FORECASTING QPF UNCERTAINTY FOR HEAVY RAINFALLS PRODUCED BY CONVECTIVE STORMS

Daniela Rezacova[1], Petr Zacharov[2]

[1]*Institute of Atmospheric Physics AS CR, Bocni Str. II/1401, 141 31 Prague 4 - Sporilov, Czech Republic, rez@ufa.cas.cz*
[2]*petas@ufa.cas.cz*

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I. INTRODUCTION

Forecast uncertainty is currently considered to be an inherent part of high-resolution quantitative precipitation forecast (QPF), and it is particularly pronounced when predicting heavy convective precipitation. In order to assess the uncertainty in short–range QPF, several convective storms, which produced heavy local rainfalls in the Czech Republic, were studied. The storms differed in precipitation localisation and area extent and in the convective environment as well. The NWP model LM COSMO was run with a horizontal resolution of 2.8 km and a forecast ensemble was created by modifying model initial and boundary conditions. The forecasts were verified by gauge adjusted radar-based rainfalls (Sokol, 2003; Rezacova et al., 2007). We applied so-called “fuzzy” verification techniques (Ebert, 2008), which allow some relaxation of the requirement of exact matches between grid point (or area) forecasts and observations. Our verification is based on the so-called Fractions Skill Score (FSS), which corresponds to a “fuzzy” verification approach (Ebert, 2008; Roberts and Lean, 2008). The FSS expresses how the area of interest is covered by a rainfall that exceeds a given threshold.

In order to evaluate the ensemble forecast, FSS-based ensemble skill and ensemble spread were determined. The spread represents the forecast uncertainty and follows from the differences between the control forecast and the forecasts provided by ensemble members. The forecast accuracy is characterized by the skill which evaluates the differences between the precipitation forecasts and radar-based rainfalls. User-oriented information about forecast uncertainty should be available at the time of forecast, unlike forecast accuracy, which can be expressed by an a posteriori verification using measurements. The relationship between ensemble skill and ensemble spread is important information showing how the ensemble spread reflects the forecast accuracy (e.g., Whitaker and Loughe, 1998; Sherrer et al., 2004; Grimmit and Mass, 2007).

This study deals with the estimation of prognostic FSS-skill by using the ensemble FSS-spread and the relationship between FSS-spread and FSS-skill. The first numerical experiments included 5 events (Zacharov and Rezacova, 2009). They used the skill and spread values related to 4 events to estimate the skill-spread relationship. The relationship was applied to the fifth event to predict the ensemble skill given the ensemble spread.

II. THE PREDICTION OF FSS-SKILL

The ensemble values were determined for five local convective events that produced heavy local rainfall. Two events occurred in July 2002 (13th and 15th July), one storm developed on 10 July 2004 and the two last events were recorded in May 2005 (23rd and 30th May). The storms, the QPF verification, and a first analysis of the relationship between ensemble skill and ensemble spread are described in Rezacova et al. (2009).

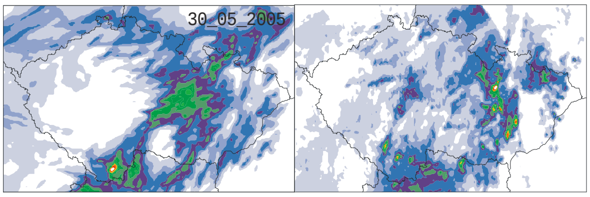

FIG. 1: An example of the event with heavy convective precipitation; the comparison between predicted (left) and gauge adjusted radar-based(right) 12h rainfall (10.00UTC – 22.00UTC) 30.5.2005. The horizontal resolution of both forecasted and observed precipitation fields is 2.8 km.

The ensemble FSS-skill and FSS-skill spread values were determined as mean values over the ensemble members. Like the FSS they depended on the scale (a size of of elementary area), and on a precipitation threshold. The evaluation was performed separately for 1, 3, and 6 h rainfalls using various threshold values (TH = 0.1, 1, 2, and 5 mm) and scales (square elementary area with sides of 5, 11, 15, 21, 25, 31, 35, 41, 51, and 61 grid points).

