No. 463.

CLOUD DRIFT

AS OBSERVED

AT KINGSTON, JAMAICA,

BY

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During the years 1907-1913.

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CLOUD DRIFT

As observed at Kingston, Jamaica, (Latitude 17° 58′ N., Long. 76° 48′ West,) during the years 1907-1913.

CLOUD MOVEMENTS.

There is an element of interest attached to the study of upper air movements, especially from the standpoint of the Meteorologist, and within recent years such an unlimited amount of attention has been directed to investigations appertaining to this subject by the aid of such appliances as box-kites, pilot balloons, etc., at various Stations, that eventually we shall be possessed of valuable data to further these researches.

The present Article, however, deals with the cloud movements at different levels as observed in Kingston in order to determine the mean cloud drift and covers a period of observation of six years and five months dating from August 1907 to December 1913, inclusive. The results are confined to the main three groups of clouds, i.e., the Lower, Middle, and Upper.

The Lower Cloud includes the Strato-cumulus, Nimbus, Stratus and Fracto stratus.

The Middle Cloud includes Cumulus, Alto-cumulus and Alto-stratus.

The Upper Cloud includes the Cirrus, Cirro-stratus and Cirro-cumulus.

The Lower Cloud is estimated to have a limit of altitude of about 1,000 feet. The Middle, 4,000 feet, and the Upper, 10,000 to 12,000 feet. But these heights have yet to be determined for the latitude of Kingston.

Each Class, or Group of Cloud, is dealt with, separately, and account is taken of the *frequency* of cases of observed direction of the drift occurring at the time of the 7 a.m.*, as well as at the 3 p.m.* daily records for each month, and quite irrespective, of course, of the percentage amount, or area of sky covered by cloud appearing at the time.

During the period under review the total numbers of observed directions tabulated for the purpose of these computations for each class of cloud are as follows:—

Lower Cloud	.. .. ..	1,446
Middle Cloud	.. .. ..	1,836
Upper Cloud	.. .. ..	1,517
	Total ..	4,799

The observed directions adopted and summarised are limited to the eight points of the compass in relation to the True Meridian. But the resultants are reduced to the nearest thirty-two points of the compass.

Each month's set of clouds, with directions of drift (from), are totalled, and these totals for each direction are employed as the components in the procedure to determine the Resultant arrived at by the usual method of the "Polygon of Forces" or by Lambert's well known formula, and the bearing of such Resultant is reduced to degrees of azimuth from the True North, Easterly or Westerly, as it occurs and then converted into its corresponding compass bearing.

Lower Cloud.

By reference to Tables I and II it will be seen that in every instance the afternoon drift is observed to lay many degrees further North than in the forenoon. This is particularly noticeable in April when it is East for the forenoon and North-east-by-East in the afternoon, and in October when it is South-east-by-South in the forenoon and East in the afternoon. The general average for the year gives the bearing of the afternoon drift 23° further to north than in the forenoon, i.e., the forenoon being East-by-South and the afternoon, East-by-North. This is possibly, attributable to the higher altitude attained by the afternoon lower cloud on account of the atmosphere then being of a higher temperature than that of the morning, and exposed to the influence of the higher elevation of the prevailing Trade Wind blowing above the local surface wind as occurs over Kingston.

There is also a tendency for the forenoon cloud, as seen in Table I, to gradually advance in direction South-easterly, month by month, from January, when it is about East-by-North, to a bearing nearly South-east in October,—but it is not so evident in the afternoon, results shown in Table II.

The 7 a.m. drifts from about East in January and farthest South-easterly (South-east-by-South) in October.

The 3 p.m. drift is farthest North in the semi-circle in April (North east by East) and farthest South-easterly (East-by-South) in June.

By the results shown in Tables I and II for both the forenoon and afternoon clouds we get the maximum percentage, 42.1 and 41.0 respectively as being observed from East, with South-east suc-

* These being the principal hours of observation for Kingston.

ceeding, giving 21.4 and 17.9 per cent. respectively; but in the morning we have the least number of cases from North-west, being 1.8 per cent., and the afternoon the least from South-west, being 2.3 per cent.

