Probable Lost Letter.	Maori.	Probable Comparative.
TH ..	IWA, *nine*	Fijian, CIWA (*thiwa*), *nine.*
H or TH ..	MOE, *to sleep*	Fijian, MOCE (mo*the*), *to sleep;* Tongan, MOHE, *to sleep.*
R ..	MAUA, *we two* (RUA, *two*)..	Marquesan, UA, *two.*
R ..	MATOU, *we* (*many*), (TORU, *three*)	Marquesan, TOU, *three.*
H ..	IHI, *to hiss*	Maori, HIHI, *to hiss.*
K ..	IWI, *a bone*	Samoan, 'IVI, *a bone.*
R ..	MAI, *hither*	Malay, MARI, *to come* (Aniwan, MY, *to come;* Sula, MAI, *to come;* Gani, MAI, *to come;* New Britain, MAI, *to come,* &c.).

These are a few examples selected to show that there is a high probability of lost consonants being capable of being replaceable in Maori. Of course, there is a possibility that consonants may be excrescent (*i.e.*, for instance, that AI may be the true form of the word for *neck*, and the *k*s of KAKI an aftergrowth); but this is very unlikely, because it is hard to suppose that many dialects in introducing consonants would have chanced upon the same consonant in almost every instance; the loss is far more probable than the gain. But enough has been shown to prove it unlikely that the Maori is quite the primitive, simple, virgin language which some have supposed it to be.

ART. LXIII.—*The Rainfall of New Zealand.*

By JOHN T. MEESON, B.A.

[*Read before the Philosophical Society of Canterbury, 7th May and 5th June, 1890.*]

Plate XLV.

PART I. THE AMOUNT AND DISTRIBUTION OF RAIN.

FOR the past twelve months or so we in New Zealand have been suffering from a spell of dry weather almost throughout the length and breadth of the colony. We cannot call it a drought, for that term would be altogether too strong. But the rainfall has been considerably below the average almost everywhere, and in some cases, as will appear when the statistics are published, remarkably so, a deficiency of over 25 per cent. being not infrequently recorded. The selection, therefore, for our consideration to-night, of such a subject as our rainfall would seem not inappropriate. For, when a little

loss or inconvenience comes from weather of any kind, our agricultural and pastoral fellow-colonists are, as a rule, inclined to complain, and permit themselves, while experiencing the exceptional, to lose sight of the usual. When the skies for a few months consecutively fail to shower down their customary blessings, it is well for us to remember that, ordinarily, we in New Zealand are exceedingly fortunate as to both the annual amount and the general distribution of rain.

Among the factors which go to make up the climate of a country—of which heat, atmospherical pressure, wind, and rainfall may be considered the principal—not the least important, whether we take into account its effects on animal or vegetable life, is the rainfall. Not the amount alone, be it remembered: the manner in which the precipitation occurs—in other words, the number of days on which it falls—is almost as important a consideration as the mean annual number of inches. But the amount and distribution of rain, considered together, can scarcely be over-rated as factors producing human happiness. They explain the difference between the comparative barrenness of Australia and the fertility of New Zealand, the soils of the two countries being perhaps, as far as chemical and mineral constituents are concerned, equally good. Not only the productivity of the ground, but the healthy development of animals, whether lower or higher, and the enjoyment of existence by human beings, all depend upon the rainfall and its distribution.

All the different branches of meteorology are so intimately connected with one another that no single element of climate can be satisfactorily examined by itself. The weight of the air, the amount of moisture which it contains, the direction from which it comes, the velocity with which it moves, its electrical condition, and its temperature—these things really form the subject-matter of other departments of the science of weather, but they must be considered more or less in connection with the rainfall if we wish to understand it properly.

Any investigation of the rainfall of New Zealand, however, must of necessity be imperfect and unsatisfactory, because rain-gauges have been kept and properly used at so very few places and for such a short period of time; whereas, for mean annual statistics of rain, the greater the number of stations and the longer the period during which observations have been made, the more trustworthy the results will be. How different our position in this respect is from that in other parts of the world will be appreciated when we reflect that there are only three places in our colony where systematic observations are regularly taken by officers paid by Government, and only nineteen additional places where such observations have been recorded more or less intermittently, and

for longer or shorter periods, within the past thirty years:* whereas in the United States there were, in 1882, 1,200 stations, and a few years earlier in Great Britain 2,200. To secure, continuously, careful daily observation of meteorological phenomena you cannot calculate in a young country like this upon the voluntary assistance of persons whose means, inclination, ability, and leisure prompt them to gratuitously gather statistics for the common benefit. It is therefore imperative that the work should be undertaken by the Government. Not that it is desirable to thoughtlessly increase still further the State functions. There has been far too much of that kind of thing already amongst us. But such work, of really trifling cost, as is not likely to be undertaken by individual effort or social co-operation, and is yet called for in the interests of the community, is precisely what the State should undertake, and do thoroughly. Something has, of course, already been done, but not nearly enough. In regard to our weather-forecasts perhaps less might be attempted without much loss being inflicted on the community; and the money saved by the suppression of the Weather-Signal Service Department could be advantageously disbursed in securing and publishing reliable meteorological statistics from the various parts of the colony. The value, industrial and commercial, of rainfall statistics particularly needs no demonstration. Drainage works, flood warnings, waterworks, sanitary considerations, agricultural operations, &c., will, in course of time, as population becomes denser and the interests involved consequently of greater magnitude, necessitate ampler returns than those available at present. However, what Scott says of the weather phenomena of the Old World applies also to the New: "Statistics are not so much wanted as brains to use them," though both perhaps are desiderata in reference to New Zealand meteorology.

