J2.4

THE EFFECT OF SENSOR PLACEMENT ON CLIMATOLOGICAL RECORDS

M. Sean Sublette*

WSET Television, Lynchburg, Virginia

1. INTRODUCTION

Since the Automated Surface Observation System (ASOS) was commissioned in Lynchburg, Virginia (KLYH) on 1 August 1996, subjective observations suggest a cold bias in surface temperature records at that site during ideal radiational cooling conditions.

According to National Oceanic and Atmospheric Administration (NOAA) climate records, 100 of the 366 (27.3%) daily minimum temperature records at KLYH have been established or tied between the date of commissioning and 25 October 2006.

This paper uses objective observations at KLYH and surrounding sites to document the existence of a cold anomaly at KLYH. It is suggested that this cold anomaly is due to microscale processes at the observation site. The anomaly frequently occurs during the summer months when nighttime radiational cooling conditions are common.

This paper complements previous studies of similar phenomena (Davey and Pielke 2005; Peterson 2006), and argues that such microscale effects can significantly alter climate records and therefore, must be taken into consideration regarding long term climate studies involving temperature.

2. BACKGROUND

Lynchburg is located in the Piedmont region of Virginia, on the east side of the Appalachian Mountains. According to the National Climate Data Center (NCDC), temperature records began in 1872, administered first by the Army Signal Corps, and then by the Weather Bureau Office. In June 1934, temperature records began at the Lynchburg Regional Airport.

Although the airport is located in an area that is generally lower in elevation than its surroundings, the initial observation site was on a modest ridge 15 meters (50 feet) above the runway. This location is next to the now defunct National Weather Service (NWS) Office (Fig. 1).

Until November 1984, observations were not taken full time at this site because the NWS office was not operating 24 hours per day. In November 1984, the observation system was upgraded with the commissioning of an Automated Weather Observation System 3 (AWOS-3). Most of the data continued to be collected at the ridge site, but the visibility sensor was placed near the approach of Runway 3, approximately 800 meters from the temperature sensor. This change was made to better represent the visibility to

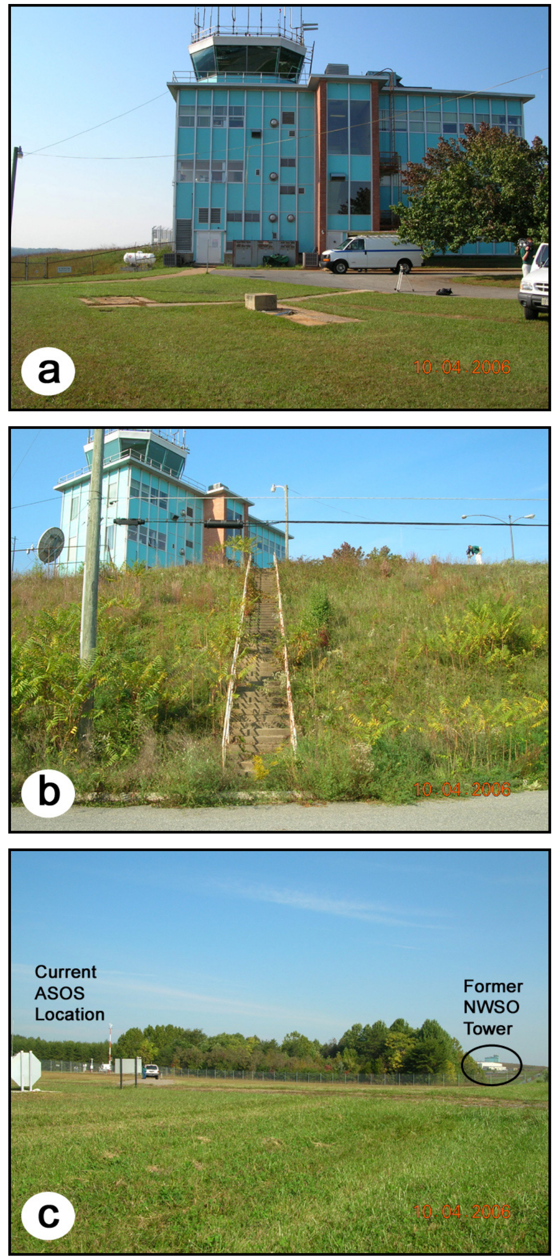

Figure 1. **(a)** Defunct NWS Office (NWSO) Lynchburg with abandoned concrete base for temperature observations in foreground. **(b)** Staircase leading from runway elevation to defunct NWSO. **(c)** Looking northeast from Runway 3 to the defunct NWS Office (circled). Current location of ASOS is on the left.

