# 2022 SURFACE STATIONS SURVEY RESULTS AND FINDINGS

In April and May of 2022, a total of 128 stations were surveyed throughout the contiguous United States. Of those, 80 were USHCN stations, most of which were in the original 2009 report. A total of 528 photographs were taken.[iv] To acquire a sample for the new *n*ClimDiv dataset, 48 GHCN sites were surveyed, with 298 photographs taken. The overall sample is broadly representative of the entire network, as it samples stations in the majority of states. Regional samples comprising many nearby stations were done in the western and southeastern United States, focusing on Alabama, California, Florida, Georgia, Idaho, Montana, Nevada, Oregon, and South Carolina.

- The 2009 report found 89 percent of stations were unacceptable by NOAA's own standards. The 2022 report found an even greater percentage of stations—approximately 96 percent—are sited unacceptably. The official U.S. temperature record, which was shown in 2009 to be heat-biased due to poor siting issues, appears to be even more biased in 2022.
- Of the 128 stations surveyed, only two were found to be a Class 1 (best-sited) station: the Dubois, Idaho Agricultural Experiment Farm, and the St. Joseph, Louisiana Agricultural Experiment Farm.
- Three stations were found to be Class 2 (acceptably sited).
- The remaining 123 stations were found to be Class 3, 4, and 5, and therefore considered unacceptably sited in accordance with Leroy's classification system and NOAA publication 10-1302.
- The 7 percent increase in unacceptably sited stations from 2009 to 2022 seems to be in line with the Gallo and Xian study noting the increase in ISAs near USHCN stations.
- Based on the sample, it appears that waste-water treatment plants (WWTP) comprise approximately 25-30 percent of the entire COOP network. It is difficult to get an accurate count because NOAA / NWS does not discern between WWTPs and other stations in the HOMR database. WWTPs are a poor place to measure data to detect climate change because they grow with population, and the industrial processes they perform (sewage digestion) generate substantial amounts of heat, creating a heat sink effect.
- In some interviews with observers, it became clear NOAA / NWS personnel are aware their station siting does not adhere to NOAA standards, but they do not have the means or the time to take corrective action. A prime example is a Class 5 USHCN station in a radio station parking lot in Grants Pass, Oregon, where the radio station engineer recognized the problem, but the local NWSFO refused to address it—even after multiple requests to relocate the MMTS sensor.
- Based on the 2022 survey sample, it appears that record continuity has been given more importance than accuracy. Even though many stations' sensor locations clearly violate standards, they were placed in sub-optimal locations regardless.
- The majority of USHCN stations that were closed since the 2009 report were stations that received wide publicity for their unacceptable siting. Other equally poor stations that did not receive a similar amount of publicity remain open. For example, compare Tucson, Arizona and Troy, Alabama. This suggests that closures by NOAA / NWS were not done for the purposes of data quality, but rather to save face in the court of public opinion.
- In three stations surveyed (Calhoun, Louisiana; Roseburg, Oregon; and Thompson, Utah) there was a conversion of the wired MMTS sensor to a solar powered wireless reporting sensor. This allowed for placement away from heat sinks in the area, but the solar panel placement directly under the sensor likely negated the value of the siting improvement. Solar panels can reach temperatures of 149°F during the summer, and the heat from them rises to the sensor.[45]

[iv] Before and after results comparing USHCN stations from 2009 to 2022 are provided in Appendix A.

- Several examples of station siting that could be categorized as "absurd" were noted during the survey. These include a GHCN station at Lava Hot Springs, Idaho—a tourist site at which the MMTS sensor was placed into a natural hole in the ground where hot water for bathing and swimming emanates from the ground; a WWTP in Ft. Pierce, Florida—where the MMTS was placed in proximity to a road, a building, and near the warm exhausts of five air conditioning units for WWTP offices; and a station in Virginia City, Nevada—at which the MMTS was not only missing its protective cap, but also placed near asphalt, generators, and air conditioning unit exhausts. Perhaps the most absurd was a USHCN station in Colfax, California, which was recently moved due to a modernization upgrade at the California fire station where it is located. The new station has been placed directly above a 20-foot rock wall that absorbs a massive amount of solar energy during the day, and releases it as LWIR at night, with heated air rising to the sensor.

- Lack of station maintenance was observed throughout the USHCN and GHCN. MMTS sensors were often discolored/yellowed, dirty, and in the case of WWTP placements, often covered in mold. This results in a lower reflectivity albedo and biases temperature readings higher due to increased absorption of sunlight during the day. Some MMTS placements were tilted, allowing solar SW and LWIR to enter the protective slats. For example, the station in Virginia City, Nevada, was missing the top sunshield cap. COOP observers report they have no maintenance schedule for these issues, and that visits from NOAA / NWS personnel can take up to three years.

- Stations using a cotton region shelter often suffered from the greatest non-maintenance issues. Peeling paint, dry rot, missing slats, mold, and other wood deterioration issues were common, such as in Elkton, Oregon.

- Every NWS Forecast Office inspected had a COOP, USHCN, or GHCN station present, and every NWSFO had siting issues that were noncompliant with NWS publication 10-1302. In many cases, MMTS and CRS thermometer shelters were in proximity to concrete and exhaust from air conditioning units. This is likely due to limited real estate and a common theme design for NWSFOs. Pocatello, Idaho and Oxnard, California are prime examples of poor siting at NWS offices. Based on our sampling, the issue likely exists at every NWSFO in the United States.

- The majority of the USHCN and GHCN station networks still use manual recording and transcription to report temperature and rainfall data. Observers must write down these values daily, and then transcribe them onto B91 forms for mailing to NCDC / NCEI in Asheville, North Carolina, which are then manually transcribed into the record. This provides significant potential for human error in the data entry process. Similarly, stations that are set up for reporting data by telephone or web page still must transcribe data from paper to the WxCoder system used by NOAA / NWS.[46]

- Similarly, though stations have thermometers capable of reading to the nearest tenth of a degree Fahrenheit, data are manually rounded by the observer before transcription. This adds potential rounding errors in addition to the potential transcription errors; in the case of reporting record highs or record lows at a station, this may create an inaccurate new record. Oddly, rainfall values at all COOP stations are reported to the nearest tenth of an inch, whereas temperature is reported to the nearest whole degree.

- NOAA / NCDC / NCEI reports that error correction processes exist for data reported by COOP observers, and that process will catch some but not all transcription errors. For example, a daytime high temperature recorded as 78 degrees might be transposed as 87 degrees during data entry. That error would likely be caught and corrected, provided there were no similar high temperatures in the area. However, a smaller transcription error such as 79 degrees instead of 78 degrees may not be caught, because the computer algorithm checking for such errors would deem it plausible.

