## Task 4.3 QPF evaluation approaches

(ARPAE-SIMC, Maria Stefania Tesini)

## Introduction

The evaluation of the amount of precipitation over catchment areas is one of the most important uses of the QPF at ARPAE for hydrological purposes and for the issuing of Civil Protection alert for possible floods. To meet the needs of end-users, such as hydrologists or forecasters, some tools that provide mean, maximum and some other percentile values of the precipitation field over the catchment areas of the Emilia-Romagna region have been developed. Exceeding predefined thresholds can give useful indications for situations of intense precipitation possibly leading to floods.



## **Description of the products**

To evaluate the hydrological response of a basin it is not necessary (although desirable) to know precisely the exact location of the amount of precipitation but it is fundamental to have an estimate of the total amount of water that will fall on the area of interest. Results of verification based on the DIST methodology applied to the warning areas (as shown in task 3.4) encourage using the average and the maximum of the precipitation of the points that fall on the area as good products derived from models forecasts. Each day, Arpae forecasters must provide hydrologists and Civil Protection Department with an assessment of the expected average precipitation on the warning basins based on the data of the models available to them, such as COSMO-5M (5 Km horizontal resolution), COSMO-2I (2.2 Km horizontal resolution) and IFS-ECMWF (9 km horizontal resolution).



To facilitate the comparison of the QPF of these models, summary tables with estimated mean and maximum precipitation over each of the eight catchment areas of the Emilia-Romagna region are produced by means of LIBSIM software developed at Arpae (<u>https://github.com/ARPA-SIMC/libsim</u>).

For each model, it is possible to visualize the estimated average precipitation over each catchment area by step of 6 or 24 hours for the available period of forecast, as shown in figure below. It is also possible to display a text file in which are tabulated the also the mean and the maximum value of the precipitation in each area and the number of points that exceed increasing thresholds (1, 5,10,20,50,100 mm in 6h). It is also possible to compare models forecast with observed mean values of the previous days using the same tool in order to have a quick validation of the forecast.



Example of total precipitation field and corresponding average value on Emilia-Romagna catchment areas of COSMO-5M (top) and IFS-ECMWF (middle) and corresponding observations (bottom) available the day after.

