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A Note on the Modification of Air Masses over the Seas Adjacent to Japan

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(Manuscript received 31 May 1957)

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Abstract

The modification of air masses over the seas adjacent to Japan based on the distribution and the variation of air temperature (θ_0) minus sea temperature (θ) are studied, and by means of several maps of ($\theta_0-\theta$) the areas of cyclogenesis or typhoon-genesis and areas of sea-fog formation, and convection clouds on the seas are discussed, in relation to their mechanisms of development.

Introduction

Proceeding to the former reports on the correlation between cyclogenesis, its development and motion,[1] the occurrence and distribution of sea-fog[2,3,4], annual amount of snow[5] and the sea conditions (water temperature, oceanic currents and its boundaries etc.), the author intended to study the modification of air masses over the seas adjacent to Japan based on the distribution and variation of air temperature (θ_0) minus sea (surface water) temerature (θ), and presented the following short note.

1. The distribution of ($\theta_0-\theta$) in Feb. and May are shown in Fig. 1 a and 1 b. based on the materials supplied by Kōbe

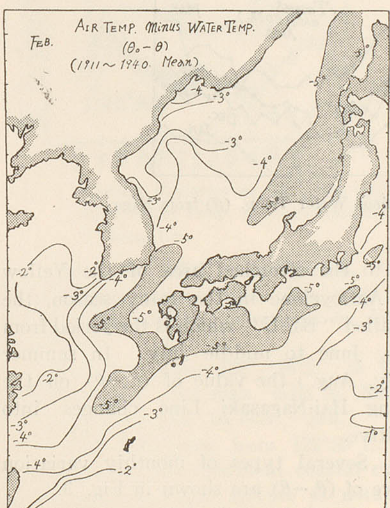

Fig. 1a Distribution of ($\theta_0-\theta$) in Feb. (Normal Year)

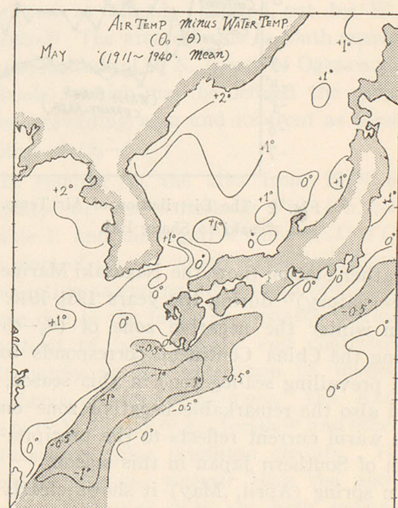

Fig. 1b Distribution of ($\theta_0-\theta$) in May. (Normal Year)

Marine Observatory.[6]

Fig. 1 generally shows $(\theta_0-\theta)<0$ in winter (Feb.) *i.e.* the sea is warmer than the atmosphere, in particular remarkable negative values (greater than −5°C) being shown in regions of Kuroshio and Tusima Warm Currents, which may be correlated with the zone of abundant precipitation (snow and rain) along the coast of the Japan Sea and the violent evaporation on the Kurosio Stream.

In spring (May), $(\theta_0-\theta)$ shows generally positive values except the negative values on Kurosio region, corresponding to still continued evaporation.

In this place the author considers that the conspicuous negative $(\theta_0-\theta)$ zone over the Kurosio and its branch correspond to the zone of vertical instability due to heating from the sea-surface and consequenthy to the habitual tracks of cyclones in winter and spring.

In summer (Aug.) the distribution of $(\theta_0-\theta)$ indicates rather complete positive values (not so high generally) on the seas, *i.e.* air warmer than the sea, especially the sea-region of $(\theta_0-\theta)$ above+1°C apparently corresponding to the dense fog (advection sea-fog) zone over the northern cold waters (Oyasio and North Korean Cold Current, Liman Current, East Saghaline Cold Current etc.) and the upwelling cold area such as off Moppo of Southwestern Korea.