- The COOP Network is almost entirely volunteer-operated. The exception is stations placed at airports with Automatic Surface Observing Systems (ASOS) operated by the Federal Aviation Administration, as well as the few MMTS stations that have been converted to wireless operations. There is very little oversight by NOAA / NWS, and the data are entirely dependent on the skill of the volunteer observers.

- There does not appear to be a central authority that oversees any station in the COOP network. Rather, it seems to be an ad hoc collection of competing interests where no central authority exists to determine if the station is properly placed, and producing accurate data. All data quality control appears to be retroactive. While NOAA / NWS are responsible for placement, they clearly do not adhere to their own public standards. This may be due to landowners having the final say on placement for aesthetic or operational reasons. The prime user of the data, NOAA / NCDC / NCEI, has no input into placement and no way to apply quality control to the data before they are recorded.
- Because of the human element in the data collection process, gaps exist in the data due to illness, weekends, vacation time, and holidays. When gaps exist in data, NOAA / NCDC / NCEI try to fill them by interpolating from other nearby station data, creating "data" where none exists. Given approximately 96 percent of stations in the COOP network have siting problems producing a warming bias, such data interpolation nearly guarantees that any well-sited station with data gaps will have those gaps infilled with biased warmer data from surrounding stations.
- Section 515 of Public Law 106-554, known as the Information Quality Act, provides guidelines for the reliability and accuracy of data produced by government agencies.[47] NOAA has acknowledged the IQA, asserting that it "creates and disseminates reliable assessments and predictions of weather, climate, the space environment…[and] works to ensure access to sustained, reliable observations from satellites to ships to radars to data buoys."[48] Yet, given that 96 percent of data generated by the COOP Network appears to be compromised, and because it has been demonstrated by Watts *et al.* that unperturbed stations do not show the same level of warming as stations not in compliance, it is clear that NOAA is producing data that is not in compliance with IQA.

# CONCLUSIONS AND RECOMMENDATIONS

The findings of both the 2009 and the 2022 Surface Stations studies clearly demonstrate the COOP network's temperature records—at both USCHN and GHCN stations—have been substantially corrupted. After surveying a comprehensive and representative sample of stations, 96 percent were found to be biased in some way by the heat sink effect, or other heat sources.

Claims by NOAA, NCDC, and NCEI that this data contamination can be statistically adjusted are disingenuous, especially considering the widescale homogenization of good and bad data. Good data exists in the unperturbed stations demonstrated by Watts *et al.* in 2015, but the amount of bad data from poorly sited stations overwhelms the accurate data from well-sited stations.

It is important to note Watts and his fellow authors found a slight warming trend when examining temperature data from unperturbed stations, which cleaved closely to the findings of the University of Alabama-Huntsville's satellite-derived temperature record.[49] This warming trend, however, is approximately half the claimed rate of increase promoted by many in the climate science community.

USCRN was created for the purpose of accurately measuring climatic temperature trends, yet is not being utilized as such. While the state-of-the-art and professionally operated network has only 17 years of data, it represents an uncontaminated climatic record, and should therefore be given preeminence in official reports. The currently utilized *n*ClimDiv data, however, has been adjusted to USCRN data post-2005, but contains no adjustments prior to 2005. This may very well be why warming trends are present in the *n*ClimDiv data. Despite NOAA's assertions to the contrary, climatic temperature increases as measured by *n*ClimDiv cannot be effectively isolated from potential confounds such as heat sinks, urbanization, WWTPs, population growth, and other factors.

In conclusion, the rate of warming as measured by unperturbed surface stations, USCRN, and UAH does not represent a climate crisis.

Based on the project's findings, the following recommendations are suggested:

1. NOAA / NWS has not fully implemented the recommendations of the OIG and GAO reports on the state of the USCHN. They should do so and apply those recommendations to the entire COOP network.
2. NOAA / NWS should immediately cease temperature data collection operations at waste-water treatment plants. These facilities have grown significantly in size and treatment volume over the past century as the U.S. population has grown, adding large heat sink capacity as well as waste heat of sewage digestion to the long-term temperature record. It is unclear if temperatures measured at these facilities reflects population growth or actual climatic changes in temperature. With thousands of reporting stations in the contiguous United States, there is a broad oversampling of temperature and the loss of these stations will not compromise data integrity, but likely improve it by removing stations with century-scale positive biases.
3. A central authority, rather than the ad hoc collection of competing interests, should be created to evaluate stations and determine if they adhere to standards and produce suitable data. The authority should have the power to upgrade or close stations that cannot be brought into compliance.
4. NOAA / NWS should work to modernize the COOP network. NOAA / NWS still inputs most data collection manually with volunteer observers performing data transcription, much like when the network was launched in 1890. Wireless weather station technology—already demonstrated to be effective—will allow placement of stations away from heat sinks and sources, remove data transcription errors, and avoid data gaps.
5. NOAA / NWS should secure funding to continue the modernization program (USHCN-M) that was successfully tested in 2008, but closed for lack of funding. Science has clearly called for a modern climate observing program.[50] Yet, data collection methods by NOAA / NWS remain rooted in manual processes first started in 1890, when the COOP network for formed by the U.S. Weather Bureau.
6. NOAA / NWS / NCEI should make a concerted effort to locate the best, unperturbed Class 1 and 2 stations in the USHCN and GHCN, and classify them as the "gold standard" for long-term climate reporting. Temperatures measured at "gold standard" stations should be reported monthly in *State of the Climate* reports issued by NOAA so the public can see the differences in blended temperature readings from the most well-sited stations.
7. Alternatively, USHCN / GHCN stations should be discontinued altogether for U.S. climate monitoring, and be replaced by the state-of-the-art USCRN stations for determination of climate trends moving forward.
8. NOAA / NWS / NCEI should start reporting the temperature results of the USCRN in monthly and yearly *State of the Climate* reports issued by NOAA. The USCRN provides the most accurate surface temperature record in the United States by design. However, the media and public are not privy to the data it provides, nor are many aware of its existence.

# APPENDIX A: BEFORE (2009) AND AFTER (2022) SITE PHOTOS

This appendix contains before and after photos from the original Surface Stations publication in 2009 compared to photos taken for the 2022 publication. In those cases where site access was unattainable, Google Earth satellite and street view imagery is relied upon. Many of these NOAA / NWS weather stations are now inaccessible due to their status as government facilities.

