# QPF OPERATIONAL VERIFICATION OVER CATCHMENT AREA

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COSMO GENERAL MEETING
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**The estimation of QPF on river basins for purposes related to the issue of Civil Protection alerts for hydro-geological or hydraulic criticality is one of the main activities carried out operationally at the Hydro-Meteo-Climate Service of Arpae-Emilia Romagna.**


- Development of tools to help forecasters and hydrologists to evaluate mean, max, or percentiles of the precipitation field on the warning areas used by the National Civil Protection Department using data from different NWP models (e.g. IFS-ECMWF, COSMO-5M or COSMO-2I)
- Exceeding predefined thresholds can give useful indications for situations of intense precipitation possibly leading to floods

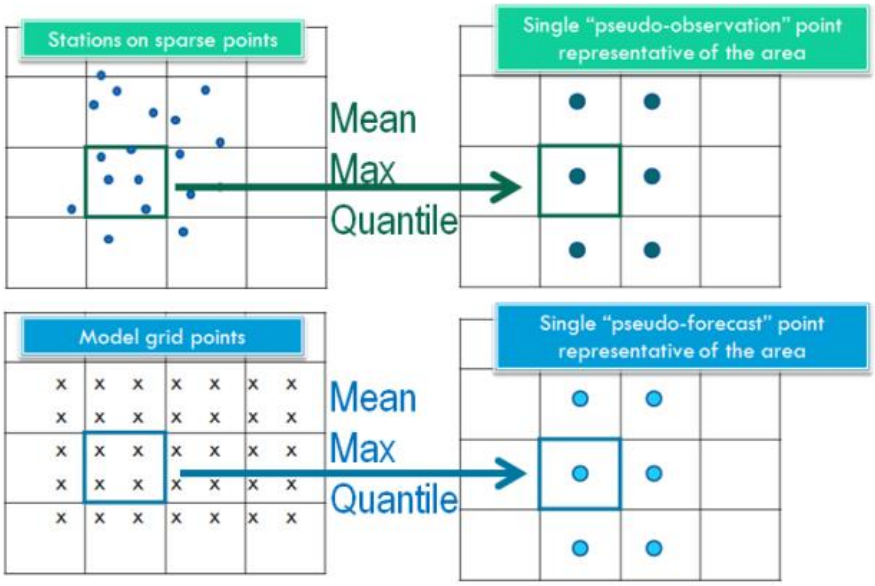
- Development of a system to verify the products used to estimate the QPF over catchment areas:
  - It should allow to carried out verification operationally on a seasonal basis using the available observational data
  - Verification results should be used directly to interpret how to use the forecast system and to decide in which situations one system is better than another

AWARE TASK 4: Overview of forecast methods, representation and user-oriented products linked to HIW
Sub Task 4.6: QPF evaluation approaches

AWARE TASK 3: Verification applications to HIW (with focus on spatial methods)
Sub Task 3.4: DIST methodology tuned on high thresholds events

# The verification system

- It is an evolution of **DIST**, a spatial verification method based on the verification of the precipitation distributions within boxes of selected size (Neighborhood obs – Neighborhood fcs)

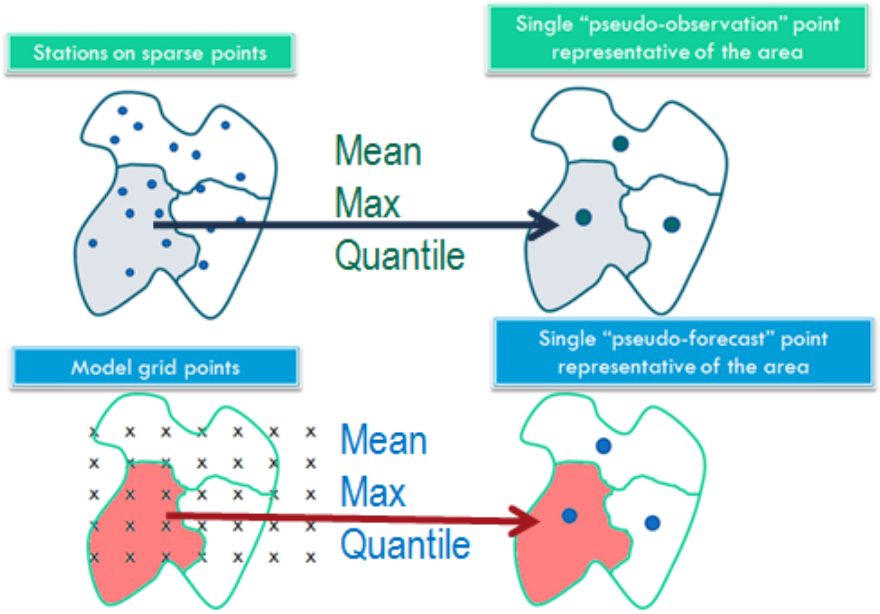



Marsigli, C., Montani, A. and Paccagnella, T. (2008), A spatial verification method applied to the evaluation of high-resolution ensemble forecasts. Met. Apps, 15: 125–143. doi: 10.1002/met.65

- The verification domain is subdivided into several boxes, each of them containing a certain number of observed and forecast values.
- For each box, several parameters of the distribution of both the observed and forecast values falling in it can be computed (mean, median, percentiles, maximum).
- Verification is then performed using a categorical approach, by comparing for each box one or more parameters of the forecast distribution against the corresponding parameters of the observed distribution, using a set of indices.

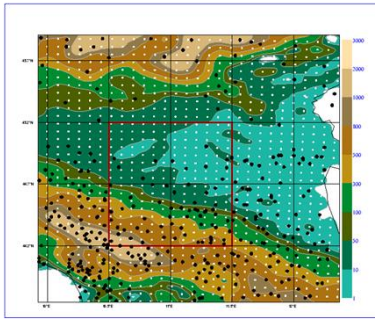
# The verification system

- Squared regular boxes are replaced with catchment areas

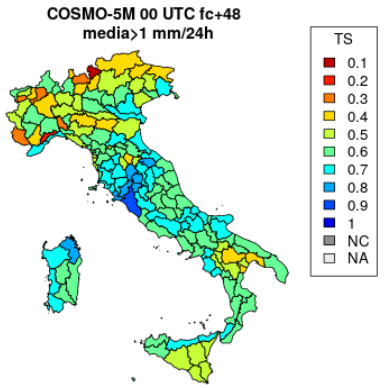



**Some advantages of this choice:**

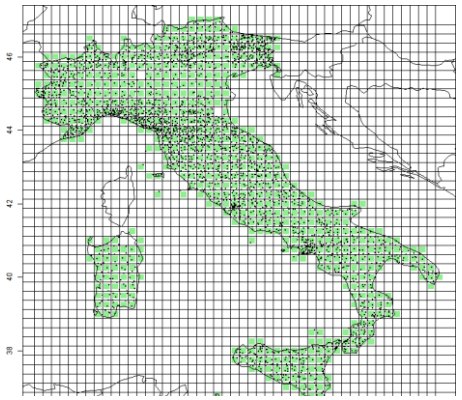
- Reduce some problems related to complex terrain, e.g. if a ridge of a mountain divide the box this can give misleading results combining upwind and downwind situation



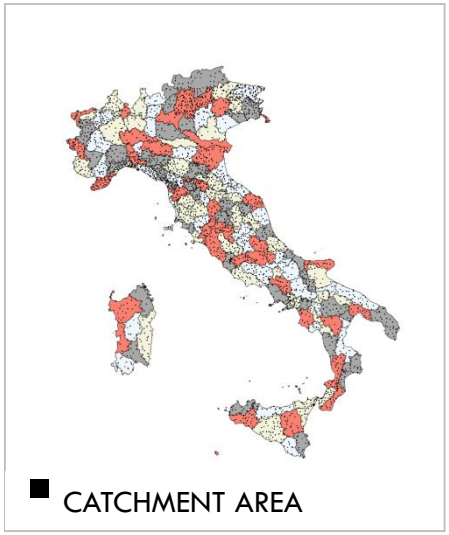
- Easier and more direct communication of the information about the usability of NWP data directly to forecasters or hydrologists
  e.g. scores are can be provided on each catchment area



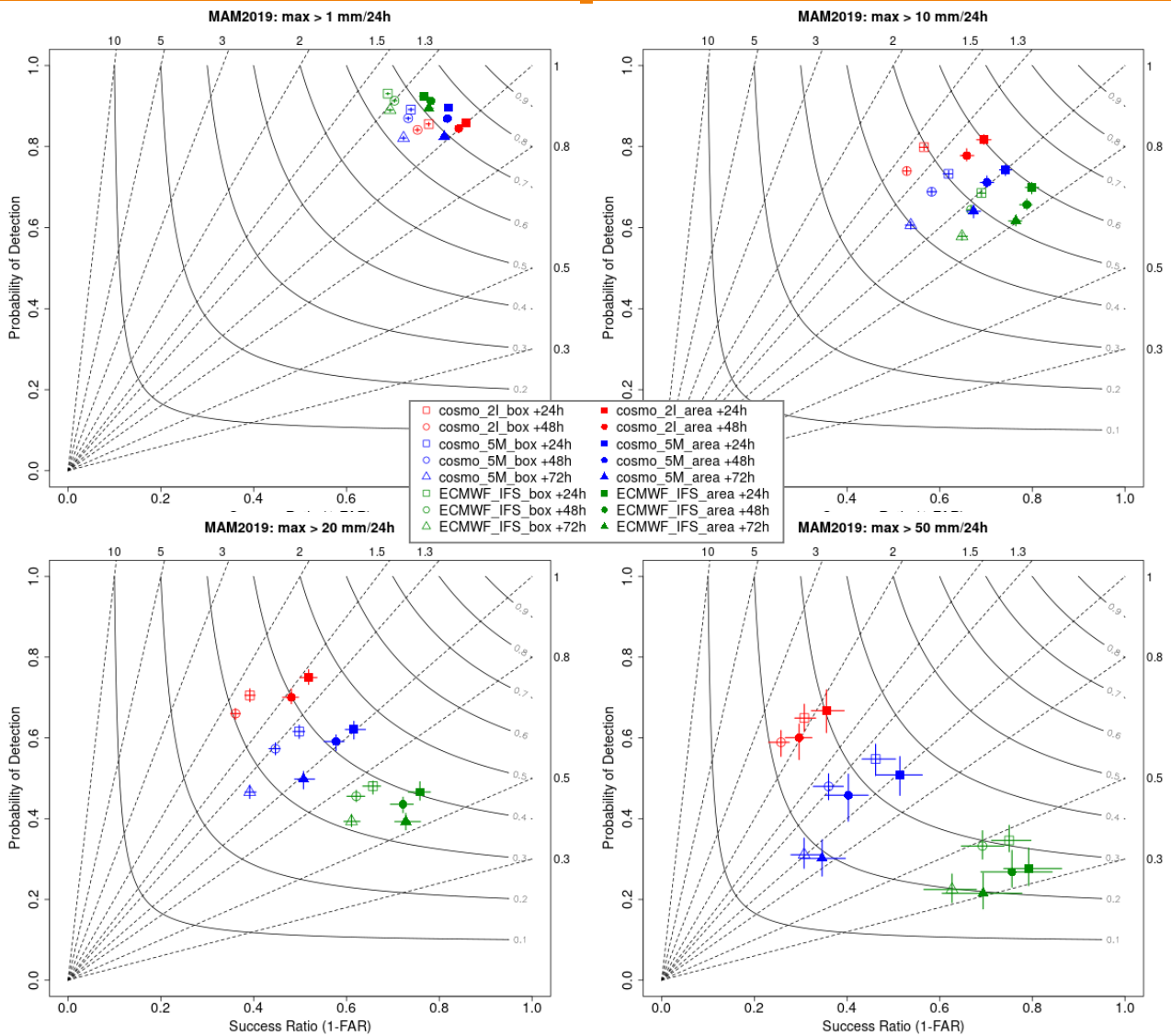
# Comparison between boxes and catchment areas – max of precipitation



❑ BOX 0.25X0.25 DEGREE

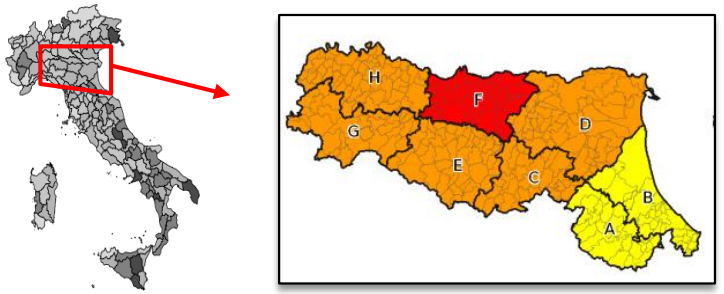


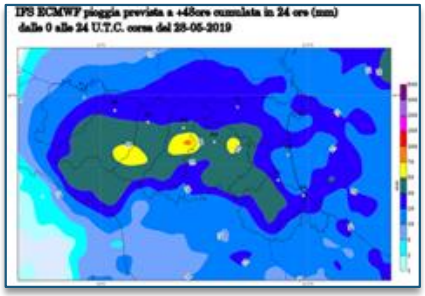
■ CATCHMENT AREA

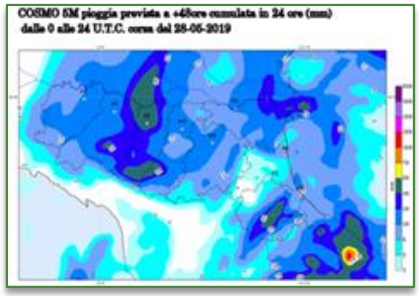


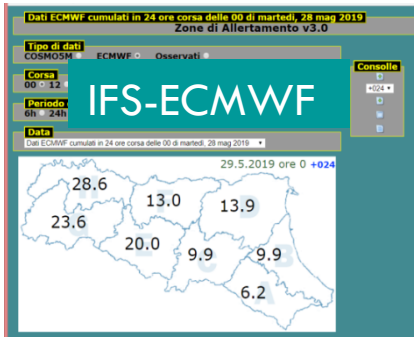
# Operational tools to estimate QPF

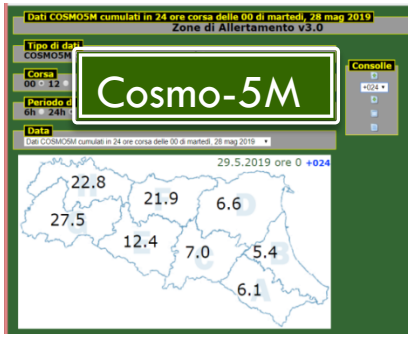
- On a daily basis, summary tables with estimated mean and maximum precipitation over each catchment areas of the Emilia-Romagna region are produced for several deterministic model with different resolutions (COSMO-5M, COSMO-2I or IFS-ECMWF).



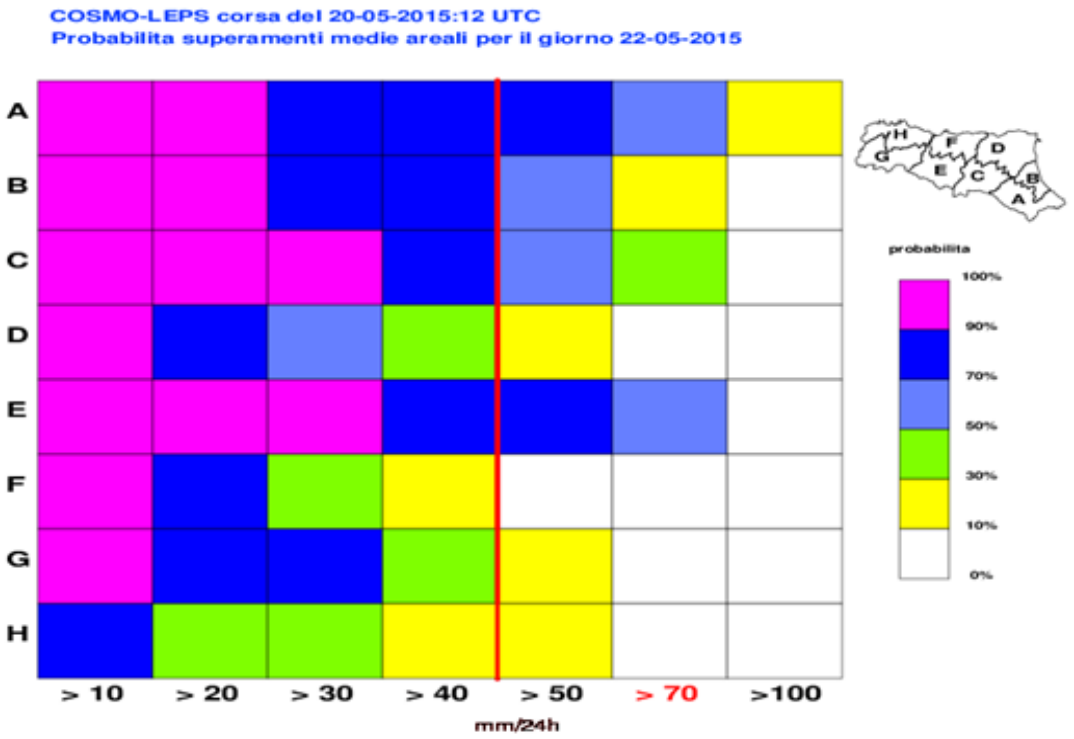




- For each area the return period (or recurrence interval) is reported: exceeding predefined thresholds can give useful indications for situations of intense precipitation possibly leading to floods.

