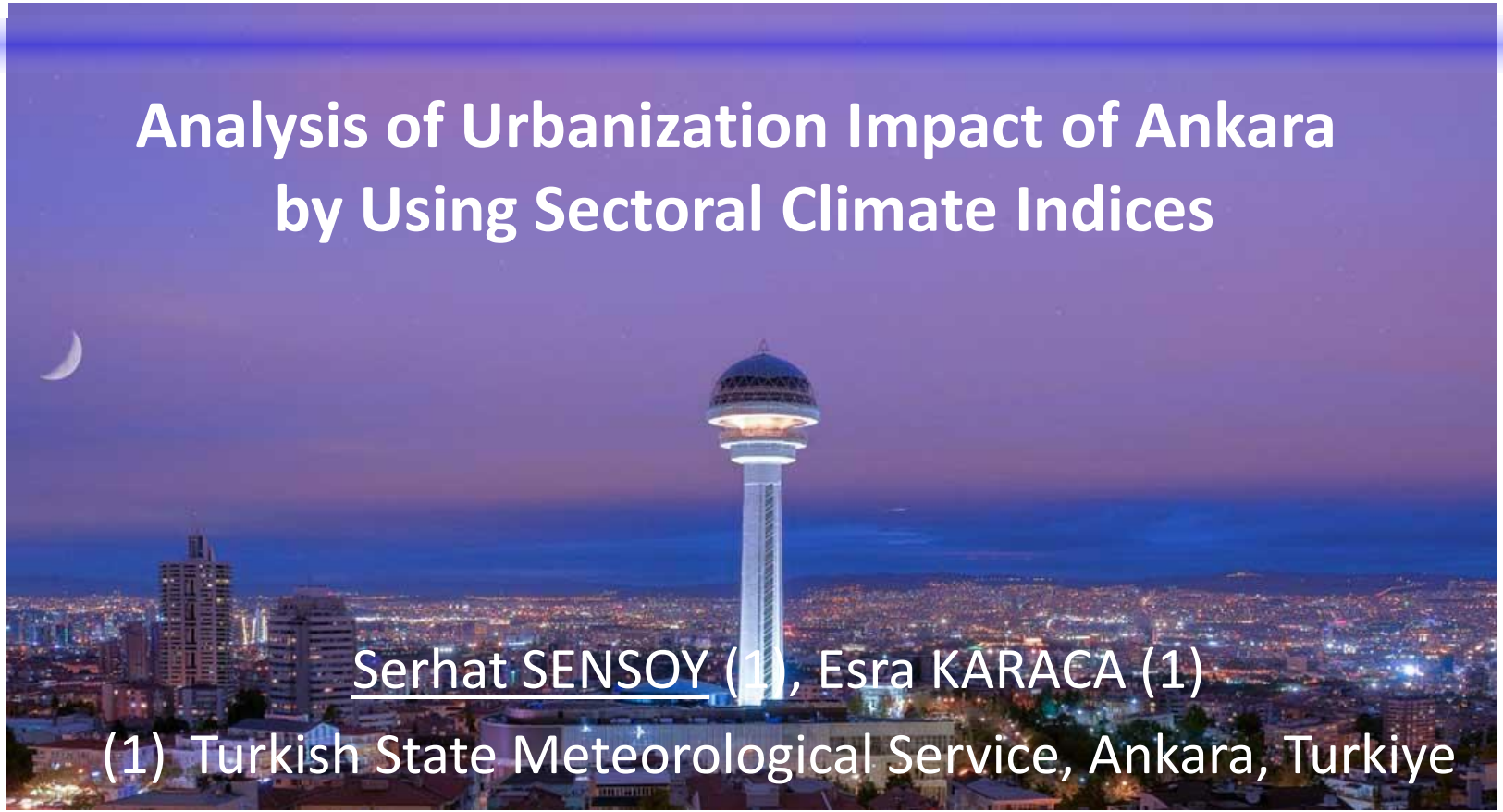
REPUBLIC OF TÜRKİYE
MINISTRY OF ENVIRONMENT, URBANIZATION AND CLIMATE CHANGE
TURKISH STATE METEOROLOGICAL SERVIC

Analysis of Urbanization Impact of Ankara by Using Sectoral Climate Indices



Serhat SENSOY (1), Esra KARACA (1)

