The Antarctic Climate
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the caverns of the Ohio valley, and of Canada; the underground cavities and waters of some of the West India islands and Brazil, would alone form a voluminous paper. In England and Ireland the investigations of Professors Boyd Dawkins and Edward Hull have, amongst others, disclosed caves, swallow-holes, and other evidence of subterranean waters whose existence was previously ignored.

In this paper readers may notice some apparent contradictions. These arise through my desire to place before the Society, not only my own views, but also those of many whose opinion I consider worthy of mention. I have recorded these views, as I do not think that, with the small amount of evidence we have before us, any one, however distinguished, can claim a perfect knowledge of the causes at work. We are only on the threshold of the subject, and I hope that the data I have been able to collect and lay before my readers will set the thinking minds at work, and produce an effect which may prove beneficial to the knowledge we possess of the world in which our lot is cast.

THE ANTARCTIC CLIMATE.

By HENRY ARCTOWSKI.

THE following is a preliminary account of some of the additions to our knowledge of the meteorology of higher southern latitudes contributed by the recent Belgian Antarctic Expedition.

These desolate antarctic regions, still so little explored, present many physical problems of the highest interest; the question of their climate, attacked as early as the time of Croll, must prove a subject of exhaustive investigation in the immediate future. The results I have obtained were not originally intended for publication in their present form, because the mean values involved can only be regarded as first approximations; however, it appears that my provisional numbers are sufficiently exact to indicate the general nature of the climatic *regime* in parts of the globe about which we have been, up to the present, practically without information. The fact that other antarctic expeditions are about to set out has decided me to publish my figures as they stand.

For the purposes of our inquiry, it is a matter of indifference whether an antarctic continent exists or not; we have undoubtedly to deal with a continuous surface of ice, which the meteorologist must regard as a land surface as opposed to an open sea. This ice-cap is entirely isolated by an ocean which surrounds it, and is subjected to the peculiar conditions of polar day and night. Hence the first points to be considered are the average distribution of pressure, and the direction of the prevailing winds. The positions (about 81° and 95° W. long., and 69° 50′ and 71° 30′ S. lat.) show a relatively small distance from the open sea and great distance from the pole. In consequence we experienced two distinct types of climate according to the direction of the wind—a continental and an oceanic—in effect a coastal climate depending on the passage of cyclones which varied in frequency with the seasons. This seems to be the key of the whole position. As regards details, I take into consideration the mean and minimum temperatures and the barometric pressures, the direction of wind, the amount of cloud, and the amount of precipitation.

Table I. gives the mean values obtained from hourly observations of temperature made on board the *Belgica* during her drift in the ice.

July was the coldest month; its mean temperature was −23°·5 C. (−10°·3 F.), and the lowest temperature observed during the month, −37°·1 C. (−34°·8 F.).

The extreme minimum of temperature was observed in September, −43°·1 C. (−45°·6 F.).

The warmest month was February, with a mean temperature of −1°·0 C. (30°·2 F.), and minimum for the month, −9°·6 C. (14°·7 F.).

If we regard June, July, and August as the antarctic winter months, and December, January, and February as summer, we may take it that the mean winter temperature is −16°·8 C. (1°·8 F.), and the mean for summer −1°·5 C. (29°·3 F.).

Table II. shows the minimum temperature for each month. The maximum temperatures are less interesting; the winter average is −1° to 0° C. (30° to 32° F.); the absolute maximum for the equinoctial months is 0° to 1° C. (32° to 34° F.), and for summer 2° C. (36° F.).

These tables show that between the seventieth and seventy-first parallels of the southern hemisphere, and amid the ice of the antarctic ocean—first, the mean temperature is lower than that of the northern coast of Spitsbergen (Mossel bay, 1872–73, −8°·9 C. (16° F.)); second, the minimum temperature is quite as low as the minima observed on the east side of Greenland (Sabine island and Scoresby sound); and third, that the mean temperature of the three summer months is lower than the corresponding mean in the ice of the arctic ocean—the observations of the *Fram* give a mean for June, July, and August of −1°·2 C. (29°·8 F.). Note that the calculations of Spitaler and Supan give a mean temperature for the parallel of 70° N. lat. of −10°·2 C. (13°·6 F.). If we consider that a considerable fraction of the seventieth parallel of south latitude is land, we can suppose that it may have a mean temperature as low as the 70° N., and include a pole of cold with lower temperature as the Asiatic or North American poles of cold.

