Progress in Operational Quantitative Precipitation Estimation in the Czech Republic

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1 Introduction

Both weather radars and raingauge measurements are important inputs into computation of spatial quantitative precipitation estimates (QPE). Weather radar measurements provide information about spatial distribution of precipitation, however their disadvantage is insufficient accuracy. Raingauges provide more accurate point measurements but their spatial representativeness is limited. Over the years many different QPE methods, combining radar and raingauge measurements, were developed. Their comparison can be found for example in (Goudenhoofdt and Delobbe, 2009) or (Keller, 2013).

The Czech Hydrometeorological Institute (CHMI) runs operational QPE algorithm for more than 10 years (Šálek, Novák, Seo, 2004). It combines weather radar and raingauge measurements utilizing their advantages and reducing their disadvantages. It is used for daily as well as for hourly precipitation accumulations. The algorithm is able to provide several types of estimates (radar-only QPE, radar QPE adjusted by radar-raingauge bias field, raingauges-only QPE, radar-raingauge combined QPE). All of these possibilities enable generation of several different QPEs for specific time, which are used for generation of probabilistic hydrological forecasts (Šálek and Novák, 2008), (Novák et al., 2009).

2 QPE algorithm

Major update of the CHMI operational QPE algorithm was done in the 2009, when kriging with external drift was implemented as combining algorithm for hourly updated precipitation estimates. Algorithm itself worked fine but its implementation was relatively slow, which didn't enable to move to full 10-minute update cycle of QPE calculation. Its implementation was not also flexible enough to implement new feature like use of foreign radars for QPE calculation. In 2013, it was decided to rewrite operational radar-raingauge combining application to remove above mentioned limitations and enable future improvements. The new application was developed during 2013-2014. It was put into experimental routine calculation in June 2014. It is planned to run old and new application during 2014 convective season. During fall/winter 2014 old application will be stopped and the new one will become fully operational.

Main updates of the new QPE application are

- incorporation of volume radar data from neighboring countries into extended Czech radar composites that are used for radar QPE
- improvement of radar data quality control causing better removal of residual non-meteorological echoes
- full integration of 10 min raingauge measurements that enables calculation of floating hourly QPE every 10 minute
- improvement and optimization of radar-raingauge combining method that enables use of extended Czech radar composites and decreases computational time to fit into 10 min update of operational run

2.1 Raingauge stations

Raingauge stations operated by the CHMI are used as an input into QPE computation. Raingauge stations are depicted in Fig.1. Precipitation data from these stations are available online in 10 minute time step.

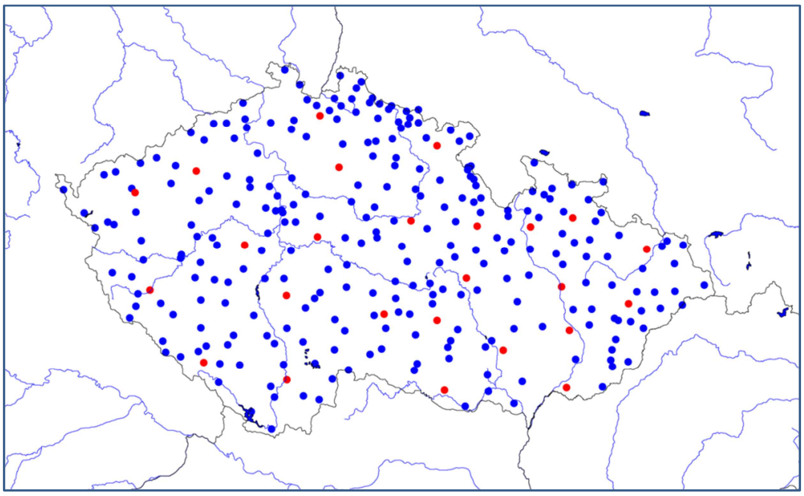


Figure 1: The CHMI raingauges operationally available in 10 minutes interval. Blue – raingauges used for QPE computation, red – raingauges used for verification during methods verification (section 4).

2.2 Radar data

The PseudoCAPPI at 2km radar reflectivity product is used for QPE computation. The Czech-only radar data or the Czech-extended information from the Czech radars and radars from neighboring countries can be used as an input to the QPE combination. Example of difference between radar-only 1-hour accumulation calculated from the Czech-only and the Czech-extended radar reflectivity data is shown in Fig.2. Influence of weather radars from neighboring countries can be seen in the left part of the pictures and also on the northern borders of the Czech Republic with Poland.

