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Climate and Weather Trends in Hot Springs, Virginia, USA

Abstract: Changing global climate patterns pose a threat to the status quo of ecosystems, and particularly to the human societies that rely on them for their current ways of living. A region's weather is the specific daily temperature and other environmental conditions, whereas climate, which global climate change is concerned with, refers to its aggregate weather patterns weather phenomenon. Predictions for climate change's effects are of substantial and severe proportions for the world overall, but may manifest themselves differently in specific regions. For example, in Virginia's temperate boreal western Ridge and Valley region that is heavily dependent on outdoor tourism activities that depend on the health of the region, climate data, although not at all conclusive, seems to indicate that average yearly maximum temperatures have risen by only 0.005 degrees Celsius a year for the past 123 years, compared to 0.0253 estimated for the whole region of Virginia over the last century. A next step to take in exploring climate change's potential impact on this region would be to explore more in-depth the relationship between precipitation, water availability, and the functioning of the Hot Springs, and to examine actual changes in precipitation patterns over the time period examined in this study. This analysis might then be combined to give further estimates about the potential impacts of climate change to the Hot Springs region in order to create a more empowered and investged local community in the face of such a weighty issue as global climate change.

It is well-established that human-caused global climate change, largely via unprecedentedly fast emissions of greenhouse gases like Carbon Dioxide, poses a threat to the status quo of ecosystems, and particularly to the human societies that rely on them for their current ways of living (Weymann et al, 2011). Already there is evidence from many sites around the U.S. and the globe of changing climate patterns, and climate models predict an increase in average global temperatures of at least 2 degrees Celsius over the next century should greenhouse gas emission levels continue at current levels ("IPCC Fourth Assessment Report"). However, this prediction does not imply that the effects will manifest themselves everywhere evenly and similarly, nor in the manner that most people would be inclined to imagine: as a stark and uniform increase in temperature throughout the globe.

Part of the discrepancy between the popular imagination of what ought to constitute global climate change, and what the phenomenon actually implies, is due to the fact that differences in weather and climate are not well distinguished. It is the latter that global climate change, as its name implies, is principally associated with. Weather describes the actual conditions at a given time, and changes from one hour or day to another, depending on temperature, humidity, prevailing winds, and local geography. However, climate, or the patterns composed of the aggregate of these daily weather patterns over time, follows seasonal, yearly, and decadal cycles, and as such patterns ought to be predictable over longer periods, and changes in these patterns observable over longer periods as well, for a specific region. This latter point about climate being a set of region-specific patterns is s the reason why climate change's effects for any locality might not be the two degree Celsius increase predicted for the whole globe. For example, most areas of the United States are projected to increase by 2 to 2.5 degrees, but much of the central U.S. has an expected increase of 3 to 3.5 degrees, and some areas of Alaska as much as 3.5 to 4 degrees ("IPCC Fourth Assessment Report"). Therefore, a region's climate change not aligning with average predictions ought not be taken as evidence against the predictions overall.

However, it is still valuable to assess the weather and climate trends in regions of various scales and to compare them to predicted trends. One way to do this in the United States is through the weather data sets available through the National Climate Data Center (NCDC) of the National Oceanographic and Atmospheric Administration (NOAA). These encompass data collected from a variety of stations across the United States, many of them spanning as much as a century by various entities. One such rather complete data set is from the Hot Springs site in the central western region of Virginia .

Hot Springs is a small census-designated place of around 750 residents in Virginia's Bath County, situated in the Ridge and Valley region on the western border of the state. This is one of five major ecological regions in Virginia, and is characterized by characterized by long, even ridges, with long, continuous valleys in between (Fleming). The area harbors a great variety of plant life—over 50 species of trees and 2,000 of shrubs and herbaceous plants, as well as much of the wildlife common to Oak and Hickory forest environment of the region: Black bear, white-tailed deer, bobcat, bald eagles, weasel, and otter to name a few. The region's natural resources strongly informs its economic activity. Hot Springs is known particularly for the hot springs for which it is named, and most of the economy in the region derives from tourism to the springs and other outdoor activities.

The presence of a springs resort town in this location from years ago is likely the reason for the temperature and weather measurements that have been taken daily at this location since 1893 and is available from NCDC. There are several limitations to this data set. One is the exclusion, for an unexplained reason, of the years 1991-1995; therefore, these years are omitted from the analysis. Relatedly, there is no information on which entity or entities collected it over the years, nor therefore on the methodology for the collection. However, it is possible to observe that it was collected at the same location across all these years, as established by coordinates associated with the data (669 ft elevation, 38 Deg N, 79.83 Deg W). The data also contained only maximum and minimum temperatures recorded for the date, and no average temperature. Beyond that, for the purposes of this analysis, only the daily maximum temperatures were examined, and only for the first six months of the year.