| 7 | r | Sca  | Valida il  | 2110  | Net | Media | WMedia | Max  | Var  | >001mm | >005mm | >010mm | >020mm | >050mm | >100mm |
|---|---|------|------------|-------|-----|-------|--------|------|------|--------|--------|--------|--------|--------|--------|
| A | 1 | +024 | 2019-05-29 | 00.00 | 99  | 6.1   | 6.1    | 14.9 | 3.2  | 96.0   | 60.6   | 7.1    | 0.0    | 0.0    | 0.0    |
|   | 1 | +030 | 2019-05-29 | 06:00 | 99  | 7.1   | 7.1    | 17.0 | 4.2  | 85.9   | 70.7   | 20.2   | 0.0    | 0.0    | 0.0    |
|   | 1 | +036 | 2019-05-29 | 12:00 | 99  | 5.0   | 5.0    | 14.9 | 3.9  | 79.8   | 48.5   | 13.1   | 0.0    | 0.0    | 0.0    |
|   | 1 | +042 | 2019-05-29 | 18:00 | 99  | 4.3   | 4.3    | 14.6 | 3.5  | 74.7   | 41.4   | 7.1    | 0.0    | 0.0    | 0.0    |
|   | 1 | +048 | 2019-05-30 | 00:00 | 99  | 11.0  | 11.0   | 58.3 | 12.5 | 83.8   | 56.6   | 34.3   | 20.2   | 2.0    | 0.0    |
|   | 1 | +054 | 2019-05-30 | 06:00 | 99  | 19.0  | 19.0   | 65.1 | 15.4 | 100.0  | 87.9   | 56.6   | 38.4   | 5.1    | 0.0    |
|   | 1 | +060 | 2019-05-30 | 12:00 | 99  | 17.0  | 17.0   | 58.6 | 13.9 | 100.0  | 82.8   | 54.5   | 34.3   | 3.0    | 0.0    |
|   | 1 | +066 | 2019-05-30 | 18:00 | 99  | 16.5  | 16.5   | 58.2 | 13.9 | 100.0  | 80.8   | 49.5   | 34.3   | 3.0    | 0.0    |
|   | 1 | +072 | 2019-05-31 | 00:00 | 99  | 9.8   | 9.8    | 29.3 | 7.5  | 100.0  | 70.7   | 38.4   | 11.1   | 0.0    | 0.0    |
|   | 2 | +024 | 2019-05-29 | 00:00 | 101 | 5.4   | 5.4    | 12.4 | 2.0  | 100.0  | 48.5   | 4.0    | 0.0    | 0.0    | 0.0    |
|   | 2 | +030 | 2019-05-29 | 06:00 | 101 | 6.2   | 6.2    | 12.4 | 2.2  | 100.0  | 68.3   | 5.9    | 0.0    | 0.0    | 0.0    |
|   | 2 | +036 | 2019-05-29 | 12:00 | 101 | 5.9   | 5.9    | 15.7 | 2.6  | 100.0  | 62.4   | 6.9    | 0.0    | 0.0    | 0.0    |
|   | 2 | +042 | 2019-05-29 | 18:00 | 101 | 3.5   | 3.5    | 24.8 | 3.6  | 77.2   | 21.8   | 3.0    | 1.0    | 0.0    | 0.0    |
|   | 2 | +048 | 2019-05-30 | 00:00 | 101 | 7.9   | 7.9    | 53.4 | 7.8  | 98.0   | 59.4   | 22.8   | 7.9    | 1.0    | 0.0    |
|   | 2 | +054 | 2019-05-30 | 06:00 | 101 | 9.9   | 9.9    | 53.1 | 8.7  | 97.0   | 67.3   | 37.6   | 12.9   | 1.0    | 0.0    |
|   | 2 | +060 | 2019-05-30 | 12:00 | 101 | 9.0   | 9.0    | 51.6 | 7.9  | 99.0   | 66.3   | 26.7   | 8.9    | 1.0    | 0.0    |