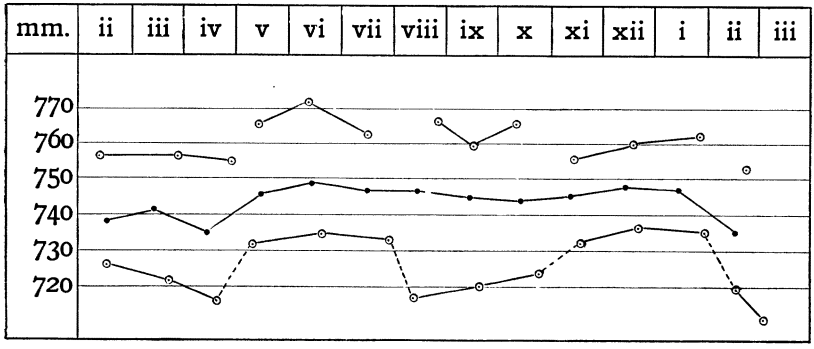

FIG. 1.

As in the case of the mean temperatures, the values I am able to give for mean barometric pressure must be regarded only as first approximations. During our drift in the pack-ice hourly observations were made with a marine barometer and with an aneroid. I have not yet been able to apply exact corrections to these observations, but if we bear in mind that while the temperature correction is negative, the correction for latitude is positive, and that for temperatures about 13° to 15° C. (55° to 60° F.), these corrections are numerically nearly equal, we can accept the uncorrected values as near enough for our present purpose. Table III. gives the averages of the aneroid observations, calculated to whole millimetres only. The mean for the year is 744·7 mm. (29·319 inches).

Tables IV. and V. give the principal minima and maxima of pressure observed, the values are reduced to the freezing-point and gravity at 45° lat. The lowest

pressure observed during our wintering was 711·74 mm. (28·022 inches), and the highest 772·14 mm. (30·400 inches), a range of 60·40 mm. (2·378 inches). Table VI. gives the monthly variations of the barometer, the mean value of which amounts to 34·30 mm. (1·350 inch), showing even more clearly than Table IV. that the cyclonic belt extends beyond the polar circle. From this table it appears, further, that the three months of almost continuous daylight (November, December, and January) are characterized by a very small variation of pressure—only 23·95 mm. (0·943 inch). The three corresponding months of winter have also a mean less than those for the intermediate or equinoctial months. Compare this with the mean pressures (Table III.): the differences between the annual and monthly means (Table VII.) show that February, March, and April form a negative group, in which the pressure is relatively low; the three months of polar night form another group of maximum barometric pressure; then follow August, September, and October, months of decreasing pressure, a group which, although not actually negative, forms a distinct secondary minimum; and, lastly, three months of polar day forming a secondary maximum of pressure. The general result is illustrated in Fig. 1—high pressure at the solstices, low pressure at the equinoxes—and the existence of a direct simple relation between the barometric pressure and the progress of the sun is at once obvious.

Table VIII. gives the observed wind-directions: the figures indicate the number of hours during which the wind blew from each direction during the twelve months, the sums constituting the "wind-rose," of the point of observation. Fig. 2 shows that winds blow from northerly and southerly points with almost equal frequency, and that easterly winds predominate over westerly. The directions of greatest frequency were west, east, and north-east.

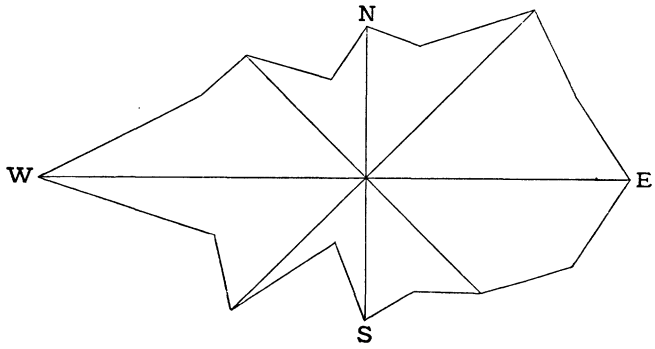

FIG. 2.

The monthly wind-roses show some interesting seasonal variations in the prevailing directions of the wind; we note specially the predominance of north-east to south-east over westerly winds from November to February, and the relative frequency of westerly winds during June, July, and August (Fig. 3). The figures show that on the whole the station was beyond the westerly wind region, although at certain seasons the westerly system did extend as far south.

