

# *How not to measure temperature: NOAA cites errors with Baltimore's Rooftop USHCN Station*

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**SPPI Commentary and Essay series**

## How not to measure temperature, part 48 NOAA cites errors with Baltimore's rooftop USHCN Station

It happened across a NOAA internal training manual a couple of weeks ago. It contained a photo of a USHCN official climate station that I thought I'd never get a photo of; the Baltimore Customs House.

*Baltimore USHCN station circa 1990's photo  
courtesy NOAA*

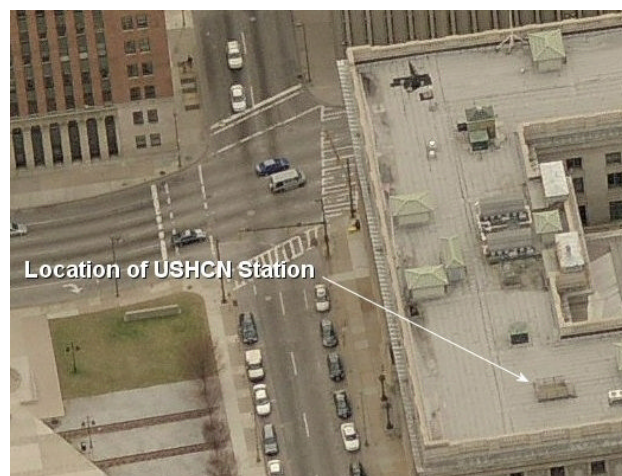
What is interesting about this station is that it is a rooftop station, like we've seen in San Francisco, Eureka, and many other US cities. Rooftop stations are suspected to impart a warm bias to the surface temperature records, for obvious reasons. The NWS/NOAA has been reluctant to change these stations to ground-level, wanting to keep a continuous record. The Baltimore USHCN station closed in 1999 and has not been replaced at this location.



From this single photo, and with the help of Google Earth and Microsoft Live Earth, I was able to complete this station survey, *post mortem*, giving it a CRN 5 rating. Below is one of the aerial photos:

Earlier this year, [www.Surfacestations.org](http://www.Surfacestations.org) volunteer John Goetz located an early historical photo of the Baltimore station, seen below:

But, this NOAA internal training manual not only cited this example photographically, they



also did a correlation study that proved that the rooftop placement was actually warmer.

Here is what NOAA said about the Baltimore USHCN station in their training manual:

*Instrument exposure standards are really compromised with rooftop locations (figure 11).*

*Figure 11: An Early Rooftop Meteorological Station.*

*While the number of NOAA rooftop climate stations has remained at about 40 for the last decade, the number of private rooftop stations has grown during that period into the thousands. Rooftop exposures have an advantage of increased instrument security and good exposure for wind sensors (standard height is about 33 feet). However, there are also drawbacks. Access for*

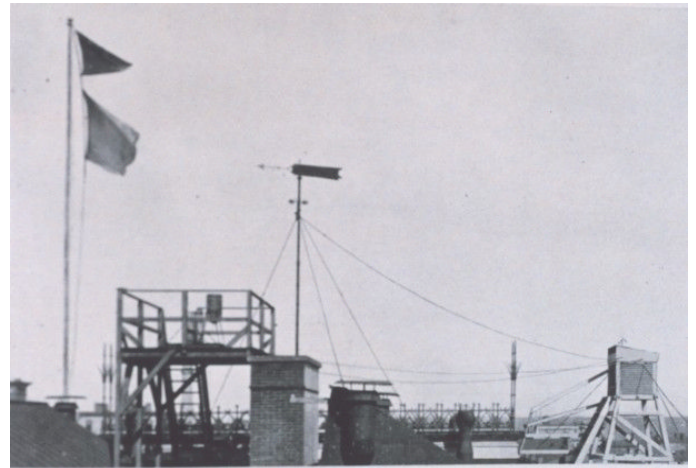


FIG. 1.—ROOF OF BUILDING SHOWING INSTALLATION OF INSTRUMENTS, BALTIMORE.