2. The distribution of $(\theta_0-\theta)$ on the ship-route from Shang Hai to Nagasaki are are shown in Fig. 2.

The materials were obtained by Nagasaki

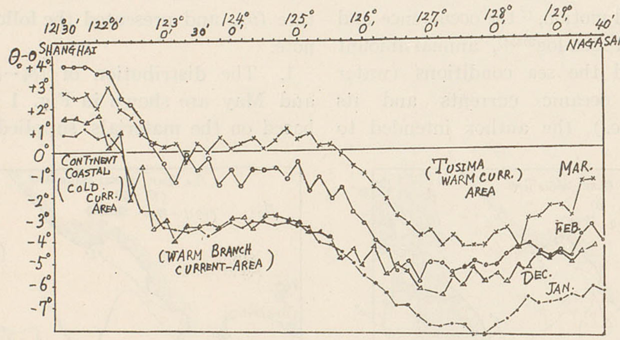

Fig. 2 The Distribution of Air Temp. (θ_0) minus Water Temp. (θ) from Nagasaki to Shang Hai.

Weather Station (now, the Nagasaki Marine Observatory)[7] during the years 1931-1940.

In winter the negative zone of $(\theta_0-\theta)$ along the China Continent corresponds to the prevailing sea-fog zone in this season, and also the remarkable negative zone on the warm current reflects to the precipitation of Southern Japan in this season.

In spring (April, May) it shows clearly that in the East China Sea $\theta_0<\theta$ on the eastern Warm Current Area whereas $\theta_0>\theta$ on the western continental side corresponding to the stretched area of the Yellow Sea Anticyclone in the rainy season, the so-called "Bai-U" which is the period from early June to middle July. In summer (July, Aug.) the value of $(\theta_0-\theta)$ on the Shang Hai-Nagasaki Line changes into positive.

3. Several types of monthly variation curve of $(\theta_0-\theta)$ are shown in Fig. 3.

The maximum and minimum of the curve seem to shift from west to east, *i.e.* as shown in the following three areas I, II, III:

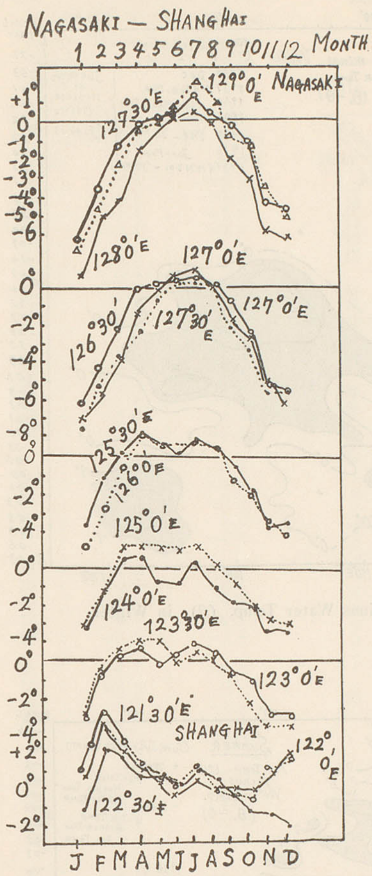

Fig. 3 Monthly Variation of Air Temp. (θ_0) minus Water Temp. (θ) from Nagasaki to Shang Hai.

I. East from 127°E to Nagasaki, the Tusima Warm current Area. The max. in July (summer) and the minimum in Jan. (winter)

II. The area from 123°-126°E. in the East China Sea. The max. falls in (Mar.—July) and the min. in Nov.—Jan.)

III. The area west from 122°30′ E to Shang-hai. On the continent coastal cold water area the peculiar feature is notable *i.e.* the primary max. in Feb, second max. in Dec. and the primary min. in Oct. and second min. in Jan.

This feature is interesting in relation to the distribution and occurrence of sea-fog in winter along the China Continent.

4. Fig. 4 a. b (based on the data taken from the Hydrographic Bulletin. Special number of Oceanogr. Report published by Hydr. Dept. of Japan)[8] show the distribution of ($\theta_0-\theta$) on the Northwestern Pacific south to Japan.

We can recognize the remarkable change in patterns from winter to summer in correspondence to the alternative monsoons from northerly to southerly winds after half a year.

