# 9th INTERNATIONAL SYMPOSIUM ON ATMOSPHERIC SCIENCES
# ATMOS 2019
# E-PROCEEDINGS

**MAIN THEME**

## INTERACTION BETWEEN CLIMATE CHANGE & SECTORS

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## OCTOBER 23-26, 2019 - ISTANBUL, TURKEY

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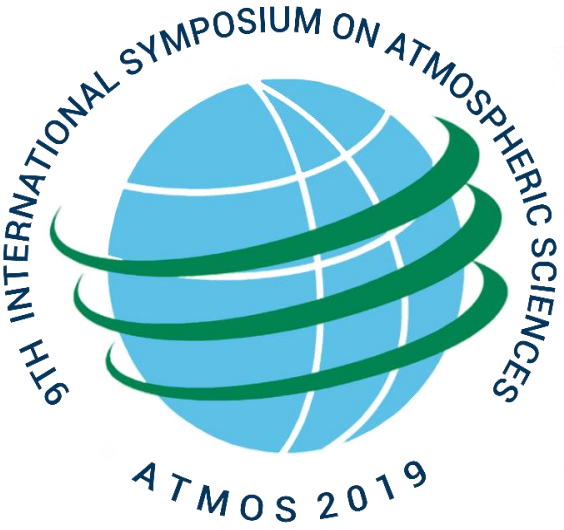


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# PREFACE

The journey of the Atmospheric Science Symposium (ATMOS), which is organized by the Istanbul Technical University (ITU), Department of Meteorology, began in 1981. This year, we marked our calendars for the 9th ATMOS. Considering the 38 years since the beginning of this journey, nine meetings may sound too few for such an event. However, during this period, the ITU/Department of Meteorology organized many other scientific meetings, which individually focused on several topics such as water resources, air pollution, hydrometeorology, meteorological disasters, renewable energy and so on. ATMOS, among these, is unique in the sense that it includes all these research topics and provides a platform to communicate ideas and findings across disciplines. Hence, ATMOS became biennial since 2008 with the need to adapt to the increasing importance of atmospheric sciences in the modern world.

Since ATMOS has now become one of the very important traditional meetings of not only our department, but also our country, as our department is the only department that provides BSc, MSc and PhD in the atmospheric sciences, I would like to give you a very brief history on it. ATMOS was born as a result of the need to bring the national scientists working in the field of atmospheric sciences together. Its second goal was to create public awareness about the problems in the field of meteorology and related fields such as hydrology, environmental sciences (via air quality and air pollution studies), agricultural and forest meteorology, aeronautical meteorology etc. As a result, when the first ATMOS was held in 1981, it was a national meeting bringing together only the national scientists working in the field of atmospheric sciences in Turkey. However, parallel to the developments in our departmental education following the lines of the new mission and vision of our university, ATMOS became international after the year 2011. Also, while it was organized in a more general sense without a specific main theme in the past, today it is organized with main themes focusing on the critical problems of the world and atmospheric sciences.

As you would appreciate, even a simple event in nature cannot be excluded and evaluated separately from the effects of climate change. In this respect, climate change whether natural or anthropogenic, will remain the most important issue regarding our future on this planet. Since it is closely related to almost every sector and scientific discipline, the symposium organizing committee selected the main theme for this year's symposium as "Interactions Between Climate Change and Sectors".

As can be seen from the symposium program, the interactions between climate change and various sectors including agriculture, economy, energy, environment, forestry, health, society, tourism, transportation and water resources were addressed and discussed during the three symposium days. In addition, many papers covering other branches of atmospheric sciences and their application were presented and discussed in the various sessions of the symposium.

At this point, I would like to thank again to all the scientists who contributed to the symposium with their research papers.

Secondly, I would like to thank the respected referees who played an important role in the scientific quality of the symposium. Thanks to the referees' significant efforts during the peer review process, we followed many qualified presentations in this symposium.

Of course, any meeting, regardless of the main theme, with such a broad spectrum of topics in Atmospheric Sciences, cannot be accomplished without several facts:

I would like to start with the invited speakers of the symposium. They are all worldwide very well-known and well-regarded scientists in their field of study. Here are our respected keynote speakers: Dr. Andrea N. Hahmann from Technical University of Denmark, Dr. Anthony Lupo from University of Missouri, Dr. Christian Bernhofer from Dresden Technical University, Dr. Josef Eitzinger from University of Natural Resources and Life Sciences, Dr. Reiji Kimura from Arid Land Research Center, Tottori University, Dr. Timo Vesala from University of Helsinki, Finland and Dr. Zafer Aslan from Istanbul Aydın University.