For the whole year the normal direction for the 7 a.m. is East-by-South, and for the 3 p.m. East-by-North, representing a range of arc of about 23°.

For the year the mean direction of the surface wind for 7 a.m. is North-by-East, and for 3 p.m. South-east, and differs from the lower cloud. But it should be noted that all the lower clouds are not of the Stratus class.

Middle Cloud.

Similar conditions of drift do not appear to altogether prevail with this class as with the lower. The results derived from both the forenoon and afternoon observations as shown in Tables III and IV reveal a tendency to a near coincidence in each month in bearing. There is, however, a departure in the month of October, for the afternoon resultant gives the bearing somewhat East-north-east (North 62° East) whereas, the forenoon shows about East-by-South (North 98° East). Then, also, in a less degree in July, when the afternoon indicates 15° further to the North. But the difference in the year's means between the two sets is only 5°, i.e., East-by-North (North 78° East), as compared with East-north-east (North 73° East).

There is evidently also a disposition, from month to month, to show a variation, or shifting, of the bearing of the drift. For in the month of April means of Tables III and IV, we have a direction from nearly North-east-by-east (or North 54° East). And during the hurricane disturbed months of July August and September, this class of cloud becomes almost due East, or North 88° East, then in the months following gradually resuming a somewhat north-easterly bearing.

As in the case of the Lower Clouds, the preponderance of drift is from the East, and this is particularly evidenced in the afternoon drift for June and July, when we have 56 cases out of 87, or about 64 per cent., and 77 cases out of 101, or 77 per cent. respectively. Then, followed by North-east, occupying second place in point of percentage. In the forenoon, generally, there is a very insignificant percentage of drift apparent from the South, South-west, West and North-west, representing only about 5 per cent. for each bearing. Then, in the afternoon, almost similar conditions prevail, but with a remarkably smaller percentage of cases from the South, representing only 1.8 per cent.

There are certain directions from which this class of cloud was not at all seen to drift in some months during the whole period of over six years. For example, neither South-west nor North-west occurred in the month of February in the 7 a.m. set, and other months have similar features of absence.

The general mean drift of the Middle Cloud, inclusive of the 7 a.m. and 3 p.m., for the entire period, places the bearing about 18° further North of East than the Lower Cloud. The combined mean of the Lower Cloud being about East (North 93° East) and that of the Middle about East-north-east (North 75° East).

Upper Cloud.

With this class of clouds it has been found sufficient, and expedient, to combine the 7 a.m. and 3 p.m sets into Table V, for it has been discovered that the variation of the bearing of the drift between the forenoon and afternoon does not amount to more than a few degrees; but it may be mentioned, however, that the afternoon series of observations shift inappreciably to the North of the forenoon sets. As would be expected with clouds of such high altitude, the influence of any diurnal effect would not so readily manifest itself as with the clouds of a lower level which would be more affected by surface conditions.

The mean for the whole year gives the drift North 82° West which corresponds with a compass bearing of West by North.

Table V shows that in clouds of this class the greatest frequency of their presence occurs in September and the least in March.

Figure 1 gives the mean compass bearing, or direction from, for each month of the year.

During the undisturbed six months, January, February, March, April, May and December, or months which may be regarded as being exclusive of the Tropical Hurricane Season, and when the atmospheric conditions may be taken as fine, the normal bearing of drift for these months is from North 107° West which is equivalent to a compass bearing of about West-south-west and agrees nearly with the results arrived at by other observers.

Mr. John D. Quin, of St. Croix, Danish West Indies, mentioned this bearing in his article in the United States Monthly Weather Review, November 1907, page 511, and it is left to be seen whether this is supported generally by other stations in this latitude, North.

But if we embody the other months from June to November (6 months), which cover most of the Tropical Hurricane period, a mean bearing of North 57° West is derived, equivalent to North-west-by-North, a clear swinging around an arc of 50° from the point arrived at for the fine months, owing no doubt to either Cyclonic action or to Solar effect.

By examining Figure 2, evidence is produced of the steady progress in the Western semicircle of the drift from a bearing South-westerly to more and more North. Beginning with the month of February at the extreme point, where it is found to be North 120° West, or South-west-by-West, and following the several months until we reach the month of August, we have the direction of drift so far as North 15° West, or North by West. The veering around to extremes takes place in a 6 month's period.

