Available online at www.worldscientificnews.com

World Scientific News

An International Scientific Journal

WSN 132 (2019) 1-15 EISSN 2392-2192

Analysis of Regional Global Climate Changes due to Human Influences

Igor G. Zurbenko[1], Amy L. Potrzeba-Macrina[2,*]

[1]University at Albany, Department of Epidemiology & Biostatistics,
1 University Place, Rensselaer, NY 12144, USA

[2]Syracuse University, Department of Mathematics,
215 Carnegie Building, Syracuse, NY 13244, USA

*E-mail address: amacrina@syr.edu

ABSTRACT

In recent years global climate change has been the focus of much scientific research as well as a focal point in the media. A recent period of significant increases in global temperatures has caused much concern. This period was followed by a relative slowdown, which in turn has created confusion. There are two major reasons for global temperatures variations, one of which is oscillations of total solar activity in time. Another reason is atmospheric pollutants causing greenhouse effects. Obviously, solar activities cannot be controlled, but relevant pollutants can. Since these two reasons are independent components of global temperature variations, they must be separated in order to adequately study global climate changes. Solar irradiation transferred to Earth is proportional to sunspot numbers, which have been recorded for centuries. The purpose of this paper is to separate this solar component from long-term temperature data, thus leaving for examination the component created by human activities. This separation of components and examination thereof can be performed at numerous locations over Earth, that is, the time component and rates of its increases can be mapped over the globe. This paper smooths these images to display the different rates of temperature increases over different global regions, which allows for a comparison of different regional efforts to fight climate changes. In some regions, negative rates were occurring as of recent years, but other regions those rates are becoming alarmingly high. The average rate of temperature increase due to human influence over the planet is remaining positive. The regional comparisons offer a great opportunity for assessing different methods of control of global climate changes.

***Keywords*:** separation of scales, Kolmogorov-Zurbenko time and space filtration, total solar irradiation

(Received 17 June 2019; Accepted 05 July 2019; Date of Publication 06 July 2019)

1. INTRODUCTION

The Sun is the main energy source on Earth and therefore Earth's climate depends on solar energy supplies. Fluctuations in solar activities may cause essential differences in Earth's climate. Zurbenko and Potrzeba-Macrina (2019) and Potrzeba-Macrina and Zurbenko (2019) prove that delivery of that solar energy to Earth is proportional to sunspots numbers. The Sun's creation was in large part due to gravity, which continues to be fundamental to the Sun's functioning. The planets in the solar system also have gravitational forces that are contributing factors to the periodic component of the Sun's activity expressed by sunspot numbers. This periodic component has been recorded for years, dating back to 28 BC, through the observations of sunspot numbers (Hathaway 2015; Stephenson and Clark 1978). Spectral analysis of the accurate observations of sunspot numbers, which have been recorded since the mid-1700s, can be used to determine precise inherent periodicities of solar activity up to approximately 100 years. There are two main periodicities in sunspot numbers (figure 1). One period is composed of three spectral lines around 9-11 years and another is a period of approximately 90 years. Longer periodic components within sunspot numbers may exist, but there is not enough data to attain an accurate determination thereof. These periodic components are clearly visible in the raw sunspot number data (Figure 1). Potrzeba-Macrina and Zurbenko (2019) provide recommendations for the calculation of long-term solar periodicities based on the astronomically precise periods within the total planetary solar system.

Oscillations in temperature are perfectly aligned with some delay to those oscillations in solar energy fluctuations. The delay is due to atmospheric processes. While there has been a great deal of current research pertaining to the visual impact of solar influences to Earth's climate such as Grey et al. (2010), Kossobokov et al. (2010), Soon and Legates (2013), Trenberth (2014), Sun et al. (2016), and Tiwari et al. (2016), the research did not separate the different scaled components; such a separation is necessary in order to prevent making erroneous conclusions and to distinguish between the effects of the differing variables (Zurbenko and Sowizral 1999; Tsakiri and Zurbenko 2010). Using the Kolmogorov-Zurbenko (KZ) filter the scales can be separated which allows researchers to remove the solar effects on climate and focus on the effects due to human factors.

Some long-term deviations from the strict proportionality from solar energy fluctuations must be due to human activities providing greenhouse effects in Earth's atmosphere. The purpose of this paper is to offer a linear separation of the two major contributors to the global climate changes. By removing the effects of solar energies fluctuations, this permits the authors to identify regional effects due to human contributions. This knowledge may provide an opportunity to identify some of the most dangerous types of human contributions.

One may remove the linear projection of regional long-term temperature on sunspot numbers. Following the cosine square law introduced by Zurbenko and Cyr (2011), solar energies are proportional everywhere, therefore through the removal of the projection of long-term temperature on sunspot numbers one will be left with a component corresponding to human contributions.

Long-term trends of those contributions may be examined over different regions. While the average trend, in the world and in the United States is positive, there are still regional differences. For example, in Montrose, Colorado it is highly positive, whereas in Greensboro, Alabama it is highly negative. The application of the spatial KZ filter permits the authors to draw a map of those derivatives.

Those maps provide well organized patterns across the globe with highly positive areas in the Western United States and negative values in the middle of the United States. These maps with the regional patterns permit researchers to discuss regional differences, which is essential information to the identification of areas with the most harmful impact on the climate.