| Area | 2yh6 | 2yh12 | 2yh24 | 2yh48 | 2yh72 | 5yh6 | 5yh12 | 5yh24 | 5yh48 | 5yh72 | 10yh6 | 10yh12 | 10yh24 | 10yh48 | 10yh72 | 20yh6 | 20yh12 | 20yh24 | 20yh48 | 20yh72 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 35 | 46 | 62 | 84 | 100 | 46 | 63 | 84 | 115 | 137 | 54 | 73 | 98 | 131 | 156 | 62 | 83 | 113 | 150 | 178 |
| B | 33 | 43 | 56 | 75 | 88 | 43 | 59 | 77 | 103 | 121 | 51 | 68 | 90 | 118 | 139 | 59 | 78 | 103 | 136 | 159 |
| C | 35 | 48 | 66 | 91 | 109 | 46 | 66 | 90 | 123 | 149 | 54 | 76 | 105 | 141 | 170 | 62 | 86 | 120 | 161 | 193 |
| D | 29 | 38 | 49 | 64 | 74 | 39 | 52 | 67 | 87 | 101 | 45 | 60 | 78 | 99 | 115 | 52 | 68 | 89 | 114 | 132 |
| E | 40 | 55 | 76 | 110 | 135 | 52 | 72 | 100 | 144 | 176 | 60 | 84 | 115 | 166 | 204 | 68 | 95 | 130 | 188 | 230 |
| F | 30 | 38 | 50 | 65 | 76 | 40 | 52 | 67 | 87 | 102 | 47 | 61 | 79 | 103 | 120 | 54 | 70 | 91 | 118 | 138 |
| G | 47 | 64 | 88 | 128 | 157 | 62 | 85 | 115 | 169 | 207 | 72 | 98 | 134 | 197 | 241 | 82 | 112 | 153 | 224 | 275 |
| H | 35 | 45 | 59 | 79 | 93 | 46 | 61 | 79 | 106 | 125 | 55 | 72 | 93 | 125 | 147 | 63 | 83 | 107 | 144 | 170 |

# Operational tools to estimate QPF

- Using the COSMO-LEPS system we also evaluate the probability of exceeding selected thresholds as average precipitation over the selected catchment areas.
- We don't use thresholds on probability to issue alert, but it help the forecaster to assess confidence in one modeling chain or the other

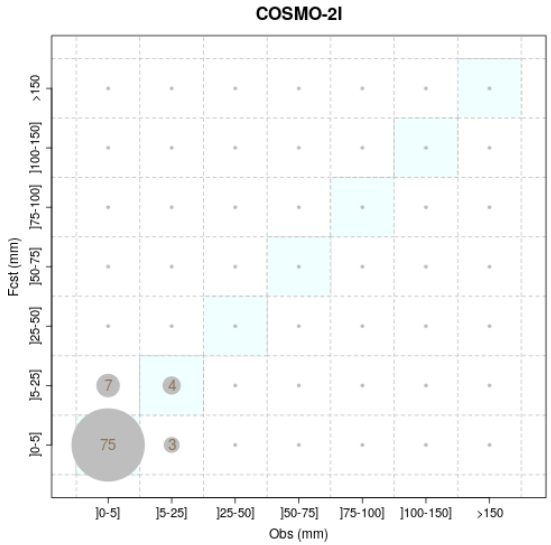


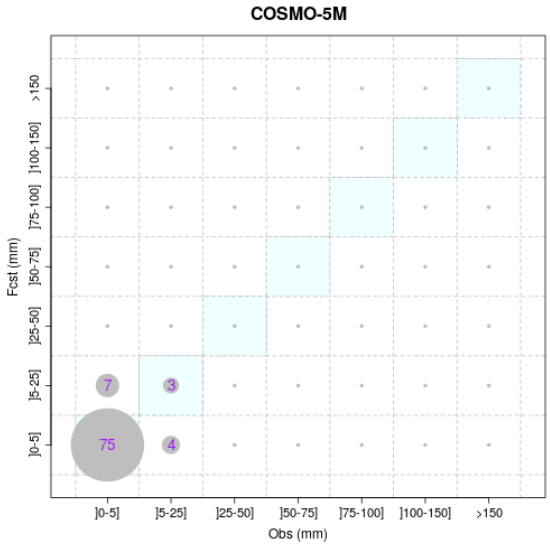

Similar table is available for all the Italian catchment areas

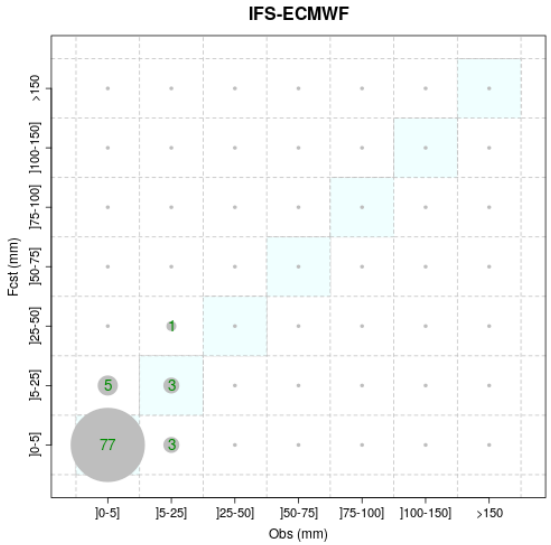
# Evaluation of QPF over a single area

DJF2018-19

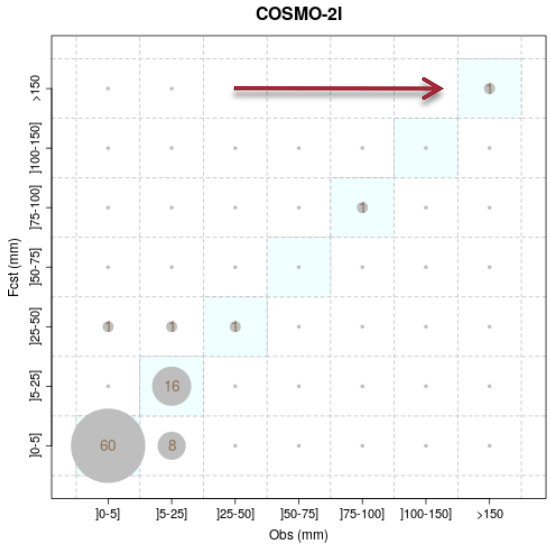
MEAN

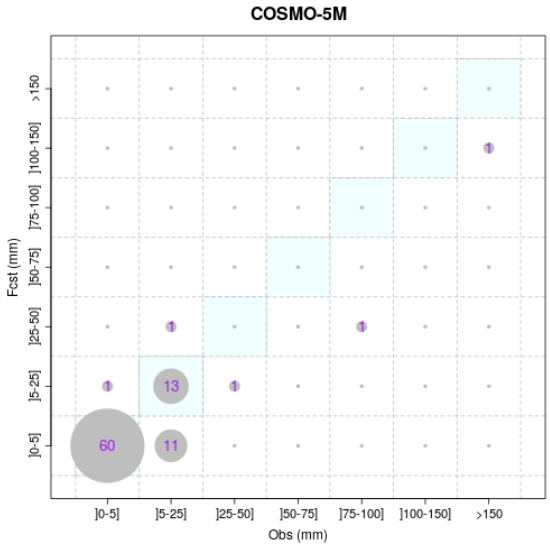


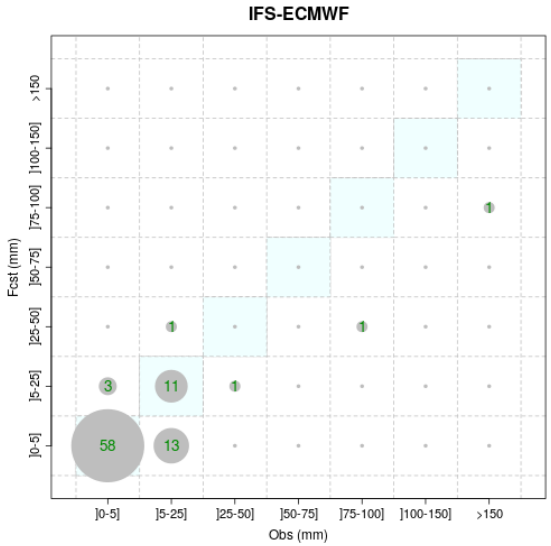




MAX



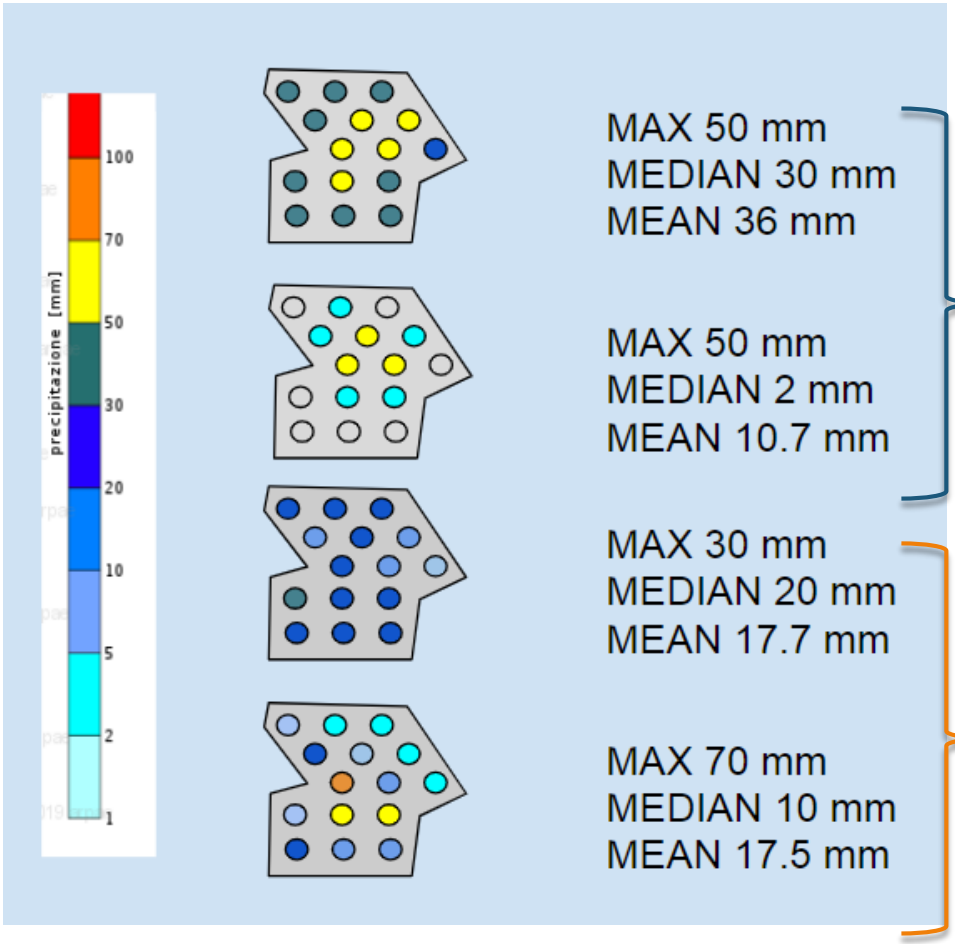



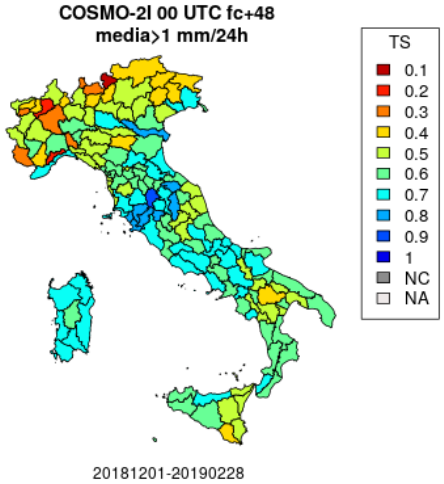
# Operational use of DIST

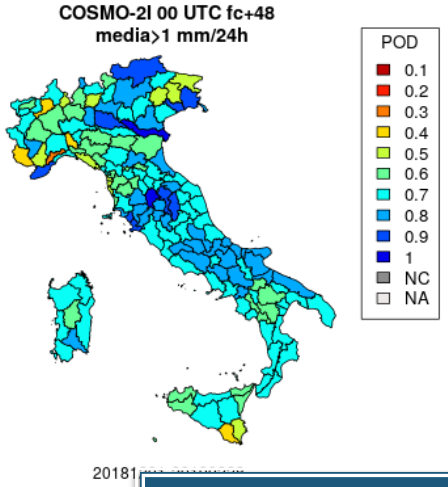
- The verification is performed evaluating some characteristics of the precipitation field:
  - Average
    - It can be used to investigate the ability of models in reproducing different amounts of precipitation
  - Maximum
    - The use of the maximum of precipitation over the areas can provide some information on high precipitation, even if not in the correct location but in the neighborhood, represented by the catchment area.
  - Median & Maximum
    - The combination of a condition on the median and one on the maximum of precipitation can separate high localized precipitation from extensive precipitation.

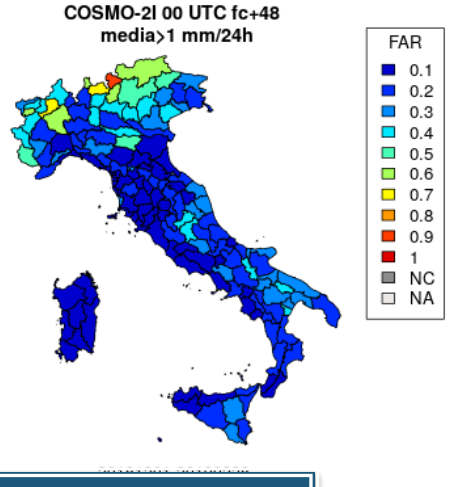
# Examples of precipitation distribution over an area

