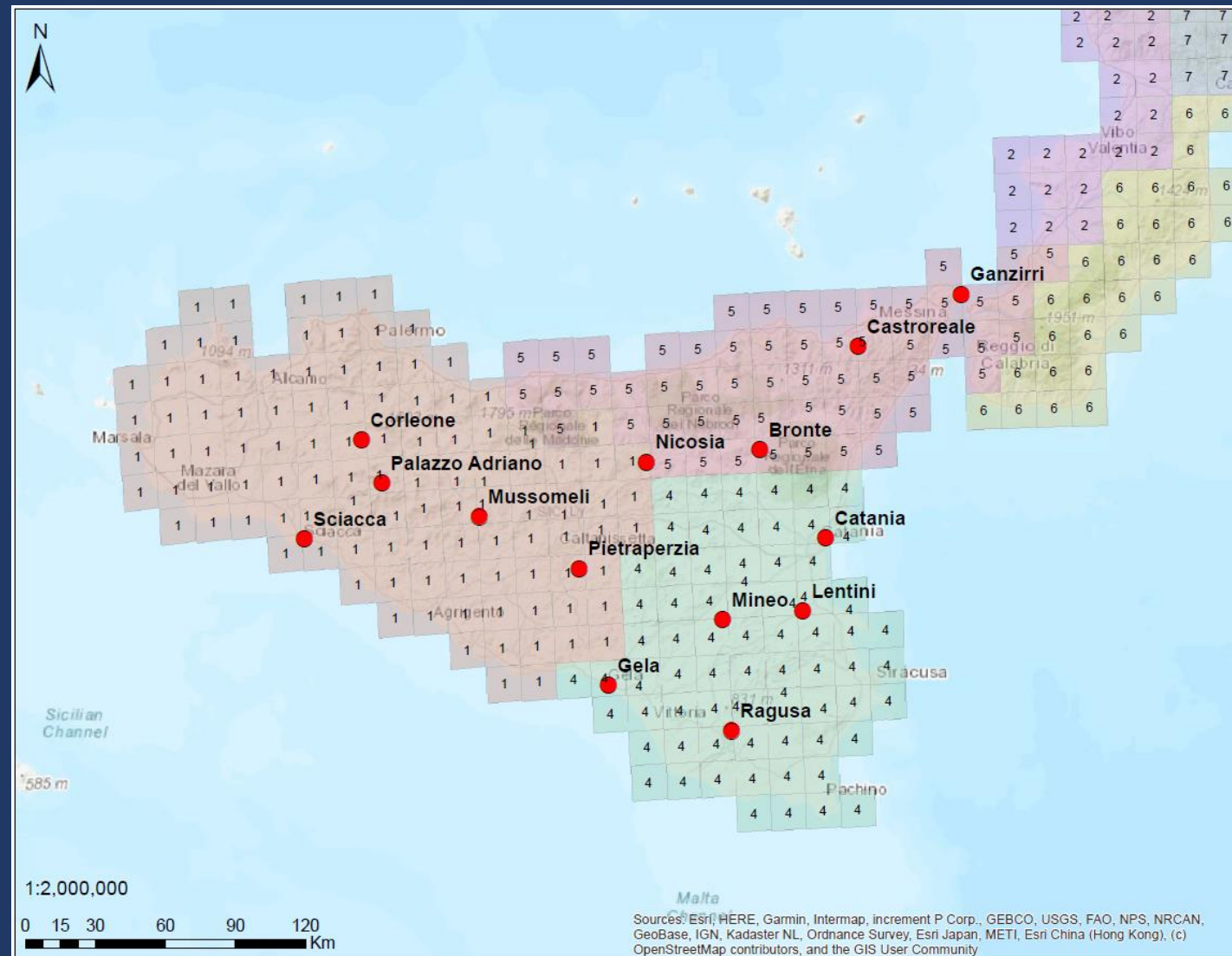


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We carried out our study in Sicily (island of southern Italy) using:

- 14 stations selected in 3 climatic homogeneous areas obtained by PCA (Principal Component Analysis).
- 11 RCM to be tested on each station
- Rainfall data at three-hour scale belong to the period 1990-2005.
- Rainfall maxima annual data in the period 1975-2005



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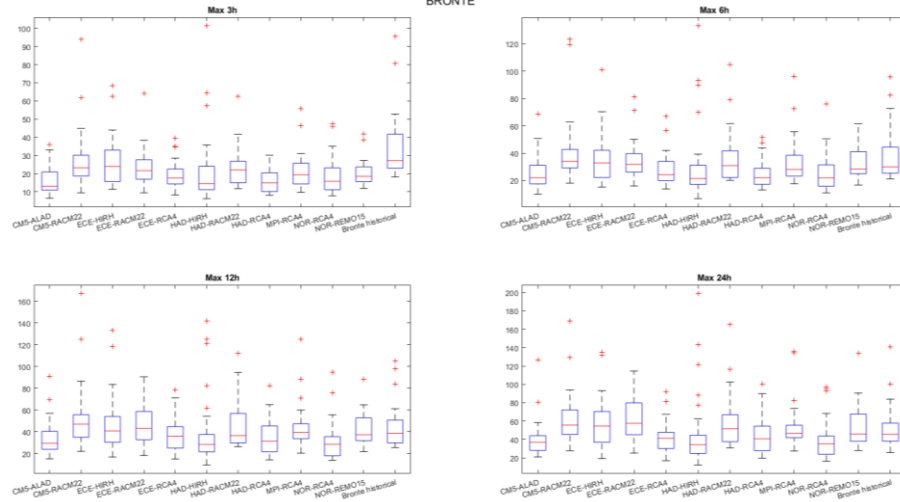
RAINFALL ANNUAL MAXIMA COMPARISON