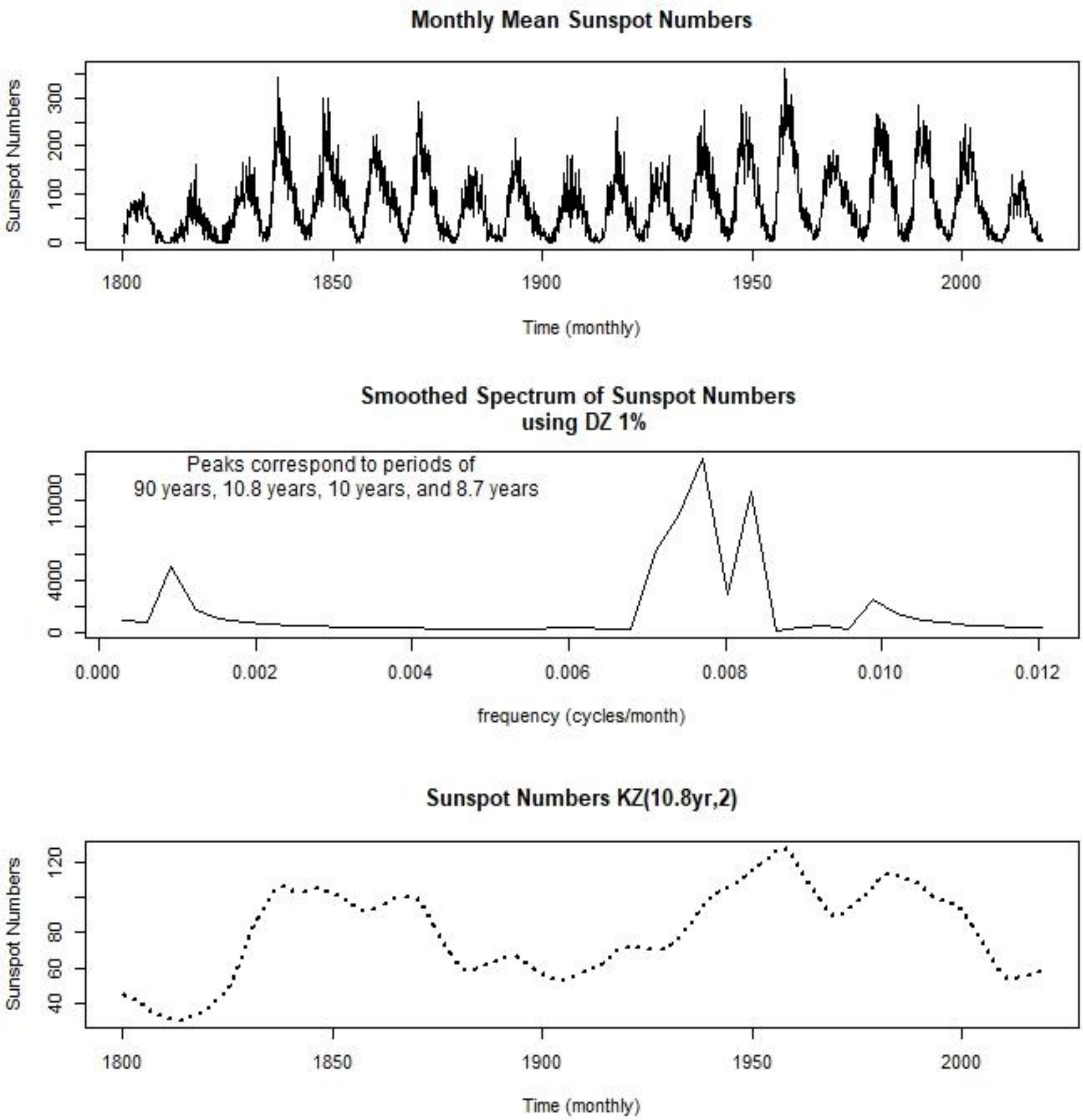

Figure 1. Monthly mean sunspot numbers from January 1800 – December 2018, Smoothed Spectrum of Sunspot Numbers and KZ (10.8yr,2) applied to Sunspot numbers.

2. DATA SOURCES

For the analyses in this paper, the authors consider average monthly sunspot data and temperature data. The average monthly sunspot data is freely available online from the Sunspot Index and Long-term Solar Observations (SILSO). The temperature data was downloaded from the National Climatic Data Center on the website www.ncdc.noaa.gov. The downloaded temperature dataset was the Global Historical Climatology Network Monthly Version 3 (NCDC_NOAA_GHCNM_TempAVG_QCA v3) dataset. In addition, the data analyses used the ggmap library from R-software (Khale, Wickham).

3. KOLMOGOROV-ZURBENKO FILTER

In order to conduct the analysis, the authors needed to smooth the datasets and to do this the authors used the Kolmogorov-Zurbenko (KZ) filter. The KZ filter is a symmetric filter that is an iterated moving average and is available in the KZA package of R-software (Close Zurbenko Sun, 2018). The KZ filter has parameters: window size (m) and number of iterations (k). It is denoted KZ(m,k). Parameters are selected through a physical understanding of the data. The KZ filter works well with datasets that have missing values as well as multidimensional datasets. For more information on the KZ filter refer to Zurbenko and Smith (2017) and Yang and Zurbenko (2010).

4. SUNSPOT NUMBERS AND TOTAL SOLAR IRRADIANCE

Since 28 BC researchers have known that sunspot numbers have a periodic component of 10-11 years and have observed it in recorded data since the 18th century (Stephenson and Clark 1978; Hathaway 2015). Potrzeba-Macrina & Zurbenko (2019) use spectral analysis of this data and the DiRienzo-Zurbenko (DZ) smoothing algorithm in KZA package of R-software (and also available in the KZFT package of R-software) to smooth the spectrum to show clear spectral lines at frequencies corresponding to periods of 90 years, 10.8 years, 10 years and 8.7 years.

Zurbenko and Potrzeba-Macrina (2019) and Potrzeba-Macrina and Zurbenko (2019) discuss the periodicities of sunspot numbers in addition to showing there is a relationship between sunspot numbers and total solar irradiance. Total solar irradiance (TSI) is, according to the Oxford dictionary of Astronomy, a measure of radiation on Earth from all wavelengths of the Sun. After removing the short-term or noisy fluctuations within the sunspot numbers data using the KZ filter, Zurbenko and Potrzeba-Macrina (2019) conduct a correlation analysis between sunspot numbers and satellite orbital TSI and conclude that there is a very strong linear relationship between KZ(13,3) of sunspot numbers (X) and KZ(13,3) of TSI (Y) given by equation $\mathrm{Y} = 1360.6 + 0.0069\mathrm{X}$ with $\mathrm{R}^2 = 99.1\%$. This result thereby permits researchers to substitute sunspot number observations for TSI (Zurbenko and Potrzeba-Macrina, 2019). It proves that fluctuations of sunspot numbers contribute approximately 0.1% of the total fluctuations in satellite measurements of TSI. This is a convenient substitution as sunspot number observations are available for a much longer timeframe. The change in average U.S. temperatures from 1927 – 1985 is approximately 0.3 °C, which can be contributed to the changing activities in TSI. Zurbenko and Potrzeba-Macrina (2019) discuss that some time shifts between orbital TSI and ground TSI may cause time shifts in the temperature compared with sunspots numbers. This is perfectly noticeable in the comparison of KZ(10.8 yr, 2) of sunspot numbers and KZ(13 yr, 3) of U.S. average temperatures from 1927-1985 (Figure 2). This corresponds to approximate 0.1% change in absolute temperature (Kelvin scale). This change is supported by Zurbenko and Cyr (2011, 2013) who found about the same influence of solar activities on temperature fluctuations in a 250-year span of temperature records from Central England Temperature. This was the longest temperature record that existed and had a correlation of 0.56 with long-term solar activity (Zurbenko and Cyr, 2011, 2013). After 1985 an increase of more than 0.4 °C US average temperature is observed despite solar activity being at a 100-year minimum (Figure 1 & Figure 3). Those temperature increases can be attributed to human activities and the greenhouse effect. In another 5 - 25 years long-term temperature may move up 0.5 °C due to increasing solar activities. It will cause further acceleration of the melting of glaciers and as a result have a major contribution to the greenhouse effect. This further increase in long-term temperature may yield catastrophic extreme weather events in separate regions all over the world.