(1) Turkish State Meteorological Service, Ankara, Turkiye

ssensoy@mgm.gov.tr ekose@mgm.gov.tr

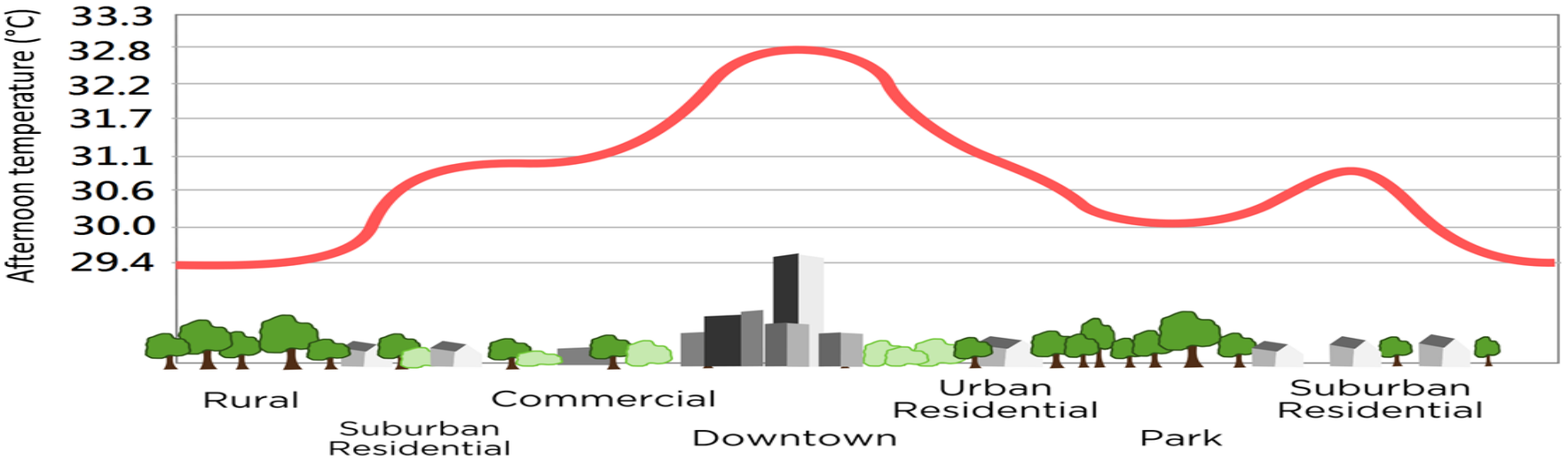
Concept

Understanding the long-term change of extreme temperature events is important to the detection and attribution of climate change. However, it's unclear how much effect coming from the urbanization. Many NMHSs have robust access to data, but extracting meaningful insights from that data, still takes time. **The true value of data lies in being able to see the story within it.**

In this study we selected Ankara climate station which has the city characteristics and Esenboğa station which has rural characteristics. Esenboğa is located 27 km northeast of the city center and It's altitude is 953m

If the population less than 100 thousand it's determined as rural area (Kındap et al., 2012; Hua et al, 2007). Esenboğa is a neighborhood in Çubuk district and has a population of 2,544.

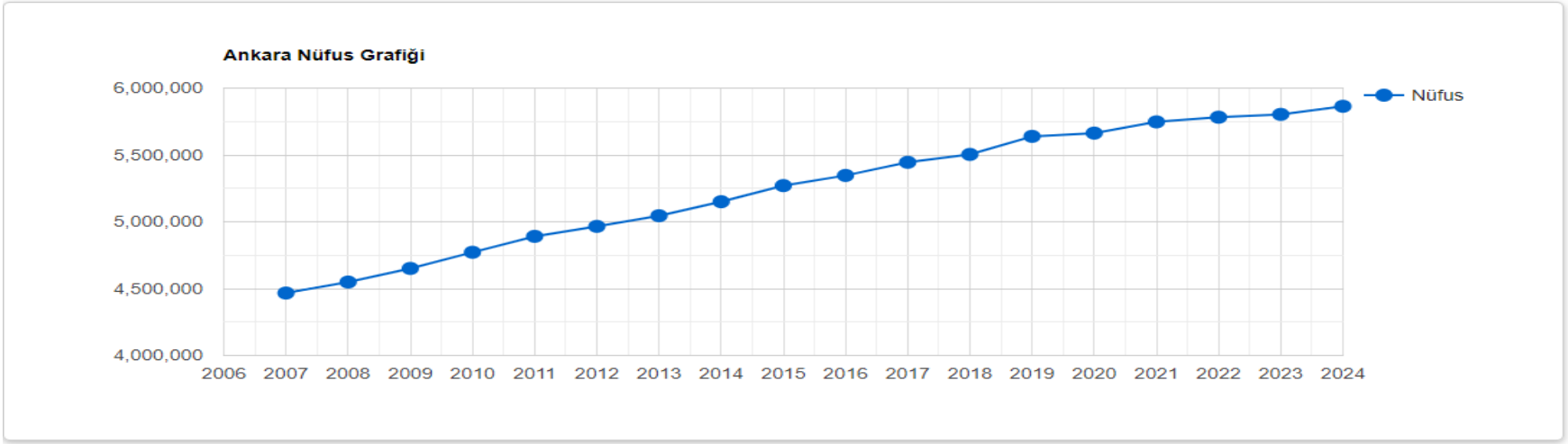
Urbanization - Climate Relationship



Half of the world's population (4.4b) currently lives in cities, and this proportion will rise to 70% by 2050. Cities are responsible for two-thirds of global emissions. Poorly planned cities are more vulnerable to increasing **air pollution, heat waves, floods, storms**, and **SLR**. Different latent heat flux and heating from traffic and other energy uses can raise air temperature in a city by **1 - 3°C**. This phenomenon is known as an "**Urban Heat Island [UHI]** " (Oke, 1982). Large concrete buildings and roads due to their thermal capacity store and emit greater heat than the lighter surfaces and vegetation.

Ankara population

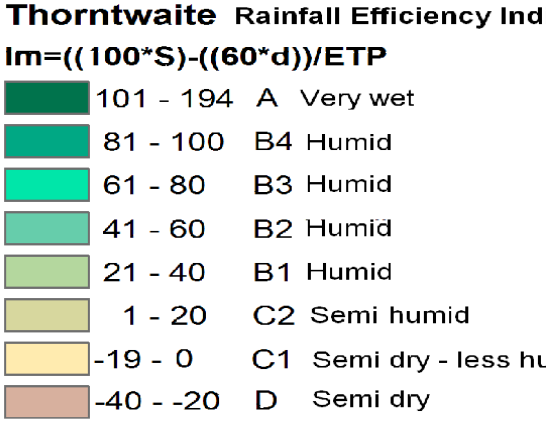
Ankara Nüfus Grafiği



Ankara urban environment under the stress of increased and migrant population, enhanced energy consumption of the growing population, increased traffic load and industrial activity, deforestation and release of waste product into the atmosphere and hydrosphere. Ankara rural population ratio has decreased from 35% to 0 while urbanization ratio increased from 65% to 100% due to metropolitan municipality law.

