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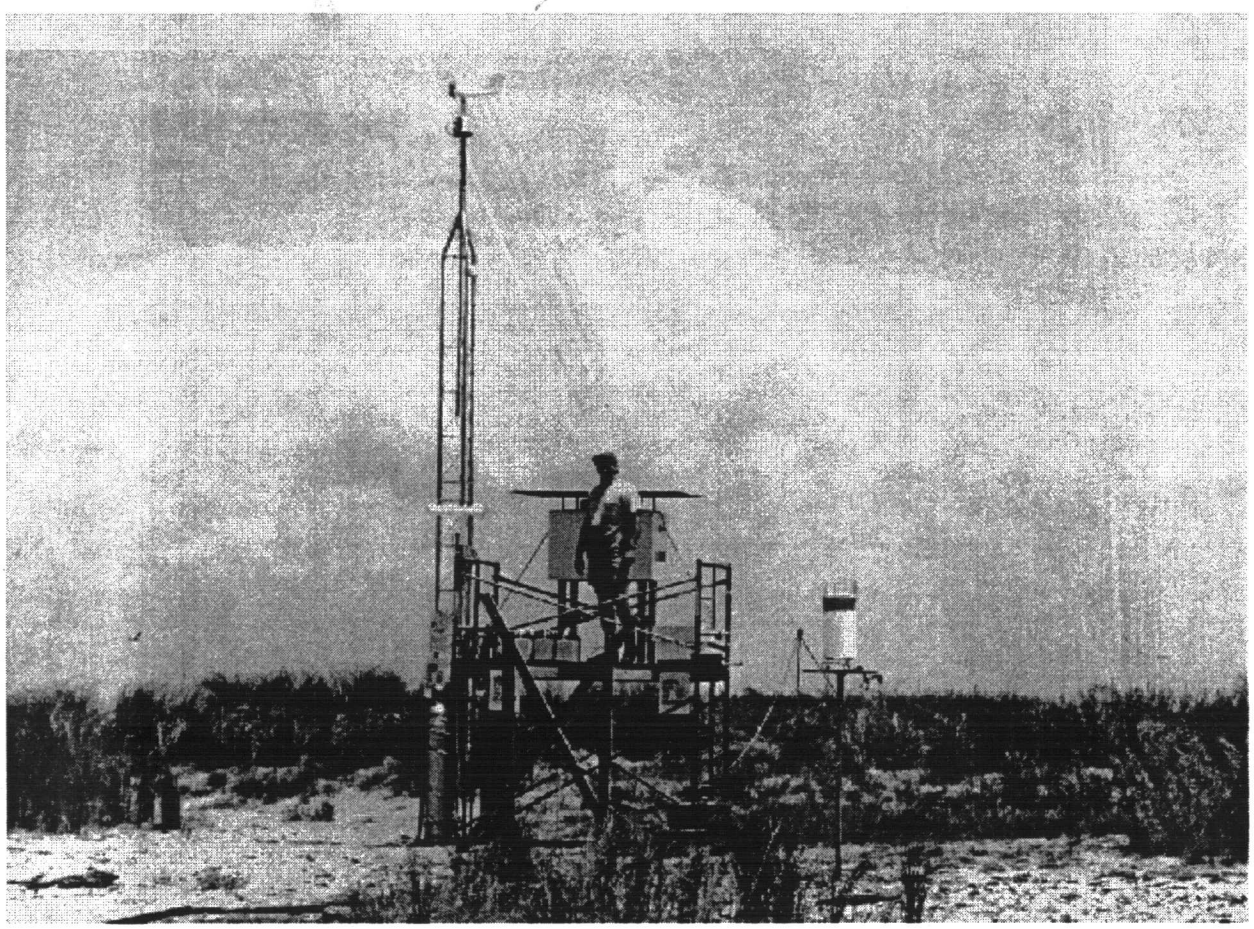
MMS 96-0062

Coastal Marine Institute

Analysis of Ambient Pollutant Concentrations and Meteorological Conditions Affecting EPA Class I and II Areas in Southeastern Louisiana

Volume I: Technical Report



MMS U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region

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Volume I: Technical Report

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FRONT COVER

Coastal Studies Institute technician Bill Gibson inspecting the Gosier Island, Louisiana, SO_2 and meteorological monitoring station, August, 1994.

ABSTRACT

Seasonal weather patterns over the northeast Gulf of Mexico can produce prolonged periods of onshore flow. Since areas of the coastlines and barrier islands of Louisiana, Mississippi, and Alabama have been designated as Class I and II by the EPA, there is concern that pollutants from Outer Continental Shelf (OCS) activities, such as petroleum drilling and production, may be acting to degrade these pristine environments. Three air quality and meteorological monitoring stations were deployed during the period of July through mid-September 1994 to measure ambient levels of SO_2 and NO_x as well as meteorological conditions. Two stations were in the Class I Breton National Wildlife Area while the third was in the Class II Delta National Wildlife Refuge of southeastern Louisiana. It was found that the majority of all measurements of SO_2 and NO_x acquired during the period were less than 5 - 10 ppb. Concentrations in the Breton Refuge were generally higher than those measured in the Delta Refuge, with highest concentrations being from the north and northeast. In addition, distinct short-lived episodes of higher than average (for the data record) NO_x concentrations were evident in the Breton data set. Radiosondes released throughout the study period reveal the average mixing height to be 600 - 700 m, well below the climatic average believed to prevail over our area during the summer. A method of estimating the offshore mixing height from surface temperature values is presented. Long-term monitoring is recommended to gain a better understanding of offshore pollutant transport, to delineate between OCS and onshore pollutant contributions, and to compare with the PSD increments for our area.

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ACKNOWLEDGMENTS

The successful execution of this field measurement study would not have been possible without the involvement of several agencies. We would like to thank Ms. Elizabeth Souheaver of the U.S. Fish and Wildlife Service and Mr. Mike Windham and Mr Emil Leblanc of the Louisiana Department of Wildlife and Fisheries for allowing us to establish our stations at Gosier Island and Pass-A-Loutre, respectively. During the height of fishing season, Mr. Dennis Good provided space on board his charter houseboat *Chandeleur Islander* for our third station, as well as excellent hospitality and a safe haven for our field crew during rough offshore weather. Mr. Joey Landreneau, Mr. Mark Kimball, and Mr. Carl Nagle of Environmental Science and Engineering, Inc. supplied the air quality equipment and assisted in the station setup and maintenance. The field technicians of the Coastal Studies Institute (CSI) Field Support Group are to be commended for their logistic support during the entire field program; special recognition to Mr. Bill Gibson for his considerable efforts in keeping all three stations operational. Brian Blanchard of CSI was involved in the field servicing and later helped reduce the data and produce this document. Finally, we appreciate the cooperation and assistance of Dr. Jim Kendall, Dr. Bill Hutzell, and Mr. Bill Steorts of the Minerals Management Service, New Orleans, regarding this project.

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

The U.S. Environmental Protection Agency (EPA) has designated sections of southern Mississippi and Alabama as Class I and II areas due to their status as National Seashores. Part of the Breton National Wildlife Area in the Chandeleur Islands of Louisiana provides protected haven for the abundant wildlife inhabiting these environments, and is also Class I. The Delta National Wildlife Refuge in the Mississippi River Delta is Class II. Having attained this ranking, these areas fall under the restrictions of the Prevention of Significant Deterioration (PSD) regulations of the Clean Air Act. Although the air quality is presumably quite clean at present, it is mandatory that pollutants transported into the areas do not lower the air quality beyond a specified significant increment.

Offshore oil and gas production to the east and south of the Mississippi River Delta is currently very active and will likely increase in the future. Atmospheric releases of sulphur and nitrogen compounds are a natural by-product of the production processes. Since the National Seashores and Wildlife Refuges are coastally located, they are in a unique position in which they can be affected by land-based as well as offshore (Outer Continental Shelf) pollutant sources.

To gain a better understanding of the current ambient levels of both SO_2 and NO_2, three air quality and meteorological monitoring stations were deployed during the period of July through mid-September 1994. High pressure normally dominates over the area during this time, which can lead to air stagnation and in turn, higher pollutant levels. Two stations were established in the Breton National Wildlife Area and one at the headquarters of the Louisiana Wildlife and Fisheries at Pass-A-Loutre, Louisiana (see Fig. 1). Measured parameters included SO_2, NO_2, air temperature, atmospheric pressure, relative humidity, and wind speed and direction.

Analysis of the available data records shows that measured pollutant levels at all three stations were well below the National Ambient Air Quality Standard maximums. Allowable limits on pollutant concentrations applying to PSD Class I and II areas are increments with respect to a baseline concentration. Due to the unavailability of these baseline measurements combined with the relatively short and non-continuous record obtained in this program, direct comparisions with PSD increments were not valid. On the other hand, average and maximum concentrations of both SO_2 and NO_2 were considerably higher at Breton Island than at Pass-A-Loutre. Furthermore, several distinct episodes of higher than average NO_x concentrations were evident in the Breton Island record. The data indicates that these short-lived (on the order of hours) events may be due to local sources rather than long distance transports. Highest concentrations of NO_2 and SO_2 at Breton Island during the study period were from the north and northeast, while at Pass-A-Loutre highest NO_2 concentrations were observed from the northwest and southwest and highest SO_2 from the north. For SO_2, the highest 3-hourly and daily concentration was 13.3 ppb (± 6.4) and 2.8 ppb (± 0.8) at Breton Island and 5.7 ppb (± 1.5) and 1.4 ppb (± 1.6) at Pass-A-Loutre, respectively. The highest 3-hourly and daily NO_2 concentrations were 31 ppb (± 5.6) and 12 ppb (± 12.8) for Breton Island and 13 ppb (± 1.7) and 5.1 ppb (± 3.8) for Pass-A-Loutre, respectively. The majority of all hourly samples were less than 5 ppb.

Twelve atmospheric profiles (radiosondes) were obtained during the study period. It is shown that the average mixing heights are nearly identical to the average lifting condensation level (LCL). A method for estimating the LCL from surface temperatures is given with a root mean square error of approximately 70 m. Mixing heights over the marine area are found to be significantly lower than the previously accepted climatic mean.

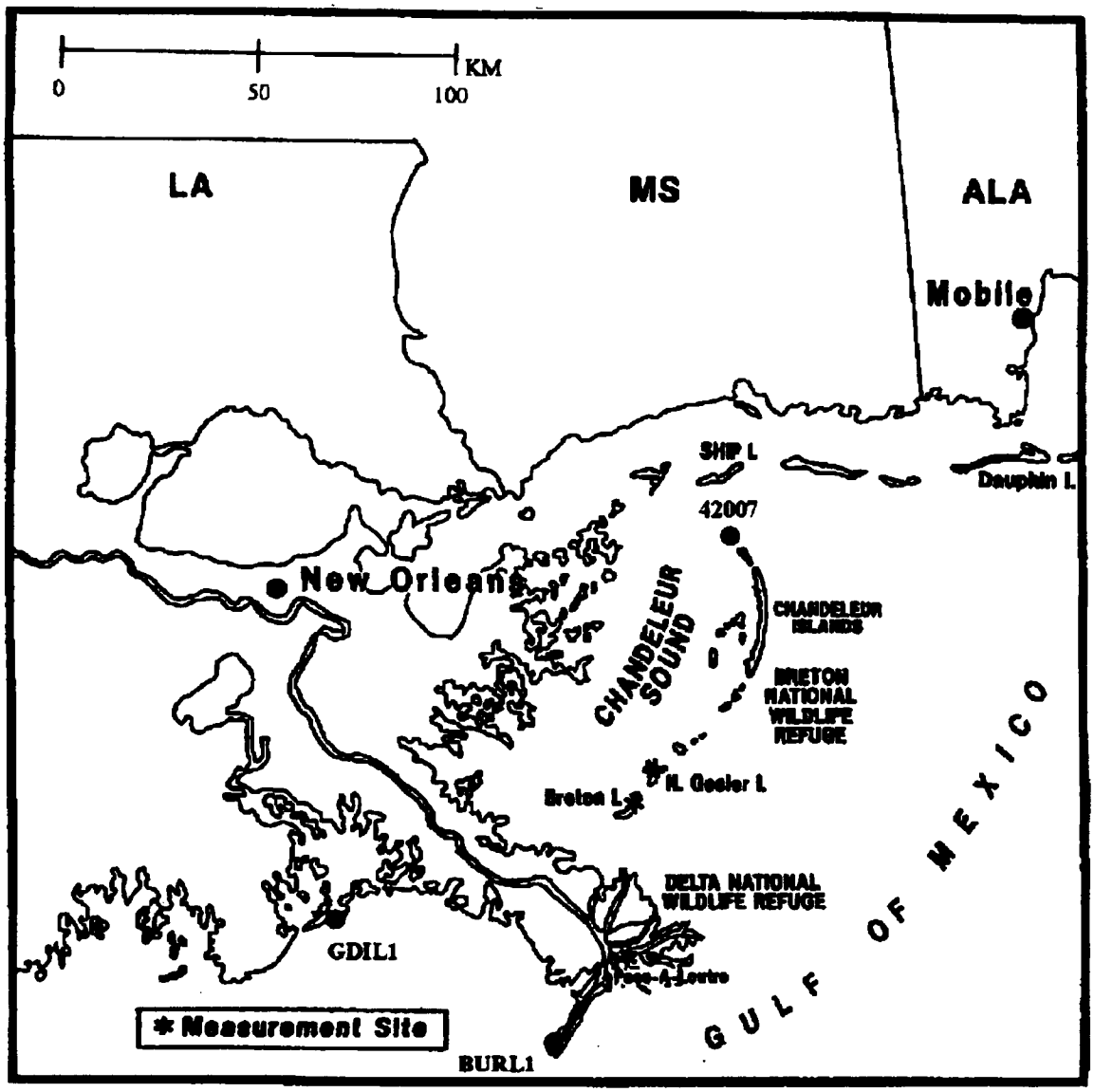


Figure 1. Air quality and meteorological stations deployed during the summer of 1994.

METHODOLOGY

METHODOLOGY

1. Introduction

During the 1994 summer months of July through mid-September, air quality and meteorological data was collected from three field stations located within the Mississippi River Delta and off the Louisiana coast in the Chandeleur Islands. In essence, this deployment was a repeat of our pilot study conducted during the summer of 1993 (see Hsu, 1995) but with a much more comprehensive measurement program. Details of the setup, equipment, calibration techniques and results, and data collected for each station is provided in the following sections.

2. Equipment

All three stations were originally designed to be equipped with the same suite of meteorological sensors and air quality analyzers; however frequent operational problems and malfunctions during the deployment resulted in the use of several different brands of instrumentation. In general, the minimum detectable threshold for all air quality analyzers used was 1 ppb. All data was stored on site via Campbell CR10 dataloggers. These dataloggers utilize a 10-second scan rate and were programmed for 5-minute averages (30 samples). Depended on the parameter, average values were recorded every 5 minutes or hourly.

Gosier Island

Gosier Island is situated in the southern part of the Chandeleur Island chain, north of the Mississippi River Delta. These islands are within the Breton National Wildlife Area, which has been designated as an EPA Class I area. The measurement station was established on the beach at approximately 29°33.69'N 89° 03.39'W. Major equipment deployed included a Thermo-Environmental (TECO) Model 43A SO_2 Analyzer, Weathertronics Micro-Response Anemometer and Wind Vane (later changed to a single Weathertronics Stratavane Windbird), and a Campbell Scientific CR10 datalogger. The SO_2 Analyzer and CR10 housing were placed inside of a ventilated shelter on a scaffold about 2 m above ground level. An air temperature sensor and the wind instruments were tower mounted next to the scaffold with observation heights of 3 m and 6 m, respectively. In addition, a pond located adjacent to the beach site was instrumented with an Model PHTX-20 pH transmitter and Model CDTX-20 conductivity transmitter, both manufactured by Omega Engineering, Inc., and a water temperature sensor. Due to the lack of any commercial power source, all equipment was run off of a bank of 12V car batteries. This fact, combined with the remote locale and harsh environmental conditions, produced a non-continuous data record and made servicing the station difficult and, on occasion, hazardous to equipment and personnel.

Meteorological parameters (wind speed and direction and air temperature) were recorded every five minutes while limnological values (pH, conductivity, temperature) were obtained hourly, whereas ambient SO_2 concentrations were measured on a 45-60 minute basis. This was accomplished

by programming the CR10 to activate the SO_2 Analyzer, allow it five minutes to stabilize (at which point a measurement was taken), and then de-activate. The measurement interval was calculated to provide the most observations possible given the expected power drain on the batteries between servicings.

Power restraints also ruled out the use of an automated gas calibrator for the SO_2 Analyzer. Therefore, a calibration system consisting of flowmeters, a gas proportioner, and cylinders of zero air and span gas was assembled. Flows necessary to produce a five-point calibration of the Analyzer were derived.

Ogawa Passive SO_2 and Palmes Passive NO_x sensors were exposed throughout the field deployment at Gosier Island. Although correctly handled in the field, the long exposure times and improper storage of the sample tubes casts doubts on the validity of this data.

Given the rugged conditions and the non-conventional method of operation, it is surprising that the only missing data in the air quality (SO_2) record occurred during 7 - 13 July. When the station was serviced on 7 July, it was found that the UV lamp in the Analyzer had failed, and the unit was subsequently taken offline. The lamp and socket were replaced on the next trip out (13 July) and the Analyzer returned to service.

On the other hand, wildlife inhabiting the island caused several problems. Pelicans and other marine waterfowl destroyed the Micro-Response Anemometer, resulting in a data gap in the wind speed record from 5 through 13 July. The wind vane was also damaged but apparently could still rotate for wind direction. The most serious damage was done to the cables connecting the pond instruments to the datalogger system, which were run on the surface over the dunes. Over time, animals apparently chewed into the cables, causing system shorts and the eventual failure of reliable data from the pond instruments on 21 July. These intermittent shorts were not detected in the field until 24 August, at which point the cables were disconnected from the datalogger. Large negative values in the SO_2 record from 13 to 24 August are probably due to these shorts.

The station deployment and servicing schedule is listed below as taken from field log excerpts:

29 June - all equipment deployed

1 July - start of monitoring

7 July - download, damage to wind instruments, SO_2 Analyzer taken offline due to lamp failure

13 July - download, Stratavane Windbird installed, SO_2 Analyzer online

21 July - download, SO_2 Analyzer calibration, failure of pond instruments

5 August - download, SO_2 Analyzer calibration

17 August - download

24 August - download, SO_2 Analyzer calibration, pond instruments disconnected

31 August - download, SO_2 Analyzer calibration

8 September - download, SO_2 Analyzer calibration

26 September - station had exhausted power supply previous to this date. All equipment removed. Post calibration of SO_2 Analyzer performed at CSI lab.

Breton Island (*Chandeleur Islander*)

Breton Island is also in the EPA Class I area of the Chandeleur Islands, less than 10 miles southwest of Gosier Island. The reason for having this second site in such close proximity to the Gosier station was that AC power was available here. Although this area is more developed and utilized than pristine Gosier Island (considerable boat traffic, moored houseboats and camps, and the Kerr-McGee facility), continuous air quality measurements could be made which would back up those acquired at nearby Gosier.

As in 1993, the houseboat *Chandeleur Islander* served as host to our station. The *Islander* was semi-permanently moored in Breton Sound at approximately 29°29.34'N 89°10.45'W. Air quality equipment for this station consisted of a TECO Model 43A SO_2 Analyzer (rotated with a Model 43), a Monitor Labs, Inc. Model 8840 NO_x Analyzer, and a TECO Model 146 Gas Calibrator (later changed to an Environics Series 100 Calibrator) with associated zero and span gas supplies. These units, along with the CR10 datalogger, were installed in a loft inside of the houseboat's loading bay. Unfortunately, this left them exposed to the marine environment and high temperatures (which may have contributed to problems later encountered with the units). Passive air quality sensors (Ogawa and Palmes) were also deployed here as at Gosier. Meteorological parameters monitored were air temperature, relative humidity, atmospheric pressure, and wind speed and direction.

Ambient concentrations of SO_2, NO, NO_2, and NO_x were recorded every five minutes along with wind speed and direction; air temperature, humidity and pressure were recorded hourly. Since the *Chandeleur Islander* was moored at a single point, it would turn on this axis in response to the wind and wave conditions. This necessitated the addition of a compass heading in order to determine the true wind direction. After field measurements were completed, it was discovered that the compass had not been functional during the entire period. Therefore, the wind record for this station has not been included in this analysis.

This station experienced several other equipment problems which resulted in the loss of data. The TECO 146 Gas Calibrator failed on installation and was returned for repairs. On 13 July, the TECO 43A could not be calibrated and was taken offline. This created a gap in the SO_2 record until

27 July, when the unit was replaced with an older Model 43. While functional, this Analyzer required considerable time to stabilize and so only minimal calibrations (0 - span) were done. The Calibrator was pulled again on 27 July due to incorrect gas flows. An Environics Gas Calibrator was installed on 5 August, but this unit required a larger pump to generate the flow volumes needed for calibrating the NO_x Analyzer. A large-capacity pump was supplied on 16 August, and the Model 43 Analyzer was replaced with a Model 43A. The 43A also displayed slow response time as well as considerable drift during calibration. To correct this, the optical bench in the unit was replaced on 23 August and good calibrations resulted. The second data gap occurred during the period of 27 - 30 August due to *Islander* personnel cutting power to the air quality monitors. Finally, the Model 43A Analyzer appeared to fail again on 2 September, ending the SO_2 record for Breton.

Servicing dates and notes are summarized below:

30 June - station established, failure of Gas Calibrator
1 July - observations start

7 July - download, TECO 146 installed, air quality analyzers calibrated

13 July - download, NO_x Analyzer adjusted and re-calibrated, SO_2 Analyzer taken offline

27 July - download, Model 43 (SO_2) installed and calibrated, TECO 146 pulled

5 August - download, partial calibration after installation of Environics Calibrator

16 August - download, new zero air pump installed, Model 43 replaced with Model 43A, calibration

23 August - download, Model 43A repair, calibration

30 August - download, calibration

7 September - download, Model 43A pulled, calibration of NO_x Analyzer

12 September - download, calibration of NO_x Analyzer

26 September - download, calibration of NO_x Analyzer, end of station record

Pass-A-Loutre

The headquarters building of the Louisiana Wildlife and Fisheries in the Pass-A-Loutre (PAL) Game and Fish Reserve was the site of the third monitoring station. The building is located on Dennis Pass in the Mississippi River Delta, an EPA designated Class II area. This was the most favorable site in that it offered ease of access (by boat or seaplane) regardless of weather, continuous AC power

for the Analyzers, and a climate-controlled room for the equipment. The effect of these factors is evident in the higher percentage of data obtained here.

Station setup was similar to that at Breton Island. TECO Models 43A (SO_2), 42 (NO_x), and 146 (Calibrator) were installed for air quality monitoring. A 10 m tower was erected for wind speed and direction (via Weathertronics Micro-Response Anemometer and Vane). Other recorded parameters were air temperature, relative humidity, and atmospheric pressure. Sample interval for the air quality parameters as well as wind speed and direction was five minute; remaining meteorological parameters were recorded hourly. No passive sensors were deployed.

The only significant data loss resulted from the failure of the NO_x Analyzer as the station was being established. The NO_x Analyzer was repaired and installed on 7 July. The unit remained in service throughout the rest of the deployment, although problems with the keyboard and display prompted the replacement of the processor board on 16 August. On 7 September, the NO_x Analyzer could not be calibrated. The field technician dis-assembled the unit on site and cleaned the lens and then partially removed the pump. A foreign substance was found inside the pump which was obstructing the flapper valves. Once removed, the unit operated normally and good calibrations followed. Following are field servicing notes for the PAL station:

1 July - station established and measurements begin, NO_x Analyzer failure

7 July - NO_x Analyzer installed

14 July - download, air quality Analyzers adjusted and calibrated but suspect error in Calibrator

22 July - download, Calibrator checked with Gilibrator bubble meter and adjusted, good calibrations of Analyzers

26 July - download, calibration

4 August - download, anemometer changed, calibration

11 August - download, calibration

16 August - download, processor board in NO_x Analyzer changed, calibration

23 August - download, calibration

30 August - download, calibration

7 September - download, repair of pump in NO_x Analyzer, calibration

12 September - download, calibration, end of station record

3. Calibrations

As indicated in the servicing records for each station, considerable effort was devoted to keeping the air quality monitors calibrated and in good operating condition. Typically when the stations were serviced, the monitors were either within acceptable error or not working at all.

Calibrations were performed by exposing the analyzers to known concentrations of the desired pollutants (SO_2, NO) at several points from 0 ppb to nearly 500 ppb (full scale). Test concentrations were obtained from compressed gas cylinders (traceable EPA Protocol gases) containing a mix of approximately 50 ppm SO_2 and 50 ppm NO with a nitrogen balance. This gas was then diluted through a zero-air system with scrubbers to produce concentrations at several points. As described in the Code of Federal Regulations (40 CFR 58, App. B, 1994), one precision point and two or more additional points evenly spaced up to the full scale were checked to establish the relationship between the analyzer response and the pollutant concentration. If properly calibrated and operating nominally, the analyzers used in this study should exhibit a linear response as shown in Fig. 2; therefore accuracy of measurements should be consistent from low to high concentrations. At Gosier Island, calibration of the SO_2 analyzer was performed manually by mixing test gas with that from a cylinder of zero air through a gas proportioner (all flowmeters were certified at the Louisiana Department of Environmental Quality). Automated gas calibrators were required at Breton Island and Pass-A-Loutre to produce the gas phase titration needed for calibration of the NO_x analyzers. In this technique, ozone (O_3) is added to the calibrated NO channel in the reaction

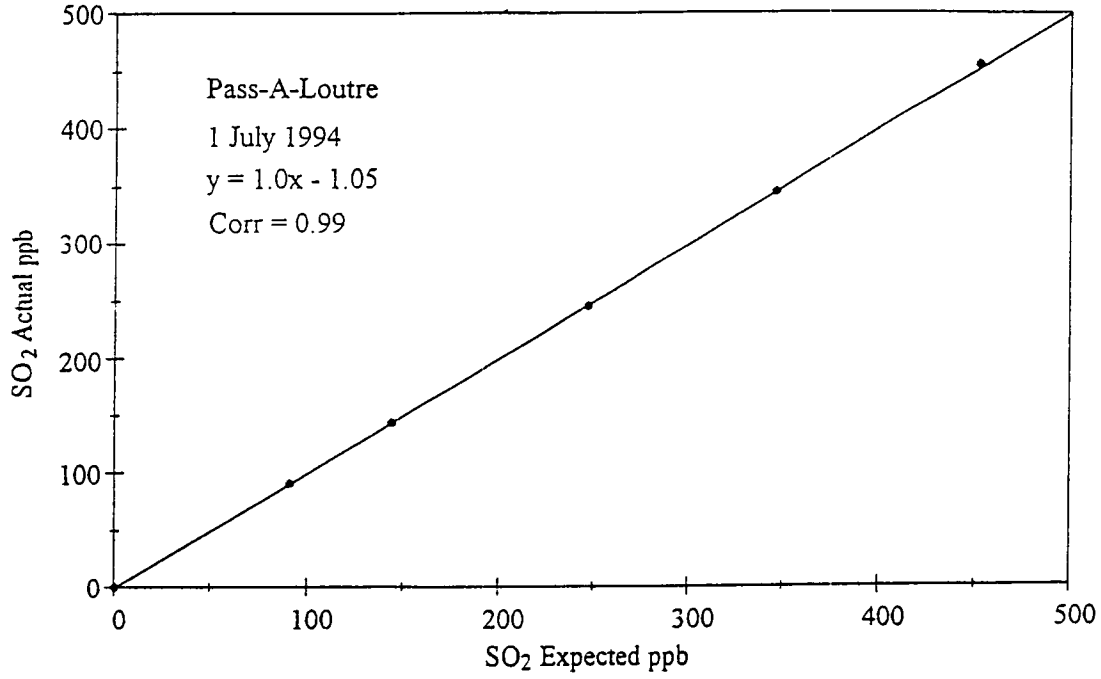
$$NO + O_3 \rightarrow NO_2 + O_2$$

The decrease in the NO concentration from this reaction is equivalent to the NO_2 produced. Thus NO_2 concentration is derived from the difference between calibrated NO_x and NO channels.

Gosier Island

Table 1A lists the precision data for the TECO Model 43A SO_2 Analyzer deployed at Gosier Island. The data are reported as a 95 percent confidence interval bounded by two percentile values as described in 49 CFR 58, App. B (1994). The interpretation is that for any randomly selected value within the database represented, there is only 5 percent probability that its accuracy is outside of the boundaries defined as the upper and lower 95-percent confidence limits. All air quality measurements are in ppb.

Table 1B presents accuracy data at other selected calibration points. It should be noted that the Tables reflect values obtained immediately before the Analyzer was adjusted (greatest error). Also, a final calibration of the Analyzer on-site was not possible due to the lack of power. The unit was shipped back to the Coastal Studies Institute and calibrated under laboratory conditions.



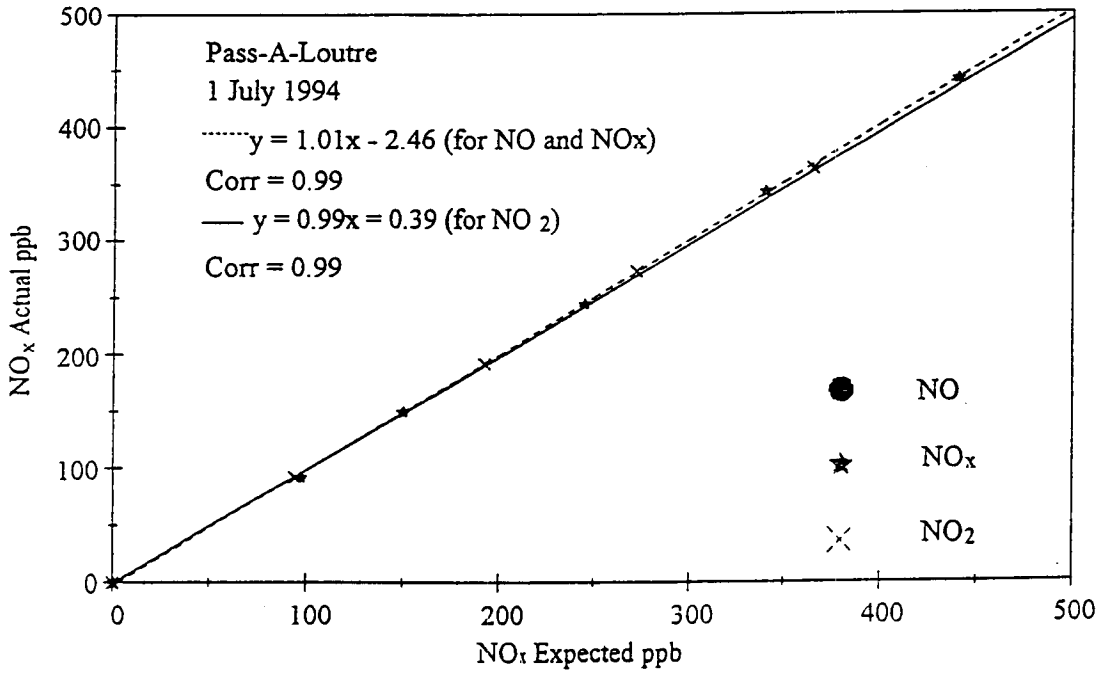


Figure 2. Calibration curves from Pass-A-Loutre air quality analyzers.

Whenever an analyzer is physically moved to a new location, has undergone repairs, has been inoperative for an extended period, or has obviously malfunctioned, a new multi-point calibration must be conducted (EPA, 1979). Obviously, this calibration may not be representative of the response of the analyzer in its former state. In this case, if this post-calibration is excluded, the mean precision error would be -0.13 with a standard deviation of 13.12. Accuracy values would likewise improve. Since deleting the final calibration would also invalidate all air quality data collected between that point and the last acceptable calibration, it has been included in the tables.

Breton Island

Calibration values at this station were made more complicated due to the previously described problems with the calibration system and exchange of the SO_2 Analyzer on two occasions. Precision and accuracy data for the SO_2 Analyzer are listed in Tables 2A and 2B while values for the NO_x Analyzer are in Tables 3A and 3B. The wide range of expected values for NO_2 in Tables 3A and 3B are the result of different flow rates (and thereby concentrations) associated with the gas calibration systems and zero air supplies used at this station.

Pass-A-Loutre

Precision and accuracy data for the SO_2 Analyzer at the PAL station are listed in Tables 4A and 4B and for the NO_x Analyzer in Tables 5A and 5B, respectively. The calibration performed at this station on 14 July is not included due to incorrect flows in the TECO 146 Gas Calibrator; however, values obtained after the Calibrator was corrected on 22 July (before the Analyzers were adjusted) are incorporated. If only values measured after the re-calibration are considered, the mean precision error for SO_2 reduces to 2.4 with a standard deviation of 2.6. On 7 September, a partial calibration was performed on the defective NO_x Analyzer before the unit was taken offline and repaired. These values are listed in Tables 5A and 5B but could have been deleted as described under Gosier Island above. Again, if excluded the average precision error and accuracy for the NO_x Analyzer would improve significantly.

4. Data Return

Due in part to the relatively short duration of the field measurement period, virtually all available data from each station is employed for this report. It has been shown that each air quality monitor was subjected to frequent multi-point calibrations with resulting mean precision errors of less than 10%. The minimum requirements for PSD monitoring are determined by many factors including field conditions, the objectives of monitoring, level of quality data needed, expertise of personnel, cost of control procedures, and pollutant concentration levels (40 CFR 58, App. B, 1994). The goal is to provide data of adequate quality to meet the monitoring objectives, and to minimize the loss of air quality data due to malfunctions and out-of-control conditions. Taking into account the operating environments and logistic difficulties, it was not intended that these stations would conform to EPA recommendations for Class I and II PSD Air Monitoring (i.e., regulatory purposes); rather, they were

Table 1A.
Gosier Island SO_2 Precision Data
Analyzer: TECO 43A

Date	Expected ppb	Precision Actual ppb	% Error
7/21/94	129	92	-28.68
7/21/94 (Re-cal)	129	135	4.65
8/5/94	129	142	10.08
8/24/94	129	137	6.20
8/31/94	129	138	6.98
9/8/94	129	129	0
Post-Cal	129	174	34.88
Sum of D(I)			34.11
Mean of D(I)			4.87
Standard Deviation			17.25
Upper 95% Probability			38.68
Lower 95% Probability			-28.94

Table 1B.
Gosier Island SO_2 Accuracy Data
Analyzer: TECO 43A

Date	Expected ppb	Actual ppb	% Error
7/21/94	464	309	-33.41
7/21/94 (Re-cal)	464	464	0
8/5/94	464	463	-0.22
8/24/94	464	468	0.86
8/31/94	464	456	-1.72
9/8/94	464	616	32.76
9/8/94 (Re-cal)	464	466	0.43
Post-Cal	464	600	29.31
Mean			3.5
Standard Deviation			19.22
7/21/94	229	154	-32.75
8/5/94	229	258	12.66
9/8/94	229	232	1.31
Post-Cal	229	305	33.19
Mean			3.6
Standard Deviation			23.9

Table 2A.
Breton Island SO_2 Precision Data
Analyzer: TECO 43 and 43A

Date	Expected ppb	Precision Actual ppb	% Error
7/7/94	92	92	0
8/6/94	90	88	-2.22
8/23/94	90	110	22.22
8/30/94	90	105	16.67
Sum of D(I)			36.67
Mean of D(I)			9.17
Standard Deviation			10.49
Upper 95% Probability			29.73
Lower 95% Probability			-11.39

Table 2B.
Breton Island SO_2 Accuracy Data
Analyzer: TECO 43 and 43A

Date	Expected ppb	Actual ppb	% Error
7/7/94	449	461	2.67
7/27/94*	449	443	-1.34
8/5/94*	449	360	-19.82
8/5/94 (Re-cal)*	449	447	-0.45
8/16/94	450	428	-4.89
8/23/94	450	448	-0.44
8/30/94	450	451	0.22
Mean			-3.44
Standard Deviation			7.01

*Model 43

Table 3A.
Breton Island NO_x Precision Data
Analyzer: Monitor Labs 8840

Date	Expected ppb	Actual NO ppb	Actual NO_x ppb	% Error NO	% Error NO_x
7/7/94	91	96	97	5.50	6.59
7/13/94	91	91	88	0	-3.30
7/27/94	91	93	89	2.20	-2.20
8/5/94	91	81	80	-10.99	-12.09
8/5/94 (Re-cal)	91	72	72	-20.88	-20.88
8/16/94	91	90	88	-1.10	-3.30
8/23/94	90	89	89	-1.11	-1.11
8/30/94	90	86	85	-4.44	-5.56
9/7/94	90	88	89	-2.22	-1.11
9/12/94	90	92	91	2.22	1.11
9/26/94	90	88	86	-2.22	-4.44
Sum D(I)				-33.04	-46.29
Mean D(I)				-3	-4.21
Standard Deviation				6.94	6.82
Upper 95% Probability				10.6	9.16
Lower 95% Probability				-16.60	-17.58

Table 3A Continued

Date	Expected ppb	Actual NO_2 ppb	% Error
7/7/94	79	80	1.27
7/13/94	82	83	1.22
7/27/94	64	65	1.56
8/16/94	119	127	6.72
8/23/94	103	128	24.27
8/30/94	119	139	16.81
9/7/94	126	139	10.32
9/12/94	126	126	0
9/26/94	113	137	21.24
Sum D(I)			83.41
Mean D(I)			9.27
Standard Deviation			8.86
Upper 95% Probability			26.64
Lower 95% Probability			-8.10

Table 3B.
Breton Island NO_x Accuracy Data
Analyzer: Monitor Labs 8840

Date	Expected ppb	Actual NO ppb	Actual NO_x ppb	% Error NO	% Error NO_x
7/7/94	465	475	478	2.15	2.80
7/13/94	465	463	464	-0.43	-0.22
7/27/94	465	465	465	0	0
8/5/94	465	401	411	-13.76	-11.61
8/5/94 (Re-cal)	465	462	464	-0.65	-0.22
8/16/94	450	451	454	0.22	0.89
8/23/94	450	449	451	-0.22	0.22
8/30/94	450	459	463	2.00	2.89
9/7/94	450	458	459	1.78	2.00
9/12/94	450	455	454	1.11	0.89
9/26/94	450	440	441	-2.22	-2.00
Mean D(I)				-0.91	-0.4
Standard Deviation				4.25	3.80

Table 3B Continued

Date	Expected ppb	Actual NO_2 ppb	% Error NO_2
7/7/94	265	268	1.13
7/13/94	387	385	-0.52
7/13/94 (Re-cal)	350	353	0.86
8/16/94	328	350	6.71
8/23/94	340	363	6.77
8/30/94	340	362	6.47
9/7/94	357	374	4.76
9/12/94	372	378	1.61
9/26/94	346	364	5.20
Mean D(I)			3.67
Standard Deviation			2.72

Table 4A.
Pass-A-Loutre SO_2 Precision Data
Analyzer: TECO 43A

Date	Expected ppb	Precision Actual ppb	% Error
7/1/94	91	91	0
7/22/94	85	47	-44.71
7/22/94 (Re-cal)	85	86	1.18
7/26/94	85	83	-2.35
8/4/94	85	84	-1.18
8/11/94	85	87	2.35
8/16/94	85	87	2.35
8/23/94	85	88	3.53
8/30/94	85	89	4.71
9/7/94	85	89	4.71
9/12/94	85	90	5.88
Sum D(I)			-23.53
Mean D(I)			-2.14
Standard Deviation			13.68
Upper 95% Probability			24.67
Lower 95% Probability			-28.95

Table 4B.
Pass-A-Loutre SO_2 Accuracy Data
Analyzer: TECO 43A

Date	Expected ppb	Actual ppb	% Error
7/1/94	452	455	0.66
7/22/94	427	244	-42.86
7/22/94 (Re-cal)	427	428	0.23
7/26/94	427	422	-1.17
8/4/94	427	426	-0.23
8/11/94	427	435	1.87
8/16/94	427	435	1.87
8/23/94	427	434	1.64
8/30/94	427	439	2.81
9/7/94	427	440	3.04
9/12/94	427	450	5.39
Mean D(I)			-2.43
Standard Deviation			12.90

Table 5A.
Pass-A-Loutre NO_x Precison Data
Analyzer: TECO 42

Date	Expected ppb	Actual NO ppb	Actual NO_x ppb	% Error NO	% Error NO_x
7/22/94	85	70	69	-17.65	-18.82
7/22/94 (Re-cal)	94	96	97	2.13	3.19
7/26/94	85	87	87	2.35	2.35
8/4/94	94	90	90	-4.26	-4.26
8/11/94	94	80	79	-14.89	-15.96
8/11/94 (Re-cal)	94	90	91	-4.26	-3.19
8/16/94	94	95	95	1.06	1.06
8/23/94	94	84	84	-10.64	-10.64
8/23/94 (Re-cal)	94	95	95	1.06	1.06
8/30/94	94	92	92	-2.13	-2.13
9/7/94	94	46	46	-51.06	-51.06
9/7/94 (Re-cal)	94	97	97	3.19	3.19
9/12/94	94	89	89	-5.32	-5.32
Sum D(I)				-100.42	-100.53
Mean D(I)				-7.73	-7.73
Standard Deviation				14.06	14.25
Upper 95% Probability				19.83	20.20
Lower 95% Probability				-35.29	-35.66

Table 5A Continued

Date	Expected ppb	Actual NO_2 ppb	% Error NO_2
7/22/94	73	63	-13.70
7/22/94 (Re-cal)	89	94	5.62
7/26/94	90	87	-3.33
8/4/94	97	92	-5.16
8/11/94	99	98	-1.01
8/16/94	97	96	-1.03
8/23/94	98	98	0
8/30/94	92	92	0
9/12/94	92	93	1.09
Sum D(I)			-17.52
Mean D(I)			-1.95
Standard Deviation			5.01
Upper 95% Probability			7.87
Lower 95% Probability			-11.77

Table 5B.
Pass-A-Loutre NO_x Accuracy Data
Analyzer: TECO 42

Date	Expected ppb	Actual NO ppb	Actual NO_x ppb	% Error NO	% Error NO_x
7/22/94	454	336	329	-25.99	-27.53
7/22/94 (Re-cal)	454	452	451	-0.44	-0.66
7/26/94	454	420	421	-7.49	-7.27
8/4/94	454	433	431	-4.63	-5.07
8/11/94	454	407	404	-10.35	-11.01
8/11/94 (Re-cal)	454	446	448	-1.76	-1.32
8/16/94	454	451	452	-0.66	-0.44
8/23/94	454	398	398	-12.34	-12.34
8/23/94 (Re-cal)	454	453	455	-0.22	0.22
8/30/94	454	427	429	-5.95	-5.51
9/7/94	454	293	293	-35.46	-35.46
9/7/94 (Re-cal)	454	453	453	-0.22	-0.22
9/12/94	454	422	424	-7.05	-6.61
Mean D(I)				-8.66	-8.71
Standard Deviation				10.32	10.59

Table 5B Continued

Date	Expected ppb	Actual NO_2 ppb	% Error NO_2
7/22/94	262	249	-4.96
7/22/94 (Re-cal)	346	346	0
7/26/94	324	319	-1.54
8/4/94	340	330	-2.94
8/11/94	350	346	-1.14
8/16/94	352	346	-1.71
8/23/94	310	287	-7.42
8/23/94 (Re-cal)	352	349	-0.85
8/30/94	335	333	-0.6
9/7/94	357	354	-0.84
9/12/94	331	329	-0.6
Mean D(I)			-2.06
Standard Deviation			2.15

designed for scientific purposes (to obtain a quantitative first-look at the pollutant levels existing over these areas and the meteorological conditions which could affect those levels). With this in mind, and considering that the monitors were generally well calibrated, the air quality data is presented as recorded with the only adjustment being the removal of zero offsets.

Hourly values of wind speed and direction were derived through a vector average for all hours reporting six or more 5-minute measurements. Other meteorological parameters not reported hourly and all air quality data were reduced by arithmetic average. Average concentrations less than zero were considered non-detect and reported as zero assuming the analyzer was operating nominally. In other words, if negative values were recorded during a period between two acceptable calibrations, those measurements were considered valid and retained as 0 ppb. Over time, cumulative zero drifts of 20 to 30 ppb and span drifts of 20 - 25% of full scale may be observed before the analyzer should be adjusted and re-calibrated (EPA, 1979).

Table 6 lists the percentage of hourly data return for measured parameters at each station (note that NO_2 implies NO and NO_x). Values represent percentage of possible record, not month. Computed hourly values are presented graphically for Gosier Island in Figs. 3a - 3m, for Breton Island in Figs. 4a - 4u, and for Pass-A-Loutre in Figs. 5a - 5aa. Numerical values are listed in Appendices A - C. Interpretation of the data is provided in the Results and Discussion Section.

It can be seen in the figures that parts of the air quality records have been designated as "Questionable", due primarily to lack of successful monitor calibration or related equipment failures as described previously. In the Gosier SO_2 record, July 1 - 7 is suspect since no span calibration was performed on installation and the Analyzer subsequently failed (Fig. 3a). Large negative values were recorded during 12 - 24 August (Fig. 3b), however good calibrations were obtained on 5 and 24 August. It should be noted that, at an undetermined point before the end of the Gosier SO_2 record, battery power levels had become insufficient to run to air quality monitor (Fig. 3c).

Both SO_2 and NO_x data have been removed from the Breton Island air quality record during the period of 7 - 14 July due to an unexplained lack of response from the monitors (Figs. 4a, d, g, and j). In Figure 4c, failure of the SO_2 Analyzer caused hourly measurements to go negative after 2 September.

Calibration of the air quality monitors at Pass-A-Loutre was performed on 14 July even though it was suspected that the Gas Calibrator was out of specifications. This was confirmed on 22 July, at which point the Calibrator was corrected and the air quality monitors brought back into line (see Calibrations). In addition, no span calibration was conducted on the NO_x Analyzer when installed on 7 July. Figures 5a, d, g, and j illustrate these events. As shown in Figs. 5f, i, and l, the pump in the NO_x Analyzer began failing before being repaired on 7 September; however NO_x data appears consistent throughout the period of 30 August to 7 September.

Table 6.
Percentage Data Return

Month	Air Temp.	Press.	Relative Humidity	Wind Speed	Wind Direct.	SO_2	NO_2
Gosier Island							
July	99.9	NM	NM	73.8	99.6	79.4	NM
Aug	99.3	NM	NM	99.3	99.3	98.4	NM
Sept	100	NM	NM	100	100	99.7	NM
Breton Island							
July	97.3	97.3	97.3	NM	NM	34.3	77.6
Aug	96.4	96.4	96.4	NM	NM	85.6	85.6
Sept	99	99	99	NM	NM	6.6	98.7
Pass-A-Loutre							
July	97.5	97.5	97.5	97.9	97.9	97.9	78.7
Aug	97.6	97.6	97.6	98.3	98.3	98	98
Sept	97.5	97.5	97.5	97.9	97.9	97.9	97.9

NM - Not Measured

5. Radiosondes

The final component of the field measurement program consisted of atmospheric profiles obtained at each station throughout the deployment period. Table 7 denotes the date, time, and location of each launch. The majority of launches were scheduled to coincide with 00 and 12 GMT (standard National Weather Service launch times). Those remaining were launched in the local afternoon hours to investigate the variation of the mixing heights.

Sensor packages used were A.I.R., Inc. Model AS-3A-403 Airsondes carried aloft on 200 gm balloons. The Airsonde measures air temperature via bead thermistor, relative humidity by carbon hygristor, and barometric pressure with an electronic aneroid capacitance pressure sensor mounted internally on the circuit board. Data is sampled and transmitted every 5 - 6 seconds. An A.I.R., Inc. Atmospheric Data Acquisition System (ADAS) was employed to receive and interpret the transmitted signal.

