QPF operational verification over catchment area

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Verification in complex terrain

- Spatial Verification Methods and NWP Model Performance -
(MesoVICT - Final workshop)

8-9 July, 2019, Vienna, Austria

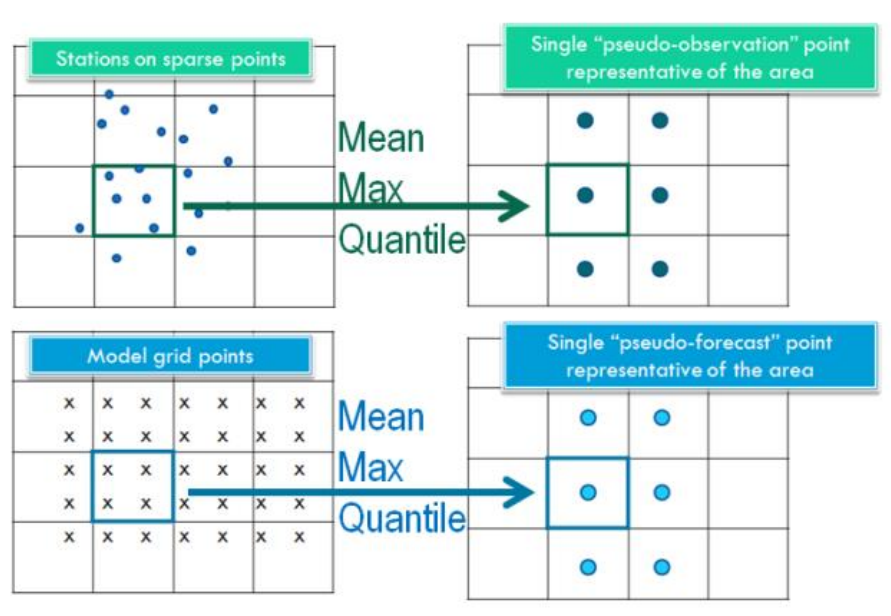
The estimation of QPF on river basins for purposes related to the issue of Civil Protection alerts for hydro-geological or hydraulic criticality is one of the main activities carried out operationally at the Hydro-Meteo-Climate Service of Arpae-Emilia Romagna.

- 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

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

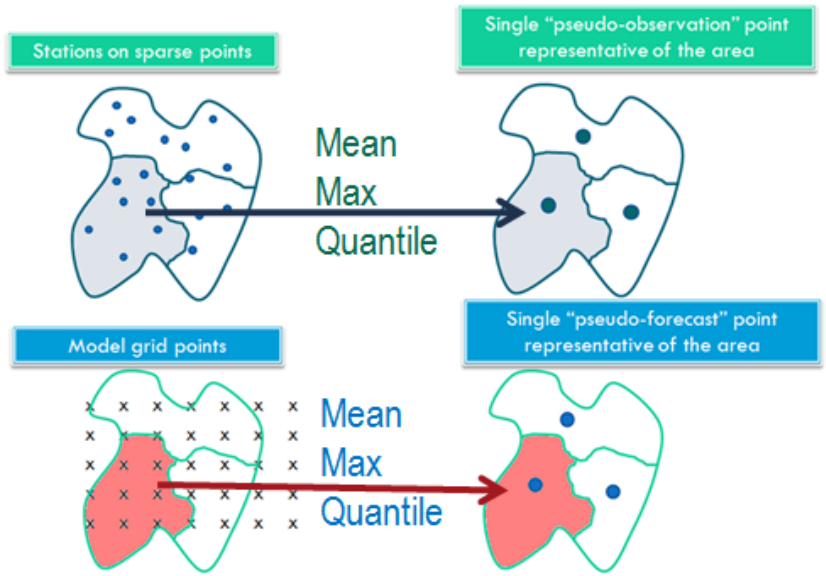


Marsigli, C., Montani, A. and Paccangnella, T. (2008), A spatial verification method applied to the evaluation of high-resolution ensemble forecasts. Met. Apps, 15: 125–143. doi: 10.1002/met.65

- 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.

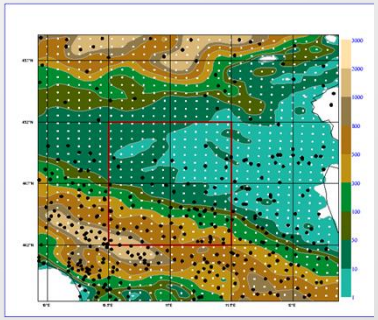
The verification system

- Squared regular boxes are replaced with catchment areas

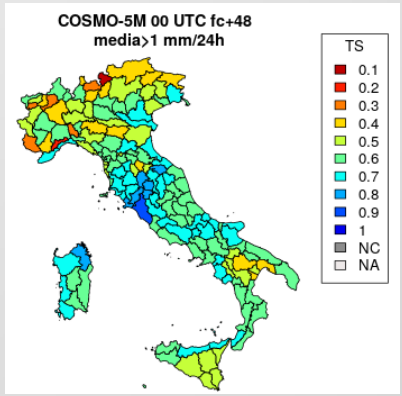


Some advantages of this choice:

- 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

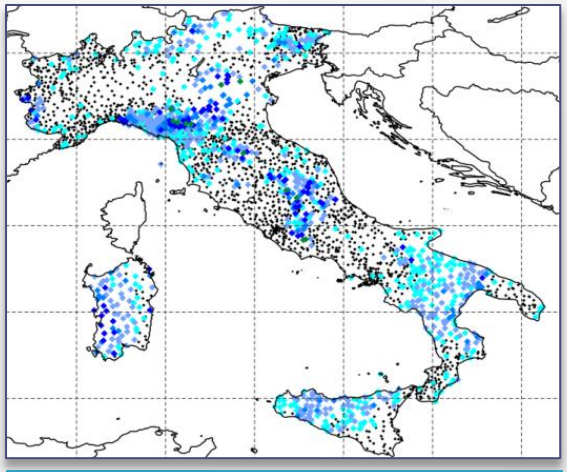


- Easier and more direct communication of the information about the usability of NWP data directly to forecasters or hydrologists e.g. scores are can be provided on each catchment area



Required observational dataset

- One of (our) main problem for the application of several spatial verification methods is the difficulty to have gridded observation data
- DIST does not need gridded data and can be applied either to sparse points or gridded data (e.g. radar precipitation analysis)
- Until now we have used it operationally with the data of a high-resolution rain-gauges network , some test are in progress for the use of a radar + rain-gauges analysis of precipitation

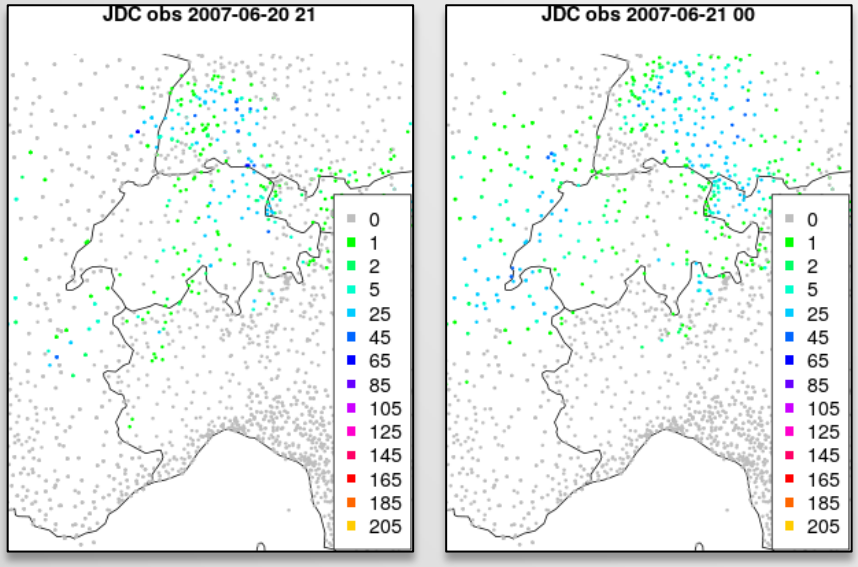


More than 1000 rain-gauges provided by the Italian Department of Civil Protection network

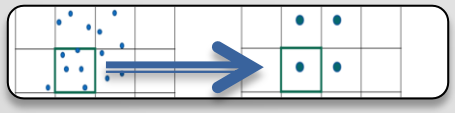
MesoVict project gives us the possibility to compare the application of DIST for the verification of COSMO-1 using the VERA analysis or the JDC observations:

- the use of sparse point observations (JDC) gives results comparable to that obtained with gridded observations (VERA)
- the use of sparse point observations for the verification provides best results for maxima of precipitation

