NOAA TECHNICAL MEMORANDUM NWS CR-104

LINCOLN ASOS TEMPERATURE TEST JANUARY 13-15, 1993

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March 1994

U.S DEPARTMENT OF Commerce / National Oceanic and Atmospheric Administration / National Weather Service

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NWS CR 46	The Temperature Cycle of Lake Michigan 2. (Fall and Winter). Lawrence A. Hughes, September 1971 (COM 71-01039).

(Continued on Back Cover)

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UNITED STATES
DEPARTMENT OF COMMERCE
Ronald H. Brown
Secretary

National Oceanic and
Atmospheric Administration
D. James Baker
Under Secretary

National Weather
Service
Elbert W. Friday, Jr.
Assistant Administrator

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1. INTRODUCTION

Since the commissioning of the new Automated Surface Observation Systems (ASOS), questions about the accuracy of the temperature sensors have arisen. At Lincoln, Nebraska some low temperatures were sharply colder than reported in the surrounding area. Were the new instruments faulty? Were the changes in location, even small ones, the major contributing factor for the temperature disparities? We needed to find out.

Central Region Systems Operation Division (SOD) needed dependable data to answer these questions on the performance of ASOS. Lincoln, Nebraska was selected for a 48-hour field test to evaluate the winter performance and accuracy of the ASOS temperature and dew point sensors. The test was scheduled from 1200 LST, Wednesday, January 13 through 1200 LST, Friday, January 15, 1993.

2. TEST REQUIREMENTS

The test compared temperatures of an unsheltered sling psychrometer (liquid-in-glass) and the Automated Surface Observation System (ASOS) Resistive Temperature Device (RTD) with chilled mirror hygrothermometer, to determine any erratic or systematic errors in the systems. The Max/Min Temperature System (MMTS), extensively used in the substation network program, was included so as to establish a comparison of all active temperature systems employed by the National Weather Service.

The sling psychrometer was not placed in a shelter to eliminate any errors introduced by sheltering. Both the ASOS and MMTS remained sheltered as they are normally deployed.

The centerfield HO-83 temperatures were also collected to determine if the 24-foot elevation difference between the new ASOS site and the old HO-83 site provided significant temperature differences under high radiational conditions. For this part of the test to be successful clear skies and calm winds, at least at the optimum radiational cooling periods near sunrise and sunset, were necessary.

[1] Current position: Forecast Systems Meteorologist, NWS Central Region Headquarters, Scientific Services Division.

3. TEST PREPARATION

Preliminary instrument preparation required a pre-test of the sling psychrometers to find two sets, each having identical readings when compared dry. Two sets of slings were obtained, tested and compared in case one set broke during the test.

To gain access to the ASOS site the Lincoln Airport Authority provided a large front-end loader to open the snow packed access road and plow a road into the site for the motor home (Figure 1). An MMTS system was installed on the ASOS instrument array approximately 30 feet to the east of the ASOS temperature sensor (Figure 2). The ASOS temperature and dew point sensors were checked and adjusted to meet system calibration standards two days before the beginning of the test (Figure 3).

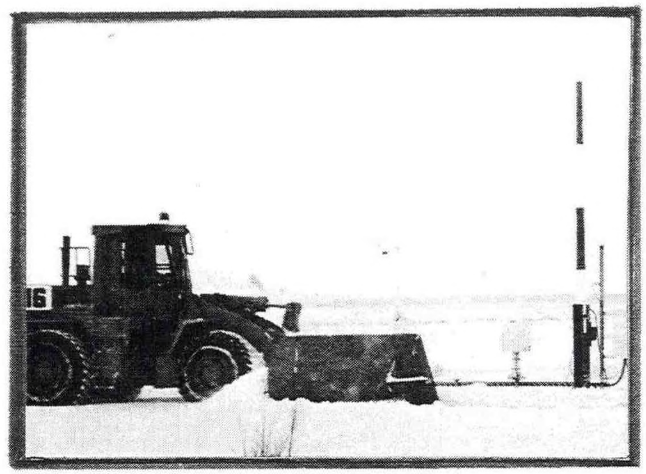


Figure 1. Plowing access into the ASOS site.

Figure 2. Terry Landsvork the Cooperative Program Manager installing a MMTS on the ASOS instrument array.

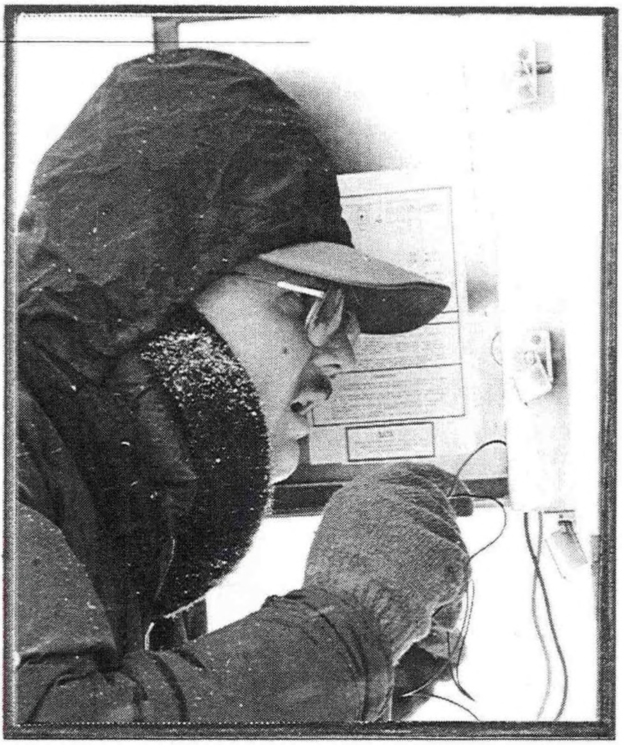


Figure 3. Electronics Technician Larry Howard calibrates the ASOS sensors prior to the test.

4. COLLECTING THE DATA

A 27-ft motor home was carefully located at the site to avoid wind shielding or the transport of any heat to the ASOS site (Figure 4). This provided a working and sleeping area for the 48 hours.

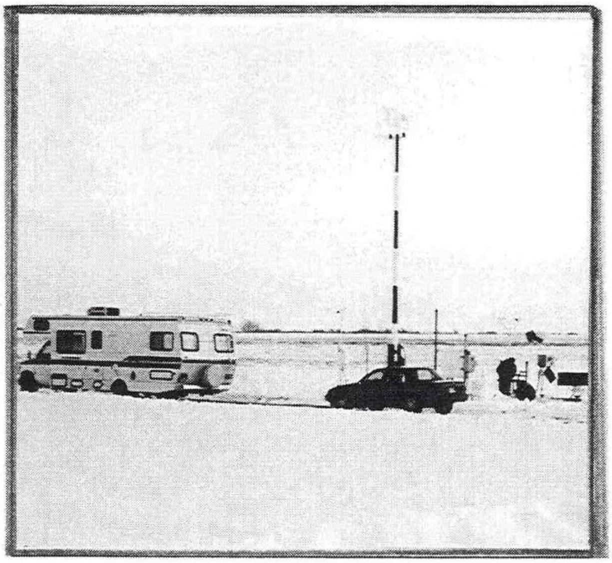


Figure 4. Motorhome at the ASOS site.

A sling psychrometer was hung within a foot of the ASOS temperature sensor fully exposed to the environment save being shielded from direct sunshine by a crude but effective cardboard shield (Figure 5). The psychrometer was slung by hand, facing into the wind, and read several times until the lowest reading possible (FMH 1 and Training Paper #1 Requirements). Both the wet and dry bulb temperatures were read and recorded. After each reading the wick of the wet bulb was dipped into an insulated cup containing water. This melted the old ice and wetted the wick with clean water. The psychrometer was returned to its temporary mount near the ASOS sensors. The fresh water froze and was ready for reading again in 15 minutes. This procedure eliminated any ice buildup on the wick that may have provided an inaccurate wet bulb reading.

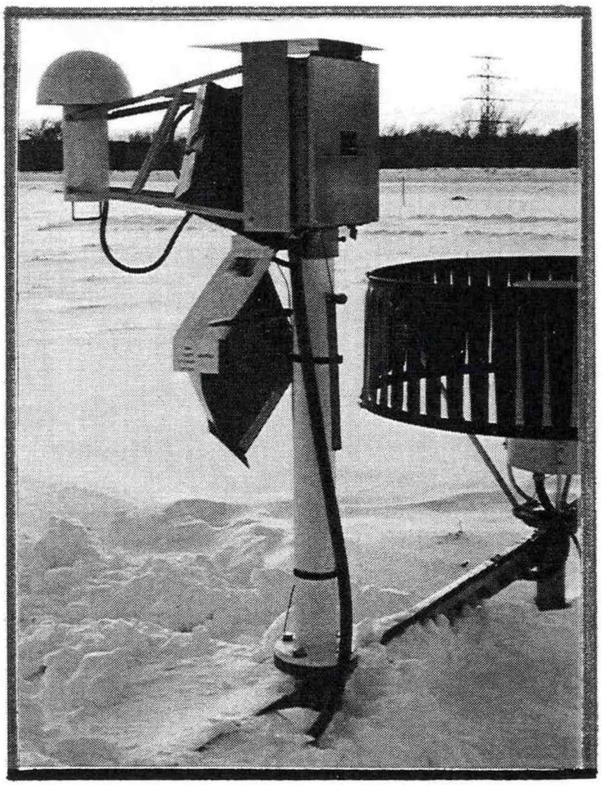


Figure 5. Crude box shelter to keep direct sunshine off the sling psychrometers.

Immediately after the sling temperatures were determined the temperature and dew point were read directly from the LED readout at the ASOS site (Figure 6). The MMTS was read at the same time (Figure 7). All readings at the ASOS site were collected every 20 minutes for 48 hours. The centerfield HO-83 temperatures were collected by the observer at the Weather Service Office approximately 10 minutes before the hour and 20 minutes past the hour.

The data was entered into a portable computer in the motor home to maintain a running check on data quality and evaluate sensor performance during the test (Figure 8).

Figure 6. Steve Mekis from Central Region, Systems Operation Division, taking a set of readings.

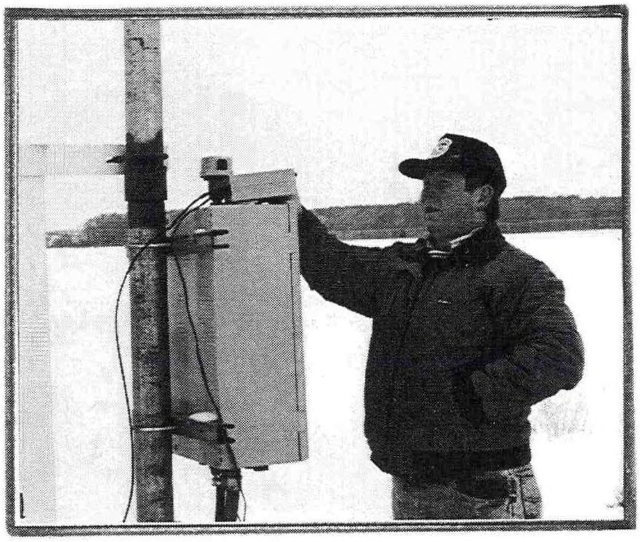
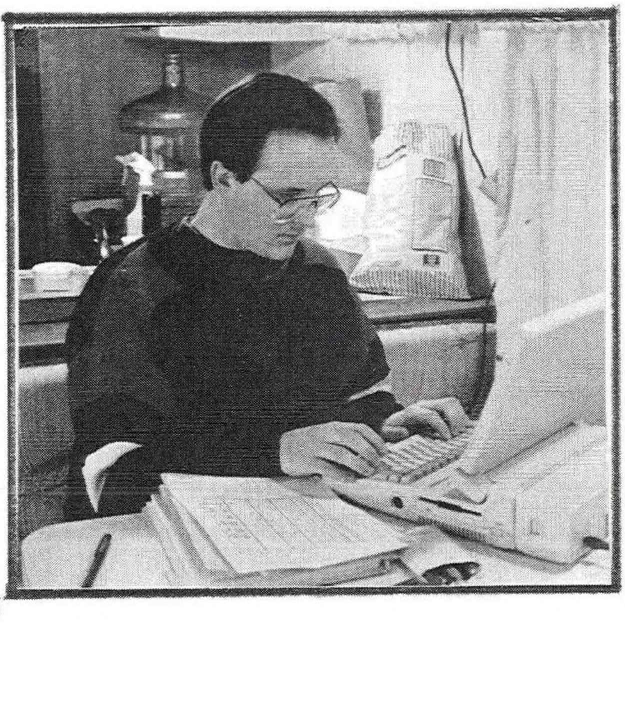


Figure 7. Phil Clark, AMIC at WSO Lincoln and WSEO at WSFO Omaha, reading the MMTS.

Figure 8. Gregg Grosshans a Met Intern Graduate, enters test data into the computer.



5. TEST RESULTS

A buffet of weather conditions provided an optimum test. Eight to twelve inches of snow were on the ground around the site and temperatures remained below freezing throughout the test. Two periods of clear skies and calm winds occurred, one near sunset and the other at sunrise, to meet the basic test requirements. A variety of clouds and weather added additional elements that enhanced the overall test. Greater detail of the weather can be found in the attached Almanac and surface observations.

Overall the performances of the ASOS temperature and dew point sensors were very good. The test indicated that ASOS temperatures were nearly one degree cooler than the liquid-in-glass sling temperatures. As shown in Figure 9, the temperature errors fell easily within the sensor accuracy requirements (ASOS User's Guide, B-1).

	TEMPERATURE RMSE	DEW POINT RMSE
(SLING-ASOS)	0.89 °F	1.98 °F
(SLING-MMTS)	0.96 °F	
(ASOS-MMTS)	0.60 °F	
TEMPERATURE RMSE REQUIREMENTS		(0.90 °F - 1.80 °F)
DEW POINT RMSE REQUIREMENTS		(1.30 °F - 7.90 °F)
RMSE (ROOT MEAN SQUARE ERROR)		

Figure 9. Overall Performance Errors.

The greatest temperature difference between the sling and ASOS occurred shortly after sunrise at 0940 LST on the 14th with a calm wind and full sunshine. The sling measured a rapid temperature rise to 10.8 °F. The ASOS missed this rise and remained 6 °F cooler. This appeared to occur with a stratification of air near the snow field with calm winds. Possibly the aspiration of the ASOS sensor pulled colder air from the lower colder layer and did not measure the true temperature at the sensor height. By 1000 LST the temperatures were again close. It may improve the temperature sensor performance by reversing the aspirator fan to pull air flow over the temperature and dew point sensors from above and not from below.