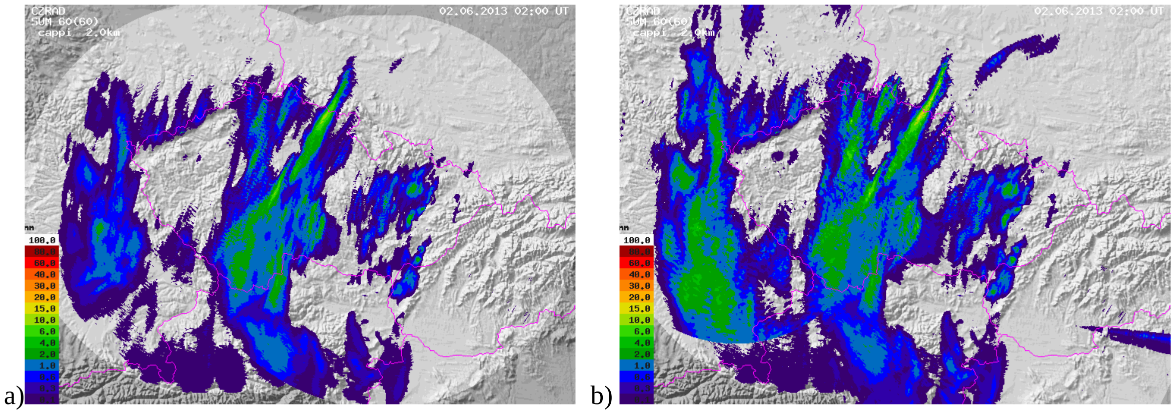


Figure 2: 2nd June 2013, 2:00 UTC. Example of comparison 1 hour precipitation sums computed from Czech only weather radar information a) and extended radar information b).

Because the Czech-extended composites are available only in 10 minute interval, the Czech-extended radar reflectivity data are interpolated into fields with 1 minute time step. These interpolated fields are used alternatively for the radar QPE accumulation. The difference between non-interpolated and interpolated 1-hour radar-only sums is in Fig. 3 a) and b).

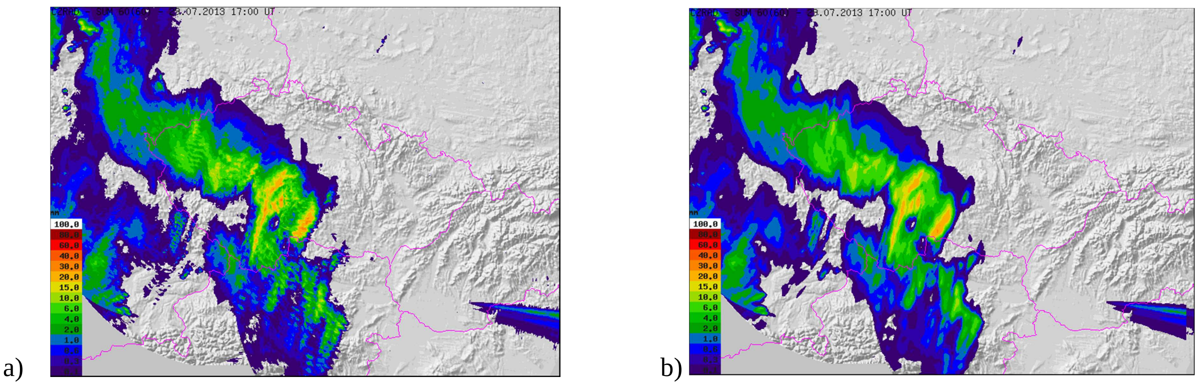


Figure 3: Example of a comparison 1 hour precipitation sums computed from non-interpolated a) and interpolated b) extended radar information.

Distribution of relative difference between mean precipitation over operative catchments used in the CHMI computed from non-interpolated and interpolated 1 hour sums is shown in Fig 4. Relative difference was greater than 10% in 9.4% of cases. Greatest absolute difference between non-interpolated and interpolated precipitation sums was 7.5mm/h (30.1mm/h vs. 22.6mm/h).

