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U.S. DEPARTMENT OF COMMERCE
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AN NODC EVALUATION OF PAIRED N3S AND NØE NOMAD BUOY SURFACE OBSERVATIONS

Project SEA SENSE

Prepared For

Naval Air Systems Command

By

S.J. Halminski, K.R. Avery and D. LaMar

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PREFACE

The following report for Project SEA SENSE is one of a continuing series being performed on data received from the Navy NOMAD (Navy Oceanographic Meteorological Automatic Device) buoys. Project SEA SENSE, at the National Oceanographic Data Center (NODC), is funded by the Meteorological Division of the Naval Air Systems Command (NASC).

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S.J. Halminski, K.R. Avery, D. LaMar

National Oceanographic Data Center
Environmental Data Service
National Oceanic and Atmospheric Administration
Rockville, Md. 20852

ABSTRACT

Three-hourly instantaneous, independent surface observations of air-and sea-surface temperatures, pressure, and wind direction and speed from the N3S and NØE NOMAD buoys are paired according to date-time group and evaluated. The distance of 28 n.mi. separating the buoys in the central Gulf of Mexico and the observing-time difference of about 20 minutes in January and 1 hour in July were considered to be operationally insignificant. The differences of the paired observations, put in frequency distribution form for January and July of 1968, showed dispersions of several types with small and large variances. The paired observations of surface pressure and wind speed showed platykurtic dispersions with excellent uniformity for the 2 months. Pressures were generally low for each buoy, and surface wind speeds from both buoys appeared reliable. In January, the paired differences in air temperatures were very slight. Problems with NØE in January caused large sea-surface temperature (SST) differences with N3S, while in July, no differences between N3S and NØE were available because no SST observations were reported by NØE. Wind direction differences in January were normally dispersed, with wind directions of N3S being more clockwise than those of NØE. Because unreliable wind directions were reported by N3S in July, the comparisons with NØE were extreme.

INTRODUCTION

During a portion of 1968, two NOMAD (Navy Oceanographic Meteorological Automatic Device) buoys, the N3S and NØE, were located in the central Gulf of Mexico about 28 nautical miles (n.mi.) apart. Each buoy reported observations at nearly the same times. NOMAD N3S was located at latitude 25.1°N. and longitude 89.9°W., while NOMAD NØE was located at latitude 24.7°N and longitude 89.6°W. (see fig. 1). Two months -- January and July of 1968 -- of 3-hourly instantaneous observations from each buoy were processed, paired according to date-time groups, and evaluated. In January, the reported 3-hourly observations between each buoy were 20 $\pm$ 2 minutes apart and in July, the observations were 1 hour $\pm$ 3 minuted apart. These time differences and the distance of 28 n.mi. between the buoys were considered operationally insignificant in the observation pairing and evaluation of the N3S and NØE.

DATA PROCESSING

Observations, transmitted by N3S and NØE, were monitored by the Federal Communications Commission (FCC) radio stations at Fort Lauderdale, Fla., and Kingsville, Tex. (see fig.1). The data from these observations were processed at the National Oceanographic Data Center (NODC). Before comparing the N3S-buoy and NØE-buoy observations, some modifications were made to the buoy reports. The surface air temperatures, sea-surface temperatures, and surface wind speeds, all of which were reported in tenths, were rounded to the nearest whole number in degrees Fahrenheit (°F) and knots (kt), respectively. For surface-gradient wind directions, reported in units of degrees, the values were rounded to the nearest tens of degrees. No changes were made to the buoy surface-pressure observations which were reported in tenths of a millibar (mb).

An IBM 360/40 computer was used in processing and computing the results shown in all tables except table 15. The computer was also programmed to match and pair each buoy observation by date-time and to compute the difference. These differences are used to obtain the frequency-distribution curves and time-series described in this report. The frequency-distribution curves of the differences should approach normal distributions (see fig. 2 for January as an example) with minimum variance and near zero central tendency in each case. This would be true if: (1) the distance between the buoys and the time difference of observations are zero; (2) observations from both buoys are accurate; and (3) the same sensing techniques are used on each buoy. In the first, we assume the distance and time to be negligible. In the second, accuracy is partially unknown except for N3S where some degree of operational reliability and accuracy have been determined (see Halminski, Avery, and LaMar 1971)[1]. In the third, the sensing techniques for observing the parameters are the same for each buoy, except for wind direction where a modified Kollsman aircraft compass indicator was used by N3S and a Kelvin-White Model 357 compass indicator was used by NØE. The N3S and NØE both reported instantaneous directions.

SURFACE AIR TEMPERATURE

The frequency distribution of air-temperature differences between N3S and NØE is shown in figure 2, with the January curve showing the desired dispersion pattern. Figure 2 was determined from the distribution of temperature differences in table 1. Table 1 shows that 82.3 percent of the January paired synoptic surface-air temperatures from N3S and NØE are within ± 1°F of each other and that only 3.4 percent of the differences are equal to or greater than ± 4°F. In figure 2, most of the air temperatures for N3S for January appear to be between 0° and 1°F higher than those for NØE. The overall January temperature average for each buoy shows a mean of 70.7° for N3S and a mean of 70.6° for NØE (see table 2). The difference between these means indicates that N3S averaged 0.1°F higher than NØE. Table 2 contains all air temperature observations reported by N3S and NØE, whether paired or not. In another comparison, based on January paired differences (table 3), the temperature difference observed by N3S is, on the average, 0.6°F higher than NØE.

The time-series chart (fig. 3) shows the buoy differences of air temperatures for January 1968. Note that in the first one-half of the month, the differences appear equally divided about the zero difference, whereas, in the latter one-half of the month, N3S is noticeably higher but only by about 1°F.

The accuracy of air temperatures for the N3S buoy had been determined by synoptic analyses (Halminski, Avery, and LaMar 1971)[1] to average 0.2°F high. Therefore, by direct comparison, the NØE buoy appears to be about 0.4°F low. In contrast, Marcus (1969)[2], page 35 of his report, reported that the air temperatures for the NØE buoy were about 1.1°F high; however, this was for October through December 1967.

The frequency distribution of the synoptic air-temperature differences for July made a significant departure from the curve for January. The distribution, shown as a dashed line in figure 2, shows considerable disagreement between the two buoys, with 41.2 percent of the observations within a ± 1°F range. This amount is one-half as much as occurred for January. For one-fourth of the time, the temperature differences were equal to or greater than ± 4°F. From the July distribution curve (fig. 2), the majority of air temperatures for NØE appear higher than those for N3S. Note in table 3 the mean July temperature difference indicates that NØE now averages 1.3°F higher than N3S. The overall monthly mean of 84.7°F in July for NØE (see table 2) is likewise 1.3°F high in comparison to the mean of 83.4°F for N3S. Halminski, Avery and LaMar (1971)[1] on page 22 of their report stated that the air temperatures of the N3S buoy are considered, by operational analyses, to be reliable and 0.5°F high for July. If we consider this to be accurate then, by deduction, the air temperatures of NØE are about 1.8°F high. This is much higher than the low value of 0.4°F for January shown in the previous paragraph and higher than the 1.1°F value that Marcus (1969)[2] reported for October through December 1967.

The paired differences for July between N3S and NØE have a standard deviation of 3.0°F, while the differences for January are 1.1°F (see table 3). An explanation for the larger July variance, as compared to January, might be attributed to: (1) a greater time differential in July observations of 1 hour versus 20 minutes in January; (2) the diurnal temperature changes for the area are greater in summer than in winter; or (3) a faulty system exists for measuring the air temperature or for transmitting the data.

In table 2, the July statistics for NØE appear reasonably good as far as the climatic data are concerned and compare favorably with the N3S data. However, in considering the July paired differences between N3S and NØE, as shown in figure 2 and the time series in figure 4, a number of air temperatures appear questionable. The time-series difference chart of figure 4 shows an unusual trend where the N3S reported much lower temperatures at the beginning of July, with occasional large fluctuating differences during the middle of the month and these differences gradually becoming higher toward the latter part of the month. In contrast with the time-series chart for January in figure 3, note the general uniformity of paired differences. A definite trend in differences is noticeable for the January and July time-series charts.

SEA-SURFACE TEMPERATURE

During the first 12 days of January 1968, the sea-surface temperature (SST) differences for the paired N3S and NØE buoys were large (see figs. 5 and 6). Seven days later, no SSTs were reported by the NØE buoy. In early September 1968, the NØE buoy was removed from its mooring site because of power failure. Of the 85 paired SSTs for January, N3S showed a tendency to have differences that average 4.5°F lower than those for NØE (see table 5). In table 4, 55 percent of the paired observations show that the SST for NØE are higher than those for N3S by 5°F or more. In every paired observation set, the NØE SSTs are greater than those for N3S. By looking at individual SSTs for NØE reports independently, one would assume that they appear reliable; however, by observing the paired observations in figures 5 and 6 and in table 6, the differences and means between N3S and NØE are questionable. By comparison, NØE appears unreliable because the SST reports from N3S for January and July were considered very reliable -- see Halminski, Avery and LaMar (1971)[1], pages 21 and 22. By deduction, NØE appears to average 4.3°F high. A mean-paired difference of 4.5°F is shown in table 5. In table 6, the difference between the mean values for N3S and NØE is 5.3°F. Marcus (1969)[2], on page 35 of his report, determined that the SST observations from NØE were 5°F high.

Figure 6 is interesting because the SST differences were uniformily distributed near the difference level of about -6°F for the first 10 days of January 1968. Following this period, the differences gradually became less, reaching a consistent -2°F. Thereafter, NØE ceased reporting SSTs. No explanation was found for this unusual behavior, however, one might suspect that the problem was with NØE because many transmission reports of NØE were not received.

SURFACE PRESSURE

Within certain pressure range intervals, the surface pressure reports from the two buoys for January and July show a close relation to each other (see fig. 7 and table 7). Compared to NØE, the N3S buoy reported a greater number of higher surface pressures for the 2 months. The distribution of differences is also shown in time series in figures 8 and 9 for January and

July. In the time series, some discrepancies are noted in the early period of each month, with surface pressure reports from each buoy disagreeing considerably. These discrepancies accounted for the skewness in figure 7 on the positive tail. The latter part of each month depicts a drastic change and shows excellent uniformity of surface pressure observations. The occasion for the similar and unusual trend occurring in each month -- that is, wide pressure differences during the early part of each month and close agreement during the latter two-thirds of each month -- was not investigated, but it was suspected that some mechanical device used in NØE coding might be at fault.