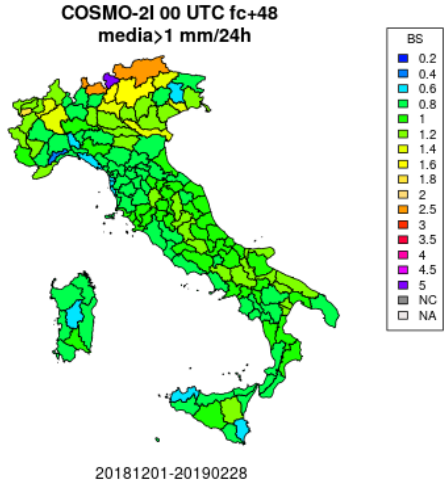


## THRESHOLD 1 mm/24h

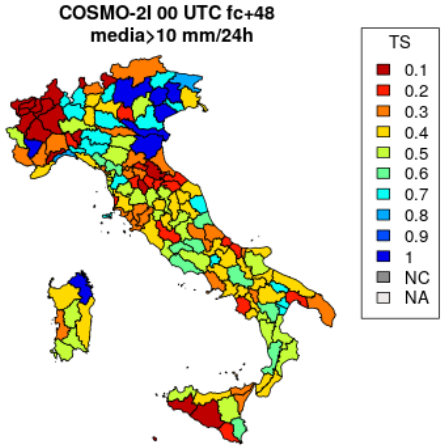


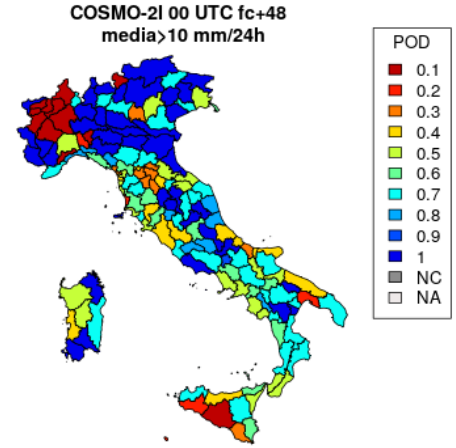



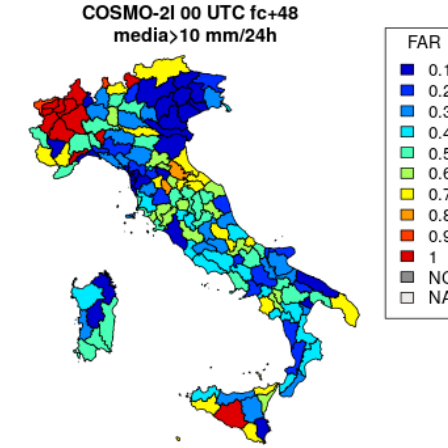



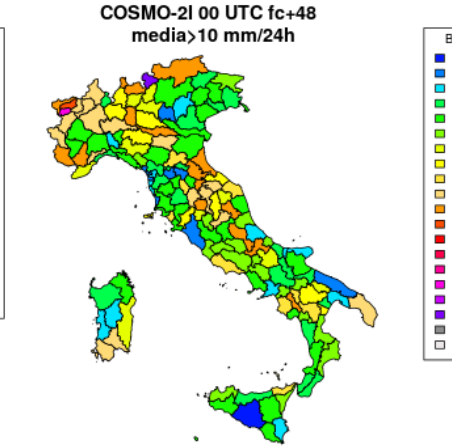




## THRESHOLD 10 mm/24h



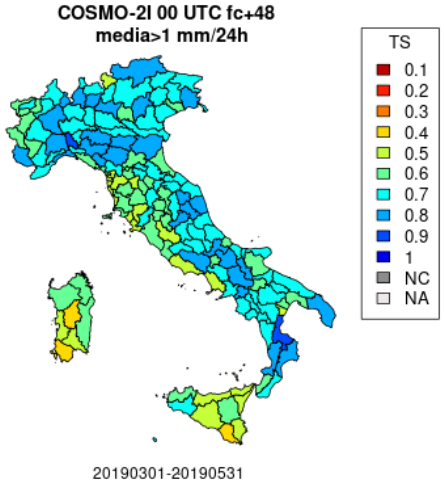



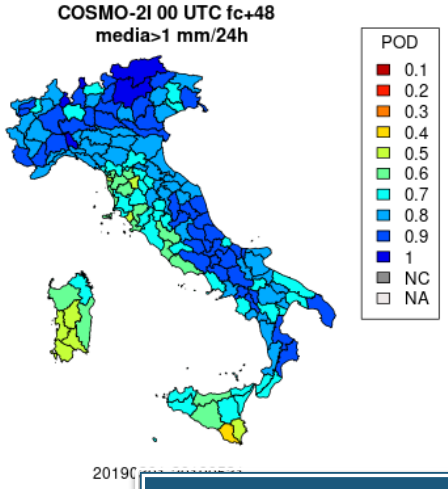

THREAT SCORE | POD | FAR | BIAS SCORE

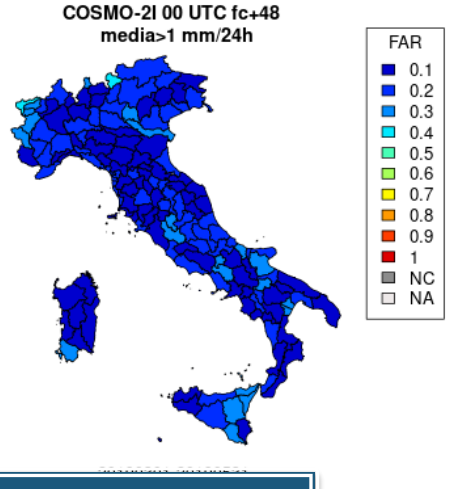
# AVERAGE

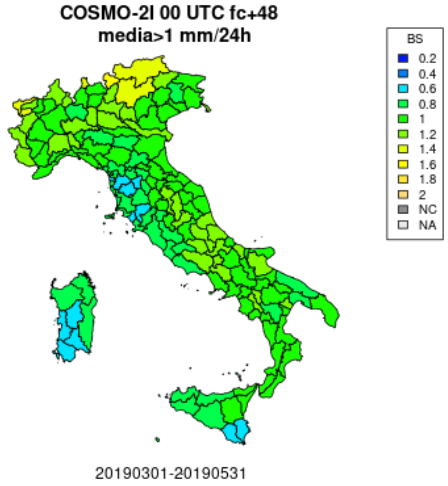
COSMO-2I DJF2018-19 fc+48

## THRESHOLD 1 mm/24h

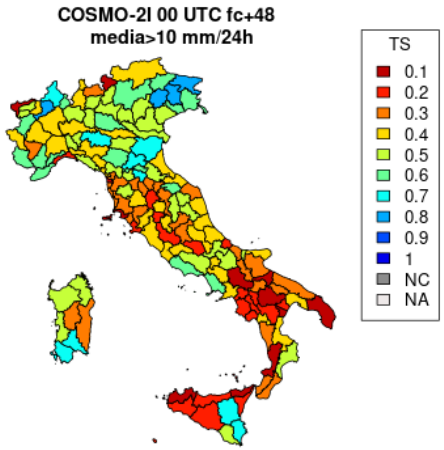


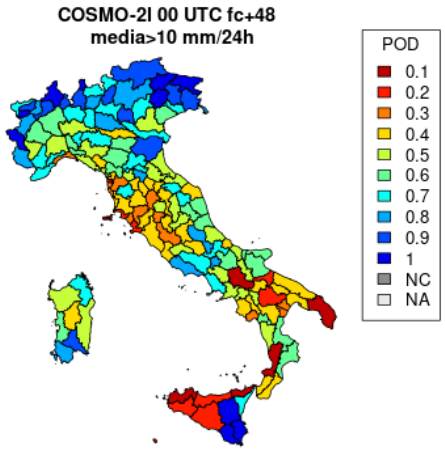



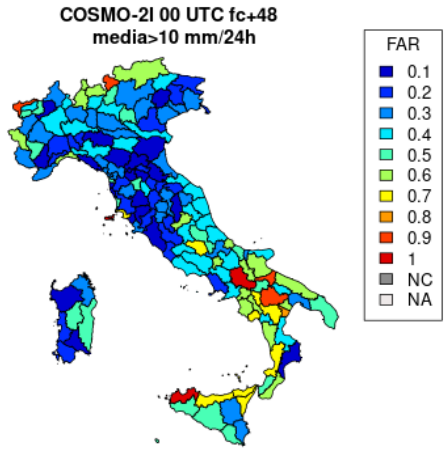



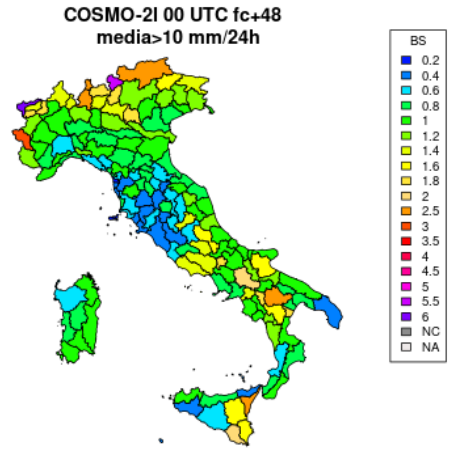




## THRESHOLD 10 mm/24h




THREAT SCORE

POD

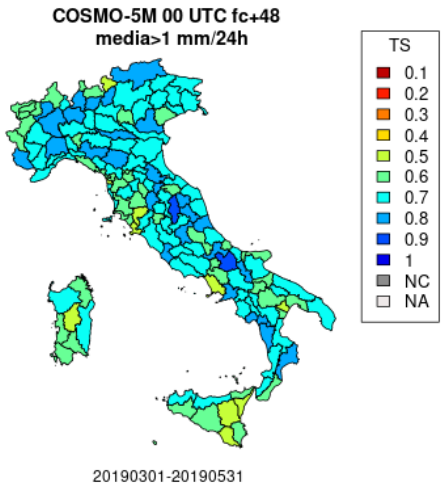
FAR

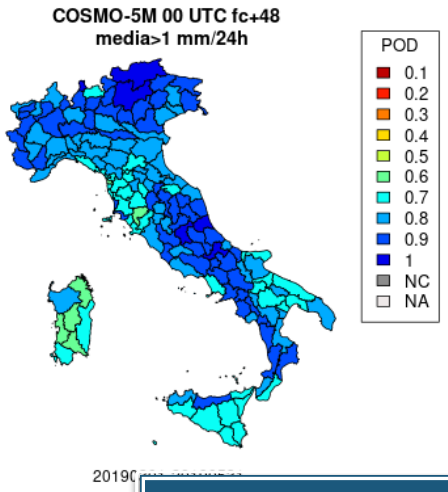
BIAS SCORE

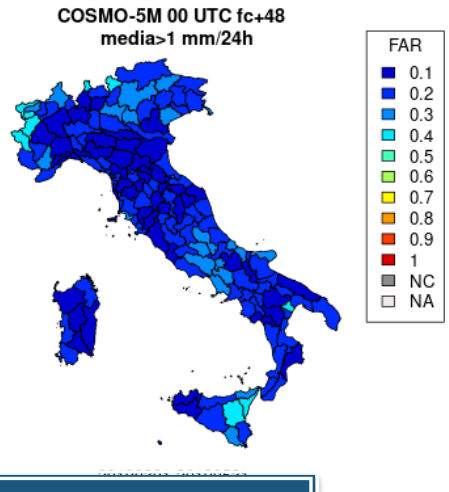
# AVERAGE

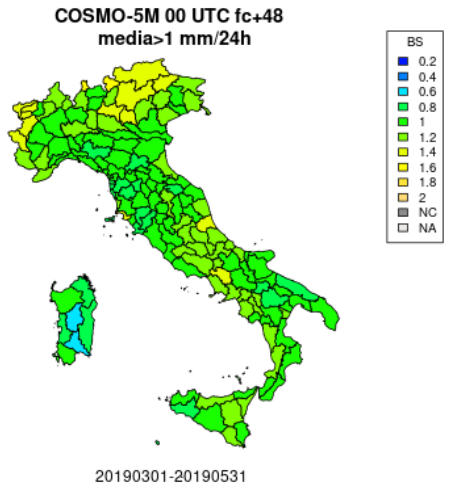
COSMO-2I MAM2019 fc+48

## THRESHOLD 1 mm/24h

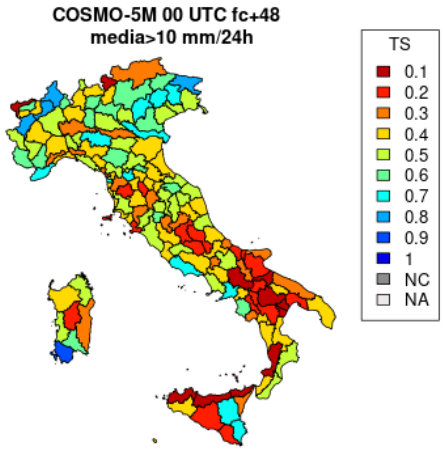


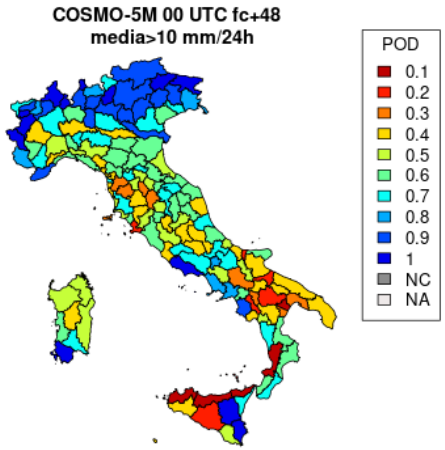



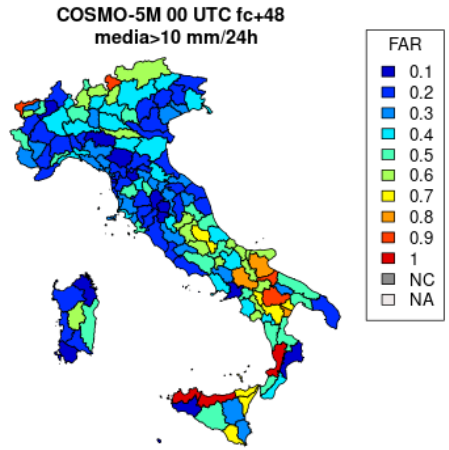



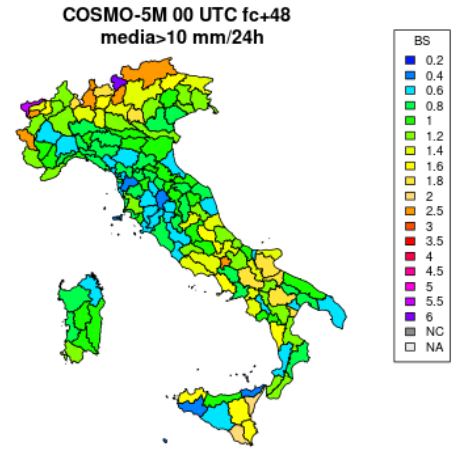




## THRESHOLD 10 mm/24h




THREAT SCORE

POD

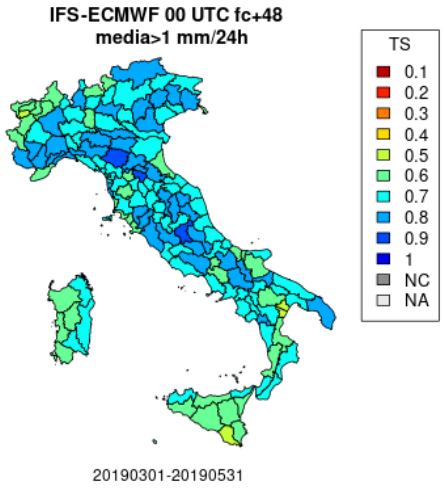
FAR

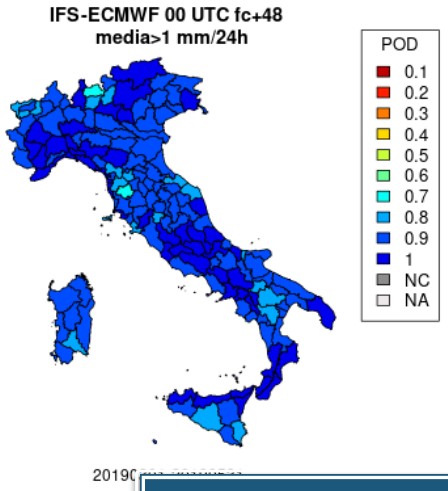
BIAS SCORE

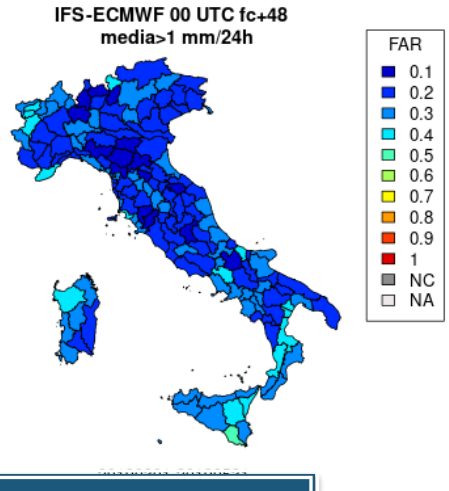
# AVERAGE

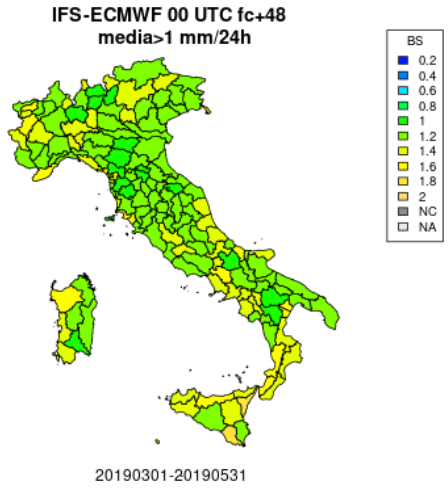
COSMO-5M MAM2019 fc+48

## THRESHOLD 1 mm/24h

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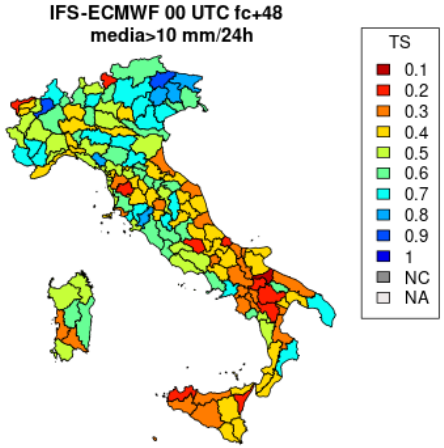
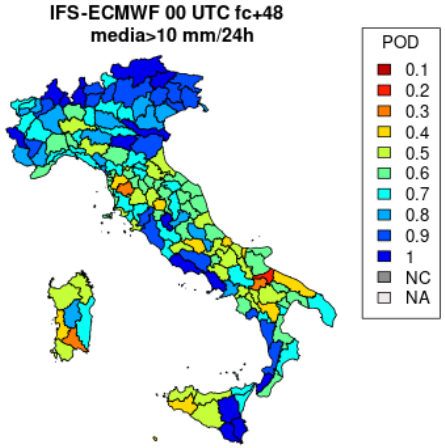
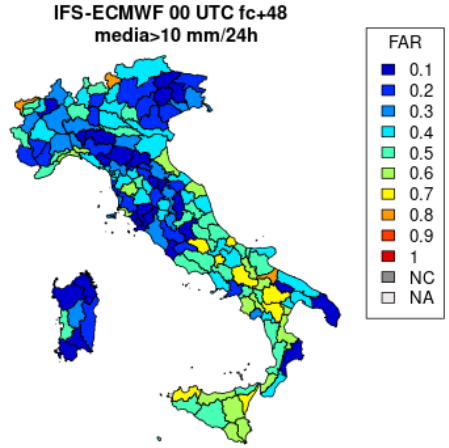
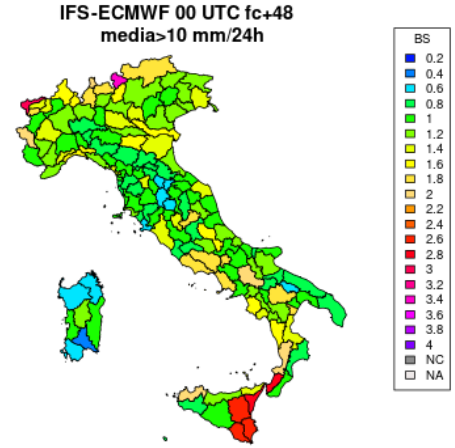



