The Flash Floods Use Case in the “MISTRAL” project: Methodology and Verification

Estíbaliz Gascón * (1), Andrea Montani (1), Tim Hewson (1), Fatima Pillosu (1,2)

(1) ECMWF, Forecast Department, Evaluation Section, Reading, United Kingdom (* estibaliz.gascon@ecmwf.int), (2) University of Reading, United Kingdom

1. Introduction

ECMWF main objective in MISTRAL project is to extract maximum benefit from **ecPoint-Rainfall** product and a 2.2km resolution COSMO limited area ensemble (**COSMO-2I-EPS**) in Italy and surrounding countries, using the CINECA supercomputer facilities in Bologna to produce real-time forecasts for operational use. To do that we apply a new and innovative scale-selective neighbourhood post-processing technique, with the primary aim being to identify and preserve the most reliable heavy rainfall signals, and then blend that output with the new experimental product ecPoint 6-h, to combine the most skilful aspects of the two systems. To do this, new 6-h ecPoint Rainfall forecasts were also developed in the framework of the project, building on pre-existing developments that now deliver 12-h ecPoint-rainfall forecasts to ECMWF customers in real-time. The blending approach aims to exploit the strong points of the two forecasting systems, to improve forecast quality in general terms, and to in particular support decisions regarding weather alerts related to flash flood prediction.

2. MISTRAL project

1 **EUROPEAN PROJECT**

Project funded under the Connecting Europe Facility (CEF) – Telecommunication Sector Programme of the **European Union** and started on 1 October 2018.

2 **GOAL**

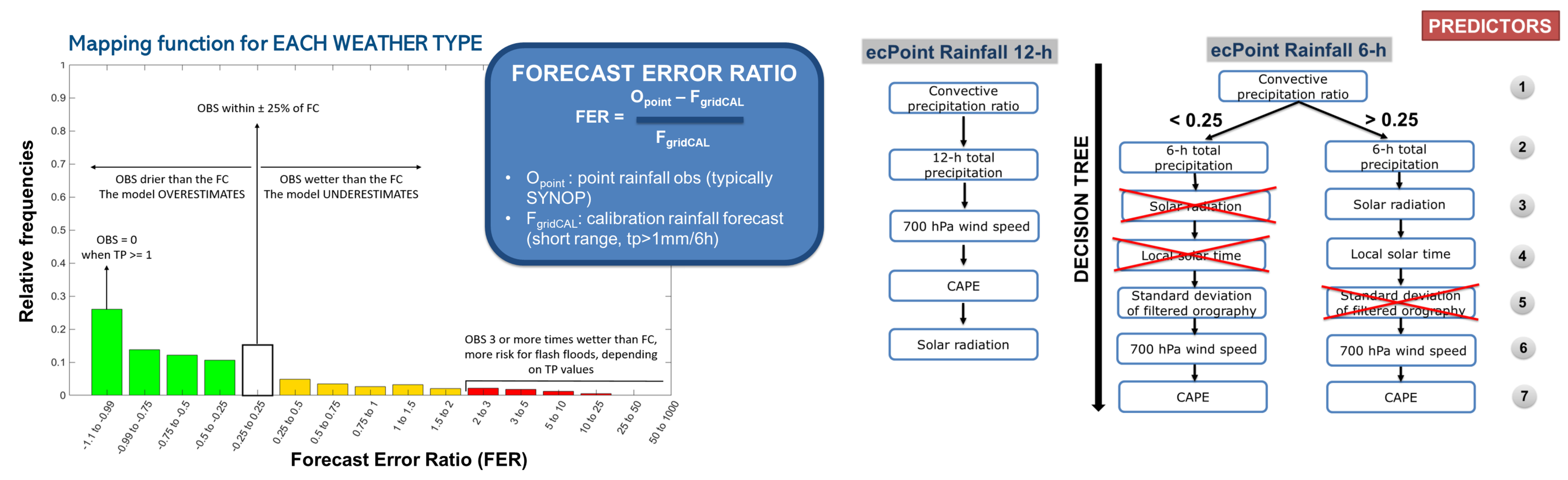
The **GOAL** of the MISTRAL portal is to facilitate and foster the **re-use of the datasets by the weather community**, as well as by its cross-area communities, to provide added value services through the use of **HPC resources**, turning it into the level of new business opportunities.