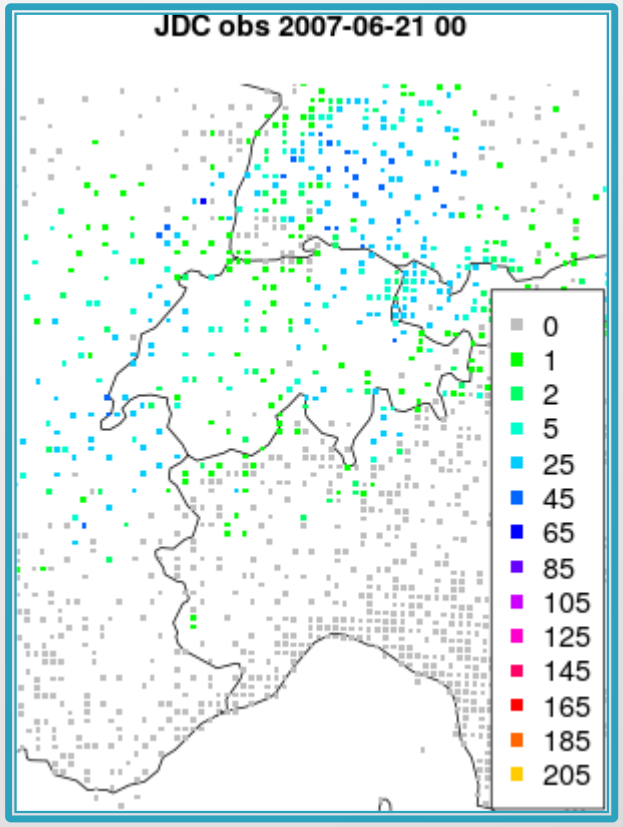
MesoVict case 1- box 24x24 Km^2



Sparse points JDC obs – 3 hr acc

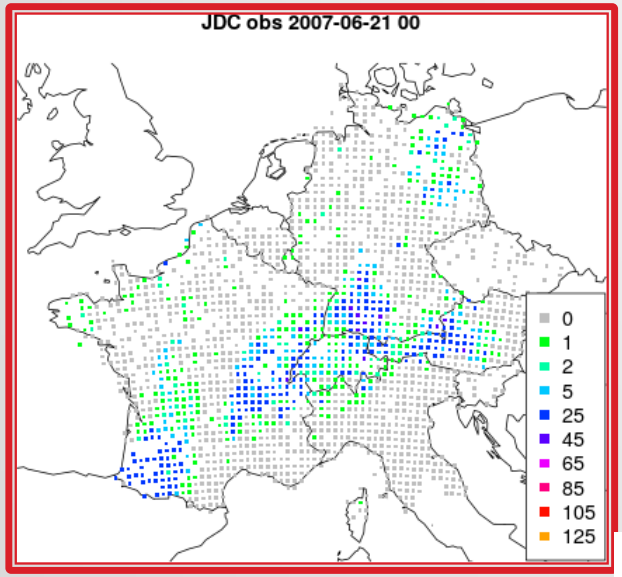


(Zoom)

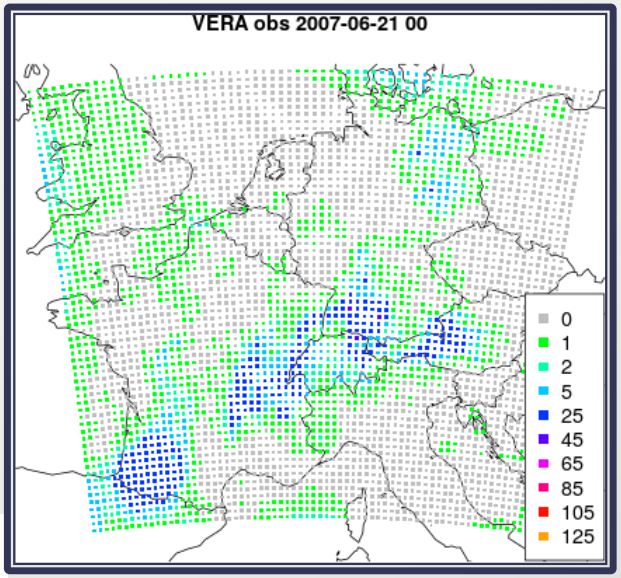


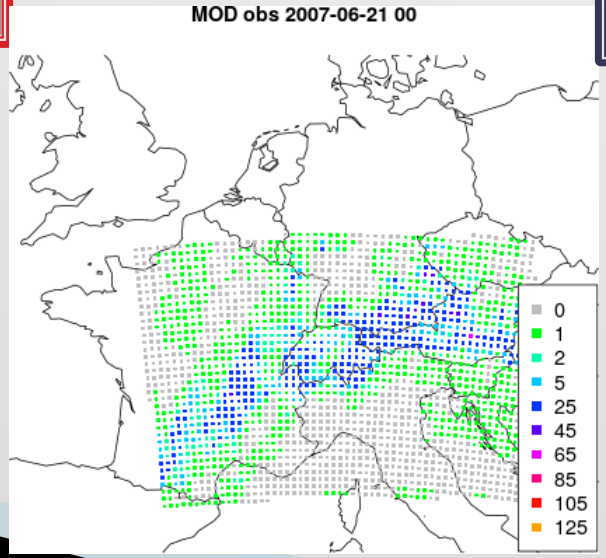
Boxed JDC obs – 6 hr acc

MesoVict case 1- box 24x24 Km^2

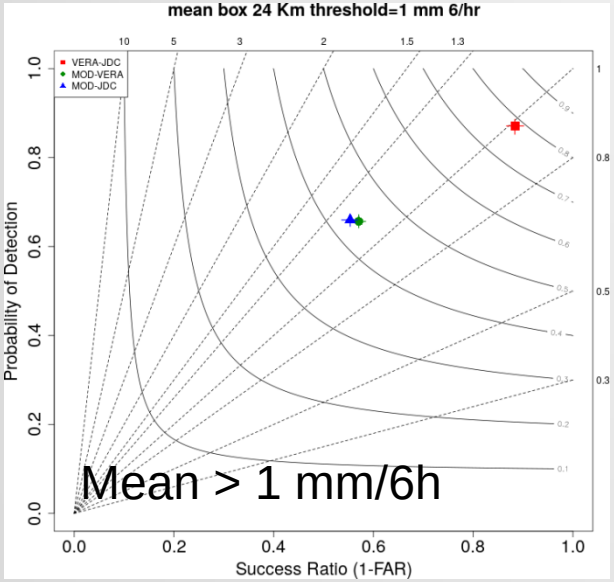


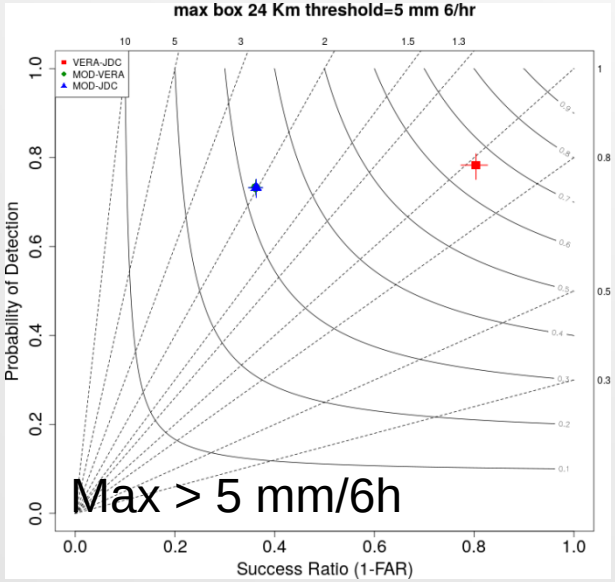
Cross verification between datasets

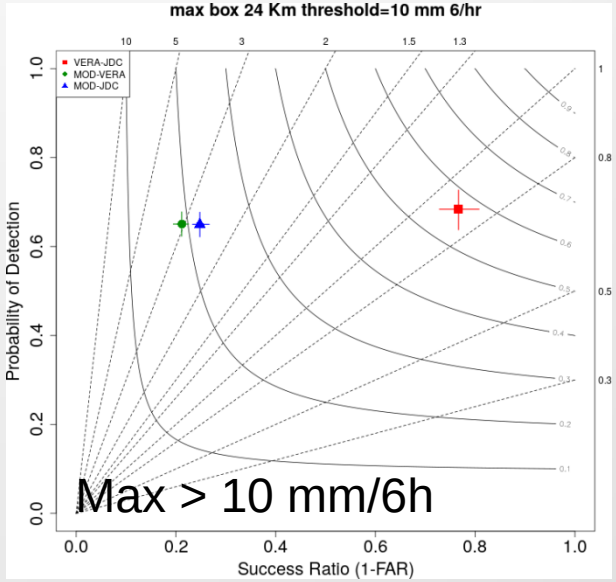




MesoVict case 1- box 24x24 Km^2





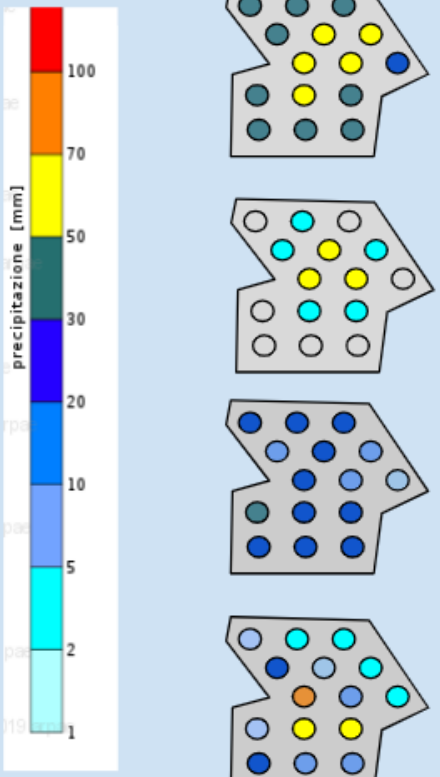


The differences in the scores relative to verification of **Model against VERA** and **Model against JDC** are not significant when **VERA against JDC** perform relatively well.
This means that the average of grid-points of the analysis that fall into each box (9 in this case) is very similar to the ones of the JDC stations.
In case of the maximum, when the threshold is low the differences are small, while when the threshold increases since the analysis tends to be smooth (for definition!). In this case the verification of Models compare to JDC perform a little better (less false alarms) , giving credit to the ability of the model (COSMO1 in the test case) in reproducing high precipitation values.