Data was processed using the data-processing software RStudio server to aggregate data into monthly averages and run linear regressions to evaluate trends for each different month over the century of observations - e.g., the average temperature for maximum temperatures recorded in Januaries during this time period were evaluated via a linear regression to estimate a mean change for Januaries overall. The average for each month was then averaged into a yearly mean change. Conducting the test first on individual months helped control for variation in temperature changes between months, as well as to observe whether any changes or patterns were more pronounced during different seasons.

Of the six months (January-June) analyzed, all except January saw an mean yearly increase in average maximum recorded temperatures of 0.007, 0.003, 0.018, 0.003, and 0.011 ° Celsius for February-June, respectively. January alone saw a decrease (0.01 °C per year). However, only April's 0.018 yearly increase could be considered statistically significant (p value less than 0.05). For its part, the estimated yearly average change using the mean change for these six months was a 0.005 °C increase per year over the 123 years observed.

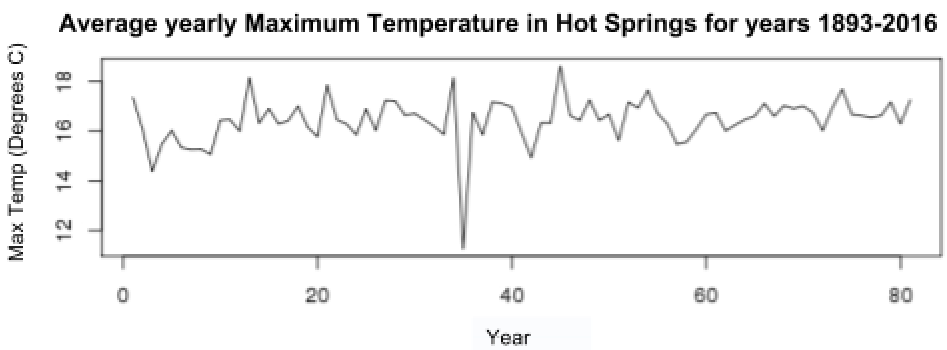

Fig. 1 - Average yearly Maximum Temperature in Hot Springs for years 1893-2016. Data seems to indicate a mean increase over this period in maximum temperature of 0.005 Deg(C)/Yr, but the conclusion is not statistically significant (p value of 0.12).

When compared to other temperature change estimates for the whole state of Virginia, this estimate seems rather low. For example, the estimate from a Climate Central (an independent organization of climate change scientists and journalists) analysis of 1912-2012 average temperature in each state in the United States, is, for Virginia, an increase of 0.456 degrees Fahrenheit increase per decade, or 0.0253 Celsius per year ("Heat is On" 2016). This is a substantially greater estimate than the 0.005 °C per year derived from the Hot Springs data.

So what could this mean for the region examined? Again, it is important to bear in mind that climate change is a complex process for which it is difficult to make exact models and processes. However, it is still worthwhile to consider the ways in which could Hot Springs be affected should Virginia's rate of climate change continue and perhaps begin or continue to have tangible effects on the Ridge and Valley region where Hot Springs is located. One aspect that stands out is precipitation, because the locality's economy depends largely on tourism to the hot springs, and most hot springs are dependent on precipitation: a spring begins with heated rain water that originally falls in valley to the north, then flows down the water gradient towards a recharge area, where the water is then funneled downward and warms as it moves through rocks in the Earth, where it is heated geothermally and then with this increase in temperature begins to move back to the surface to emerge through a crevice. It does not have time to cool before it emerges as “hot springs”. (“Follow the Water”, 2006). So the well-being of the region’s current economic and cultural status quo depends on precipitation. How might climate change affect precipitation?

In general, as temperatures rise and the air becomes warmer, more moisture evaporates from land and water into the atmosphere, which generally means more rain and snow can be expected. Again, of course, like all the other components of climate, extra precipitation will not spread evenly around the globe, and some places might actually get less precipitation than before due to climate change causing shifts in air and ocean currents, which can change weather patterns (EPA's Climate Change Indicators 2016*)*. The world is already getting more precipitation now than it did 100 years ago, nearly 2 percent more worldwide, although, again, specific effects vary by region. For example, the United States overall has seen a 6 percent increase in precipitation, but in general, the Northeast is getting more precipitation than they used to, but the South, particularly the Southwest, is becoming and predicted to continue becoming drier (“Precipitation Patterns”).

Bearing in mind the non-statistical-significance of most of the experimental data for the specific Hot Springs region, it makes sense to give weight to state trends that illustrate the presence of climate change when considering risks to the region. A next step to take in this research to explore climate change’s impact would be to explore more in-depth the relationship between precipitation, water availability, and the functioning of the Hot Springs, and to examine actual changes in precipitation patterns over the time period examined in this study. This analysis might then be combined to give further estimates about the potential impacts of climate change to the Hot Springs region in order to create a more empowered and investged local community in the face of such a weighty issue as global climate change.

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