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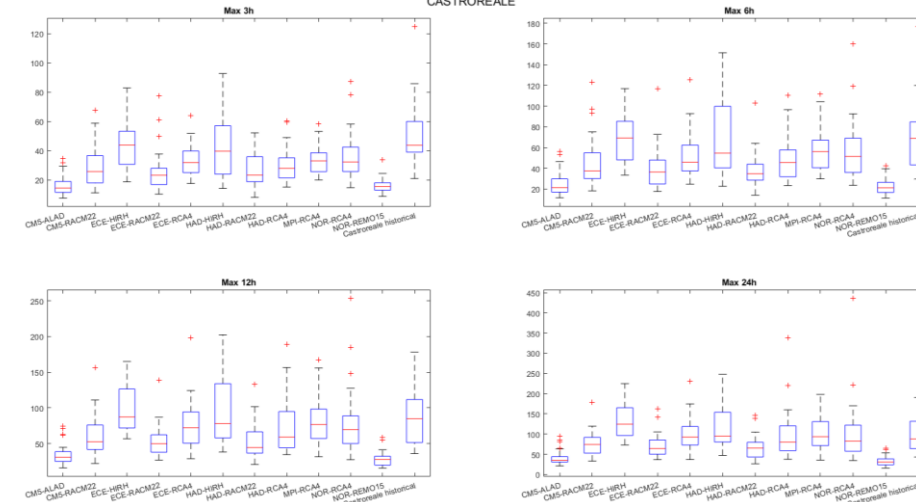
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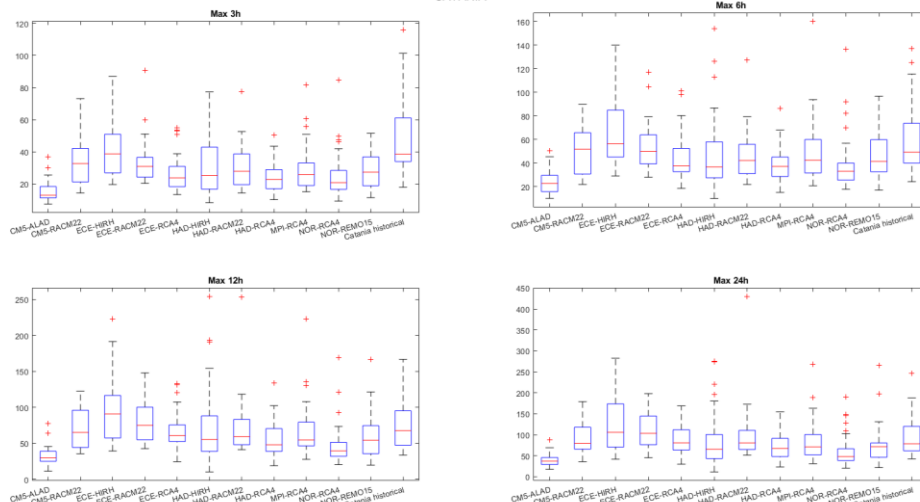
BRONTE