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



MAX 50 mm
MEDIAN 30 mm
MEAN 36 mm

MAX 50 mm
MEDIAN 2 mm
MEAN 10.7 mm

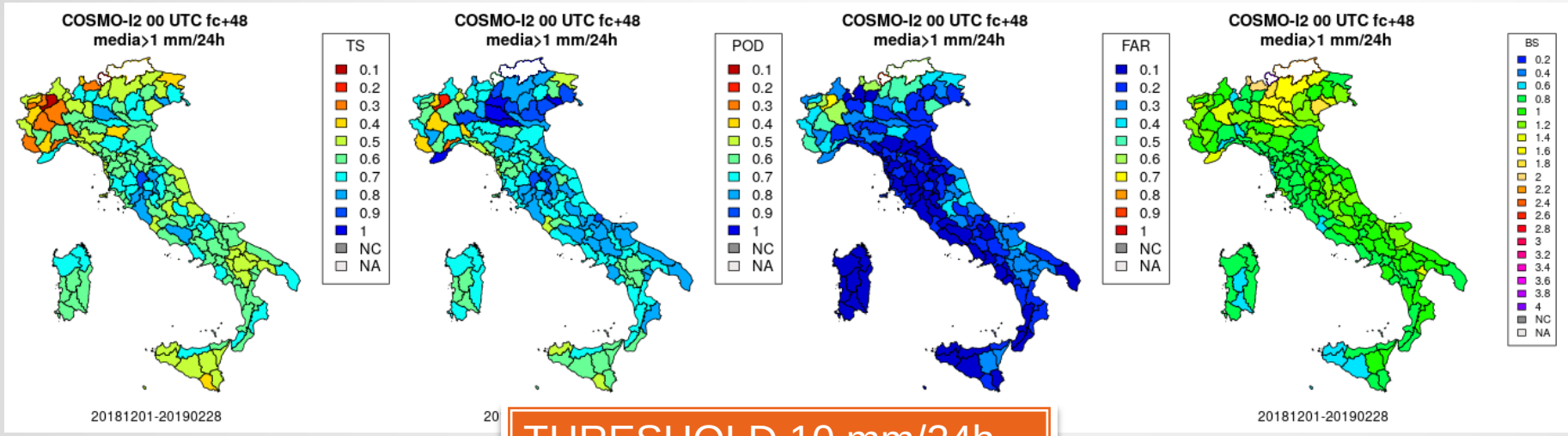
Same max but different mean/median

MAX 30 mm
MEDIAN 20 mm
MEAN 17.7 mm

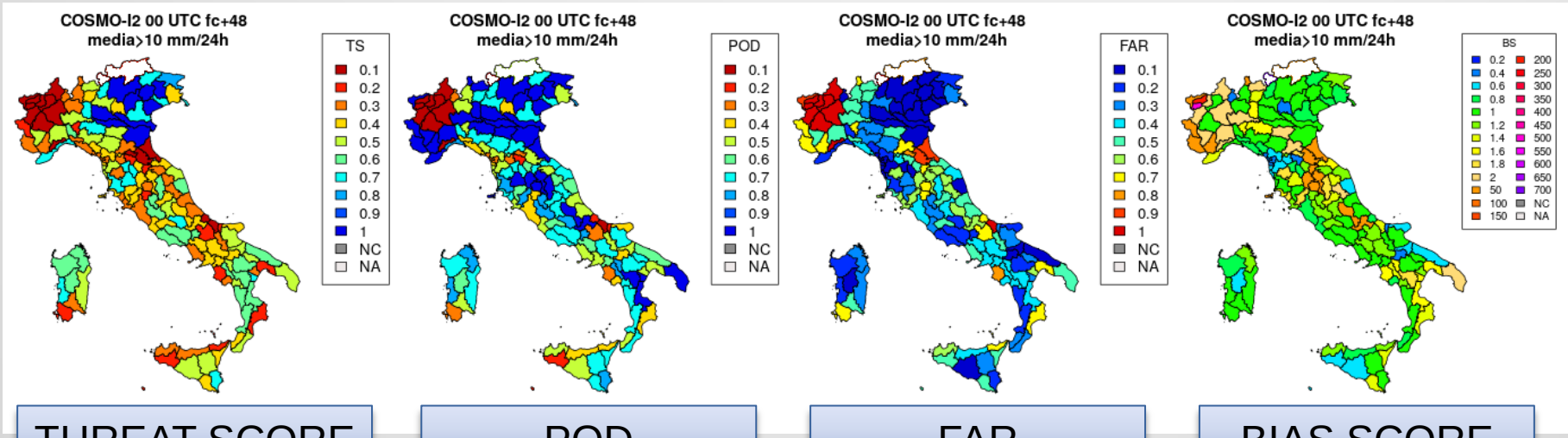
MAX 70 mm
MEDIAN 10 mm
MEAN 17.5 mm

Same mean values but different median and max

THRESHOLD 1 mm/24h



THRESHOLD 10 mm/24h



THREAT SCORE | POD | FAR | BIAS SCORE

AVERAGE

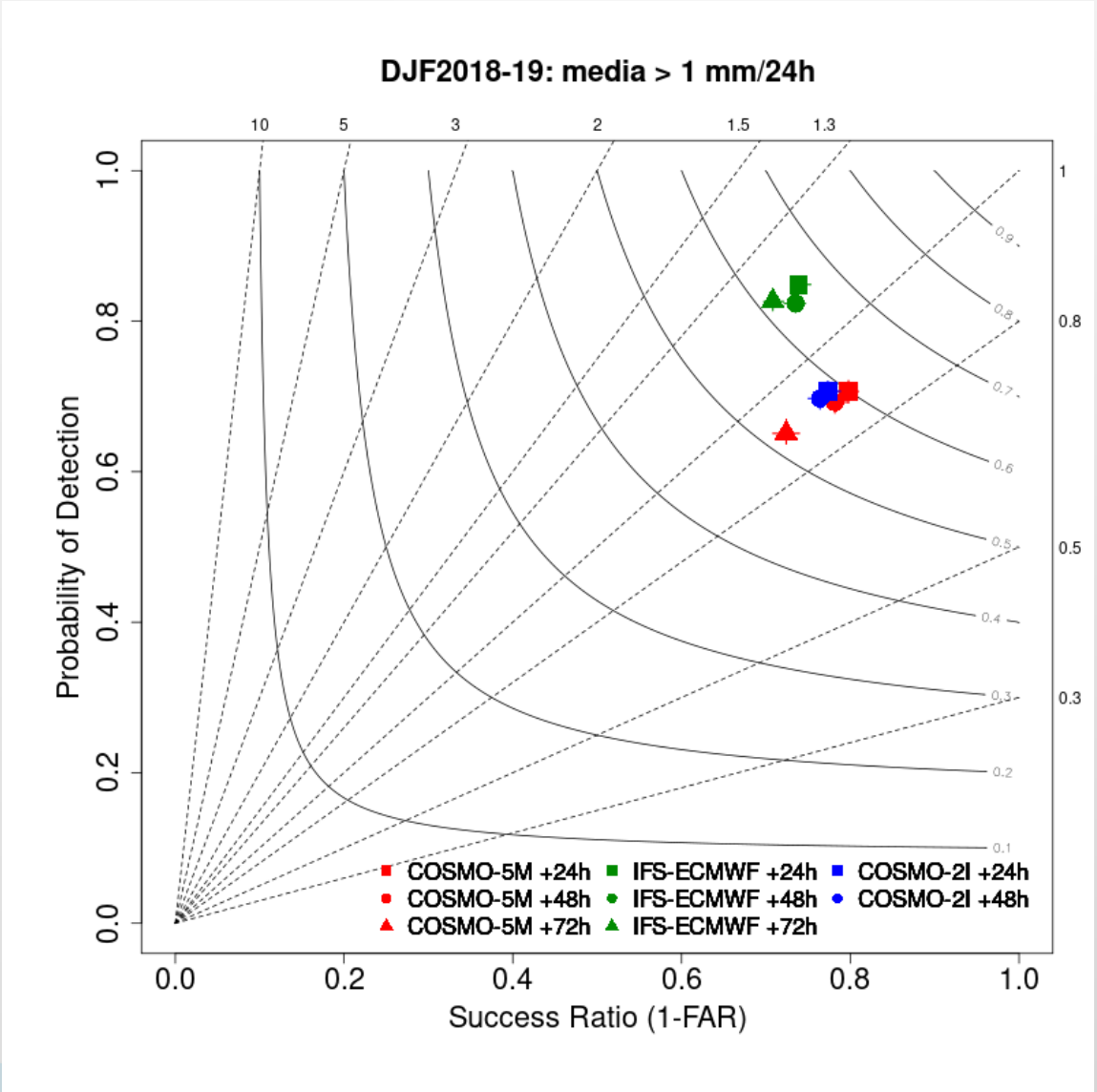
COSMO-I2 DJF2018-19 fc+48

DJF2018-19: All Italian catchment areas

AVERAGE > 1 mm/24h

COSMO-2I (2.2 Km)
COSMO-5M (5.0 Km)
IFS-ECMWF (~9 Km)