THREAT SCORE

POD

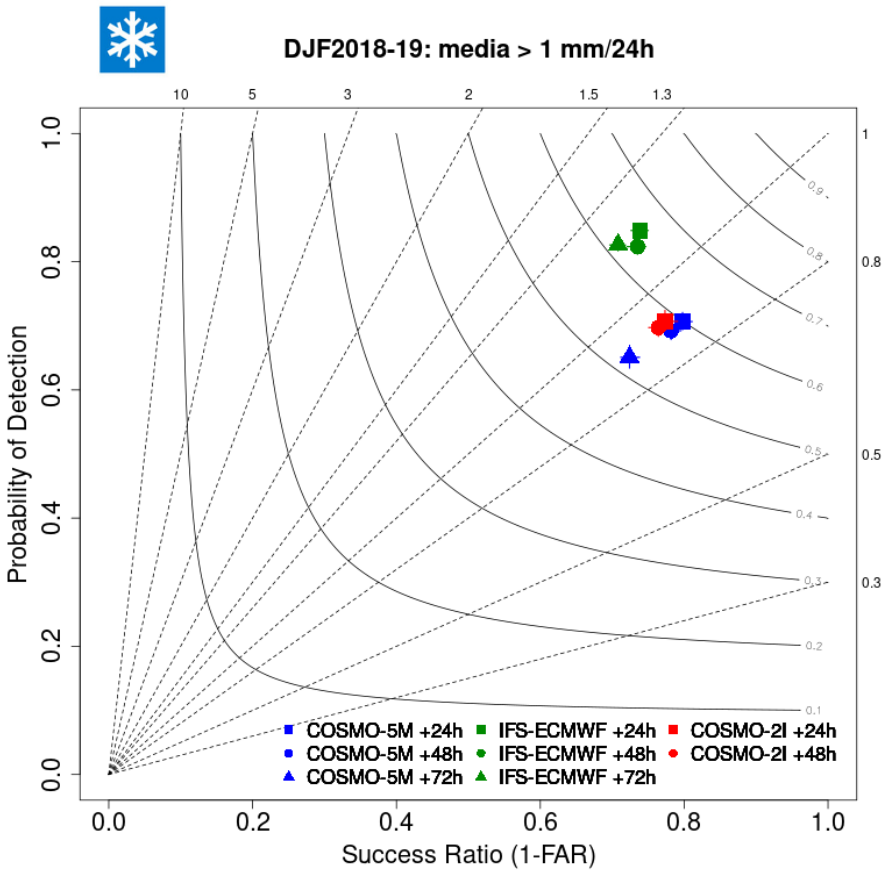
FAR

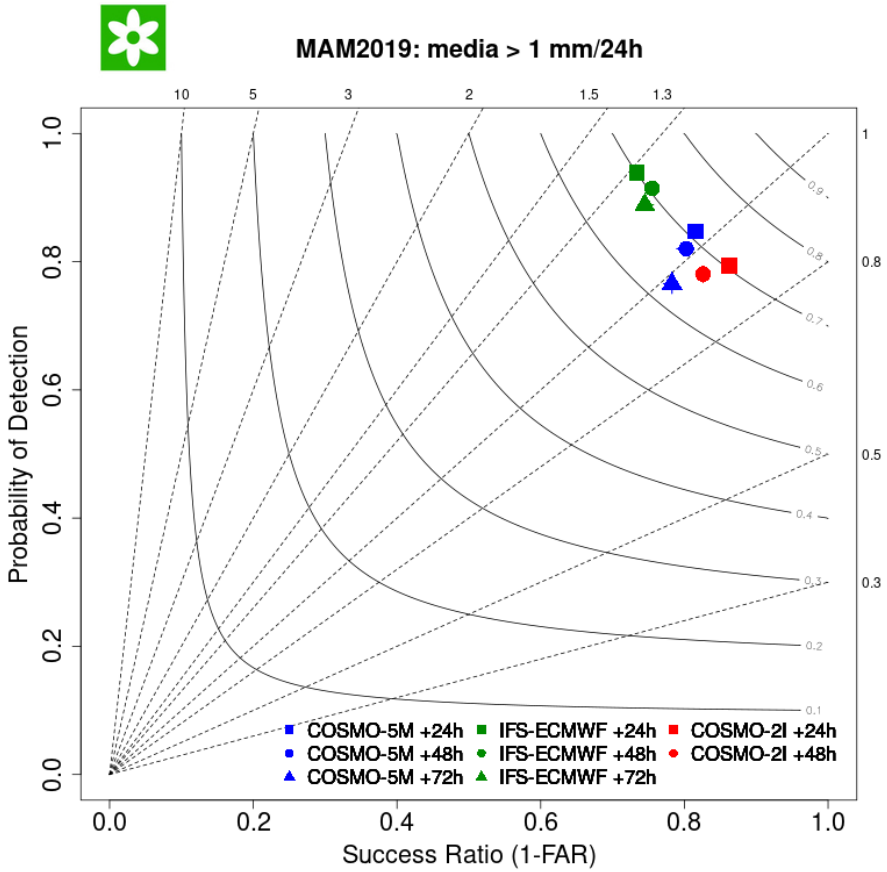
BIAS SCORE

# AVERAGE

IFS-ECMWF MAM2019 fc+48

# Results: all Italian catchment areas

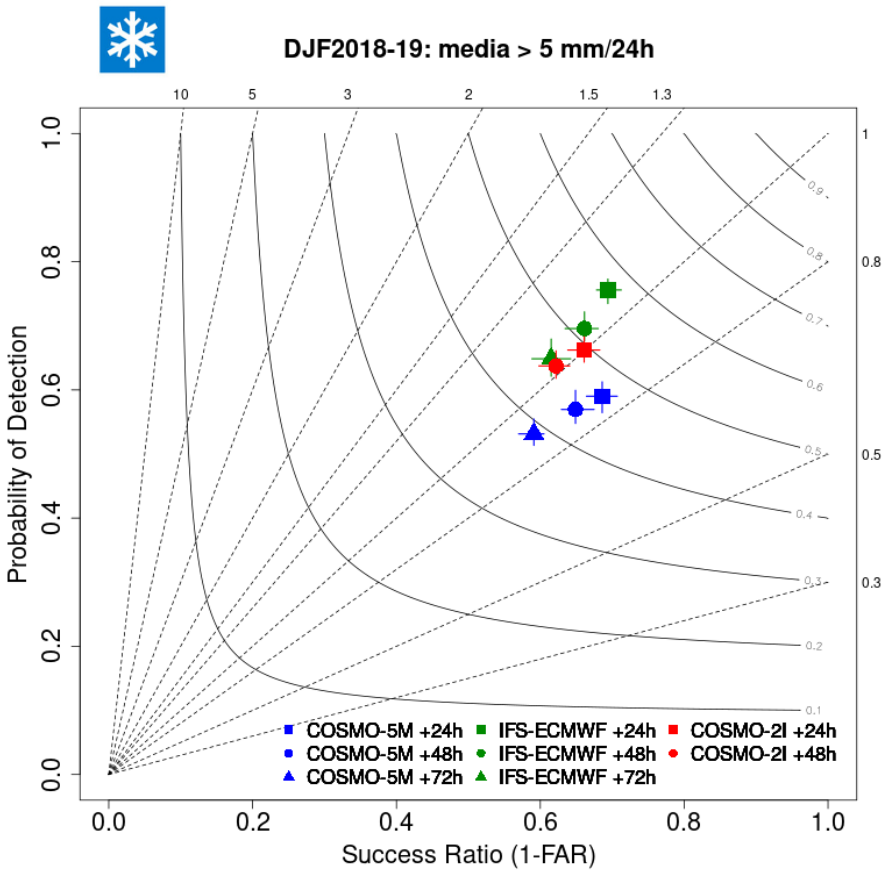


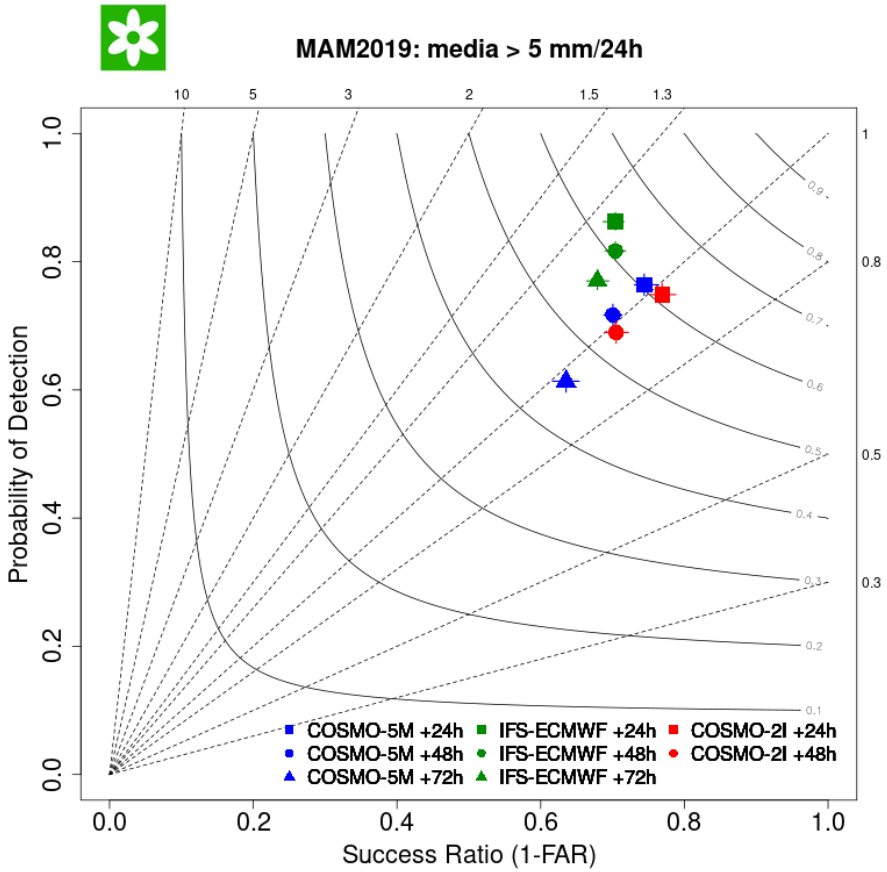




**AVERAGE > 1 mm/24h**

**COSMO-2I (2.2 Km)** ■ +24h
**COSMO-5M (5.0 Km)** ● +48h
**IFS-ECMWF (~9 Km)** ▲ +72h

# Results: all Italian catchment areas

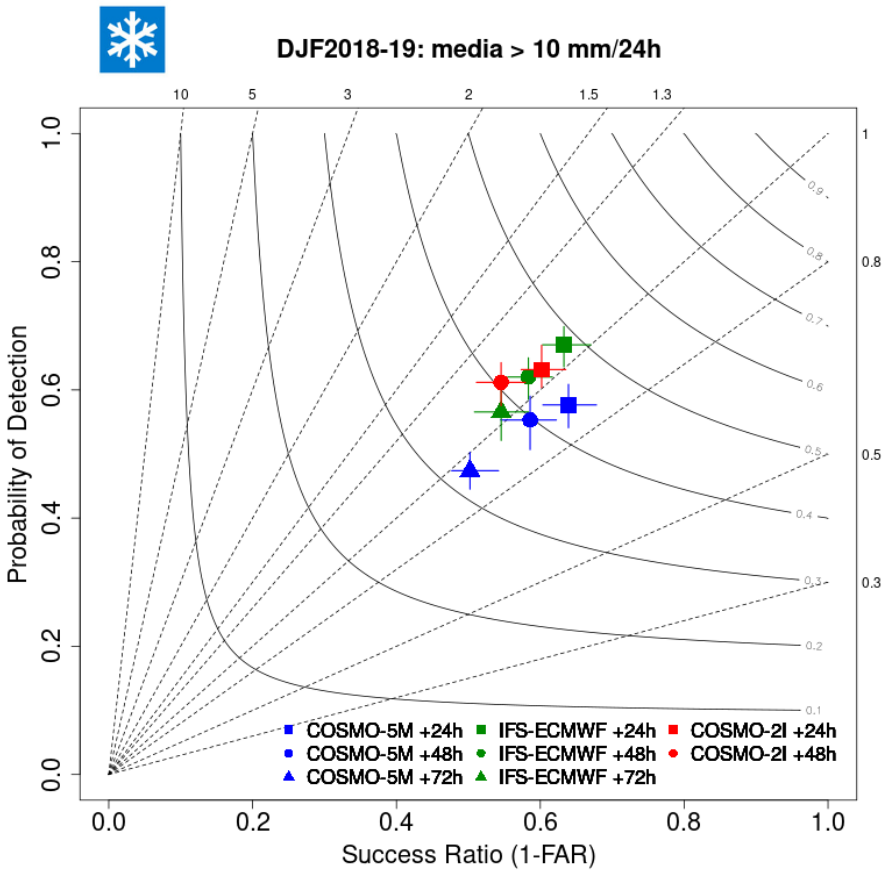


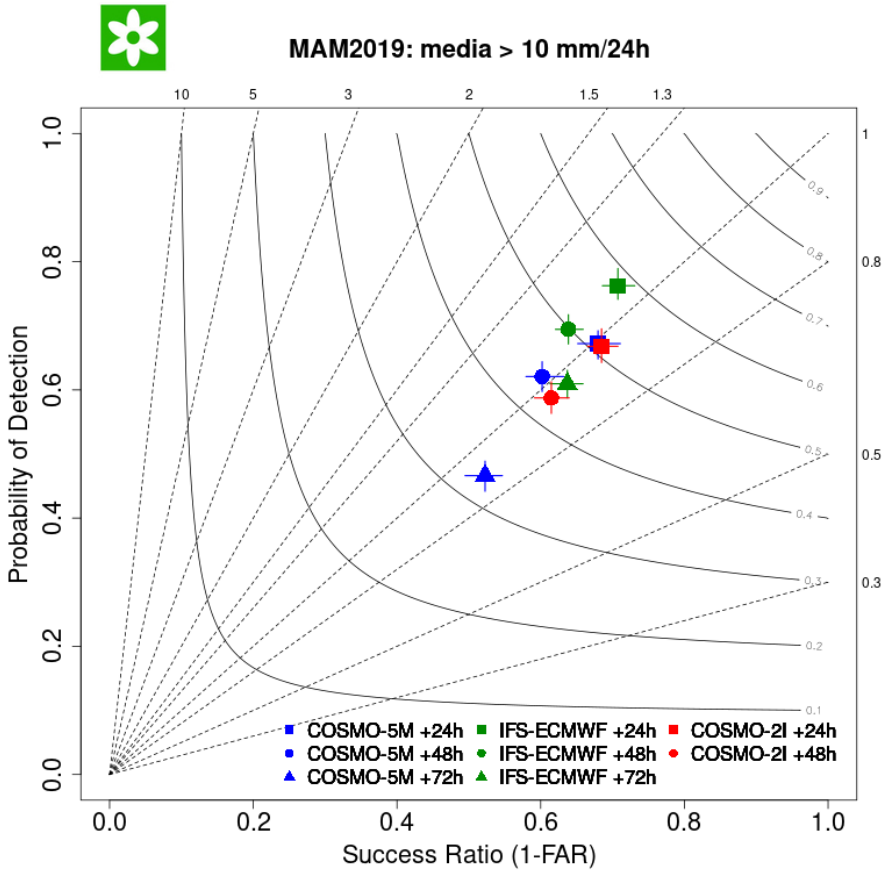




**AVERAGE > 5 mm/24h**

**COSMO-2I (2.2 Km)** ■ +24h
**COSMO-5M (5.0 Km)** ● +48h
**IFS-ECMWF (~9 Km)** ▲ +72h

# Results: all Italian catchment areas

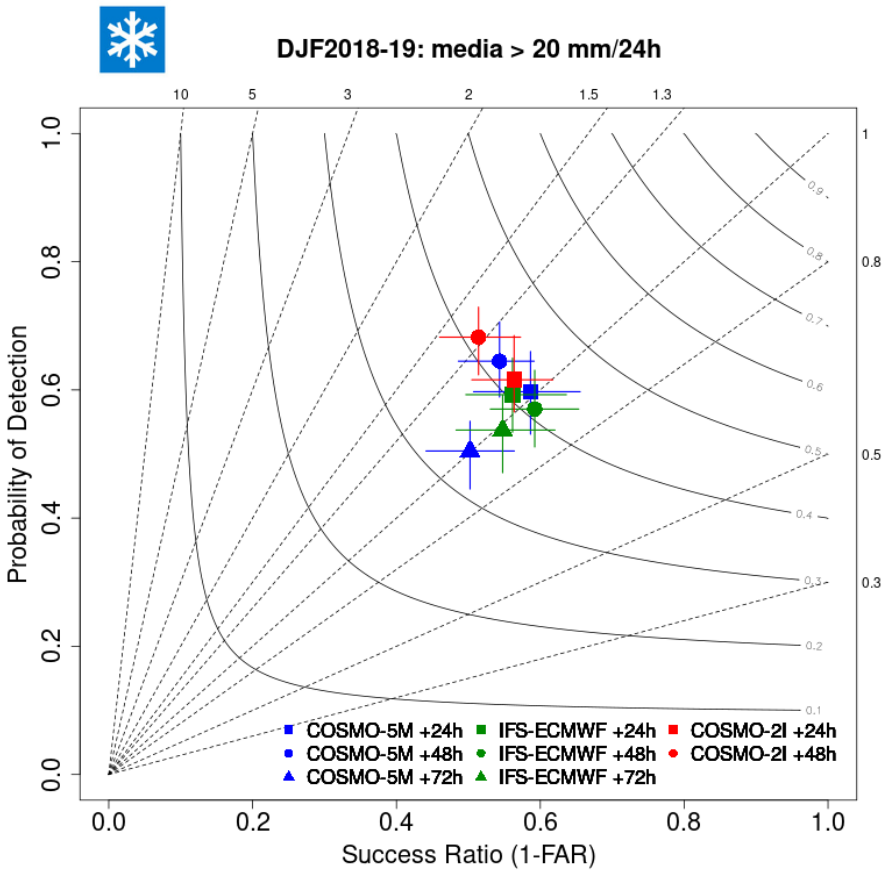


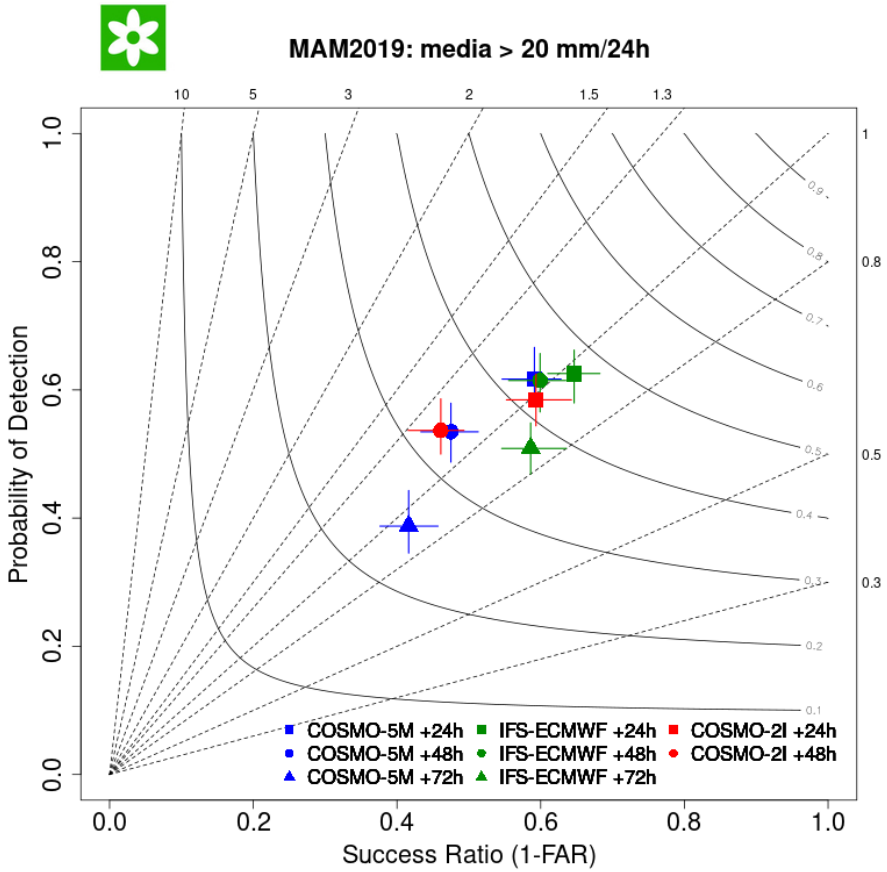




**AVERAGE > 10 mm/24h**

**COSMO-2I (2.2 Km)** ■ +24h
**COSMO-5M (5.0 Km)** ● +48h
**IFS-ECMWF (~9 Km)** ▲ +72h

# Results: all Italian catchment areas

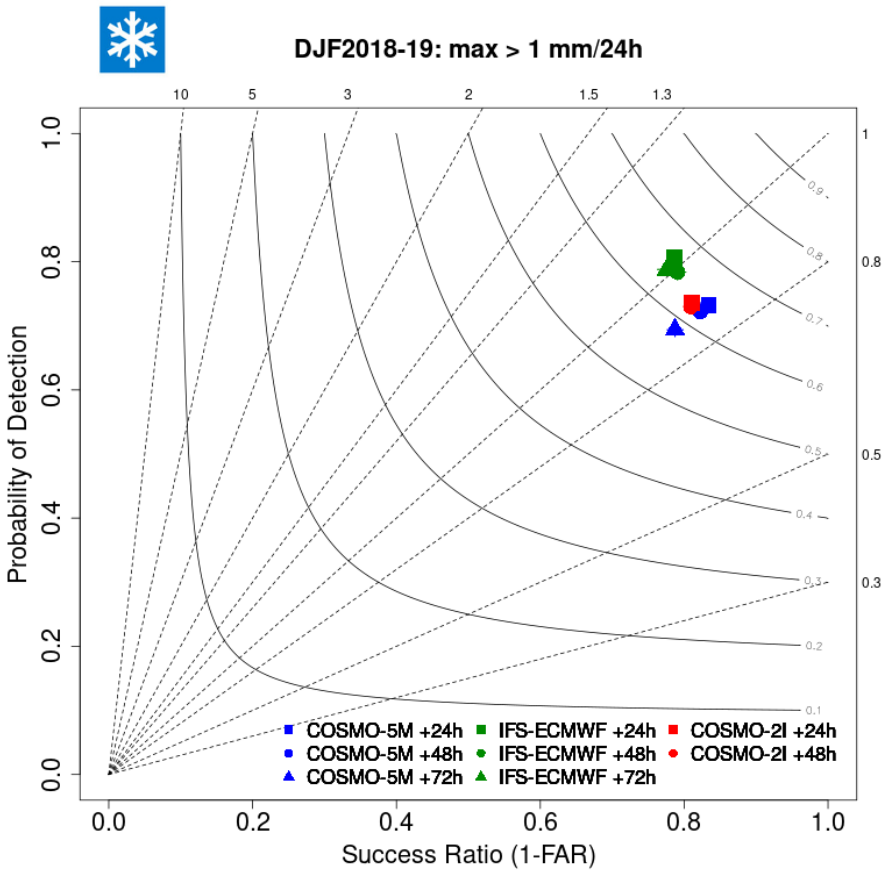


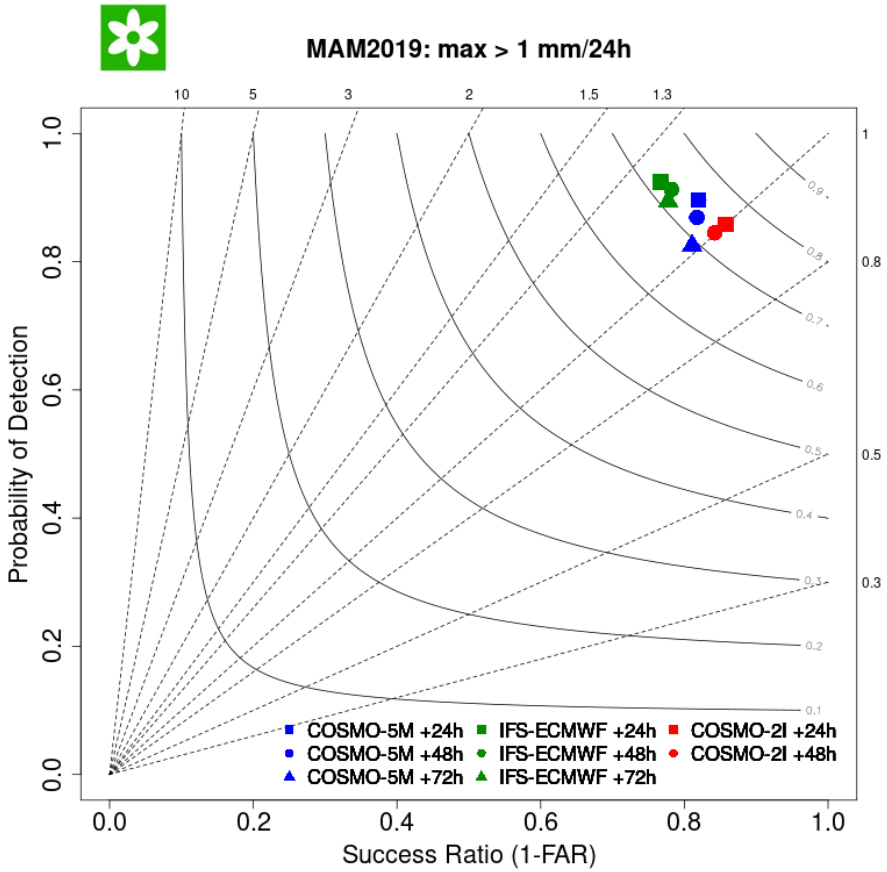