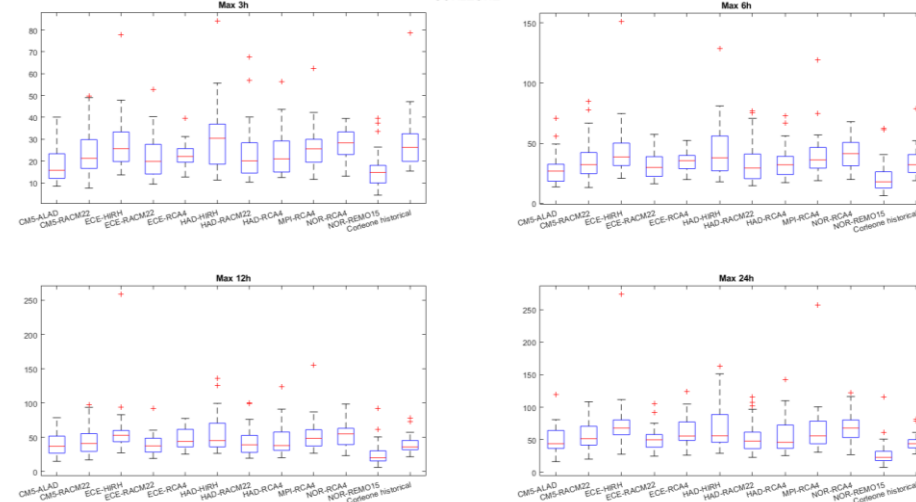
CASTROREALE



CATANIA



CORLEONE



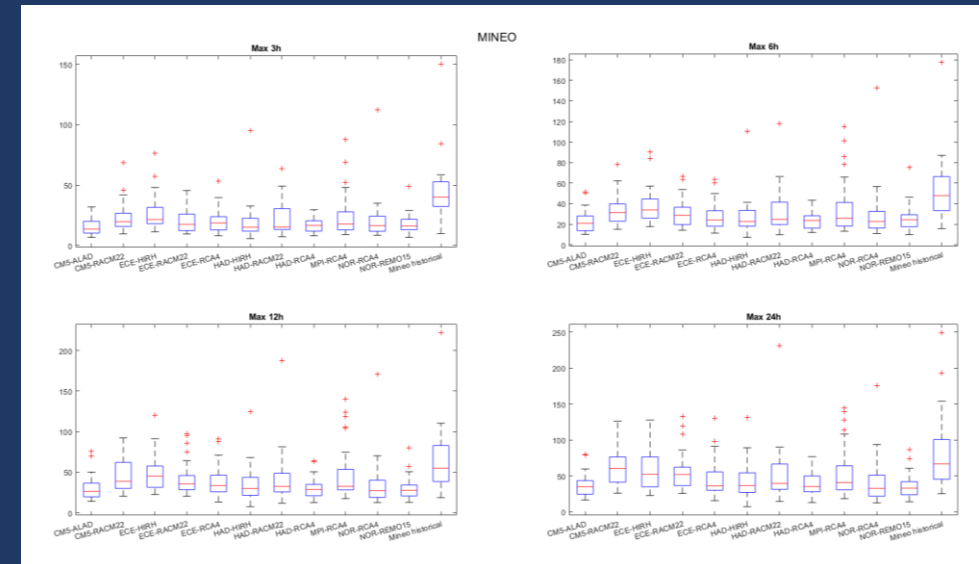
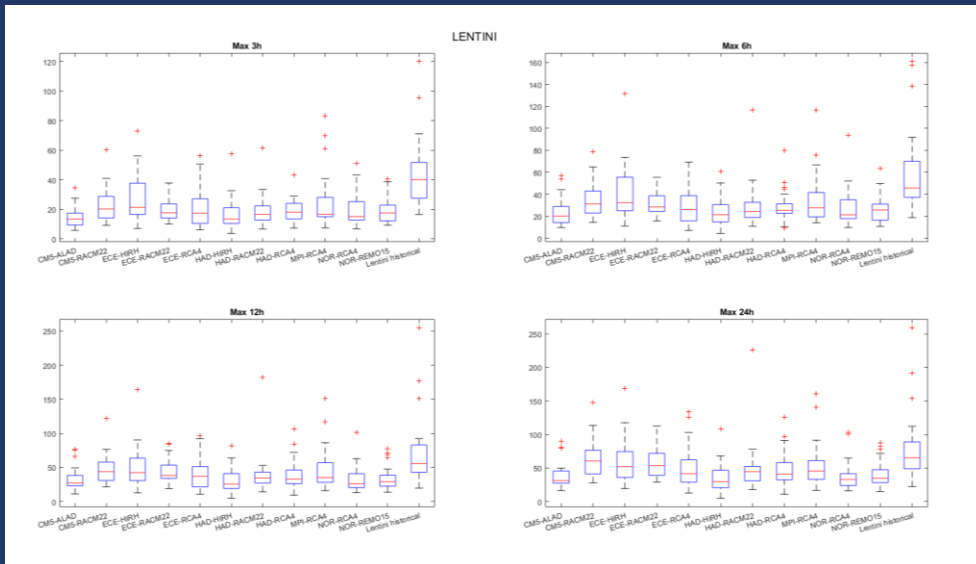
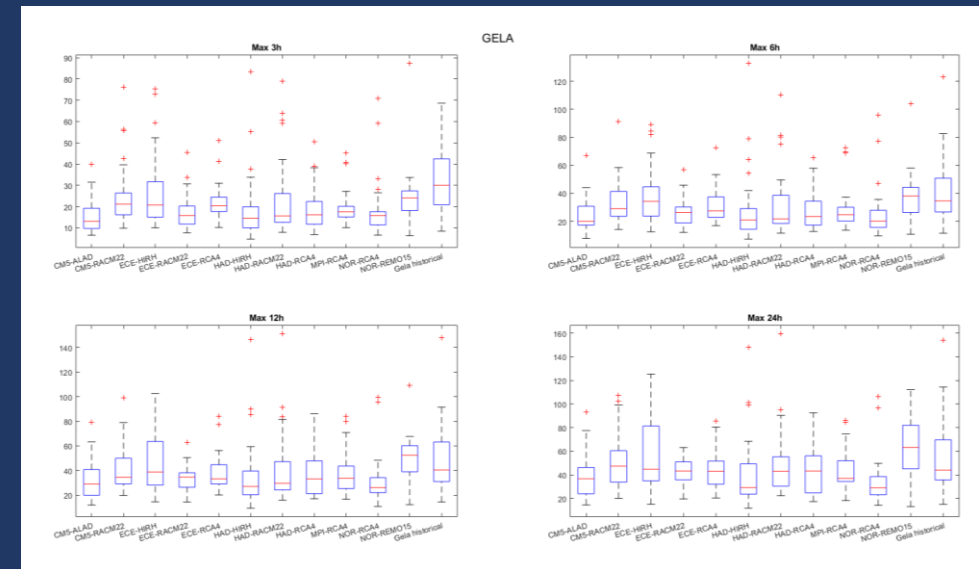
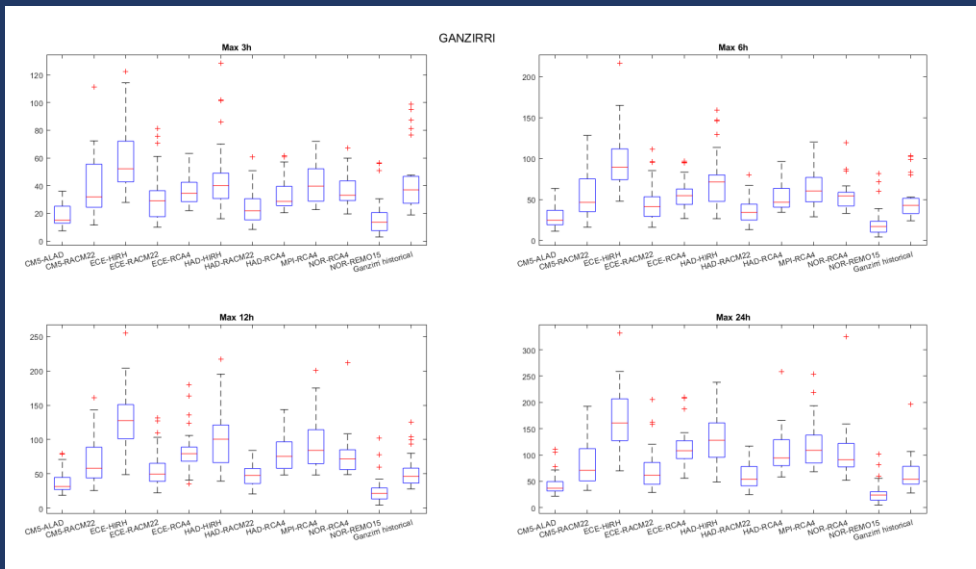
- Comparison boxplots on rainfall annual maxima in the stations of Bronte, Castoreale, Catania and Corleone

