FORECASTING OF SEVERE CONVECTION WITH A HIGH-RESOLUTION LOCAL MODEL ENSEMBLE

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I. INTRODUCTION

Due to its spatial and temporal resolution forecasting severe convection is a difficult task for models and forecasters. Improving the model and increasing its resolution NWP models create better forecasts but cannot fully solve the problem. In consequence of the chaotic nature of small scale weather phenomena, one deterministic model run will always differ from another. To overcome this problem the operational work increasingly changes from deterministic to probabilistic approaches.

Two interesting case studies (23^{rd} May 2012 and 30^{th} June) are used in this poster to carve out the advantages of a convection-allowing high resolution local model ensemble.

II. COSMO-DE ENSEMBLE
SETUP AND VERIFICATION

Since May 2012 the DWD runs the COSMO-DE Ensemble Prediction System (EPS) in operational mode. This forecast system is based on the deterministic and convection-permitting model COSMO-DE. The technical setup for both, the deterministic version and the model ensemble, is identical. They have an horizontal resolution of 2.8 km, new model runs every three hours (00 UTC, 03 UTC, ... , 21 UTC) and a forecast time up to 21 hours. The COSMO-DE EPS is an ensemble with 20 members and variations in initial conditions, boundary conditions and model physics (Theis and Gebhardt, 2012).

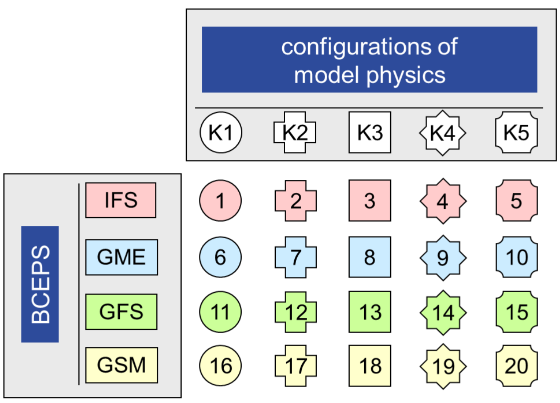

FIG. 1: Setup of the operational COSMO-DE EPS showing 20 members that result from the combination of variations within the forecast system: four different global models for initial and boundary conditions (BCEPS), five different (non-stochastic) model physics configurations (K1 – K5).

The initial and boundary conditions are taken from four global models: IFS (ECMWF, Europe), GME (DWD, Germany), GFS (NCEP, USA) and GSM (JMA, Japan). Further details about the initial and boundary conditions can be found in PERALTA et al. 2012. FIG. 1 shows a schematic of the COSMO-DE EPS setup. Each of the 20 members is created combining one of the four global boundaries with one out of five fixed model physics configuration.

Currently, the following five model physics configurations are used:

- K1.) entr_sc = 0.002 1/m (shallow convection, standard value = 0.0003 1/m)
- K2.) q_crit = 4.0 (cloud microphysics, standard value = 1.60)
- K3.) rlam_heat = 0.1 (boundary layer, standard value = 1.0)
- K4.) rlam_heat = 10.0 (boundary layer, standard value = 1.0)
- K5.) tur_len = 500.0 m (turbulence, standard value = 150.0 m)

As one can see from the choice of physics perturbation, COSMO-DE EPS was developed with focus on (convective) precipitation.

Verification results for hourly precipitation during the summer season show the benefit of the ensemble system (Theis and Gebhardt, 2012).

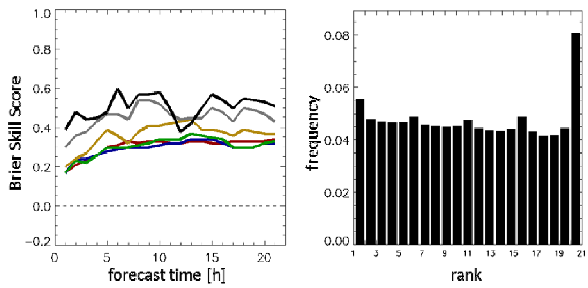

FIG. 2: Verification of COSMO-DE EPS forecasts (00 UTC run) during the summer season 2012. Left: Brier Skill Score as a function of forecast time (reference: deterministic COSMO-DE). Different lines mark different hourly precipitation thresholds: >0.1 mm/h (red), >1 mm/h (blue), >2 mm/h (green), >5 mm/h (yellow), > 10 mm/h (grey) and > 15 mm/h (black). Right: Rank Histogram.

The comparison of deterministic and probabilistic forecast can be made by making use oft the Brier Skill Score. The results indicate a gain in forecast quality (FIG. 2 (left), values higher than 0). This is valid for all chosen precipitation thresholds. Further, the highest values of BSS occur for highest thresholds. This result underlines the usefulness especially for the DWD warning management where the focus lies on extreme events (the black curve in this figure represents the DWD warning criteria > 15 mm/h). Note, the BSS does not increase with forecast time instead of the first few hours. This is probably due to the fact that the deterministic model and the ensemble behave in the same way (decreasing forecast skill with increasing forecast time.)

A second important verification result is visible in the rank histogram (FIG. 2 (right): 21 ranks represent 20 members + observation). The histogram shows how often the observation can be found on a certain rank during the whole summer season 2012 (hourly precipitation). Therefore, this measure can answer the question of spread quality. The flat histogram distribution certifies that COSMO-DE EPS precipitation forecasts have a fairly good spread, since the observations can be found on nearly each rank with the same frequency. However, it is also obvious, that the observation has an enhanced occurrence on rank 21 which means that in many cases the observed precipitation values are higher than the maximum of the ensemble.

