Performance of ECMWF ENS and COSMO-based ensemble systems for cases of high impact weather over Italy

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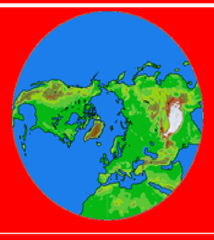
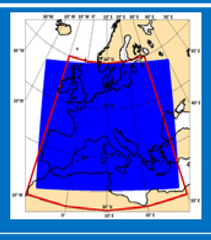
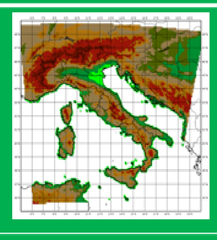
Motivation and purpose of the work

- **Motivation:** the forecast of "High-Impact Weather" (HIW) events with high spatio-temporal detail still suffers from severe limitation because HIW horizontal dimensions are too small to be explicitly resolved by state-of-art Numerical Weather Prediction (NWP) ensemble systems.
- The **main purpose** of this study is to assess the performance of a newly developed high-resolution ensemble prediction system for a number of HIW events. It is planned to compare its performance against two state-of-art ensemble prediction systems, both running on an operational basis.

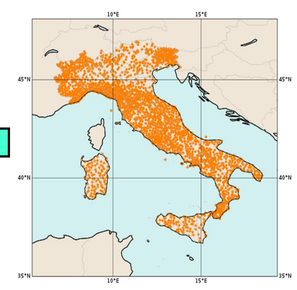
The ensemble forecast systems

ENSEMBLE SYSTEM / MAIN TECHNICAL FEATURE	ECMWF ENS	COSMO-LEPS	COSMO-2I-EPS
Integration domain			
Horizontal resolution (km)	18	7	2,2
Vertical resolution (Model level)	91	40	65
Forecast range (hours)	240	132	48
Type of model	Hydrostatic model	Non-hydrostatic model	Non-hydrostatic model
Type of convection	Parameterized convection	Parameterized convection	Explicit convection
Ensemble size	51	20	20
Starting times (UTC)	00, 06, 12, 18	00, 12	21

Description of experiment

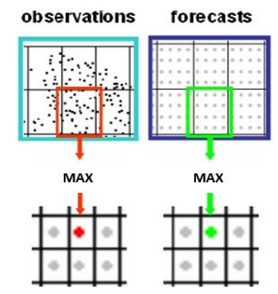
The intercomparison between the three ensemble systems is performed on the period from 21 January to 30 April 2019, starting at **00 UTC** and with a forecast range of **48 hours** (post-processing frequency every 6 hours).
The systems are compared over the **Italian region.**

Italian domain: Lat: 35N-48N, Lon: 6E-19°E
Observational network: DPCN (5524 stations)



