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SOLAR RADIATION VARIABILITY AND THE OBSERVED TREND IN TEMPERATURE IN CLUJ-NAPOCA FROM 2004 TO 2007

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Abstract
Variations in solar activity, at least as observed in numbers of sunspots, have been apparent since ancient times but to what extent solar variability may affect global climate has been far more controversial. The subject had been in and out of fashion, with connections between the Sun and climate intermittently proposed and dismissed, for at least two centuries until the early 1990s when a number of factors combined to again bring it to the forefront of scientific research. The main driving force was the international push to understand, and attribute causes to, apparent global warming. The need to distinguish between natural and anthropogenic causes of climate change led meteorologists, even those skeptical of solar-climate links, to accept that an objective analysis of the Sun's role was required. This study supposed to be an analysis of correlation between solar variations and temperature in Cluj-Napoca. Period of the observed trend in temperature in Cluj-Napoca was recorded between October 2004 and October 2007.
Keywords: *solar variability, the Sun, sunspots, observed trend in temperature.*

1. Introduction

Variations in solar activity, at least as observed in numbers of sunspots, have been apparent since ancient times but to what extent solar variability may affect global climate has been far more controversial. The need to distinguish between natural and anthropogenic causes of climate change led meteorologists, even those skeptical of solar-climate links, to accept that an objective analysis of the Sun's role was required.

Some studies (e.g. Friis-Christensen and Lassen, 1991; Reid, 1991) appeared to show an astonishingly strong influence by the Sun on surface temperatures [1; 2], although theoretical estimates (e.g. Schlesinger and Ramankutty, 1992; Kelly and Wigley, 1992) suggested that the magnitude of the variations in TSI were too small to produce such an effect [3; 4].

The objective of the present work is to investigate the annual temperature trends over Cluj-Napoca (Romania) from 2004 to 2007 It is also of interest to find out whether the overall change in temperature is due to change in minimum or maximum temperature. This will help to know changes in annual temperatures. Therefore, annually maximum, minimum and mean temperature observations are used in the present statistical analysis. Our result suggests that similarly to the global and continental trends, regional temperatures of Cluj-Napoca area

(Transylvanian Basin) have become warmer during the last years.

Cluj-Napoca, belonging to Cluj County of Romania, is located in the north-west of Transylvania, in a region surrounded by hills, more exactly in the valley of the Someşul Mic River. The climate of the city is on the whole acceptable; warm summers alternate with cold winters, and the rainfall is not great. The temperature characteristics of Cluj-Napoca city are reported in Table 1, which indicates higher variability during spring and winter season than during summer and autumn season. The mean monthly temperature is generally high (23.35°C in 2007) in July while January is low (-6.1°C, 2006). The maximum temperature during the summer is more than 32 degrees Celsius (for July is 37.8°C, in 2007), and the minimum temperature during the winter is less than -19°C (during January and February is more than 19 degrees Celsius below zero).

Table 1
Maximum, minimum, and mean monthly and annual temperatures from 2004 to 2007

	Year 2004			**Year 2005**			**Year 2006**			**Year 2007**		
Month	T_{max} (°C)	T_{min} (°C)	T_{mean} (°C)	T_{max} (°C)	T_{min} (°C)	T_{mean} (°C)	T_{max} (°C)	T_{min} (°C)	T_{mean} (°C)	T_{max} (°C)	T_{min} (°C)	T_{mean} (°C)
January	8.3	-15.5	-3.6	7.8	-16.1	-4.15	6.7	-18.9	-6.1	12.2	-7.8	2.2
February	15.5	-17.8	-1.15	7.8	-19.5	-5.85	10	-17.2	-3.6	13.3	-5.6	3.85
March	21.1	-12.2	4.45	18.9	-17.8	0.55	19.5	-12.2	3.65	18.9	-3.9	7.5
April	23.3	-0.6	11.35	21.7	-2.8	9.45	23.3	-0.6	11.35	22.2	-1.1	10.55
May	26.1	1.1	13.6	30.6	1.1	15.85	31.7	2.2	16.95	30	-2.2	13.9
June	28.9	8.3	18.6	28.3	3.9	16.1	30.5	5	17.75	33.9	9.4	21.65
July	33.9	9.5	21.7	33.3	10	21.65	32.2	8.9	20.55	37.8	8.9	23.35
August	30.6	8.9	19.75	32.2	7.2	19.7	31.7	6.7	19.2	36.1	8.9	22.5
September	27.2	1.1	14.15	26.7	5.6	16.15	25.6	4.4	15	27.2	3.3	15.25
October	21.1	0	10.55	22.2	-4.5	8.85	27.2	-6.7	10.25	22.8	-2.2	10.3
November	20.5	-6.7	6.9	14.5	-10.6	1.95	13.3	-5	4.15	12.2	-9.4	1.4
December	14.5	-11.1	1.7	12.2	-12.2	0	9.4	-10.5	-0.55	11.1	-10.5	0.3
Annual	**22.6**	**-2.92**	**9.83**	**21.35**	**-4.64**	**8.35**	**21.75**	**-3.65**	**9.05**	**23.14**	**-1.01**	**11.06**
Season	T_{max} (°C)	T_{min} (°C)	T_{mean} (°C)	T_{max} (°C)	T_{min} (°C)	T_{mean} (°C)	T_{max} (°C)	T_{min} (°C)	T_{mean} (°C)	T_{max} (°C)	T_{min} (°C)	T_{mean} (°C)
Spring	23.5	-3.9	9.8	23.73	-6.5	8.61	24.83	-3.53	10.65	23.7	-2.4	10.65
Summer	31.13	8.9	20.01	31.26	7.03	19.15	31.46	6.86	19.16	35.93	9.06	22.5
Autumn	22.93	-1.86	10.53	21.13	-3.16	8.98	22.03	-2.43	9.8	20.73	-2.76	8.98
Winter	12.76	-14.8	-1.01	9.26	-15.93	-3.33	8.7	-15.53	-3.41	12.2	-7.96	2.11

2. Method and samples

Monthly maximum and minimum temperature data were obtained by observations during the period 2004–2007. You can find these data online for Cluj-Napoca Location at www.wunderground.com or www.vremea.com or you can find them out at Cluj-Napoca Meteorological Department but the data from there are just a little different from previous ones.