**Corresponding author address:* Sean Sublette, WSET-Television, 2320 Langhorne Road, Lynchburg, VA 24501; e-mail: ssublette@wset.com

approaching aircraft, as aviation concerns take priority over climatological records (NOAA 1984).

On 1 August 1996, the ASOS station was commissioned a few meters from the runway visibility sensor, meaning the temperature data were now being collected in a broad area of lower elevation than during the previous 62 years.

3. GEOGRAPHY

The airport property is often described as a bowl: a broad area of cleared land surrounded by a forested area slightly higher in elevation. Figure 2 illustrates the observation positions relative to the runway. The ASOS station is in an area that slopes gently toward a small creek embedded in a wooded area away from the runway.

At this location, there is often nighttime decoupling of the surface air from the moving air in the residual boundary layer air a few dozen meters above it. The lack of mixing allows for efficient radiational cooling. Moreover, there is cold air drainage towards the location of the ASOS station.

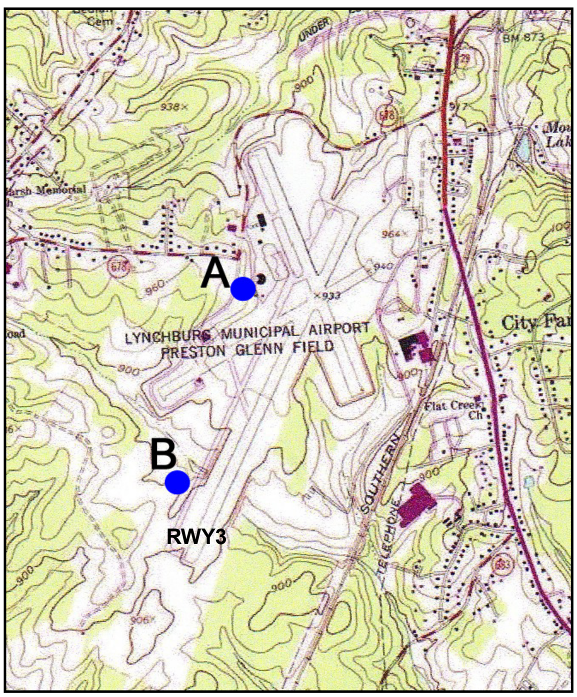

Figure 2. Topographic map of area around KLYH. Position A indicates site of defunct NWSO. Position B indicates site of current ASOS. Contour interval is 20 feet (U.S. Geological Survey).

Additionally, a large grove of trees lies 30 to 40 meters north and east of the ASOS (Fig. 3), helping to shelter the sensor suite from synoptic winds from these directions. This sheltering enhances the opportunity for decoupling in light to moderate cold advection events.

Thus, there are several microscale processes that can produce a cold anomaly at the ASOS station, and this anomaly can lead to an increased chance for fog development. In an interview with the author, the Airport Maintenance Supervisor described frequent occasions where the sky was clear on his commute to the airport, but upon arrival, described the airport property as “something out of Transylvania,” alluding to the dense fog that had formed in the lower elevations along the airport runways.

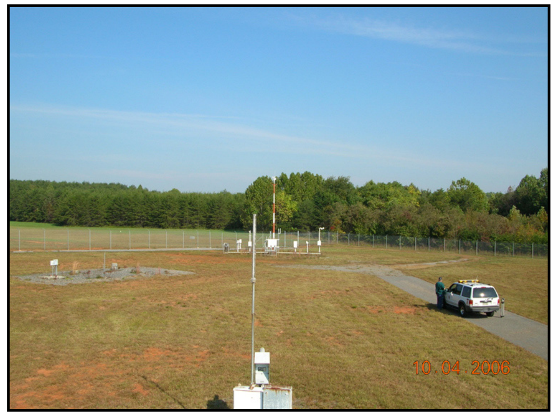

Figure 3. View of ASOS from Runway 3, looking north. Remnants of the AWOS-3 visibility sensor suite are located on the graveled area to the left.

4. INVESTIGATION

4.1 Extremes

Southeast Regional Climate Center (SERCC) records indicate 12 minimum daily temperature records were established or tied at KLYH in the first 12 months after commissioning of the ASOS station. Nearby synoptic stations at Roanoke (KROA) and Danville (KDAN) had far fewer daily record minima set during this period. KDAN set only one record minimum, and KROA set two record minima, suggesting synoptic forces were not responsible for the frequency of these records at KLYH. This is especially noteworthy because the SERCC temperature collection period for KLYH began in 1930, much earlier than KROA (1948) or KDAN (1948).