Some further points must be referred to in describing the climatic conditions we experienced. The temperature of the air is doubtless the most important element in the study of climate; but it seems to me that its importance is relatively less in polar regions than in other parts of the globe. In polar latitudes the human organism is chiefly influenced by the absence of the sun during the night of winter. In the summer, on the other hand, the radiant heat of the sun is so strongly

concentrated that the temperature of the air scarcely measures the warmth we feel. Further, the action of the solar rays is directly beneficial—the sun strengthens and reanimates. And besides direct insolation, the diffused daylight itself must be considered—one feels quite different under a cloudless vault and under a sky overcast and sombre. The presence or absence of the sun is a much more important matter to us than the state of the thermometer.

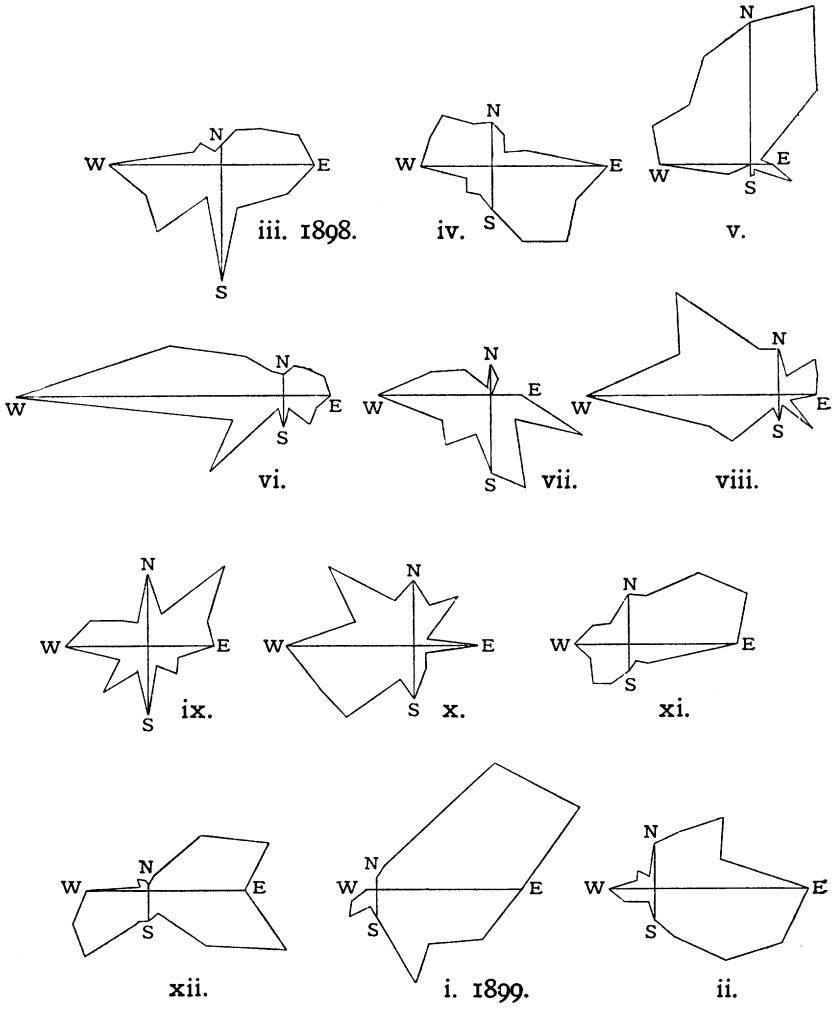

FIG. 3.

The wind is another extremely important factor from the physiological point of view. In calm weather a temperature of $-20°$ C. ($-4°$ F.) is quite tolerable, even agreeable if the sun is shining; but with a light breeze one feels the cold at once, and in strong wind it is impossible to remain long in the open air with so low a temperature. It appears to me that humidity plays a quite secondary part in the physiology of the polar climate, at least at low temperatures; in any case the humidity of the atmosphere rarely makes itself felt.

Some actinometric observations will serve to indicate the intensity of radiant heat. At 2 p.m. on December 30, the temperature of the air being −0°·2 C. (31°·6 F.), the black-bulb thermometer read 45°·1 C. (113°·2 F.) in the sun, which explains why in reality the weather felt very warm.

The sky was usually overcast, most frequently with a thick layer of stratus, which formed a uniform grey covering, and often persisted for days or even weeks together, with only short breaks. Table IX. shows the state of the sky during each month of the year.

The number of days during which the air did not remain saturated, *i.e.* on which the hygrometer indicated a humidity of less that 90 per cent., was—October, 12, November, 18; December, 22; January, 15; and February, 11.

