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Air Temperature and Wind Speed Anomalies in 1981-1987 at Coastal Weather Stations in the Northeastern U.S.A.

by

Merton C. Ingham and Grayson B. Wood

Physical Oceanography Branch, Northeast Fisheries Center, NMFS/NOAA
South Ferry Road, Narragansett, RI 02882, USA

Abstract

Monthly average air temperature and wind speed data from three first-order coastal weather stations (Portland, ME; New York - JFK, NY; and Norfolk, VA) were analyzed to determine if there were apparent anomalies in 1981-1987 from 1951-1980 mean conditions. At all three stations air temperatures were anomalously warm in 1981-1987, with about twice as many positive monthly anomalies as negative. There was weak spatial coherence of the sense (+ or -) of temperature anomaly patterns; the strongest correlation was between New York and Portland with a coefficient of only 0.556. Anomalously low wind speeds were prevalent at Portland and New York but wind speeds were anomalously high at Norfolk where they were at least one standard deviation above the long-term means in 31 months of the 84-month period. There was no spatial coherence in the wind anomaly patterns between stations.

SPECIAL SESSION ON ENVIRONMENTAL CONDITIONS

Introduction

The question has been asked, "Was the marine environment of the northwestern Atlantic region in the early 1980's significantly different from long-term average conditions?" Since atmospheric conditions are an integral part of the marine environment, serving either to affect or reflect changes, they can be used as indicators of trends and variations in the marine environment and can help answer the question. A time series of regularly-scheduled, high-quality atmospheric observations covering the last three or four decades is maintained by the U. S. Weather Service for its first order coastal weather stations bordering the Northwest Atlantic Ocean. These observations provide a convenient, relevant data base in which to detect

departures in the 1980's from the recent 30-year norm.

Some discussion of anomalous global atmospheric temperature conditions in the early 1980's compared to longer-term trends (1901-1987) was recently presented by Jones, et al (1988). Their analysis of surface air temperatures revealed that 1987 was the warmest year of the period and 1981 and 1983 were the next warmest. The upward trend of global air temperature over the period presented in their report is unmistakable, with short-term maxima about 1940 and 1960 followed by minima about 1950 and 1970.

Similar longer-term trends in annual mean temperatures (adjusted for changes in location or technology) for 1901-1983 are apparent in plots of data collected at near-coastal weather stations at Portland, Maine; New Bedford, Massachusetts; Block Island, Rhode Island; Groton, Connecticut; Atlantic City, New Jersey; and Norfolk, Virginia (Quinlan, Karl and Williams, 1987). At each of these locations the period trend lines reveal increases of about 1°C over a period of 80-90 years, and shorter term (2-5 year) variations of up to 2.5°C in magnitude (fig. 1 for example).

Data Sources and Analyses

The highest quality weather data time series available for the coastal marine environment of the northeastern U.S. are those developed from the first-order coastal weather stations of the National Weather Service. These data series are based on standard, 3-hourly observations, and are summarized and archived by the U. S. National Climatic Data Center in Asheville, North Carolina. The length of the time series varies somewhat, but generally they extend from the late 1940's or early 1950's to the present. Daily means or totals are calculated for most variables measured, and monthly and annual values are calculated for some variables.

In the northeastern U. S. there are first order weather stations located near the coast in Portland, Maine; Boston, Massachusetts; Providence, Rhode Island; JFK International Airport, New York; Atlantic City, New Jersey; and Norfolk, Virginia (fig. 2). For this study we chose Portland, New York-JFK, and Norfolk as most representative of the coastal marine environment and representative of the regions under consideration: Gulf of Maine - Georges Bank, northern Middle Atlantic Bight, and southern Middle Atlantic Bight. The time period selected for computing monthly means for comparison with the 1980's data was 1951-1980 for Portland and Norfolk and 1961-1980 for New York-JFK (established in 1953).

The variables selected for analysis at these three weather stations were monthly averages of air temperature and scalar wind speed. Period means and standard deviations were computed by month and departures from these means were computed for each month of the 1981 -1987 period. The departures are plotted in figures 3-6 expressed both in natural units and in standard deviation units.