III. CASE I – 23RD MAY 2012

On 23rd May 2012 a strong ridge was present over most parts of western Europe. Its axis reached from Spain to southern Norway. At the same time an upper level low could be found over the Balkans. Germany was lying in between those two patterns in a rather weak flow regime. For instance in the western parts of Germany the winds in 500 hPa were partly below 5 kn. Thus it was clear that any convection that could develop in this flow regime would be rather slow and driven by its own dynamics.

Convective instability and boundary layer humidity resulted in 1000 to 2000 J/kg of MLCAPE that became mostly uncapped around noon. Keeping in mind that only weak shear was present, the resulting convection had a pulsating character where outflow boundaries from dying convection triggered new thunderstorms.

Finally several heavy rain events were reported in western Germany. Also radar products showed hourly rain sums of more than 50 mm.

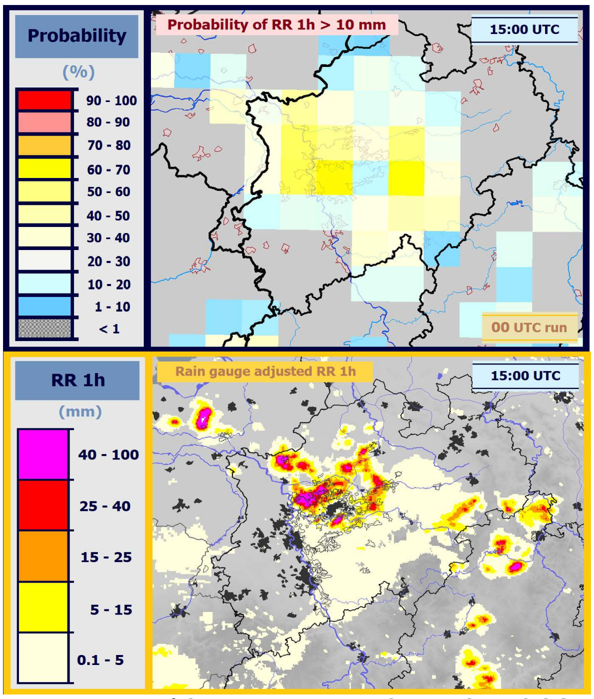

FIG. 3: Forecast of the COSMO-DE EPS showing the probability for an hourly rain sum of more than 10 mm (upper image). In comparison the rain gauge adjusted measurements of the radar (lower image).

Looking on the COSMO-DE model run from 00 UTC for that day, only a few signs for strong convection and heavy rain could be found. However, taking the 20 members of the COSMO-DE ensemble of the same model run, strong hints for higher amounts of rain were discernible in several members. Taking the maximum of all EPS members the area of interest could be clearly pointed out. Additionally, the probability products were of a great help. For example: The probability of more than 10 mm per hour was higher than 60 % and for more than 25 mm per hour the EPS still gave a value of about 30 %.

IV. CASE II – 30TH JUNE 2012

The 30th June 2012 was a totally different case. Central Europe and in particular Germany were lying on the forward flank of a highly amplified long wave trough. Its axis extended from Great Britain towards Spain. Strong advection of warm and humid air was present in the area of interest. The temperature at 850 hPa showed values of about 20 to locally 25 °C and the mixing ratio was about 14 to 16 g/kg. Together with high values of convective instability this resulted in a mean layer available potential energy of 2000 to 2500 J/kg.

Given that the atmosphere was initially capped, only a few but long-living supercells developed during the afternoon accompanied by hail of more than 7 cm in diameter and severe wind gusts. Finally, a mesoscale convective system developed in Switzerland triggered by a small short wave that was travelling northeastward upstream of the long wave trough. Besides heavy rain and very large hail, reports of severe wind gusts were popular with this MCS event that passed over Germany from southwest to northeast during the evening and night hours. The magnitude of the gusts locally reached hurricane force (Bft 12, > 118 km/h).

The output of the deterministic model run of COSMO-DE from 06 UTC indicated the possibility of gusts up to Bft 10. Apart from the point that this was too weak, also the regional placement of the maxima did not agree with the observations. Having a look at the EPS, the maximum of all members clearly showed that Bft 12 could be found within the ensemble members. In addition, making use of the probability products could have helped to identify the regions of interest. For example: The probability of winds in excess of Bft 10 showed enhanced values in the region where they eventually occurred. Even the probability for gusts up to Bft 12 could be found within the EPS.

V. RESULTS AND CONCLUSIONS

COSMO-DE EPS is an ensemble system on the convective scale developed at DWD with focus on precipitation. Since May 2012 it is running in operational mode. Verification results show the benefit compared to one single model run especially during the summer season.

The two case studies illustrated that the use of an ensemble can help to improve the forecast of convection and its accompaniments like heavy rain and severe wind gusts. While the deterministic model run sometimes gives only weak or wrongly placed hints on the regional scale for a severe weather event, the ensemble expands the forecaster's horizons and focuses him on an area of interest by giving him a certain degree of sureness with the help of probabilities.

Since the development of the COSMO-DE EPS was originally focused on convective events, the DWD started further developments to improve parameters that have a lack of spread like the 2 m temperature and cloud coverage. Also wind gusts are in the focus of improvements (rank histogram not shown here). To reach this goal, new projects especially in the field of renewable energy have been started. In addition, several calibration technics are developed (e.g. for probabilities of precipitation greater than a certain threshold) to improve the reliability of forecasts.

Besides these research plans the technical setup of COSMO-DE EPS will be extended to 40 members and probably longer forecast times.

IV. ACKNOWLEDGMENTS

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V. REFERENCES

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