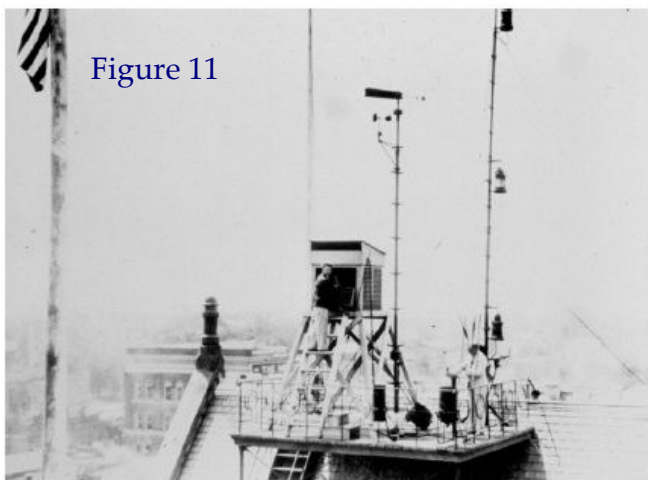


Figure 11

*maintenance can be difficult and exposure for precipitation and temperature instrumentation is clearly non-compliant, being elevated to high above the ground. Additionally the instrument exposure is usually over environmentally nonrepresentative surfaces (metal, black tar, shingle, stone etc.), while at the same time being close to a wide variety of roof surfaces which are subject to change.*

No argument there. The trade off is security versus representivity of climate. But climate usually loses in a rooftop station instance.

They go on to say:

*The unrepresentative-ness of rooftop temperature and precipitation data was discovered long ago after studies quantified the biases. The late Professor Helmut Landsburg,*

considered the “father of climatology”, stated in his 1942 “bible of climatology” textbook, “Physical Climatology” that:

*“Climate derived from records of roof stations may by no means be representative of those at the ground level.”*

*In another published paper 28 years later, Professor Landsburg again reiterated his concern about rooftop exposures with respect to the urban warming issue: **“They [rooftop stations] are certainly of little value in a full assessment of the climatic changes brought about by urbanization.”***

That leads one to wonder why they kept these stations at all, let alone appoint them as “High Quality” USHCN stations for use in climate research. The Baltimore Custom House is also a GISS station. They also write:

*Rooftops make good observation sites if you live work, play, or grow your food on a roof. Unfortunately, few people do any of the above. Rooftop exposures have been shown to exhibit biases towards warm temperatures (both maximum and minimum) and lower precipitation when compared to ground based stations. The warm temperature biases likely result from extreme daytime heating of artificial rooftop surfaces, reduced cooling of the roof at night, and from heat flow from within the building, especially in winter. The biases can be substantial. One limited study indicates 5 to 10 degrees on summer days with bright sun and light winds. Biases have been found to vary significantly, depending on many factors (location on the roof, color of roof, type of roof surface (rock, metal, etc.) time of year, etc when compared to standard ground-based sensors. On the flip side, if a station has been on a non-changing roof for decades, the site may have good continuity (value) for tracking climate change and variability. For some climate applications, consistency with a long record can be more important than accuracy with a shorter record.*

*The best of both worlds is to have an exposure compliant, long-term station.*

But the thing that really hit me was the data they compiled, comparing to other nearby stations, and thus proving the case for rooftop bias with this station:

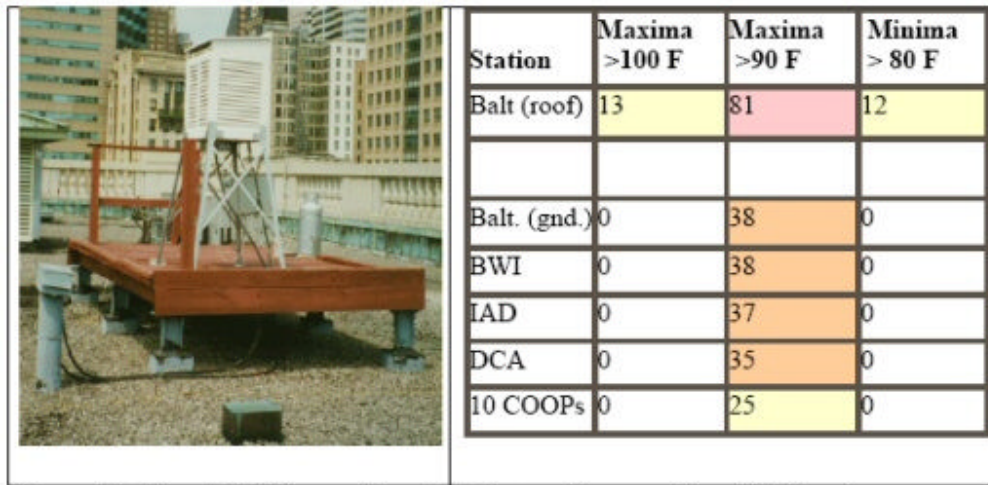


Figure 12: The old Baltimore, Maryland Custom House rooftop COOP and summary of comparison of overlapping data with surrounding ground-based stations.