Results

Air Temperature

For the 84-month period (1981-1987) the most notable features in air temperature anomaly patterns at the three coastal weather stations were the many months with temperatures significantly above the long-term means (figs. 3 and 4). Counting the months which had average air temperature anomalies of one standard deviation or more above the long term means, Portland recorded 16, New York-JFK 25, and Norfolk 18 (table 1). During the same period relatively few months showed negative air temperature anomalies one standard deviation or more below the long-term mean: 7 at Portland, 9 at New York-JFK and 10 at Norfolk. A few months at each station were more than two standard deviations above the long-term means. These extreme events did not occur simultaneously at two or three stations, so they probably reflect local rather than regional conditions, except for two months with positive anomalies of greater than 2 standard deviations at both Portland and New York-JFK (February 1981 and 1984).

Wind Speed

The most pronounced patterns in wind speed anomalies were the considerable periods of lower-than-average speeds shown at the northern two stations and the higher-than-average speeds shown at Norfolk (figs. 5 and 6). Counting the months which showed wind speeds one standard deviation or more below the long term mean, Portland recorded 12 and New York-JFK 23 (table 1).
In contrast, Norfolk recorded wind speeds one standard deviation or more above the long term mean in 31 months.

Spatial Coherence

Coherence in the sense (+ or-) of anomalies at the three weather stations was assessed by computing correlation coefficients between pairs of stations (table 2). The coefficients show that for air temperature the strongest

correlation existed between Portland and New York-JFK and the next strongest between New York-JFK and Norfolk. For wind speed anomalies there was little correlation between stations; the "strongest" (coeff. = 0.187) was between Portland and Norfolk. The negative correlation coefficients between New York and each of the other stations suggests that the New York wind conditions were aberrant for the region.

Wind Mixing Energy

The amount of mixing energy imparted to the upper layer of the oceanic water column is proportional to the cube (third power) of the wind speed (Niiler and Kraus, 1975). From the standpoint of mixing energy, relatively small changes in wind speed therefore can have a much larger effect on the ocean's upper layers. For example, a 25% increase (1.25X) in speed yields a 95% increase (1.95X) in mixing energy. Consequently, wind speeds during the spring months could strongly influence the timing and strength of vertical density stratification in the upper water column and, thereby, the primary and secondary production which occurs in the thermocline and above.

For example, the wind speed anomalies for Portland (fig. 6) indicate that the spring months of 1984 and to a lesser extent 1986 were unusually calm and should have been periods of early, strong stratification in the upper waters of the Gulf of Maine. The opposite effects can be inferred from the wind speed anomalies for Norfolk which show significantly higher wind speeds in the spring months in 1984-1987, which should have retarded the development of stratification in the upper water column and deepened the mixed layer and thermocline in the southern Middle Atlantic Bight.

Summary

Weather in the coastal environment of the northeastern United States in 1981-1987 can be characterized, in part, as warmer and calmer than average in the north, but warmer and windier in the south. When these conditions were extant in the spring and early summer, thermal stratification, and the biological processes which depend upon it, should have been accelerated in the north, but retarded in the south.

References

Jones, P. D., T. M. L. Wigley, C. K. Folland, D. E. Parker, J. K. Angell, S. Lebedeff and J. E. Hansen. 1988. Evidence for global warming in the last decade. Nature. 332: 790. 28 April 1988.

Niiler, P. P. and E. B. Krause. 1975. One-dimensional models of the upper ocean. Chapter 10 in: Modelling and prediction of the upper layers of the ocean, ed. E. B. Kraus. Pergamon Press. New York.

Quinlan, F. T., T. R. Karl and C. N. Williams. 1987. United States historical climatology network (HCN) - serial temperature and precipitation data. Contract Report NDP-019. Carbon Dioxide Information Analysis Center, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831. (65pp + Appendices + microfiche data)

Table 1. Months during 1981-1987 in which anomalous air temperatures and wind speeds were one standard deviation (SD) or more above or below the long term mean or two standard deviations or more above and below the long term mean.

	+ 1 SD or More	- 1 SD or More	+ 2 SD or More	- 2 SD or More
AIR TEMP.				
Portland	16	7	4	1
New York-JFK	25	9	6	2
Norfolk	18	10	4	1
WIND SPEED				
Portland	5	12	0	1
New York-JFK	14	23	4	11
Norfolk	31	7	9	1

Table 2. Correlation coefficients between pairs of weather stations for the sense (+ or -) of monthly anomalies in air temperature and wind speed 1981-1987.