**AVERAGE > 20 mm/24h**

**COSMO-2I (2.2 Km)** ■ +24h
**COSMO-5M (5.0 Km)** ● +48h
**IFS-ECMWF (~9 Km)** ▲ +72h

# Results: all Italian catchment areas

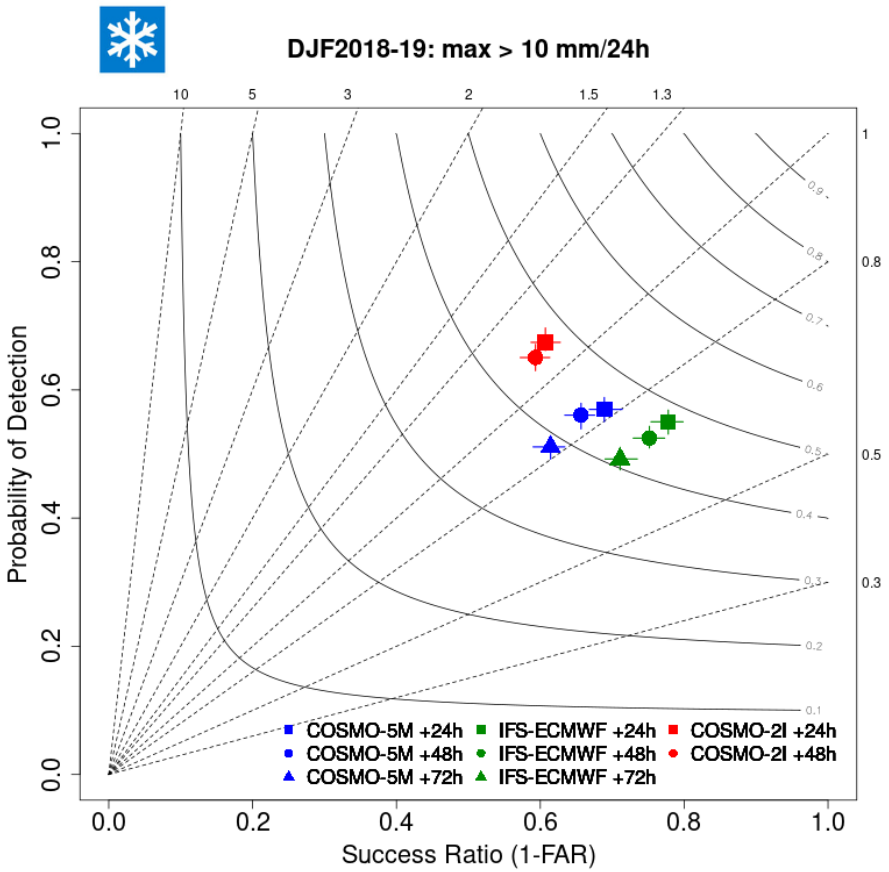


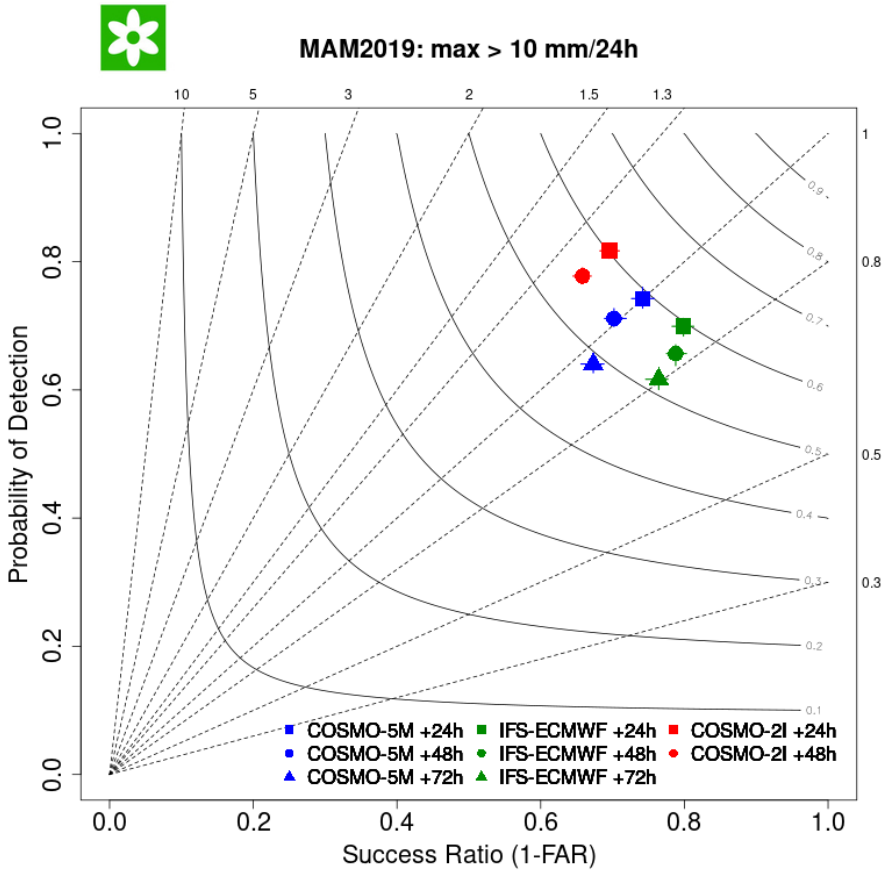




**MAX> 1 mm/24h**

**COSMO-2I (2.2 Km)** ■ +24h
**COSMO-5M (5.0 Km)** ● +48h
**IFS-ECMWF (~9 Km)** ▲ +72h

# Results: all Italian catchment areas

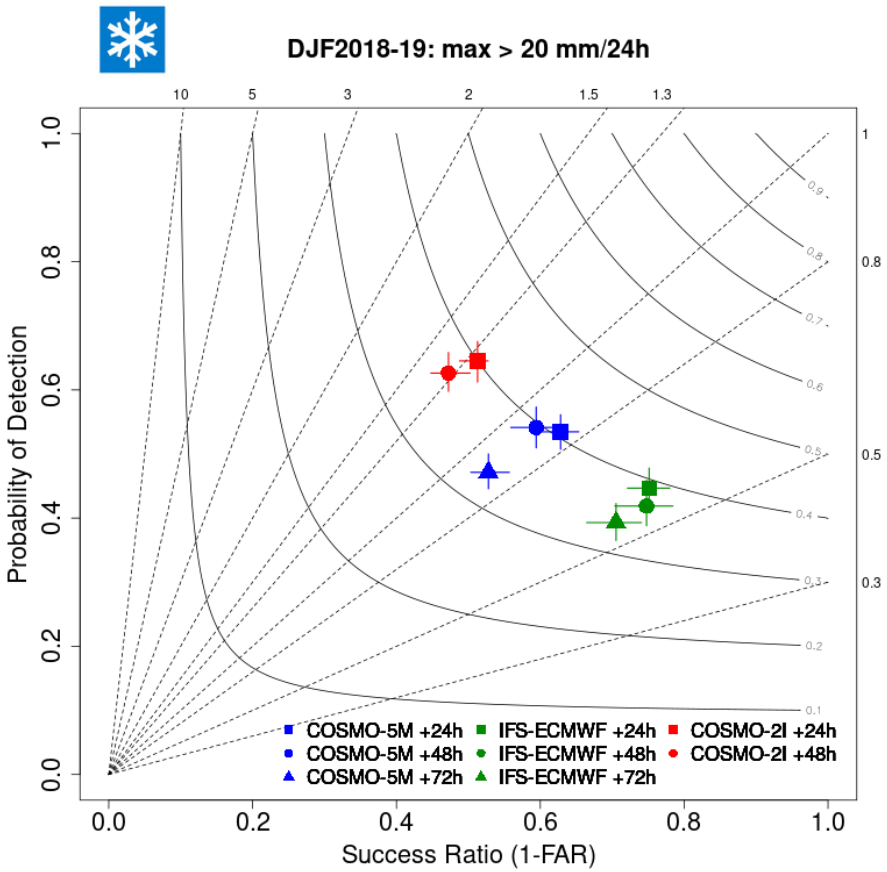


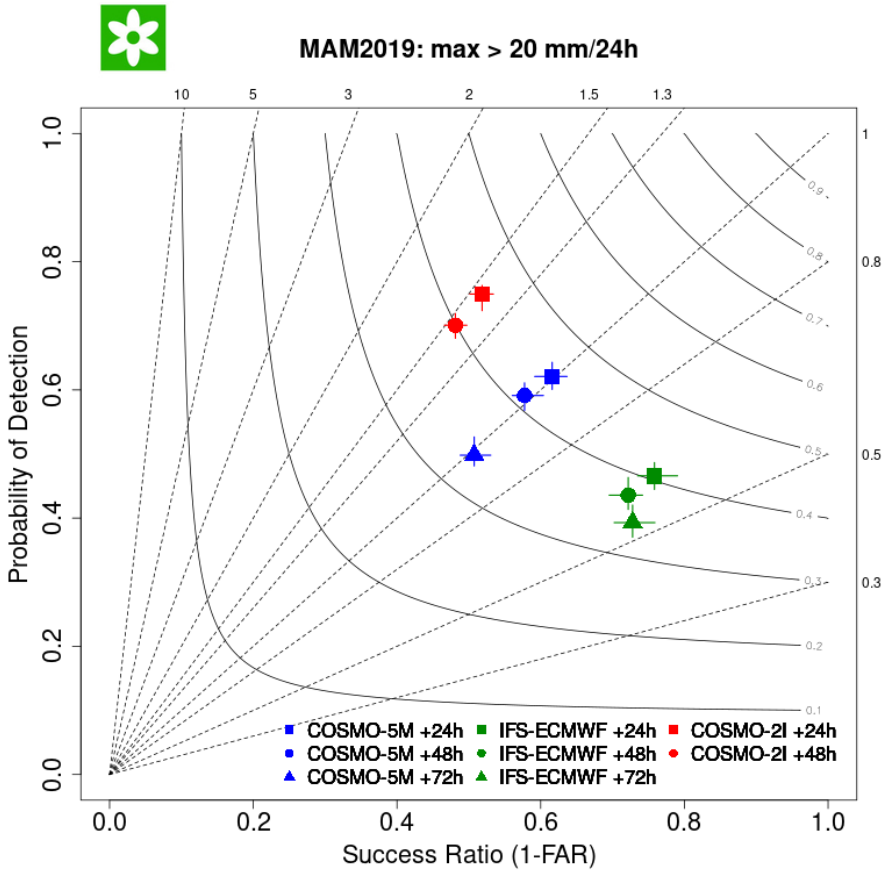




**MAX> 10 mm/24h**

**COSMO-2I (2.2 Km)** ■ +24h
**COSMO-5M (5.0 Km)** ● +48h
**IFS-ECMWF (~9 Km)** ▲ +72h

# Results: all Italian catchment areas

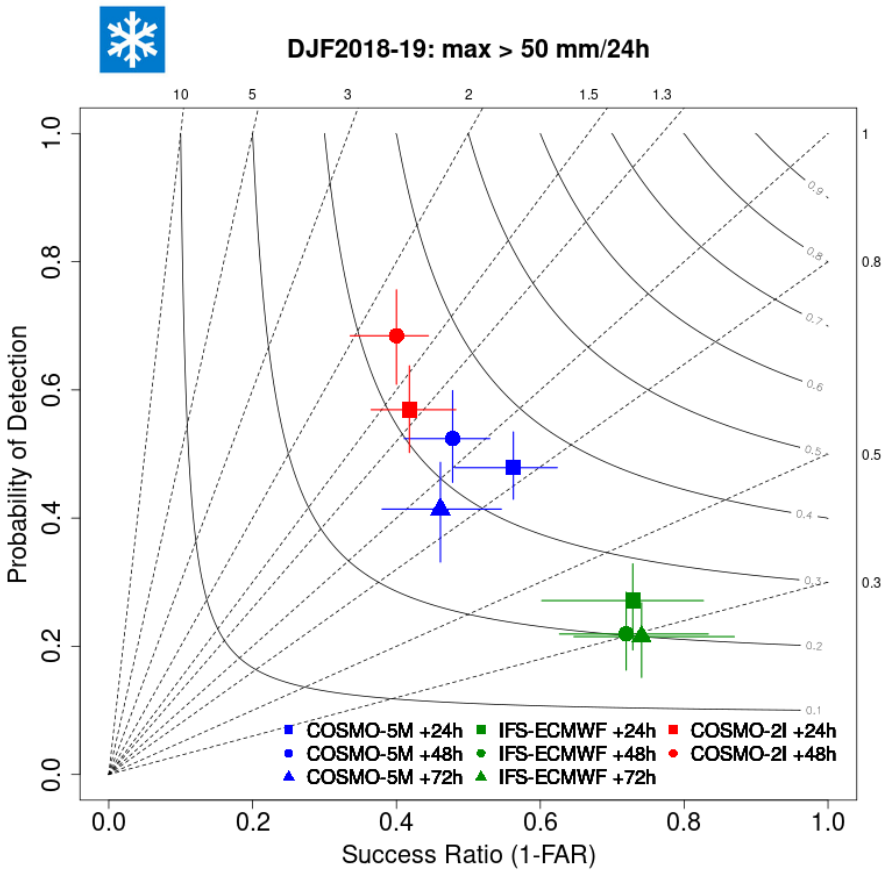


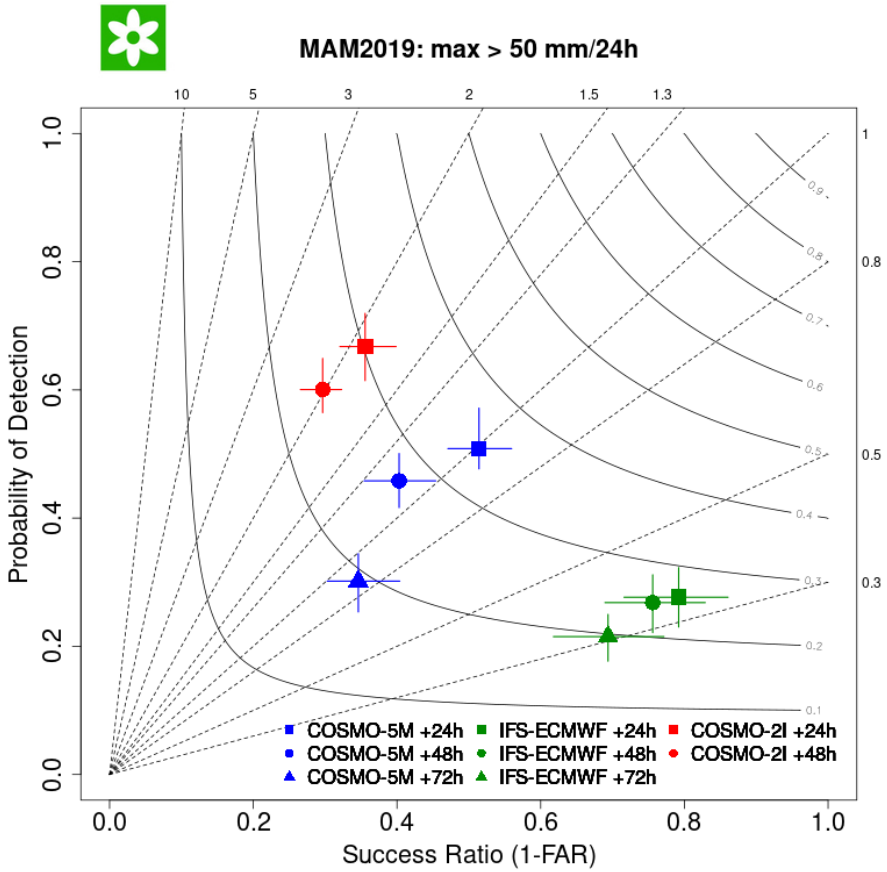




**MAX> 20 mm/24h**

**COSMO-2I (2.2 Km)** ■ +24h
**COSMO-5M (5.0 Km)** ● +48h
**IFS-ECMWF (~9 Km)** ▲ +72h

# Results: all Italian catchment areas

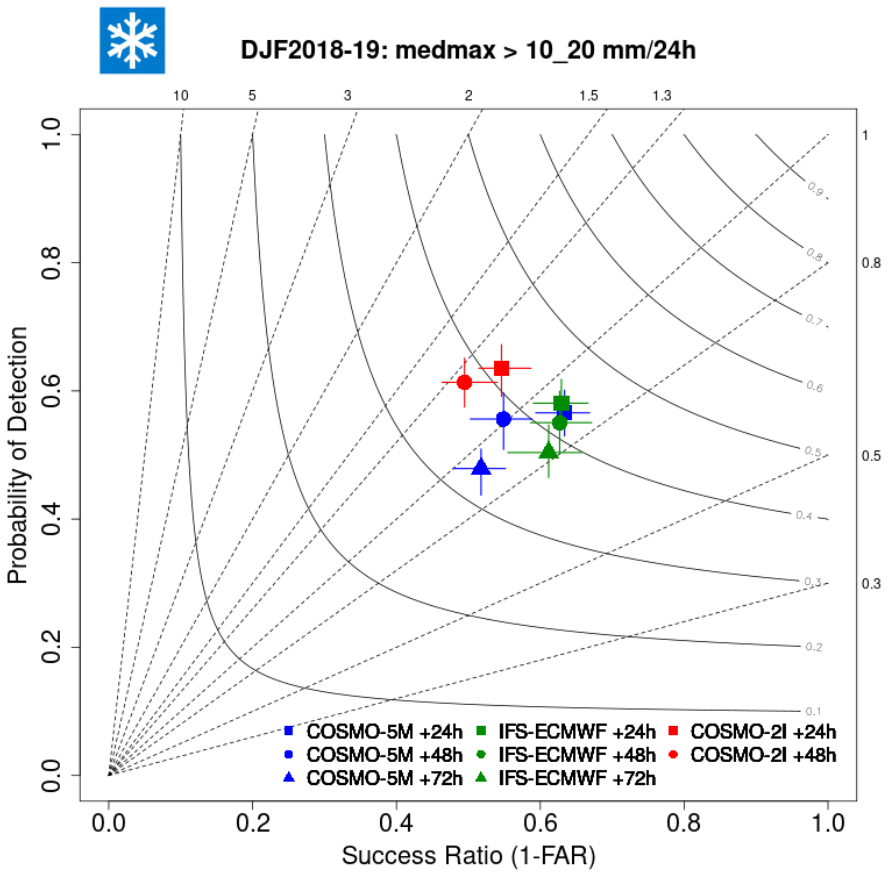


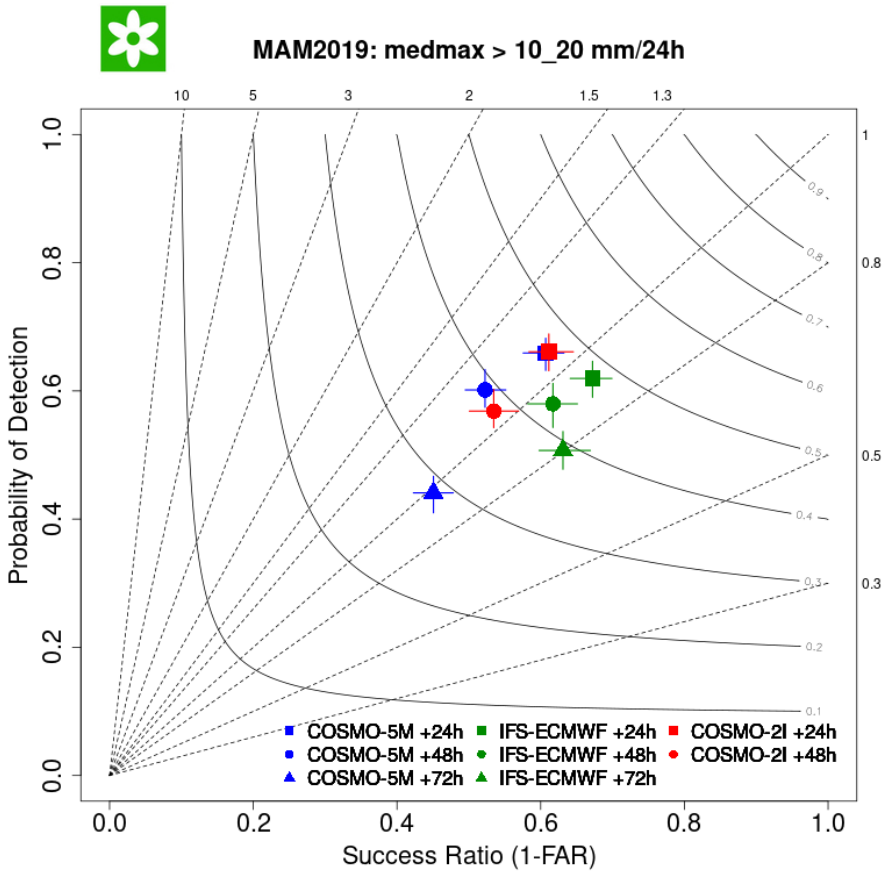




**MAX> 50 mm/24h**

**COSMO-2I (2.2 Km)** ■ +24h
**COSMO-5M (5.0 Km)** ● +48h
**IFS-ECMWF (~9 Km)** ▲ +72h

# Results: all Italian catchment areas

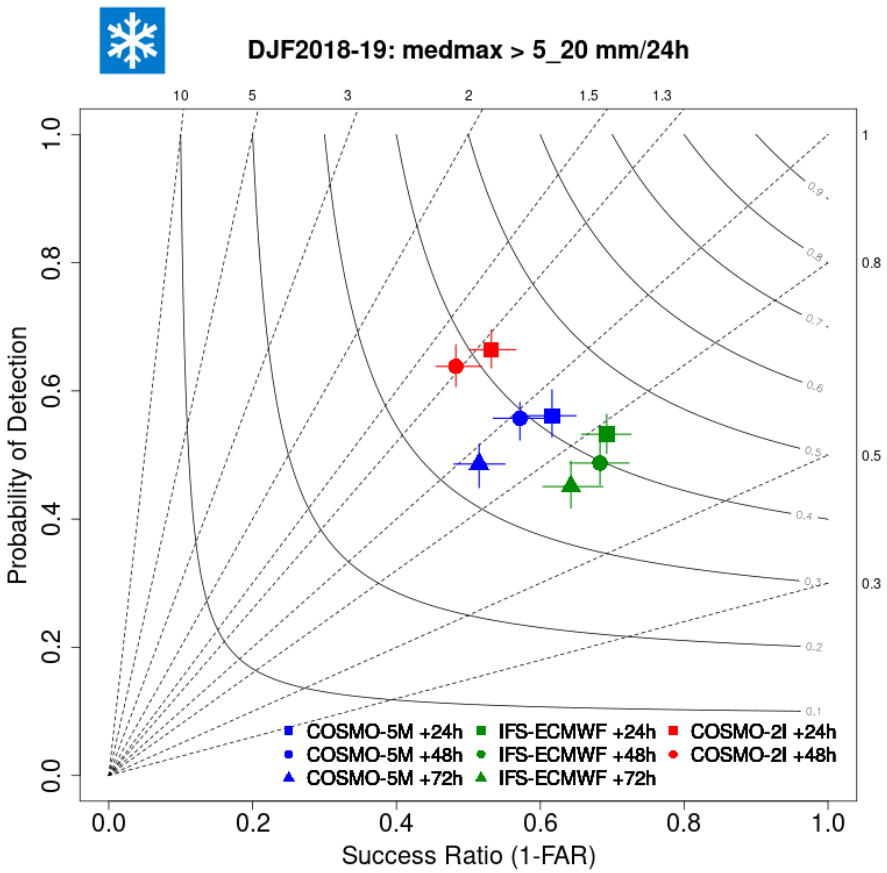


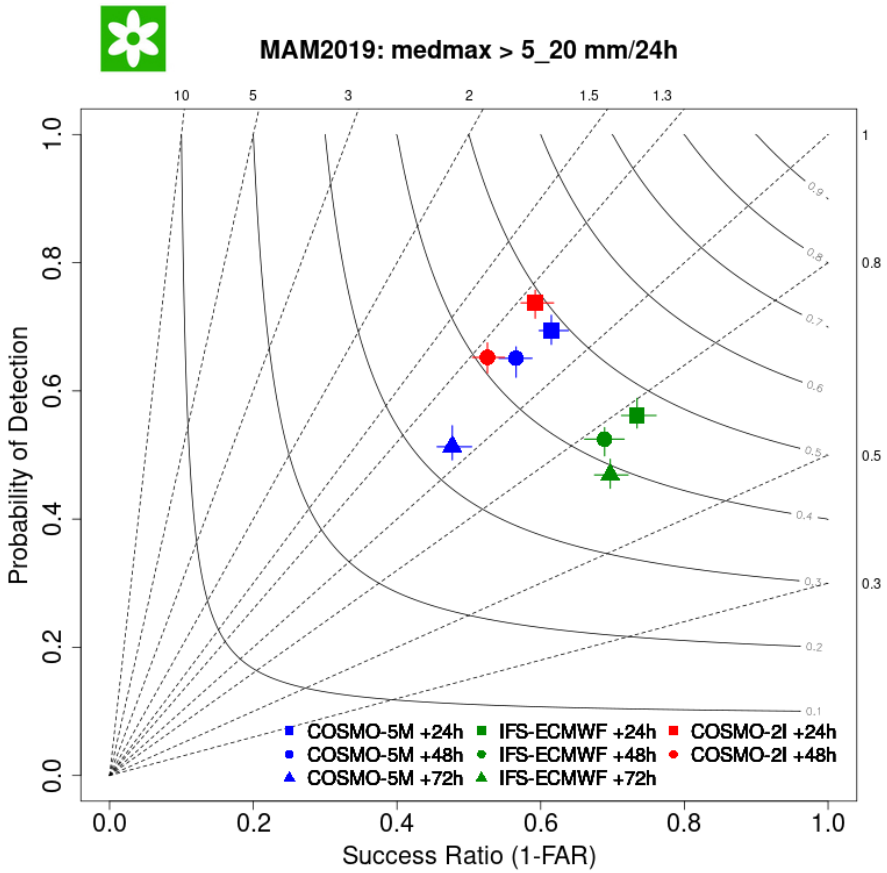