Halminski, Avery, and LaMar (1971)[1], on page 13 of their report, stated that synoptic analyses determined the buoy surface pressures of N3S were averaging 0.7 mb low. Table 8 shows the NØE averaged 0.9 mb (January) and 1.2 mb (July) lower than N3S. We can, therefore, with some degree of accuracy conclude that the pressure observations of NØE averaged 1.8 mb low. Marcus (1969)[2], on page 35 of his report, determined that the pressure observations from the NØE buoy were about 1 mb low.

Table 9 is a statistical summary of all surface pressures reported by N3S and NØE for January and July 1968. The N3S and NØE results for January and July appear good. In July, data comparisons are similar except for the standard deviation of NØE which is noticeably greater. In table 7, the pressure differences for the 2 months ranged between -0.5 mb and +1.6 mb about two-thirds of the time. An unexpected high percentage of differences, 8 and 16 percent-- greater than +3.9 mb -- occurred in January and July, respectively. These large differences can be seen in figures 8 and 9.

SURFACE WIND DIRECTION

Differences in wind direction within certain range intervals are shown in the distribution curves of figure 10 and table 10. The direction differences for N3S and NØE are normally distributed about a +20° to +40° central tendency, with the N3S reporting slightly higher degree-values (clockwise) than those of NØE. It was shown on page 21 of the Halminski, Avery and LaMar (1971)[1] report that the reported wind directions for N3S in January generally agreed with the geostrophic wind direction and could be considered acceptable for operational analyses. Based on a comparison of the paired differences and results obtained in that same report, it appeared that the NØE buoy reported a greater number of favorable surface-wind directions than N3S and that the wind directions of the NØE buoy characterized a more realistic surface-gradient wind direction.

The comparison for July is different and shows that the majority of paired comparisons are more frequent in a greater positive degree-direction (see fig. 10). This results from the wind directions of N3S reporting an even greater veering-direction in July than in January, indicating that more than one-fourth of the paired observations have a difference equal to or greater than +110 degrees, as can be seen in tables 10 and 11. The results in July show less favorable comparisons than those in January, which are attributed to the inaccurate observations by N3S that were described in Halminski, Avery, and LaMar (1971)[1] on page 19 of their report.

To verify the results, figure 11 shows wind roses for the N3S and NØE buoys and roses derived from the U.S. Navy Marine Climatic Atlas of the World (1955)[3]. For January, N3S shows a slightly more clockwise trend in direction than NØE. It is difficult to determine how accurate are the N3S and NØE observations by comparing these roses with those from the Marine Atlas wind rose for January. All one can say is that all the observations appear reliable. In the case of July, the N3S rose definitely looks about 90° more clockwise than those for the NØE and the Marine Atlas; therefore, the N3S observations are questionable. The NØE rose pattern is very similar to that of the Marine Atlas.

Figures 12 and 13 depict a time series of the surface wind-direction differences between N3S and NØE for January and July. Frequent large differences are shown between the two buoys reporting for the same synoptic time and also from one 3-hourly time to the next 3-hourly time. Investigating surface pressure charts for January and July 1968 seemed to indicate that large direction differences occurred regardless of the direction of isobars and the velocity of surface wind speed. Both time-series charts indicate that wind directions for N3S are more clockwise than those for NØE, particularly in July.

SURFACE WIND SPEED

The surface wind speed, like surface pressure, showed a nearly normal distribution of paired differences within certain range intervals, with excellent uniformity between the months of January and July (see fig.14 and table 12). The absolute-maximum wind speed reported in January by N3S was 23 kt, by NØE was 33 kt, and by ships within 2° of the buoys was 30 kt. These occurred on the same day and within a 6-hour period. In July, the maximum wind speed reported by N3S was 18 kt (reported a number of times), by NØE was 22 kt, and by ships within 2° of the buoys was 25 kt. A good correlation of all three platforms for July could not be determined because of no-reports from one or the other buoy or ship at the same time; however, all three compared favorably during periods when moderate winds occurred. The wind speeds for N3S are generally low compared to those for NØE; however, this difference only averaged within a range of 1 to 2 kt (see table 13). The distribution of the paired differences for January and July is remarkably similar. For almost one-third of the time in January and July, the wind speeds for N3S and NØE were within ± 1 kt of each other. For the same months, N3S and NØE were within ±4 kt of each other about 76 percent of the time. This is good correlation when one considers that the two wind-speed sensors reported instantaneous (with mechanical damping) and not average wind speeds. Based on the condition that the wind speeds for N3S were found reliable, Halminski, Avery, and LaMar (1971), on page 18 of their report, the wind speeds for NØE can likewise be considered reliable.

Table 13 shows the mean 5-percent maximum and minimum differences between the two buoys to be about 5 to 7 kt. The mean and standard deviations of the differences for the 2 months agree very well. Table 14 is a statistical summary of all wind speeds reported by N3S and NØE. The similarity of wind speeds reported by N3S and NØE are considered excellent; however, this does not mean that they agreed synoptically.

Figures 15 and 16 are time series of differences of paired wind-speed observations in knots for January and July 1968. The differences show considerable variability, but in most cases these were not too severe. The mean difference is approximately 1 to 2 kt (see table 13). The results do not look as impressive as the distribution curves in figure 14. The basic difference in the two displays, as revealed in figure 14, is that the differences are classified in 2-kt range intervals, whereas, in figures 15 and 16, the differences are for synoptic time and for whole units of knots. The large wind-speed differences occurred during weak-and strong-pressure gradients. Surface wind direction was not a factor for the large wind-speed differences.

SENSOR CORRECTION FACTORS

Table 15 shows approximate correction factors for each parameter on the buoys. These correction factors were determined subjectively from analyses (Halminski, Avery, and LaMar (1971)[1] and by applying the paired differences found in this report. The wind direction correction is based on a gradient direction that crosses the surface isobars at an angle of 19° toward lower pressure in a counterclockwise direction from the geostrophic (Halminski, Avery, and LaMar 1971)[1]. Unreliable or questionable parameters are noted and are based on extreme correction changes and distribution of paired differences. The negative (-) sign indicates a subtraction, and a positive (+) sign indicates an addition to the actual observation reported by the buoys.

The correction factors are approximate and, in some cases, do not change appreciably from January to July. In other cases, the changes are considerable. An accurate correction factor would be difficult to determine because the buoy instrumentation sensor-calibration positions for N3S and NØE are not uniformly distributed (see Avery, Halminski, and LaMar 1971)[4]. Another factor that makes it difficult to determine an accurate correction factor involves the reporting of instantaneous observations, especially those for surface wind direction and wind speed. The differences shown in the wind direction and wind speed (figs. 12, 13, 15, and 16) indicate that, on a number of occasions, the observations of one buoy disagrees considerably from those of the other and that a uniform disagreement may or may not occur. Correction factors would be more applicable to observations of average wind direction and wind speed than to instantaneous observations.

The application of a correction factor to surface temperatures and surface pressures can be used with good results because the short-term variability in these parameters is not large. However, one must continually monitor the buoy observations by using analyzed charts and by noting any significant real-time differences. The use of monthly climatic charts to compare data will not always be valid. An example that shows what can occur in observations can be seen in the time-series charts of figures 8 and 9. In this case, a correction factor applied to each buoy for each month must be used with caution because in each month, a period exists in which the buoys disagree considerably and then suddenly the agreement is good and consistent. Likewise, in figures 4 and 6, a definite trend in differences is noted. This may require frequent changes in the value of the correction factor.

SUMMARY

The surface air-temperature comparisons between N3S and NØE are excellent for January, with air-temperature reports from N3S averaging 0.6°F higher than those from NØE. However, during the first 20 days of July, the air-temperature differences showed large variabilities, with N3S now averaging 1.3°F lower for the month than NØE. During the latter part of July, the observed temperatures for N3S were again higher than those for NØE, with the variability of differences decreasing. The distribution of the differences for July showed a greater variance than in January, indicating that the temperatures reported by NØE and N3S were significantly different from each other. These large differences seemed to be attributed to the air-temperature observations for the NØE buoy because temperature reports of NØE were generally higher than those of surrounding ships and because technical problems appeared to be occurring on the NØE buoy.

A comparison of the January sea-surface temperature observations of the N3S and NØE buoys showed that reported temperatures for NØE averaged 4.5°F higher than those for N3S with a maximum of 8°F. The comparison also indicated that slightly more than one-half of the paired differences are equal to or greater than 5°F. This difference is highly improbable because of the relatively uniform water mass in the area. Ships in the vicinity generally reported sea-surface temperatures (SSTs) that were 3° to 5°F colder than those of NØE. The SST observations and other parameters of NØE were not transmitted regularly before mid-January 1968, indicating that some problems existed within the NØE buoy. After January 19, 1968, the SST channel did not report at all; and, in August 1968, the buoy went silent because of discharged batteries. Consequently, SSTs of NØE are considered unreliable for January.

In January and July, the surface pressure observations from the N3S and NØE buoys reported remarkably consistent paired differences during the latter two-thirds of each month, but surface-pressure measuring systems of both buoys frequently reported values on the low side. For the 2 months considered in this report, the observed surface pressures for N3S averaged 0.7-mb low while the observed surface pressures for NØE averaged 1.8-mb low. The accuracy of surface pressure observations could have been improved by making an on-site recalibration or by applying a correction factor of +0.7 mb to N3S and of +1.8 mb to NØE.

The surface wind-direction reports for the N3S and NØE buoys in January are acceptable. During January, wind direction differences of ± 40° between the two buoys occurred 59.6 percent of the time. In July, the comparisons are poor because of the unreliable wind directions reported by N3S. During that month, only 27.3 percent of the time did the two buoys report directions within ± 40° of each other. The NØE appeared to be more accurate than the N3S for the 2 months investigated.

For the surface-gradient wind speeds, the NØE averaged 0.6 to 1.5 kt higher than those of the N3S. The reported wind speeds for both the N3S and NØE buoys compared very well and are considered reliable. The frequency of 25 percent for differences of ± 5 kt or greater and of 5 percent for differences of ± 8 kt or greater might be attributed to the instantaneous sensing method and to the time differential of observations. If an averaging method was used, we might expect an even lower percentage of the large differences to occur.

Accordingly, the air- and sea-surface temperature observations of N3S were concluded as acceptable observations. The NØE reported acceptable air temperatures only for January. Because of the technical problems on NØE, the air temperatures for July and sea-surface temperatures for January are considered unreliable. The surface-pressure measuring systems on both buoys reported values that are generally low and appeared to be the result of inaccurate calibrations after the buoys were launched. The wind direction sensors of the N3S and NØE buoys reported acceptable wind directions for January. In July, the wind direction reports of NØE are acceptable, but the N3S did not perform statisfactorily, resulting in poor wind-direction comparisons for July. The existing wind-speed sensor system, reporting instantaneous wind speeds on the NOMAD N3S and NØE buoys, compared reasonably well. An average wind-speed and wind-direction observation from the buoys would improve the usefulness of these parameters from an operational point of view.