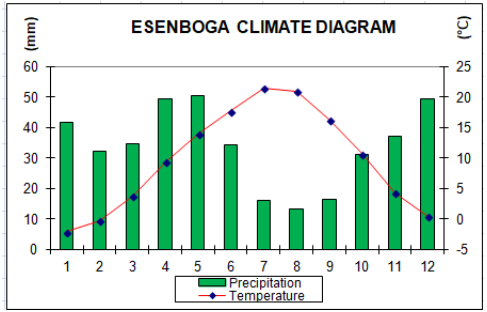
Ankara Climatic Conditions

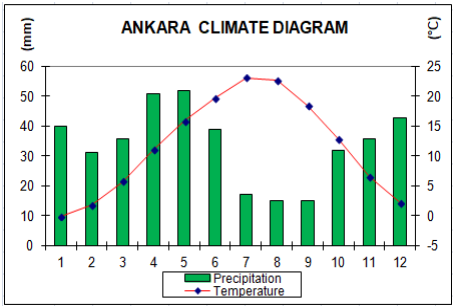
According to Thornthwaite climate classification, Ankara has been found semi dry in southern part, semi dry-less humid in northwestern part and semi humid in northern Nallıhan.



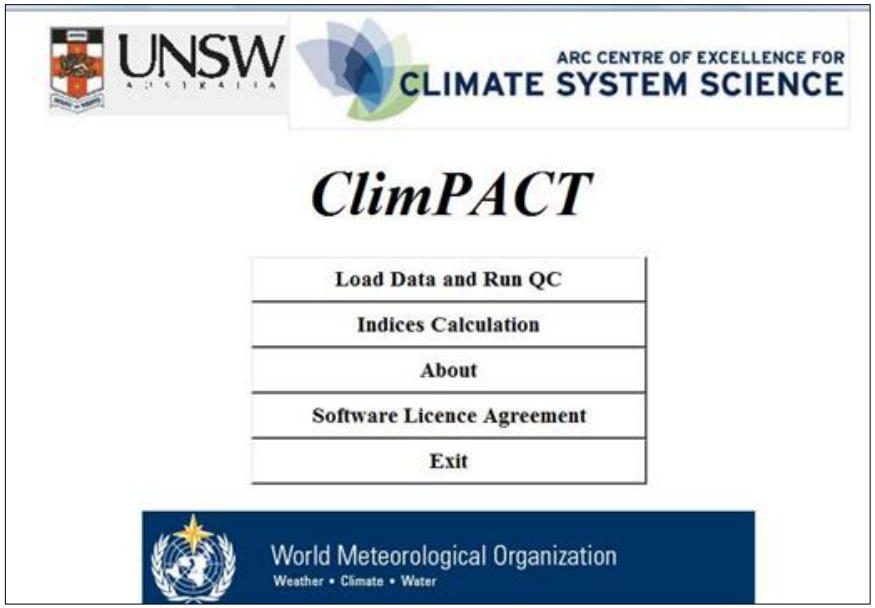
Because of the continental climate condition, there are big differences between day and night temperature and winter - summer temperature. Annual precipitation is 406 and 413 mm and Mean temperature is 10.7°C and 12.6°C respectively.

According to the Trawertha Universal Thermal Scale, winter is cold in Esenboğa while it is cool in Ankara.





Material and Methods



https://github.com/ARCCSS-extremes/climpact2

In this study, we have run **ClimPACT** software to calculate temperature related climate indices for **rural** station **Esenboğa** (33.00E, 40.07N) and **urban** station Kalaba, **Ankara** (32.53E, 39.57N) for the period from 1960 to 2020. We selected the same data period in order to compare station's outputs for the same climatic period. After the data had been **quality controlled** and tested for **homogeneity**, **ClimPACT** calculates and creates **sector specific climate indices**.

Linear trend slope estimator has been used to compute the trends. There are also **locally weighted regression** which shows when the trends changed.

List of temperature related climate indices

ID	Indicator name	Definitions	UNITS
ID0	Ice days	Annual count when TX(daily maximum)<0ºC	Days
FD0	Frost days	Annual count when TN(daily minimum)<0ºC	Days
TN10p	Cool nights	Percentage of days when TN<10th percentile	Days
CSDI2	Cold spell duration indicator	Annual count of days with at least 2 consecutive days when TN<10th percentile	Days
TR20	Tropical nights	Annual count when TN(daily minimum)>20ºC	Days
TN90p	Warm nights	Percentage of days when TN>90th percentile	Days
DTR	Diurnal temp. range	Monthly mean difference between TX and TN	ºC
SU25	Summer days	Annual count when TX(daily maximum)>25ºC	Days

RESULTS

ID0, FD0, TN10p and CSDI2 tend to decrease at both stations, but the decrease in Ankara is greater.

TR20, TN90p tend to increase at both stations, but the increase in Ankara is greater.

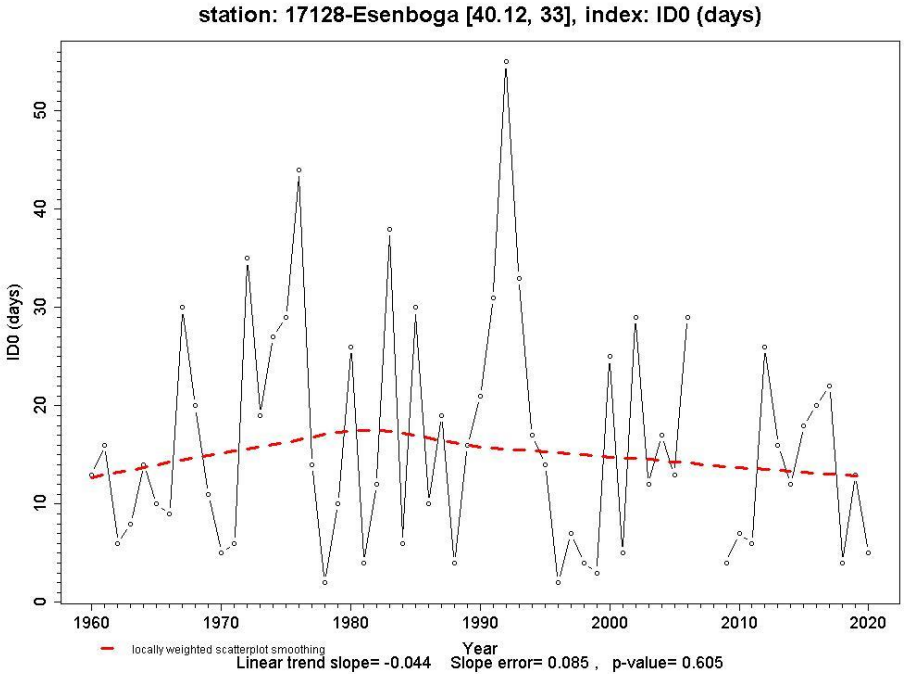
DTR is slightly increasing in Esenboğa while decreasing in Ankara due to urbanization.