Next, I would like to give our thanks to the sponsors of our symposium. Beyond all the dimensions of a meeting such as the need for long hours of work time and dedication, perhaps the finances are one of the most difficult, yet one of the most crucial parts. Hence, I would like to express my gratitude to all sponsors of ATMOS whose financial support made it possible to organize this meeting. With this, here, I would like to thank to: The Scientific And Technological Research Council Of Turkey, Food And Agriculture Organization of the United Nations, Turkish Water Foundation, Agricultural Insurance Pool Management Company, Samsun Sinop Provinces Aquaculture Producers Association, Lighthouse Worlwide Solutions Inc., ABB Electric Inc., Akarsu Engineering, BLG Chemical Technologies Inc., Dolsar Engineering, Io Environmental Solutions Inc, Meteo Energy, Mikromet Ecosystems Solutions, Sarıyer Municipality, Su-Yapi Engineering and Consulting Inc., Temelsu International Engineering Sevices Inc.

Now, it is probably the most difficult but at the same time very honorable part of my duty as being the chair of the symposium is to give my thanks to our symposium organization team without which certainly this meeting could not be made it possible. Each of the organization committee member worked very hard for the symposium and put their time and effort to make a successful organization.

Hope to meet you again at the next ATMOS meeting.

**Prof. Dr. Kasım KOÇAK**
**Chair of ATMOS 2019**

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# Temporal Changes of the Temperature and Precipitation Values in Afyonkarahisar Urban Area

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## ABSTRACT

Urban Climate appeared in urban area where urban buildings are built, residences rise, large asphalt roads are made and asphalt roads are placed instead of soil ground. The color and patterns of roof covers affected albedo, exhaust emission, fossil fuel use and growing industrial activities changed atmospheric components in cities. After the year 2000, urban area in Afyonkarahisar grew sharply. Meteorological differences appeared in particularly between urban center and campus of new settlements area. The distance between urban center and campus is approximately 8 km. The data of two meteorological stations have been analysed between city center and peripheric. Also, meteorological differences have been evaluated by making comparisons. There is 9 km. distance between these two meteorological stations. And also there are important differences between these two stations in terms of meteorological parameters such as temperature and precipitation.

Annual mean temperature of downtown is higher than that of university region in September, October, November and December except for July and August in 2015. Annual average temperature values of 2016, 2017 and 2018 are higher in downtown than that of university region. However, temperature values of 2018 are clearly similar in these two meteorological stations due to over construction in university region since 2017. Because of the urban heat island effect and intense particle in the air, the ratio of precipitation, particularly convectional precipitation increased clearly in downtown. The precipitation value in downtown in May, June, July and August are higher than that of university region in the same period. There are differences of 7-8 mm in terms of precipitation value between downtown and university region. While annual total precipitation value of 2016 is 355.6 mm in downtown, this value is 297.8 mm in university region. Annual total precipitation value of 2017 in downtown is 286.4 mm. This value is 182.3 mm in university region. In this study, meteorological differences of the stations which are in short distance in rural and urban area in Afyonkarahisar, have been produced by using Mann-Kendall and Pearson statistical methods.

**Key Words:** Urban Climatology, meteorological parameter, urbanization, student city

## INTRODUCTION

City climatology is a concept that is important in all of our daily lives and constantly a part of our lives. It emerged after the rapid migration and increase of urbanization caused by the rapid increase of population in our country and in the world. A city itself creates its own "city climate" and interacts with the environmental climate in various ways.