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- Comparison boxplots on rainfall annual maxima in the stations of Ganzirri, Gela, Lentini and Mineo

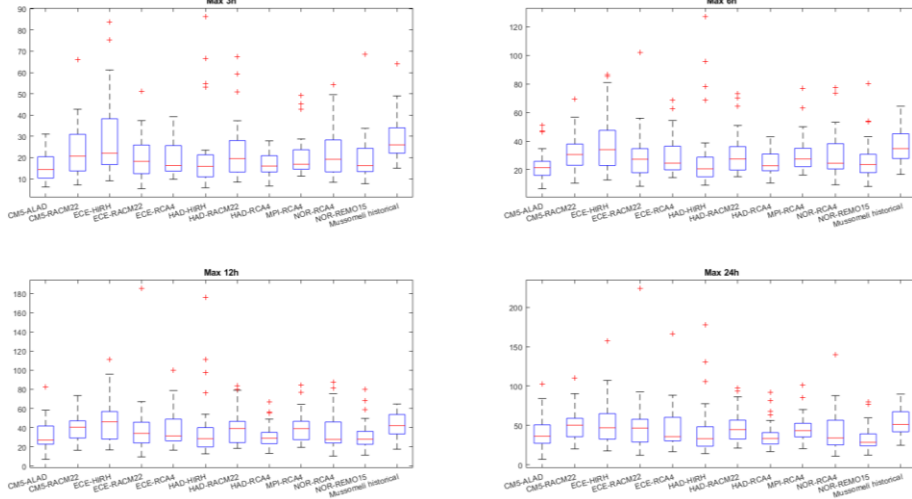
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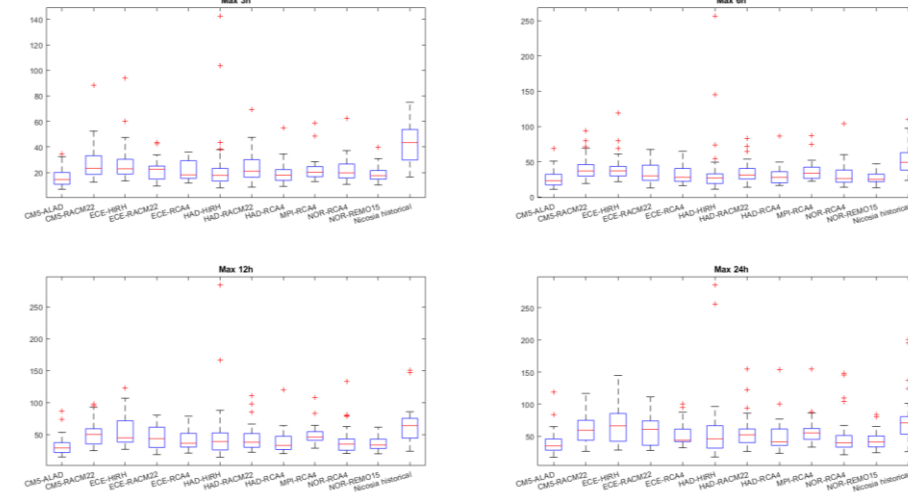
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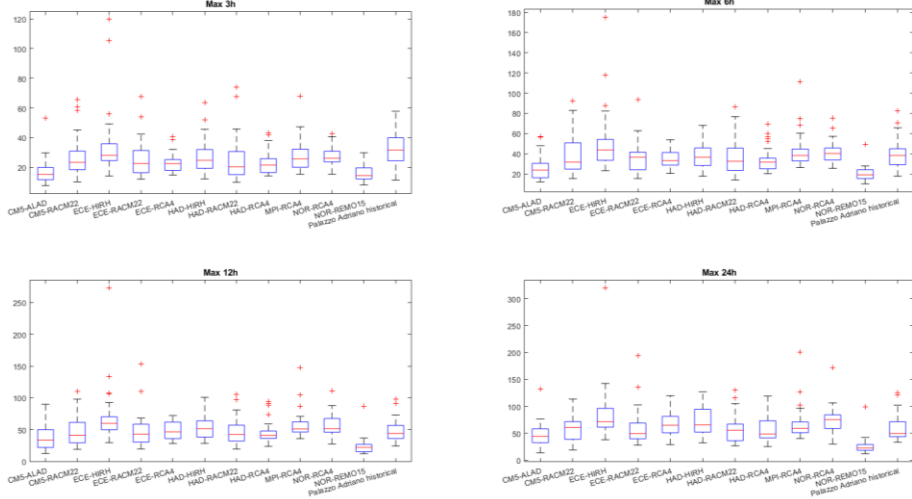
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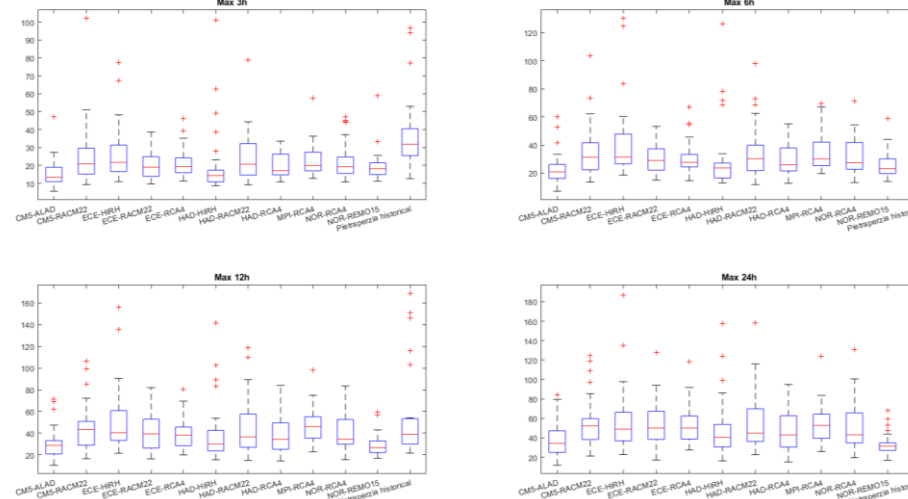
NICOSIA