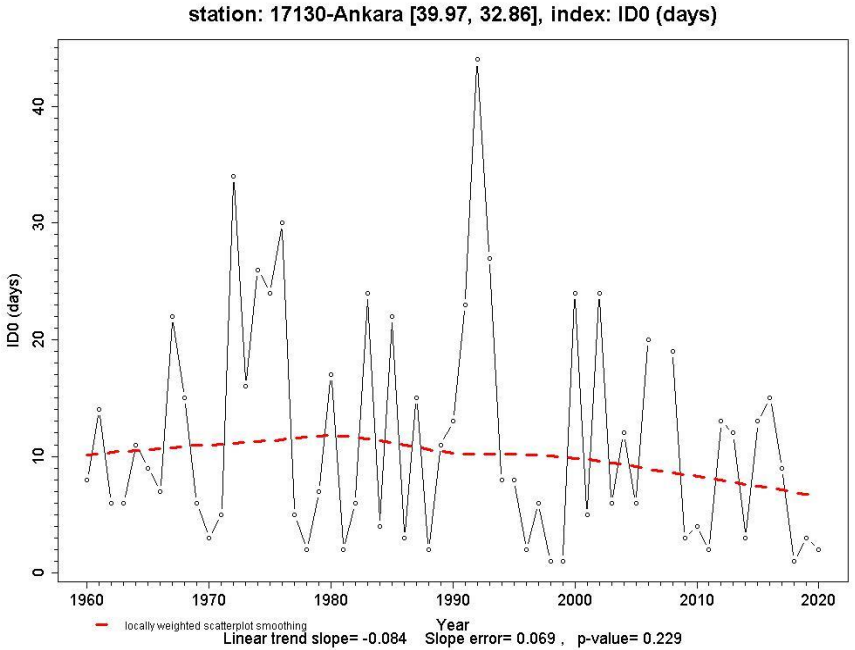
SU25 tend to increase at both stations, but the increase in Esenboğa is greater because sunlight heats the land surface quickly.

			Linear trend slope	
Indice	Start Year	End Year	Esenboğa	Kalaba, Ankara
ID0	1960	2020	-0.044	-0.084
FD0	1960	2020	-0.025	-0.325*
TN10p	1960	2020	-0.096*	-0.169*
CSDI2	1960	2020	-0.272	-0.524*
TR20	1960	2020	0.076*	0.211*
TN90p	1960	2020	0.169*	0.216*
DTR	1960	2020	0.003	-0.009*
SU25	1960	2020	0.535*	0.353*

(*) Trends are significant at 95% level (p value < 0.0.5)

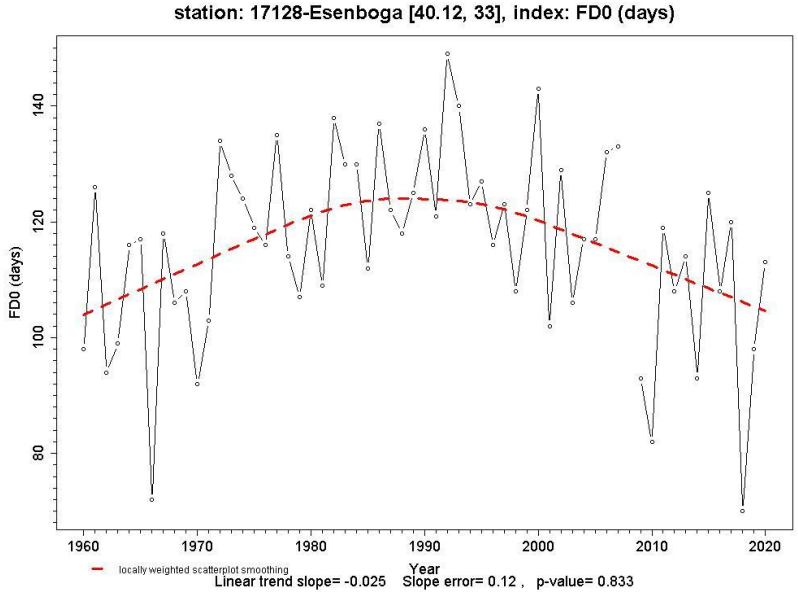
Comparison of Ice Days(ID0) Trends

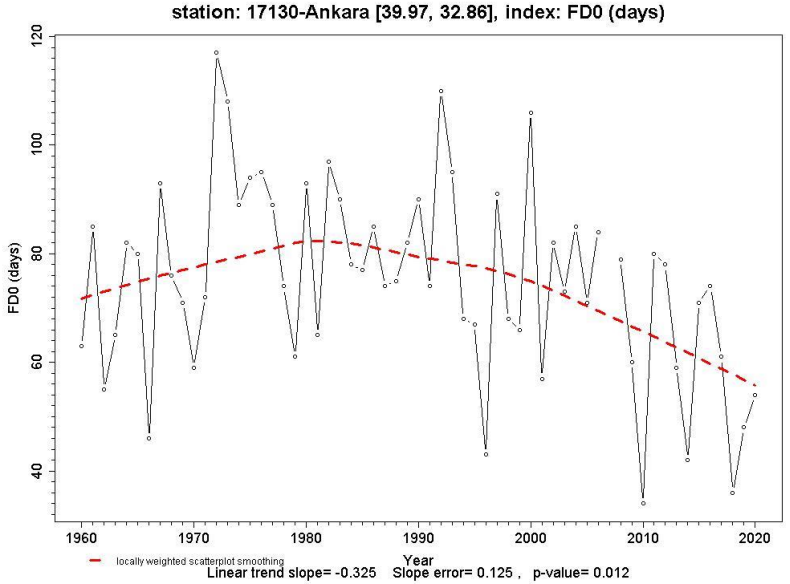




An ice day is Tmax < 0°C and have decreasing trend in Esenboğa and Ankara as 4.4 and 8.4 days/100 years respectively. Due to the global warming trend, the decreasing **trend in ice days in the city center has almost doubled**.