CONCLUSIONS

Some of the existing systems on the NOMAD buoys that report the air-sea environment must be improved to provide more reliable observations. Quality-control procedures should be provided by developing an integral system to check the data during the time of buoy mooring and to do so periodically while the buoy is on station. Areas for developing quality-control procedures will depend on the source of errors. The greatest errors seem to be caused by a lack of proper sensor calibration, probably while mooring the buoys. The largest percentage of errors that occurred are considered systematic errors and can generally be rectified by applying a correction factor to the reported observations or by shifting the letter decode sheet to correspond to the nearest correct values. The correction factor is not always constant for the entire operational period of the buoy, but will change at various times for reasons not presently known. A periodic check should, therefore, be made of the buoy reports to verify the quality of observations and to determine the existence of systematic errors so that new sensor corrections can be applied.

Other errors, such as random errors, generally involve interference in some stage of the method during observing or reporting. The percent frequency of these random errors by improper decoding and interpretation of the monitored radio-code signals caused by poor radio receptions, etc., is from 0 to 5 percent per parameter per month for the N3S and NØE buoys during 1968. However, as much as 30 percent of the random errors per parameter per month had occurred for NØE (see Avery, Halminski, and LaMar 1971)[4]. The high percentages of random errors can generally be traced to failures of not correcting immediately any faulty mechanical devices and to problems with the electrical systems, program timer, code generator, or low power. These errors can be recognized by the buoy which reports erratic values that are obviously incorrect. Preventing or minimizing random errors in observations is an engineering problem and can be accomplished by: (1) improving the individual stages for transmission and processing of data; and (2) immediately recognizing that a problem exists and then correcting it as soon as possible.

It is absolutely essential that careful calibrations be made of the buoy sensor systems at the mooring site immediately after buoy mooring is completed. To accomplish this, a ship equipped with accurate measuring devices and staffed with a competent weather observer is required alongside the moored buoy. To shorten the on-site buoy-calibration period to a minimum, which, in most cases, is necessary because of the commitments previously scheduled by the mooring ship, it is recommended that the buoy observation cycle be triggered more frequently than the programmed 3-hourly periods. The transmission of buoy observations could be programmed for 5- or 10-minute intervals during a 1-hour period, after which the 3-hourly normal reports will be resumed. If calibration adjustments cannot be accomplished manually or automatically on the buoy while it is moored, then a correction factor should be immediately determined for each parameter. This correction factor can then be applied to the raw data at the monitoring or control station before dissemination, or the correction factor can be applied by the user for operational use. The calibration decode sheet may also be shifted to correspond to the nearest value of a known observation.

In a buoy network where each buoy is programmed to transmit observations at slightly different times, average observations are more useful than instantaneous observations.

Meteorological sensors ashore are periodically checked by technicians for reliability and accuracy. Consequently, this should also be done for sensor on the buoys, particularly in the case of unmanned automated experimental devices, until such time that their reliablility and accuracy are found acceptable for operational use.

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3. U.S. Navy, "Marine Climatic Atlas of the World, Vol. 1, North Atlantic Ocean," Chief of Naval Operations, NAVAER 50-1C-528, Dec. 1955, 275 charts.

4. Avery, K.R., Halminski, S.J., and LaMar, D., "Environmental Data From AN/SMT-1 NOMAD N3S/NØE, Gulf of Mexico, 1969--Project SEA SENSE," NODC Progress Report P-98, Sept. 1971, 180 pp.

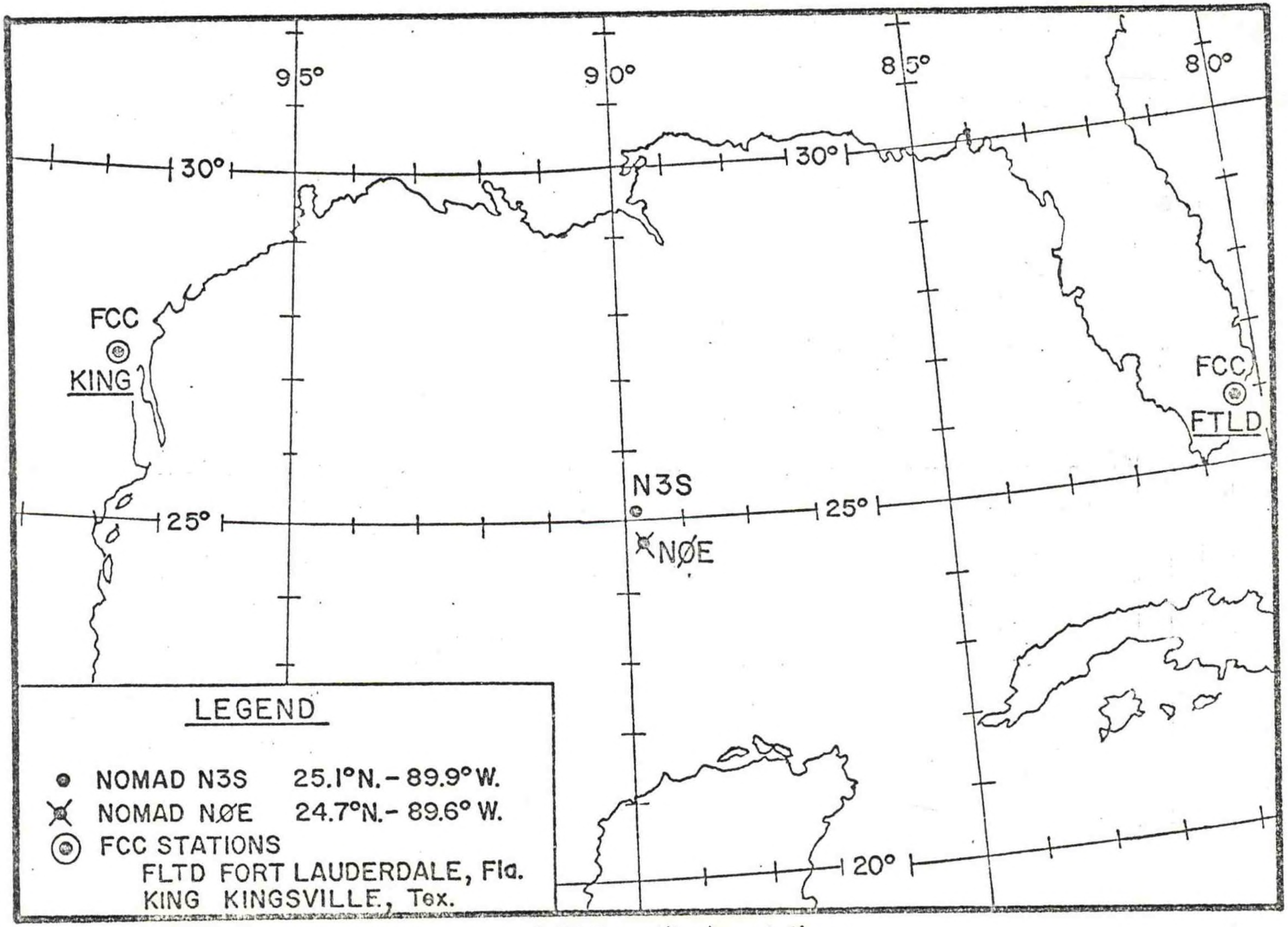

Figure 1.--Location of NOMAD buoys and FCC monitoring stations

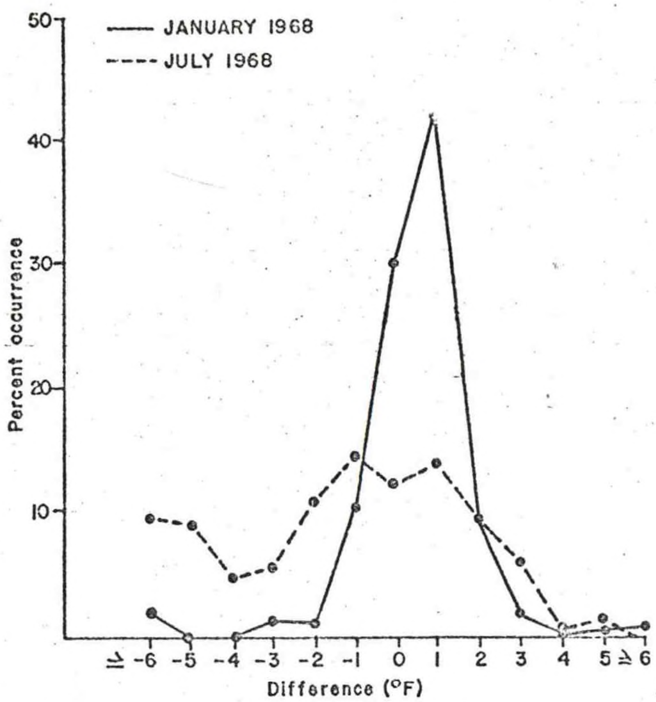

Figure 2.--Frequency of temperature differences (°F) between the paired surface air-temperature observations from N3S and NØE. (N3S - NØE = difference.)

Table 1.--Percent of differences between the paired surface air-temperature observations from N3S and NØE for January and July 1968*

Number of paired observations January 143 July 163	SURFACE AIR TEMPERATURE												
Difference (°F)	≥-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	≥-6
January	2.0	0.0	0.0	1.4	1.4	10.2	29.9	42.2	9.5	2.0	0.0	0.7	0.7
July	9.8	9.2	4.9	6.1	11.1	14.7	12.3	14.2	9.8	6.1	0.6	1.2	0.0

* N3S - NØE = difference.

Table 2.--Climatic data of the 3-hourly surface air-temperature observations from N3S and NØE for January and July 1968.