	Air Temperature			Wind Speed	
	Norfolk	New York		Norfolk	New York
Norfolk	XXXX	XXXX	Norfolk	XXXX	XXXX
New York	0.348	XXXX	New York	-0.204	XXXX
Portland	0.193	0.556	Portland	0.188	-0.098

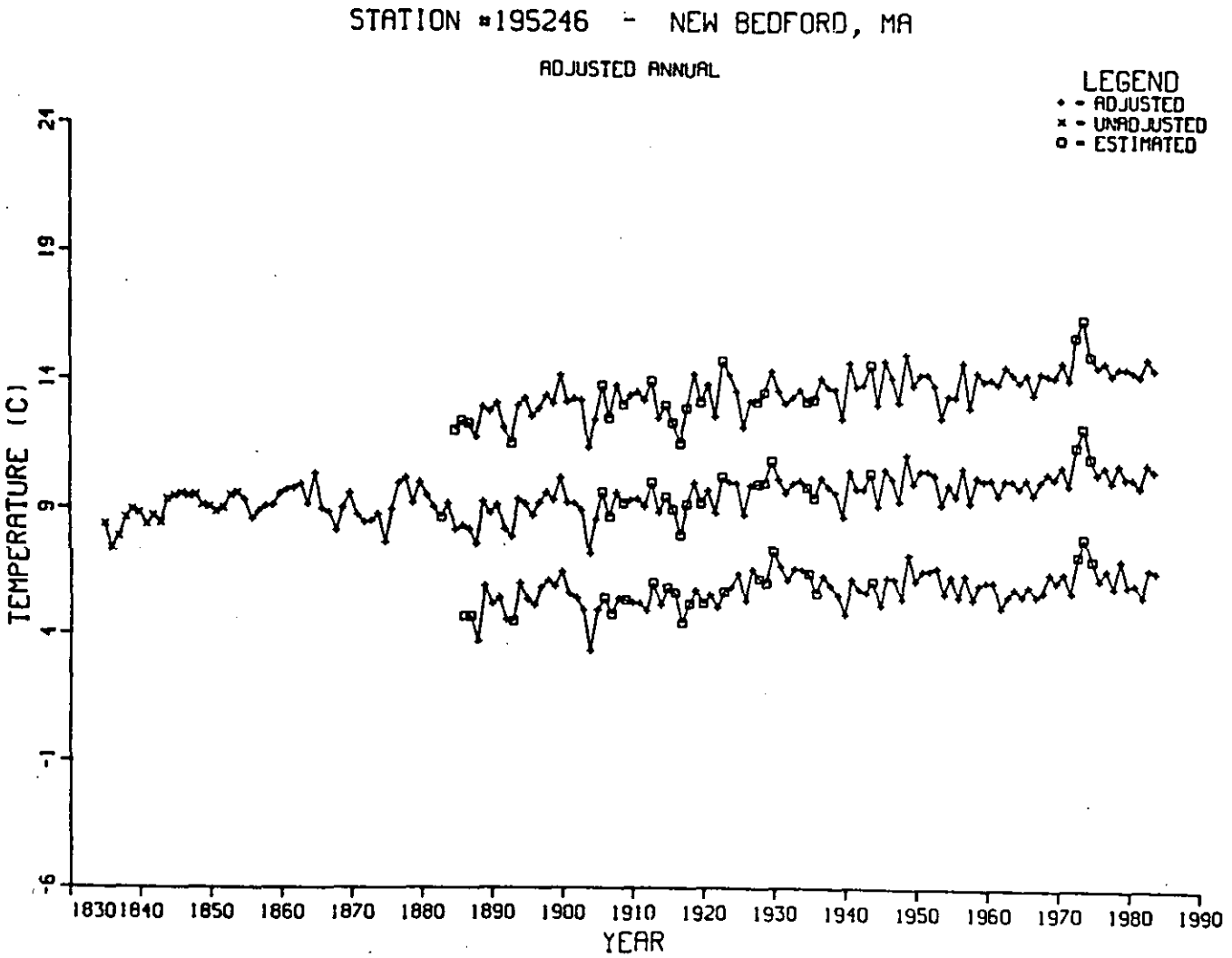

Figure 1. Sample long-term (1875-1983) plot of annual mean air temperatures (°C), computed from daily records of maximum (upper plot), minimum (lower plot) and average (middle plot) air temperature. From Quinlan, Karl and Williams, 1987.

