PRECIPITATION ASSESSMENT FROM THE VIEWPOINT DATA AVAILABILITY FOR PURPOSES OF FLOOD MODELLING

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ABSTRACT

The application of rainfall-runoff models for purposes of flood modelling is widely used either for assessment of past events or for prediction of further discharge development within warning systems. The results are highly dependent on correct precipitation input data. Floods in small to medium catchments for the conditions of Czech Republic are usually caused by summer precipitation events which are typically characterised by high intensities and totals. These events usually have high spatial variability and therefore it is crucial to involve as much information describing this variability as possible.

In this paper, the differences in total precipitation for two selected events on the catchment are assessed using data measured in a number of meteorological stations. The events were selected which caused significant raise of the discharge at the outlet of the catchment. Presented study was carried out for the catchment of Blanice River (Southern Bohemia). Data used for this purpose have hourly time step.

The total catchment precipitation was calculated using Thiessen polygons based on station data and the exclusion of single stations was assessed. This analysis was carried out in order to demonstrate the influence of missing data from one station which can be caused for example by station failure. Furthermore, the analysis was focused on the variation of precipitation volumes when considering only single stations.

The results show in general high spatial variability of rainfall but the influence of missing data from one station is not crucial when the network of gauging stations is dense enough. Analysis was performed by calculating the total volumes of precipitation on the catchment for different combinations of observed data which were compared to the volume of precipitation using all of them. Results demonstrate the difference in calculated volumes in case of leaving out one of the precipitation stations but this difference is not very high. On the contrary, there are high differences in case of considering only one station which means that in this case the uncertainty of modelled discharges would be too high for both analysed events.

Keywords: storm rainfall, precipitation gauging, spatial variability, Thiessen polygons, catchment response

1. Introduction

Precipitation data are the crucial input to most hydrologic catchment models. The spatial variability of rainfall can lead to large uncertainty of calibrated model parameters when it is not described properly (Chaubey *et al.*, 1999; Pechlivanidis, 2009). Michaud and Soroshian (1994) identified in their study that half of the difference in modelled and observed peak discharges was caused by precipitation sampling error. The importance of spatial variability of rainfall and its influence on catchment hydrological response to a thunderstorm rainfall event was also confirmed by Morin *et al.* (2006) who demonstrated it using radar rainfall data. Similar results were obtained by Tetzlaff and Uhlenbrook (2005) who used radar rainfall data as an input for distributed hydrologic model. Smith *et al.* (2004) discussed the spatial variability of rainfall and its influence on the response hydrograph with similar results. Naden (1992) identified that incorporation of the spatial distribution of rainfall can be of lower importance than other catchment characteristics and that it can be considered averaged in case of modelling large catchments. However, it is still important to have sufficient description of the precipitation in terms of its total.

It is obvious from the above, that the knowledge about precipitation total is crucial at various scales and temporal hydrologic applications. In this paper, the assumption is tested that the precipitation has significant spatial variability and that it is necessary to involve as much precipitation data as possible for hydrologic modelling. The focus is also put on the assessment of the influence of missing data in one single station.

2. Study area

For purposes of this study, the catchment of Blanice River was chosen mainly due to the good availability of input data (Figure 1). The catchment is located in the Southern Bohemia and has a total area of 860 km^2 to the confluence with the Otava River upstream from Písek. The catchment spreads from a hilly area at the foothills of Šumava Mountains to relatively flat area surrounding the Otava River between Strakonice and Písek.