PALAZZO ADRIANO



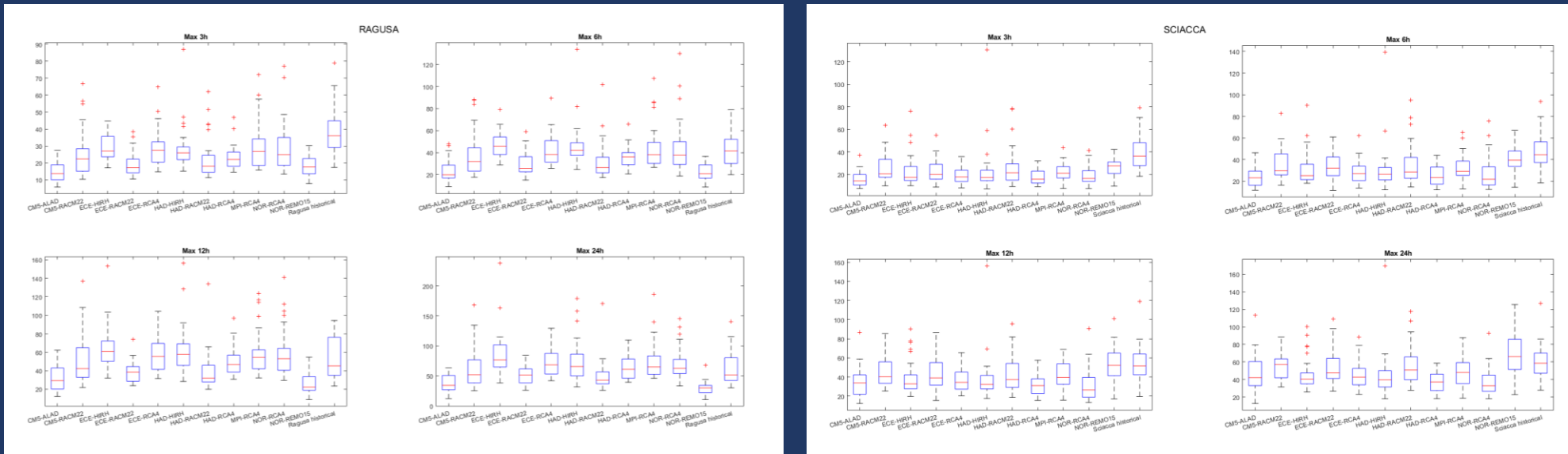
PIETRAPERZIA



- Comparison boxplots on rainfall annual maxima in the stations of Mussomeli, Nicosia, Palazzo Adriano and Pietraperzia

RAINFALL ANNUAL MAXIMA COMPARISON

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- Comparison boxplots on rainfall annual maxima in the stations of Ragusa and Sciacca
- In almost all cases the RCM models tend to underestimate real data.
- The results of the maxima at 3h are less significant, since the RCM datum is itself a three-hour datum.
- At the Castoreale and Ganzirri stations there is a greater variability of the RCM results.
- At the stations of Corleone, Mussomeli, Pietraperzia and Sciacca there is less variability in the RCM results.

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We have realized a ranking of the models on the maxima at 3h, 6h, 12h and 24h. It was made taking into consideration the 25th percentile (P_{25}) and the 75th percentile (P_{75}).

$$I = |RP_{25} - OP_{25}| + |RP_{75} - OP_{75}|$$

$$I_p = (I - I_{min}) / (I_{max} - I_{min})$$

I_p indicates the position of the model in the ranking, I is the factor calculated as the sum of the differences between the percentiles of the RCM (RP) and the observed data (OP).

