

M.O. 2451.

FOR OFFICIAL USE.

AIR MINISTRY.

METEOROLOGICAL OFFICE.

PROFESSIONAL NOTES,
VOL. 3, NO. 32.

A NOTE
ON THE
UPPER AIR OBSERVATIONS
TAKEN IN
NORTH RUSSIA IN 1919,
BY
W. H. PICK, B.Sc.

Published by the Authority of the Meteorological Committee.



LONDON:
PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE.

To be purchased through any Bookseller or directly from
H.M. STATIONERY OFFICE at the following addresses:
IMPERIAL HOUSE, KINGSWAY, LONDON, W.C. 2, and 28, ABINGDON STREET, LONDON, S.W. 1;
YORK STREET, MANCHESTER; 1, ST. ANDREW'S CRESCENT, CARDIFF;
or 120, GEORGE STREET, EDINBURGH.

1923.

Price 3d. Net.

A NOTE ON THE UPPER AIR OBSERVATIONS TAKEN IN NORTH RUSSIA IN 1919.

By W. H. PICK, B.Sc

This note is based upon pilot balloon ascents carried out over various periods between the 25th of February, 1919, and the 13th of September, 1919, at three Stations in north-west Russia by the personnel of the Meteorological Section, Royal Engineers, the Section forming part of the North Russian Expeditionary Force. The periods were irregular owing to the exigencies of Active Service.

The three stations in question were Murmansk, Archangel and Lumbushi. Murmansk stands at the head of the Kola Creek, its latitude being approximately 69° N. and its longitude approximately 33° E. The height above sea-level of the Meteorological Station from which the ascents were carried out was 30 feet. The creek runs northward and its banks are steep, rising to a height of approximately 500 to 800 feet; where Murmansk stands, it is about a quarter of a mile wide. The creek is always open to navigation even without the aid of ice-breakers. The land to the south, east and west of the town has only slight slopes with the exception that Telegraph Hill stands as an isolated peak about 1,000 feet high 2 miles to the southward. The ground is tundra and is snow covered from November to April inclusive. Archangel stands on the south-western coast of the White Sea, its latitude being $64^{\circ} 33'$ N. and its longitude $40^{\circ} 32'$ E. The station from which the pilot balloon ascents were carried out was 15 feet above sea-level. The whole country around is remarkably flat. Lumbushi stands on the Murman Railway, its latitude being approximately 68° N. and its longitude 34° E. Of the ascents examined in what follows and classified under the heading "Lumbushi," the earlier ones were done at "Siding 19" on the Murman Railway and the later ones at Lumbushi itself. The two places are, however, only a little distance apart and no appreciable error is introduced by considering the two sets as one. Again, the surrounding country is very flat. The White Sea lies to the east and lakes and marshes are within easy distance on the other three sides. The height of the ground from which the ascents were carried out is about 40 feet above sea level.

Every ascent was carried out with one theodolite only, the balloon being given a vertical lift of, theoretically, 500 feet per minute. The results suffer from the limitation to which all pilot balloon ascents are subject, namely, that heights obtained are dependent upon cloud, and therefore, when any considerable altitudes are recorded the weather conditions are such as to

produce either practically cloudless skies or only high cloud; they suffer, further, from the special defect of single theodolite ascents, namely, that the wind velocities obtained are rendered somewhat doubtful by reason of the existence from time to time of vertical currents or of defects in the balloons.

It must further be noted that the number of ascents made is not large enough to justify generalisations. Nevertheless, the results have an interest of their own in view of the high latitude in which they were obtained.

Wind velocities.—The first aim was to find the mean velocity of the wind at various selected heights when blowing from each of the four quarters. The method of treatment was as follows:—The velocity components, V_{W-E} and V_{S-N} were taken for various heights and arranged in four categories in pairs, according as their signs were $++$, $+-$, $-+$, or $--$. The aggregates and means for each pair of components for each of the heights were then worked out. From the means so obtained, the mean wind drift from each of the four quarters was computed in the usual manner.

The ascents were made either at 15h. or 18h. at Murmansk, at 15h. at Archangel and at either 10h. or 14h. at Lumbushi, all times being local. At first, the observations were treated separately for each hour of observation at each station, and, in addition in the case of Murmansk for spring and summer, but it was evident that the material was too fragmentary to give any useful information regarding diurnal and seasonal variations. In the final working up of the results all the observations made at any one station over the whole period of observation have been combined. These combined results are set out in Tables I.-III. (inclusive).

