JP1.26 THE NATIONAL WEATHER SERVICE MMTS (MAXIMUM-MINIMUM TEMPERATURE SYSTEM) – 20 YEARS AFTER

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1. INTRODUCTION

In the mid 1980s the National Weather Service (NWS) began a mass replacement of their traditional liquid-in-glass (LIG) thermometers and Cotton Region Shelters at thousands of Cooperative Observer sites across the country. The wooden shelters had become increasingly expensive and difficult to maintain. Furthermore, NWS was also having trouble obtaining high quality self-registering thermometers at an acceptable price and an aging corps of volunteer observers found these thermometers difficult to read. Over a period of a few years, about two-thirds of the official temperature measuring sites across the country were equipped with electrical resistance thermometers in specially designed radiation shields and with easy to read digital displays (Figure 1). This was called the maximum-minimum temperatures system (MMTS).

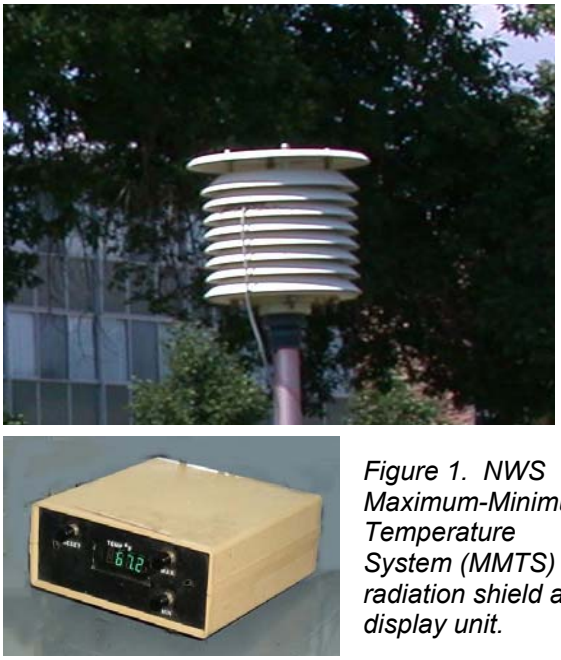

Figure 1. NWS Maximum-Minimum Temperature System (MMTS) radiation shield and display unit.

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At the time, many climatologists expressed concern about this mass observing change. Growing concern over potential anthropogenic climate change was stimulating countless studies of long-term temperature trends. Historic data were already compromised by station moves, urbanization, and changes in observation time. The last thing climatologists wanted was another potential source for data discontinuities. The practical reasons outweighed the scientific concerns, however, and MMTS deployment began in 1984. No published results of pre-deployment data comparisons were offered at the time, although some internal NWS documents describing field test results were circulated.

In the next few years, as MMTS data collection began, several organizations conducted overlap studies operating MMTS units side by side with the traditional LIG thermometers and shelters. These resulted in a few publications documenting differences in observed temperatures due to the change in instrumentation (Blackburn 1993, Wendland 1993, Doesken et al. 1995). Some specifics varied among these studies, but the overall conclusion was MMTS usually reported cooler daily maximum temperatures, slightly warmer nighttime temperatures, and lower diurnal ranges when compared to LIG. Doesken and McKee (1995) also showed convincingly that MMTS measured colder temperatures than LIG in the presence of clear skies and fresh snow cover. Under these fresh-snow conditions, daily maximum MMTS temperatures were often at least 2 degrees F cooler than LIG and as much as 4-7 degrees F colder under extreme conditions. Independent measurements of temperature taken by aspirated R.M.Young precision thermometers suggested that the MMTS measurements were likely closer to truth, and that the traditional wooden weather shelters may be prone to internal heating by solar energy reflected off fresh snow surfaces. Unpublished comparison data from a high-mountain site (Wolf Creek Pass in southwest Colorado) showed that very large differences in temperature occurred routinely over deep snow cover.

Quayle et al (1991) examined data from hundreds MMTS and CRS-LIG stations across the country that were not co-located. Their data

comparison methods detected a mean daily maximum temperature change of -0.4 deg. C associated with switching to MMTS and a mean daily minimum temperature change of +0.3 deg. C. In combination, this yielded a significant net reduction in diurnal temperature range of 0.7 deg C. They also concluded that the MMTS was likely a more accurate temperature measurement than the instruments they replaced. From these results, the National Climatic Data Center proposed a data homogeneity adjustment for the Historical Climate Network and other long-term temperature data sets potentially impacted by the MMTS transition.