The results were divided into 4 classes (from the best to the worst):

- Class 1, $I \leq 0.25$
- Class 2, $0.26 \leq I \leq 0.5$
- Class 3, $0.51 \leq I \leq 0.75$
- Class 4, $I \geq 0.76$

A ranking is present for each station for each duration (there is a mini-ranking on each column).

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RANKING

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Bronte					Catania					Castroreale					Corleone				
	3h	6h	12h	24h		3h	6h	12h	24h		3h	6h	12h	24h		3h	6h	12h	24h
CM5-ALAD	0.93	0.87	0.54	0.77	CM5-ALAD	1.00	1.00	1.00	1.00	CM5-ALAD	1.00	0.95	0.88	0.90	CM5-ALAD	0.68	0.52	0.18	0.15
CM5-RACM22	0.00	0.09	0.27	0.68	CM5-RACM22	0.30	0.12	0.00	0.00	CM5-RACM22	0.55	0.47	0.29	0.34	CM5-RACM22	0.22	0.00	0.23	0.39
ECE-HIRH	0.01	0.08	0.00	0.35	ECE-HIRH	0.00	0.10	0.37	0.55	ECE-HIRH	0.00	0.00	0.18	0.46	ECE-HIRH	0.00	0.51	0.78	1.00
ECE-RACM22	0.23	0.09	0.30	1.00	ECE-RACM22	0.36	0.00	0.12	0.32	ECE-RACM22	0.73	0.63	0.48	0.41	ECE-RACM22	0.42	0.09	0.00	0.00
ECE-RCA4	0.66	0.61	0.31	0.53	ECE-RCA4	0.59	0.31	0.28	0.03	ECE-RCA4	0.36	0.29	0.00	0.11	ECE-RCA4	0.27	0.05	0.55	0.72
HAD-HIRH	0.75	0.89	0.76	0.90	HAD-HIRH	0.38	0.31	0.16	0.32	HAD-HIRH	0.06	0.16	0.11	0.24	HAD-HIRH	0.20	0.57	0.91	0.93
HAD-RACM22	0.39	0.11	0.11	0.16	HAD-RACM22	0.41	0.28	0.12	0.06	HAD-RACM22	0.55	0.63	0.45	0.52	HAD-RACM22	0.37	0.11	0.19	0.09
HAD-RCA4	1.00	1.00	0.43	0.33	HAD-RCA4	0.66	0.51	0.40	0.36	HAD-RCA4	0.51	0.41	0.06	0.06	HAD-RCA4	0.31	0.02	0.27	0.34
MPI-RCA4	0.48	0.22	0.15	0.00	MPI-RCA4	0.53	0.20	0.17	0.23	MPI-RCA4	0.37	0.19	0.01	0.00	MPI-RCA4	0.09	0.27	0.57	0.63
NOR-RCA4	0.80	0.94	1.00	0.99	NOR-RCA4	0.68	0.65	0.74	0.70	NOR-RCA4	0.30	0.22	0.07	0.06	NOR-RCA4	0.13	0.52	0.74	0.90
NOR-REMO15	0.52	0.00	0.01	0.17	NOR-REMO15	0.46	0.19	0.38	0.48	NOR-REMO15	0.99	1.00	1.00	1.00	NOR-REMO15	1.00	1.00	1.00	0.69

Ganzirri					Gela					Lentini					Mineo				
	3h	6h	12h	24h		3h	6h	12h	24h		3h	6h	12h	24h		3h	6h	12h	24h
CM5-ALAD	0.75	0.24	0.14	0.19	CM5-ALAD	1.00	0.83	0.87	0.74	CM5-ALAD	1.00	1.00	0.96	0.86	CM5-ALAD	1.00	1.00	0.97	0.96
CM5-RACM22	0.16	0.21	0.24	0.18	CM5-RACM22	0.24	0.21	0.34	0.00	CM5-RACM22	0.41	0.39	0.17	0.00	CM5-RACM22	0.37	0.27	0.00	0.00
ECE-HIRH	0.87	1.00	1.00	1.00	ECE-HIRH	0.00	0.08	0.00	0.04	ECE-HIRH	0.00	0.00	0.00	0.15	ECE-HIRH	0.00	0.00	0.08	0.12
ECE-RACM22	0.36	0.00	0.06	0.02	ECE-RACM22	0.83	0.79	0.76	0.24	ECE-RACM22	0.60	0.47	0.20	0.13	ECE-RACM22	0.59	0.49	0.48	0.37
ECE-RCA4	0.00	0.18	0.40	0.45	ECE-RCA4	0.26	0.37	0.49	0.32	ECE-RCA4	0.61	0.70	0.63	0.52	ECE-RCA4	0.67	0.67	0.54	0.62
HAD-HIRH	0.01	0.40	0.59	0.63	HAD-HIRH	0.95	1.00	0.90	0.65	HAD-HIRH	0.83	0.94	1.00	0.97	HAD-HIRH	0.79	0.66	0.73	0.70
HAD-RACM22	0.56	0.10	0.00	0.00	HAD-RACM22	0.45	0.50	0.56	0.26	HAD-RACM22	0.70	0.77	0.71	0.66	HAD-RACM22	0.31	0.32	0.48	0.38
HAD-RCA4	0.09	0.15	0.38	0.40	HAD-RCA4	0.71	0.69	0.63	0.41	HAD-RCA4	0.61	0.71	0.65	0.52	HAD-RCA4	0.89	0.91	0.98	0.77
MPI-RCA4	0.04	0.36	0.53	0.46	MPI-RCA4	0.65	0.75	0.63	0.24	MPI-RCA4	0.41	0.52	0.27	0.45	MPI-RCA4	0.46	0.38	0.27	0.44
NOR-RCA4	0.00	0.12	0.29	0.35	NOR-RCA4	1.00	0.99	1.00	1.00	NOR-RCA4	0.60	0.74	0.97	1.00	NOR-RCA4	0.70	0.76	0.89	0.87
NOR-REMO15	1.00	0.47	0.33	0.36	NOR-REMO15	0.07	0.00	0.22	0.32	NOR-REMO15	0.70	0.88	0.97	0.81	NOR-REMO15	0.77	0.83	1.00	1.00

