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STATISTICAL ADJUSTMENT OF RADAR-BASED DAILY PRECIPITATION TO GROUND DATA FROM THE CZECH TERRITORY

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1. INTRODUCTION

An adjustment of radar-based precipitation to the ground precipitation measurement can correct systematic errors of the radar-based estimates. The adjusted radar-based precipitation is relevant information e.g. for the verification of the precipitation predicted by NWP model. There are numerous studies dealing with the statistical adjustment of radar-based precipitation e.g. the contributions of Borga and Tonelli (2000), Gabella and Amitai (2000), Michelson and Koistinen (2000), which were presented during the 1st ERAD conference.

In the Czech Republic the adjustment investigation started in the project RADHYD. The results are summarized in Kracmar *et al* (1998), and Rezacova *et al* (1998). The first procedures applied a simple regression models and used the data from the MRL5 radar Prague Libus (no more in operation). Later the data from radar Skalky were included (Gematronik METEOR 360AC radar, see Novak and Kracmar (2000) for description of Czech radar networks) and the concept of classified regression (KREG) was used. Apart from KREG the WSR-88 algorithm described by by Fulton *et al* (1998) has been tested in Salek (2000).

This contribution summarizes the newest KREG results, which are based on the three years of radar Skalky measurement. In addition the KREG adjustment of 1h precipitation is briefly mentioned. The data of the U.S. radar Tulsa were used.

2. INPUT DATA FROM THE CZECH TERRITORY

The input data included radar Skalky and gauge data from 1996-98. The gauge set consisted of 714 gauges that report daily precipitation. The radar data contained the maximum reflectivity values (Zmax). The daily sums RADX were determined by the standard CHMI software that calculates integrated rain rate RADX from Zmax. The RADX values are available in 256x256 pixels. Each pixel represents the area of 2x2km.

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The results related to the warm season (April - September) are summarized. The data from 1996, 1997 were used as developmental data set to derive regression models. The set includes the precipitation period in 07/1997 when a large part of the eastern Czech Republic was flooded. The inclusion of heavy precipitation in the developmental data makes possible to improve the radar-based precipitation in the range of large precipitation values. The 1998 data are used to the verification of the models.

Before testing the adjustment techniques the input data were checked. The coefficient of determination r^2(G,RADX) was calculated for each of 714 gauges from the 1996,97 data. From the 714 gauges only 653 gauges with r^2(G,RADX)>0.1 were accepted.

3. STATISTICAL MODELS

Several statistical models were compared: • simple reference methods based on radar data include rough radar estimate (RADX), and linear regression model (REG1), • interpolation of gauge data (STA), which provided the 1st precipitation guess, and • classified regression with classification based on the STA values (KREG_G).

To determine the REG1 values the multiple linear regression was used in the form $G = a_0 + \Sigma a_i P_i$, where G is the gauge value, P_i are the radar based independent variables – predictors, and a_j are the regression coefficients. The classified regression KREG_G consists of several REG1 models, which are developed separately for different precipitation classes <0,2), <2,5), <5,10), <10,30), <30,50), >= 50mm. The classification follows from the STA values that are obtained by the weighted average of precipitation observed in the neighborhood of the considered pixel.

The basic set of potential predictors includes • radar precipitation - RADX value, • median RADX - 3x3 pixels, • mean RADX - 3x3 pixels, • distance and logarithm of the distance from the radar to the pixel, • elevation of the pixel, • height of the lowest radar beam, • the 1st precipitation guess. In addition several variables derived from the radar data between the radar and the gauge were included in some tests. To select the most efficient predictors the forward selection algorithm was applied with maximum 5 predictors allowed. Various modifications of the KREG technique were investigated mostly depending on the subset of predictors. For instance the KREG_G_g uses the 1st guess as predictor while KREG_G does not.

The performance of the models was evaluated by the root mean square error RMSE(G,R), where G are the daily gauge values, and R are the precipitation estimates. The RMSE was calculated for all data altogether as well as for single classes.