When cities and rural areas are compared, it is seen that radiation decreases 15% on horizontal surfaces, 30% decrease in ultraviolet radiation in winter, 5% decrease in summer, 0.7 ºC in annual average temperatures and 1.5 ºC increase in winter maximum temperatures Landsberg(1981). According to the studies, urbanization is effective in increasing temperature and precipitation parameters. In the study within the scope of METROMEX project; In St. Louis, it was found that the city effect showed statistically significant increases in summer rains, heavy rains (> 25 mm), storm and hail Changnon et al. (1978). Atkinson (1971) found that the convectional cloud over the city is

developing rapidly. Accordingly, there is an increase in precipitation caused by excessive concentration nuclei in cities. In addition, excessive concretion in cities increases evaporation. Asphalt and concrete floors prevent water from leaking into the ground. Therefore, especially in summer, high evaporation rates form a basis for unstable precipitation. Cicek (2004), reflecting the effects of urbanization in the study of the meteorological station of Ankara in which precipitation characteristics were studied between the years 1926-2000 revealed an increasing tendency of precipitation annually and in all months except March, September and December.

## 1. DATA AND METHOD

In this study, the data of temperature and precipitation parameters were processed in linear, column and pie chart form in excel. In addition, the data of the meteorological stations in the city and on campus are taken as two different variables as x and y.

Pearson correlation method was used in the calculation. The correlation coefficient takes values ranging from -1 to +1 ($-1 \leq r \leq +1$). In the absence of a correlation, the coefficient is 0, 1 if there is a strong correlation in the form of a decrease or increase together, and -1 if there is an inverse and complete correlation. In evaluating the level of the correlation between the variables, it is not important whether the number obtained by the correlation coefficient is positive or negative, in other words, the absolute value of this number is taken into account. The level of the relationship between the variables is weak when the correlation coefficient is between 0-0.25, moderate if it is between 0.50-0.69, strong if it is between 0.70-0.89 and if it is between 0.90-1, it can be interpreted as very strong.

As a second statistical method, Mann-Kendall test which is a non-parametric test was applied. With this method, inferences were made to determine the degree of significance of tendencies made by both temperature and precipitation data over time.

## STUDY AREA AND STATIONS

Afyonkarahisar is located in the inner west Anatolian part of the Aegean region. It is at the crossroads on the roads connecting Central Anatolia in Anatolia. Behind the city, the land roughly extends from northeast to southwest.