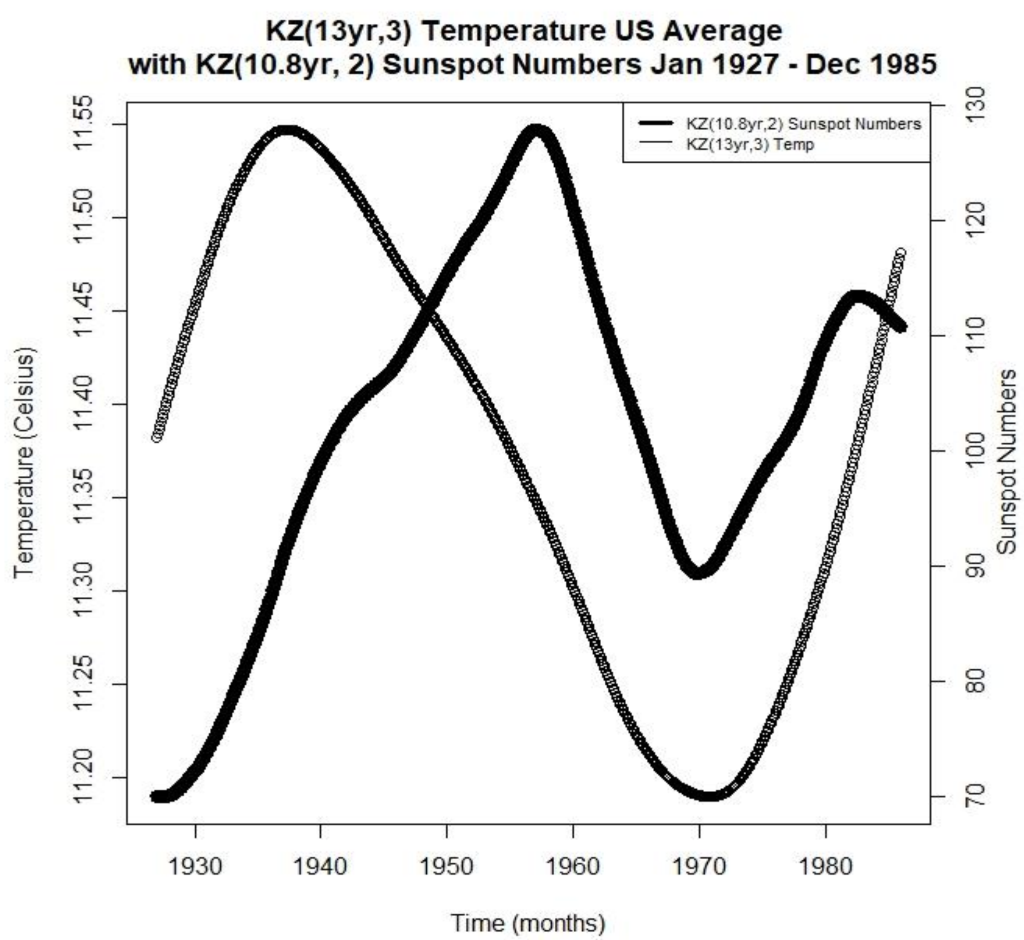

Figure 2. KZ(13yr,3) of U.S. Temperature average compared with KZ(10.8yr,2) of Sunspot Numbers January 1927 – December 1985.

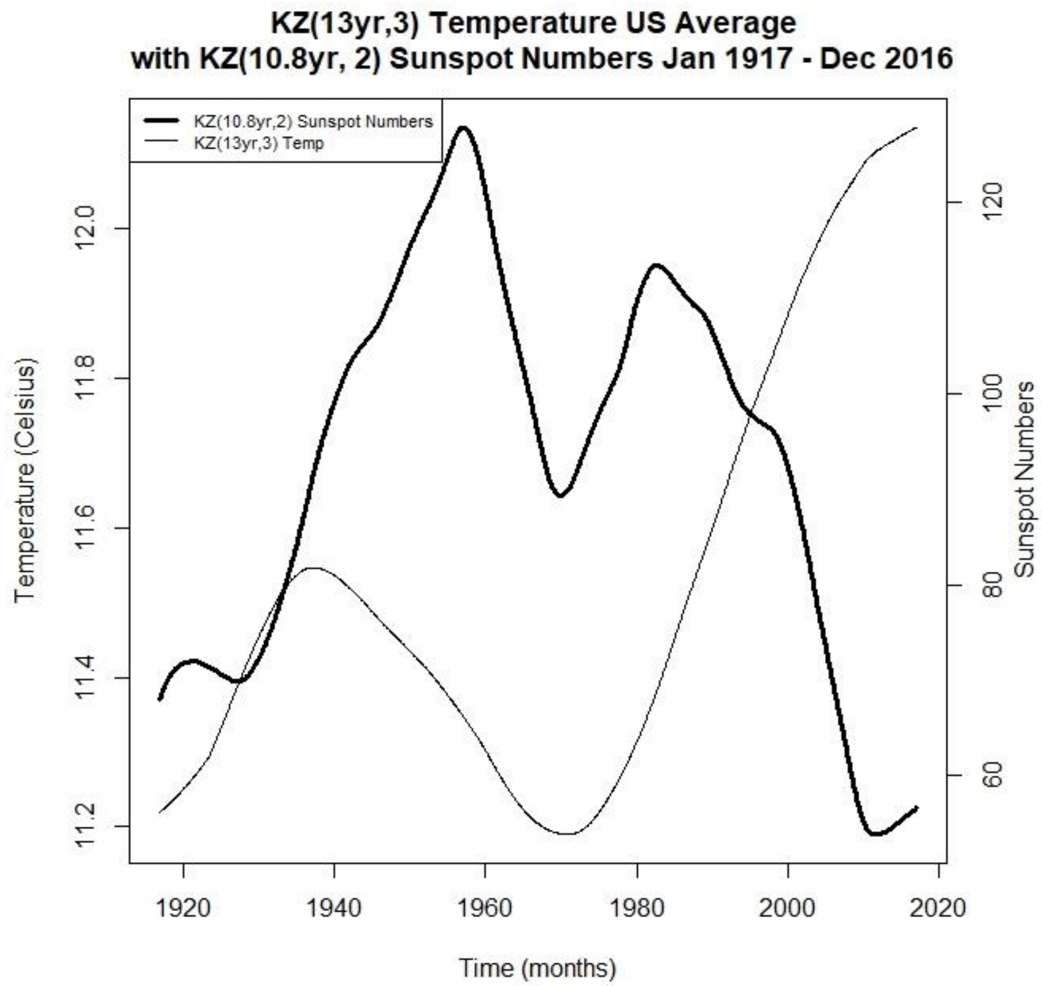

Figure 3. KZ(13yr,3) of U.S. Temperature average compared with KZ(10.8yr,2) of Sunspot Numbers January 1917 – December 2016.