Statistics of rain, even when ample, are liable to the same objections as meteorological figures generally. In other parts of the world large masses of these have been collected for long periods of time, and yet Abercrombie considers it is difficult "to attach any physical significance to them." Mean temperatures, *e.g.*, and average rainfalls are just the things that scarcely ever occur in actual experience. They can be produced, moreover, by such widely different factors that they connote nothing reliably. In weather, more than in anything else, it is true that "*rien n'est certain que l'imprévu.*" The destruction of Napoleon's army by unusually early winter in 1812—considerably earlier than Laplace had foretold it—

* Omitting the seven places where observations have been only made for twelve months or less.

shows the fallacy of general averages for determining weather at any particular season and at any particular place. There are, however, many facts connected with the law of storms and meteorology generally that we can only get at properly by means of statistics.

Up to 1859 observations in our colony were of a very irregular character. The following table—compiled from the Meteorological Reports since that date—shows approximately the mean annual average of rainfall, and also the average number of days on which that rainfall occurs:—

—	Period.	Mean Annual Average in Inches.	Average Number of Rainy Days.
Auckland	1866–88 inclusive	43·213	187
Wellington	" "	50·178	159
Dunedin	" "	33·612	164
Christchurch	1866–84 "	25·774	107
Napier	1866–80 "	37·260	74
Taranaki	" "	58·084	157
Hokitika	" "	112·156	206
Wallacetown	" "	43·674	168
Bealey	1866–79 "	104·138	214
Mongonui	1866–80 "	58·152	152
Wanganui	1866–72 "	38·12	135
Nelson*	" "	62·634	84
Foxton	1874–82 "	37·14	133
Gisborne	1875–81 "	49·721	145
Blenheim	1862–81 "	26·84	88
Cape Campbell	1874–80 "	21·197	..
Pakawau, Golden Bay ..	1869–77 "	108·3	152
Oamaru	1869–74 "	22·696	96
Queenstown	1872–79 "	36·612	117
Wairarapa	July, 1870, to June, 1872	42·59	..
Wellington Reservoir ..	1881–82 inclusive	45·57	..
Farewell Spit	" "	37·802	..
Rotorua	1887	53·55	..
The Brothers	1882	33·33	..
Puysegur Point	11 months of 1882†	110·59	..
Milford Sound	June–Dec., 1863	87·00	..
Bluff	1869	64·67	184
Waiau	1881	37·38	110
Chatham Islands	1882	31·15	..

* See subsequent remarks; only 38·28in. in 1880, and only 30in. now.
† All save April.

It will be seen that, although this table deals with twenty-nine places, anything like a mean annual average of rainfall for a number of consecutive years is only given in the case of the first nineteen places. As far as the others are concerned, the figures given are only the mean of the rainfall of two or three consecutive years; and as regards seven places, there is given merely the number of inches for a particular year or part of a

year. This is, however, the most complete table I can make from a careful examination of the various returns available. It is, therefore, very evident that our materials for generalization on the subject are very meagre. We are justified, however, in saying that New Zealand as a whole is remarkably well watered. The average amount of rain all over the world, including, therefore, the excessive precipitation of the tropics, is said—on questionable authority, certainly—to be about 30in. Our average will be much more than that, and we are in a latitude where, comparatively speaking, a little rain goes a long way.

Moreover, the table shows that New Zealand, though of no very great area, has very considerable diversity in the amount of its rainfall. It varies from nearly 120in. on the West Coast to 26in. at Christchurch, 23in. at Oamaru, and perhaps even less in the interior of Otago, where, however, accurate observations have not as yet been recorded. For the sake of comparison we may call to mind that Australia, though subject to frequent local and general droughts, and occasionally excessive rainfall, still has no mean annual average of more than 74·84in. (at Mackay, Queensland: Loomis), nor any one less than 6·37in. (at Eucla, South Australia: Loomis). (Mr. Todd says 6in. at Charlotte Waters; 5in. at Cowarie, South Australia.) Our mean annual average, therefore, though it never sinks so low as in the great anticyclonic belt of the interior of Australia, yet mounts much higher among and on the western side of our Southern Alps. Again, the yearly average number of rainy days in some parts of New Zealand is nearly three times as great as in others: Auckland with 187, Wellington with 159, and Bealey with 214, may be compared with Napier which has 74, Nelson which has 84, and Oamaru which has 96. The rain in some places, in fact, comes down in heavy occasional falls—9½in. having been registered in Nelson in one day, and as much as 16·39in. at Pakawau (Golden Bay) in the twenty-four hours of 24th July, 1872. In other places—Dunedin, *e.g.*—the precipitation comes down by a succession of drizzles. Droughts lasting for some weeks, but not very severe, occur occasionally along the greater part of the East Coast; but Sir J. Hector says that "only in two cases do the records show a whole month at any station without rain." The figures from Hokitika and Bealey would indicate that three days out of every five are rainy on the West Coast, and amongst the Southern Alps. Generally speaking, in the wetter parts of the country rain falls, as in England, about every other day; but in the drier districts it comes one day in three or four; in Nelson and Napier one day in five. In some parts of the colony, rain is much more frequent by night-time than during the day—the great fall in

temperature which takes place after the sun sets rendering the air incapable of holding the moisture which was easily borne during the warmer hours of the day.

