Estimating the Global Warming Impact on Health in USA via Wet Bulb Temperature Analysis

Humidity is is a key indicator of health impact of extreme heat (heat stress). Primary tool for human body to lose heat is evaporative cooling(sweating), that has an inverse relationship with humidity. Wet Bulb Temperature (TW) is a metric of heat stress representing the minimum temperature to which human body can drop via sweating. With increased proximity of TW to the temperature of human body heat becomes intolerable and 35°C has been established as a threshold for 'unlivable' environment. However, even temperatures of 26 °C are a severe hazard for human health, espessially with pre-existing conditions.

By establishing the relationship between anthropogenically induced global warming and TW, this research aims to reveal hots spots of climate change related health risk in USA. By incorporating CMIP6 climate models data from two contrasting scenarios – SSP1-2.6 and SSP 5-8.5, this study will reveal that taking no prevention or mitigation action of atmospherically rising temperatures larger areas will be under high heat stress. CMIP5 models projected a 1.33 – 1.49°C rise of TW for a 1.5°C of atmospheric warming with +-3.7 °C of uncertainty, implying significant spatial expansion of heat stress globally. However, recently launched CMIP6 models are much more technically advanced, and have different scenarios, thus exploiting their data is vital for making more reliable projections of climate change risks.

TW is a function of Atmospheric temperature and relative humidity and is calculated with Equation 1

$$T_w = T\,\mathrm{atan}[0.151\,977(\mathrm{RH\%} + 8.313\,659)^{1/2}] + \mathrm{atan}(T + \mathrm{RH\%}) - \mathrm{atan}(\mathrm{RH\%} - 1.676\,331) + 0.003\,918\,38(\mathrm{RH\%})^{3/2}\,\mathrm{atan}(0.023\,101\mathrm{RH\%}) - 4.686\,035. \quad (1)$$

Initially, Pearson's correlation test will be used to examine relationship of atmospheric temperature and TW and Kruskal Wallis test will be used to detect whether changes of last decade are statistically significant. Figure 1 is time series plot showing that two variables are closely related, and Figure 2 is a scatter plot implying strong passive relationship that is yet to be statistically described.

