6.4 CLIMATOLOGY TEMPERATURE MAPPING FOR CALIFORNIA URBAN HEAT ISLAND STUDY SITE SELECTION

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(31 March 2005)

Abstract---- Existing climate data sources can be used in two general types of analysis for the detection of urban heat islands, local historical trends and current spatial variations. Historical analyses use long-term data records,—preferentially from several locations in and around an urban area,—to trace the gradual influence of urban development on its climate. This paper uses existing temperature climatology data from 300 cooperative weather stations to analyze the spatial distribution in temperature during 60 year period in California. Temperature maps of long-term mean monthly temperature and recent monthly mean were produced for all months of the year. During the summer months, there is an increase of 1-3 ^{o}F in average monthly temperature for Sacramento, Modesto and San Jose relative 50 years ago. In addition, a long term summer time average monthly temperature for San Jose, Sacramento, and Modesto was done to show the temperature trends in the past 60 years. The summer time temperature trends in San Jose, Modesto and Sacramento showed a statistically significant increase of 0.65, 0.46, and 0.49 ^{o}F per decade respectively. The historical temperature trend is compared to the localization of the temperature increase and the population growth and urban expansion. These observed increases in temperatures may be due to long-term climate changes, micro-climate influences, or local-scale heat islands. This information will be used to select a site for mesoscale model simulations of urban heat islands in the central San Joaquin valley cities.

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1. INTRODUCTION

Urban heat islands have been quite extensively studied research using observational data (e.g. Bornestein 1968; Price 1979; Rao 1972; Brian 2000) and also numerical modeling (e.g. Myrup 1969; Dixon *et al.* 2003). Goodridige, 1991 used 112 station average temperatures records to show the Urban bias influences on long-term California air temperature trends. He analyzed 80-year shelter level temperature and showed that urban heat island effects influenced the magnitude of the observed warming trend in the overall data set. The warming trends also corresponded to areas containing the state's major population centers with warming magnitude increasing in counties with higher population. Cooling trends were also observed on rural areas and counties with small population size. He also showed SST warming was found to be highly correlated with the warming of shelter level temperatures at coastal land observations.

In the current study, 60 years of collected data weather station data are used to show the trends and 2D distribution of California temperature focusing on the central San Joaquin valley stations. Since 1970, Sacramento, Modesto, and San Jose have experienced an urban area growth of (42%, 50%, 21%) and a population growth of (78%, 118%, 40%) respectively (US Department of Transportation). This growth is believed to have effect on the warming trends of these major cities.

2. METHOD

One method of analysis for the detection of urban heat island is to use long-term existing climate data sources. Historical analyses use long-term data records, preferentially from several locations in and around an urban area, to trace the gradual influence of urban development on its climate. Primary sources of such data include the cooperative network, first-order National Weather Service stations, and military weather stations. In the current study, data from 300 cooperative stations, including 40-60 years monthly average temperature are used for the preparation of the climatological temperature maps of California. A Kirging gridding method is used for the 2D interpolation (Cressie, 1991). The difference between monthly average temperature of years 2000-2003 and the 55 years monthly average temperature is calculated to do the climatology mapping. For the difference calculation a four year average was (2000-2003) was used to minimize single annual variation.

3. RESULTS

The summer time months (June, July and August) long-term monthly average shelter temperature data was analyzed for the station in the Sacramento city center, Sacramento airport, Modesto city center and San Jose city center (Fig. 1). The trends show the average temperature increases at (0.49, 0.14, 0.46 0.64) ^{0}F per decade respectively. San Jose has the highest trend increase while Sacramento city and Modesto had a comparable rate of increase. It is interesting to see that the Sacramento airport station has a lesser increase as compared to Sacramento city. This could be attributed to the location of the airport station in the suburban area while city station experiences an urban heat island. The 2D climatology of mean monthly temperatures plots show there is a heating on the specified central valley cities with local variation of heating in the different parts of the cities.