The rainfalls were determined with a time step of 1 h starting after 7 h (13UTC - 14UTC), 5 h (11UTC - 14UTC), and 4 h (10UTC - 16UTC) of integration time for 1, 3, and 6 h rainfalls, respectively. The last considered rainfalls corresponded to the time periods 21UTC - 22UTC (1h rainfalls), 19UTC - 22UTC (3h rainfalls), and 16-22UTC (6h rainfalls). It means that the FSS related values were computed for 9 (1h rainfalls), 9 (3h rainfalls), and 7 (6h rainfalls) rainfall fields at every event. The whole set of {FSS-skill, FSS-spread} couples comprised 360 values (1h and 3h rainfalls) and 280 values (6h rainfalls) for each of five convective events.

III. RESULTS AND CONCLUSIONS

The results show that the skill estimation based on determining the ensemble spread and on a simple statistical evaluation of the spread-skill relationship appears to be a useful technique. The distribution of differences between prognostic and diagnostic skill shows low bias, and the interquartile range between 0.10 and 0.30. The Percent Correct score gave a mean of 0.68. One of five events showed a marked overestimation of the FSS-skill and the mean PC of 0.39. The mean PC over the other 4 events gave a value 0.75.

A decrease in the ensemble spread (increasing FSS-spread) and an increase in the forecast skill (increasing FSS-skill) are event-dependent. This means that there is no fixed scale that can give a threshold FSS-skill value. This is why the regression projecting the FSS-spread on the FSS-skill was constructed for all the scale sizes together. However, it would be worth testing the stratification of the skill (spread) relationship according to the scale after extending the input dataset.

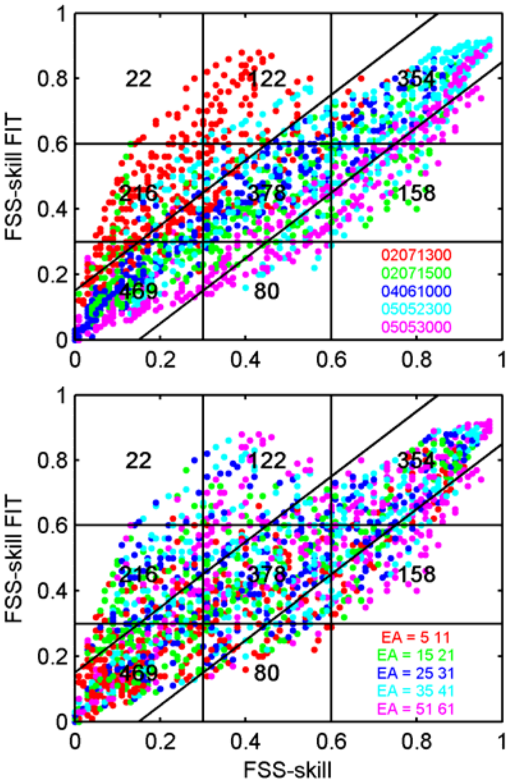

FIG. 2: Forecast skill (FSS-skill FIT, vertical axis) against measurement-based skill (FSS-skill, horizontal axis) for 3 h rainfall and all the thresholds considered. The numbers placed inside the blocks represent absolute frequency values in corresponding FSS intervals. The values referring to various events are distinguished by colors in the upper panel. The values referring to scale are distinguished by colors in the lower panel.

We show that the so called fuzzy verification measures, like FSS, are applicable also in estimating the regional ensemble spread/skill relationship. Second conclusion deals with the fact that it is difficult if possible to find general threshold scale given forecast accuracy. The scale effect can be event dependent. Searching an effective expression of the spread-skill relationship, it is perhaps more useful to take advantage of the whole scale dependence.

The FSS appeared to be a suitable score to overall assess the forecast over the whole verification domain. However, a more extended dataset comprising more heavy precipitation events should allow us to consider smaller sub-areas of the Czech territory. This is why enlarging the case studies from the days with severe convective weather and/or local flash floods is our main aim in future work. Next, a technique of ensemble construction should be improved and we suppose that future application to time series would be useful in order to examine the technique with more general precipitation fields.

IV. AKNOWLEDGMENTS

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