Prior to launch, surface temperatures (dry- and wet-bulb) were measured with an electric psychrometer, and station pressure with both an aneroid and digital barometer. Other conditions (wind speed and direction, cloud cover, etc.) were estimated by the observer.

Table 7.
Radiosonde Launch Information

Profile	Location	Date/Time Local	Date/Time GMT
STA1RS01	Gosier Island	8/24/94 1216CDT	8/24/94 1716GMT
STA2RS01	Breton Island	8/5/94 1558CDT	8/5/94 2058GMT
STA2RS02	Breton Island	8/16/94 1900CDT	8/17/94 0000GMT
STA2RS03	Breton Island	8/17/94 0631CDT	8/17/94 1131GMT
STA2RS04	Breton Island	8/23/94 1902CDT	8/24/94 0002GMT
STA2RS05	Breton Island	8/24/94 0706CDT	8/24/94 1206GMT
STA2RS06	Breton Island	8/30/94 1905CDT	8/31/94 0005GMT
STA2RS07	Breton Island	8/31/94 0703CDT	8/31/94 1203GMT
STA2RS08	Breton Island	9/7/94 1930CDT	9/8/94 0030GMT
STA2RS09	Breton Island	9/8/94 0701CDT	9/8/94 1201GMT
STA3RS01	PAL	8/4/94 1900CDT	8/5/94 0000GMT
STA3RS02	PAL	9/7/94 1304CDT	9/7/94 1804GMT

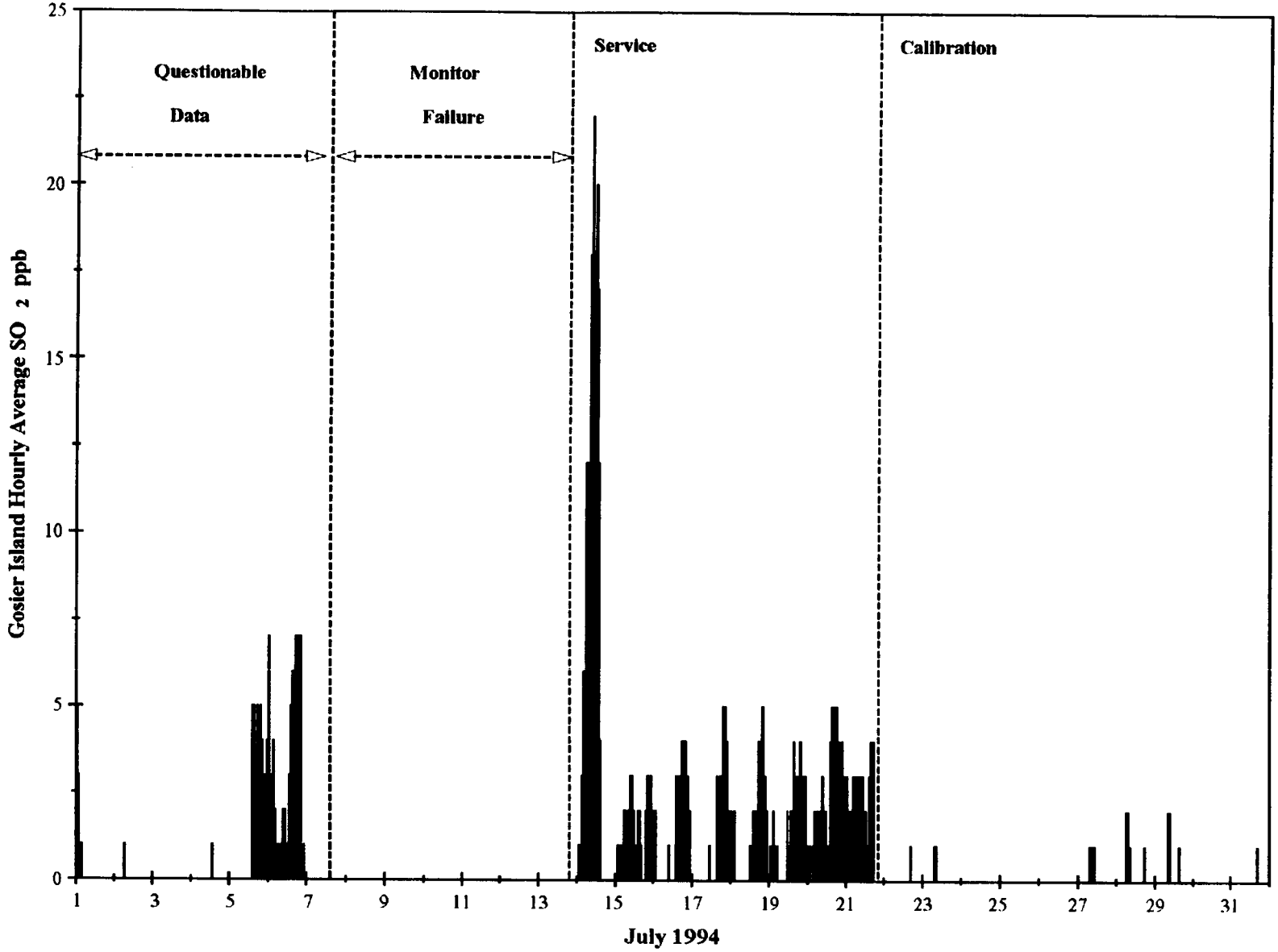


Figure 3a. July 1994 hourly SO_2 concentrations at Gosier Island.

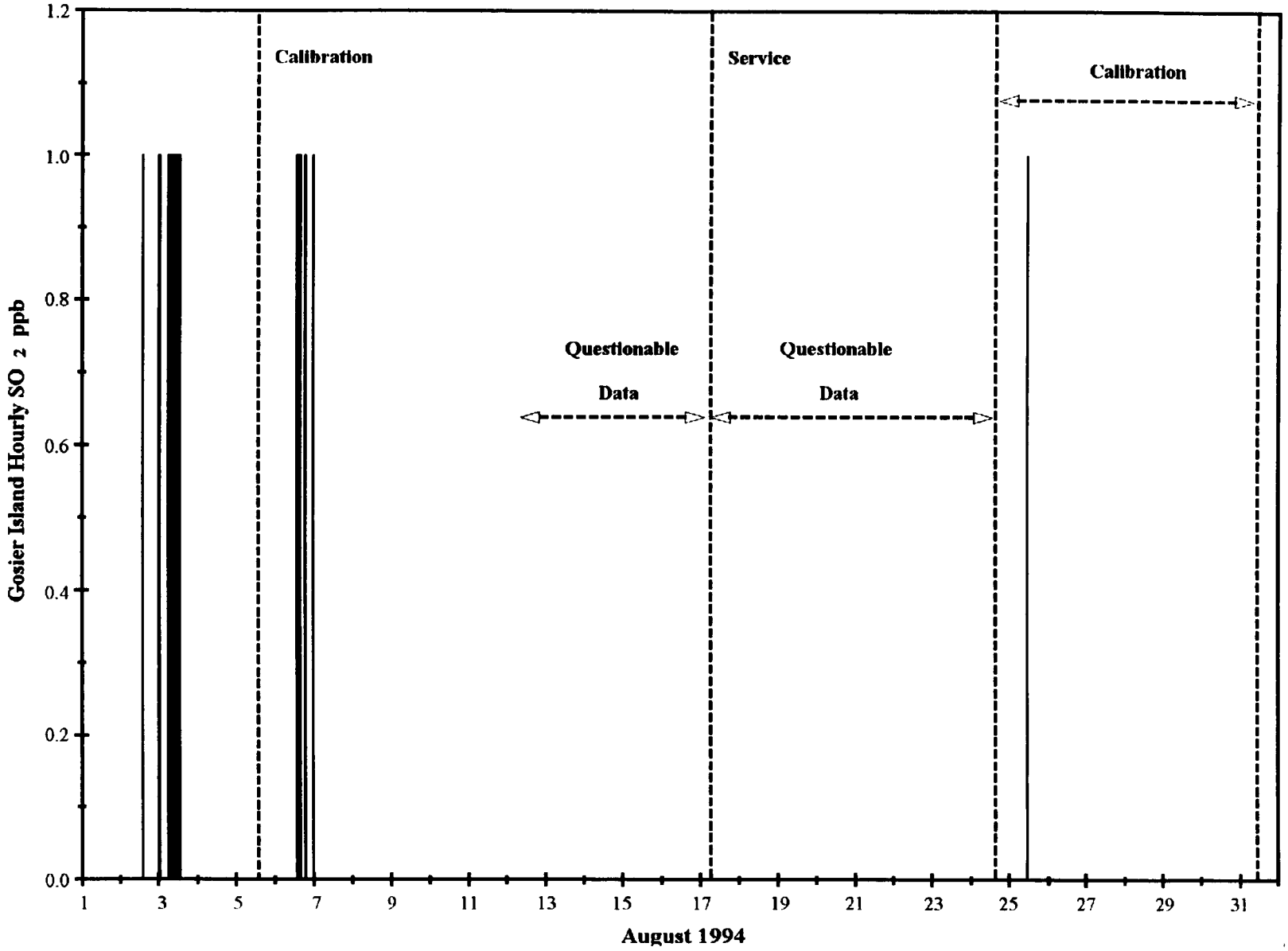


Figure 3b. August 1994 hourly SO_2 concentrations at Gosier Island.

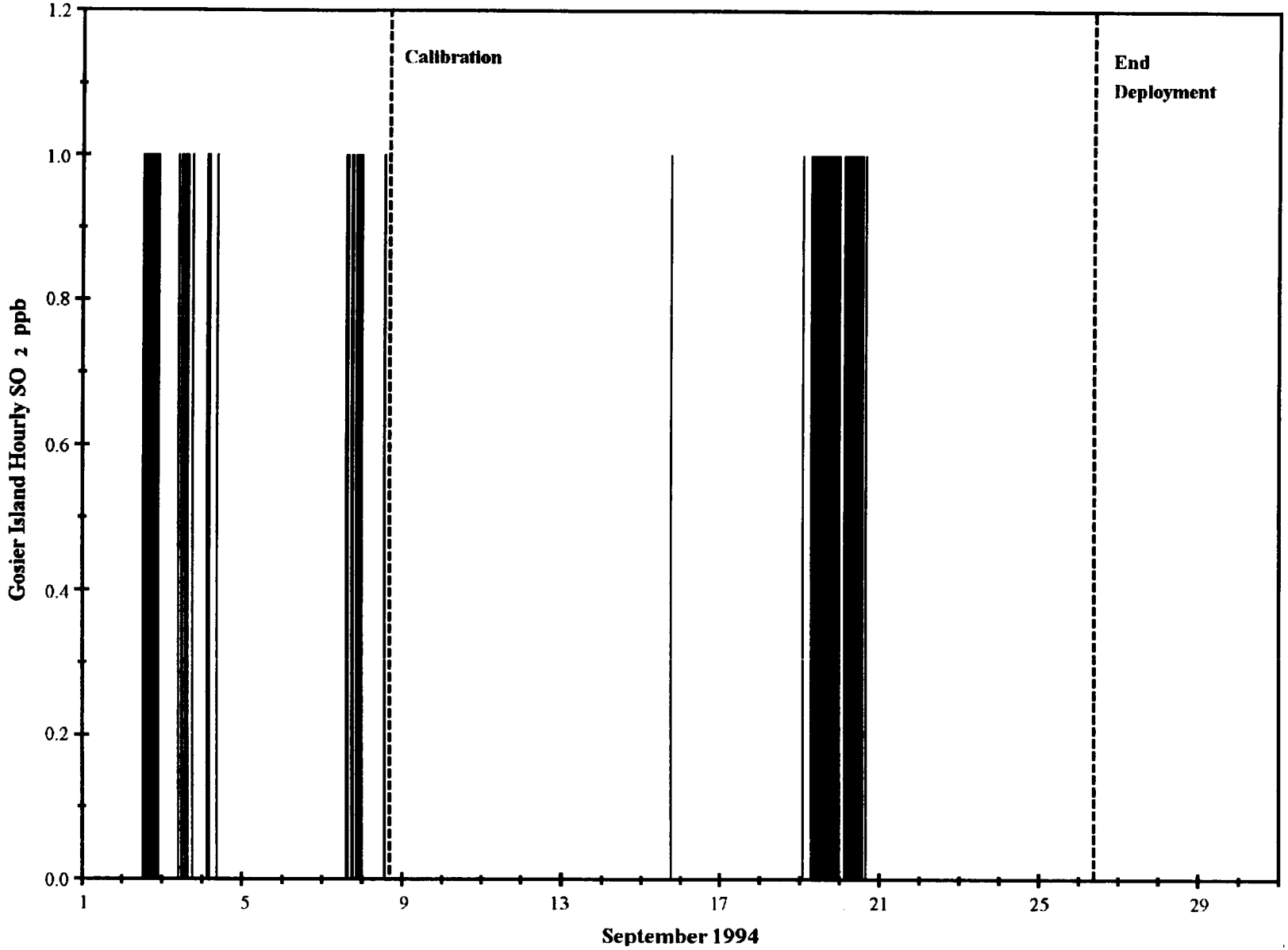


Figure 3c. September 1994 hourly SO_2 concentrations at Gosier Island.

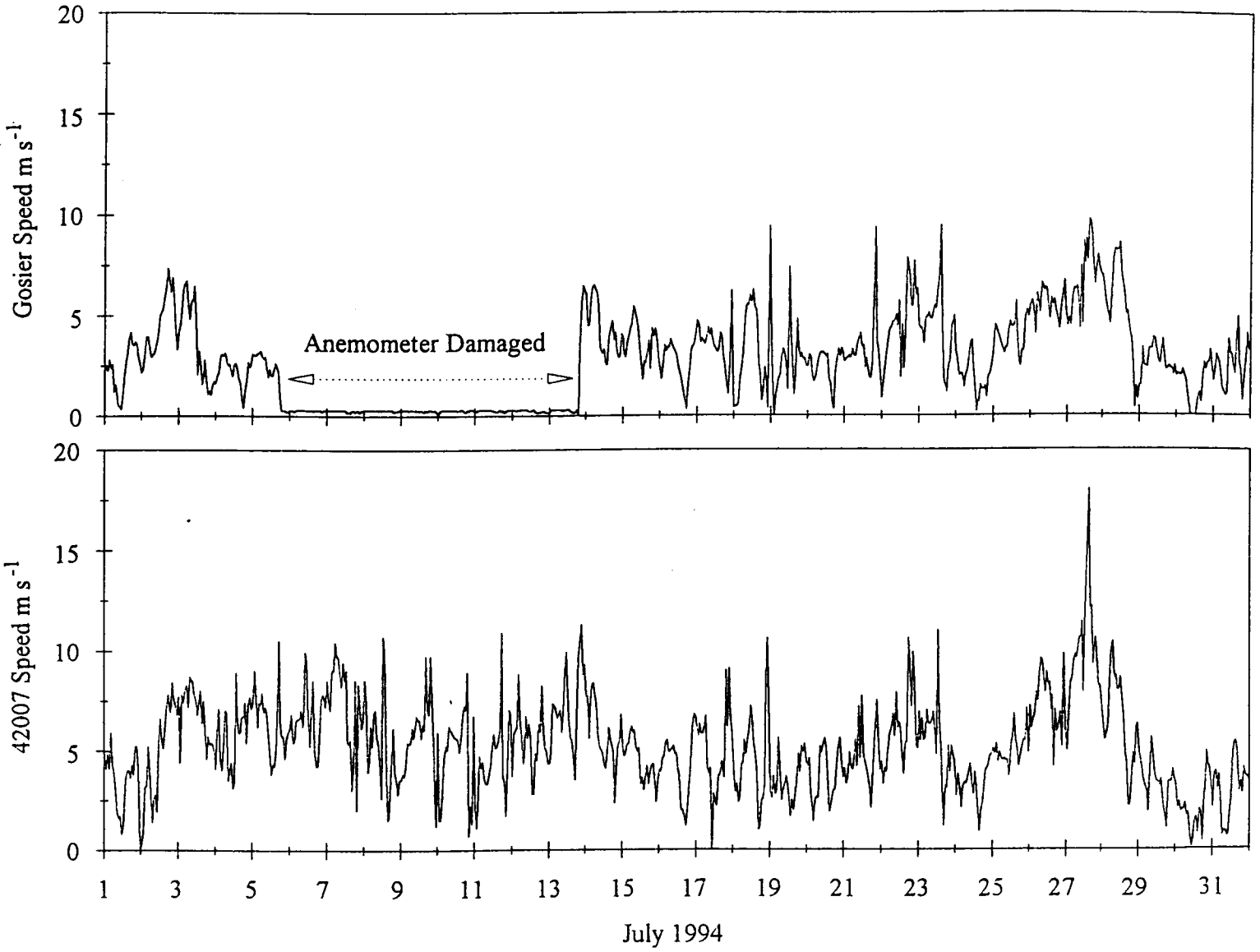


Figure 3d. July 1994 hourly wind speeds at Gosier Island and NOAA buoy 42007.

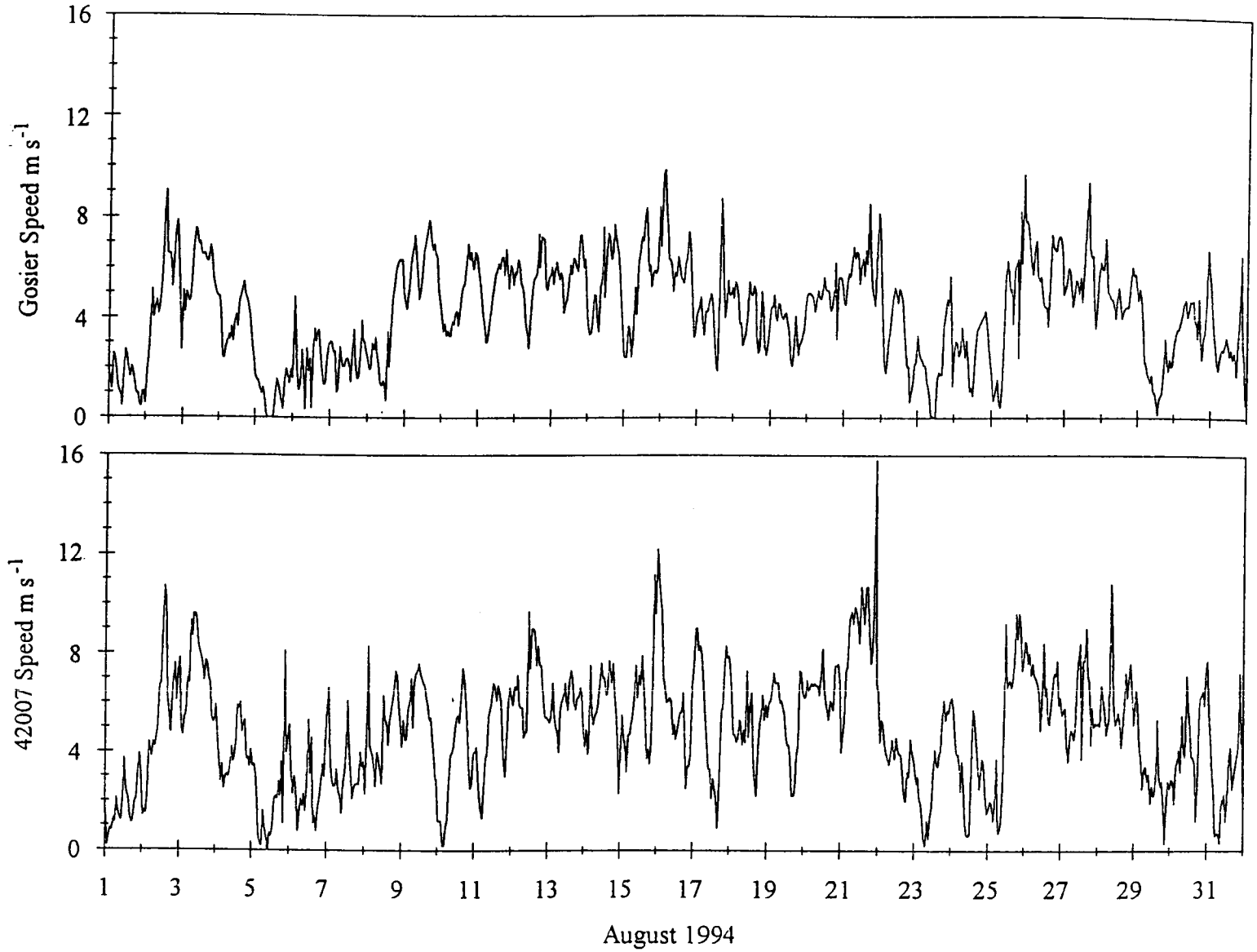


Figure 3e. August 1994 hourly wind speeds at Gosier Island and NOAA buoy 42007.

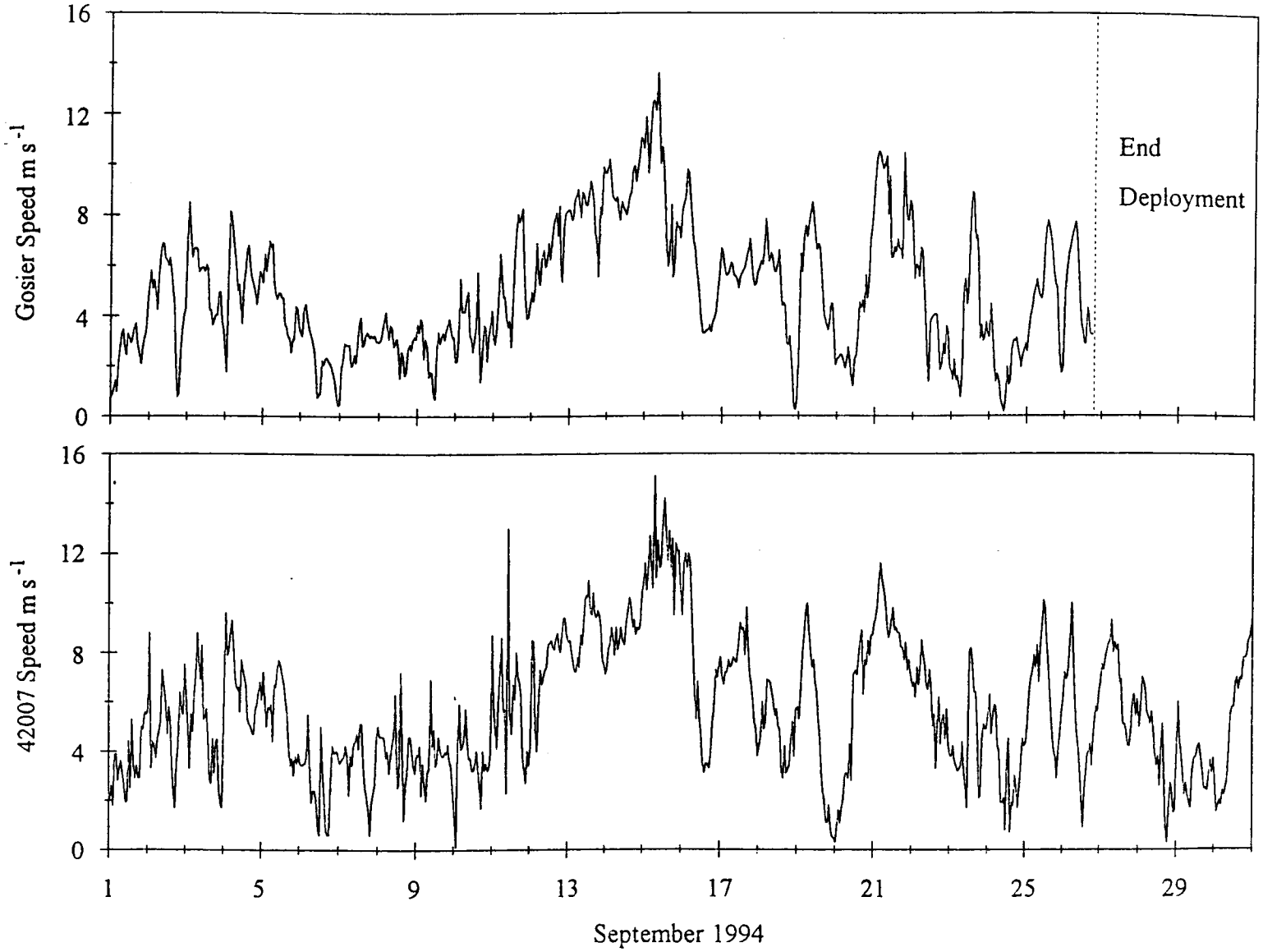


Figure 3f. September 1994 hourly wind speeds at Gosier Island and NOAA buoy 42007.

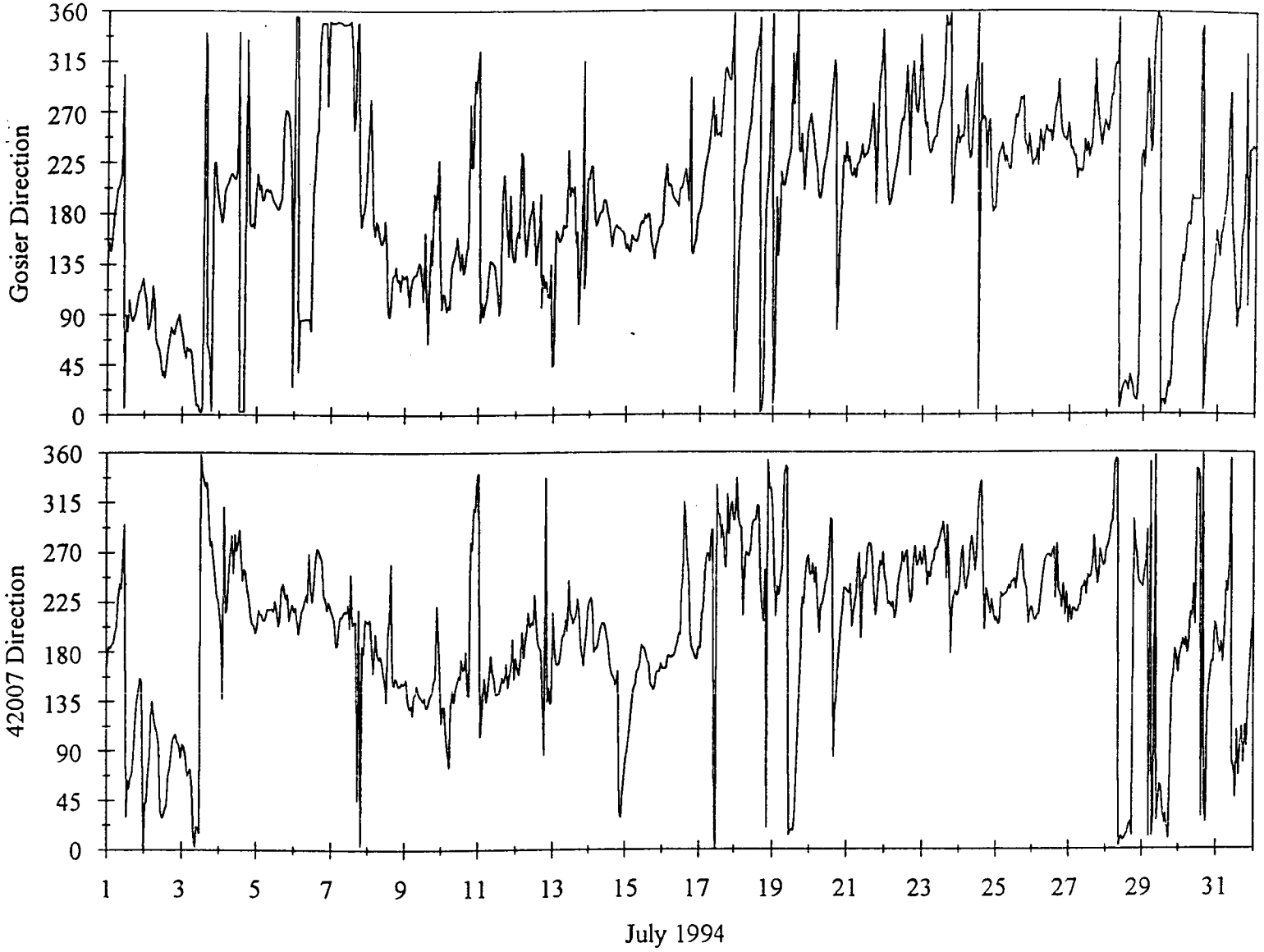


Figure 3g. July 1994 hourly wind directions from Gosier Island and NOAA buoy 42007.

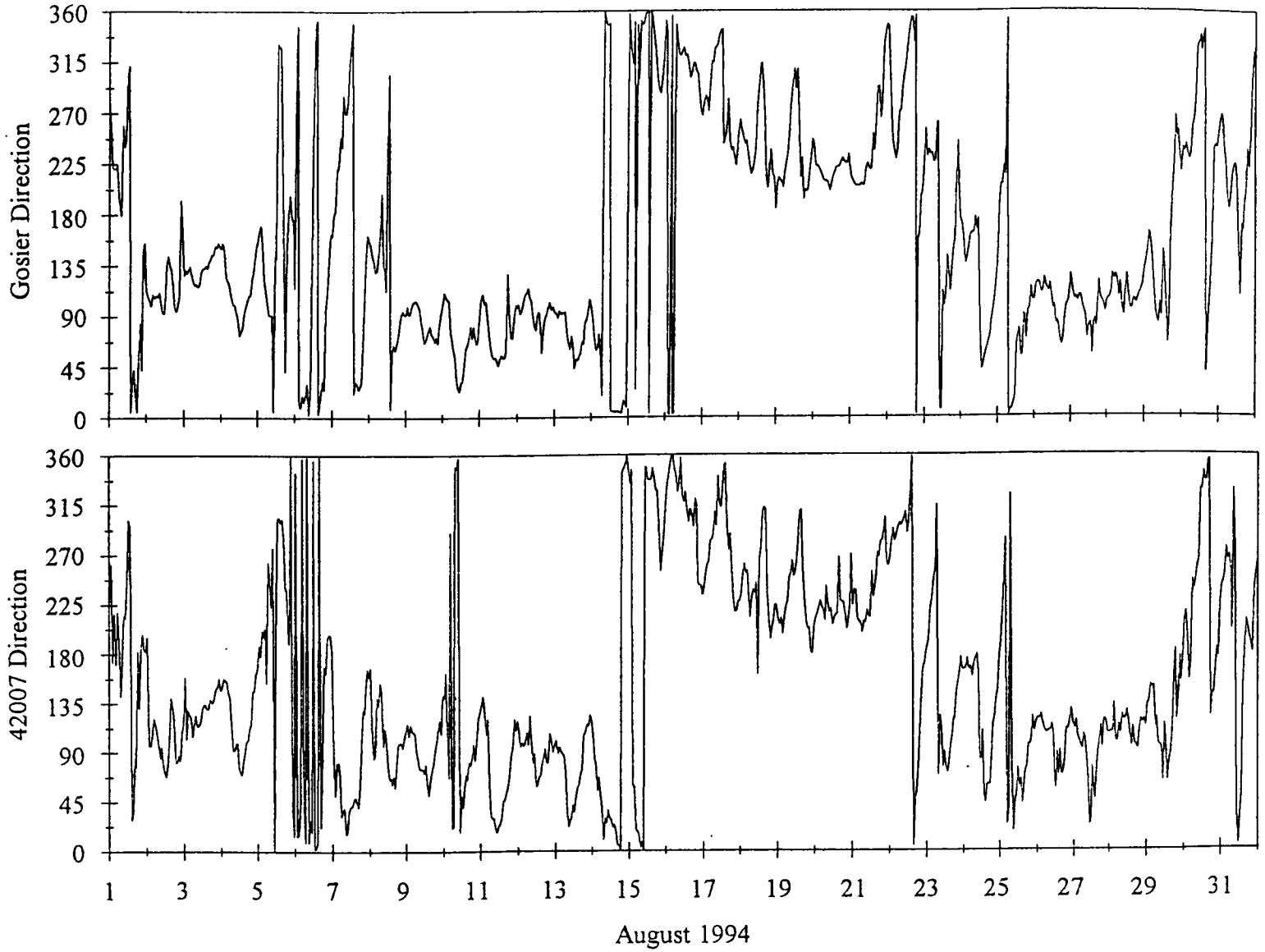


Figure 3h. August 1994 hourly wind directions from Gosier Island and NOAA buoy 42007.

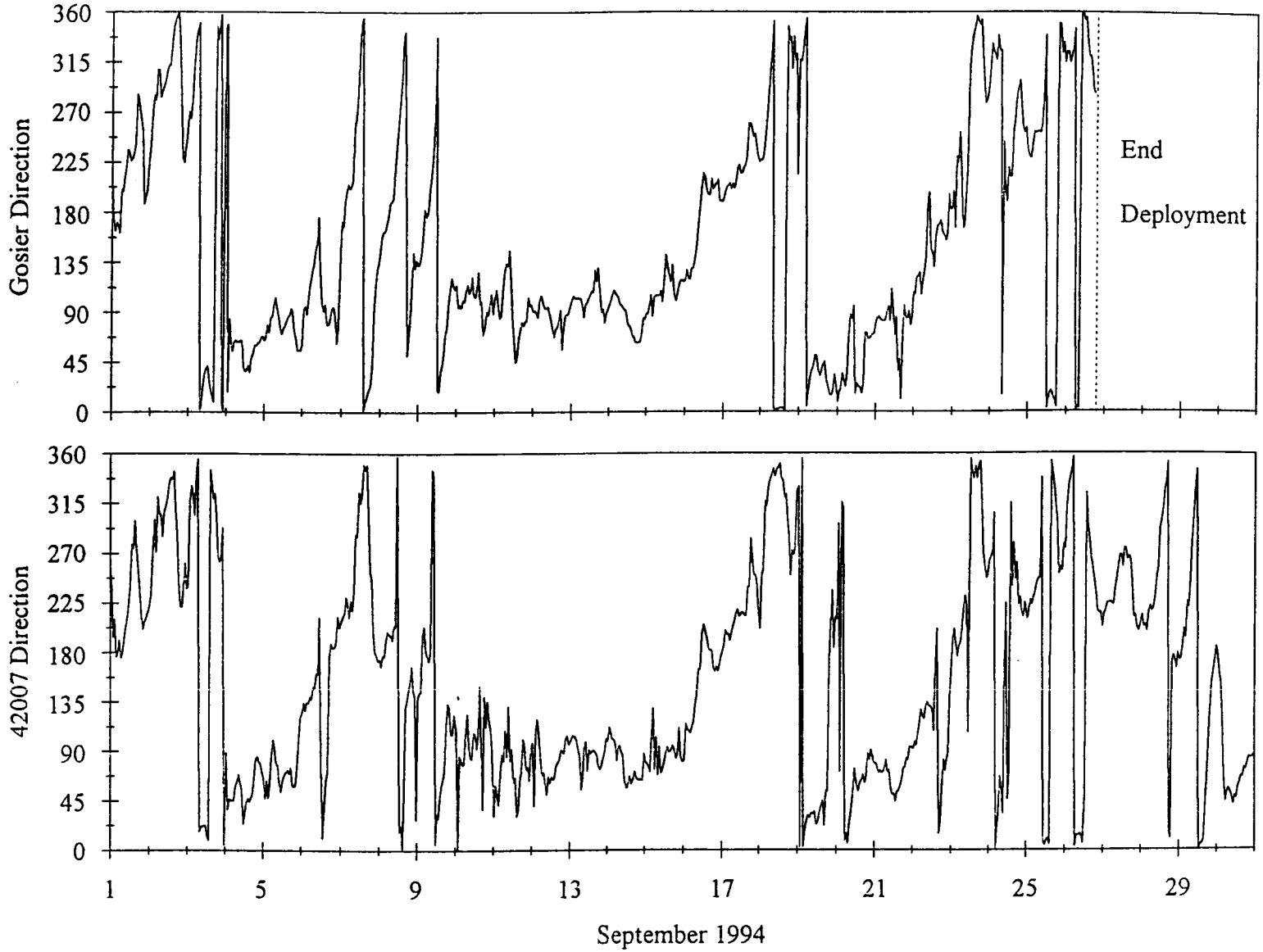


Figure 3i. September 1994 hourly wind direction at Gosier Island and NOAA buoy 42007.

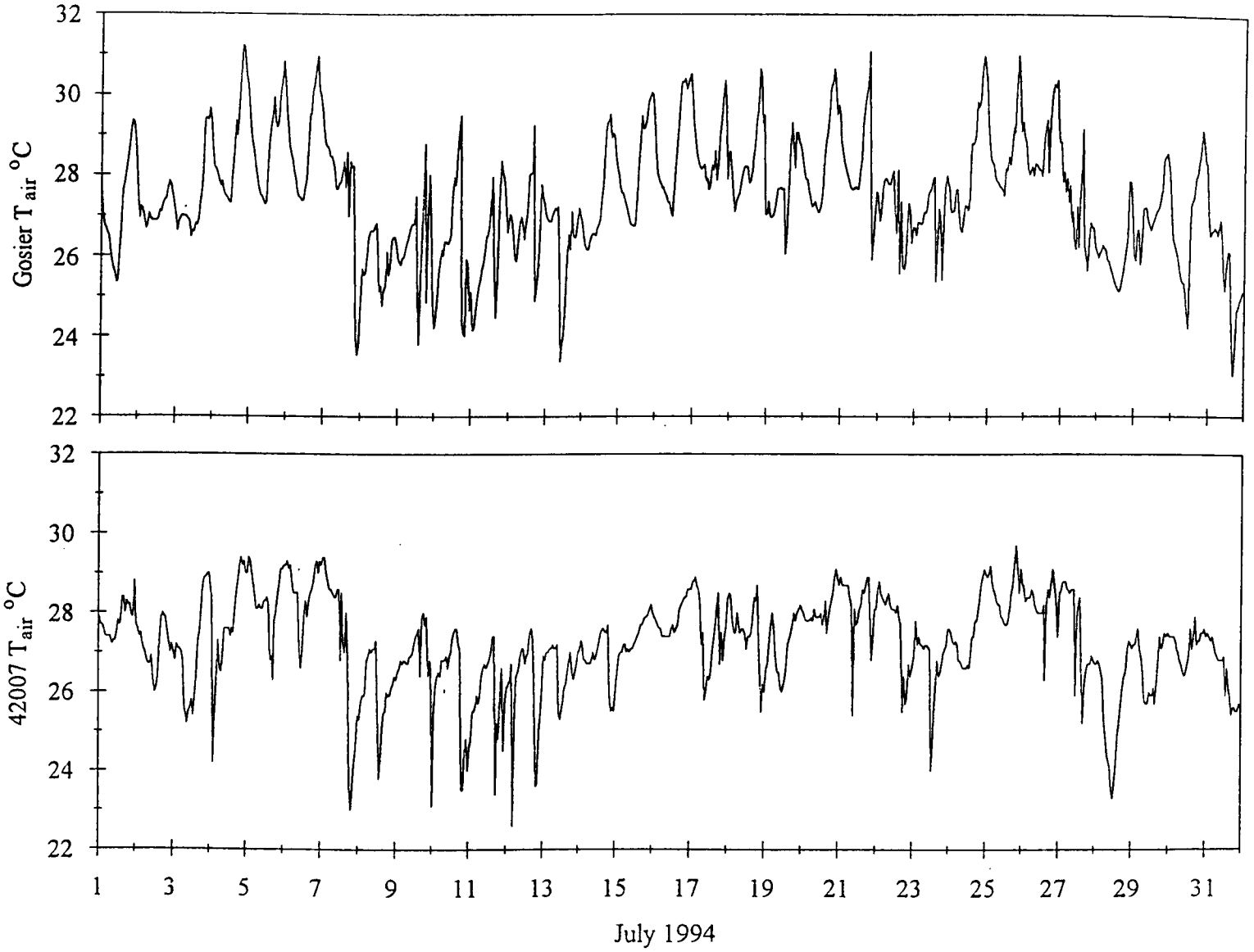


Figure 3j. July 1994 hourly air temperatures at Gosier Island and NOAA buoy 42007.

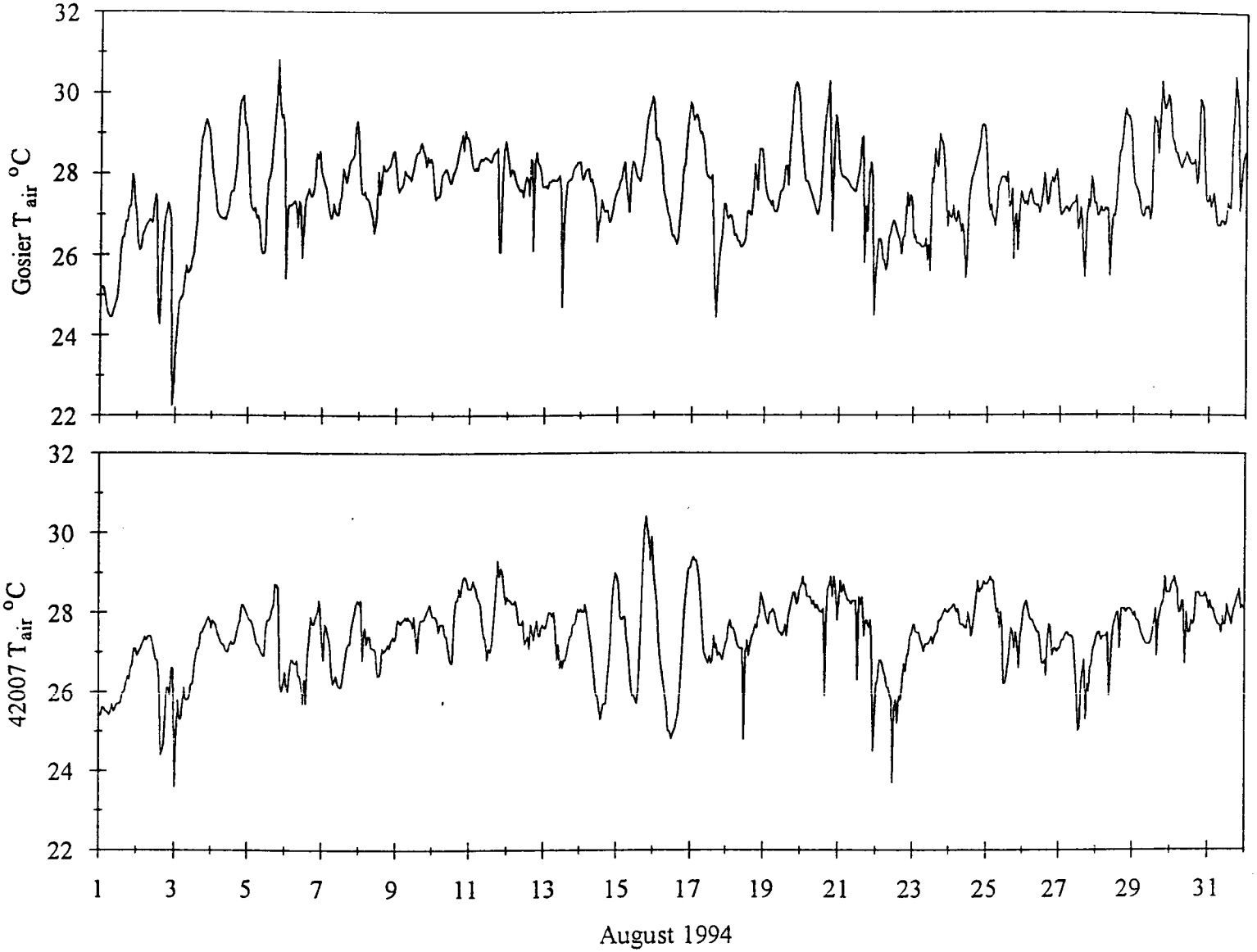


Figure 3k. August 1994 hourly air temperatures at Gosier Island and NOAA buoy 42007.

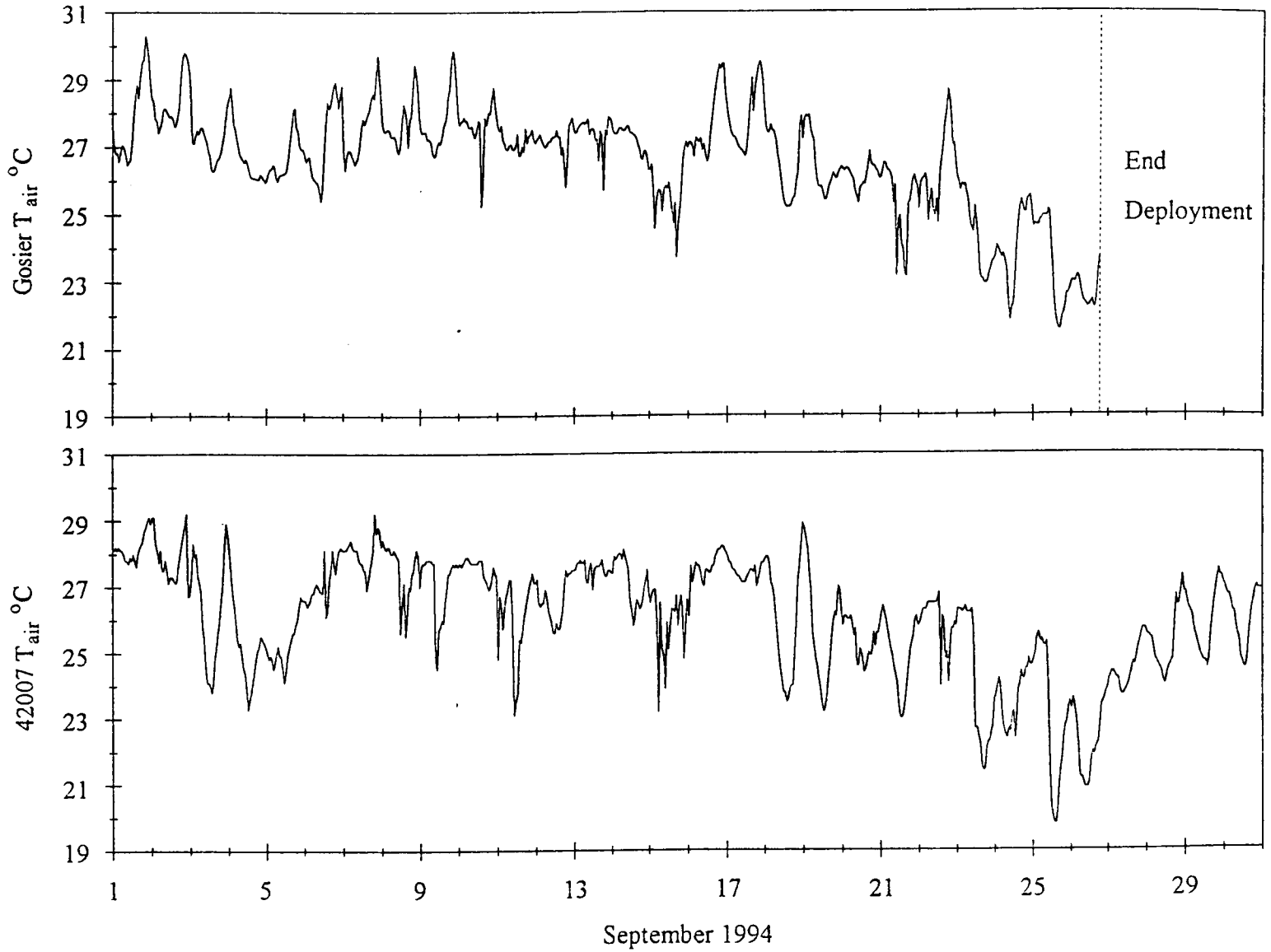


Figure 31. September 1994 hourly air temperatures at Gosier Island and NOAA buoy 42007.