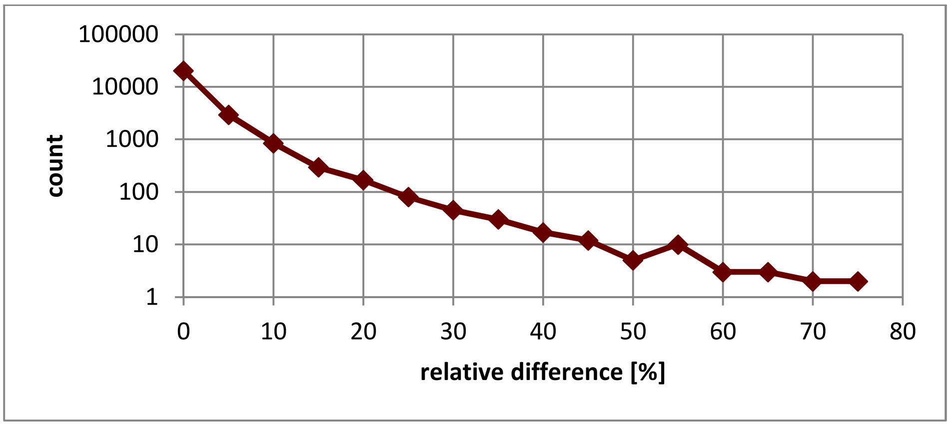


Figure 4: Distribution of relative difference between mean precipitations over operative catchments used in the CHMI computed from non-interpolated and interpolated 1 hour sums.

2.3 QPE methods

The new QPE application is able to generate following QPE products:

- RADAR_ORIG – radar-only QPE - accumulated quality-controlled PseudoCAPPI at 2km radar reflectivity fields
- RADAR_ADJ – radar-only QPE adjusted by mean field bias coefficient obtained from radar-raingauge comparison
- GAGE – QPE interpolated from raingauge values using ordinary kriging
- KED – QPE computed using KED (kriging with external drift) method
- OKRE – QPE computed using OKRE (ordinary kriging of radar errors) method
- MERGE – it contains KED QPE; if KED is not available or the correlation between RADAR_ADJ and GAGE field is less than 0.2 or there are less than 4 non-zero raingauge values then RADAR_ADJ method is used. But if maximum value of RADAR_ADJ field is less than 1mm then GAGE method is used instead of RADAR_ADJ.

Operationally QPE application will be run every 10 minute to calculate floating QPE products of 1-hour sums. RADAR_ORIG, RADAR_ADJ, GAGE and MERGE products will be operationally available (KED and OKRE products are used for evaluation only). The 1-hour QPE products will then be used for calculation of 3h, 6h, 12h, 24h 48h and 72h sums. In addition, QPE products of 24h sums will be calculated daily from 24h radar sums and 24h raingauge measurements.