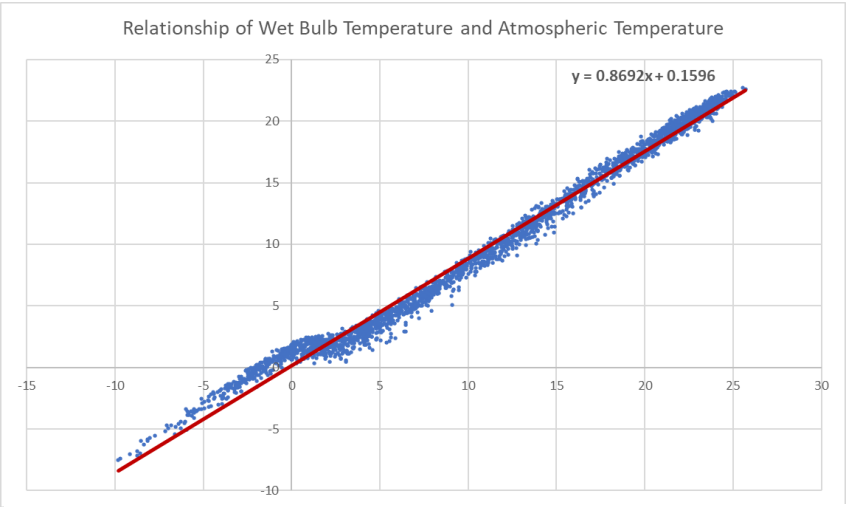


Figure1: TW & Atmospheric temperature scatter plot

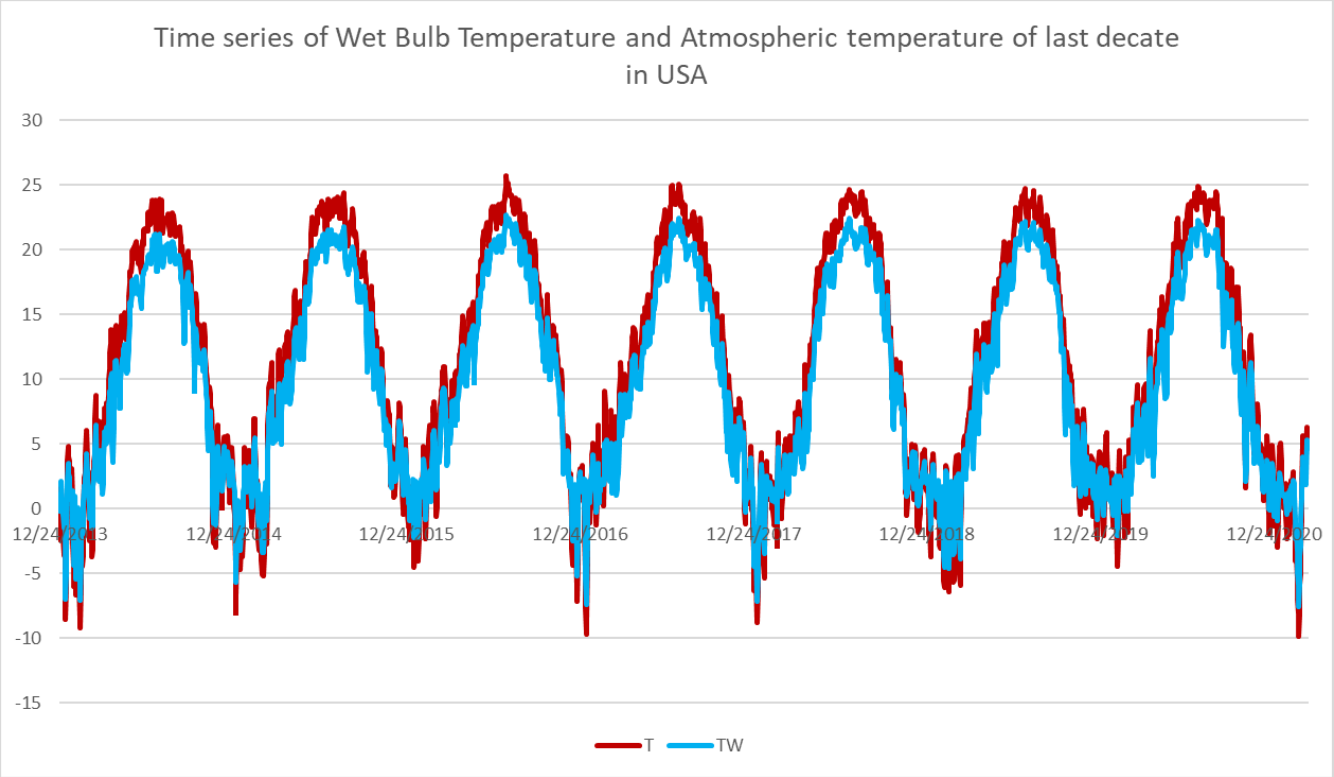
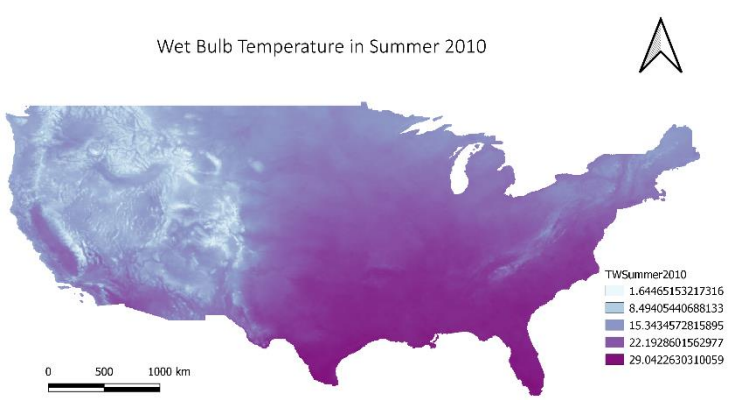
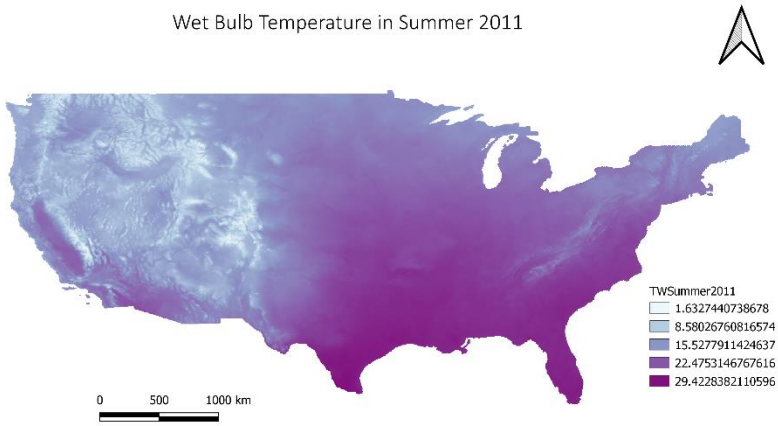