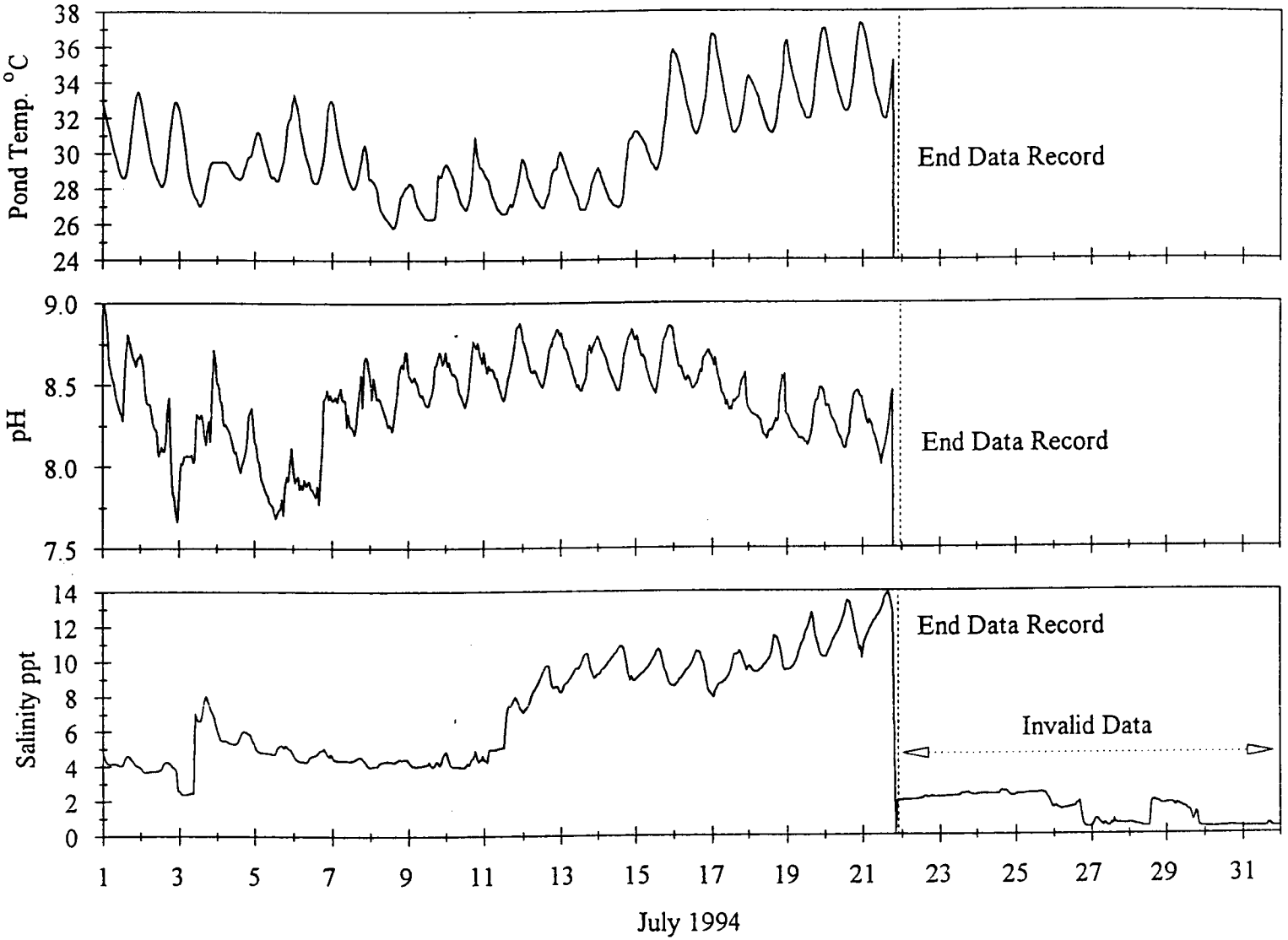


Figure 3m. July 1994 hourly pond data Gosier Island (see text for explanation).

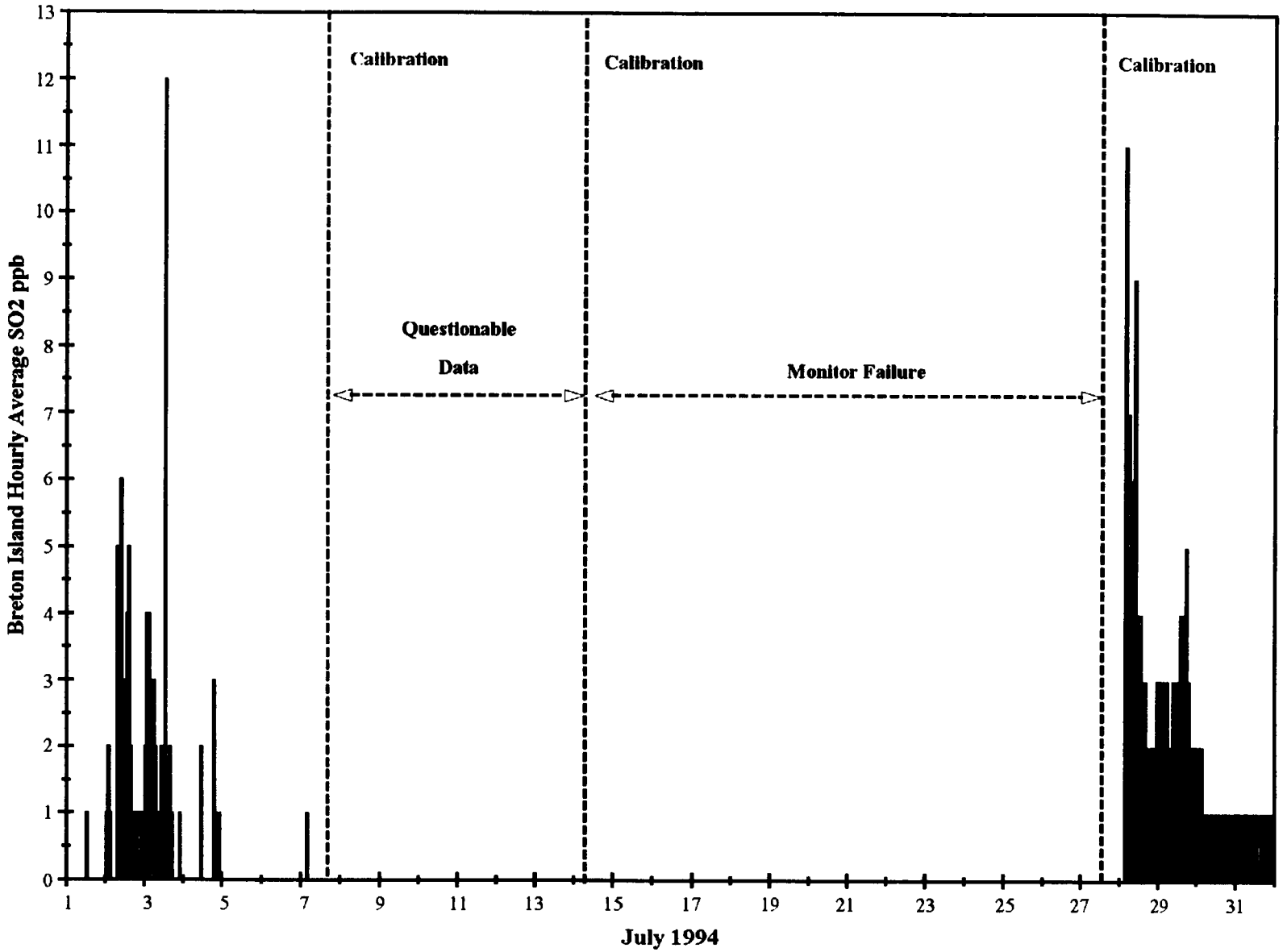


Figure 4a. July 1994 hourly SO_2 concentrations at Breton Island.

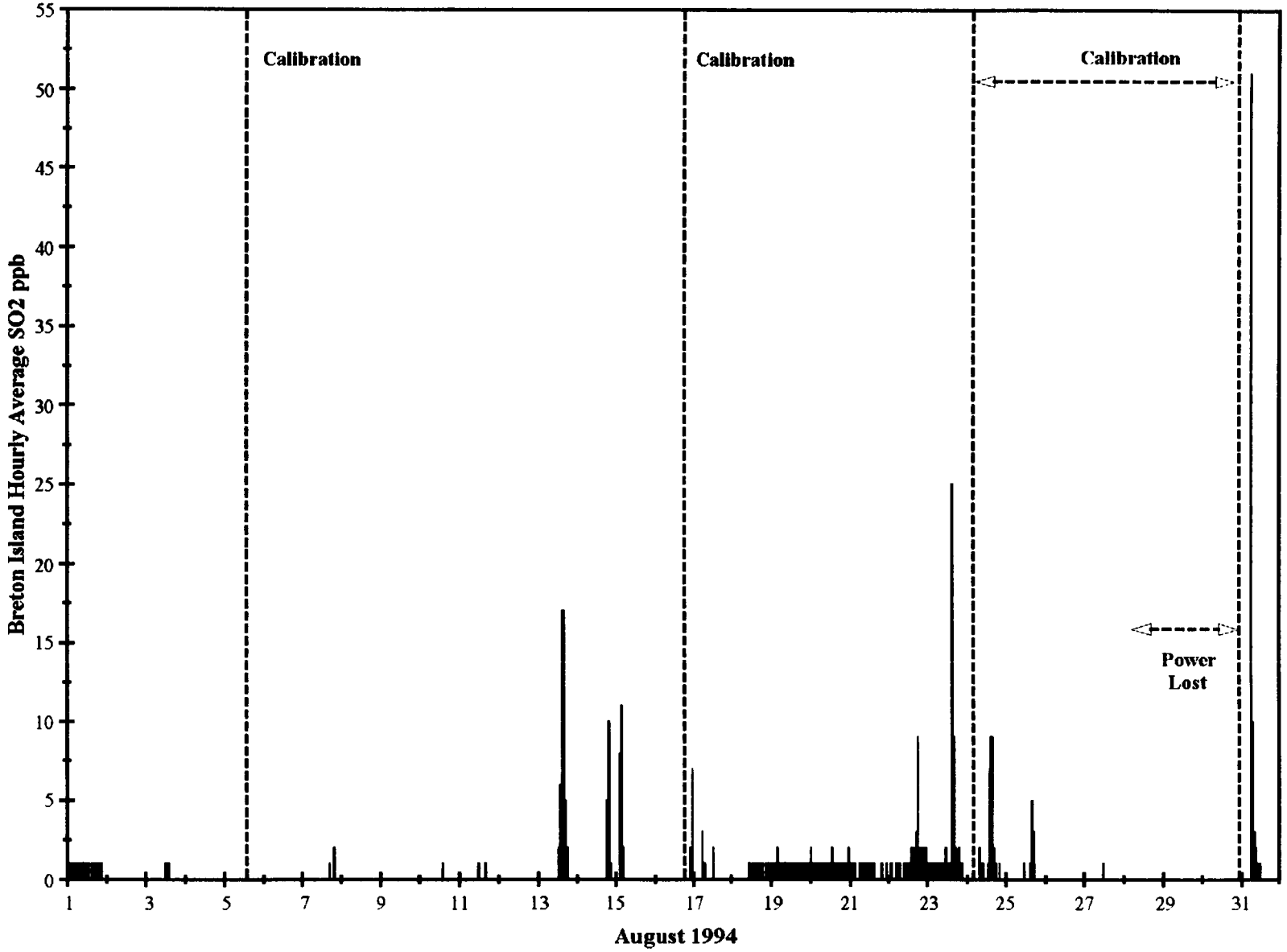


Figure 4b. August 1994 hourly SO_2 concentrations at Breton Island.

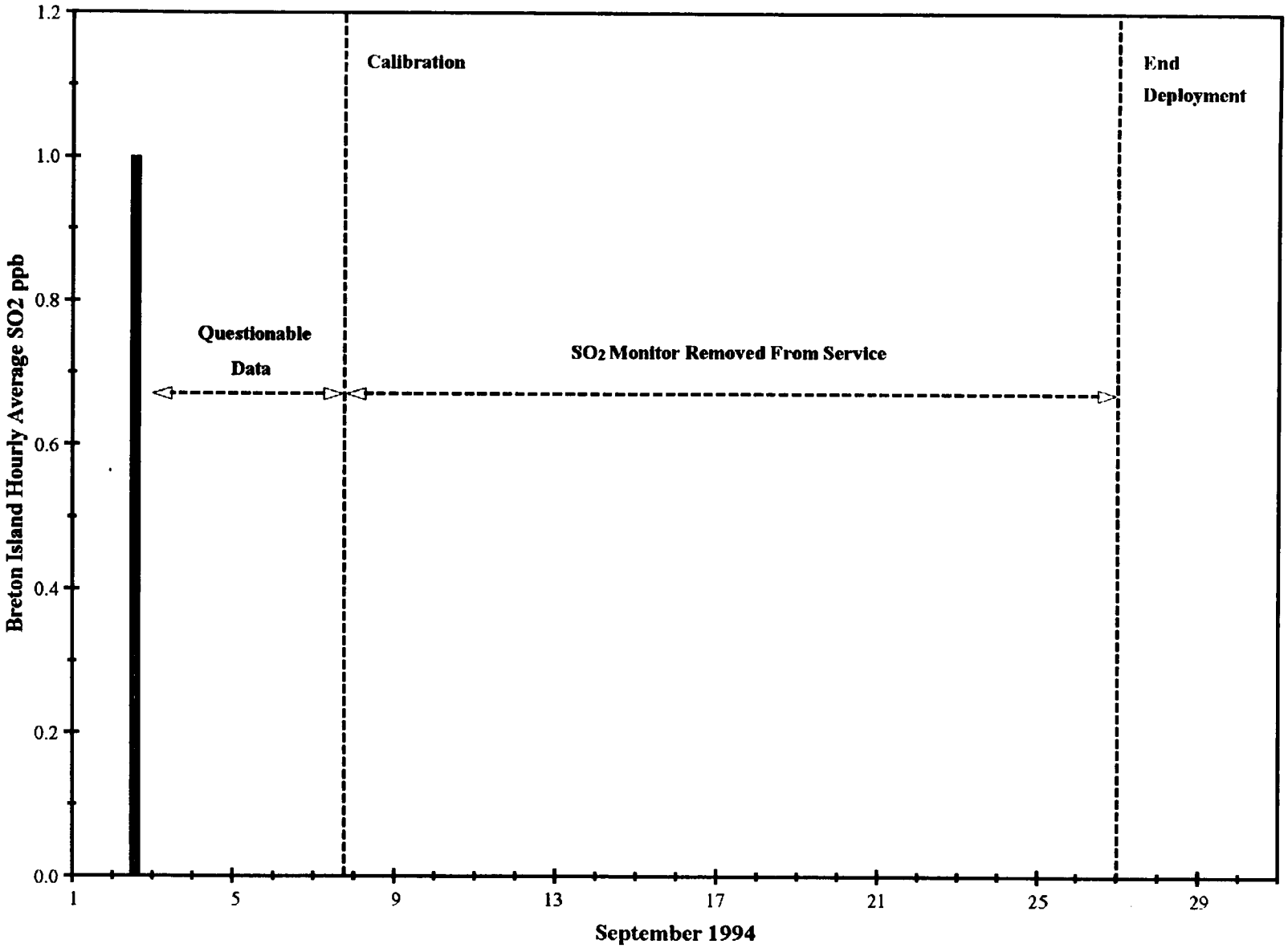


Figure 4c. September 1994 hourly SO_2 concentrations at Breton Island.

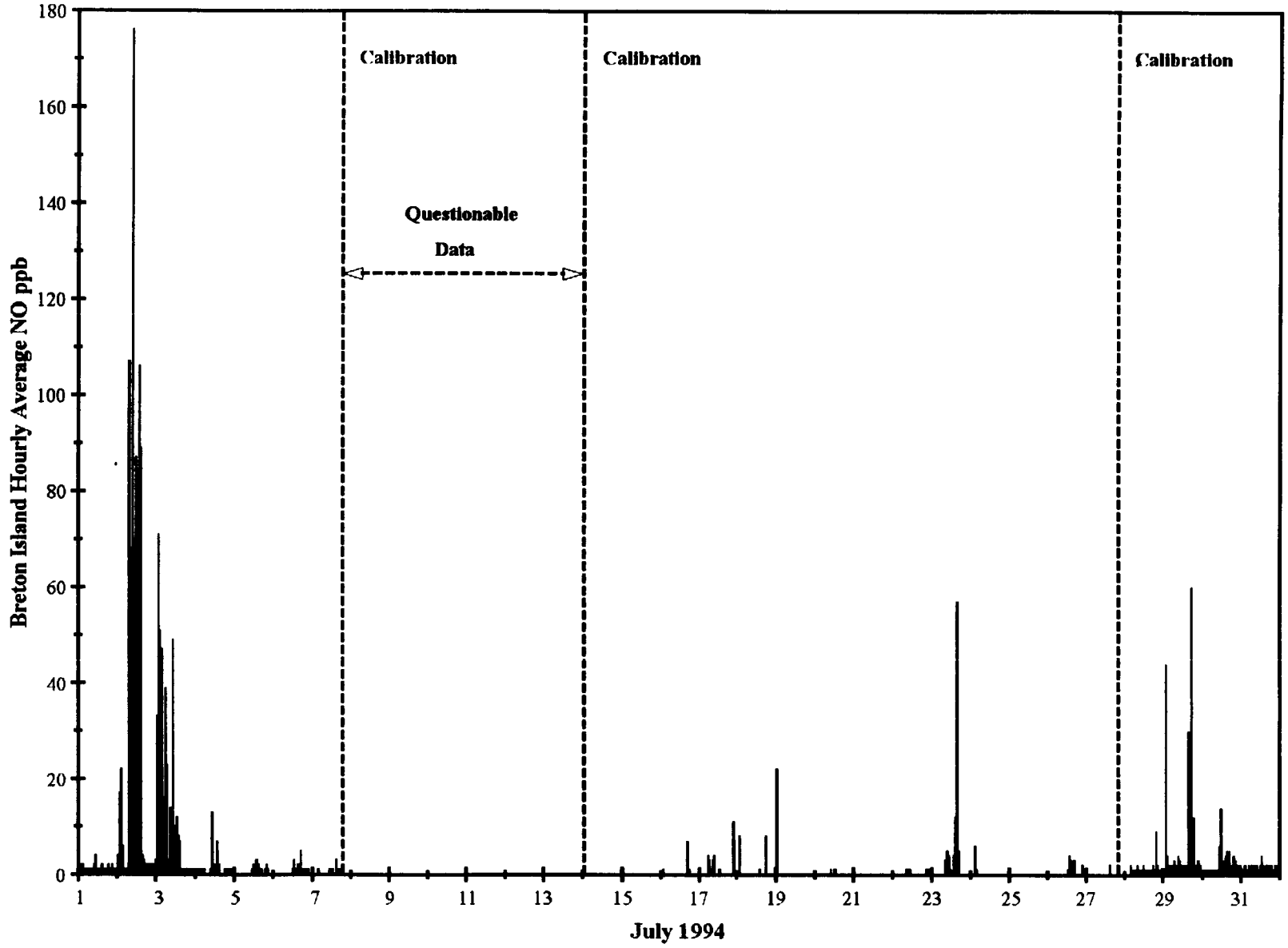


Figure 4d. July 1994 hourly NO concentrations at Breton Island.

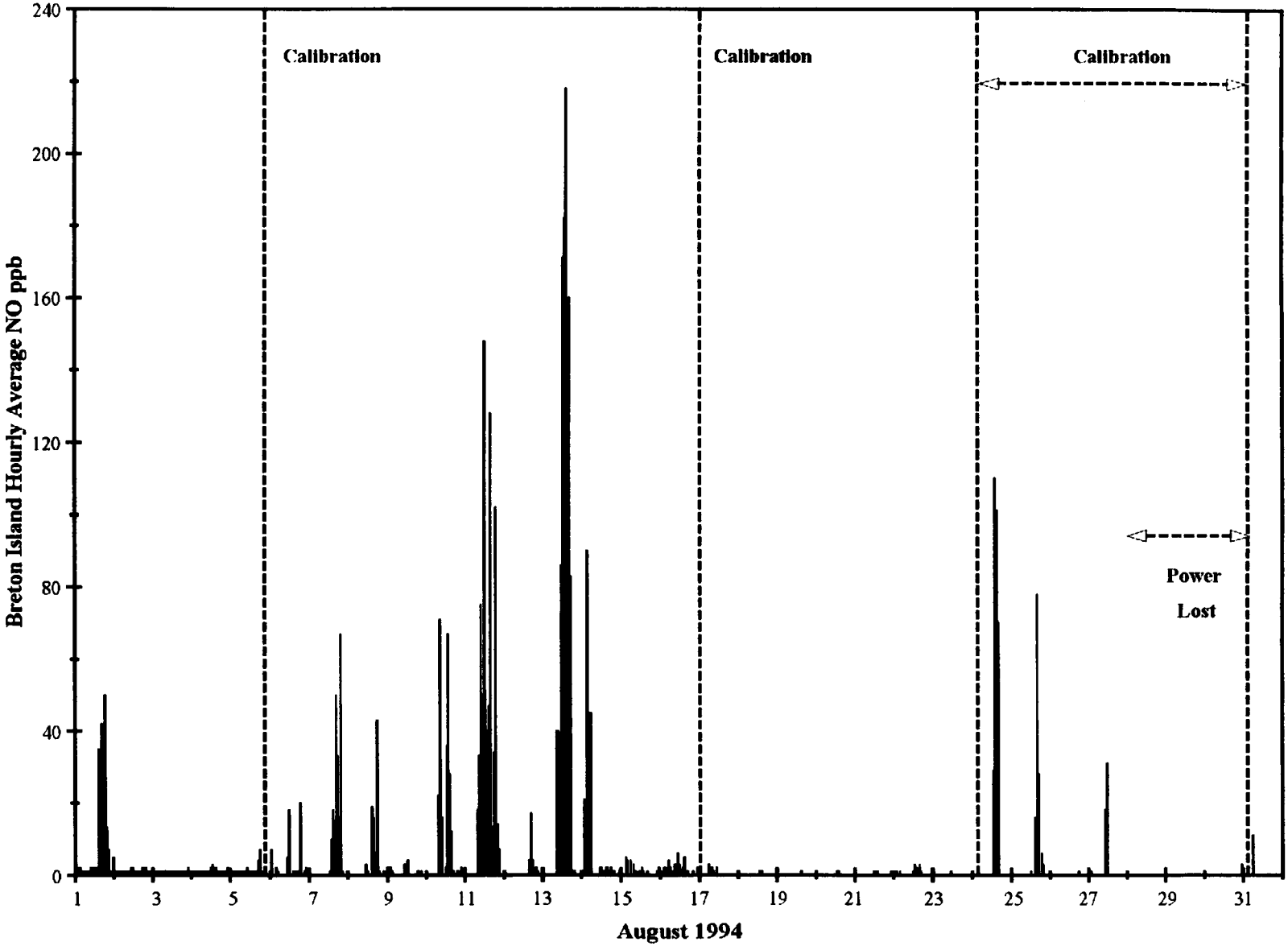


Figure 4e. August 1994 hourly NO concentrations at Breton Island.

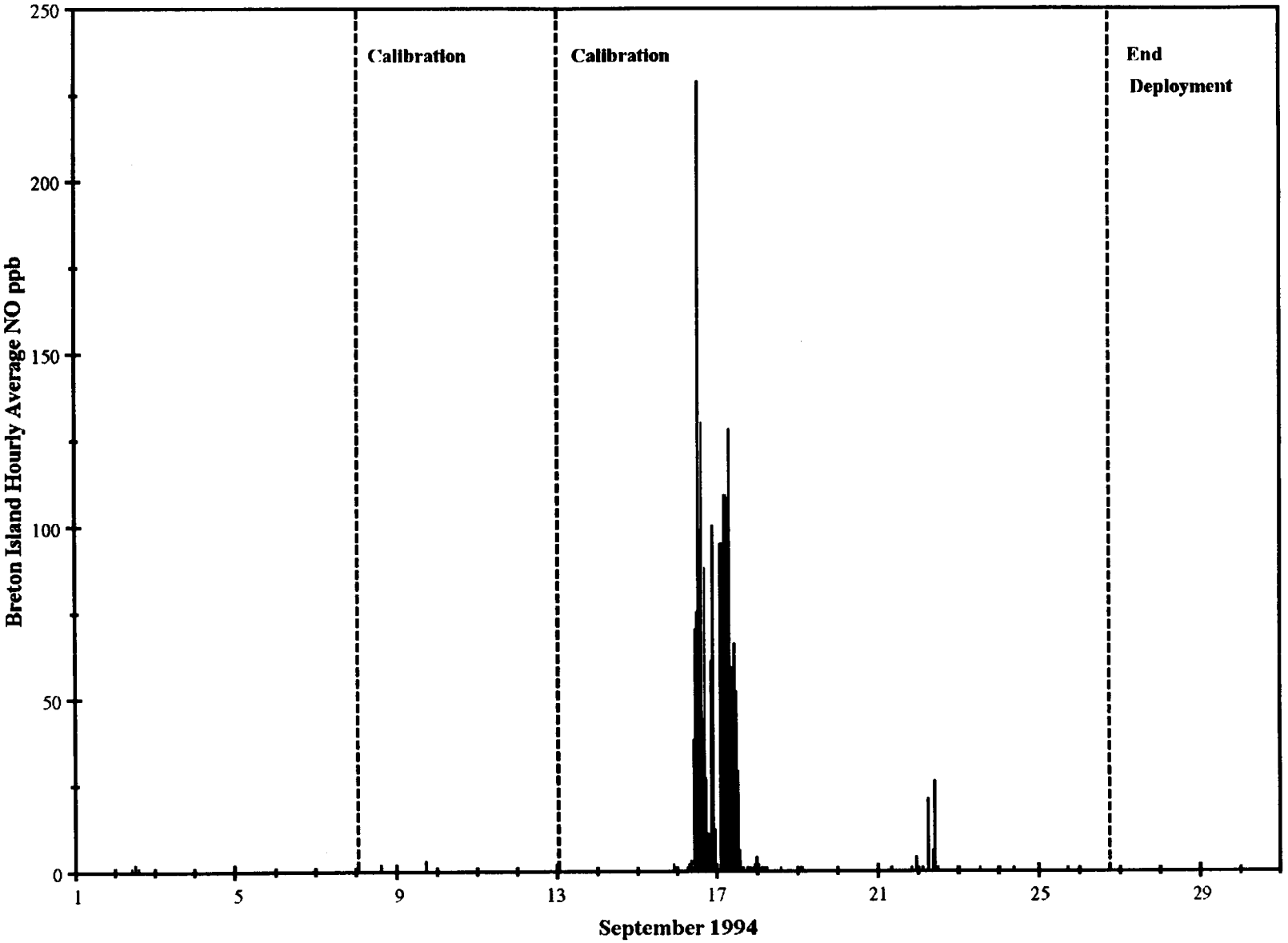


Figure 4f. September 1994 hourly NO concentrations at Breton Island.

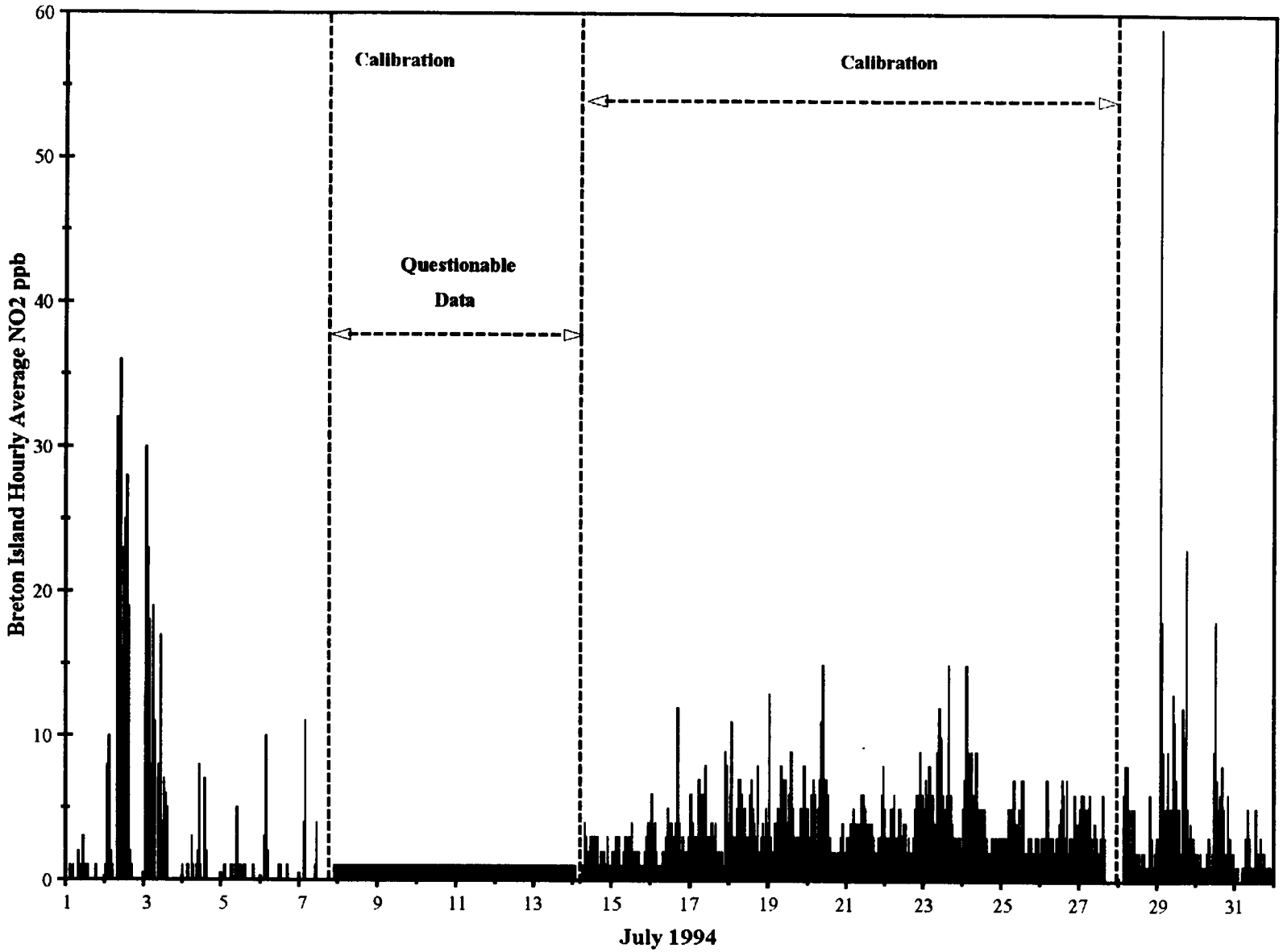


Figure 4g. July 1994 hourly NO_2 concentrations at Breton Island.

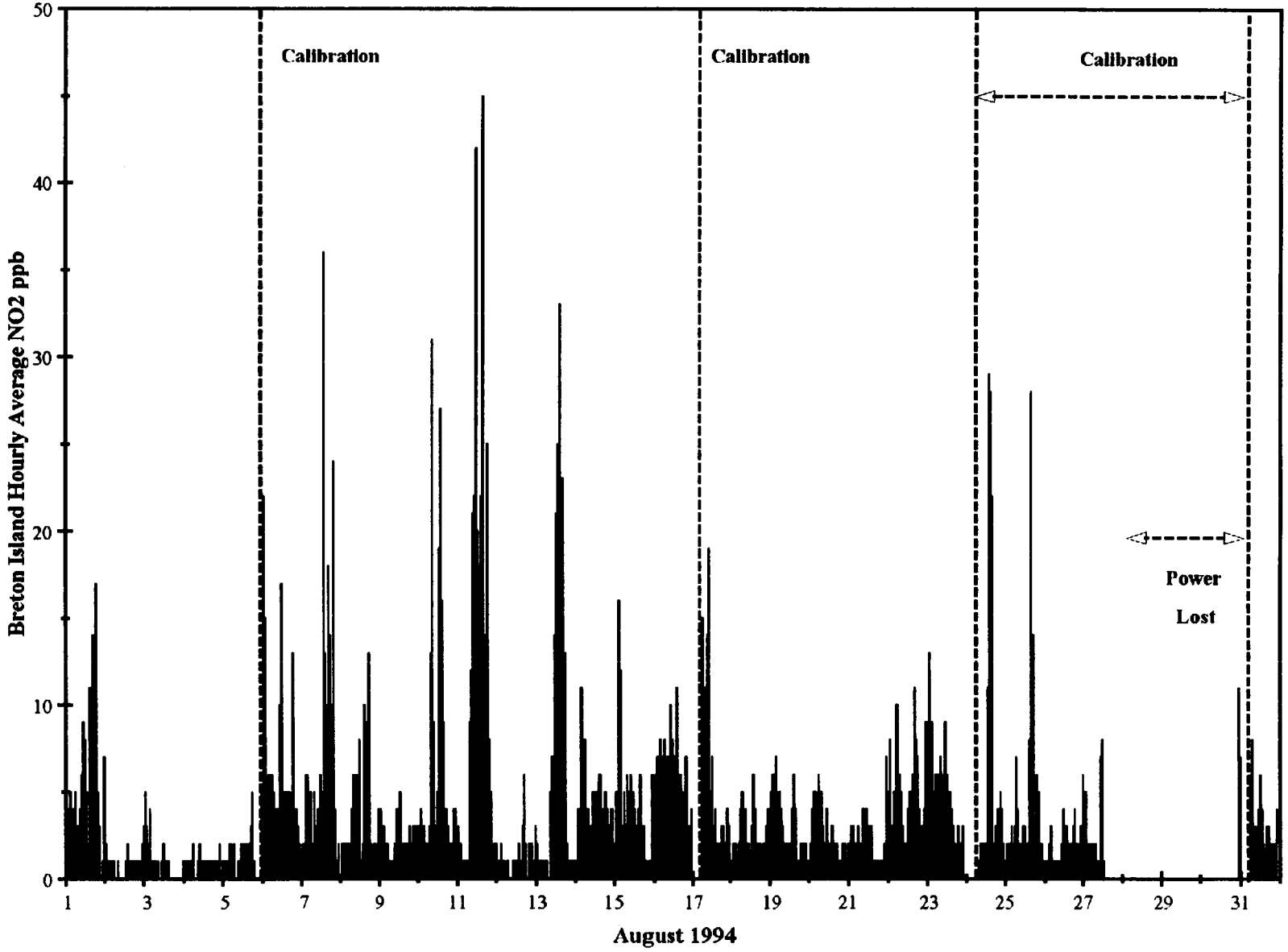


Figure 4h. August 1994 hourly NO_2 concentrations at Breton Island.

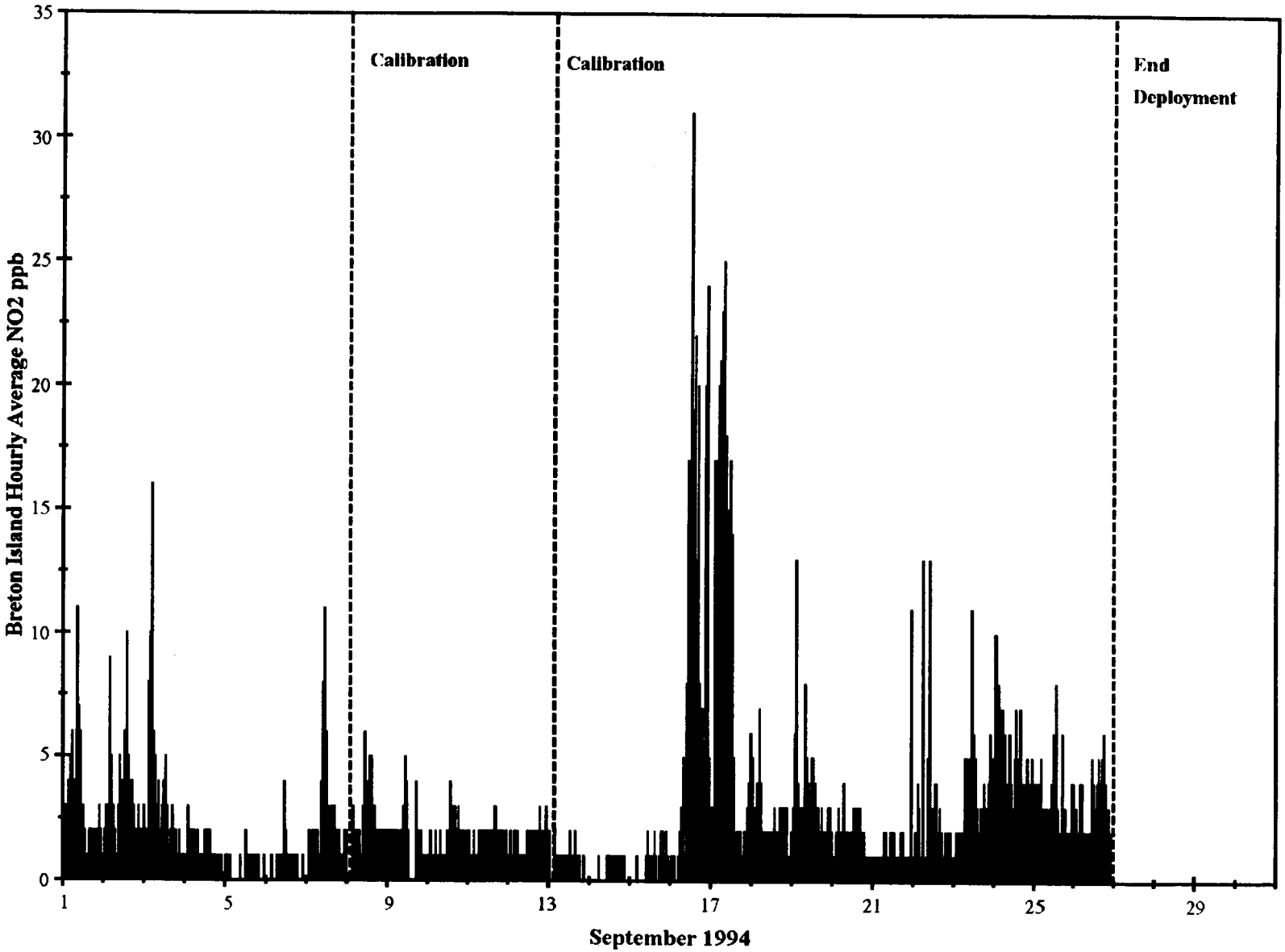


Figure 4i. September 1994 hourly NO_2 concentrations at Breton Island.

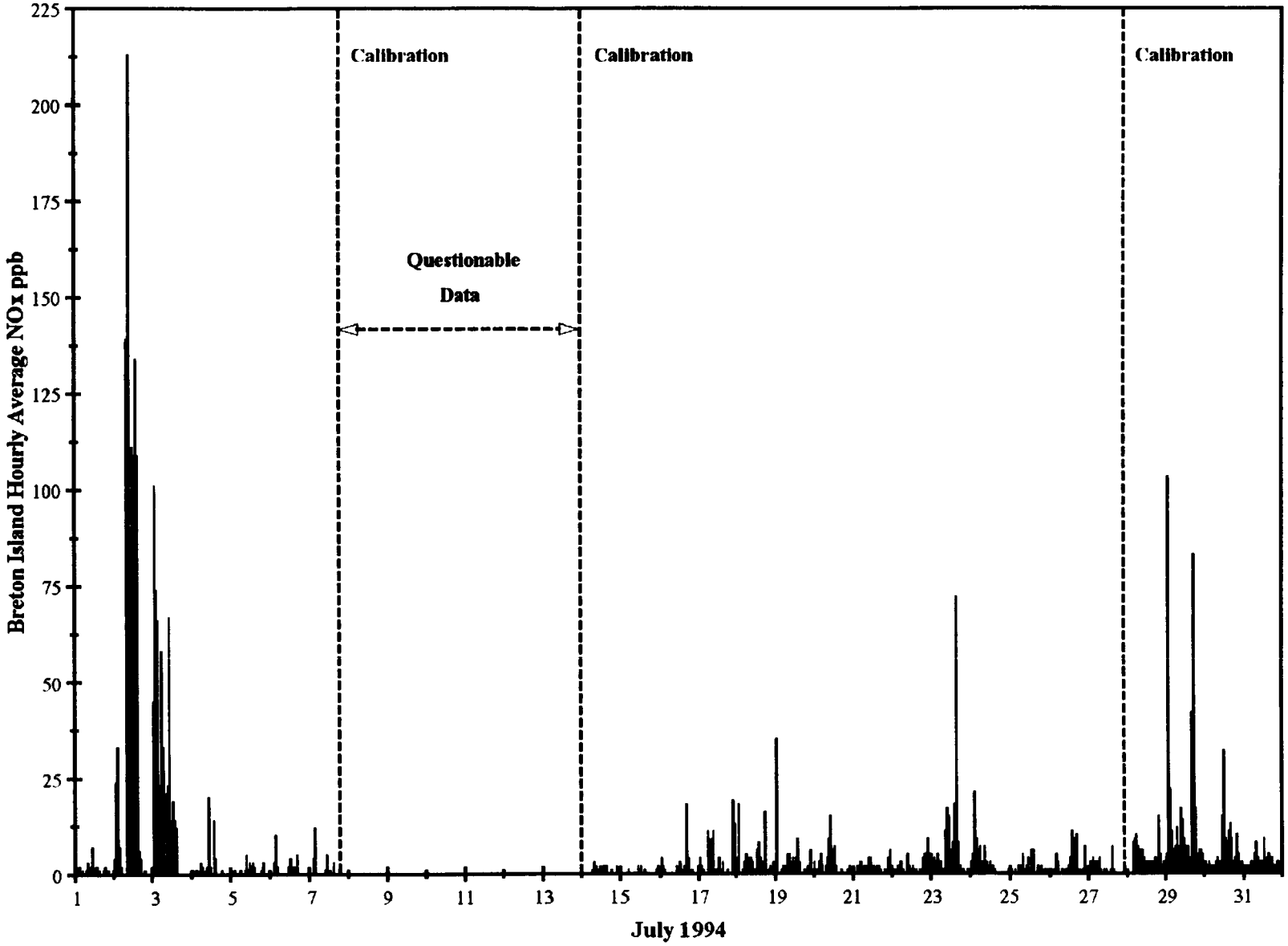


Figure 4j. July 1994 hourly NO_x concentrations at Breton Island.

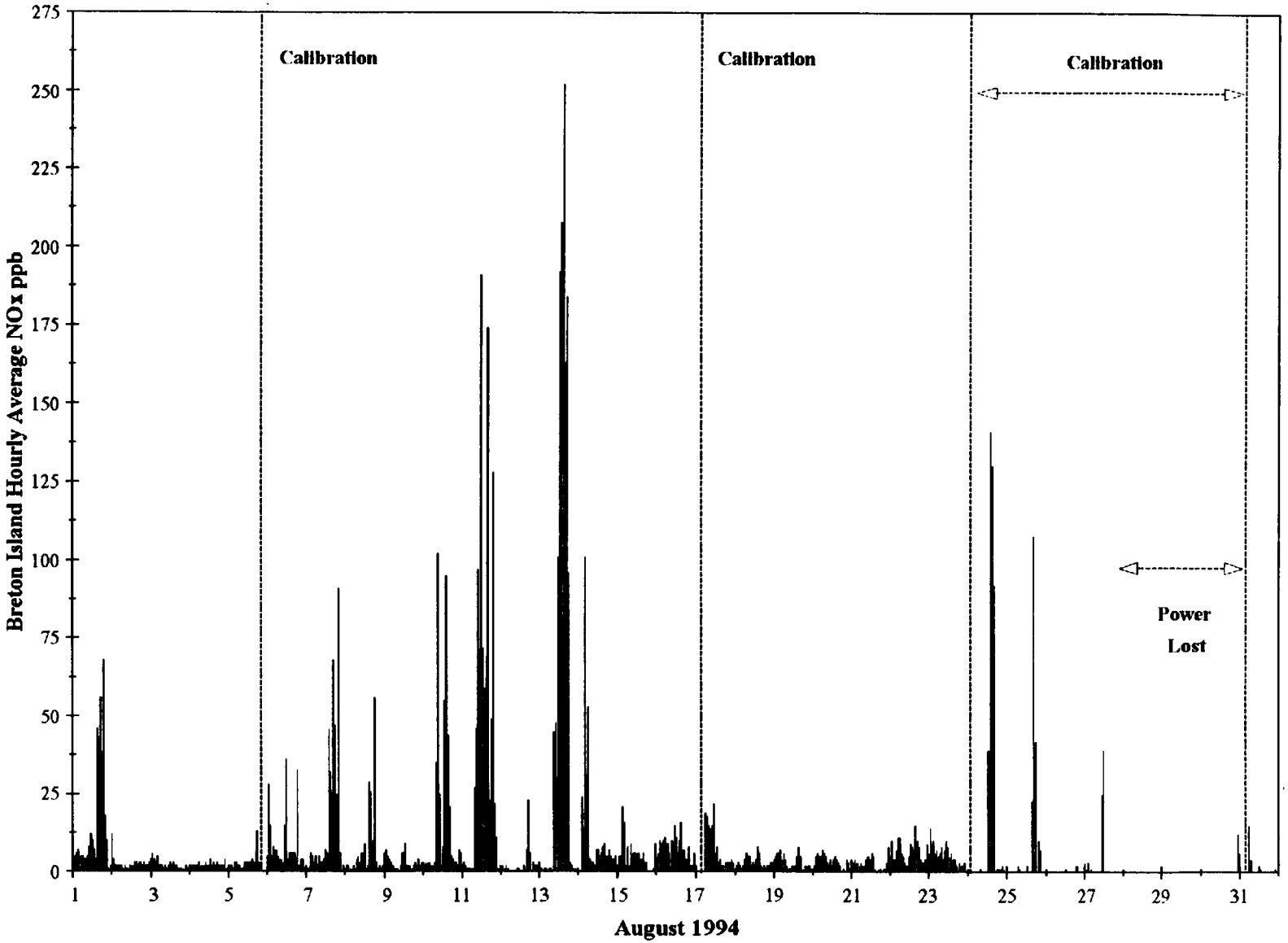


Figure 4k. August 1994 hourly NO_x concentrations at Breton Island.