TABLE I.—ANALYSIS OF WINDS AT MURMANSK.

Period 25th February 1919–13th September 1919: Time of ascent either 15h. or 18h. local time.

Height in Feet.	Percentage Frequency and Mean Velocity in m.p.h. for each Quadrant.											
	South-west.			North-west.			North-east.			South-east.		
	No. of Occurrences.	Percentage Frequency.	Mean Velocity.	No. of Occurrences.	Percentage Frequency.	Mean Velocity.	No. of Occurrences.	Percentage Frequency.	Mean Velocity.	No. of Occurrences.	Percentage Frequency.	Mean Velocity.
500	70	32	10.5	64	29	8.5	57	26	8.7	30	13	8.9
1,000	62	29	13.4	63	29	11.8	51	23	10.5	42	19	9.8
2,000	73	37	13.5	58	29	13.5	29	15	10.2	37	19	11.9
6,000	49	40	14.3	37	31	20.4	6	5	13.4	29	24	12.9
10,000	37	43	17.3	35	40	22.1	3	3	7.5	12	14	15.7
16,000	15	33	19.2	20	45	19.5	5	11	8.8	5	11	13.0

produce either practically cloudless skies or only high cloud; they suffer, further, from the special defect of single theodolite ascents, namely, that the wind velocities obtained are rendered somewhat doubtful by reason of the existence from time to time of vertical currents or of defects in the balloons.

It must further be noted that the number of ascents made is not large enough to justify generalisations. Nevertheless, the results have an interest of their own in view of the high latitude in which they were obtained.

Wind velocities.—The first aim was to find the mean velocity of the wind at various selected heights when blowing from each of the four quarters. The method of treatment was as follows:—The velocity components, V_{W-E} and V_{S-N} were taken for various heights and arranged in four categories in pairs, according as their signs were $++$, $+-$, $-+$, or $--$. The aggregates and means for each pair of components for each of the heights were then worked out. From the means so obtained, the mean wind drift from each of the four quarters was computed in the usual manner.

The ascents were made either at 15h. or 18h. at Murmansk, at 15h. at Archangel and at either 10h. or 14h. at Lumbushi, all times being local. At first, the observations were treated separately for each hour of observation at each station, and, in addition in the case of Murmansk for spring and summer, but it was evident that the material was too fragmentary to give any useful information regarding diurnal and seasonal variations. In the final working up of the results all the observations made at any one station over the whole period of observation have been combined. These combined results are set out in Tables I.-III. (inclusive).

TABLE I.—ANALYSIS OF WINDS AT MURMANSK.

Period 25th February 1919–13th September 1919: Time of ascent either 15h. or 18h. local time.

Height in Feet.	Percentage Frequency and Mean Velocity in m.p.h. for each Quadrant.											
	South-west.			North-west.			North-east.			South-east.		
	No. of Observations.	Percentage Frequency.	Mean Velocity.	No. of Observations.	Percentage Frequency.	Mean Velocity.	No. of Observations.	Percentage Frequency.	Mean Velocity.	No. of Observations.	Percentage Frequency.	Mean Velocity.
500	70	32	10.5	64	29	8.5	57	26	8.7	30	13	8.9
1,000	62	29	13.4	63	29	11.8	51	23	10.5	42	19	9.8
2,000	73	37	13.5	58	29	13.5	29	15	10.2	37	19	11.9
6,000	49	40	14.3	37	31	20.4	6	5	13.4	29	24	12.9
10,000	37	43	17.3	35	40	22.1	3	3	7.5	12	14	15.7
16,000	15	33	19.2	20	45	19.5	5	11	8.8	5	11	13.0

TABLE II.—ANALYSIS OF WINDS AT ARCHANGEL.

