Long-term Comparison of Temperatures Observed from Multiple Sensors at the New Brunswick, NJ, NWS Cooperative Weather Station

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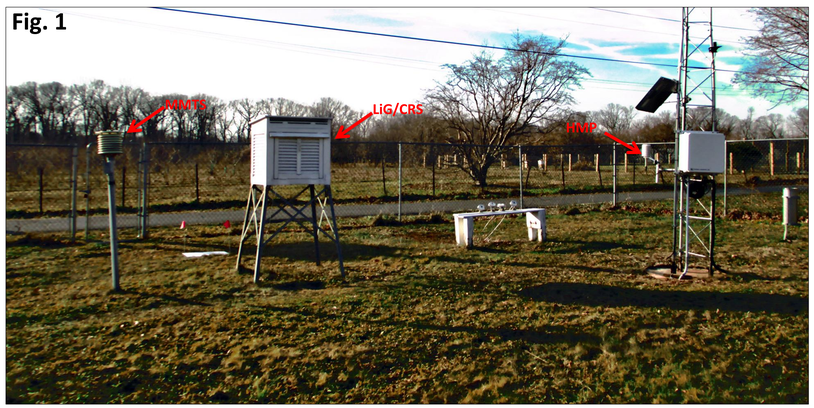
Background

During the mid-1980s, the National Weather Service began a mass replacement of traditional LiG thermometers mounted in Cotton Region Shelters (LiG/CRS) with electronic thermometers called Maximum-Minimum Temperature Systems (MMTS). Parallel LiG/CRS and MMTS observations have been gathered at the New Brunswick, NJ, cooperative weather station since 1984 (Fig. 1). Croft and Robinson (1993) evaluated eight years of parallel LiG/CRS and MMTS reports at New Brunswick from 1984 to 1992. A study by Doesken (2005) also compared temperatures from parallel LiG/CRS and MMTS between 1984 and 2004 in Fort Collins, CO, and to our knowledge represents the only other study comparing temperature records with co-located sensors. Quayle et al. (1991) compared changes in temperature differences between 675 LiG/CRS and 424 MMTS stations, thus providing potential insight into larger scale systematic differences between the two sensor types.

The purpose of this study is to evaluate seventeen additional years of coincident LiG/CRS and MMTS observations at New Brunswick, as well as the introduction of a third thermometer in 2008 (Campbell Scientific HMP45C, used as the primary temperature sensor from 2009 to present), in order to provide an enhanced understanding of the possible impacts of various thermometry on the temporal homogeneity of temperature records at New Brunswick and potentially other stations where similar changes from LiG/CRS to MMTS have occurred.

Fig. 1



Methodology

Daily maximum and minimum temperatures (TMAX and TMIN, respectively) from the LiG/CRS and MMTS sensors were gathered from paper records for Aug. 1995 through May 2012 and digitized. Daily TMAX/TMIN data were also gathered from the Campbell Scientific HMP45C (henceforth HMP) from July 2008 forward. All data were purged on days where measurements from at least one sensor were missing (resulting in 166 days being removed over the entire study period). A quality control check was also employed such that on days where a given sensor's TMAX or TMIN differed from any other study sensor by 3°F or more (likely the result of observer error), the entire day's data values were removed (23 removals in total). An additional 809 days (13.2% of all possible days within the study period) were not included because of missing paper records for these days.

