LATE REQUEST FOR A SPECIAL PROJECT 2016–2018

MEMBER STATE: Italy

Principal Investigator[1]**:** Valerio Capecchi

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Other researchers: ……………………………………………………………………..……

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Project Title: High-impact precipitation events prediction with a convection-permitting model nested in the ECMWF ensemble

Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for 2016-2018: (The project duration is limited to a maximum of 3 years, agreed at the beginning of the project.)		**2016**	**2017**	**2018**
High Performance Computing Facility	(units)	3 000 000	6 000 000	6 000 000
Data storage capacity (total archive volume)	(gigabytes)	25 000	25 000	25 000

*An electronic copy of this form **must be sent** via e-mail to:* *special_projects@ecmwf.int*

Electronic copy of the form sent on (please specify date): ……………………………………………

Continue overleaf

[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide an annual progress report of the project's activities, etc.

Principal Investigator: Valerio Capecchi

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Extended abstract

Scientific background

The development of Ensemble Prediction Systems (EPS) at the convection-permitting (CP) scale is currently in the agenda of a number of weather forecasting services and research centers. Examples at national services include COSMO-DE at 2.8 km horizontal resolution (Gebhardt et al, 2008), MOGREPS-UK at 2.2 km horizontal resolution (Tennant, 2015), AROME-EPS at 2.5 horizontal resolution (Vié et al, 2011), COSMO-H2-EPS (Marsigli et al, 2014) and CNMCA-LETKF (Special Project 2015-2017 ITLEKF). Examples at research centers include experiences with the WRF model at 3 km horizontal resolution (Clark et al, 2010, Schwartz et al, 2014, Schwartz et al, 2015a and Schwartz et al, 2015b) or at lower resolution (Tapiador et al, 2012).

In the recent literature (Raynaud et al, 2016 and Tennant, 2015) it has been suggested that the baseline approach, of a dynamical downscaling using convection-permitting models nested in global ensemble with a coarser horizontal resolution (eg 33 km) provide valuable information. Besides the fact that this technique simply interpolates, dynamically, the driving ensemble on the high resolution grid, it has been judged to be a valuable method since it captures the large-scale flow which is the dominant driver of variability. Furthermore, it has the advantage of being simple to implement and basically with a very low CPU costs. On the other hand it suffers, if compared to other CPU consuming methods, a spin-up time of about 9-12 h.

The recent availability of higher-resolution global ensemble data (the ECMWF ensemble now runs with an 18-km resolution since March 2016), gives the possibility to investigate the value of this simple dynamical downscaling approach on high-impact weather events, with a limited-area convection-permitting model directly nested in the new ECMWF global ensemble. This is a pragmatic approach to fully take advantage of improved global data (in terms of model physics, model resolution and data assimilation techniques). Moreover, it removes the need of any intermediate grid with the potential benefits outlined in Marsigli et al (2014), namely: avoiding any grid where the convection is partially resolved.

Results will allow us to estimate the value of the cascade ‘ECMWF global ensemble’ plus ‘regional convection-permitting ensemble’, following ECMWF recent upgrade.

Motivation of the Special Project

The rationale of the Special Project is to evaluate the accuracy of a cascade of state-of-the-art ensembles, from global-to-local, by re-forecasting past high-impact precipitation events. Starting from the recently implemented ECMWF suite of high-resolution analysis (at Tco1279L137 resolution, with a corresponding 9 km horizontal grid) and the medium-range ensemble (at Tco639L91 resolution, with a corresponding 18 km horizontal grid), the plan is to use a dynamical downscaling method to obtain limited-area ensemble forecasts at convection-permitting scale.

This project has been designed following the work carried out in the first months of 2016 by the Principal Investigator (see ECMWF Newsletter No 148, summer issue), which focused on the ‘Alluvione di Firenze del 1966’ (the famous flood of Florence of November 1966). The key idea is to expand the data set to include more high-impact weather events, to be able to draw more statistically sound conclusions. This will be achieved by considering some past cases of high-impact precipitation that affected the Mediterranean region, and Italy in particular, during the last few years (rather than 50 years ago as it is the case for ‘Florence 1966’), to take full advantage of the fact that today the analyses are better because of the availability of many more observations.

