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TRENDS IN INDICES FOR EXTREMES IN DAILY AIR TEMPERATURE OVER UTAH, USA

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ABSTRACT

The main objective of this study was to obtain analysis of the trends in eleven annual extreme indices of temperature for Utah, United State of America (USA). The analyses have been obtained for 28 meteorological stations, in general, for the period of 1930 to 2006, characterizing a long-term period and with high quality data. The software used to process the data was the RClimdex 1.0. The analysis has identified that the temperature increased in Utah during the last century, evidencing the importance of the ongoing research on climate change in many parts of the world.
Keywords: Climate change, RClimdex, climatology, IPCC

RESUMO: TENDÊNCIAS DE INDICES DE EXTREMOS PARA TEMPERATURA DO AR DIÁRIA SOBRE UTAH, EUA.
O principal objetivo desse estudo foi analisar as tendências de onze indices de extremos climáticos baseados em dados diários de temperatura do ar, obtidos a partir de 28 estações meteorológicas localizadas em Utah, Estados Unidos da America (EUA). Em geral, os dados foram coletados entre 1930 e 2006, apresentando coerente resolução temporal e espacial. O *software* utilizado no processamento dos dados foi o RClimdex 1.0. As análises dos índices extremos mostraram que a temperatura aumentou em Utah durante o último século, evidenciando a importância das pesquisas sobre mudanças climáticas em diferentes partes do mundo.
Palavras-chave: Mudanças climáticas, RClimdex, climatologia, IPCC

1. INTRODUCTION

There is growing evidence that the global changes in extremes of the climatic variables that have been observed in recent decades can only be accounted for if anthropogenic, as well as natural, factors are considered, and under enhanced greenhouse gas forcing the frequency of some of these extreme events is likely to change (IPCC, 2007; Alexander et al., 2007). Folland et al. (2001) showed that in some regions both temperature and precipitation extremes have already shown amplified responses to changes in mean values. Extreme climatic events, such as heat waves, floods and droughts, can have strong impact on society and ecosystems and are thus important to study (Moberg and Jones, 2005).

Climate change is characterized by variations of climatic variables both in mean and extremes values, as well as in the shape of their statistical distribution (Toreti and Desiato, 2008) and knowledge of climate extremes is important for everyday life and plays a critical role in the development and in the management of emergency situations. The study of climate change using climate extremes is rather complex, and can be tackled using a set of suitable indices describing the extremes of the climatic variables.

The Expert Team on climate change detection, monitoring and indices, sponsored by WMO (World Meteorological Organization) Commission for Climatology (CCI) and the Climate Variability and Predictability project (CLIVAR), an international research program started in 1995 in the framework of the World Climate Research Programme, has developed a set of indices (Peterson et al., 2001) that represents a common guideline for regional analysis of climate.

It is widely conceived that with the increase of temperature, the water cycling process will be accelerated, which will possibly result in the increase of precipitation amount and intensity. Wang et al. (2008), show that many outputs from Global Climate Models (GCMs) indicate the possibility of substantial increases in the frequency and magnitude of extreme daily precipitation. These increases are also seen in observed data. Karl and Knight (1998) found that the 8% increase in precipitation across the contiguous United States since 1910 is reflected primarily in heavy and extreme daily precipitation events. These results were confirmed in Kunkel et al. (1999) that found national trend in short duration (1-7 days) extreme precipitation events for the United States upward at a rate of 3% decade^{-1} for the period between 1931 and 1996.

Many studies investigated climate change and extremes on a very large scale (Easterling et al., 2000; Vincent et al., 2005; Haylock et al., 2006) or at national levels (Brunetti et al., 2006) but few of them made this on a local scale, using a great number of weather stations (Brunetti et al., 2004; Santos and Brito, 2007). The Intergovernmental Panel on Climate Change (IPCC) in its reports (2001 and 2007) evidenced the need for more detailed information about regional patterns of climate change. Dufek and Ambrizzi (2008) affirm that the factors identified through the analysis of recent climate variability can also be important in understanding future changes.