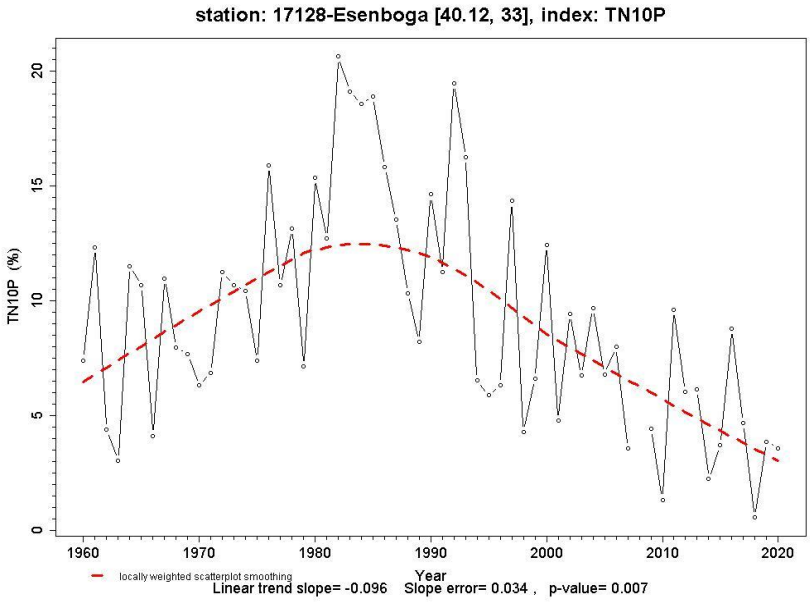
Comparison of Frost Days (FD0) Trends

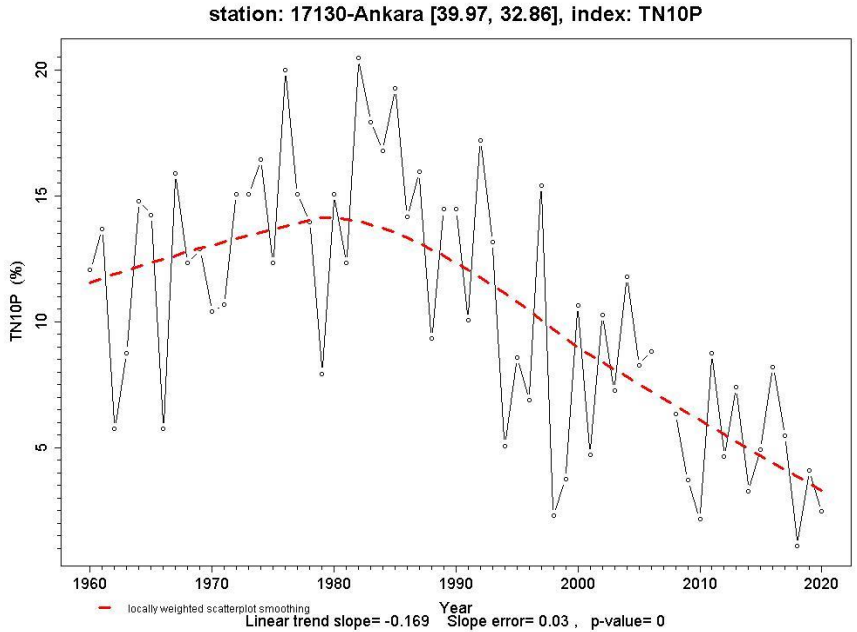




Number of frost days is the day which Tmin < 0°C and have decreasing trend in Esenboğa as 2.5 days/100 years but **sharply decreasing (32.5 days/100 years) in Ankara**. This shows that **UHI** causes less frost day in the city center.