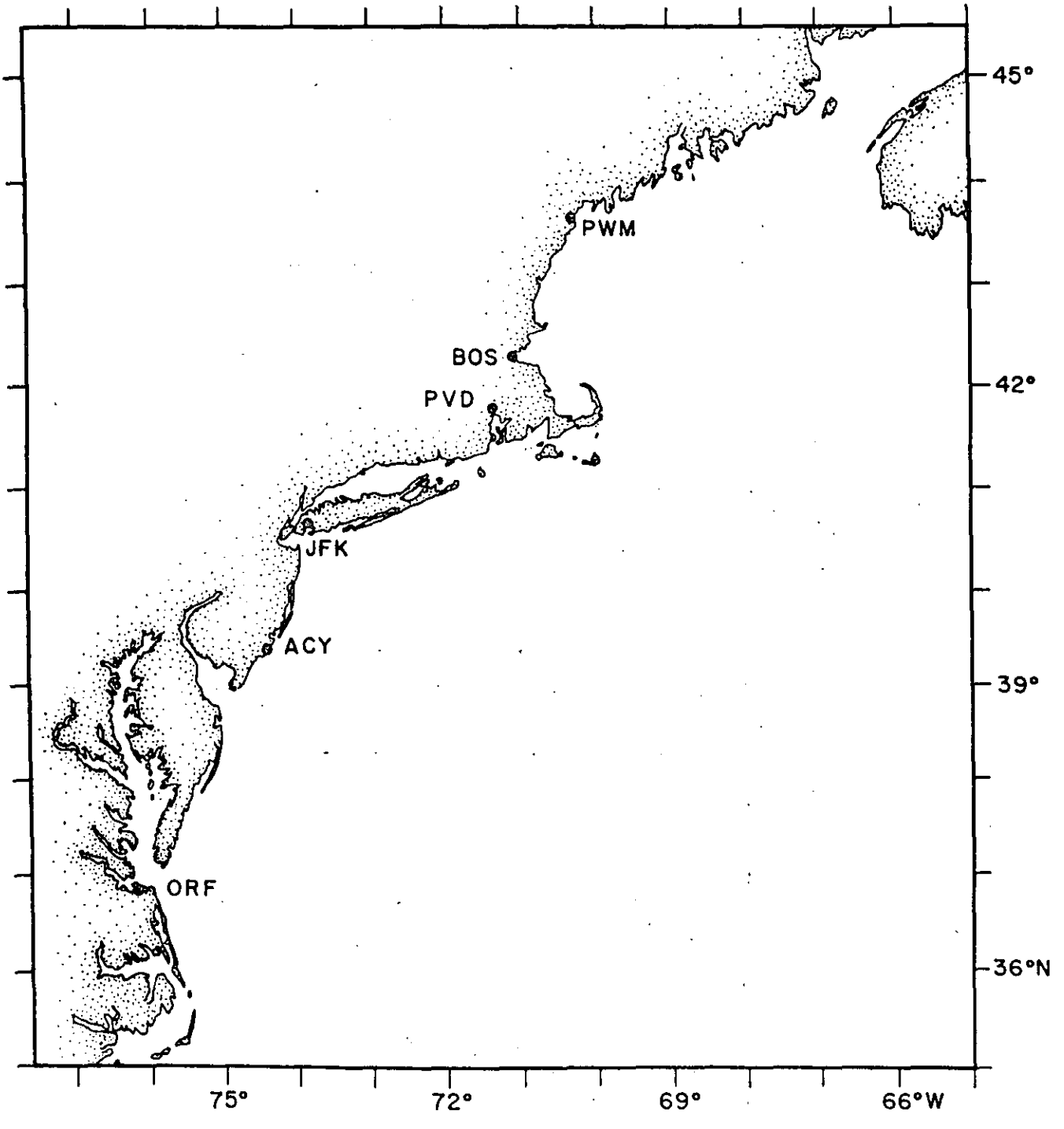

Figure 2. Locations of first-order coastal weather stations of the U. S. National Weather Service in the northeastern United States. Portland, Maine = PWM, Boston, Massachusetts = BOS, Providence, Rhode Island = PVD, New York/JFK International Airport, New York = JFK, Atlantic City, New Jersey = ACY, and Norfolk, Virginia = ORF.