The late Professor E. B. Garriott of the United States Weather Bureau tabulates in his articles on "West Indian Hurricanes" (W. B. No. 232) year 1900, page 25, that the greatest frequency of hur-

ricane occurs in August and from later statistics, including subsequent disturbances, Professor Oliver L. Fassig of the United States Weather Bureau, (in W. B. No. 487) year 1913, computes the greatest frequency in September. Then after passing this period there occurs a remarkably uniform South-westerly return of the Upper Cloud drift until February is again reached. This retrogression being at the rate of about 25° per month, and a total compass change or swing, or veering round, of 105°.

In the months of August and September, the greatest percentage of frequency of direction is from the North and North-west, and the least from South-east and South.

In the foregoing results no discrimination has been made for the different descriptions of upper cloud, for the reason that they are for the most part comprised of the cirrus type. And in a summary of the number of observations, it is found that we have about 62 per cent. of cirrus, 32 per cent. of cirro-stratus and only 6 per cent. of cirro cumulus.

Taking the Kingston daily records of the United States Weather Bureau from the year 1899 to 1902, although covering a different series of years than those under review for their 8 a.m. observations of the upper cloud for February, and for August, being at the extremes, and reducing each of them so as to obtain their Resultants, the writer derives a bearing of South-west-by-West (North 120° West) for February, which is identical with the mean bearing given in Table V. And for August we obtain North-by-West (North 12° West) or a difference of only 3°. The August means from 1907 to 1913 being North 15° West.

The cirrus group of this class presents special importance in studies concerning the locating of a hurricane vortex, and it appears to be the opinion of several observers that the feathery cirrus of high altitude is an index of the cyclone centre, and is more or less divergent from the vortex, affording a means of aiding the determination of the bearing of such centre within reasonable limits of distance and bearing, hence these determinations may afford some aid in Meteorological matters.

It is on record that when the volcanos in Central America in the Spanish Main were eruptive in January 1835, ashes appeared to have been borne, from Coseguina, on the Bay of Fonseca, in four days to Kingston, Jamaica, in the teeth of the Trade Wind (vide Scott's "Elementary Meteorology" 1890 page 243). Now, the bearing of Fonseca Bay, near San Salvador is just West-south-west (North 112° West) from Kingston, and about 750 miles distant, and the normal direction of drift of the upper cloud for January is North 116° West: practically coincident. This supports the belief that, occasionally, these high upper currents of air convey volcanic dust. In this particular case after travelling with the high upper currents the dust may have descended into the East-by-North Trade Wind and driven back into the direction of Kingston, but this is perhaps conjectural.

Table VI has been prepared so as to show the means of the amount of each class of cloud present at the time of observation for each of the years 1908 to 1913, for the 7 a.m. and for the 3 p.m. sets, in tenths of the sky. The 3 p.m. lower gives the greatest amount.

For the purpose of illustrating the number of occasions the different classes of cloud were *visible*, during a single year, one year (1908) was selected, and the following gives the number of days out of the 366 of that year.

7 a.m.	Lower	Cloud	.. ..	75 days
"	Middle	"	.. ..	120 "
"	Upper	"	.. ..	123 "
3 p.m.	Lower	"	.. ..	158 "
"	Middle	"	.. ..	222 "
"	Upper	"	.. ..	121 "

It will therefore be seen that, in a great number of days there was a total absence, of many of the clouds, or clear sky. There were fewer cases in the 7 a.m. set when any Lower cloud could be seen and the drift taken than in the 3 p.m. one, being 75 as against 158. Likewise, with the middle cloud. But with the cirrus an equal frequency of observations was presented at both hours.

In order to render the definitions of the bearings tabulated more clearly understood, it may be stated that the zero, or 0, is taken as true North, and 180° as South ,and all bearings are arranged as East or West of this line. For example, North 45° East equals North-east, and North 135° East equals South-east.