Graphs (Figures 10-13) of the sling temperatures and ASOS temperatures depict how closely the two sensors parallel one another. ASOS nearly always reported the cooler temperature.

The MMTS also (Figures 14-17) closely paralleled ASOS. The graphs hint that the MMTS may actually be a bit cooler than even ASOS. The Root Mean Square Error (RMSE) of ASOS compared with the MMTS was 0.60 °F.

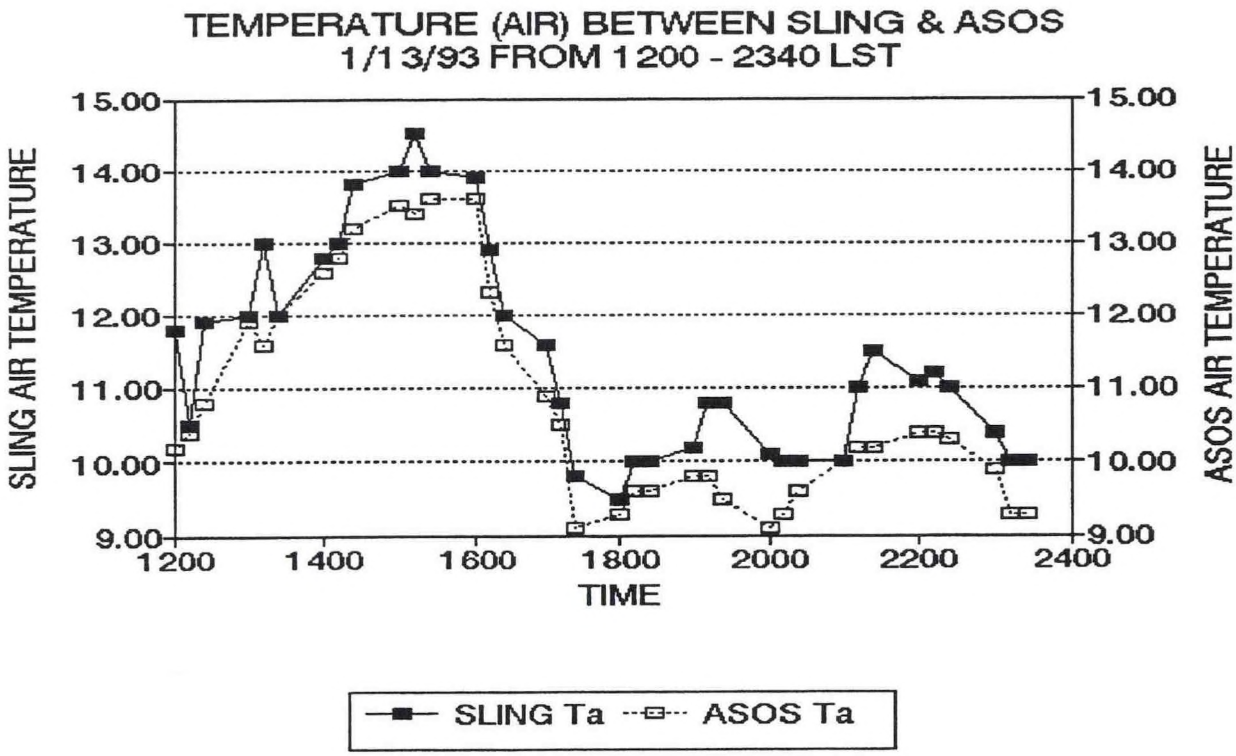


Figure 10

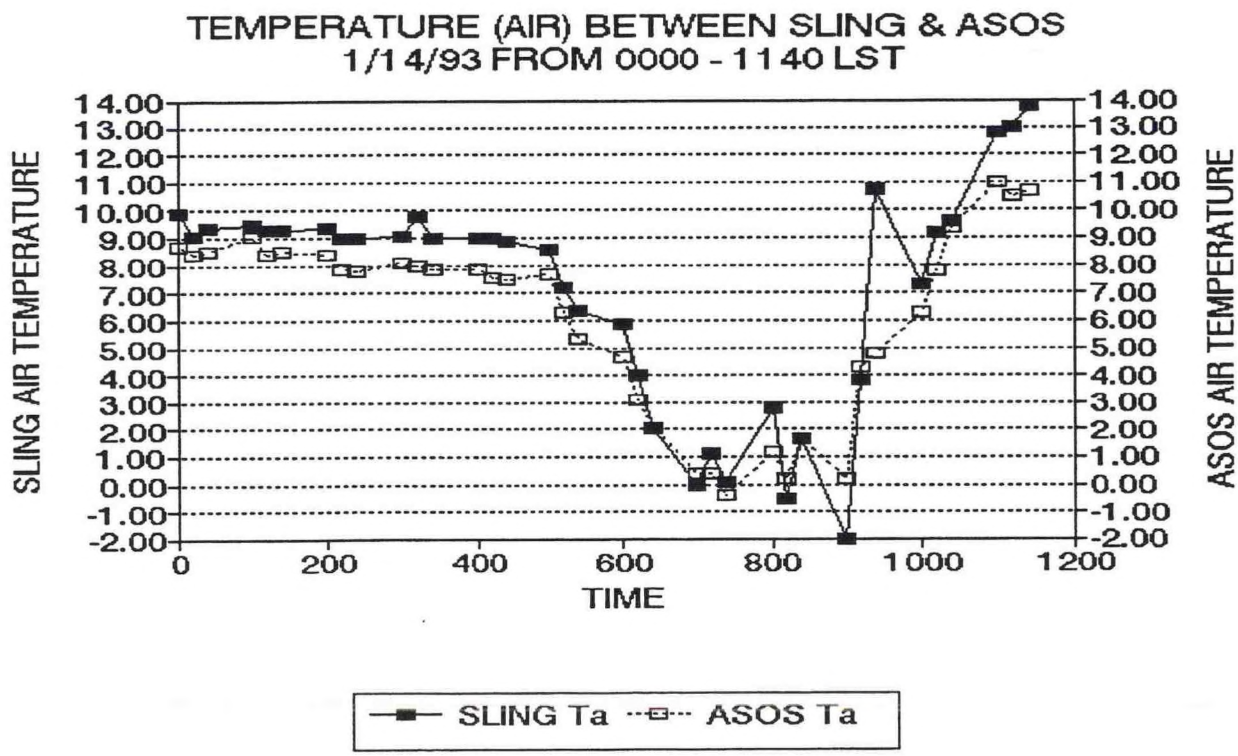


Figure 11.

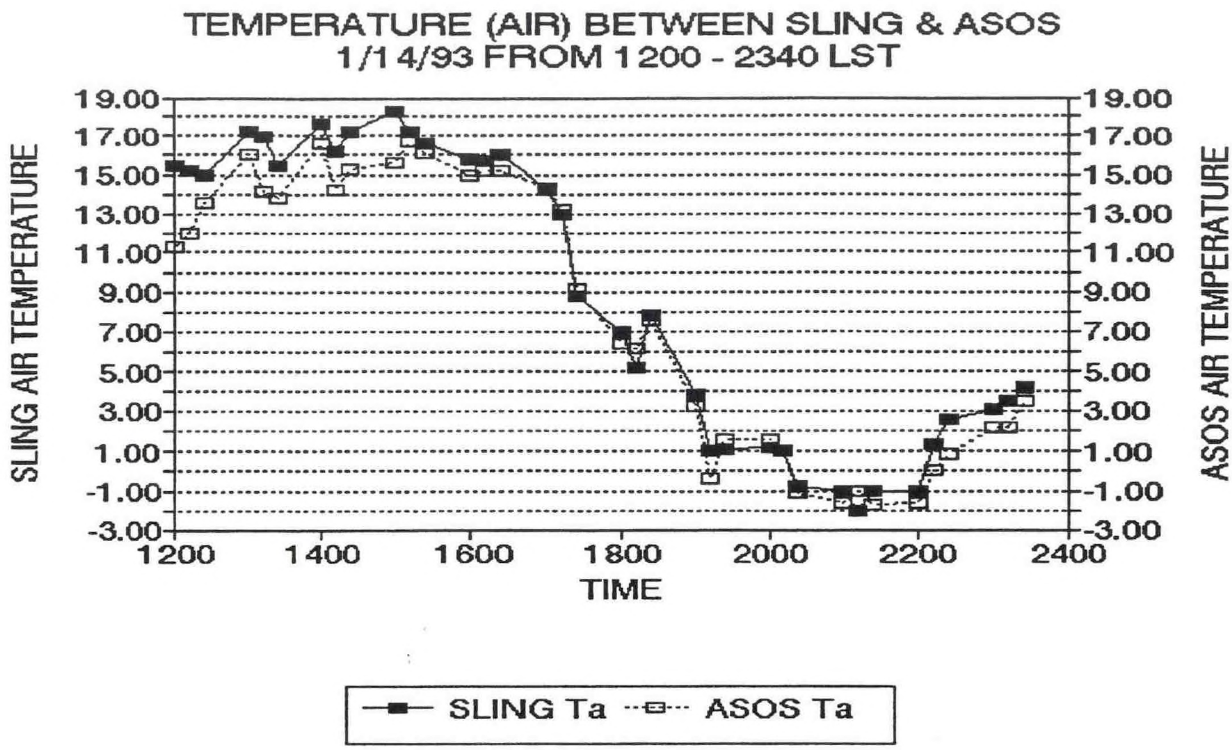


Figure 12.

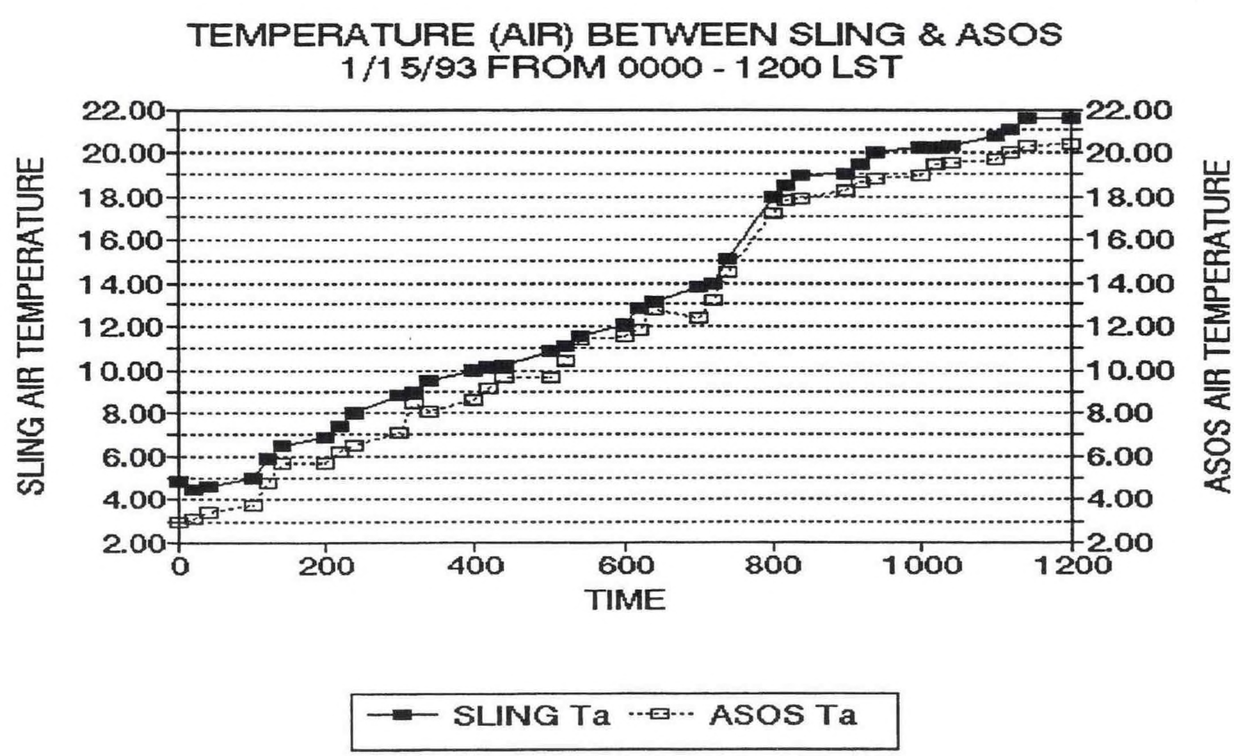


Figure 13.

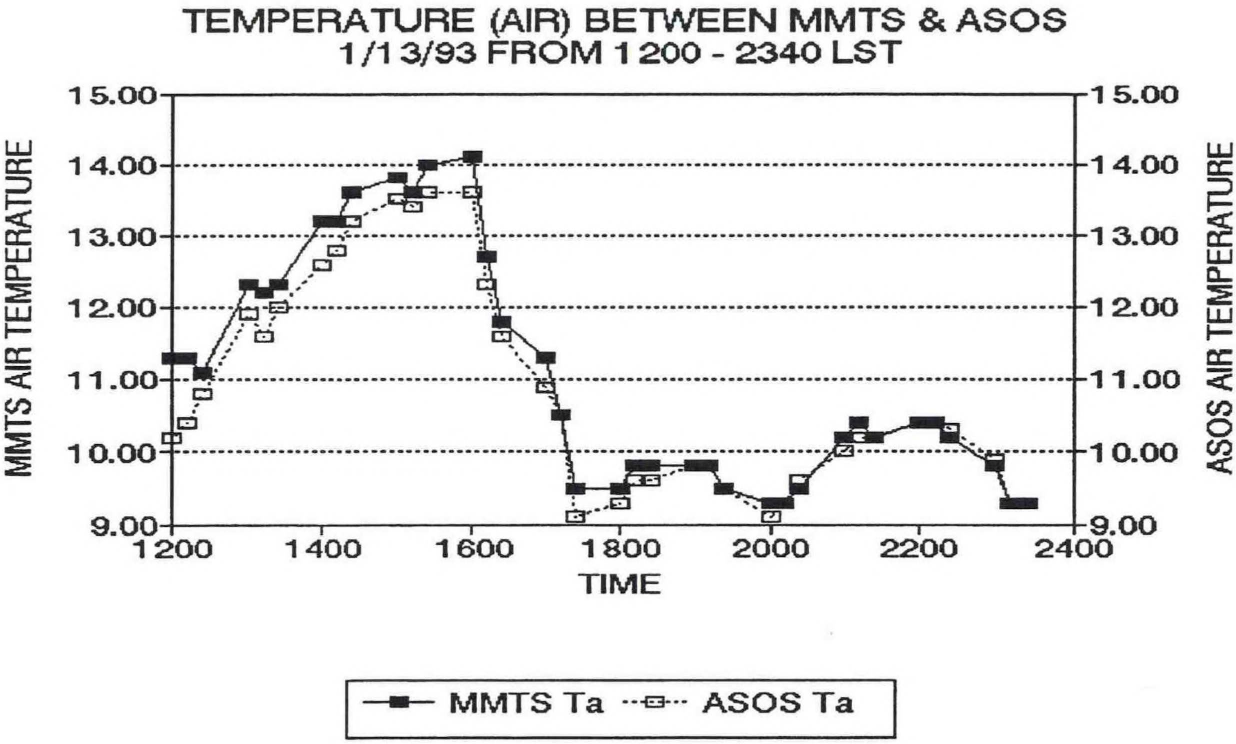


Figure 14.