One aspect of the MMTS transition that was always a concern but was not well documented was siting differences. Since the MMTS initially required trenching and a buried cable, ideal or preferred instrument exposures were sometimes abandoned in favor of sites closer to buildings that required shorter cables and little or no trenching. Concerns over lightning also contributed to shorter cabling configurations. Davey and Pielke (2005) documented several of these situations in Eastern Colorado and suggested that instrument location could be the most critical factor affecting in tracking long-term temperature changes.

All studies and results agree on one thing. The change from LIG to MMTS did introduce a detectable and not fully correctable inhomogeneity to the U.S. long-term temperature time series. None of these studies, however, addressed the interesting question of long-term stability. Do the relationships between MMTS and LIG established in the 1980s still hold in the 2000s? MMTS radiation shields that have been in the field now for 20 years have dirtied and yellowed over time. Little routine maintenance and calibration are performed on these systems. So it is fair to ask if any long-term changes have occurred and can be detected.

2. 20-YEAR ON-GOING OVERLAP STUDY

The staff of the Historical Climate Network station on the campus of Colorado State University in Fort Collins has maintained a consistent ongoing comparison of MMTS with LIG. The exact same LIG thermometers are still in use as when MMTS was first installed (Figure 2). The MMTS indoor display unit has been replaced once during the 20-year period. Unlike most cooperative stations that used the traditional Cotton Region Shelter, the Fort Collins station has always been equipped with the larger and more ornate Hazen shelter, the type formerly used at many of the old first-order urban stations in the U.S. Being a larger size and a different design, some differences are possible compared to the standard CRS. But since no changes have occurred in LIG measurements over time at the Fort Collins station, this should not cause any difficulties evaluating long-term MMTS performance.

Figure 2. MMTS and LIG thermometer shelters at the Colorado State University campus weather station (05-3005-4) in Fort Collins, Colorado.

Daily maximum and minimum temperatures from the MMTS and from the maximum and minimum self-registering LIG thermometers have been read at 1900 MST every day and recorded on paper forms to the nearest 0.1 degrees F. The temperature at the time of observation was also recorded to the nearest 0.1 deg. F. Data had previously been digitized for the period August 1984 through July 1994. In the interest of time, we only digitized daily temperatures for the past three years, January 2002 through December 2004, although all records 1994 through 2001 are available in hard copy form. Daily and monthly differences between MMTS and LIG were computed for the 2002-2004 period and then compared with the previously published results from 1984-1994.

3. RESULTS

3.1 MMTS-LIG differences during the past 3 years

Figure 3 shows the average monthly temperature difference between observed maximum and minimum daily temperatures (MMTS minus LIG) for the period 2002 through 2004. Negative differences mean that the MMTS temperatures were cooler than the LIG's. MMTS daily maximums were cooler than LIG every month with most months showing a mean difference between 0.4 to 0.7 degrees F. Occasionally larger differences appear such as the -1.4 deg F difference in November 2002. Larger differences in maximum temperatures were found to be associated with months that had experienced episodes with snow followed by periods of clear skies and light winds. Differences in minimum temperatures were much smaller and less variable. They showed evidence of a seasonal cycle with MMTS temperatures 0.1 to 0.3 degrees F cooler than LIG in most winter months, but as much as 0.2 degrees warmer than LIG in some summer months.

3.2 MMTS-LIG differences now compared to 1984-1994

Average MMTS-LIG temperature differences by month for the 2002-2004 period are overlayed with the 1984-1994 monthly averages in Figure 4 to determine what, if any, long-term changes in the MMTS-LIG relationship has occurred. While there are more month to month variations in the recent 3-year average, especially for maximum temperature differences, nevertheless the outcomes are very similar. Differences in daily maximum temperatures are slightly less on average than was found for the 1984-1994 period. MMTS minimum temperatures have been slightly cooler with respect to LIG in recent years, but the change averages less than 0.1 deg F per month. The diurnal range as measured by MMTS is now more similar to LIG diurnal range than when the instruments were first compared, but again the change has been small. The difference in mean annual temperature measured with MMTS compared with LIG for the 2002-2004 period was -0.38 deg F. Interestingly, difference was exactly