**MAX> 20 mm/24h**
**&**
**MEDIAN > 10 mm/24h**

**COSMO-2I (2.2 Km)** ■ +24h
**COSMO-5M (5.0 Km)** ● +48h
**IFS-ECMWF (~9 Km)** ▲ +72h

# Results: all Italian catchment areas

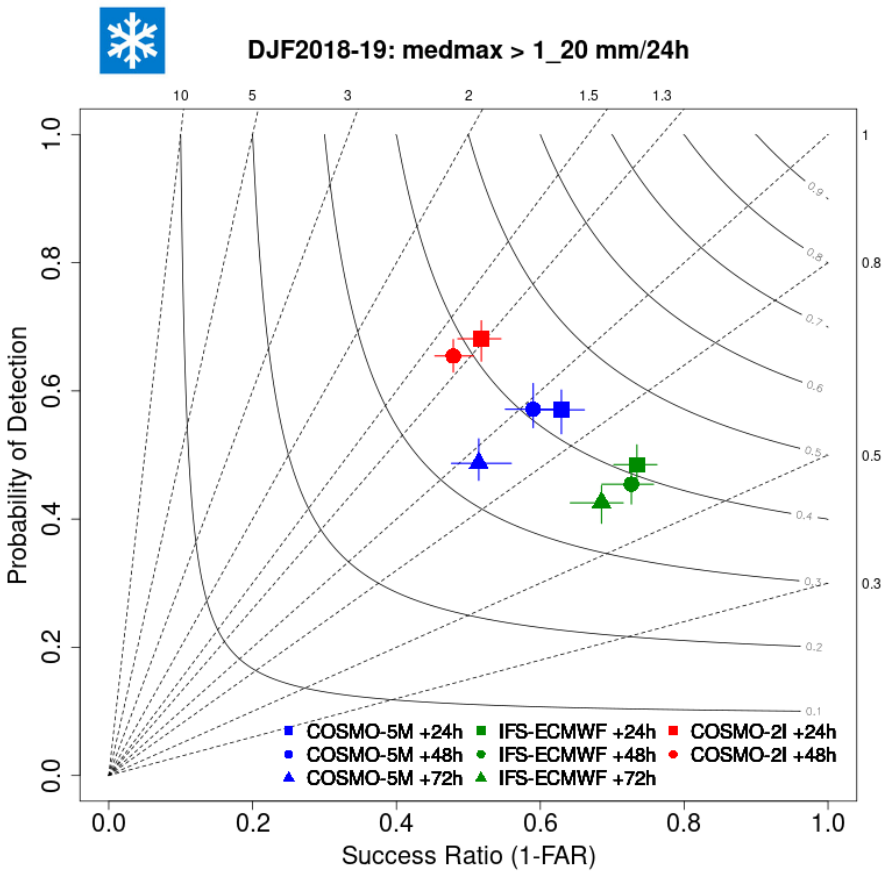


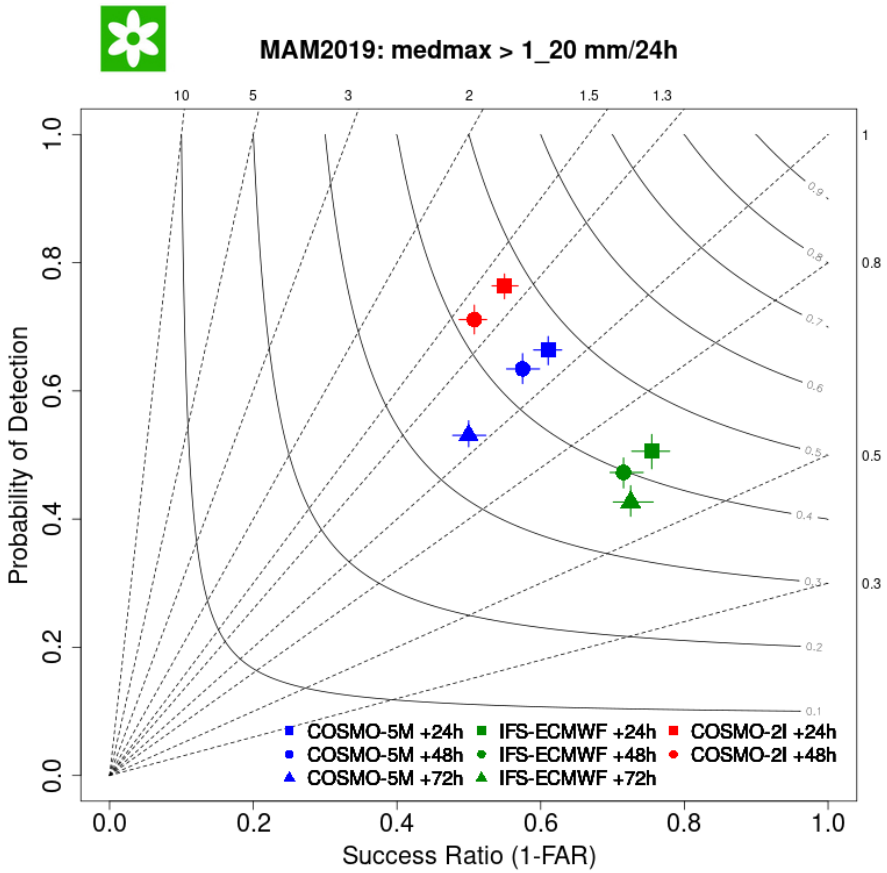




**MAX> 20 mm/24h**
**&**
**MEDIAN > 5 mm/24h**

**COSMO-2I (2.2 Km)** ■ +24h
**COSMO-5M (5.0 Km)** ● +48h
**IFS-ECMWF (~9 Km)** ▲ +72h

# Results: all Italian catchment areas

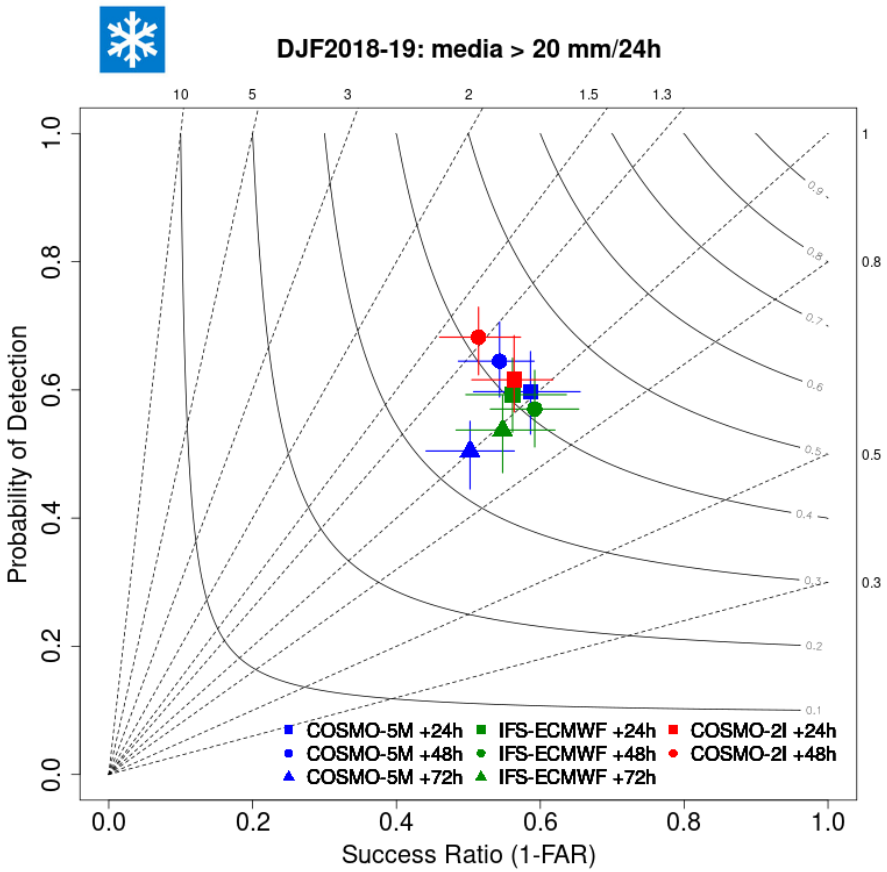


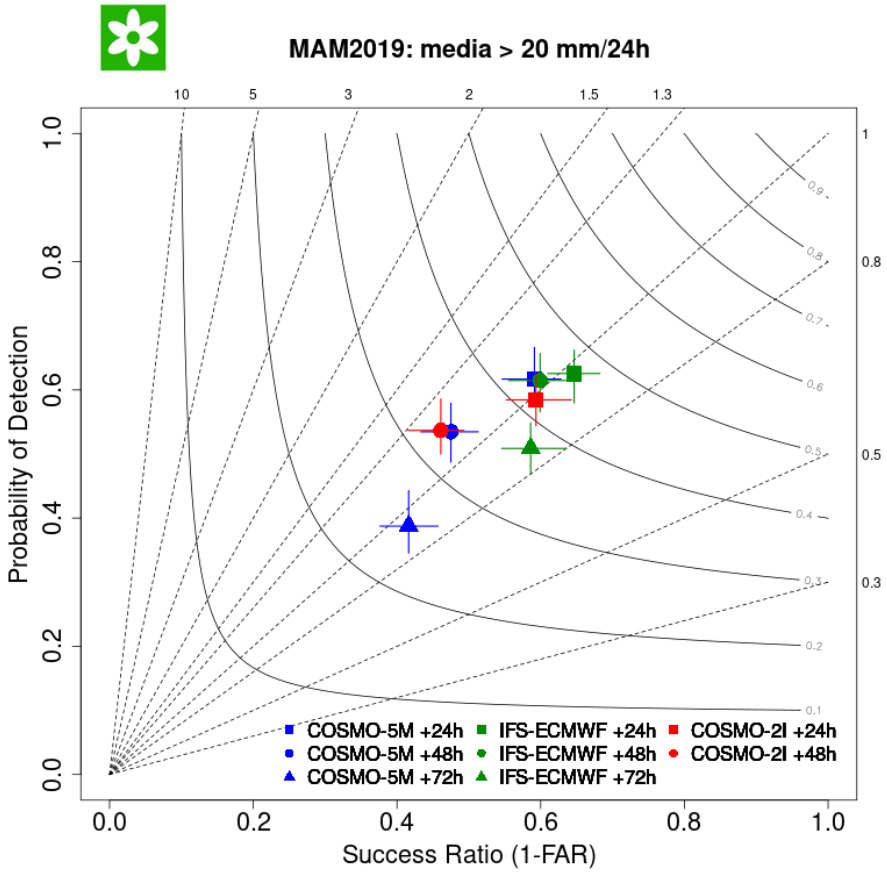




**MAX> 20 mm/24h**
**&**
**MEDIAN > 1 mm/24h**

**COSMO-2I (2.2 Km)** ■ +24h
**COSMO-5M (5.0 Km)** ● +48h
**IFS-ECMWF (~9 Km)** ▲ +72h

# Results: all Italian catchment areas

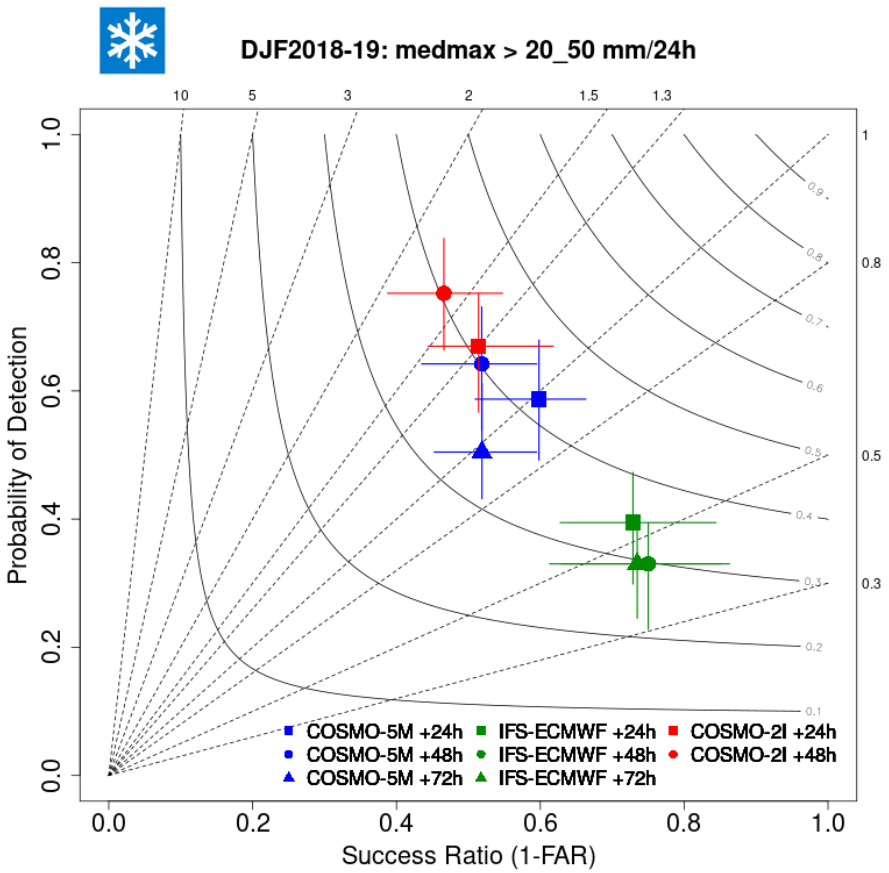


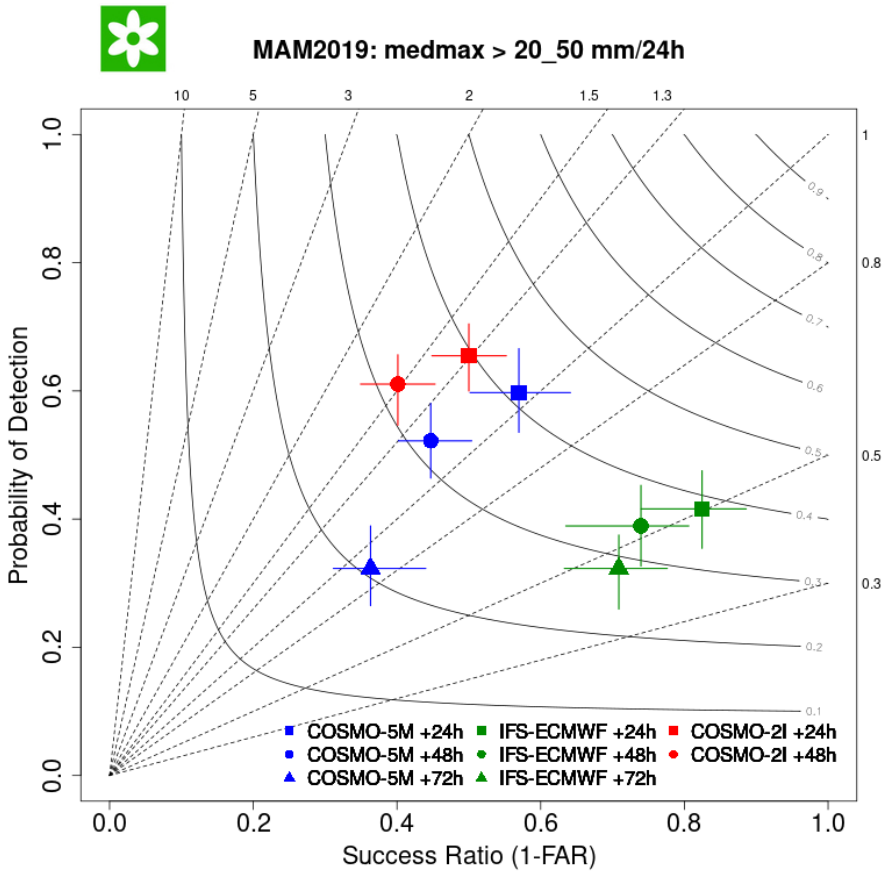




**AVERAGE > 20 mm/24h**

**COSMO-2I (2.2 Km)** ■ +24h
**COSMO-5M (5.0 Km)** ● +48h
**IFS-ECMWF (~9 Km)** ▲ +72h

# Results: all Italian catchment areas

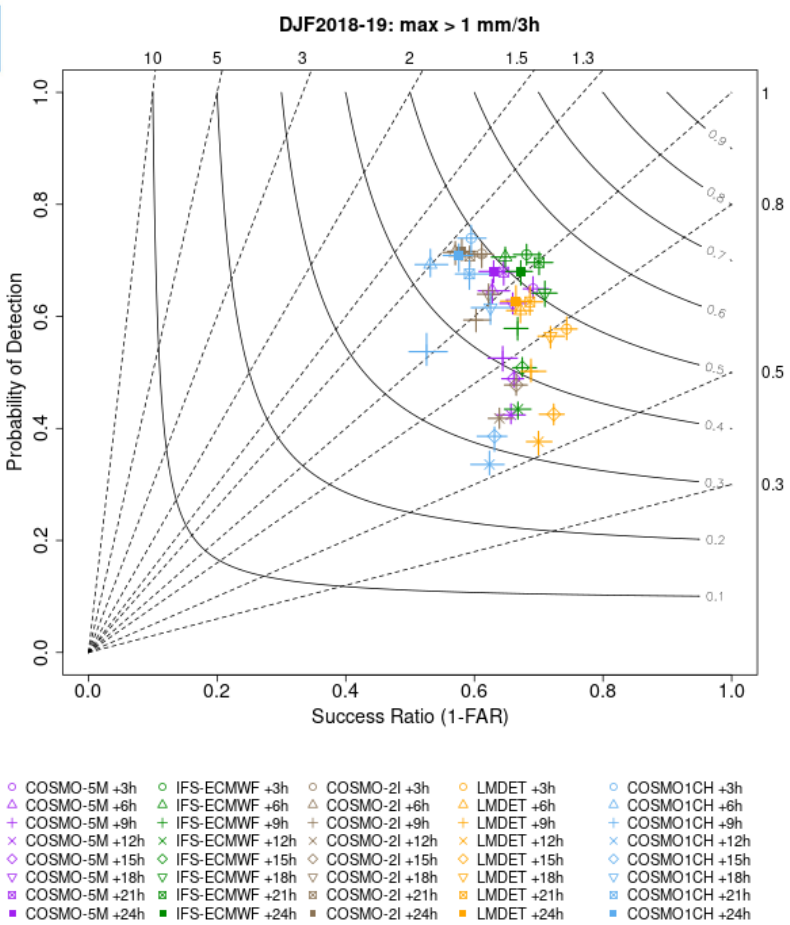


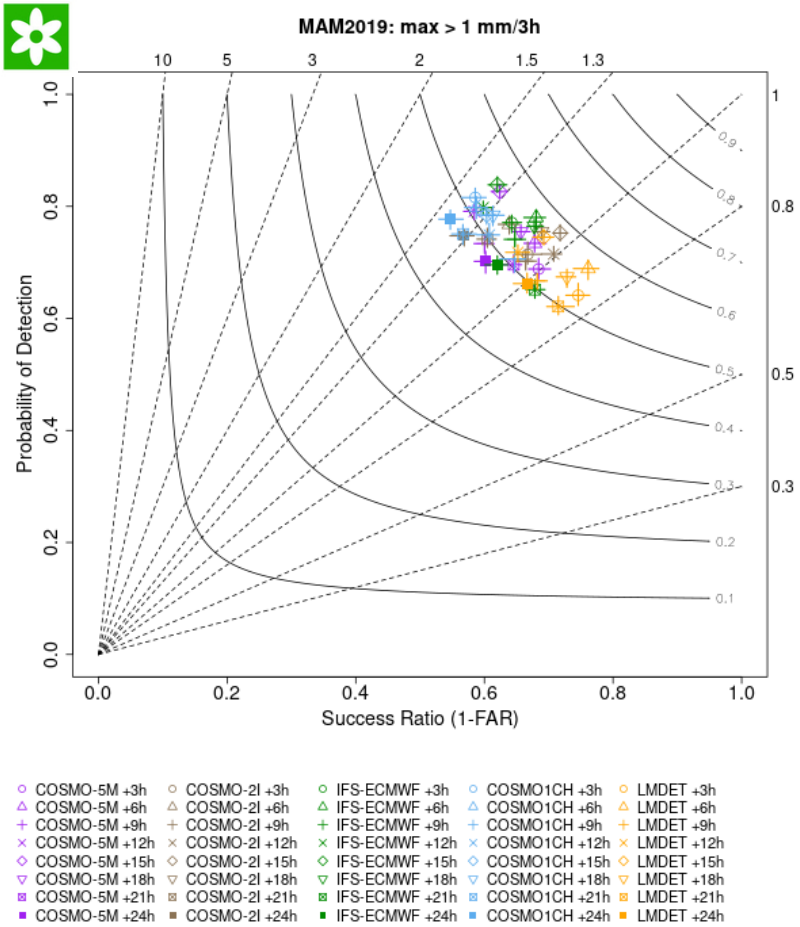