They cite the table with:

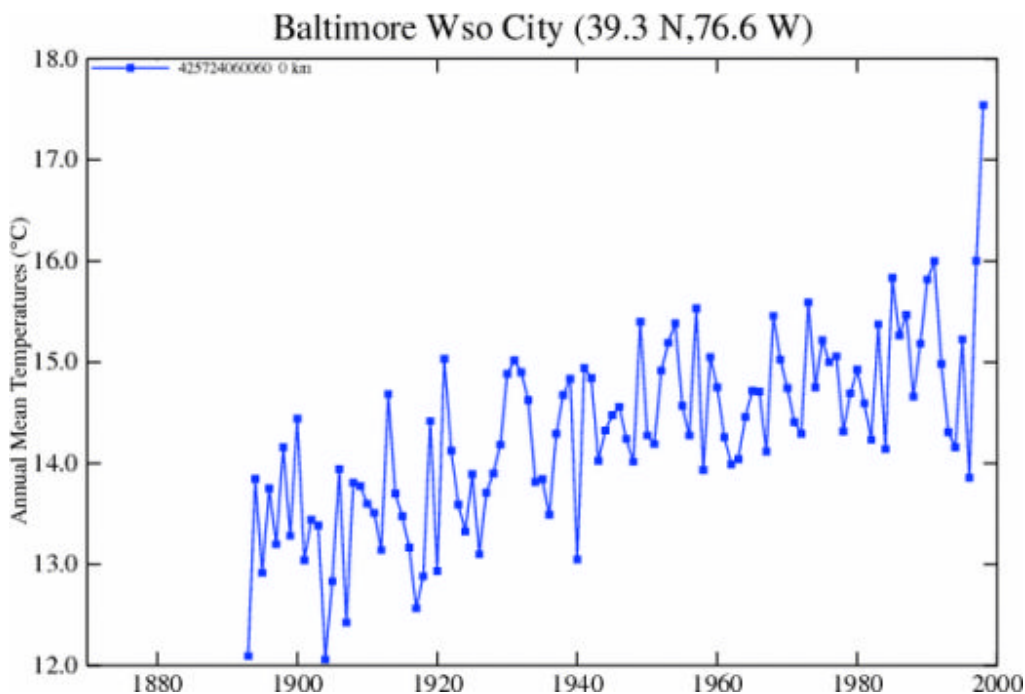
*The table to its right summarizes a comparison of 12 months of overlapping data that was collected on the rooftop and at the new relocated site (for data continuity), relocated several blocks away at ground level with other nearby standard, ground based stations. A combination of the rooftop and downtown urban siting explain the regular occurrence of extremely warm temperatures. Compared to nearby ground-level instruments and nearby airports and surrounding COOPs, it is clear that a strong warm bias exists, partially because of the rooftop location.*

*Maximum and minimum temperatures are elevated, especially in the summer. The number of 80 plus minimum temperatures during the one-year of data overlap was 13 on the roof and zero at three surrounding LCD airports, the close by ground-based inner Baltimore harbor site, and all 10 COOPs in the same NCDC climate zone. Eighty-degree minimum are luckily, an extremely rare occurrence in the mid-Atlantic region at standard ground-based stations, urban or otherwise. Temperatures can be elevated on roofs due to the higher solar radiation absorption and re-radiation associated with many roof surfaces including black tar, shingles, stone, and metal. During the colder months, ongoing upward heat transfer through the roof from the heated interior of the building also can contribute to the warm bias although stronger winter winds tend to create better mixing and minimize this impact.*

The table shows that the rooftop station has Tmax >90°F more than twice as often as other stations and a Tmax >100°F 13 times where no nearby station achieved it. Similarly we have this station recording a Tmin >80°F where no other stations did.

Yet amazingly, knowing all this, stations like this, and stations that have instrumental biases such as Tucson, with its [parking lot placement](#) (USHCN) and [HO83 problems](#) (GISS) still remain as part of the USHCN and GISS datasets. The official all-time high temperature record of Tucson of 117°F still stands, set by a known faulty HO83 thermometer.

In the case of Baltimore, the question is, in the plot below what really has been measured? Is it city growth, building energy use/dissipation, rooftop albedo variations, nearby building changes, or climate change? Given that it is impossible to disentangle all these things, the data, in my opinion, should be deemed compromised and discarded.



**GISTEMP Plot of Baltimore City USHCN station #180470**

In any other line of scientific study or in engineering, data that has been so badly compromised would likely be forced out by peer review, or the researchers themselves once the errors were discovered. Yet here we are today, keeping this station record for use in climatological study.

**Reference:** NOAA [Professional Competency Unit 6](#) (PCU6) manual (PDF)

**Source:** <http://wattsupwiththat.wordpress.com/2008/01/23/how-not-to-measure-temperature-part-48-noaa-admits-to-error-with-baltimores-rooftop-ushcn-station/>

**Watts** is a former television meteorologist who operates a weather technology and content business, as well as continues daily forecasting on radio.