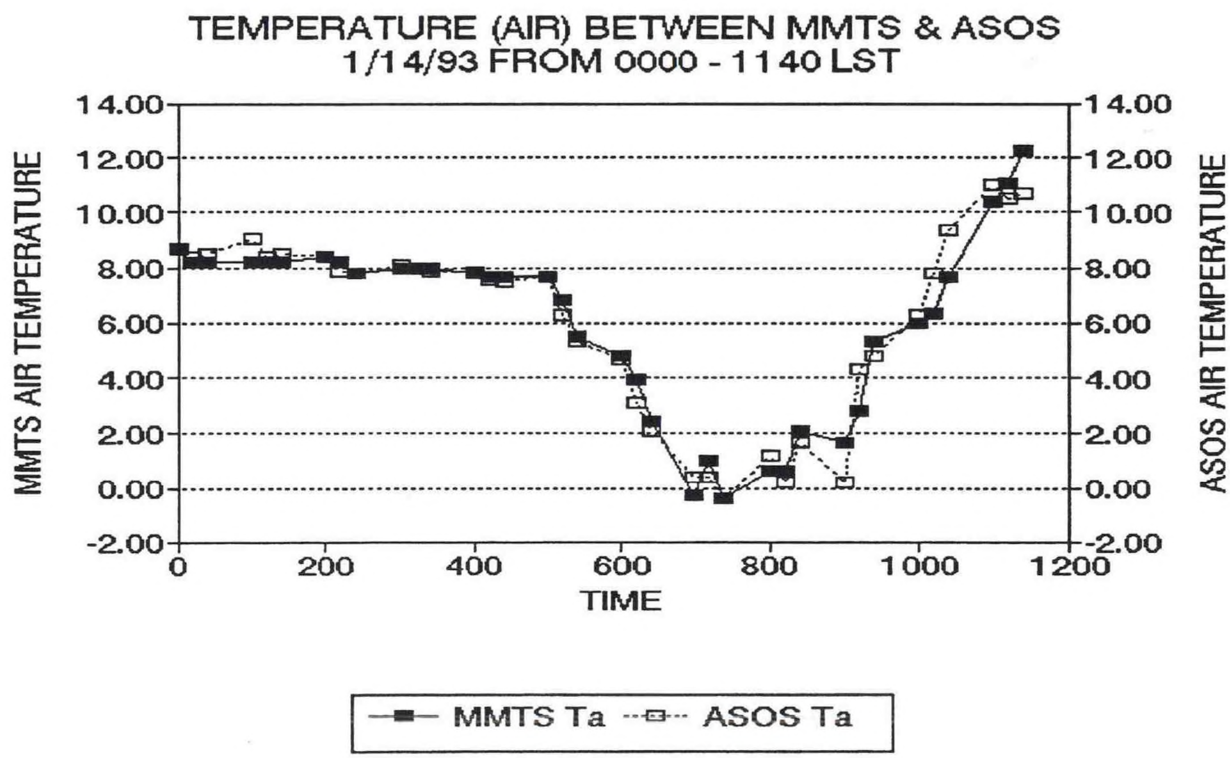


Figure 15

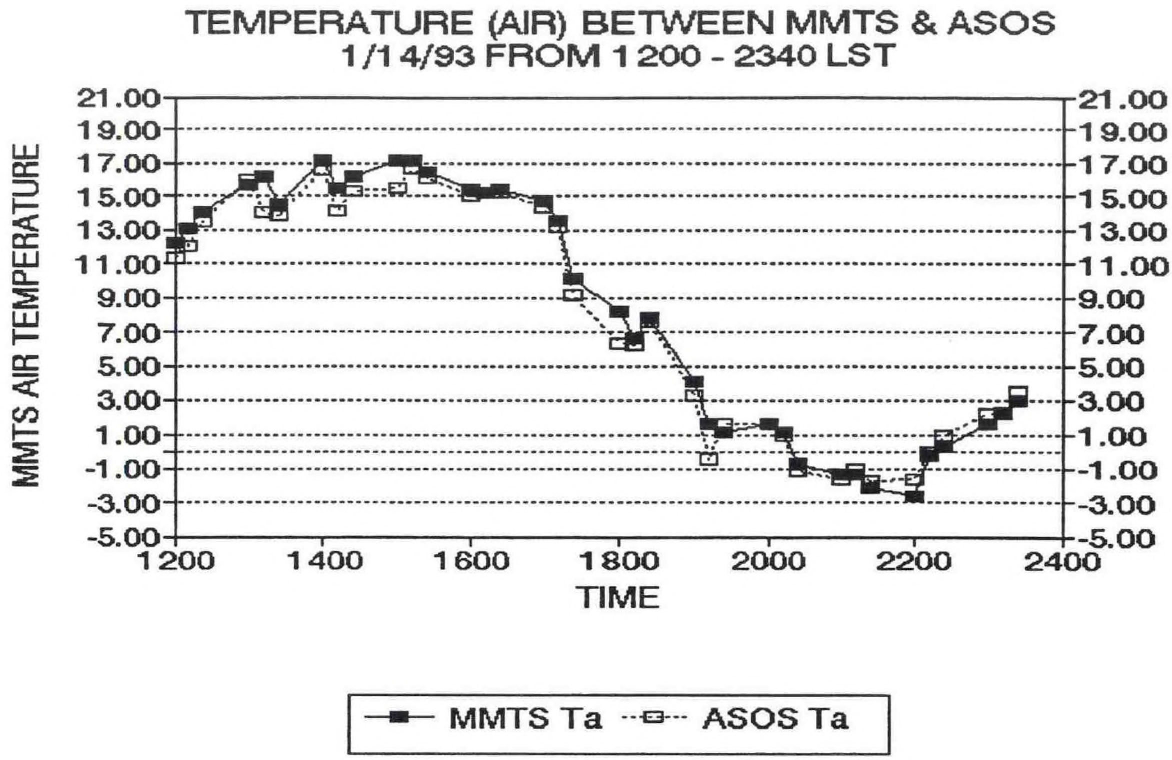


Figure 16

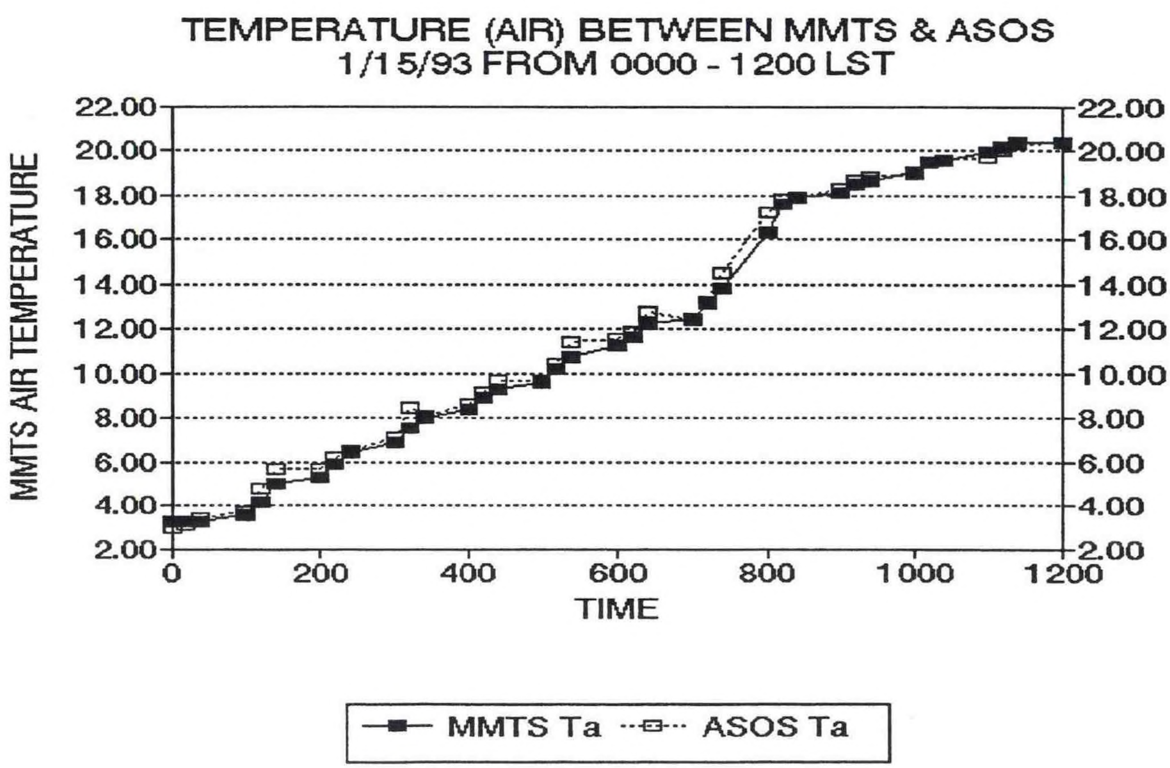


Figure 17.

The RMSE between the sling and MMTS was 0.96°F, nearly the same as ASOS (Figures 18-21). Indeed looking at the graphs the MMTS plot is very close to the ASOS in temperature and response.

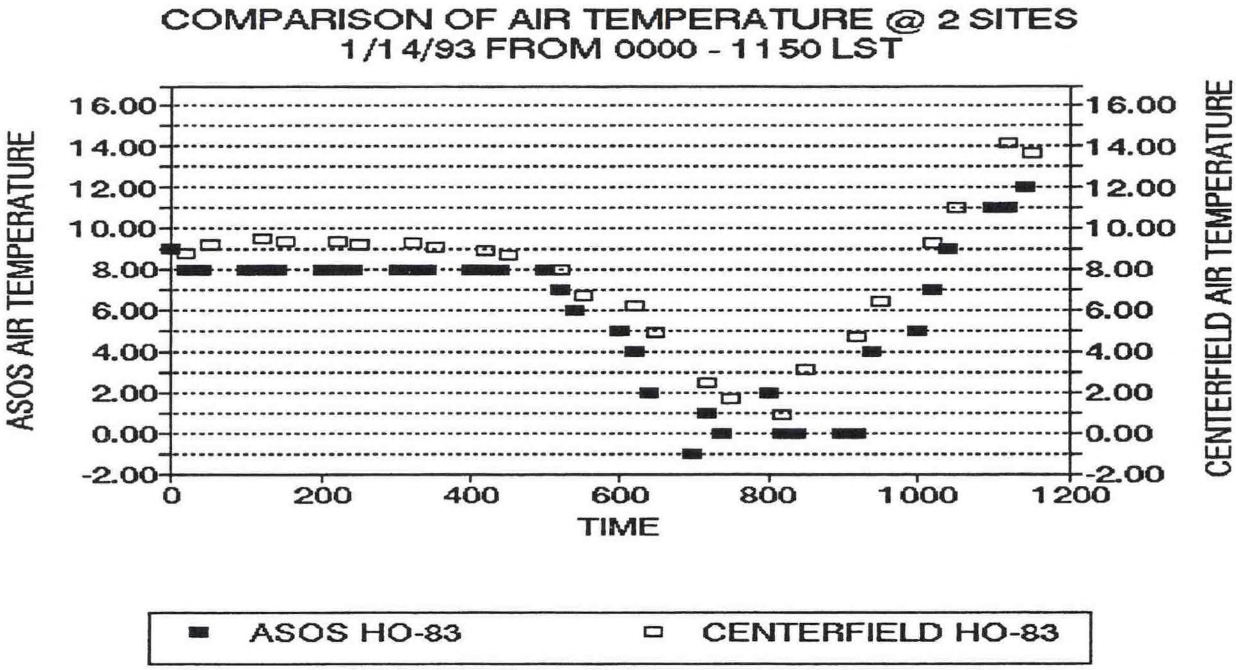


Figure 18.

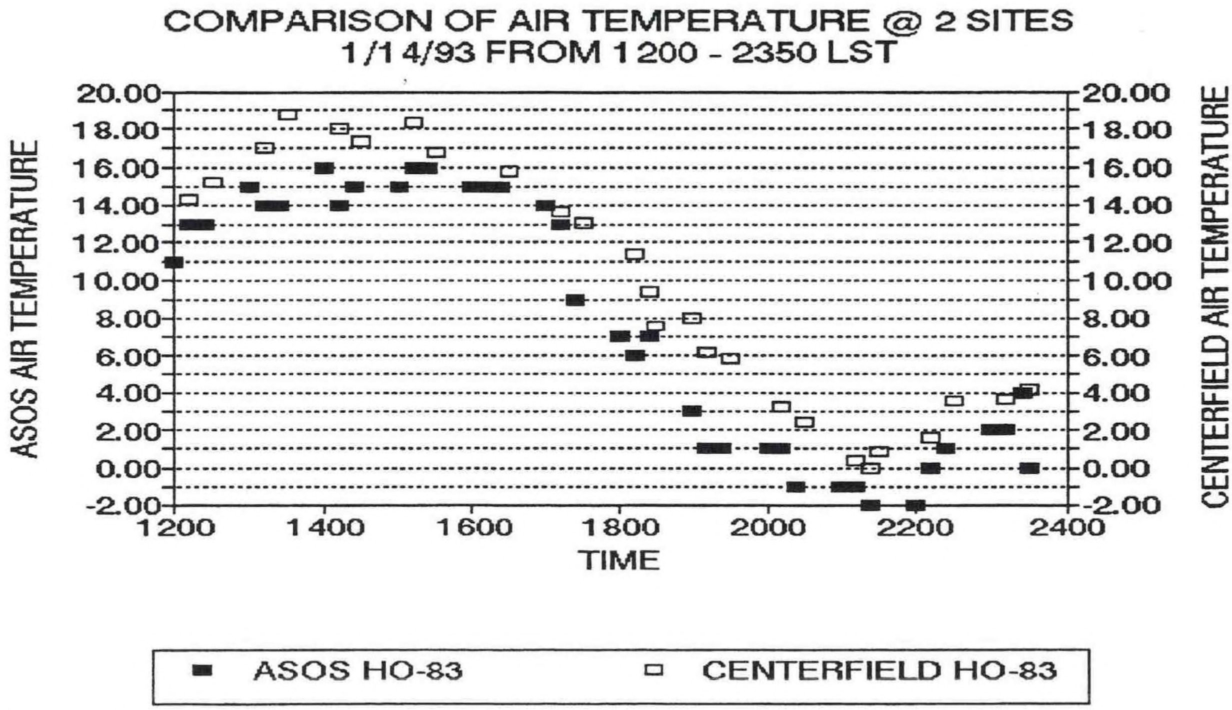


Figure 19.