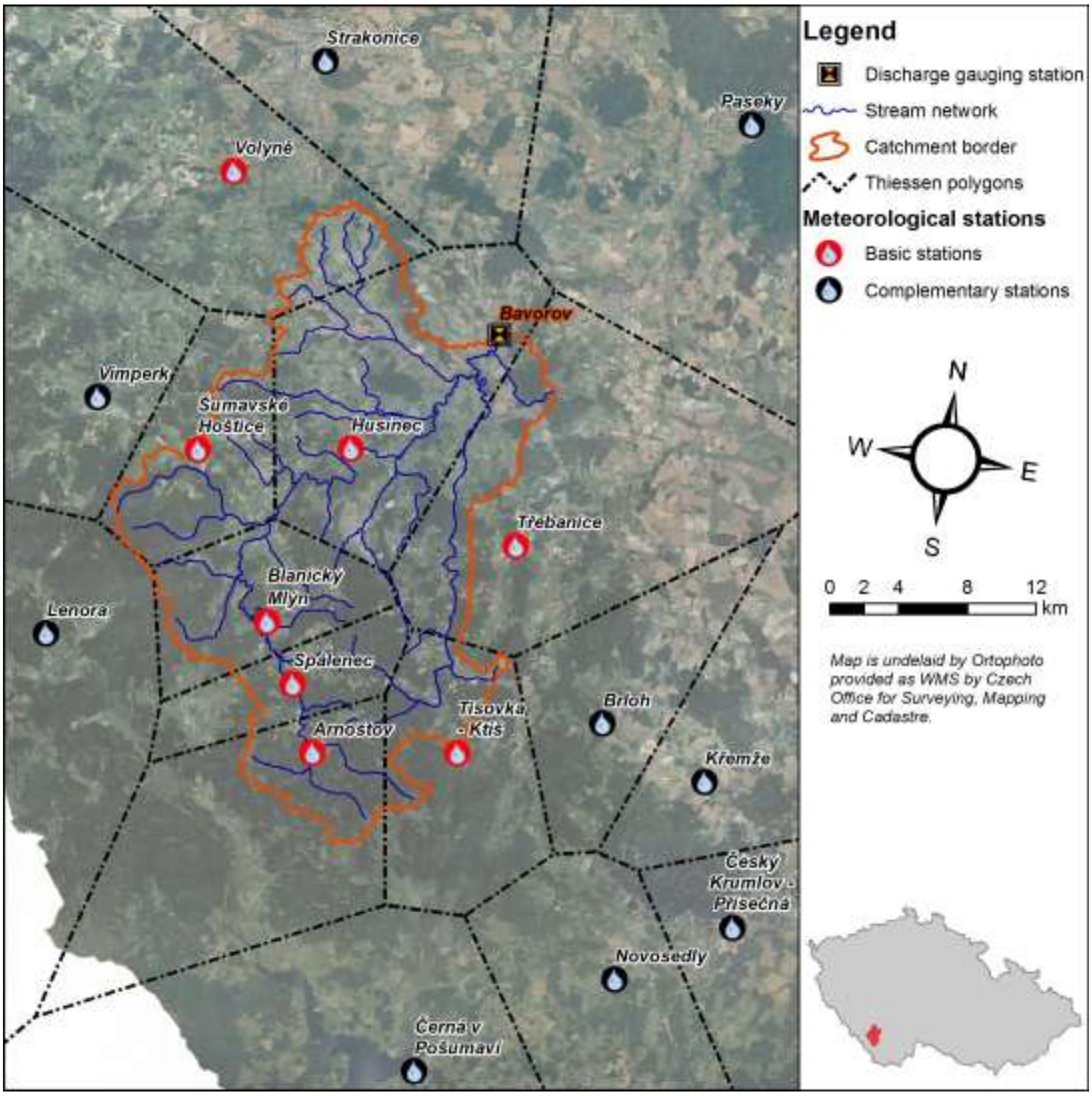

Figure 1: The catchment of the Blanice River at the Bavorov discharge gauging station with the location of precipitation gauging stations.

The analysis was carried out for the part of the catchment to the outlet in Bavorov where the discharge gauging station is located. The area of this subcatchment is 501 km^2. In this area, the mean annual precipitation total is 916 mm varying from 751 to 1212 mm and the mean temperature is 6.4 °C varying from 4.5 to 7.9°C according to the data contained in EFSA Spatial Data (Hiederer, 2012).

3. Input data

There are eight meteorological stations recording precipitation in which Thiessen polygons were applied (basic stations). Six of them are located inside the catchment or on its border (see Figure 1). The most representative station according to Thiessen polygons is Husinec having corresponding area 156.8 km^2 which is 31.3 % of the total study area. Data from five other stations were used as complementary (complementary stations).

For the analysis, two events were chosen which occurred at the end of August (Event 1) and at the end of September (Event 2) in 2015. Characteristics of the events are provided in Table 1 and Figure 2.

