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Day Laborers & Extreme Heat: Recommendations for Reducing Heat Stress

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Day Laborers & Extreme Heat: Recommendations for Reducing Heat Stress

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Abstract

The Intergovernmental Panel on Climate Change (IPCC) has various Global Climate Models (GCM). One of them, models three greenhouse gases. The increasing amount of greenhouse gases are just a fraction of factors that fuel global climate change. According to the IPCC 2014, climate related extremes such as heatwaves are likely to occur more regularly and are likely to increase in duration. Since 1979, there has been over 9000 deaths that occurred from heat-related incidents in the United States (U.S. Environmental Protection Agency, 2016). Which brings attention to population groups who are exposed to hot temperatures on a frequent basis due to their occupation. The research questions focus on looking at the local picture and exploring what could be done at local levels to protect those susceptible to increasing temperatures. What temperature trends occur in local historical temperature data? What patterns occur in local historical monthly data? What recommendations can be made to protect vulnerable groups such as day laborers? Python was used to create a simple linear regression using data from the National Oceanic & Atmospheric Administration (NOAA) climate data online. Although the simple linear regressions cannot be used to estimate precise projections for the future, they show that local yearly and monthly temperatures in the observed cities, have increased over the years. Future work would be to examine the temperature data of other cities in the United States to see if there are similar trends.

Key Words: local temperatures, linear regression model, extreme heat

Day Laborers & Extreme Heat:

Recommendations for Reducing Heat Stress

The Environmental Protection Agency (EPA) has indicated that there is an increasing temperature average rate of 0.14°F per decade since 1901 in the contiguous 48 states. In fact, they say that the rate of warming temperature for the contiguous 48 states is faster than the global rate (U.S. Environmental Protection Agency, 2016). The EPA notes that the 48 contiguous states have warmed in rates between 0.29°F to 0.46°F per decade since 1979. Hot temperatures can lead to heat-related illness and even death. The Intergovernmental Panel on Climate Change (IPCC) estimates that the length and number of heat waves will continue to rise as seen by the 0.85°F temperature increase in land and water since 1880 (IPPC 2014). This suggests that day laborers will be exposed to greater temperatures on the job. Day laborer jobs such as construction and agriculture work require employees to work under direct sunlight for prolonged hours at time. A study conducted by Maria C. Mirabelli and David B. Richardson 2005, state that 40 of 161 heat related deaths were caused on the job and 45% of these work-related deaths occurred in farm working labor in North Carolina (Mirabelli & Richardson, 2005). Occupational heat stress adds a layer of complexity to the heat stress day laborers experience due to the physical labor required in their jobs (Roelofs, 2018). It is known that extreme heat can lead to casualties in the general population, hence it is important to find ways to help vulnerable populations minimize the heat stress that they experience in their daily jobs. The objective of this study is to find out what heat trends are occurring locally to help recommend changes for reducing heat stress in day laborers.

Methodology

Descriptive Statistics

We used descriptive statistics (Diez, Barr, & Rundel, 2015) to analyze maximum temperatures in historical temperature data. The data was retrieved from the climate data online on the National Oceanic and Atmospheric Administration (NOAA) website: https://www.ncdc.noaa.gov/cdo-web/search? Daily summary data temperature was requested for three cities Seattle-Tacoma, WA, Portland, OR, and Sacramento, CA. The data for Seattle-Tacoma is from the Seattle-Tacoma International Airport, WA US station USW0002433 dates 1/1/1948-12/31/2017. The Portland data is from two different stations, Portland Regional Forecast Office City, OR US station USW00024274 dates 1/1/1940-6/30/1973 and Portland KGW TV, OR US station USC00356749 dates 8/1/1973-12/31/2017. The Sacramento data is from Sacramento Executive Airport, CA US station USW00023232 dates 11/10/1941-12/31/2017. To graph the data, the program Python was used (Lutz, 2013) as well as the following libraries: Matplotlib, NumPy, Pandas, and SciPy. Stats. We calculated how many days per year reached high temperatures in these three west coast cities. The threshold for what was considered high temperatures were determined as follows: Seattle-Tacoma and Portland was 90°F (V. Shandas, personal communication, July 13, 2018) for Sacramento it was 92°F (U.S. Climate Data). We viewed the data in two different ways. The first was to graph the number of days above the temperature threshold per year. For example, plotting how many days were above 90°F in Seattle-Tacoma for the year 1948 and so forth. The second way we graphed the data was by graphing the temperature thresholds monthly. Specifically, for the months: May, June, July, August, and September. The purpose of this was to see if the trends were clearer through focused months. We also calculated the best fit trendline for both the yearly and monthly graphs and extended the trendline for the monthly graphs to the year 2048.

Results

Yearly Temperatures

The following figures contain graphs for the number of days 90°F or above per year for Seattle-Tacoma, WA and Portland, OR and days 92°F or above for Sacramento, CA. The years accounted for Seattle-Tacoma are 1948 to 2017, Portland 1940 to 2017 and Sacramento 1941 to 2017.