In addition to the photos and descriptions, an estimate of site quality is provided. A rating of CRN5 represents the "worst" sites, with CRN1 representing the "best" sites. Ratings of CRN1 and CRN2 are considered to be acceptably sited; CRN3, CRN4, and CRN5 are not. According to the published standards for station siting provided by NOAA / NWS,[51] the vast majority of these USHCN stations have not met these standards in 2009 or 2022.

Note that many of the worst examples of USHCN station siting from 2009 have now been closed. Determination of station closure has been sourced from NOAA's HOMR database.[52]

**Amherst, MA,** sited on gravel bed near driveway at WWTP. RATING = CRN4



No change. RATING = CRN4

**Ardmore, OK,** between city hall and sidewalk, main street. RATING = CRN5


2022

CLOSED

**Ashland, OR,** patch of green, sea of concrete. RATING = CRN5



Moved, converted to MMTS, better siting. RATING = CRN4

**Atchison, KS,** near corner of large stone buildings. RATING = CRN4



Location unchanged, but on 2009-06-01, site was removed from USHCN network and now is COOP “B” network (not climate). RATING = CRN4

**Baltimore, MD,** sited on red platform on city rooftop. RATING = CRN5


2022

CLOSED

**Bartow, FL,** nearby building, road, parking lot. RATING = CRN5


2022

CLOSED

(Moved to private residence, unable to survey new location)

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**Blacksburg, VA,** at NWSO, nearby concrete platforms, satellite dish. RATING = CRN4



No change. RATING = CRN4

**Block Island, RI,** adjacent to parking lot and aircraft parking area. RATING = CRN4



No change. RATING = CRN4

**Brinkley, AR,** nearby building with 3 air blowers, dirt mound, raw sewage at WWTP. RATING = CRN3



No change. RATING = CRN3

**Brookville, IN,** nearby driveway, building. RATING = CRN4



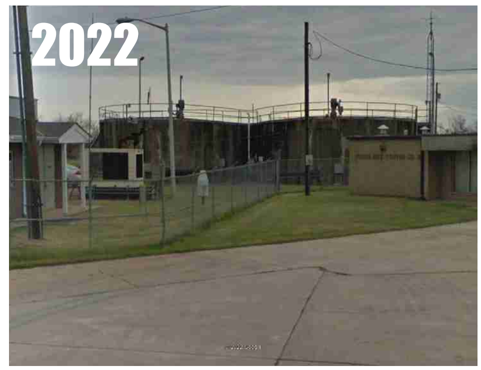
No change. RATING = CRN4

**Buffalo Bill Dam, WY,** sited on concrete, between two buildings. RATING = CRN5



Moved, converted to MMTS. Next to a asphalt parking lot and vehicle. RATING = CRN5

**Bunkie, La,** too close to sidewalk and Building at WWTP. RATING = CRN4


No change. RATING = CRN4

**Champion, MI,** nearby road, parking area, house. RATING = CRN4


**2022**

**CLOSED**

**Conway, SC,** near large asphalt area, building. RATING = CRN4


**2022**

**CLOSED**

**Cornwall, VT,** nearby residence, road approximately 50 feet away. RATING = CRN3



No change. RATING = CRN3

**Crosby, N.D,** nearby building, patio.
RATING = CRN4


2022

# CLOSED

(Private residence, unable to survey new location)

**Dayton, WA.** Water plant, over cinder.
RATING = CRN5
rock, near vents, buildings.



No change. RATING = CRN5

**Detroit Lakes, MN,** nearby air-conditioning unit, building, gas tank.
RATING = CRN5



Moved 70 feet west away from building and A/C unit. RATING = CRN2

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**Dillon, MT,** at power plant building, sited on concrete border of sidewalk 6’ from brick wall. RATING = CRN5



No change. RATING = CRN5

**Durham, N.H,** nearby building, parking lot. RATING = CRN4



Moved to new location, siting similar.
RATING = CRN4

**Ennis, MT,** nearby building, trailer, assorted junk. RATING = CRN4


2022

# MOVED TO ACCOMMODATE CONSTRUCTION

(Unable to survey)

**Enosburg Falls, VT,** adjacent to driveway, nearby building. RATING = CRN4


2022

CLOSED

**Falls Village, CT,** nearby building and parking lot. RATING = CRN4


2022

CLOSED

**Fort Morgan, CO,** huge industrial building, parking lot. RATING = CRN4



Moved, but new station is compromised by addition of mailbox and solar panel. RATING = indeterminate, there is no formula for mailboxes.

**Fort Scott, KS,** overwhelmed by large paved area, nearby building (Funeral Home). RATING = CRN5



Closed, moved 1.8 miles southeast to an improved location at private residence. RATING = CRN3

**Gainesville, GA,** between two driveways. RATING = CRN4


No change. RATING = CRN4

**Grace, ID,** CRS over concrete, industrial nightmare. RATING = CRN5



No change to location, but MMTS added improperly to the roof of the CRS, resulting in warmer temperature. RATING = CRN5

**Greenville, TX,** nearby building, satellite dish, two air-conditioning units. RATING = CRN4



No change in location, but MMTS is now tilting due to lack of maintenance. RATING = CRN4

**Greenwood, DE,** sited on concrete platform. RATING = CRN5


2022

**CLOSED**

**Gunnison, CO,** nearby parking lot. RATING = CRN4



Location unchanged, but note new two-story construction nearby. RATING = CRN4

**Haskell, TX,** between road and parking lot, nearby building. RATING = CRN4



Location moved, but now near sidewalk and A/C unit, building. RATING = CRN4

**Hay Springs, NE,** next to building, narrow sidewalk, telephone pole. RATING = CRN4


2022

**CLOSED**

**Hendersonville, NC,** nearby parking lot, satellite dish, building. RATING = CRN5



Location unchanged, but MMTS moved about 15 feet away from parking lot. Improved siting. RATING = CRN4

**Heppner, OR,** MMTS in a sea of dark crushed rock, at city WWTP. RATING = CRN5



No change in location. Unable to ground survey. RATING = CRN5

**Hillsdale, MI,** near large paved area at WWTP. RATING = CRN4



No change in location. Unable to ground survey. RATING = CRN4

**Hopkinsville, KY,** adjacent residence, driveway, accumulated junk, BBQ. RATING = CRN5



Same location, but MMTS moved 126 FEET SW to front yard, for better siting. RATING = CRN4

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**Hot Springs, SD,** partially obscured by foliage. RATING = CRN3



MMTS remains partially obscured by foliage, but new generator has been installed nearby. RATING = CRN3