**MAX> 50 mm/24h**
**&**
**MEDIAN > 20 mm/24h**

**COSMO-2I (2.2 Km)** ■ +24h
**COSMO-5M (5.0 Km)** ● +48h
**IFS-ECMWF (~9 Km)** ▲ +72h

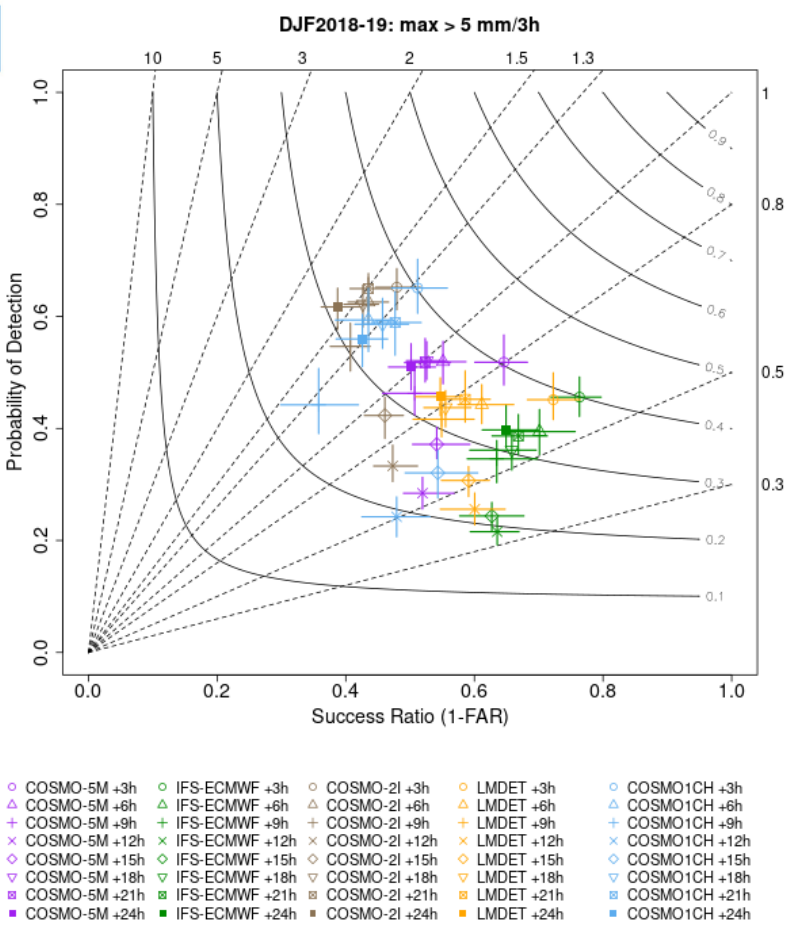
# Results: all Italian catchment areas

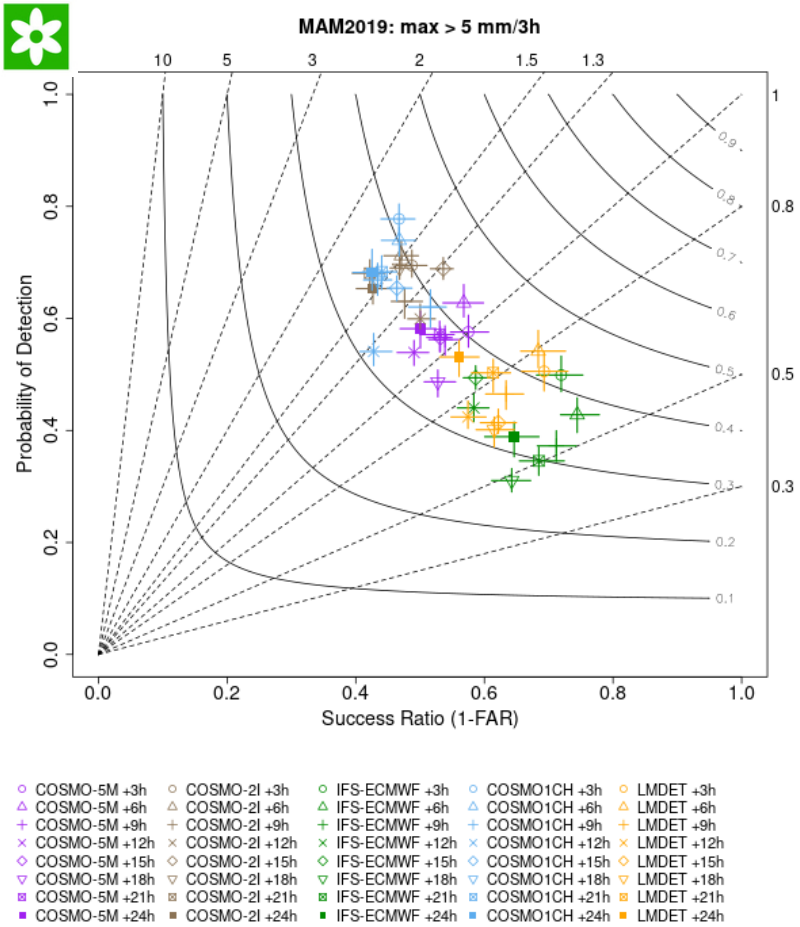



**MAX> 1 mm/3h**

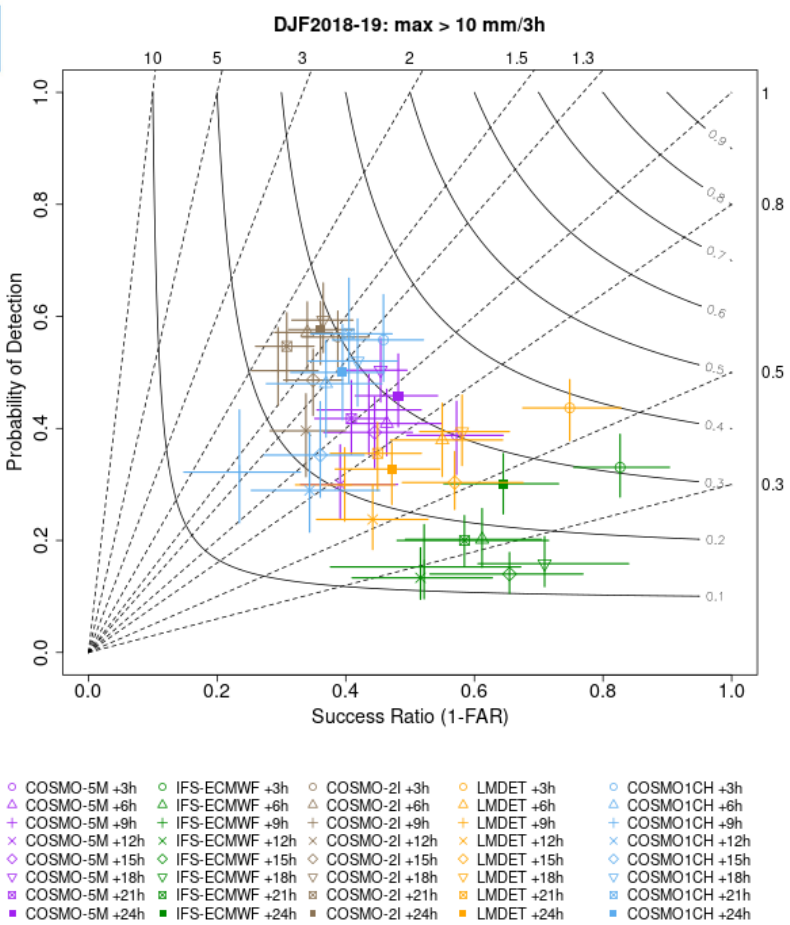
# Results: all Italian catchment areas

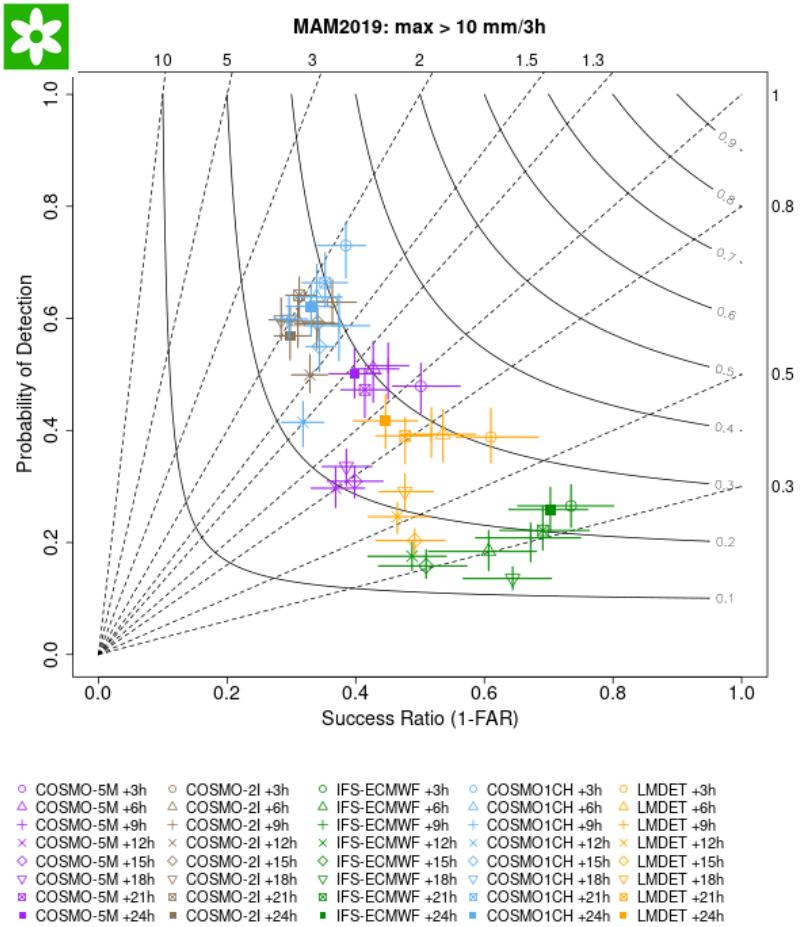



**MAX> 5 mm/3h**

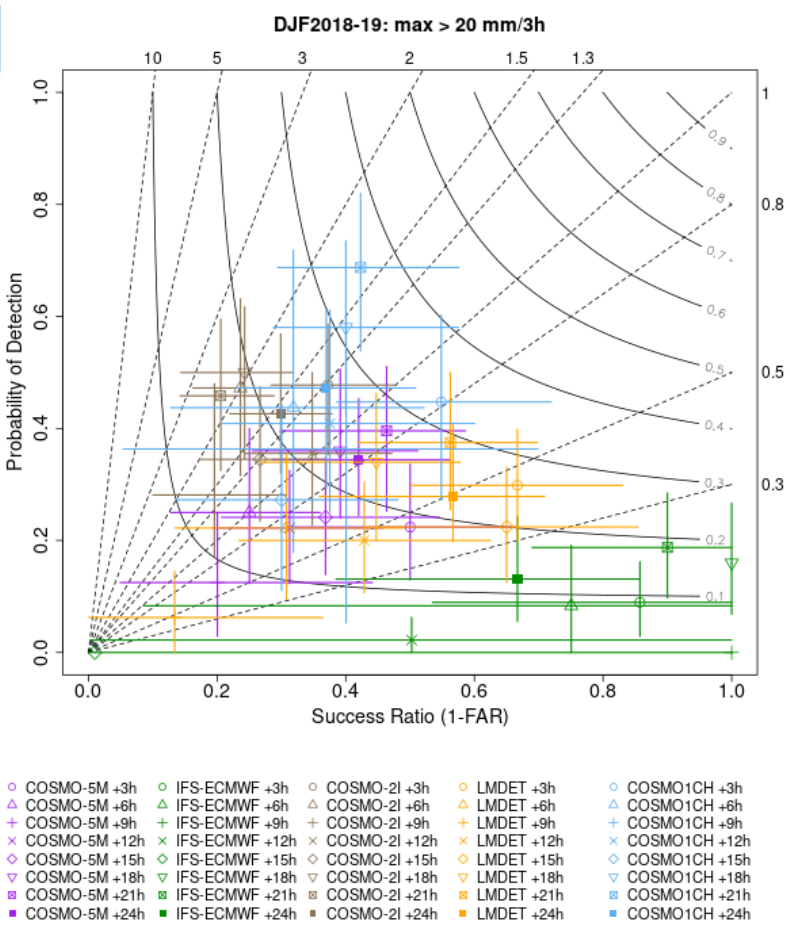
# Results: all Italian catchment areas

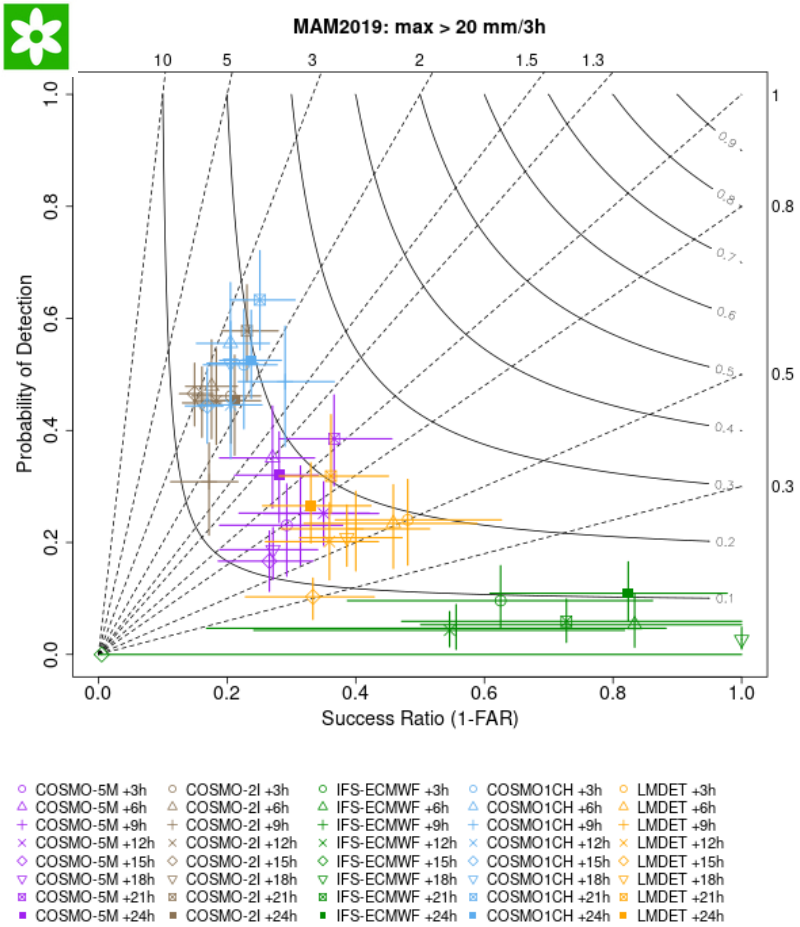



**MAX> 10 mm/3h**

# Results: all Italian catchment areas



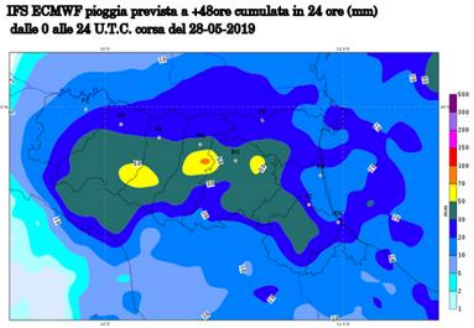



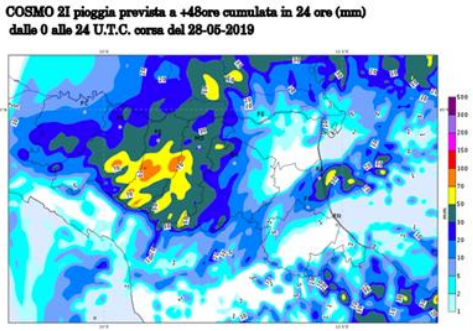

**MAX> 20 mm/3h**

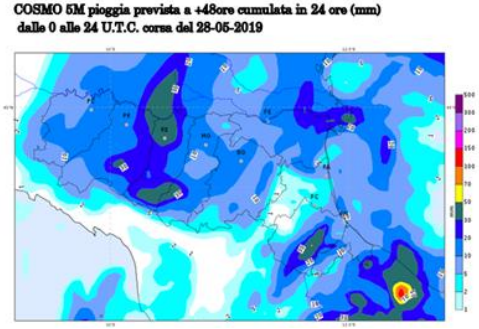
# Conclusion

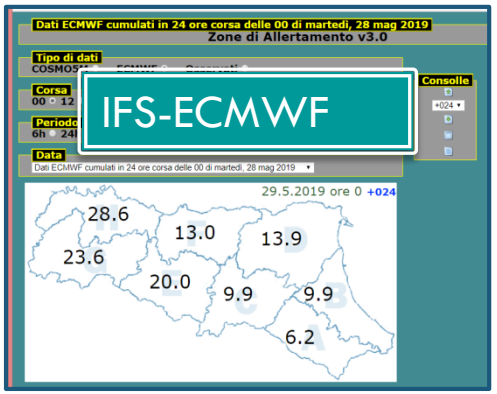
- At Arpae we have adapted the spatial verification methodology DIST to verify the QPF estimation over catchment areas to meet the needs of hydrologist and forecasters.
- The verification is performed using some parameter of the precipitation distribution with different thresholds: in this way we try to address verification results to specific issue of the users (e.g. separate high localized precipitation from extensive precipitation).