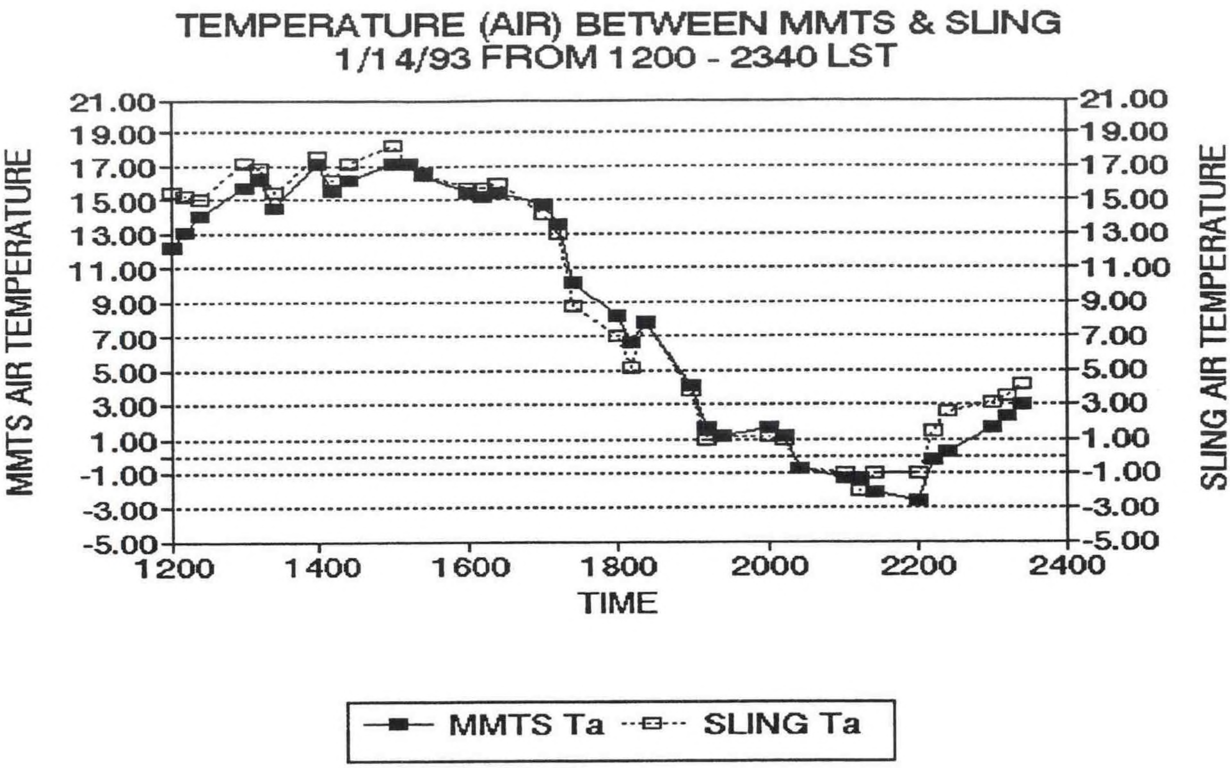


Figure 20.

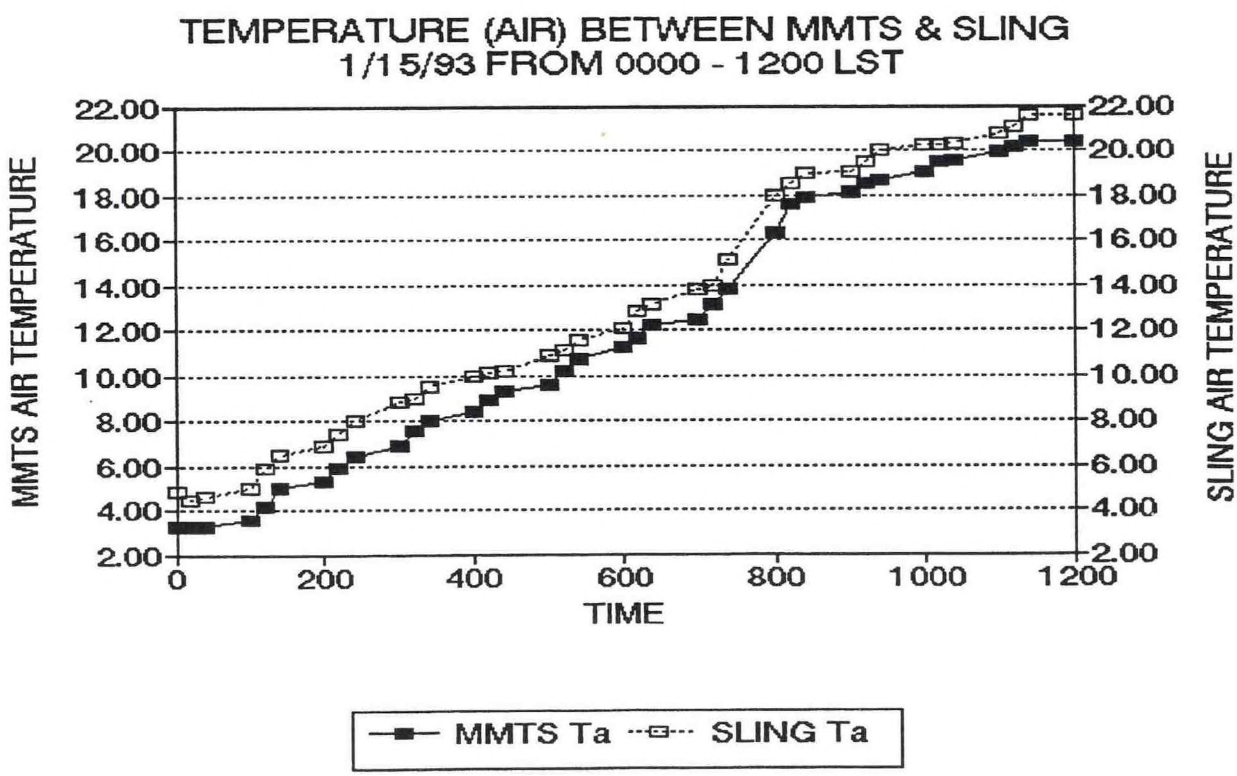


Figure 21.

The minor temperature differences between ASOS and the MMTS may be due to the ASOS having an aspirated sensor. The performance differences between the ASOS and MMTS compared with the sling may be a reflection of sheltering.

Even though we were unable to relate any consistent temperature differences to environmental conditions we found a few characteristics puzzling. The time of occurrence of the maximum and minimum temperatures did not match between the sensors. The MMTS and ASOS, both sheltered sensors, matched well but were behind when compared with the sling. Sheltering the sensors may be dampening rapid sensor response to temperature changes. Ironically, the maximum and minimum temperatures were still very nearly the same in all systems.

The dew point proved more erratic but not beyond the acceptable system requirements (ASOS User's Guide, B-1,). At the beginning of the test (Figure 22) under sunny skies and some wind the dew cell performance was not matching the sling consistently, usually reporting a cooler temperature. On the early morning of the 14th with sunny skies, the two sensors again were not matching well. In contrast, under overcast skies the ASOS RTD dew point was much closer to the sling, especially noticeable on the 15th (Figure 25). During this time the relative humidity was approaching 100 percent and by the end of the test light snow was falling.

It may be wise to test reversing the airflow over the RTD. This would ventilate the sensor with air from approximately five feet above the surface of the ground and may improve sensor response and accuracy.

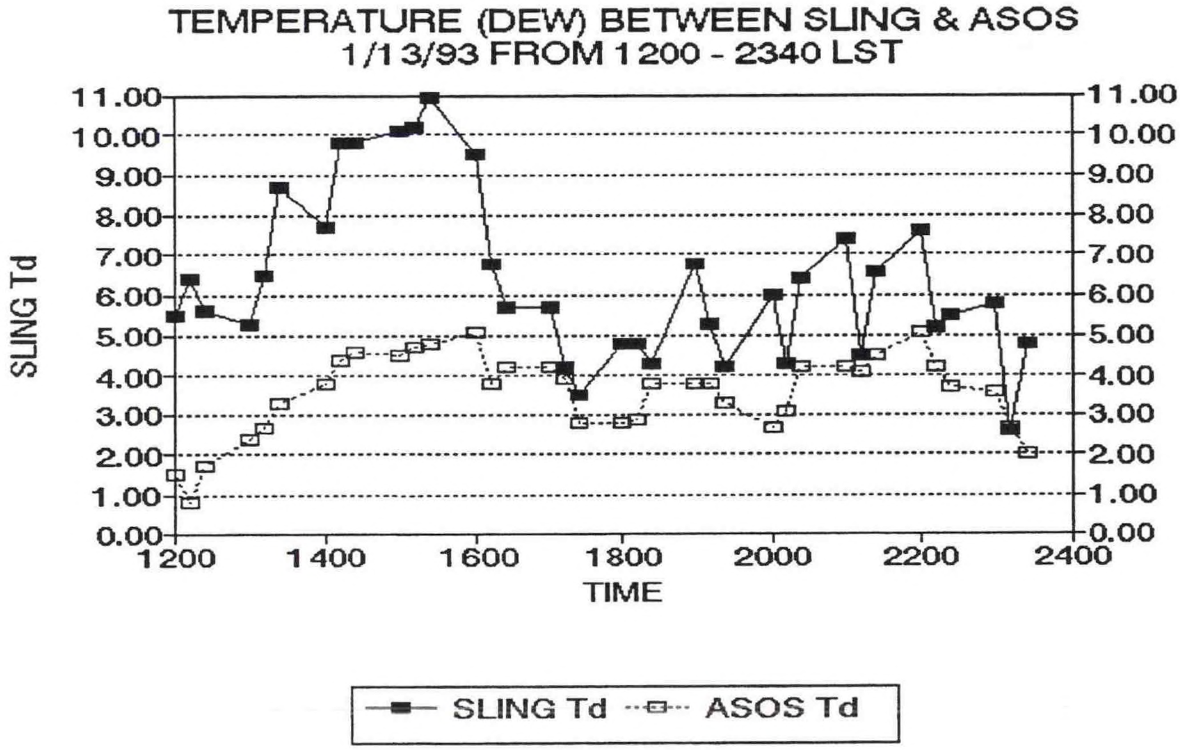


Figure 22.

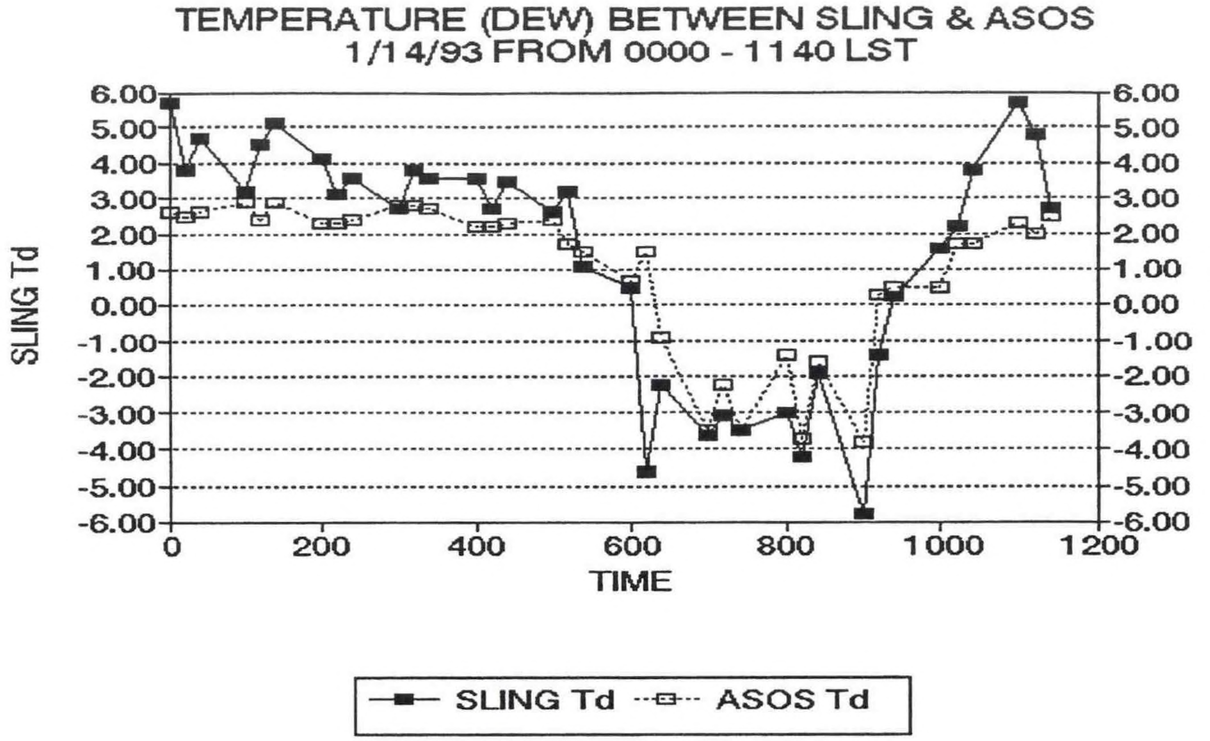


Figure 23.

