58. *Effect of the Direction of Wind on the Observed Latitude.*

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1. The effect of wind on the observations of latitude was first noticed by Dr. Yamamoto¹⁾ and also by Greenwich astronomers.²⁾ According to the report of the latter, "for any direction of the wind, the mean residual could be represented by the simple harmonic, $+0''.05 \cos (\theta - 45^\circ)$, where θ is measured from N. through E. S. W.;" $\theta = 90^\circ$ corresponding to an E. wind, etc. But there, "no correlation was found to exist between the sign or magnitude of the residuals and the strength of the wind." It should be remembered, however, that the instrument used at Greenwich is the Cookson Floating Zenith Telescope with photographic equipment, which is quite different from the ordinary visual zenith telescope used in the International Latitude Stations. On the other hand, a close correlation of the longitude difference between Washington and Greenwich and the winds at these two places was recently found by Dr. Willis³⁾ of U. S. Naval Observatory. Moreover, when the provisional results of the present paper were communicated to Dr. Bowie of U. S. Coast and Geodetic Survey, he sent a letter to Dr. Kimura, saying he had himself noticed that the direction of the wind and its strength had some effect on the horizontal angle of triangulation.

2. The present writer has intended to make a systematic investigation on the relation, if any, between the observed latitude and the meteorological elements. Fortunately, in the Mizusawa International Latitude Station, meteorological observations have been carried out continuously since the end of the year 1901, and the data are now abundant enough for this purpose. In the first place, he took the elements of the wind and the values of the latitude observed in the years from 1901.9 to 1912.0.

1) Unpublished paper by Dr. I. Yamamoto (Kyoto Imp. Univ. Obs.) who treated a series of Mizusawa observations in 1914. The results are expected to be published shortly.

2) Observations made with the Cookson Floating Zenith Telescope in the Years 1911-1918. London, 1921.

3) A. J. No. 872.

The mean direction and the mean strength of the wind during the interval when the observation of latitude was actually made, were read from graphs drawn by self-recording apparatus, while the observed latitude in each night was corrected for the variable quantity, $x\cos\lambda + y\sin\lambda + z$, which was determined graphically by using the values given in the "Resultate des Internationalen Breitendienstes."

In the record of the wind, sixteen directions were registered, but to eliminate any accidental errors, in the present investigation, they were combined successively two by two, and thus eight directions were taken in all. Four seasons were taken as usual, so that each season covers three consecutive months: spring includes March, April and May, and so on. With respect to the above eight directions and four seasons, the corrected latitudes were grouped into thirty-two, and then their mean value for each group was formed.

Table I. Effect of the Wind at Mizusawa.

(unit 0''.001)

Direction of Wind	Spring		Summer		Autumn		Winter		Mean
	d φ	n	d φ	n	d φ	n	d φ	n	
W-WNW	+ 7	429	+44	64	+16	316	+ 5	570	+18
NW-NNW	+ 7	1234	+10	340	-- 6	1229	0	1485	+ 3
N-NNE	+ 2	631	+11	505	+13	483	+16	641	+11
NE-ENE	-10	122	-10	191	+ 4	109	+ 7	137	- 2
E-ESE	-13	181	-23	123	-12	132	-45	115	-23
SE-SSE	- 1	438	-14	337	-16	295	-24	232	-14
S-SSW	+ 3	1028	+ 2	1358	-14	865	+21	287	+ 3
SW-WSW	+ 5	365	-24	62	+12	205	+18	226	+ 3

The first column in Table I gives the direction of the wind; the second, headed d φ , gives the residual of mean value of the corrected latitude for each group, the total mean of the eight values for the corresponding season being subtracted; in the third column, the corresponding number of star-pairs observed is mentioned with small figure; and the last column gives their annual mean.

It is clear at a glance that, at Mizusawa, in all season, winds affect the observed latitude generally in the same sense, and that the observed latitude for W-WNW winds is the largest, while for E-ESE winds it is the least. Perhaps it will not be accidental, that for NW-NNW winds the observed latitude is smaller.