January 1968	Number of observations	Mean 5% maximum	Mean 5% minimum	Mean	Standard deviation
NOMAD N3S 25.1°N-89.9°W.					
Air temperature (°F)	234	77.1	62.7	70.7	3.8
NOMAD NØE 24.7°N.-89.6°W.					
Air temperature (°F)	155	76.7	62.0	70.6	3.9

July 1968	Number of observations	Mean 5% maximum	Mean 5% minimum	Mean	Standard deviation
NOMAD N3S 25.1°N.-89.9°W.					
Air temperature (°F)	233	87.0	79.2	83.4	1.9
NOMAD NØE 24.7°N.-89.6°W.					
Air temperature (°F)	171	90.3	78.6	84.7	3.0

Table 3.--Statistical differences between the paired surface air-temperature observations from N3S and NØE for January and July 1968*

	Number of observations	Mean 5% maximum	Mean 5% minimum	Mean	Standard deviation
January 1968					
Air temperature (°F)	143	2.9	-1.9	0.6	1.1
July 1968					
Air temperature (°F)	163	3.6	-7.8	-1.3	3.0

* N3S - NØE = difference.

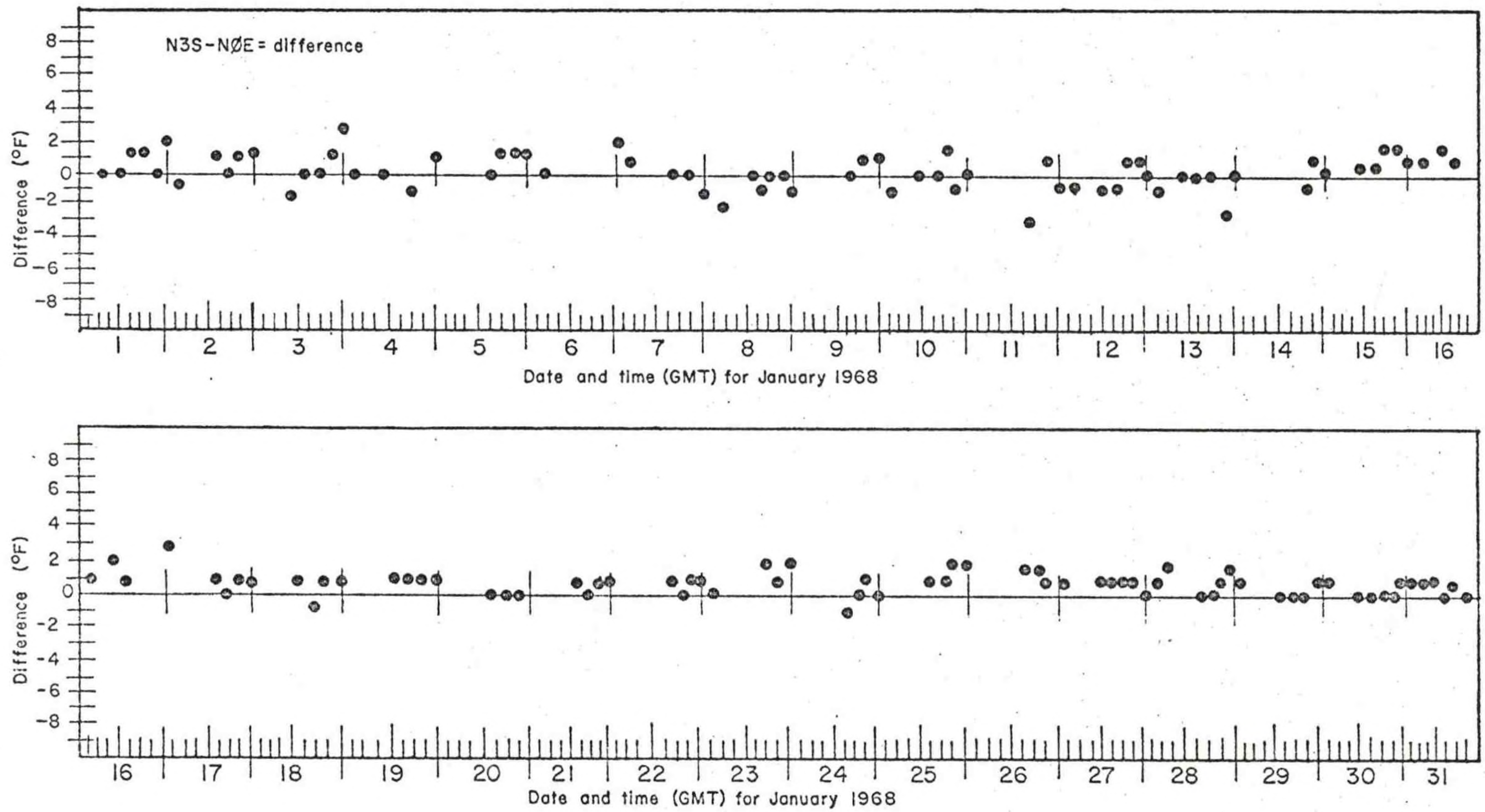

Figure 3.--Three-hourly time series of differences between the paired air-surface temperatures from N3S and NØE for January 1968. (Note general uniformity of differences as compaired to fig. 4.)

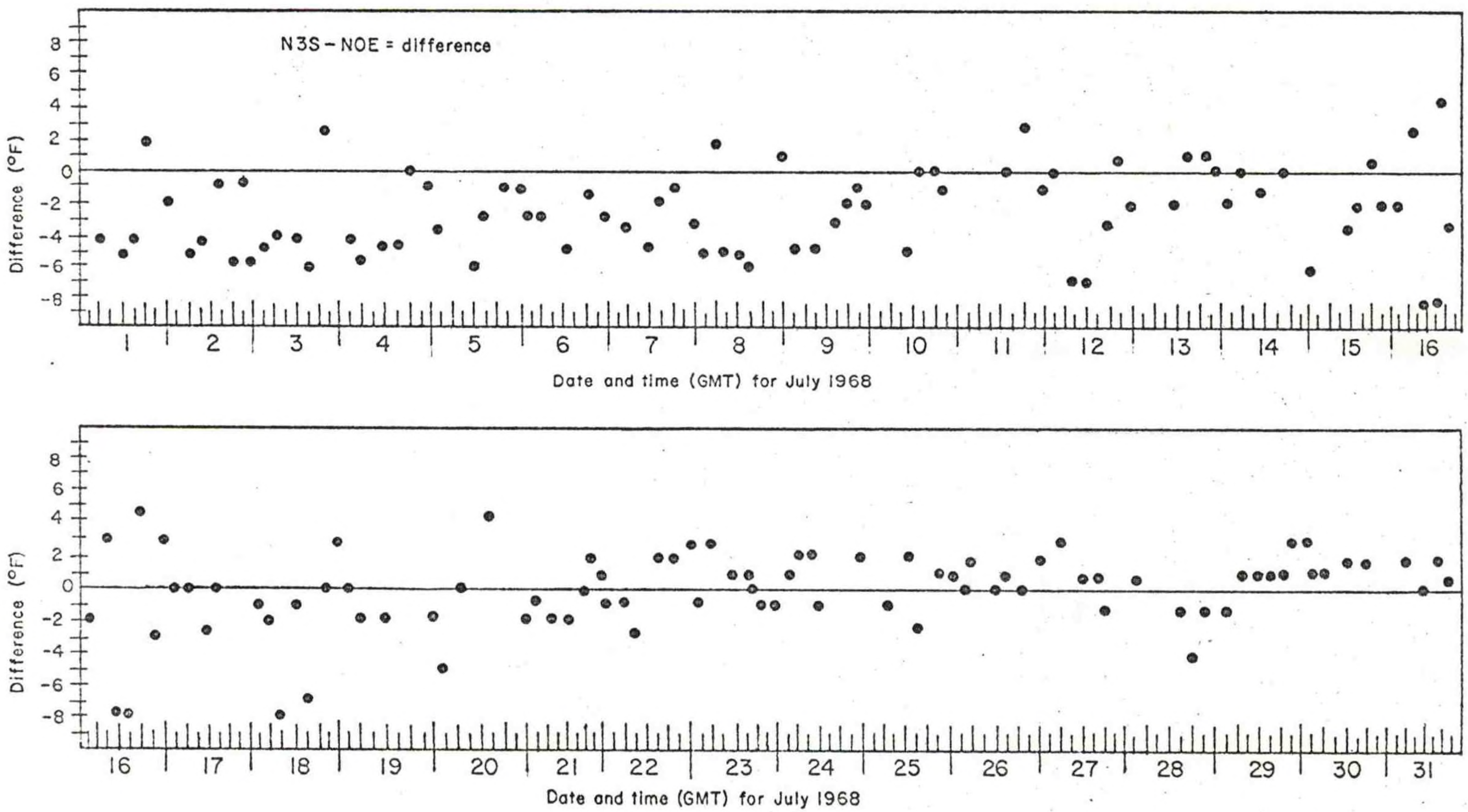

Figure 4.--Three-hourly time series of differences between the paired air-surface temperatures from N3S and NØE for July 1968. (Note trend of negative differences during first one-half of month, with variable differences during midperiod to positive during latter part of month.)

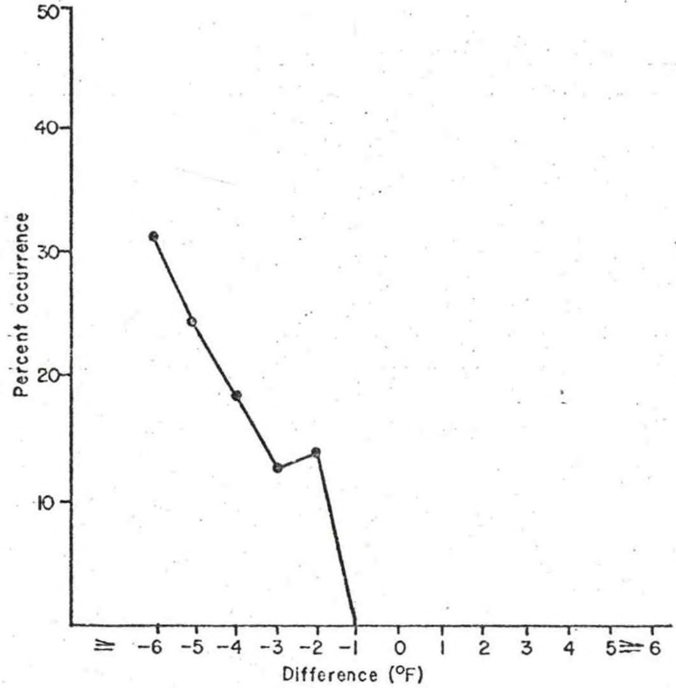

Figure 5.--Frequency of temperature difference (°F) between the paired sea-surface temperature observations from N3S and NØE for January 1968 only. (N3S - NØE = difference.)