Figure 1: TW and Atmospheric temperature fluctuations

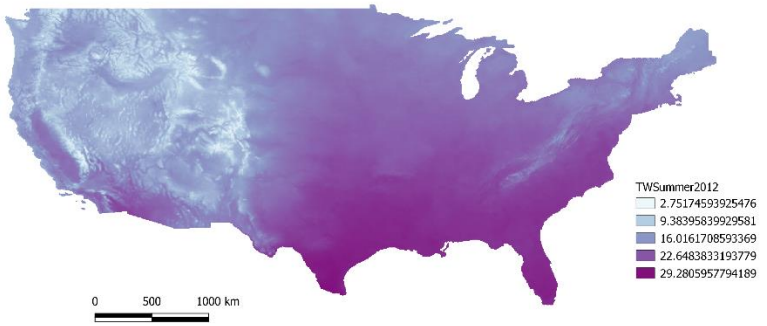
Tiff files will be downloaded from Climate Engine Data and TW temperatures will be plotted for last decade. Heat stress is more pronounces during summer, thus May-September period for each year is selected– Figure 3. This plot shows a trend of increasing minimum TW and thus is an indication that rising temperatures enhance heat stress. Next, area that is above 26 ^{o}C will be classified as under 'high risk' and surface area will be calculated for each year to reveal whether it is increasing, quantifying the extent of climate change effect on health in USA.

Lastly, CMIP6 model's data will be used to investigate two contrasting scenarios of TW progression and corresponding heat stress expansion or shrinkage. Clusters of 'high risk' will be examined to detect whether they have re-located, expanded, or lessened. If the statistical difference (Kruskal Wallis test) will be significant between 2 scenarios it reveals that mitigating climate change is necessary.