3. The above attempt for Mizusawa having been fulfilled, it was desired to extend the similar investigations for the other International Latitude Stations. But Carloforte was the only one of them, where the regular observations of the wind are made, and the copies of its observed results were kindly sent by the Director of that Station, Dr. Peisino, on the request of Dr. Kimura. Using the data, which were observed in the years from 1900.3 to 1912.0, the effect of the direction of the wind at Carloforte was determined in the same way as before. Table II gives the results.

Table II. Effect of the Wind at Carloforte.

(unit $0''.001$)

Direction of Wind	Spring		Summer		Autumn		Winter		Mean
	d φ	n	d φ	n	d φ	n	d φ	n	
W-WNW	+ 4	1013	- 2	650	+ 9	611	0	903	+ 3
NW-NNW	- 8	2449	-20	5309	-11	1968	- 7	1081	-12
N-NNE	+ 9	705	0	2123	+ 4	960	-10	654	+ 1
NE-ENE	+13	289	+16	202	0	636	+10	415	+10
E-ESE	+19	607	- 1	286	- 3	1178	+ 5	844	+ 5
SE-SSE	+ 7	263	+ 6	311	- 2	381	+38	275	+12
S-SSW	-36	162	- 3	201	+14	140	-16	74	-10
SW-WSW	-11	372	+ 2	372	-11	368	-17	252	- 9

As seen in the above table, the mutual accordance between the values for each direction of the wind for four seasons is not so good as that of Mizusawa; in some directions, however, more or less systematic relations are clearly shown.

4. The effect of the strength of the wind on the observed latitude was studied carefully. Though some trace of such effect seemed to exist, no definitive conclusions have been attained at present.

5. The amount of the effect of the wind on the monthly mean values of latitude was calculated in the following manner.

On one hand, the effect of the wind for sixteen directions was determined from the harmonic expressions

$0''.0147\cos(\theta-27^\circ28') + 0''.0057\cos(2\theta-234^\circ30') + 0''.0064\cos(3\theta-34^\circ39')$
for Mizusawa, and

$0''.0083\cos(\theta-178^\circ3') + 0''.0043\cos(2\theta-18^\circ31') + 0''.0080\cos(3\theta-6^\circ52')$
for Carloforte. These expressions were found from the annual mean values of the foregoing tables, and θ is measured from W. through

N.E.S. On the other hand, the number of star-pairs, observed for each direction of the wind, was reckoned for each month. Then the calculated numerical value of the effect of the wind was multiplied by the corresponding number of star-pairs, and the total sum of such products was divided by the total number of star-pairs. Table III gives these results, the mean value being subtracted.

Table III. Annual Term Caused by Winds.

(unit 0''.0001)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mizusawa	+32	+19	+ 8	0	- 9	-20	-20	-28	- 5	+ 8	-- 3	+22
Carloforte	+26	+13	+13	- 9	-18	-30	-44	-37	+ 4	+19	+33	+35

As shown in Table III, it became now clear that the monthly character of the wind gives rise to an annual term in the latitude variation. Though its amplitude is small, its phase bears much resemblance to that of z-term, and, if the effect of the wind were as great as at Greenwich, the annual term here obtained would be more manifest. The complete explanation of z-term is not yet given, but it is conceivable from the above results that, it is partly, if not wholly, of the meteorological or geophysical origin. Hence to study z-term at any station, attention should be paid to its meteorological conditions.

6. Provisional results of another investigation is added below.

Not only winds, but the duration of sunshine seems to have some effect on the latitude observed in the night immediately following. The present writer has found that, in the night when the preceding day is clear, the observed latitude is about 0.''02 larger than that observed in the night following the overcast day.

7. It may be concluded from the above investigations :

a. The observed value of latitude has a close correlation with the direction of the wind.

b. The effect of the wind gives rise to an annual variation in the observed latitude, which probably forms a part of z-term.

c. By the actual examples it is clear that, to make an accurate astrometric observation, simultaneous meteorological observations should regularly be carried out at the same place.

The writer expresses his cordial thanks to Dr. Kimura for his kind guidance throughout the course of the present investigation.