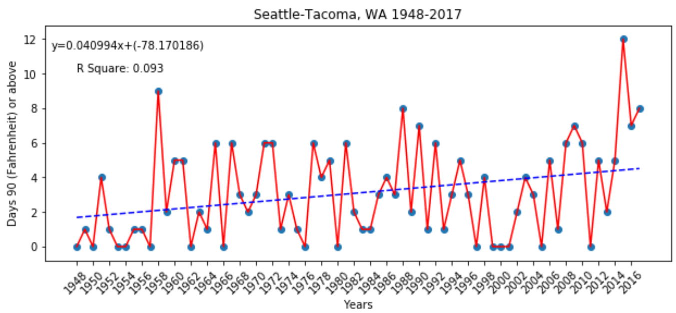

Figure 1;Yearly Look into Local Maximum Temperatures (Tmax) in Seattle-Tacoma, WA (1948-2017)

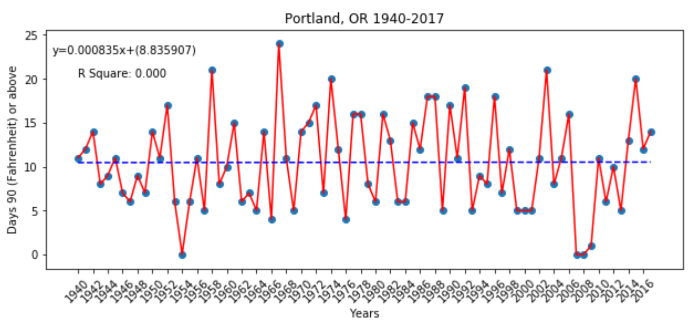

Figure 2; Yearly Look into Local Maximum Temperatures (Tmax) in Portland, OR (1940-2017)

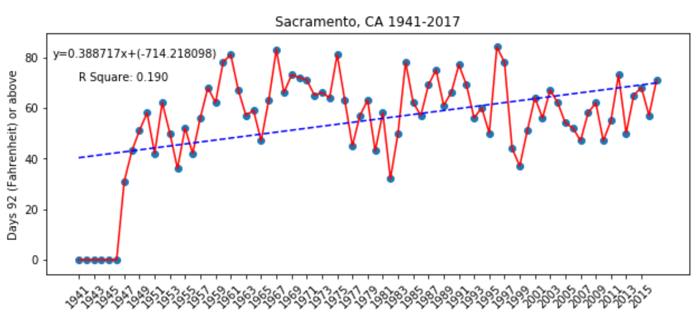

Figure 3;Yearly Look into Local Maximum Temperatures (Tmax) in Sacramento, CA (1941-2017)

Monthly Temperature
Seattle-Tacoma, WA

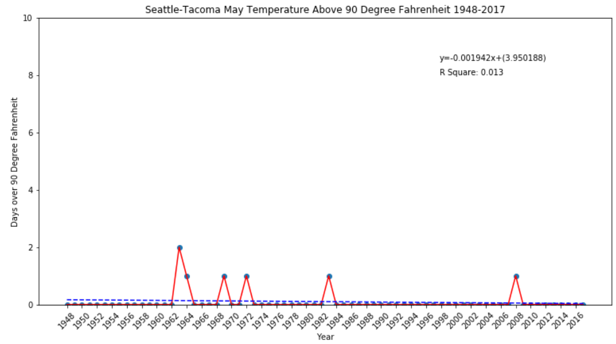

Figure 4 May Extreme Heat Temperatures for Seattle-Tacoma (1948-2017)

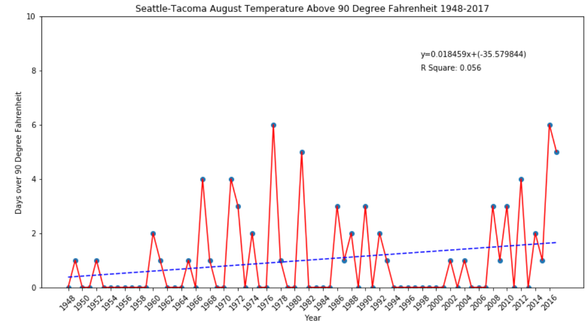

Figure 5 August Extreme Heat Temperatures for Seattle-Tacoma (1948-2017)

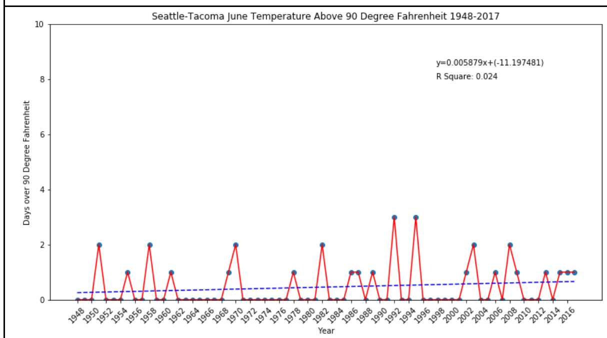

Figure 6 June Extreme Heat Temperatures for Seattle-Tacoma (1948-2017)