Figure 4 illustrates the dates in which daily minimum temperature records were set at these three stations. A cluster of points at the top of the KLYH graph represents the large number of records set since 1996, most notably in the non-winter months when baroclinic forcing is weaker and more opportunities for decoupling occur. This cluster is absent at both KROA and KDAN.

4.2 Means

To determine how this signal has altered the climatological record, mean monthly maximum / minimum temperature data from the SERCC were compared during two 30-year climatological periods: 1961-1990 and 1971-2000. The difference in the mean

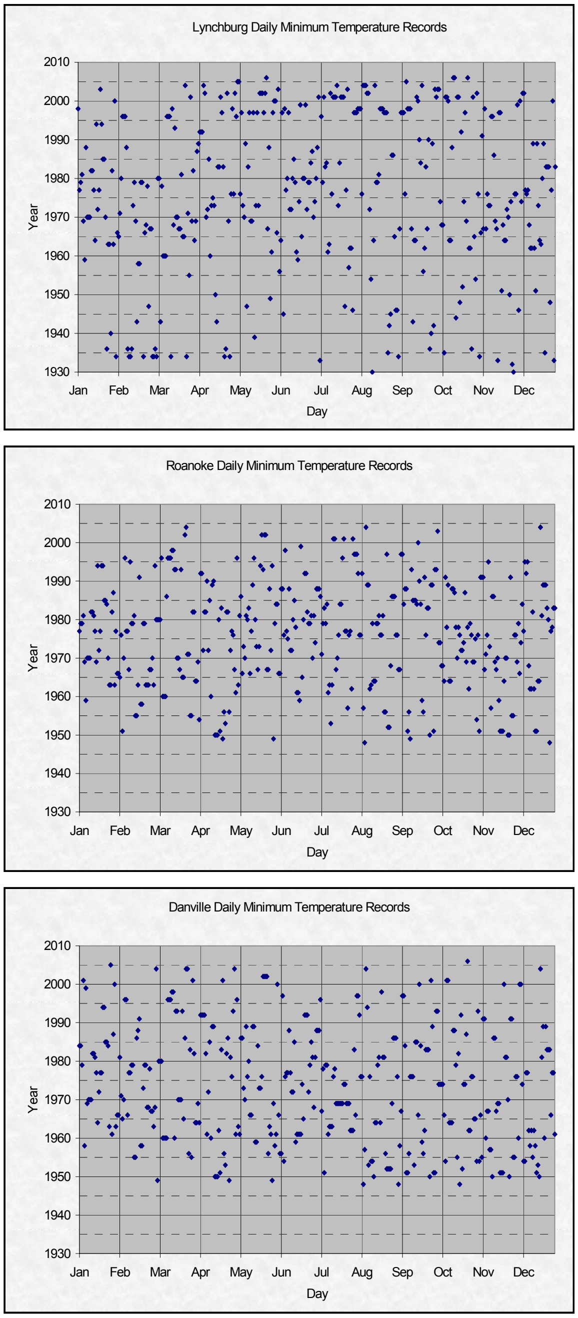

Figure 4. Year of the Daily Minimum Temperature record for each calendar day.