The climate features of Utah State in the United States is determined by its distance from the equator; its elevation above sea level; the location of the State with respect to the average storm paths over the Intermountain Region; and its distance from the principal moisture sources of the area, namely, the Pacific Ocean and the Gulf of Mexico. Also, the mountain ranges over the western United States, particularly the Sierra Nevada and Cascade Ranges and the Rocky Mountains, have a marked influence on the climate of the State. The prevailing westerly air currents reaching the Utah State are comparatively dry, resulting in light precipitation over most of the State. There are definite variations in temperature with altitude and with latitude (Moller and Gillies, 2008). Consequently, in case of a local variability in climate change, it is important to know which areas of this region could be more affected by these changes and thus, more at risk directly for human health, and indirectly for human activities.

This study attempts to provide new information on trends, in regional scale, using long-term records of daily air temperature over Utah State, USA, through the analysis of different indices based on observational data from several stations in the region. This analysis is important for Utah State since any change in climate can have large impacts on the daily life of the population and environment.

2. MATERIAL AND METHODS

2.1 Data and quality control

Daily maximum and minimum surface air temperature data were taken from 28 meteorological stations across the Utah State, USA, between 37 - 41º N latitude and 109 - 114º W longitude and, in general, for the period between 1930 – 2006. The station locations are shown in Figure 1; the numbers indicating the stations and their names and locations are shown in Table 1. The Utah Climate Center of Utah State University provided the data.

In this study an exhaustive data quality control was applied, because indices of extremes are sensitive to changes in station, exposure, equipment, and observer practice (Haylock

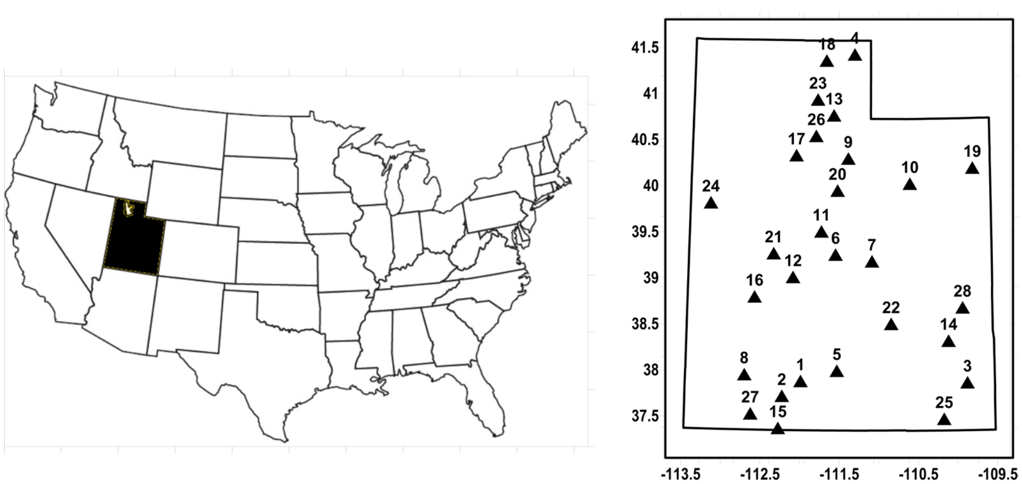

Figure 1 - Map of the USA with highlight to Utah State (a); and map of Utah State with the locations of the stations used in this study (b). The numbers indicate the name, latitude, longitude and elevation of the stations presented in Table 1. In general, the time series is between 1930 and 2006.

Table 1 - Meteorological stations used for the analysis of maximum and minimum daily temperature in Utah State, USA

ID	STATION	LAT (N)	LON (W)	START	END	ELEVATION (m)
1	Bryce Canyon	37.633	-112.183	1930	2006	2440
2	Alton	37.440	-112.482	1930	2006	2181
3	Blanding	37.613	-109.485	1930	2006	1841
4	Laketown	41.825	-111.321	1930	2006	1823
5	Escalante	37.769	-111.598	1930	2006	1757
6	Manti	39.258	-111.631	1930	2006	1732
7	Castle Dale	39.174	-111.029	1930	2006	1725
8	Cedar City	37.709	-113.094	1930	2006	1713
9	Heber	40.491	-111.426	1930	2006	1704
10	Duchesne	40.168	-110.395	1930	2006	1684
11	Levan	39.554	-111.867	1932	2006	1616
12	Fillmore	38.966	-112.328	1940	2005	1556
13	Morgan Power	41.043	-111.672	1930	2006	1546
14	Canyonlands	38.150	-109.782	1930	2006	1537
15	Kanab	37.027	-112.537	1930	2006	1528
16	Black Rock	38.708	-112.953	1932	2006	1482
17	Toole	40.527	-112.298	1930	2006	1470
18	Logan	41.745	-111.803	1930	2006	1458
19	Jehsen	40.364	-109.345	1940	2006	1446
20	Spanish Fork	40.079	-111.604	1930	2006	1437
21	Deseret	39.267	-112.652	1930	2006	1384
22	Hanksville	38.371	-110.715	1930	2006	1360
23	Ogden	41.244	-111.946	1930	2006	1327
24	Callao	39.899	-113.713	1930	2006	1324
25	Mexican Hat	37.149	-109.868	1930	2006	1296
26	Salt Lake City	40.778	-111.969	1930	2006	1296
27	Zion□s National Park	37.208	-112.984	1930	2006	1235
28	Moab	38.574	-109.546	1930	2006	1220