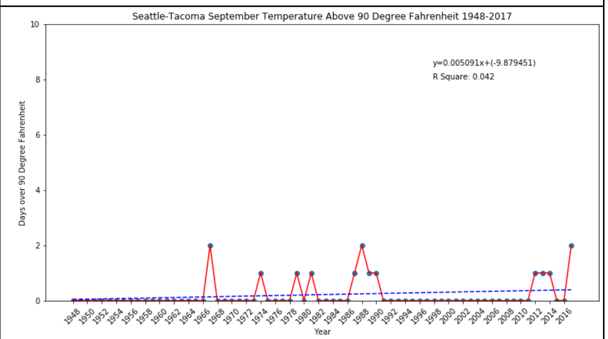

Figure 7 September Extreme Heat Temperatures for Seattle-Tacoma (1948-2017)

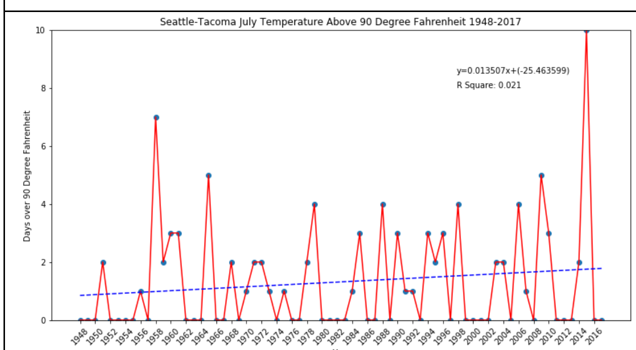

Figure 8 July Extreme Heat Temperatures for Seattle-Tacoma (1948-2017)

Portland, OR

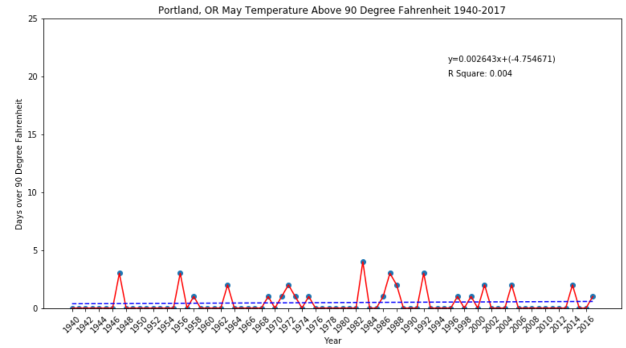

Figure 9 May Extreme Heat Temperatures for Portland, OR (1940-2017)

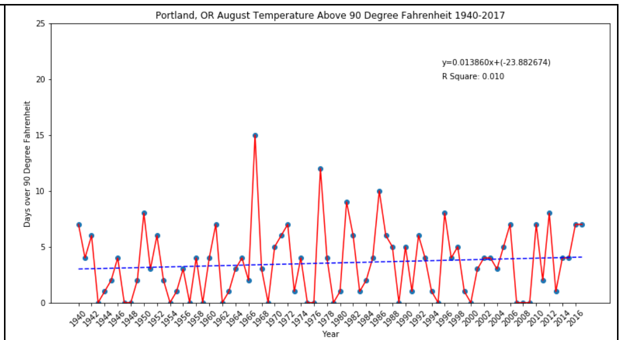

Figure 10 August Extreme Heat Temperatures for Portland, OR (1940-2017)

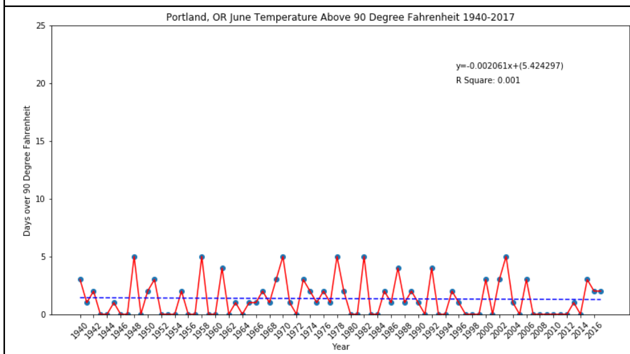

Figure 11 June Extreme Heat Temperatures for Portland, OR (1940-2017)

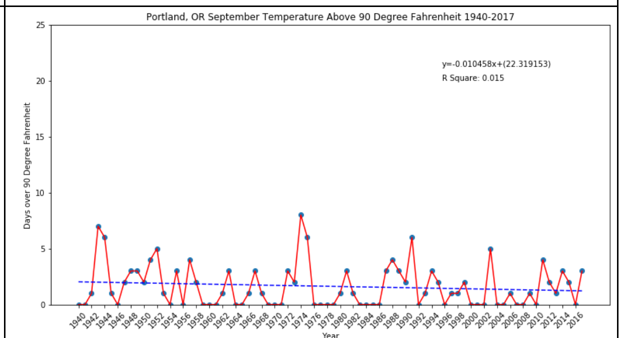

Figure 12 September Extreme Heat Temperatures for Portland, OR (1940-2017)

