Comparison of Temperature Trends Using an Unperturbed Subset of The U.S. Historical Climatology Network

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Introduction

A 410-station subset of U.S. Historical Climatology Network (version 2.5) stations is identified that experienced no changes in time of observation or station moves during the 1979-2008 period. These stations are classified based on proximity to artificial surfaces, buildings, and other such objects with unnatural thermal mass using guidelines established by Leroy (2010)[5]. The United States temperature trends estimated from the relatively few stations in the classes with minimal artificial impact are found to be collectively about 2/3 as large as US trends estimated in the classes with greater expected artificial impact. The trend differences are largest for minimum temperatures and are statistically significant even at the regional scale and across different types of instrumentation and degrees of urbanization. The homogeneity adjustments applied by the National Centers for Environmental Information (formerly the National Climatic Data Center) greatly reduce those differences but produce trends that are more consistent with the stations with greater expected artificial impact. Trend differences are not found during the 1999-2008 sub-period of relatively stable temperatures, suggesting that the observed differences are caused by a physical mechanism that is directly or indirectly caused by changing temperatures.

Method

Comprehensive metadata analysis for each USHCN site in this study was performed. Ground photography (Figure 1), Google Earth street level, and or aerial photography (Figure 2) was obtained.

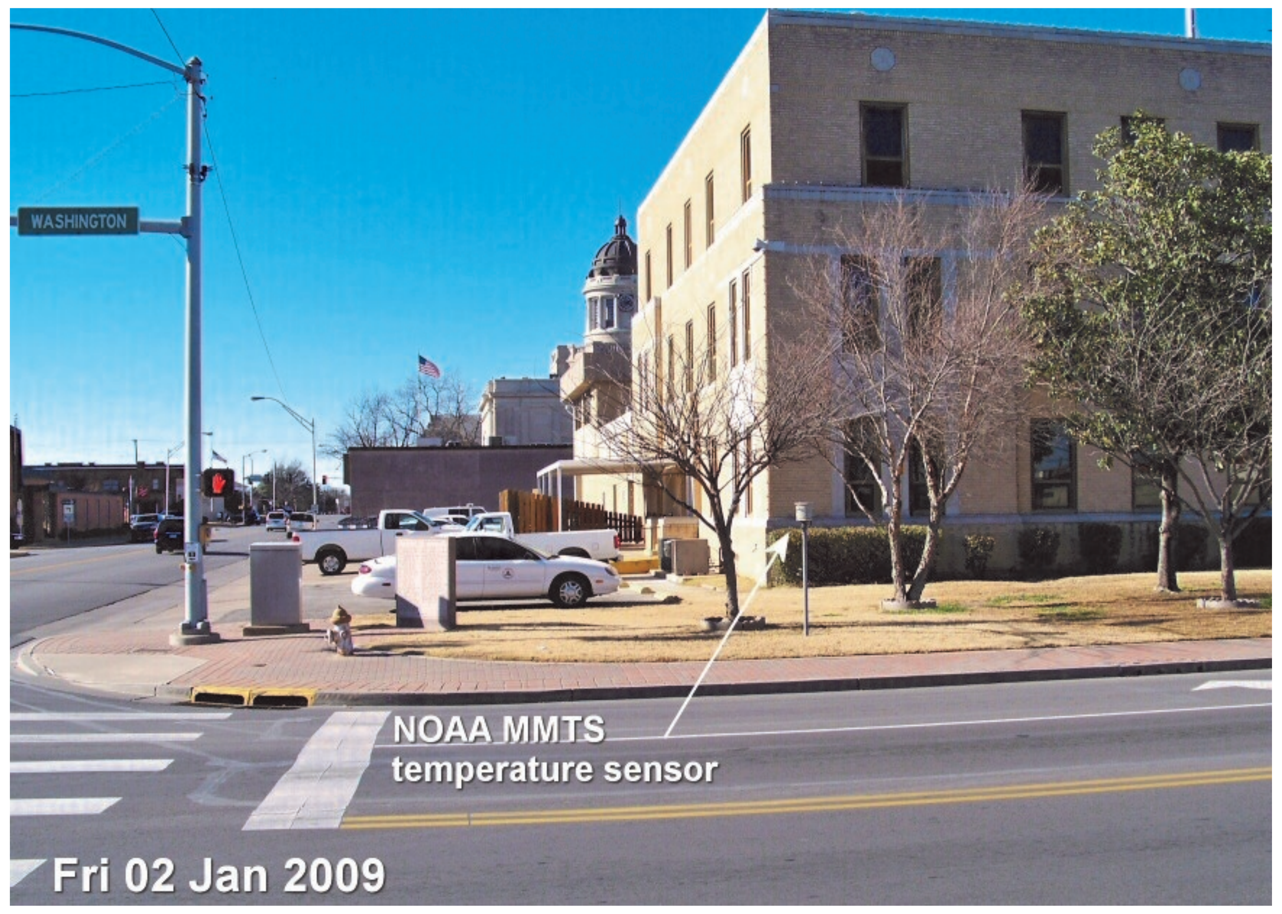

Figure 1—USHCN Temperature sensor located on street corner in Ardmore, OK in full viewshed of multiple heatsinks.

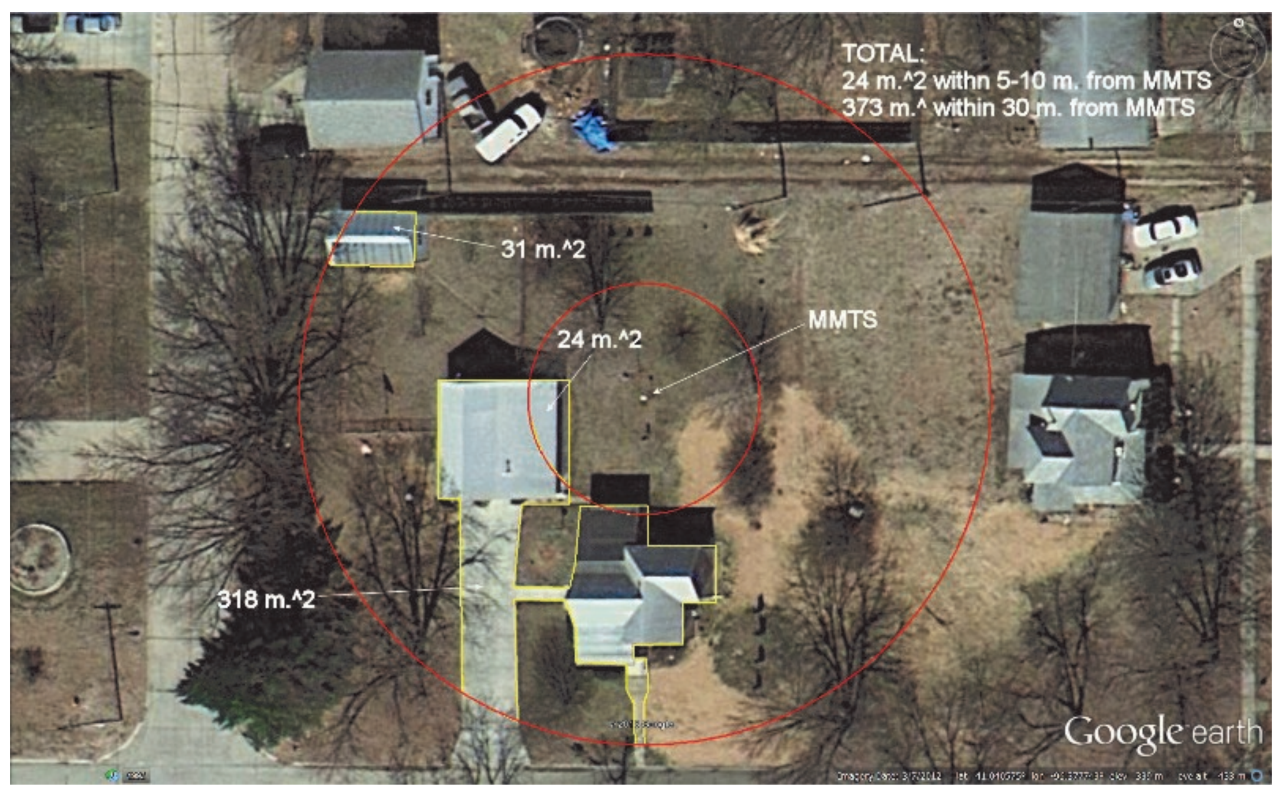

Figure2—Analysis of artificial surface areas within 10 and 30 meter radii at Ashland, NE USHCN station (COOP# 250375) using Google Earth tools. The NOAA temperature sensor is labeled as MMTS.