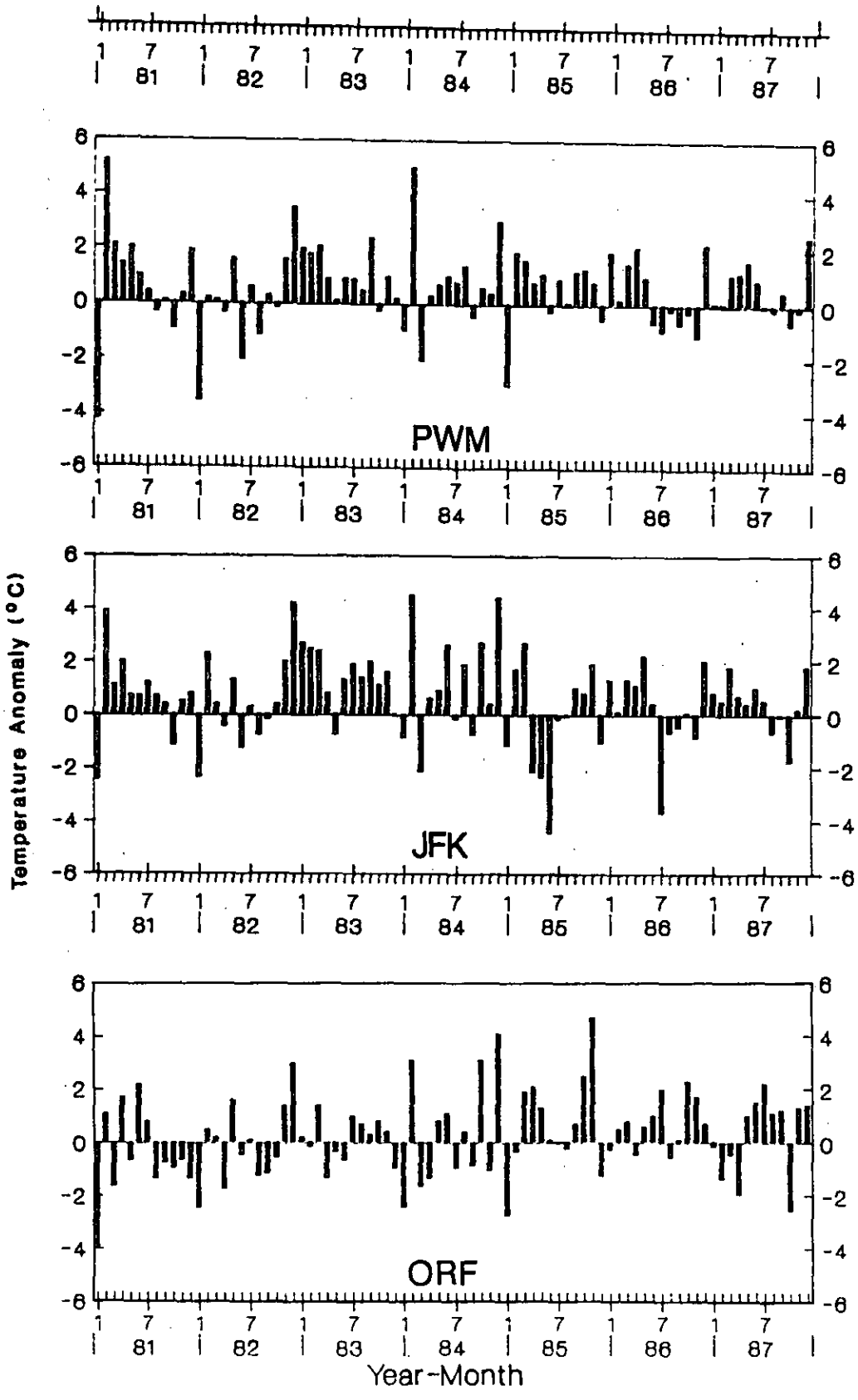

Figure 3. 1981-1987 monthly average air temperature anomalies (°C) from 1951-1980 means (1961-1980 means for JFK) at Portland, ME (PWM), New York City (JFK), and Norfolk, VA (ORF).