Our heavy rains—particularly on the West Coast—must tend to render the air milder, because one gallon of rainfall gives out latent heat sufficient to melt 75lb. of ice (Scott): in other words, every inch of rain could melt 8in. of ice spread over the ground.

Some people might suppose that the copious rains of New Zealand are sufficiently accounted for by its insular position, but a moment's reflection will dispel such an illusion. Ascension Isle, in the middle of the Atlantic Ocean, is one of the driest places in the world. Its rainfall is only 2in. or 3in. annually, and except on the very summit of its solitary hill, Green Mountain, nothing grows on the island except Madagascar roses. Again, Malden Island, and others remarkable for guano deposits, in the Pacific Ocean, are absolutely rainless. St. Vincent, also, one of the Cape de Verde Islands, is sometimes without rain for three consecutive years. Neither will it do to give our mountain-chains the sole credit for causing our rains, for the rainless desert of Atacama lies at the feet of higher mountains than our Southern Alps. Of the various circumstances that affect climate—latitude, elevation, prevalent winds; position, direction, and height of neighbouring mountains; slope of ground, character of soil, proximity to sea, and degree of cultivation—not any one can be assigned as the cause of our rainfall, which is simply owing to a combination of several favourable circumstances. What this combination is, it will be for us—*inter alia*—to inquire, and thus we may arrive at the general features of our climate, apart from local, diurnal, seasonal, and cyclical variations.

Now the question arises, With such figures of the rainfall of New Zealand as have been exhibited, is it possible to construct a map of the colony showing by gradations of shading, or by different colours, the comparative amount of rain which falls in different parts? This, as far as I know, has never been attempted, and it must be borne in mind that, apart from the peculiar difficulty of scanty statistics, to construct a rainfall-map at all for a large area of country is no easy matter. Let us remember that the fall at any one spot is by no means an exact criterion of the precipitation elsewhere—even in the neighbourhood. Local circumstances, slope, proximity to sea or hills, &c., all affect the rainfall: and these circumstances are seldom or never exactly the same for any two places, though they may be near together. Yet we register the number of inches in a particular spot, and assume that it is the same over perhaps a wide area round about. Nothing can be more fallacious.

Among the circumstances which help to determine the rainfall in any place, none is more important than the *elevation.* Mainly because at a higher elevation the air, being colder, will not carry so much moisture as the warmer air lower down—rain is heavier up the side of a mountain than at its base, and gradually increases up to a certain height at the rate of 3 or 4 per cent. for each 100ft. of altitude. Yet, having no statistics of rainfall in the mountains of New Zealand—except at the Bealey, 2,155ft. high (Hochstetter), where one of our heaviest falls is recorded—we have for the most part to assume that the number of inches falling in the hills and mountains will be the same as are recorded at the nearest places, on the seashore, where records are kept. This must be productive of great error, particularly as to the rainfall on the west coast of the South Island. The observatory at Hokitika is only 12ft. above the sea, but the rainfall 2,000ft. up the western side of the Alps must be enormously heavier than that at Hokitika, though even the latter is regarded by Loomis as tropical; yet we have to draw our map as though the rainfall all along the West Coast was the same as that at Hokitika. The heaviest rainfalls in the world, such as that of Cherra Poonjee, which is situated 4,000ft. high on the Khasia Hills—200 miles from Chittagong, north-east of Calcutta—610in. in six months, and that of Mahabeleshwar in the West Ghauts, 300in. in twelve months, occur at places where warm humid winds strike against abrupt heights, corresponding in position to the western slopes of our Southern Alps at the elevation of 2,000ft. or 3,000ft. Therefore in these latter places it is quite likely that the rainfall is very much greater even than that recorded on the western sea-coast. But what it actually is must for some time to come be a matter of pure conjecture, though the time will arrive when there will be in New Zealand observatories corresponding in position to those on Ben Nevis and, perhaps, Pike's Peak. Of course, beyond a certain height snow falls, instead of rain, and there is no doubt, as has often been remarked, that the glaciers on the western side of our Alps descend so low as compared with those in many other parts of the world, and that our glaciers altogether are so extensive, simply in consequence of the excessive deposit of snow on the heights above them. A good illustration of the fact that elevation materially affects the amount of rainfall is seen in the case of the Bealey—over 2,000ft. high—where the number of inches recorded is greater than elsewhere in the colony; and this large precipitation—though there are other circumstances which help to account for it—is probably, in some measure, owing to exceptional altitude. Mainly from an appreciation of these arguments, Scott, in his "Elementary Meteorology," refrains from at-

tempting any graphic representation of general rain-distribution.