**Kennebec, SD,** sited on gravel path, nearby Shed at private residence. RATING = CRN4



Same location, but NWS reports: “moved MMTS 35 feet to the northwest due to bad location.” Unable to ground survey. RATING = CRN4

**Lampasas, TX,** next to sidewalk, near satellite dish, road, parking lot, building. RATING = CRN5


**2022**

**CLOSED**

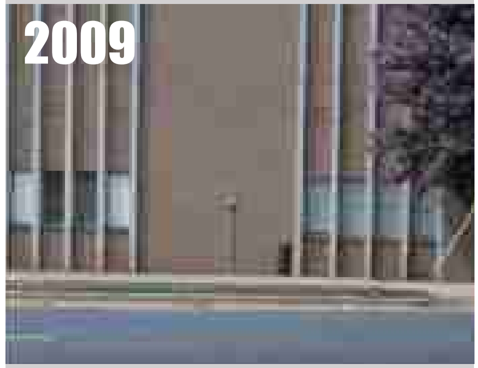
(NWS reports: “DATA AT THIS LOCATION IS NO LONGER REPRESENTATIVE DUE TO CONSTRUCTION AND URBANIZATION.”)

**Lebanon, MO,** nearby radio station building. RATING = CRN4



No change in location. Unable to ground survey. RATING = CRN4

**Lenoir, NC,** nearby sidewalk, road, building. RATING = CRN4





Location unchanged. RATING = CRN4

**Lexington, VA,** sewage plant, near building, sidewalks, road, parking lot at WWTP. RATING = CRN4


**2022**

**CLOSED**

(Moved to private residence. Unable to ground survey.)

**Logan, IA,** nearby building, concrete slabs. RATING = CRN4


**2022**

**CLOSED**

**Lovelock, NV,** nearby residence, U-Haul unit. RATING = CRN4



Closed, then moved to an industrial area, worse location. RATING = CRN5

**Marengo, IL,** nearby buildings, parking lot at WWTP. RATING = CRN4

**2022**

**CLOSED**

**Miami, AZ,** sited on dark gravel, next to building. RATING = CRN5


2022

CLOSED

**Midland, MI,** next to concrete and a vent at WWTP. RATING = CRN5



Same location at WWTP, but moved and converted to MMTS. Slightly better siting compared to original location. RATING = CRN4

**Milwaukee, WI,** nearby road. RATING = CRN4


2022

CLOSED

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**Mohonk Lake, NY,** much too close to ground, shading issues, nearby building, chimney. RATING = CRN4


2022

UNCERTAIN FATE

(NWS reports: REMOVING TEMPERATURE, 24-HOUR PRECIPITATION, AND SNOW ELEMENTS TEMPORARILY DUE TO NON-NWS EQUIPMENT BEING USED. OBSERVER UNABLE TO USE OFFICIAL NWS EQUIPMENT TO REPORT TEMPERATURE AND MANUAL PRECIPITATION/SNOW DATA.)

**Monticello, MS,** between two buildings, nearby sidewalk. RATING = CRN4



Moved to new location at city offices on lawn. Improved location, but still too close to buildings. RATING = CRN3

**Morrison, IL,** sited on concrete, between open wastewater tanks at WWTP. RATING = CRN5



Same location at city WWTP, but moved away from tanks when converted to MMTS. RATING = CRN3

**Mount Vernon, IN,** nearby road, building, ironwork. RATING = CRN4



Location unchanged, but ironwork has been removed and replaced by chain-link fence. RATING = CRN4

**Napoleon, OH,** over concrete, near wastewater Tank at WWTP. RATING = CRN5


2022

CLOSED

**Neosho, MO,** nearby driveway and house. RATING = CRN4



Moved MMTS. NWS reports: SOMETIME IN THE SUMMER OF 2010 THE SRG AND MMTS WERE MOVED 556 FT TO THE NE, CLOSER TO THE NEW VISITOR CENTER. Siting is slightly better at new location. RATING = CRN3

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**Northfield, VT,** nearby driveway, building. RATING = CRN4


2022

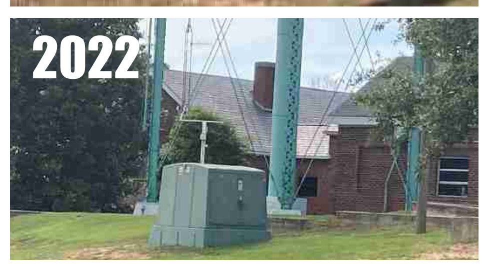
CLOSED

**Okemah, OK,** sited on edge of driveway, nearby street. RATING = CRN4


2022

CLOSED

**Orangeburg, SC,** nearby metal coverings, parking lot, building at WWTP. RATING = CRN4


Uncertain. Surveyor in 2022 reports that readings are coming from non-standard weather station (shown) but NWS reports in HOMR that official NOAA MMTS is being used. RATING = CRN4

**Orono, ME,** sited on roof of powerplant building with parking lot. RATING = CRN5


2022

**CLOSED**

**Panguitch, UT,** former location (screen removed) on concrete, by parking lot. RATING = CRN5



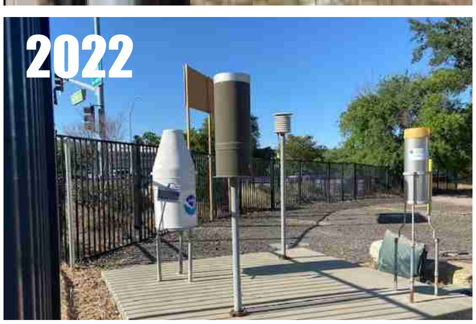
Station closed, moved to private residence. Siting is better than a parking lot, but has issues with shading and irrigation. RATING = CRN4

**Paris, IL,** adjacent brickwork and rooftop at city waterworks. RATING = CRN4



MMTS was moved to a somewhat better location at city WWTP. NWS reports: “RELOCATED STATION 2 MILES SOUTHEAST OF PREVIOUS SITE, TO THE PARIS SEWAGE TREATMENT PLANT.” RATING = CRN3

**Paso Robles, CA,** sited on concrete slab next to sidewalk, nearby road, interstate. RATING = CRN5


Location unchanged, but wooden slat/ chain-link fence to the north has been removed. RATING = CRN5

**Pocahontas, AR,** fairly well sited. RATING = CRN2



Updated to MMTS and moved to a new location, now closer to buildings and more wind sheltered than before. RATING = CRN4