Distance measurements of visible encroachments were made, and a calculation was done to determine the percentage of area within the different radii (3m, 5m, 10m, 30m, and 100m) surrounding the thermometer per Leroy (2010)[5], containing heat sinks and/or heat sources. The class rating assigned to the stations corresponds to the portion of the Leroy (2010)[5] rating system dealing with artificial surfaces. The distance and area values were applied to the final rating for each station. Quality control checks were routinely done to ensure that the proper station was identified, that it matched descriptions in metadata provided by NCDC, that it was consistent with the latitude and longitude given for the station, and that the equipment seen in photography and described in survey reports matched the equipment description according to the NCDC HOMR metadatabase.

Trend Comparisons

(All Unperturbed Stations vs. Official Record)

Raw, Class 1\2 (Compliant): **+0.204**
Raw, Class 3\4\5 (Non-Compliant): **+0.319**
All 1218 Official NOAA-Adjusted, Class 1-5 (All): **+0.324**

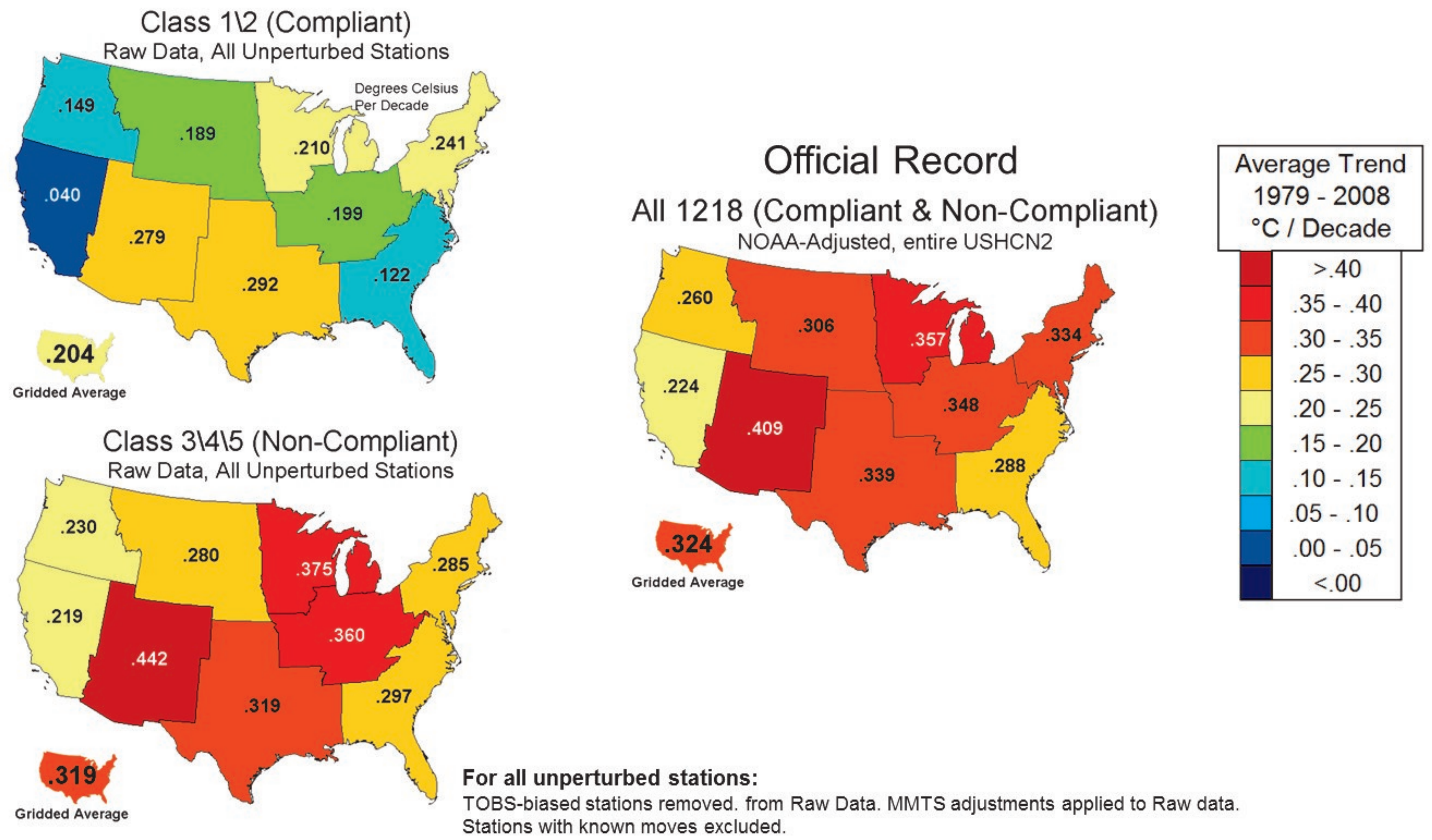