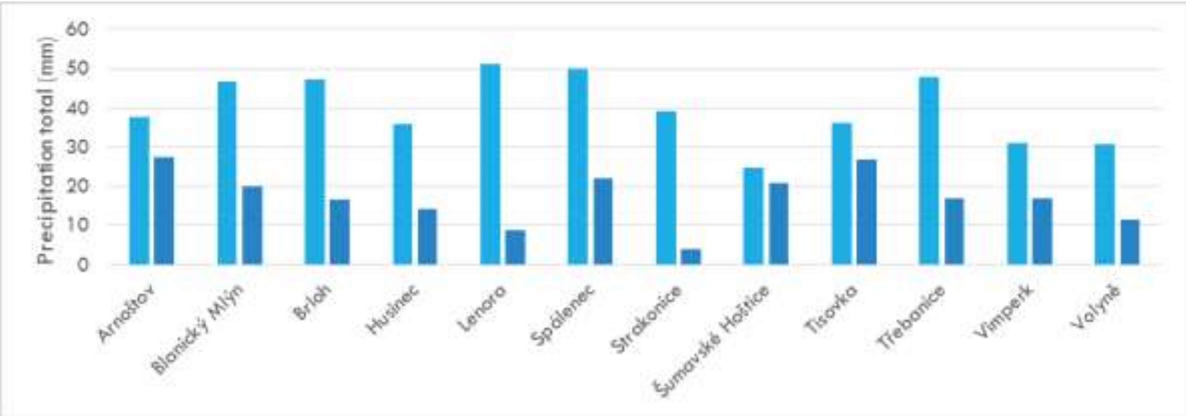

Figure 2: Precipitation totals at various stations for Event 1 (light blue) and Event 2 (dark blue).

For the analysis, the volume of precipitation was calculated for different combinations of the available gauging stations. First, the volume was calculated considering all available data using the Thiessen polygons for the identification of parts of the catchment corresponding to each station. Second, volumes were calculated for subsets of the gauging stations created by leaving out one of the basic stations (see Figure 3 and Table 2). Third, volumes were calculated based on the data from the single stations.

Table 1: Basic information about the events considered in the analysis.

	Event 1	Event 2
Duration	30/08/2015 – 03/09/2015	30/09/2015 – 01/10/2015
Maximum intensity at one of eight basic stations (mm·hr^{-1})	16.6 (Spálenec)	11.8 (Tišovka – Ktiš)
Maximum total (mm)	50.0 (Spálenec)	27.4 (Arnoštov)
Minimum total (mm)	24.6 (Šumavské Hoštice)	11.6 (Volyně)
Volume of response hydrograph (m^3)	2945956	1370180