3 Operational implementation

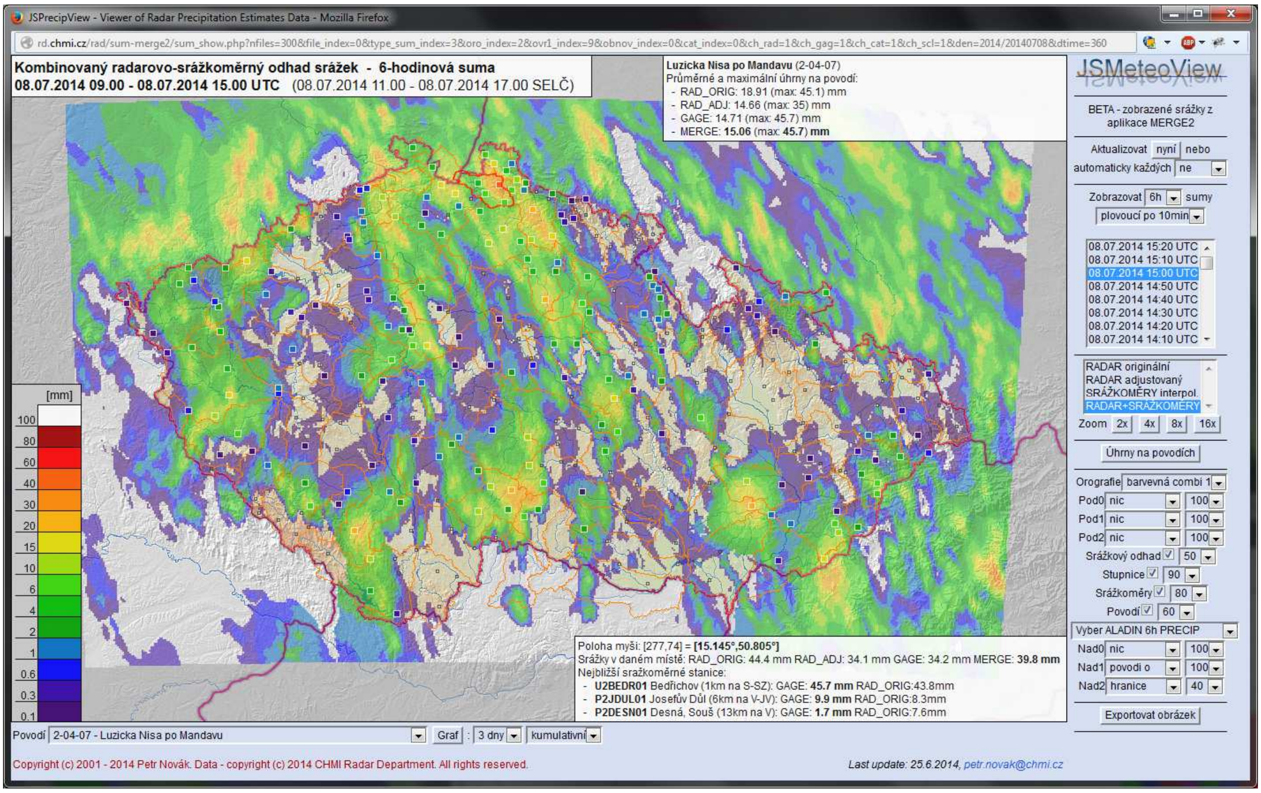
The QPE products are available to the end-user as a GIS-compatible raster files, as an average precipitation over predefined catchments or as graphical visualization in web application.

Raster files or average preciptation over predefined catchements are used by hydrological application, e.g.: hydrological model Hydrog (Starý and Tureček, 2010) or flash-flood guidance nowcasting tool FFG-CZ (Šercl, 2011).

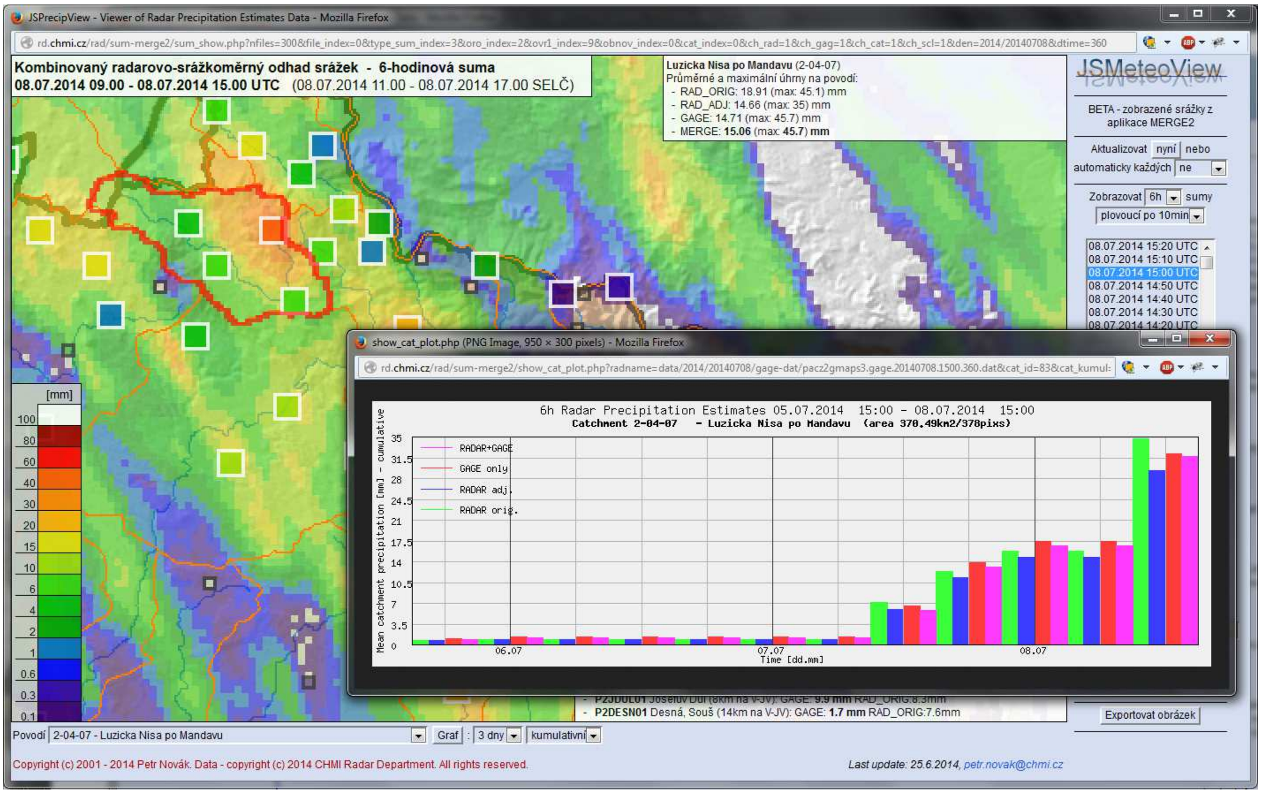
Graphical visualization of individual QPE products is available in the new version of web application JSPrecipView. It is used mainly by meteorologists and hydrologists in the CHMI forecast offices. An example of its output is in Fig. 5. This application enables display of all 4 QPE products and all lengths of accumulation. It contains GIS features like possibility of combination of different geographical layers (borders, catchments, orography, roads, rivers, cities, etc.), zoomimg maps or showing precise geographical location of the cursor.