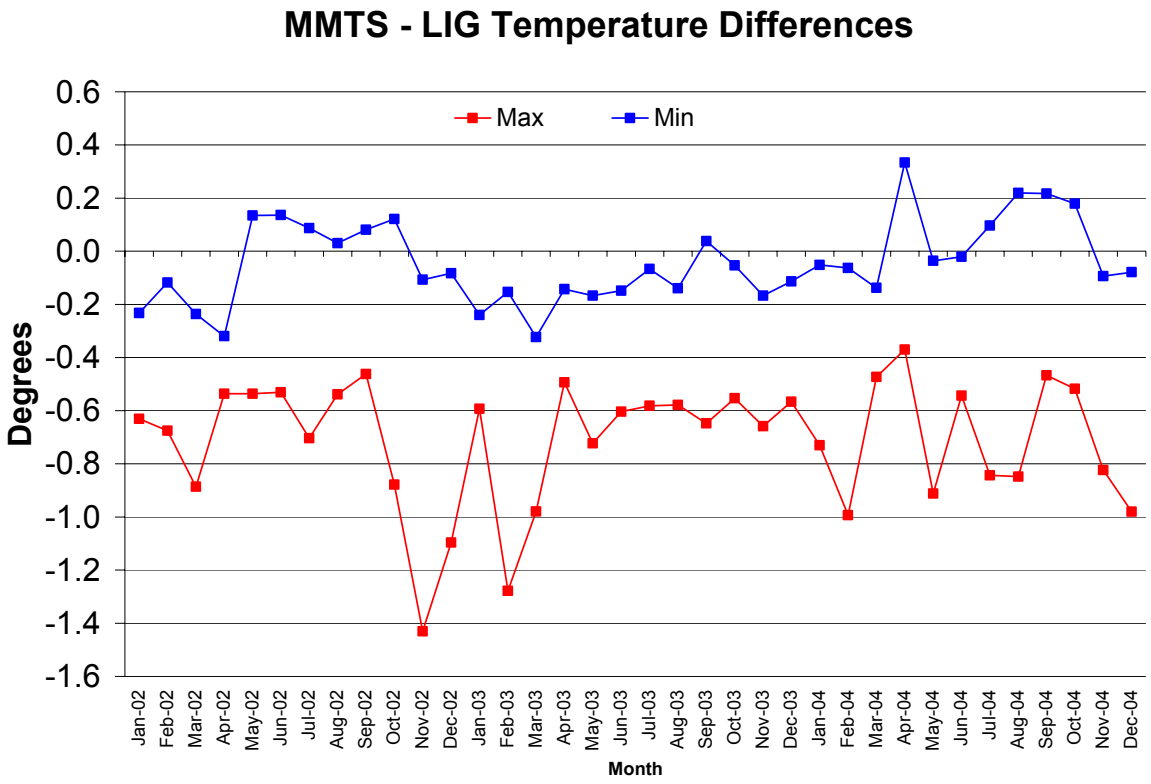

Figure 3. MMTS – LIG temperature differences (Deg F) by month for the period January 2002 through December 2004 for Fort Collins, Colorado.