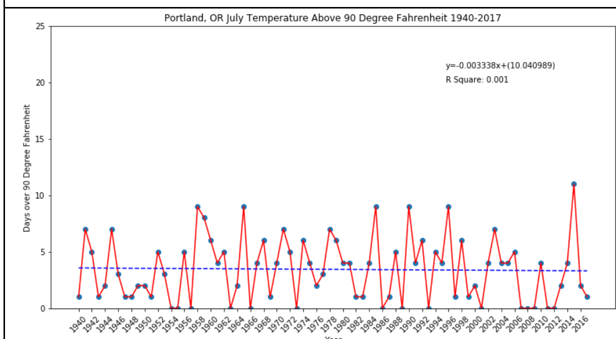

Figure 13 July Extreme Heat Temperatures for Portland, OR (1940-2017)

Sacramento, CA

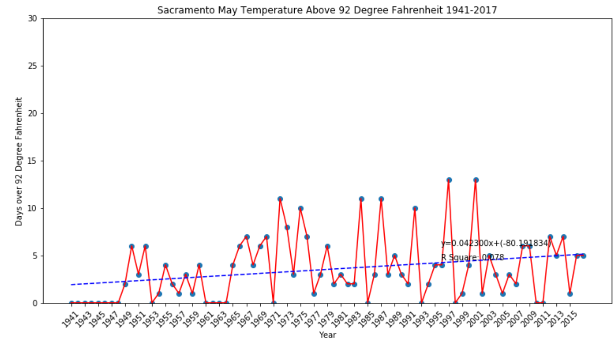

Figure 14 May Extreme Heat Temperatures for Sacramento, CA (1941-2017)

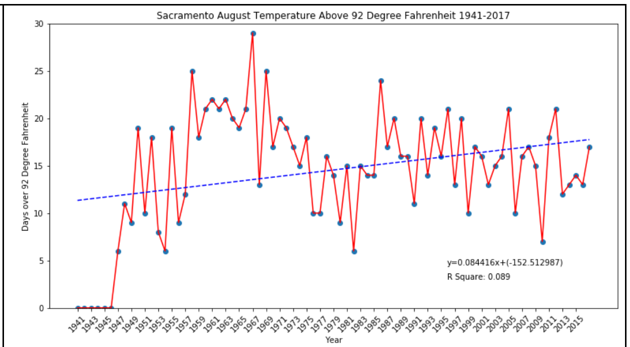

Figure 15 August Extreme Heat Temperatures for Sacramento, CA (1941-2017)

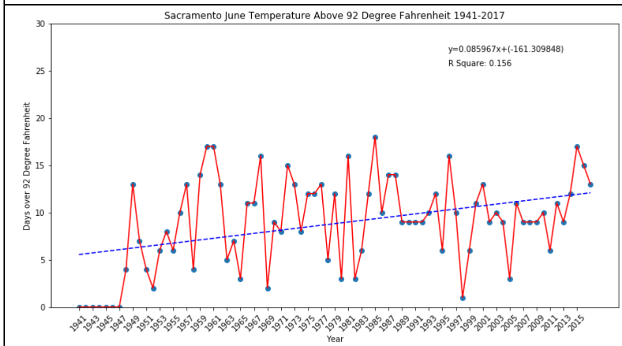

Figure 16 June Extreme Heat Temperatures for Sacramento, CA (1941-2017)

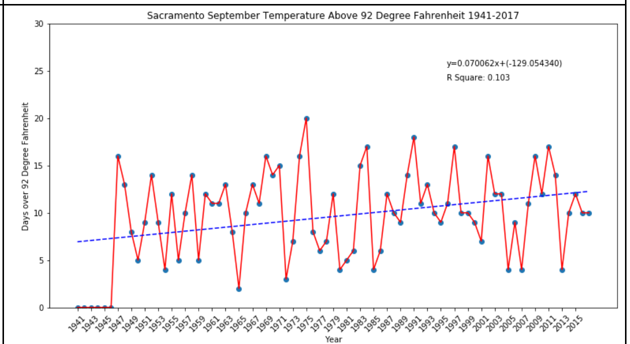

Figure 17 September Extreme Heat Temperatures for Sacramento, CA (1941-2017)