Following these conclusions since TSI values may be substituted with sunspot numbers Potrzeba-Macrina and Zurbenko (2019) were able to investigate long-term fluctuations in temperature with TSI by using available sunspot number observations in lieu of TSI data. This is an important investigation as other researchers, namely Zurbenko and Cyr (2011, 2013), Valachovic and Zurbenko (2014, 2017) and Arndorfer and Zurbenko (2017) have demonstrated how solar radiation energies impact human life on Earth. Using the periodic components determined from their spectral analysis, Zurbenko and Potrzeba-Macrina (2019) considered the sunspot number data as the composition of its long-term component, mid-term (8-11 year) component, and short-term (noise) component and determined these components using the KZ filter. It is necessary to first separate the data into its scaled components in order to avoid erroneous results (Zurbenko and Sowizral 1999; Tsakiri and Zurbenko 2010). This process involved first determining the long-term component of sunspot numbers by applying KZ(10.8years, 3) to the raw sunspot numbers data, then applying KZ(1yr, 3) to the sunspot number data that had the long-term component removed in order to obtain the mid-term component. The remaining residuals comprise the short-term component. Zurbenko and Potrzeba-Macrina (2019) confirmed the accuracy of their decomposition using a QQ-normal plot of the residuals.

Zurbenko and Potrzeba-Macrina (2019) and Potrzeba-Macrina and Zurbenko (2019) discuss the relationship between TSI data using the sunspot number data and temperature with the conclusion that the fluctuations in temperature, not explained by TSI, are due to human influence on the solar energy transported to Earth. Furthermore, Zurbenko and Sun (2014, 2015, 2016) and Zurbenko and Potrzeba (2009, 2013a, 2013b) provide evidence that fluctuations in solar irradiation impact extreme weather phenomena such as tornados and hurricanes. While the analysis of Zurbenko and Potrzeba-Macrina (2019) and Potrzeba-Macrina and Zurbenko (2019) investigate temperature in a different location, it was specified that the human influence may have regional variations. Therefore, in the next section the authors consider the human impact on a global scale.

5. HUMAN COMPONENT OF TEMPERATURE FLUCTUATIONS

Zurbenko and Potrzeba-Macrina (2019) prove that the sunspot numbers, which are available for a sufficient amount of time, may be used in lieu of total solar irradiance. Using this information, the authors downloaded sunspot number data from SILSO. The downloaded data file contained monthly sunspot numbers from January 1749 – December 2018 (Figure 1). The authors considered the 100-year timespan from 1917 – 2016. Figure 1 clearly displays oscillations in solar activity of 11 years as well as some longer periods and the spectrum of sunspot numbers also clearly confirms these periodicities. Climate changes are slow processes so it is necessary to work with long periods, which can be done by eliminating the periodicities of 8-11 years.

The authors first smooth the sunspot number data using the KZ filter with a window size of 129 months. The selection of 129 months corresponds to removal of the periodicities of approximately 10.8 years within the sunspot data. In addition, to remove the similar effects that correspond to scales of approximately up to 13 years in temperature, a window size of 157 months was selected to be applied to the temperature data. Therefore, KZ(129,2) was applied to sunspot numbers and KZ(157,3) was applied to the temperature data.

After smoothing both datasets, the authors conducted a linear regression between the smoothed sunspot numbers (X_1) and the smoothed temperature data (Y_1). A second linear regression was then determined between the residuals (Y_2) of the first linear regression and a time index of 1200 months (i.e. a 100-year time span). The resulting slope of the second linear regression was then multiplied by 12 to get the unexplained average annual change or in other words the human component annual rate of the temperature fluctuations.

Zurbenko and Cyr (2011, 2013) prove there is a reasonable correlation between long-term components in sunspot numbers and temperature over the longest existing record of temperature in central England. For the spatial analysis of climate effects, it is enough to use records of temperatures of 100 years span. The application of the KZ filters with the aforementioned parameters to sunspot numbers and the total U.S. average monthly temperature data is shown in Figure 3. Those curves display a reasonable correlation for years 1920-1990. However, in the last 30 years long-term temperature was increasing while solar activity has been decreasing, which could be caused by the greenhouse effect and other relevant human activities. This effect can be identified by removing the solar effect as a linear projection of temperature data on sunspot number data as was done by Zurbenko and Potrzeba-Macrina (2019) and Potrzeba-Macrina and Zurbenko (2019). The authors used this process to identify the human component for the long-term average U.S. temperatures (Figure 4).

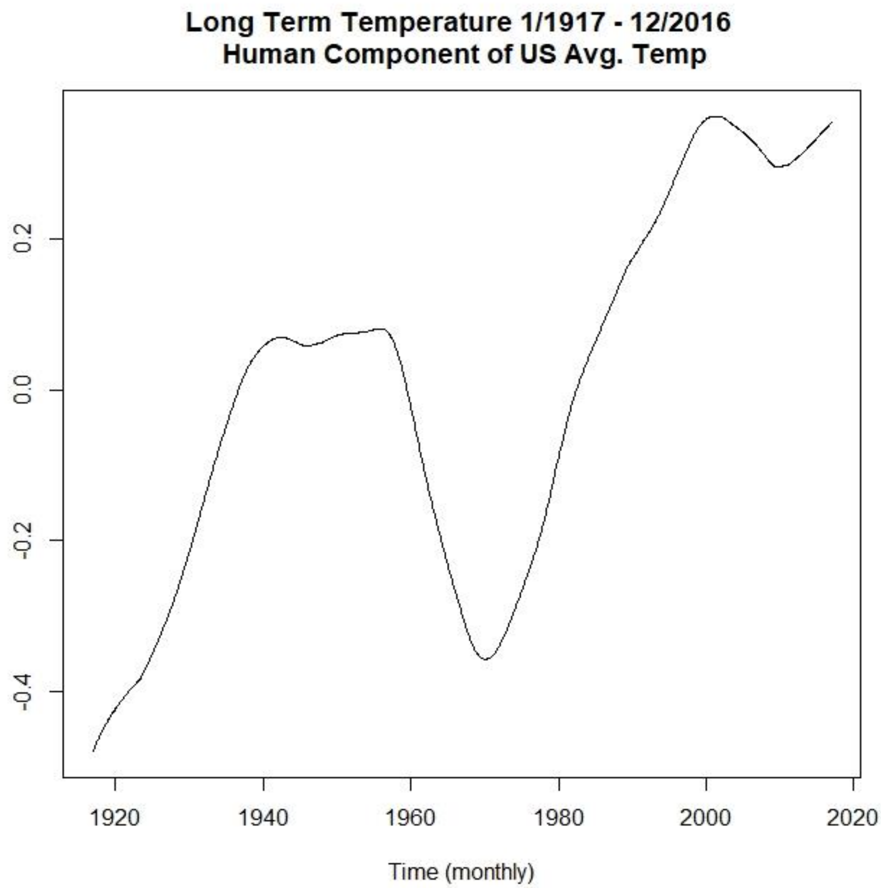

Figure 4. Human Component of Average U.S. Temperature.