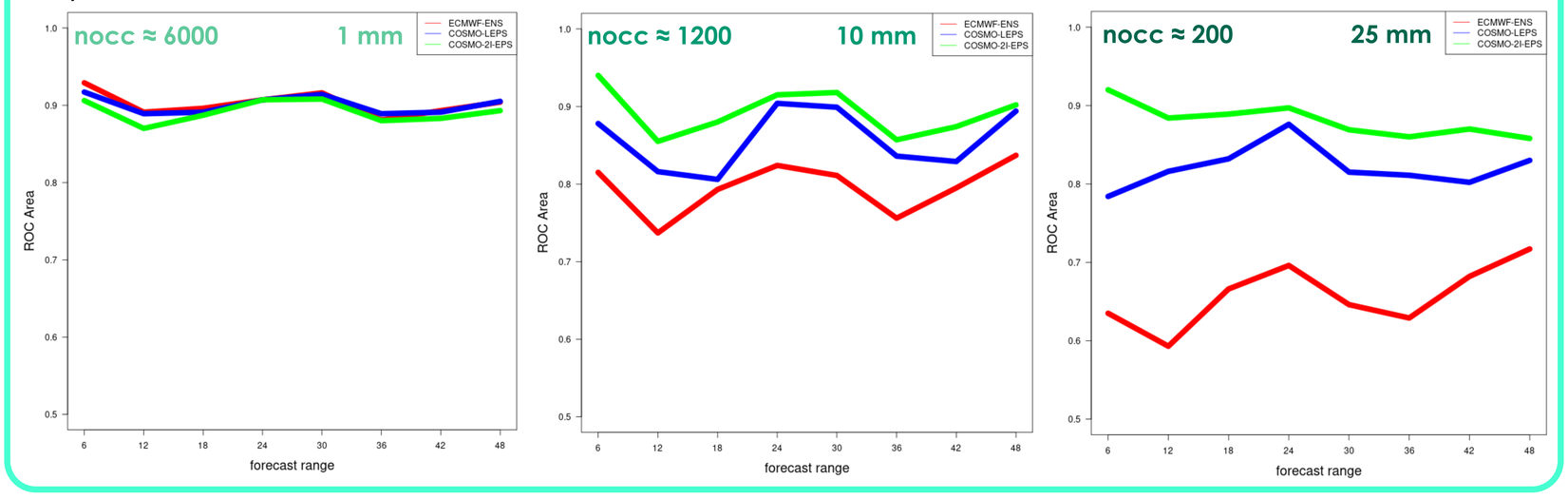
Verification method

The domain is divided in squared area (***0.25° x 0.25°)***; the precipitation values of all stations and all model grid points falling in the same box are aggregated and processed. The **maximum** value for the precipitation field in each **box** has been performed.

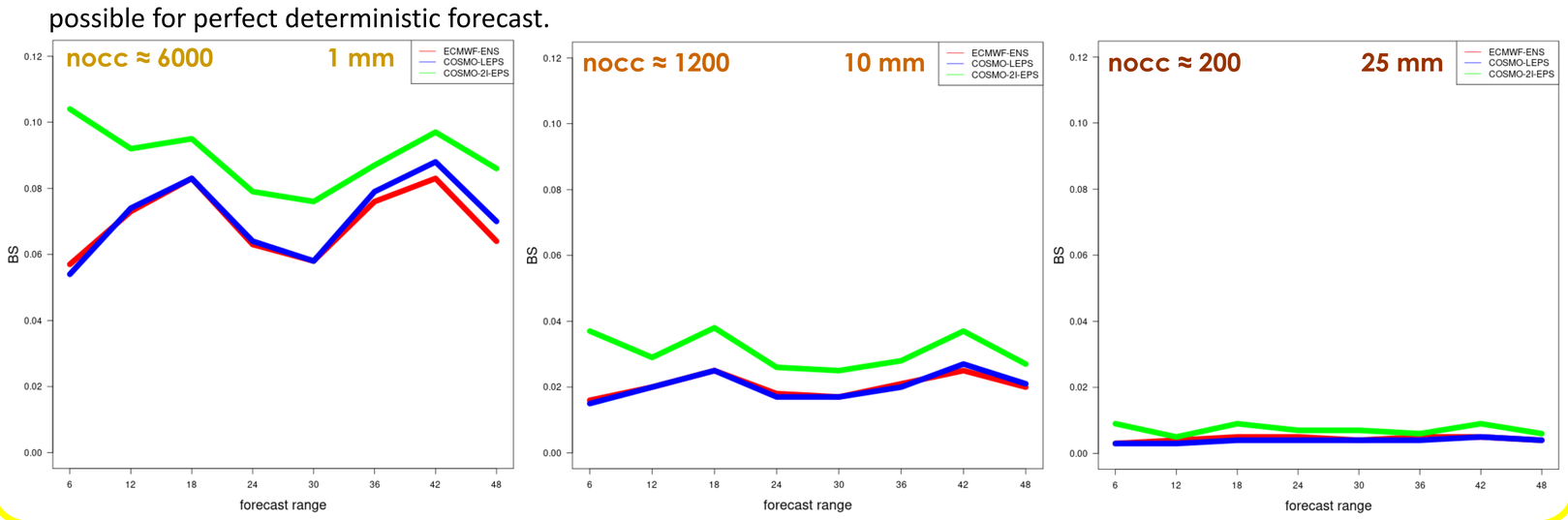


Performance of the ensemble systems for 6 h total precipitation: ECMWF ENS, COSMO-LEPS, COSMO-2I-EPS