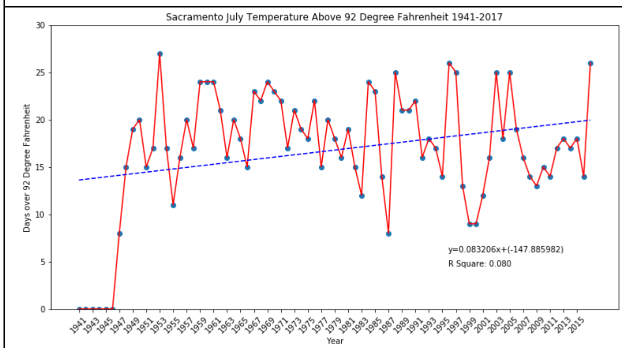

Figure 18 July Extreme Heat Temperatures for Sacramento, CA (1941-2017)

Monthly Trendlines Extended to Year 2048
Seattle-Tacoma

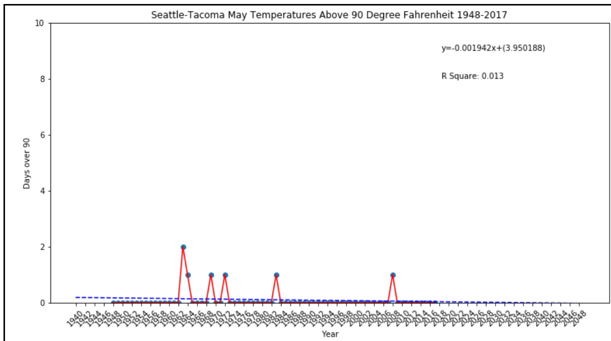

Figure 19 May Extreme Heat Temperature Trendline Extended to the year 2048 for Seattle-Tacoma, WA

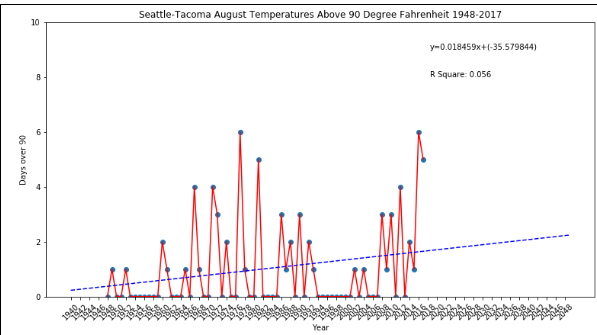

Figure 20 August Extreme Heat Temperature Trendline Extended to the year 2048 for Seattle-Tacoma, WA

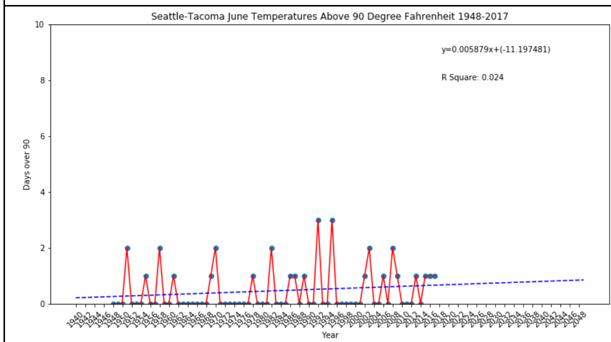

Figure 21 June Extreme Heat Temperature Trendline Extended to the year 2048 for Seattle-Tacoma, WA

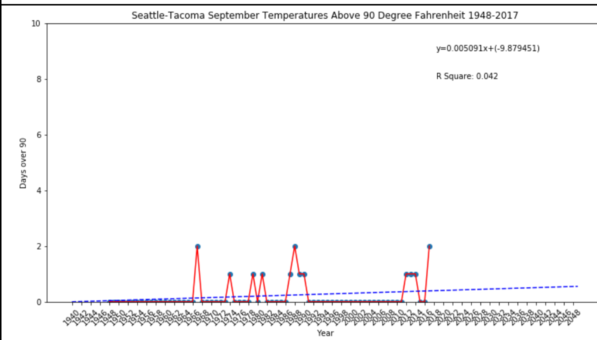

Figure 22 September Extreme Heat Temperature Trendline Extended to the year 2048 for Seattle-Tacoma, WA

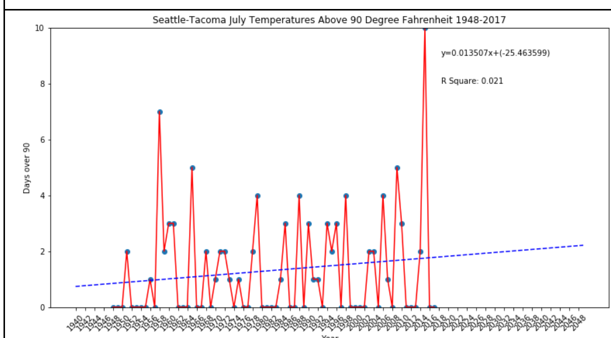

Figure 23 July Extreme Heat Temperature Trendline Extended to the year 2048 for Seattle-Tacoma, WA