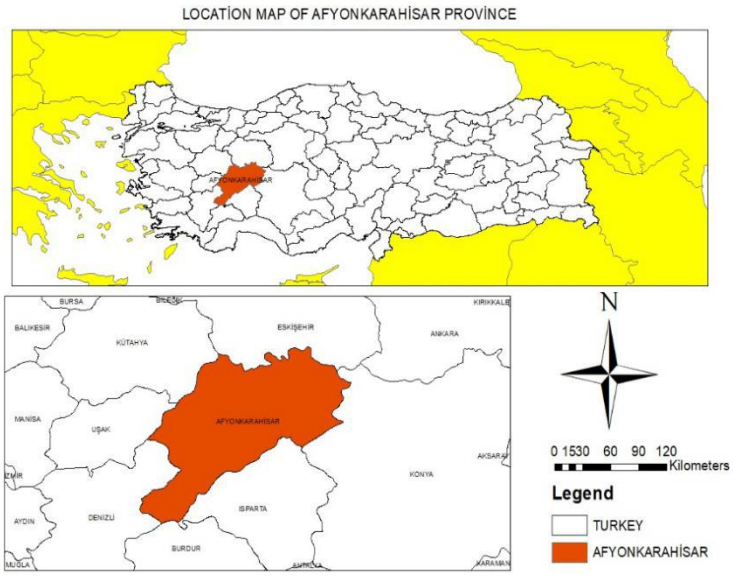


**Figure 1.** Location map of Afyonkarahisar province

## METEOROLOGICAL DIFFERENCES WHICH ARE OBSERVED BETWEEN TWO STATIONS IN AFYONKARAHİSAR CITY CENTER

### Comparative Average Temperature Analysis of University and Afyonkarahisar Central Stations between 2015 and 2018

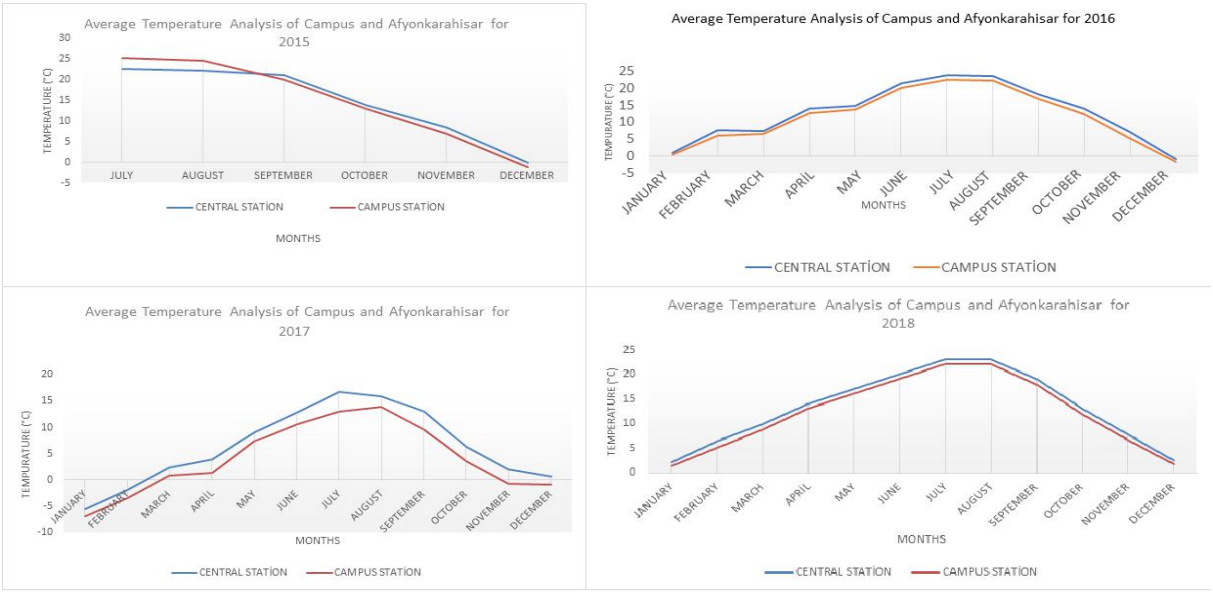


**Figure 2.** Average temperature diagram of the central and university stations for 2015, 2016, 2017 and 2018

Since the meteorological station within the borders of the university was put into service in July 2015, the comparison started as of July 2015. Except July and August, the average temperature of the city center was higher than the university region in September, October, November and December (figure:2). Campus region was not affected completely by urban climate because construction in Erenler was very weak in 2015. The ground was generally soil, so temperature could not accumulate on the ground. In other words, Erenler was reflecting a rural condition in relations to the center of Afyonkarahisar at that time. On the other hand, in the center of Afyonkarahisar, the conditions are opposite. According to this study, the decrease in long wave radiation losses caused by city canyons, the decrease in albedo amounts caused by canyon geometry, the thermal properties of cities, the anthropogenic heat, the city greenhouse effect, increasing apparent air temperature due to decreasing evapotranspiration, decreased latent heat are the results of complex structures. According to Pearson correlation analysis, there was a significant positive correlation between two stations' data. The main reason for that was the short distance between two stations and similar topographic conditions.

In all months of 2016, the monthly average temperature of the meteorological station in the center is higher than the monthly average temperature of the university's meteorological station. The average temperature in January was 2.2 ºC in the center and it was 0.3 ºC at the university station. The average monthly temperature in July was 23.1 ºC. The measured value in the campus area was 21.0 ºC (figure:2). The reason why the temperature values are so different between the two stations located 9 km from each other is that the ground in the city center is generally covered with concrete and asphalt, and the reflection rate of the temperatures from the ground is quite high compared to the campus area. On the other hand, in the campus area, soil temperature facilitates absorption rather than reflecting back and there is a heat transfer to the lower layers of soil.

In January 2017, the average temperature was measured -5 ºC, while it was measured as -6.8 ºC on campus. Although the difference was obvious in other months, July had the highest temperature. The average temperature in July 2017 was 16.8 ºC in the center, while it was measured 13.1 ºC on campus(figure:2). Landsberg (1981) Oke et al. (1987) made similar findings in their studies. According to the study, the decrease in long wave radiation losses caused by city canyons played an active role in the formation of the city heat island. Radiation from the ground plays an important role in the formation of SHIA. Differences in soil properties of rural and urban areas cause significant temperature differences. Reflection of the incoming energy from the ground is not the same in rural and urban areas because in rural areas, the reflected energy is reflected without any physical obstacles, but in urban areas, it is significantly retained between tall buildings and there are significant temporal delays in its propagation Çiçek, I.(2005), Dogan., U. (2005).