RANKING

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Mussomeli					Nicosia					Palazzo Adriano					Pietraperzia				
	3h	6h	12h	24h		3h	6h	12h	24h		3h	6h	12h	24h		3h	6h	12h	24h
CM5-ALAD	1.00	1.00	0.70	0.57	CM5-ALAD	1.00	1.00	1.00	1.00	CM5-ALAD	1.00	0.78	0.36	0.32	CM5-ALAD	0.91	1.00	1.00	0.73
CM5-RACM22	0.12	0.20	0.13	0.09	CM5-RACM22	0.00	0.00	0.31	0.00	CM5-RACM22	0.38	0.26	0.16	0.02	CM5-RACM22	0.16	0.33	0.09	0.25
ECE-HIRH	0.00	0.00	0.00	0.00	ECE-HIRH	0.12	0.09	0.00	0.03	ECE-HIRH	0.00	0.36	0.50	0.60	ECE-HIRH	0.00	0.00	0.35	0.05
ECE-RACM22	0.52	0.55	0.45	0.32	ECE-RACM22	0.57	0.26	0.37	0.20	ECE-RACM22	0.43	0.20	0.07	0.05	ECE-RACM22	0.46	0.47	0.12	0.07
ECE-RCA4	0.46	0.39	0.18	0.20	ECE-RCA4	0.34	0.49	0.55	0.36	ECE-RCA4	0.60	0.07	0.02	0.21	ECE-RCA4	0.39	0.52	0.29	0.19
HAD-HIRH	0.90	0.92	0.92	0.75	HAD-HIRH	0.73	0.90	0.62	0.46	HAD-HIRH	0.31	0.00	0.11	0.43	HAD-HIRH	1.00	0.96	0.57	0.41
HAD-RACM22	0.34	0.41	0.39	0.24	HAD-RACM22	0.25	0.37	0.56	0.39	HAD-RACM22	0.51	0.14	0.00	0.13	HAD-RACM22	0.06	0.40	0.22	0.08
HAD-RCA4	0.78	0.65	1.00	0.88	HAD-RCA4	0.74	0.75	0.71	0.49	HAD-RCA4	0.62	0.36	0.10	0.00	HAD-RCA4	0.35	0.47	0.28	0.18
MPI-RCA4	0.53	0.36	0.24	0.28	MPI-RCA4	0.49	0.27	0.28	0.25	MPI-RCA4	0.27	0.06	0.25	0.06	MPI-RCA4	0.18	0.22	0.23	0.16
NOR-RCA4	0.31	0.29	0.44	0.46	NOR-RCA4	0.45	0.63	0.81	0.78	NOR-RCA4	0.20	0.11	0.36	0.38	NOR-RCA4	0.39	0.31	0.00	0.00
NOR-REMO15	0.55	0.71	0.98	1.00	NOR-REMO15	0.74	0.81	0.76	0.78	NOR-REMO15	0.99	1.00	1.00	1.00	NOR-REMO15	0.58	0.77	0.96	1.00

Ragusa					Sicacca				
	3h	6h	12h	24h		3h	6h	12h	24h
CM5-ALAD	1.00	1.00	0.76	0.65	CM5-ALAD	1.00	1.00	0.87	0.35
CM5-RACM22	0.52	0.36	0.01	0.02	CM5-RACM22	0.05	0.29	0.33	0.00
ECE-HIRH	0.00	0.22	0.13	0.63	ECE-HIRH	0.47	0.68	0.75	0.68
ECE-RACM22	0.76	0.61	0.55	0.28	ECE-RACM22	0.32	0.39	0.39	0.01
ECE-RCA4	0.21	0.00	0.00	0.20	ECE-RCA4	0.67	0.75	0.70	0.56
HAD-HIRH	0.26	0.23	0.10	0.13	HAD-HIRH	0.64	0.77	0.77	0.71
HAD-RACM22	0.67	0.65	0.54	0.39	HAD-RACM22	0.35	0.47	0.46	0.01
HAD-RCA4	0.49	0.31	0.21	0.00	HAD-RCA4	0.78	0.87	0.95	0.94
MPI-RCA4	0.22	0.01	0.17	0.13	MPI-RCA4	0.38	0.49	0.39	0.32
NOR-RCA4	0.19	0.02	0.10	0.14	NOR-RCA4	0.69	0.88	1.00	1.00
NOR-REMO15	0.76	1.00	1.00	1.00	NOR-REMO15	0.00	0.00	0.00	0.24

Class 1	0 - 0.25
Class 2	0.26 - 0.5
Class 3	0.51 - 0.75
Class 4	0.76 - 1

Finally, the number of occurrences for each RCM in each class of the ranking was counted. Therefor for each RCM the class in which the greatest number of occurrences falls is the class it belongs to.