4. RESULTS

4.1 Effect of gauge density on the accuracy of KREG

The density of gauges affects the accuracy of the precipitation 1st guess. To assess this influence we randomly selected 30, 50, 80, 100, 200, 300, 400, and 500 gauges in sequence. The selection was repeated 20 times for 30 and 50 gauges, and 15 times for other numbers of gauges. The mean RMSE over all repeated attempts were determined. The figures 1, and 2 show examples of the results obtained with the verification data set.

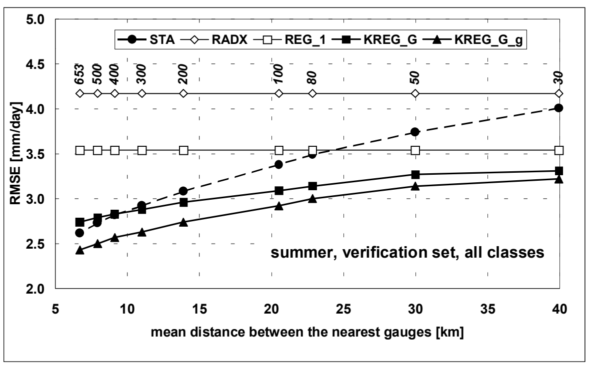

Fig.1: RMSE values for considered techniques in dependence on the mean distance between the nearest gauges. The number of gauges is labeled at the RADX values.

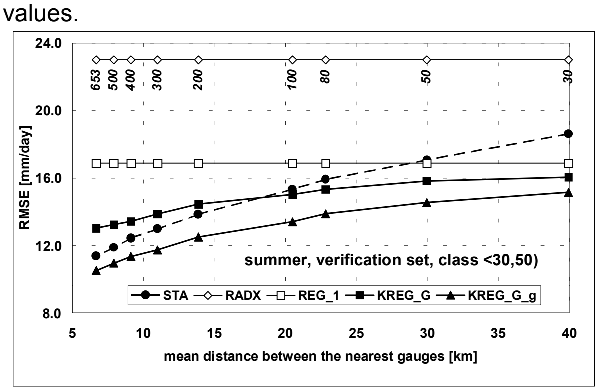

Fig.2: The same as Fig.1 but for the precipitation class <30mm, 50mm).

4.2 KREG based on the data of 81 on-line gauges

The KREG equations were developed for 81 gauges operating in on-line regime on the Czech territory. The table 1 shows the RMSE values for independent 1998 data.

Class	0-999	0-5	5-10	10-30	30-50	50-999
KREG_G_g	2.96	1.33	3.77	6.81	14.13	33.18
REG1	3.54	1.79	4.52	8.18	16.60	33.93
STA	3.43	1.55	4.17	7.68	15.52	43.41
RADX	4.17	1.20	4.51	10.85	23.00	43.11

Table 1: RMSE values of four techniques used. The KREG_G_g and STA are based on the 81 on-line gauges.

To understand the global consequence of the KREG application we calculated the logarithmic enhancement factor logAF=log[ΣR/ΣG], where ΣR is the sum of radar-based precipitation and ΣG is the corresponding gauge value. The logAF values were determined for RADX and for KREG_G_g based on the 81 on-line gauges. Data of all the 653 gauges from the verification year 1998 were used. The results are shown in fig.3.

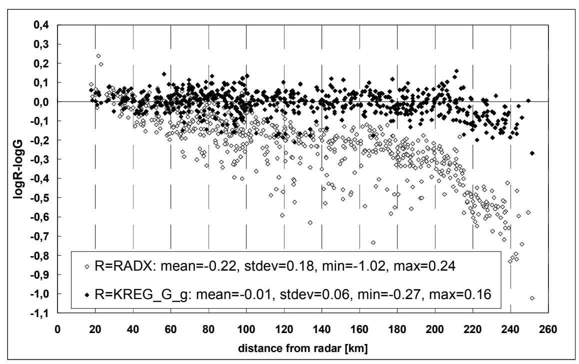

Fig.3: Dependence of the logarithmic enhancement factor on the distance of gauges from radar.

To check the application of KREG to a particular precipitation event the RADX and KREG results were compared for the daily precipitation from 22 July 1998 06UTC - 23 July 1998 06UTC when an organized convection caused a flash flood in the NE part of the Czech Republic. Maximum daily precipitation of 204mm was reported. The meteorological background of the precipitation event can be found in Salek (2000). The KREG_G_g procedure using data from the 81 on-line gauges was applied. It resulted in the RMSE(KREG)=17.7mm/day as compared with RMSE(RADX)=28.4 mm/day. The RMSE values were determined on 60 independent gauges from the relevant region.