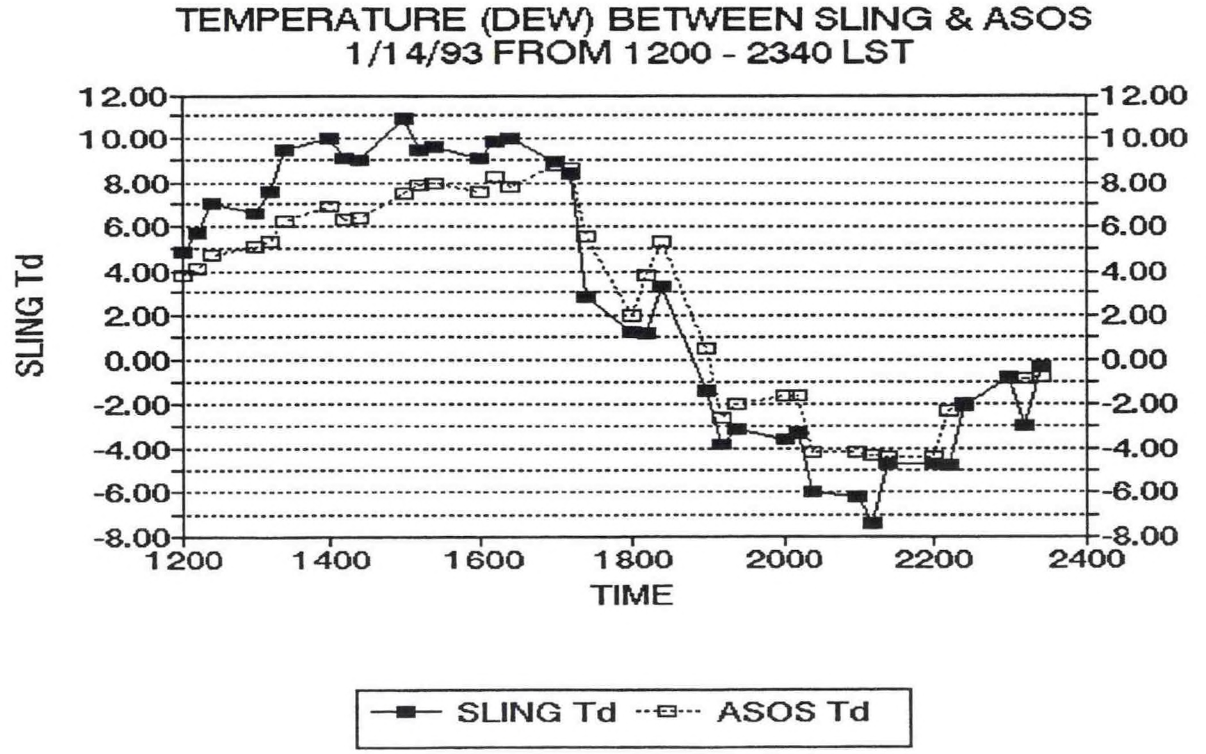


Figure 24.

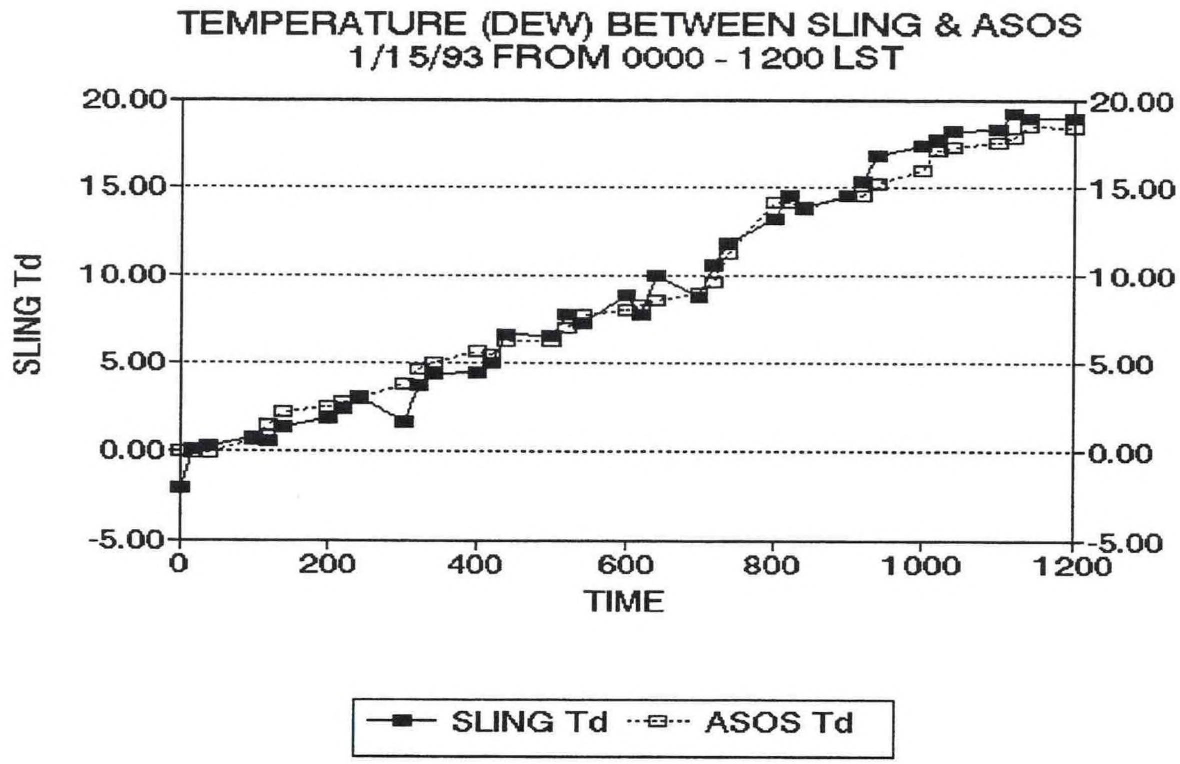


Figure 25.

6. SITING

The ASOS site at Lincoln conforms to all the required standards set forth in the Federal Standards for Siting Meteorological Sensors at Airports. The Lincoln ASOS site is approximately one mile farther south and 24 feet lower than the old official temperature site. When comparing the two sites under conditions of high radiational cooling we found there were large temperature differences.

At 0700 LST on January 14 under clear skies, the ASOS reported -1 °F (Figure 27, Best seen in Primary Data Attachment) while the HO-83 reported 4.9 °F. By 0820 LST, both sensors were within 1 °F. Clearing skies on the evening of January 14 provided a sharp temperature drop and by 1800 LST ASOS reported 6.4 °F compared with 13.1 °F at the old site (Figure 28). These two incidents pointed toward the real source of the temperature discrepancies, the lower elevation of the ASOS site.

Early morning low temperature differences between ASOS and the HO-83 have been as great as 12 °F. This occurred when the ground was bare in the fall. It would appear that under these conditions the cold air pools at the ASOS site (Figure 30). As time progresses, the cold air pool grows deeper. Then before the cold air can reach the sensors at the old site, the sun rises and warms the bare ground causing the cold air pool to shrink and retreat. Thus, the very cold early morning lows reported by ASOS are not measured at the old official temperature site.

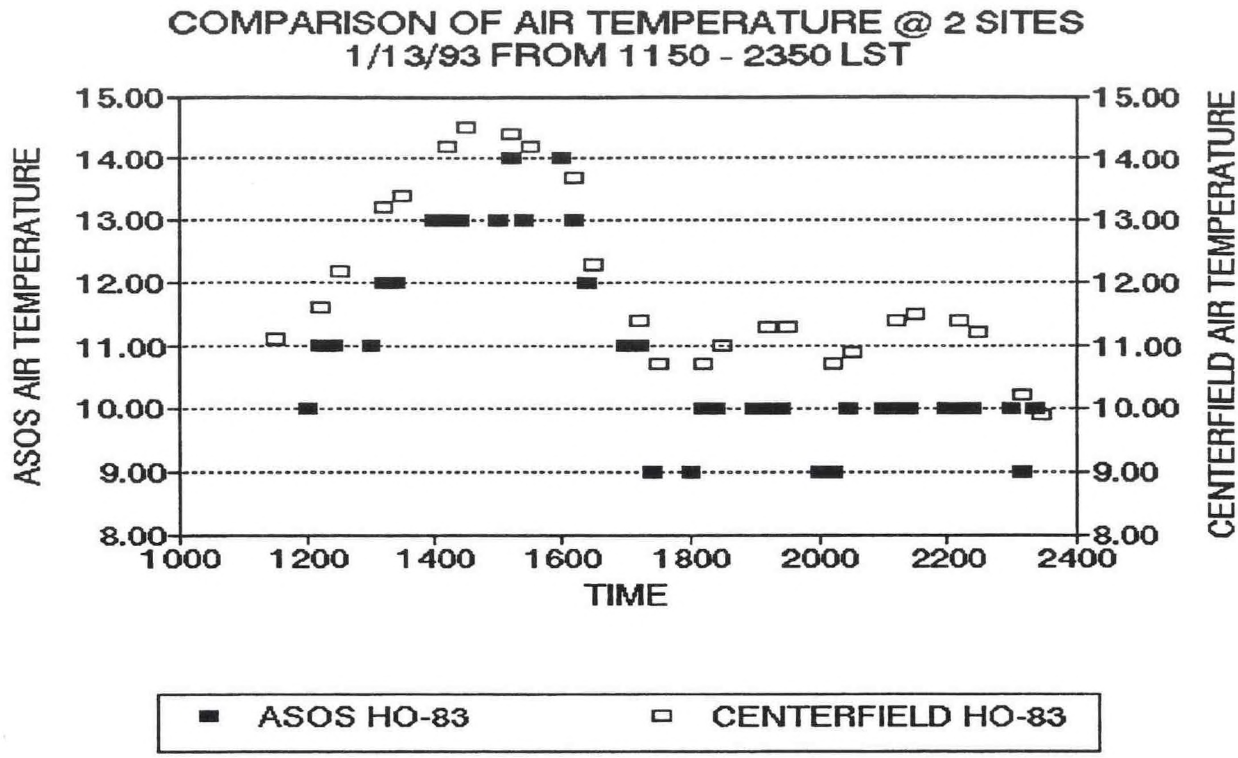


Figure 26.

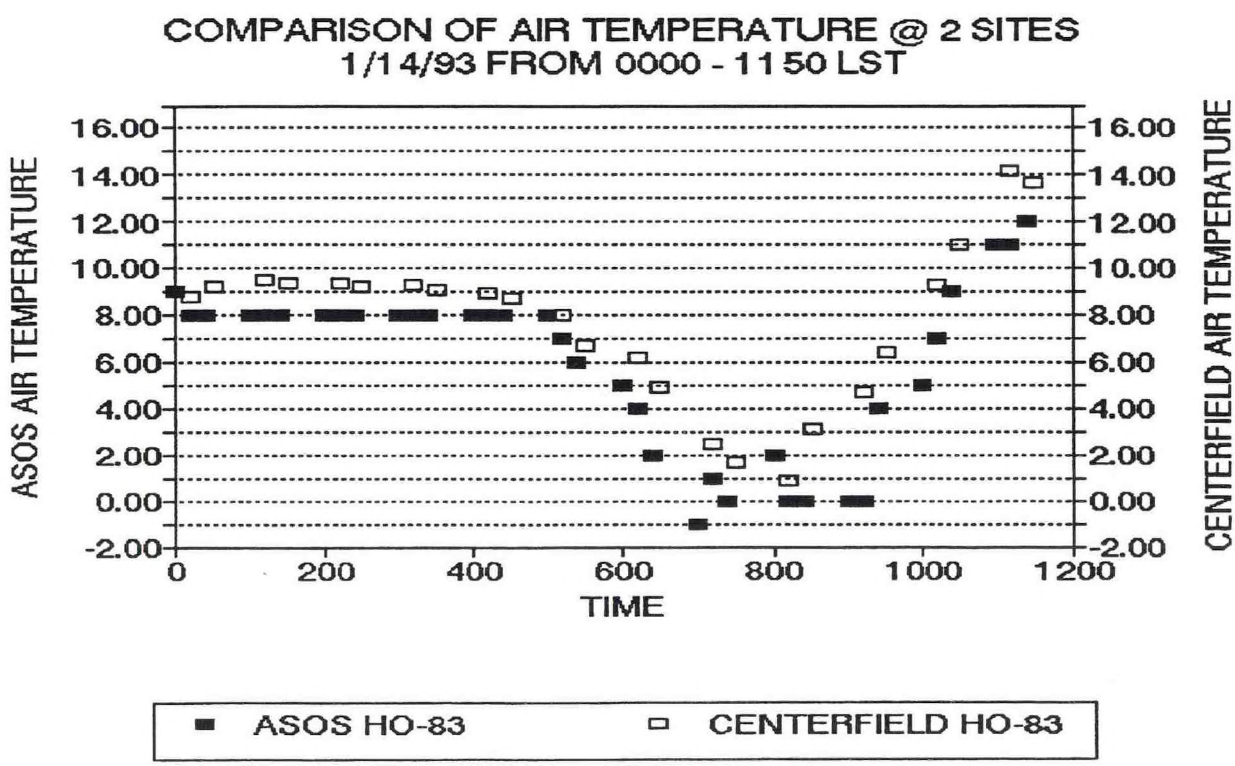


Figure 27.