But, besides elevation, there are other circumstances which invalidate the testimony of a few local figures as to the rainfall of a wide district. It is, indeed, no easy matter to place a rain-gauge in such a situation as will secure a fair average for the immediate neighbourhood within the radius of a few miles. Every peculiarity of geographical configuration affects the precipitation. A river-valley attracts thunderstorms; dense neighbouring woods will diminish local temperature, and so, to some small extent, attract rain; a single neighbouring hill will produce ascending currents of air, and a circle of hills round about the observatory, particularly if facing the prevailing rain-bringing winds, will considerably increase the rainfall. The observations made at Nelson in the earlier days of the colony—assuming them to have been accurately taken—may, perhaps, in this latter way be explained. They were taken, as Sir James Hector observes, in a situation too much surrounded by hills—namely, in the City of Nelson itself—to be by any means a fair criterion of the general rainfall of the district. They give an average of 62in.; whereas, from my own observations during the years 1883–86, I feel justified in saying that the average (mean annual) in the immediate neighbourhood—the Waimea Plains—was not more than half that amount. But there must have been something altogether wrong about the figures for even Nelson itself, or else the rainfall must have diminished very much within twenty years. My friend Dr. Hudson, who resides in Nelson, has made careful observations for some years back on the rainfall, amongst other matters meteorological, and he gives me the fall of 29·04in. for 1887, 28in. for 1888, and 26·93in. for 1889 (the latter year, it will be remembered, had a very scanty rainfall generally in New Zealand); and he says that, although there may be some truth in what is commonly asserted,—that the climate of Nelson was wetter in the earlier days of the colony than now,—he does not think that the fall has averaged as much as 30in. for the last ten years, during which he has lived in that city, or that the precipitation has lessened materially as the years have rolled onward. Dr. Hudson's observations are borne out by those of Dr. Müller, of Blenheim, who gives for the past twenty years an average of 26·84in., with a slight increase during the latter decade, attributed—rightly or wrongly—to increased cultivation and arboriculture. Nelson and Marlborough have very similar climates—that of the former being, as shown, somewhat the wetter of the two, but certainly not so materially different as to double the Blenheim average. Marlborough gets its rain mainly from the north-west; Nelson,

strangely enough, from the north-east, though it lies fully exposed to the north-west. Perhaps the great heat of the Nelson district, lying as it does so directly to the sun, accounts for the north-west winds not precipitating their moisture there. But both places have northerly rains, and the trend and height of the mountain-ranges between them may explain local differences. The trend would be likely to give a direction, as from north-east, to such tempests as come from the north and perhaps north-west, and so account for the quarter and amount of rain at the head of Blind Bay; while the height of the hills, not being very considerable, allows a good deal of north-west weather to pass over them to their leeward—*i.e.*, Marlborough-side. The north-east rains of Nelson, however, may be coincident with those from the same quarter on the east coast, and so arise from cyclones passing from the south-west to the north of New Zealand. I observed a curious fact concerning these north-eastern rains of Nelson during my residence there. The weather forecasts from Wellington invariably foretold these rains correctly; but as to rains from any other point of the compass the prognostications of Captain Edwin invariably failed.

Notwithstanding that much of what has just been said weakens confidence in the earlier figures for the Nelson Province, I have accepted them, as they cover a greater number of years than recent observations.

For the above and other reasons it will be clearly impossible for us to very sharply divide New Zealand into rainfall provinces. We can only roughly approximate to the truth from such information as we do possess. We know certain points where precipitation is heavy, and round these we place our darker tints; others where the fall is light, and to the districts round these we give light hues. An acquaintance with the leading principles of the law of storms and with local geographical peculiarities will help to give firmness to our touch; but, after all, such a map for a colony of such area as ours, and such diversity in its rainfall, and so few observing-stations, must be largely a matter of conjecture, based on slight premisses. I give it for what it is worth, merely remarking that I have found it convenient, in view of the data possessed, to divide the colony into five zones or belts, two of which are only found in the South Island—viz., that of 20in. to 30in. (on the eastern side), and that of over 75in. (on the western); the other three—30in. to 40in., 40in. to 50in., and 50in. to 75in.—extend, in all probability, more or less continuously through the entire length of both Islands.

PART II. RAIN-BRINGING WINDS AND CYCLONIC TRACKS.

To understand the rainfall of a country and its causes we must inquire what are the winds which, in the various places where observatories have been made, bring the rain. Existing differences of climate mainly have their origin in prevailing winds, and the science of meteorology is for the most part comprised in the law of storms, since that law deals chiefly with wind and rain. To be more precise, rainfall is determined by prevailing winds considered in relation to the regions from which they come and the physical configuration and temperature of the country blown over; the maximum occurring where winds, after traversing the ocean, come against mountain-chains in their passage to colder places, and the minimum where the prevalent winds come over mountain-ridges to warmer lands.—(Loomis.)

Now, in our attempts to get at the rain-bringing winds of New Zealand, the want of statistics is again painfully evident. The full particulars which we need for the investigation are only given for the three first-class meteorological stations. It is so far fortunate that these places are situate as widely apart in the colony as they well could be—Auckland in the north, Wellington in the centre, and Dunedin in the south. They are, moreover, places more exposed to western weather, as it happens, and therefore more representative of the climate of the colony than many places on the east coast which could have been chosen. For these places the rainfall of each day in the year is recorded, with the direction of the wind, so we can construct for them what are called "wind-roses." It is to be regretted, however, that the tables do not seem to be compiled precisely on a uniform system. Unless they are, the figures are misleading. For example, in the year 1880 there was not recorded a single calm day in Auckland, only two in Wellington, but 115 in Dunedin! On examining the figures carefully we find an explanation of this remarkable testimony to the tranquillity of the Dunedin climate. In Auckland, if the air moves only at an average of two miles an hour, the direction of the wind is given, and no calm is recorded, though, according to the Beaufort scale, the average velocity of wind in a calm is taken at as much as three miles an hour. In Wellington, similarly, no calm is returned, even when the total motion of the air during the day is only ten miles; but yet, as it would seem, inconsistently enough, on the 29th June and on the 4th August, on each of which days the wind travelled fifty miles, calm is recorded. In Dunedin the meaning of "calm" is even more incomprehensible, for under the heading "Direction of Wind" we see "calm" recorded even when the wind travelled as much as