Figure 3—Comparisons of well sited (compliant Class 1&2) USHCN stations to poorly sited USHCN stations (non-compliant, Classes 3,4,&5) by CONUS and region to official NOAA adjusted USHCN data (V2.5) for the entire (compliant and non-compliant) USHCN dataset.

RAW (+MMTS Adjustments only)

	COMPLIANT: RAW+MMTS ADJUSTMENT				NON-COMPLIANT: RAW+MMTS				Number of Stations per Subset		
		TMEAN	TMAX	TMIN		TMEAN	TMAX	TMIN	1\2	3\4\5	Total
ALL UNPERTURBED	Class 1\2	0.204	0.263	0.145	Class 3\4\5	0.319	0.311	0.326	92	318	410
MMTS ("Gold Standard")	Class 1\2	0.163	0.113	0.218	Class 3\4\5	0.318	0.322	0.315	34	174	208
URBAN (Gridded)	Class 1\2	0.258	0.242	0.266	Class 3\4\5	0.359	0.323	0.387	12	39	51
URBAN (Ungridded)	Class 1\2	0.175	0.098	0.226	Class 3\4\5	0.326	0.285	0.364	12	39	51
NON-URBAN	Class 1\2	0.204	0.267	0.143	Class 3\4\5	0.317	0.309	0.326	80	279	359
CRS-ONLY	Class 1\2	0.317	0.431	0.223	Class 3\4\5	0.362	0.442	0.282	29	81	110
RURAL MMTS	Class 1\2	0.149	0.106	0.191	Class 3\4\5	0.326	0.272	0.379	27	96	123
CROPS	Class 1\2	0.241	0.337	0.145	Class 3\4\5	0.333	0.308	0.355	22	98	120
PERTURBED	Class 1\2	0.126	0.100	0.151	Class 3\4\5	0.190	0.153	0.228	113	430	543
PERTURBED + UNPERTURBED	Class 1\2	0.153	0.177	0.129	Class 3\4\5	0.232	0.209	0.256	205	748	953
ALL 1218 USHCN	All Classes	0.218	0.202	0.234							