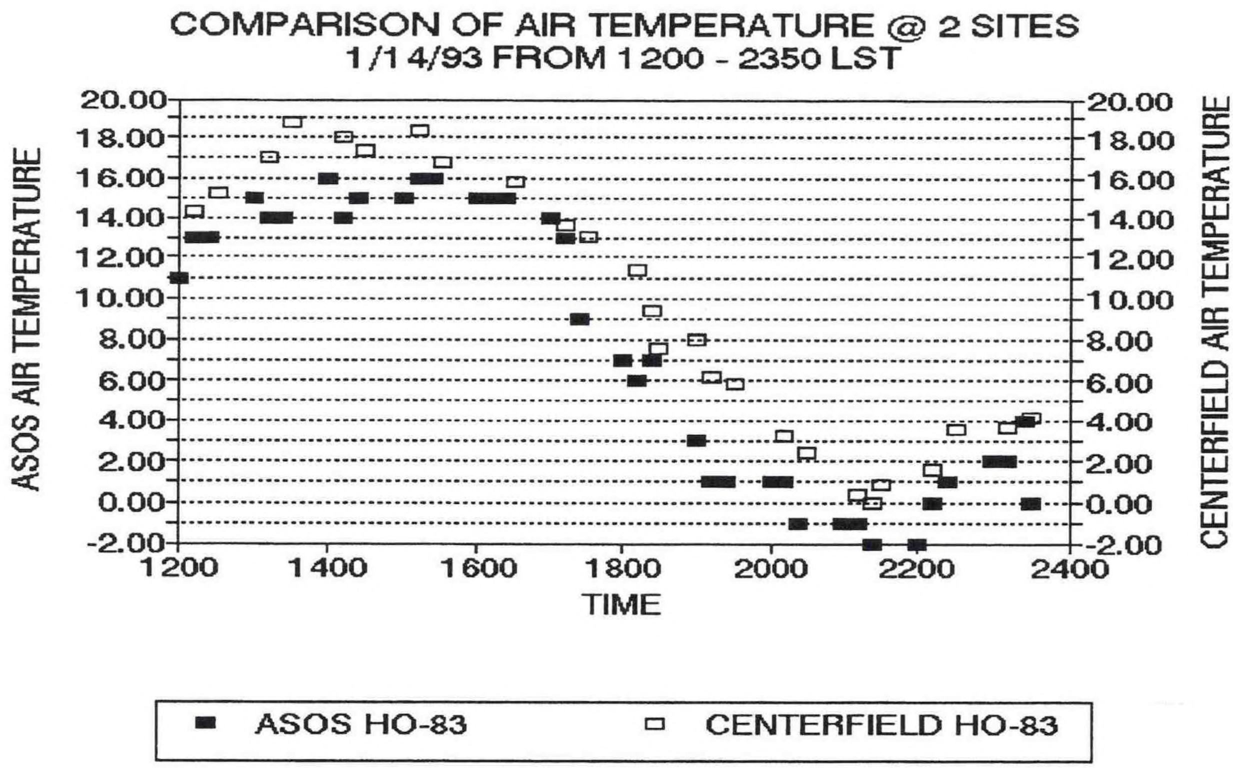


Figure 28.

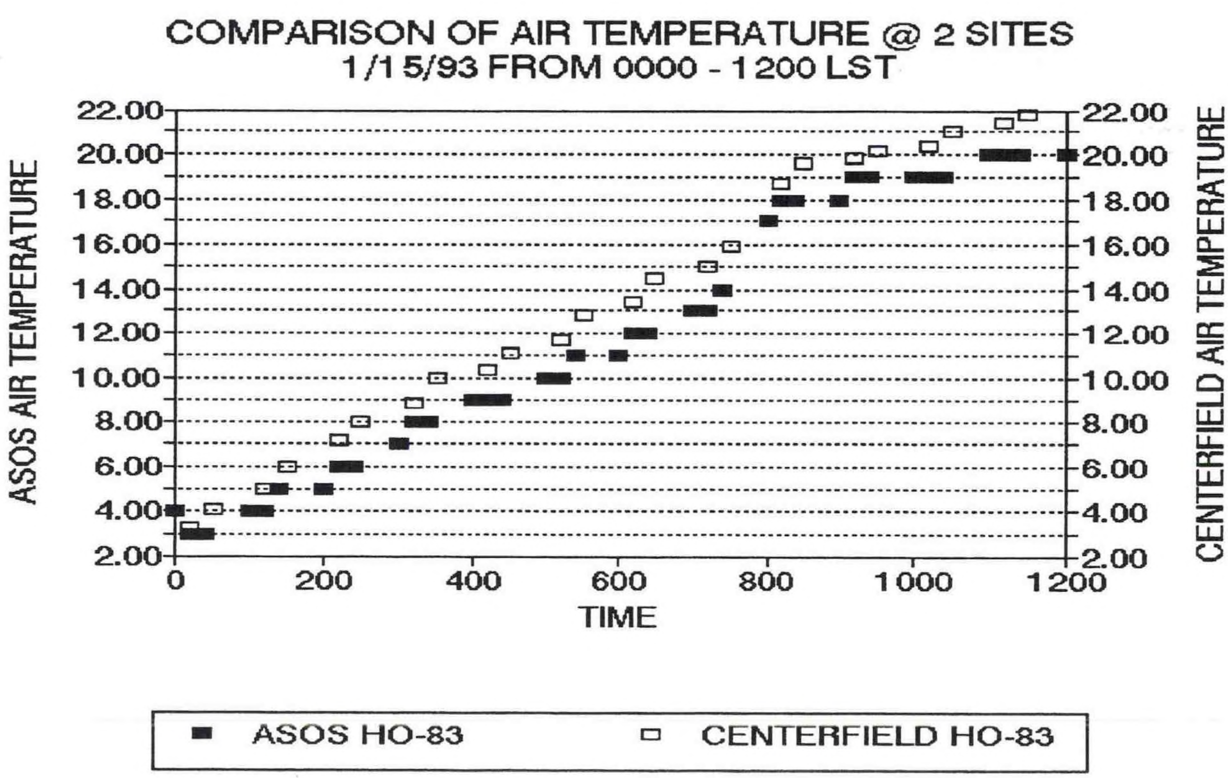


Figure 29.

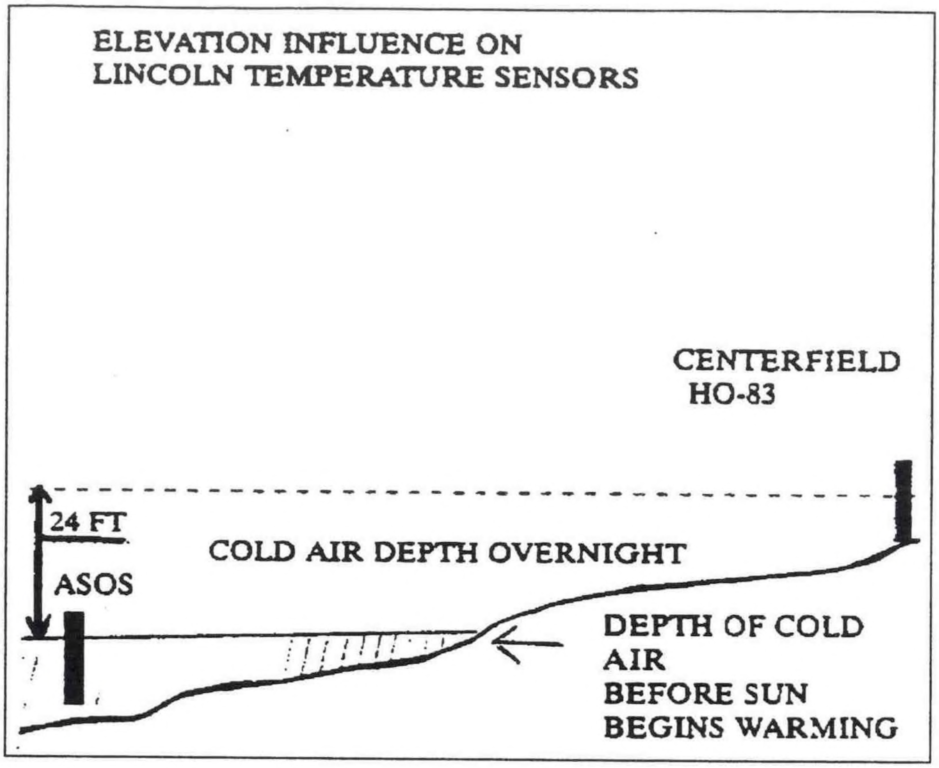


Figure 30.

This same phenomenon occurs in the evening, but as the night progresses the cold air pool has time to deepen and eventually reach the sensors at the old site. Thus, the minimum temperatures reported are close.

7. SUMMARY

Our initial findings support the accuracy of the automated sensors. Many of the small errors or differences in response may possibly be corrected by improvement in sensor aspiration. The dew point sensor of ASOS also fell within the required performance standards.

It is evident that even minor variations in elevation can contribute significantly to temperature differences under high radiational cooling regimes. Therefore, when installing ASOS at an existing observation site care must be exercised to avoid large elevation changes to prevent a major climatic shift at the same "official site". This consideration alone may prevent unnecessary criticism and resistance to the ASOS data from the public and media.

8. ACKNOWLEDGEMENTS

The authors thank Tom Townsend and Tom Schwein of Central Region for recommending and supporting this project. Steve Mekis of Central Region provided welcomed relief allowing us a few precious hours of sleep. The Lincoln Airport Authority made the test possible by providing the equipment to reach the site and a cellular telephone to maintain contact

with the outside world. This proved vital in assessing ASOS performance. The FAA Tower personnel, also were patient and helpful throughout the test. The entire WSO staff at Lincoln provided valuable support and assistance.

9. REFERENCES

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Office of the Federal Coordinator for Meteorological Services and Supporting Research, 1988: Federal Meteorological Handbook #1, Surface Observations (FCM-H1-1988), , April Sections A9-5, 3.3.1, 4.1.2.

Office of the Federal Coordinator for Meteorological Services and Supporting Research (OFCM), 1987: Federal Standards for Siting Meteorological Sensors at Airports (FCM-S4-1987).

10. DATA NOTE

You may obtain the data derived from this test by sending a data disk (DOS formatted) to: National Weather Service, ASOS Test Data, 11404 N. 72nd Street, Omaha, NE 68122.

PRETEST SLING COMPARISON CHECK

		SLING 1		SLING 2	
DATE	TIME	Ta	Tw	Ta	Tw
1/08/93	2042	75.5	75.5		
1/08/93	2350	16.0	16.0		
1/11/93	0912	75.6	75.6		
1/11/93	1150			76.5	76.5
1/11/93	1600	24.0	24.0	24.0	24.0
1/11/93	1750	75.6	75.6	75.5	75.5
1/12/93	1236	75.9	75.9	76.1	76.1
1/12/93	1458	26.1	26.1	26.4	26.4
1/12/93	1703	75.8	75.8	76.0	76.0
1/12/93	1728	75.2	75.2	75.4	75.4

MAXIMUM TEMPERATURE DIFFERENCE BETWEEN SLING 1 AND SLING 2 WAS 0.3 °F. MOST OFTEN AROUND 0.0 TO 0.3 °F.

SLING 1: BOTH WB/DB (Tw/Ta) THERMOMETERS AGREED EXACTLY DRY

SLING 2: BOTH WB/DB (Tw/Ta) THERMOMETERS AGREED EXACTLY DRY

ALMANAC

LINCOLN ASOS TEST LINCOLN, NE
JANUARY 13-15, 1993
(all times LST)

1/13/93...

1030 SET UP CAMPER, PLUGGED IN MMTS, DID INITIAL SLING CHECKS, PREPARED ALL EQUIPMENT FOR TEST. CAMPER LOCATION WAS CAREFULLY SELECTED SOAS TO NEITHER EFFECT AIR FLOW AT THE TEMPERATURE SENSORS NOR TRANSLATE ANY RESIDUAL HEAT FROM THE UNIT INTO THE SITE. WINDS WERE MONITORED TO MAINTAIN THIS CONDITION.

1220 ASOS TD AROUND THIS TIME WAS VERY VARIABLE. AT 1220 ASOS TD VARIED FROM 0.0 TO 1.8 DEGREES F IN LESS THAN ONE MINUTE UNDER SUNNY SKIES AND WINDY CONDITIONS. SEE NOTE ON 1/13/93 AT 2340.

1030-1700 SKIES WERE MOSTLY CLEAR

1640 TOWER CONTACTED PHIL ENROUTE TO SAY ASOS WAS REPORTING 1500 FT. BKN DECK WHEN NO DECK EXISTED. OBSERVER AUGMENTED SKY TO CORRECT FOR THIS.

1730 CIGS AT 1800 FT MOVED IN.

IT SEEMS ASOS CHI STILL DETECTS A POSSIBLE MOISTURE DENSITY DIFFERENCE EVEN WHEN CLOUDS ARE NOT PRESENT. ASOS REPORTED CIGS AT 1640 WHEN NONE EXISTED THEN AN HOUR LATER A DECK AT 1800 FT MOVES IN. (IE. AROUND WHERE ASOS THOUGHT IT OBSERVED CLOUDS AT 1640). IS ASOS CHI TOO SENSITIVE?

1845 PAM (IN WSO) CONTACTED WSFO OMA AND FOUND OUT SITE WAS ON WEST EDGE OF 900 MB MOISTURE LAYER (INDICATED ON SOUNDING). HAD CAUSED SC IN SD DURING DAY. ADDITIONAL CLOUDS NOTED.

1930 OVERCAST SOME VERY LIGHT SNOW.
FLURRIES FROM EARLY EVENING THROUGH MID EVENING.

2300 THROUGH 2340 BKN TO BINOVC.

2340 SIMILIAR PROBLEM WITH ASOS TD AS NOTED ON 1/13/93 AT 1220.
IS THIS A CYCLE OF COOLING AND HEATING THE MIRROR FOR THE TD?

ALSO THE WINDS HAD PICKED UP SOME DURING THIS TIME.

1/14/93..

0000 THROUGH 0300 OCNL THN SPTS IOVC TO SMALL BINOVC.

0300 THROUGH 0400 OCCASIONALY SEE MOON THROUGH OVC BUT NO CLEAR SKIES.

0440 MOON VISIBILE (HAS SOME RING AND THIN CLOUDS), STARS VISIBLE THROUGH NUMEROUS BREAKS BUT NOT CLR FROM 0400 THROUGH 0600.

0510 MOON & STARS!! SOME THIN CLOUDS BUT SHOULD HAVE GOOD RADITATION NEXT FEW HOURS. WINDS NEARLY CALM.

0620 CLR/CALM.

0700 THROUGH 0720 SCT OCNL -BKN HIGH CI CLOUDS, WIND CALM.

0740 -SCT AND NEARLY CALM WINDS.

CHARACTER OF SUNRISE...CLEAR.-

0915 HIGH -BKN.

0930 HI BKN.

1000 MID AND HIGH CLD OVC NO THIN SPOTS.

1020 CLDY AC/CI.

1040 CLDY AC/CI FEW SC.

1100 CLDY AC/CI WIND INCRG A LITTLE, WAS CALM, NOW ESTIMATED 6-8 MPH.

1120 CLDY AC/CI SOME THN SPTS.

1140 CLDY AC/CI SOME THN SPTS.

1200 CLDY, BUT A FEW THN SPTS AND SOME SUN.

1220 CLDY BUT GETTING THINNER.

1240 CLDY BUT SKY GETTING BRIGHTER (THINNING CLDS), SOME SHADOWS!

1300 SCT AC THN BKN CI, SOME SUNSHINE

1320 THN OVC SOME SUNSHINE.

1400 THN BKN MOSTLY SUNSHINE.

1520 THN SCT MOSTLY SUNSHINE.

1540 THN BKN SUN BEHIND THICK CLDS.

1700 SUNSET HI THIN CLDS 6 TENTHS GOOD RADIATION OVER SITE.

1720 CLR OVERHEAD CALM WINDS.

CHARACTER OF SUNSET...CLOUDY WITH CLR SKIES OVHD.

