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THE OCCURRENCE OF EXTREME MONTHLY TEMERPATURES AND PRECIPITATION IN TWO GLOBAL REGIONS

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There has been a lot of focus on the occurrence of extreme weather events and a possible connection to climate change and variability. Much of this work has been related to individual events, rather than for long periods of time. This work will examine the occurrence of extreme conditions in the monthly temperature and precipitation for two geographically disparate regions of the Northern Hemisphere. These regions are the central USA (cUSA), and the southwest region of Russia (swRUS). The data were provided by the Missouri Climate Center for a 125 year period and the Russian Hydrometeorological Center for a 72 year period. For this study, an extreme temperature event was defined as a month that was two monthly or three seasonal standard deviations from the period mean. Since precipitation is not normally distributed, the three (two) wettest and driest months were chosen for the cUSA (swRUS) region in order to provide for a data set that was of similar size to the temperature data set for each region. The initial results demonstrate that in cUSA, there was preference for the occurrence of warm anomalies during eras of mean regional temperature increase and vice versa. For swRUS, there was a preference for the occurrence of cold anomalies early in the data set, and warm anomalies in the later part, although this period is one of steadily increasing mean temperatures for the region. There was a strong tendency in both locations for occurrence of extreme months during a preferred phase of the El Niño and Southern Oscillation (ENSO). In cUSA (swRUS), there were fewer (more) extreme monthly temperature occurrences in the La Niña phase. However, for monthly precipitation extremes in cUSA (swRUS) favored the La Niña (El Niño) periods. In both regions, there was no signal in temperature as related to longer-term climatic cycles, while for precipitation there were weak relationships to the Pacific Decadal Oscillation and the North Atlantic Oscillation. In both regions, cold monthly anomalies were associated with persistent and strong upstream blocking events.

Introduction

In recent years, there has been increased attention to the reccurrence of extreme weather in the research and general community, especially within the context of climate and climate change (e.g. IPCC, 2013). However, recent research has demonstrated that even with an increase in temperature globally, important interannual and interdecadal variability can still impart a strong signal on local or regional climate (Johnstone and Mantua, 2014). Johnstone and Mantua (2014) show that interdecadal variability related to the Pacific Decadal Oscillation (PDO) contributed strongly to the climate record of the Northwest USA since 1900. Also, many researchers have examined the interannual and interdecadal variability of temperature and other variables regionally. (e.g. Birk et al. 2010 and Lupo et al.. 2012a).

Studies of the interannual or interdecadal variability of the occurrence of extreme events is not new and has typically been accomplished using phenomenological events such as hurricanes (e.g., Zuki and Lupo, 2008; Lupo, 2011), tornadoes (e.g., Akyuz et al. 2004), or blocking events (e.g., Lupo et al. 2012b; Mokhov et al. 2012). Many have examined the occurrence of extreme temperatures and how their occurrence might change in the 21st century (e.g., Birk et al. 2010). However, very few have examined the occurrence of extreme months.

The goal of this paper is to examine the occurrence of extremely warm and cold months occurring in two regions of the globe, the Midwest USA (cUSA) and southwest Russia (swRUS). To our knowledge, there is no comparable study for either region. Section two will present the data and analysis methods used, section three will examine the climatological results, and section four will present the interannual and interdecadal vaiability. Thus, the results of this study would have implications for long range forecasting.