In winter the effect of NW or NE monsoon on the warm water surface resulted the conspicuous negative zone of ($\theta_0-\theta$) corresponding to the area of active convection in the atmosphere which has already been experienced by aviators as the wellknown peculiar rolling of planes or by navigators as the banks of cumuli-form or cumulonimbus type clouds on the margin of the warm current *i.e.* somewhat local line of discontinuity or stationary front. This area also corresponds to the highly active evaporation as already pointed out by W. Jacobs,[9] The area extends to south nearly to the latitude of 30°N. (north of Ogasawara Islands), which may be defined the monsoon prevailing area and its front as some isoline of ($\theta_0-\theta$).

In summer in the area from 20°N to Equator we can remark in Fig. 4 b and Table 1. and the negative value of (1°-2°C) or more of ($\theta_0-\theta$) which seems to indicate the active ascending air column of cellular type due to the labile or unstable vertical gradient of (air) density and contribute ultimately to the generation of midget-typhoons or tropical cyclones. Drs. Kasahara,[10] Y. Sasaki,[11] K. Terada[11] and others discussed similar problems already. The tropical seas are warmer than the above cooler air coming from the high pressure area in the southern hemisphere by the absorption of solar radiation.

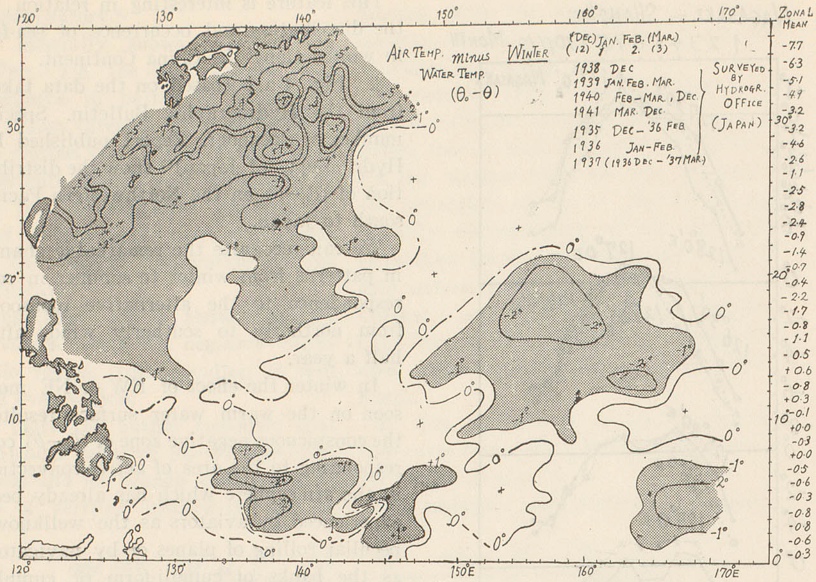

Fig. 4 a Distribution of Air Temp. (θ_0) minus Water Temp. (θ). in Winter.

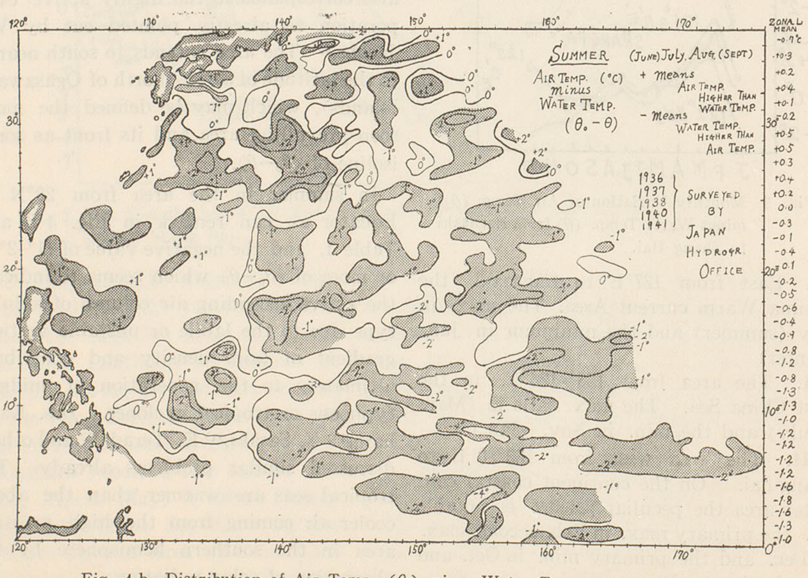

Fig. 4 b Distribution of Air Temp. (θ_0) minus Water Temp. (θ). in Summer.