One can make the same operation over temperature at any specific U.S. or global location. The authors downloaded temperature data from the NCDC available Climatology data. The data file contained monthly mean temperatures for 927 global stations. The authors considered a 100-year time span (January 1917 – December 2016) for each of these 927 stations and applied the aforementioned process to determine the human component of the temperature fluctuations at each station.

This operation was applied to long-term temperature at San Francisco, CA to determine the human component and was compared with the average human component for long-term global temperature (Figure 5). The human components for the San Francisco location and the global average both indicate a very strong upward anomaly in the last 30 years. The strongest upward anomaly, which exceeds 2 degrees, was in Montrose Colorado (Figure 6). Nevertheless some U.S. locations, such as Alabama (Figure 7) were displaying very little or even a negative human created effect (Figure 8).

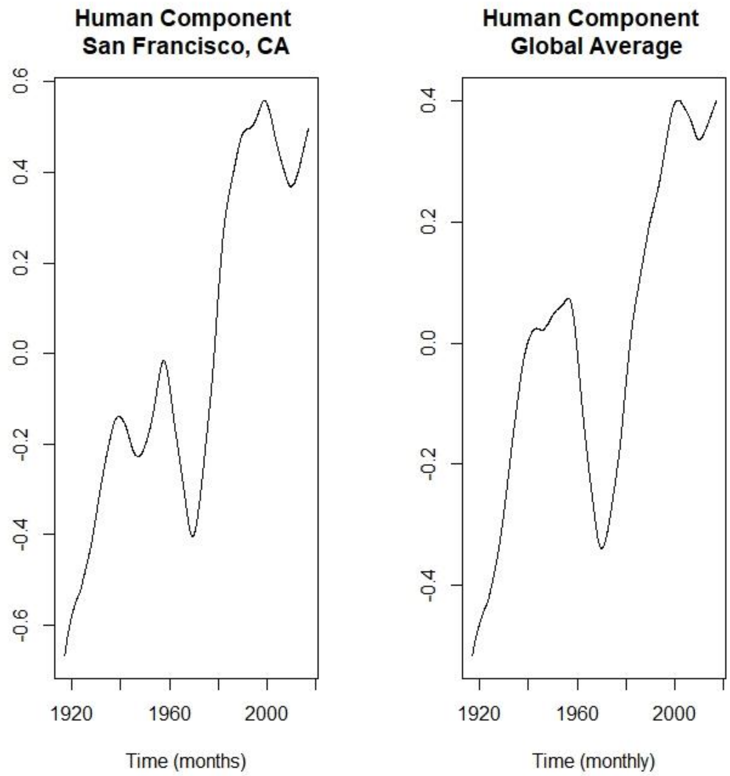

Figure 5. Human Component of long-term temperature for San Francisco, CA and the global average of 927 stations.

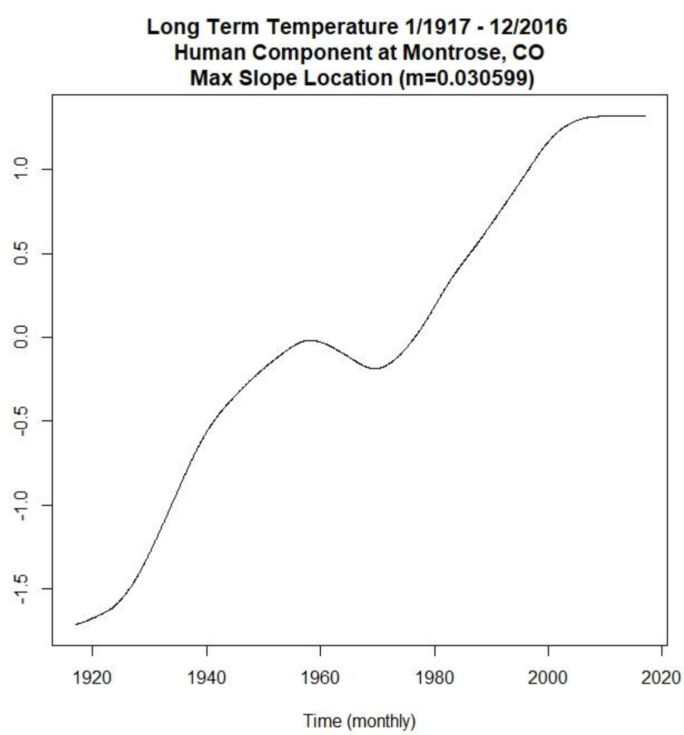

Figure 6. Human component for Montrose, CO, which had the largest slope (0.030599).

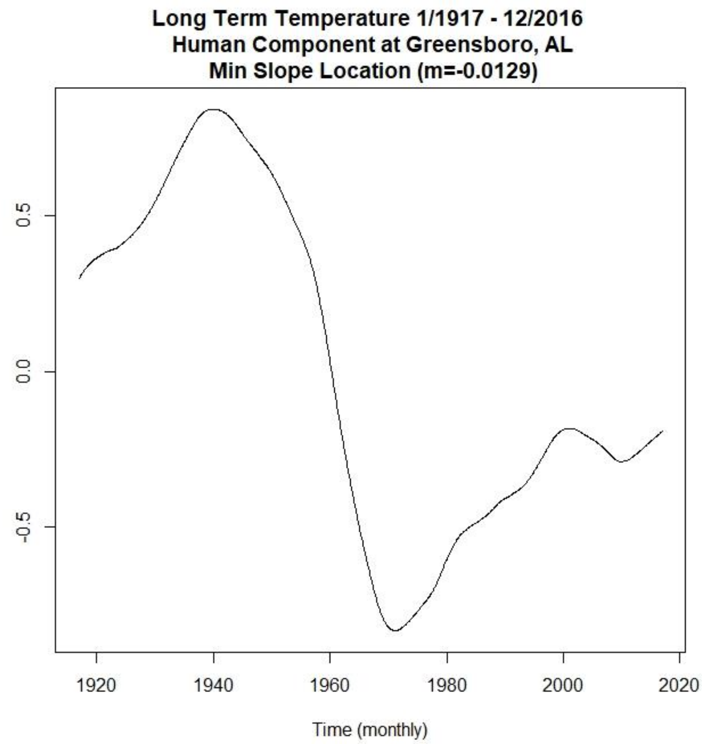

Figure 7. Human component for Greensboro, Alabama, which had the largest negative slope (-0.0129).