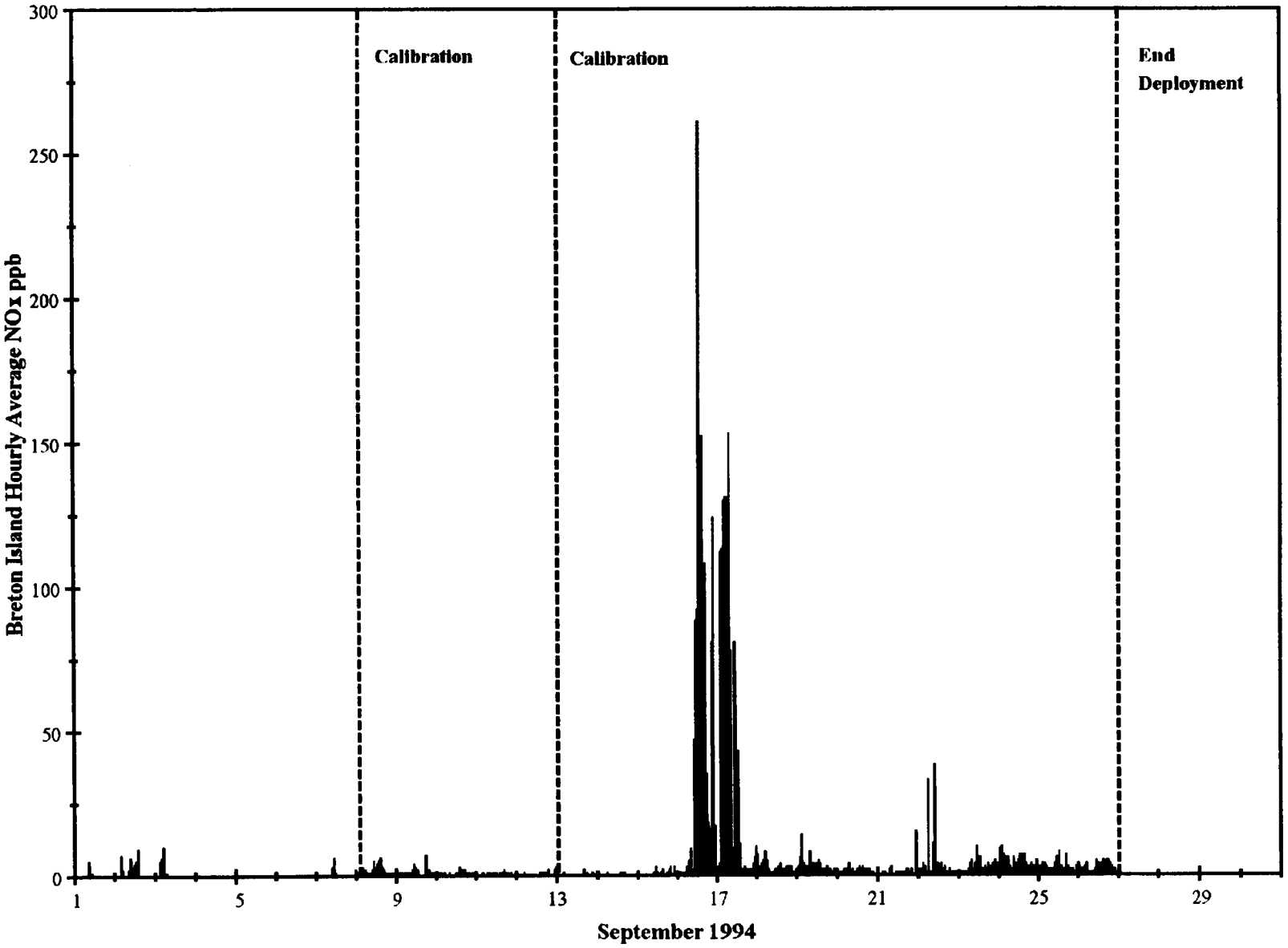


Figure 41. September 1994 hourly NO_x concentrations at Breton Island.

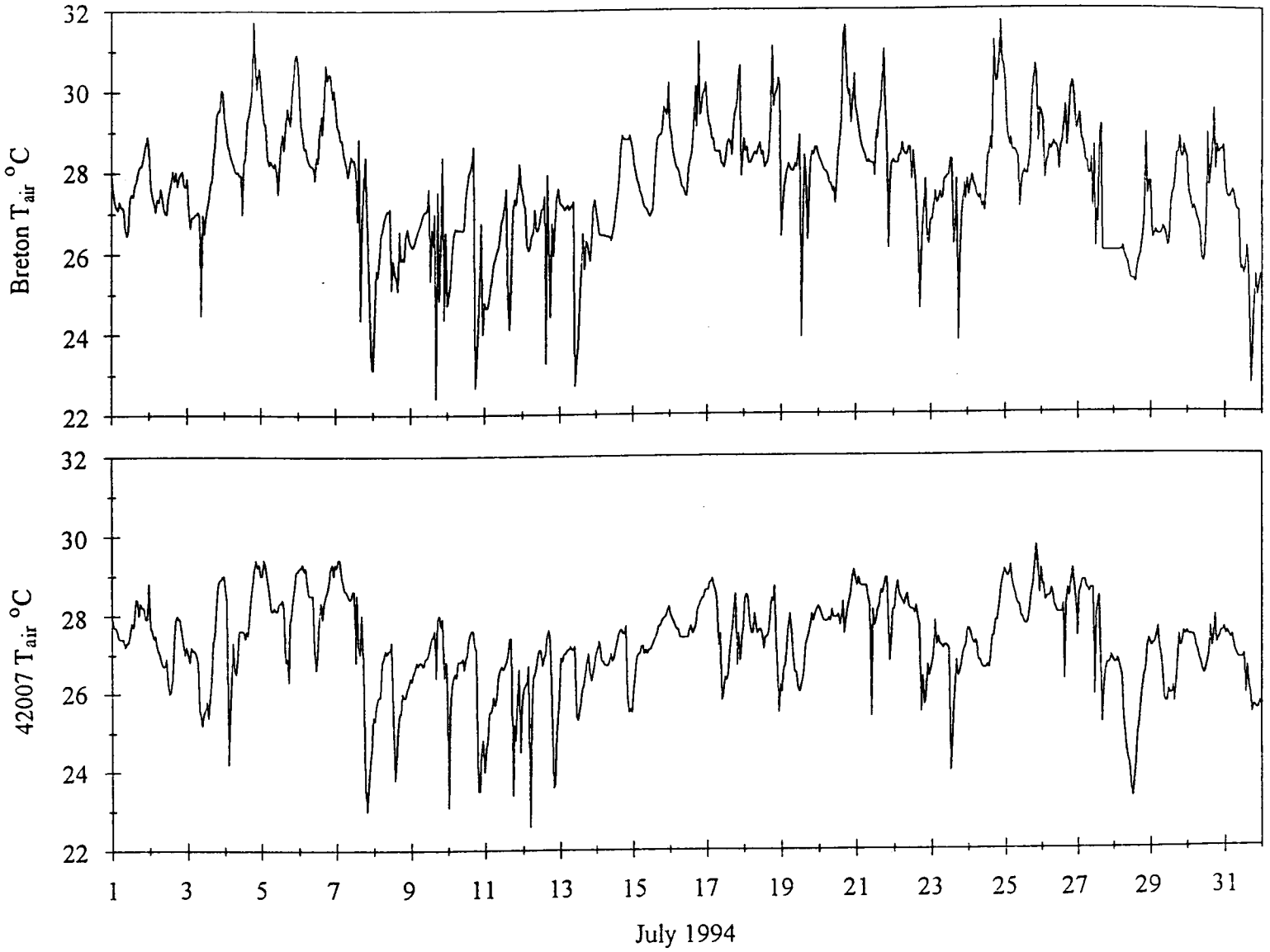


Figure 4m. July 1994 hourly air temperatures from Breton Island and NOAA buoy 42007.

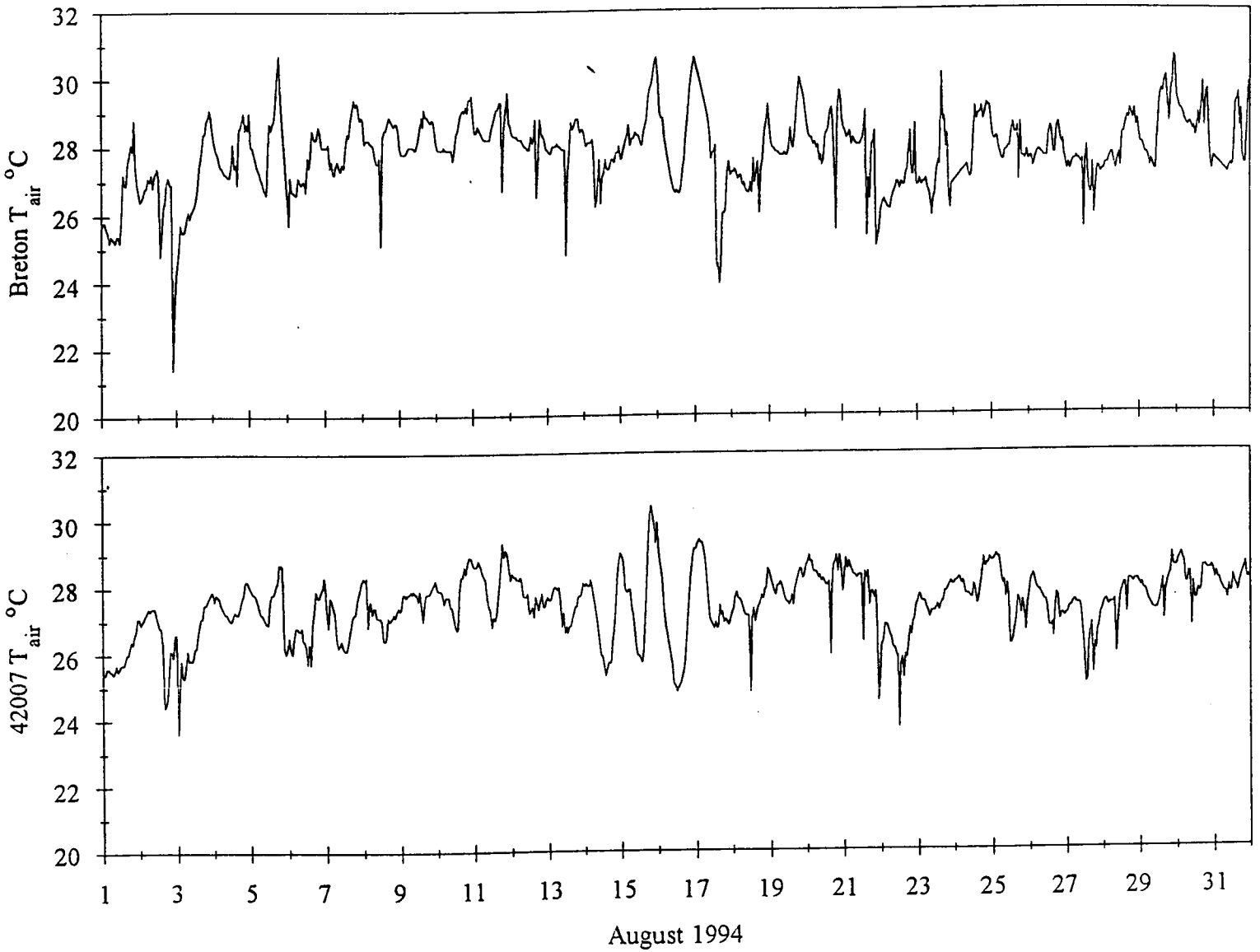


Figure 4n. August 1994 hourly air temperatures from Breton Island and NOAA buoy 42007.

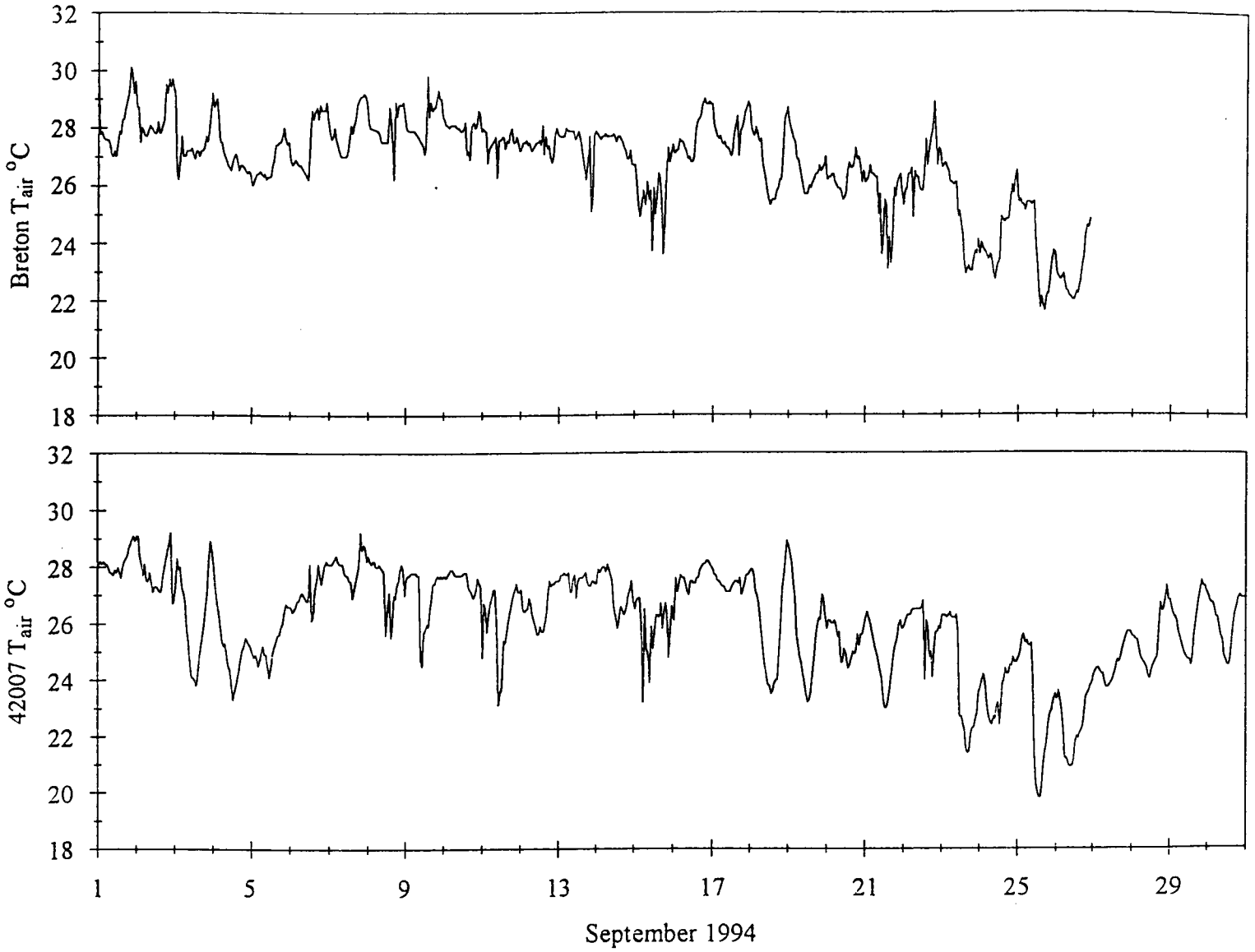


Figure 4o. September 1994 hourly air temperatures from Breton Island and NOAA buoy 42007.

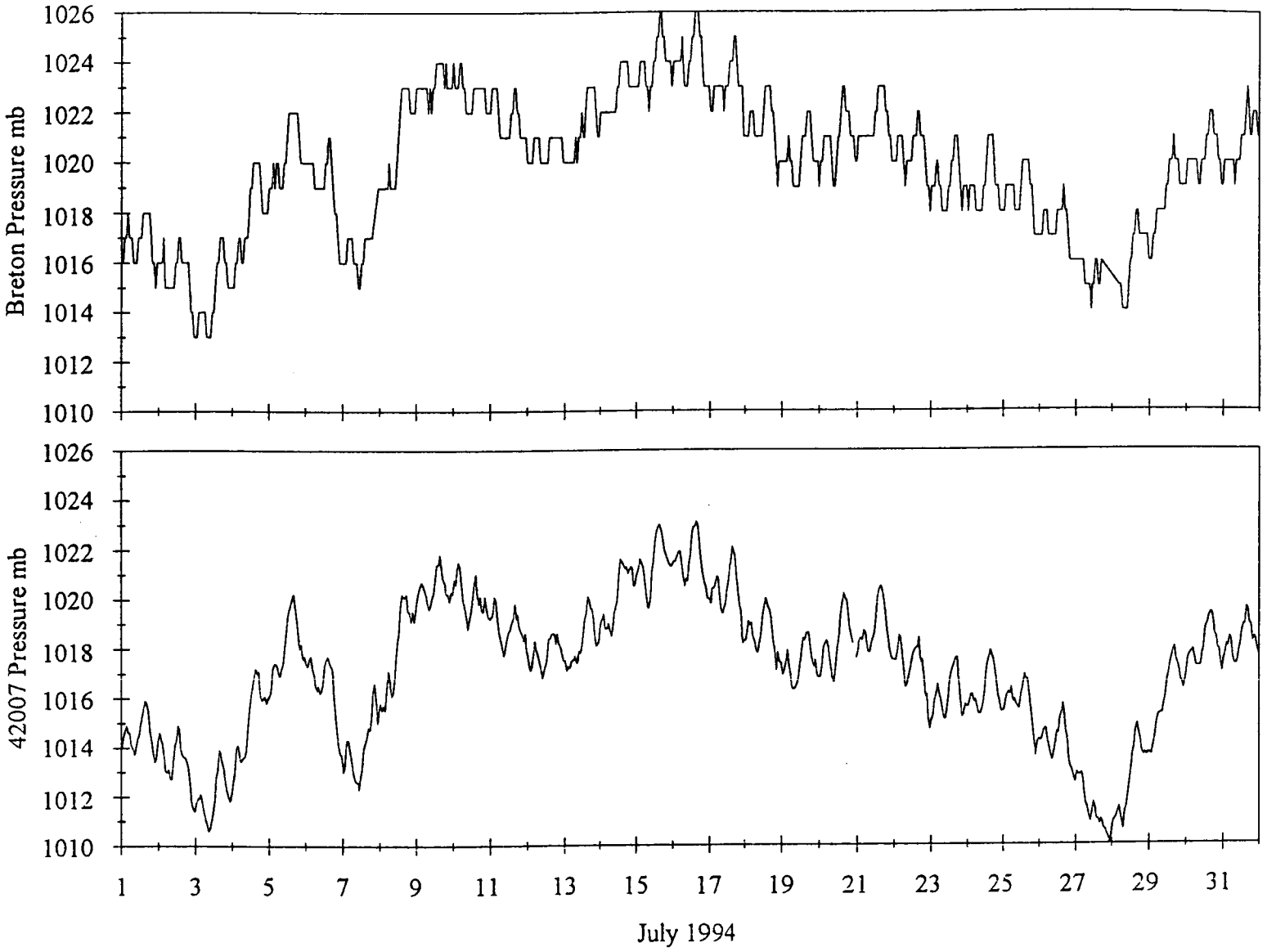


Figure 4p. July 1994 hourly atmospheric pressure from Breton Island and NOAA buoy 42007.

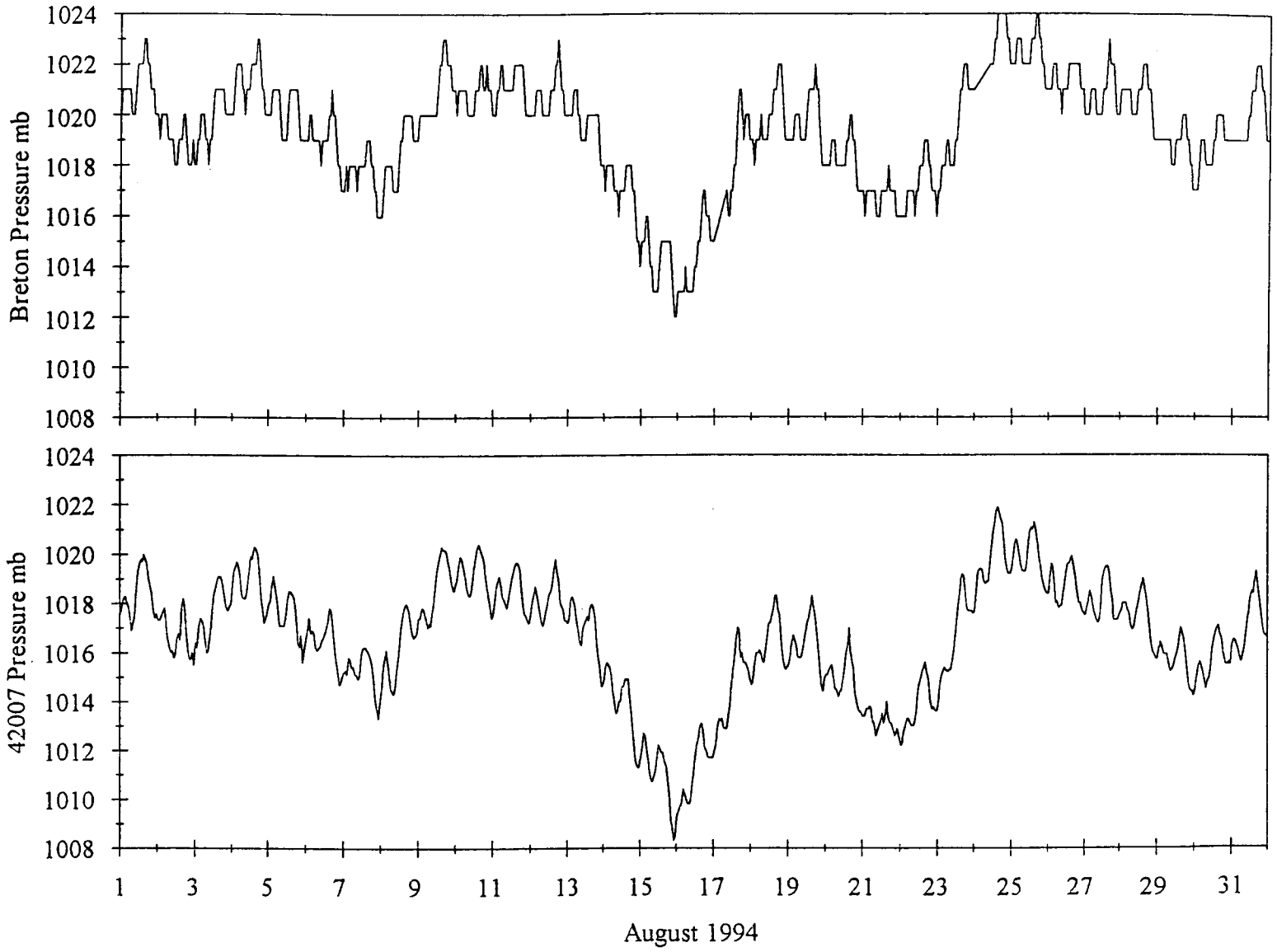


Figure 4q. August 1994 hourly atmospheric pressure from Breton Island and NOAA buoy 42007.

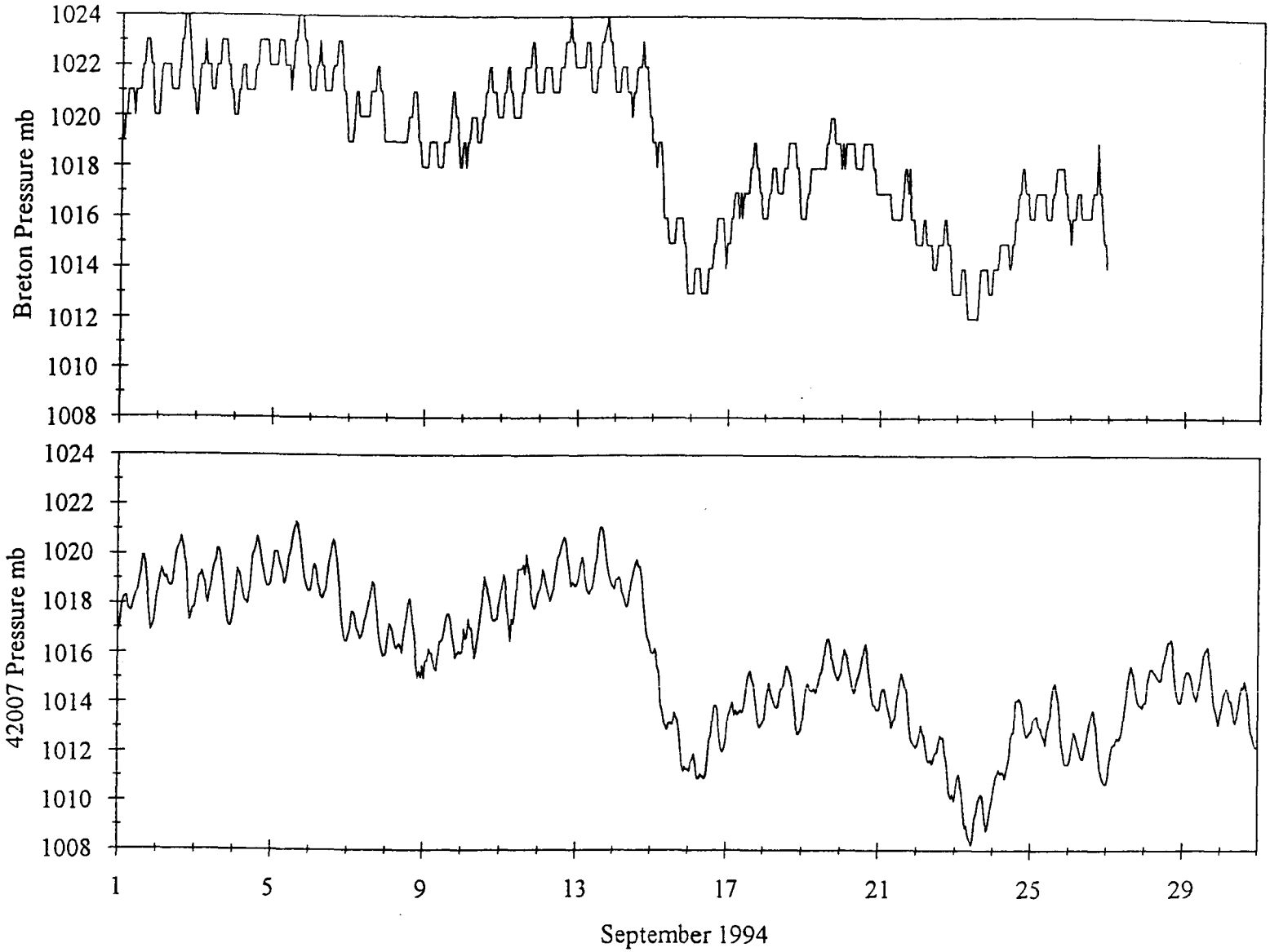


Figure 4r. September 1994 hourly atmospheric pressure from Breton Island and NOAA buoy 42007.

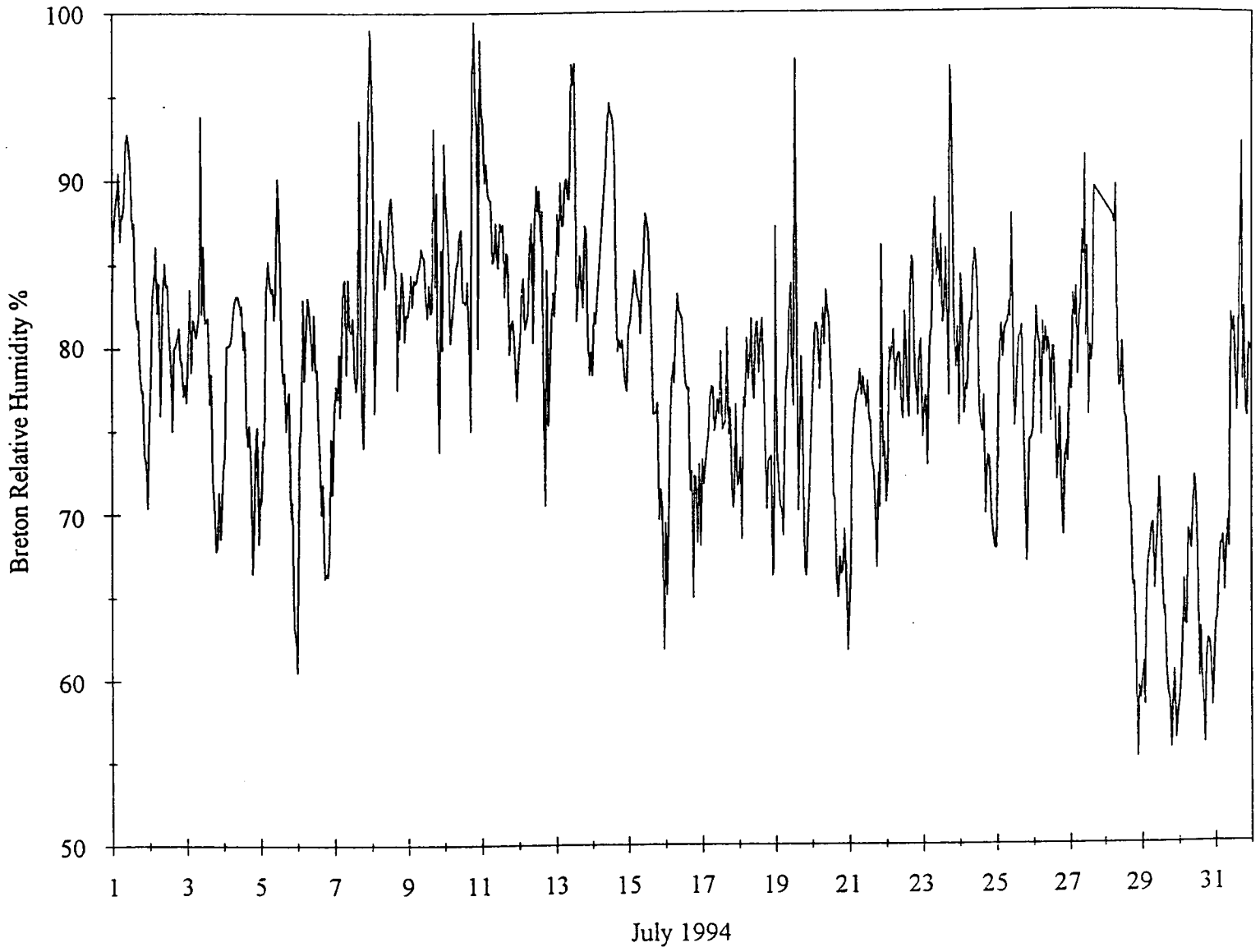


Figure 4s. July 1994 hourly relative humidity from Breton Island.

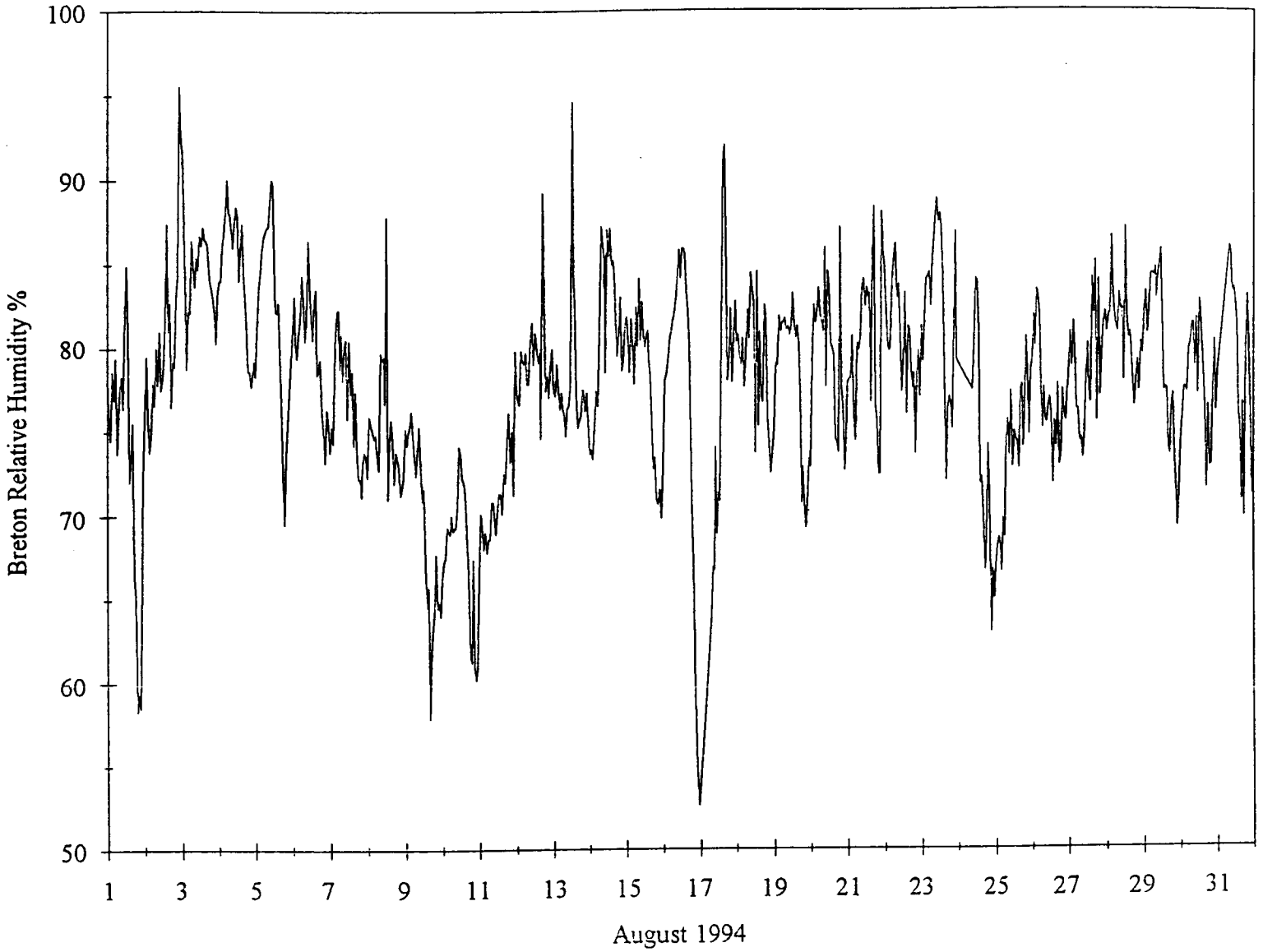


Figure 4t. August 1994 hourly relative humidity from Breton Island.

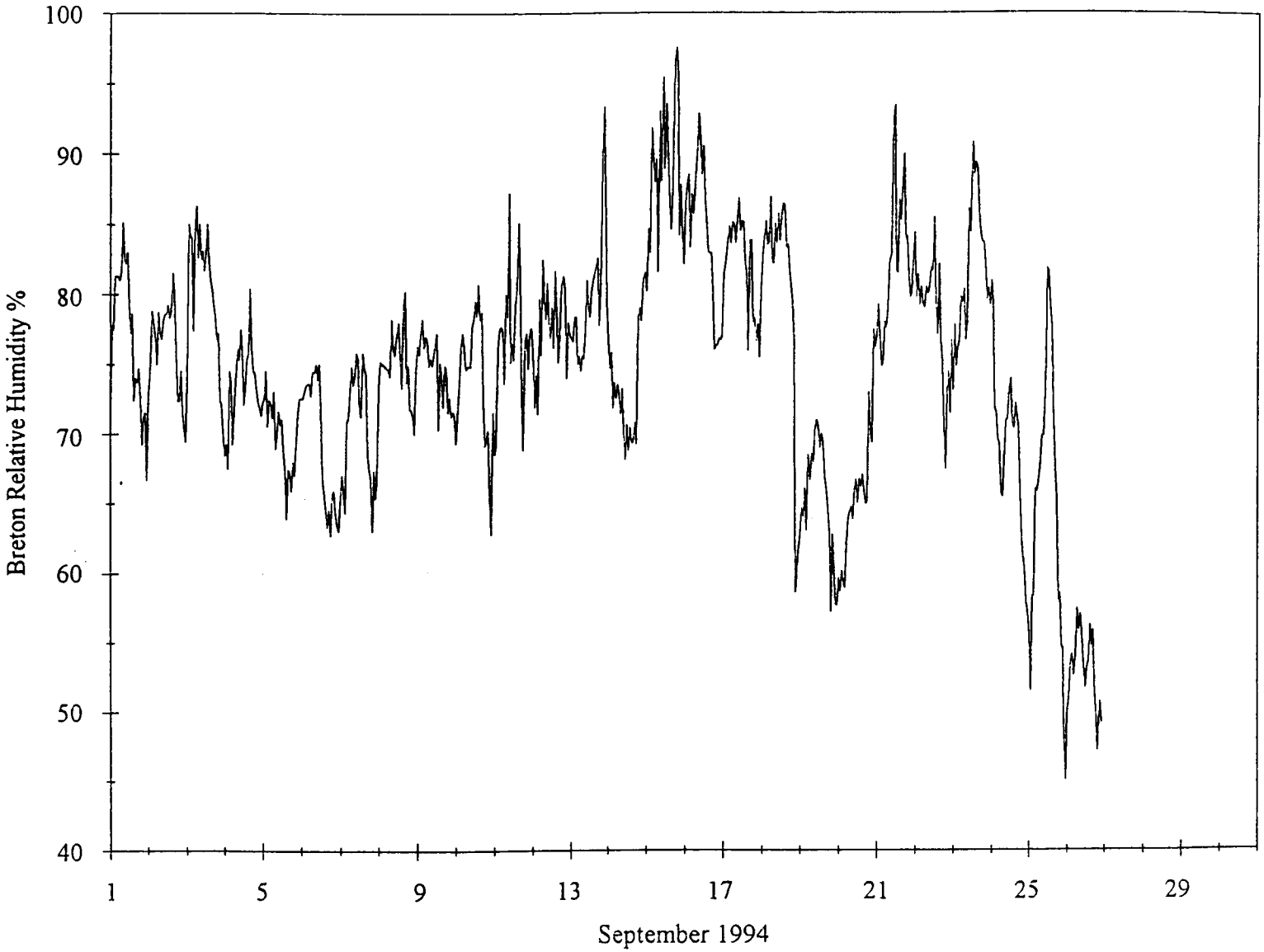


Figure 4u. September 1994 hourly relative humidity from Breton Island.

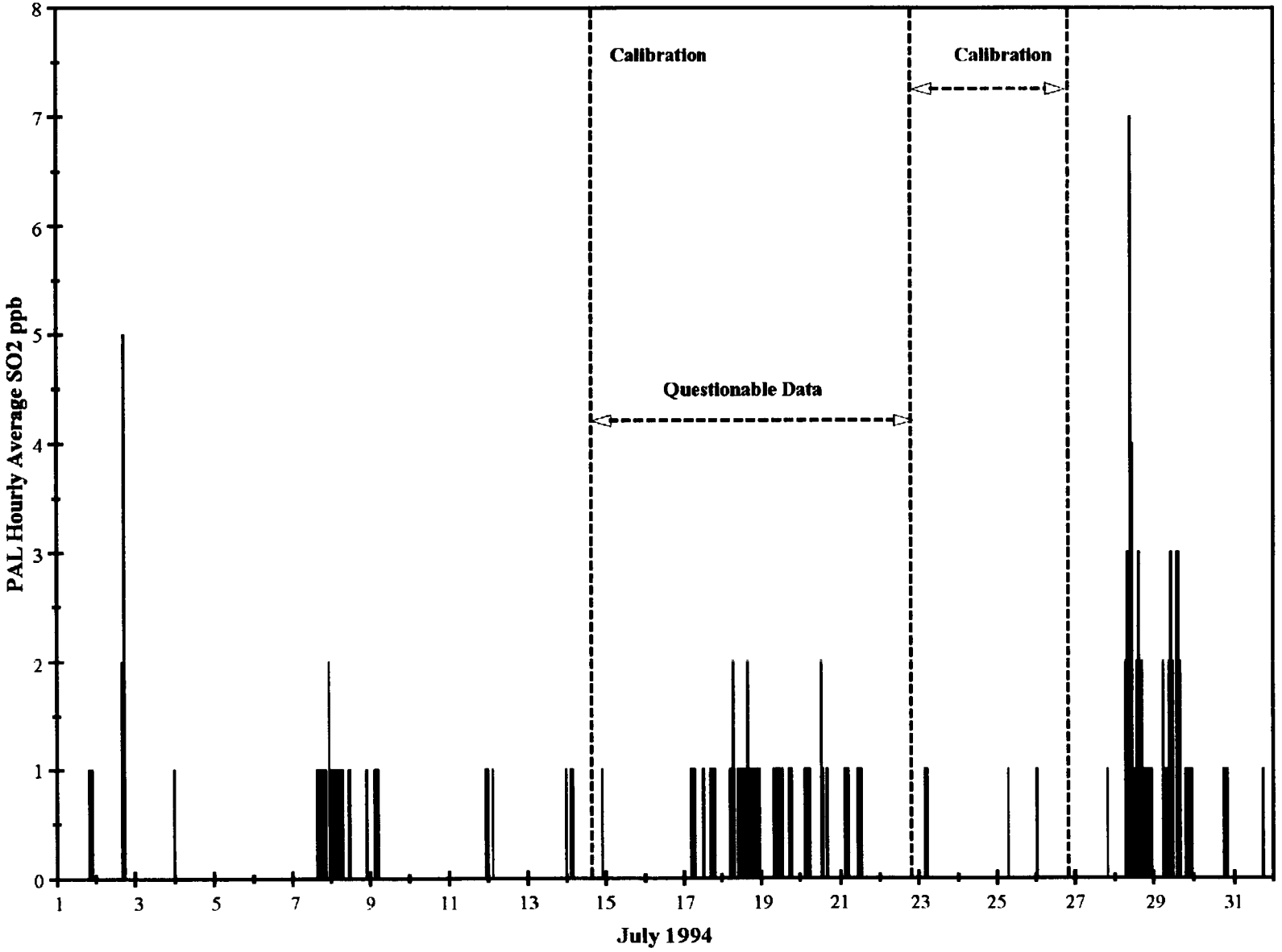


Figure 5a. July 1994 hourly SO_2 concentrations at PAL.

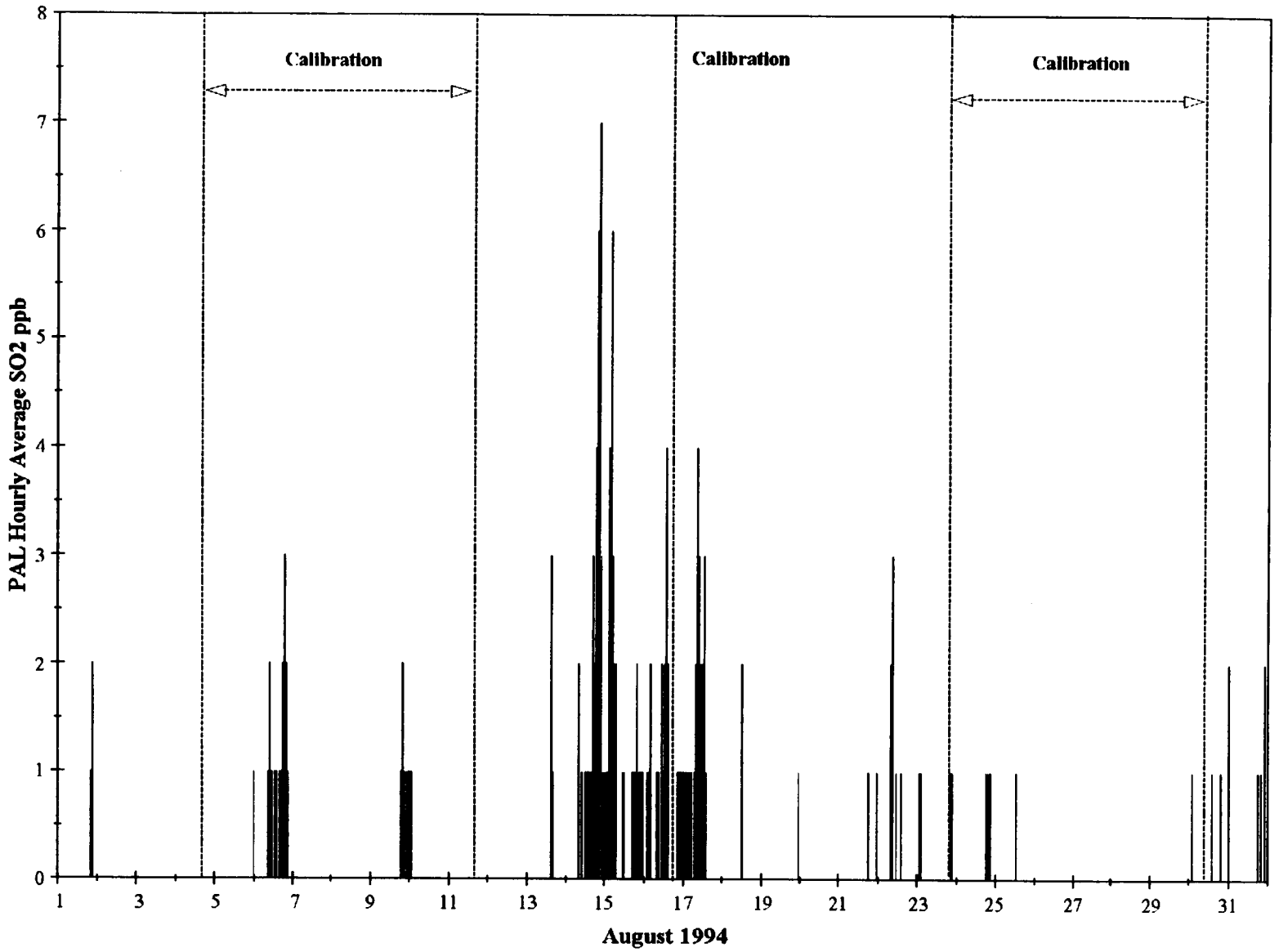


Figure 5b. August 1994 hourly SO_2 concentrations at PAL.

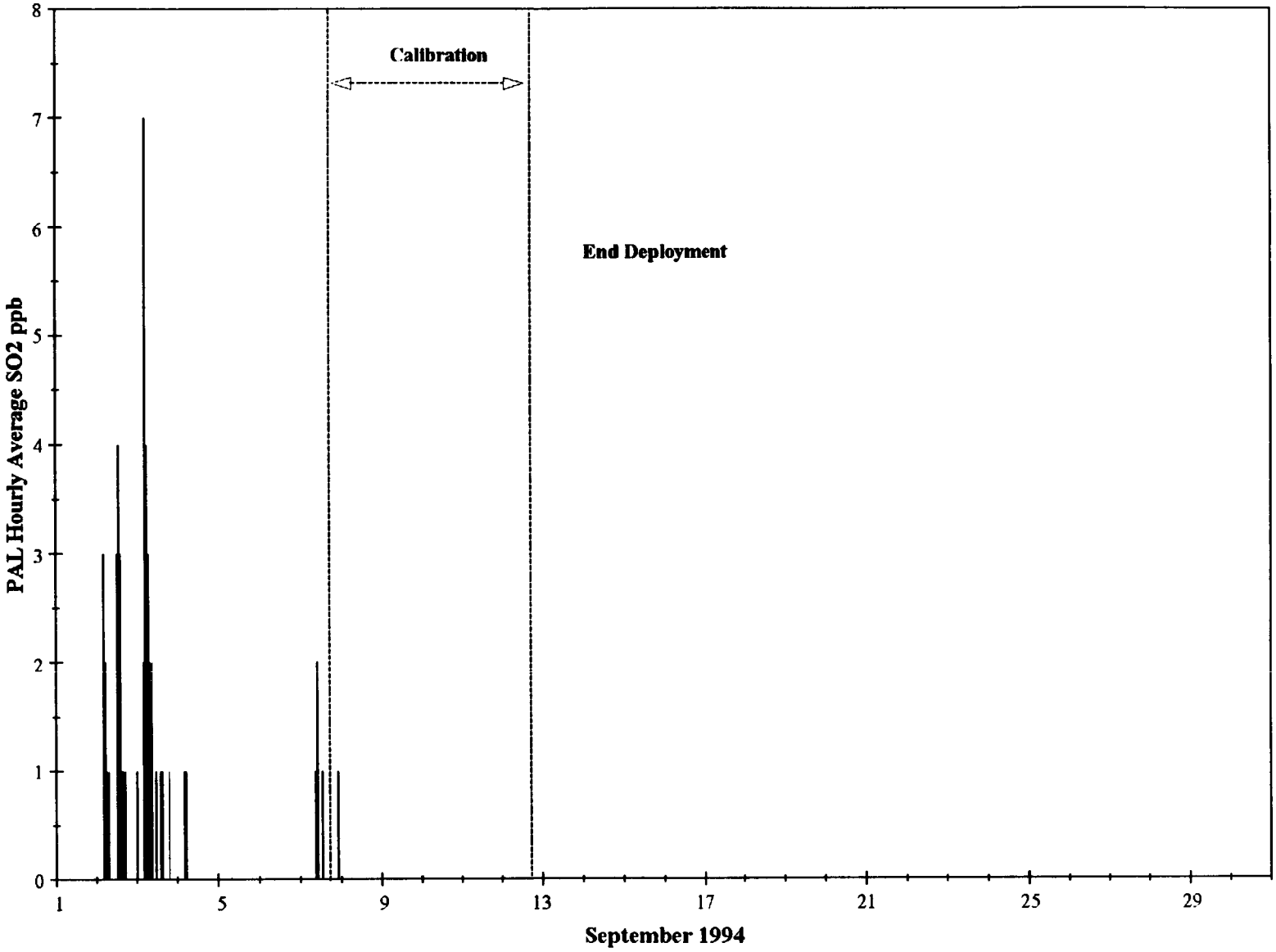


Figure 5c. September 1994 hourly SO_2 concentrations at PAL.