Table 1 Zonal mean of $(\theta_0-\theta)$ in the NW Pacific south to Japan (1935—'41 basing on the data surveyed by Hydr. Dept.

Zonal Lat.	Winter (Jan. Feb.)	Summer (Jul. Aug.)
36°N	—	−0.7°C
35°	−7.7°C	+0.3
34°	−6.3	+0.2
33°	−5.1	+0.4
32°	−4.9	+0.1
31°	−3.2	−0.2
30°	−3.2	+0.5
29°	−4.6	+0.5
28°	−2.9	+0.3
27°	−1.1	+0.4
26°	−2.5	+0.2
25°	−2.8	0.0
24°	−2.4	−0.3
23°	−0.9	−0.1
22°	−1.4	−0.4
21°	−0.7	−0.1
20°	−0.4	−0.2
19°	−2.2	−0.5
18°	−1.7	−0.6
17°	−0.8	−0.4
16°	−1.1	−0.9
15°	−0.5	−0.8
14°	+0.6	−1.2
13°	−0.8	−0.8
12°	+0.3	−1.3
11°	−0.1	−1.3
10°	+0.0	−1.0
9°	−0.3	−1.2
8°	+0.0	−1.2
7°	−0.5	−1.2
6°	−0.6	−1.2
5°	−0.3	−1.6
4°	−0.8	−1.8
3°	−0.8	−1.6
2°	−0.6	−1.3
1°	−0.3	−1.0
0°		

Table 2 Examples for Diurnal Variation of Air Temp. θ_0. Water Temp. θ and the Difference $(\theta_0-\theta)$. in Sagami Bay off Cape Manaduru.

Date	1933 Jan. 16—17			1933 Feb. 15—16			1933 Feb. 20—21		
Hour \ Elem.	θ_0	θ	$\theta_0-\theta$	θ_0	θ	$\theta_0-\theta$	θ_0	θ	$\theta_0-\theta$
9h.	3.5	14.8	**−11.3**	—	—	—	6.6	14.0	−7.4
10	3.6	14.8	−11.2	8.5	14.7	−6.2	6.9	14.0	−7.1
11	4.2	14.8	−10.6	8.7	14.7	−6.0	7.2	14.1	−6.9
12	8.0	14.9	−6.9	8.8	14.5	−5.7	7.5	14.1	−6.6
13	11.6	14.3	−2.7	8.6	14.5	−5.9	7.4	13.6	−6.2
14	11.4	14.6	−3.2	8.4	14.6	−6.2	9.0	13.9	−4.9
15	9.7	14.5	−4.8	—	14.4	—	9.8	14.0	−4.2
16	9.6	14.5	−4.9	9.0	14.2	−5.2	9.8	13.7	−3.9
17	7.0	14.5	−7.5	9.5	14.5	−5.0	9.5	13.7	−4.2
18	6.0	14.5	−8.5	9.0	14.4	−5.4	9.2	13.9	−4.7
19	5.6	14.5	−8.9	8.0	14.4	−6.4	8.1	13.9	−5.8
20	6.0	14.6	−8.6	7.5	14.3	−6.8	8.0	13.9	−5.8
21	6.0	14.7	−8.7	7.0	14.5	−6.5	7.7	13.9	−6.2
22	6.0	14.7	−8.7	6.1	14.4	−8.3	7.7	14.0	−6.3
23	6.7	14.6	−7.9	6.0	14.1	−8.1	8.5	13.8	−5.3
0	6.7	14.7	−8.0	6.0	14.3	−8.3	7.6	14.0	−6.4
1	—	14.9	—	5.7	14.3	−8.6	7.9	14.0	−6.1
2	—	14.7	—	5.7	14.4	−8.7	8.0	14.0	−6.0
3	7.2	15.0	−8.2	5.1	14.2	−9.1	7.8	13.7	−5.9
4	8.0	15.1	−7.1	5.0	14.4	−9.4	6.6	13.8	−7.2
5	6.0	15.2	−9.2	4.7	14.5	**−9.8**	6.5	13.8	−7.3
6	6.1	15.2	−9.1	4.5	14.3	**−9.8**	6.1	13.8	−7.7
7	4.5	15.1	−10.6	5.0	14.4	−9.4	6.0	13.9	**−7.9**
8	5.2	15.0	−10.2	6.0	14.5	−8.5	6.1	13.9	−7.8
9	3.7	15.1	**−11.4**	7.0	14.2	−7.2	6.8	13.5	−6.7
10	—	—	—	7.5	14.1	−6.6	—	—	—