Data and Analysis

a. Data

The data used in this study were surface temperature and precipitation records and these were obtained from the Missouri Climate Center (MCC) at the University of Missouri in Columbia. These records go back to 1889, providing for a 126 year data set through 2014, and provided in Fahrenheit and inches. The data for southwest Russia were surface temperature and precipitation data for the Belgorod Oblast obtained from the All Russia Research Institute of Hydrometeorological Information-World Data Centre (RIHMI-WDC http://meteo.ru/) from 1946 to 2014. These data were provided in Celsius and millimeters. Birk et al. (2010) and Lebedeva et al. (2015) demonstrate that these data will generally be representative of their regions as a whole. The study regions include the Midwest region (cUSA) which is defined as Missouri and surrounding states and the Belgorod Oblast and surrounding regions (swRUS). In this study, the actual units for surface temperature are not germane to the analysis since this will examine departures from the means (Lupo et al. 2003).

b. Analysis

To be considered an extreme event in the cUSA, this study specified that the monthly mean temperature for the region of study had to be at least three standard deviations above or below the seasonal mean derived from the entire data set for that particular month. The three standard deviation value was based on the seasonal mean in order that the sample size produced was large enough for statistical analysis. The values used in this study are presented in Table 1.

Table 1

The criterion used of each season for the cUSA months

Season	Three Seasonal σ (cUSA °F / sw RUS °C)
Winter – DJF	10.2 / 7.8
Spring – MAM	6.6 / 5.6
Summer – JJA	6.5 / 4.4
Fall – SON	6.3 / 4.4

In a normally distributed dataset such as temperature (e.g., Lupo et al. 2003), three standard deviations represents approximately 1% of the distribution. Since there were about 1500 events in the cUSA and 864 in swRUS, our sample size based on three standard deviations from the monthly mean would represent only 15 and 9 events, respectively. The seasonal criterion used here gave us a sample size of 89 and 31 months (6% and 4% of all) in the cUSA and swRUS, without obtaining so many months that the meaning of an extreme event would be lost. Since precipitation is not normally distributed (Lupo et al. 2003), only the three (two) wettest and driest months were chosen.

The definition for El Niño and Southern Oscillation (ENSO) used was the Japanese Meteorological Association (JMA) definition. The list of years and their associated ENSO phase can be found at (http://coaps.fsu.edu/jma). This definition has been used in many published studies (see Birk et al. 2010 and references therein). The Pacific Decadal Oscillation is defined as a warm or cool phase as defined in Birk et al. (2010), and the eras are as follows; warm: 1924-1946, 1977-1998, cool: 1900-1923, 1947-1976, 1998 - 2014. In swRUS, we examined eras association with the North Atlantic Oscillation (NAO) as well. The eras for this oscillation are defined as; positive: 1944-1950, 1974-2008, negative: 1951 – 1973, 2009 – 2014.

Climatological Study

The climatological analysis found 89 months for cUSA which met the three seasonal and two monthly standard deviation criterion used here, respectively. Table 2 shows the seasonal breakdown of the normalized extreme monthly temperature anomalies for cUSA and swRUS. Overall, there were more warm anomalies for the cUSA, but the differences were small enough to not be far from that which would be expected if occurrence of extreme months in the 125 year period was random. In swRUS, cold anomalies occurred nearly twice as often overall. Examining individual seasons for both regions demonstrates that while the raw anomalies were largest in the winter months (not shown), the normalized anomalies were largest in the transition seasons of spring and fall (not shown). Table 2 shows that this is true for the largest of the anomalies as well. During the winter season in the cUSA, cold anomalies occurred three times as often as warm anomalies, however, in the summer season, warm anomalies accounted for 13 of 16 extreme months. This dominance of cold (warm) anomalies in the cold (warm) season is particularly true for swRUS as well. Precipitation is not examined here since each month/season contributed a set number of wet and dry anomalies as per the method described in section 2b.