Table 4.--Statistical differences between the paired sea-surface temperature observations from N3S and NØE for January 1968*

Number of paired differences January 85						SEA-SURFACE TEMPERATURE							
Difference (°F)	≥-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	≥ -6
January	31.0	24.2	18.4	12.6	13.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

*N3S - NØE = difference

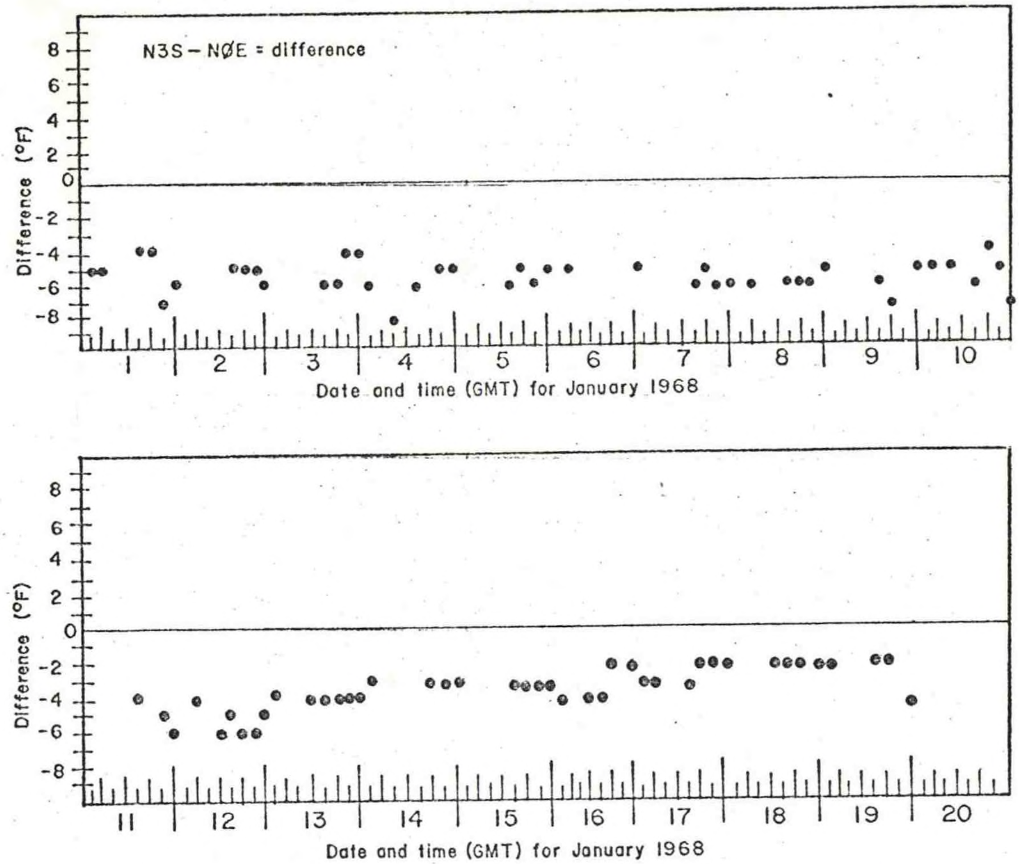

Figure 6.--Three-hourly time series of differences between the paired sea-surface temperatures from N3S and NØE for January 1968.

Table 5.--Percent of differences bwtween the paired sea-surface temperature observations from N3S and NØE for January 1968*

	Number of observa-tions	Mean 5% maximum	Mean 5% minimum	Mean	Standard deviation
January 1968					
Sea temperature (°F)	85	-2.0	-7.3	-4.5	1.5

*N3S - NØE = difference

Table 6.--Climatic data of the 3-hourly sea-surface temperature observations from N3S and NØE for January and July 1968*

January 1968	Number of observations	Mean 5% maximum	Mean 5% minimum	Mean	Standard deviation
NOMAD N3S 25.1°N.-89.9°W.					
Sea temperature (°F)	239	75.4	71.9	73.5	1.1
NOMAD NØE 24.7°N.-89.6°W.					
Sea temperature (°F)	92	81.3	75.9	78.8	1.8
July 1968	**Number of observations**	**Mean 5%**	**Mean 5% minimum**	**Mean**	**Standard deviation**
NOMAD N3S 25.1°N.-89.9°W.					
Sea temperature (°F)	240	85.6	82.8	84.2	0.7
NOMAD NØE 24.7°N.-89.6°W.					
Sea temperature (°F)	--	--	--	--	--

* NØE did not report SSTs in July.

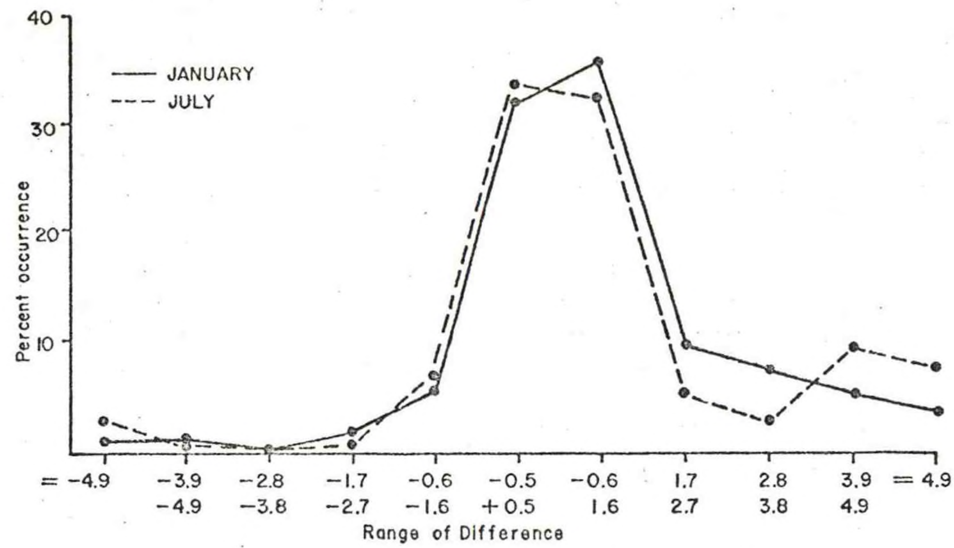

Figure 7.--Frequency of surface pressure differences (mb) between the paired surface-pressure observations from N3S and NØE for January and July 1968. (N3S - NØE = difference.)

Table 7.--Percent frequency of differences between the paired surface-pressure observations from N3S and NØE for January and July 1968*

Number of paired observations: January 154, July 155	SURFACE PRESSURE										
Difference (mb)	≥ -5.0	-3.9 -4.9	-2.8 -3.8	-1.7 -2.7	-0.6 -1.6	+0.5 -0.5	+0.6 +1.6	+1.7 +2.7	+2.8 +3.8	+3.9 +4.9	≥ +5.0
January	1.3	1.3	0.0	1.3	5.2	31.8	35.1	9.1	7.1	4.6	3.2
July	3.1	0.6	0.0	0.6	6.8	33.4	32.1	4.9	2.5	8.6	7.4

* N3S - NØE = difference.

Table 8.--Statistical differences between the paired surface-pressure observations from N3S and NØE for January and July 1968*

	Number of observations	Mean 5% maximum	Mean 5% minimum	Mean	Standard deviation
January 1968					
Pressure (mb)	154	+5.7	-3.9	+0.9	2.1
July 1968					
Pressure (mb)	155	+5.9	-1.4	+1.2	1.9

* N3S - NØE = difference.

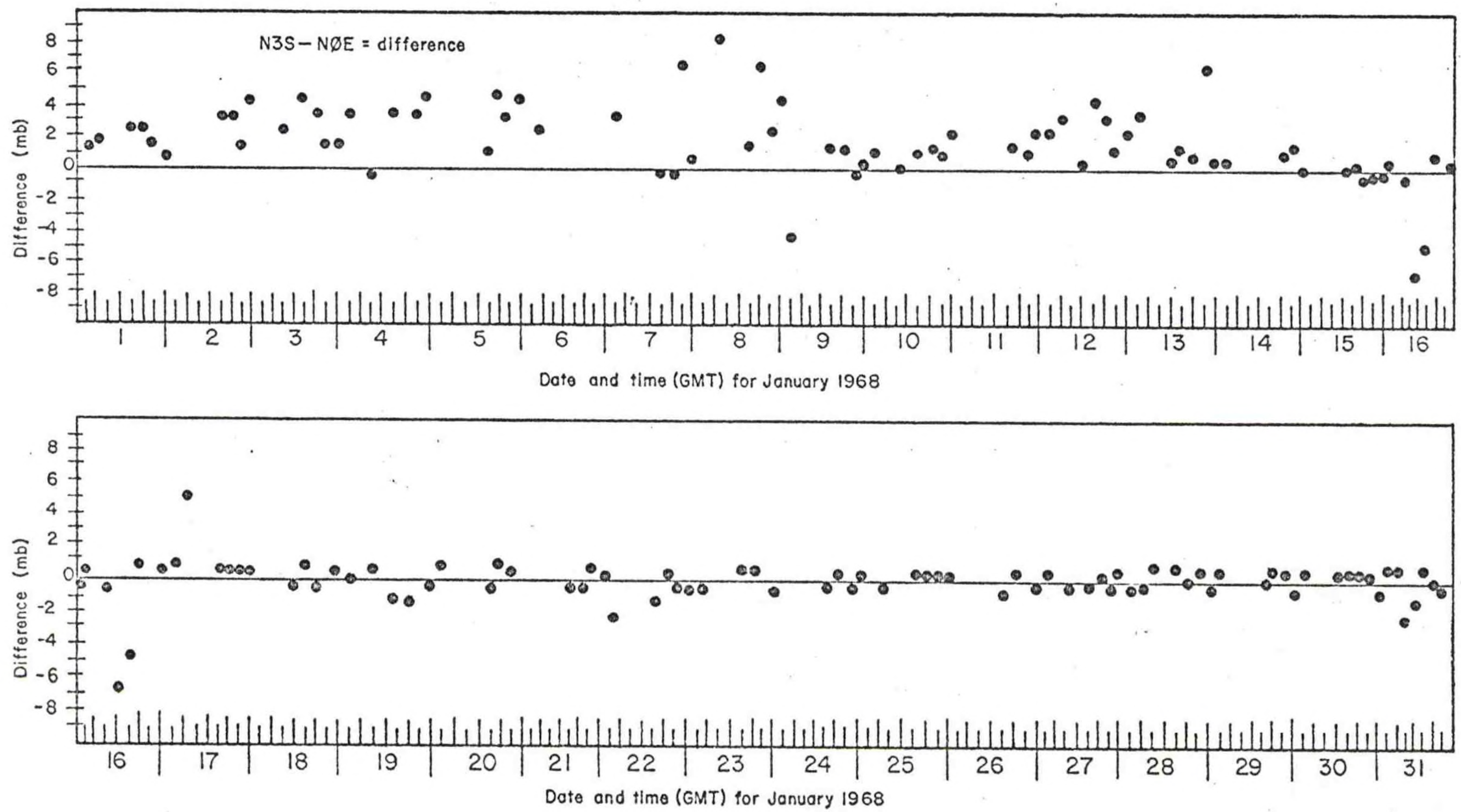

Figure 8.--Three-hourly time series of differences between the paired surface-pressure observations from N3S and NØE for January 1968