■ +24h
● +48h
▲ +72h

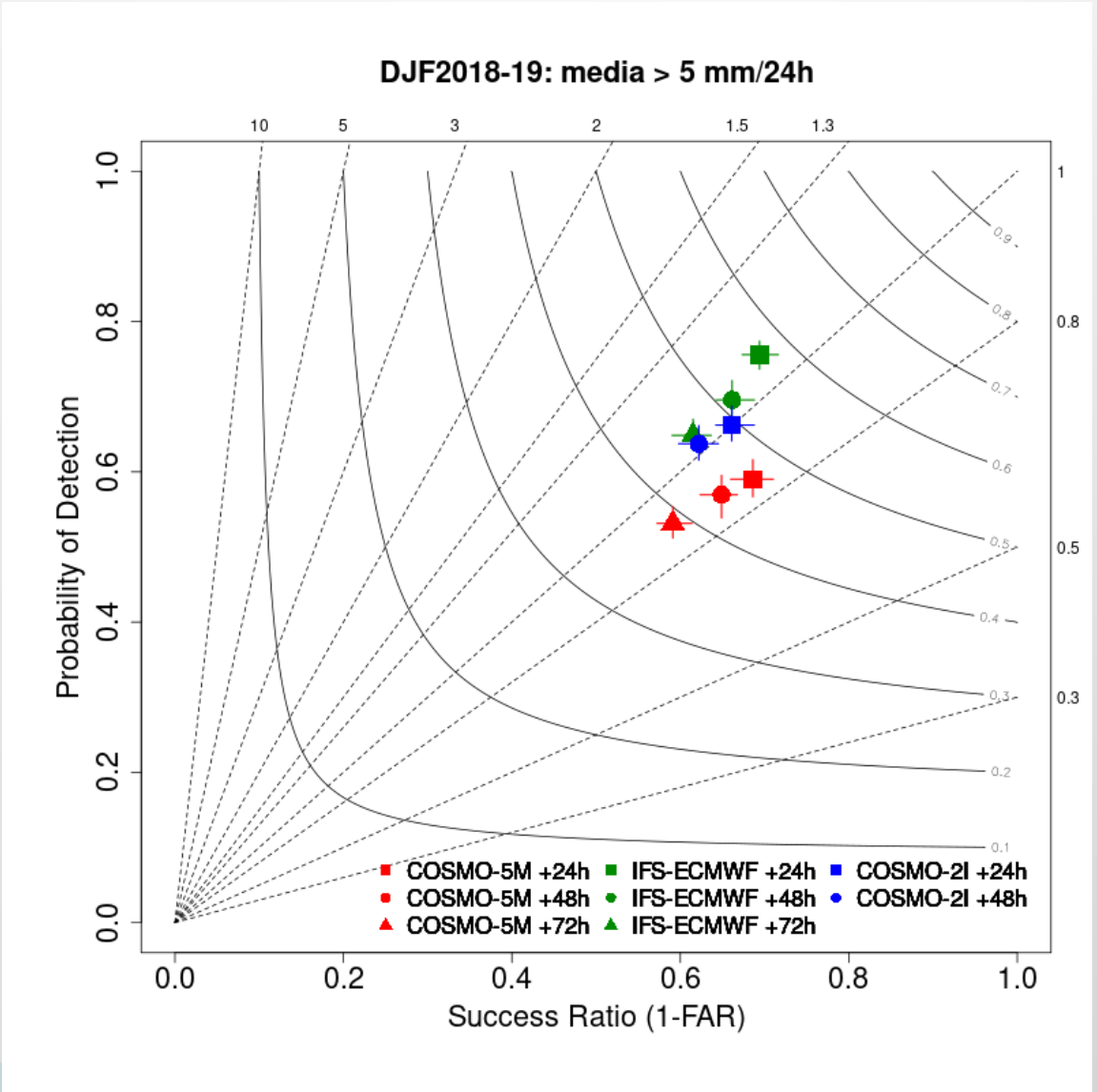


DJF2018-19: All Italian catchment areas

AVERAGE > 5 mm/24h

COSMO-2I (2.2 Km)
COSMO-5M (5.0 Km)
IFS-ECMWF (~9 Km)

■ +24h
● +48h
▲ +72h

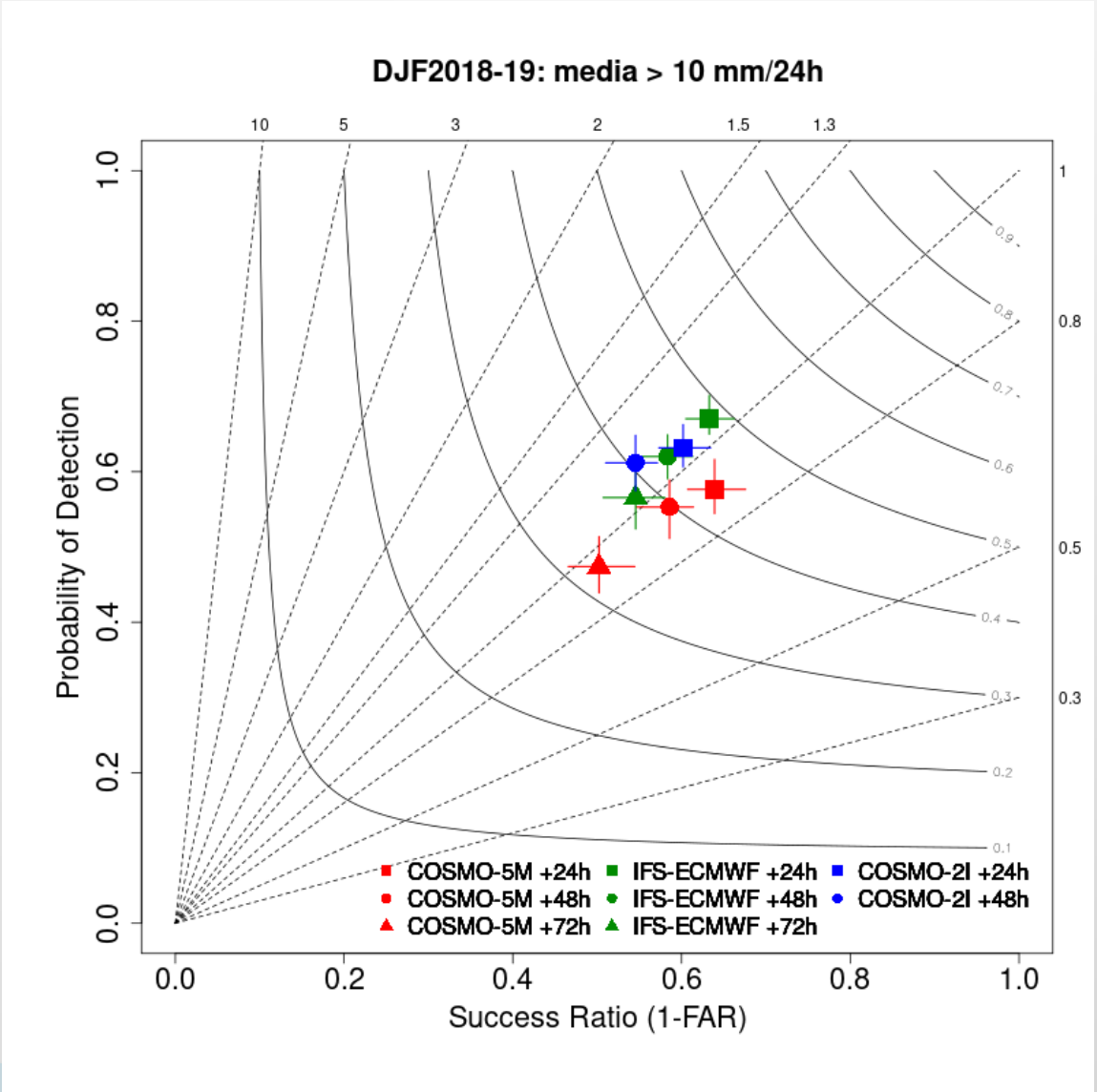


DJF2018-19: All Italian catchment areas

AVERAGE > 10 mm/24h

COSMO-2I (2.2 Km)
COSMO-5M (5.0 Km)
IFS-ECMWF (~9 Km)

■ +24h
● +48h
▲ +72h

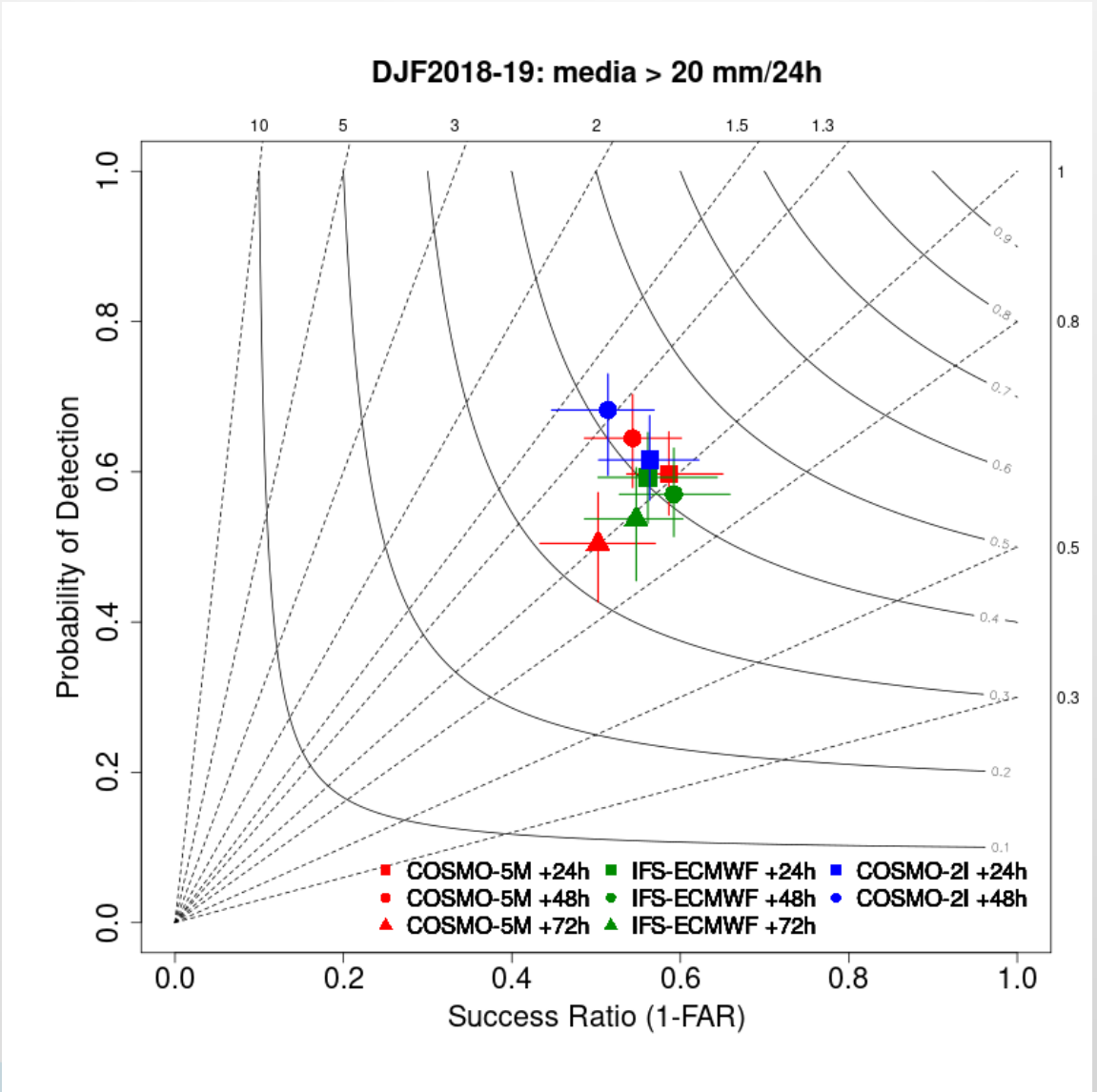


DJF2018-19: All Italian catchment areas

AVERAGE > 20 mm/24h

COSMO-2I (2.2 Km)
COSMO-5M (5.0 Km)
IFS-ECMWF (~9 Km)

