Temperature Variable Trends for High Elevations of the Southern Appalachians 1951-2015

Ryan P. Shadbolt, Ph.D. (shadb1rp@cmich.edu)
Department of Geography, Central Michigan University, Mount Pleasant, Michigan, 48859

ABSTRACT

Low-elevation sites placed less than 1000 meters above sea level overwhelmingly represent surface observations throughout the southern Appalachian region. Given that high-elevation environments often possess similar climates and ecosystems to high-latitude environments, it is hypothesized that such high-elevation sites may have experienced different trends when compared to the overall cooling trend documented for the region. Monthly observation summaries from the Global Historical Climatology Network spanning 1951-2015 all ready indicate that statistically significant warming trends are indeed present for minimum temperature, maximum temperature, mean temperature, extreme minimum temperature, and extreme maximum temperature for stations located at elevations exceeding 1000 meters above sea level. In this new study additional temperature-derived variables are considered: cooling degree days (CLDD), heating degree days (HTDD), the number of days in a month where minimum temperature ≤ 0 °F (DT00), the number of days in a month where minimum temperature ≤ 32 °F (DT32), the number of days in a month where maximum temperature ≥ 90 °F (DT90), and number of days in a month where maximum temperature ≤ 32 °F (DX32). Statistically significant trends were more common in the 1000-1499 meters above sea level range compared to the ≥ 1500-meter category. Results generally show that cooling degree days and the number of warm days increased, while heating degree days and the number of cold days decreased over the 65-year study period.

METHODS

All monthly values were determined by calculating the mean value of the variable from all daily observations collected during the month. Missing daily observations were common and impact monthly values. To minimize the impact of missing observations, stations needed to report at least 75% of the daily observations in a month for the monthly value to be included in the climatology. Stations were subdivided into two categories: 1000-1499 m and ≥ 1500 m above sea level. For each month and year the number of stations reporting a value was determined. A complete period of record was necessary to make conclusions about temporal trends so at least one station in each elevation category was necessary for a month and year to be included. Given the above criteria, the period of record is 1951-2015.

Beginning with January 1951, all reporting stations for each elevation category were used to determine the mean value of each variable. The same process was repeated for each subsequent year in order to create a temporal trend of each variable. Next, a Pearson's correlation was computed for each variable at each elevation category, as well as the two-sided deviation. Deviation values of ≤ 0.05, ≤ 0.01, and ≤ 0.001 were deemed as statistically significant. A linear fitted line was calculated for each time series. The difference between the ending (2015) and starting (1951) values of the linear fit was used to express the linear temporal trend of each variable over the 65-year period.

RESULTS FOR 1000-1499 m

Fig. 1 shows the location of 13 stations positioned at 1000-1499 m. Table 1 highlights all monthly trend values from the six temperature variables. All months show an increase in the number of cooling degree days with five statistically significant values. July is included as an example (Fig. 2). Heating degree days decreased for all months with seven significant values. No significant values existed for trends of days when minimum temperature ≤ 0 °F. However, for days when minimum temperature was ≤ 32 °F nearly all months had decreasing trends with five significant values. For number of days when maximum temperature ≥ 90 °F, February had a significant increase. Lastly, variability existed in trends for the number of days when maximum temperature was ≤ 32 °F. October experienced a significant increase, while November had a significant decreasing trend.

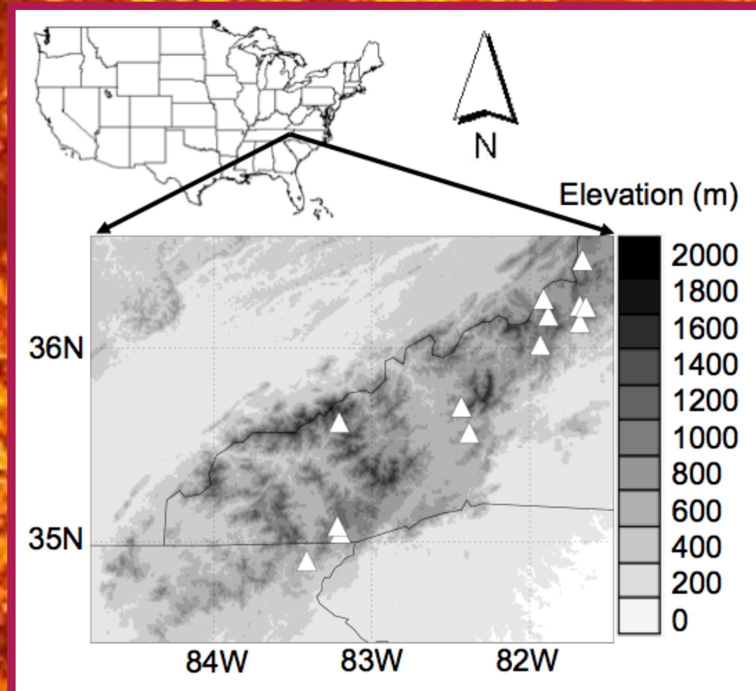

Fig. 1. Study site bounded by 34.50 to 36.55 °N and 81.50 to 84.75 °W. Elevation in meters above sea level is in gray tones. Triangles indicate 13 stations at elevation of 1000-1499 m.