In the graph 2018, the temperature differences between the two stations began to close compared to previous years. The main reason for this may be the fact that the construction of the Erenler student campus located in the campus in 2018 gradually accelerates and the effects of the city climate gradually affect the campus region. With over-structuring, air circulation is adversely affected and stagnant weather conditions occur, increasing the temperature values.

**Average Temperature Correlation Analyses of Campus and Afyonkarahisar Central Stations**

**Table 1.** Average Temperature Correlation Analysis of University and Afyonkarahisar Central Stations for 2015

**Correlations**

| | | CENTER | CAMPUS |
|---|---|---|---|
| CENTER | Pearson Correlation | 1 | ,989** |
| | Sig. (2-tailed) | | ,000 |
| | N | 6 | 6 |
| CAMPUS | Pearson Correlation | ,989** | 1 |
| | Sig. (2-tailed) | ,000 | |
| | N | 6 | 6 |

**. Correlation is significant at the 0.01 level (2-tailed).

**Table 2.** 2016 Average Temperature Correlation Analyzes of University and Afyonkarahisar Central Stations

**Correlations**

| | | CENTER | CAMPUS |
|---|---|---|---|
| CENTER | Pearson Correlation | 1 | ,989** |
| | Sig. (2-tailed) | | ,000 |
| | N | 6 | 6 |
| CAMPUS | Pearson Correlation | ,989** | 1 |
| | Sig. (2-tailed) | ,000 | |
| | N | 6 | 6 |

**. Correlation is significant at the 0.01 level (2-tailed).

According to Pearson Correlations analyzes the relationship between the average temperature values of central and ANS stations of 2016 showed a significant positive correlation tendency. According to these analyzes, there was a direct correlation between two stations' data.

**Table 3.** 2017 Average Temperature Correlation Analyses of University and Afyonkarahisar Central Stations

**Correlations**

| | | CENTER | CAMPUS |
|---|---|---|---|
| CENTER | Pearson Correlation | 1 | ,989** |
| | Sig. (2-tailed) | | ,000 |
| | N | 6 | 6 |
| CAMPUS | Pearson Correlation | ,989** | 1 |
| | Sig. (2-tailed) | ,000 | |
| | N | 6 | 6 |

Correlation is significant at the 0.01 level (2-tailed)

According to Pearson Correlations analyses, the relationship between the minimum average temperature values of the central and ANS stations of 2017 showed a significant positive correlation tendency. According to these analyzes, there was a direct correlation between two stations' data.

In this graph, when compared with the average monthly temperature values of 2015, 2016 and 2017, it was observed that the difference between the stations had decreased considerably.

**Table 4.** Monthly average temperature correlation analyses of the University and Afyonkarahisar Central Stations for 2018

**Correlations**

| | | CENTER | CAMPUS |
|---|---|---|---|
| CENTER | Pearson Correlation | 1 | ,989** |
| | Sig. (2-tailed) | | ,000 |
| | N | 6 | 6 |
| CAMPUS | Pearson Correlation | ,989** | 1 |
| | Sig. (2-tailed) | ,000 | |
| | N | 6 | 6 |

**. Correlation is significant at the 0.01 level (2-tailed).

The Pearson test results were quite striking. The gap between the average monthly temperatures of the previous years between two stations almost completely closed in 2018. The main reason for this is that the campus area has now similar to the meteorological conditions of the city center as a result of over-construction.

**Table 5.** Monthly precipitation correlation analysis of University and Afyonkarahisar Central Stations for 2016

**Correlations**

| | | CENTER | CAMPUS |
|---|---|---|---|
| CENTER | Pearson Correlation | 1 | ,864** |
| | Sig. (2-tailed) | | ,000 |
| | N | 12 | 12 |
| CAMPUS | Pearson Correlation | ,864** | 1 |
| | Sig. (2-tailed) | ,000 | |
| | N | 12 | 12 |

**. Correlation is significant at the 0.01 level (2-tailed).

**Table 6.** Monthly precipitation correlation analysis of University and Afyonkarahisar Central Stations for 2017

**Correlations**

| | | CAMPUS | CENTER |
|---|---|---|---|
| CAMPUS | Pearson Correlation | 1 | ,793** |
| | Sig. (2-tailed) | | ,002 |
| | N | 12 | 12 |
| CENTER | Pearson Correlation | ,793** | 1 |
| | Sig. (2-tailed) | ,002 | |
| | N | 12 | 12 |

**. Correlation is significant at the 0.01 level (2-tailed).

Correlation analyses of precipitation of the year 2017 are not included here, since they have the same results. Correlation analysis in precipitation data gives a positive significant relationship between the two stations as in the temperature data. This means that there is a direct proportion between the data of two stations, there is an amount of precipitation that increases and decreases simultaneously, but geomorphological differences and urbanization lead to some differences in detail in these simultaneous increases and decreases.