■ +24h
● +48h
▲ +72h

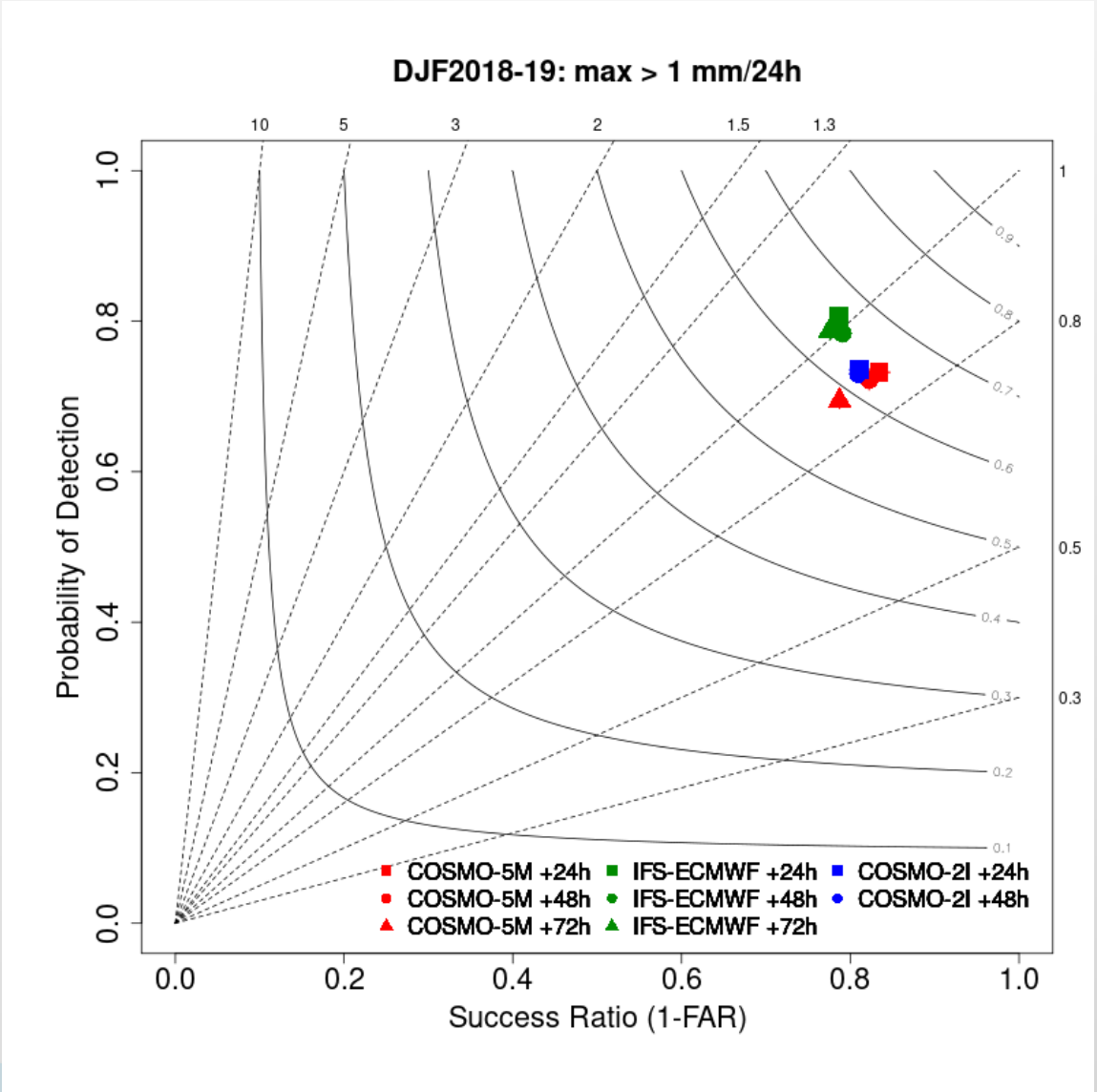


DJF2018-19: All Italian catchment areas

MAX> 1 mm/24h

COSMO-2I (2.2 Km)
COSMO-5M (5.0 Km)
IFS-ECMWF (~9 Km)

■ +24h
● +48h
▲ +72h

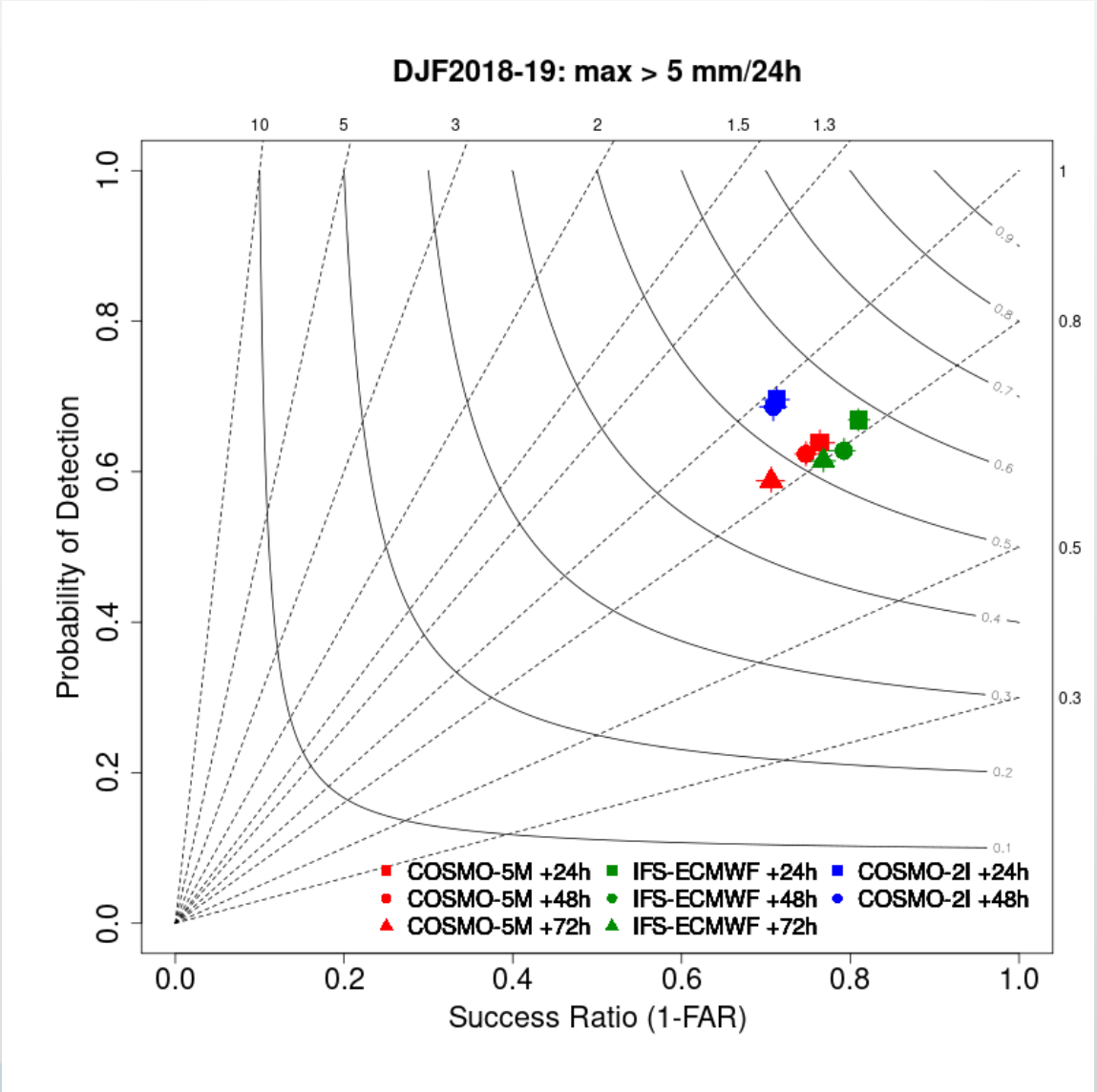


DJF2018-19: All Italian catchment areas

MAX> 5 mm/24h

COSMO-2I (2.2 Km)
COSMO-5M (5.0 Km)
IFS-ECMWF (~9 Km)