et al., 2006). Data Quality Control (QC) is a prerequisite for determining climatic indices. The quality control of RClimdex software performs the following procedure: 1) Replaces all missing values (currently coded as -99.9) into an internal format that the software recognizes (i.e. NA, not available), and 2) Replaces all unreasonable values into NA. Those values include daily maximum temperature less than daily minimum temperature. In addition, QC also identifies outliers in daily maximum and minimum temperature. The outliers are daily values outside a region defined by the user. Currently, this region is defined as *n* times standard deviation (*sdt*) of the value for the day, that is, (mean – *n* x *std*, mean + *n* x *std*), where *std* for the day and *n* is an input from the user (Zhang and Yang, 2004; Vincent et al., 2005). Initially, data from 50 meteorological stations were available, and after the QC, only stations with less than 10% of missing data for a period of at least 50 years were considered resulting in 28 locations (Table 1).

2.2 Methodology

In this study the RClimdex 1.0 software developed by Zhang and Yang (2004) at the Canadian Meteorological Service was used to obtain the climatic extremes indices following methodologies of Zhang et al. (2005) and Haylock et al. (2006). RClimdex provides 27 indices in total (including temperature and precipitation indices). However, only 11 indices based on air temperature data were chosen for discussion here (Table 2) that better explain the climate behavior of Utah State. The resulting series were analyzed through trends. The slopes of the annual trends and their statistical significance to climate indices were calculated based on non-parametric Mann–Kendall test and least square method in order to detect trends within the time series. The Mann–Kendall test has proven to be useful in determining the possible existence of statistically significant trends assuming a 95% probability level (Haylock et al., 2006;

Dufek and Ambrizzi, 2008). The products of the test are the statistics S and Z. A positive value of S indicates upward trend and a negative value a downward trend while Z determines the significance or the acceptance or rejection of the null hypothesis, H_0, which states that the dataset is formed by n independent and identically distributed random variables. When H_0 is rejected at a given significance level, α, one can say that the dataset has a significant trend (Satyamurty et al, 2008). Further details can be obtained in Partal and Kahya (2006).

To run the RClimdex 1.0 software the input data file has several requirements: 1) ASCII text file; 2) Columns sequence: Year, Month, Day, Precipitation (PRCP), Maximum air temperature (TMAX), and Minimum air temperature (TMIN). (NOTE: PRCP units = millimeters and TMAX and TMIN units = degrees Celsius); 3) the format as described above was space delimited (e.g. each element was separated by one or more spaces); 4) for data records, missing data were coded as -99.9 (in this study the precipitation values were replaced by -99.9) and data records were in calendar date order (Zhang and Yang, 2004).

The spatial distribution of the indices trends obtained using Mann-Kendall test was represented using the symbols (✚) for positive trends, and (●) for negative trends, statistically significant at 95% level, i.e. p<0.05. The representation of the trends which are statistically non-significant used the symbols (+) for positive trends, and (O) for negative trends.

3. RESULTS

Table 3 shows the decadal trends of the extreme indices of air temperature in Utah State for 28 locations. The bold and highlighted values represent significant level of 5% (p<0.05), and values only highlighted represent significant level of 10% (0.05<p<0.1). The analyses presented in this study are only those trends that showed significance at 5% level. The index *Summer Days* (SU) showed 10 stations with positive trend and 3 stations with negative trend, evidencing an increase in the annual number of days when the maximum air temperature was higher than 25ºC. The spatial distribution of the trends of this index is shown in Figure 2. The index *Iced Days* (ID) showed 7 stations with negative trends, 1 station with positive trend and one station (Laketown) that did not present any trend (trend = 0), showing that the annual number of days when the maximum air temperature was less than 0ºC is decreasing. These results are in agreement with the results shown by SU index. Figure 3 shows the spatial distribution trends of ID index; in general, the significant values are in the southern portion of the studied area. It is possible to identify the heterogeneous behavior of the indexes presenting positive and negative trends, indicating a possible influence of local factors. These results are in agreement with those of Karl and Knight (1998).