5. ADJUSTMENT OF THE 1H PRECIPITATION

In addition to the adjustment of radar-based daily precipitation very first results were obtained showing the applicability of KREG to the 1h-accumulated precipitation. The tests used the data from U.S. radar TULSA as there are not hourly data available in the Czech Republic yet.

Radar and precipitation data from May-September 1997-98 were used in the tests. From that period data from 249 gauges were available but only the terms with positive precipitation at least at one gauge were considered. Filtering was applied to the gauge data. First the 16 gauges with less than 1000 data were decided not to be considered. Second the 18 gauges with CC(R,G) < 0.3 & CC(R>0,G>0) < 0.3 were excluded. All the others 215 gauges were taken into account.

In the statistical tests the classification was made with all gauges, with randomly selected 1/2 and 1/4 of gauges. The both variants were calculated, which means that the KREG equations were determined with 1997 or 1998 data and they were verified with corresponding independent set. RMSE and BIAS values were determined with developmental as well as with verification sets. Resulting RMSE and BIAS values will be presented in the poster. They show an improvement in RMSE values gained by KREG as compared with RADX and STA estimates. The results with U.S. data support KREG application to the shorter accumulation periods. Similar tests with shorter accumulation periods will be carried out with Czech data as soon as they are available from the on-line networks.

6. CONCLUSION

Following conclusions can be drawn.:

- Classified regression (KREG) improves the radar-based estimate of daily precipitation in comparison with the other models tested as well as with the interpolation of ground data.
- KREG is better than interpolation for a wide range of gauge density (including the 81 on-line gauges on the Czech territory).
- The first tests with KREG adjustment of 1h precipitation (U.S. data) show improvement in RMSE and BIAS. Nevertheless, additional tests with Czech data are needed.
- Potential for improvement of the KREG can be expected (1) in considering a more complex radar information than the Zmax values, and (2) in the inclusion of other physical aspects into the classification. Especially separate dealing with convective and stratiform precipitation should be considered.

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7. REFERENCES

Borga,M., Tonelli,F, 2000 : Adjustment of range-dependent bias in radar rainfall estimates. Phys. Chem. Earth(B), **25**, 909-914.

Fulton,R.A., Breidenbach,J.P., Seo,D.J., Miller, D.A.,O'Bannon,T., 1998 : The WSR-88 rainfall algorithm. Wea. Forecasting, **13**, 377-395.

Gabella,M., Amitai,E., 2000 : Radar rainfall estimates in an alpine environment using different gage adjustment techniques. Phys. Chem. Earth (B), **25,** 927-931.

Kracmar,J., Joss,J., Novak,P., Havranek,P., Salek,M., 1998 : First steps towards quantitative usage of data from Czech weather radar network. COST75 Advanced Weather Radar Systems. COST75 Final Seminar, Locarno, Switzerland, 23 - 27 March 1998, 91-101.

Michelson,D.B., Koistinen,J., 2000 : Gauge-radar network adjustment for the Baltic sea experiment. Phys. Chem. Earth(B), **25**, 915-920.

Novak,P., Kracmar,J., 2000: Exploiting 3D Volume Data from the Czech weather radar network. Phys.Chem.Earth (B), Vol.25, No 10-12, pp 1163-68.

Rezacova,D., Sokol,Z., Kracmar,J., Havranek,P., Joss,J., 1998 : Statistical correction of radar based precipitation amount. COST75 Advanced Weather Radar Systems. COST75 Final Seminar, Locarno, Switzerland, 23 - 27 March 1998, 136-142.

Sokol,Z., Rezacova,D., 2001 : Application of classified regression to the statistical correction of radar-based daily precipitation (in Czech with English summary), Meteorol.Zpr.,**54**, in print.

Salek.M., 2000 : Torrential rainfalls in the foothils of the Orlicke hory Mts. on the 22 and 23 July 1998 (in Czech with English summary), Meteorol.Zpr.,**53**, 4-15.