NOAA-ADJUSTED, HOMOGENIZED

	COMPLIANT: NOAA-ADJUSTED/HOMOGENIZED				NON-COMPLIANT: NOAA-ADJUS				Number of Stations per Subset		
		TMEAN	TMAX	TMIN		TMEAN	TMAX	TMIN	1\2	3\4\5	Total
ALL UNPERTERBED	Class 1\2	0.336	0.376	0.295	Class 3\4\5	0.330	0.376	0.284	92	318	410
MMTS	Class 1\2	0.310	0.304	0.316	Class 3\4\5	0.321	0.356	0.286	34	174	208
URBAN (Gridded)	Class 1\2	0.326	0.330	0.323	Class 3\4\5	0.326	0.340	0.311	12	39	51
URBAN (Ungridded)	Class 1\2	0.340	0.323	0.356	Class 3\4\5	0.345	0.350	0.339	12	39	51
NON-URBAN	Class 1\2	0.333	0.375	0.291	Class 3\4\5	0.329	0.377	0.281	80	279	359
CRS-ONLY	Class 1\2	0.325	0.406	0.246	Class 3\4\5	0.338	0.423	0.257	27	96	123
RURAL MMTS	Class 1\2	0.303	0.309	0.303	Class 3\4\5	0.329	0.360	0.301	29	81	110
CROPS	Class 1\2	0.353	0.390	0.317	Class 3\4\5	0.338	0.381	0.296	22	98	120
PERTURBED	Class 1\2	0.312	0.346	0.280	Class 3\4\5	0.315	0.354	0.276	113	430	543
PERTURBED + UNPERTURBED	Class 1\2	0.319	0.362	0.277	Class 3\4\5	0.322	0.364	0.280	205	748	953
ALL 1218 USHCN	All Classes	0.324	0.361	0.248							

Table 1—Tabulation of station types showing 30 year trend for compliant Class 1&2 USHCN stations to poorly sited non-compliant, Classes 3,4,&5 USHCN stations in the CONUS, compared to official NOAA adjusted and homogenized USHCN data.

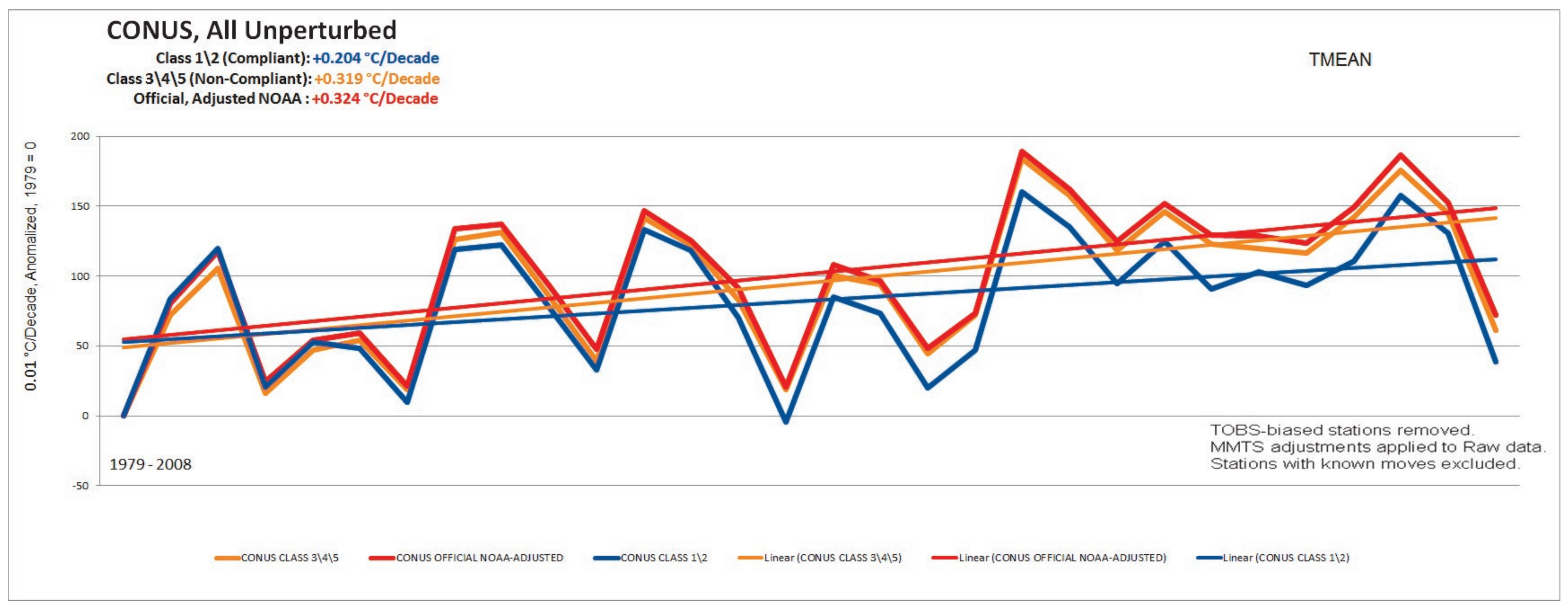

Figure 4—Comparisons of 30 year trend for compliant Class 1,2 USHCN stations to non-compliant, Class 3,4,5 USHCN stations to NOAA final adjusted V2.5 USHCN data in the CONUS