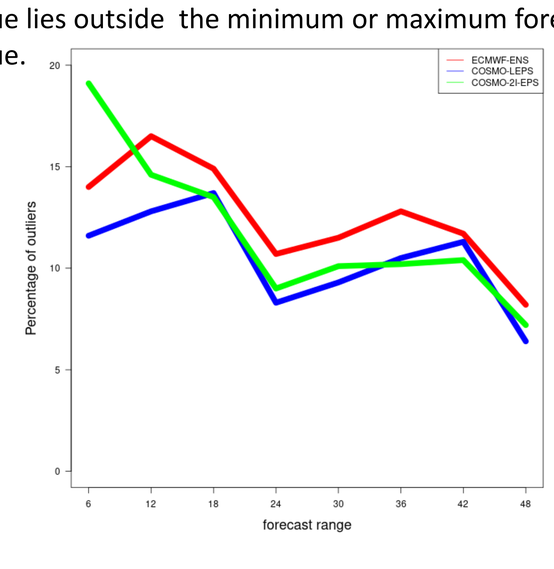
❖ **Relative Operating Characteristic Curve Area (ROC Area)** is defined as the area under the curve generated by plotting the cumulative Hit Rate against False Alarm Rate. The two score indicate, respectively, the proportion of events which were predicted by k ensemble members and actually happened, and the proportion of events forecast by k members and did not occur. It is commonly used as a probabilistic score, its maximum value being 1 and a value of 0.5 indicating a no-skill forecast system.



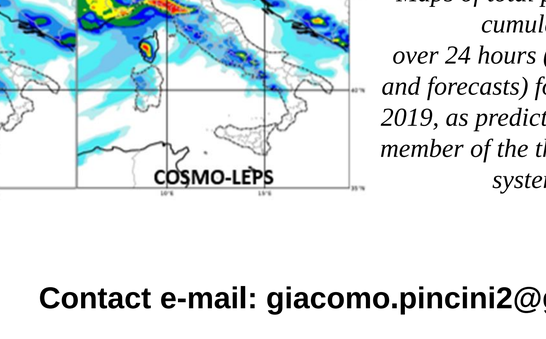
❑ **The Brier Score (BS)** measure the avererage square error of a probability forecast. The Brier Score measure the error with which a discrete event is predicted and it is sensitive to climatological frequency of the event. The perfect score is 0 and that is possible for perfect deterministic forecast.



➢ **Ranked Probability Score (RPS)** is an extension of the RMSE to the probabilistic world and to the multi-category events. RPS ϵ (0, 1); the lower the RPS, the better the ensemble system.

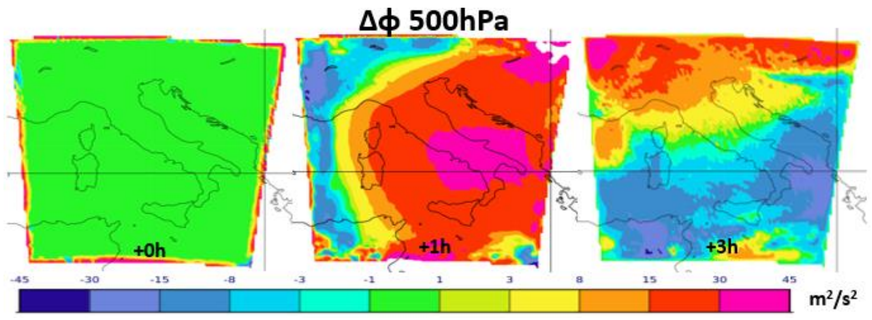


✓ **The percentage of outliers** is computed as the fraction of points of the domain where the observed value lies outside the minimum or maximum forecast value.



Recent Investigation

To solve the problem that COSMO-2I-EPS seems to have in the first 6 hour of the forecast range, the first boundary condition of COSMO-2I-EPS was changed from AM to KENDA.
This test was made for the run of 22 May 2019.
The results are meaningful for the geopotential at 500hPa.
In the images below the geopotential difference is plotted for the same COSMO-2I-EPS run inizialized once with the first boundary condition from AM and once from KENDA.
At zero time on the edge of the domain a considerable variation of geopotential was observed with respect to the case with boundary condition from AM.
In the following three hours this variation of geopotential spreads within the domain.



Conclusions

- Cosmo-2I-EPS has the best ROC AREA for high precipitation thresholds;
- COSMO-based ensemble systems have the lowest percentage of outliers;
- Regarding BS and RPS, ECMWF ENS and COSMO-LEPS are lined up, while COSMO-2I-EPS is the worst;
- COSMO-2I-EPS gets the worst score in particular in the first 6 hours of the forecast range.

The precipitation predicted by COSMO-2I-EPS is the one closest to the observations both for distribution and intensity

Maps of total precipitation cumulated over 24 hours (observations and forecasts) for 2 February 2019, as predicted by the first member of the three ensemble systems.

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