**Comparative Precipitation Analysis of the University and Afyonkarahisar Central Station for 2016 and 2017**

Precipitation trends between two stations are not similar to the trends of temperature of these two stations. Because the structure of precipitation is chaotic. Many factors play a role over precipitation values.

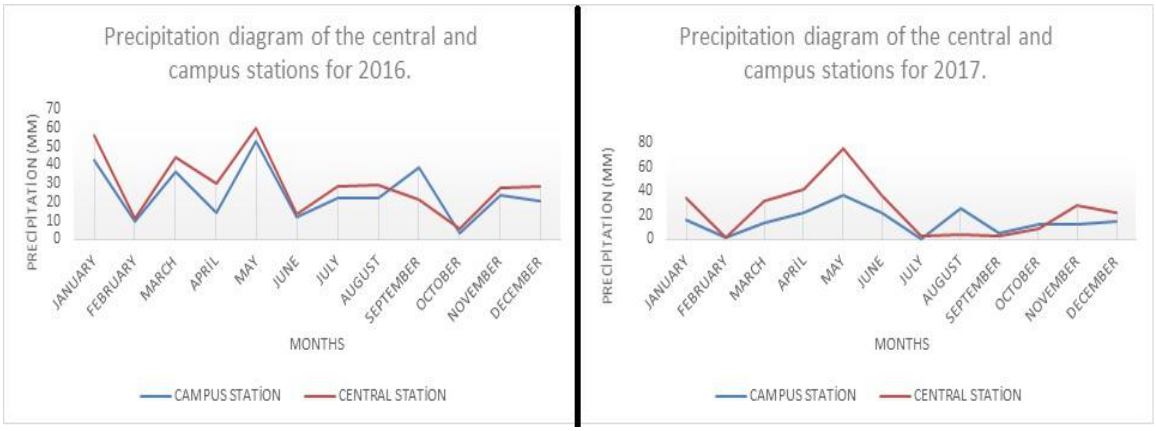


**Figure 3.** Precipitation diagram of the central and campus stations for 2016 and 2017.

Excessive construction in the city and being surrounded by mountains affect the air circulation negatively. This leads to stagnant weather conditions, especially in April, May and June, which leads to an increase in thermal-based convectional precipitation. Especially in May, the precipitation data of the central station is quite high compared to the precipitation data of the university station (Figure: 3). The total amount of precipitation in May 2016 was 60 mm in Afyonkarahisar city center and 52.7 mm on campus. Similarly, in June, when the convectional precipitation was common, the total amount of precipitation was 13.6 mm while it was 12.1 mm on campus. The heat island occurring in the city also affects the evaporation conditions and at the same time the particles coming out of the chimneys of the industrial and residential buildings form a condensation core in the atmosphere. This also increases the amount of precipitation. Similar findings have been found in the studies conducted within the scope of Metropolitan Meteorological Experiment (METROMEX) project Changnon et al. (1978). In the works carried out within the scope of METROMEX project in St.Louis, which is one of the most detailed researches on city climatology, it was found that the city effect showed statistically significant increases in summer rains, heavy rains (> 25 mm), thunderstorm and hail Changnon et al. (1978). Within the scope of this project, it was also determined that the impact of the city on heavy torrential rainfall was mostly seen in June and gradually decreased in July and August Çiçek, İ. (2004). In addition, asphalt and concrete floors prevent water from leaking into the ground. Therefore, especially in summer, high evaporation rates are suitable for unstable rainfall. As a matter of fact, Çiçek (2002), in his study examining the precipitation characteristics of Ankara Meteorological Station between 1926 and 2000, which reflects the effects of urbanization, revealed an increasing tendency in all months and annual rainfall except March, September and December.