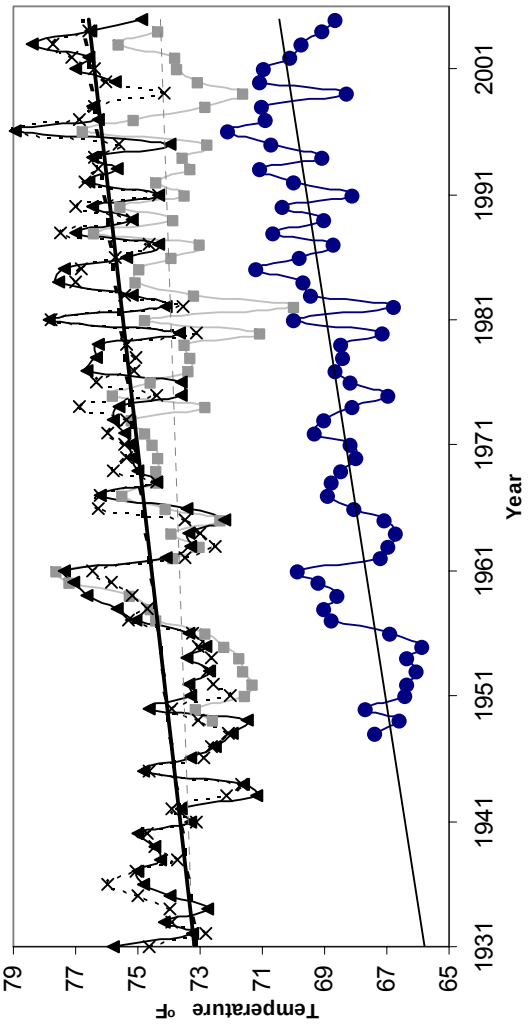

Fig.1. Summer months (June, July August) monthly average temperature trends for Central California Cities (San Jose ●, Sacramento city ■, Modesto ▲, and Sacramento airport **X**. For the trend lines, Sacramento city bold ____, Modesto bold - - - - -, Sacramento airport light - - - - - and San Jose light ___.)

For the month of June, Figure 2 shows that Sacramento has a relative temperature increase of 3-3.5 ^{0}F with a broad cold region on the southwest of the city. Modesto also has a temperature increase of 2.5-3 ^{0}F, again with colder region on the northwest, all the way to Stockton. San Jose on the other hand has a similar pattern as Modesto. It has

a 2.5-3 ^{0}F increase surrounded by a broad range of colder area on the west.

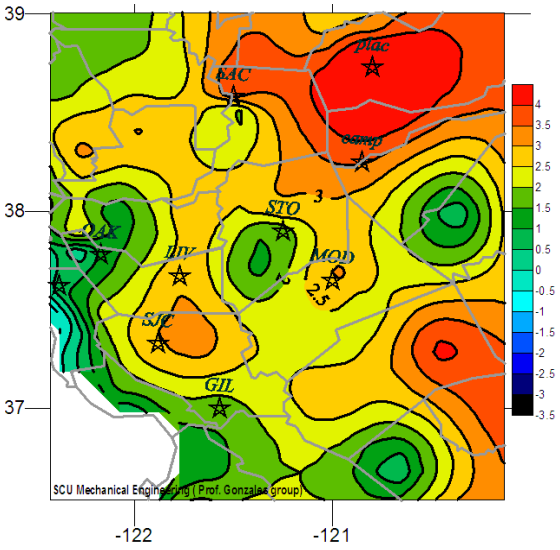

Fig. 2. Climatology Difference map for the month June—cities are indicated by stars and abbreviations, scale is given in latitude and longitude

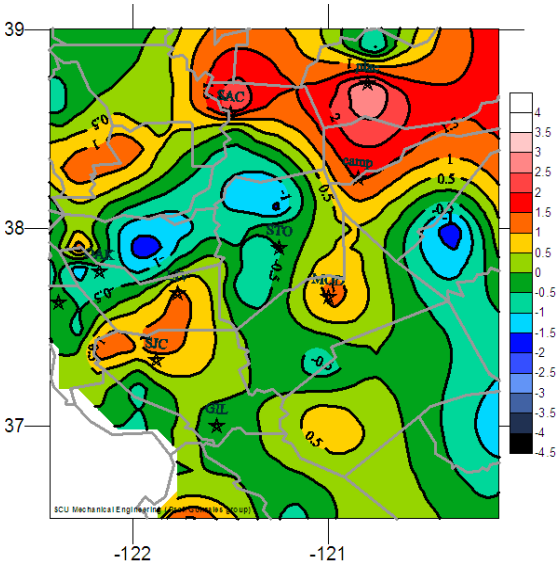

Fig. 3. Climatology Difference map for the month July

In July (Fig. 3), the difference temperature had decreased by about 1 ^{0}F all over the region. Sacramento had the highest difference (2 ^{0}F) and surrounded by colder region in all directions. Modesto's difference decreased to 1 ^{0}F and had a slightly colder region on the western side. San Jose also had a difference of 0.5 ^{0}F and with a different pattern than the two other cities. It was located on a strip of colder region with a hotter area on the north and colder area on the south. During August (Fig. 4), the difference in Sacrament and Modesto dropped by another 0.5 ^{0}F to 1.5 ^{0}F and 0.5 ^{0}F respectively. The region surrounding these cities was still colder by -0.5 ^{0}F. On the other hand the difference increased by 0.5 ^{0}F in San Jose to 1 ^{0}F with colder region on the west and south west.

