

Local-scale distribution of precipitation in the growing season of 2019

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Abstract: Agriculture, including crop cultivation, is the most weather- and climate-dependent economic activity. With the help of various weather-plant models and statistical correlation studies, it can be established that the average yield-increasing and yield-reducing effect of weather reaches or exceeds 20% for most economic plants. Precipitation is a climatic element which is showing extreme variability in space and time and the spatial distribution of precipitation is becoming more and more extreme year after year. Our research focused on the spatial distribution of precipitation on horizontal scale up to 1-2 km. We established a low cost rain gauge network with 18 plastic rain gauges which are widely used in the Hungarian private sphere in the settlement Csabacsúd located on the Great Hungarian Plain (N46.49°, E20.39°, 85 m above sea level) where we did daily measurements between May and September 2019. It was clearly visible in the results of the 4-month measurement program that the standard deviation and the CV value showed a decrease compared to the 2018 research year. However, larger differences were also detected this year with a difference of 8.8 mm in the case of a distance of 1400 meters. On 22.06.2019, a difference in the amount of precipitation of 3.7 mm was detected between two gauges located 220 meters apart. This value represents a difference of 1.68 mm/100 m. These data show that *on-site measurements are needed in the growing season for practical agrometeorological purposes such as irrigation scheduling.*

• Introduction

There are several reasons why accurate rainfall measurement is important, for example in agriculture accurate rainfall data is critical for agricultural production as it helps farmers schedule the planting and harvesting of crops.

It also helps in irrigation planning and management. Furthermore precise measurement of rainfall is crucial for the proper management of water resources. It is the primary source of water for many regions, and accurate data helps in regulating dams and reservoirs, predicting floods or droughts, and managing water supply for households, industries, and agriculture.

Understanding the temporal and spatial distribution of precipitation is also a prerequisite for climate change impact assessment. (Busuioc et al. 2001)

The spatial variability of precipitation can vary greatly across different regions and even within the same region. In some cases, certain regions may experience heavy rainfall while nearby areas remain dry for extended periods of time. The spatial variability of precipitation can be quite spectacular even in a small sample area. Pedersen (2010) was able to show a difference of 2.5-12.4 mm in an area of 0.25 square kilometers.

The regional distribution of precipitation can be easily quantified with the spatial variation coefficient. Jensen and Pedersen (2005) surprisingly showed that the results of the experiment showed large fluctuations within independent events during the precipitation event observed by the nine gauges. Expressed as a coefficient of variation (CV), the variability ranged from 10% to 100%, and even when the most extreme measurement device was omitted from the analysis, the standard deviation exceeded 50% in several cases.

One of the most frequently used functions for describing and analyzing the spatial structure of precipitation events is the semivariogram. (Ly et al. 2011)

If we observe research covering a longer period, then for example, in the Amazon rainforest, areas along the eastern edge receive an average of 1700-2500 mm of rainfall per year while areas just a few hundred miles west can receive as little as 250-500 mm of rainfall per year (Phillips et al. 2009) This dramatic difference in precipitation is caused by the region's complex atmospheric and geological processes.

• Material and method

The aim of our research was to investigate the spatial variability of precipitation during the growing season. In Hungary, the Hellman rain gauge used for official measurements, but unfortunately that was only available in limited quantities, so during our research we used a commercially available plastic rain gauge. It cannot be used for official measurements, but when we try to examine the spatial variability of precipitation, due to its low purchase price, it can even be used at a higher density. However, it is worth noting that its use is only advisable during the growing season, as it can easily freeze in the winter and is inaccurate for measuring snow.

The measurements were carried out in the interior of a lowland village Csabacsúd located on the Great Hungarian Plain (N46.49° E20.39°, 85 m above sea level). The size of the sample area is about 1.2 km². A high-density rain gauge network with 18 measurement points was established within the settlement. The distance between the two measuring points closest to each other is 150 m, while the distance between the two furthest rain gauge is 1.5 km.

