*Guiding questions and sample results*

**Are there significant signatures of the urban heat island effect and/or climate change? Are there regional trends?**

We used the results of the one-way ANOVA to determine which cities produced

significant linear regressions signifying urban heat island (UHI) and climate change. Of the 207 total cities examined, 53.4% were deemed significant. Of the significant datasets, 90.91% demonstrated climate change, indicated by a positive slope in TMAX or TMIN, indiscriminate of climatic zone. Only 49.1% of cities out of the significant datasets showed UHI effects as the convergence of TMAX and TMIN slopes. This shows that climate change, or overall atmospheric processes, has a much greater effect than localized changes in cities contributing to the UHI effect. See Fig. 2 for an example plot of one city’s temperature trends (same city as Fig. 1).



**Figure 2.** Yearly mean temperature anomaly for TMAX (red) and TMIN (blue) over time (year).

**What types of cities/towns are expected to show signatures of the urban heat island effect? Why do the data follow/not follow this expected pattern?**

We expected that large cities, and their increased concrete cover, would have greater UHI signatures than surrounding rural areas. The lack of UHI signal in many large California cities does not align with previous literature (Tamrazian et al., 2008b; Voogt, 2004), and there is no individual reason why this is the case. One compelling reason for a lack of signal is high urban landscaping (Peng et al., 2011). The UHI effect is influenced by a number of factors outside of data artifacts. Precipitation, population, land cover, vegetation, and even aquifer depth can influence UHI. The most influential factors are land cover and vegetation, although recent studies have identified a link between precipitation and UHI (AghaKouchak et al., 2014).

Another approach to explaining our UHI paucity is in “clustering”. Cities such as San Francisco, Oakland, and Vallejo or Los Angeles and Long Beach are in close proximity and may have influence over the UHI of their neighbors (Zhou et al., 2013). If UHI was enhanced by city proximity in “clusters”, these cities contained in clusters would exhibit UHI more than cities not in clusters. We did not find support for this phenomenon. The last major factor in UHI is heat emitted from anthropogenic sources, independent of surface albedo (Menberg et al., 2013).

The presence of agriculture in regions four and six brought the incidence of UHI higher than the average of the other regions (28.6%, region seven was not included due to sample size), suggesting that agriculture plays a large role in perpetuating UHI and may be responsible for more significant indications of UHI than those in large metropolises. Region four had 4.9 million acres of farmland and a 44% incidence of UHI, and region six had 1.4 million acres of farmland and 63.2% incidence of UHI. Agriculture contributes to water vapor in the atmosphere, overloading of nutrients in the soil, and relatively higher heat absorption and retention of the heat in the ground surface (Kalnay and Cai, 2003).

**Are there significant changes in the number (or seasonality) of extremely hot or cold days over time?**

No cities showed significant change in heat season duration or seasonality. While the length and starting/ending dates of the heat season did not shift significantly, the number of days per year that are categorized as heat days (based on the 1960-1990 standard climate period mean and standard deviation) increased in 62.81% of significant cities overall. Only 37.19% of significant cities decreased their number of heat days, which is consistent with only 45.45% of significant cities showing a decreasing trend for TMAX and 22.73% of significant cities showing a decreasing trend for TMIN. Region seven had the least number of significantly warmer cities, which could be attributed to the effects of altitude on climate variability (Ohmura, 2012). Regions four, five, and six experienced a more equal distribution of increasing and decreasing hot days, possibly due to the positive feedback loop of desertification, present in agricultural areas where irrigation is heavy, and the resulting widening of extreme temperatures occurs (Sivakumar, 2007).

Cold days showed a more universal trend, with 89.47% of all significant cities experiencing a decrease in cold days per year and only 10.53% increasing in cold days. This is consistent with our findings indicating that 77.27% of our significant cities showing an increasing TMIN. We can surmise that increasing minimum daily temperatures manifest as overall warming and a decrease in extreme cold events in California. See Fig. 3 for an example plot (same city as Fig. 1) of hot and cold extreme days.

****

**Figure 3.** Number of extreme days (hot in red, cold in blue) plotted over time (year).