*Period 15th July 1919–23rd August 1919: Time of ascents
approx. 15h. local time.*

Height in Feet.	Percentage Frequency and Mean Velocity in m.p.h. for each Quadrant.											
	South-west.			North-west.			North-east.			South-east.		
	No. of Occurrences.	Percentage Frequency.	Mean Velocity.	No. of Occurrences.	Percentage Frequency.	Mean Velocity.	No. of Occurrences.	Percentage Frequency.	Mean Velocity.	No. of Occurrences.	Percentage Frequency.	Mean Velocity.
500 -	3	10	9.6	14	45	8.9	6	19	9.6	8	26	6.1
1,000 -	5	17	7.5	12	40	10.9	6	20	10.2	7	23	9.6
2,000 -	8	27	8.2	9	30	10.9	7	23	10.9	6	20	11.6
4,000 -	9	35	11.6	7	27	11.6	5	19	13.0	5	19	13.0
6,000 -	8	35	16.4	8	35	12.3	4	17	16.4	3	13	16.4
8,000 -	5	29	18.4	8	47	13.6	1	6	?	3	18	17.7
10,000 -	5	38	19.1	7	54	13.6	—	—	—	1	8	?

TABLE III.—ANALYSIS OF WINDS AT LUMBUSHI.

*Period 21st May 1919–29th August 1919: Time of ascents
approx. 10h. and 14h. local time.*

Height in Feet.	Percentage Frequency and Mean Velocity in m.p.h. for each Quadrant.											
	South-west.			North-west.			North-east.			South-east.		
	No. of Occurrences.	Percentage Frequency.	Mean Velocity.	No. of Occurrences.	Percentage Frequency.	Mean Velocity.	No. of Occurrences.	Percentage Frequency.	Mean Velocity.	No. of Occurrences.	Percentage Frequency.	Mean Velocity.
500 -	48	29	8.2	33	20	9.6	28	17	10.6	55	34	9.2
1,000 -	40	24	9.3	42	26	11.6	28	17	11.8	54	33	10.6
2,000 -	45	28	11.6	44	28	13.6	28	18	11.2	41	26	13.3
4,000 -	37	26	14.0	53	38	14.9	24	17	10.8	27	19	17.4
6,000 -	29	27	16.4	46	42	14.4	16	15	11.4	17	16	16.7
10,000 -	22	42	11.1	18	34	15.8	6	11	9.6	7	13	20.3

TABLE IV.—THE WIND BEHAVIOUR IN THE FIRST 2,000 FEET.

Place.	Period 1919.	Time of Ascents (Local time).	Total No. of Ascents.	Percentage that veered from surface continually, up to :—			Percentage that backed continually up to 2000 feet.	Percentage remaining.
				2000 feet.	1500 feet only.	1000 feet only.		
Murmansk	25th Feb.—12th May	15h.	58	36.2	13.8	12.1	3.4	34.5
Murmansk	13th May—13th Sept.	15h.	115	14.8	1.7	11.3	8.7	63.5
Murmansk	21st April—12th June	18h.	48	39.6	6.2	6.2	6.2	41.8
Archangel	15th July—23rd Aug.	15h.	31	9.7	12.9	3.2	9.7	64.5
Lumbushi	21st May—29th Aug.	10h.	82	19.5	4.9	12.2	6.1	57.3
Lumbushi	21st May—29th Aug.	14h.	82	15.8	9.8	12.2	6.1	56.1

Wind directions.—Tables I.—III. give the percentage frequency for the four principal directions for each height. The main point emerging is a marked decrease in the frequency of easterly components up to 10,000 feet.

The behaviour of the wind in the first 2,000 feet.—The behaviour of the wind in the first 2,000 feet is shown in greater detail in Table IV. Whilst the table is self-explanatory there is one point in connection with the Murmansk readings which it does not show and which is interesting. That point arises in connection with those occasions when the wind backed from the surface continually up to 2,000 feet. Over the period examined there were 15 such cases and in no less than 10 of those cases the surface wind was in the north-east quarter. This accompaniment of backing upper winds with north-easterly surface ones deserves attention. Expressed otherwise to bring out the relationship more clearly, there were 57 occasions on which the surface wind was in the north-east quadrant and on 10 of these, that is 17.5 per cent. of the total, the wind backed continuously up to 2,000 feet. On the other hand there were 164 occasions on which the surface wind was not in the north-east quadrant and on only five of these, that is 3.0 per cent. of the whole, did the wind back continuously upward.

The behaviour of the wind at high altitudes.—The fact that all the ascents carried out were single theodolite ones leaves some uncertainty in the case of the great heights. At Murmansk during the period 25th February 1919 to 12th May 1919, three ascents reached to a computed height of 40,000 feet. At that height, two of the winds found were NW and one was SW. Further, two of the ascents reached to a computed height of 60,000 feet, at which height both of the winds found were SW.