■ +24h
● +48h
▲ +72h

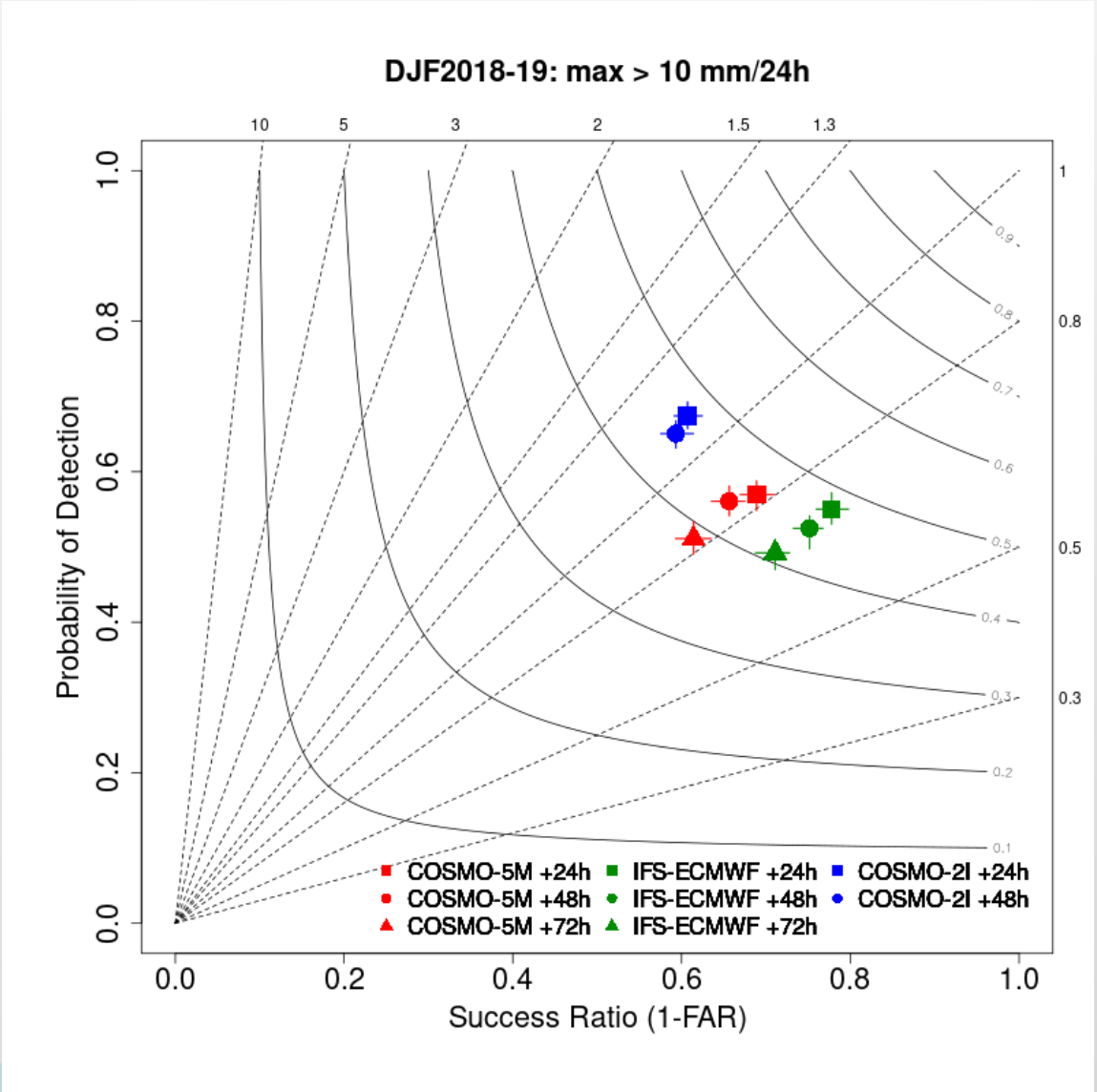


DJF2018-19: All Italian catchment areas

MAX> 10 mm/24h

COSMO-2I (2.2 Km)
COSMO-5M (5.0 Km)
IFS-ECMWF (~9 Km)

■ +24h
● +48h
▲ +72h

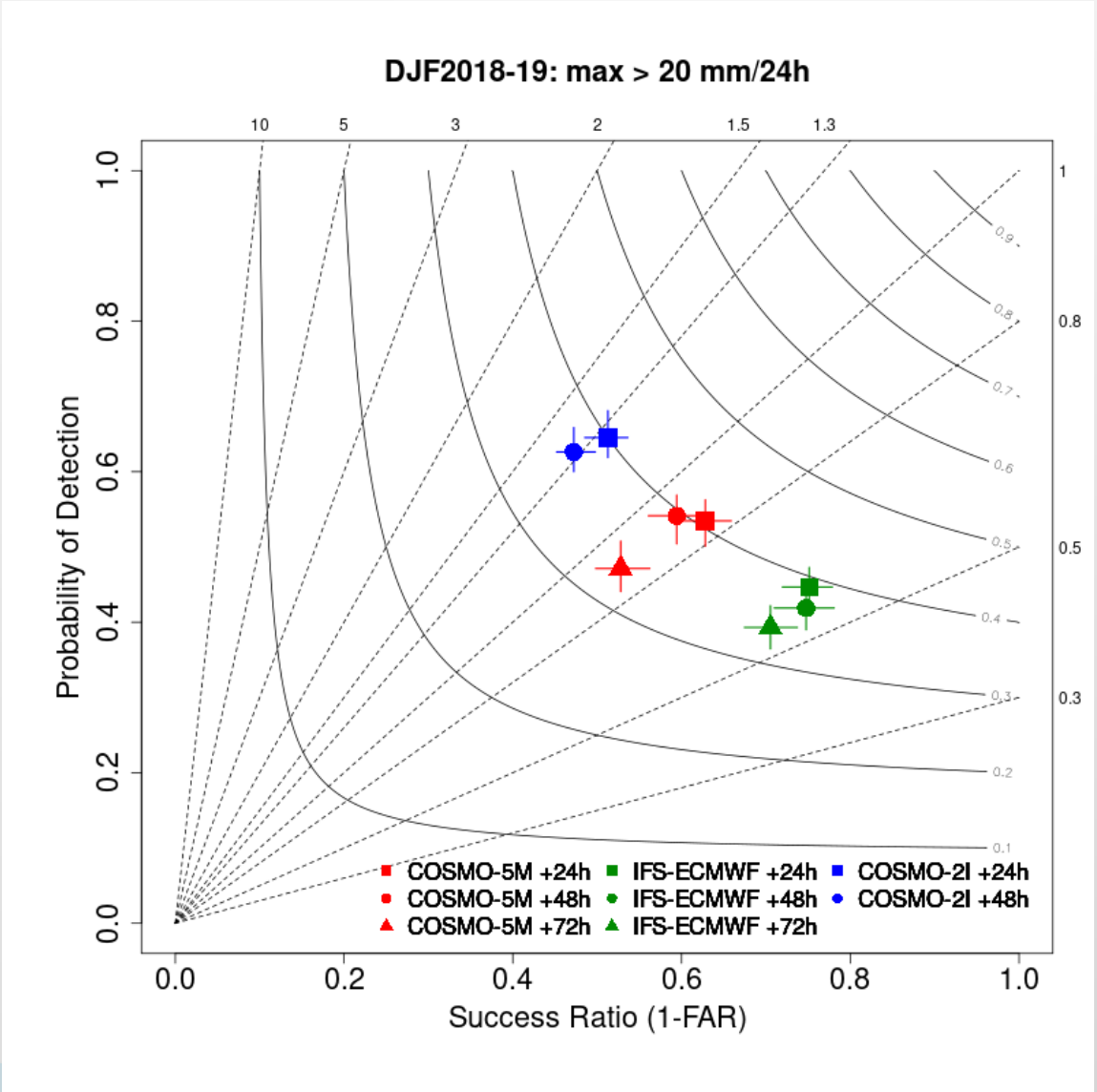


DJF2018-19: All Italian catchment areas

MAX> 20 mm/24h

COSMO-2I (2.2 Km)
COSMO-5M (5.0 Km)
IFS-ECMWF (~9 Km)