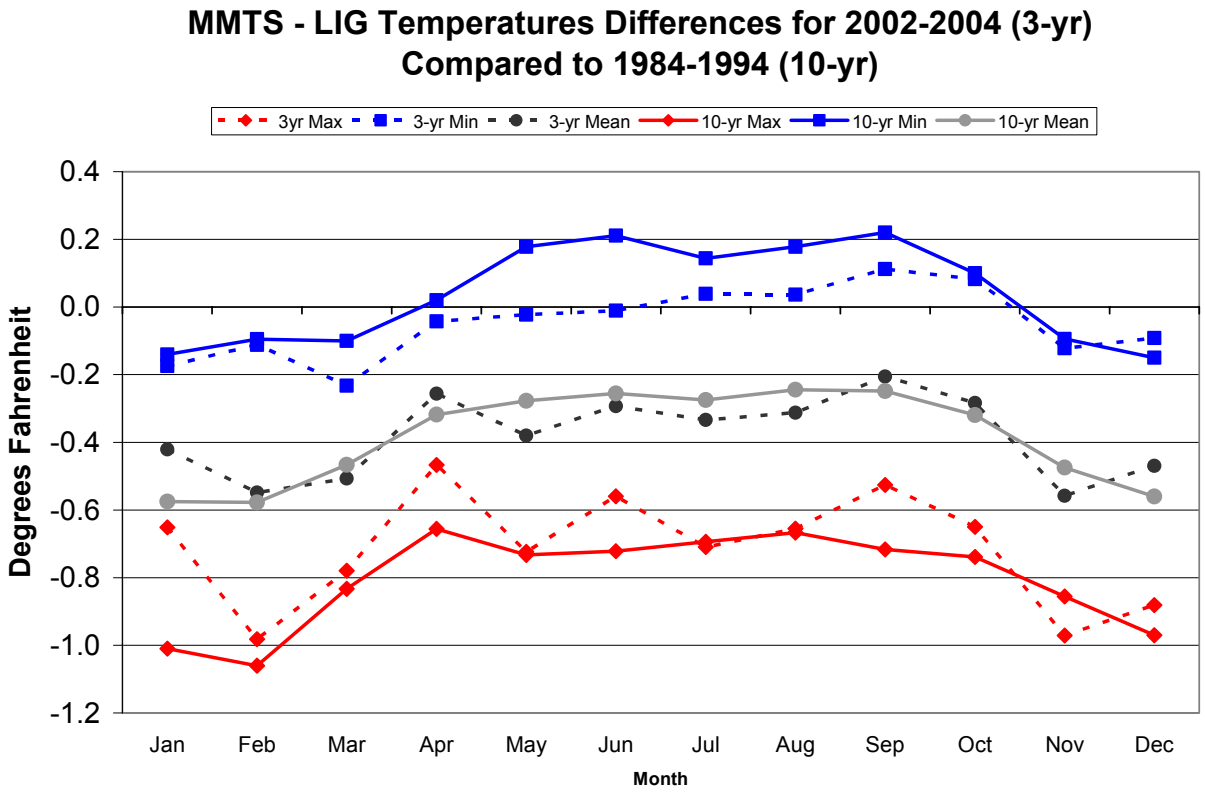

Figure 4. Average monthly MMTS-LIG temperature differences (Deg. F) for the 2002-2004 period compared with the 1984-1994 period.

the same (-0.38 deg F) for the original 1984-1994 10-year period. The seasonal cycle of differences that was identified 10-years ago continues to be evident today. Looking at the frequency of large daily differences of 2 degrees F or larger, they continue to occur almost exclusively in the winter months and are consistently associated with fresh snowcover. This is exactly what was observed in the original study.

4. CONCLUSIONS

From the very first year when the MMTS was installed at the Fort Collins weather station back in 1984, MMTS has consistently measured lower daily maximum temperatures with the largest differences occurring in winter. Daily minimum temperatures showed very small differences but with a consistent seasonal cycle. The patterns that were first observed in 1984 and 1985 continue to be repeated each year. Twenty years later, the patterns of MMTS-LIG temperature differences remained largely unchanged. The MMTS-LIG daily maximum temperatures differences are smaller now than they were in the early years of the intercomparison, but the average monthly change has been less than 0.1 deg F. It is possible that with aging and yellowing of the MMTS radiation shield that there is slightly more interior daytime heating causing recent MMTS readings to be more similar to LIG temperatures. But in a larger perspective, these changes are very small and would be difficult to detect and explain, except in a controlled co-located environment. Vary small (less than 0.1 deg F) changes in MMTS-LIG minimum temperatures have also been observed, with MMTS slightly cooler with respect to LIG. The mean annual MMTS-LIG temperature differences are unchanged.

Just as in the early years of the intercomparison, we continue to see months with larger and smaller differences than the average. These are likely a function of varying meteorological conditions particularly variations in wind speed, cloud cover and solar radiation. These are the factors that influence the effectiveness of both the MMTS and LIG radiations shields. Clearly, fresh snowcover continues to affect MMTS-LIG differences and contributes to MMTS daily maximum temperatures showing the largest differences with LIG during the winter months. The overall conclusion is that no significant change in the relationship between MMTS and LIG has been detected at the Fort

Collins, Colorado, weather station over the past 20 years.

5. FUTURE WORK

Drawing national generalizations based on the results at one station is probably not advisable. We are hopeful that more sites in the U.S. have continued side by side observations from both observing systems. We hope to identify other data sets where MMTS and LIG have been operated continuously, compile results and hopefully publish a more comprehensive MMTS long-term performance evaluation.

6. ACKNOWLEDGEMENT

Thanks to all the weather observers at the CSU weather station who have continued to faithfully check and record all these extra temperature readings for the past 20 years. This research was supported by the Colorado Agricultural Experiment Station at Colorado State University.

7. REFERENCES

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