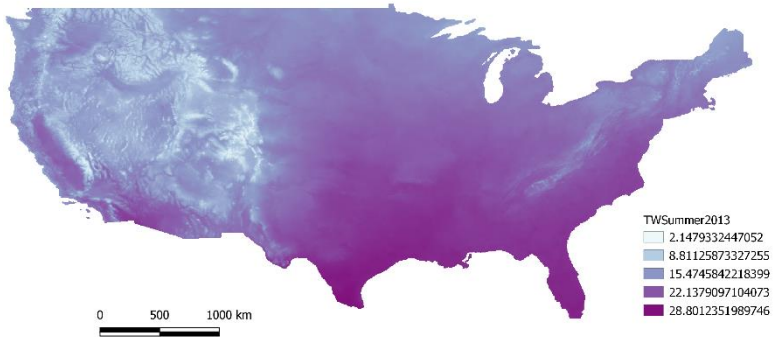




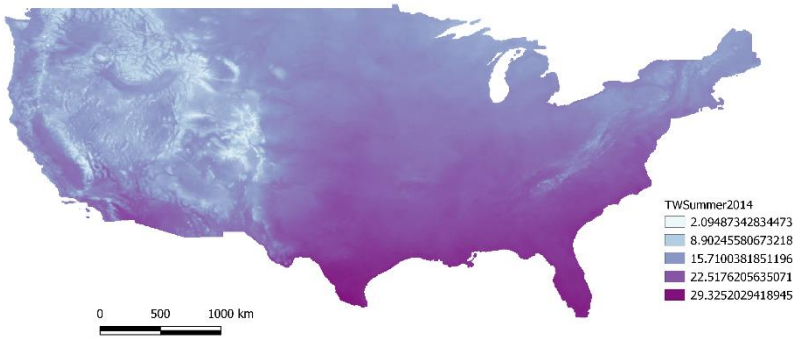
Wet Bulb Temperature in Summer 2012



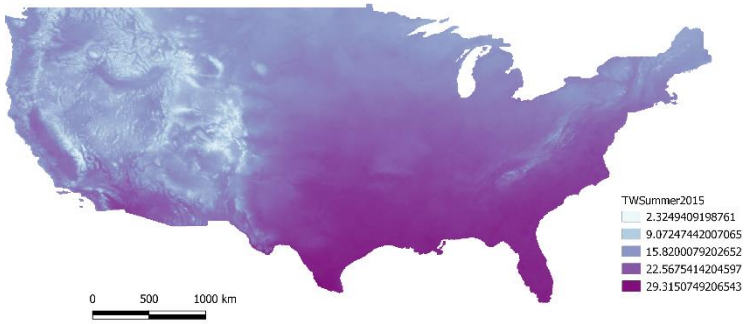
Wet Bulb Temperature in Summer 2013



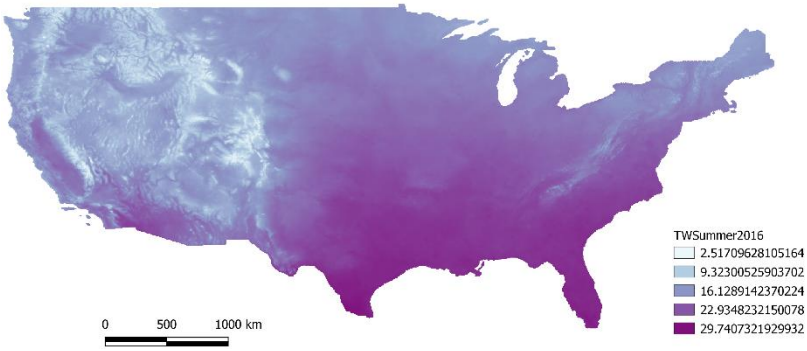
Wet Bulb Temperature in Summer 2014