**Racine, WI,** between building and road. RATING = CRN4



No change. RATING = CRN4

**Red Cloud, NE,** on premises of city power plant. Nearby brick wall, structures. RATING = CRN4



Same location, but MMTS moved in 2010, improved siting. NWS reports on HOMR: "MMTS RELOCATED 282 FT SW". RATING = CRN3

**Richardton Abbey, ND,** at edge of sidewalk, nearby road, building. RATING = CRN5



No change. RATING = CRN5

**Rock Rapids, IA,** nearby building, sidewalk, driveway. RATING = CRN4



No change. RATING = CRN4

**Salisbury, MD,** nearby building, air-conditioning unit. RATING = CRN4


2022

CLOSED

**Sandpoint, ID,** heavy gravel base, near road. RATING = CRN4



MMTS was relocated to even worse site 0.31 miles away to the airport parking lot, sandwiched between airport tarmac and airport parking. Note vehicle radiator is directly under the sensor. RATING = CRN5

**Santa Rosa, NM,** exposed cabling, nearby metal boats, burn barrel, junk. RATING = CRN4


2022

CLOSED

**Searchlight, NV,** in Department of Transportation parking lot, heavy equipment. RATING = CRN5



Same location, but CRS updated to MMTS. Still close to building and asphalt parking lot. RATING = CRN4

**Spanish Fork, UT,** sited on gravel, near concrete wall at power station. RATING = CRN4



No change. RATING = CRN4

**Spooner, WI,** nearby parking lot and building. RATING = CRN4



Same location, but CRS upgraded to MMTS and moved to front lawn. Better siting, but still only 25' from brick building. RATING = CRN4

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**St. George, UT,** between building and raised parking lot, car radiator level. RATING = CRN5


**2022**

**CLOSED**

(Moved to private residence. Unable to ground survey)

**St. Joseph, LA,** well-sited station. RATING = CRN1



No change. However, CRS is in serious need of maintenance and peeling paint/ dirt/missing slats will make it warmer than normal. RATING = CRN1

**State College, PA,** nearby concrete path, building, construction. RATING = CRN4



No change, but construction has ended. RATING = CRN4

**Staunton, VA,** at WWTP, between tank wall and paved road. RATING = CRN4



No Change. RATING = CRN4

**Thompson, UT,** nonstandard equipment, over asphalt, nearby building. RATING = CRN4



Site moved, new wireless MMTS provided. Better location. NWS reports: “SITE MOVED 1.99 MILES EAST SOUTHEAST” RATING = CRN2

**Tifton, GA,** nearby air-conditioning units, sidewalk, road. RATING = CRN5



No Change. However, MMTS is dirty/discolored and needs maintenance. RATING = CRN5

**Titusville, FL,** at city WWTP. Mounted near sewage digester, near air-conditioning unit, generator. RATING = CRN5



Same location at WWTP, but NWS reports: “MMTS MOVED 102 FEET SOUTHEAST.” However, new site on rooftop is just as bad if not worse than original siting. Note exhaust fan nearby. RATING = CRN5

**Troy, AL,** nearby parking lot, MMTS at rear of satellite dish. RATING = CRN4



Same location, but MMTS was moved to top of brick wall, closer to building and parking lot. Worse siting than original. NWS seems unaware of move, no mention in HOMR. RATING = CRN5

**Troy, NY,** nearby parking lot, sidewalk, building. RATING = CRN4



No change. RATING = CRN4

**Tuckerton, NJ,** unshielded sensor attached to building. RATING = CRN5


**2022**

**CLOSED**

**Tucson, AZ,** sited on concrete in a parking lot. RATING = CRN5


**2022**

**CLOSED**

**Tularosa, NM,** at edge of gravel road. RATING = CRN3


**2022**

**CLOSED**

**Tullahoma, TN,** at city WWTP, electrical transformer, cement path. RATING = CRN5



No change. Unable to get access for ground survey. RATING = CRN5

**Union Springs, AL,** nearby building. RATING = CRN4


**2022**

**CLOSED**

**Uniontown, PA,** nearby building, road, parking areas. RATING = CRN4


**2022**

**CLOSED**

**Urbana, OH,** at city WWTP, mounted on brick wall, other multiple violations (see labels). RATING = CRN5



Same location at city WWTP, but MMTS moved to a better location over grass in front of office. Better site, but still too close to road and the building. See markers. RATING = CRN4

**Vale, OR,** next to road, CRS facing wrong direction per NWS standards. RATING = CRN5


2022

**CLOSED**

**Waterville, WA,** over cinder rock, adjacent to sidewalk, parking lot. RATING = CRN5


2022

**CLOSED**

**West Point, NY,** sited on edge of paved path, nearby stone building. RATING = CRN4


2022

**NO CHANGE**

(Unable to get access to re-survey)

**Wickenburg, AZ,** adjacent building, parking lot, accumulated junk. RATING = CRN5


2022

**CLOSED**

**Williamsburg, KY,** next to brick building (note the adjacent exhaust vent). RATING = CRN4


2022

**CLOSED**

**Winfield Locks, WV,** MMTS is up on the roof. RATING = CRN5


**2022**

**NO CHANGE**

Unable to resurvey due to locks/dam now a “restricted area.”
NWS notes in HOMR on 2/6/20: “THIS EQUIPMENT HAS BEEN ON THE ROOFTOP SINCE THE BEGINNING OF SERVICE AT THIS SITE AND HAS NOT BEEN MOVED...”
Siting is in direct violation of NOAA/NWS siting standards.
RATING = CRN5

**Winnebago, MN,** at city WWTP, nearby sewage tanks, concrete pad.
RATING = CRN4



NWS notes in HOMR: “UPDATED DUE TO MAJOR CONSTRUCTION AT WWTP. MOVED EQUIPMENT FROM WWTP BACK TO VERY CLOSE TO ORIGINAL REND 8 LOCATION.” Now located between street and brick building. Siting not improved. RATING = CRN4

**Woodville, MS,** nearby building.
RATING = CRN4


**2022**

**CLOSED**

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**Worland, WY,** nearby sidewalk, brick sign mount, gravel at base, outbuilding.
RATING = CRN4



No change. RATING = CRN4

**Yreka, CA,** CRS sited on cinder rock, nearby concrete driveway, parking lot, road. RATING = CRN5



CRS converted to MMTS, but moved next to building, parking lot, sidewalk, and A/C unit. Very slight improvement in siting but could go either way RATING = CRN4/5