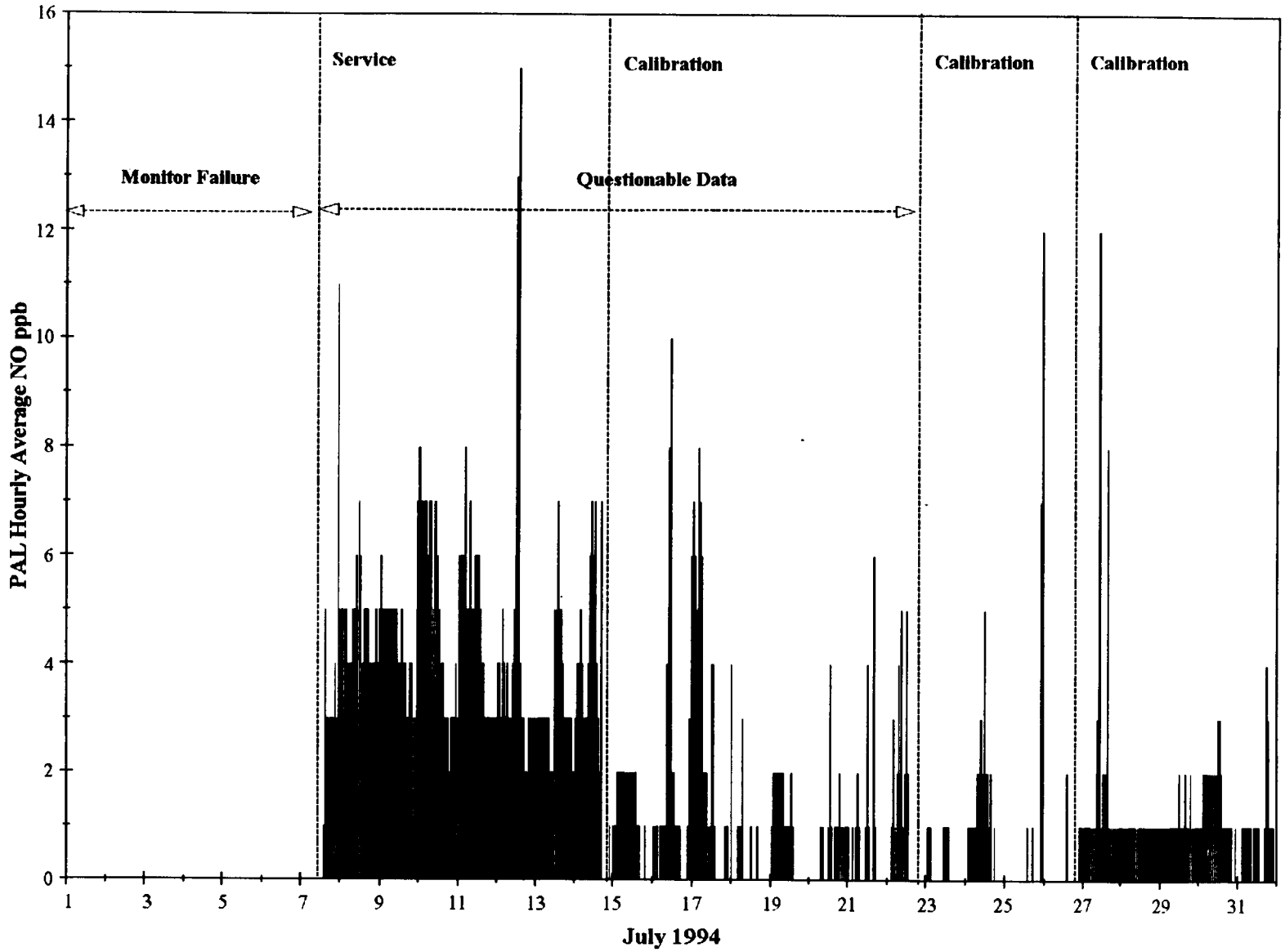


Figure 5d. July 1994 hourly NO concentrations at PAL.

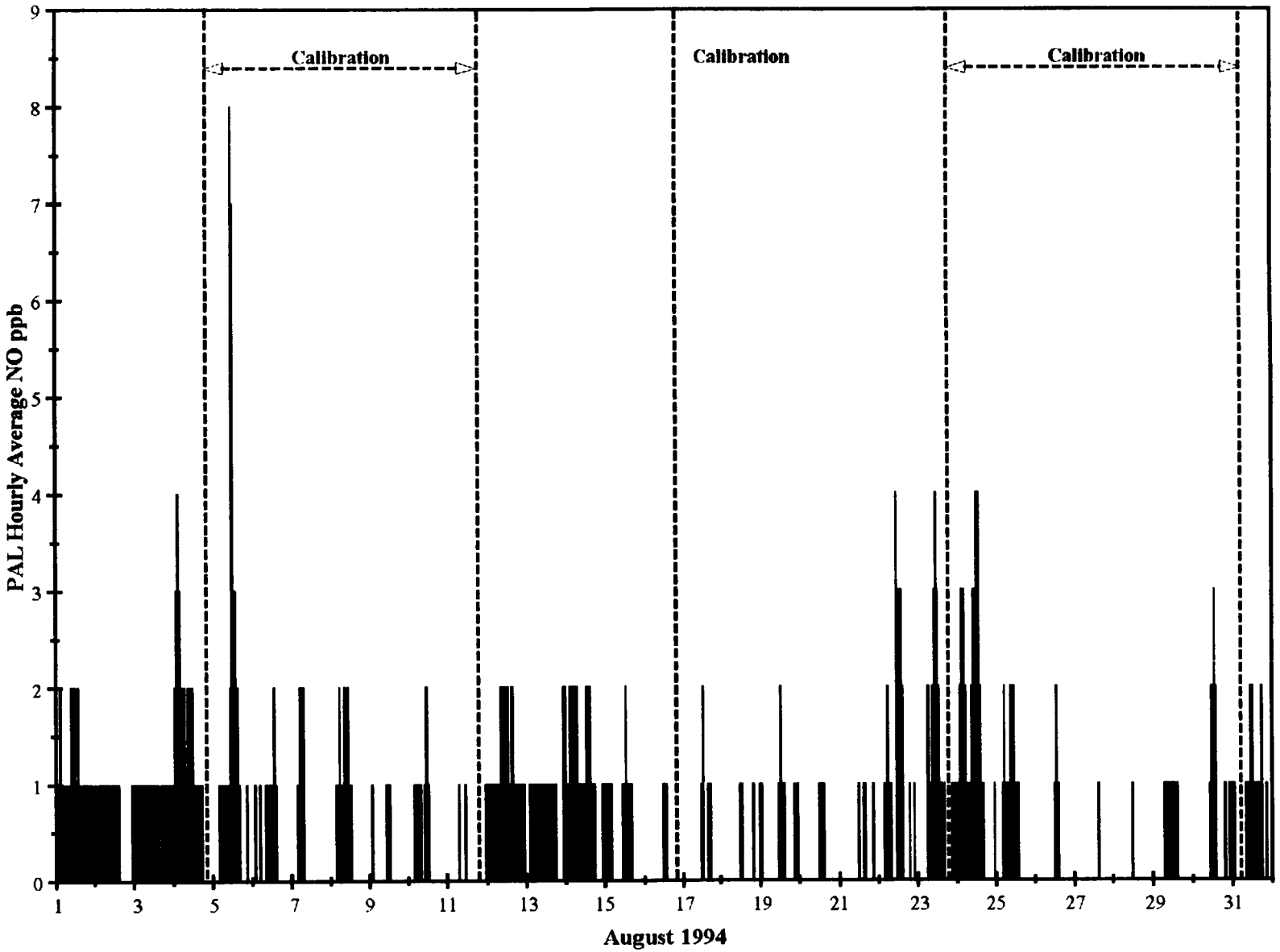


Figure 5e. August 1994 hourly NO concentrations at PAL.

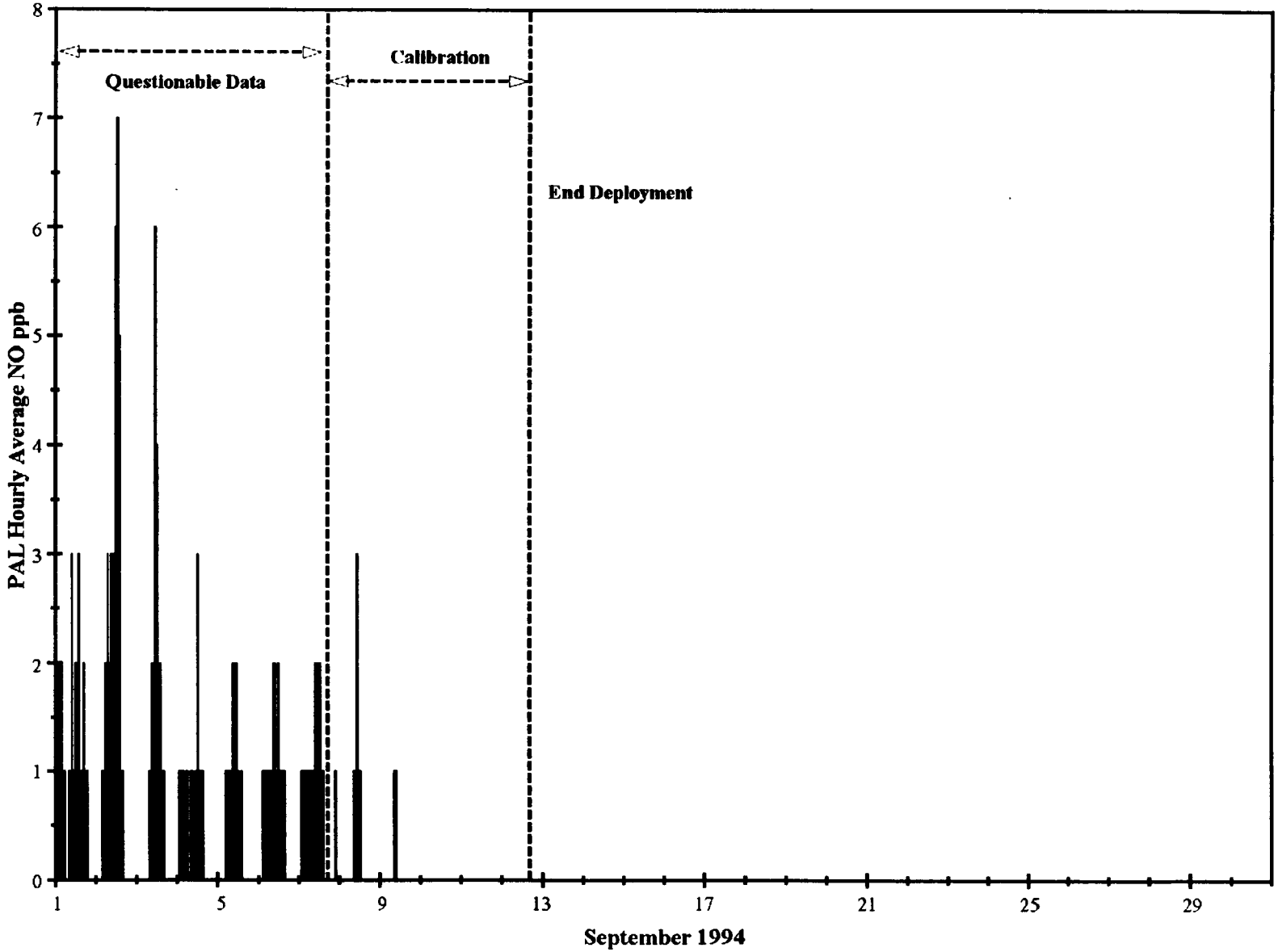


Figure 5f. September 1994 hourly NO concentrations at PAL.

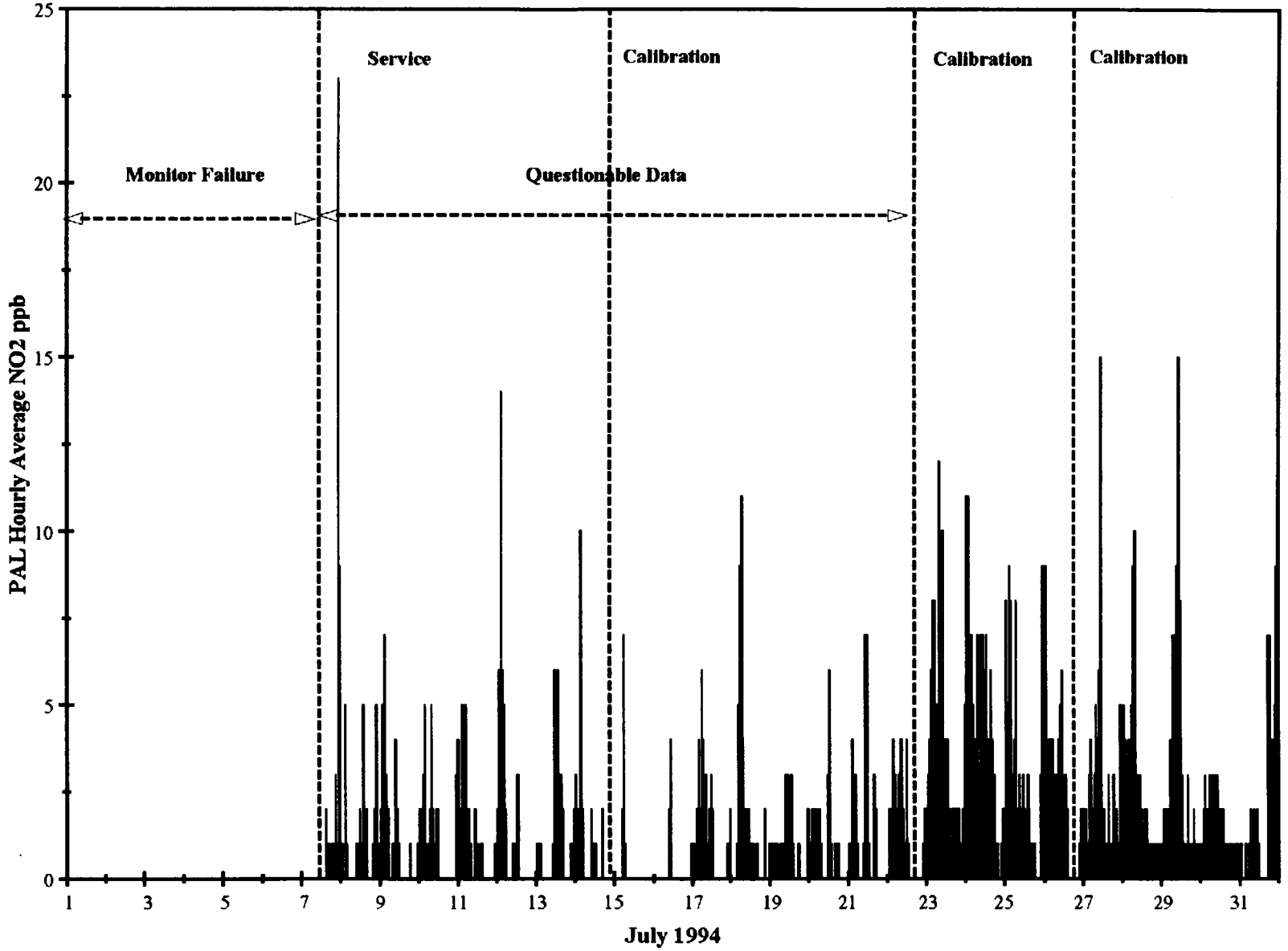


Figure 5g. July 1994 hourly NO_2 concentrations at PAL.

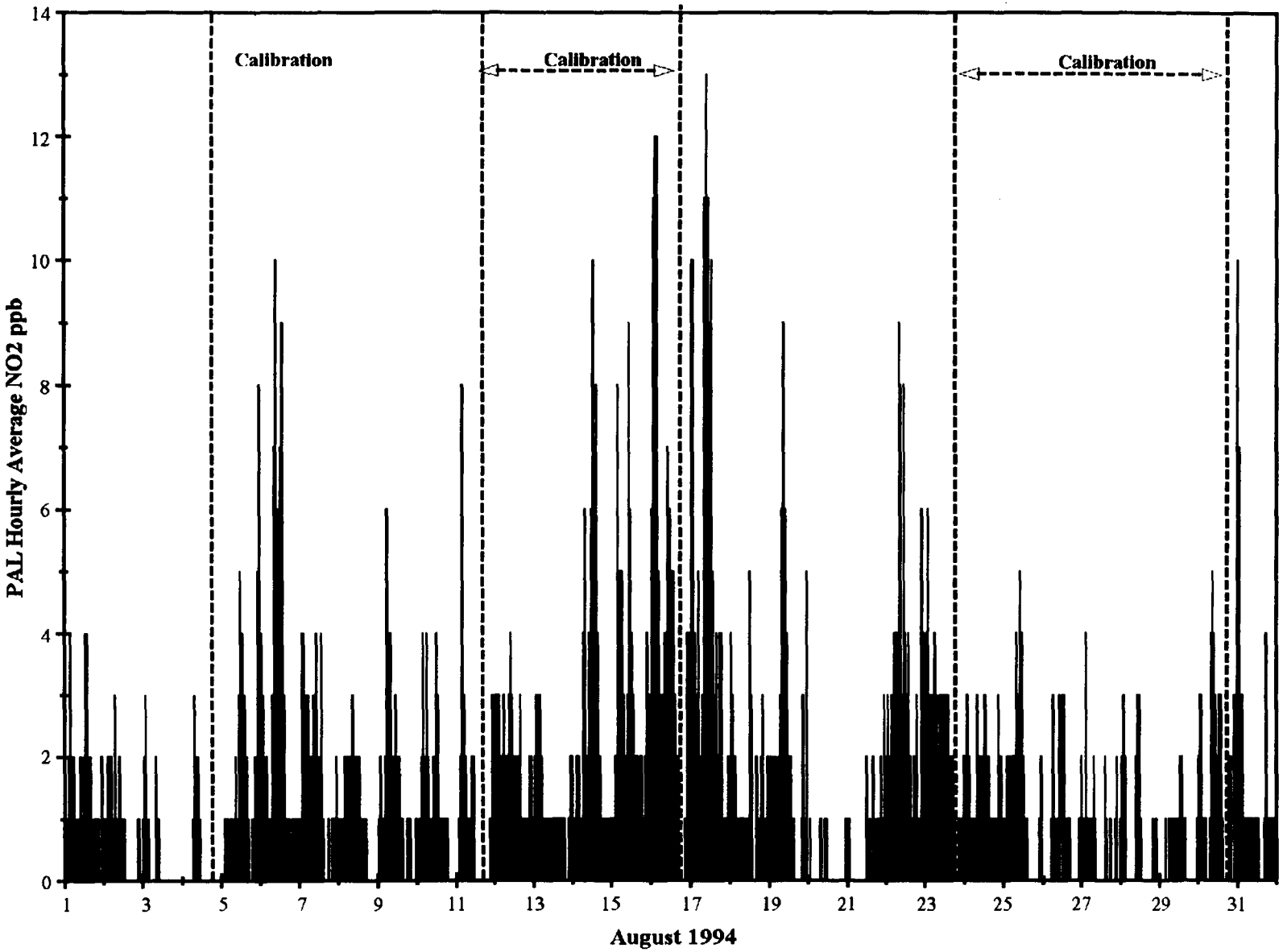


Figure 5h. August 1994 hourly NO_2 concentrations at PAL.

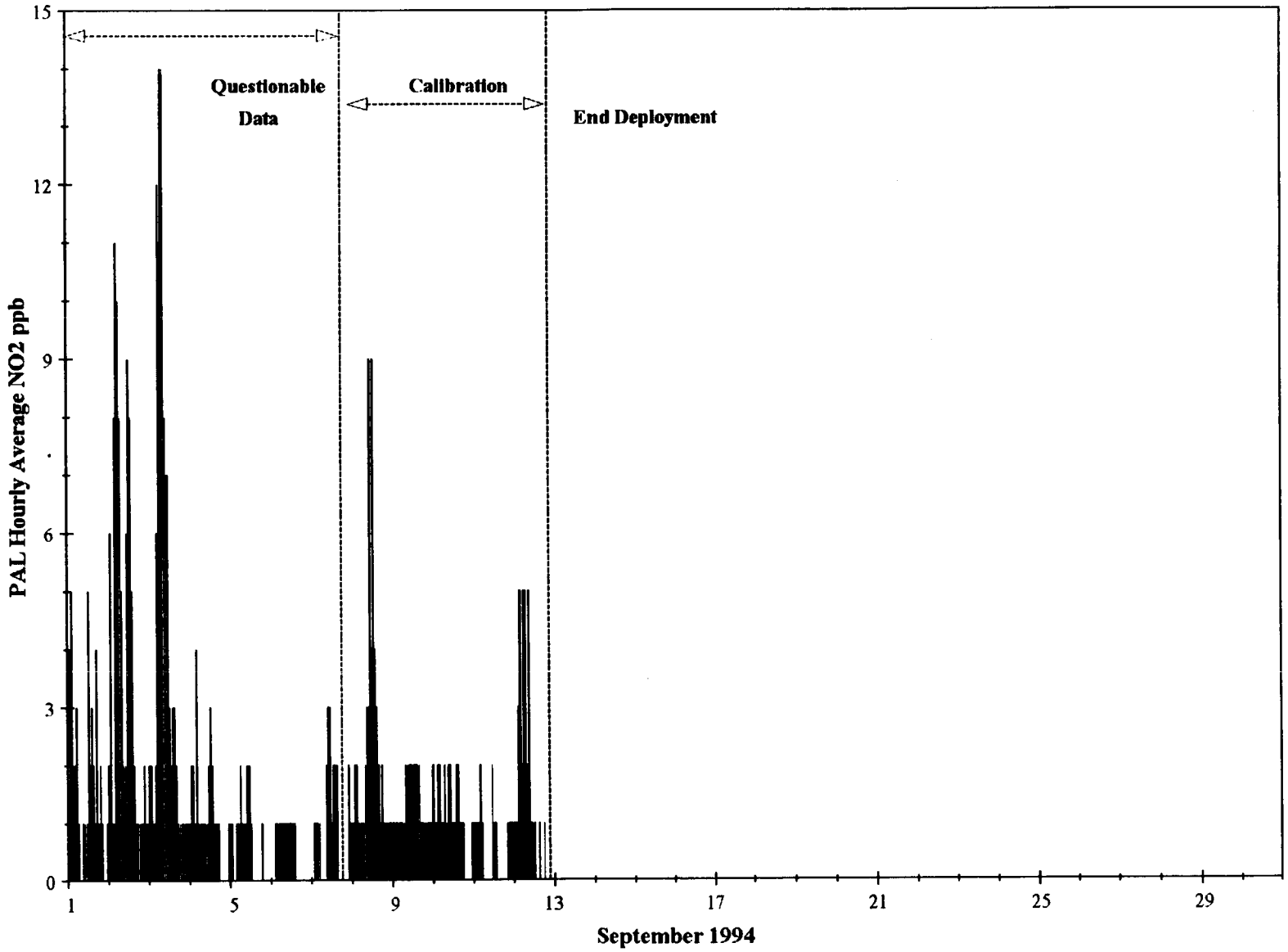


Figure 5i. September 1994 hourly NO_2 concentrations at PAL.

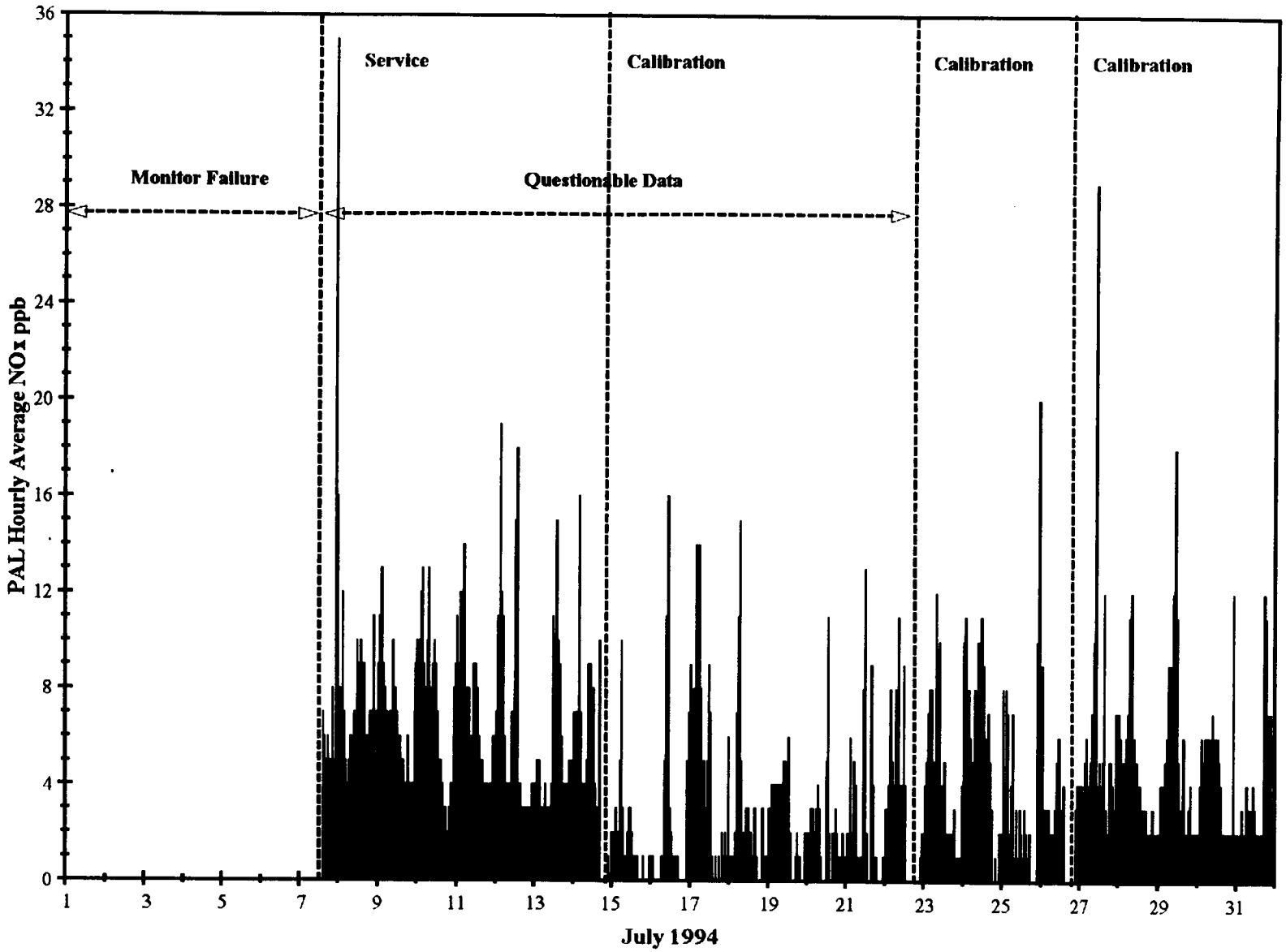


Figure 5j. July 1994 hourly NO_x concentrations at PAL.

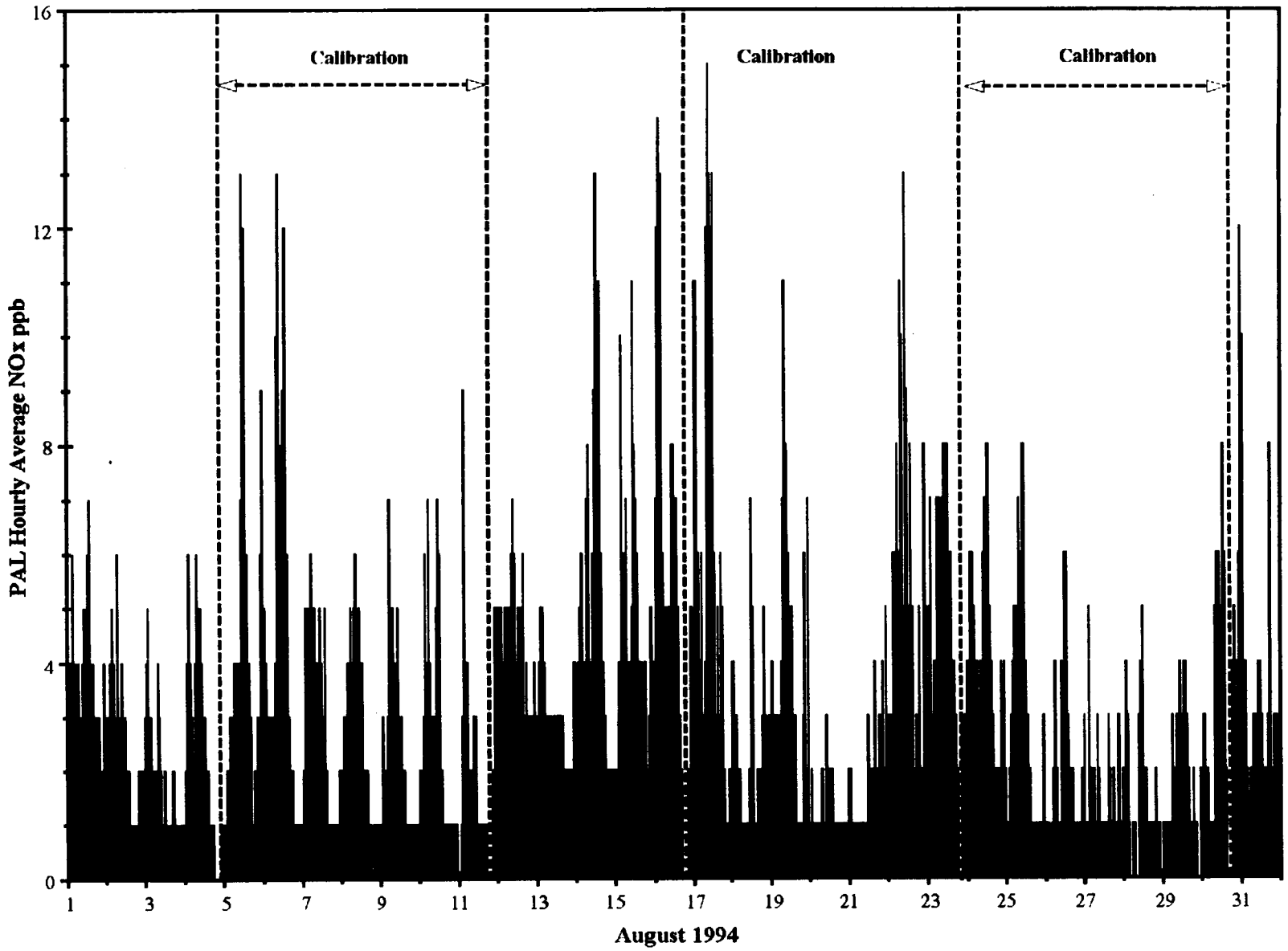


Figure 5k. August 1994 hourly NO_x concentrations at PAL.

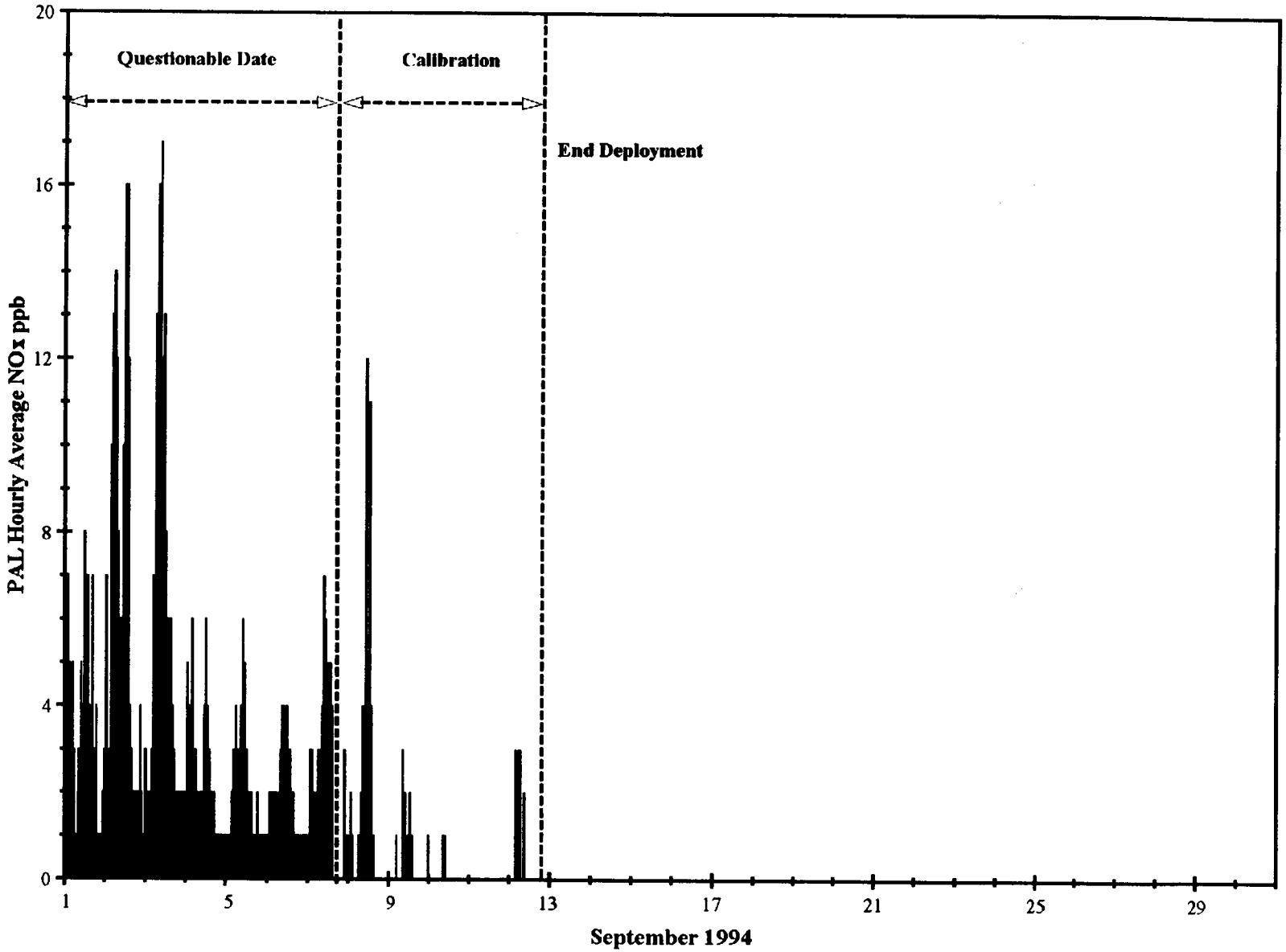


Figure 51. September 1994 hourly NO_x concentrations at PAL.

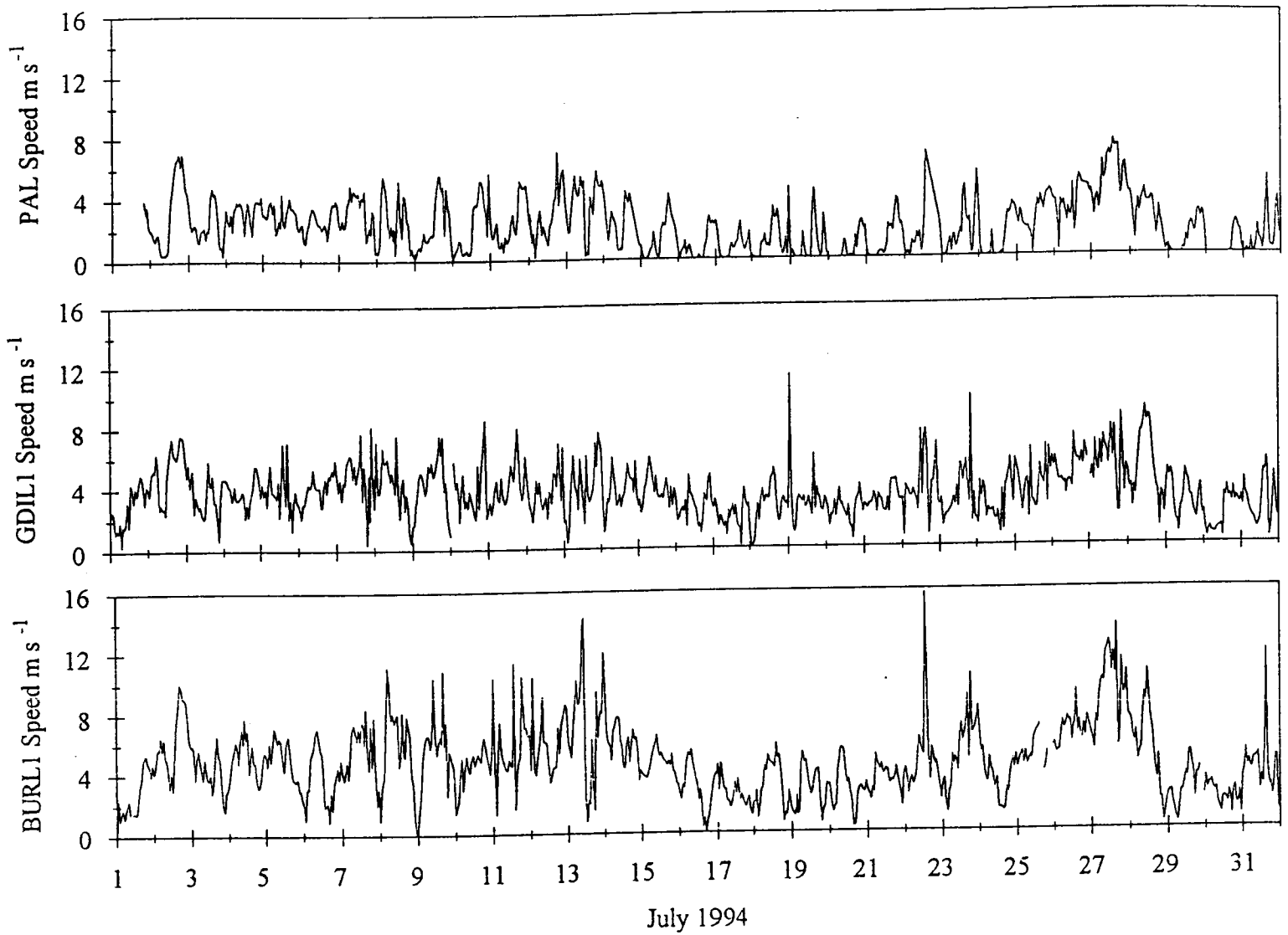


Figure 5m. July 1994 hourly wind speeds at PAL and NOAA stations GDIL1 and BURL1.

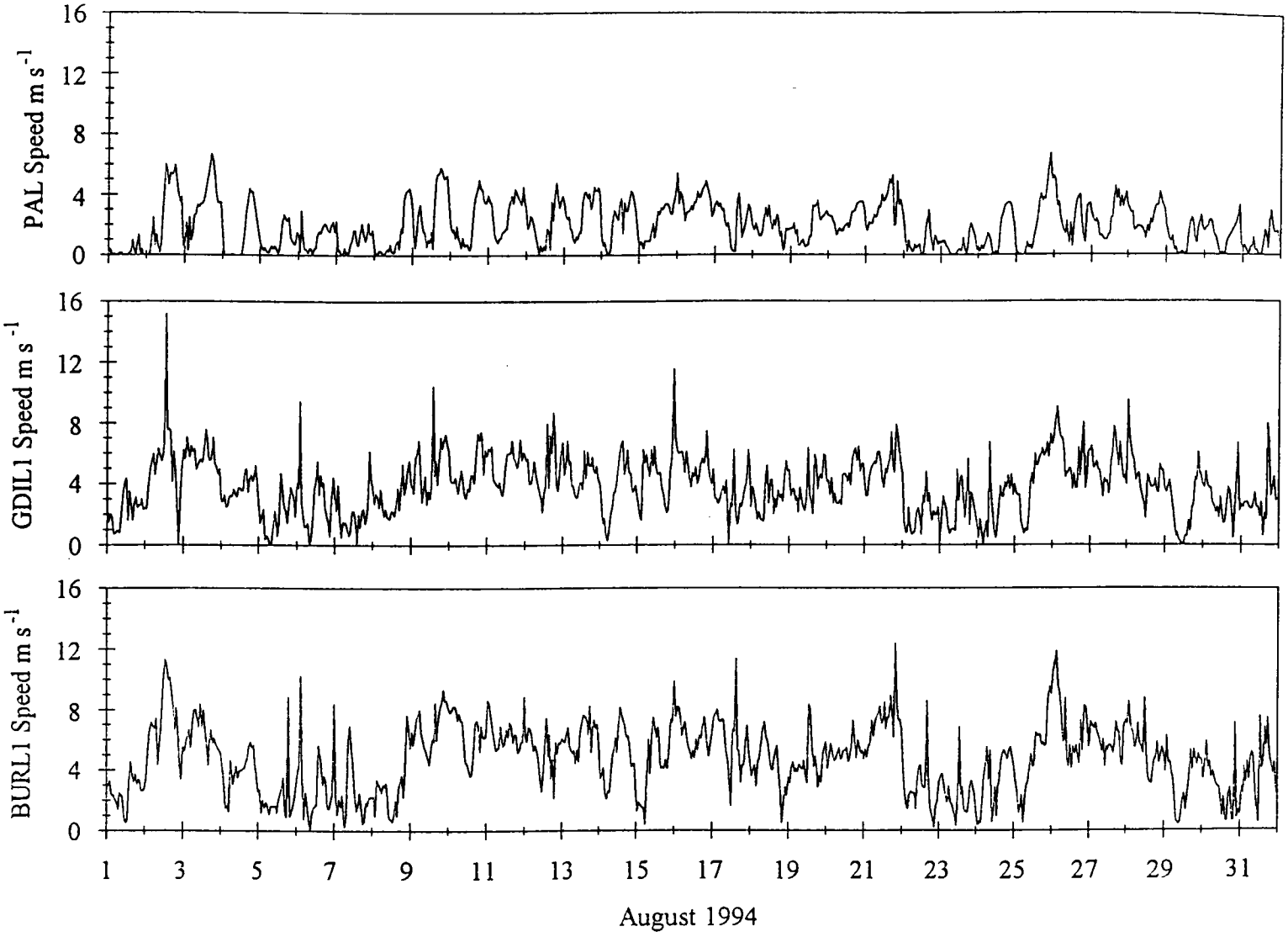


Figure 5n. August 1994 hourly wind speeds at PAL and NOAA stations GDIL1 and BURL1.

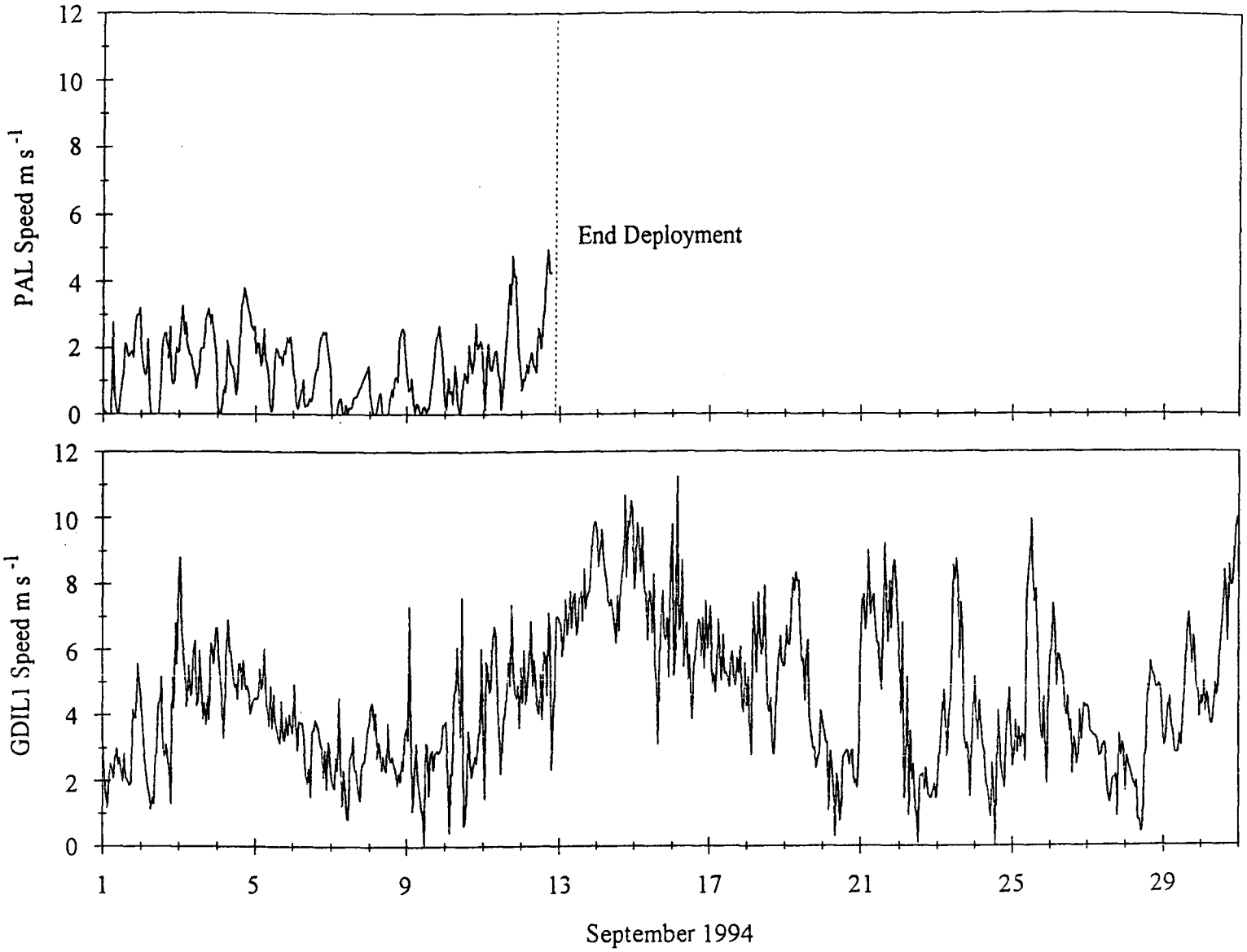


Figure 5o. September 1994 hourly wind speeds at PAL and NOAA station GDIL1.