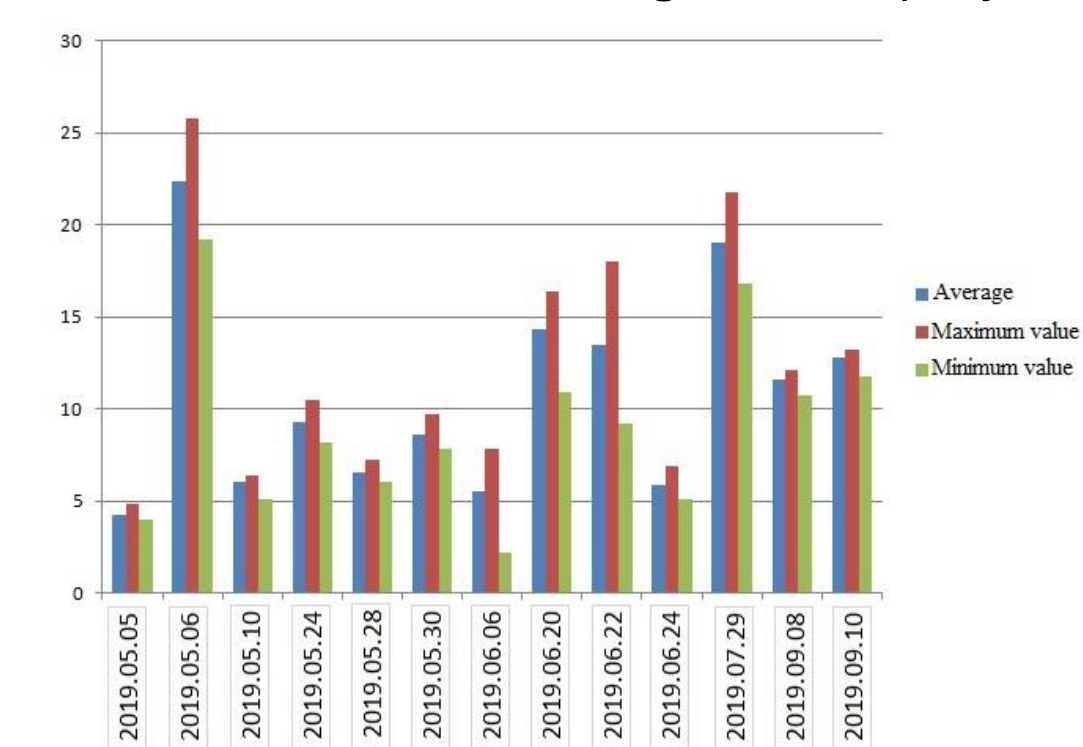


It is worth mentioning that this is the second year of the research period, the data of 18 stations was still available. During the research period, 13 precipitation events were assessed.

