

**Researches on the Variations of Oceanographic Conditions
in the Region of the Ocean Weather Station "Extra"
in the North Pacific Ocean (VI)**

— A Note on the Diurnal Variation of Air Temperature on the Open Sea —

by

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(Received October 1, 1956)

Abstract

The swelling in the forenoon appearing in the diurnal variation curve of air temperature at Ocean Weather Stations "Extra" (39°N, 153°E) and "Tango" (29°N, 135°E), described in detail in the fourth of the author's present series of studies [1], may pretty well be explained by considering an adiabatic change due to the diurnal variation of atmospheric pressure.

The present author, when describing the characteristics of the diurnal variations in air and sea-surface temperatures at the ocean weather stations "Extra" (39°N, 153°E; St. "X") and "Tango" (29°N, 135°E; St. "T") in the fourth paper [1], pointed out that at both stations air temperature shows a diurnal variation curve with a swelling or sometimes a maximum in the forenoon, but he did not touch upon the cause of the swelling.

The swelling in question may be due to various causes. The diurnal variation of atmospheric pressure may be considered as one of them. If the variation of atmospheric pressure progresses adiabatically, the air temperature is to experience a rise or fall according as the pressure becomes higher or lower. The diurnal variation of atmospheric pressure observed at a station is attributed to a pressure wave which has a wave length comparable with half the periphery of the earth and progresses from east to west. In cases where the whole system of the pressure wave is under consideration, it will be allowed that the diurnal variation of atmospheric pressure is regarded as an adiabatic change. The effect on air temperature of the temperature change due to the change of atmospheric pressure will be quantitatively estimated in the following.

The relation between temperature (T : the absolute temperature) and pressure (p) in an adiabatic change is

$$(1) \quad Tp^{-\frac{\gamma-1}{\gamma}} = \text{const.},$$

where $\gamma = C_p/C_v$ (C_p and C_v represent specific heat at constant pressure and constant volume, respectively). And $\gamma = 1.40$ in the case of air. From equation (1), we have

$$(2) \quad dT = \frac{\gamma-1}{\gamma} \frac{T}{p} dp.$$

If we denote the observed air temperature by θ_a and put $\theta'_a = \theta_a - dT$, θ'_a means the air temperature corrected for the effect of temperature change due to atmospheric pressure variation.

Table 1. Diurnal variation of θ_a , p , dT , and θ'_a , based upon the data of 1951.
(Represented by the deviation from the diurnal mean)

I-time (h)	0	3	6	9	12	15	18	21	Diurnal mean
St. "X" (39°N, 153°E)									
θ_a (°C)	-0.18	-0.18	-0.12	0.11	0.18	0.20	0.03	-0.05	13.79
p (mb)	-0.02	-0.34	0.33	0.55	-0.49	-0.53	0.02	0.49	1012.73
dT (°C)	0.00	-0.03	0.03	0.04	-0.04	-0.04	0.00	0.04	
θ'_a (°C)	-0.18	-0.15	-0.15	0.07	0.22	0.24	0.03	-0.09	
St. "T" (29°N, 135°E)									
θ_a (°C)	-0.14	-0.28	-0.24	0.13	0.23	0.33	0.07	-0.15	21.53
p (mb)	0.22	-0.50	-0.10	0.80	0.19	-0.79	-0.36	0.54	1015.15
dT (°C)	0.02	-0.04	-0.01	0.07	0.02	-0.07	-0.03	0.04	
θ'_a (°C)	-0.16	-0.24	-0.23	0.06	0.21	0.40	0.10	-0.19	

Remarks: "I-time" is the time referred to 135°E meridian.

The three-hourly values of θ_a , p , dT , and θ'_a in Table 1 are for the whole year, based upon the data of 1951 for Sts. "X" and "T". Diurnal variation curves of θ_a , p , and θ'_a are given for every three months and for the whole year in Fig. 1. The time used in the tables and figures in this paper is I-time, that is, the time referred to 135°E meridian. The local time at St. "T" is identical with I-time, but that at St. "X" is 1 h 12 m earlier than I-time. When looking at the tables and figures, regard should be paid to this point.

In the diurnal variation of atmospheric pressure at Sts. "X" and "T" there appear two maxima and two minima, as is usually the case; the maxima are reached at 9 h~10 h and 21 h~22 h, respectively, in local time, the maximum generally being higher at the former than at the latter, and the minima at 3 h~4 h and 15 h~16 h, respectively, the minimum being lower at the latter. At both stations the diurnal range has a tendency to be wider in autumn and winter than in spring and summer. And it is naturally to be expected that the diurnal range is wider at St. "T" which is located at a lower latitude than St. "X".

As seen from Fig. 1, the diurnal variation curve of air temperature (θ_a) is considerably deformed by the said effect of the diurnal variation of atmospheric pressure, but the corrected curve (θ'_a) approaches to such a simple pattern as is ordinarily seen. The remarkably distorted shape of the temperature curve for St. "X" for October-December in the figure is perhaps due to large accidental

