P1.24 EXAMINING LOCAL AND REGIONAL TEMPERATURE CHANGES FOR THE 1977-2003 PERIOD USING A TRULY HOMOGENEOUS STATION RECORD

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1. INTRODUCTION

The globally averaged annual temperature time series since 1900 clearly shows at least three distinct periods with different trends. During the early part of the record, warming is observed to the early 1940s, then a period of little change or possibly even cooling is observed. However, since the late 1970s the observed trend in global surface air temperature is approximately 0.2C/decade (Karl et al. 2000). Furthermore, these changes appear to be manifested more strongly in the daily minimum temperature (nighttime lows), rather than the daily maximum temperature (daytime highs) for most parts of the world (Karl et al. 1993, Easterling et al. 1997). However, globally averaged temperature trends for the troposphere since 1979 appear to be much less than what has been observed at the surface (Christy et al. 2000).

Questions regarding the nature of observed warming in surface air temperatures continue to be raised. These questions include the impact of land use/land cover changes, including urbanization on *in situ* temperature records, and how much these land use/land cover changes impact the observed trend in global or regional averages calculated from individual station temperature records. These questions are compounded at the local level, when the site characteristics of individual stations are considered. Christy and Norris (2004) examined stations in central California that were grouped according to whether they were in the irrigated valley, foothills, or mountains of the Sierra Nevada. They found no trend in either maximum or minimum temperature in the mountains, slight negative trends for maximum temperature in both the foothills and valley, but significant trends in the valley minimum temperatures. They hypothesize that local irrigation increases have impacted valley minimum temperatures through local changes in the energy balance caused by increases in water vapor from the evaporation of irrigation water.

Here we examine temperature time series from individual stations in western North Carolina including a mountain top station, a station located in a moderately urbanized environment, and a number of more rural sites, plus Microwave Sounding Unit (MSU) tropospheric temperature data for the same region that were available from the University of Alabama at Huntsville (Christy et al. 2000).

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2. DATA

It is rare that an observing station's time series of temperature can be considered truly homogeneous for any extended period. One such station that we have tested that can be considered truly homogeneous is a mountain-top station in the U.S. Cooperative Network near Asheville, NC (Swannanoa 2 SSE hereafter called Flat Top Mountain). This site has station history information and personal assurance by the observer that there have been no landscape or instrument changes, or missing data, that might impact the observed time series for the period 1977-2003 (G. Goodge, personal communication). We use the temperature record for a number of Cooperative observing stations in the region around Asheville for comparison with the temperature signal from Flat Top Mountain and examine one aspect of urban influence on temperature trends using a station (downtown Asheville) that has been an urbanized rooftop station for the entire 1977-2003 period. The instruments were moved from one part of the roof to another for repair work during the late 1990s, but then moved back to the original position after the repairs were made. This resulted in discontinuities detected using the methodology described below requiring adjustments to the data to make the time series relatively homogeneous during the period the instruments had been relocated.

Table 1. Cooperative stations used. * are US Historical Climatology Network sites.

Coop #	Name	Elevation
313106	Flat Top Mtn. (Swannanoa 2 SSE)	1317 M above s/l (asl)
310301	Downtown Asheville	683M asl
313976	Hendersonville 1 NE *	658M asl
310724	Bent Creek	643M asl
319147	Waynesville *	810M asl
316805	Pisgah Forest	643M asl

Mean annual and mean monthly maximum and minimum temperature values from Swannanoa were evaluated for artificial change points using two different objective techniques. In the first technique, a composite reference series was calculated using a correlation-weighted average of temperature values from stations surrounding the target site. The series of annual and monthly differences between the target series (mean maximum or mean minimum temperatures from Flat Top Mountain) and the composite reference were evaluated for abrupt changes using three separate change point test statistics. Unfortunately, reference series homogeneity cannot be assumed in general. Requiring multiple tests to reject the null hypothesis of series homogeneity reduces the number of Type I errors caused by change points in the reference series components (Menne and Williams, 2004). Nevertheless, there is some risk of falsely attributing change points in the reference series to the target even when multiple test statistics are used. In the case of values from Swannanoa, all abrupt changes in the difference series were traced to apparent changes in observations from surrounding stations.

In the second approach, paired temperature series are tested for relative change points. In this case, there is no target or reference series. Rather, temperature series from the region are used to form all possible combinations of paired differences. Each difference series is then examined for abrupt change points and the station whose values are implicated by jumps in three or more difference series is attributed the change point. Evaluation of change points from the various paired difference series using observations from numerous stations in western North Carolina did not reveal any abrupt changes that were linked to values from the Flat Top Mountain target site. There is, however, an apparent local trend in temperature values at the target site, especially in maximum temperatures.

3. RESULTS

The trend analysis for Flat Top Mountain (Table 2) shows a clear warming signal for the period, with a trend in the annual maximum of 0.63C/decade and in the annual minimum of 0.36C/decade. The MSU time series for the grid box outlined by the latitude/longitude 35-37.5N, 82.5-85W has a linear trend in the annual temperature time series for 1979-2003 of 0.3C/decade, consistent with the trend in minimum temperature for Flat Top Mountain for the same period, and the maximum temperature for downtown Asheville. However, it is much less than the observed trend for the annual maximum temperature at Flat Top Mountain. The area average is derived by averaging the four remaining stations in Table 1 (excluding Flat Top and downtown Asheville).

Table 2. Trends in annual maximum and minimum temperature for two stations, the area average of four stations, and the Microwave Sounding Unit (mean only). ** Significant at the 5% level, * Significant at the 10% level.

Station	Max trend deg C/Decade	Min trend deg C/Decade
Flat Top Mtn.	0.63**	0.36**
Downtown Asheville	0.29*	0.14
Area Average	0.52**	0.17
MSU Mean only	0.3** (mean)	-

4. DISCUSSION

If it is assumed that the temperature data for Flat Top Mountain is strongly related to the free atmosphere, since it is a highly exposed mountain-top site more than 1300 meters above sea-level and 600 meters above the valley floor, then it is interesting to note that the trend for the MSU is the same as the trend for the minimum temperature at Flat Top, and only half that of the maximum temperature trend.

In general, with station observations that are not as well ventilated as Flat Top it would be expected that the best relationship would be between the maximum temperature and the MSU, since the maximum temperature usually occurs in mid-late afternoon coincident with maximum mixing of the atmosphere, while minimum temperatures usually occurs in early morning when the atmosphere is stable and stratified. However, being a mountain top station, Flat Top Mountain is typically well above the inversion layer, and usually is well ventilated even in the early morning hours. Moreover, recent unpublished research (T. Peterson personal communication, manuscript in preparation) found that, globally, the MSU trends are more closely related to maximum temperature trends than to minimum temperature trends likely due, at least in part, to the mixing scenario described above.

The second question, regarding trends in temperature at an urbanized station also provides interesting results. The downtown Asheville site has been urbanized for the entire period, and the trends are clearly less than the Flat Top Mountain trends. They both show, as does the regional average, larger positive trends in maximum temperature than minimum temperature. Also, the trends for downtown Asheville are smaller than those for the regional average of the four other stations in Table 1 not including the Asheville or Flat Top Mountain sites. This suggests that once a station becomes urbanized, it gives consistent trends with surrounding, less urban sites.

5. ACKNOWLEDGEMENTS

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