- Results of the verification can provide useful information on how to use the various forecasting systems and to decide in which situations one system is better than another:
  - In general seems that the resolution of the model plays an important role: higher values of precipitation are better forecast by higher resolution model (COSMO-2I in our case) despite a larger number of false alarm.
  - On the contrary lower resolution model (IFS in this case) tend to overestimate the number of low precipitation events and to miss some of the higher precipitation events even if with very high Success Ratio.
  - Added value of higher resolution model in representing the distribution of precipitation within the area.

# But…

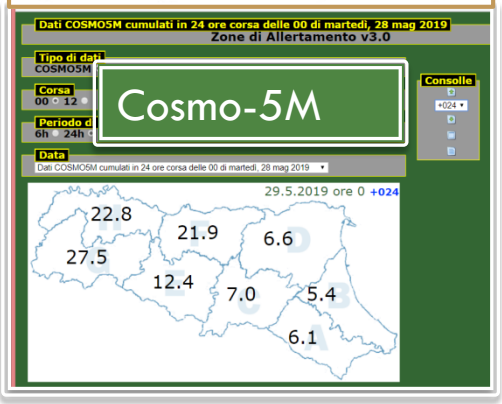


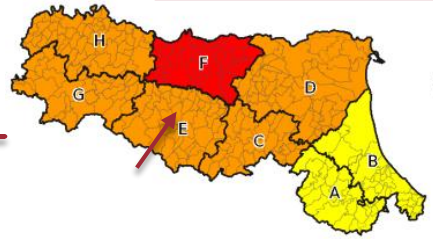



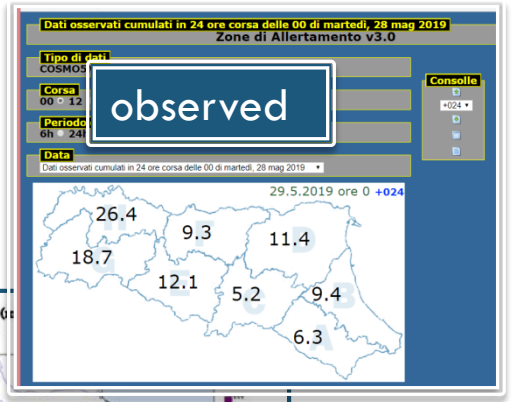



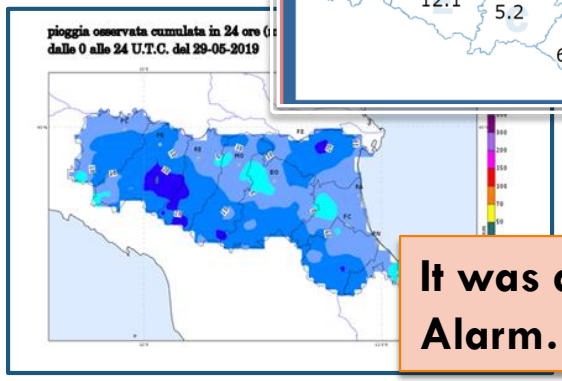





Hydraulic criticality warning map




**It was a False Alarm…lukily!!**

# Thanks!