If we include ice-deposits from fog and similar precipitation, we find that snow-fall is recorded on 257 days of the year, made up as shown on the first column of Table X. The second column of Table X. shows the number of days on which rain (even a few drops) was recorded. Speaking generally, it may be said that the weather was extremely cloudy, that fogs were frequent, that snow fell on many days, and that the air was saturated nearly the whole time.

Table XI. gives particulars with regard to wind-force.

TABLE I.—MEAN TEMPERATURE.

		°C.		°F.	
1898. March		− 9·1		15·6	
April		−11·8	− 9·1	10·8	15·6
May		− 6·5		20·3	
June		−15·5		4·1	
July		−23·5	−16·8	−10·3	1·8
August		−11·3		11·7	
September		−18·5		− 1·3	
October		− 7·9	−11·1	17·8	12·0
November		− 6·9		19·6	
December		− 2·2		28·0	
1899. January		− 1·2	− 1·5	29·8	29·3
February		− 1·0		30·2	
Year		− 9·6		14·7	

TABLE II.—MONTHLY MINIMA OF TEMPERATURE.

	°C.	°F.
1898. February 23, at 10 p.m.	− 7·6	18·3
March 15, at 4 a.m.	−20·3	− 4·5
April 3, at 6 p.m.	−26·5	−15·7
May 29, at 8 p.m.	−25·2	−13·4
June 3, at 6 p.m.	−30·0	−22·0
July 17, at 10 p.m.	−37·1	−34·8
August 28, at 3 a.m.	−29·6	−21·3
September 8, at 4 a.m.	−43·1	−45·6
October 25, at 3 a.m.	−26·3	−15·3
November 2, at 4 a.m.	−21·4	− 6·5
December 2, midnight	−14·5	5·9
1899. January 2, at 2 a.m.	− 8·1	17·4
February 11, at 2 a.m.	− 9·6	14·7
March 4, midnight	−12·0	10·4

TABLE III.—MONTHLY MEANS (APPROXIMATE) OF BAROMETRIC PRESSURE.

		mm.	Inches.
1898.	February *	738·5	29·075
	March	741·4	29·190
	April	735·6	28·961
	May	746·3	29·382
	June	749·5	29·508
	July	747·8	29·441
	August	747·2	29·418
	September	745·5	29·351
	October	744·7	29·319
	November	746·0	29·371
	December	748·2	29·457
1899.	January	747·3	29·422
	February	736·5	28·997
	Year	744·7	29·319

* Latter half of month only.

TABLE IV.—MINIMUM PRESSURES OBSERVED.

		Reduced to freezing-point.		Reduced to freezing-point and lat. 45°.	
		mm.	inches.	mm.	inches.
1898.	February 18, at 6 a.m. ...	724·53	28·526	725·93	28·581
	March 22, at 4 a.m.... ...	719·96	28·345	721·48	28·405
	April 20, at 3 a.m.	714·66	28·136	716·15	28·195
	May 10, at 11 p.m.	730·26	28·751	731·78	28·811
	June 21, at 1 a.m.	733·58	28·881	735·11	28·941
	July 31, at 2 a.m.	731·77	28·811	733·28	28·870
	August 12, at 4 a.m. ...	715·81	28·182	717·31	28·241
	September 22, at 6 a.m. ...	719·29	28·319	720·77	28·377
	October 23, at 4 a.m. ...	722·06	28·428	723·53	28·486
	November 19, at 3 p.m. ...	731·33	28·793	732·82	28·852
	December 22, at 10 p.m. ...	735·52	28·958	737·01	29·016
1899.	January 30, at 10 p.m. ...	733·92	28·895	735·43	28·955
	February 17, at 11 p.m. ...	718·59	28·292	720·08	28·350
	March 2, at 3 a.m.	710·26	27·963	711·74	28·022

Absolute minimum, 711·74 = 28·022 inches.

TABLE V.—MAXIMUM PRESSURES OBSERVED.

		Reduced to freezing-point.		Reduced to freezing-point and lat. 45°.	
		mm.	inches.	mm.	inches.
1898.	February 11, at 4 p.m.	755·82	29·757	757·11	29·808
	March 29, at 1 a.m. ...	755·35	29·739	756·95	29·802
	April 26, at 7 a.m. ...	753·80	29·678	755·37	29·739
	May 13, at 4 p.m. ...	764·28	30·090	765·90	30·154
	June 11, at 1 a.m. ...	770·48	30·334	772·14	30·400
	July 18, at 8 p.m. ...	761·53	29·983	763·10	30·044
	August 29, at 6 p.m. ...	765·43	30·135	766·99	30·197
	September 16, at 9 p.m.	757·77	29·834	759·31	29·894
	October 12, at 8 a.m. ...	764·80	30·111	766·35	30·172
	November 13, at 4 a.m.	754·05	29·688	755·58	29·748
	December 18, at 5 a.m.	757·65	29·829	759·20	29·890
1899.	January 24, at 8 p.m. ...	760·76	29·951	762·33	30·013
	February 22, at 3 a.m....	751·63	29·593	753·17	29·653

Absolute maximum, 772·14 mm. = 30·400 inches.