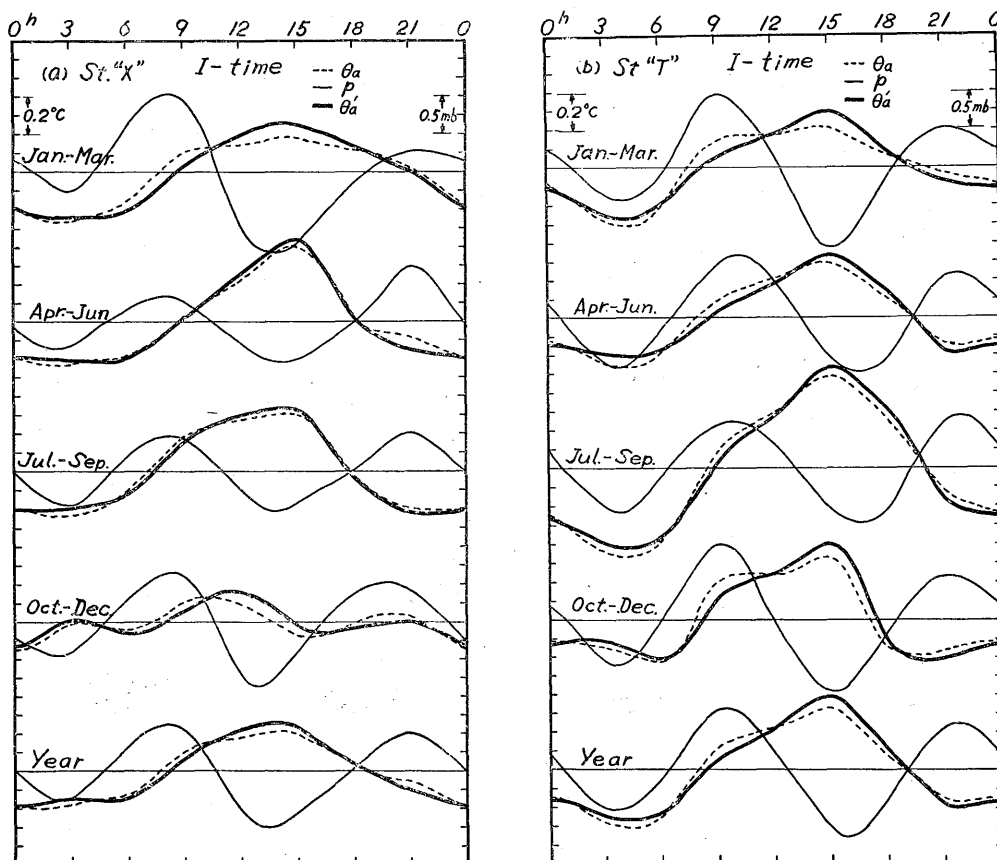


Fig. 1. Diurnal variation of θ_a , p , and θ'_a . "I-time" is the time referred to 135°E meridian. In order to see the curves for Station "X" (a) in local time, the time must be moved about one hour to the left in the figure.

disturbances. Anyway, the curve of air temperature is in most cases favourably corrected by taking into account the effect of the atmospheric pressure variation.

Since, as is well known, the diurnal variation of atmospheric pressure is a phenomenon occurring all over the earth, the effect of it on air temperature must also exist all over the earth. On land, however, that effect will not appreciably appear on the diurnal variation curve of air temperature, because the diurnal range of air temperature on land is generally large (more than a few degrees in centigrade) [2] while the diurnal range of atmospheric pressure is at most 2 mb wide, the temperature change due to pressure change accordingly being less than 0.2°C . On the open sea, on the other hand, the diurnal range of air temperature is far less than that on land, as seen from our examples (less than 1°C wide) and therefore it is considered that the effect of temperature change due to the diurnal variation of atmospheric pressure appreciably appears on the diurnal variation curve of air temperature (there was in our examples a case that dT amounted in amplitude to 30% of θ_a). Thus, we see that on the open sea the effect of the

diurnal variation of atmospheric pressure on that of air temperature is in no way negligible. In order to ascertain validity of this consideration, the present author desires to have an opportunity of examining the data for stations other than Sts. "X" and "T".

The swelling in question in the diurnal variation curve of air temperature at Sts. "X" and "T" seems to retain slight traces even after correction of temperature change due to the diurnal variation of atmospheric pressure was made.

Table 2. Diurnal variation of cloud amount (C) at St. "X" (39°N, 153°E), based upon the data of 1950.
(Represented by the deviation from the diurnal mean)

I-time (h)	0	3	6	9	12	15	18	21	Diurnal mean
C	-0.5	-0.3	0.6	0.5	0.5	0.3	-0.2	-0.6	7.7

It will be evident that the change of cloud amount may influence air temperature. Table 2, where the diurnal variation of cloud amount at St. "X" is given by the deviation from the diurnal mean, shows that the amount of cloud varies between 7.1 and 8.3 and that it is greater in the daytime than at night (This relation is for the whole year, for particular months or seasons the relation being less regular). However, it seems impossible to deduce from this that the diurnal variation of cloud amount produced the swelling in question in the diurnal variation curve of air temperature.

Table 3. Diurnal variation of wind velocity (W).
(Represented by the deviation from the diurnal mean)

I-time (h)	0	3	6	9	12	15	18	21	Diurnal mean
W (m/sec) { "X" (1950)	0.0	0.0	-0.1	0.1	0.0	0.1	0.0	0.2	9.8
{ "T" (1951)	-0.1	0.2	0.4	0.2	0.0	0.0	-0.2	-0.1	8.2

Wind may also have some effect in changing air temperature. However, remarkable diurnal variation in this element can hardly be expected on the open sea far off land and actually, according to statistical results (Table 3, in which only the values for the whole year are adopted), wind velocity shows no regular diurnal variation, being nearly constant during the day (St. "X") or having a tendency to be somewhat larger in the daytime than at night with a range of only 0.6 m/sec (St. "T"). Consequently, it may be inferred that there is no appreciable relation between the diurnal variation of wind velocity and the swelling in question in the diurnal variation of air temperature.

Acknowledgments—The author wishes to express his thanks to Dr. K. TAKAHASHI of this Institute for his useful suggestion. He also expresses his indebtedness to Prof. K. HIDAHA, Prof. M. UDA, and Dr. M. NAKANO for their kind advice and

constant encouragement.

References

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