1740 NEARLY CLR SKIES...FEW HI CLDS, NO WIND!

1800 CLR/CALM.

1840 CLR / WIND SWITCHED TO S (LIGHT NRLY CALM). TEMPS ROSE. ASOS INDICATED CALM BUT WINDS WERE VERY LIGHT.

1900 CLR DEAD CALM...EXCELLENT RADIATION...5 DEGREE F DIFFERENCE BETWEEN HO-83 AND ASOS Ta.

1940 CLR / CALM WIND NW. TEMPS DROPPED WHEN WIND SWITCHED TO NW.

2040 FROST ON INSTRUMENT ARRAY. FROST ON SLINGS. CAN SEE REDUCED VSBY IN SHALLOW LAYER ON HORIZON. MUST BE INVERSION. SMOKE RISING STRAIGHT UP AT BUILDING ON EAST HORIZON AND LEVELING OUT 100 TO 200 FEET ABOVE GROUND LEVEL. CLEAR ABOVE...SEE SOME MID LVL CLDS ON SRN HORIZON UP TO 35 DEGREES.

2045 ASOS DROPPED VSBY FROM 10+ TO 11/2 FOG. NO EVIDENCE AT SITE OF ANY FOG AT ASOS SITE...VSBYS AT ASOS SITE WERE 10+. COULD FROST BE FORMING ON VSBY LENSES, AS FROST WAS FORMING ON EVERYTHING PER 2040 DISCUSSION, AND IF SO DOES THIS REDUCE VSBY?

2200 ASOS VSBY BACK TO 10+....WHAT IS HAPPENING???? 43 BKN CLDS OVER SITE...CLR TO THE NORTH.

2220 PAM CALLED AND SAID ASOS WAS REPORTING A VSBY OF 2 MILES IN FOG AT 2215...WHILE SHE OBSERVED 10+ WITH NO FOG AT WSO LNK. FOG WAS OBSERVED AT THE ASOS SITE AS WELL AS ICE CRYSTALS. FOG RESTRICTED VSBY TO LESS THAN 7 MILES BOTH NORTH AND SOUTH FROM ASOS SITE, BUT NOT TO THE EAST OR WEST. THIS IS WHERE THE SHALLOW VALLEY IS ON THE AIRPORT. MOST RESTRICTED VSBYS WERE TO THE SSW OF THE ASOS SITE, BOUNDED BY THE ASOS SITE, TAXIWAY GULF AND THE SOUTHERN MOST END OF THE RUNWAY/AIRPORT WITHIN AIRPORT COMPLEX.

COULD ICE CRYSTALS BE INCREASING THE RECEIVED SIGNAL ON VSBY AND THEREFORE REDUCING THE VSBY MORE THAN WHAT IT SHOULD BE? SKIES WERE OVC AND WINDS WERE CALM.

2240 OVC SKIES, NO WIND, ICE CRYSTALS AND LIGHT FOG AS DESCRIBED AT 2220, BUT NOT QUITE AS RESTRICTIVE TO THE VSBY.

2300 OVC SKIES, VERY LIGHT NW WIND NEARLY CALM. NO MORE FOG OR ICE CRYSTALS.

2320 OVC SKIES WITH CALM WINDS.

1/15/93..

0020 OVC CALM-LIGHT NW WIND.

0040 OVC CALM-LIGHT NW WIND.

0100 THROUGH 0240 OVC CALM-LIGHT NW WIND.

0540 STILL OVC DEAD CALM WIND.

0740 VERY LIGHT/CALM AND VARIABLE WINDS W/OVC

0800 LIGHT SOUTH WIND OVC

CHARACTER OF SUNRISE CLOUDY

0840 OVC WIND S BREEZE

0900 OVC BREEZY S WIND

0920 OVC S BREEZE WIND VRY LGT S- (FLURRIES)

0940 OVC S WIND VRY LGT SNOW FLURRIES

1120 OVC S WIND ZL- AND S- (FLURRIES)

1200 OVC ZL- AND S- (FLURRIES) BREEZY SOUTH WIND. FINISHED!!!!

LINCOLN ASOS TEST LINCOLN NE
JANUARY 13-15, 1993

COLLECTED PRIMARY DATA (°F)

TIME		SLING		INSTANT ASOS		1-MINUTE SCREEN ASOS		MMTS	HO-83		TIME OF HO-83
	Ta	Tw	Td	Ta	Td	Ta	Td	Ta	Ta	Td	
1200	11.8	11.0	5.5	10.2	1.5	10	1	11.3	11.1	1.6	1150
1220	10.5	10.2	6.4	10.4	0.8	11	1	11.3	11.6	2.0	1220
1240	11.9	11.1	5.6	10.8	1.7	11	2	11.1			
1300	12.0	11.1	5.3	11.9	2.4	11	2	12.3	12.2	2.6	1250
1320	13.0	12.1	6.5	11.6	2.7	12	3	12.2	3.2	3.8	1320
1340	12.0	11.8	8.7	12.0	3.3	12	3	12.3			
1400	12.8	12.2	7.7	12.6	3.8	13	4	13.2	13.4	3.7	1350
1420	13.0	12.8	9.8	12.8	4.4	13	4	13.2	14.2	4.7	1420
1440	13.8	13.4	9.8	13.2	4.6	13	4	13.6			
1500	14.0	13.6	10.1	13.5	4.5	13	5	13.8	14.5	4.7	1450
1520	14.5	14.0	10.2	13.4	4.7	14	5	13.6	14.4	4.8	1520
1540	14.0	13.8	10.9	13.6	4.8	13	5	14.0			
1600	13.9	13.4	9.5	13.6	5.1	14	5	14.1	14.2	4.8	1550
1620	12.9	12.1	6.8	12.3	3.8	13	4	12.7	13.7	4.8	1620
1640	12.0	11.2	5.7	11.6	4.2	12	4	11.8			
1700	11.6	10.9	5.7	10.9	4.2	11	4	11.3	12.3	4.2	1650
1720	10.8	10.0	4.2	10.5	3.9	11	3	10.5	11.4	4.0	1720
1740	9.8	9.1	3.5	9.1	2.8	9	3	9.5			
1800	9.5	9.1	4.8	9.3	2.8	9	3	9.5	10.7	3.7	1750
1820	10.0	9.5	4.8	9.6	2.9	10	3	9.8	10.7	3.9	1820
1840	10.0	9.4	4.3	9.6	3.8	10	3	9.8			
1900	10.2	10.0	6.8	9.8	3.8	10	4	9.8	11.0	4.1	1850
1920	10.8	10.2	5.3	9.8	3.8	10	4	9.8	11.3	4.3	1920
1940	10.8	10.0	4.2	9.5	3.3	10	4	9.5			
2000	10.1	9.8	6.0	9.1	2.7	9	3	9.3	11.3	4.2	1950
2020	10.0	9.4	4.3	9.3	3.1	9	3	9.3	10.7	4.1	2020
2040	10.0	9.8	6.4	9.6	4.2	10	4	9.5			
2100	10.0	10.0	7.4	10.0	4.2	10	4	10.2	10.9	3.8	2050
2120	11.0	10.2	4.5	10.2	4.1	10	4	10.4	11.4	4.7	2120
2140	11.5	11.0	6.6	10.2	4.5	10	4	10.2			
2200	11.1	10.9	7.6	10.4	5.1	10	5	10.4	11.5	5.0	2150
2220	11.2	10.5	5.2	10.4	4.2	10	4	10.4	11.4	4.6	2220
2240	11.0	10.4	5.5	10.3	3.7	10	4	10.2			
2300	10.4	10.0	5.8	9.9	3.6	10	4	9.8	11.2	3.9	2250

TIME	SLING Ta	SLING Tw	SLING Td	INSTANT ASOS Ta	INSTANT ASOS Td	1-MINUTE SCREEN ASOS Ta	1-MINUTE SCREEN ASOS Td	MMTS Ta	HO-83 Ta	HO-83 Td	TIME OF HO-83
2320	10.0	9.1	2.6	9.3	2.7	9	3	9.3	10.2	3.7	2320
2340	10.0	9.5	4.8	9.3	2.0	10	4	9.3			
0000	9.9	9.6	5.7	8.7	2.6	9	3	8.7	9.9	3.6	2350
0020	9.1	8.6	3.8	8.4	2.5	8	2	8.2	8.8	2.8	0020
0040	9.4	9.0	4.7	8.5	2.6	8	2	8.2			
0100	9.5	8.8	3.2	9.1	2.9	8	3	8.2	9.2	3.1	0050
0120	9.3	8.9	4.5	8.4	2.4	8	3	8.2	9.5	3.4	0120
0140	9.3	9.0	5.1	8.5	2.9	8	2	8.2			
0200	9.4	8.9	4.1	8.4	2.3	8	3	8.4	9.4	3.1	0150
0220	9.0	8.4	3.1	7.9	2.3	8	3	8.2	9.4	2.2	0220
0240	9.0	8.5	3.6	7.8	2.4	8	3	7.8			
0300	9.1	8.4	2.7	8.1	2.8	8	2	8.0	9.2	3.3	0250
0320	9.8	9.0	3.8	8.0	2.8	8	3	8.0	9.3	2.7	0320
0420	9.0	8.4	2.7	7.6	2.2	8	2	7.7	8.9	2.6	0420
0340	9.0	8.5	3.6	7.9	2.7	8	2	8.0			
0400	9.0	8.5	3.6	7.9	2.2	8	2	7.8	9.1	2.6	0350
0440	8.9	8.4	3.5	7.5	2.33	8	2	7.7			
0500	8.6	8.0	2.6	7.7	2.4	8	2	7.7	8.7	2.7	0450
0520	7.2	7.0	3.2	6.3	1.7	7	2	6.8	8.0	2.1	0520
0540	6.4	6.0	1.1	5.3	1.5	6	2	5.5			
0600	5.9	5.5	0.5	4.7	0.7	5	1	4.8	6.7	1.5	0550
0620	4.0	3.2	-4.6	3.1	1.5	4	0	3.9	6.2	1.5	0620
0640	2.0	1.9	-2.2	2.1	-0.9	2	-1	2.4			
0700	0.0	0.0	-3.6	0.4	-3.5	-1	-4	-0.3	4.9	0.8	0650
0720	1.1	1.0	-3.1	0.4	-2.2	1	-2	1.0	2.5	-1.1	0720
0740	0.1	0.1	-3.5	-0.4	-3.5	0	-3	-0.4			
0800	2.8	2.5	-3.0	1.2	-1.4	2	-1	0.6	1.7	-1.6	0750
0820	-0.5	-0.5	-4.2	0.2	-3.7	0	-4	0.6	0.9	-2.7	0820
0840	1.7	1.7	-1.9	1.7	-1.6	0	-3	2.1			
0900	-2.0	-2.0	-5.8	0.2	-3.8	0	-4	1.7	3.1	-0.8	0850
0920	3.8	3.4	-1.4	4.3	0.3	0	-4	2.8	4.7	-1.3	0920
0940	10.8	9.3	0.2	4.8	0.5	4	-1	5.3			
1000	7.3	6.8	1.6	6.3	0.5	5	-1	6.0	6.4	-0.7	0950
1020	9.2	8.4	2.2	7.8	1.7	7	1	6.4	9.3	1.1	1020
1040	9.6	9.0	3.8	9.4	1.7	9	1	7.7			
1100	12.8	11.8	5.7	11.0	2.3	11	2	10.4	11.0	1.7	1050
1120	13.0	11.8	4.8	10.5	2.0	11	3	11.1	14.2	3.5	1120
1140	13.8	12.0	2.7	10.7	2.5	12	3	12.3			
1200	15.4	13.6	4.9	11.3	3.8	11	3	12.2	13.7	3.8	1150
1220	15.2	13.6	5.7	12.0	4.1	13	4	13.1	14.3	4.2	1220

TIME	SLING Ta	SLING Tw	SLING Td	INSTANT ASOS Ta	INSTANT ASOS Td	1-MINUTE SCREEN ASOS Ta	1-MINUTE SCREEN ASOS Td	MMTS Ta	HO-83 Ta	HO-83 Td	TIME OF HO-83
1240	15.0	13.7	7.0	13.5	4.7	13	4	14.1			
1300	17.2	15.2	6.6	16.0	5.1	15	6	15.7	15.2	5.2	1250
1320	16.9	15.2	7.6	14.1	5.3	14	5	16.3	17.0	5.8	1320
1340	15.4	14.5	9.4	13.8	6.2	14	6	14.6			
1400	17.6	16.2	10.0	16.6	6.9	16	7	17.2	18.8	8.0	1350
1420	16.2	15.0	9.1	14.2	6.3	14	7	15.6	18.0	7.2	1420
1440	17.2	15.7	9.0	15.3	6.4	15	7	16.3			
1500	18.3	16.9	10.9	15.6	7.5	15	8	17.2	17.4	7.3	1450
1520	17.2	15.8	9.4	16.7	7.9	16	8	17.2	18.4	8.5	1520
1540	16.6	15.4	9.6	16.1	8.0	16	8	16.5			
1600	15.8	14.7	9.1	15.0	7.6	15	8	15.4	16.8	8.1	1550
1620	15.7	14.8	9.8	15.2	8.2	15	8	15.2	15.0	8.4	1620
1640	16.0	15.2	10.0	15.2	7.8	15	8	15.4			
1700	14.2	13.5	8.9	14.3	8.8	14	8	14.7	15.8	8.4	1650
1720	13.0	12.5	8.4	13.2	8.6	13	8	13.6	13.6	7.8	1720
1740	8.8	8.2	2.8	9.1	5.5	9	5	10.2			
1800	7.0	6.5	1.3	6.4	2.0	7	4	8.2	13.1	8.0	1750
1820	5.2	5.0	1.2	6.2	3.8	6	3	6.6	11.4	6.3	1820
1840	7.8	7.5	3.3	7.6	5.3	7	4	7.8	9.4	5.5	1840
1900	3.8	3.5	-1.4	3.3	0.5	3	1	4.1	7.6	3.8	1850
1920	1.0	0.8	-3.8	-0.4	-2.6	1	-1	1.7	6.2	2.4	1920
1940	1.1	1.0	-3.1	1.6	-2.0	1	-1	1.2			
2000	1.2	1.0	-3.6	1.6	-1.6	1	-1	1.7	5.8	2.7	1950
2020	1.0	0.9	-3.3	1.0	-1.6	1	-2	1.2	3.	0.3	2020
2040	-0.8	-1.0	-6.0	-1.1	-4.2	-1	-4	-0.8			
2100	-1.0	-1.2	-6.2	-1.6	-4.2	-1	-4	-1.3	2.5	-0.9	2050
2120	-2.0	-2.2	-7.4	-1.0	-4.3	-1	-4	-1.3	0.4	-3.5	2120
2140	-1.0	-1.0	-4.7	-1.7	-4.4	-2	-5	-2.1			
2200	-1.0	-1.0	-4.7	-1.6	-4.4	-2	-5	-2.6	0.9	-2.7	2150
2220	1.4	1.0	-4.8	0.0	-2.3	0	-3	-0.3	1.6	-1.8	2220
2240	2.6	2.4	-2.1	0.9	-2.0	1	-2	0.3			
2300	3.1	3.0	-0.8	2.2	-0.9	2	-1	1.7	3.6	-0.2	2250
2320	3.5	3.0	-3.0	2.2	-0.9	2	-1	2.3	3.7	-0.4	2320
2340	4.2	4.0	-0.3	3.5	-0.8	4	0	3.0			
0000	4.8	4.2	-2.1	3.0	0.0	4	1	3.3	4.2	0.5	2350
0020	4.5	4.3	0.1	3.	-0.1	3	0	3.3	3.3	-0.6	0020
0040	4.6	4.4	0.2	3.4	-0.1	3	0	3.3			
0100	5.0	4.8	0.7	3.7	0.6	4	1	3.5	4.1	0.0	0050
0120	5.9	5.5	0.5	4.7	1.4	4	1	4.2	5.0	1.0	0120
0140	6.5	6.1	1.3	5.7	2.1	5	2	5.0			