1 **ECMWF ROLE**

Exploit CINECA supercomputer facilities to combine the most skilful aspects of two **6-h precipitation forecasts**:

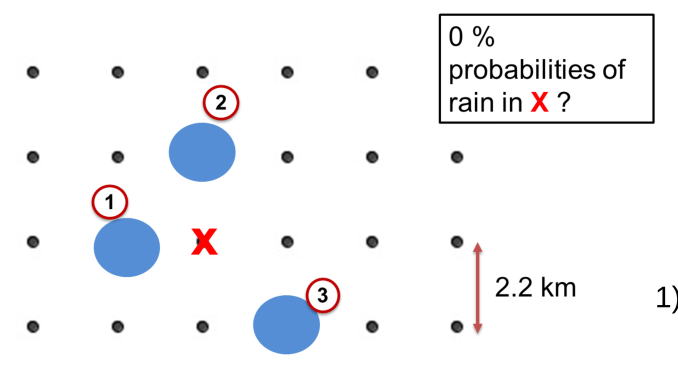
1. **ecPoint Rainfall** product from IFS ENS (ECMWF)
2. **COSMO-2I EPS 2.2 km** resolution + **new post-processing** method

3. ecPoint-Rainfall 6h



- ecPoint is **a new statistical post-processing** system that introduces relevant physical processes in the rainfall generation mechanism not represented in the NWP model, as well as describes its error sources for point-verification. This contributes to anticipate sub-grid variability and improve biases in the model (*https://confluence.ecmwf.int/display/FUG/Point+Rainfall*)
- 12-h ecPoint-Rainfall is currently an experimental operational product available in ecCharts. 6-h ecPoint-Rainfall has been developed in the framework of MISTRAL project and it is currently being tested.

4. Nearest neighbour COSMO post-processing



Ensemble members disagreement: *precipitation predicted by 3 different ensemble members (1,2, 3) in different grid points for the same period of time.*

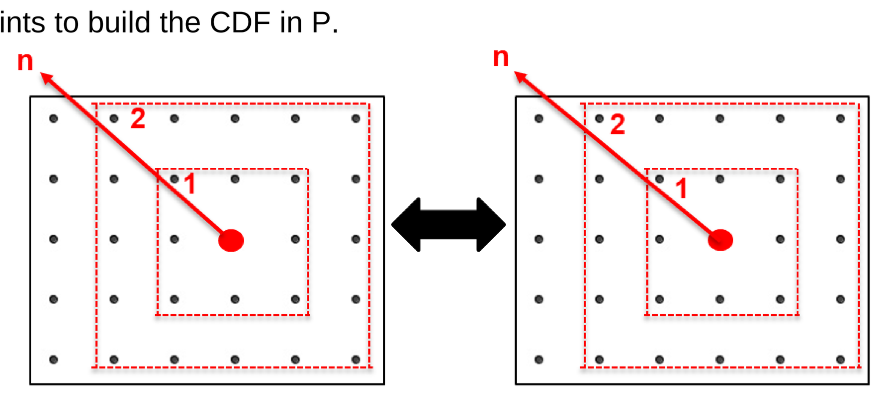
The product from **post-processing COSMO-2I-EPS** is related to the computation of the agreement scale S between the different ensemble members and described in Dey et. al (2016a, 2016b) and Blake et al. (2018):

1) At grid point P of the model, the difference in precipitation between all the ensemble members is considered; their similarity is assessed by pairs on ensemble members (190 separate comparisons with 20 members).

2) If the forecasts are quite similar, the agreement scale at point P is the grid scale of the model itself. If not, a square neighbourhood size = 3 x 3 grid points, centred upon the point P, is considered, adding those surrounding points to build the CDF in P.

3) Then we evaluate the ensemble members agreement again and if this time, the forecasts are found to be similar, then the agreement scale is set to 3x3. If the fields are not similar enough, then the scale is increased again, to give a 5x5 grid-point neighbourhood.