The JSPrecipView directly processes binary data (not pre-generated graphical files like PNGs), therefore it is possible to display precise precipitation values of individual QPE products in the location of cursor, precipitation at the 3 closest raingauges and also average precipitation in the corresponding catchment.

The application allows look through both archive and operative QPE data including their automatic update. Several lengths of summation can be displayed (1h, 3h, 6h, 12h, 24h, 48h, 72h). Floating summations can be also displayed (time step 10min and 1 hour). Mean and maximum QPE values over operative catchments can be displayed as a table. Moreover for each individual catchment a graph displaying standard and cumulative QPEs (RADAR_ORIG, RADAR_ADJ, GAGE, MERGE) are available for the time span of 1 to 21 days.



a)



b)

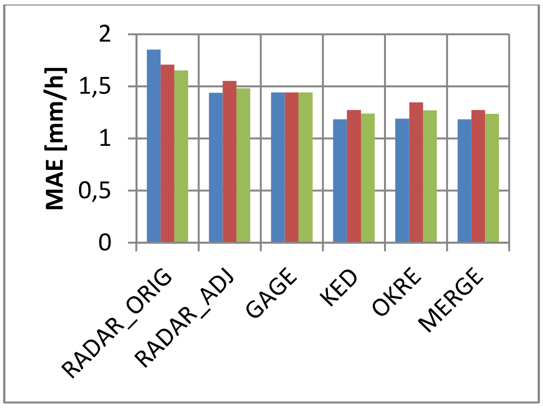
Figure 5: Example of new version of the JSPrecipView web application.

4 Comparison of QPEs

Different QPE methods computed from the Czech raingauge stations and both the Czech-only and the Czech-extended radar information have been evaluated on 34 days from summer season 2013 when significant convective or stratiform precipitation occurred.

Raingauge stations operated by the CHMI were used as an input into QPE computation. 25 of them were excluded from the computation and used as verification stations. Raingauge stations used in the comparison are depicted in Fig.1.