**Mann-Kendall Analysis of Some Comparative Meteorological Data of University and Afyonkarahisar Central Station for 2016, 2017 and 2018**

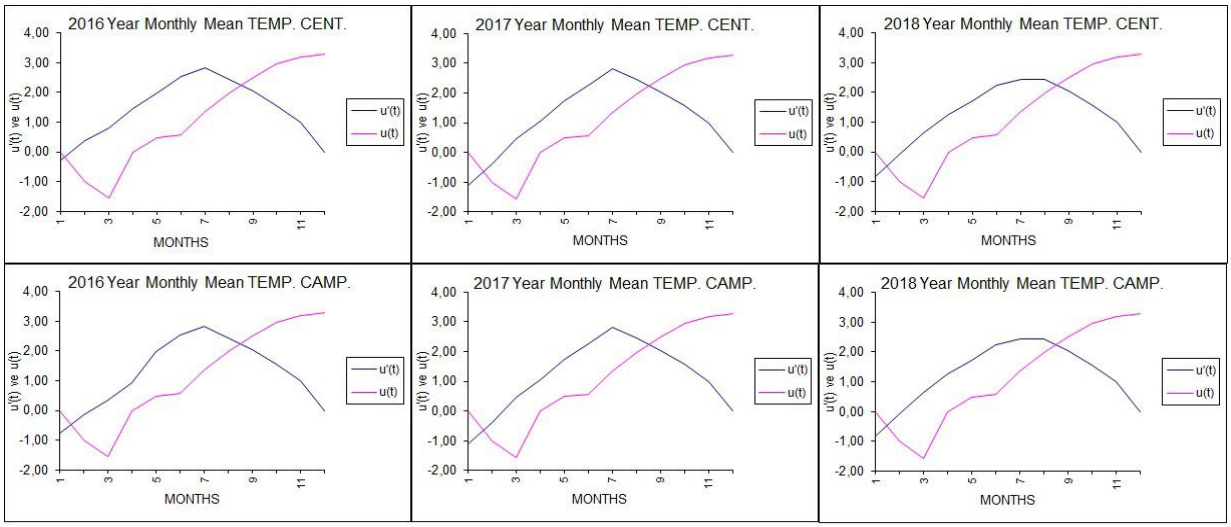


**Figure 4.** Man-Kendall temperature trend of 2016, 2017 and 2018 for the central and campus region

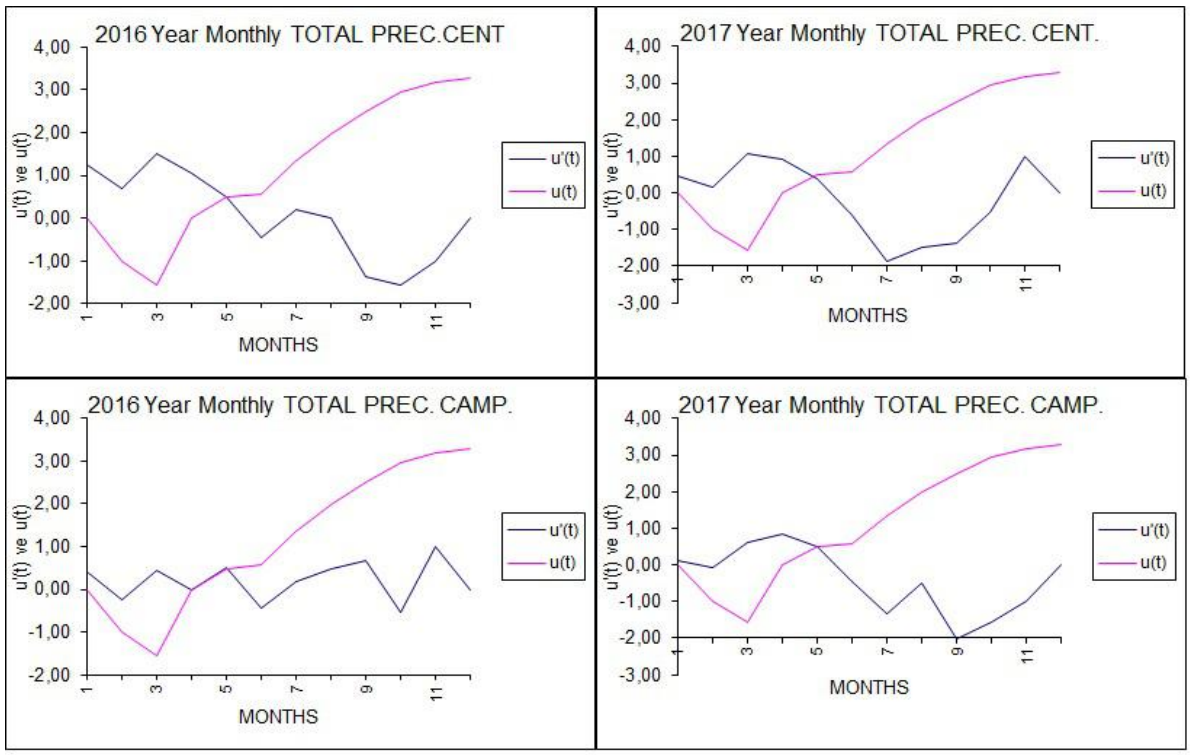


**Figure 5.** Man-Kendall precipitation trend of 2016 and 2017 belonging to central and campus region

Since the meteorological station on campus was opened in July 2015, not having long-term data led to the lack of meaningful results in the Man-Kendall analyses. In addition, in a year 12-month trends were considered and each year was analyzed in itself. Accordingly, the monthly temperature data of the meteorological station in the city center and the meteorological station on campus area were compared with the Mann-Kendall test, as a result more significant and positive tendency was found, but this significance was not found in the precipitation data. The most important reason for this can be shown that the temperature data has a more stable structure compared to precipitation, whereas precipitation has a more variable structure.

## CONCLUSION

In a short distance of 9 km, significant meteorological differences have been identified between the meteorological stations which are in the city center and in the plain and also represent urban and rural areas.

Within the boundaries of the university, it was possible to make comparative analyses of meteorological stations located in the city center and in the university, which was put into service in July 2015.

The average monthly temperatures of the city center in 2015, except in July and August, were higher in September, October, November and December than in the university district. In September, the average temperature was 21.1 ºC at the central station and 20 ºC on campus area. Monthly average temperature was 13.9 ºC at the central station in October and 13 ºC at the university station. The average temperature difference between the two stations increased in November. The average temperature in November was 8.34 ºC and 6.79 ºC on campus.