TIME	SLING Ta	SLING Tw	SLING Td	INSTANT ASOS Ta	INSTANT ASOS Td	1-MINUTE SCREEN ASOS Ta	1-MINUTE SCREEN ASOS Td	MMTS Ta	HO-83 Ta	HO-83 Td	TIME OF HO-83
0200	6.9	6.5	1.7	5.7	2.4	5	2	5.3	6.0	1.9	0150
0220	7.4	7.0	2.3	6.2	2.7	6	3	5.9	7.2	3.0	0220
0240	8.0	7.6	3.0	6.5	2.9	6	3	6.4			
0300	8.8	8.0	1.6	7.1	3.7	7	4	6.9	8.0	4.1	0250
0320	9.0	8.5	3.6	8.5	4.6	8	4	7.5	8.8	4.7	0320
0340	9.5	9.0	4.3	8.1	4.9	8	5	8.0			
0400	10.0	9.4	4.4	8.6	5.6	9	5	8.4	10.0	5.8	0350
0420	10.1	9.6	5.0	9.1	5.4	9	5	8.9	10.3	6.0	0420
0440	10.2	10.0	6.6	9.7	6.2	9	6	9.3			
0500	10.9	10.5	6.4	9.7	6.2	10	6	9.6	11.1	7.0	0450
0520	11.1	10.9	7.7	10.4	6.9	10	7	10.2	11.7	7.9	0520
0540	11.5	11.1	7.2	11.4	7.7	11	7	10.7			
0600	12.1	11.9	8.8	11.5	7.9	11	8	11.3	12.8	8.6	0550
0620	12.8	12.2	7.7	11.8	8.2	12	8	11.6	13.4	9.3	0620
0640	13.1	12.9	9.9	12.7	8.5	12	9	12.2			
0700	13.8	13.2	8.7	12.4	8.9	13	9	12.5	14.5	10.4	0650
0720	14.0	13.7	10.5	13.2	9.6	13	10	13.1	15.0	10.9	0720
0740	15.1	14.8	11.8	14.5	11.2	14	11	13.8			
0800	18.0	17.2	13.1	17.2	14.1	17	13	16.3	15.9	11.9	0750
0820	18.5	17.9	14.5	17.8	14.1	18	14	17.6	18.7	14.2	0820
0840	18.9	18.0	13.8	17.9	13.7	18	14	17.9			
0900	19.0	18.2	14.4	18.2	14.5	18	14	18.1	19.6	14.9	0850
0920	19.4	18.7	15.2	18.6	14.4	19	14	18.5	19.8	15.4	0920
0940	20.0	19.0	16.7	18.8	15.1	19	15	18.6			
1000	20.2	19.8	17.3	18.9	15.9	19	16	19.0	20.1	16.5	0950
1020	20.2	19.9	17.7	19.4	17.0	19	17	19.4	20.4	17.3	1020
1040	20.3	20.1	18.1	19.5	17.2	19	17	19.5			
1100	20.7	20.4	18.2	19.7	17.5	20	18	19.9	21.0	18.1	1050
1120	21.0	20.9	19.2	20.0	17.8	20	18	20.1	21.4	18.4	1120
1140	21.6	21.2	18.9	20.3	18.4	20	18	20.4			
1200	21.6	21.2	18.9	20.4	18.3	20	18	20.4	21.8	18.8	1150

LINCOLN, NEBRASKA

ASOS SURFACE OBSERVATIONS

FROM: 01/13/93 11:58 THRU 01/15/93 11:59

1/13...

LST
11:58 LNK SA 1756 A02A CLR BLO 120 10+ 286/10/01/3113/030/50005 10010 20003
12:58 LNK SA 1856 A02A CLR BLO 120 10+ 279/11/02/3110G18/028/PRESFR
13:58 LNK SA 1956 A02A CLR BLO 120 10+ 273/12/04/3207/026
14:58 LNK SA 2056 A02A CLR BLO 120 10+ 279/14/05/3009/028/ 55006
15:58 LNK SA 2156 A02A CLR BLO 120 10+ 289/14/05/3105/03
16:49 LNK SP 2249 A02A 16 SCT M21 BKN 10+ 293/11/04/2806/032/BKN V SCT
16:58 LNK RS 2256 A02A M18 BKN 10+ 296/11/04/2806/032
17:14 LNK SP 22314 A02A 18 SCT 10+ 299/11/03/2704/033 (FIBI)
17:22 LNK SP 2320 A02A 18 SCT 10+ 298/11/03/3003/033
17:28 LNK SP 2328 A02A M18 OVC 10+ 299/10/03/0000/033/ OVC LYR IS THN (FIBI)
17:36 LNK SP 2334 A02A M18 OVC 10+ 301/09/03/0000/034/ OVC LYR IS THN
17:58 LNK SA 2356 A02A M20 OVC 10+ 303/09/03/2605/034/ OVC LYRIS THN
18:58 LNK SA 0056 A02A M20 OVC 10+ 307/10/04/2903/036
19:59 LNK SA 0157 A02A M18 OVC 10+S- 313/09/03/2504/037/ SB42 PCPN 0000
20:58 LNK SA 0256 A02A M18 OVC 10+S- 315/10/04/2805/038/ PCPN 0000
21:58 LNK SA 0356 A02A M18 OVC 10+S- 315/10/05/3106/038/ PCPN 0000
22:58 LNK SA 0456 A02A M18 OVC 10+S- 313/10/04/3297/038/ PCPN 0000
23:58 LNK SA 0556 A02A M16 BKN 10+ 308/09/03/3306/036/ 90410 58003 6000/ 10014
20003 BKN V SCT SE26 PCPN 0000

1/14...

LST
00:06 LNK SP 0604 A02A 16 SCT 10+ 308/09/03/3306/036
00:45 LNK SP 0645 A02A M14 BKN 10+ 303/08/03/3405/035/ BKN V SCT (FIBI)
00:58 LNK RS 0656 A02A M14 BKN 10+ 300/08/03/3406/034
01:32 LNK SP 0732 A02A 14 SCT 10+ 302/08/03/3203/034 (FIBI)
01:40 LNK SP 0738 A02A 14 SCT 10+ 302/08/03/3404/035
01:58 LNK SA 0756 A02A CLR BLO 120 10+ 301/08/03/3203/034
02:58 LNK SA 0856 A02A CLR BLO 120 10+ 306/08/02/0000/036/55003
03:58 LNK SA 0956 CLR BLO 120 10+S- 303/08/02/2504/035/ SB55 PCPN 0000 (FIBI)

1/14..

LST
04:00 LNK SA COR 0956 A02A CLR BLO 120 10+ 303/08/02/2504/035/
04:58 LNK RS 1056 A02A CLR BLO 120 10+ 304/08/02/0000/035
05:58 LNK SA 1156 A02A CLR BLO 120 10+ 304/05/01/0000/035/ 90410 56005 6000/ 10014 20005
06:58 LNK SA 1256 A02A CLR BLO 120 10+ 305/-1/-4/0000/034
07:58 LNK SA 1356 A02A CLR BLO 120 10+ 304/01/-2/0000/034
08:58 LNK SA 1456 A02A 120 SCT 10+ 302/02/-2/0000/034/ 58002
09:58 LNK SA 1556 A02A M120 BKN 10+ 302/04/-1/0000/034
10:58 LNK SA 1656 A02A 120 SCT 10+ 300/10/01/0000/034
11:58 LNK SA 1756 A02A 120 SCT 10+ 288/11/03/0000/031/90410 58010 6000/10012 21002
12:58 LNK SA 1856 A02A M110 OVC 10+ 279/14/05/0000/028
13:58 LNK SA 1956 A02A E70 BKN 10+ 268/15/06/0000/025
14:58 LNK SA 2056 A02A 70 SCT 10+ 262/15/07/0000/024/57026
15:58 LNK SA 2156 A02A CLR BLO 120 10+ 261/15/08/2403/023
16:58 LNK SA 2256 A02A M55 OVC 10+ 259/15/08/0000/023
17:58 LNK SA 2356 A02A CLR BLO 120 10+ 258/09/05/0000/022/90409 58005 6000/ 10016 21002
18:58 LNK SA 0056 A02A CLR BLO 120 10+ 261/05/03/0000/021
19:58 LNK SA 0156 A02A CLR BLO 120 10+ 260/02/00/0000/021
20:46 LNK SP 0246 A02A CLR BLO 120 21/2VF 259/-1/-4/0000/020/ VSBY 3/4V5 (FIBI)
20:49 LNK SP 0247 A02A CLR BLO 120 13/4VF 259/-1/-4/0000/020/ VSBY 1/2V5
20:48 LNK SP 0248 A02A CLR BLO 120 11/2VF 259/-1/-4/0000/020/ VSBY 1/2V5 (FIBI)
20:58 LNK SA 0256 A02A CLR BLO 120 10+ 260/-2/-4/0000/020/ 57004
21:58 LNK SA 0356 A02A M45 BKN 10+ 258/-3/-5/0000/020/ BKN V SCT
22:15 LNK SP 0415 A02A M43 OVC 21/2F 257/00/-2/0000/020 (FIBI)
22:19 LNK SP 0417 A02A M43 OVC 13/4F 257/00/-2/0000/020
22:18 LNK SP 0418 A02A M43 OVC 11/2F 257/00/-2/0000/020 (FIBI)
22:58 LNK SA 0456 M43 OVC 10+ 254/02/-1/0000/020/ PATCHY GRND FOG
23:58 LNK SA 0556 A02A M43 OVC 10+ 250/03/00/0000/019/ 90409 58003 10016 21003

1/15..

LST
00:58 LNK SA 0656 A02A M41 OVC 10+ 244/04/01/0000/018
01:40 LNK SP 0740 A02A M29 BKN 34 OVC 10+ 241/05/02/0000/017 (FIBI)
01:48 LNK SP 0746 A02A M29 OVC 10+ 241/06/02/0000/017
01:58 LNK SA 0756 A02A M27 OVC 10+ 240/06/02/0000/017
02:58 LNK SA 0856 A02A M23 OVC 10+ 238/07/04/0000/016/ 56010
03:58 LNK SA 0956 A02A M19 BKN 28 OVC 10+ 230/08/05/0000/014/ BKN V SCT
04:58 LNK SA 1056 A02A M16 BKN 26 OVC 10+ 228/10/06/0000/013
05:58 LNK SA 1156 A02A M23 OVC 10+ 225/12/08/0000/012/ 56012 10016 21003
06:58 LNK SA 1256 A02A M21 OVC 7 225/13/09/0000/012

1/15..

LST

07:58 LNK SA 1356 A02A M17 OVC 7 218/16/12/1303/010

08:31 LNK SP 1431 A02A M13 OVC 10+ 216/18/14/1505/010 (FIBI)

08:39 LNK SP 1437 A02A M13 OVC 10+ 217/18/14/1606/010

08:58 LNK SA 1456 A02A M13 OVC 10+ 219/18/14/1707/010/ 58009

09:58 LNK SA 1556 A02A M11 OVC 5S-F 221/19/16/1506/010/ SB52 PCPN 0000

10:26 LNK SP 1626 A02A M9 OVC 4S-F 221/19/17/1705/011/ PCPN 0000 (FIBI)

10:29 LNK SP 1627 A02A M9 OVC 4S-F 222/19/17/1705/011/ PCPN 0000

10:58 LNK SA 1656 A02A M9 OVC 3S-F 226/20/18/1704/013/ PRESENT WX ZL- SFC VSBY 31/2 PCPN 0000

11:42 LNK SP 1742 A02A 6 SCT M9 OVC 3S-F 218/20/18/1609/011/ PRESENT WX ZL- OVC V BKN PCPN 0000 (FIBI)

11:46 LNK SP 1744 A02A M9 BKN 13 OVC 21/2S-F 218/20/18/1608/011/ PRESENT WX ZL- SFC VSBY 3 PCPN 0000

11:46 LNK SP 1746 A02A 6 SCT M13 OVC 21/2S-F 218/20/18/1607/011/ PRESENT WX ZL- SFC VSBY 3 PCPN 0000 (FIBI)

11:49 LNK SP 1747 A02A 6 SCT M13 OVC 21/2S-F 218/20/18/1607/011/ PRESENT WX ZL- SFC VSBY 3 PCPN 0000

11:58 LNK SA 1756 A02A 6 SCT M12 OVC 21/2S-F 215/20/18/1708/010/ PRESENT WX ZL- 90409 50002 6000/ 10020 21003 SFC VSBY 3 PCPN 0000

11:59 LNK SP 1759 A02A 8 SCT M12 OVC 21/2S-F 216/20/18/1608/010/ PRESENT WX ZL SFC VSBY 3 PCPN 0000 (FIBI)

END OF TEST

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