4) Until the agreement scale has been set, the code will repeat steps similar to 2) and 3), incrementing the neighbourhood size each time. At some pre-defined level computations will stop even if agreement has not been reached (for computational efficiency reasons)



Variable-size neighbourhood method
Dey at al. (2014, 2016) and Black et al. (2018)
Iterative process between pairs of ensemble members.
More similar forecasts = smaller neighbourhood

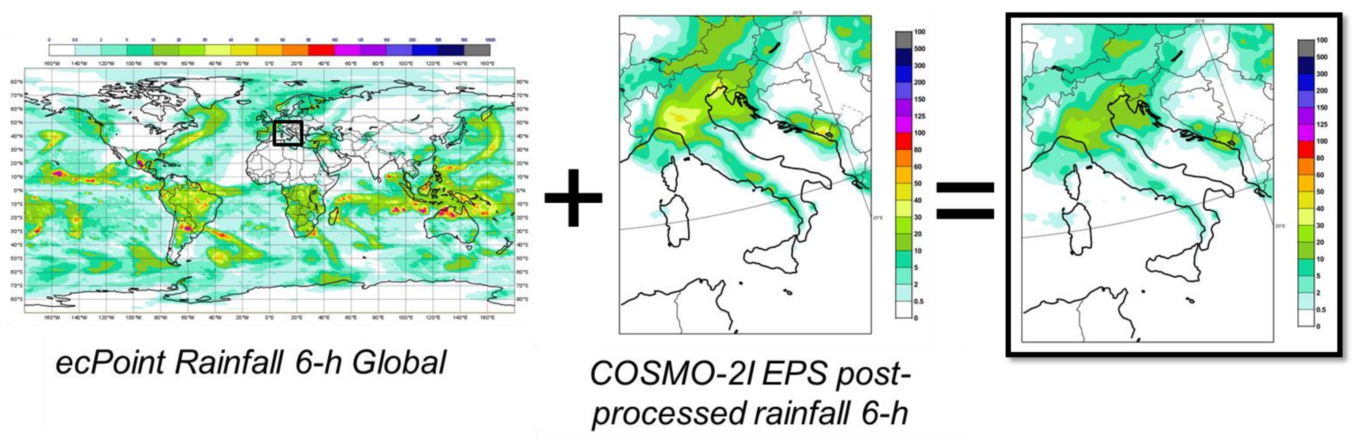
5. Blending product

COSMO and ecPoint 6-h Rainfall blending

Combine the **most skilful aspects of the two systems** after applying different post-processings.

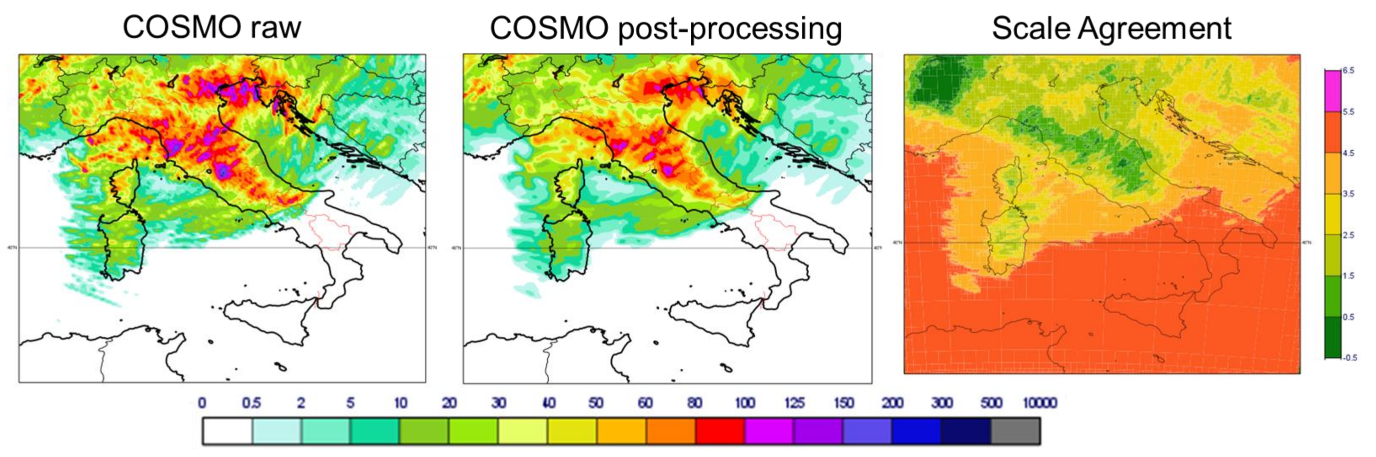
- All using the **CINECA supercomputer**.
- The final product will comprise **percentiles** (1, 2,..99) and **probabilities of exceeding** specific precipitation thresholds, for each COSMO gridbox.
- Lead times up to **48 h (the blending)** and **240 h** for the **ecPoint** Rainfall 6-h.