TABLE VI.—MAXIMUM VARIATIONS OF PRESSURE, AND MEANS OF THOSE VARIATIONS.

	mm.		inch.
1899. February	33·09		1·303
1898. March	35·47	35·93	1·397
April	39·22		1·544
May	34·12		1·343
June	37·03	33·66	1·458
July	29·82		1·174
August	49·68		1·955
September	38·54	43·68	1·518
October	42·82		1·686
November	22·76		0·897
December	22·19	23·95	0·874
1899. January	26·90		1·059
Mean	34·3 0		1·350

Extreme range for the year: 772·14 − 711·74 = 60·40 mm.
30·400 − 28·022 = 2·378 inches.

TABLE VII.—DIFFERENCES OF MONTHLY MEANS OF PRESSURE FROM THE MEAN OF THE YEAR.

(The + sign indicates pressure greater than the mean, the − sign pressure less than the mean.)

	mm.	Inches.	
1899. February	−8·2	−0·323	
1898. March	−3·3	−0·130	minimum.
April	−9·1	−0·358	
May	+1·6	+0·063	
June	+4·8	+0·189	maximum.
July	+3·1	+0·122	
August	+2·5	+0·098	
September...	+0·8	+0·031	2nd minimum.
October	0·0	0·000	
November	+1·3	+0·051	
December	+3·5	+0·138	2nd maximum.
1899. January	+2·6	+0·102	

TABLE VIII.—TABLE OF WIND-DIRECTIONS.

The figures show the number of hours during which the wind blew from each direction.

	N.	N.N.E.	N.E.	E.N.E.	E.	E.S.E.	S.E.	S.S.E.	S.	S.S.W.	S.W.	W.S.W.	W.	W.N.W.	N.W.	N.N.W.
1898.																
March	14	26	38	60	68	50	34	30	82	22	64	56	78	22	22	10
April	30	22	13	27	84	64	76	59	32	21	25	20	51	49	50	31
May	100	121	72	8	17	33	4	7	9	1	2	17	65	75	61	83
June	14	22	26	33	34	25	28	9	24	8	76	38	191	87	37	16
July	22	10	1	—	24	72	31	70	54	28	48	38	81	48	25	4
August	32	14	38	29	26	9	34	5	19	10	47	56	141	76	104	38
Sept.	51	24	74	44	46	22	28	14	49	16	47	21	59	45	24	17
Oct.	47	31	46	8	45	11	7	18	41	24	69	74	91	42	83	32
Nov.	34	35	69	93	79	32	21	14	21	31	37	28	38	28	18	21
Dec.	3	12	53	92	67	107	55	16	21	24	63	58	44	5	11	7
1899.																
Jan.	8	16	124	156	104	84	52	72	20	12	28	16	8	—	—	—
Feb.	32	42	70	49	111	99	72	37	22	10	13	23	35	13	17	6
	387	375	624	599	705	608	442	351	394	207	519	445	882	490	452	265

TABLE IX.

Column 1 shows number of days of continuous fog or overcast sky.
Column 2 shows number of days with sky partially clear for several hours in succession (cloud amount 30 per cent. or more).
Column 3 shows number of days on which fog was observed.

	1	2	3
March	6	15	14
April	10	14	26
May	15	8	27
June	5	16	28
July	7	22	17
August	9	15	25
September	9	14	14
October	16	12	23
November	13	10	18
December	9	13	13
January	17	6	17
February	21	1	23

TABLE X.

Column 1 shows the number of days on which snow was recorded.
Column 2 shows the number of days on which rain was recorded.

	1	2
March	13	—
April	22	—
May	30	4
June	24	—
July	14	—
August	26	1
September	19	—
October	25	2
November	25	—
December	18	—
January	19	4
February	22	3
Year	257	14

TABLE XI.

Column 1 shows the number of days of calm, or of wind not exceeding force 1.
Column 2 shows the number of days of wind-force less than 4.

	1	2
March	0	11
April	2	5
May	3	13
June	3	11
July	15	25
August	3	15
September	7	20
October	4	11
November	8	21
December	4	21
January	5	24
February	1	12