Investigating the Effect of Sunspots on the Temperature of Kerman and Shiraz Stations during the Last Half Century Using Wavelet Analysis

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1. Introduction

In recent years, regarding climate changes, the analysis of natural variability of climate at different time scales has attracted a lot of attention. While, the data series with short statistical period just shows a likelihood estimation of a few decades of climate variability, the data series with long period shows the fluctuations of several decades with statistical importance from climate variability with heterogeneous spatial pattern. Multiple activities occur in the sun surface such as flares, explosions, and solar wind, which result in increasing the plasma displacement and increasing radiation intensity subsequently. Oscillations and climate changes associated with these activities play a major role in the living conditions and life on the earth. The changes of output energy from the sun or its temperature oscillations can cause the changes and oscillations on the earth atmosphere. Sunspots, as an activity of the sun, is a phenomenon that in recent decades has attracted the attention of climatologists and is known as one of the options that can affect the planet's climate in different time scales and leads to the oscillations and changes in climate at last. The concept of wavelet in today's theory was proposed by Johnson Morlet, the French geophysicist. In this method, the problem of dividing the signal into different sections is solved using scaling and transferring a function. This function is transmitted during the data series and for each position the whole data series is calculated. It is repeated for functions with different scales. Studies performed in and out of the country indicated the significant effect of the sunspots on atmospheric parameters. These studies showed that by increasing the sunspots, the amount of rainfall and temperature will be increased as well and vice versa; i.e. by reducing the sunspots the amount of these parameters will also be reduced. However, wavelet theory is a topic in pure mathematics but what is discussed here, is its practical aspect. The main objective of this study is to determine the effect of sunspots on temperature changes occuring in Kerman and Shiraz stations using wavelet theory. The reason of using wavelet theory in this study is that wavelet transform needs a lower volume of calculation than Fourier transform.

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2. Material and Methods

In this research, Shiraz and Kerman stations located in the southern foothills of the Zagros were use. The reason for using these stations is their temperature oscillation over the last few years, and also estimating the effect of sunspots on the temperature of the two stations through wavelet analysis. We examined the effect of sunspots on temperature changes in this study. Because of the need for the long-term data to do this, just the two stations of Shiraz and Kerman were studied. The data related to the sunspots were provided from the American Geophysical Union for a statistical period of 60 years (1950 to 2010), and the temperature data for the two mentioned stations were provided for a statistical period of 60 years (1950 to 2010). To do this study, the researcher benefited from statistical analysis and wavelet analysis using MATLAB software. Sunspots are the most important indicator of variability of the solar radiation; so that in the majority of studies the relative number of sunspots is mainly used for analyzing the sunspot changes. In the present study, the annual, seasonal, and monthly averages of the sunspots during the statistical period of 60 years (1950 to 2010) were used. The data related to the spots were provided from the American Geophysical Union. Annual, seasonal, and monthly data related to the temperature parameter for the statistical period of 60 years (1950 to 2010) were provided from Fars and Kerman Meteorological Bureaus, and for examining the relationship between temperature and sunspots wavelet analysis and statistical analysis were used. MATLAB software was used for programming. Then wavelet of Morlet was chosen as the mother wavelet.

3. Discussion

Based on the wavelet analysis, it was obvious that during all months of the year sunspots activity left behind an 11-year-old cycle. Of course, in different months, extremes of activities and fluctuations period are different. Observing plotted wavelets for different months of the year, we can see during the statistical period of 60 years there are 4 cycles in the sunspot activity that the intensity of activity differs in each of the cycles, so that as seen in most months the first and fourth cycles have the least activity. Of course, there are also expectations such as December in which regular fluctuation is seen in different cycles. In terms of duration, the longest cycle of sunspot activity is the first cycle that lasts for 12 years. However, in the third cycle, which the intensity of the sunspot activity reaches a peak, the sunspot activity lasts for 10-years. Between the sunspots and the average temperature of Shiraz there is an inverse relationship in most months of the year and this relationship is significant only in February. These results show that the relationship between temperature and sunspots is mostly significant in South East and East of the country. With an increase in sunspots, the temperature of the mentioned months decreases. And there is not a significant relationship between the temperature of Shiraz and sunspots in most months of the year during the seasonal and annual time periods other than fall. In the other time periods the relationship between temperature and sunspots is inverse and this relationship is also significant in winter. It means that with increasing the sunspots activity the temperature of Shiraz station will be decreased and vice versa. The results gained from Kerman and

Shiraz can be compared, so that in Kerman station during December, January, and April a direct relationship is observed between the raising of temperature and sunspots activity.

4. Conclusion

Sunspots are the most important indicator of variability of the solar radiation; so that in the majority of studies the relative number of sunspots is mainly used for analyzing the sunspot changes. In the present study, annual, seasonal, and monthly averages of the sunspots during the statistical period of 60 years (1950 to 2010) derived from the American Geophysical Union was used and annual, seasonal, and monthly data related to the temperature parameter for the statistical period of 60 years (1950 to 2010) provided from Fars and Kerman Meteorological Bureaus. In order to examine the data, wavelet analysis and statistical analysis were used. Monthly, seasonal, and annual correlations of temperature with sunspots in Kerman and Shiraz stations indicates that in most months and in the studied timescales there is not a significant correlation between temperature and sunspot activity, and coefficients gained from Pearson's analysis were mostly negative and reflect an inverse relationship between the two variables. Means, with increasing the sun activity temperature will be decreased. Only in February a significant and inverse relationship is visible between the two parameters. Observing plotted wavelets for different months of the year, we can see during the statistical period of 60 years there are 4 cycles in the sunspot activity that the intensity of activity differs in each of the cycles. Most cycles observed in different months of the year are 5 and 7 years, and it is in March and June that the scope of the cycle reaches to 15 years, and in February which a significant inverse relationship is observed with sunspots activity including the maximum cycle with a 20-year period.

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