Portland, OR

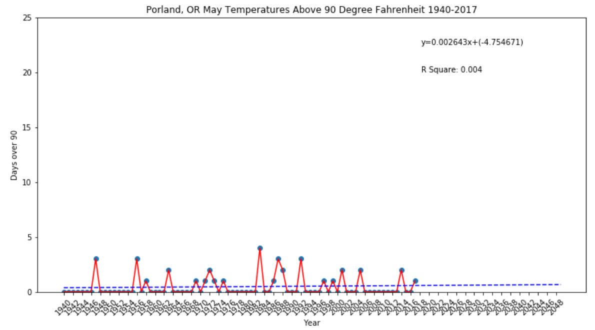

Figure 24 May Extreme Heat Temperature Trendline Extended to the year 2048 for Portland, OR

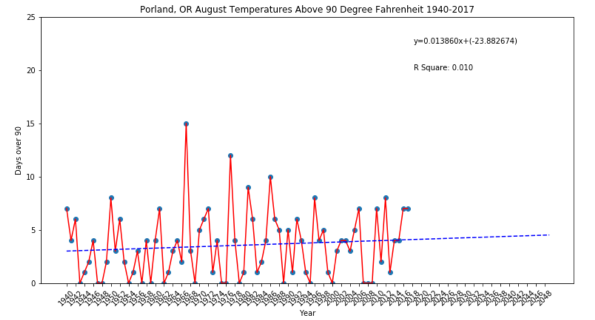

Figure 25 August Extreme Heat Temperature Trendline Extended to the year 2048 for Portland, OR

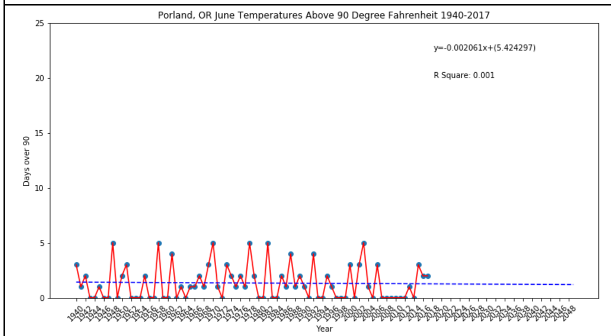

Figure 26 June Extreme Heat Temperature Trendline Extended to the year 2048 for Portland, OR

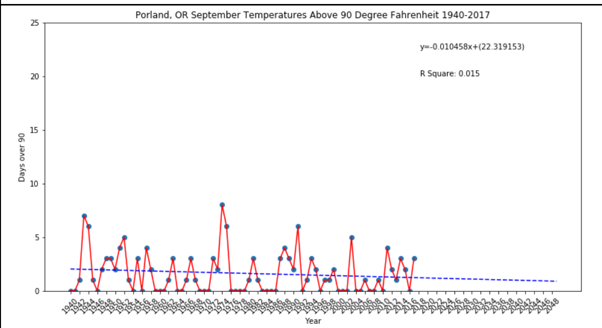

Figure 27 September Extreme Heat Temperature Trendline Extended to the year 2048 for Portland, OR

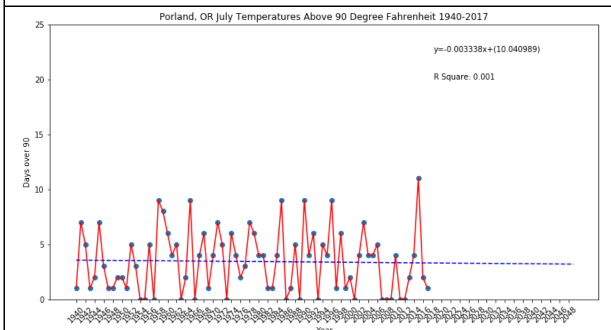

Figure 28 July Extreme Heat Temperature Trendline Extended to the year 2048 for Portland, OR

Sacramento, CA

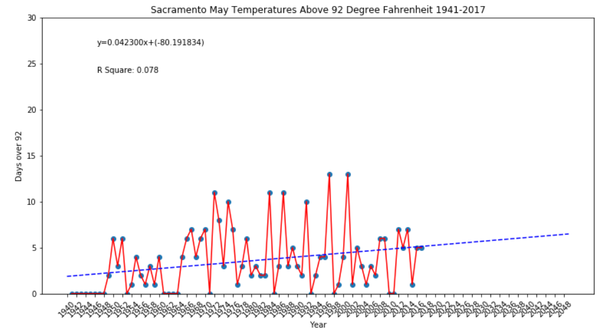

Figure 29 May Extreme Heat Temperature Trendline Extended to the year 2048 for Sacramento, CA

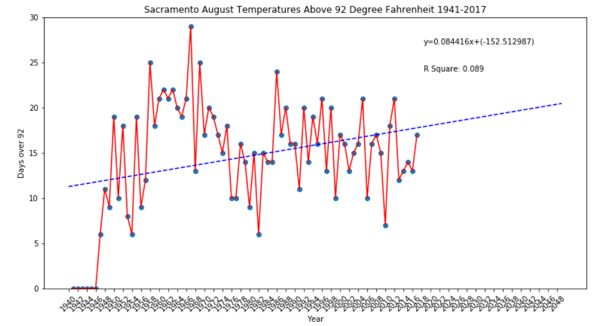

Figure 30 August Extreme Heat Temperature Trendline Extended to the year 2048 for Sacramento, CA