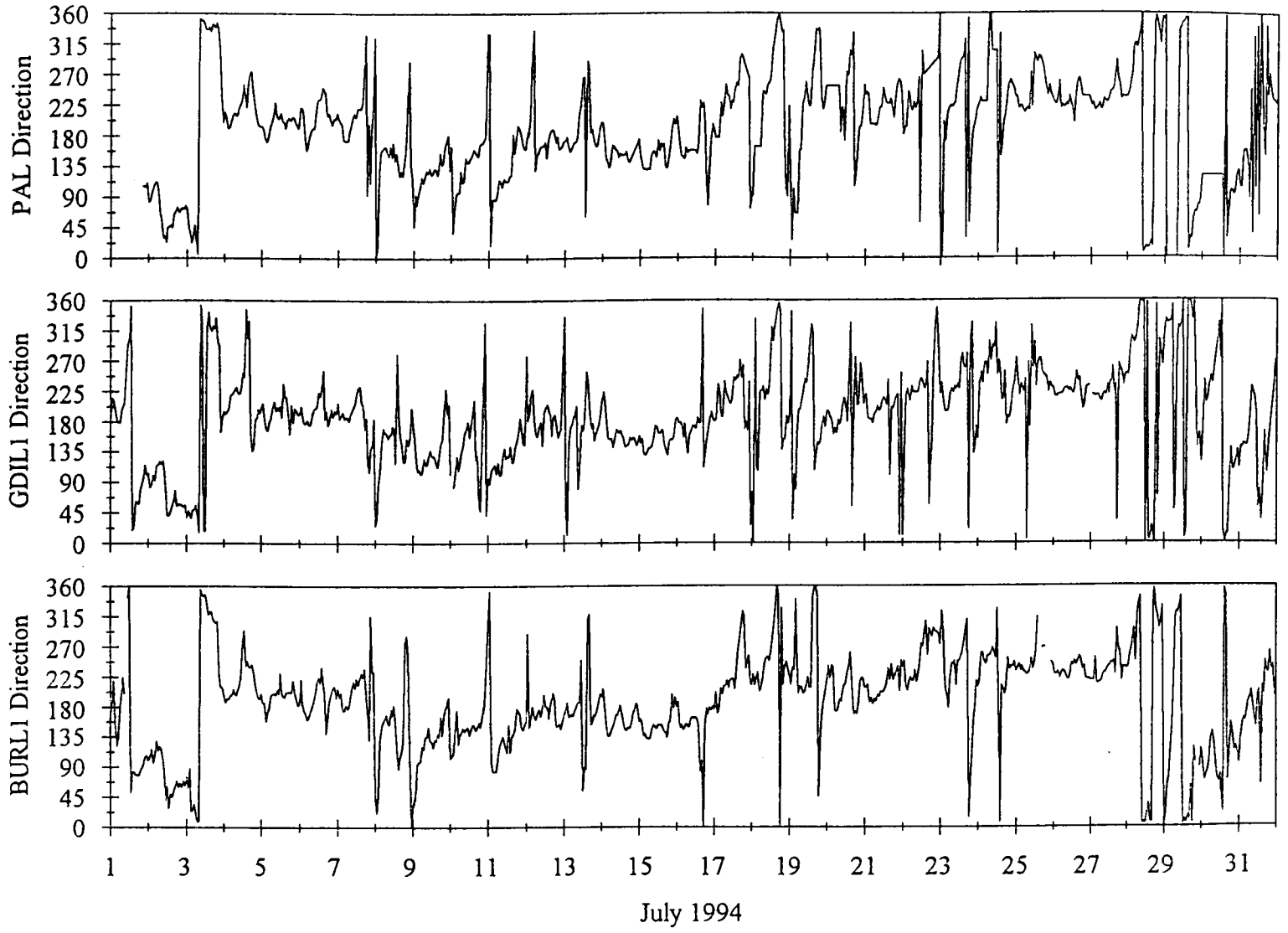


Figure 5p. July 1994 hourly wind directions at PAL and NOAA stations GDIL1 and BURL1.

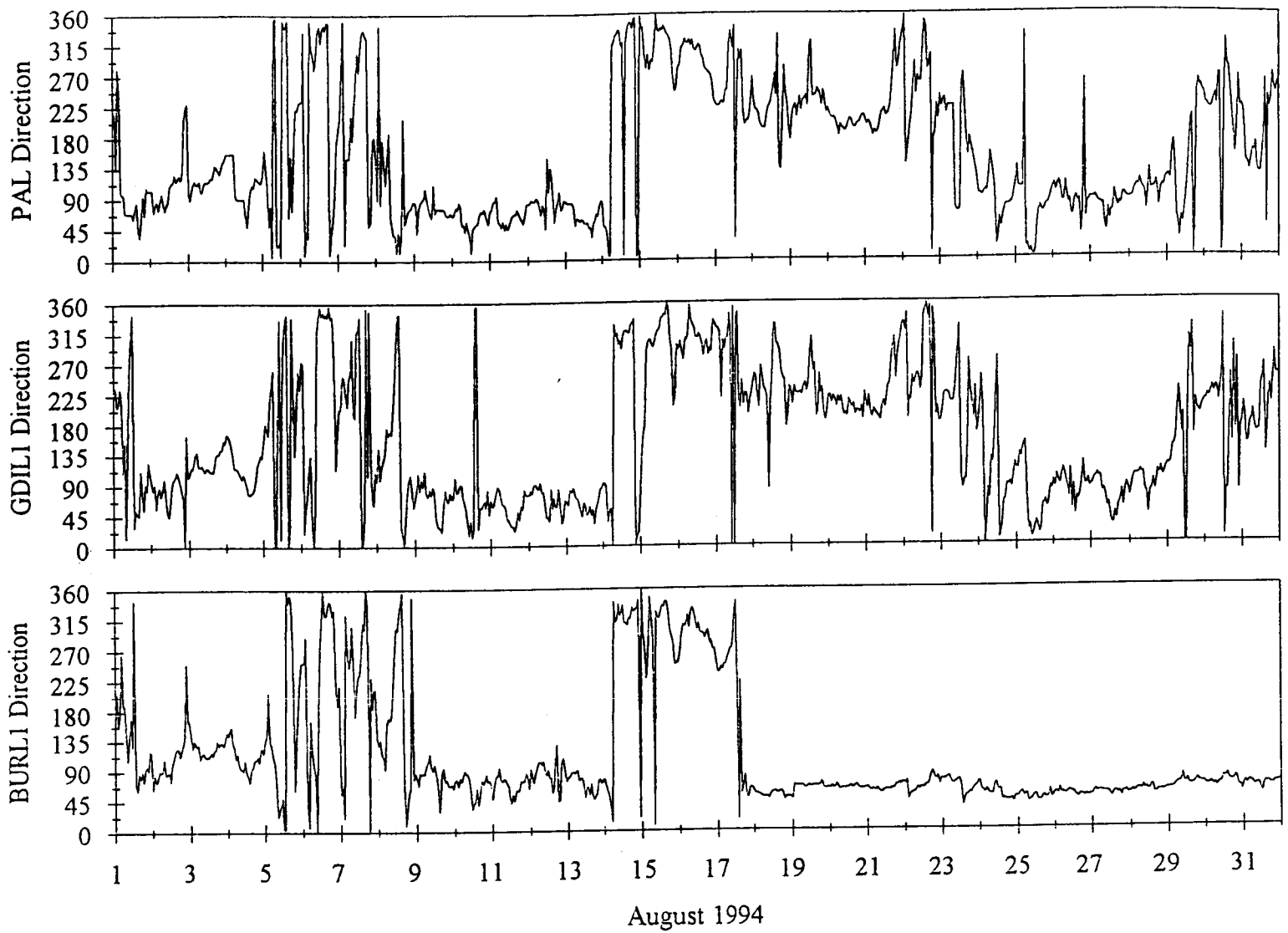


Figure 5q. August 1994 hourly wind directions at PAL and NOAA stations GDIL1 and BURL1.

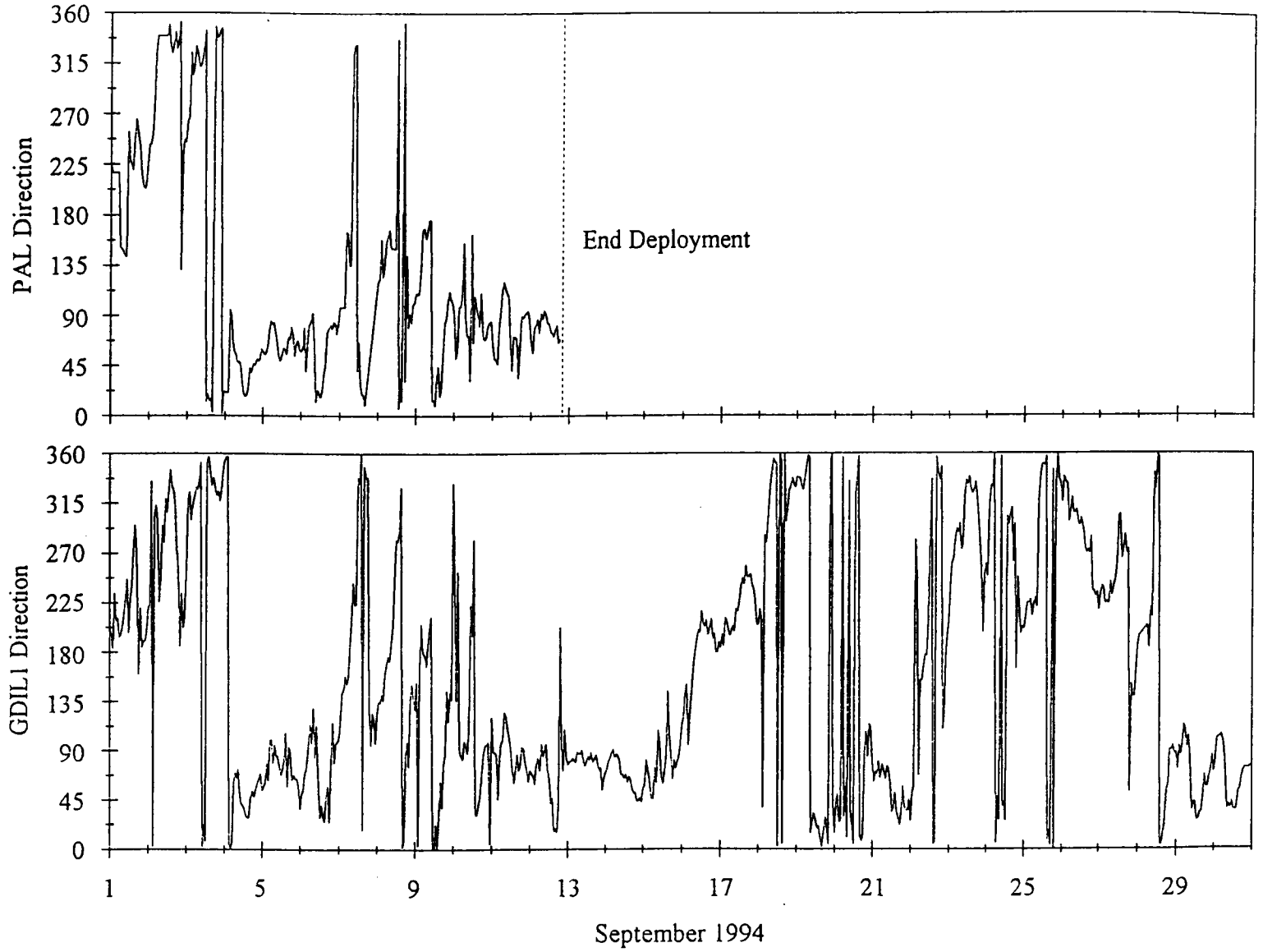


Figure 5r. September 1994 hourly wind directions at PAL and NOAA station GDIL1.

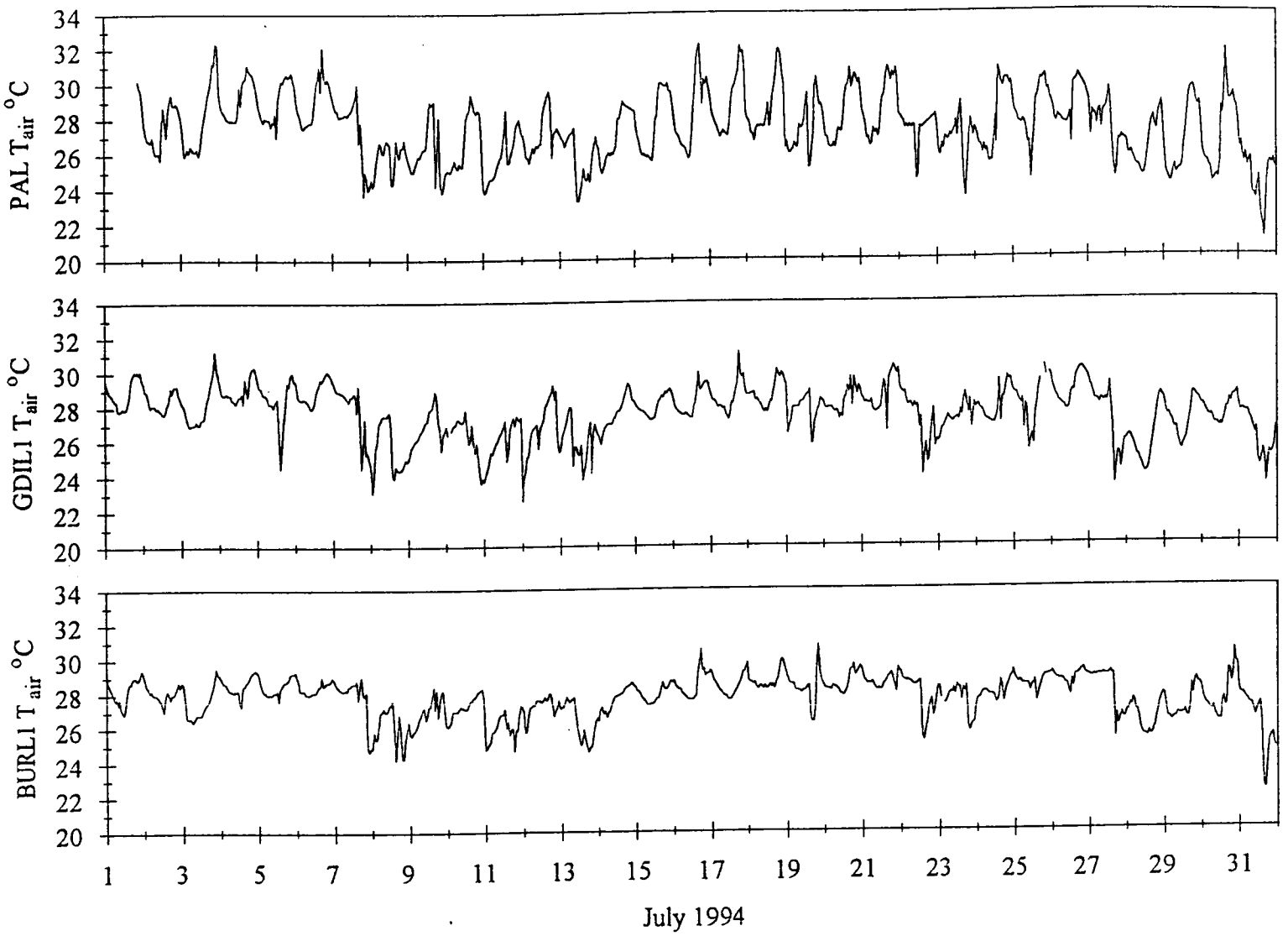


Figure 5s. July 1994 hourly air temperatures at PAL and NOAA stations GDIL1 and BURL1.

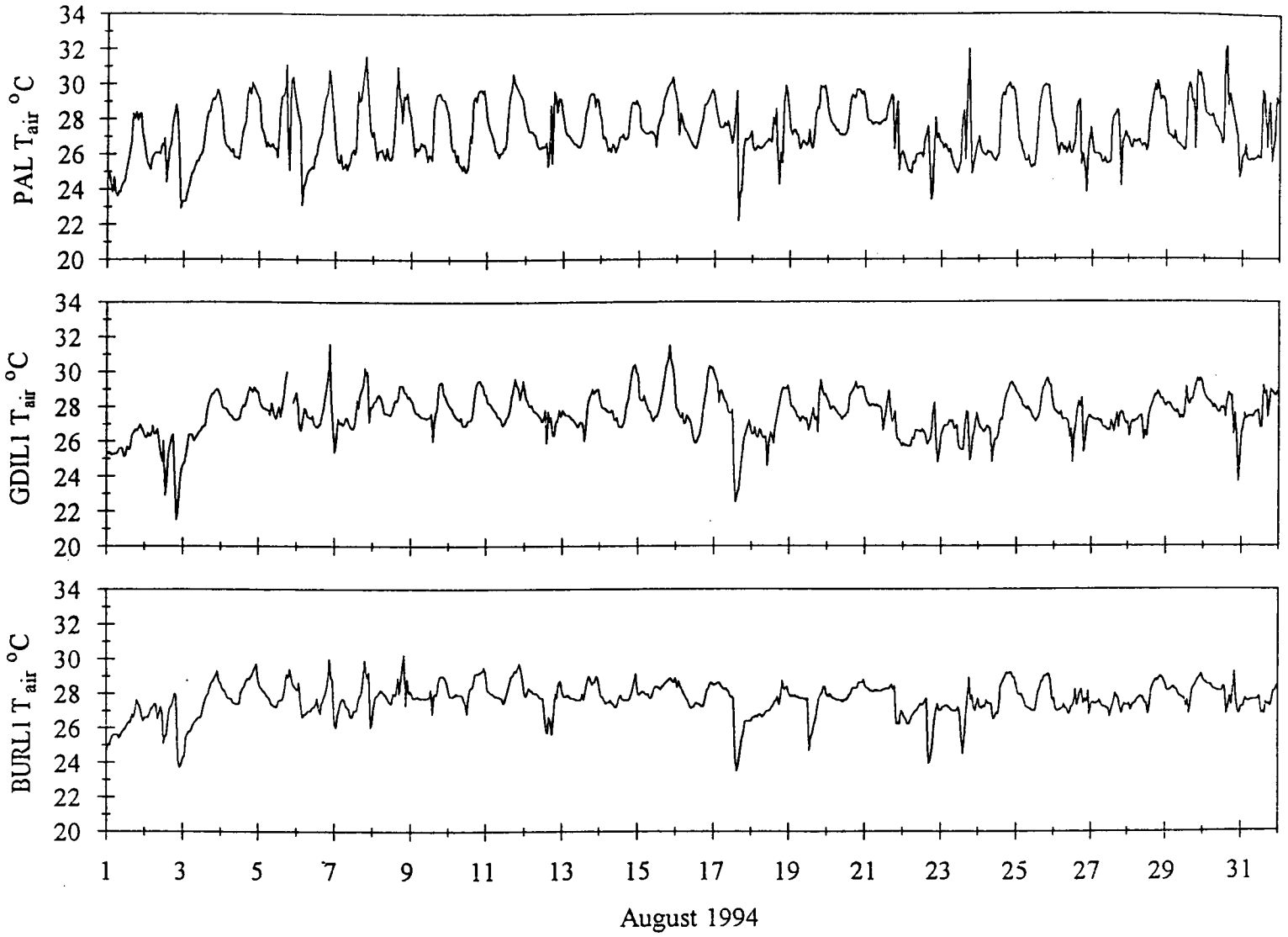


Figure 5t. August 1994 hourly air temperatures at PAL and NOAA stations GDIL1 and BURL1.

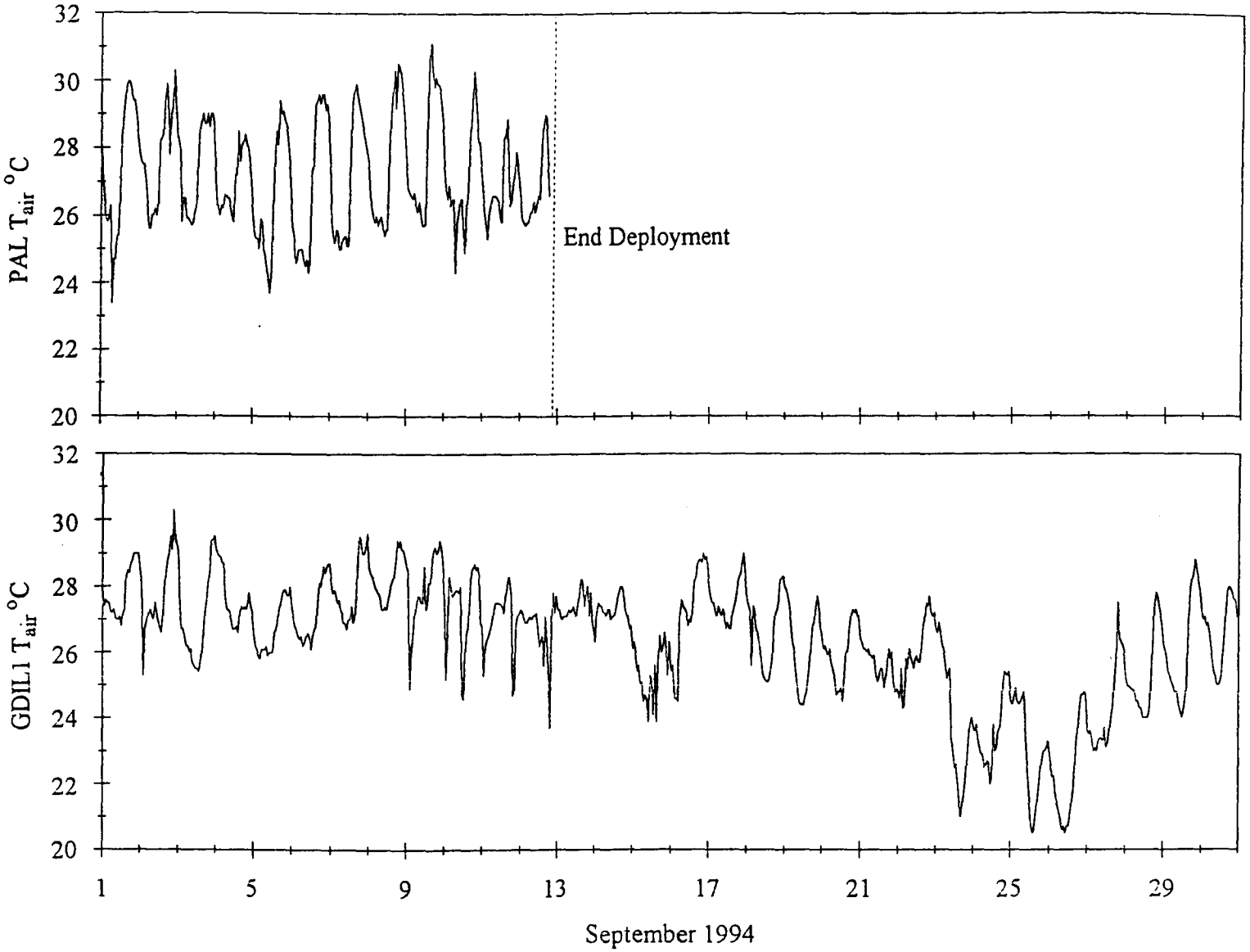


Figure 5u. September 1994 hourly air temperatures at PAL and NOAA station GDIL1.

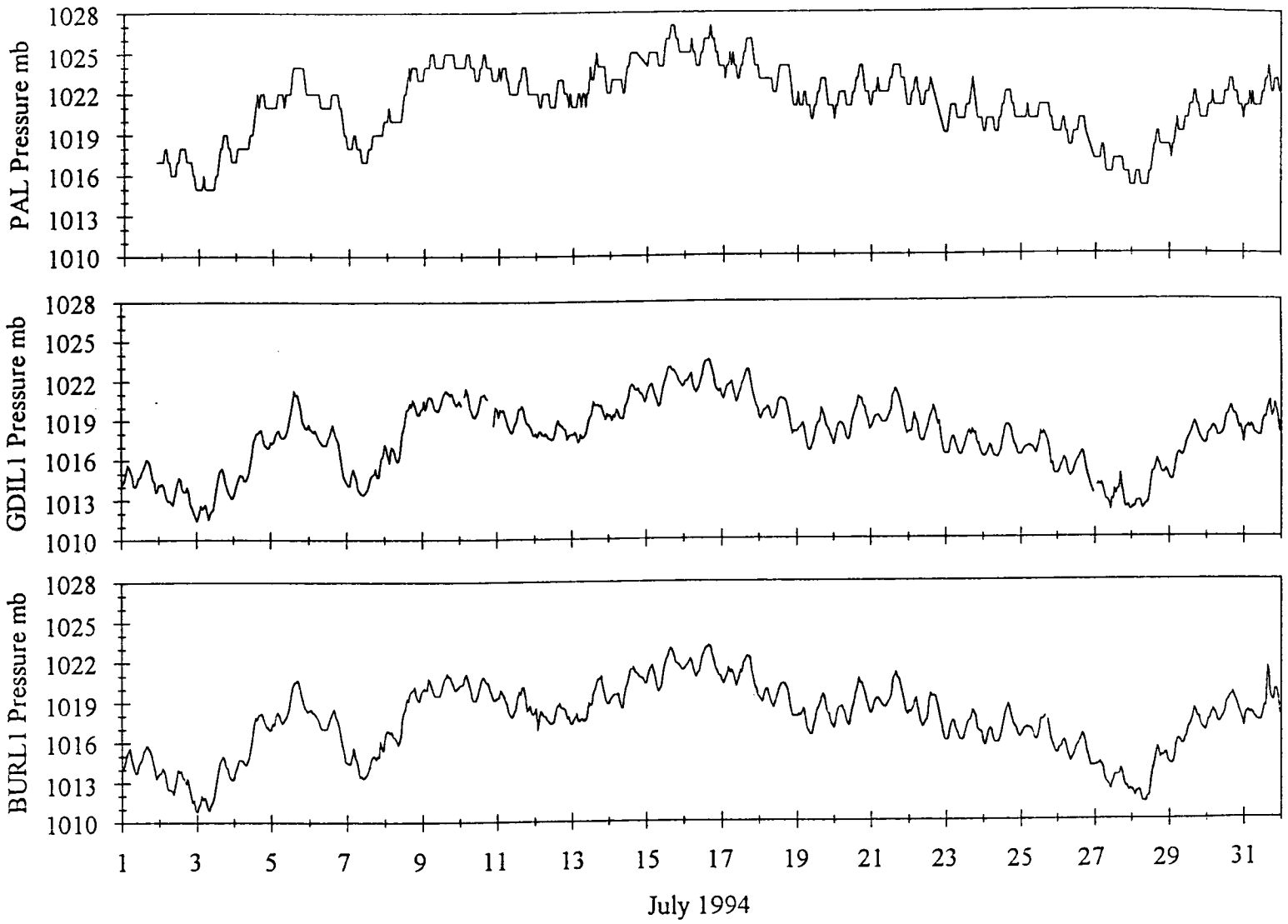


Figure 5v. July 1994 hourly atmospheric pressure at PAL and NOAA stations GDIL1 and BURL1.

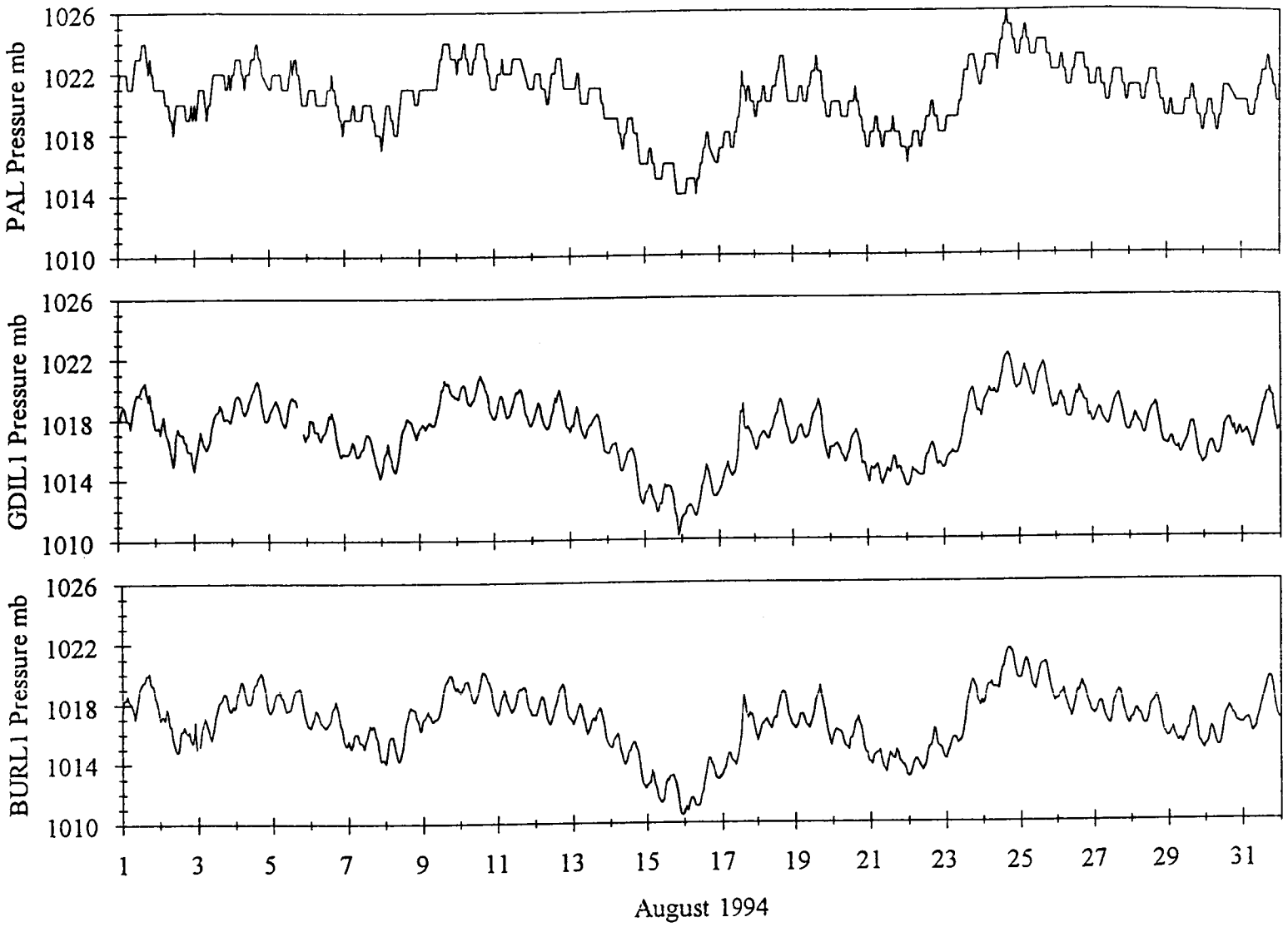


Figure 5w. August 1994 hourly atmospheric pressure at PAL and NOAA stations GDIL1 and BURL1.

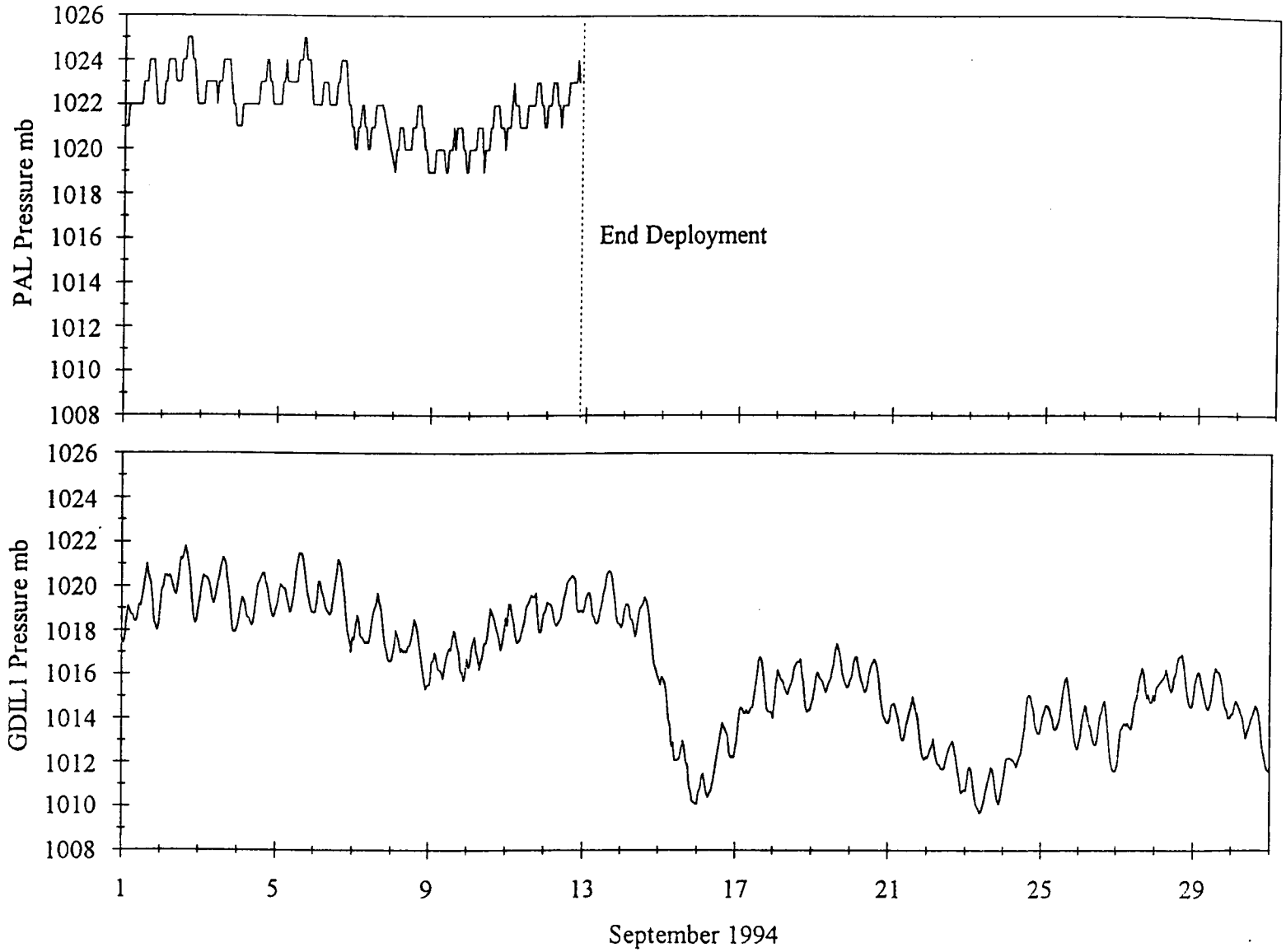


Figure 5x. September 1994 hourly atmospheric pressure at PAL and NOAA station GDIL1.

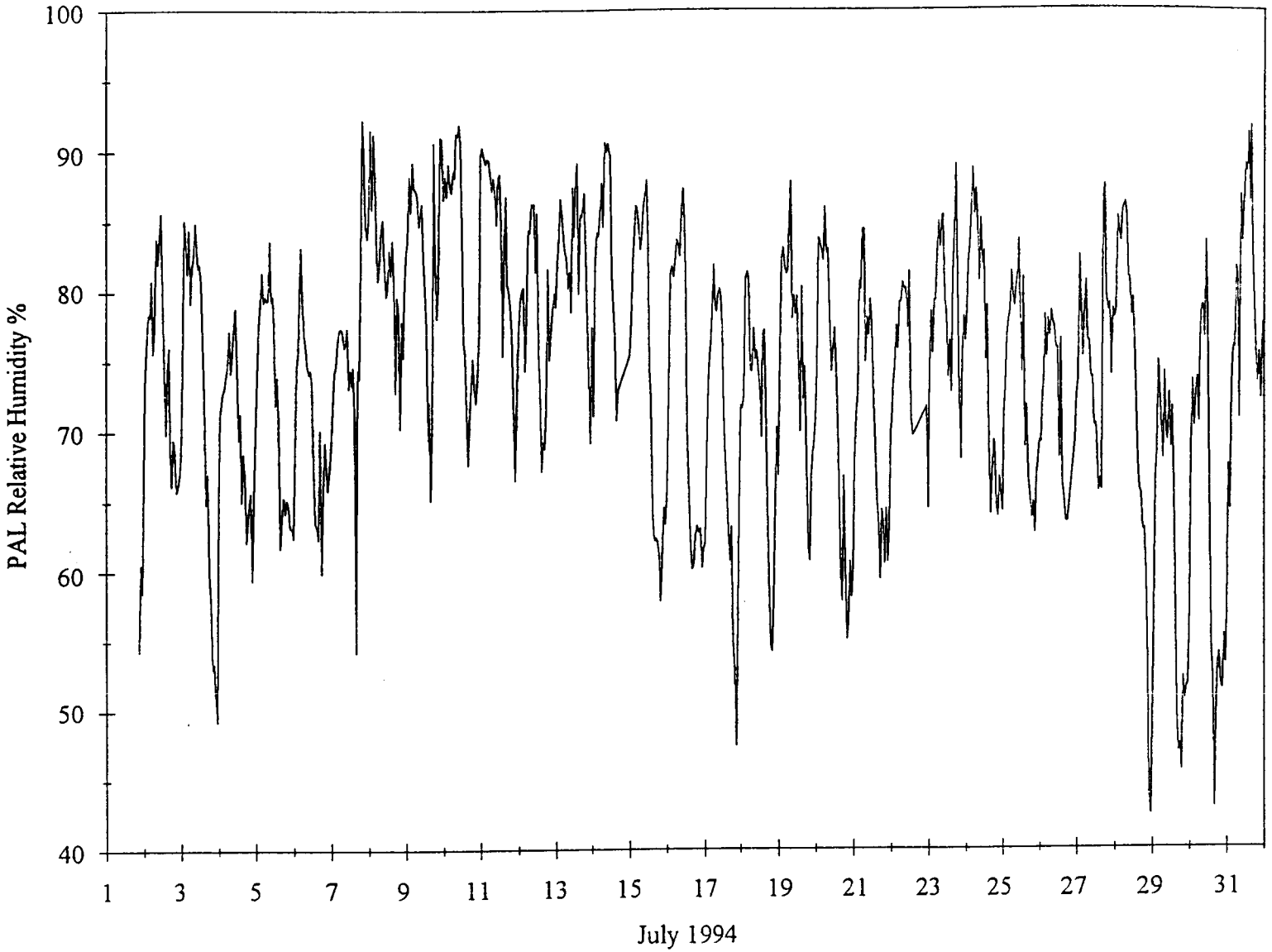


Figure 5y. July 1994 hourly relative humidity at PAL.

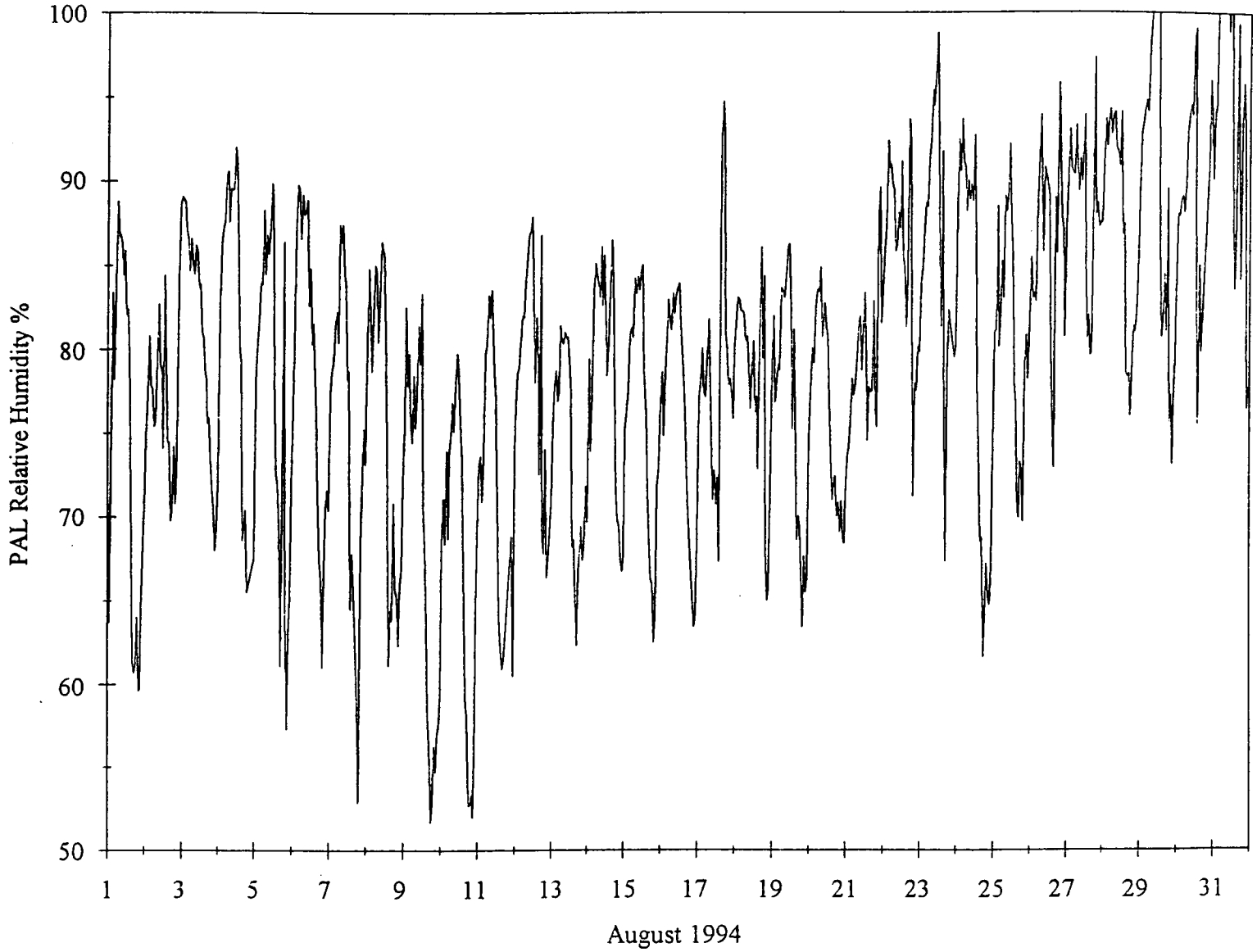


Figure 5z. August 1994 hourly relative humidity at PAL.

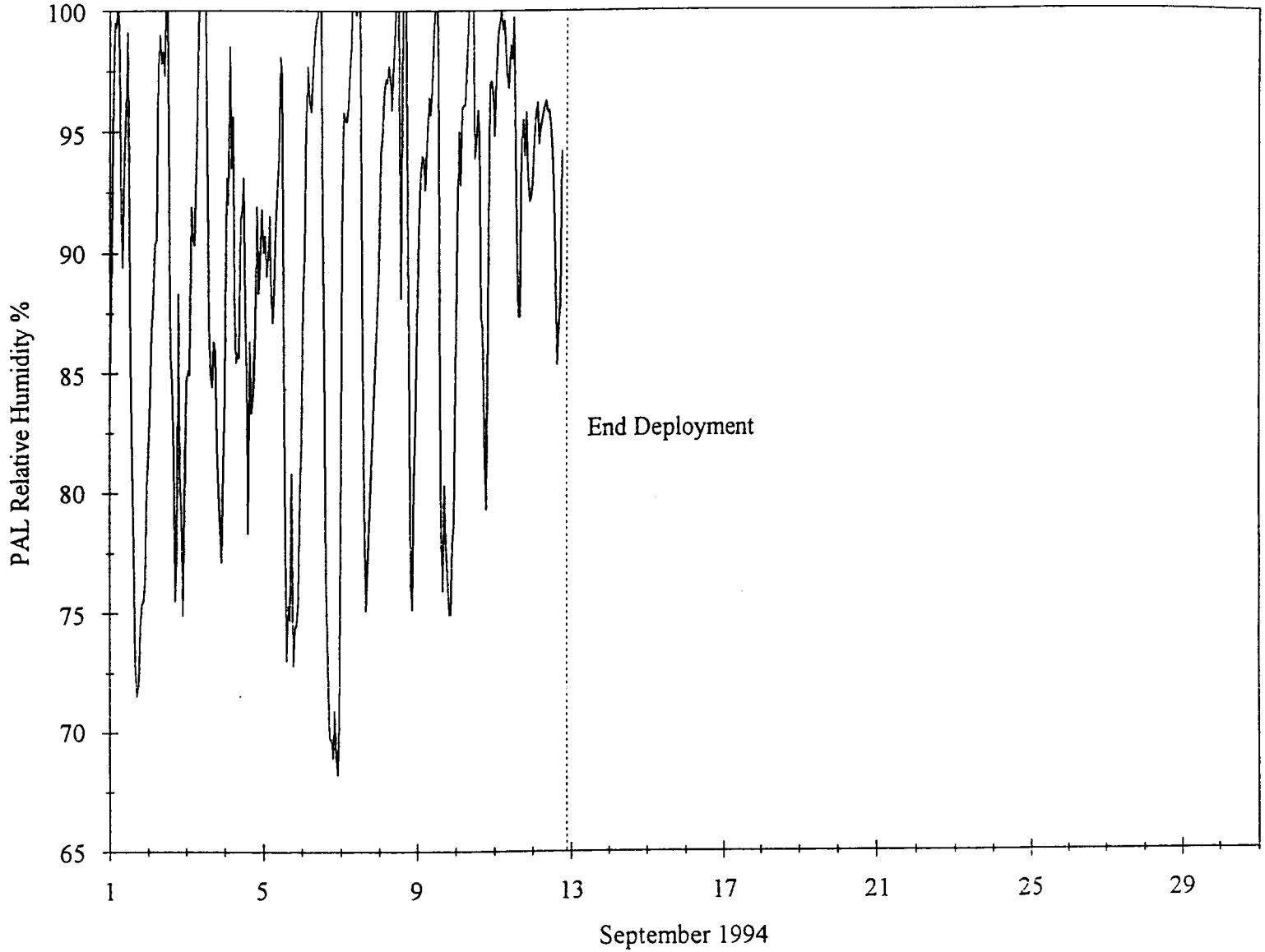


Figure 5aa. September 1994 hourly relative humidity at PAL.

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

1. Introduction

The three air quality and meteorological monitoring stations deployed during the summer of 1994 were all located within an area centered on the Breton Sound in the northeast Gulf of Mexico. In view of this fact, it was anticipated that nearly the same meteorological conditions would exist at each site. An examination of the time series plots of the meteorological parameters shows that this was the case (Figs. 3d - 3m for Gosier, 4m -4u for Breton, and 5m -5aa for PAL). For further verification, the data records were compared to those obtained at several nearby NOAA stations (see Fig. 1 for station locations). NOAA buoy 42007 is located near the northern tip of the Chandeleur Islands at approximately 30.1°N 88.8°W. The 12 m discus buoy is moored in 13 m of water and records meteorological and oceanographic data hourly. GDIL1 and BURL1 are Coastal-Marine Automated Network (C-MAN) stations located at the Grand Isle U.S. Coast Guard Station and at the entrance to Southwest Pass, Louisiana, respectively. It can be seen from the figures that generally homogeneous conditions prevailed over the study area even though several frontal passages and storm systems were experienced during the deployment. (Note that an apparent offset exists in the Breton and PAL pressure records, however the trends are in good agreement.)

The three stations were deployed in areas that have been designated as Class I (Gosier and Breton) and II (PAL) by the EPA. National Ambient Air Quality Standard (NAAQS) maximums for the monitored pollutants are listed in Table 8, while Prevention of Significant Deterioration (PSD) Increments are given in Table 9. Due to the timing and duration of this study and the unavailability of a baseline measurement, it is not valid to compare results with the PSD increments; however they are presented here for reference.