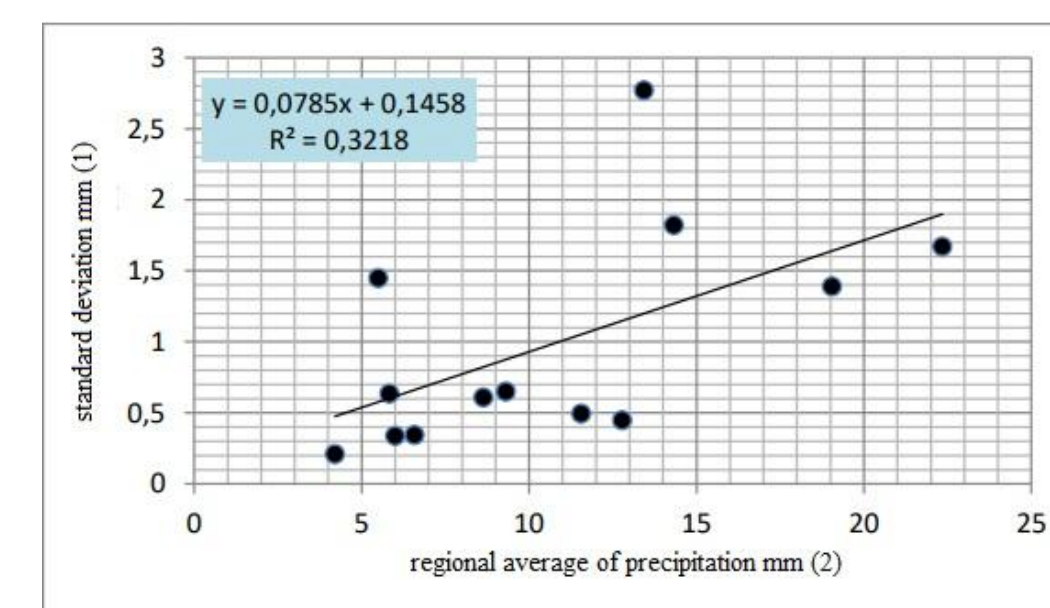
We examined the qualitative and quantitative correlations of the data with the help of the ESRI ArcGIS software Spatial variance, deviation, and CV values of precipitation were calculated using Microsoft Office Excel.

• Results and discussions

Precipitation activity occurred on 13 days and was reliably measured at all 18 stations. With one exception (on 05/05/2019, the daily average of precipitation was 4.2 mm), the amount of measured precipitation events reached an average of 5 mm/day.



In 2019, no significant difference could be observed during major precipitation events, as was the case more often in 2018. During the 13 days, the value of the standard deviation exceeded the value of 2 mm only once with its value of 2.77 mm on 22.06.2019, with an average of 13 mm/day.



The minimum value of the CV value was 6%, and the maximum value was 26% based on the data of the 13 days, in the area of approx. The CV value of 26% belongs to the precipitation event measured on 06.06.2019. On this day, the regional average of precipitation was 5 mm, with a maximum of 7.8 mm and a minimum of 2.2 mm. The minimum amount of precipitation was in the north-western part of the settlement, then it reached the maximum in the central part, and a minimal decrease was observed in the north-east direction.

In the 2019 research period, the second highest CV value with 21% was on 22.06.2019. On this day, the average of precipitation was 13 mm, while the maximum and minimum values were between 18 mm and 9 mm. The maximum amount of precipitation was on the west side of the settlement, and then showed a decrease towards the east.

In the 2019 period, only 4 days of CV value reached or exceeded 10%, and 4 days did not even exceed 5%. During the research period, although there were precipitation events where spectacular differences were created in the entire area of the settlement, however, in the case of pairs of stations close to each other, the differences were no longer so spectacular.

It is also worth examining the precipitation event which was measured on 06.05.2019 when the north-west side of the village had the smallest amount of precipitation, while the north-east side showed an increase in precipitation. On this day, the CV value was only 7%, and the difference between the highest and lowest precipitation amount was 6.6 mm, and the average was 22 mm.

On 22.06.2019, a difference in the amount of precipitation of 3.7 mm was detected between two gauges located 220 meters apart. This value represents a difference of 1.68 mm/100 m. In the 2019 research year, this precipitation event gradient was the most prominent.

• Conclusions

During the research aimed at examining the spatial variability of precipitation, it was clearly visible from the results of the 4-month measurement program that the value of the standard deviation and the CV value showed a decrease compared to 2018. However, larger differences were also detected this year with a difference of 8.8 mm in the case of a distance of 1400 meters.

The areal standard deviation and the absolute deviations also increase with higher daily precipitation, while the coefficient of variation shows the opposite trend.

The variation in the amount of precipitation shown in the research can already affect the optimization of the decision in the operative practice of irrigation, therefore it may be advisable to measure the local precipitation during the growing season.

Outside the growing season, the amount of precipitation taken over a longer period counts, for which the standard deviation is usually much lower. It may be sufficient to use data of a correctly installed precipitation gauge within a distance of 5-10 km.