Tropical Nights (TR) index shows 8 stations with positive trends and 1 station with no trend. These results evidence that the annual number of days when the minimum air temperature was higher than 20ºC is increasing and the spatial distribution is shown in Figure 4, presenting predominant increase in the northern and eastern areas of Utah State. The *Frost Days* (FD) index presented only negative trends (15 stations) as shown in Figure 5 evidencing the homogeneous behavior of this index in the studied area. The *Max Tmax* (TXx) index, i.e. monthly maximum value of daily maximum temperature, presented 13

Table 2 - Definition of extreme air temperature indices used in this study

Indices	Name	Definition	Units
SU	Summer Days	Annual count when TX(daily maximum)>25ºC	Days
ID	Iced Days	Annual count when TX(daily maximum)<0ºC	Days
TR	Tropical Nights	Annual count when TN(daily minimum)>20ºC	Days
FD	Frost days	Annual count when TN(daily minimum)<0ºC	Days
TXx	Max Tmax	Monthly maximum value of daily maximum temp	ºC
TNx	Max Tmin	Monthly maximum value of daily minimum temp	ºC
TXn	Min Tmax	Monthly minimum value of daily maximum temp	ºC
TNn	Min Tmin	Monthly minimum value of daily minimum temp	ºC
WSDI	Warm spell duration indicator	Annual count of days with at least 6 consecutive days when TX>90th percentile	Days
CSDI	Cold spell duration indicator	Annual count of days with at least 6 consecutive days when TN<10th percentile	Days
DTR	Diurnal temperature range	Monthly mean difference between TX and TN	ºC