■ +24h
● +48h
▲ +72h

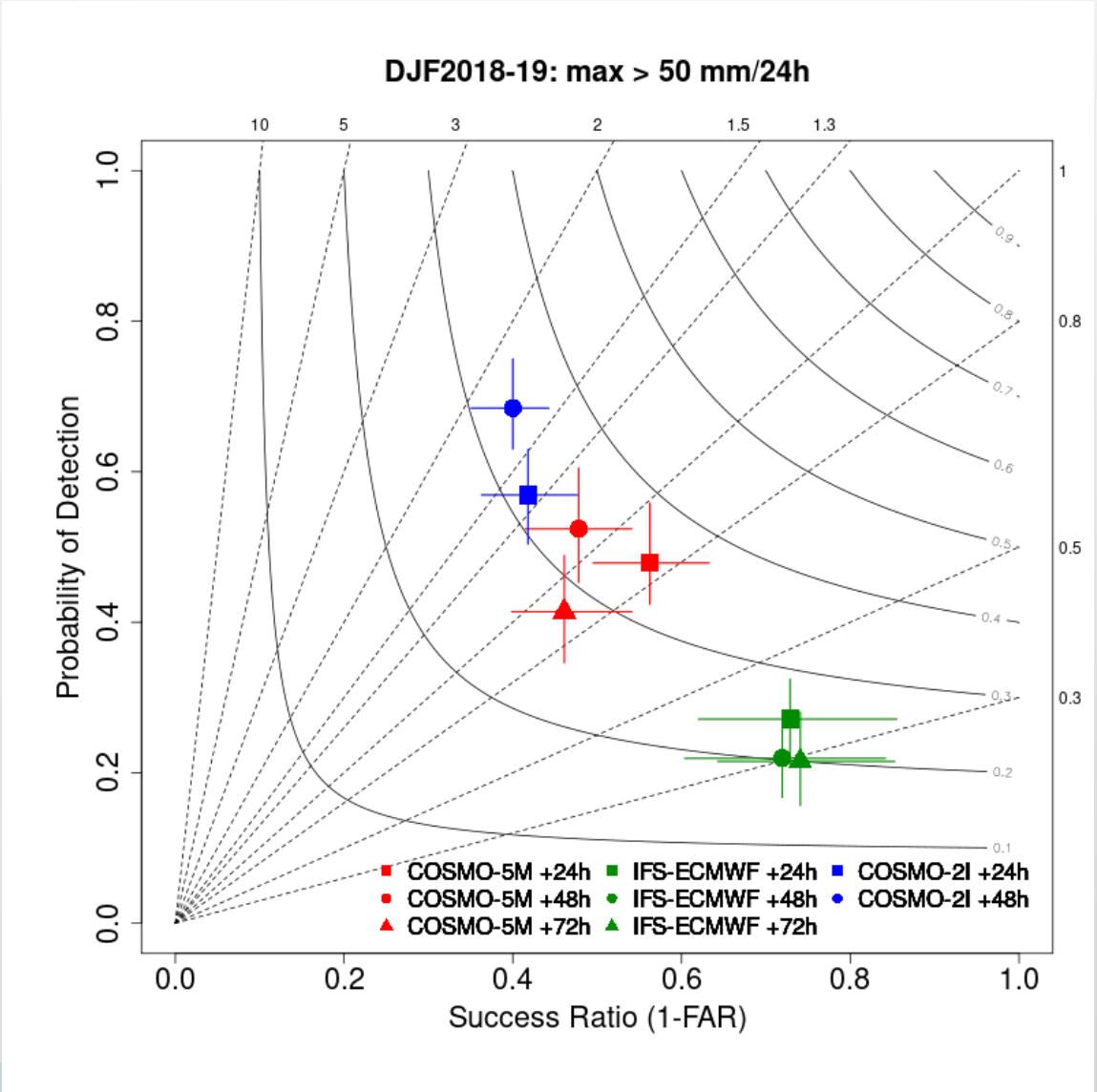


DJF2018-19: All Italian catchment areas

MAX> 50 mm/24h

COSMO-2I (2.2 Km)
COSMO-5M (5.0 Km)
IFS-ECMWF (~9 Km)

■ +24h
● +48h
▲ +72h

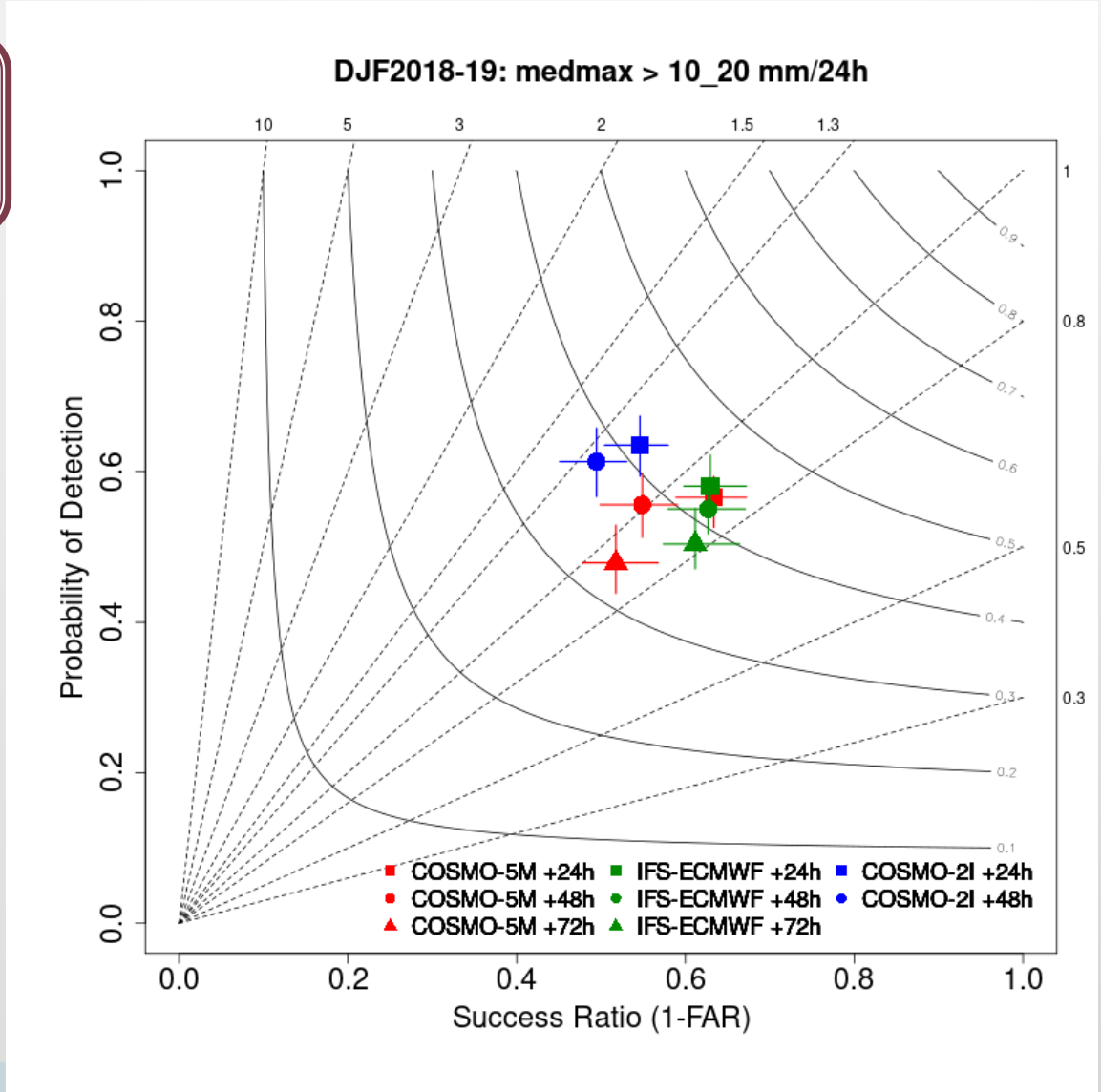


DJF2018-19: All Italian catchment areas

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

COSMO-2I (2.2 Km)
COSMO-5M (5.0 Km)
IFS-ECMWF (~9 Km)

■ +24h
● +48h
▲ +72h

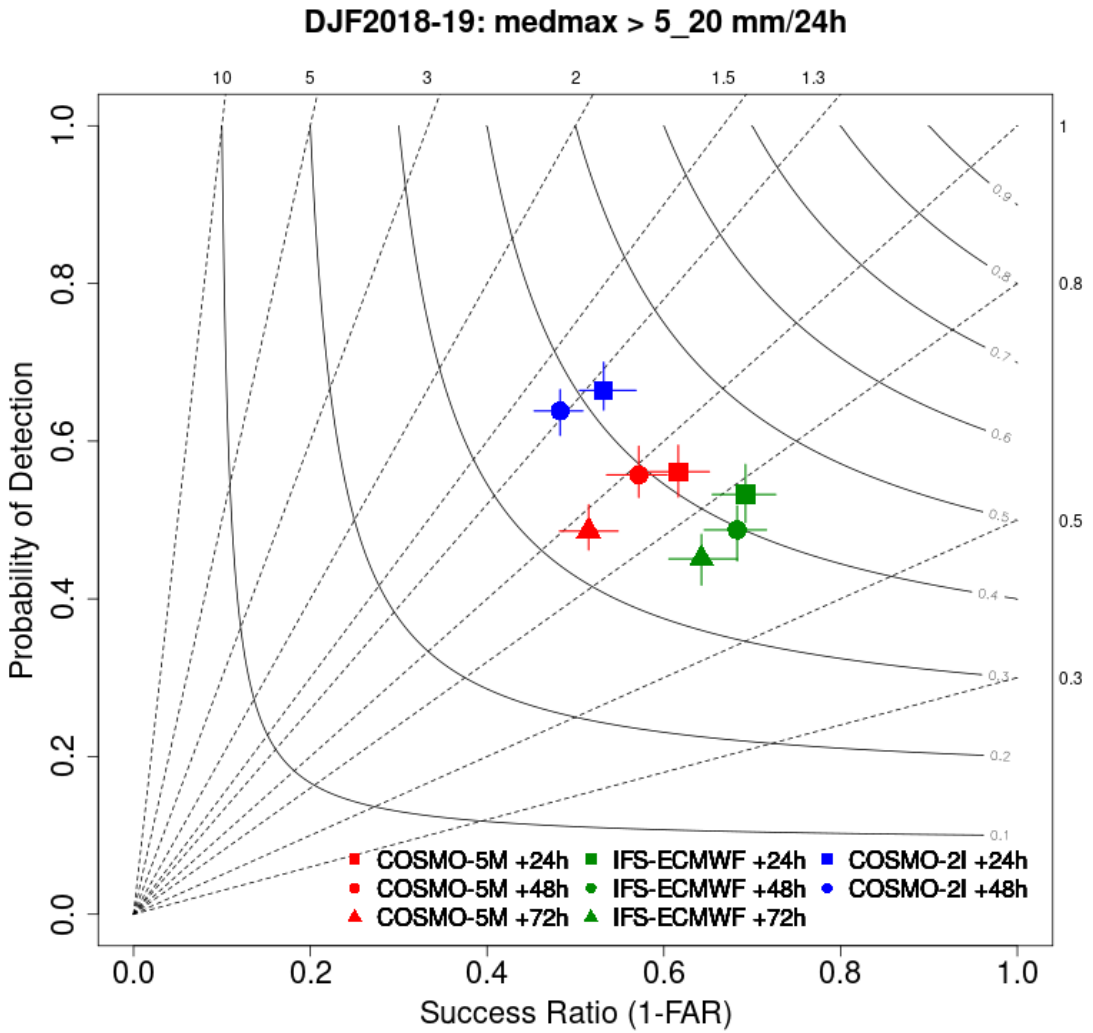


DJF2018-19: All Italian catchment areas

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

COSMO-2I (2.2 Km)
COSMO-5M (5.0 Km)
IFS-ECMWF (~9 Km)