From the basic temperature data, T_{max}, T_{min} and T_{mean}, have been computed for each month and four seasons (spring, summer, autumn and winter), that are depicted in Table 1. December, January and February are considered for the analysis of winter temperature as these 3 months record lowest temperatures (Table 1). June, July and August are months with highest maximum temperatures and, therefore, represent the summer season. March to May months constitute spring season, and September to November months represent autumn season. Solar variations induce some temporal changes in the annual and seasonal values, but not so significant like the difference between the highest maximum temperature from July, 2007, and July, 2006. The lowest minimum temperature for this study was recorded on February, 2005 (-20°C).

3. Results and Discussions

The trend of the annual maximum, minimum, and mean temperature, T_{max}, T_{min}, and T_{mean} is presented in Fig. 1, and it shows an easy decreasing and then an increasing trend on short-term. It can be also seen in annual T_{max}, T_{min}, and T_{mean} an alternation with slight differences in relative dominance of warm and cool periods.

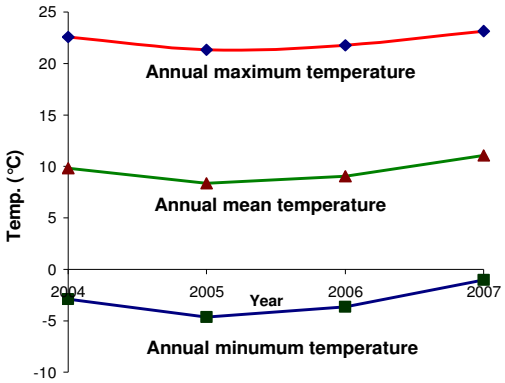
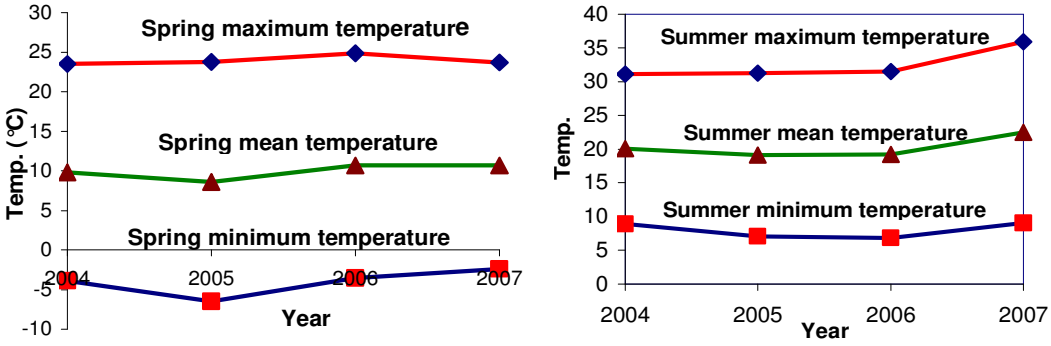


Fig. 1. Annual temperature trends (2004-2007) at Cluj-Napoca

The mean temperature (T_{mean}), T_{max} and T_{min} for spring, summer, autumn, and winter during the period 2004–2007 are presented in Fig. 2.



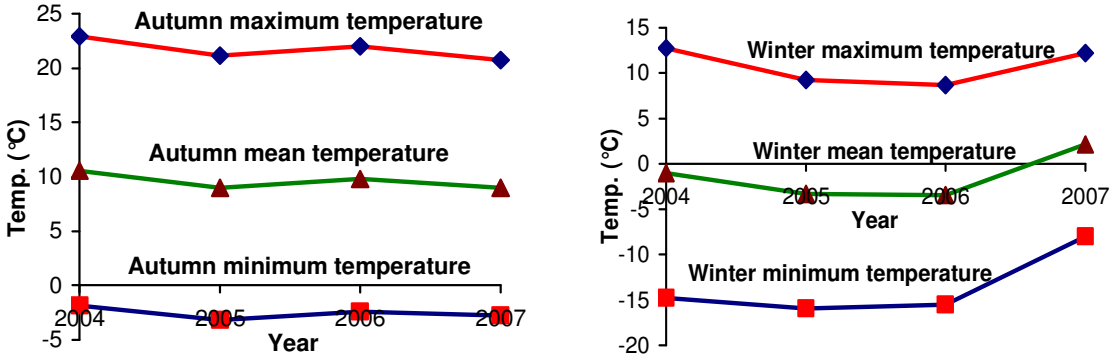


Fig. 2. Temperature trends for spring, summer, autumn and winter at Cluj-Napoca

4. Conclusions

An important aspect of the present study is the significant warming trend in mean annual temperature, which is more predominant during summer season. The summer season also shows significant warming trend due to increase in T_{max} and T_{min}. The other seasons (spring, autumn, and winter) show a lightly down and rise in temperature. The observed warming trend for the city, therefore, may be attributed to phenomenal increase in urbanization during the last years and solar variability.

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