Where discrepancies existed, interviews were conducted with the station curator, when possible, to ensure the location of the thermometer in some aerial photos that had marginal resolution. Where such discrepancies could not be resolved, or it was determined from photographs, metadata, or curator interviews, that the station had been moved and either its prior location could not be established or the move resulted in a change of rating, that station was excluded from consideration and not included in this study. Figure 2 illustrates how the USHCN station COOP# 250375) in Ashland, NE, was evaluated per Leroy (2010)[5] procedures, showing the 10 meter and 30 meter radii, along with polygon surface (area outlines of visible heat sinks created with Google Earth Pro tools, providing a value of ~373 square meters of heat sink surface area within the 30 meter radius, and ~24 square meters within the 5-10 meter annulus.

Hypothesis

It is well established that heat sinks have an effect on temperature offset. But, we contend the effect manifests itself into temperature trends, as well, in contradiction to the conclusions of Menne et al. (2009, 2010). The overall warming effect of a heat sink on a nearby sensor is greater at the end of a warming phase than at the start of it. Therefore, the trend will be spuriously exaggerated by warming over the 30-year study period (Figure 4).

Conversely, the effect of a heat sink is less at the end than at the beginning of an overall cooling phase. Therefore, the cooling phase is exaggerated in the reverse manner as during a warming phase. This explains why warming is exaggerated from 1979 - 2008 and from 1979 - 1998, when overall warming was reported. Likewise, It also explains why the cooling from 1999 - 2008 is exaggerated. We contend that heat sinks will amplify the trends.

Furthermore, if there is no trend in either direction (as during the last decade-plus), there will be no divergence. This explains why there has been no overall divergence between USHCN and CRN since CRN was not activated until 2005, and the CONUS Tmean trend has been flat.

Key findings

1. Comprehensive and detailed evaluation of station metadata, on-site station photography, satellite and aerial imaging, street level Google Earth imagery, and curator interviews have yielded a well-distributed 410 station subset of the 1218 station USHCN network that is unperturbed by Time of Observation changes, station moves, or rating changes, and a complete or mostly complete 30-year dataset. It must be emphasized that the perturbed stations dropped from the USHCN set show significantly lower trends than those retained in the sample, both for well and poorly sited station sets.

2. Bias at the microsite level (the immediate environment of the sensor) in the unperturbed subset of USHCN stations has a significant effect on the mean temperature (Tmean) trend. Well sited stations show significantly less warming from 1979 - 2008. These differences are significant in Tmean, and most pronounced in the minimum temperature data (Tmin). (Figure 3 and Table 1)

3. Equipment bias (CRS v. MMTS stations) in the unperturbed subset of USHCN stations has a significant effect on the mean temperature (Tmean) trend when CRS stations are compared with MMTS stations. MMTS stations show significantly less warming than CRS stations from 1979 - 2008. (Table 1) These differences are significant in Tmean (even after upward adjustment for MMTS conversion) and most pronounced in the maximum temperature data (Tmax).

4. The 30-year Tmean temperature trend of unperturbed, well sited stations is significantly lower than the Tmean temperature trend of NOAA/NCDC official adjusted-homogenized surface temperature record for all 1218 USHCN stations.

5. We believe the NOAA/NCDC homogenization adjustment causes well sited stations to be adjusted upwards to match the trends of poorly sited stations.

6. The data suggests that the divergence between well and poorly sited stations is gradual, not a result of spurious step change due to poor metadata.

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[5]Leroy, M. (2010): Siting Classification for Surface Observing Stations on Land, Climate, and Upper-air Observations *JMA/WMO Workshop on Quality Management in Surface*, Tokyo, Japan, 27-30 July 2010.