LEPS, the Limited–area–model Ensemble Prediction System at ARPA-SMR

Chiara Marsigli, Andrea Montani, Fabrizio Nerozzi,
Tiziana Paccagnella and Stefano Tibaldi

ARPA-SMR, Bologna, Italy

The Ensemble approach allows to associate a probability of occurrence to meteorological events, providing further scope to quantitative precipitation forecasting. Current operational implementations of the ensemble prediction technique are currently based upon global circulation models essentially covering the global scale. In the limited–area model (LAM) environment, it appears to be difficult to produce perturbations of the initial conditions which can efficiently grow for time ranges longer than 12–24 hours, depending on the size of the integration domain, possibly due to the driving/damping effects of the lateral boundary conditions. One natural approach to regionalize and adapt the global–scale ECMWF Ensemble Prediction System (EPS) on the local scale should be to nest limited–area models in each EPS member. The obvious drawback of this procedure is connected to the large amount of computer resources required and to the intense data–flow necessary if the LAM integrations are not performed in the same centre where the EPS is produced.

At the Regional Meteorological Service of Emilia–Romagna (ARPA-SMR, in Bologna, Italy) the dynamical adaptation of the EPS on the local scale through LAM nesting, is founded on an ensemble reduction technique where only few members of the entire global ensemble are selected to drive LAM integrations (Molteni et al., 2001; Marsigli et al., 2001). The reduction procedure is carried on by performing, on a restricted area (53–35N; 5W–25E), an independent cluster analysis of the 51 EPS members by a complete linkage method, where clustering is based on dynamic and thermodynamic fields in the lower–to–middle troposphere. The number of clusters is fixed to 5. A Representative Member (RM) for each of the 5 clusters is then defined by selecting the cluster member with the minimum distance from the other members of the same cluster and the maximum distance from all the remaining EPS members. These 5 RMs provide initial and boundary conditions for 5 LAM integrations up to three-to-five days ahead. The 5 individual LAM integrations are then used to compute a–priory probability of occurrence of meteorological events of interest, e.g. the exceeding of a given accumulated precipitation threshold, by combining them with weights proportional to the population of the cluster they represent.

Another practically important feature of the ARPA-SMR methodology is the use of the concept of "super-ensemble". Rather than using only one ECMWF EPS set, more (up to three) consecutive daily EPS sets, progressively lagged in time, are used, providing initial sets of up to 153 individual members. From preliminary evaluations, the use of the super-ensemble technique increases the reliability of the computed a-priory probability of occurrence of the predicted event (surpassing of a precipitation threshold). The LAM employed so far is LAMBO (Limited Area Model BOlogna), the hydrostatic limited-area

model in operational use at ARPA-SMR. LAMBO is based on the NCEP ETA model and has an operational horizontal resolution of 10 or 20 km with 32 vertical levels.

The LEPS technique is under evaluation on a set of individual case studies of severe precipitation events in Europe. In the following figure, an example of the results of the LEPS application is shown in the case of the Soverato flood event (September 2000), which occurred in the Calabria region (the "tip" of the "Italian boot"). Precipitation exceeding 340 mm/day was observed in the land areas of the Calabria region, this causing landslides, great disruption and losses of life. Fig.1 shows the rainfall probability maps (exceeding the 20 and 100 mm/day thresholds) generated by the super–ensemble methodology 60 hours before the event. Both localisation and intensity of the flood are properly captured, despite the fact that these maps are obtained by combining only 5 (weighted) LAMBO integrations (Montani et al., 2002).

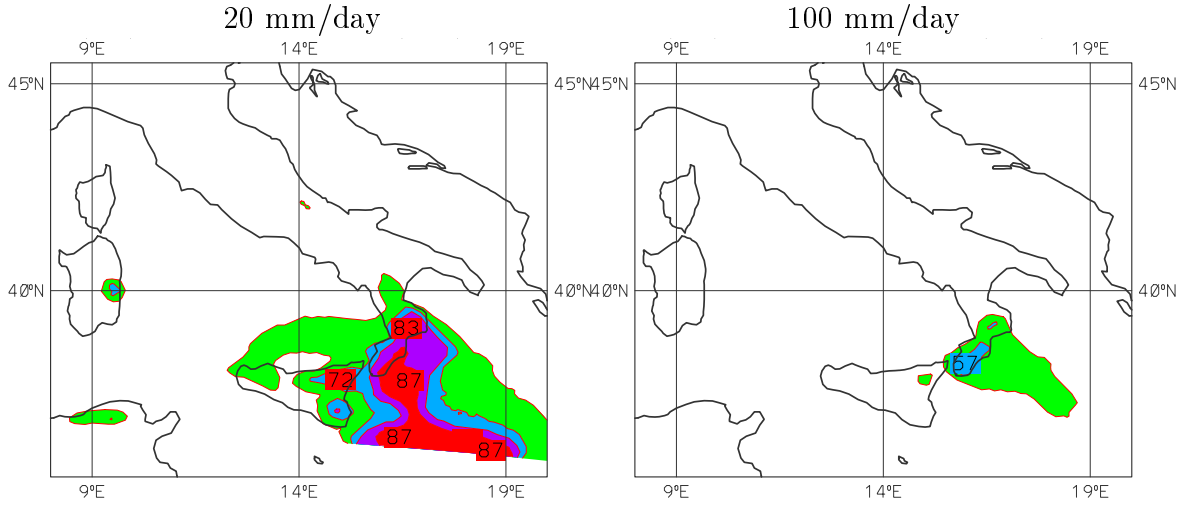

Figure 1: Probability maps (valid at 00UTC 10 September 2000; 60 hour forecast) for 24h accumulated rainfall exceeding 20 and 100 mm (left and right panel, respectively) as predicted by the super–ensemble. Contours every 20%.

Currently, the LEPS technique is still being tested and developed. The first major change will involve the type of LAM employed, since the non–hydrostatic Lokal Modell replaces LAMBO. The name of the project will also reflect this change, from LEPS to COSMO–LEPS, to officially frame this project in the COSMO (COnsortium for Small–scale MOdelling) project. During 2002, COSMO–LEPS will be tested on a quasi–operational basis, to allow a comprehensive verification effort, based on subjective and objective criteria.

References

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