# SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

| | |
|---|---|
| **Reporting year** | 2020 |
| **Project Title:** | Investigation of case studies using COSMO-based deterministic and ensemble systems |
| **Computer Project Account:** | SPCOLEPS |
| **Principal Investigator(s):** | Ines Cerenzia |
| **Affiliation:** | ARPAE Emilia-Romagna, SIMC, Viale Silvani, 6 Bologna, Italy |
| **Name of ECMWF scientist(s) collaborating to the project** (if applicable) | Andrea Montani |
| **Start date of the project:** | 01/01/2018 |
| **Expected end date:** | 31/12/2020 |

## Computer resources allocated/used for the current year and the previous one (if applicable)

Please answer for all project resources

| | | Previous year | | Current year | |
|---|---|---|---|---|---|
| | | Allocated | Used | Allocated | Used |
| **High Performance Computing Facility** | (units) | 2.100.000 | 4.496.284 (214%) | 2.100.000 | 0 |
| **Data storage capacity** | (Gbytes) | 600 | 600 | 600 | 0 |

## Summary of project objectives (10 lines max)

To assess the sensitivity of model performance of horizontal resolution and, in particular, to the use of parameterised or explicit convection

## Summary of problems encountered (10 lines max)

During 2019 and 2020 no problems have been encountered.

## Summary of plans for the continuation of the project (10 lines max)

## List of publications/reports from the project with complete references

2019/11 Oral presentation with title: " Previsione per l'alluvione del '94: performance del sistema di previsione d'ensemble ad alta risoluzione" (Ines Cerenzia[1], Giacimo Pincini[1], Tiziana Paccagnella[1], Davide Cesari[1], Thomas Gastaldo[1], Enrico Minguzzi[1], 1. Arpae-Emilia Romagna, HydroMeteoClimate Service, Bologna, Italy) Workshop: 25 years after the major Piedmont flood of 1994

Paper: "Forecast for the 1994 flood in Piedmont: performance of the ensemble system at high resolution" (Ines Cerenzia[1], Giacomo Pincini[1], Tiziana Paccagnella[1], Enrico Minguzzi[1], Thomas Gastaldo[1], Virginia Poli[1], Maria Stefania Tesini[1], Paolo Patruno[1], Davide Cesari[1]. 1. Arpae-Emilia Romagna, HydroMeteoClimate Service, Bologna, Italy). Submitted to the Bulletin of Atmospheric Science and Technology

## Summary of results

If submitted **during the first project year**, please summarise the results achieved during the period from the project start to June of the current year. A few paragraphs might be sufficient. If submitted **during the second project year**, this summary should be more detailed and cover the period from the project start. The length, at most 8 pages, should reflect the complexity of the project. Alternatively, it could be replaced by a short summary plus an existing scientific report on the project attached to this document. If submitted **during the third project year**, please summarise the results achieved during the period from July of the previous year to June of the current year. A few paragraphs might be sufficient.

The billing units of the project were used to run the convection-permitting ensemble prediction system COSMO-2I-EPS for a number of past cases, so as to compare its performance against those provided by ECMWF ENS and COSMO-LEPS.

Of relevance was the experimentation performed for the re-forecast of the major flood of Piedmont (North-West Italy) of 1994. After 25 years from the catastrophic event, a workshop was held in Piedmont with the aim of highlighting the forecast improvements accomplished in these years and the steps that still need to be done (Ferrero and Balsamo, 2020). Several operational services

participate to this large re-forecast project. ARPAE-SIMC performed a re-forecast using the high resolution ensemble system based on the COSMO model, i.e. COSMO-2I-EPS. All the experimentation was performed on ECMWF HPC.

Initial and boundary conditions were provided by the ECMWF re-forecast of the global ensemble ENS (IFS Cycle 46r1), at grid spacings of 18km. COSMO-2I-EPS at 2.2km horizontal resolution was 1-way nested into the driver. Actually, this was a simplified version of the currently pre-operational model chain COSMO-2I-EPS has been used, due to the unavailability of an intermediate resolution COSMO-based ensemble (normally run by COMET). The COSMO-based ensemble was initialized on 3 November 1994 at 00UTC with a forecast range of 5 days. The re-forecast was performed with an ensemble size of 20 members (default of COSMO-2I-EPS) and with an enlarged population of 50 members (i.e. downscaling all 50 members of ENS ensemble). The ECMWF billing units used in 2019 exceeded the allocated amounts, due to the decision to perform this sensitivity test. However, this sensitivity test did not evidence significant changes in the final results in terms of probability of occurrence, ensemble mean and ensemble spread of precipitation and proved the good representativity of a random sub-sample of ENS.

All the verification was focused to evaluate the accuracy of the probabilistic forecast for intense precipitation. The details of the experiment and of the results were reported in the paper Cerenzia et al. 2020 (submitted). However, the main outcomes are herein summarized.