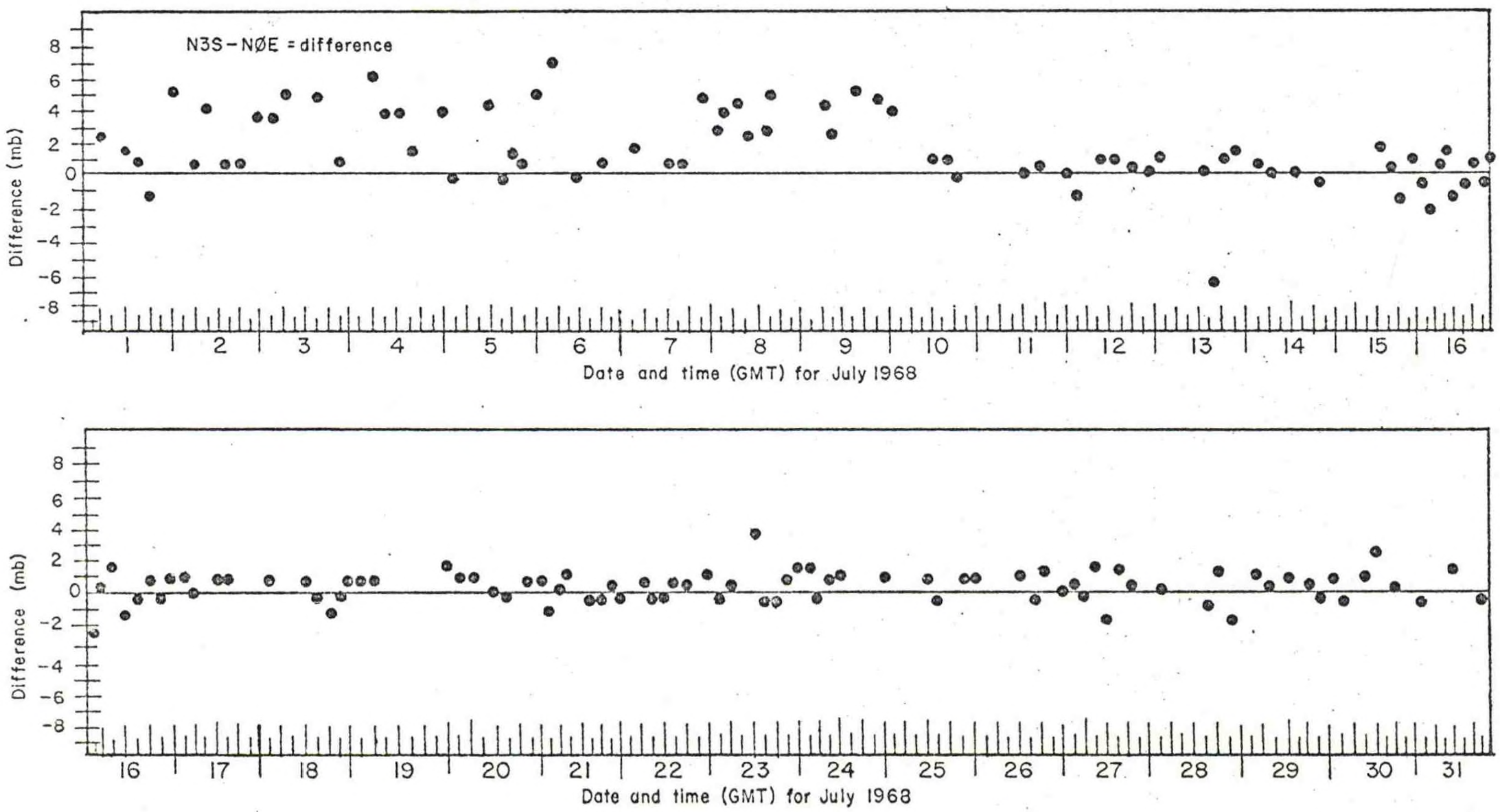

Figure 9.--Three-hourly time series of differences between the paired surface-pressure observations from N3S and NØE for July 1968

Table 9.--Climatic data of the 3-hourly surface-pressure observations from N3S and NØE for January and July 1968

January 1968	Number of observations	Mean 5% maximum	Mean 5% minimum	Mean	Standard deviation
NOMAD N3S 25.1°N.-89.9°W.					
Pressure (mb)	241	1025.0	1014.7	1020.4	2.6
NOMAD NØE 24.7°N.-89.6°W.					
Pressure (mb)	159	1024.8	1015.2	1019.7	2.8

July 1968	Number of observations	Mean 5% maximum	Mean 5% minimum	Mean	Standard deviation
NOMAD N3S 25.1°N.-89.9°W.					
Pressure (mb)	236	1021.0	1013.7	1017.8	1.7
NOMAD NØE 24.7°N.-89.6°W.					
Pressure (mb)	172	1021.7	1010.2	1016.8	3.2

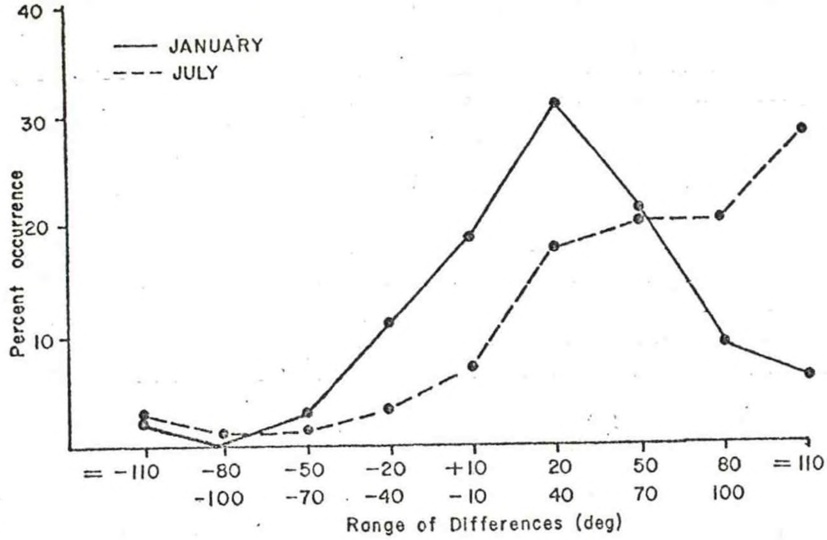

Figure 10.--Frequency of surface wind-direction differences (deg) between the paired surface wind-direction observations from N3S and NØE for January and July 1968. (N3S - NØE = difference.)

Table 10.--Percent frequency of differences between the paired surface wind-direction observations from N3S and NØE for January and July 1968*

Number of paired observations January 139 July 162	SURFACE WIND DIRECTION								
Difference (deg.)	-110	-80 -100	-50 -70	-20 -40	+10 -10	+20 +40	+50 +70	+30 +100	+110
January	2.8	0.0	2.8	10.6	18.5	30.5	20.6	8.5	5.7
July	3.1	1.2	1.2	3.1	6.8	17.4	19.7	19.7	27.8

* N3S - NØE = difference.

Table 11.--Statistical differences between the paired surface wind-direction observations from N3S and NØE for January and July 1968*

	Number of observa-tions	Mean 5% maximum	Mean 5% minimum	Mean	Standard deviation
January 1968					
Wind direction (deg.)	139	115.7	-72.9	29.0	44.2
July 1968					
Wind direction (deg.)	162	162.5	-110.0	65.4	61.9

* N3S - NØE = difference

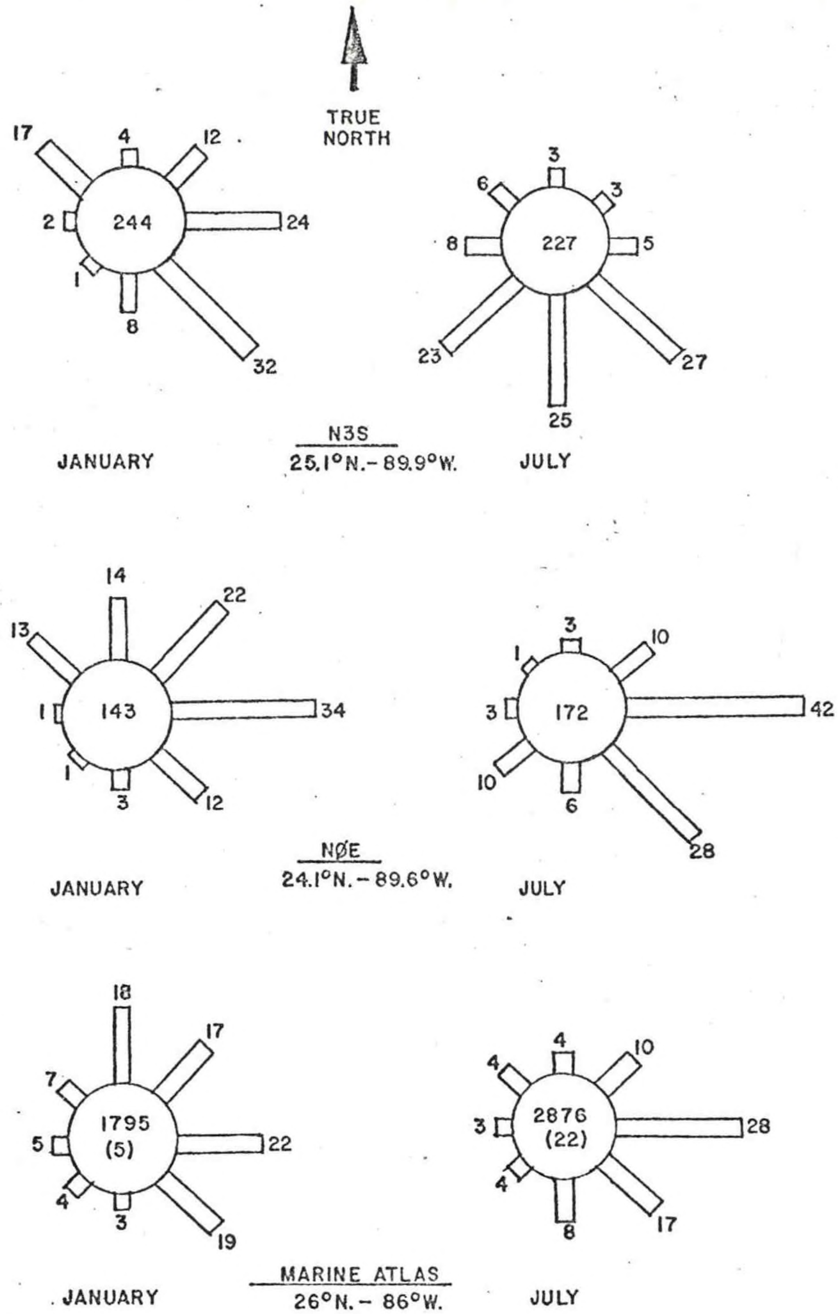

Figure 11.--Surface wind-direction frequencies from the N3S and NØE buoys and from the _U.S. Navy Marine Climatic Atlas of the World_, Vol. 1, (1955). (Number in circle represents total number of observations. Number within parenthesis indicates percent of no directions.)