|   | 2 | +066 | 2019-05-30 | 18:00 | 101 | 7.8   | 7.8    | 51.6 | 7.8  | 98.0   | 48.5   | 22.8   | 6.9    | 1.0    | 0.0    |
|   | 2 | +072 | 2019-05-31 | 00:00 | 101 | 3.3   | 3.3    | 16.9 | 3.1  | 85.1   | 19.8   | 4.0    | 0.0    | 0.0    | 0.0    |
|   | 3 | +024 | 2019-05-29 | 00:00 | 115 | 7.0   | 7.0    | 17.4 | 4.1  | 97.4   | 64.3   | 21.7   | 0.0    | 0.0    | 0.0    |
|   | 3 | +030 | 2019-05-29 | 06:00 | 115 | 6.7   | 6.7    | 15.9 | 3.9  | 95.7   | 61.7   | 20.0   | 0.0    | 0.0    | 0.0    |
|   | 3 | +036 | 2019-05-29 | 12:00 | 115 | 3.1   | 3.1    | 12.0 | 2.4  | 81.7   | 16.5   | 2.6    | 0.0    | 0.0    | 0.0    |
|   | 3 | +042 | 2019-05-29 | 18:00 | 115 | 5.7   | 5.7    | 21.0 | 5.4  | 73.9   | 47.0   | 17.4   | 1.7    | 0.0    | 0.0    |
|   | 3 | +048 | 2019-05-30 | 00:00 | 115 | 7.4   | 7.4    | 19.7 | 4.4  | 97.4   | 63.5   | 23.5   | 0.0    | 0.0    | 0.0    |
|   | 3 | +054 | 2019-05-30 | 06:00 | 115 | 8.1   | 8.1    | 19.3 | 4.1  | 99.1   | 71.3   | 25.2   | 0.0    | 0.0    | 0.0    |
|   | 3 | +060 | 2019-05-30 | 12:00 | 115 | 8.2   | 8.2    | 19.4 | 4.1  | 99.1   | 73.0   | 27.0   | 0.0    | 0.0    | 0.0    |
|   | 3 | +066 | 2019-05-30 | 18:00 | 115 | 3.1   | 3.1    | 9.3  | 2.0  | 90.4   | 23.5   | 0.0    | 0.0    | 0.0    | 0.0    |
|   | 3 | +072 | 2019-05-31 | 00:00 | 115 | 0.9   | 0.9    | 6.0  | 1.4  | 21.7   | 3.5    | 0.0    | 0.0    | 0.0    | 0.0    |
|   | 4 | +024 | 2019-05-29 | 00:00 | 169 | 6.6   | 6.6    | 27.6 | 5.6  | 95.3   | 50.9   | 23.7   | 4.1    | 0.0    | 0.0    |
|   | 4 | +030 | 2019-05-29 | 06:00 | 169 | 6.0   | 6.0    | 29.1 | 6.0  | 92.9   | 38.5   | 21.3   | 4.7    | 0.0    | 0.0    |
|   | 4 | +036 | 2019-05-29 | 12:00 | 169 | 7.8   | 7.8    | 29.1 | 6.1  | 94.7   | 59.2   | 36.7   | 5.3    | 0.0    | 0.0    |
|   | 4 | +042 | 2019-05-29 | 18:00 | 169 | 14.9  | 14.9   | 35.7 | 8.7  | 91.1   | 83.4   | 68.6   | 30.8   | 0.0    | 0.0    |
|   | 4 | +048 | 2019-05-30 | 00:00 | 169 | 11.5  | 11.5   | 31.2 | 6.8  | 96.4   | 84.6   | 53.3   | 11.2   | 0.0    | 0.0    |
|   | 4 | +054 | 2019-05-30 | 06:00 | 169 | 11.7  | 11.7   | 31.2 | 6.7  | 100.0  | 85.2   | 53.3   | 11.8   | 0.0    | 0.0    |
|   | 4 | +060 | 2019-05-30 | 12:00 | 169 | 10.1  | 10.1   | 24.5 | 5.0  | 100.0  | 85.2   | 45.0   | 3.6    | 0.0    | 0.0    |

