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Numerical studies of severe convective phenomena using "robust radar impact" method

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1 Introduction

Flash floods and heavy convective storms sometimes cause serious damages in the Carpathian Basin (Horvath 2001, Horvath 2003). To understand and to make reliable forecasts of these kinds of severe weather a high resolution numerical model (Penn State-NCAR MM5) was applied (Grell 1994). Several case studies show that success of a severe convective event forecast mainly depend on the initial conditions. Variational assimilation methods may filter out those perturbations from initial fields of parameters which can give triggers for the model to develop thunderstorms on the right place. A possible way to ""inform"" the model about location of thunderstorms is the creation of artificial triggers. During the "robust radar impact procedure" (**RRI**) radar observations are applied to localize thunderstorms and set out those grid points of the model domain where artificial perturbations are reasonable.

2 Description of the method

The method is based on theory and numerical experiments which show that the vertical profile of equivalent potential temperature (EPT) can be considered as a nearly constant value especially at cases of severe thunderstorms (figure.1) (Gregoric 2001, Houze 1993, Klemp 1981) . Supposing that the air in thunderstorms are saturated (relative humidity profile is 100 %) it is possible to retrieve a pressure-temperature profile which is valid only in cores of thunderstorms. In this way thunderstorms appear like warm and wet bubbles isolated from theirs environment. Case studies were made to determinate the most efficient way to calculate the characteristic EPT value. It was found that EPT of the most unstable layer of the lowest 1000 meters can be considered for air mass thunderstorms. Best results were given when the EPT was taken from grid points which were ahead along the estimated track of the thunderstorm. Places of thunderstorms and theirs movement were taken from radar reflectivity measurement. This procedure expected high resolution model run, at least 2.5-3 km horizontal resolution which allows the model to run without cumulus parameterization.

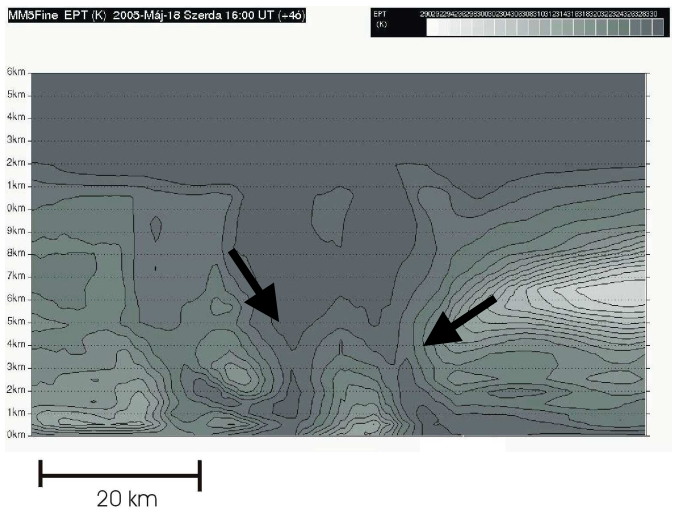

Fig. 1. A vertical section of EPT crossing a numerically simulated severe thunderstorm. The equivalent potential temperature profile is close to be vertically constant at places of thunderstorm cells (indicated by arrows).

3. Using nudging technique to upgrade RRI

The trigger method works well at cases when the objective analysis is successful. At these cases RRI places thunderstorms exactly to those grid points where they are in reality, using radar measurements. When the analysis deviates notably from the real meso-scale structure, the method may fail. Numerical experiments show that RRI is most sensible for errors at humidity analysis. At case of underestimated humidity the artificial thunderstorms dry out and disappear. Overestimation of humidity with analysis can cause false spreading convection. Nudging technique with RRI may help to recover analysis error. Temperature and humidity nudging are applied using MM5 grid nudging technique. During nudging time (the first 1 or 2 hours of the model run) the air is considered to be saturated at all grid points where precipitating clouds are observed by radar. On those grid points where thunderstorms are, RRI method is applied and temperature profiles are modified.

4. An example for application of RRI method.

A severe weather event happened in the north-west part of Hungary in 9 of June 2004. The operative model run did not predicted severe thunderstorms. In reality a supercell developed (figure 2).

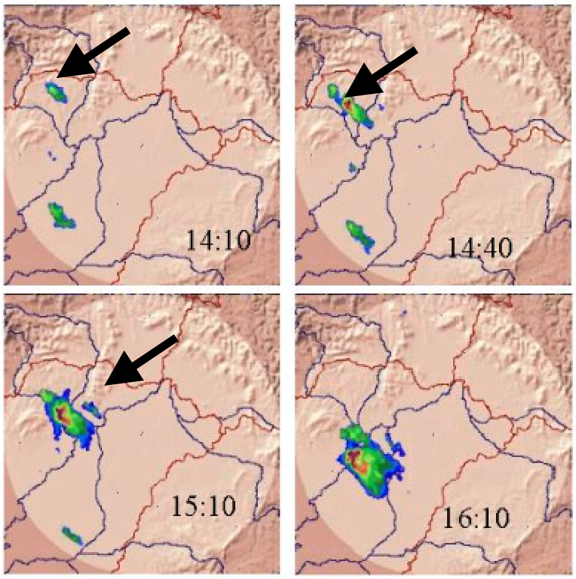

Fig. 2. Radar reflectivity of a developing supercell on 9th of Jun 2004. Arrows indicate the growing echo

The RRI procedure was applied for grid points of the developing thunderstorm (indicated by arrows on figure 2) using 1 hour nudging period. In this experiment the model was able to simulate convection, and 1 hour after the end of nudging period the simulated thunderstorms reached the rotating phase with regular mesocyclone (figure 3).

4. Limitations of RRI method

The RRI method has some limitations. First is that in operative practice the method can be used when thunderstorms have already been detected by radar and RRI is not suitable for early warnings of thunderstorms. The RRI is really "robust impact" which may good for triggering but probably decreases the forecast quality on convection free areas. Making numerical forecast needs more time and computer capacity. This method is useful if it is applied more frequently, which means that model run needed in all hours in convective period.

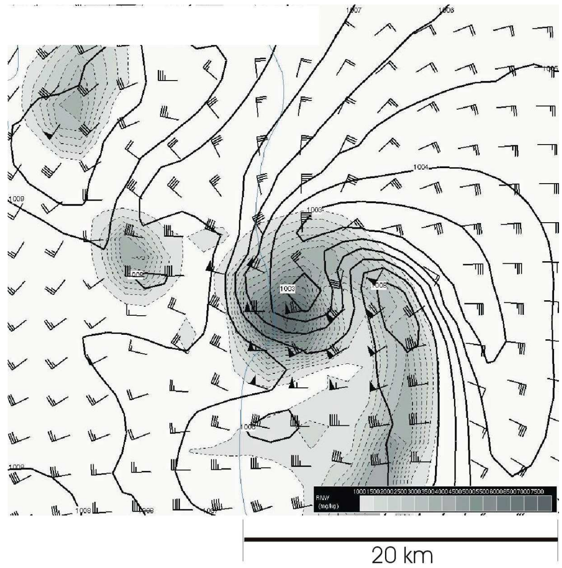

Fig. 3. Predicted mean sea level pressure, 925 hPa wind and rain water mixing ration on 700 hPa levels (shaded line) indicate supercell structure on 3 hours numerical forecas

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