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Meteorology. — *"On the relation between meteorological conditions in the Netherlands and some circumjacent places. Difference of atmospheric pressure and wind."* By Dr. J. P. VAN DER STOK.

1. In previous communications it was proved that the relation between direction and magnitude of the gradient of atmospheric pressure on the one hand, and force and angle of deviation (between wind and gradient) of the wind on the other hand is not a constant quantity, but varies with the azimuth of the gradient [1]) and with increase and decrease of pressure difference [2]).

If we select from the gradients, as calculated for the Netherlands and published in the weather charts, those pointing to eight points of the compass, then, for the period 1904—1910, the wind at De Bilt and the whole year, we find the following results:

TABLE I.. Average values of angle of deviation α and force of the wind (Beaufort scale) for different directions of unity gradient.

Direction-gradient	Number of observations $\alpha =$				Average force $\alpha =$			Aver. force for grad. = 1	Average deviation
	45°	67°.5	90°	Sum	45°	67°.5	90°		
N	208	165	66	439	1.9	1.8	2.0	1.86	60°
NE	44	123	112	279	1.8	1.9	2 0	1.93	73
E	17	44	59	120	3.0	2.8	3.2	2 97	79
SE	14	54	42	110	3 4	2.9	3.2	3.06	73
S	69	71	39	179	2.2	2.0	2.0	2.05	64
SW	38	92	51	181	1.9	2.1	2.6	2.17	69
W	75	73	28	176	2.1	2.3	2.3	2.14	62
NW	180	122	29	331	1.9	2.0	2.3	1.95	57
Total	645	744	426	1815	Aver. 1.94	2.03	2.30	2.05	64.8

Various objections against the method followed in this inquiry may be raised.

Angles of deviation smaller than 45° are left out of consideration

[1]) On the angle of deviation between gradient of atmospheric pressure and air motion. Amsterdam. Proc. Sci. K. Akad. Wet. **14**, 1912 (865—875).

[2]) The relation between changes of the weather and local phenomena. Ibid. **14**, 1912 (856—865).

because these are usually associated with feeble wind forces, so that the direction becomes uncertain.

It appears however from the large frequencies for $\alpha = 45°$ and N and NW directions of the gradient (208 and 180), greater than any other, that the omission of smaller values of α in these cases certainly gives too great a value for the average angle of deviation, whereas for E and SE directions of the gradient the influence of smaller values than 45° are compensated by those greater than 90°. The results of this inquiry are therefore to be considered as doubtful, not only in an absolute but also in a relative sense.

A more serious objection against this method is that it appears from table I that the meteorological field is by no means to be taken as uniform: easterly and south-easterly gradients are generally associated with wind forces and angles of deviation considerably greater than northerly and north-westerly directed gradients. The frequencies indicate that a gradient of a given magnitude and direction may be accompanied by different forces and angles of deviation so that the gradient, calculated as a *resultant* difference of pressure in a central point and four circumjacent stations cannot be considered as a reliable measure of the wind. A positive difference in a given direction does not exercise the same influence as a negative difference in the opposite direction. If, therefore, we wish to investigate this relation, the computation of a resultant must be avoided and each direction is to be taken into account with its proper coefficient of influence.

2. To this purpose *differences* of atmospheric pressure between Flushing on the one hand and Valencia, Biarritz, Munich, Neufahrwasser and Lerwick in the other hand are associated with the wind at the first named station, as published in the annals of the K. N. M. Institute for each day of the eight months: January, February, December 1912 and 1913, and January, February 1914. The average differences for the whole period are:

1.	Flushing—Valencia	+ 5.8 mm.
2.	„ —Biarritz	— 1.9
3.	„ —Munich	— 4.3
4.	„ —Neufahrwasser	+ 0.4
5.	„ —Lerwick	+ 7.9.

The average wind at Flushing during the same period is:

3.70 m.p.s.	S 25°36′ W
$W_n = -3.34$	N component
$W_e = -1.60$	E component.

The length D and the azimuth A of the arcs joining Flushing and the other stations are:

1.	$D = 8°34'$	$A = N\ 278°41'\ E$
2.	$8°40'$	$205°31'$
3.	$6°8'$	$119°39'$
4.	$9°23'$	$66°4'$
5.	$9°8'$	$345°4'$

Denoting the deviations from the average values of the pressure differences by $x_1, x_2 \ldots x_5$, and those of the north- and east components of the wind, by x_6 and x_7, and further assuming that a linear relation is justified we can put:

$$x_6 = b_{61}x_1 + b_{62}x_2 + \ldots + b_{65}x_5$$
$$x_7 = b_{71}x_1 + b_{72}x_2 + \ldots + b_{75}x_5 .$$

The treatment was the same as explained in a previous paper and the following results were obtained:

