STORM RAINFALL DETECTION AND FORECASTING - THE CZECH EXPERIENCE

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Abstract

Contribution presents the state of the art of operational radar meteorology in the Czech Republic. Some common treads are documented on the case of Nový Jičín disastrous flash flood in June 2009. Nowcasting and other tools developed in the Czech Republic to warn and inform on the flash flood risk are also introduced.

1 Introduction

This paper presents current practice of storm precipitation forecasting and detection in the Czech Republic. Rainstorms causing flash floods in Central Europe are often of relatively small spatial extent and duration. In addition they are not always connected to meso-scale atmospheric phenomena such as fronts. Therefore its prediction by Numerical Weather Prediction (NWP) model is very complicated. In general a favourable condition for convection can be forecasted by NWP, but not the exact locality and intensity of rainstorms.

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2 Precipitation detection and observation

2.1 Meteorological radars

Meteorological radars provide spatial information on reflectivity of raindrops in clouds. Than an empirical Z-R relation is used to estimate the precipitation intensity. Czech radar network consists of 2 radars covering fully the area of the Czech Republic (scanning frequency is 5 minutes, 1 km grid, CAPPI 2km). Operational radar precipitation estimates are corrected for long term bias and adjusted by coefficients delivered from real-time evaluation of radar estimates and data from the network of operational rain gauges.

Meteorological radars are the most effective tool for storm detection. However estimates of rainfall intensity may fail in some cases. A significant underestimation of rainfall intensity occurred in case of Nový Jičín flash flood in June 2009 (fig. 1). Two main reasons of underestimation were documented. Attenuation of radar beam due to presence of other storms between the radar and affected area was the one (fig. 2). The second reason was the extraordinary physic of the storm. Due to very moist, hot and unstable air mass storm clouds a warm convection process developed (between the altitude of condensation and altitude of zero isotherm), therefore raindrops diameter was smaller, but their number was much higher than in typical convective storm. Smaller raindrops provide smaller reflectivity for the same amount of water in the cloud.

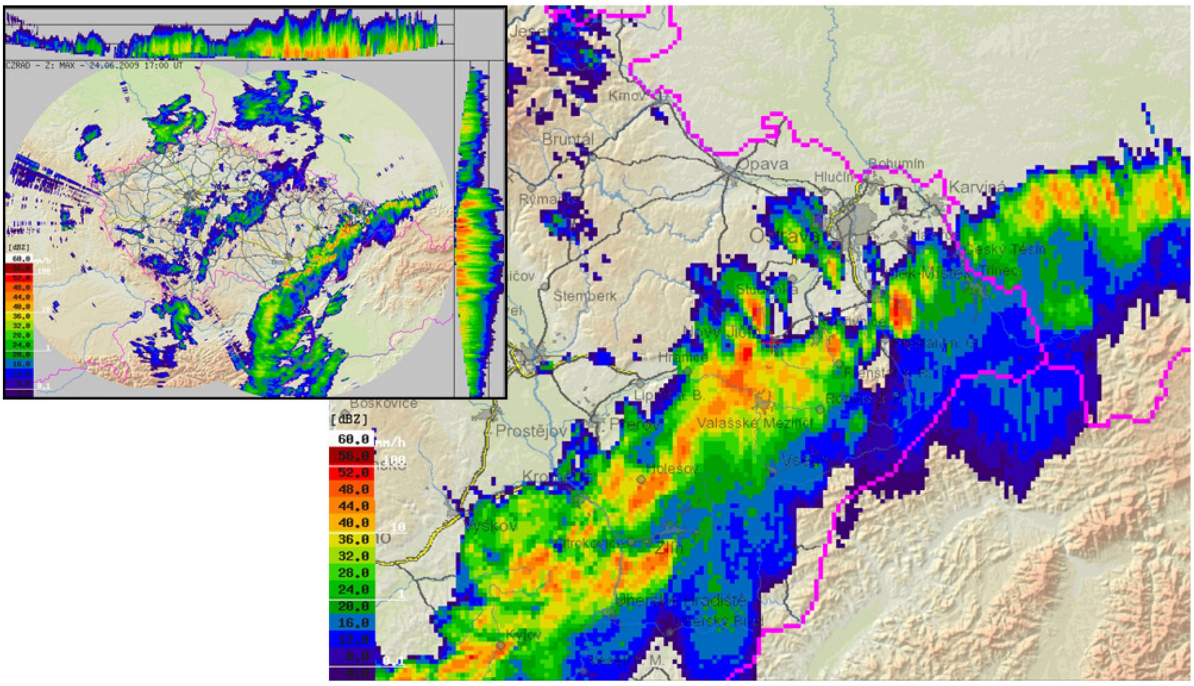

Figure 1. Operational radar rainfall estimates over the Nový Jičín district during June 2009 24th.