2. Gosier Island

As described previously, the Gosier Island station was plagued by several problems during its deployment, not the least of which was its dependence on battery power. This forced the implementation of a non-continuous measurement scheme in which air quality was sampled only once (5-minute average) an hour. The highest concentration of SO_2 recorded was 22 ppb on 14 July at 1000 UTC with winds of 3.2 m s^{-1} from 188°. Note that this measurement was obtained before the SO_2 Analyzer was calibrated on-site. After calibration, the highest concentration recorded during the rest of the deployment was 2 ppb, which may reflect background noise or zero fluctuation. With these considerations, extensive analysis of this data record was not attempted.

In order to investigate the possibility of acid rain deposition, pH measurements were made in a pond adjacent to the air quality station. Salinity (conductivity) and water temperature were also recorded. The pond was shallow (less than 2 foot estimated) but appeared to supply an important feeding and nesting area for many of the protected marine waterfowl. The sensors were attached to

Table 8.
U.S. Federal Primary and Secondary Ambient Air Quality Standards
Source: 40 CFR § 50, July 1992
(From Boubel et al., 1994)

Pollutant	Type of Standard	Averaging Time	Frequency Parameter	Concentration $\mu g / m^3$	Concentration ppm
Sulfur oxides (as sulfur dioxide)	Primary	24 hr	Annual Maximum*	365	0.139
		1 yr	Arithmetic Mean	80	0.030
	Secondary	3 hr	Annual Maximum*	1300	0.494
Nitrogen dioxide	Primary and Secondary	1 yr	Arithmetic Mean	100	0.053

*Not to be exceeded more than once per year.

Table 9.
U.S. Federal PSD Concentration Increments
Source: 40 CFR § 51.166, July 1992
(From Boubel et al., 1994)

Pollutant	Increment $\mu g / m^3$	Increment ppm
Class I		
SO_2		
Annual Arithmetic Mean	2	0.001
24-hr Maximum	5	0.002
3-hr Maximum	25	0.010
NO_2		
Annual Arithmetic Mean	2.5	0.001
Class II		
SO_2		
Annual Arithmetic Mean	20	0.008
24-hr Maximum	91	0.035
3-hr Maximum	512	0.195
NO_2		
Annual Arithmetic Mean	25	0.013

a pipe and submerged in approximately 6 - 8 inches of water (the water level was noted to have dropped considerably by the end of July). Measurements obtained show that the water was brackish; however pH values were generally greater than 8 (more alkaline). Diurnal variations are evident in the time series plot (Fig. 3m), particularly after 12 July. Positive correlation of pH and temperature is seen, while salinity appears inversely related due to evaporation and cooling effects.

Passive air quality sensors (Ogawa and Palmes tubes) were exposed throughout the deployment. Analysis was later performed by the Harvard School of Public Health through a sub-contractor, Environmental Science and Engineering, Inc. Their results are given in Tables 10 and 11. Long exposure times and improper storage of the tubes in all likelihood invalidates this data.

3. Breton Island

Tables 12 and 13 present the daily maximum and average concentrations of SO_2 and NO_2, respectively, as recorded at Breton Island. Monthly maximum hourly, 3-hourly, and daily concentrations are listed in Table 14. From Fig. 6, it is apparent that ambient SO_2 levels are well below the NAAQS at this site.

It has been shown that meteorological conditions were consistent in the study area. Therefore, the Gosier Island wind record has been applied in the Breton analysis. Monthly wind roses with average pollutant concentration are shown in Figs. 7 - 10. In July and August, the highest NO_2 concentrations were from the northeast quadrant with an average value of approximately 12 - 13 ppb. This level dropped to near 5 ppb in September, with highest concentrations from the south and southwest. Average SO_2 concentrations are even lower in August, with the maximum being about 3 ppb from the south.

The frequency distribution of the entire NO_2 record is illustrated in Fig. 11 and Fig. 12 for SO_2. Highest concentrations were from the north and northeast during the study period, however the majority of hourly measurements were less than 10 ppb for NO_2 and 5 ppb for SO_2.

The station record for NO_2 indicates that, during the deployment, several short-term episodes of higher than average NO_2 levels were observed. Table 15 shows those cases in which hourly NO_2 concentrations exceeded 18.2 ppb. Assuming the data is normally distributed, this should include only the highest 0.3% of the record (see Spiegel, 1961, p. 71). In most cases, the prevailing wind directions were from the east-northeast. The high ratio of NO to NO_x is an indication of the chemical conversion which is a function of the residence time of the pollutant in the air mass (i.e., high ratio - short time, nearby source) since the conversion of NO to NO_2 is fairly rapid in the troposphere (Manahan, 1993). High levels are typically observed for only a few hours (daily maximums are about 30% or less of the hourly maximums). Unfortunately, a complete emissions inventory for the area during our measurement period has not been included here. Potential local sources are mostly mobile (pleasure or commercial vessels) or semi-mobile (generators on moored houseboats in Breton

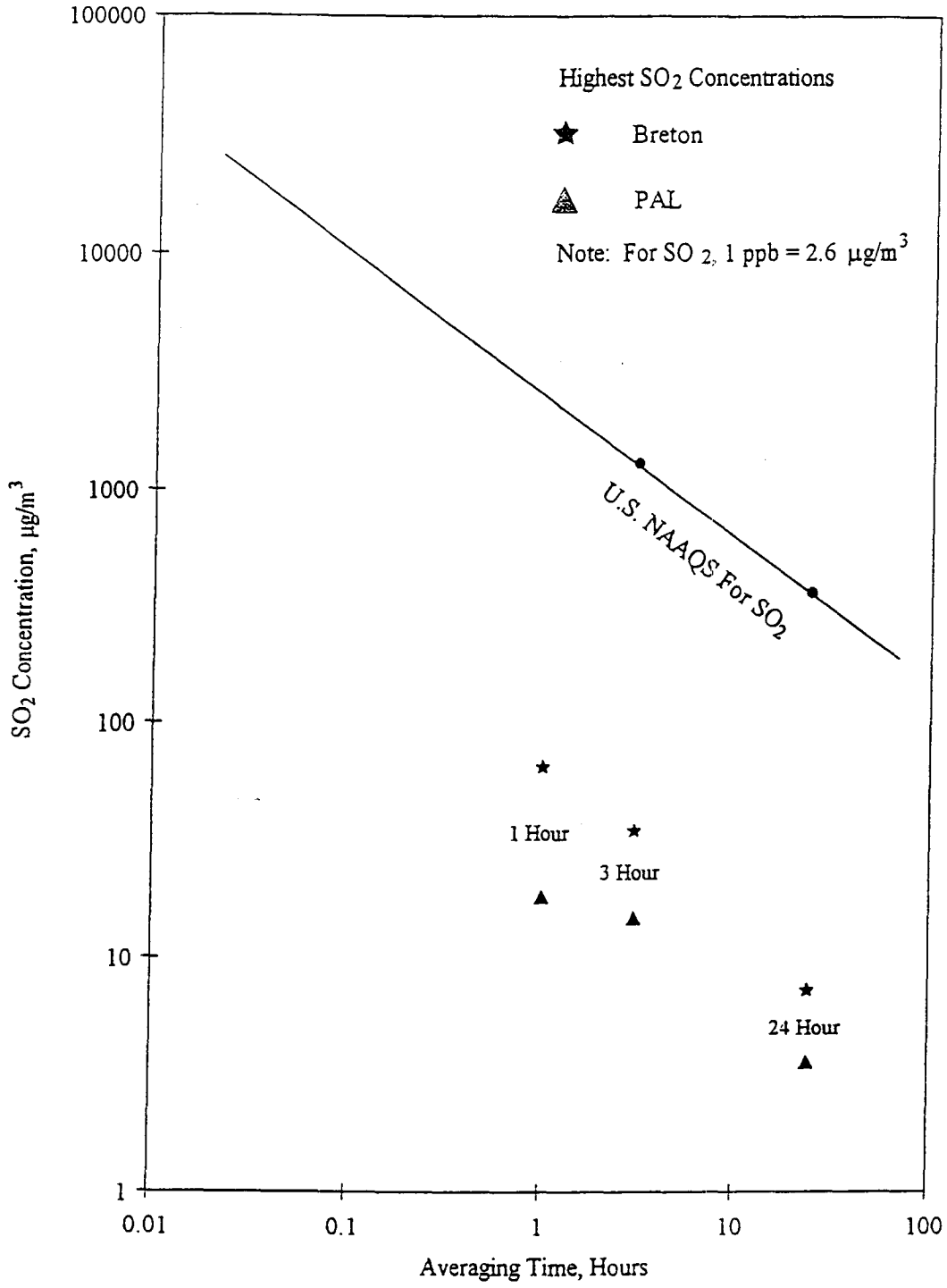


Figure 6. NAAQS standards and maximum SO_2 concentrations at PAL and Breton Island.

Table 10.
Gosier Island Ogawa (SO_2) Passive Data

CSI Design.	Harvard Design.	Time On	Time Off	Total Hours	Net PPB SO2
G001	ESC 1	6/29 1631	Missing	--	
G003	ESC 3	7/7 1140	7/13 1825	150.8	3.4
G005	ESC 5	7/13 1827	7/28 0830	350	2.9
G007	ESC 7	7/28 0830	8/5 1244	196.3	3.3
G009	ESC 9	8/5 1246	8/17 0955	285.2	9.5
G013	ESC 13	8/17 0955	8/24 1240	170.4	2.0
G015	ESC 15	8/24 (8/23)[+] 1241	8/31 1058	166.2 (190)	2.1
G017	ESC 17	8/31 1058	9/8 1208	193.2	0.8
G019	ESC 19	9/8 1208	9/26 1840	438	6.2

[+] Dates and times in parentheses are incorrect, but were used in Harvard's chemical analysis.
NOTE: Ogawa tube #'s 11, 12, and 21 were not exposed.

Table 11.
Gosier Island Palmes (NO_2) Passive Data

CSI Design.	Harvard Design.	Time On	Time Off	Total Hours	Mean Conc. NO2 PPB
G001		6/29 1630	7/7 1140	187.2	
G003	ESC-003	7/7 1140	7/13 1825*	150.8	449.4
G005	ESC-005	7/13 1827	7/28 0830	350	5.58
G007	ESC-007	7/28 0835	8/5 1244	196.2	5.74
G009	ESC-009	8/5 1246	8/17 0955	285.2	5.08
G011	ESC-011	8/17 0955	8/24 1240	170.8	5.82
G015	ESC-015	8/24 (8/23)+ 1241	8/31 1058	166.3 (190.3)	5.10
G017	ESC-017	8/31 1058	9/8 1208	193.2	13.05
G019	ESC-019	9/8 1208	9/26 1840	438.5	3.75

* Tube found on beach near tower.
+ Dates and times in parentheses are incorrect but were used in Harvard's chemical analysis.
NOTE: Palmes tubes # 13, 14, and 21 were not exposed.

Table 12.
Breton Island Daily SO_2 Maximums and Averages (ppb)

	July 1994		August 1994		September 1994	
Day	Maximum	Average	Maximum	Average	Maximum	Average
1	1	0	1	0.9	0	0
2	6	1.8	0	0	1	0.3
3	12	1.8	1	0.1		
4	3	0.3	0	0		
5	0	0	0	0		
6	0	0	0	0		
7	0	0	2	0.1		
8			0	0		
9			0	0		
10			1	0		
11			1	0.1		
12			0	0		
13			17	2		
14			10	0.7		
15			11	0.9		
16			7	0.4		
17			3	0.4		
18			1	0.5		
19			2	1		
20			2	1.1		
21			1	0.6		
22			9	1.5		
23			25	2.4		
24			9	2.1		
25			5	0.4		
26			0	0		
27			1	0.1		
28	11	4.2				
29	5	2.8				
30	2	1.1				
31	1	0.9	51	3.6		
Number Hours	255		637		41	
Maximum	12		51		1	
Arith-Mean	1.2		0.7		0.1	

Total Samples = 933
% Of Possible Observations = 44.2

Table 13.
Breton Island Daily NO_2 Maximums and Averages (ppb)

	July 1994		August 1994		September 1994	
Day	Maximum	Average	Maximum	Average	Maximum	Average
1	3	0.5	17	5.9	11	3.5
2	36	9.5	7	1.2	10	3.6
3	30	7.3	5	1.1	16	3.8
4	8	1.2	2	1	3	1.4
5	5	0.6	5	1.7	2	0.7
6	10	0.8	22	6.8	4	0.8
7	11	1.1	36	7.8	11	2.7
8			13	3.8	6	2.8
9			5	2.5	5	1.9
10			31	7.4	4	1.8
11			45	12	3	1.9
12			6	1.4	3	1.7
13			33	7.7	2	1.1
14	4	2.3	11	4.4	1	0.5
15	4	2.1	16	4.6	2	0.8
16	12	3.1	11	6.4	31	9.6
17	9	4	19	6.9	25	9.3
18	11	4.9	6	2.6	7	2.9
19	13	5.1	7	3.3	13	3.9
20	15	4.7	6	2.8	4	2.1
21	8	4	7	2.3	11	1.7
22	9	4.2	11	5.5	13	3.2
23	15	5.8	13	5.2	11	3.7
24	15	5.1	29	7.7	10	5.5
25	7	3.7	28	4.5	8	3.6
26	7	3.8	4	2	6	3.4
27	6	4.1	8	3.5		
28	8	3.3				
29	59	9.4				
30	18	3.8				
31	5	1.5	8	3.6		
Number Hours	577		637		615	
Maximum	59		45		31	
Arith-Mean	3.9		4.5		3.0	

Total Samples = 1829
% Of Possible Observations = 86.6

Table 14.
Breton Island 1994 Pollutant Maximums

Month	Pollutant	%	Averaging Period	Maximum ppb	Average Wind Speed / Direction	Date / Time UTC
July	SO_2	34.3	1 hr	12	3.2 / 9	7/3/94 @ 1300
			3 hr	8.3 6.3	5.2 / 311 8.3 / 19	7/28/94 @ 0600* 7/28/94 @ 1100
			24 hr	4.2 2.8	5.3 / 340 2.7 / 358	7/28/94* 7/29/94
	NO_2	77.6	1 hr	59	3.4 / 317	7/29/94 @ 0200
			3 hr	31	3.4 / 51	7/2/94 @ 1000
			24 hr	9.5	4.5 / 73	7/2/94
August	SO_2	85.6	1 hr	51 25	2.4 / 195 1.7 / 143	8/31/94 @ 0600* 8/23/94 @1500
			3 hr	21.3 13.3	2.6 / 192 6.2 / 52	8/31/94 @ 0800* 8/13/94 @ 1600
			24 hr	2.4	2.2 / 206	8/23/94
	NO_2	85.6	1 hr	45	6.4 / 53	8/11/94 @ 1600
			3 hr	28.3	5.6 / 50 6.3 / 54	8/11/94 @ 1200 and 1600
			24 hr	12	5.3 / 76	8/11/94
September	SO_2	6.6	1 hr	1	6.2 / 312	9/2/94 @ 1100
			3 hr	1	5.1 / 352	9/2/94 @ 1600
			24 hr	0.3	4.8 / 296	9/2/94
	NO_2	98.7	1 hr	31	3.3 / 200	9/16/94 @ 1300
			3 hr	24	3.4 / 197	9/16/94 @ 1500
			24 hr	9.6	5.7 / 175	9/16/94

*Average concentration values may reflect residual measurements from instrument calibration runs.
NOTE: Wind speed in m sec^{-1} and direction in degrees.

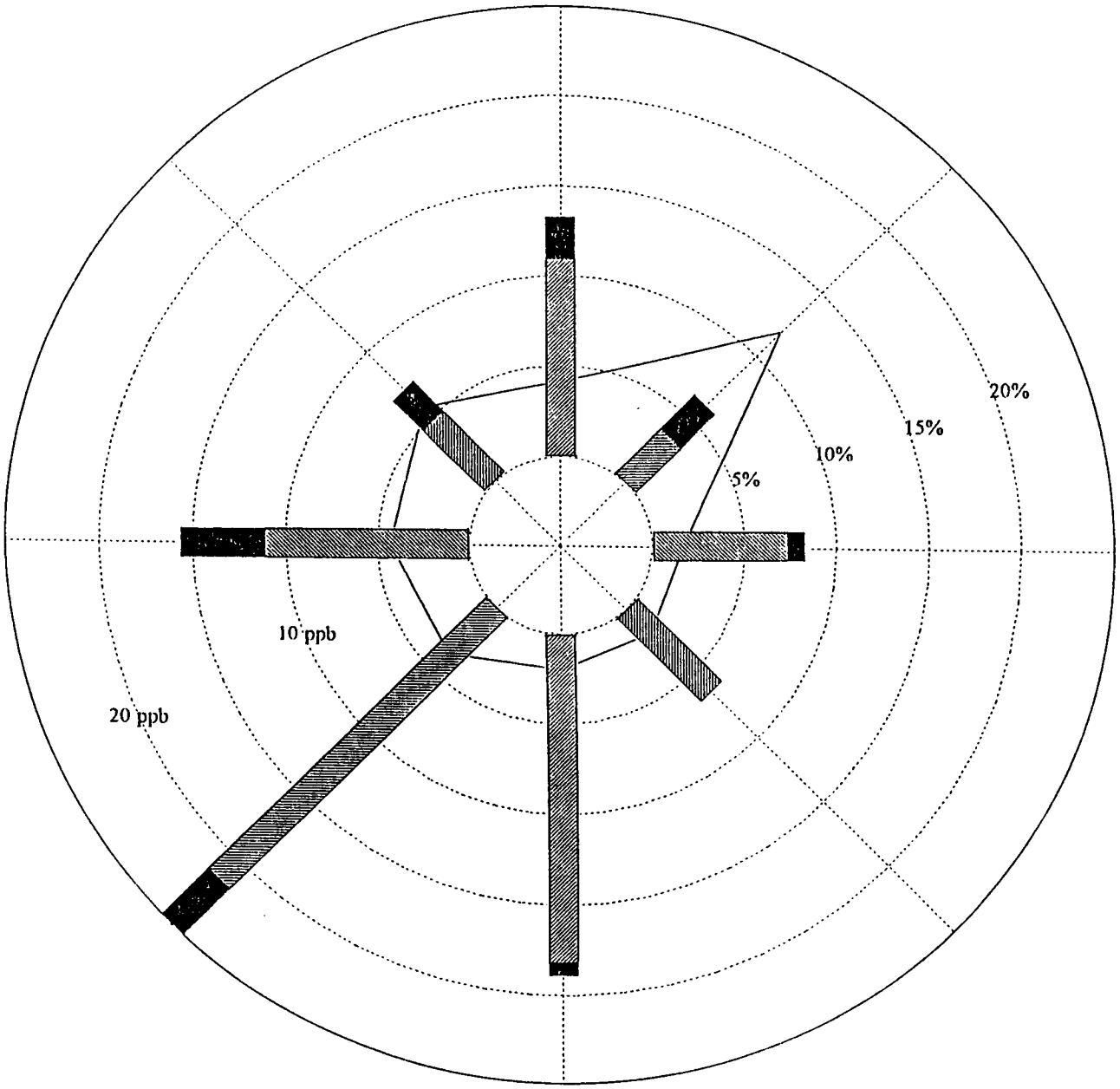


Figure 7. July 1994 wind rose from Gosier Island. Solid bar denotes percentage of speeds greater than 5 m sec^{-1}. Solid line is average NO_2 concentration in ppb at Breton Island (576 samples, 77.4% of month).

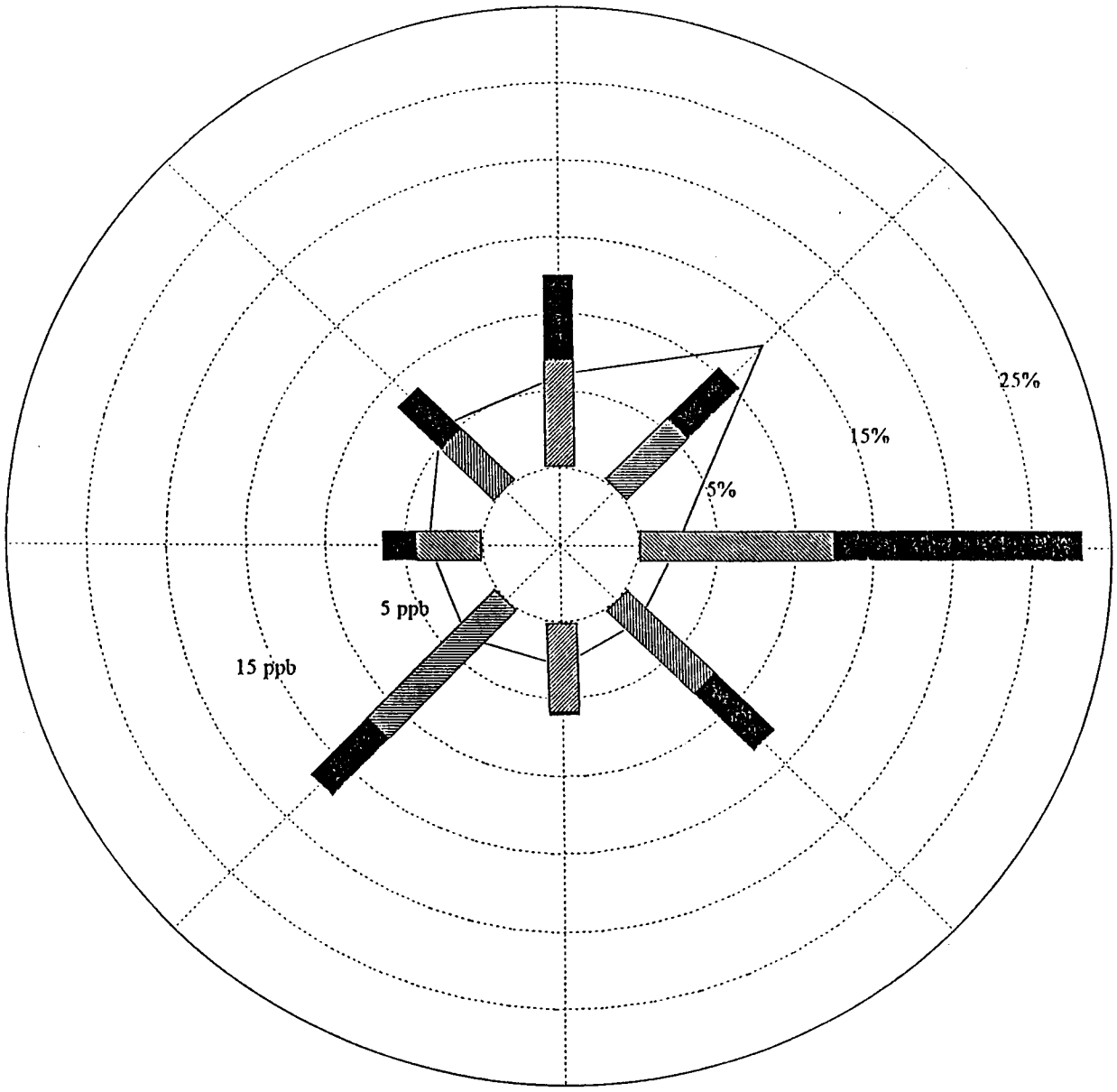


Figure 8. August 1994 wind rose from Gosier Island. Solid bar denotes percentage of wind speeds greater than 5 m sec^{-1}. Solid line is average NO_2 concentration in ppb at Breton Island (632 samples, 84.9% of month).

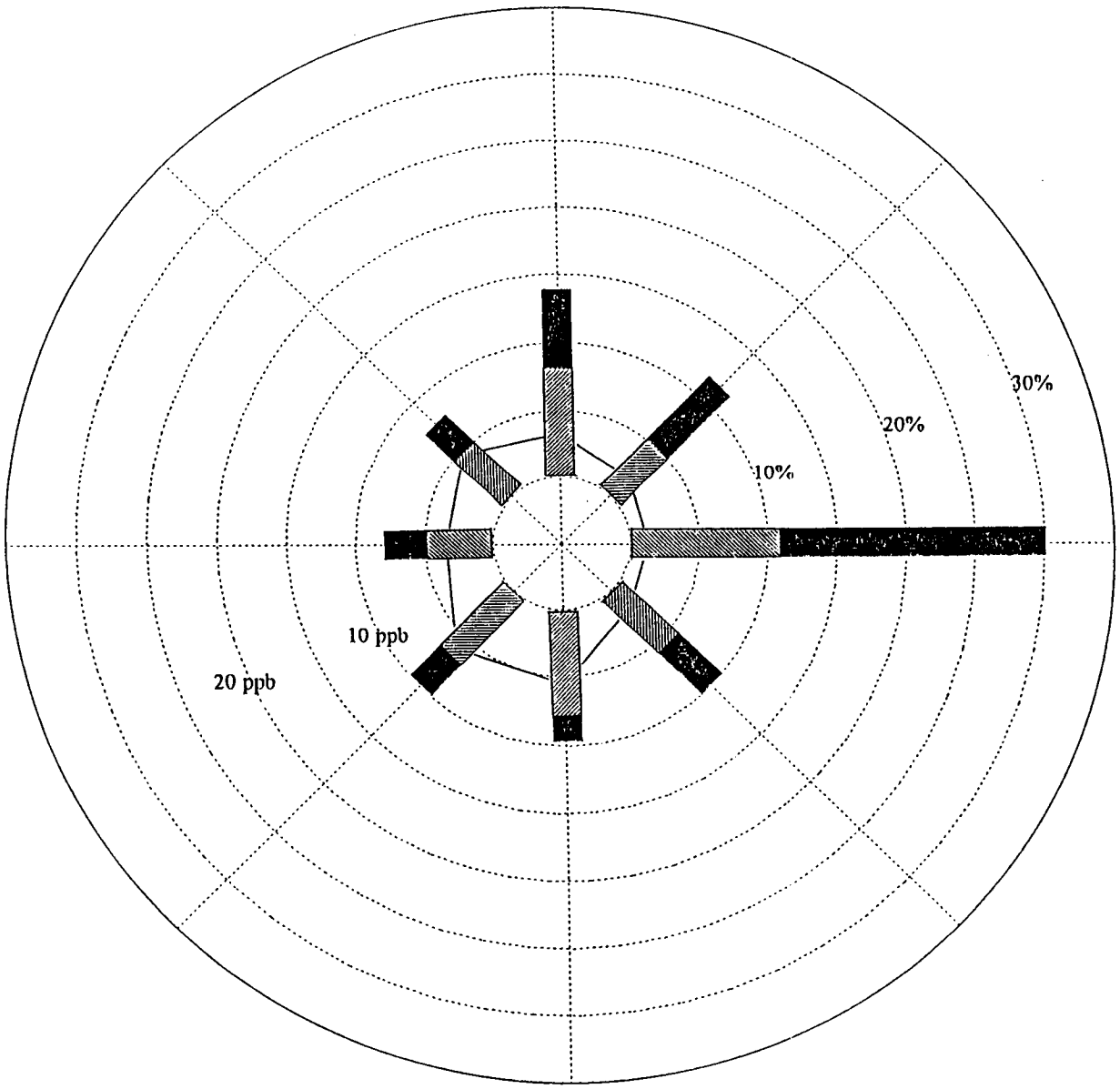


Figure 9. September 1994 wind rose from Gosier Island. Solid bar denotes percentage of wind speeds greater than 5 m sec^{-1}. Solid line is average NO_2 concentration in ppb at Breton Island (611 samples, 98.6% of possible record).

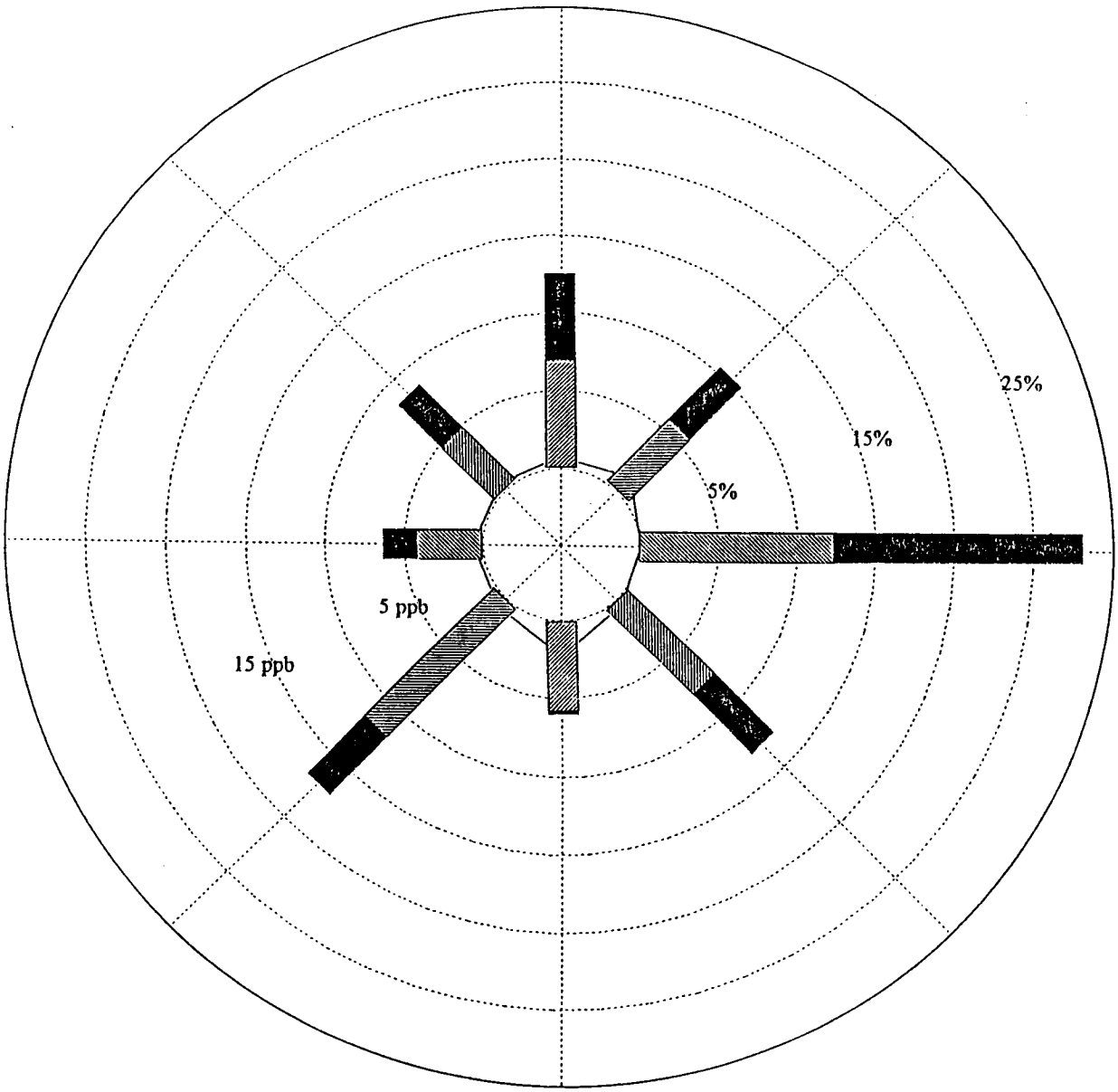


Figure 10. August 1994 wind rose from Gosier Island. Solid bar denotes percentage of wind speeds greater than 5 m sec^{-1}. Solid line is average SO_2 concentration in ppb at Breton Island (632 samples, 84.9% of month).

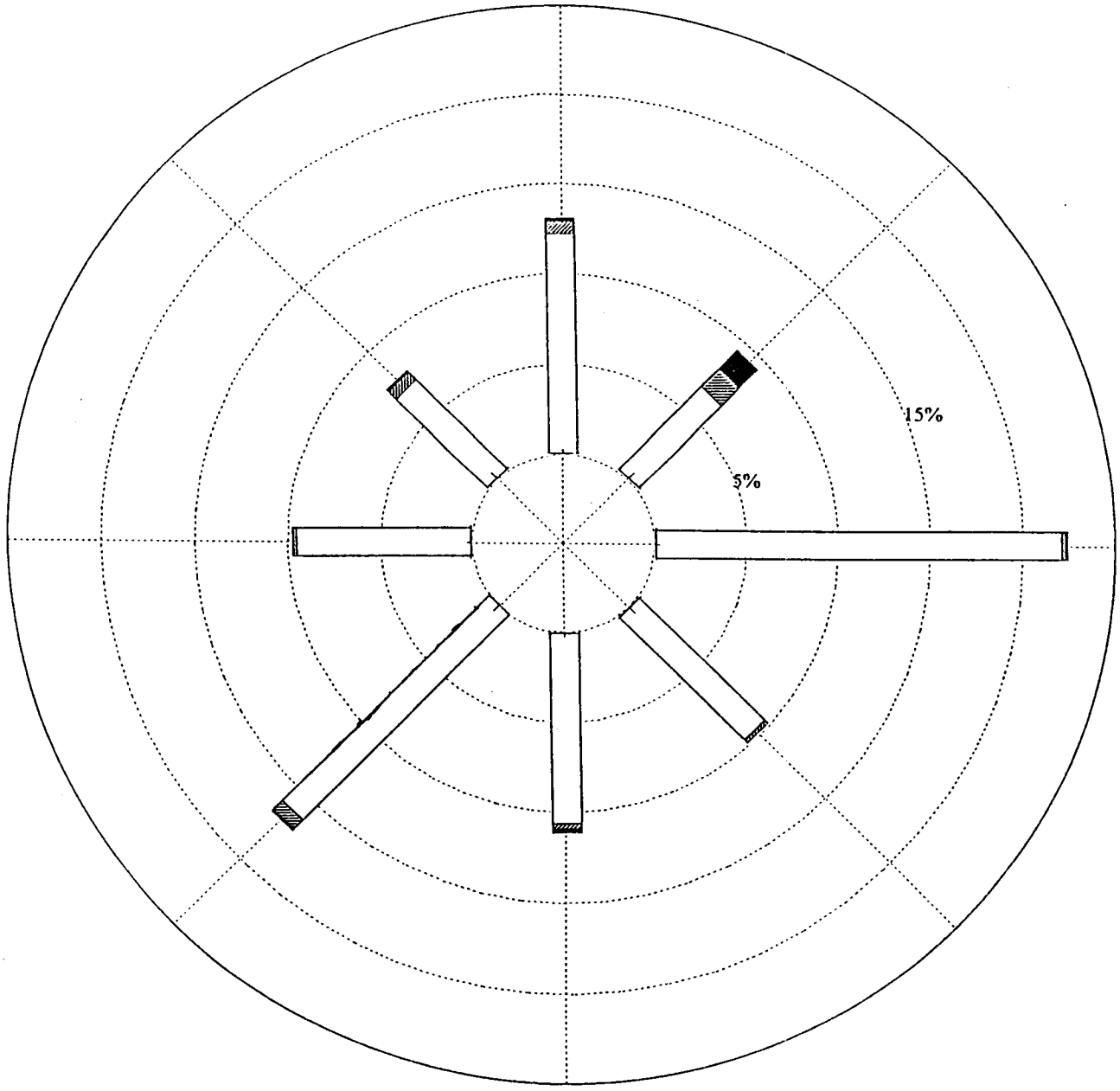


Figure 11. Frequency distribution of NO_2 (in ppb) at Breton Island during the period of 1 July to 26 September 1994 based on Gosier Island winds (1819 samples, 86.2% of possible record). Bar is divided into 0-10 ppb (clear), 10-20 ppb (hatched), and >20 ppb (solid).

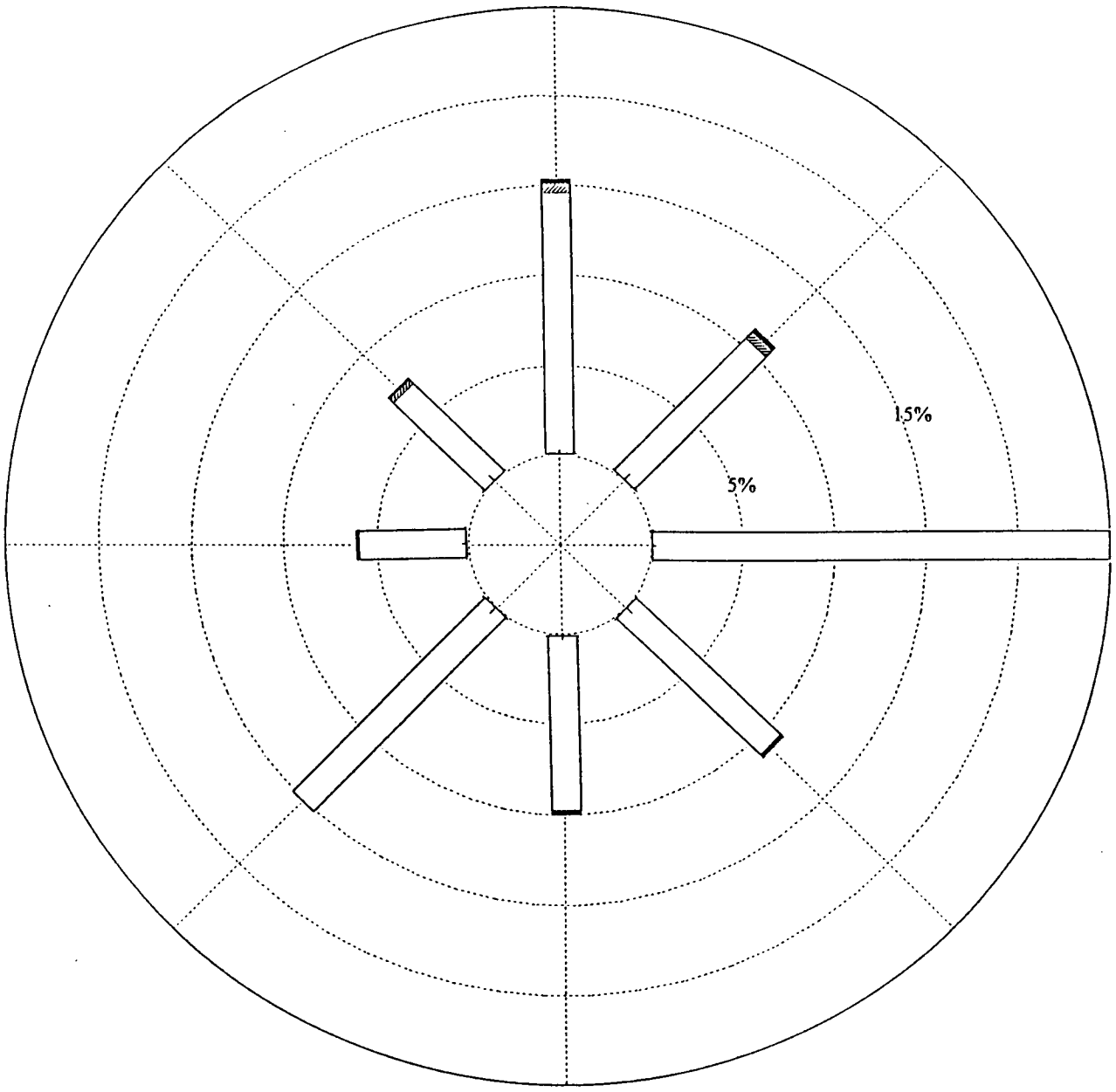


Figure 12. Frequency distribution of SO_2 (in ppb) at Breton Island for the months of July and August 1994 based on Gosier Island winds (887 samples, 59.6% of possible record). Bar is divided into 0-5 ppb (clear), 5-10 ppb (hatched), and >10 ppb (solid).

Table 15.
Events of Breton Island NO_2 Concentration > 18.2 ppb

Date / Time	NO_2	NO	NO_x	NO / NO_x Ratio	WS m s^{-1} / WD	Previous 6 Hour WS / WD
7/2/94 0800	32	107	139	0.8	3.1 / 62	3.4 / 87
0900	25	68	94	0.7	3.4 / 60	3.3 / 83
1000	36	176	213	0.8	3.7 / 51	3.3 / 77
1200	23	87	111	0.8	5 / 39	3.8 / 53
1300	25	84	109	0.8	5.2 / 33	4.1 / 47
1400	28	106	134	0.8	5.4 / 42	4.5 / 43
1500	19	89	109	0.8	5.9 / 58	4.9 / 43
7/3/94 0200	30	71	101	0.7	5.6 / 51	4.6 / 73
0300	23	51	74	0.7	6.3 / 61	4.7 / 68
0600	19	39	58	0.7	5.6 / 54	5.9 / 57
7/29/94 0200	59	44	103	0.4	3.4 / 317	1.5 / 276
1800	23	60	83	0.7	2.3 / 35	2.9 / 21
8/6/94 0100	22	7	28	0.3	4.9 / 326	2.3 / 135
8/7/94 1400	36	10	46	0.2	2.8 / 22	2.2 / 321
2000	24	67	91	0.7	3.9 / 66	2.6 / 36
8/10/94 0900	31	71	102	0.7	4.2 / 36	3.7 / 68
1300	19	36	55	0.7	5 / 33	4.2 / 34
1400	27	67	95	0.7	5.3 / 46	4.5 / 33
8/11/94 1000	21	75	97	0.8	5.3 / 53	4.1 / 65
1100	22	49	71	0.7	5.7 / 52	4.5 / 59
1200	42	148	191	0.8	5.9 / 46	5 / 54
1300	20	51	72	0.7	6.2 / 52	5.3 / 52
1500	22	47	69	0.7	6.4 / 53	5.9 / 52
1600	45	128	174	0.7	6.4 / 53	6.1 / 52
1900	25	102	128	0.8	6 / 94	6.2 / 74
8/13/94 1300	21	171	192	0.9	5.7 / 44	5.1 / 65
1400	25	182	208	0.9	6.4 / 51	5.5 / 60
1500	33	218	252	0.9	6.3 / 51	5.8 / 58
1600	23	139	163	0.9	6 / 54	5.9 / 57
1700	23	160	184	0.9	5.9 / 57	6.1 / 54
8/17/94 1100	19	2	22	0.1	3.1 / 339	4.3 / 326
8/24/94 1400	29	110	141	0.8	2.8 / 43	1.7 / 115
1500	28	101	130	0.8	3.5 / 51	1.9 / 93
1600	22	70	92	0.8	M / M	1.9 / 93
8/25/94 1600	28	78	108	0.7	6.2 / 54	5.3 / 57
9/16/94 1300	31	229	261	0.9	3.3 / 200	4.4 / 195
1400	19	99	119	0.8	3.4 / 195	4 / 201
1500	22	130	152	0.9	3.4 / 196	3.7 / 203
1700	20	88	108	0.8	3.3 / 201	3.4 / 202
2100	20	61	81	0.8	5 / 190	4 / 204
2200	24	100	124	0.8	5.8 / 191	4.3 / 201
9/17/94 0500	20	109	130	0.8	6.1 / 201	5.9 / 201
0600	21	109	131	0.8	6 / 206	5.9 / 203
0700	23	108	131	0.8	5.6 / 202	5.8 / 204
0800	25	128	153	0.8	5.6 / 208	5.8 / 205

Sound), but frequency or amount of traffic is not know. Another possible local source is the generator at the Kerr-McGee facility on Breton Island which is in continuous operation.

Passive sampler data for Breton Island as provided by the Harvard School of Public Health is given in Tables 16 and 17 with the same considerations as at Gosier.

4. Pass-A-Loutre

Observed ambient levels of both SO_2 and NO_2 at the PAL station were lower than those at Breton during the study period. Daily maximums and averages for SO_2 and NO_2 are in Table 18 and 19, respectively. Monthly hourly, 3-hourly, and daily maximums are in Table 20.

Wind roses with average pollutant levels are shown in Figs. 13 - 16. Highest levels of NO_2 occurred from the southwest and northwest quadrants in July, and again from the northwest in August. Average NO_2 values were less than 5 ppb. SO_2 appeared to be more evenly distributed; however average concentrations were near to zero.

Figures 17 and 18 display the frequency distributions for the entire record of NO_2 and SO_2, respectively. Highest concentrations of NO_2 were from northwest and southwest, while highest SO_2 concentrations came from the north. The majority of all measurements were 5 ppb or less.

Table 21 is constructed similar to Table 15, but for PAL. The NO/NO_x ratios here are much lower, suggesting a more aged air mass (distant source); however it should be noted that the wind speeds were generally very light. The highest ratios appear to be associated with westerly transport. A possible cause may be ship traffic in the heavily utilized South and Southwest Passes of the Mississippi River delta.

5. Radiosondes

Atmospheric profiles obtained by radiosondes were analyzed to determine the mixing heights prevailing over the study area. Profiles of the lower 1000 - 2000 m of potential temperature (θ) and mixing ratio (q) for each sounding are shown in Figs. 19a - c. In a well-mixed boundary layer, θ and q remain nearly constant with height until reaching the top of the layer, at which point there is usually rapid increase of θ and decrease of q. Each profile was examined to identify the height where this change (in slope) occurred.

Assuming the presence of cumulus cloud (which often prevail over the marine layer), Garratt (1992) has shown that the mixing height h = LCL, the lifting condensation level. The LCL may be estimated (see McIlveen, 1986) by

$$H_{sea} \approx 125\left(T_{air} - T_{dew}\right) \qquad \textbf{(1)}$$

where H_{sea} is the mixing height over the water surface, and T_{air} and T_{dew} are the air and dewpoint temperatures (°C). If the clouds are stratiform, then the mixing height extends to the cloud top rather than base.

Table 22 lists all heights as determined by the methods described. LCL_p is obtained from the plot of the profile on a Skew-T Log-p thermodynamic diagram, while LCL_c was calculated from Eq. (1) and h is from θ and q. If one accepts a root mean square error of approximately 71 m, then Eq. (1) may be used to estimate the LCL over our study area. The lifting condensation levels and mixing height estimates for each profile are generally within 100 - 200 m, however excellant agreement is found between the mean LCL_p (507 m) and the mean mixing height (505 m). Since heights h and LCL_p are measured directly by radiosonde which LCL_c is derived from theoretical considerations, it should be possible to refine Eq. (1) to more accurately represent our study area given further investigation and measurements. At this point, considering the upper-air measurement void which exist over the Gulf of Mexico, Eq. (1) is offered here as a first approximation. Regardless, all of the heights found through this analysis are well below the climatic mean for summer as given by Holzworth (1972).

Table 16.
Breton Island Ogawa (SO_2) Passive Data

CSI Design.	Harvard Design.	Time On	Time Off	Total Hours	Net PPB SO2
B002	ESC 2	6/30 1158	7/7 1550	171.9	4.7
B004	ESC 4	7/7 1550	7/13 2105	149.3	5.2
B006	ESC 6	7/13 2110	7/27 (7/26)[+] 1405	328.9 (305)	26.0
B008	ESC 8	7/27 (7/26) 1409	8/5 1706	218.9 (243)	9.5
B010	ESC 10	8/5 1708	8/16 1946	266.6	9.1
B014	ESC 14	8/16 1950	8/23 1918	167.5	1.8
B016	ESC 16	8/23 1921	8/30 1919	168	4.5
B018	ESC 18	8/30 1920	9/7 1948	192.5	1.2
B020	ESC 20	9/7 1949	9/26 1852	455	12.6
B022	ESC 22	9/26 1855	10/4 1040	183.8	9.3
B023		10/4 1040	10/13 1525	220.8	

[+] Dates and times in parentheses are incorrect, but were used in Harvard's chemical analysis.
NOTE: Ogawa tube #'s 11, 12, and 21 were not exposed.