Temperature data show that Afyonkarahisar city center is an open heat island. In January 2016, the average temperature in January was 2.2 ºC in the center and 0.3 ºC in the university station. The average monthly temperature in July was 23.1 ºC. The measured value on campus area was 21.0 ºC. In January 2017, the average temperature was measured as -5.7 ºC in the center, while it was -6.8ºC on campus. In July 2017, the average temperature was 24.4 ºC in the center and 22.5 ºC on campus.

The average monthly temperature in 2018 gives a striking result. As mentioned above, as the construction of Erenler area gained momentum in 2018, the differences in meteorological parameters between the city center and the campus area were almost closed, especially at the end of this year.

In 2018, the average monthly temperature values were higher in the city center compared to the campus area, but the difference decreased considerably. The most important reason for this is that since the second half of 2017, Erenler residential area was exposed to over-structuring and meteorological parameters showed an obvious similarity with the city center.

The number of rainy days and the amount of precipitation was high in the city center as in the temperature.

When the precipitation data for 2016 and 2017 were analyzed, the amount of precipitation was higher in the city center than on campus except for September. This difference was particularly evident in the months when convectional precipitation was common. In May 2016, the total precipitation in Afyonkarahisar was 60 mm while it fell to 52.7 mm on campus. Similarly, in June where convectional precipitation was common, total precipitation was 13.6 mm while it was 12.1 mm on the campus. While the total annual precipitation in 2016 was 355.6 mm at the central station, the total annual precipitation at the campus station was 297.8 mm. When the total precipitation values of 2017 were considered, the total annual precipitation of the central station was 286.4 mm. The total annual precipitation of the campus station was 182.3 mm. The mountainous area that rises just behind the city has a slight orographic effect and this is reflected as an increase in precipitation values. Especially the air masses coming from the north and northwest leave their moisture more due to the mountainous mass behind the city. According to Mann-Kendall test analyses, there is a positive and significant correlation between temperature and precipitation data.

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