Table VII has been added to give the amount of *Upper Cloud*, in tenths, for each month. And it will be noted that the maximum appearance of this cloud occurs in September as 2.9 tenths, and the least in the earlier months. January showing only 0.5 tenth. The mean for the year is 1.7 tenth, or about one-fifth of the sky covered on an average.

J. F. B.

TABLE I.—LOWER CLOUD.

1907-1913.

7 a.m.

Bearing.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.	Percentage.
N ..	4	3	2	..	3	..	..	..	2	5	2	3	24	5.3
NE ..	9	6	3	3	2	2	..	3	2	3	10	5	48	10.7
E ..	16	19	17	17	13	17	19	11	11	6	25	18	189	42.1
SE ..	6	5	6	5	5	12	4	5	7	22	11	8	96	21.4
S ..	2	2	3	..	1	4	1	3	8	8	3	1	36	8.0
SW ..	3	..	..	..	2	2	..	1	5	8	8	4	33	7.4
W ..	..	2	..	..	3	3	..	..	2	2	1	2	15	3.3
NW ..	..	..	2	1	..	1	..	1	..	2	..	1	8	1.8
Totals ..	40	37	33	26	29	41	24	24	37	56	60	42	449	100.0
Resultant Bearings	E	E	E	E	E b S	ESE	E b S	ESE	SE	SE b S	E b S	E b S	E b S	

TABLE II.—LOWER CLOUD.

3 p.m.

Bearing.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.	Percentage.
N ..	5	8	12	19	8	2	4	8	12	10	8	8	104	10.4
NE ..	14	8	7	14	17	4	8	14	20	18	20	16	160	16.0
E ..	29	25	29	30	31	21	34	45	40	37	50	37	408	41.0
SE ..	7	9	9	7	9	20	16	20	19	34	18	10	178	17.9
S ..	3	1	8	2	1	1	..	2	7	4	6	1	36	3.6
SW ..	2	1	4	..	1	1	1	2	3	5	1	2	23	2.3
W ..	4	4	2	2	3	1	..	6	5	4	..	1	32	3.2
NW ..	3	2	4	7	8	5	3	4	4	6	6	4	56	5.6
Totals ..	67	58	75	81	78	55	66	101	110	118	109	79	997	100.0
Resultant Bearings	E b N	E b N	E	NE b E	ENE	E b S	E	E	E b N	E	E	E b N	E b N	

TABLE III—MIDDLE CLOUD.

1907-1913.

7 a.m.

Bearing.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.	Percentage.
N	6	6	7	18	8	6	2	2	5	6	1	8	75	10.6
NE	20	11	10	21	14	11	3	10	4	10	25	17	156	22.1
E	24	33	33	29	28	29	25	20	8	10	14	22	275	39.0
SE	5	4	7	..	4	5	3	3	6	17	5	2	61	8.7
S	2	3	..	1	5	3	6	4	2	3	5	2	36	5.1
SW	4	..	2	..	4	4	1	2	5	3	9	3	37	5.2
W	6	1	5	..	4	4	2	2	2	4	5	2	37	5.2
NW	5	..	5	1	3	4	3	1	3	2	2	..	29	4.1
Totals ..	72	58	69	70	70	66	45	44	35	55	66	56	706	100.0
Resultant Bearings	ENE	E b N	ENE	NE	E b N	E b N	E b S	E	E	E b S	E b N	ENE	E b N	..

TABLE IV.—MIDDLE CLOUD.

3 p.m.

Bearing.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.	Percentage.
N ..	7	8	13	20	9	5	6	3	3	12	11	11	108	9.6
NE ..	24	22	23	27	12	11	14	20	18	15	26	30	242	21.4
E ..	49	47	45	36	50	56	77	44	29	28	38	49	548	48.5
SE ..	9	5	8	2	3	8	2	18	11	11	7	10	94	8.3
S ..	..	2	2	1	3	..	..	1	4	3	3	1	20	1.8
SW ..	2	3	1	1	4	2	..	1	4	3	2	2	25	2.2
W ..	8	1	5	1	7	1	1	4	6	5	4	1	44	3.9
NW ..	6	1	4	1	2	4	1	1	5	11	9	4	49	4.3
Totals ..	105	89	101	89	90	87	101	92	80	88	100	108	1,130	100.0
Resultant Bearings	ENE	E b N	ENE	NE b E	E b N	E b N	E b N	E	E b N	ENE	ENE	ENE	ENE	

TABLE V.—UPPER CLOUD.