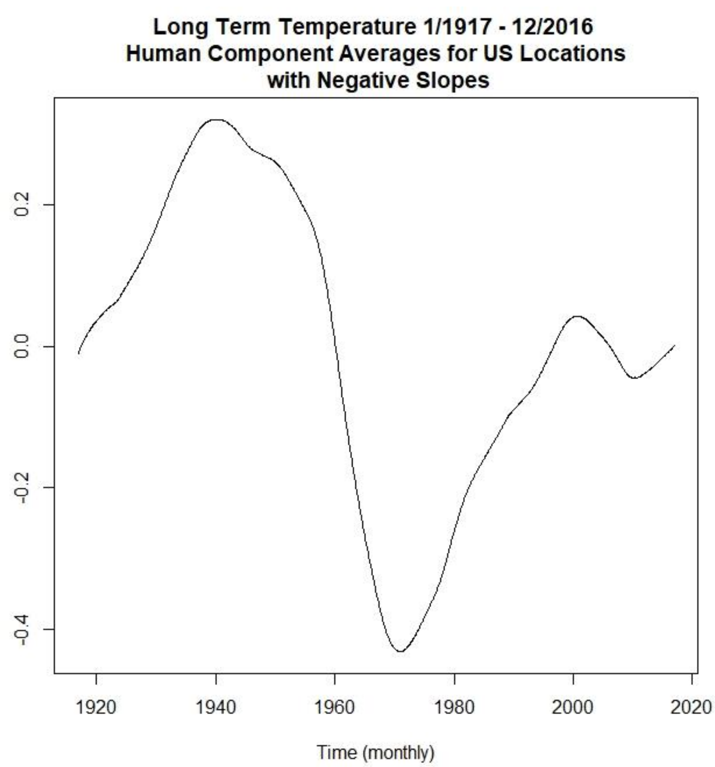

Figure 8. Average human component for the U.S. stations that had a negative slope.

Spatial images of human component effects can be determined by displaying annual average value of human component over the U.S. (Figure 9) or the world (Figure 10). It is evident that there is a more positive increase within the western U.S. as well as some places in Russia (Figure 9 and 10). Nevertheless, the middle of the U.S. has sufficient areas with negative average annual values.

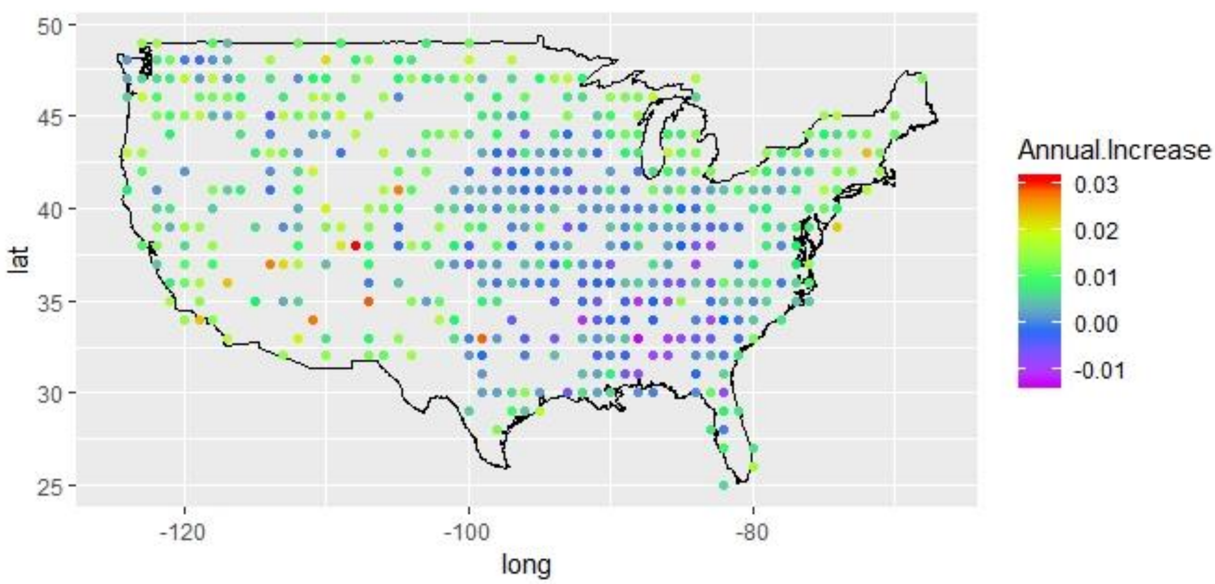

Figure 9. Unexplained annual fluctuations at 762 U.S. stations.

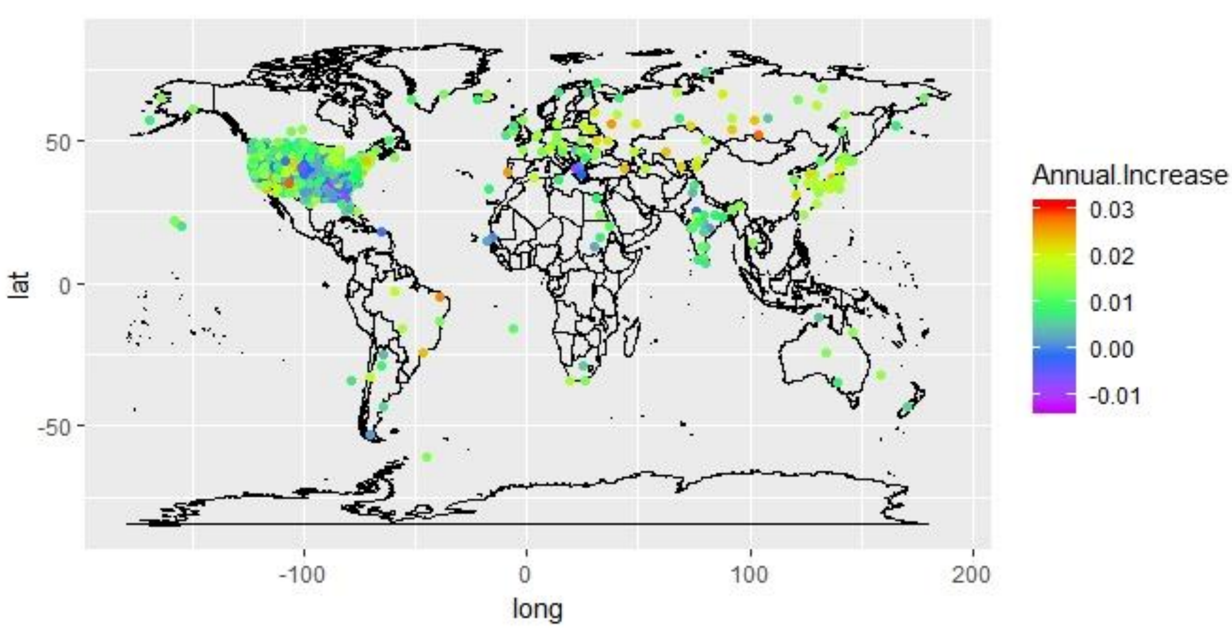

Figure 10. Unexplained annual fluctuations at 927 global stations.