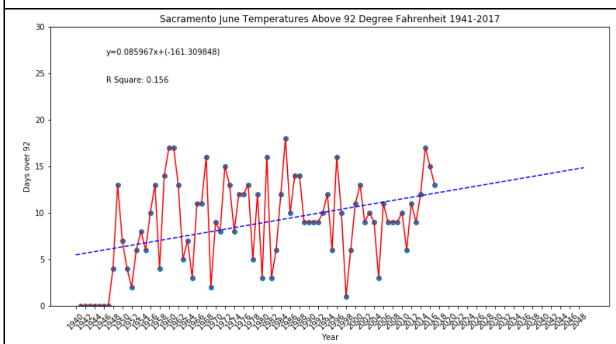

Figure 31 June Extreme Heat Temperature Trendline Extended to the year 2048 for Sacramento, CA

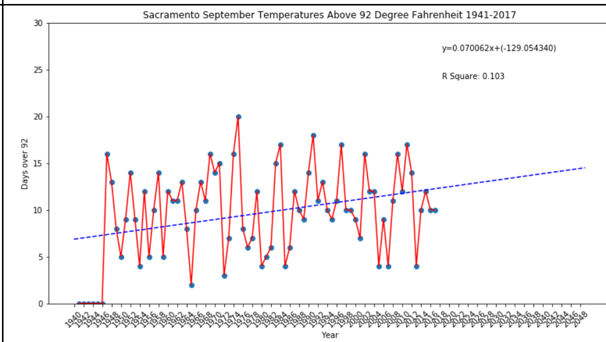

Figure 32 September Extreme Heat Temperature Trendline Extended to the year 2048 for Sacramento, CA

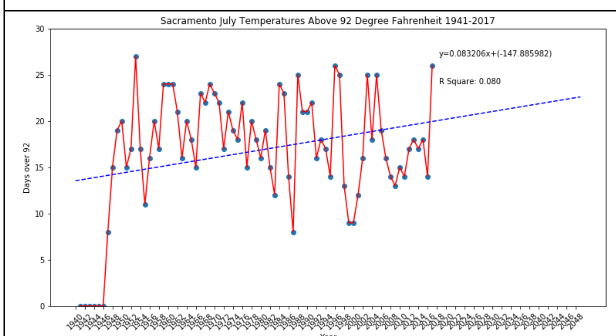

Figure 33 July Extreme Heat Temperature Trendline Extended to the year 2048 for Sacramento, CA

Summary of Yearly and Monthly Data

MONTHLY TEMPERATURE DATA SUMMARY			
Seattle-Tacoma, WA (1948-2017)			
Month	Slope	y	r^2
May	0.001942	3.950188	0.013
June	0.005879	-11.197481	0.24
Juy	0.013507	-25.463599	0.021
August	0.018459	-35.579844	0.056
September	0.005091	-9.879451	0.042
Portland, OR (1940-1973)			
Month	Slope	y	r^2
May	0.002643	-4.754671	0.004
June	-0.002061	5.424297	0.001
July	-0.00338	10.040989	0.001
August	0.013860	-23.882674	0.010
September	-0.010458	22.319153	0.015
Sacramento, CA (1941-2017)			
Month	Slope	y	r^2
May	0.0423	-80.191834	0.078
June	0.085967	-161.309848	0.156
July	0.083206	-147.885982	0.08
August	0.084416	-152.512987	0.089
September	0.070062	-129.05434	0.103

YEARLY SUMMARY DATA			
City, State, (Years)	m	b	r^2
Seattle-Tacoma, WA (1948-2017)	0.040994	-78.170186	0.093
Portland, OR (1940-2017)	0.00083526	8.835907	0.0
Sacramento, CA (1941-2017)	0.388717	-714.218098	0.19

Discussion

According to the data, there will be one more day of extreme heat in Seattle-Tacoma, WA about every 24 years. Sacramento, CA will experience one more day of extreme heat about every 2.5 years. Sacramento, CA appears to be heating up at a rate of .347723 days faster than Seattle-Tacoma, WA every year. The analyzed months for Seattle-Tacoma, WA and Sacramento, CA also all have increasing slopes. The slopes for the months in Portland, OR are oscillate. The highest rate for the months observed for Seattle-Tacoma, WA is August, with a rate of 0.018459 days with extreme heat temperature increase per year, or a 1 day increase about every 54 years. June is the month with the steepest slope for Sacramento, CA, with the rate of 0.085967 day increase per year or 1 day with extreme heat increase about every 11 years. Hence, it appears that these months will have an increase of extreme temperature days at faster rates than other months. These are conservative estimates; hence these are very rough estimates. What does that means for cities that are not used to hot weather? It is important for people in communities to be able to adapt to changing temperatures. For communities that previously have not experienced frequent days of extreme heat, it is important for them to be equipped with strategies to cope as the number of hot days increase. The three major themes to prepare communities to cope with extreme heat, in this case day laborers who are more exposed to extreme heat due to their occupational requirements are: practices, education and policy. Practices are the strategies one uses to cope with heat such as drinking water and wearing protective clothes. Education includes any form of awareness brought to induvial about the dangers of extreme heat such as heat stress. Policies includes changes needed at an authority's level to provide resources of changes for the protection of such populations.