320 miles in the day. Taking, however, the returns for the years 1880–82 as they stand, and analysing them, we find that in Auckland, in 1880,—

W.	wind blew on	64	days, during which	11·825in.	rain fell on	39	days.
S.W.	"	72	"	5·885in.	"	42	"
N.W.	"	37	"	5·740in.	"	25	"
S.	"	46	"	5·505in.	"	26	"
N.	"	28	"	3·445in.	"	14	"
N.E.	"	54	"	2·550in.	"	19	"
E.	"	43	"	2·215in.	"	18	"
S.E.	"	22	"	1·525in.	"	6	"

But it would be misleading to confine our inquiry, as far as Auckland is concerned, to the year 1880; for the rainfall there that year was 6·416in. below the mean annual. In 1882, when the rainfall was only 0·324 above the average,—

Rain came	from	S.W.	on 61 days, to amount of	10·425in.
"		W.	" 49 "	10·390in.
"		N.W.	" 19 "	7·365in.
"		N.E.	" 19 "	8·360in.
"		N.	" 13 "	3·730in.
"		S.	" 16 "	2·795in.
"		E.	" 5 "	2·080in.
"		S.E.	" 9 "	1·520in.

A similarly-compiled table for 1881 gives—

S.W.	as bringing	10·092in.	in 46	days.
W.	"	6·440in.	" 43	"
E.	"	3·850in.	" 17	"
N.E.	"	3·790in.	" 14	"
N.	"	3·045in.	" 13	"
N.W.	"	3·010in.	" 18	"
S.	"	2·475in.	" 17	"
S.E.	"	1·425in.	" 7	"

But the rainfall in 1881 was 11·069in. below the mean annual, and so, as in the case of 1880, must not be relied on for showing us whence the rain usually comes. 1882 gives more trustworthy figures, and from it we argue that the rain-bringing winds in Auckland, in the order of their importance, are south-west, west, north-east, and north-west, and much corroboration of this view is obtained from the returns of the preceding and following years.

In Wellington, during 1880,—

S.E.	wind blew on	118	days, during which	22·437in.	fell on	77	days.
N.W.	"	189	"	16·146in.	"	70	"
N.E.	"	36	"	3·570in.	"	9	"
S.W.	"	16	"	3·464in.	"	16	"
E.	"	4	"	0·850in.	"	1	"
W.	"	1	"	0·000in.	"	0	"

From north and south there was neither wind nor rain. But the rainfall in 1880 was 4·014in. below the mean annual. So we take another year, 1881, when the fall was only

0·649 below the average, and we get for this year the following :—

21·872in.	fell on	46 days,	wind being S.E.
15·150in.	"	25 "	S.W.
11·788in.	"	56 "	N.W.
0·943in.	"	6 "	N.E.
0·340in.	"	3 "	E.
0·070in.	"	1 "	W.

and, as in 1880, nothing from north and south. This table probably represents what we want fairly correctly. Combined with the other, it shows us that, while the wind in Wellington comes almost entirely from south-east and north-west—as we might suppose from the peculiar configuration of the surrounding country—the rain comes from south-east, north-west, and south-west. Wind from the last-mentioned quarter is rare in Wellington, but when it does blow it almost invariably brings heavy rain. *En passant* it may be remarked that the great prevalence of north-west weather at Wellington must be owing to more than local physical features, for it predominates also largely at Wanganui, where the country round about is comparatively open.

For Dunedin the year 1880 had a rainfall sufficiently near the average (only 1·044in. below it) to justify us in accepting the results deducible therefrom.

S.W. blew on	77 days,	and	12·324in.	fell on	50 of those days
Calm prevailed on	115 "		6·544in.	"	49 "
N.E. blew on	73 "		5·005in.	"	31 "
S.E. "	14 "		4·864in.	"	8 "
W. "	47 "		3·454in.	"	26 "
E. "	22 "		0·338in.	"	9 "
N.W. "	6 "		0·320in.	"	2 "
S. "	6 "		0·182in.	"	2 "
N. "	6 "		0·002in.	"	1 "

It would not help us much to compare with these the returns from 1881 and 1882, for the rainfall in the former of these years was nearly 6in. below the average, and that in the latter nearly 10in. above it. So we may consider the quarters from which the rain comes in Dunedin to be south-west, north-east, south-east, and west, though a summary given in the Meteorological Report of 1868 makes the rain for the years 1853 to 1860 to have come principally from west, south-west, south, and north-east. It will be noticed that the disparity is not great.

As regards Christchurch, the returns for the period in question are too meagre to enable me to construct such tables as the above. But fuller and more reliable statistics are available if we accept those recorded at Lincoln Agricultural College. The average annual rainfall is 2in. or 3in. greater at Lincoln than at Christchurch, though the places are so near

to one another, which is an illustration of what has been previously mentioned about the difficulty of getting fairly representative figures of rainfall: but the rain-bringing winds may be taken as about the same at the two places; and a table prepared by Mr. G. Gray, of the Agricultural College, in his 1886 report as to the chemical department, exhibits the following facts for the year 1885:—

Of the total rainfall of the year,—

71·9	per cent.	came from	S.W. on	74 days.
12·0	"	"	N.E. "	19 "
5·6	"	"	S.E. "	4 "
3·1	"	came during	calm "	12 "
2·4	"	came from	E. "	1 "
2·1	"	"	W. "	2 "
2·1	"	"	N.W. "	3 "
0·6	"	"	S. "	2 "
0·2	"	"	N. "	1 "

Similarly, for the past year, 1889, through the kindness of Mr. Ivey, who has supplied me with the daily records of wind and rain, I find—

S.W. wind	brought	12·337in.	of rain on	43 days.
N.E. "		2·405in.	"	25 "
S.E. "		1·847in.	"	4 "
W. "		1·499in.	"	11 "
Calm prevailed	while	0·830in.	"	13 "
S. wind	brought	0·615in.	"	3 "
N.W. "		0·360in.	"	4 "
N. "		0·312in.	"	3 "
E. "		0·203in.	"	3 "
		20·408in.	"	109 "

Whence we see conclusively that the rain-bringing wind with us is—even more conspicuously than elsewhere in New Zealand—the south-west; after that north-east and south-east.