Table 3 - Definition of extreme air temperature indices used in this study

STATION	SU	ID	TR	FD	TXx	TXn	TNx	TNn	WSDI	CSDI	DTR
Bryce Canyon	-1.88	**2.53**	0	**-3.33**	0.14	0.39	0.20	**1.21**	-0.16	-0.63	**-0.49**
Alton	**5.45**	**-1.25**	-0.01	0.09	**0.41**	**0.32**	**-0.18**	**0.26**	**1.90**	-0.17	**0.28**
Blanding	**2.84**	**-1.07**	0.02	**-2.75**	**0.34**	**0.31**	0.07	**0.53**	**2.41**	**-0.67**	-0.03
Laketown	**-1.31**	**0.00**	**0**	**-1.94**	**-0.15**	-0.07	0.04	0.30	**-0.61**	-0.30	**-0.20**
Escalante	**4.07**	**-1.80**	0.05	**-4.41**	**0.52**	**1.03**	**0.31**	**1.04**	**3.75**	**-0.55**	-0.05
Manti	0.03	0.44	**0.03**	**-0.93**	**0.10**	-0.13	**0.24**	**0.47**	**0.54**	-0.12	**-0.13**
Castle Dale	1.15	**-3.56**	0	0.22	0.27	**0.87**	0.10	**0.84**	**1.99**	0.02	**0.21**
Cedar City	0.26	-0.28	0.05	-0.51	**0.19**	0.37	0.11	**0.65**	**1.20**	-0.29	0
Heber	**0.72**	-0.19	0	**-2.58**	0.03	0.13	0.07	**0.38**	**0.96**	**-0.33**	**-0.15**
Duchesne	**0.75**	**-1.22**	-0.01	**-3.29**	**0.10**	0.03	**0.18**	**0.67**	0	**-1.62**	**-0.25**
Levan	0.39	0.05	0.02	0	**0.28**	0.08	0.01	**0.41**	0.21	-0.18	-0.02
Fillmore	**-1.74**	**1.46**	-0.03	**-2.24**	**-0.31**	-0.28	0.01	0.32	**-0.76**	-0.10	**-0.27**
Morgan Power	-0.06	-0.35	**0.03**	**-7.32**	**0.26**	0.38	**0.47**	**1.13**	0.75	**-1.41**	**-0.45**
Canyonlands	-0.28	-1.11	**3.79**	-2.71	**0.34**	0.48	**0.45**	**0.99**	-0.13	-0.20	**-0.34**
Kanab	0.03	-0.14	-0.11	-2.07	-0.06	0.15	0.02	**0.74**	-0.51	**-0.52**	**-0.15**
Black Rock	0.20	0.36	0.04	**-3.33**	0.04	0.32	0.07	0.54	-0.81	-0.38	**-0.23**
Toole	**1.68**	-0.45	**0.68**	-0.57	**0.14**	**0.19**	0.04	0.17	**1.08**	0.01	**0.07**
Logan	0.42	-0.02	0.01	**-1.04**	0	0.05	-0.02	**0.31**	**0.51**	**-0.60**	**-0.06**
Jehsen	0.93	**-2.35**	-0.01	**-1.99**	0.11	**0.71**	0.07	**0.73**	0.89	-0.45	-0.13
Spanish Fork	**-1.34**	0.77	0.08	**-2.06**	**-0.18**	0.02	0.08	**0.33**	**-0.75**	**-0.66**	**-0.21**
Deseret	**0.79**	0.03	0.05	-0.51	**0.21**	-0.06	-0.01	0.19	0	-0.62	-0.04
Hanksville	**2.50**	-0.67	0.31	-0.60	**0.55**	0.25	**0.29**	0.29	0.71	**-0.72**	0
Ogden	**1.10**	-0.12	**0.82**	**-2.24**	**0.12**	0.03	**0.17**	**0.48**	-0.03	**-0.35**	**-0.17**
Callao	**5.29**	**-2.98**	**0.68**	**-3.40**	**0.73**	**1.08**	**0.64**	0.54	0.51	-1.31	0.19
Mexican Hat	**4.68**	**-2.17**	**4.50**	-3.88	0.14	**2.01**	**0.72**	1.02	1.53	**-2.51**	-0.06
Salt Lake City	0.18	-0.81	**1.96**	**-3.77**	0.06	0.29	**0.30**	**0.63**	0.07	**-0.87**	**-0.24**
Zion's N. Park	**1.02**	-0.06	-0.43	**-1.20**	**0.12**	**0.30**	-0.02	0.11	**1.15**	0.03	**0.12**
Moab	**3.75**	**-1.95**	0.88	0.08	**0.57**	**1.01**	0.13	**0.96**	**2.96**	-0.16	**0.40**

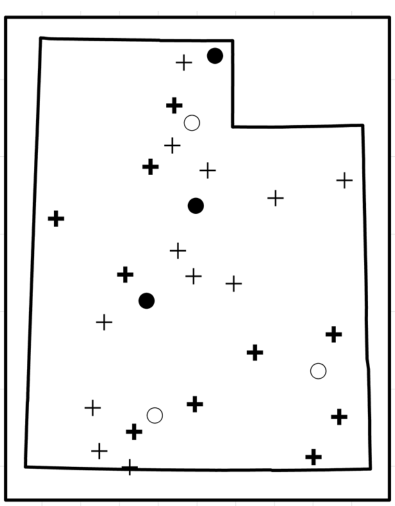

Figure 2 - Spatial distribution of trends of SU index to Utah State. The symbols (+), for positive trends, and (•) for negative trends, statistically significant at 95% level ($p<0.05$), and (+) for positive trends, and (O), for negative trends (non-significant at 95% level).

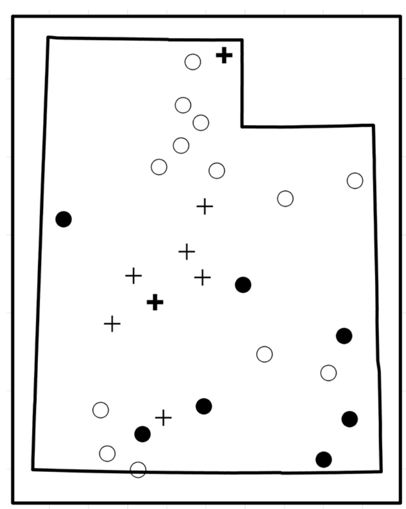

Figure 3 - Spatial distribution of trends of ID index to Utah State. The symbols (+), for positive trends, and (•) for negative trends, statistically significant at 95% level ($p<0.05$), and (+) for positive trends, and (O), for negative trends (non-significant at 95% level).