By applying an ensemble approach, re-forecasts will be generated using the latest ECMWF model cycle 41r2 run at spectral resolution TCo639 and the most updated WRF model, run at convection-permitting scale (about 3 km of horizontal resolution). The work is extremely relevant to understand the potential value of a cascade of state-of-the-art ensembles (global hydrostatic and regional convection-permitting) to predict high-impact events, and thus guide future developments. The possibility to have this special project approved is extremely valuable for a small research centre/ regional weather office as LaMMA, where CPU time-consuming numerical methods (such those developed to perturb regional initial conditions) are a limiting factor to perform this type of research work.

Technical plan

The focus of the Special Project will be the medium-range prediction of Heavy Precipitation Events (HPEs; see e.g. Vié et al, 2012 and references therein) that affected Italy in the recent past. For each HPE, a set of different starting dates will be considered starting with 5 days in advance the HPE (day-5) up to 1 day in advance the HPE (day-1). Limited-area, convection-permitting model runs will be nested from day-3 up to day-1.

A preliminary set of HPEs has been selected to estimate the amount of units requested and on the basis of the pre-existing scientific literature (possible future modifications might occur):

- Cinque Terre, 25 October 2011 (study case analysed in Buzzi et al, 2014)
- Genoa, 4 November 2011 (study case analysed in Buzzi et al, 2014)
- Genoa, 9-10 October 2014 (study case analysed in Silvestro et al, 2015)

The area of interest is Italy and the domain of the limited-area numerical integrations is sketched in Figure 1.

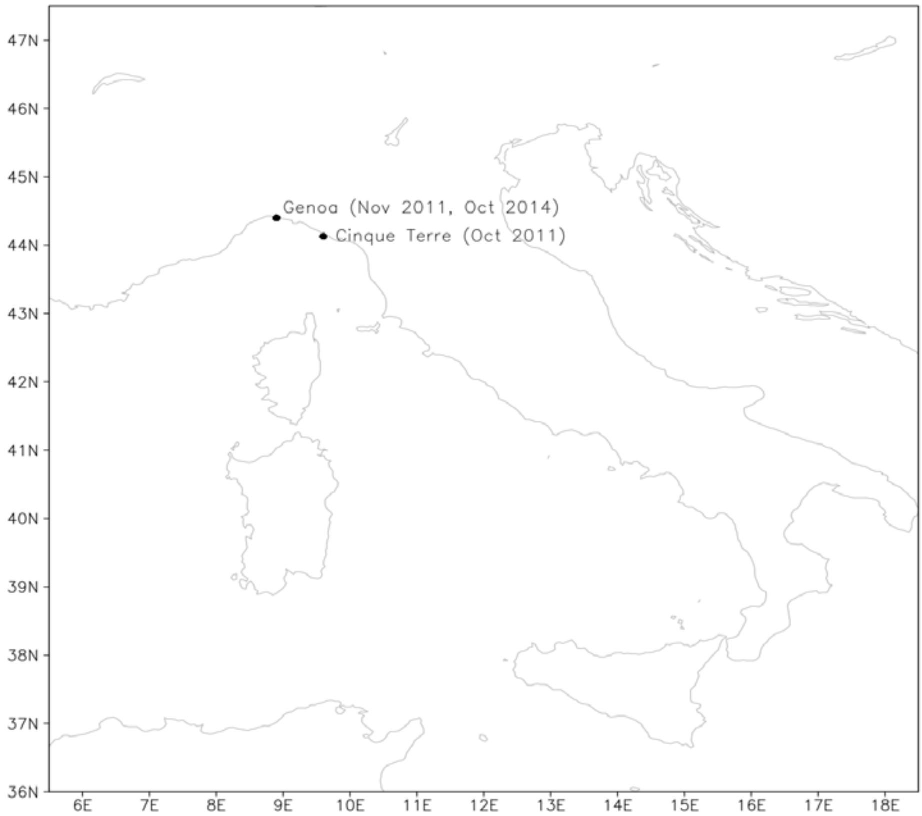

Figure 1: Domain of the limited-area numerical integrations with the locations (Genoa and Cinque Terre) of the selected study case

The computer-resource requirements have been estimated on the basis of the current integrations of the ECMWF TCo639 ensemble system:

- the SBU needed to perform a single study case with the ECMWF global model is 5.5 million SBUs,
- the SBUs estimated to perform a single study case with the WRF limited-area model is 0.5 million SBUs.

The total data storage required to store a single study case is 12000 GB for the ECMWF global data and about 13000 GB for the WRF limited-area data.