In regard to Nelson, through the kindness of Dr. Hudson I am able to give the following facts pertaining to the year 1888. In that year rain fell to the amount of—

11·64in.	on 21	days of	N.E. weather.
4·08in.	" 20	"	N.W. "
2·81in.	" 15	"	calm "
2·58in.	" 18	"	S.W. "
2·54in.	" 10	"	N. "
2·46in.	" 10	"	S.E. "
1·87in.	" 5	"	E. "
0·41in.	" 5	"	W. "
0·05in.	" 1	"	S. "

So that the rain-bringing winds of Nelson are north-east, north-west, south-west.

Whence the rain comes at other stations in the colony I have no means of telling; but an analysis of the tables of the

Meteorological Reports of 1869–79, giving the prevailing winds at all the principal stations, presents the following results:—

Mongonui	S.W.	N.W.	
Auckland	S.W.	N.E.	W.
Taranaki	S.W.	N.E.	S.E.
Wanganui	N.W.	S.W.	
Napier	N.E.	S.W.	S.E.
Wellington	N.W.	S.E.	
Nelson	N.E.	N.	N.W.
Cape Campbell ..	N.W.	S.	S.E.
Hokitika	S.E.	S.W.	N.E.
Bealey	N.W.*		
Christchurch	S.W.	N.E.	
Dunedin	W.	S.W.	N.E.
Queenstown	N.W.	S.W.	
Southland	W.	S.E.	N.W.
Bluff (1869)	S.W.	N.W.	S.E.

Dr. Hann, in his essay on the climate of New Zealand, and Buchan in the "Mean Pressure over the Globe," make the most prevalent winds of the North Island to be south-west, west, and north-west; and of the South Island, west, south-west, north-west, and north-east; and of Hokitika in particular, south-west and north-east—which, notwithstanding a general agreement, does not seem exactly to tally with the meteorological tables of 1869–79 just referred to. But into a criticism of this matter it does not seem desirable to enter at present, for, whatever the prevalent winds may be, it does not follow that those are the rain-bringers: indeed, we know well that in many cases they are not. The north-east wind, *e.g.*, although in many parts of the Islands, and specially on the east coasts, a very prevalent wind, does not seem, except at Nelson, to bring anywhere the bulk of the yearly supply of moisture, though very heavy rain comes occasionally from the north-east at Auckland, and probably elsewhere on the east coast of the North Island. The north-east wind of Christchurch, so common and so trying in spring and early summer, brings only 12 per cent. of the yearly rainfall, and is, as a rule, a hard and dry wind, very biting and yet not sending down the thermometer at all low. The south-east and north-east winds of Hokitika, though very frequent, are not heavy rain-bringers, and can scarcely be expected to be so considering whence they come. They are probably reflex under-currents, produced by the north-west and south-west winds respectively. That the north-west is the most frequent upper wind in Westland is shown by the fact that at the Bealey it is recorded as blowing 220 days in the year.

But if the prevalent winds blow from the sea to a mountainous shore—and from whatever quarter the wind comes in

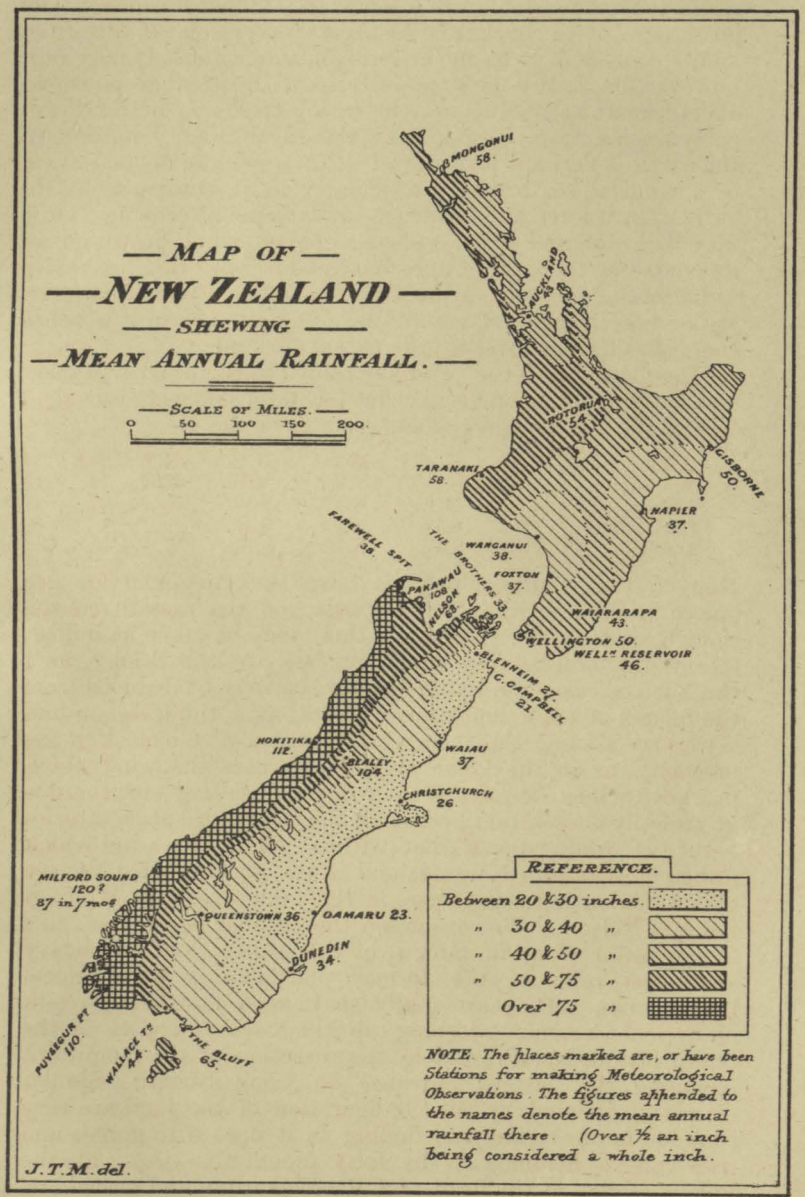
* 220 days in year.

