European Conference on Severe Storms 2015
14–18 September 2015, Wiener Neustadt, Austria
ECSS2015-35-1

A severe bow echo in Western Germany on June 9, 2014: Aspects in forecasting and the use of latent heat nudging to optimize regional models

Helge Tuschy and Marcus Beyer
Deutscher Wetterdienst, Offenbach am Main, Germany, (helge.tuschy@dwd.de)

I. Introduction

Thunderstorms are a common meteorological feature during the spring and summer seasons and even in winter. A complex interaction of numerous ingredients results in the occurrence of a full spectrum of thunderstorm events. Attendant degree of organization varies from short-lived single cells with a low chance for severe accompaniments all the way to cycling and long-lived supercells. The latter poses a considerable threat for property and life due to very large hail, extreme wind gusts, torrential rain and sometimes also due to tornadoes.

Using physically based ingredients like the content of humidity in the atmosphere, the degree of instability as well as lifting processes and the intensity of vertical wind shear (directional and speed shear), the forecaster is able to determine the degree of organization and severity of thunderstorms, as well as their accompaniments (Johns and Doswell, 1992). This approach is called the "ingredient based forecasting method".

With the lack of one or numerous of those ingredients, numerical models sometimes display major problems with wrong spatiotemporal forecast of convection. Even the total loss of convective signals can occur which is a major source of uncertainty for the operationally working forecaster as model data is most often heavily weighted when preparing the forecast. Despite the chance for forecasters to partly absorb the impact of the missing signals for example by the use of "hand analysis" and the "ingredient based forecasting method" to some extent, the source of error, which led to such a model failure, has to be analyzed to improve the prediction of severe thunderstorm events in the future.

This poster will highlight such an event, where models failed to indicate the chance for organized convection over West and Northwest Germany on June 9, 2014. This was by far the most damaging and the deadliest severe thunderstorm event of that summer season. Post-processing of the local DWD model COSMO-EU revealed that significant improvements of the precipitation forecast were achieved by the use of "latent heat nudging".

II. The Pentecost severe weather event in Western Germany

Around Pentecost 2014 (June 8 to 11), Western Europe including Germany was affected by several severe weather events that caused widespread damage and resulted in multiple fatalities. A preliminary peak of this weather pattern occurred in the evening hours of June 9, 2014 (Pentecost Monday).

An extensive upper level trough was situated to the west of Ireland with downstream ridging affecting Eastern Germany. To the east of the trough, a hot and humid air mass spread into France and West-Germany. The combination of lift and humidity led to predicted MLCAPE values of locally more than 3000 J/kg which is a significant value for Central Europe.

However, while humidity and instability showed a substantial overlap, a lack of large scale lift was noted. Enhanced lift was instead forecast upstream over France. As a consequence, models showed the development of convection over France but did not give a hint for initiation over Germany.

Strong deep layer shear (0-6 km: 20 to 25 m/s) in Western Germany combined with the aforementioned amount of CAPE were favorable for long-lived and severe convection. Despite the lack of support by model data, the extensive use of the ingredient-based forecasting method resulted in the expectation of organized and long-lived convection by the forecasters of the DWD. As a result, a preliminary information about severe thunderstorms was issued during the morning hours with the issuance of subsequent severe thunderstorm warnings as the event unfolded. Nevertheless, lack of signals in the quantitative precipitation forecast of numerical models inserted a considerable uncertainty about if and where deep moist convection would evolve.

III. Latent heat nudging (LHN) in COSMO

Within Deutscher Wetterdienst (DWD) we use two regional numerical weather prediction models operationally, named COSMO-EU (7 km mesh size) and the COSMO-DE (2.8 km mesh size). The latter is expected to permit the explicit simulation of deep convection. To optimize the forecast of convective events during the summer season, radar derived precipitation rates are assimilated by applying latent heat nudging. This is done by introducing increments of temperature and humidity, which are introduced into the model. The goal is to improve the quantitative precipitation forecast of the numerical model compared to the observed rain rates in case of discrepancies. Experience with COSMO-DE showed improvements for precipitation forecasts, especially in the first hours of the forecast (Stephan et. al., 2008 and others).
In the aftermath of the Pentecost event, a similar assimilation was performed for COSMO-EU, where precipitation rates of the European Weather Radar Network (OPERA) were used. Despite less timely staggered radar updates (images every 15 minutes with a horizontal resolution of 2x2 km^2) and the fact that radar observations often suffer of substantial errors which have to be removed, an overall improvement of the convective precipitation rates was noted.

IV. Results and Conclusions

The Pentecost event on June 9, 2014 clearly showed the importance of using the assimilation scheme of latent heat nudging in numerical models. Assimilating radar data of OPERA into COSMO-EU resulted in a substantial improvement of the numerical forecast with clear signals of convective initiation. Given the strength of the environmental parameters, the development of an organized and long-lived mesoscale convective system could have been expected with these signals, which would have crossed Western Germany during the evening hours. As operational forecasters also evaluate the precipitation forecast of numerical models in case of questionable convective initiation, the use of this assimilation increases their confidence substantially.
Therefore, using the latent heat nudging scheme in numerical models is heavily recommended especially when preparing forecasts for the summer (convective) season, as numerical models often struggle to forecast the onset and the path of organized convection. By assimilating rapidly updating radar data into the model' forecasts increases the chance for highlighting the onset of convection. The Pentecost event is a very good example how significant the latent heat nudging can improve the forecast. And it also shows the need of cross-border exchange of radar and observation data for Nowcasting and very short range applications.

V. Acknowledgements

The authors like to thank "Deutscher Wetterdienst" for offering date from remote sensing, measurements and models. A special thank goes to Dr. Gebhardt and Dr. Stephan who supported us with numerous fruitful discussions and delivered us the visualized products of the COSMO-EU runs without latent heat nudging. In addition we like to thank Dr. Ulrich Pflüger who helped to make this data available in NinJo.

VI. References

Johns, R. H., and C. A. Doswell III, 1992: Severe local storms forecasting. Wea. Forecasting, 7, 588–612.

Stephan, K., Klink, S. and C. Schraff, 2008: Assimilation of radar-derived rain rates into the convective-scale model COSMO-DE at DWD. Q. J. R. Meteorol. Soc., 134, 1315-1326

Documentary of COSMO: http://www.cosmo-model.org/