Scientific plan

The questions that will be addressed in the framework of Special Project are:
1) How many days in advance a HPE, such those listed in the previous section, can be foreseen by using the global state-of-the-art ensembles?
2) Which is the added value of running a regional convection-permitting high-resolution ensemble in terms of QPF (Quantitative Precipitation Forecast)?

The first question will be addressed by estimating the forecast uncertainty and by assessing the probability that extreme precipitation values might occur for different starting dates. Starting from a 10-day forecast, and then considering shorter forecast lengths, this will be done first by looking to the ensemble distribution (ensemble-mean, spread and single members, possibly applying a clustering algorithm) of the geopotential height at isobaric level 500 hPa to assess the accuracy and reliability of the prediction of the large-scale synoptic features. Then, we will consider the precipitation field, and look both at single members, the ensemble-mean and the spread, and at the probability of precipitation exceeding high thresholds (such as 50 mm/1 day or 100 mm/1 day) over the target domain (Figure 1).

Forecast assessment will be based both on objective metrics (eg. the continuous ranked probability score, the relative operating characteristic, the Brier score) and on a visual comparison between the patterns of the observed precipitations (obtained by radar data or by interpolation of the existing rain-gauges) and the forecast patterns. Furthermore, point-wise verification of the precipitation at key locations will also be performed (an example of such plot is shown in figure 2).

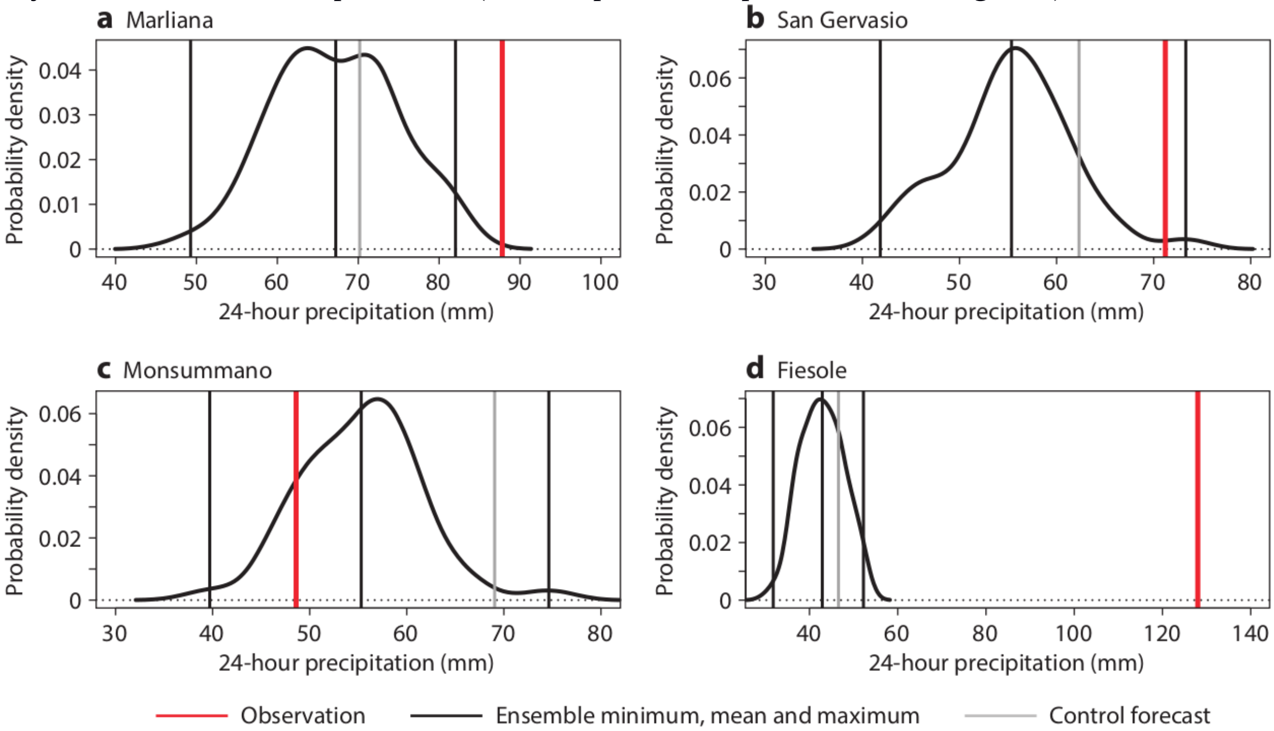

Figure 2: Example of a point-wise comparison between probability distribution of global ensemble precipitation forecast and observed rainfall amounts for four rain-gauges. The red vertical line is the observed value, the three black vertical lines are the minimum, mean and maximum value of the respective ensemble members, and the grey vertical line is the control forecast value . Distributions are estimated by means of the kernel density function .