The U.S. locations with temperature measurements available from the database are located sufficiently close to each other, but still there is not a uniform coverage of the continental U.S. The data (Figure 9) display some small spatial uncertainties within the average annual increase. Therefore, the researchers applied spatial smoothing using KZ($5° \times 5°$, 3) from the KZA package in R-software (Figure 11). Applying the spatial KZ filter to the 927 global stations is not ideal due to the spatially rare points that were available since the KZ filter starts to expand over those areas. However, due to the numerous available observations in the United States, it is suitable for application over the U.S. The authors viewed the global result and the U.S. results (Figure 11). These figures allow one to see regional patterns and differences across the globe and within the United States. It is evident that there are highly positive areas in the Southwestern United States and negative values in the middle of the United States.

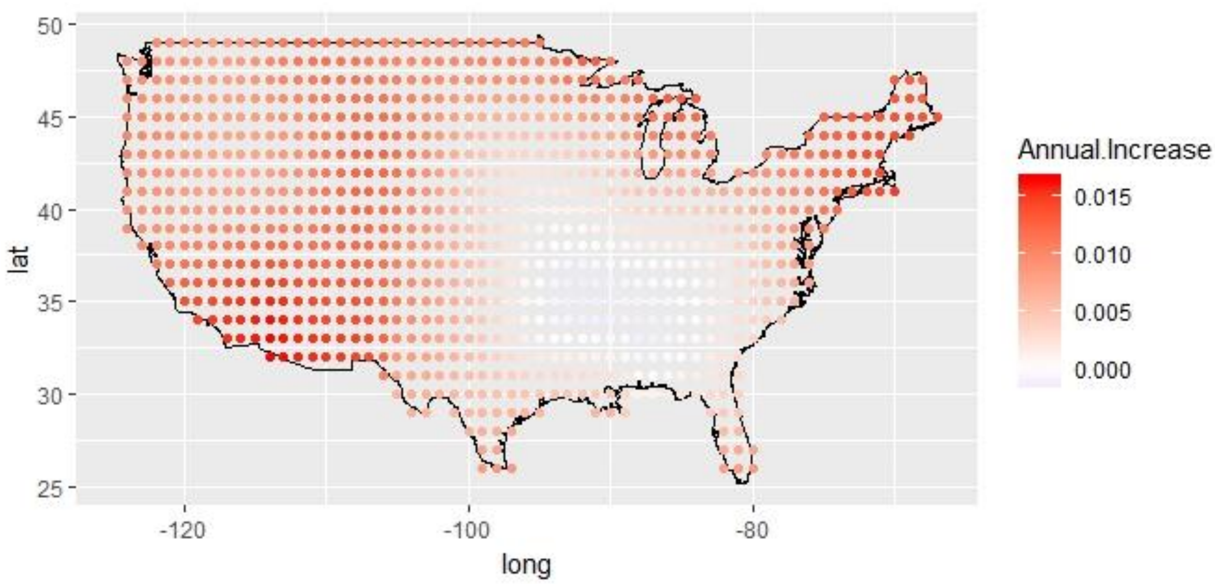

Figure 11. Annual human components of temperature in the U.S. after smoothing KZ(5,5,3).

6. CONCLUSIONS

Total solar irradiation delivered to Earth is the main energy source on planet Earth. There are strong fluctuations in the levels of that energy supply and its long-term scales are certainly affecting Earth's climate. Correlations between solar activities and the long-term scale of regional and average temperatures are clearly noticeable. Part of long-term temperature can be linearly explained by long-term solar activity, but the unexplained portion can be attributed to local factors on Earth. While human activities can contribute to the greenhouse effects, an increase of water levels, triggered by melting glaciers, are also causing enormous accumulations of water vapor within the atmosphere which further contribute to greenhouse effects and extreme weather events (Zurbenko and Smith 2017, Zurbenko and Luo 2015). The vapor energy increases over North American and the Atlantic over the past few decades have exceeded any reasonable imaginations. Those energies are ready to be released in extreme weather events with catastrophic consequences. Simultaneously a strong dry out is occurring on the opposite coast through Arizona, Nevada, California and Australia (Zurbenko and Smith, 2017). The separation of scales of temperature allows temperature to be viewed by its long-term components, one of which is proportional to solar activity and another is an independent component, which is due to regional effects on Earth. This independent component can be called the human component of long-term temperature fluctuations. The human component has been rapidly increasing over the last 30 years. In approximately 1985, the solar component begins to rapidly decline whereas average temperatures start to go in the opposite direction. This can only be due to the independent human component (Figure 3). Originally the human component has been created by human activities, which has led to the greenhouse effect. This triggered the melting of glaciers and the rise of water levels in the ocean lead to an increase in humidity to accelerate greenhouse effects and natural processes for further climate changes.

The annual increases due to human activities strongly depend on the geographical region. Within the last 60 years solar activity has been essentially decreasing and has currently reached its lowest point within 100 years. There are indications that within the next few decades solar activity will be essentially increasing. Potrzeba-Macrina and Zurbenko (2019) offer computer prediction methods of these changes. Temperature levels are currently high and further increases may cause critical changes in Earth's climate as well as extreme weather events. Since these temperature changes differ by region, examinations of these regional differences and their causes should be examined as it may identify the reasons for the differences. Extended satellite measurements of total solar irradiations and spectral fluctuations of solar radiation in time can be very useful in determining more accurate regional differences in climate change as well as an explanation of their causes. Connections between long-term regional fluctuations and the high variations within them will provide valuable explanations of local weather and extreme weather events.