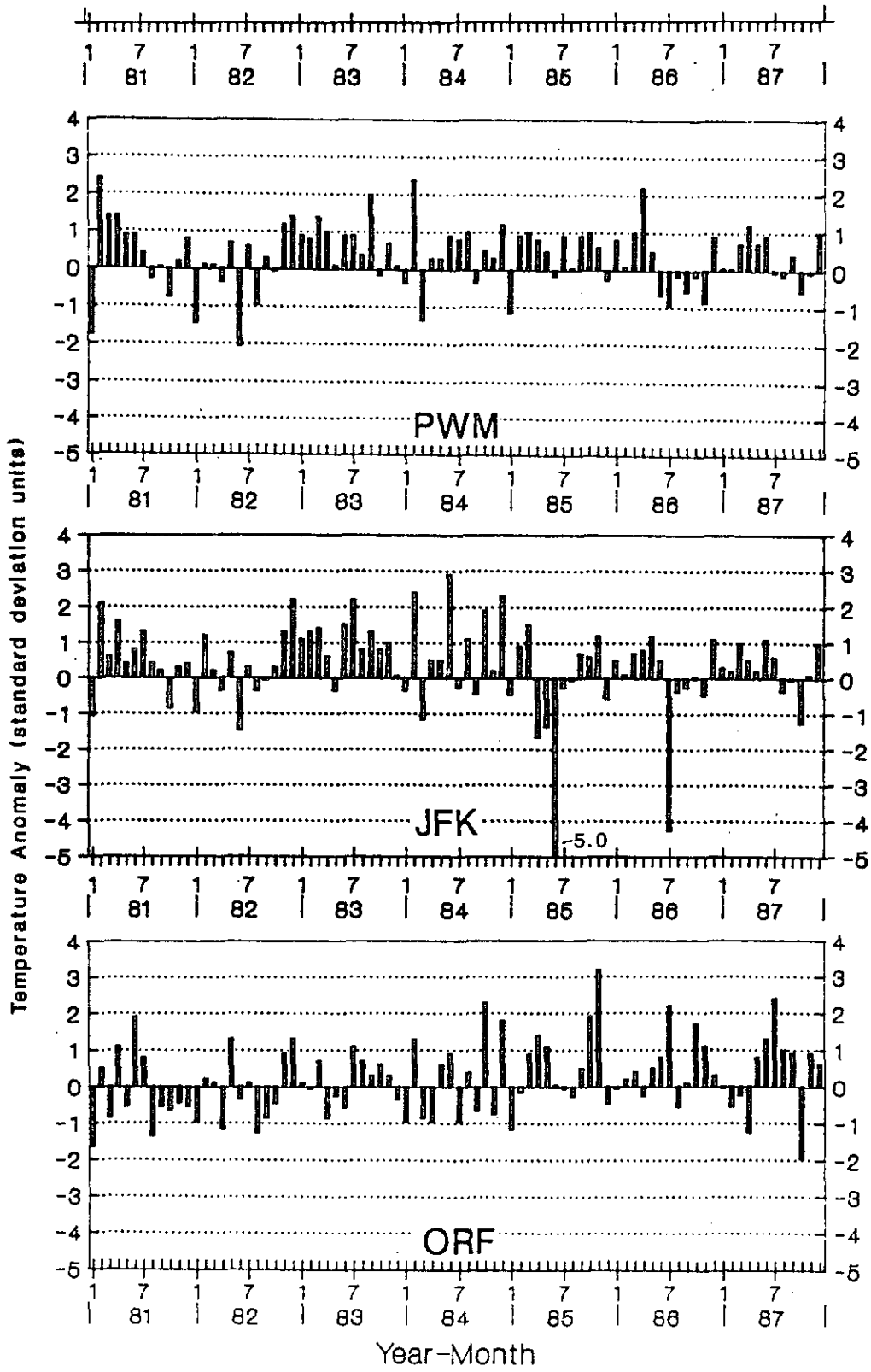

Figure 4. 1981-1987 monthly average air temperature anomalies (standard deviation units) from 1951-1980 means (1961-1980 means for JFK) at Portland, ME (PWM), New York City (JFK), and Norfolk, VA (ORF).