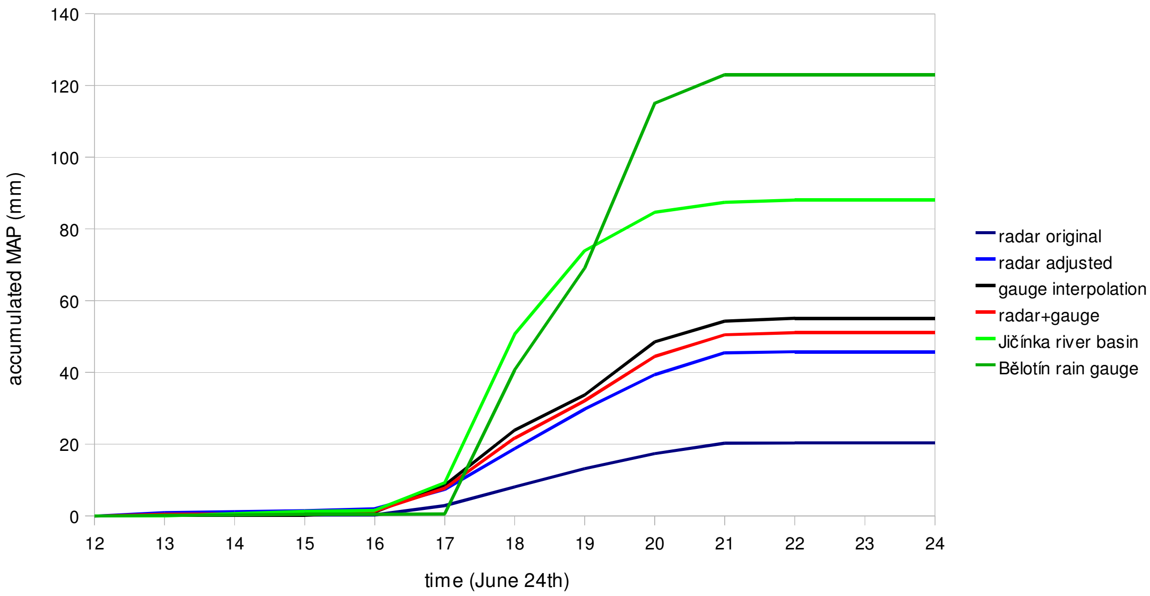

Figure 2. Comparison of radar estimates and rain gauge measurements over the Nový Jičín district during June 2009 24th. The evaluated amount of rainfall reached 124 mm in about 3 hours in Bělotín rain gauge.

Radar-rain gauge combined product is prepared in real-time for different aggregation time from 1h to 24h. Radar precipitation estimate is adjusted to point rain gauges measurement using regression kriging (in case of missing radar data for more than 20 % of time the rain gauge data interpolation is used instead). For adjustment in shorter periods (1h, 3h, 6h) the correction factor is based on evaluation of data from last 20 hours.

2.2 Nowcasting

Radar echo extrapolation using COTREC procedure and NWP ALADIN wind field are used as a storm movement vector field are used in the Czech Republic. Extrapolation up to 90 minutes is operated. Extrapolation methods analyse movement of existing storm cells but do not change its intensity and do not create new storm cells.

Small basins (generally <50 km^2) are the one mostly affected by flash floods in the Czech Republic. Those are especially sensitive to nowcasting disadvantages as described above and proved by Šálek et al. (2006) who researched the coupled system of nowcasting and hydrological model HYDROG in the case of Hodonínka 2005 flash flood.

3 Response to 2009 flash floods

Experience from 2009 flash flood showed that meteorologists need more frequent information on rain gauge measured precipitation to support radar information for issuing the warning. Hourly precipitation sum from rain gauge was not sufficient. Therefore the frequency of data transmission and summing was increased to 10 minutes. In addition radar-rainfall combination was implemented in moving 10 minute time step. Another simple tool was made to evaluate maximum radar rainfall estimates (including nowcasting up to 90 minutes) on district level (warning are defined on the scale of districts). WarnView uses defined precipitation thresholds for different temporal aggregations (15-, 30-, 60-, 180-minutes). The future plan is to implement variable thresholds (in time and space) based on Flash Flood Guidance evaluation of flash flood risk (see below).