New Zealand that condition in most places would be fulfilled —then the prevalent winds would be the rain-bringers, particularly if they came from a lower to a higher latitude. The north-east of Christchurch seems an exception to this rule, and, I confess, it is to me an inexplicable wind. It may not, however, be so dry as it appears, and its peculiar power to affect human sensations may be owing to some electrical property arising from its opposing the revolutionary motion of the earth. Perhaps it is quite local and is more of the nature of a tropical sea-breeze, particularly as it always seems to gather extra force and virulence towards the afternoon. Or it may be a diverted south-east—*i.e.*, polar—wind, drawn out of its course by the warm Canterbury plains, with their excessive radiation. Moreover, it must be remembered that it does not strike directly against mountain-sides, but, before it reaches them, has to blow over a wide extent of land.

Combining now the results obtained in the previous tables, and ignoring for the present what has been said as to prevalent winds, the rain-bringing winds seem to be at—

Auckland ..	..	S.W.	W.	N.E.	N.W. N.
Wellington	..	S.E.	S.W.	N.W.	N.E.
Nelson ..	..	N.E.	N.W.	S.W.	N.
Christchurch	..	S.W.	N.E.	S.E.	
Dunedin ..	..	S.W.	N.E.	S.E.	W.

Now, if the results which we have thus obtained for five places widely separated, and mostly on the eastern coasts, though exposed to western weather, may be taken as indicative of the rain-bearing winds generally in the colony, as I think is the case, and if the general law may be deduced from the figures of a few consecutive years, as I think it can, and if we may assume that the wind recorded at 8 o'clock in the morning was in the great majority of cases the wind which prevailed while the rain of each day was falling—for there is no tri-daily observation here as in the Old-World observatories —then it would appear that without doubt the wind which brings most rain in New Zealand is the south-west. We see that it comes first everywhere in the table except at Wellington and Nelson. We considered the peculiar north-east rains of the latter place in Part I. of this paper; and the heavy south-east rains of the former place are a purely local phenomenon. They are really south-west rains—the result of cyclonic storms sweeping up the eastern coasts of the South Island, but diverted by the direction of the mountains bounding the eastern entrance to Cook Strait. Similar diversions of wind by the configuration of the land are very common in our colony, abounding as it does with gorges and river-valleys hemmed in by lofty mountains—*e.g.*, at the Rakaia Gorge, at the head of Lake Wakatipu, and elsewhere.


— MAP OF —
— NEW ZEALAND —
— SHEWING —
— MEAN ANNUAL RAINFALL. —
— SCALE OF MILES. —
0 50 100 150 200
MONGONUI 58.
AUCKLAND
ROTORUA 54
GISBORNE 50.
TARANAKI 58.
NAPIER 37.
FAREWELL SPIT 35.
THE BROTHERS
WANGANUI 38.
FOXTON 37.
PAKAWAU
NELSON 58
WAIARARAPA 43.
WELLINGTON 50.
WELLTN RESERVOIR 46.
BLENHEIM 27.
C. CAMPBELL 21.
HOKITIKA 112.
BEALEY 104.
WAIAU 37.
CHRISTCHURCH 26.
MILFORD SOUND 120 ? 87 in 7 mos
QUEENSTOWN 36.
OAMARU 23.
DUNEDIN 34.
PUYSEGUR PT 110.
WALLACE Tc 44.
THE BLUFF 65.
REFERENCE.
Between 20 & 30 inches.
" 30 & 40 "
" 40 & 50 "
" 50 & 75 "
Over 75 "
NOTE. The places marked are, or have been Stations for making Meteorological Observations. The figures appended to the names denote the mean annual rainfall there. (Over ½ an inch being considered a whole inch.
J.T.M. del.

Moreover, generally the rain comes with a westerly wind of some kind rather than with one from any other quarter. Very little indeed comes from north or south upon the whole, and not much from any quarter of east, although occasional heavy storms from north-east or south-east make one or the other of those points of the compass take the second place here and there in the tables.