Table 1. Temporal changes over 1951-2015 for stations located at 1000-1499 m elevation above sea level in the southern Appalachians. Monthly values of cooling degree days (CLDD), heating degree days (HTDD), number of days in a month where minimum temperature ≤ 0 °F (DT00), number of days in a month where minimum temperature ≤ 32 °F (DT32), number of days in a month where maximum temperature ≥ 90 °F (DT90), and number of days in a month where maximum temperature ≤ 32 °F. (DX32). Statistically significant values in bold are indicated by * for values significant at ≤ 0.05, ** for values significant at ≤ 0.01, and *** for values significant at ≤ 0.001.

Month	CLDD	HTDD	DT00	DT32	DT90	DX32
January	+16.15	-43.07	-0.43	-2.04	+0.41	-0.53
February	+1.11	-41.33	-0.64	-0.94	**+0.06***	+0.23
March	+0.08	**-75.70****	-0.04	**-5.19****	0.00	-0.83
April	**+8.02***	**-42.15***	0.00	**-3.21***	+0.18	+0.10
May	**+5.52***	-25.33	0.00	-0.61	0.00	0.00
June	**+18.22***	**-26.57****	0.00	-0.09	+0.10	0.00
July	**+32.61*****	-6.79	0.00	0.00	+0.11	0.00
August	**+23.04***	**-9.21***	+0.01	+0.07	+0.10	+0.04
September	+6.47	**-25.39***	+0.01	-0.24	-0.10	+0.01
October	+0.16	-33.40	0.00	**-3.48****	+0.04	**+0.22***
November	+0.05	**-62.22****	-0.07	**-4.66****	0.00	**-1.13***
December	+7.37	**-77.94***	-0.52	**-4.42***	+0.20	-1.44

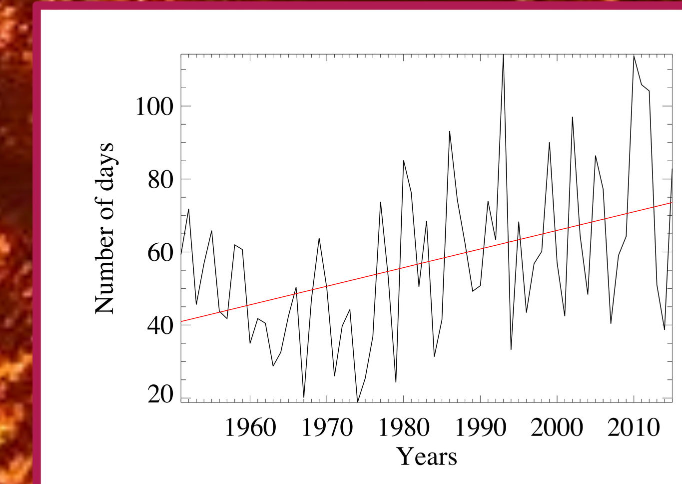

Fig. 2. Trend (black) and linear fit (red) for cooling degree days (CLDD) during July for elevations 1000-1499 m over 1951-2015.

Background photo credit: National Park Service

RESULTS FOR ≥ 1500 m

Fig. 3 shows the location of seven stations positioned at ≥ 1500 m. Table 2 shows all monthly trend values from the six temperature variables. All warm season months experienced an increase in the number of cooling degree days with three statistically significant values. June is included as an example (Fig. 4). Heating degree days decreased for most months with June having a significant trend. There was a significant decreasing trend during November for days when minimum temperature ≤ 0 °F. Also, for days when minimum temperature was ≤ 32 °F there was a significant decreasing trend for the month of March. No significant trends existed for the number of days when maximum temperature ≥ 90 °F or for the number of days when maximum temperature was ≤ 32 °F.