stations with positive trends and 3 stations with negative trends, showing a predominant increase in the monthly maximum value of daily maximum temperature in this area (Figure 6). It is possible to observe in *Min Tmax* (TXn) index a similar behavior, with only positive trends (9 stations), evidencing that the monthly minimum value of daily maximum temperature is increasing as well. The spatial distribution is shown in Figure 7 and these results show an increase in the temperature in the studied area. The *Max Tmin* (TNx) index, i.e. monthly maximum value of daily minimum air temperature, shows 9 stations with positive trends and 1 station with negative trend (Figure 8). The *Min Tmin* (TNn) index presented a similar behavior with only positive trends (15 stations), evidencing that the minimum temperature is increasing in this region (Figure 9). The increase of the air temperature in the study area was also identified by Karl and Knight (1998) and Alexander et al. (2007).

The *Warm Spell Duration Indicator* (WSDI) index, that represents the annual count of days with at least 6 consecutive days on which TX is more than the 90th percentile, showed 9 stations with positive trends and 2 stations with negative trends

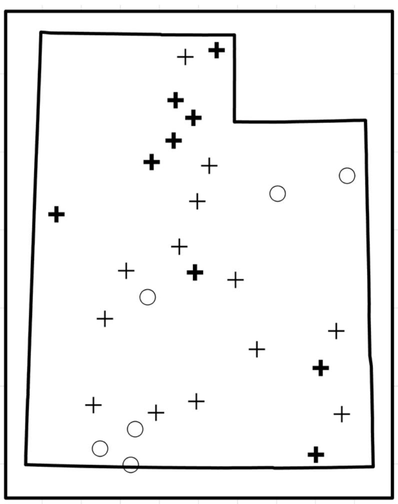

Figure 4 - Spatial distribution of trends of TR index to Utah State. The symbols (+), for positive trends, and (•) for negative trends, statistically significant at 95% level ($p<0.05$), and (+) for positive trends, and (O), for negative trends (non-significant at 95% level).

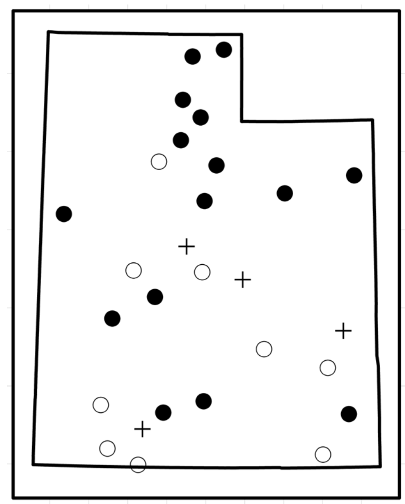

Figure 5 - Spatial distribution of trends of FD index to Utah State. The symbols (+), for positive trends, and (•) for negative trends, statistically significant at 95% level ($p<0.05$), and (+) for positive trends, and (O), for negative trends (non-significant at 95% level).

Table 4 - The percentage of stations showing significant and not significant trends at the 5% level for the temperature indices for Utah State, USA

INDICE	Positive significant trend (%)	Positive not significant trend (%)	Negative significant trend (%)
SU	35.7	42.9	10.7
ID	7.1	21.4	25
TR	32.1	46.4	0
FD	0	14.3	53.6
GSL	14.3	60.7	0
TXx	46.4	39.3	10.7
TXn	32.1	53.6	0
TNx	32.1	53.6	3.6
TNn	53.6	46.4	0
WSDI	32.1	39.3	7.1
CSDI	0	10.7	28.6
DTR	14.3	14.3	50

(Figure 10), evidencing the increase of warm spell duration. Figure 11 shows the spatial distribution of *Cold Spell Duration Indicator* (CSDI) index that represents the annual count of days with at least 6 consecutive days where TN is less than the 10th percentile. Table 3 shows that the CSDI index presented only negative trends (8 stations) evidencing that cold spell durations are decreasing; this result is in agreement with the result presented by the WSDI. In addition, *Diurnal Temperature Range* (DTR) index shows negative trends to 14 stations and positive trends to 4 stations (Figure 12), evidencing that the monthly mean difference between maximum and minimum temperature is decreasing in the studied area. These results are in agreement with the results obtained for TXx, TXn, TNx and TNn indices. There is a similar pattern in the results obtained by Alexander et al. (2007).