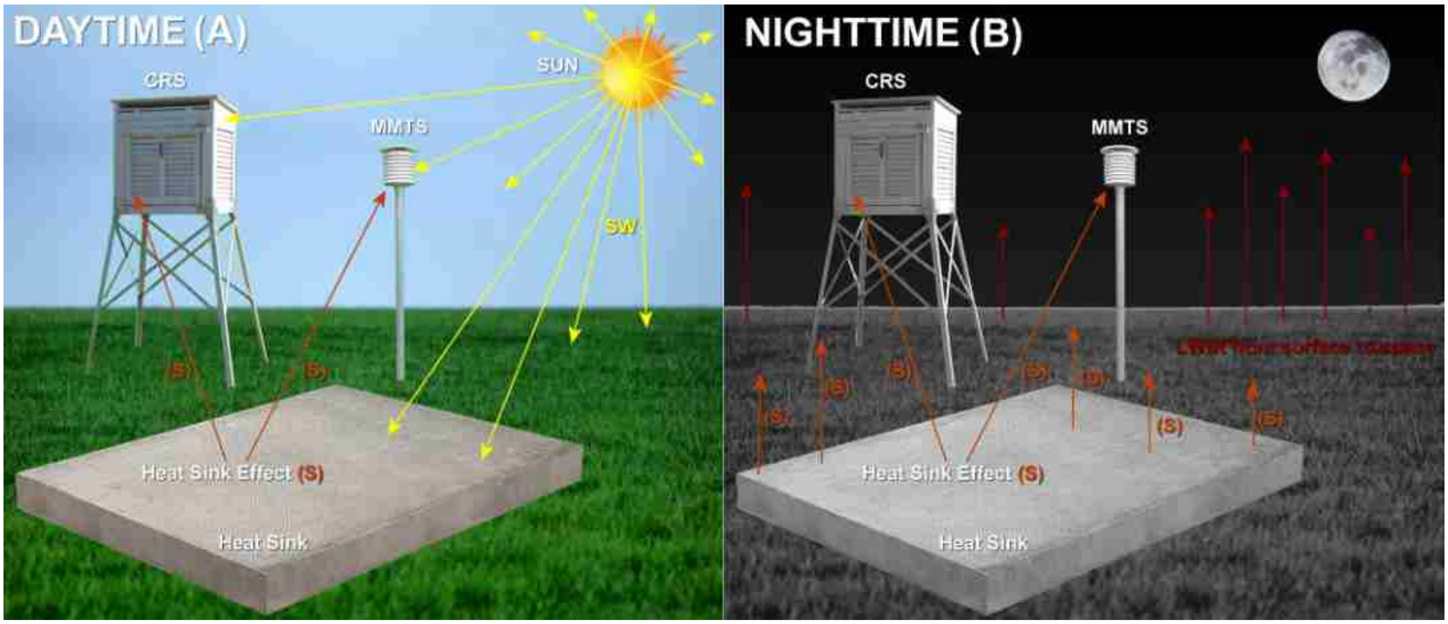
## Photo Credits:

Photos in this appendix and in the body of the report have been obtained from a variety of sources, including SurfaceStations.org volunteers, and associates of The Heartland Institute including H. Sterling Burnett, Linnea Lueken, Tim Benson, and Anthony Watts. A special thanks to Doug Lynch who worked with the author for almost a month to locate the mislabeled NOAA USHCN station in Sandpoint, ID.

Some photos are satellite and/or street view images sourced from Google Earth, and are used with their fair use licensing, with the [required attributions]: Map data ©2022 Google, Street View ©2022 Google. Some imagery provided by Google may not be from 2022, but earlier. Care was taken to be certain earlier photos are still valid in 2022 for the purpose intended.

# APPENDIX B: THE SCIENCE OF HEATSINKS AND THERMOMETERS

To provide an understanding of how both distance and surface area affect temperature near a NOAA / NWS thermometer used to measure long-term climate change, Figure 1 illustrates what happens in the environment around the thermometer between daytime and nighttime.




**Figures 1A and 1B:** During daytime (Figure 1A), visible sunlight known as shortwave light (SW) heats the earth, the NOAA / NWS thermometer shelters (CRS and MMTS), and a nearby concrete slab. A minimal amount of the SW light is redirected from the heat sink effect (S) towards the thermometer. During nighttime (Figure 1B), the accumulated SW light from the sun during the day is radiated from the surface, grass, soil, and the concrete slab as long-wave infrared light (LWIR). The concrete slab has a greater ability to retain SW light energy and emit it at night as LWIR energy, thus making the heatsink effect (S) greater. The closer the concrete slab is to the thermometers, and the greater the surface area of the concrete slab, the greater the heatsink effect. The LWIR energy from the heat sink effect warms the air near the surface locally and biases the nighttime temperature near the thermometers to a higher number than would exist in the absence of a heat sink. Source: Anthony Watts.

The issue with artificial surfaces such as asphalt, brick, and concrete near thermometers has to do with the heat sink effect. During the day, sunlight impacts these surfaces and heats them. According to NASA, the average irradiance value measured on the edge of space and outside the Earth's atmosphere on a flat surface positioned perpendicular to the sun is about 1,360 watts per square meter (or 1.36 kilowatts per $m^2$).[53] By the time the sun's rays pass through the Earth's atmosphere and reach the surface at sea level, the maximum solar irradiance across a $1m^2$ flat surface at ground level can be measured. At an equatorial location on a clear day around solar noon, the amount of solar radiation that is approximately 1000 watts per square meter (or 1.0 $kW/m^2$).