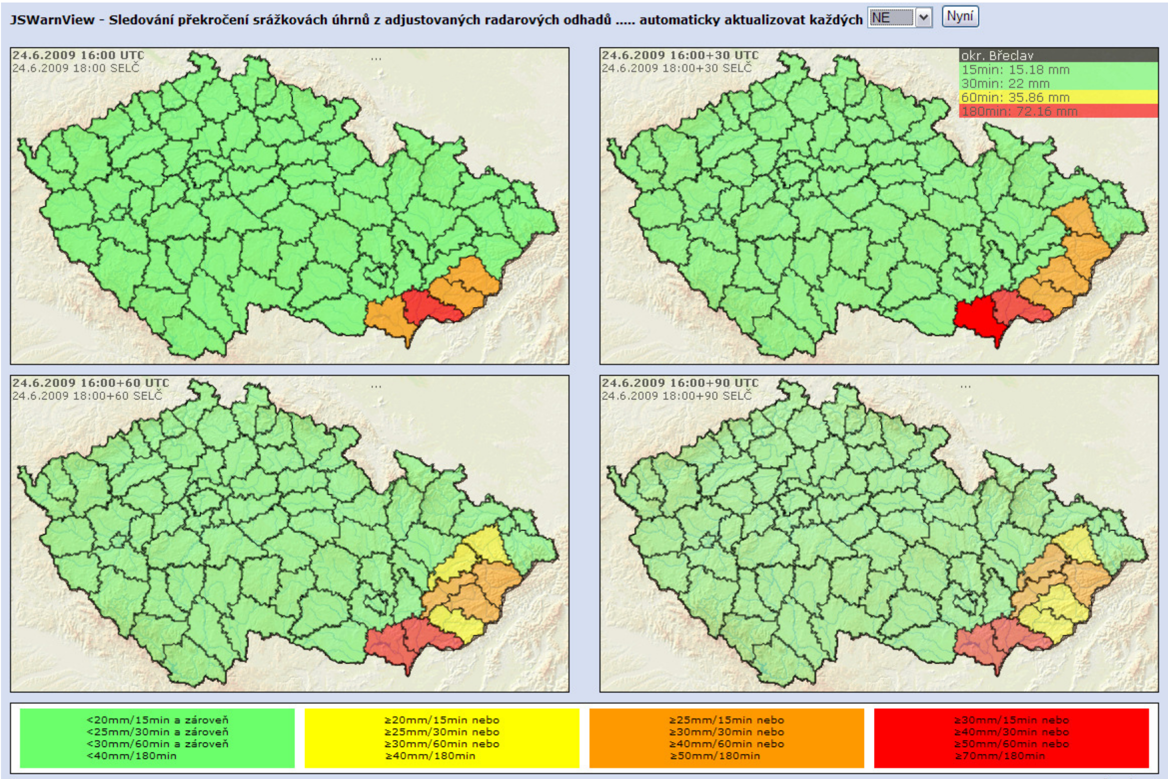

Figure 3. Warnview – a tool for real time evaluation of maximum radar estimates at district level for observation and three nowcasting horizons – case of June 24th 2009.

Flash Flood Guidance (FFG) is system operated in the United States by National Weather Service, but FFG could by understand as a general concept of flash flood risk evaluation in real-time. FFG evaluates basic relevant geographical conditions of landscape (at basin scale or grid) to estimate its retention capacity. Than an actual soil saturation is computed and consequently thresholds of precipitation possibly causing the fast surface runoff are derived. Thus FFG provides precipitation limits that if exceeded may lead to pluvial flood of flash flood at site. Publishing those limits, Flood Authority may start its action sooner based on precipitation rather than based on the observed river rise.

FFG-CZ has been developed since 2008. It is based on CN method. CN values were evaluated based on infiltration and retention of soils and vegetation cover and the average slope of the area. CN values are updated daily based on the radar-rain gauge precipitation estimate between stage I (dry condition) and III (wet condition). Method of CN values updating was developed by CHMI for the condition of the Czech Republic. Based on actual CN a critical rainfall for 1 and 3 hours are computed using ESRI GIS environment.

In the second step HEC-HMS model was implemented for headwater areas (including simple river networking) representing about 2/3 of the area of the Czech Republic. A 10 minute operational radar precipitation estimates input automatically FFG-CZ. Based on this a runoff response is computed and then compared to theoretical limits of 0.4*Q100, 0.6*Q100, 0.8*Q100 (Q100 for ungauged basins was computed based on theoretical equation using geographical characteristics of the basin).