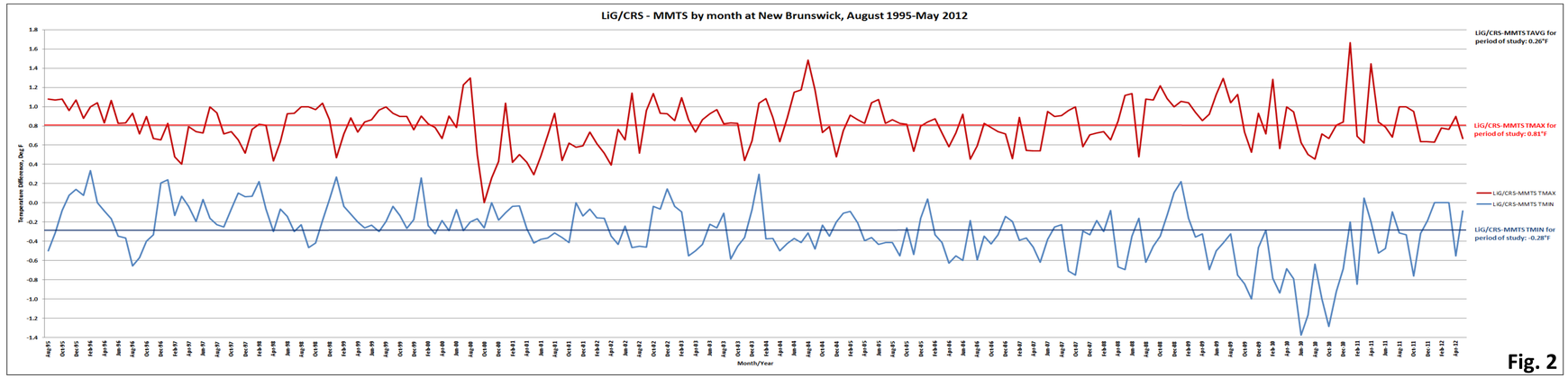


Fig. 2

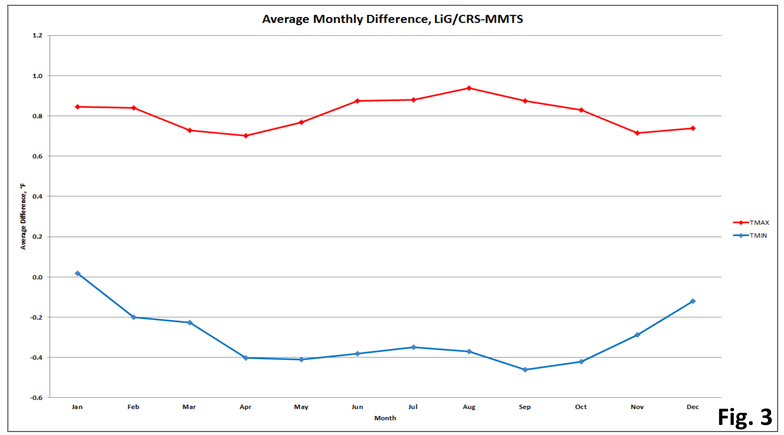


Fig. 3

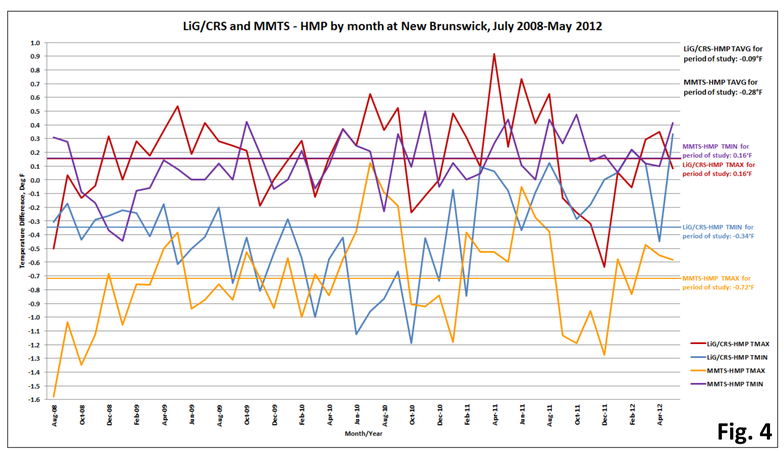


Fig. 4

Results

Means derived from the nearly seventeen years of temperature records from co-located LiG/CRS and MMTS sensors show the MMTS maxima to run 0.81°F lower, minima 0.28°F higher, with overall means 0.26°F cooler than LiG/CRS temperatures (Fig. 2) resulting in an average diurnal temperature range that is 1.09°F lower with the MMTS than LiG/CRS. This compares relatively well with Croft and Robinson (1993), Doesken (2005), and Quayle et al. (1991) in terms of the signs of the differences, though the magnitudes of the offsets (with the exception of TMAX in the Quayle et al. study) were lower in our comparison. Specifically, Croft and Robinson found MMTS maxima to run 1.1°F lower, minima 0.5°F higher, and overall temperature means 0.4°F lower than LiG/CRS values, while Doesken's results indicate that the MMTS temperatures were 0.38°F cooler overall than the LiG/CRS. Quayle et al. found a decrease in MMTS maxima of 0.72°F, an increase in MMTS minima of 0.50°F, a decrease in overall average MMTS temperatures of 0.11°F, and a 1.22°F reduction in average diurnal temperature range for MMTS when compared to LiG/CRS.

A seasonal cycle is apparent when comparing monthly average differences between the two sensors, especially with respect to TMIN (Fig. 3). During the winter months, the LiG/CRS and MMTS compares more closely on average (with differences typically ranging between 0.00°F and 0.20°F) than over the warmer months of Apr.-Oct., when the MMTS recorded average TMINs around 0.40°F higher than the LiG/CRS. A more subtle seasonal cycle is suggested when comparing TMAX, with the months of Jun.-Oct. and Jan.-Feb. demonstrating MMTS maxima that were 0.80°-0.90°F° cooler than LiG/CRS, compared to about 0.70°F cooler during the other months. Though the reasons for such differences in TMAX/TMIN between sensors and the presence of seasonal changes are not definitively known, it's possible that differences in sensor response, mechanics (e.g., column separation in LiG thermometers leading to erroneously high and low readings), and characteristics of the shelter microenvironment of the CRS and MMTS (such as the possibility of enhanced heating in the CRS shelter during the day and radiation loss from the CRS during the night through its single slatted bottom) may explain the differences in behavior between sensors.

The New Brunswick station experienced another sensor change in 2009, with the Campbell Scientific HMP45C becoming the primary temperature sensor. Comparisons between all three sensors between July 2008 and May 2012 indicate that the HMP maxima averaged 0.16° cooler, minima 0.34° F warmer, and overall average temperatures 0.09° warmer than LiG/CRS values (Fig. 4). HMP maxima averaged 0.72°F warmer, HMP minima 0.16°F cooler, and overall average temperatures 0.28°F warmer than MMTS. The presence of such a marked difference in TMAX between the two electronic MMTS and HMP sensors is somewhat surprising, but again may be related (but not limited) to differences in sensor response, sensitivity, and calibration.