Results indicated that both COSMO-2I-EPS and ENS could predict with high probability and advance the timing and the spatial patterns of the precipitation up to the province scale. The benefit of high resolution was shown mainly in the prediction of intense precipitation, in terms of correct amounts, location and confidence of occurrence. A 48-hour forecast for 4 and 5 November 1994, produced using the COSMO-2I-EPS system, predicted accumulated rainfall very close to the observed 200 mm in the southern part of Piedmont and close to the 400 mm observed in the western Alpine and pre-Alpine areas (Figure 1).

Additionally, convection permitting resolution improved the representation of orographic precipitation, avoiding the rainfall drain too far upstream typical of coarser models and including the possible development of strong convection episodes embedded in the large-scale-forced orographic rise.

Finally regarding the ensemble spread, in the high-resolution ensemble it indicated large uncertainty at the local scale, mainly in defining the flow tendency to flank or flow over each mountain. Vice versa, the global ensemble showed high spread associated with large scale features like the velocity of the frontal passage and its position.

In conclusion, this experiment clearly evidenced as modern probabilistic ensemble systems have the ability to correctly forecast and provide a timely alarm in case of major floods driven by large scale forcings, as the one occurred in Piedmont in 1994. The improvements with respect to the probabilistic forecast performed in 1994 (at grid spacings of 320km) were extremely high, in terms of accuracy, localization and intensity of precipitation, with a significant step forward done by employing a convective-scale resolution system.

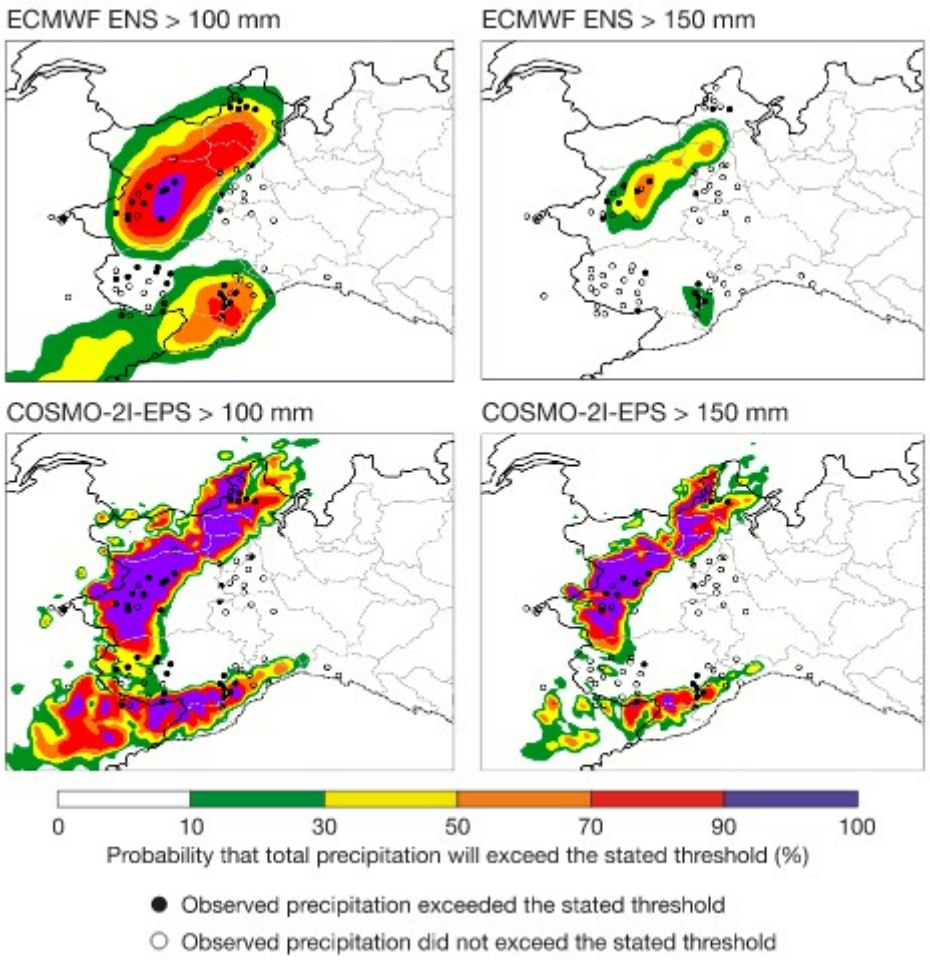


Figure 1. The charts show modern re-forecasts, starting at 00 UTC on 3 November 1994, of the probability that total precipitation on 5 November 1994 will exceed the thresholds indicated, for an ECMWF re-forecast at a grid spacing of 18 km resolution (top row), and for a COSMO-2I-EPS re-forecast at a grid spacing of 2.2 km (bottom row)

## References

Cerenzia I., G. Pincini, T. Paccagnella, E. Minguzzi, T. Gastaldo, V. Poli, M. S. Tesini, P. Patruno, D. Cesari, Forecast for the 1994 flood in Piedmont: performance of the ensemble system at high resolution, Submitted to the Bulletin of Atmospheric Science and Technology

Ferrero E. and G. Balsamo, The 1994 Piedmont flood revisited, ECMWF Newsletter 2020, N 162.