TABLE IV.—THE WIND BEHAVIOUR IN THE FIRST 2,000 FEET.

Place.	Period 1919.	Time of Ascents (Local time).	Total No. of Ascents.	Percentage that veered from surface continually, up to :—			Percentage that backed continually up to 2000 feet.	Percentage remaining.
				2000 feet.	1500 feet only.	1000 feet only.		
Murmansk	25th Feb.—12th May	15h.	58	36·2	13·8	12·1	3·4	34·5
Murmansk	13th May—13th Sept.	15h.	115	14·8	1·7	11·3	8·7	63·5
Murmansk	21st April—12th June	18h.	48	39·6	6·2	6·2	6·2	41·8
Archangel	15th July—23rd Aug.	15h.	31	9·7	12·9	3·2	9·7	64·5
Lumbushi	21st May—29th Aug.	10h.	82	19·5	4·9	12·2	6·1	57·3
Lumbushi	21st May—29th Aug.	14h.	82	15·8	9·8	12·2	6·1	56·1

Wind directions.—Tables I.—III. give the percentage frequency for the four principal directions for each height. The main point emerging is a marked decrease in the frequency of easterly components up to 10,000 feet.

The behaviour of the wind in the first 2,000 feet.—The behaviour of the wind in the first 2,000 feet is shown in greater detail in Table IV. Whilst the table is self-explanatory there is one point in connection with the Murmansk readings which it does not show and which is interesting. That point arises in connection with those occasions when the wind backed from the surface continually up to 2,000 feet. Over the period examined there were 15 such cases and in no less than 10 of those cases the surface wind was in the north-east quarter. This accompaniment of backing upper winds with north-easterly surface ones deserves attention. Expressed otherwise to bring out the relationship more clearly, there were 57 occasions on which the surface wind was in the north-east quadrant and on 10 of these, that is 17·5 per cent. of the total, the wind backed continuously up to 2,000 feet. On the other hand there were 164 occasions on which the surface wind was not in the north-east quadrant and on only five of these, that is 3·0 per cent. of the whole, did the wind back continuously upward.

The behaviour of the wind at high altitudes.—The fact that all the ascents carried out were single theodolite ones leaves some uncertainty in the case of the great heights. At Murmansk during the period 25th February 1919 to 12th May 1919, three ascents reached to a computed height of 40,000 feet. At that height, two of the winds found were NW and one was SW. Further, two of the ascents reached to a computed height of 60,000 feet, at which height both of the winds found were SW.

During the period 13th May 1919 to 13th September 1919 at the same station, seven ascents reached to 20,000 feet. At that height, four of the winds found were SW and two NW.

Of the ascents carried out at Archangel for the period 15th July to 23rd August 1919, only one reached 20,000 feet, giving a southerly wind at that height.

Of the ascents at Lumbushi during the period 21st May, 1919 to 29th August 1919, six attained to a height of 20,000 feet, giving two north-westerly winds there, three north-easterly ones, and one southerly one.

Conclusion.—The main object of this paper is to place on record the results obtained in view of the fact that very few soundings of the upper air have been carried out so far north. The period over which the soundings continued is too short to justify generalisations; attention, however, may be drawn to the following points:—

(a) The mean velocities computed as explained and set out in Tables I.–III. (inclusive) do not differ appreciably in magnitude from those obtained in the temperate latitudes of Europe.

(b) There is a decrease in the easterly component up to 10,000 feet.

(c) The behaviour of the wind in the first 2,000 feet (*see* Table IV.) is markedly irregular. This is probably mainly to be accounted for by the distortions of temperature within that 2,000 feet in the Arctic Regions where, in winter, temperature inversions are extremely common and where, in summer, the lower layers of air are strongly heated in comparison with those above. A second cause is to be found in the fact that both Archangel and Murmansk may be regarded as coast stations and that, consequently, land and sea breezes introduce disturbing effects, and that Lumbushi has the White Sea to the east of it and several large lakes in its vicinity so that similar breezes disturb its winds.

(d) Most of the winds at altitudes of 20,000 feet and above blew from a westerly point. Too much stress, however, must not be laid upon this, owing to the fact that such heights were only explorable under conditions which made for cloudless skies.