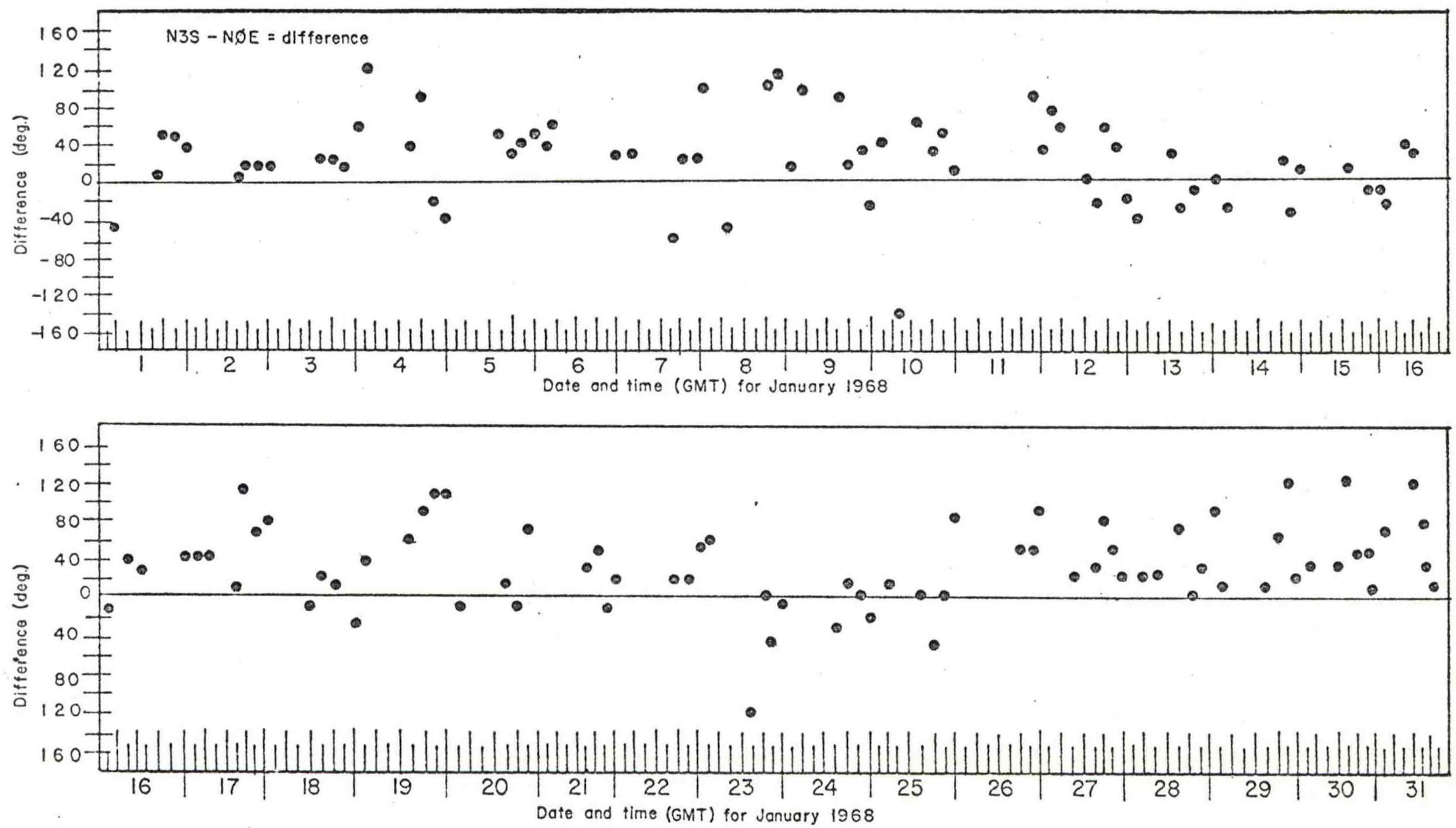

Figure 12.--Three-hourly time series of differences between the paired surface wind-direction observations from N3S and NØE for January 1968

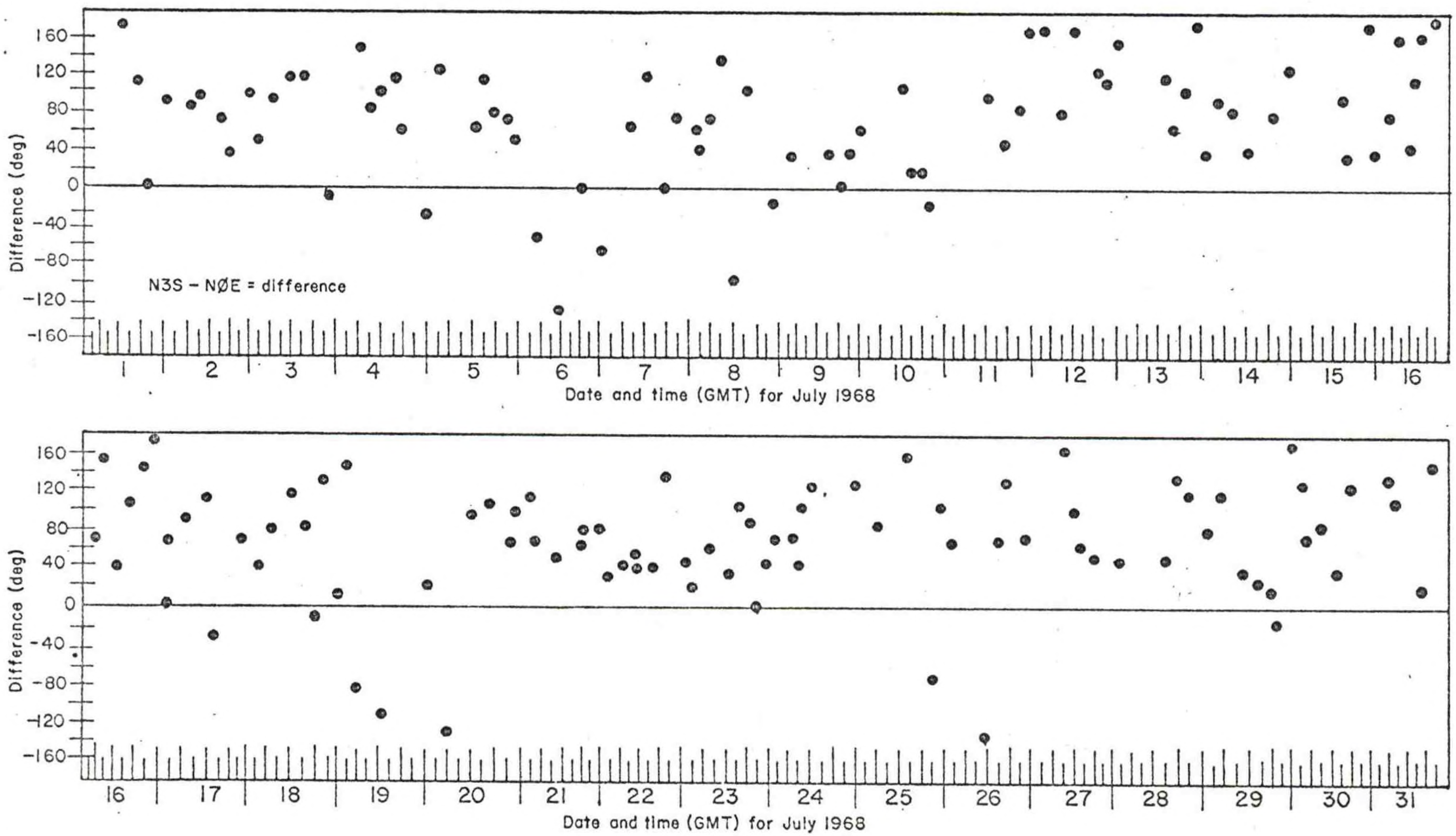

Figure 13.--Three-hourly time series of differences between the paired surface wind-direction observations from N3S and NØE for July 1968

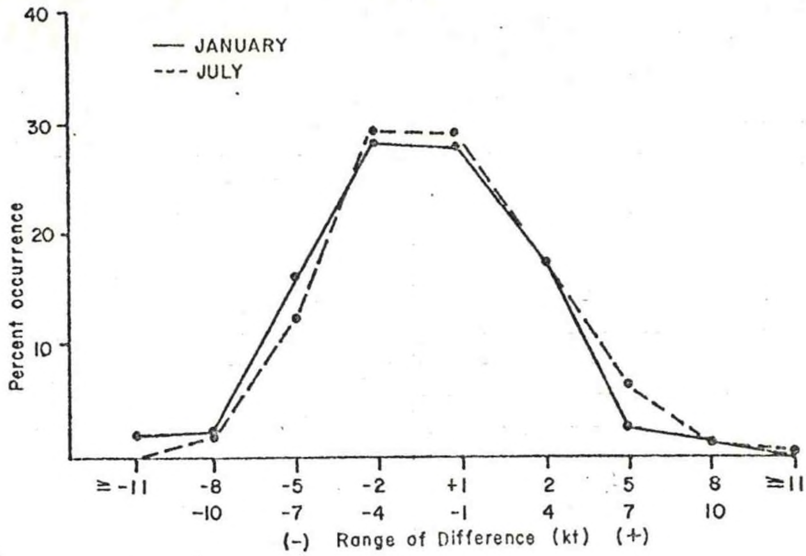

Figure 14.--Frequency of surface wind-speed differences (kt) between the paired surface wind-speed observations from N3S and NØE for January and July 1968. (N3S - NØE = difference.)