Table 2

Statistics for the cUSA and swRUS normalized monthly temperatures (T is total, W is warm, and C is cold)

Category	Winter	Spring	Summer	Fall	Total
cUSA					
Occurrence	20T 5W 15C	28T 15W 13C	16T 13W 3C	25T 14W 11C	89T 47W 42C
Percent of All	16T 4W 12C	22T 12W 10C	13T 10W 3C	20T 11W 9C	71T 38W 33C
Extreme W	1.6 –12/1899	2.5 – 3/2012	1.4 – 7/1980	1.8 - 10/1963	2.5 – 3/2012
Extreme C	1.6 – 1/1977	1.8 – 3/1906	1.3 – 8/1915	1.6– 10/1925	1.8 – 3/1906
swRUS					
Occurrence	8T 1W 7C	9T 3W 6C	3T 3W 0C	11T 4W 7C	31T 11W 20C
As percent	11T 1W 10C	12T 4W 8C	4T 4W 0C	15T 5W 10C	43T 15W 28C
Extreme W	1.0 – 2 /2002	1.1 – 3 /2007	1.5 – 8/2010	1.6 - 11/2010	1.6– 11/2010
Extreme C	1.4 – 1/1950	1.4 – 3/1952	N/A	1.9 - 11/1993	1.9– 11/1993

Interannual and Interdecadal Variability

In this section, occurrences stratified by ENSO phase will be normalized as a mean annual occurrence since ENSO neutral years account for a majority of the periods of study for both regions. In the cUSA, there were 68 neutral years, 30 (27) La Niña (El Niño events, while in swRUS, these counts were 41, 16, and 15 respectively. Table 3 shows the ENSO variability of extremes for both temperature and precipitation in both regions.

An examination of Table 3 shows that extremely warm or cold monthly temperatures in cUSA are most likely during the neutral phase and El Niño phase, and occur maybe extremely warm and cold moths are much likely that during La Niña months. During La Niña months, extremely warm or cold months were likely to occur during one month in two La Niña years, translating to a 4% chance of any given month being extreme. In swRUS, the occurrence of extreme monthly temperature was opposite that of the cUSA, or these were more likely in La Niña and neutral months. There was some variability by season in swRUS in that during some seasons (spring, summer), El Niño was more likely to have an extreme temperature occurrence. This table also demonstrates that the transition season months were most likely to have the occurrence of extreme warm or cold months in both regions.

In the cUSA, the occurrence of an extremely warm or cold monthly event was close to 75%, which means three months in four years during these periods were classified as extreme. In swRUS, the probability of extreme warm or cold months was less than that of cUSA overall, which is due to the greater continentality of the cUSA. For neutral (El Niño) extreme months in the cUSA, there were more warm (cold) anomalies. I the cUSA summer, neutral months accounted for 80% of all summer extremes, and this was the highest percentage among any of the seasons for that region.

For precipitation in both regions, the distributions were different from the temperature. In the cUSA, neutral years produced the most extreme wet or dry months, while in swRUS it was El Niño and neutral years producing the most extremes. In the cUSA the neutral years dominated every season, while in swRUS, La Niña years were as common as the other phases during winter only.

Table 3

The occurrence of extreme temperature and precipitation months stratified by ENSO phase and season expressed as an occurrence per year for each individual phase for the total numbers in Table 2, temperature only. These will appear as T/P in each cell.

Phase	Winter	Spring	Summer	Fall	Total
cUSA					
El Niño	0.19 / 0.19	0.27 / 0.07	0.07 / 0.07	0.30 / 0.07	0.74 / 0.41
Neutral	0.19 / 0.19	0.24 / 0.16	0.21 / 0.19	0.16 / 0.18	0.79 / 0.65
La Niña	0.07 / 0.03	0.13 / 0.20	0.00 / 0.10	0.17 / 0.13	0.50 / 0.47
swRUS					
El Niño	0.13 / 0.20	0.20 / 0.13	0.13 / 0.20	0.00 / 0.27	0.40 / 0.80
Neutral	0.10 / 0.15	0.10 / 0.22	0.00 / 0.20	0.20 / 0.20	0.39 / 0.78
La Niña	0.19 / 0.19	0.13 / 0.06	0.06 / 0.06	0.19 / 0.00	0.56 / 0.31

An examination of the occurrence of extreme months in association with the positive and the negative PDO eras, showed only a weak tendency for the occurrence of extreme warm (cold) anomalies with the warm (cold) phase of the PDO in the cUSA or sw RUS, and also not the NAO in the latter region. For the precipitation occurrences, there was a statistically significant association for the occurrence of wet (dry) extremes during the positive (negative) phase of the PDO in the cUSA. The same pattern, but weaker and not significant, was noted in the swRUS region, however, no tendency obvious in the NAO phases.