To assist with the interpretation of figures that involve analyses of temperature extreme indices, the percentage of

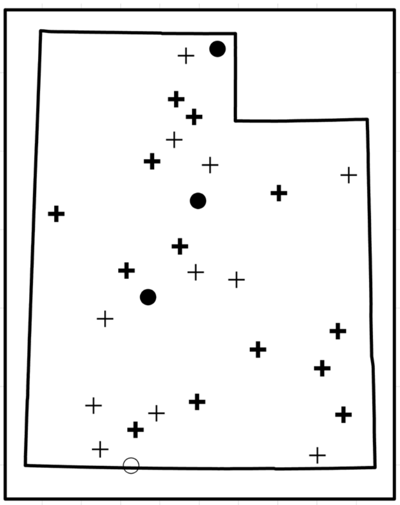

Figure 6- Spatial distribution of trends of TXx index to Utah State. The symbols (+), for positive trends, and (•) for negative trends, statistically significant at 95% level (p<0.05), and (+) for positive trends, and (O), for negative trends (non-significant at 95% level).

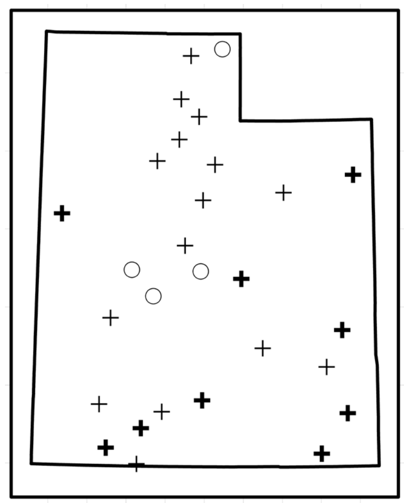

Figure 7 - Spatial distribution of trends of TXn index to Utah State. The symbols (+), for positive trends, and (•) for negative trends, statistically significant at 95% level (p<0.05), and (+) for positive trends, and (O), for negative trends (non-significant at 95% level).

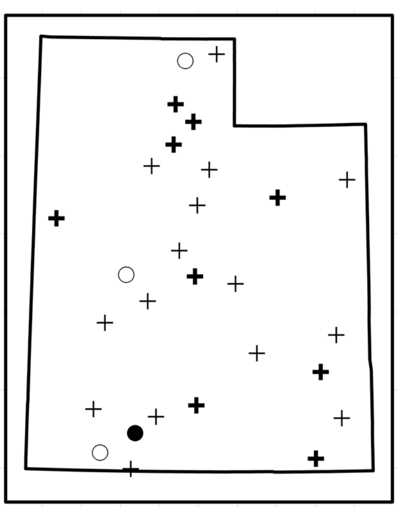

Figure 8- Spatial distribution of trends of TNx index to Utah State. The symbols (+), for positive trends, and (•) for negative trends, statistically significant at 95% level (p<0.05), and (+) for positive trends, and (O), for negative trends (non-significant at 95% level).

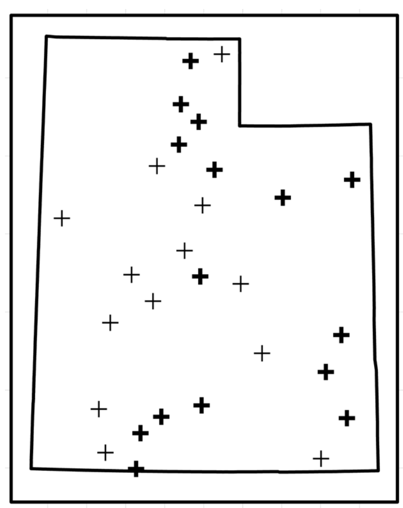

Figure 9 - Spatial distribution of trends of TNn index to Utah State. The symbols (+), for positive trends, and (•) for negative trends, statistically significant at 95% level (p<0.05), and (+) for positive trends, and (O), for negative trends (non-significant at 95% level).

stations with statistically significant and non-significant trends at the 5% level were calculated and are shown in Table 4. It is possible to see that 35.7% of the stations show a significant increase in SU, as well as 32.1% in TR, 46.4% in TXx, 32.1% in TXn, TNx and WSDI, and 53.6% in TNn, evidencing the increase of temperature. While there is a significant decrease of 25% in ID, 53.6% in FD, 28.6% in CSDI and 50% in DTR, evidencing a decrease in these indices and agreeing with the results shown previously.