Conclusion

The maximum data temperature for most of the cities shows increasing slopes. Thus, showing that the there is a likelihood of rising days with extreme temperatures in the cities of Seattle-Tacoma, WA and Sacramento, CA. Day laborers in these areas of increasing days with extreme heat need further protections than currently at place. Regions that ae not used to extreme temperatures will have to change the way they do things to cope with extreme heat. The following are some recommendations for reducing heat stress in Day Laborers. Day laborers in areas such as Seattle, WA, Tacoma, WA, and Portland, OR may have to use coping strategies more often in the decades to come. We recommend that employers provide heat stress protection training for their employees prior to beginning their jobs. We recommend that water is made easily accessible to all workers. We also recommend that there be frequent rest period for workers during extremely hot days. Future Research would be to examine the maximum temperatures for other cities in the United States to see if similar patterns are present.

Acknowledgements

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References

Buchanan, S. N., Nickels, L., & Morello, J. (2005). Occupational Health Among Chicago Day Laborers: An Exploratory Study. Archives of Environmental & Occupational Health, 60(5), 276-280. doi:10.3200/aeoh.60.5.276-280

Diez, D. M., Barr, C. D., & Rundel, M. C. (2015). OpenIntro Statistics (3rd ed.).

Inaba, R., & Mirbod, S. M. (2007). Comparison of Subjective Symptoms and Hot Prevention Measures in Summer between Traffic Control Workers and Construction Workers in Japan. Industrial Health, 45(1), 91-99. doi:10.2486/indhealth.45.91

IPCC (Intergovernmental Panel on Climate Change). 2014. Climate change 2014:

Impacts, adaptation, and vulnerability. Working Group II contribution to the IPCC

Fifth Assessment Report. Cambridge, United

Li, X., Chow, K. H., Zhu, Y., & Lin, Y. (2016). Evaluating the impacts of high-temperature outdoor working environments on construction labor productivity in China: A case study of rebar workers. Building and Environment, 95, 42-52. doi:10.1016/j.buildenv.2015.09.005

Lutz, M. (2013). Learning Python (5th ed.). Sebastopol, CA: O'Reilly Media.

Melillo, J.M., T.C. Richmond, and G.W. Yohe (eds.). 2014. Climate change impacts in the United States: The third National Climate Assessment. U.S. Global Change Research Program. http://nca2014.globalchange.gov

Kingdom: Cambridge University

Press. www.ipcc.ch/report/ar5/wg2.

Mirabelli, M. C., & Richardson, D. B. (2005). Heat-Related Fatalities in North Carolina. American Journal of Public Health, 95(4), 635-637. doi:10.2105/ajph.2004.042630

Nerbass, F. B., Pecoits-Filho, R., Clark, W. F., Sontrop, J. M., Mcintyre, C. W., & Moist, L. (2017). Occupational Heat Stress and Kidney Health: From Farms to Factories. Kidney International Reports, 2(6), 998-1008. doi:10.1016/j.ekir.2017.08.012

Roelofs, C. (2018). Without Warning: Worker Deaths From Heat 2014–2016. NEW SOLUTIONS: A Journal of Environmental and Occupational Health Policy, 104829111877787. doi:10.1177/1048291118777874

Schulte, P. A., & Chun, H. (2009). Climate Change and Occupational Safety and Health: Establishing a Preliminary Framework. Journal of Occupational

Spector, J. (2016). O36-3 A case-crossover study of heat exposure and injury risk in agricultural workers in Washington state, USA. Agriculture & Environmental Science Database. doi:10.1136/oemed-2016-103951.184

and Environmental Hygiene, 6(9), 542-554. doi:10.1080/15459620903066008

U.S. Climate Data, U. C. (n.d.). Temperature - Precipitation - Sunshine - Snowfall. Retrieved from https://www.usclimatedata.com/climate/sacramento/california/united-states/usca0967

U.S. Environmental Protection Agency. 2016. Climate change indicators in the United States, 2016. Fourth edition. EPA 430-R-16-004. www.epa.gov/climate-indicators.

Yi, W., & Chan, A. P. (2015). Which Environmental Indicator Is Better Able to Predict the Effects of Heat Stress on Construction Workers? Journal of Management in Engineering, 31(4), 04014063. doi:10.1061/(asce)me.1943-5479.0000284