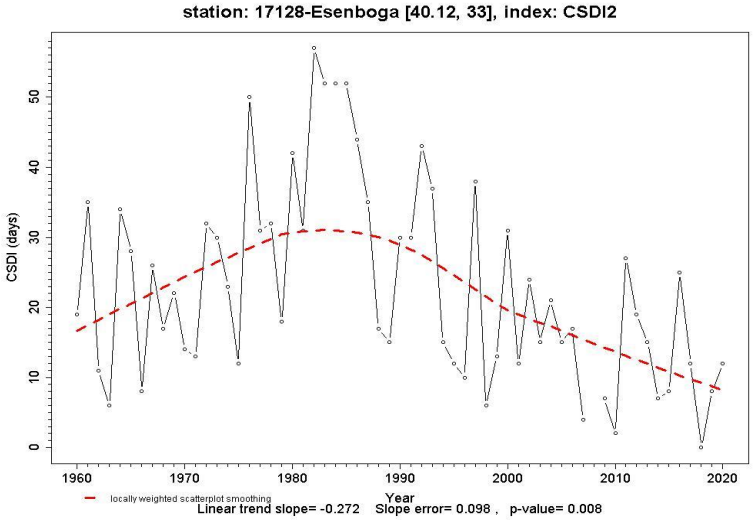
Comparion of Cool Nights (TN10p) Trends

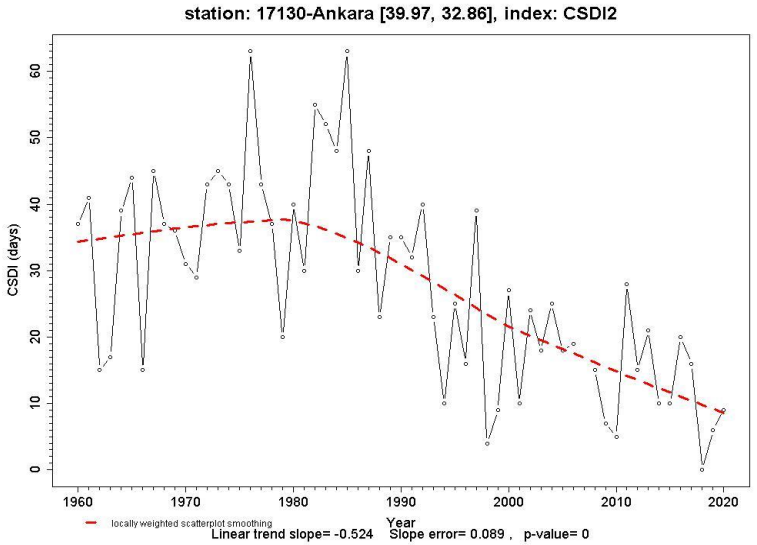




Cool nights (TN10p) is Tmin < 10th percentile and have decreasing trend in Esenboğa and Ankara as 9.6 and 16.9 days/100 years respectively. This shows that the cool night is rapidly decreasing in urban areas than rural due to increased minimum temperature. **Ankara trend is two times stronger** and more significant at 100% level of confidence.

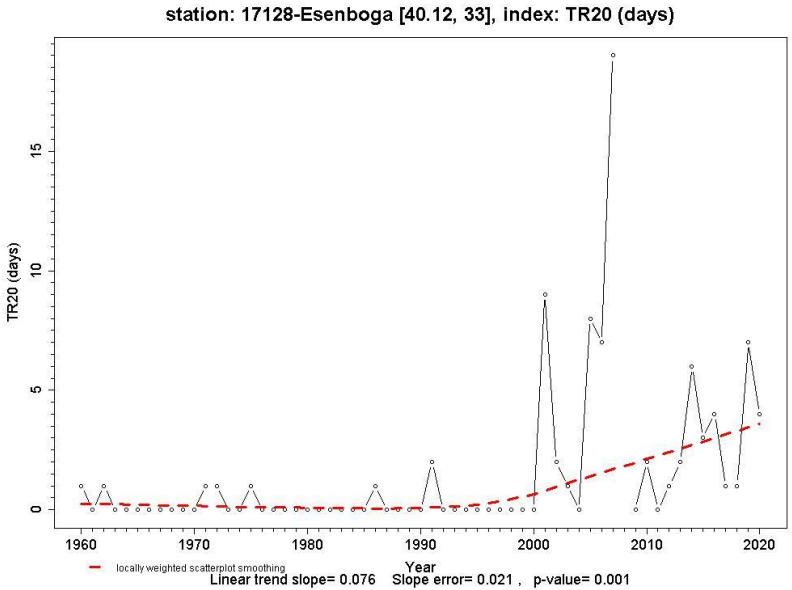
Comparion of Cold Spell Duration Indices(CSDI)Trends

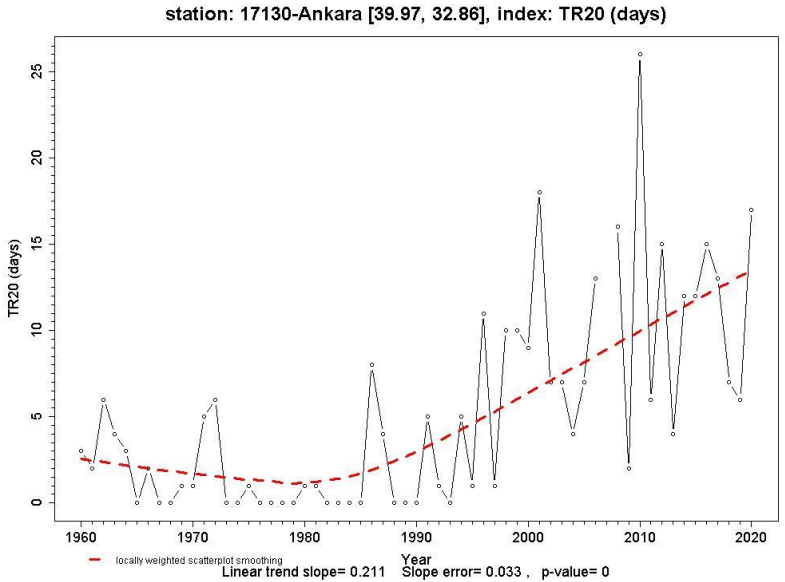




Cold spell duration indicator is annual count of days with at least 2 consecutive days when TN<10th percentile and have decreasing trend in Esenboğa and Ankara as 27.2 and 52.4 days/100 years respectively. This shows that the cold spell is rapidly decreasing in urban areas than rural due to increased minimum temperature. **Ankara trend is two times stronger** and more significant at 100% level of confidence.

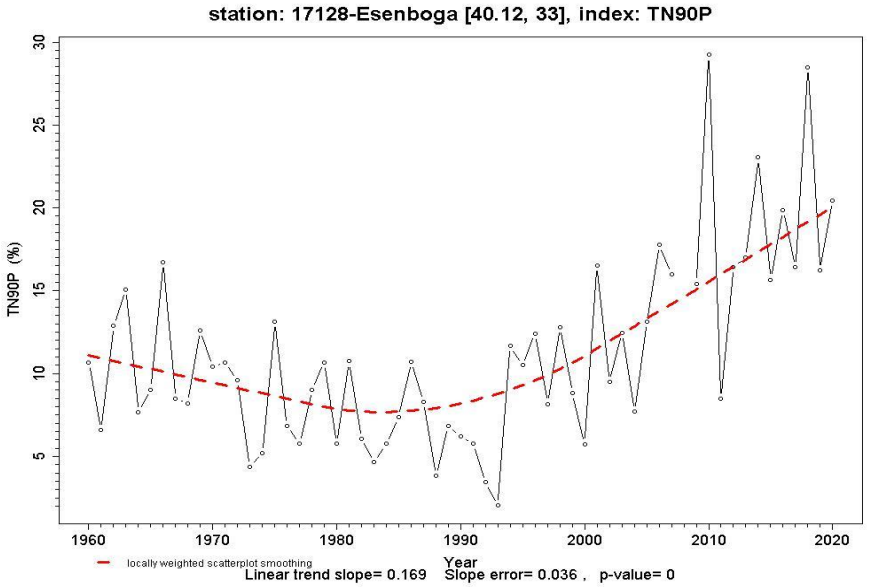
Comparison of Tropical Nights (TR20)Trends