The indices results, except TR, FD, TXn, TNn and CSDI, present heterogeneous behavior, i.e. positive and negative

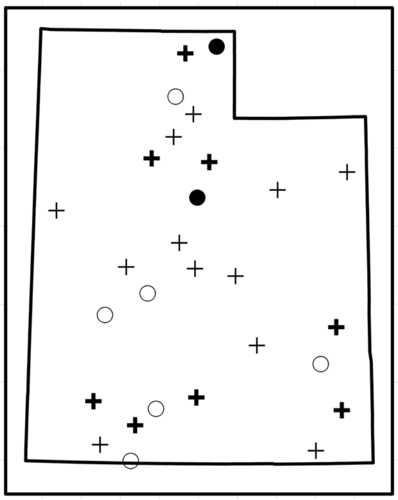

Figure 10 - Spatial distribution of trends of WSDI index to Utah State. The symbols (+), for positive trends, and (•) for negative trends, statistically significant at 95% level ($p<0.05$), and (+) for positive trends, and (O), for negative trends (non-significant at 95% level).

significant trends ($p<0.05$), and evidencing the influence of local factors such as urbanization and topography. For example, Laketown station has an elevation of 1.823m above sea level (only Bryce Canyon, Alton and Blanding locations have higher elevation), and presented different signal of the trends for SU, ID, TXx and WSDI indices, indicating its topography influence.

4. CONCLUSIONS

This study presents analyses of the trends in eleven annual extreme indices of air temperature for Utah State, USA. The analyses were done for 28 meteorological stations, in general, for a period between 1930 and 2006, which characterizes a long-term period and with high quality data set.

An increase was seen in the annual number of days when the maximum air temperature was higher than 25ºC and a decrease is seen in the annual number of days when the maximum air temperature was less than 0ºC, showing that this decrease has occurred in the southern portion of Utah. The annual number of days when the minimum temperature was higher than 20ºC is increasing predominantly in the Northern and Eastern areas of the studied area. The number of days, when the daily minimum temperature is below zero, showed only negative trends with homogeneous behavior in the studied area. A predominant increase was identified in the monthly maximum value of daily maximum air temperature and monthly minimum value of daily maximum air temperature, and the warm spell duration increased while the cold spell duration decreased. The monthly mean difference between maximum and minimum

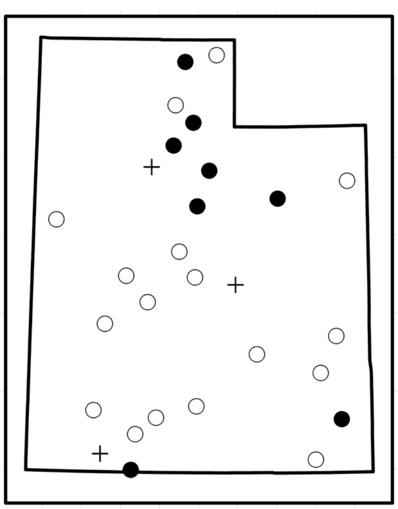

Figure 11 - Spatial distribution of trends of CSDI index to Utah State. The symbols (+), for positive trends, and (•) for negative trends, statistically significant at 95% level ($p<0.05$), and (+) for positive trends, and (O), for negative trends (non-significant at 95% level).

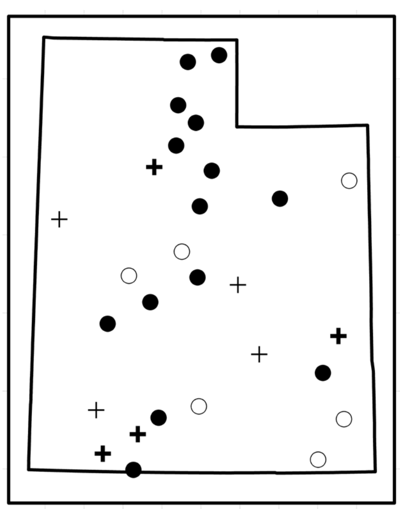

Figure 12 - Spatial distribution of trends of DTR index to Utah State. The symbols (+), for positive trends, and (•) for negative trends, statistically significant at 95% level ($p<0.05$), and (+) for positive trends, and (O), for negative trends (non-significant at 95% level).

temperatures has also decreased. These analyses identified the temperature increase in Utah State during the last century.

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