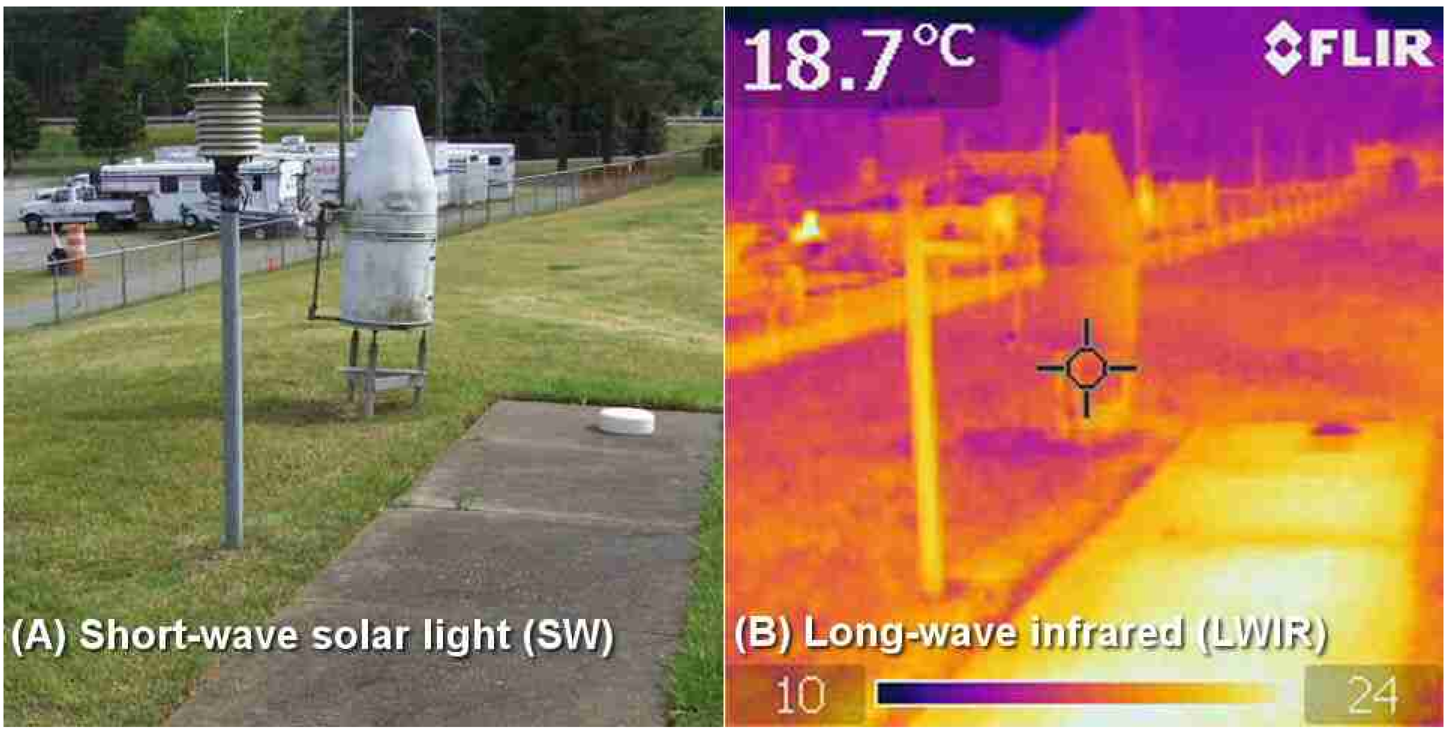
Solar irradiation values will vary by season, latitude, and weather. As an example, if the average solar energy reaching the surface during the summer months is 800 watts per square meter and the weather is clear for a full eight hours, daily solar irradiance would equal:

**800 W/m2 x 8 hours = 6400 Watt-hours/m2 or 6.4 kWh/m2 (6.4 kilowatt hours)**

6.4 kilowatt-hours are comparable to the amount of electricity an average home might use during a summer daytime hour when air-conditioning is running. As indicated, a section of asphalt, brick, and concrete near an official thermometer will absorb quite a large amount of solar energy during the day. At night, that energy will be released as long-wave infrared light (LWIR).[54]

One can see this process for themselves by simply standing next to a brick or concrete wall—that has been illuminated by the sun during the day—just after sunset. The heat emanating from the wall is LWIR. Alternatively, one can observe LWIR as the "shimmer" effect from a heated road during a hot summer day.

Nightly emissions of LWIR into space are a primary reason for night-time temperatures being cooler, as the Earth sheds its energy absorbed from the sun during the day. Figure 2 illustrates these effects.




**Figures 2A and 2B**: Figure 2A (left) shows the USHCN station at Fayetteville, NC in visible light (SW - shortwave daytime solar) versus Figure 2B (right), the same station viewed in long-wave infrared (LWIR). Note the concrete slab is significantly warmer. The MMTS temperature sensor on the pole will "sense" the warmer air at night due to the emission of LWIR. Source: Anthony Watts.

In the paper "Determination of temperature differences between asphalt concrete, soil and grass surfaces of the City of Erzurum, Turkey," the authors illustrate via experiment that temperature differences of 7.54 degrees C existed between asphalt/concrete and grass surfaces.[55] That heat-sink experiment clearly demonstrated that significant divergences in air temperature measurement exist across different surface types.

# APPENDIX C: GLOSSARY AND ACRONYMS

**A/c:** Abbreviation for an outside Air Conditioner unit, sometimes called a heat exchanger.

**Albedo:** Albedo is an expression of the ability of surfaces to reflect sunlight. Light-colored surfaces (high albedo) return a large portion of the sun's rays back to the atmosphere. Dark-colored surfaces (low albedo) absorb the sun's rays and tend to heat up more than lighter colored surfaces.

**ASOS:** The Automated Surface Observing Systems (ASOS) program is a joint effort of the National Weather Service (NWS), the Federal Aviation Administration (FAA), and the Department of Defense (DOD). ASOS is designed to support weather forecast activities and aviation operations and, at the same time, support the needs of the meteorological, hydrological, and climatological research communities. However, due to many of these installations being located at airports, the substantial heat sink volume associated with tarmacs and runways may be upwardly biasing temperature readings, especially with the growth of air travel in recent decades necessitating further airport expansion.

**Average Air Temperature:** The mathematical average of the daily high and low temperature recorded daily from a USHCN or COOP weather station. Daily average temperatures are amalgamated to create monthly and yearly average temperatures, which are used to track changes in climate temperature over a 30-year period.

**COOP**: The Cooperative Observer network (COOP) is comprised of thousands of volunteer-operated weather stations in the United States, managed by the National Weather Service (NWS), with data reported to the National Climatic Data Center (NCDC) for dissemination. COOP stations exist at airports, police stations, fire stations, ranger stations, dams/locks, newspaper offices, TV/radio stations, college campuses, National Weather Service offices, agricultural experiment stations, waste-water treatment plants, and in the yards of U.S. citizens.

**CRS**: A Cotton Region Shelter (CRS)—also known as Stevenson screens or instrument shelters—is used to shield meteorological instruments against precipitation and direct heat radiation from outside sources, while still allowing air to circulate freely around them. A CRS forms part of a standard COOP weather station and typically holds two thermometers (ordinary, plus a maximum/minimum recording thermometer), and sometimes other weather instruments.

Their purpose is to provide a standardized environment for measuring temperature, humidity, dewpoint and other variables. Typically, a CRS is a box made of wood with slats for ventilation and is placed about 5 feet above ground. It is painted white to reflect direct solar radiation. The CRS design is being phased out of use in the COOP network because of maintenance issues with paint, dry rot, and other exposed wood related problems. The MMTS is the replacement for the CRS.