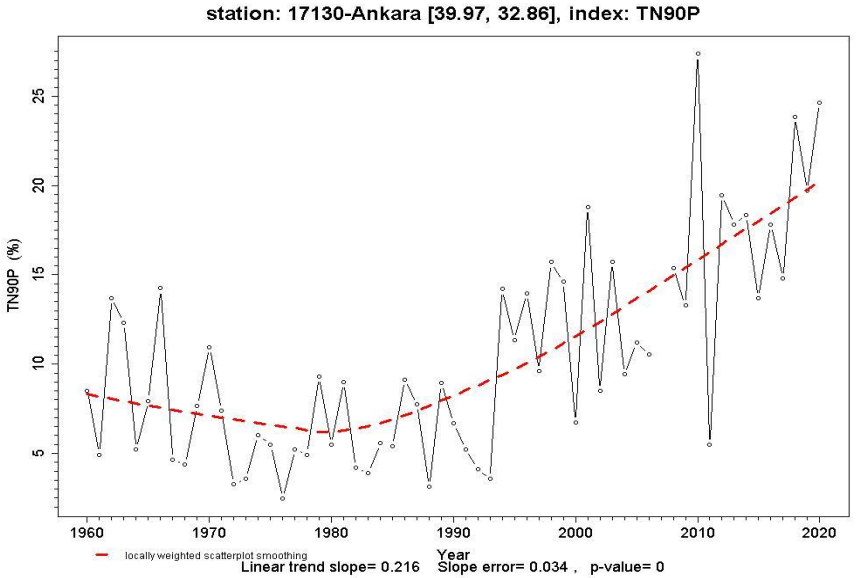




A tropical night is Tmin > 20°C and have increasing trend in Esenboğa and Ankara as 7.6 and 21.1 days/100 years respectively. But **urban trend 3 times stronger than rural**. This shows that the urban cause a clear increase over the minimum temperature due to heated surface release temperature more slowly than rural in the night. Both trends are statistically significant at 99.9% and 100% respectively.

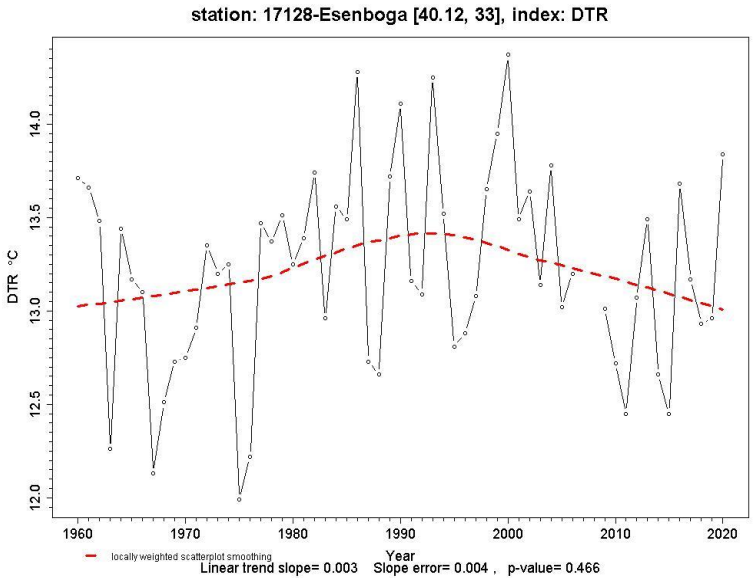
Comparion of Warm Nights (TN90p) Trends

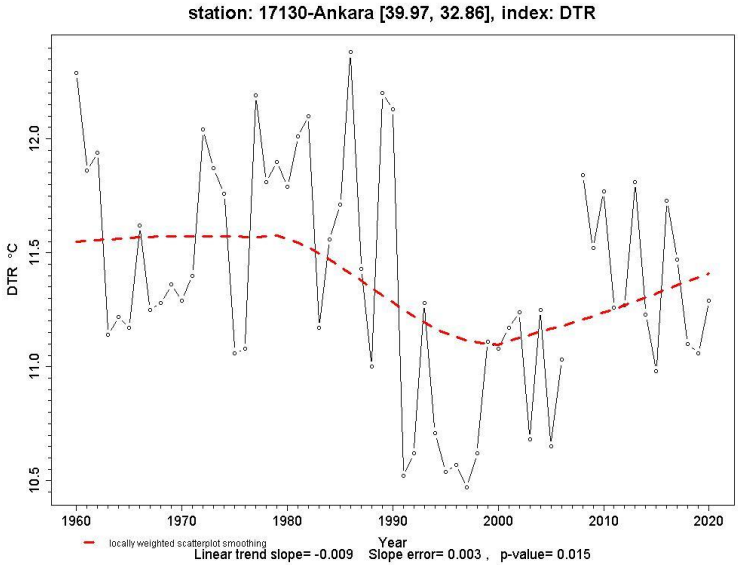




Warm nights (TN90p) is Tmin > 90th percentile and has increasing trend both in Esenboğa and Ankara as 16.9 and 21.6 days/100 years respectively. This shows that the **warm night is rapidly increasing in urban areas than rural** due to increased minimum temperature. Both trends are statistically significant at 100% level.