References

[1] Arndorfer S, Zurbenko I (2017) Time Series Analysis on Diabetes Mortality in the United States, 1999-2015 by Kolmogorov-Zurbenko Filter. *Journal of Biometrics & Biostatistics* Vol 8 (6). DOI: 10.4172/2155-6180.1000384

[2] Close B, Zurbenko I, Sun M (2018). kza: Kolmogorov-Zurbenko Adaptive Filters. R package version 4.1.0. https://CRAN.R-project.org/package=kza

[3] Gray LJ, Beer J, Geller M, Haigh JD, Lockwood M, Matthew K, Cubasch U, Fleitmann D, Harrison G, Hood L, Luterbacher J, Meehl GA, Shindell D, van Geel B, White W (2010) Solar influences on climate. *Rev Geophys* 48 RG4001. doi:10.1029/2009RG000282

[4] Hathaway, D (2015). The Solar Cycle. *Living Reviews in Solar Physics* 12 (4). DOI: 10.1007/lrsp-2015-4.

[5] Kahle D & Wickham W. ggmap: Spatial Visualization with ggplot2. *The R Journal,* 5(1), 144-161. URL: http://journal.r-project.org/archive/2013-1/kahle-wickham.pdf

[6] Kossobokov V, Le Mouël JL, Courtillot V (2010) A statistically significant signature of multi-decadal solar activity changes in atmospheric temperatures at three European

stations. *Journal of Atmospheric and Solar-Terrestrial Physics* 72: 595-606. doi:10.1016/j.jastp.2010.02.016

[7] National Climatic Data Center. National Oceanic and Atmospheric Administration. Global Historical Climatology Network Monthly Version 3. http://www.ncdc.noaa.gov/ghcnm and ftp://ftp.ncdc.noaa.gov/pub/data/ghcn/v3

[8] Potrzeba-Macrina AL & Zurbenko IG (2019). Periods in Solar Activity. *Advances in Astrophysics* Vol 4, No 2, p 47-60. https://dx.doi.org/10.22606/adap.2019.42001

[9] Soon W, Legates DR (2013) Solar irradiance modulation of Equator-to-Pole (Artic) temperature gradients: Empirical evidence for climate variation on multi-decadal timescales. *Journal of Atmospheric and Solar-Terrestrial Physics* 93, 45-56. http://dx.doi.org/10.1016/j.jastp.2012.11.015

[10] Stephenson, FR & Clark, DH (1976). Applications of Early Astronomical Records. Monographs on Astronomical Subjects: 4. Oxford University Press, New York.

[11] Sun Z, Wang Q, Batkhishig O, Ouyang Z (2016) Relationship between Evapotranspiration and Land Surface Temperature under Energy- and Water-Limited conditions in dry and cold climates. *Advances in Meteorology* Article ID 1835487. http://dx.doi.org/10.1155/2016/1835487

[12] Tiwari RK, Rajesh R, Padmavathi, B (2016) Evidence of Higher-Order Solar Periodicities in China Temperature Record. *Pure Appl Geophys* 173: 2511-2520. DOI 10.1007/s00024-016-1287-y

[13] Trenberth KE, Fasullo, JT, Balmaseda, MA (2014) Earth's Energy Imbalance. *Journal of Climate* Vol 27 (9): 3129-3144.

[14] Tsakiri K, Zurbenko I (2010). Prediction of Ozone Concentrations using Atmospheric Variables. *Journal Air Quality, Atmosphere & Health.* Vol 4 (2): 111-120. DOI: 10.1007/s11869-010-0084-5

[15] WDC-SILSO, Royal Observatory of Belgium, Brussels. Sunspot Numbers: http://www.sidc.be/silso/datafiles

[16] Valachovic E, Zurbenko I (2014). Skin Cancer, Irradiation, and Sunspots: The Solar Cycle Effect. *Biomedical Research International.* Vol 2014. http://dx.doi.org/10.1155/2014/538574

[17] Valachovic E, Zurbenko I (2017). Multivariate Analysis of Spatial-Temporal Scales in Melanoma Prevalence. *Cancer Causes Control* Vol 28 (7), p. 733-743. doi:10.1007/s10552-017-0895-x

[18] Yang W, & Zurbenko I (2010). Kolmogorov-Zurbenko filters. *WIREs Comp Stat* Vol 2: 340-351. https://doi.org/10.1002/wics.71

[19] Yang W, Zurbenko I (2012) KZFT package version 0.17, R-software first published version (19-Sept-2007) and latest published version (2012), Package Sources https://cran.r-project.org/web/packages/kzft/kzft.pdf

[20] Zurbenko IG, Cyr DD (2011) Climate fluctuations in time and space. *Climate Research* Vol (46): 67-76. DOI 10.3354/cr00956.

[21] Zurbenko IG, Cyr DD (2013) Climate fluctuations in time and space. *Climate Research* Vol 57: 93–94. doi: 10.3354/cr01168

[22] Zurbenko I, Luo M (2015) Surface Humidity Changes in Different Temporal Scales. American Journal of Climate Change 4: 226-238.

[23] Zurbenko, IG & Potrzeba, AL (2009) Tidal Waves in Atmosphere and Their Effects. *Acta Geophysica*, Vol 58 (2): 356-373. DOI 10.2478/s11600-009-0049-y

[24] Zurbenko, IG & Potrzeba, AL (2013 a) Tides in the Atmosphere. *Air Quality, Atmos, & Health*, 6 (1): 39-46. Springer, DOI 10.1007/s11869-011-0143-6. http://www.springerlink.com/content/e124604331626295

[25] Zurbenko, IG & Potrzeba, AL (2013 a). Periods of Excess Energy in Extreme Weather Events. *Journal of Climatology*, Vol. 2013. Article ID 410898. http://dx.doi.org/10.1155/2013/410898

[26] Zurbenko IG & Potrzeba-Macrina AL. Solar Energy Supply Fluctuations to Earth and Climate Effects. *World Scientific News* 120 (2) (2019) 111-131

[27] Zurbenko IG, Smith D (2017). Kolmogorov-Zurbenko filters in spatiotemporal analysis. *WIREs Comput Stat*, e1419. DOI: 10.1002/wics.1419

[28] Zurbenko I, Sowizral, M (1999) Resolution of the destructive effect on noise on linear regression of two time series. *Far East Journal of Theoretical Statistics* Vol 3 (1): 139-157

[29] Zurbenko, I.G. & Sun, M (2014). Periods of High Risk in Tornado Outbreaks in Central USA. *Advances in Research*, 2 (8). DOI : 10.9734/AIR/2014/10247

[30] Zurbenko, I.G. & Sun, M (2015). Associations of Jet Streams with Tornado Outbreaks in the North America. *Atmospheric and Climate Sciences*, Vol. 5 (3), p. 336-344. http://dx.doi.org/10.4236/acs.2015.53026

[31] Zurbenko, I.G. & Sun, M (2016). Jet Stream as a major factor of tornados in USA. *Atmospheric and Climate Sciences*, Vol. 6 (2), p. 236 – 253. DOI: 10.4236/acs.2016.62020