$r_{12} = +0.383$	$r_{16} = -0.456$	$\sigma_1 = 8.47$ mm.
$r_{13} = -0.185$	$r_{26} = +0.256$	$\sigma_2 = 7.15$,,
$r_{14} = -0.354$	$r_{36} = +0.737$	$\sigma_3 = 4.57$,,
$r_{15} = +0.297$	$r_{46} = +0.300$	$\sigma_4 = 7.72$,,
$r_{23} = +0.576$	$r_{56} = -0.561$	$\sigma_5 = 8.97$,,
$r_{24} = -0.116$	$r_{17} = +0.313$	$\sigma_6 = 4.55$ m.p.s.
$r_{25} = -0.201$	$r_{27} = +0.765$	$\sigma_7 = 6.01$,,
$r_{34} = +0.290$	$r_{37} = +0.522$	
$r_{35} = -0.491$	$r_{47} = -0.375$	
$r_{45} = +0.197$	$r_{57} = -0.463$	

The condition equations then become:

$$\left.\begin{aligned} x_6 &= -0.134\,x_1 + 0.002\,x_2 + 0.537\,x_3 + 0.061\,x_4 - 0.123\,x_5 \\ x_7 &= +0.089\,x_1 + 0.426\,x_2 + 0.293\,x_3 - 0.227\,x_4 - 0.155\,x_5 \end{aligned}\right\} \quad (1)$$

The general correlation coefficient of the first equation (N. component) is R=0.825, of the second equation (E. component) R=0.870. It follows from these results that the actual pressure differences, deduced from observations made at 5 circumjacent stations enable us to account for the wind blowing in the centre to a degree of 85% or, in other words, the expected deviation from the mean value with an average uncertainty of $\sigma_6 = \pm 4.55$ and $\sigma_7 = \pm 6.01$ as a first, rough approximation of the wind components is improved by equation (1) with

$$(1 - \sqrt{1 - R^2}) \times 100 \left\{ \begin{aligned} &= 43^5 \\ &= 50^5 \end{aligned} \right. \text{ per cent.}$$

It appears from equ. (1) that a positive gradient in the direction of Valencia produces a SE wind, in the direction of Biarritz an E, of Munich a NE, of Neufahrwasser a NW, and of Lerwick a SW wind and further, that, although the distance from Flushing is about the same, Biarritz exercises a much stronger influence than Valencia. These results are in accordance with the experience afforded by the study of the weather charts, but they give quantitative relations by means of which a calculation of the resulting wind becomes possible.

With the help of equ. (1) it is possible to demonstrate in a more conspicuous manner the influence of the gradient direction on the velocity of the wind and the angle of deviation by putting the question: which wind will be caused by or, rather, will be associated with a fictitious distribution where the pressure difference in the whole field is uniform and represented by isobars, successively drawn in the directions of eight principal points of the compass, and at distances from each other equal to unity (1 mm. per degree of latitude).

Denoting the distance of a station from Flushing by D, the azimuth of the joining arc by A, the azimuth of the gradient by α and the average difference of pressure by β, then

$$x_i = D \cos (A_i - \alpha) - \beta_i$$

where i is to be given successively the values 1 to 5.

The components of the wind then follow from the values computed from (1):

$$W_n = w_n + x_6 \qquad W_e = w + v_7.$$

The results of this calculation are given in table II.

TABLE II.

Direction gradient	Wind velocity for grad. = 1 m. p. s.	Direction of wind	Angle of deviation
N	5.43	N 248° E	68°
NE	5.29	294	69
E	5.53	349	79
SE	7.21	35	80
S	8.35	67	67
SW	7.55	97	52
W	5.56	139	49
NW	4.90	198	63

According to the expectation formulated in § 1, by this improved method a smaller minimum value is found for the angle of deviation than in table 1; at the same time the positions of the maxima and minima are somewhat shifted.

It may be noticed that for the correlation between Munich and Lerwick for pressure *differences* a negative value, $r_{35} = -0.491$ has been found of the same order of magnitude as the *partial* correlation of deviations from pressure between Clermont and Christiansund viz. — 0.536, and between the region of the Azores and Iceland.

The laborious calculations of partial corr. coeff. may, therefore, often be avoided by forming *differences*, by which process large common influences are eliminated.

3. For a third investigation the average wind for the Netherlands has been calculated (for the same period as mentioned in § 2 and 7 a.m.) from the stations De Bilt, Flushing, Helder, and Groningen and this average wind has been associated with pressure differences between De Bilt on the one hand and Sylt, Dresden, Mülhausen, Ile d'Aix, Valencia, and Lerwick on the other hand; the azimuths of these stations differ about 60° C.