Example of tabular file with number of points exceeding some thresholds and some statistical index for each area and forecast step.

Using the COSMO-LEPS system, we also evaluate the probability of exceeding some thresholds of average precipitation in 24 hours over all the 133 Italian catchment areas.

The product was initially developed for the Emilia-Romagna region as a table in which rows represent the catchment area of the Emilia-Romagna region, columns the threshold (mm/24) and the color of the cell the probability of exceeding the corresponding threshold.

The probability is evaluated considering the average precipitation on the area of interest for each of the members of the ensembles. The product has been subsequently extended to all 133 Italian alert areas with a new graphical version. It is possible to visualize these products for the 5 days of the Cosmo-Leps forecast.

It should be pointed out that we do not use thresholds on probability to issue alert, but they help forecaster to assess confidence in one modeling chain or the other



Probability of exceeding increasing thresholds of the average areal precipitation based on the COMSO system (indicated by the colors). In the table rows represent the catchment area of the Emilia-Romagna region, while columns the threshold (mm/24).

| https://sim | nc.arpae.it/scacchieraita | ilia/ - Google Chrome |                     |                     |           |           | - 6 <b>x</b> |  |  |  |  |  |
|-------------|---------------------------|-----------------------|---------------------|---------------------|-----------|-----------|--------------|--|--|--|--|--|
| a simc.ar   | pae.it/scacchieraital     | ia/                   |                     |                     |           |           | Lī Q         |  |  |  |  |  |
| =           | ven 05 0                  | 0-MER 03              | 12-MAR 02 00-MAR 02 | 12-LUN 01           | 00-LUN 01 | 12-DOM 31 | 0            |  |  |  |  |  |
| mA          | >10                       | >20                   | >30 >40             | >50                 | >70       | >100      | 0            |  |  |  |  |  |
| Ligu-E      | 89                        | 66                    | 32                  | 4                   | 2         | 0         | 0            |  |  |  |  |  |
| Lombardia   |                           |                       |                     |                     |           |           |              |  |  |  |  |  |
| Lomb-01     | 100                       | 100                   | 100                 | 100                 | 100       | 48        | 13           |  |  |  |  |  |
| Lomb-02     | 100                       | 100                   | 89                  | 67                  | 37        | 4         | 0            |  |  |  |  |  |
| Lomb-03     | 100                       | 89                    | 46                  | 11                  | 2         | 0         | 0            |  |  |  |  |  |
| Lomb-04     | 100                       | 100                   | 98                  | 73                  | 39        | 5         | 0            |  |  |  |  |  |
| Lomb-05     | 100                       | 100                   | 100                 | 87                  | 83        | 15        | 0            |  |  |  |  |  |
| Lomb-06     | 100                       | 100                   | 100                 | 89                  | 87        | 41        | 2            |  |  |  |  |  |
| Lomb-07     | 100                       | 100                   | 96                  | 58                  | 52        | 4         | 0            |  |  |  |  |  |
| Lomb-08     | 100                       | 100                   | 85                  | 76                  | 57        | 0         | 0            |  |  |  |  |  |
| Lomb-09     | 100                       | 42                    | 21                  | 15                  | 0         | 0         | 0            |  |  |  |  |  |
| Lomb-10     | 90                        | 39                    | 0                   | 0                   | 0         | 0         | 0            |  |  |  |  |  |
| Lomb-11     | 87                        | 28                    | 0                   | 0                   | 0         | 0         | 0            |  |  |  |  |  |
| Lomb-12     | 52                        | 0                     | 0                   | 0                   | 0         | 0         | 0            |  |  |  |  |  |
| Lomb-13     | 75                        | 20                    | 0                   | 0                   | 0         | 0         | 0            |  |  |  |  |  |
| Lomb-14     | 26                        | 0                     | 0                   | 0                   | 0         | 0         | 0            |  |  |  |  |  |
|             |                           |                       |                     | Trentino Alto Adige |           |           | +048         |  |  |  |  |  |
|             |                           |                       |                     |                     |           | •         |              |  |  |  |  |  |

Probability of exceeding increasing thresholds of the average areal precipitation based on the COMSO system (indicated by the colors). The rows represent the catchment areas subdivided by regions, columns represent increasing threshold (mm/24).

## Validation

Deterministic products for each Italian warning area are validate on a seasonal basis using "bubbles plot" charts, a sort of the scatter plot in which the data points are replaced with bubbles and the sizes of the bubbles are determined by the number of events. Observed and forecast precipitation, aggregated on the catchment areas are divided into classes for average and maximum precipitation on the area and separate plots for each indicator are produced.

| CLASSES                | MEAN AMOUNT |  |  |  |  |
|------------------------|-------------|--|--|--|--|
| FOR MEAN PRECIPITATION | IN 24h (mm) |  |  |  |  |
| NO PRECIPITATION       | <0.2        |  |  |  |  |
| NON SIGNIFICANT        | 0.2 – 5     |  |  |  |  |
| LIGHT                  | 5-20        |  |  |  |  |
| MODERATE               | 20-45       |  |  |  |  |
| HEAVY                  | >45         |  |  |  |  |

| CLASSES FOR MAX PRECIPITATION |        |      |       |       |        |         |      |  |  |  |  |
|-------------------------------|--------|------|-------|-------|--------|---------|------|--|--|--|--|
| MAX AMOUNT<br>IN 24h (mm)     | 0.2 -5 | 5-25 | 25-50 | 50-75 | 75-100 | 100-150 | >150 |  |  |  |  |



seasonal report for MAM2019. In the top panel are displayed the charts for mean value, in the bottom panel those for maximum for the three models (COSMO-2I, COSMO-5M, IFS-ECMWF from left to right)

Seasonal reports (in Italian) starting from 2018 containing plots for each of the Italian warning areas are available in pdf-format. <u>GO TO EXAMPLE</u>