1907-1913.

7 a.m. and 3 p.m. combined.

Bearing.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.	Percentage.
N	3	.	..	3	9	20	18	41	45	22	5	2	168	11.1
NE	.	.	1	1	2	14	23	36	36	20	5		138	9.1
E	2	3		1	4	2	7	13	16	9	2	..	59	3.9
SE	1	2	.	..		1	9	10	11	9	1	..	44	2.9
S	5	2	1	3	2	9	4	11	11	9	3	3	63	4.2
SW	20	15	8	21	25	17	25	12	27	25	26	53	274	18.0
W	17	14	17	20	74	87	79	28	42	42	48	27	495	32.6
NW	3	2	2	6	16	47	50	39	43	39	20	9	276	18.2
Totals	51	38	29	55	132	197	215	190	231	175	110	94	1517	100 0
Resultant Bearings.	WSW	SW b W	W b S	W b S	W	WNW	WNW	N b W	NW b N	W NW	W	WSW	W b N	

TABLE VI.—AMOUNT OF CLOUD—THREE CLASSES.

Year.	Clouds; in Tenths.					
	Lower.		Middle.		Upper.	
	7 a.m.	3 p.m	7 a.m.	3 p.m.	7 a.m.	3 p.m.
1908 ..	1.2	3 0	1 3	2.1	1.8	1.6
1909 .	1 5	2.9	0.8	1.9	1.8	2.0
1910 .	1 5	3.1	0.7	2.1	1.8	1.9
1911 ..	1 1	3.0	0.8	2.1	1.8	1.5
1912 ..	1.3	3 5	0.7	1.9	1.2	1.2
1913 ..	1 6	3.4	1.1	1.4	1.·	1.9
Means ..	1	3.1	1.8	1.9	1.7	1.7

TABLE VII.

Amount of Upper Cloud: *in tenths of the sky*, **combined means for 7 a.m. and 3 p.m.**

Year.	January.	February.	March	April	May.	June.	July	August	September.	October	November.	December.	Means for the Year
1908	0·2	1·3	1·7	1·7	2·1	2·8	2·7	2·4	3·3	1·1	0·3	0·8	1·7
1909	0·5	1·3	0·3	0·5	1·5	3·3	2·4	3·4	3·1	2·9	1·5	2·0	1·9
1910	0·6	1·2	0·0	1·7	1·5	2·7	3·1	2·7	3·0	1·5	2·0	2·3	1·9
1911	0·5	0·6	0·7	0·5	2·4	3·2	3·1	2·4	2·6	2·2	1·0	0·2	1·6
1912	0·2	0·3	0·4	0·5	0·9	1·4	1·3	2·1	2·6	2·6	1·2	0·7	1·2
1913	1·0	0·2	0·2	1·1	1·7	2·8	2·8	2·5	3·0	2·0	2·5	1·5	1·8
Means	0·5	0·8	0·6	1·0	1·6	2·7	2·6	2·6	2·9	2·1	1·4	1·2	1·7