The second question will be addressed by comparing the probability of precipitation predicted by the global ensemble run at 18 km with the probability of precipitation of the regional ensemble in the short-forecast range (say up to 5 days). The idea is to obtain from the regional forecast, larger areas highlighted by high probabilities of intense precipitations with respect to global forecast (see in Figure 3 what has been obtained for the HPE of 4 November 1966, as described in the ECMWF Newsletter No 148, summer issue). Moreover, since scientific papers dealing with the HPEs listed above were published recently (for example Buzzi et al, 2014 for the study case Cinque Terre occurred on 25 October 2011), the results will be compared with those present in the literature to trigger considerations on results obtained by different models or different numerical suites.

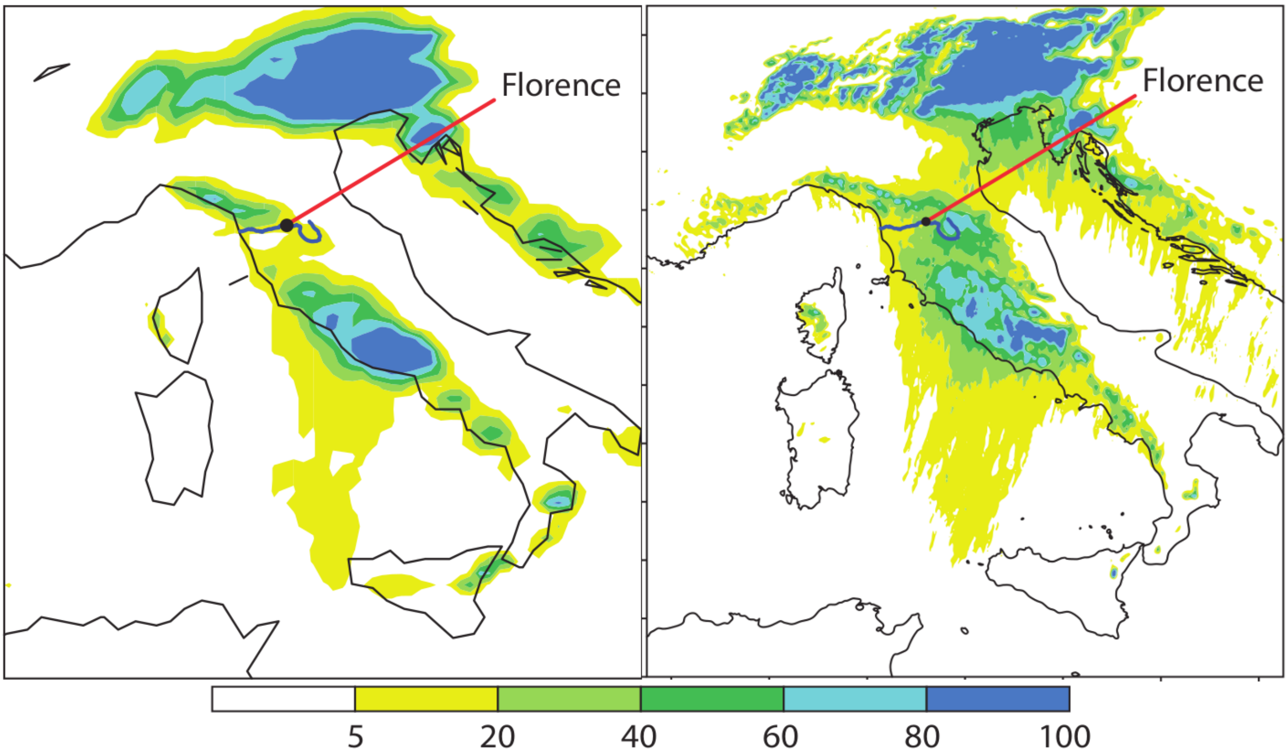

Figure 3: Probability of Precipitation exceeding 50 mm/1 day for global forecast (left) and regional forecast (right) on 4 November 1966 (t+72 hour forecast)

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