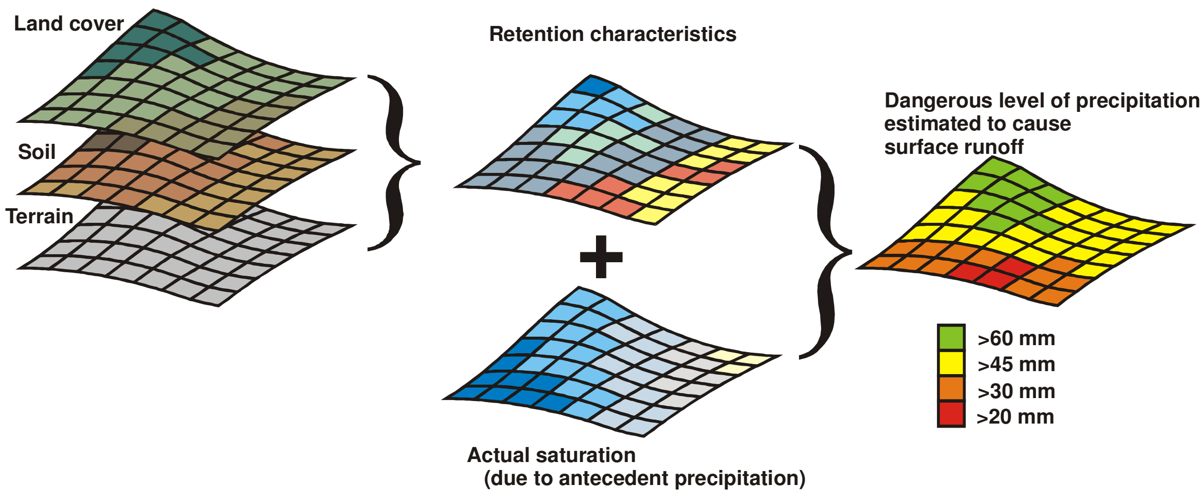

Figure 5. Flash flood guidance general principle – retention characteristics are described by CN value, while actual saturation is accounted trough CN value update based on precipitation in last 30 days.

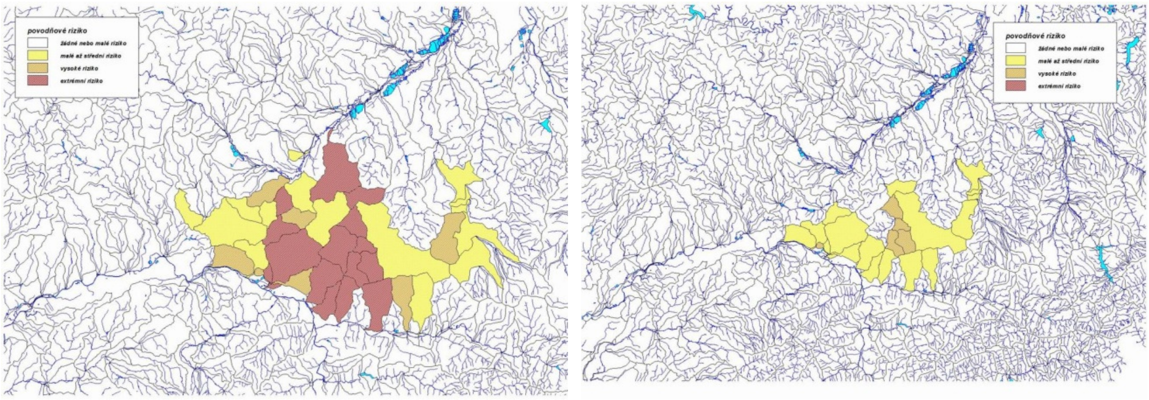

Figure 6. FFG-CZ a simulation of a June 24th 2009 flash flood in Nový Jičín district. Hindcast of flash flood risk level for adjusted radar rainfall estimate (left) and raw radar rainfall estimate (right) for 15:30 19:30 UTC.

4 Conclusions

Meteorological radars provide the most valuable information on development of heavy precipitation. However its precipitation estimates could not provide exact amounts of precipitation especially in some specific cases. Therefore the network of automatic rain gauges is important to be used together with radars. In case of small basins local flash flood warning systems based on one or more rain gauges seems to be reasonable solution.

Central and eastern Europe is vulnerable to small scale rainstorms and flash floods. Therefore the development of flash floods are sudden and does not provide enough time for modelling of potential response to the precipitation and targeted central warning in real time. Therefore an effort is given to the development of automatic evaluation tools and especially to providing preliminary information on flash flood risk based on evaluation of basin saturation and characteristics. That information will be available to flood authorities to support (together with the local information on precipitation) the decision making.

References

Šálek, M., Březková, L., Novák, P. 2006: The use of radar in hydrological modeling in the Czech Republic – case studies of flash floods. Nat. Hazards Earth Syst. Sci., 6, 229–236, 2006