■ +24h
● +48h
▲ +72h

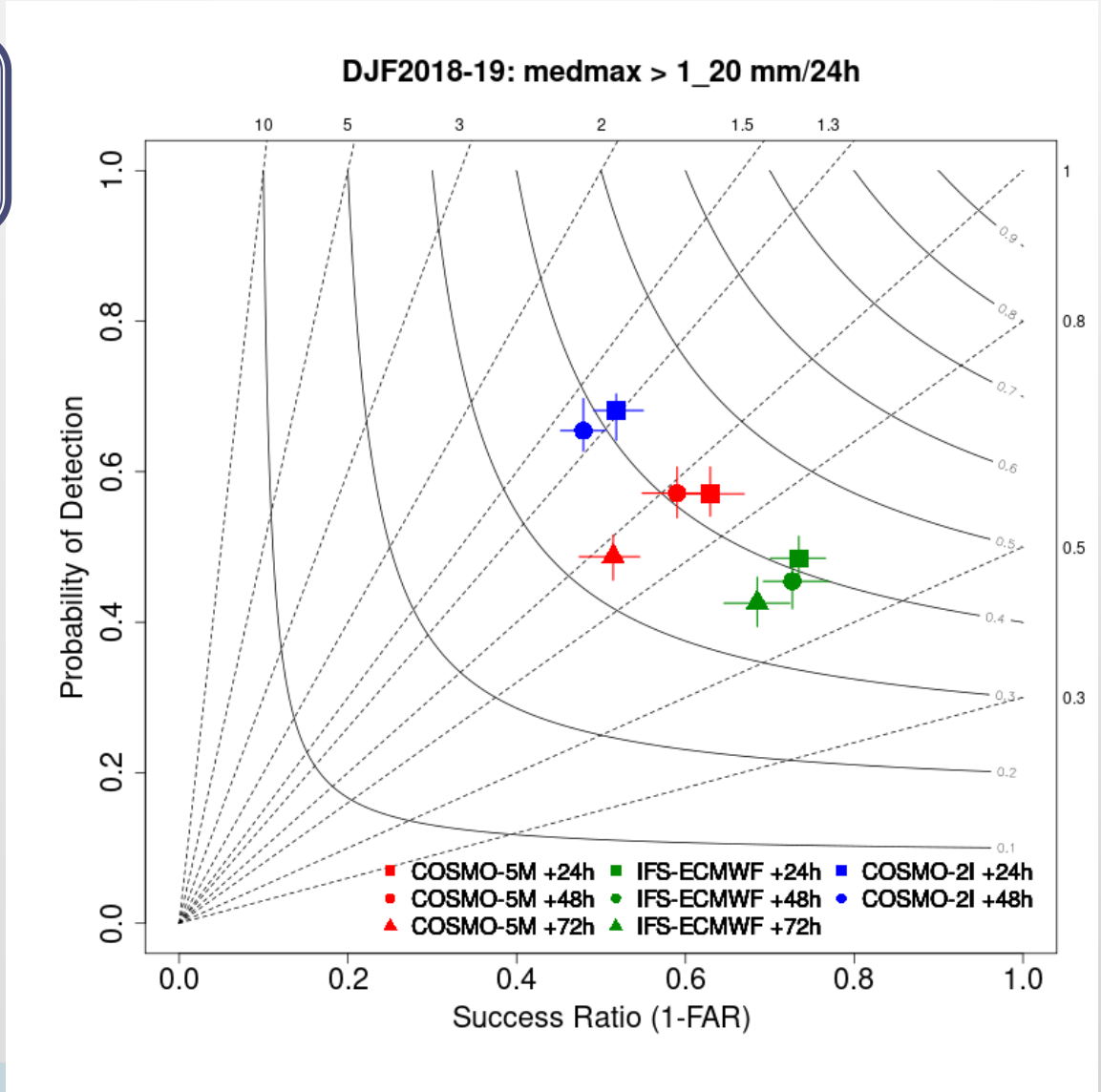


DJF2018-19: All Italian catchment areas

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

COSMO-2I (2.2 Km)
COSMO-5M (5.0 Km)
IFS-ECMWF (~9 Km)

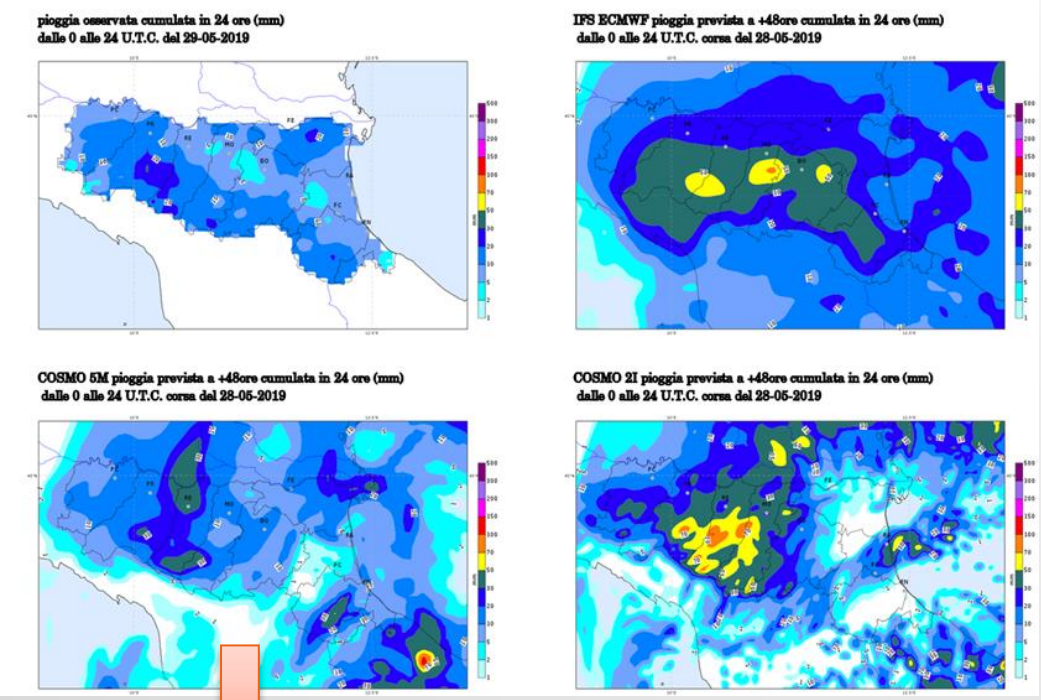
■ +24h
● +48h
▲ +72h

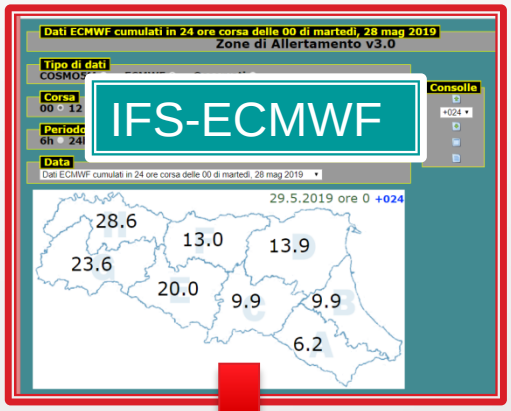


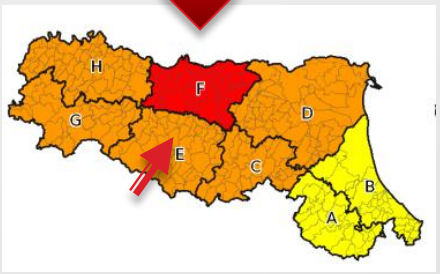
Conclusion

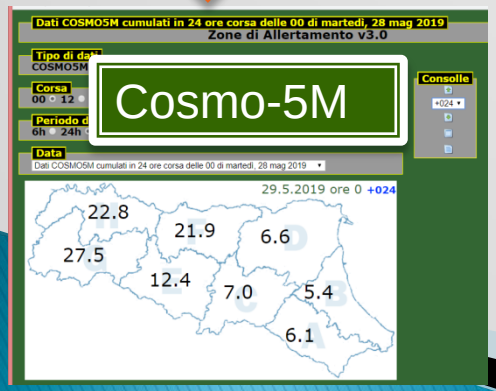
- We have adapted the spatial verification methodology DIST to verify the QPF estimation over catchment areas
- DIST can be used both with sparse data and gridded analysis, this allow to us to perform verification on a seasonal basis using a high resolution network of rain-gauges (pragmatic approach!)
- 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

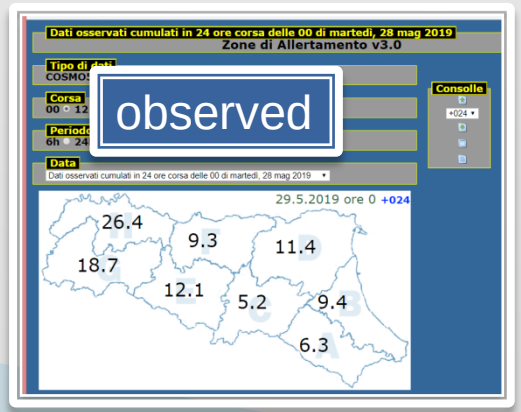
But…











It was a False Alarm…lukily!!

Thanks!