SELECTED RCM MODELS	Class 1	Class 2	Class 3	Class 4
CM5-ALAD	5	3	8	39
CM5-RACM22	35	18	3	0
ECE-HIRH	36	6	5	6
ECE-RACM22	20	22	9	4
ECE-RCA4	16	18	20	0
HAD-HIRH	12	9	14	21
HAD-RACM22	19	21	12	1
HAD-RCA4	10	18	14	13
MPI-RCA4	23	22	9	0
NOR-RCA4	14	12	11	19
NOR-REMO15	11	7	7	31

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RCM MODELS

CM5-ALAD

CM5-RACM22

ECE-HIRH

ECE-RACM22

ECE-RCA4

HAD-HIRH

HAD-RACM22

HAD-RCA4

MPI-RCA4

NOR-RCA4

NOR-REMO15

- In our study area the best models are CM5-RACM22, ECE-HIRH and MPI-RCA4 (green).
- In our study area the worst models are CM5-ALAD, HAD-HIRH, NOR-RCA4 and NOR-REMO15 (red).
- The other models have medium quality performance (yellow and orange).

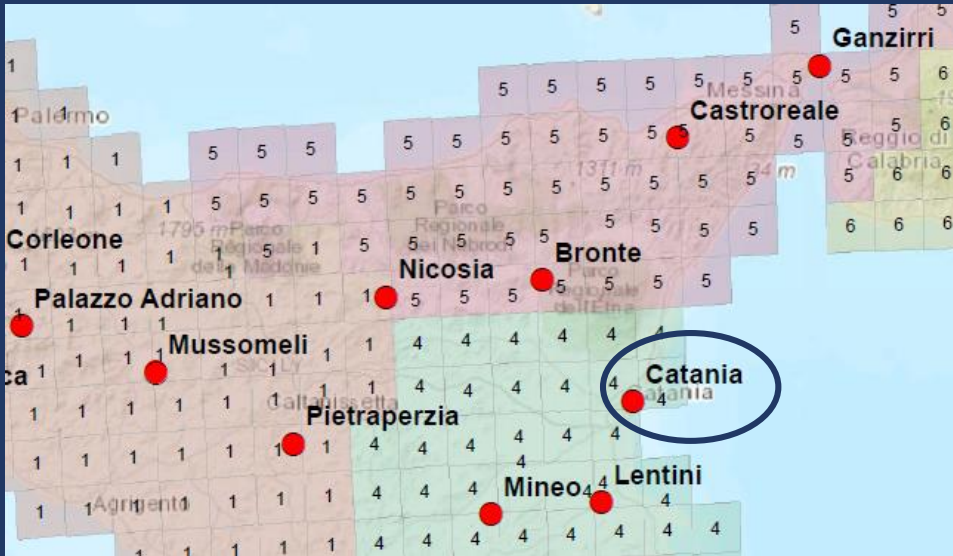
This ranking highlights the differences between RCMs and proposes a selection of the most suitable climate model to assess the impacts in Sicily.

This will be useful to understand which trends of intense precipitation are expected in the future.

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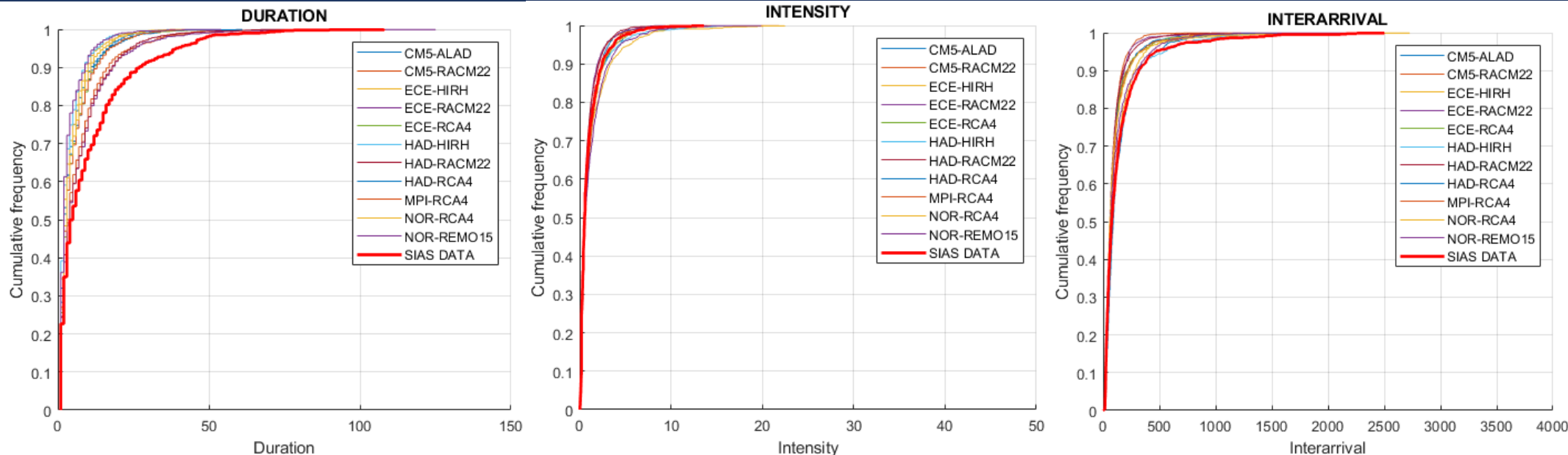
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We are currently collecting data to analyze some rainfall characteristics such as duration, intensity and events inter-arrival.

This is an example in Catania:

- Empirical cumulative distribution function show that the models reliably reproduce the intensities but tend to underestimate the duration and time of inter-arrival.



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