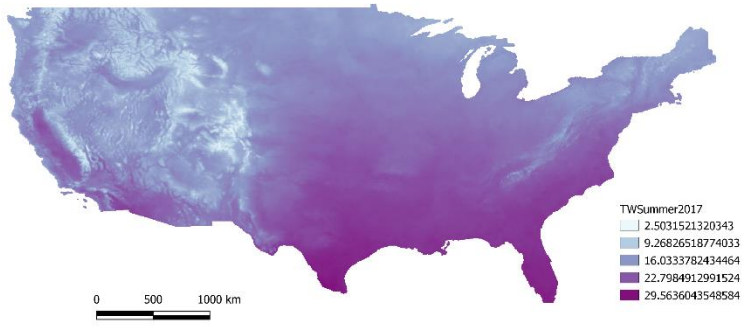
Wet Bulb Temperature in Summer 2015



Wet Bulb Temperature in Summer 2016



Wet Bulb Temperature in Summer 2017



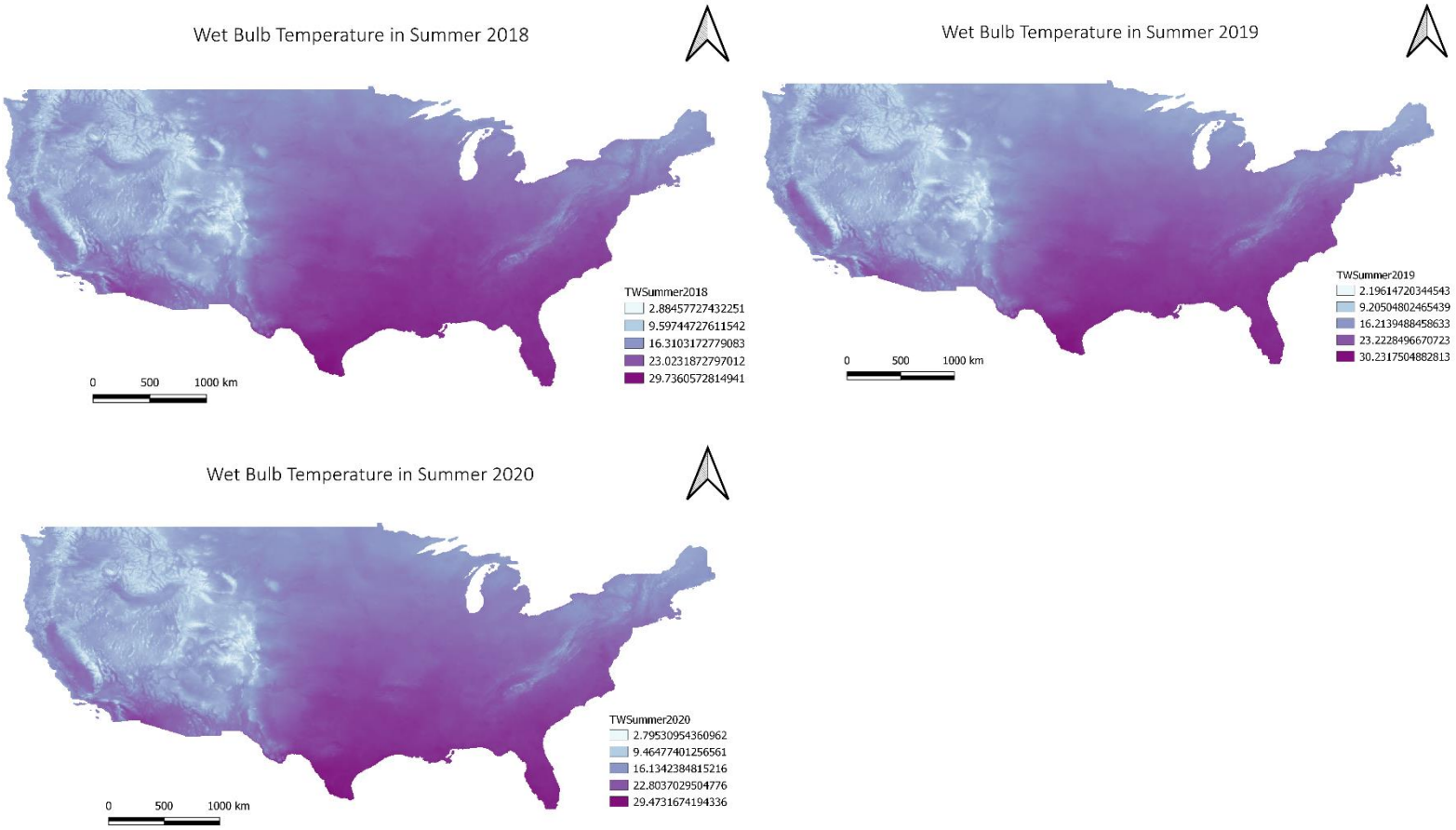


Figure 2: Spatial dynamics of TW over USA during last decade