Figures 6 a) and b) show comparison based on MAE (Mean Absolute Error) of these QPEs for 1.0mm/h and 10.0mm/h precipitation threshold (i.e. only values from verification raingauge stations above this threshold were compared with QPE output). For small precipitation thresholds incorporating of radars from neighboring countries doesn't give better results except radar only QPE. Reason for that could be that more radars can see more noise. For higher precipitation thresholds MAE is generally higher. Also incorporating radar data from neighboring countries gives better results, but the differences in case of MERGE, KED and OKRE methods are negligible. These methods are able to compensate for lesser quality of radar data at longer distances from radar if enough raingauge station data are available.

a) 

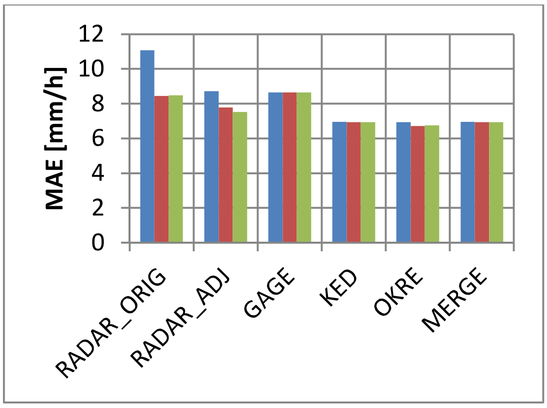
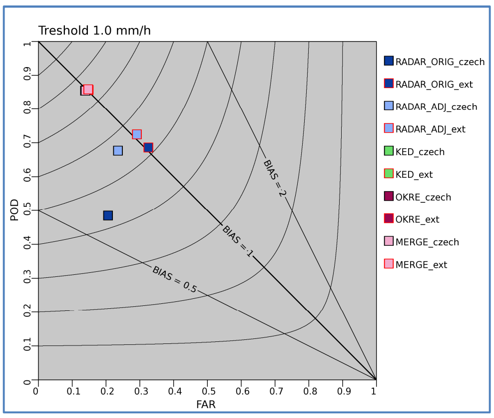
b) 

Figure 6: comparison of MAE for different QPE methods and precipitation threshold. Blue color is used for QPE based on the Czech-only radar data, red for the Czech-extended radar data, green for the Czech-extended radar data interpolated into 1minute time step fields. Fig. a) shows comparison for 1.0mm/h precipitation threshold, fig. b) shows comparison for 10.0mm/h precipitation threshold.

Another comparison was based on CSI (Critical Success Index), FAR (False Alarm Ratio) and POD (Probability of Detection). Figures 7 a) and b) show the comparison of different QPEs for 1.0mm/h and 10.0 mm/h precipitation threshold. For both precipitation thresholds the QPEs using extended radar data are less biased. For higher precipitation thresholds KED and OKRE methods reach significantly better CSI than radar only QPE and ADJ method. The differences between MERGE, KED and OKRE methods are negligible.

a) 

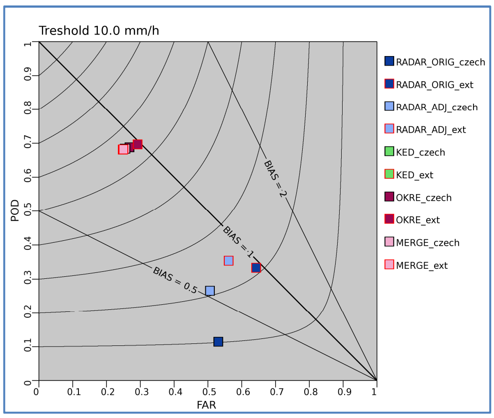
b) 

Figure 7: Comparison of different QPEs based on CSI, FAR and POD. a) for precipitation threshold value 1.0mm/h b) for precipitation threshold value 10.0 mm/h. Czech means the Czech-only radar data and ext means the Czech-extended radar data. The curves depict CSI isolines.

5 Conclusion

The newly developed QPE application gives satisfying results. Analysis of 1h sums can be updated every 10 minute when new raingauge and radar data are available.

The Czech-extended radar data can be used for QPE calculations. These data are useful mainly when number of available raingauges is limited or one of the Czech radars is not working. It could shorten time when QPE analysis could be started after nominal time (when not enough raingauge data is available in the database). If there is sufficient coverage by raingauge stations, improvement of QPE based on the Czech-extended radar data over the QPE based on the Czech-only radar data is only marginal.

So far only basic quality filters are implemented especially for raingauge station data. Plan of future work includes primarily improvement of quality control algorithms, improvement of graphical presentation of the results and development of tools for on the fly tracking of the quality of the input data and individual QPEs.

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