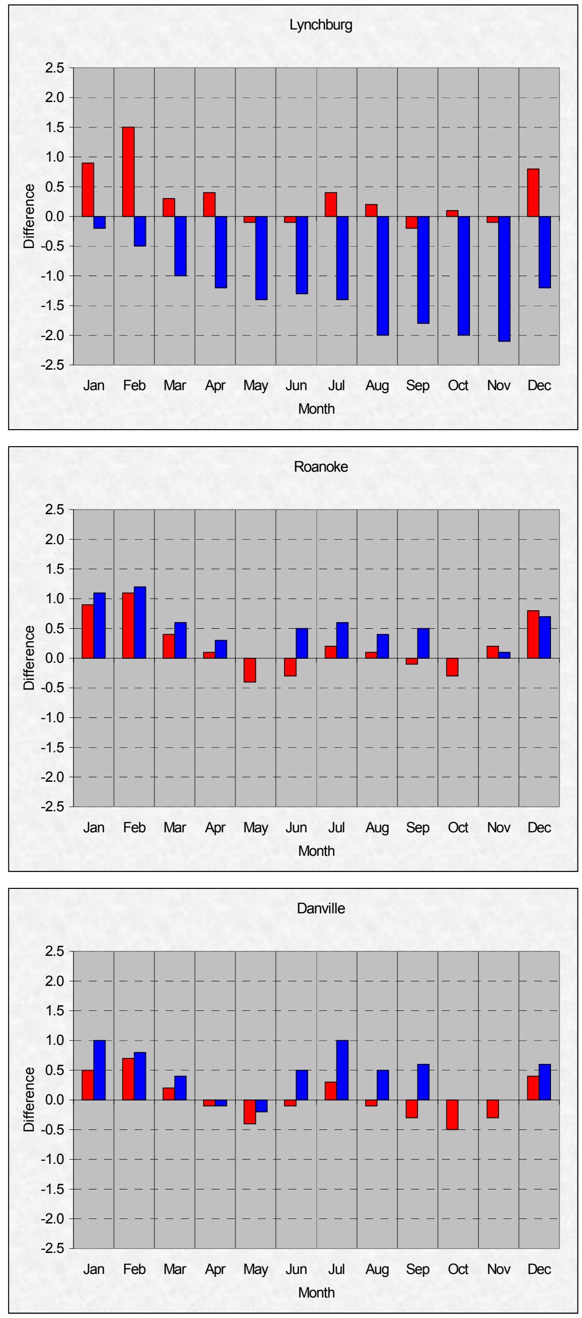

Figure 5. Difference (degrees Fahrenheit) in Mean Monthly Temperature from the 1961-90 climatological record to the 1971-2000 climatological record. Maximum temperatures are in red, minimum temperatures in blue. Negative values indicate a lower 30-year mean monthly temperature during 1971-2000.

monthly maximum / minimum temperatures between the two climatological periods for each station is found in Figure 5.

At both KROA and KDAN, differences in mean monthly minimum and maximum temperatures are generally less than 1 degree Fahrenheit from 1961-1990 to 1971-2000. Conversely, a large drop in mean monthly minimum temperature is observed at KLYH in the latter climatological period. Ten of the twelve months have observed mean monthly minimum temperature differences greater than or equal to 1 degree Fahrenheit, and in three of those months, the difference is greater than or equal to 2 degrees Fahrenheit. The greatest discrepancy is in November, when the mean monthly minimum temperature dropped from 37.3 degrees in 1961-1990 to 35.2 degrees in 1971-2000. This difference is entirely absent at KROA and KDAN.

5. DISCUSSION

The data presented above strongly suggest that the large decrease in mean monthly minimum temperature at KLYH between the two observation periods is due to the relocation of the meteorological observation site, not a climatic trend. With the high public profile given to climate studies of temperature, great care must be given when using data such as KLYH for climate studies. Karl et al. (1987) and Peterson et al. (1998) provide guidance for employing data in which site location has changed the baseline of a station's climate record.

In addition to climate record impacts, ASOS station placement can affect commerce. One such example concerns the power generation and trading industry. To forecast the demand for power (load), accurate temperature data are required for the area being serviced. During the summer, erroneously low temperature observations can lead to load being underforecast, as the anticipated demand for air-conditioning is lower. Consequently, actual load may be significantly higher than is forecast, causing utilities to buy power at spot or market prices to cover the excess demand.

6. ACKNOWLEDGEMENTS

The author would like to thank Michael Robertson and Bill Glaize from Lynchburg Regional Airport for assistance around the airport property. Diana O'Connell (NCDC) and Robert Stonefield (NWSFO Blacksburg) assisted in researching climate records. Richard Lewis (NOAA) and Joe Fiore (SAIC) performed background research on the instrumentation history of KLYH. Corey Lefkof (Exelon) provided insights on the power trading industry. Dr. Todd Sikora (Millersville University) assisted in preparation of the manuscript.

7. REFERENCES

Davey, C.A. and R. A. Pielke Sr, 2005: Microclimate exposures of surface-based weather stations. *Bull. Amer. Meteor. Soc.*, **86**, 497-504.

Karl, T. R., and C. N. Williams Jr., 1987: An approach to adjusting climatological time series for discontinuous inhomogeneities. *J. Climate Appl. Meteor.*, **26**, 1744-1763.

NOAA/NWS Test and Evaluation Division Report 4-84, "Operational Demonstration of the Lynchburg Automated Observing system", 1984, 95pp.

Peterson, Thomas C., 2006: Examination of potential biases in air temperature caused by poor station locations. *Bull. Amer. Meteor. Soc.*, **87**, 1073-1080.

Peterson, T. C., and Coauthors, 1998: Homogeneity adjustments of in situ atmospheric climate data: A review. *Int. J. Climatol.*, **18**, 1493-1517.