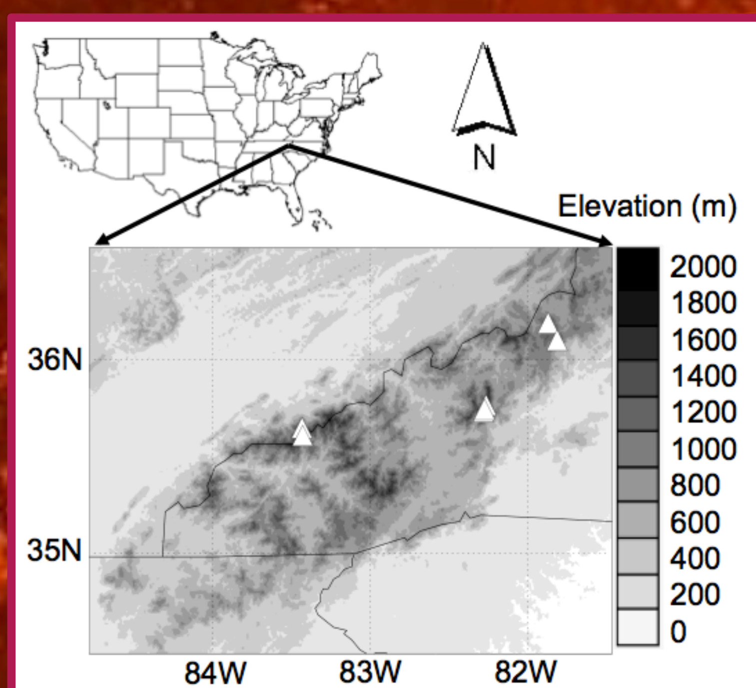

Fig. 3. Study site bounded by 34.50 to 36.55 °N and 81.50 to 84.75 °W. Elevation in meters above sea level is in gray tones. Triangles indicate 7 stations at elevation of ≥ 1500 m.

Table 2: Temporal changes over 1951-2015 for stations located at ≥ 1500 m elevation above sea level in the southern Appalachians. Monthly values of cooling degree days (CLDD), heating degree days (HTDD), number of days in a month where minimum temperature ≤ 0 °F (DT00), number of days in a month where minimum temperature ≤ 32 °F (DT32), number of days in a month where maximum temperature ≥ 90 °F (DT90), and number of days in a month where maximum temperature ≤ 32 °F. (DX32). Statistically significant values in bold are indicated by * for values significant at ≤ 0.05, ** for values significant at ≤ 0.01, and *** for values significant at ≤ 0.001.

Month	CLDD	HTDD	DT00	DT32	DT90	DX32
January	0.00	+6.11	+0.73	-1.49	0.00	+0.56
February	0.00	-2.32	-1.13	+0.30	0.00	-0.26
March	0.00	-50.03	+0.13	**-4.33***	0.00	-1.69
April	+0.09	-24.92	+0.02	-1.38	0.00	+0.07
May	**+0.84****	-18.32	+0.03	-0.01	0.00	-0.04
June	**+4.37****	**-29.64***	0.00	-0.17	+0.02	+0.06
July	**+10.36***	-21.56	0.00	+0.05	+0.02	0.00
August	+6.04	-18.01	0.00	+0.02	0.00	0.00
September	+0.60	-19.34	0.00	+0.07	0.00	+0.01
October	+0.03	-13.50	+0.01	-0.40	0.00	+0.48
November	0.00	-45.76	**-0.35***	-1.61	0.00	-0.91
December	0.00	-55.70	-0.90	-2.33	0.00	-1.99

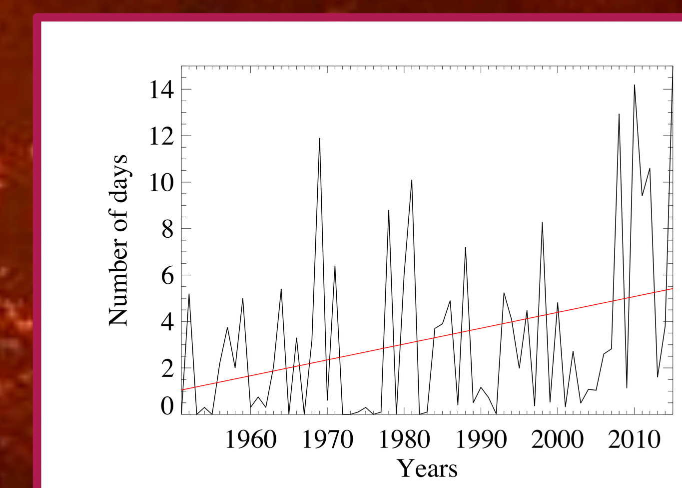

Fig. 4. Trend (black) and linear fit (red) for cooling degree days (CLDD) during June for elevations ≥ 1500 m over 1951-2015.

WANT TO KNOW MORE???

Go to the extended abstract at: https://ams.confex.com/ams/97Annual/webprogram/Paper306802.html