

ON THE ERROR OF POSITION OF A SHIP DETERMINED ASTRONOMICALLY IN THE AREA OF THE "KUROSION"

by

LIEUTENANT A. SONE, NAVIGATING OFFICER
OF THE JAPANESE SURVEYING SHIP "*Mansyû*".

(Translated from Japanese in the "*Suïro Yôhô*" (*Hydrographic Bulletin*))

Vol. 5, pp. 155-158, 1926.)

1. INTRODUCTION.

The Japanese Surveying Ship *Mansyû* was ordered by Rear Admiral YONEMURA, the Director of the Hydrographic Department, to make observations of the Sun's altitude and to find out their errors with reference to the ship's position as determined by the terrestrial objects, near the coasts of Sio Misaki (Lat. $33^{\circ} 26'$ N., Long. $135^{\circ} 45'$ E.) on the South coast of Honsyû, Muroto Saki ($33^{\circ} 14'$, $134^{\circ} 10'$) on the South coast of Sikoku and Toi Saki ($31^{\circ} 22'$, $131^{\circ} 21'$) on the East coast of Kyûsyû, whereon, the "Kurosio" or Japan Current running near the coasts, the difference of temperature between air and sea water is very great in winter. The observations were made during the period from the end of January to the beginning of February, 1926.

2. THE RESULTS OF OBSERVATIONS.

The observed altitude of the Sun was corrected by Tables 2 A and 2 B of the "*New Altitude and Azimuth Tables*" published by the Japanese Hydrographic Department, and the true altitude was obtained, the corrections for the difference of temperature between air and sea water being ignored. The true altitude of the Sun was calculated for the position as determined by the terrestrial objects. In the following table the "Error" gives the difference of the observed and calculated true altitudes, which mainly results from the variation of the dip of sea horizon due to the difference of temperature between air and sea water. The time is given by the Japanese Central Standard Time. In the column of "Place", I, II, and III denote the vicinity of Sio Misaki, Muroto Saki and Toi Saki, respectively. The temperature of the air is measured at the height of 9 metres above the surface of the sea.

1926	TIME	PLACE	Altitude	Error	TEMPERATURE			Height of Eye	REMARKS
					Air	Water	Diff.		
I. LOW ALTITUDE.									
<i>Morning.</i>									
	^h ^m				C	C	C	m	
Jan. 24...	7 15	I. 0'.5 SW by W of Hako Sima.....	3°59'	+3'5	1°	13°0	12°0	11.6	Horizon not good.
Jan. 21...	7 25	I. 4'.0 off Kinomoto.....	4 12	+4.8	3	11.0	8.0	11.6	Worse than the above.
Jan. 24...	7 15	I. 0'.5 SW by W of Hako Sima.....	4 26	+4.0	1	13.0	12.0	6.0	Horizon not good.
Jan. 22...	7 30	I. 6'.5 off Sio Misaki.....	5 45	+4.3	6	18.8	13.0	11.6	Horizon very bad.
<i>Evening.</i>									
Feb. 2...	17 30	II. 8'.0 off Muroto Saki.....	0 48	+3.9	12	19.5	7.5	6.0	Horizon not good.
Feb. 2...	17 30	II. 8'.0 off Muroto Saki.....	1 5	+3.8	12	19.5	7.5	11.6	Horizon not good.
*Jan. 22...	17 0	I. Kusimoto Kō.....	2 48	+0.7	3	12.5	9.5	11.6	Water line of a ship 1.050 metres distant used instead of horizon.
Jan. 21...	17 0	I. 1'.0 off Sio Misaki.....	3 12	+0.3	5	17.0	12.0	11.6	Horizon good.

Mean of error Mean of Temp. diff.
 Morning: + 4'.15 11°0
 Evening (Excluding*) + 2.7 9.0