Discussion and Conclusions

A study of the occurrence of extremely warm, cold, wet, and dry months for extended time series of data for the cUSA and swRussia was conducted. The results showed that in the cUSA there was no general tendency toward the occurrence of warm versus cold anomalies. While the strongest raw temperature anomalies occurred during the winter months, the strongest normalized anomalies were in the transition seasons in both regions. The interannual variability showed no strong interdecadal variability, except for the PDO with wet and dry precipitation in the cUSA. With respect to ENSO, there was a tendency toward the more frequent occurrence of extreme temperature anomalies was during El Niño and neutral years in the cUSA, but during La Niña in swRUS. For precipitation there was a stronger tendency toward extreme precipitation occurrences in El Niño and neutral years in swRUS, but in neutral years only in the cUSA.

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СТРУКТУРНАЯ ХАРАКТЕРИСТИКА ГУМИНОВЫХ ВЕЩЕСТВ ПОЧВ КРАСНОДАРСКОГО КРАЯ КАК ОСНОВА БИОПРОТЕКТОРНОЙ ФУНКЦИИ ГУМУСА

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Почвы Краснодарского края - уникальный природный объект, характеризующийся разнообразием условий формирования, а, следовательно, состава и структурно-функциональных свойств их органического вещества – гумуса.

Одной из экологических функций гумуса является биопротекторное действие, обусловленное способностью связывать и детоксицировать различные поллютанты. Результатом антропогенного воздействия на почвы явилась устойчивая тенденция к уменьшению содержания гумуса в пахотном слое, возникает проблема снижения не только плодородия почв, но и способности их противостоять загрязнению. Одна из важнейших особенностей гумусовых веществ – непостоянный химический состав и структурные характеристики, которые зависят от климатических условий, рельефа местности, состава растительных остатков и других факторов. Молекулы гуминовых кислот – основы гумуса, содержат устойчивое ароматическое ядро и периферическую часть, представленную разветвленными алифатическими углеводородами и их производными [1, 2, 3].

Определение структурно-функциональных характеристик гуминовых кислот в настоящее время проводится при помощи методов физико-химического анализа, преимущественно спектральных: спектрофотометрия в видимой области спектра, инфракрасная и ультрафиолетовая спектроскопия, ЯМР- и ЭПР- спектроскопия. Один из перспективных методов анализа гуминовых кислот – ЯМР-спектроскопия на ядрах ^{13}C и ^{1}H. Этот метод позволяет получать информацию о доминирующих типах связей С-С в молекулах, что дает возможность количественно оценить преобладающие углеводородные структуры, входящие в состав гумусовых веществ.

Целью настоящей научной работы было исследование структурно-функциональных свойств гумусовых веществ почв Краснодарского края методом ЯМР-спектроскопии.

На мониторинговых площадках были отобраны образцы почвы: чернозем обыкновенный (карбонатный) малогумусный сверхмощный (ЧК), луговато-черноземная слабогумусная почва с сверхмощным гумусовым горизонтом (ЛЧ) и серая лесная почва с мощным гумусовым горизонтом (СЛ). Основные характеристики исследуемых почв приведены в табл. 1.

Для получения ЯМР-спектров навеску 50 мг выделенных традиционными методами гуминовых кислот растворяли в 0,3 М гидроксиде натрия в дейтерированной воде, выдерживали в ультразвуковой бане, центрифугировали в течение 5 мин. при частоте 10 000 об/мин, отделяли жидкость от осадка. ЯМР-спектры регистрировали при помощи ЯМР-спектрометра Agilent 400 MR.