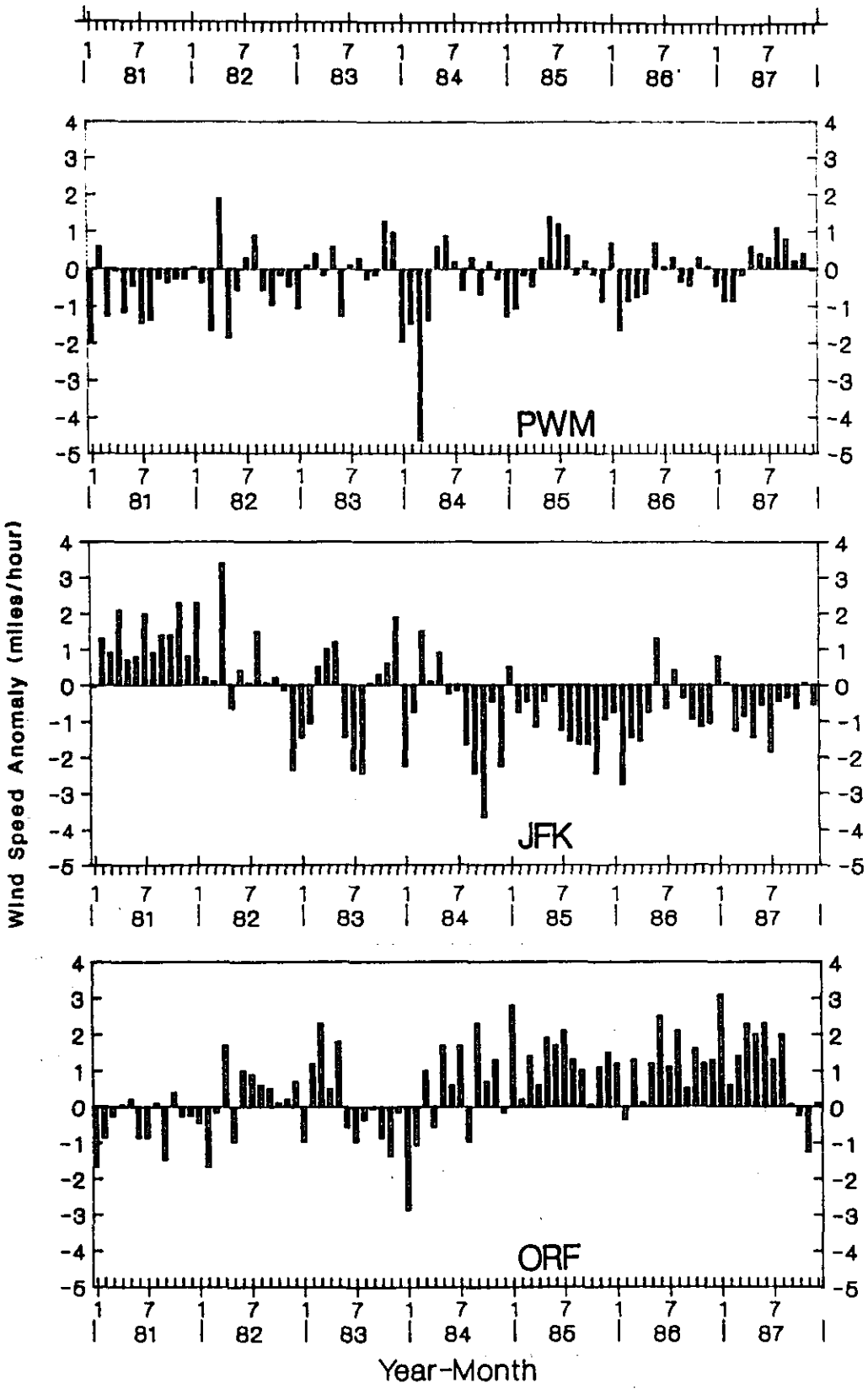

Figure 5. 1981-1987 monthly average wind speed anomalies (miles/hr) from 1951-1980 means (1961-1980 means for JFK) at Portland, ME (PWM) New York City (JFK), and Norfolk, VA (ORF).