II. HIGH ALTITUDE.

Jan. 21...	^h ^m	I. 4'.0 off Singū.....	14°46'	-1'1	3°	11°0	8°0	—	Water line of a ship 1.170 metres distant used instead of horizon.
Jan. 21...	8 30	I. 4'.0 off Singū.....	14 35	+1.9	3	11.0	8.0	11.6	Horizon not good.
Jan. 21...	10 0	I. 2'.0 off Kasino Saki.....	27 28	+2.6	4	11.0	7.0	11.6	Horizon not good.
Jan. 21...	15 0	I. 5'.0 off Sio Misaki.....	23 55	+2.2	5	17.0	12.0	11.6	Horizon not good.
Jan. 23...	8 50	I. 10'.0 off Sio Misaki.....	18 37	+2.5	5.5	18.5	13.0	11.6	Horizon not good, hazy.
Jan. 23...	11 20	I. 10'.0 off Sio Misaki.....	35 53	+2.1	7	19.3	12.3	11.6	Horizon not good, hazy.
Jan. 29...	10 30	III. 5'.0 off Toi Saki.....	33 20	+1.3	12.8	18.0	5.0	11.6	Horizon rather good.
Jan. 23...	8 50	I. 10'.0 off Sio Misaki.....	18 50	+0.5	5.5	18.5	13.0	6.0	Horizon not good, hazy.
Jan. 23...	11 20	I. 10'.0 off Sio Misaki.....	35 56	+0.4	7	19.3	12.3	6.0	Horizon not good, hazy.
Jan. 29...	11 0	III. 5'.0 off Toi Saki.....	35 40	+0.7	12.8	18.0	5.0	6.0	Horizon rather good.

Mean of error Mean of Temp. diff.
 Height of eye 11^m6 +2'1 10°8
 Height of eye 6^m0 +0'5 10°1

3. NOTES.

The experiments having been made during the course of the hydrographic survey, the number of observations is not quite enough to arrive at any definite conclusion, but the writer will give here some notes on the accuracy and practice of astronomical observations in the sea where the difference in temperature between air and sea water is comparatively great in winter. The writer, however, has apprehensions as to whether he is quite right because of his lack of sufficient practice in the astronomical observations.

a) It is of special necessity to determine the height of eye accurately, as it is so for all astronomical observations at sea. In the sea where the horizon is not good, we must endeavour as much as possible to eliminate even one slight error.

b) The smallness of the error of observation of the Sun's low altitude in the evening as compared with that in the morning may be attributed to the conditions of sea horizon. The conditions of sea horizon seems to be much affected by the temperature of air as well as the direction of wind. At the end of January, 1926, the strong North-Westerly wind prevailed and the water vapour near the surface of the sea was thicker to leeward than to windward, and therefore the sea horizon appeared generally to be better to the West than to the East. Moreover, at the time near sun-rise, the air temperature being generally lower, and the difference in temperature between air and sea water being greater than at the time near sun-set, it seems to the writer that the horizon about sun-rise is worse due to much condensation of water vapour. In such a case the observation of the Sun's low altitude gives rise to a great amount of error, the error of 3 to 4 miles in the result being unavoidable.

c) When the sea horizon is very bad, the best method for astronomical observations is to utilize the water line of a ship at a known distance instead of sea horizon. However, if we can determine from a great number of experiments the proper error of observation for bad horizons, we shall be able to obtain good position by astronomical observations. It will be possible to investigate theoretically the errors arising from the uncertainty of sea horizon, basing upon the great number of determinations of the error due to the difference of temperature between air and sea water, or of the distance at which the horizon becomes indistinct for a given difference of temperature of air and sea water. The writer's experiments show that in the sea where the difference of air and sea water temperatures is 7° to 8° C. a ship's water line is good to a distance of as much as about 8,000 metres, but it becomes bad at about 10,000 metres. According to these experiments, the distance at which a good sea horizon is visible being within about 4 miles, good results may be obtained if the Sun's altitude is observed at such a height of eye as the distance therefrom to the visible horizon is smaller than 4 miles.

d) The conditions of sea horizon were found to be considerably different from place to place in the area of the "Kuroshio". The worst is in the vicinity of Sio Misaki; it becomes better as we go southwards from there, and between latitudes 31° N. and 32° N. the horizon is fairly good, the difference between air and sea water temperatures being 5° to 6° C. there. In the vicinity of Toi Saki the horizon is not so bad as in the vicinity of Sio Misaki. At the place about 30 miles South of Asizuri Saki, Southward tip of Sikoku (Lat. $32^{\circ} 44'$ N, Long. $133^{\circ} 1'$ E), where the difference of temperature between air and sea water was 7° to 8° C., the horizon was not so bad. From these facts it seems probable that the horizon is worst in a zone of about 30 miles in breadth where the "Kuroshio" is strongest, and it becomes better as we go southwards. The sea horizon is pretty good if the difference of air and sea water temperatures is less than 5° C., it is not good between 5° and 10° , and very bad above 10° . Much more experience is needed.