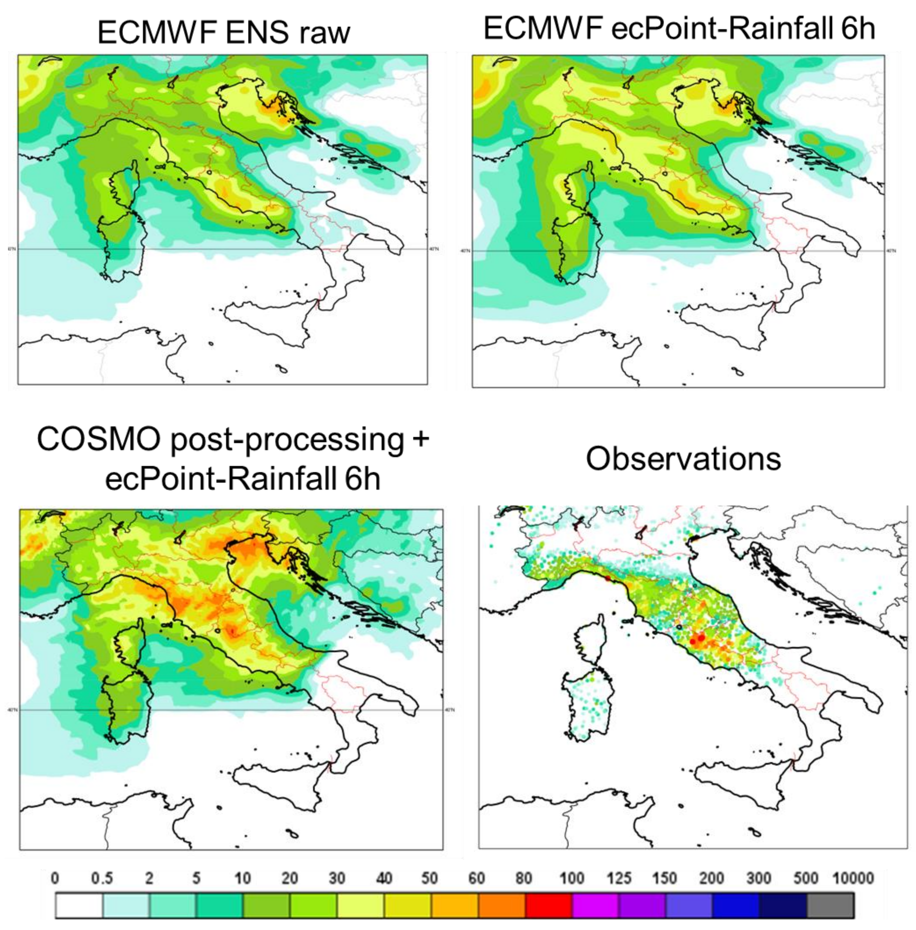
THE WEIGHTS OF EACH SYSTEM IN THE BLENDING WILL BE LEAD-TIME DEPENDANT



ecPoint + COSMO post-processing rainfall 6-h for Italy and surroundings

6. Case study: 28 July 2019

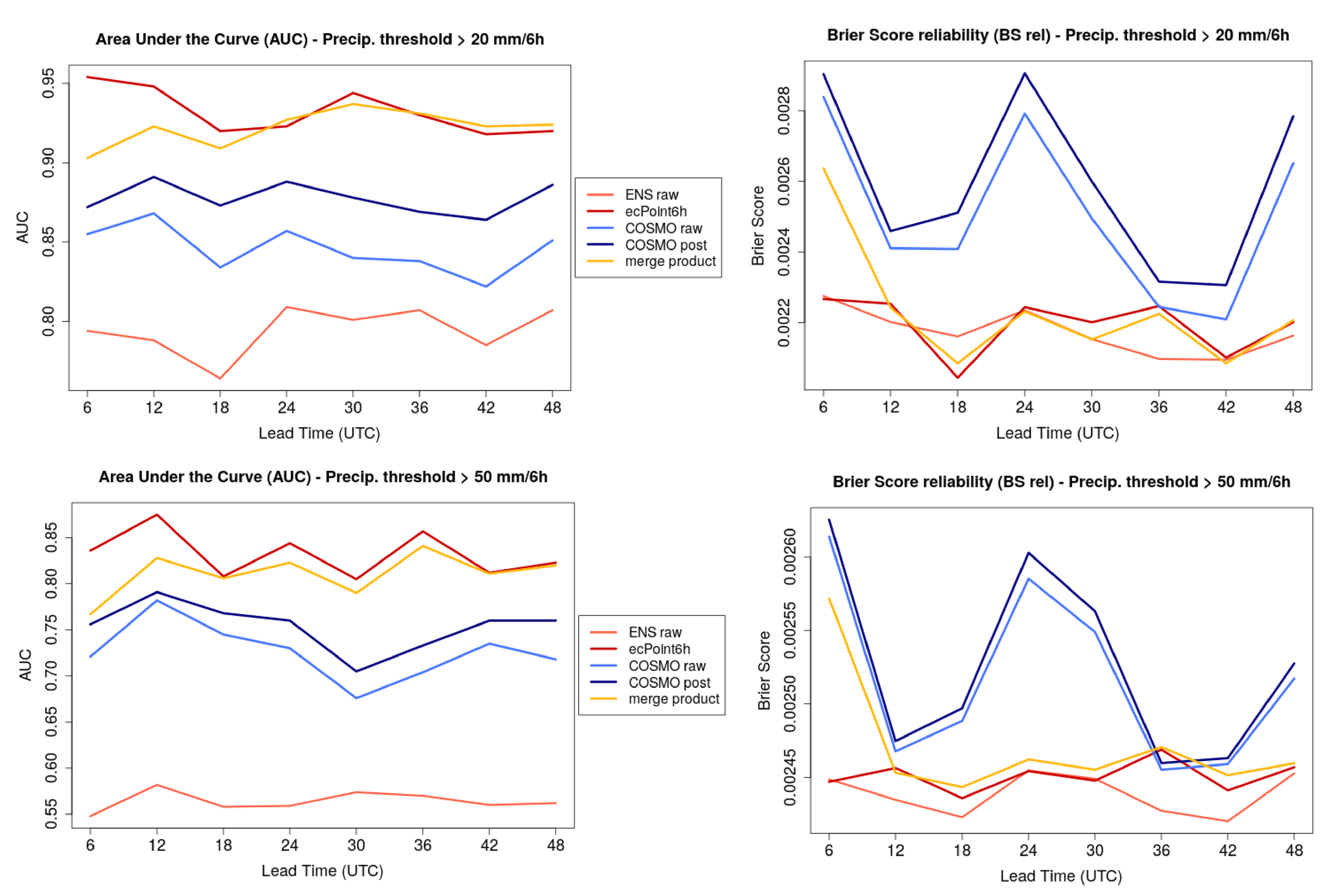




95th percentile of 6-h total precipitation from different ensemble systems *valid on 28th July 2019 at 06th at lead time t+30h (for the merging COSMO post + ecPoint6h product). Base time of ENS raw and ecPoint is 26th July at 12 UTC and for COSMO raw and COSMO post on 26th July at 21 UTC. Scale agreement and observations plots included.*

COSMO post-processing reduced the overestimation of convective precipitation in COSMO raw outputs where the scale agreement level is high, but some overestimation is still left. ecPoint6h underestimates the amount in some areas, but it highlights the right most affected areas. Merging product obtains the benefits from both, highlighting the right areas with a more accurate precipitation amount.

7. Verification: preliminary results



Area under the curve (AUC) (left) and Brier Score reliability (right) for different lead times and all the ensemble systems. Verification period 1 year (2019) every 6 hours up to 48h. Verification scores for precipitation greater than 20mm (top) and 50 mm (bottom) in 6h.

- Merging product (COSMO post + ecPoint6h) is always the best in resolution and reliability, but quite close to the skills of ecPoint6h. The only lead time which is worse is 6h, when we give more weight to COSMO post model (should we reduce COSMO weight?)
- COSMO post-processing and ecPoint6h improve the resolution for large precipitation thresholds, but not the reliability (with smaller thresholds, both, resolution and reliability are improved)

Farther reading

- Pillosu F., Hewson T., 2017, New point-rainfall forecasts for flash flood prediction, ECMWF Newsletter Number 153 - Autumn 2017
- Hewson, T.D. and F.M. Pillosu, 2020: A new low-cost technique improves weather forecasts across the world. arXiv preprint, https://arxiv.org/abs/2003.14397
- Dey, S.R.A., Roberts, N.M., Plant, R.S. and Migliorini, S. (2016), A new method for the characterization and verification of local spatial predictability for convective-scale ensembles. Q.J.R. Meteorol. Soc., 142: 1982-1996.

This work has been supported by the MISTRAL project under the Connection Europe Facility (CEF) Telecommunication Sector Programme of the European Union