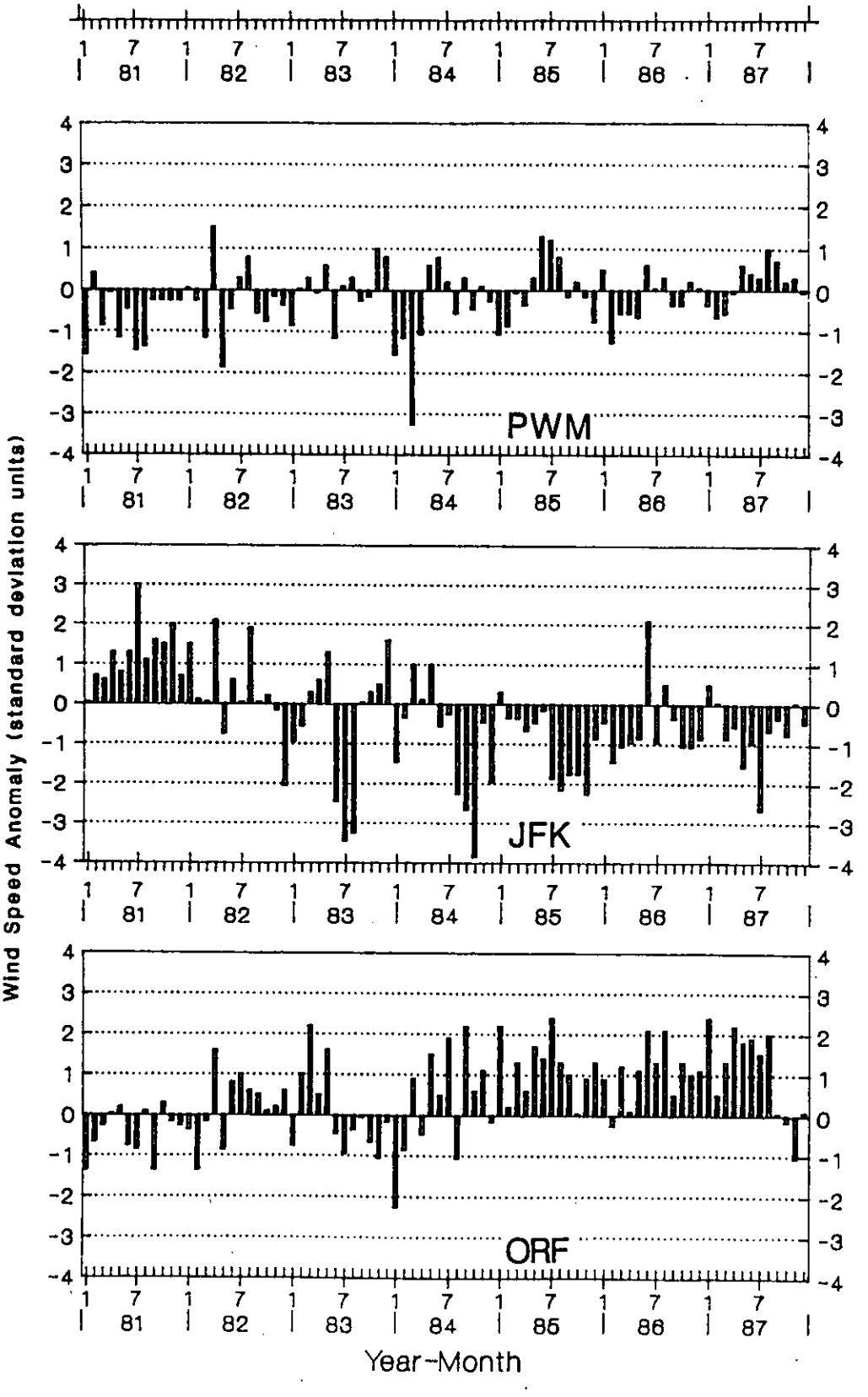

Figure 6. 1981-1987 monthly average wind speed anomalies (standard deviation units) from 1951-1980 means (1961-1980 means for JFK) at Portland, ME (PWM), New York City (JFK) and Norfolk, VA (ORF).