The ranknumbers, average values and standard deviations now become:

	Pressure differences	Average differences	Standard deviation
1.	De Bilt—Sylt	+ 1.58 mm.	$\sigma_1 = 4.96$ mm.
2.	„ —Dresden	— 1.99	$\sigma_2 = 4.16$
3.	„ —Mülhausen	— 3.71	$\sigma_3 = 4.74$
4.	„ —Ile d'Aix	— 1.48	$\sigma_4 = 6.38$
5.	„ —Valencia	+ 5.31	$\sigma_5 = 8.47$
6.	„ —Lerwick	+ 7.95	$\sigma_6 = 8.97$
	Wind		
7.	North-component	— 2.63 m.p.s.	$\sigma_7 = 3.61$ m.p.s.
8.	East-component	— 0.95	$\sigma_8 = 4.52$

The correlation-coefficients are:

$r_{12} = +0.366$ $r_{25} = -0.411$ $r_{45} = +0.420$
$r_{13} = -0.446$ $r_{26} = -0.271$ $r_{46} = -0.289$
$r_{14} = -0.520$ $r_{27} = +0.663$ $r_{47} = +0.243$
$r_{15} = -0.253$ $r_{28} = -0.246$ $r_{48} = +0.763$
$r_{16} = +0.546$

$r_{17} = -0.168$	$r_{34} = +0.782$	$r_{56} = +0.300$
$r_{18} = -0.820$	$r_{35} = +0.014$	$r_{57} = -0.398$
	$r_{36} = -0.508$	$r_{58} = +0.323$
$r_{23} = +0.354$	$r_{37} = +0.624$	$r_{67} = -0.635$
$r_{24} = -0.061$	$r_{38} = +0.687$	$r_{68} = -0.535$

The condition equations reduced from these values are:

$$\left.\begin{aligned} x_7 &= -0.085x_1+0.396x_2+0.255x_3-0.038x_4-0.060x_5-0.103x_6 \\ x_8 &= -0.239x_1-0.346x_2+0.454x_3+0.068x_4+0.083x_5-0.129x_6 \end{aligned}\right\} \quad (2)$$

with the general correlation-coefficients ·

$$R_7 = 0.856\,, \quad R_8 = 0.938$$

With respect to a first expectation with the average uncertainty σ_7 and σ_8 the expectation has been, therefore, improved respectively 48 and 65 per cent, and the computation with the help of 6 stations affords an improvement with respect to the use of 5 stations with only 5% for the north-component, but with 15% for the east-component. The probable uncertainty becomes $\pm$ 1.24 and $\pm$ 1.05 m.p.s.

TABLE III.

Direction gradient	Direction wind	Wind-velocity	Angle of deviation
N	N 231° E	3.43 m.p.s.	51°
NNE	258	3.39	56
NE	285	3.35	60
ENE	309	3.56	62
E	338	3.76	68
ESE	3	4.11	70
SE	25	4.44	70
SSE	45	4.96	67
S	62	5.28	62
SSW	80	5.46	57
SW	96	5.39	51
WSW	114	5.14	47
W	133	4.73	43
WNW	154	4.27	42
NW	178	3.86	43
NNW	204	3.58	47

Table III (p. 326) shows the values of the wind velocity, the direction of the wind and the angle of deviation as calculated from equation (2) for 16 different directions of the gradient and a uniform field of 1 mm. difference of pressure per degree of latitude.

A comparison of these results with those of table II shows that the use of an average wind for the whole country has induced a more regular course in the numbers, but also that considerable differences are due to this method. The wind velocity and the angles of deviation have become smaller as also the azimuths and wind directions. From this result we may conclude that the northerly stations behave differently in many respects from Flushing and that a combination as made in this inquiry is not desirable.

Physics. — *"On a General Electromagnetic Thesis and its Application to the Magnetic State of a Twisted Iron Bar".* By Dr. G. J. ELIAS. (Communicated by Prof. H. A. LORENTZ).

(Communicated in the meeting of May 29, 1915).

WIEDEMANN has already observed that in a longitudinally resp. circularly magnetized iron bar a circular resp. longitudinal magnetisation arises in consequence of torsion. Moreover he discovered that a bar which is at the same time longitudinally and circularly magnetized, is twisted. These observations formed the starting point of the following considerations.

In a magnetic field, in which the magnetic induction can be an arbitrary vector function of the magnetic force variable from point to point, whereas the media in the field can be anisotropic also with respect to the conductivity, but in which no phenomena of hysteresis occur, the equation

$$T = \frac{1}{c} \int \Sigma \, i dM \text{ [1]} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

holds for the magnetic field energy.

In this i means the current in a circuit M, the induction flux passing through this circuit, c representing the ratio of the electromagnetic to the electrostatic unity of electricity. The summation extends over all the circuits, the integration covering a range from M for $i = 0$ to the final value which M assumes.

1) In this and following formulae LORENTZ's system of unities is used.