Table 12.--Percent frequency of differences between the paired surface wind-speed observations from N3S and NØE for January and July 1968*

Number of paired observations January 140 July 162	SURFACE WIND SPEED								
Difference (kt)	≥ -11	-8 -10	-5 -7	-2 -4	+1 -1	+2 +4	+5 +7	+8 +10	≥ +11
January	2.1	2.1	16.5	28.9	28.3	17.9	2.8	1.4	0.0
July	0.0	1.9	12.4	29.6	29.6	17.9	6.8	1.2	0.6

* N3S - NØE = difference.

Table 13.--Statistical differences between the paired surface wind-speed observations from N3S and NØE for January and July 1968*

	Number of observa-tions	Mean 5% maximum	Mean 5% minimum	Mean	Standard deviation
January 1968					
Wind speed (kt)	140	+4.7	-7.4	-1.5	3.2
July 1968					
Wind speed (kt)	162	+7.5	-7.1	-0.6	3.5

* N3S - NØE = difference.

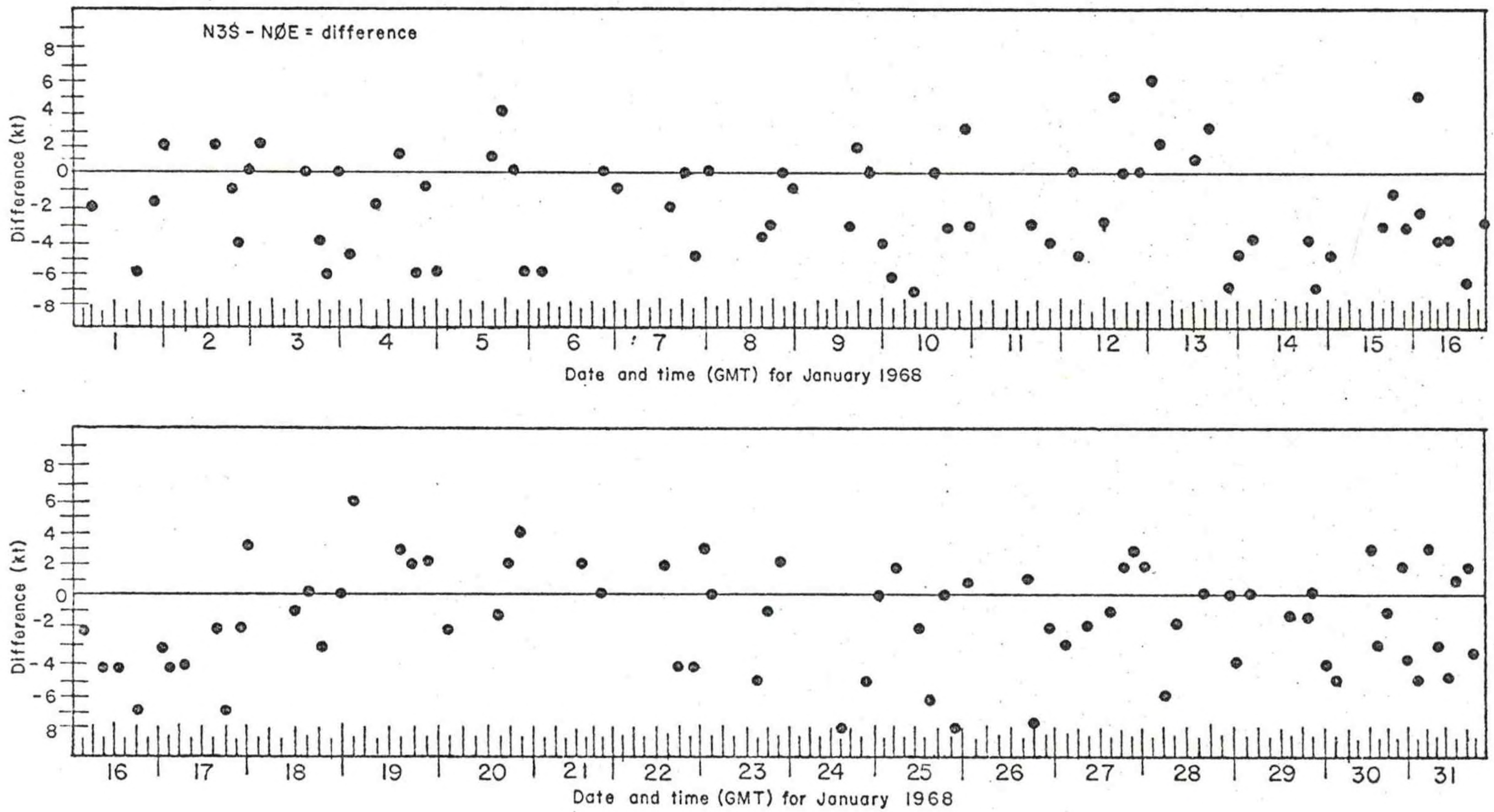

Figure 15.--Three-hourly time series of differences between the paired surface wind-speed observations from N3S and NØE for January 1968

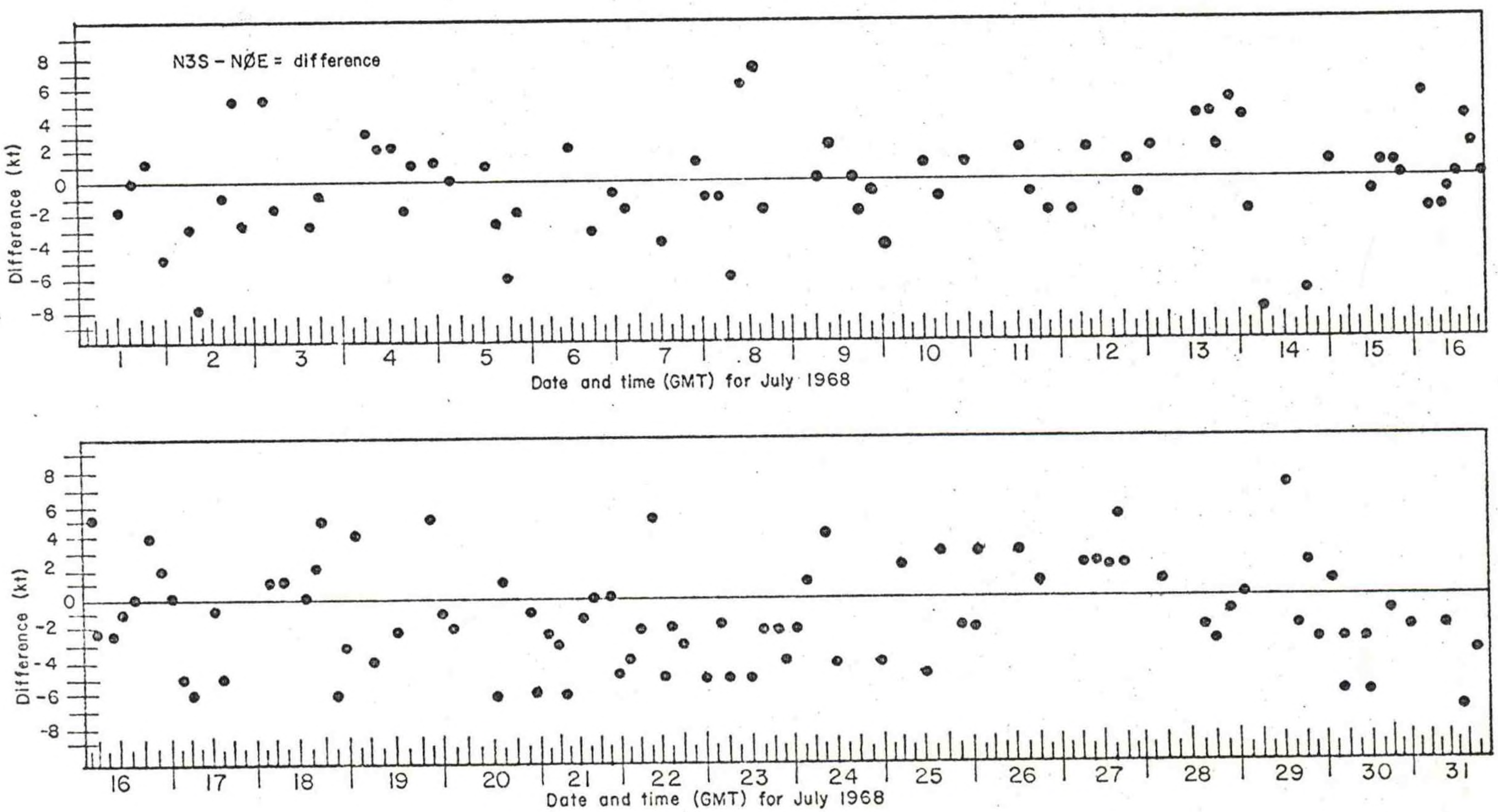

Figure 16.--Three-hourly time series of differences between the paired surface wind-speed observations from N3S and NØE for July 1968

Table 14.--Climatic data of the 3-hourly surface wind-speed observations from N3S and NØE for January and July 1968

January 1968	Number of observations	Mean 5% maximum	Mean 5% minimum	Mean	Standard deviation
NOMAD N3S 25.1°N.-89.9°W.					
Wind speed (kt)	245	22.0	2.5	13.2	5.0
NOMAD NØE 24.7°N.-89.6W.					
Wind speed (kt)	146	24.6	5.9	14.0	4.4
July 1968	**Number of observations**	**Mean 5% maximum**	**Mean 5% minimum**	**Mean**	**Standard deviation**
NOMAD N3S 25.1°N.-89.9°W.					
Wind speed (kt)	242	18.0	1.3	10.1	4.1
NOMAD NØE 24.7°N.-89.6°W.					
Wind speed (kt)	166	16.6	2.0	10.1	3.5

Table 15.--Aproximate correction factors for N3S and NØE for January and July 1968

	January 1968		July 1968	
	N3S	NØE	N3S	NØE
Air temperature (°F)	-0.2	+0.4	-0.5	unreliable -1.8
Sea temperature (°F)	+0.3	unreliable -4.2	0.0	no reports
Pressure (mb)	+0.7	+1.6	+0.7	+1.9
Wind direction (deg)	-13.8	+15.2	unreliable -57.1	+8.3
Wind speed (kt)	-0.1	-1.6	-1.0	-1.6