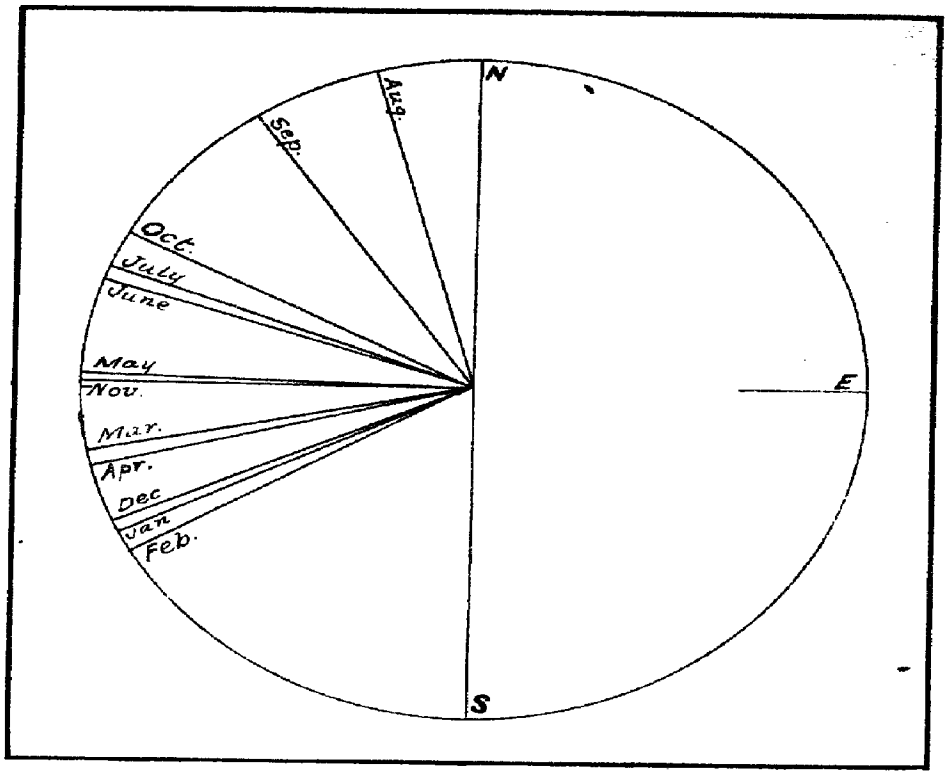

Figure 1. Upper cloud drift. Resultant directions for each month.

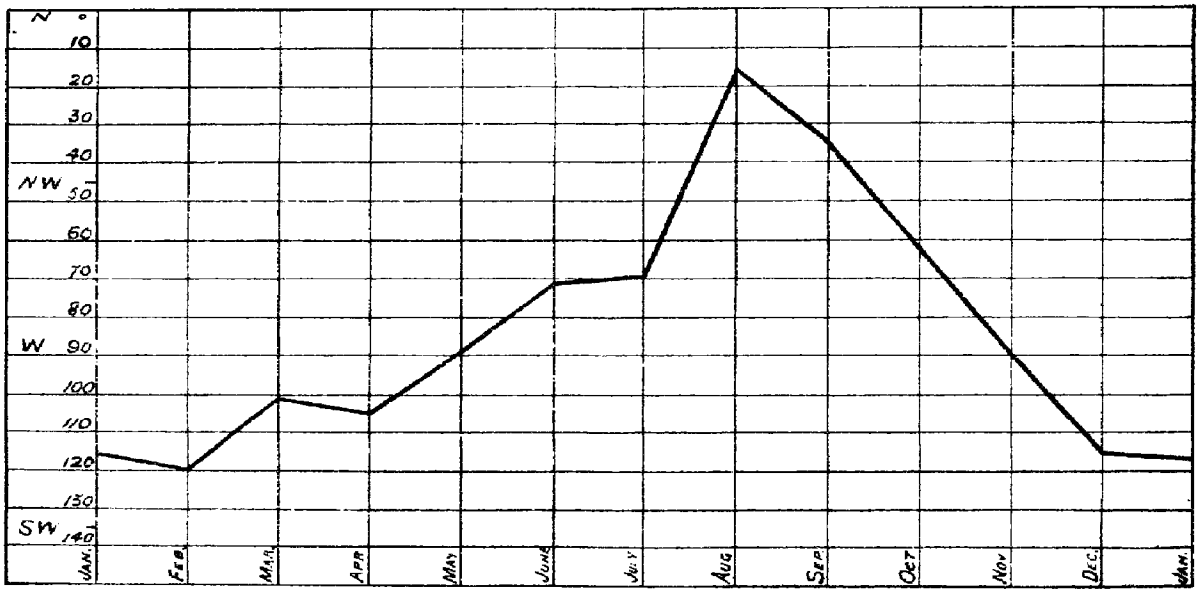

Figure 2. Upper cloud drift. Resultant directions for each month showing the gradual veering around of drift from south-westerly in February to about NNW in August and the early return to south-westerly