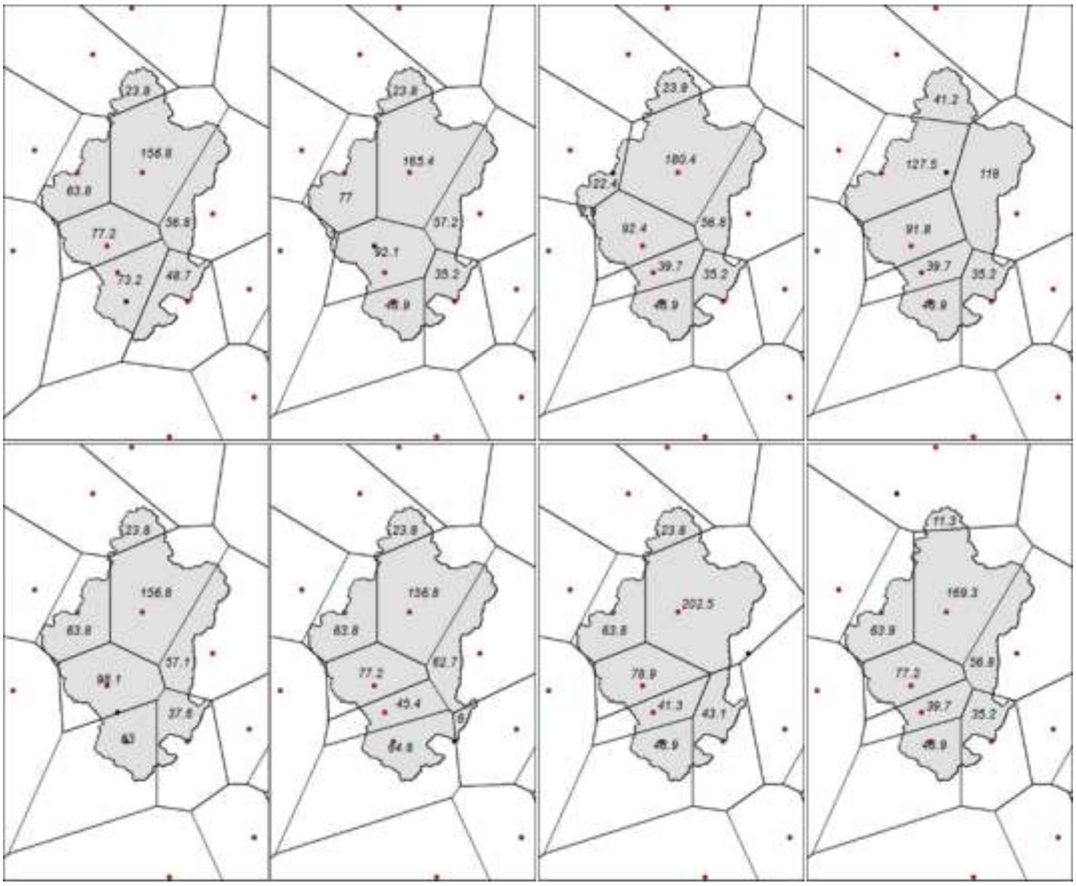

Figure 3: Thiessen polygons delineated for different combinations of the precipitation gauging stations based on leaving out one of the basic stations.

Table 2: Thiessen polygons delineated for different combinations of the precipitation gauging stations.

Station name	Thiessen polygon area within the catchment (km²)								
Arnoštov	46.9	0	46.9	46.9	46.9	63.0	64.6	46.9	46.9
Blanický Mlýn	77.2	77.2	92.4	91.8	0	98.1	77.2	78.9	77.2
Brloh	0.0	0.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0
Husinec	156.8	156.8	180.4	0	165.4	156.8	156.8	202.5	169.3
Lenora	0.3	0.3	2.9	0.3	3.0	0.3	0.3	0.3	0.3
Spálenec	39.7	73.2	39.7	39.7	92.1	0	45.4	41.3	39.7
Strakonice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.3
Šumavské Hoštice	63.8	63.8	0	127.5	77.0	63.8	63.8	63.8	63.9
Tisovka - Ktiš	35.2	48.7	35.2	35.2	35.2	37.6	0	43.1	35.2
Třebanice	56.8	56.8	56.8	118.0	57.2	57.1	62.7	0	56.8
Vimperk	0.0	0.0	22.4	0.0	0.0	0.0	0.0	0.0	0.0
Volyně	23.8	23.8	23.9	41.2	23.8	23.8	23.8	23.8	0

4. Results

The total precipitation volume calculated using all available stations is 9 435 295 m³ and 19 319 912 m³ for Event 1 and Event 2 respectively. Volumes calculated by leaving out one of basic stations vary from 9 147 351 to 10 054 143 m³ for Event 1 and from 18 691 899 to 20 139 123 m³ for Event 2; standard deviations are 274 563 and 447 716 m³ respectively. Volumes calculated for single stations vary then from 5 807 714 to 13 718 221 m³ for Event 1 and from 12 316 337 to 25 033 206 m³ for Event 2; standard deviations are 2 807 170 and

4 450 704 m^3 respectively. The value of runoff coefficient is 0.145 for Event 1 and 0.152 for Event 2 when considering all stations. This coefficient vary then from 0.136 to 0.150 for Event 1 and from 0.146 to 0.157 for Event 2 when applying the method based on leaving out one of basic stations. In case of single station consideration, the value of runoff coefficient varies from 0.100 to 0.236 for Event 1 and from 0.118 to 0.239 for Event 2.

5. Conclusions

The results of a relatively simple assessment of the spatial distribution of precipitation are presented in here. We show that by missing data from one station would not significantly affect the spatial precipitation. However, high spatial variability of precipitation can lead to a very high uncertainty in comparison to results from only one precipitation gauging station. The consideration of only one precipitation gauging station for hydrologic modelling could result in a significant under or overestimation of response hydrograph volume. Further research will focus more in depth on a model-based approach to assess the influence of precipitation's spatial variability on the catchment hydrological response.

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