Table 17.
Breton Island Palmes (NO_2) Passive Data

CSI Design.	Harvard Design.	Time On	Time Off	Total Hours	Mean Conc. NO2 PPB
B002	ESC-002	6/30 1157	7/7 1550	171.9	9.38
B004	ESC-004	7/7 1550	7/13 2104	149.3	15.56
B006	ESC-006	7/13 2108	7/27 (7/26)[+] 1405	329 (304)	8.66
B008	ESC-008	7/27 (7/26) 1409	8/5 1706	219 (243)	6.62
B010	ESC-010	8/5 1708	8/16 1946	266.6	11.91
B012	ESC-012	8/16 1950	8/23 1918	167.5	13.64
B016	ESC-016	8/23 1921	8/30 1919	168	7.92
B018	ESC-018	8/30 1920	9/7 1948	192.5	7.28
B020	ESC-020	9/7 1949	9/26 1852	455	5.52
B022	ESC-022	9/26 1855	10/4 1040	183.8	4.86
B023		10/4 1040	10/13 1525	220.8	

[+]Dates and times in parentheses are incorrect, but were used in Harvard's chemical analysis.
NOTE: Palmes tubes #'s 13, 14, and 21 were not exposed.

Table 18.
Pass-A-Loutre Daily SO_2 Maximums and Averages (ppb)

	July 1994		August 1994		September 1994	
Day	Maximum	Average	Maximum	Average	Maximum	Average
1	1	0.8	2	0.1	0	0
2	5	0.3	0	0	4	0.8
3	0	0	0	0	7	1
4	1	0	0	0	1	0.1
5	0	0	0	0	0	0
6	0	0	3	0.7	0	0
7	2	0.4	0	0	2	0.3
8	1	0.5	0	0	0	0
9	1	0.1	2	0.3	0	0
10	0	0	1	0.1	0	0
11	1	0	0	0	0	0
12	1	0.1	0	0	0	0
13	0	0	3	0.2		
14	1	0.2	7	1.4		
15	0	0	6	1.3		
16	0	0	4	1		
17	1	0.4	4	1		
18	2	0.8	2	0.1		
19	1	0.4	1	0		
20	2	0.3	0	0		
21	1	0.3	1	0.1		
22	0	0	3	0.3		
23	1	0.1	1	0.1		
24	0	0	1	0.2		
25	1	0	1	0		
26	1	0	0	0		
27	1	0	0	0		
28	7	1.4	0	0		
29	3	1	0	0		
30	1	0.1	1	0.1		
31	1	0	2	0.3		
Number Hours	709		729		277	
Maximum	7		7		7	
Arith-Mean	0.2		0.2		0.2	

Total Samples = 1715
% Of Possible Observations = 97.9

Table 19.
Pass-A-Loutre Daily NO_2 Maximums and Averages (ppb)

	July 1994		August 1994		September 1994	
Day	Maximum	Average	Maximum	Average	Maximum	Average
1			4	1.7	5	1.8
2			3	0.9	11	4
3			3	0.5	14	4.2
4			3	0.5	4	1.2
5			5	1.7	2	0.6
6			10	3.2	1	0.5
7	23	3.8	4	2	3	1.2
8	9	1.5	3	1.2	9	2.4
9	7	1.3	6	1.4	2	1.4
10	5	1.3	4	1.5	2	1.2
11	5	1.5	8	1.3	2	0.6
12	14	1.9	4	2.2	5	1.8
13	6	1.3	3	1.3		
14	10	1.4	10	3		
15	7	0.4	9	3.2		
16	4	0.3	12	5		
17	6	1.4	13	5.1		
18	11	1.8	5	1.6		
19	3	1	9	2.4		
20	6	1.2	1	0.3		
21	7	1.3	3	0.7		
22	4	2.3	9	3.5		
23	12	4.1	6	2.6		
24	11	4.8	3	1.8		
25	9	3.3	5	1.5		
26	9	2.9	3	0.8		
27	15	3	4	0.9		
28	10	2.9	3	0.8		
29	15	3.3	2	0.6		
30	3	1.8	5	2.2		
31	9	2	10	1.8		
Number Hours	570		729		277	
Maximum	23		13		14	
Arith-Mean	2		1.8		1.7	

Total Samples = 1576
% Of Possible Observations = 97.8

Table 20.
Pass-A-Loutre 1994 Pollutant Maximums

Month	Pollutant	%	Averaging Period	Maximum ppb	Average Wind Speed / Direction	Date / Time UTC
July	SO_2	97.9	1 hr	7	3.5 / 8	7/28/94 @ 1000
			3 hr	4	3.5 / 12	7/28/94 @ 1200
			24 hr	1.4	2.6 / 334	7/28/94
	NO_2	78.7	1 hr	23	0.5 / 324	7/7/94 @ 2300
			3 hr	11	0.5 / 356	7/8/94 @ 0100
			24 hr	4.8	1.1 / 260	7/24/94
August	SO_2	98	1 hr	7	3.6 / 355	8/14/94 @ 2100
			3 hr	5.7	4 / 349	8/14/94 @ 2100
			24 hr	1.4	2.3 / 354	8/14/94
	NO_2	98	1 hr	13	0.5 / 325	8/17/94 @ 1000
			3 hr	11.7	3.8 / 316 0.8 / 322	8/16/94 @ 0400 and 8/17/94 @ 1100
			24 hr	5.1	2.3 / 262	8/17/94
September	SO_2	98.2	1 hr	7	2.1 / 330	9/3/94 @ 0500
			3 hr	4.7	1.9 / 322	9/3/94 @ 0700
			24 hr	1	2.2 / 336	9/3/94
	NO_2	98.2	1 hr	14	1.4, 1.3 / 312, 319	9/3/94 @ 0800, 0900
			3 hr	13	1.5 / 314	9/3/94 @ 0900
			24 hr	4.2	2.2 / 336	9/3/94

NOTE: Wind speed in m sec^{-1} and direction in degrees.

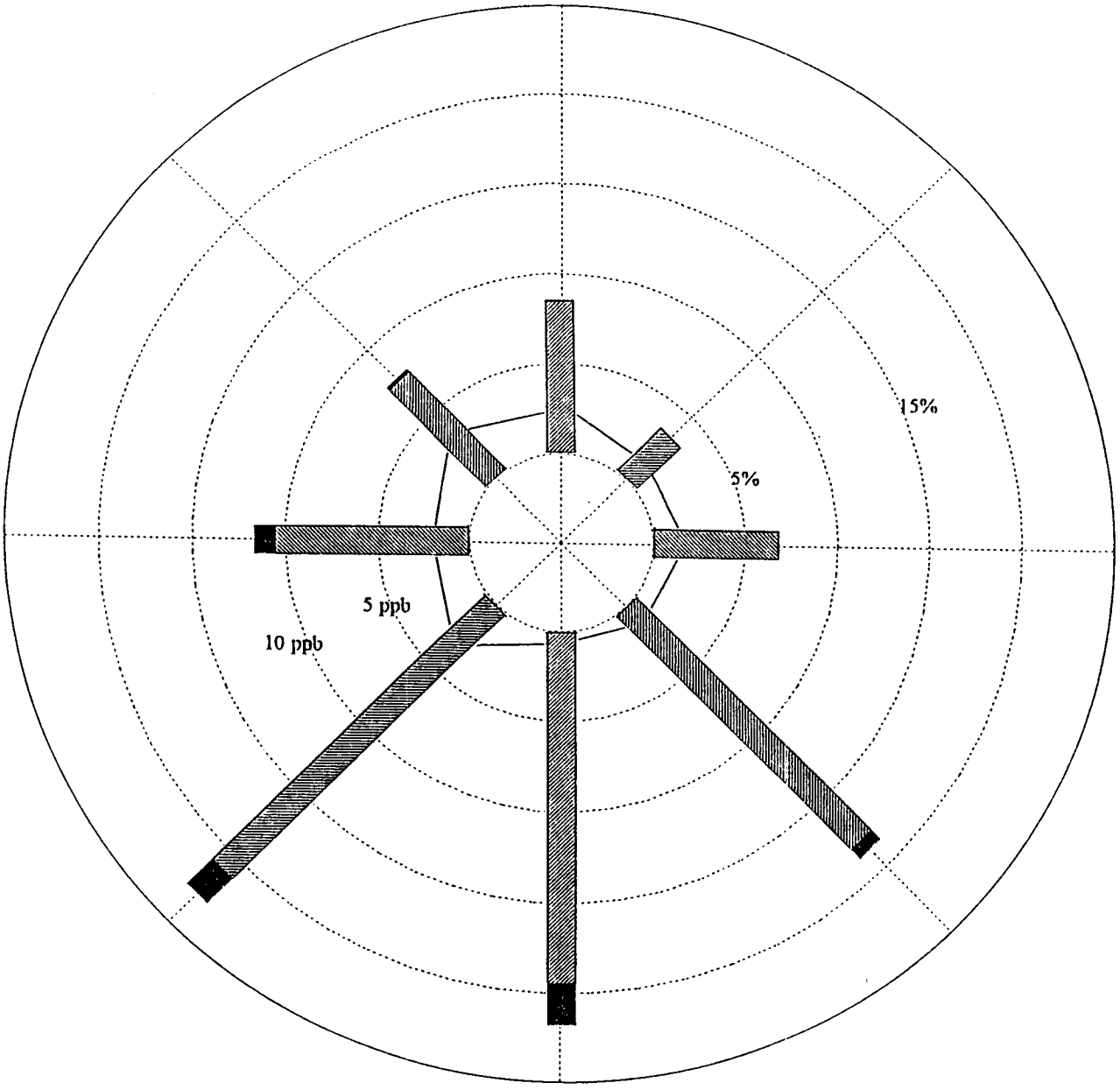


Figure 13. July 1994 wind rose from PAL. Solid bar denotes percentage of wind speeds greater than 5 m sec^{-1}. Solid line is average NO_2 concentration in ppb (569 samples, 78.6% of month).

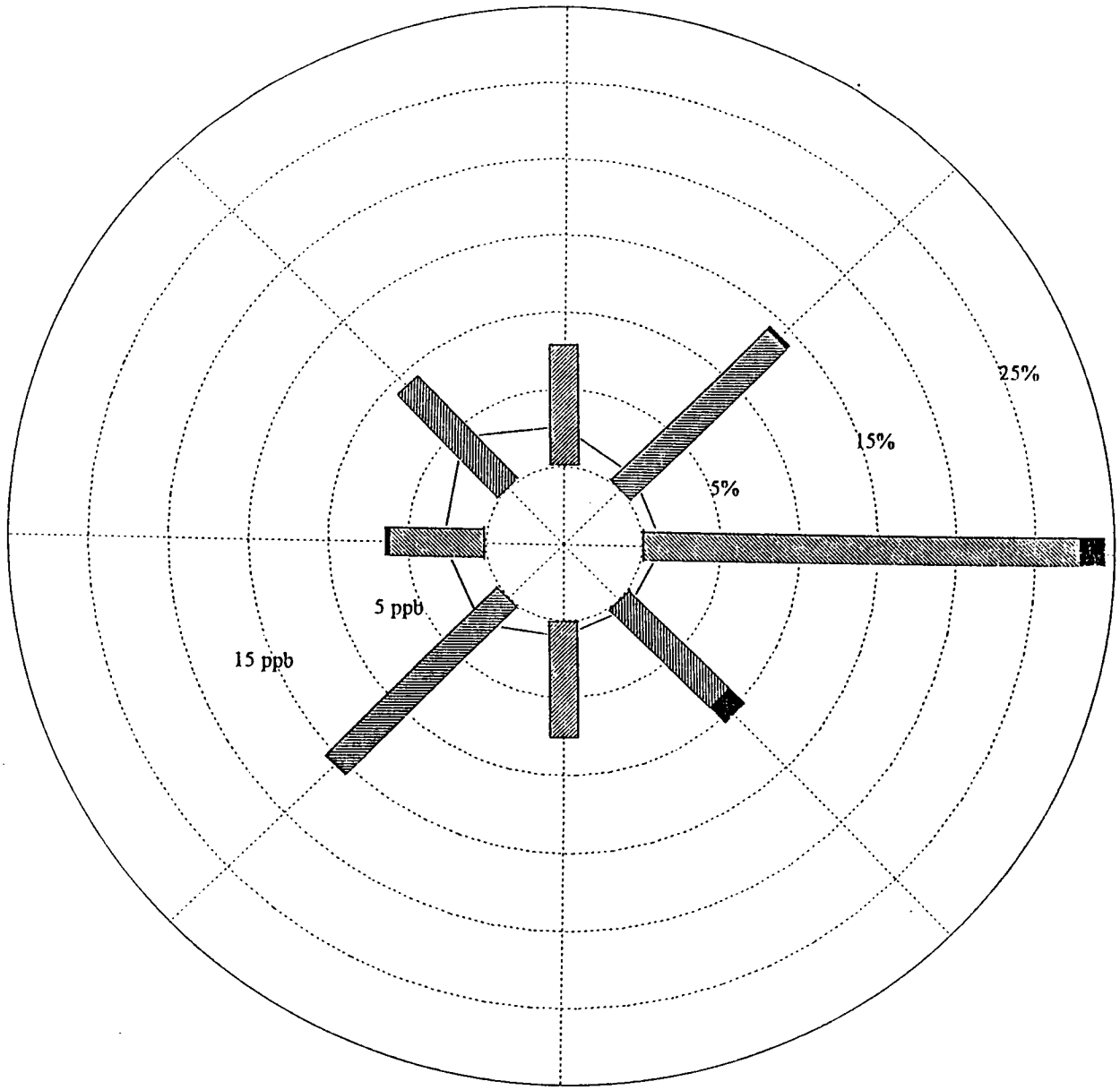


Figure 14. August 1994 wind rose from PAL. Solid bar denotes percentage of wind speeds greater than 5 m sec^{-1}. Solid line is average NO_2 concentration in ppb (729 samples, 98% of month).

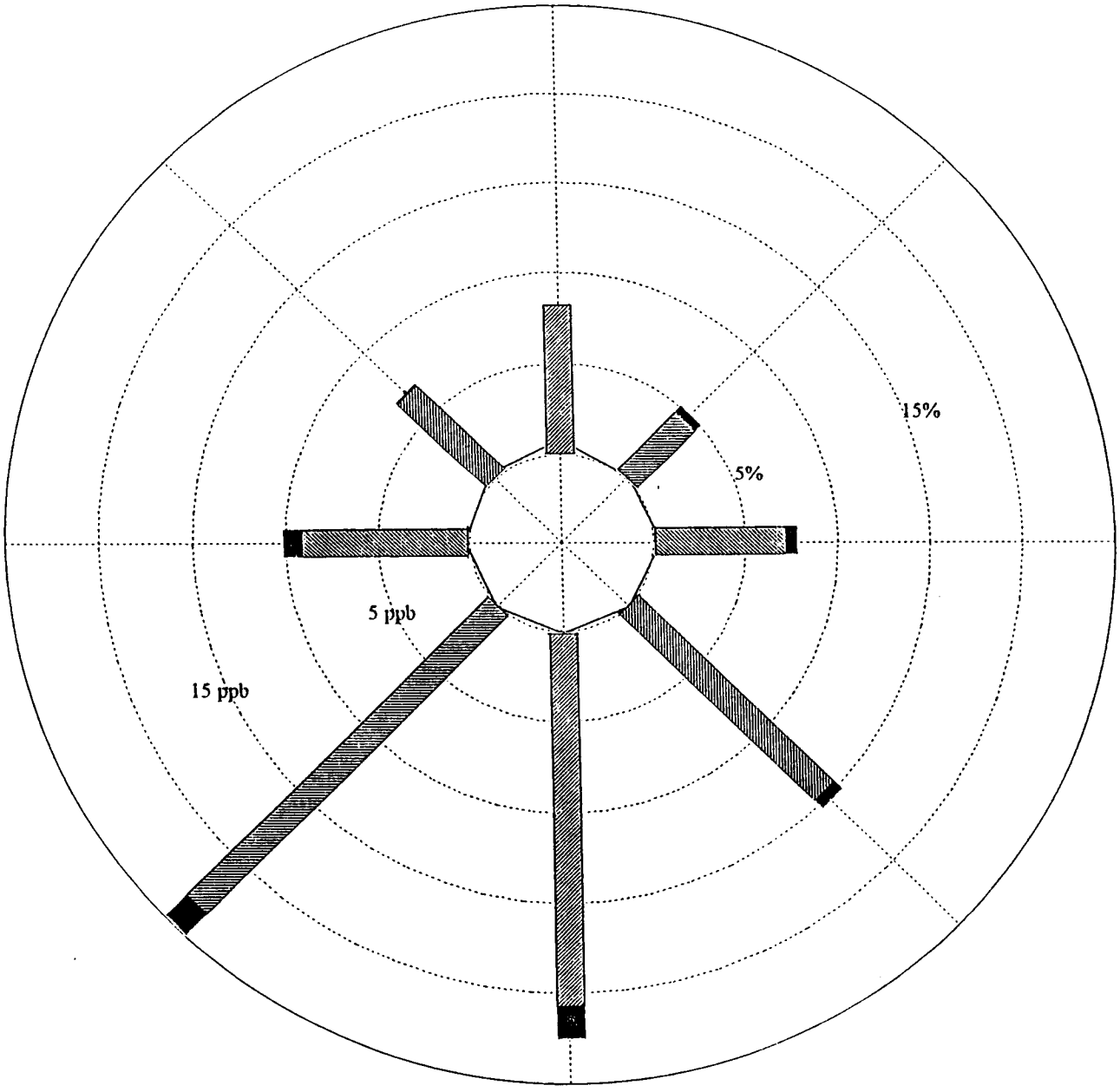


Figure 15. July 1994 wind rose from PAL. Solid bar denotes percentage of wind speeds greater than 5 m sec^{-1}. Solid line is average SO_2 concentration in ppb (724 samples, 97.9% of month).

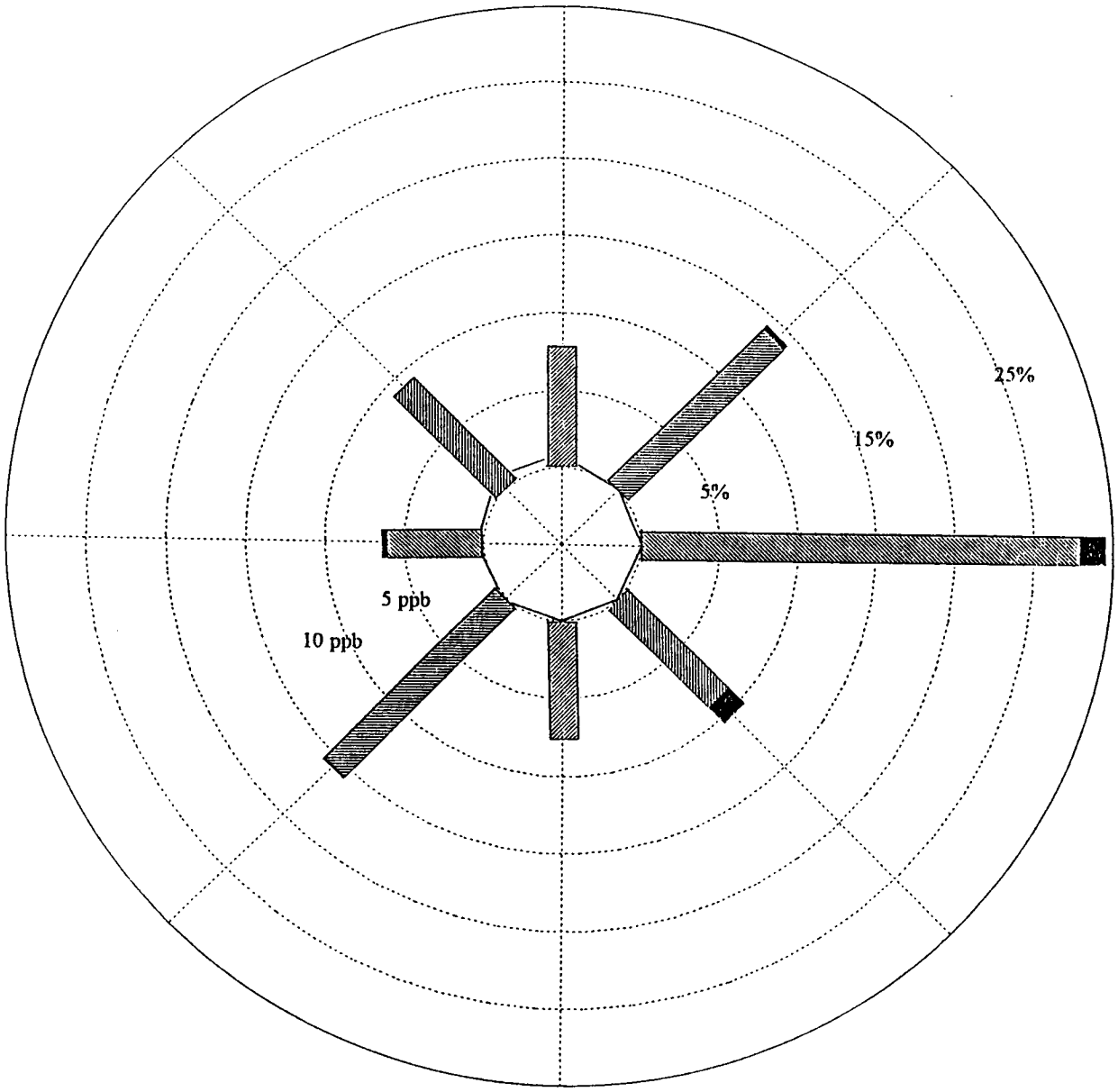


Figure 16. August 1994 wind rose from PAL. Solid bar denotes percentage of wind speeds greater than 5 m sec^{-1}. Solid line is average SO_2 concentration in ppb (729 samples, 98% of month).

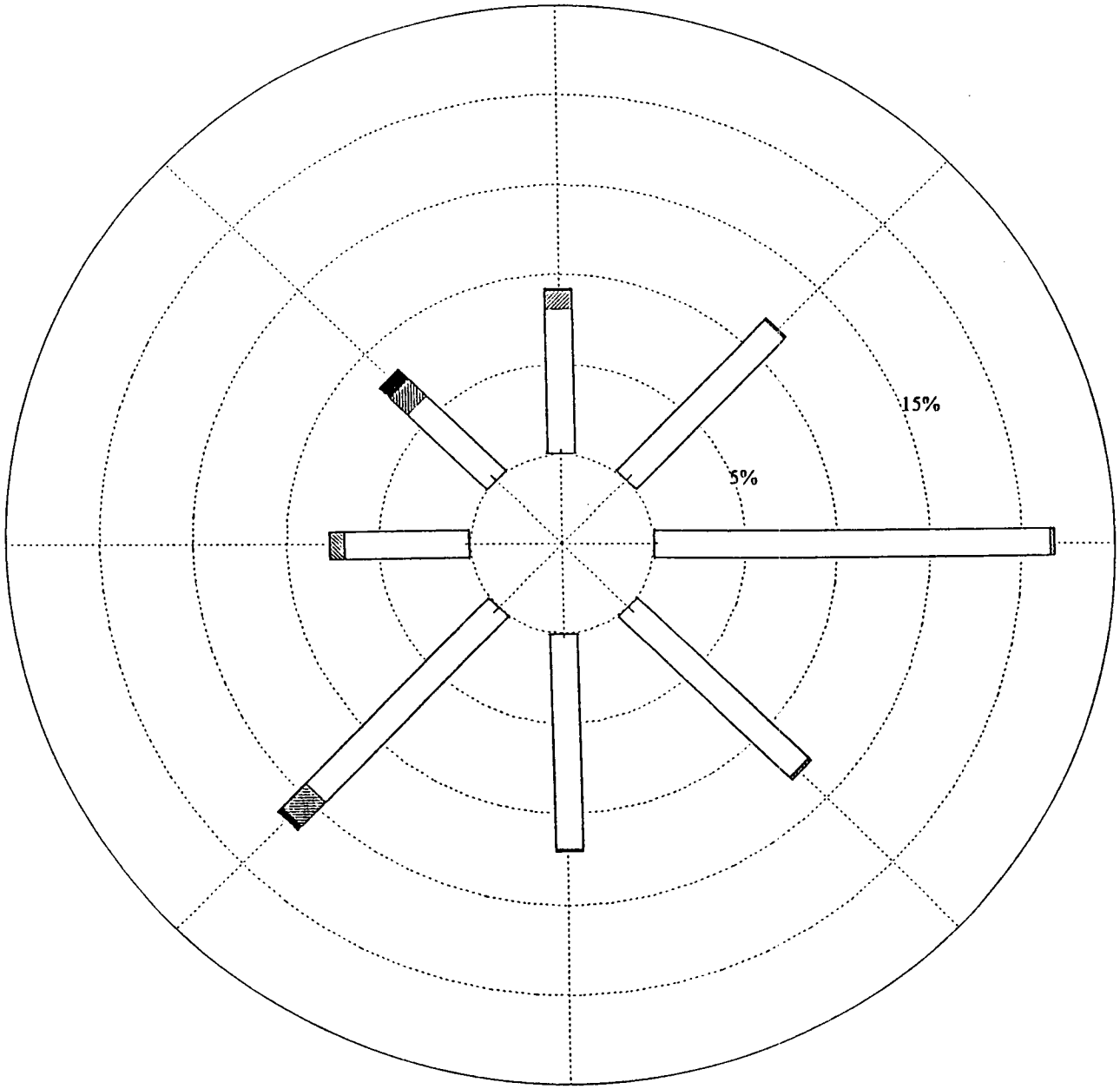


Figure 17. Frequency distribution of NO_2 concentration (in ppb) at PAL during the period of 1 July to 12 September 1994 (1574 samples, 89.9% of possible record). Bar is divided into 0-5 ppb (clear), 5-10 ppb (hatched), and >10 ppb (solid).

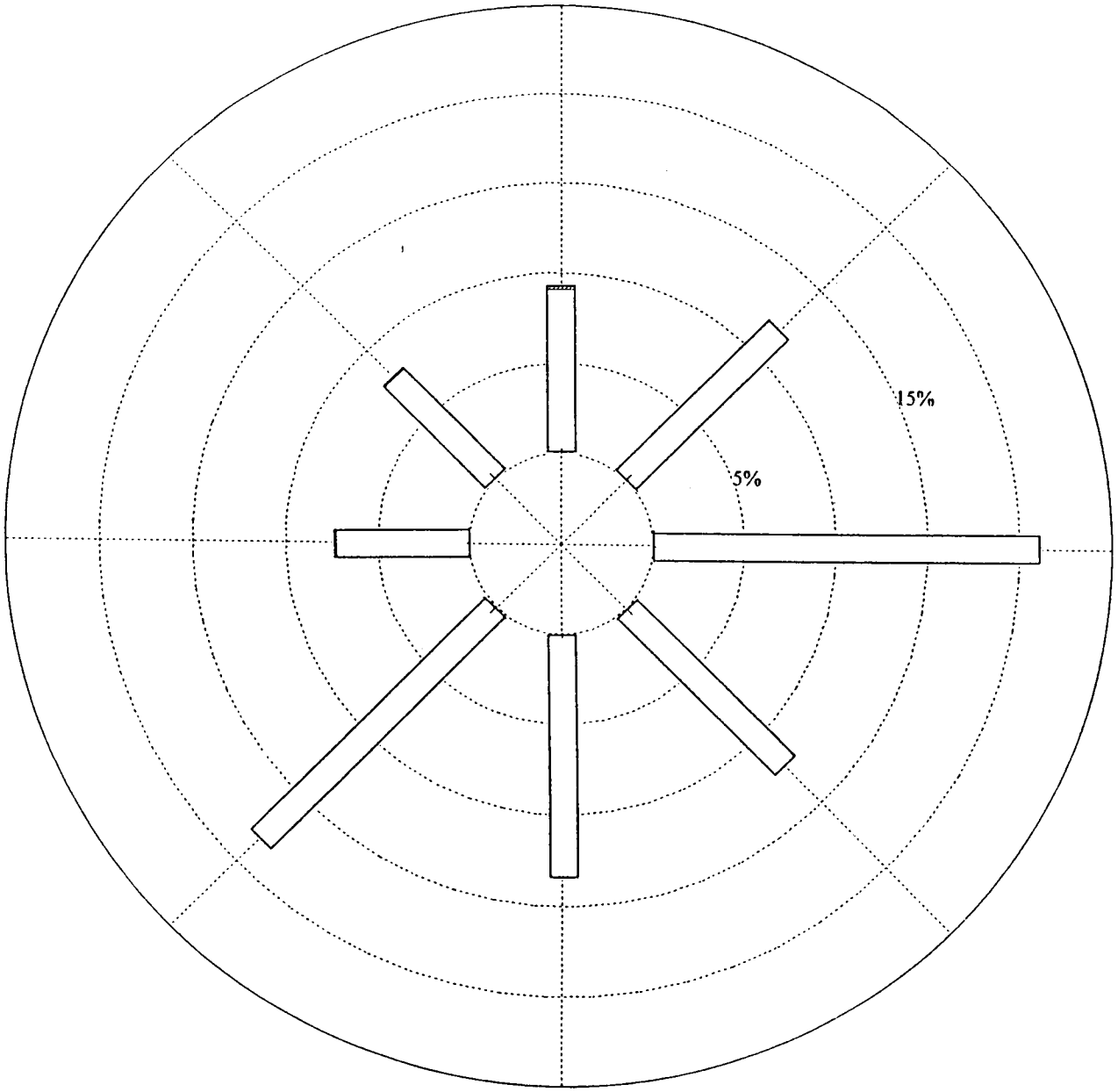


Figure 18. Frequency distribution of SO_2 concentration (in ppb) at PAL during the period of 1 July to 12 September 1994 (1715 samples, 97.9% of possible record). Bar is divided into 0-5 ppb (clear) and >5 ppb (hatched).

Table 21.
Events of Pass-A-Loutre NO_2 Concentrations > 8.8 ppb

Date / Time	NO_2	NO	NO_x	NO / NO_x Ratio	WS m sec^{-1} / WD	Previous 6 Hour WS / WD
7/7/94 2300	23	11	35	0.3	0.5 / 324	2.1 / 189
7/8/94 0000	9	5	16	0.3	0.6 / 6	1.9 / 235
7/12/94 0300	14	3	19	0.2	1.7 / 301	2.9 / 200
7/14/94 0400	10	5	16	0.3	2 / 132	3.2 / 166
7/18/94 0600	9	1	11	0.1	1 / 245	0.2 / 178
0700	11	3	15	0.2	1 / 244	0.3 / 191
7/23/94 0800	12	0	12	0	1.4 / 227	0.9 / 214
0900	9	0	9	0	0.6 / 227	1 / 223
1000	10	0	10	0	0.8 / 252	1 / 229
7/24/94 0100	11	0	10	0	0.6 / 236	2.8 / 212
0200	11	1	11	0.1	0 / 230	2.7 / 219
7/25/94 0300	9	0	8	0	2.5 / 223	2.8 / 232
2300	9	12	20	0.6	3.8 / 236	4 / 247
7/26/94 0100	9	0	9	0	3.5 / 226	3.9 / 237
7/27/94 1100	15	12	29	0.4	6.8 / 232	5.6 / 228
7/28/94 0700	9	1	11	0.1	3.5 / 323	2.6 / 300
0800	10	1	12	0.1	3.9 / 336	2.9 / 312
7/29/94 1000	9	1	12	0.1	0.2 / 340	0 / 354
1100	15	1	18	0.1	1.2 / 347	0.3 / 351
7/31/94 2300	9	1	12	0.1	1.2 / 228	1.7 / 243
8/6/94 1000	10	1	13	0.1	0.4 / 299	0.3 / 323
1400	9	2	12	0.2	1.4 / 341	0.9 / 321
8/14/94 1300	10	2	13	0.2	3.8 / 318	3 / 327
8/15/94 1100	9	1	11	0.1	1.8 / 336	1.4 / 311
8/16/94 0200	11	0	12	0	4.2 / 311	3.9 / 274
0300	12	0	14	0	3.9 / 313	4.1 / 281
0400	12	0	13	0	3.2 / 323	4 / 294
8/17/94 0100	10	0	11	0	3.6 / 224	3.2 / 242
0200	10	0	11	0	3.2 / 225	3.2 / 240
0900	11	0	12	0	1.5 / 334	2.3 / 267
1000	13	0	15	0	0.5 / 325	1.9 / 283
1100	11	0	13	0	0.3 / 308	1.4 / 296
1200	9	1	12	0.1	0.2 / 341	1.1 / 311
1300	10	2	13	0.2	0.2 / 31	0.8 / 335
8/19/94 0900	9	0	11	0	0.5 / 234	0.7 / 226
8/22/94 0800	9	1	11	0.1	0.5 / 289	0.5 / 214
8/31/94 0000	10	1	12	0.1	0.5 / 223	1.9 / 210
9/2/94 0500	11	1	13	0.1	0.5 / 340	1.4 / 280
0600	10	2	14	0.1	0 / 340	1.1 / 296
1200	9	6	16	0.4	0.8 / 349	0.1 / 342
9/3/94 0600	12	0	13	0	1.8 / 323	2.6 / 310
0700	11	0	13	0	1.8 / 312	2.4 / 307
0800	14	1	16	0.1	1.4 / 312	2.1 / 315
0900	14	2	17	0.1	1.3 / 319	1.9 / 318
9/8/94 1100	9	3	12	0.3	0 / 150	0.2 / 155
1300	9	1	11	0.1	0.4 / 7	0.1 / 97

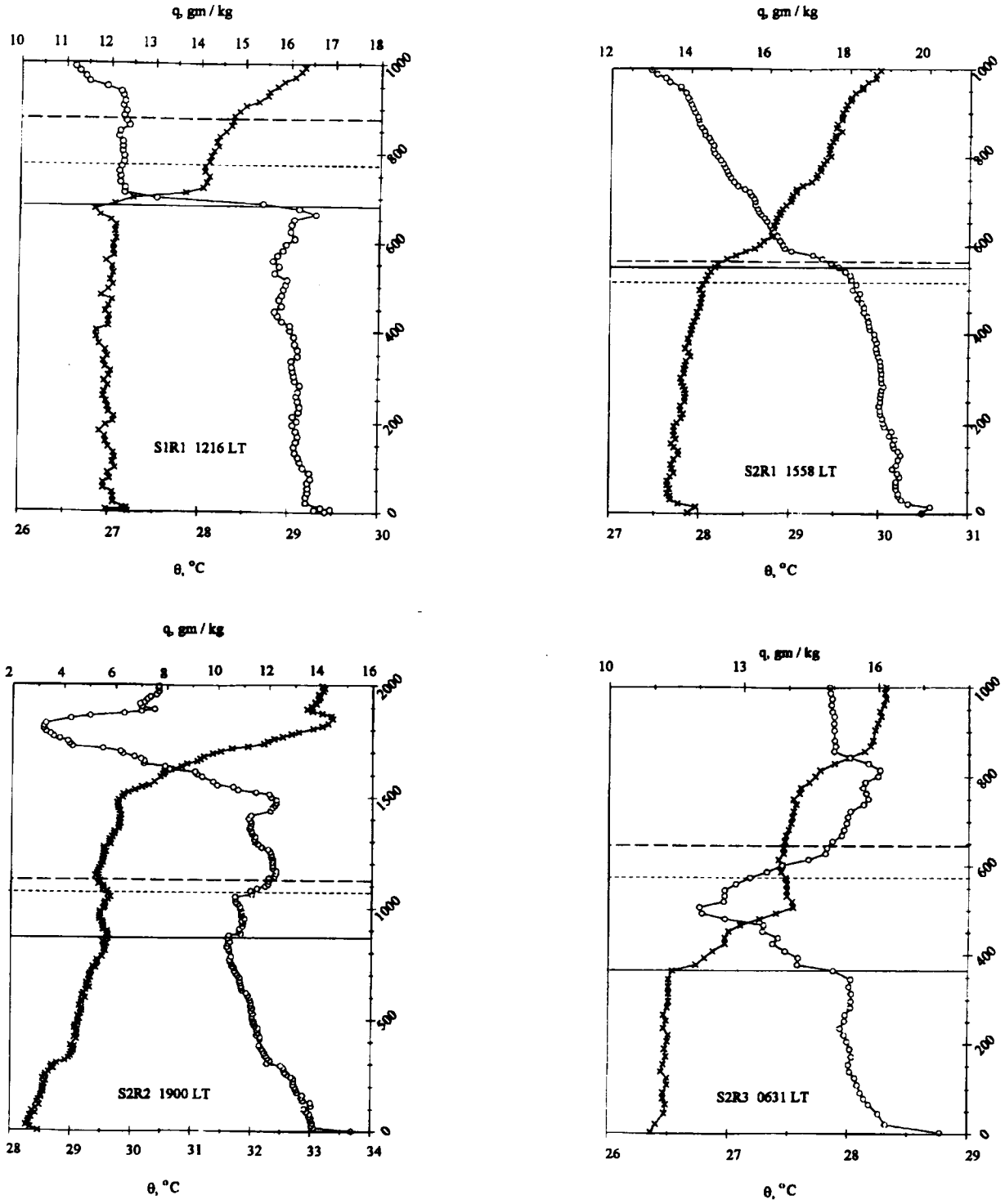


Figure 19. Atmospheric profiles of potential temperature (θ, X-line) and mixing ratio (q, o-line) versus height in m over our study area. Light solid line denotes mixing height h, light dotted line is LCL_p, and heavy dashed line is LCL_c (see text for details).

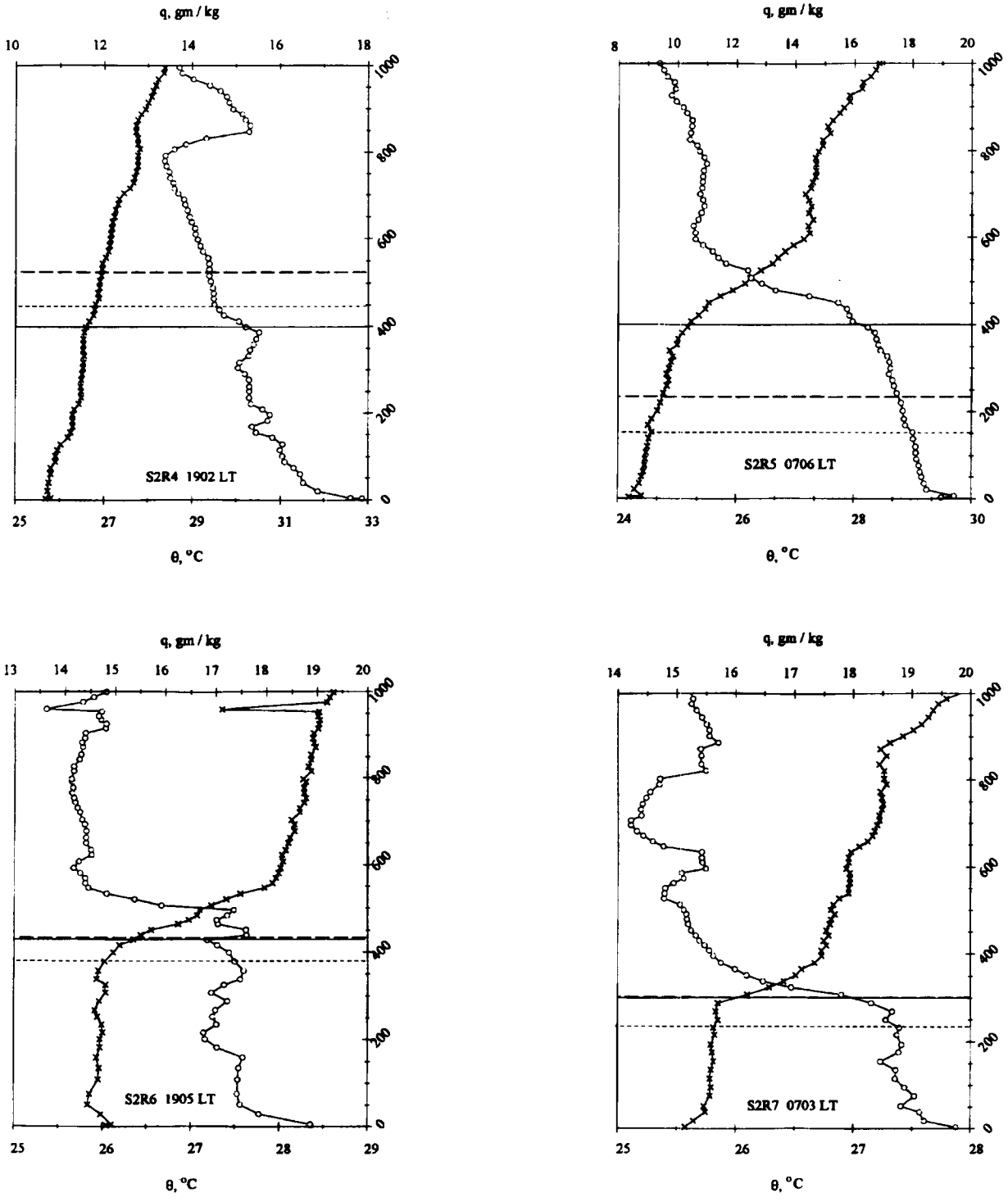
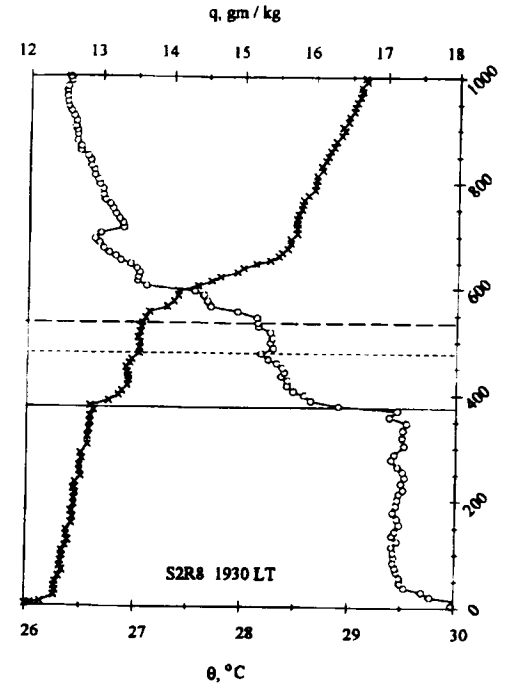
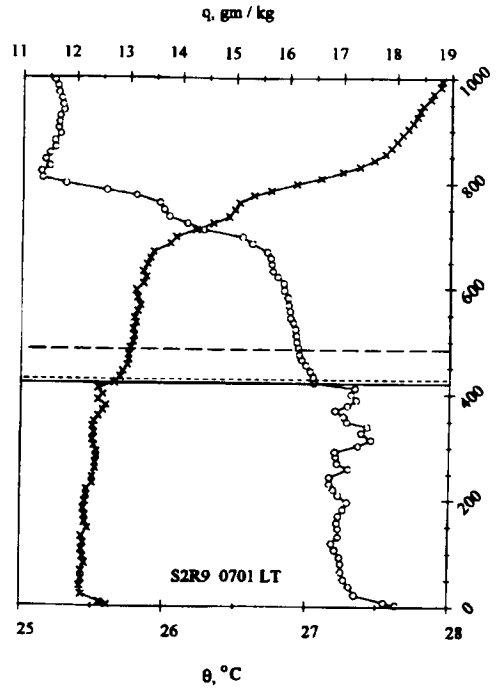
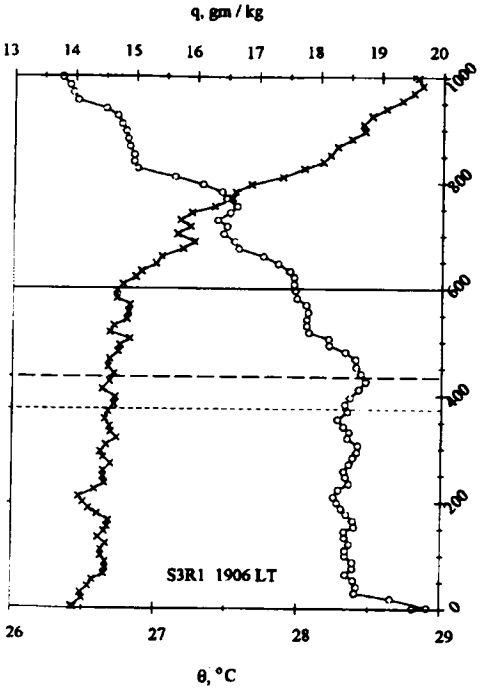


Figure 19 continued.







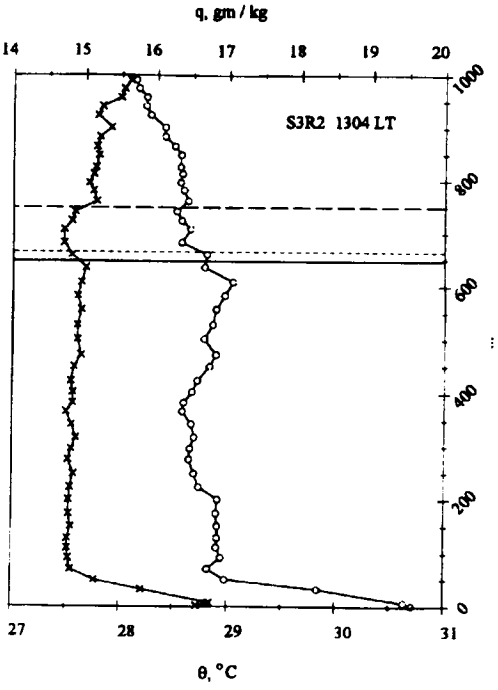


Figure 19 continued.

Table 22.
Lifting Condensation Levels and Mixing Heights

Profile	Time	Cloud Cover	LCL_p m	Mixing Height (h) m	LCL_c m
STA1RS01	1216 LT	CLR, HAZE	761	675	875
STA2RS01	1558 LT	BKN CU, CB	515	550	562
STA2RS02	1900 LT	SCT CI	1073	880	1125
STA2RS03	0631 LT	BKN ST, CU	570	370	625
STA2RS04	1902 LT	BKN SC	448	400	525
STA2RS05	0706 LT	STC AC	152	400	238
STA2RS06	1905 LT	BKN AC, CS	379	430	438
STA2RS07	0703 LT	BKN CU, CB	237	300	300
STA2RS08	1930 LT	SCT CI, CC	477	380	538
STA2RS09	0701 LT	SCT CU, BKN CI	428	420	488
STA3RS01	1906 LT	SCT CU, CI	370	600	438
STA3RS02	1304 LT	BKN CU	670	650	750

LCL_p is obtained from profile while LCL_c was calculated and h is from θq plot.

Where:
CLR - clear
SCT - scattered
BKN - broken
CU - cumulus
CB - cumulonimbus
CI - cirrus
ST - stratus
SC - stratocumulus
AC - altocumulus
CS - cirrostratus
CC - cirrocumulus

RECOMMENDATIONS

RECOMMENDATIONS

Ambient levels of SO_2 and NO_2 recorded from three remote stations near the Mississippi River Delta during the summer of 1994 have been shown to be much lower than the NAAQS. Short-lived episodes of higher than average NO_x appear intermittently in the Breton Island record. Since this area is subject to EPA Class I PSD regulations, it is recommended that long-term (at least one year) continuous monitoring be conducted so that comparisons to PSD increments can be made. The long term record will also allow investigation into the frequency and intensity of the high NO_x events. It is further suggested that the monitoring network be expanded so that pollutant sources (both on land and OCS) may be identified and overwater transport processes better understood. To this end, offshore meteorological monitoring (including atmospheric profiles) should be continued. A more rigorous program for OCS air quality monitoring and station maintenance should be developed (including the acquisition of additional analyzers to minimize downtime). Finally, an additional station in the northeast Gulf of Mexico should be established to improve the spatial resolution as described above.

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REFERENCES

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The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Royalty Management Program** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.