5. The examples of diurnal variation of $(\theta_0-\theta)$ are shown in Tab. 2. In winter on Sagami Bay near C. Manaduru during our current measurements,[12] the max. of $(\theta_0\text{-}\theta)$ falls in early morning and attains to 10°C or more, which may explain the reason why we see the cumuli-form clouds as the violent sign of vertical instability in the early morning.

In winter and spring usually we can observe such banks of cloud stretched from west to east in the early morning (mainly from twilight to sunrise on the horizon along the marginal area of Kurosio Stream, which seems to correspond to the above most highly negative values of $(\theta_0-\theta)$.

Conclusion

The author has remarked the important meaning of maritime meteorological studies of $(\theta_0-\theta)$ on the actual seas and oceans in order to make clear the mechanism of the cyclogenesis (such as so-called "Taiwan Bōzu") or typhoon-genesis and their development, area of sea-fog formation, and convection clouds or cumulonimbus cloud-banks over the marginal area of warm currents, and the modification of warm tropical airmass on the colder sea or the cold polar air mass on the warm current, especially of the vorticity on coming to the margin of the warm and cold currents. In future he wishes the progress of those quantitative researches on this line through the present short note.

References

1) **Uda, M.** 1934: Distribution of air temperature over the broad sea surface adjacent to Japan. (In Japanese) *J. meteor. Soc. Japan.* **12.** No. 8. —2) **Uda, M.,** 1956: Sea fog in relation to water temperature *J. Naut. Soc. Japan.* 3)—**Uda, M. and K. Nasu.,** 1956: *Sci. Rep. Whale Res. Ins.* (Tokyo) No. 11. —4) **Uda, M.,** 1943: On the cyclogenesis and the passage of cyclone in relation to sea conditions. (In Japanese). Part. I. *Umi to Sora* (*Sea & Sky*) **23,** 6. 1943. Part. II. *Umi to Sora* (*Sea & Sky*) **23** (8), 1943. —5) **Uda, M.,** 1936: Amount of snow fall in relation to water temperature (In Japanese). "*Tenki to Kikō*" (*Weather and Climate*). Aug. —6) **The Imperial Marine Observatory (Kōbe).** The mean atmospheric pressure, cloudiness, air temperature and sea surface temperature of the North Pacific Ocean and the neighbouring seas during the years 1911 to 1935. (1937), and the same during the years 1911 to 1940. (1942). —7) The Results of Hydr. Obs. (by Nagasaki Weather Station) on the Ship Line From Nagasaki. J. Oceanogr. (*the Imp. Marine Observatory*) Kōbe. Vol. 1-13, 1930-1942. —8) *Hydrographic Bulletin. Special Number of Oceanogr. Reports. by Hydr. Dept. Japan.* 1947-1955. —9) **Jacobs, W.,** 1951: Large scale aspects of energy transformation over the oceans. *Compendium Meteor.* pp. 1057-1070. —10) **Kasahara, A.,** 1954: Supplementary notes on the formation and the schematic structure of typhoons. *Collected Meteor. Pap.* **5.** No. 1. *Tokyo. Univ. and J. meteor. Soc. Japan.* **32.** No 2. 1954. —11) **Sasaki Y.,** 1954: *The recent studies on the formation and the development of tropical cyclones in Japan.* Prcc. UNESCO Symposium on Typhoon. Tokyo Nov. K. Terada's paper also in the same Proceedings. —12) *The Semi-annual Oceanogr. Investigetions.* No. 52. 1933 (The Imperial Fisheries Expt. St.˙ Tokyo.)