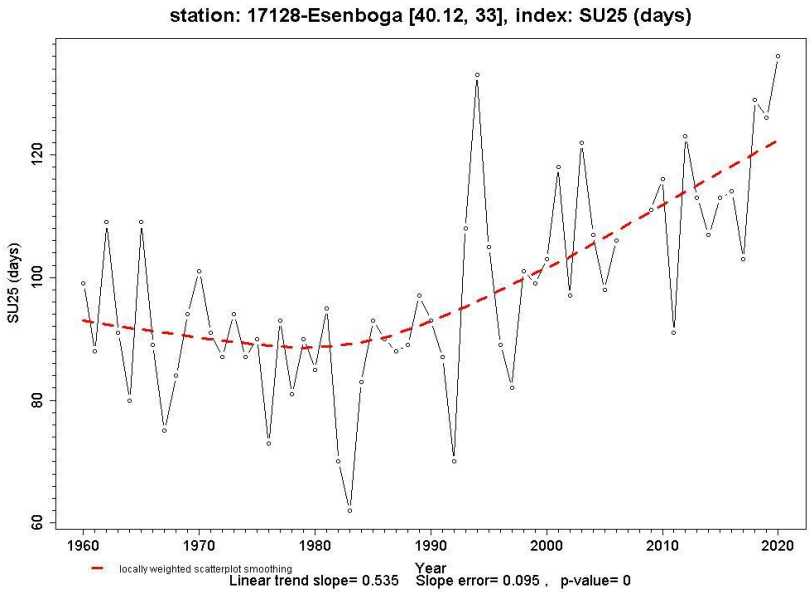
Comparion of Diurnal Temp. Range (DTR) Trends

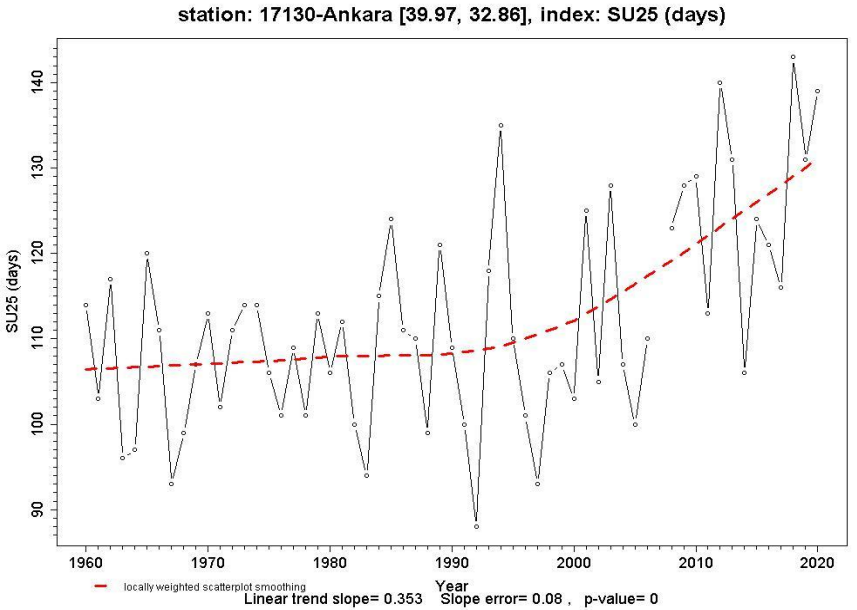




Diurnal temperature ranges (DTR) is Tmax - Tmin. and have slightly increasing trend in Esenboğa but decreasing trend the city. This shows that Ankara **city center causes a clear increase over the minimum temperature** and this causes decreasing trend in DTR. Ankara trend is statistically significant at 98.5% level of confidence.

Comparion of Summer Days (SU25) Trends





A summer days is Tmax > 25°C and have increasing trend in Esenboğa and Ankara as 53.5 and 35.3 days/100 years respectively. **Summer day trend is higher in rural areas because sunlight heats the land surface quickly.** In cities, asphalt and concrete take time to heat up and cool down at night. This increases minimum temperatures in the city center. Both trends are statistically significant at 100% level.

Conclusions 1/2

In this study urbanization effects on trends of extreme temperature indices in Ankara have been evaluated. With a **population** approaching **6 million**, Ankara is the rapidly growing city in Türkiye and became a **2nd mega city** after the Istanbul. Esenboğa is located 27 km north of the city center and It's altitude (953m) is approximately 100m higher than Ankara. The most decisive climate indices which show urbanization effects, have been found **ID0, FD0, TN10p** and **CSDI** which they have a **decreasing** trends in Esenboğa and Ankara. But **Ankara trend is almost double**.

Other indices like **TR20** and **TN90p** have **increasing** trends in both rural and urban areas. Urban areas trends are stronger than rural due to increased minimum temperature.

DTR has been slightly increasing in Esenboğa while decreasing in Ankara due to minimum temperature more increased in the city center.

Summer Days (**SU25**) have increasing trends both in Esenboğa and Ankara as 53.5 and 35.3 days/100 years respectively. **Summer day trend is higher in rural areas because sunlight heats the land surface quickly**.

Conclusions 2/2

In cities, asphalt and concrete take time to heat up and cool down at night. This increases minimum temperatures in the city center and is known as **UHI**. The results show that the most obvious effect of urbanization on climate is on minimum temperature. Most of these trends found **statistically significant** at more than 95% level.

These results show that there is **stronger urbanization effect in Ankara** due to increasing population, decreasing green areas, increasing concrete and asphalt surfaces, low albedo values, different latent heat flux and heating from traffic and other energy uses. Its geomorphology and accordingly development of **inversion effect** (especially in winter) causes additional **air pollution.** According to results, **there is clear urbanization effect on trends** of **minimum** temperature indices in Ankara. Most of these trends found statistically **significant at 95% level**.

Sector-specific climate indices provide **scientific information** to **decision-makers** in many sectors, such as urbanism, agriculture, water resources, health, DRR, and energy.

Thanks for your attention…