**GHCN:** The Global Historical Climatology Network (GHCN) is a data set of temperature, precipitation and pressure records managed by the National Climatic Data Center (NCDC). The data are collected from many continuously reporting fixed stations at the Earth's surface. In 2012, there were 25,000 stations within 180 countries and territories, including several thousand as part of the United States COOP network. GHCN stations are intended to report both the total daily precipitation and the maximum and minimum temperature, though stations that measure both are predominantly located in the United States. Overall, 66 percent of GHCN stations report only the daily precipitation and not temperature.

**Heat Sink**: In the context of this report, a heat sink is a solid surface such as asphalt, brick, or concrete absorbing visible sunlight energy during the day, raising the temperature of the surface. At night, the heat sink surface cools by radiating or releasing that stored energy as infrared heat, warming the air near the heat sink surface.

**HOMR**: The Historical Observing Metadata Repository (HOMR) is an online database tracking detailed information for a variety of weather stations throughout their lifespans, including identifiers, names, locations, observation times, reporting methods, and equipment modifications and siting. Station histories are most extensive for the National Weather Service COOP network, including officially documented station changes that adhere to an NWS approval process.

HOMR is used in this report to verify equipment placement and station status. HOMR did not exist prior to the original 2009 Surface Stations report. It is possible the 2009 report was the impetus for HOMR's creation in 2013, as the previous database was unwieldy, incomplete, and error-ridden.

**Maximum Temperature:** Also referred to as "Tmax," maximum temperatures in the context of this report consist of the highest temperature recorded in a 24-hour period at a USHCN or COOP weather station. Typically, this occurs in the afternoon or early evening. Under certain weather events, this may change.

**Minimum Temperature:** Also referred to as "Tmin," minimum temperatures in the context of this report consist of the lowest temperature recorded in a 24-hour period at a USHCN or COOP weather station. Typically, this occurs in the early morning, just before or a few minutes after sunrise. Under certain weather events, this may change.

**MMTS**: The Maximum Minimum Temperature System (MMTS) is an electronic thermometer, similar to what one might find at a local electronics store. The MMTS enclosure houses an electronic thermistor. A thermistor converts air temperature values into electrical values, typically by varying electrical resistance. The MMTS shelter appears very similar to a beehive. They require a cable to connect the sensor with a display, which is often located within an indoor office or residence. The display records and stores the maximum and minimum temperatures recorded each day. The internal display is often called the "Nimbus," due to the name given by the manufacturer. Introduction of the MMTS in the COOP network began in the late 1980s and has gradually replaced the CRS system.

**NCDC**: The National Climatic Data Center (NCDC), previously known as the National Weather Records Center (NWRC), was the world's largest active archive of weather data. Starting as a tabulation unit in New Orleans, Lousiana in 1934, the climate records were transferred to Asheville, North Carolina in 1951, and renamed the National Weather Records Center (NWRC). It was later renamed the NCDC in 1993. In 2015, NCDC merged with the National Geophysical Data Center (NGDC) and the National Oceanic Data Center (NODC) to create the National Centers for Environmental Information (NCEI).

**NCEI**: The National Centers for Environmental Information (NCEI) is the new name for the NCDC, with the two acronyms often used interchangeably in literature.

**nClimDiv**: The U.S. Climate Divisional Dataset (*n*ClimDiv) replaced the previous U.S. Historical Climatology Network (USHCN) in March 2014. Compared to USHCN, *n*ClimDiv uses a much larger set of stations—more than 10,000—and a different computational approach to calculate the average temperature of the United States.

**NOAA**: The National Oceanic and Atmospheric Administration (NOAA) is the scientific and regulatory agency within the United States Department of Commerce that forecasts weather, monitors oceanic and atmospheric conditions, charts the seas, conducts deep-sea exploration, and manages fishing and protection of marine mammals and endangered species in the United States. It has several sub-agencies including the National Weather Service (NWS) and the National Climatic Data Center (NCDC).

**NWS**: The National Weather Service (NWS) is tasked with providing "weather, hydrologic and climate forecasts and warnings for the United States, its territories, adjacent waters and ocean areas, for the protection of life and property and the enhancement of the national economy." This is done through a collection of national and regional centers, 13 river forecast centers (RFCs), and more than 120 local weather service forecast offices (WSFOs).

**Temperature Anomaly:** Temperature anomalies measure the departure from the average temperature, positive or negative, over a certain period (day, week, month, or year). They use a 30-year average baseline temperature for positive or negative departure. In standard use, the normal average temperature would be calculated over a period of at least 30 years over a homogeneous geographic region, such as the contiguous United States.

**USHCN**: The U.S. Historical Climatology Network (USHCN), sometimes also referred to as simply "HCN," is a hand-picked collection of 1,218 long-record COOP stations in the United States that were once assumed to be of "high quality." However, the USHCN dataset was discontinued in March 2014 after severe criticism of station siting quality was published by The Heartland Institute, and independent investigations were carried out by the U.S Inspector General and the U.S. General Accounting Office.

**USHCN-M:** USHCN-M was a failed modernization program of the USHCN. This program was to have installed 1,000 modernized state-of-the-art stations throughout the United States that would have enhanced the capability of the USCRN by providing additional observations of temperature and precipitation of the same quality but with more dense spatial coverage, thus enabling detection of regional climate trends with greater confidence. The program included a few dozen stations as a test in 2008 but was later discontinued due to lack of funding.

**USCRN**: The U.S. Climate Reference Network (USCRN) consists of 114 stations in the contiguous United States, 29 stations in Alaska, and 2 stations in Hawaii. These stations have been developed, deployed, managed, and maintained by NOAA for the express purpose of detecting climate change.

The vision of the USCRN program is to maintain a sustainable high-quality climate observation network that can decisively answer how the national climate changes over a long periods. The USCRN has state-of-the-art sensors, with triple redundancy to reduce errors. The stations are located far away from human urbanization influences so that the type of issues found in the USHCN and COOP networks do not influence the temperature and precipitation data they record. The data produced by USCRN does not need any of the corrective adjustments that the USHCN and COOP networks necessitate.

**WSFO**: The Weather Service Forecast Office (WSFO) is comprised of more than 120 local weather service forecast offices in the United States.

**WWTP**: Waste-Water Treatment Plants (WWTP) house a substantial number of GHCN, USHCN and COOP network stations, as treatment plants are constantly manned and can provide continuity of daily records. In the early days of the COOP network, all data were recorded on paper called a B91 form, and mailed into the NWRS / NCDC, where they were transcribed.[56] Station placement at facilities such as WWTPs has become a preferred option to facilitate a continuous record of daily weather data.

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