Data were also analyzed for the remaining months of the year, but the winter months showed strong variability and the fall and spring showed similar trends will small increases in temperature.

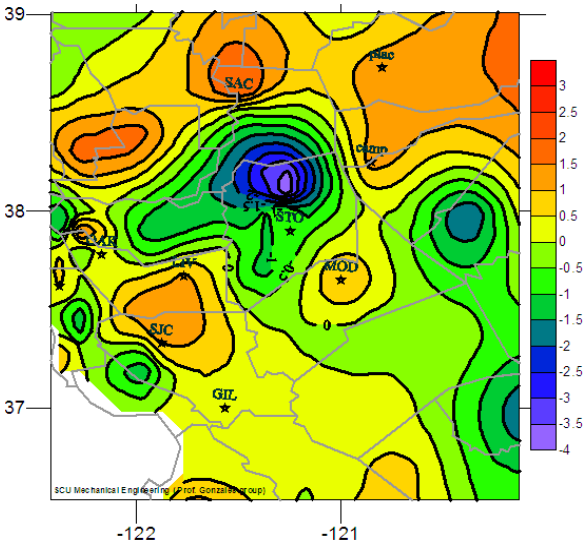

Fig. 4. Climatology Difference map for the month August

There is a strong local variation of the heating with was demonstrated on the trends and 2D plots. The heating and cooling effects are complicated by the variations on temperatures of the adjacent sea, major changes in topography, and the local circulations that can occur because of the urban morphology and the complex terrain. This topographical influence is illustrated in the variability of the heating effect around Sacramento

and the difference in the airport and city weather station. In summary these maps showed that during the summer months, the northern San Joaquin valley had an average increase in temperature and the cities had experienced local heating effects with colder region surrounding them.

3. MODELING MOTIVATION

Based on the analysis of the long-term climatology data, urban heat island modeling of the cities of Sacramento and Modesto in the Northern San Joaquin Valley is suggested with the domain shown in Figure 5. The Regional Atmospheric Modeling System (RAMS) will be used to do the research study in both cities. A common outermost grid will be used for both cities and then construct an innermost gird which will focuses on each city. The research of the UHI can be tackled by running the case with the full city and another case with only portion of the city and then differencing the fields. The specific effects of the city on the local temperature can be identified in this way. Comparing both cities, Sacramento and Modesto will demonstrate the influence of topography and local circulation.

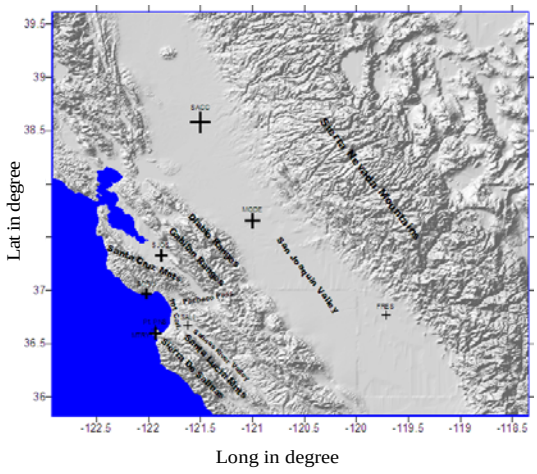

Fig. 5. Proposed modeling area

4. SUMMARY AND CONCLUSION

In summary, this review analysis result may be considered a progress report on some aspects of our ongoing research on characterizing the urban heat island effect in northern California. This analysis of the cooperative weather station data has been used to identify the location of proposed modeling. The objectives of the research program are to understand the spatial variation of the climatology temperature in California to verify the existence of the heat Island and understand the influence of local topography. The long-term climatology maps showed there is an increase of temperature trends by an average 1-3 ^{o}F over the locations considered at an average rate of 0.5 ^{o}F per decade in the northern San Joaquin valley cities. The observed increases in temperatures may be due to long-term climate changes, micro-climate influences, or local-scale heat islands. Modesto and Sacramento had shown similar pattern increase in temperature while San Jose had the highest rate of increase.

5. REFERENCES

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