The prevalence of westerly weather in New Zealand is not at all exceptional, but just what our latitude would lead us to expect. In the Temperate Zone twenty-miles-an-hour westerly winds usually predominate, as in the Torrid Zone easterly winds blow almost continuously. The latter are nothing but the Trades, as the former are the Return Trades, which, overflowing in the first place from the equatorial regions, set off as upper currents towards the lower pressures of high latitudes—*i.e.*, in our Southern Hemisphere, in a southerly direction; but on account of their coming from a portion of the earth where the rotatory motion is greatest to a part where it is less, we see, by adapting Hadley's law, that they get an easterly tendency—*i.e.*, come to us in the first place as north-west and then as west or south-west winds. Up to lat. 23½° they are upper winds, the currents of air below them being, of course, the south-east trades. But at the Tropic of Capricorn these upper winds cross the lower ones, and sweep the surface of the earth. At some seasons the point of crossing is nearer the equator than at other seasons, but wherever it may be it produces a belt of calms and variable winds or cyclones rotating and succeeding one another in the opposite direction to the hands of a watch. But the north-west or anti-trade winds move on polewards. Being equatorial in origin, they are warm and moist. They lose and gain heat in their travels by ascending and descending intervening mountain-chains; also by licking up moisture as they pass over the ocean, and discharging it again when by any means whatever their temperature is lowered. Although they are interfered with by the irregularities of pressure consequent on the variation of temperature which arises from difference of latitude and the unequal distribution of land and water, they are wonderfully persistent even so far as 50° S. lat.; and for some degrees before they reach that latitude, following the general law which expresses the regular succession of the winds to one another, they haul or veer to the right hand—*i.e.*, to the place where prevails the lowest pressure—and become the well-marked and widely-extended westerly winds of the "roaring forties." These, in their various forms of cyclones, V-depressions, wedges, and secondaries, dash up against our western mountains, which lie right athwart their course, and there quickly lose their moisture, and are largely deflected to the

south-east of New Zealand by the coast-line and mountain-chain combined. As accounting for the persistency of these north-west and west and south-west winds in the Southern Hemisphere, and assisting in their formation, the uniformly low barometric pressure which, to judge from the observations of Sir J. Ross, seems to prevail between the 70th and 75th parallels of south latitude, must be regarded as of primary importance, though the higher latitudes of the Southern Hemisphere have as yet been so little explored that it is not safe to build any theories upon the few observations that have been made.

The prevalence of westerly weather with us, however, clearly explains the main feature of our rain-map, which is that of the heaviest fall on the west coast, and lighter as the east coasts are approached. A similar law obtains in a very marked degree in Tasmania, of which a rain-map recently published shows a fall of over 50in. on the west coast, from 40in. to 50in. in the central third of the island, and from 20in. to 40in. over the eastern third. Symon's map of the rainfall of the British Isles may also be called to mind with advantage. It shows a marked excess of precipitation along the high lands of the western counties, the deep tints denoting over 75in. on the western coasts gradually giving place to the lighter lines denoting under 25in. along the eastern. In some of the mountain districts of Westmoreland the annual fall is as much as 150in. to 200in., while in the eastern half of England there are many places with less than 20in. The western counties, in consequence, are characterized as pasture counties, the eastern as grain-growing. Symon's general law is, "The rainfall of a district [in England, presumably] is mainly influenced by its proximity to the western coasts of the country, and by the lie of the mountain-ranges by which it is traversed or encircled."

This law undoubtedly obtains in New Zealand. Wind from some quarter of the west prevails through the greater part of the year, even at places like Bealey and Queenstown, quite in the interior—and the north-east winds of the eastern coasts, as we have said, do not interfere with this law largely—and the west wind, except where it has to cross high mountains and so gets robbed of its moisture, will be undoubtedly rain-bringing. Moreover, as a rule, those places most exposed to the west will have the heaviest rainfall. Compare, *e.g.*,—

Taranaki,	with 58in.,	to	Napier,	with	37in.
Wellington,	" 52in.,	"	Wairarapa,	"	42in.
Nelson,	" 60in.,(?)	"	Blenheim,	"	27in.
Hokitika,	" 112in.,	"	Christchurch,	"	26in.
Milford Sound,	" 87in.,*	"	Oamaru,	"	23in.
Wallacetown,	" 50in.,	"	Dunedin,	"	35in.

* In six months.

For this comparison, as will be seen, places are chosen as nearly as possible on the same parallel. There is thus a marked diminution of rainfall on the eastern side of the Islands, and this diminution is greatest where the mountains are highest. "The excess of precipitation on the [west?] coast is clearly illustrated," says Sir J. Hector, "by the descent of the glaciers on the opposite sides of the range: those on the west slope descend to a line where the mean annual temperature is 50°, while on the eastern slope they descend only to the mean annual temperature of 37°. The winter snow-line on the Southern Alps is 3,000ft. on the east side, while that on the western rises to 3,700ft."

The small amount of rain in Marlborough, Canterbury, Otago, and Hawke's Bay—*i.e.*, generally on the east side of our Islands—is paralleled in many other parts of the world similarly situated as regards the prevailing winds and neighbouring mountain-ranges. In Patagonia, east of the Andes; in Sweden, east of the Dovrefeld Mountains; in British North America, east of the Rockies; in eastern Europe as compared with western (Dr. Krümmel: Gesellschaft für Erdkunde, 1878); and, as already observed, in the eastern counties of Great Britain as compared with the western, we see precisely similar phenomena. Also in the Atacama Desert of Peru, for in that latitude the prevailing winds are east, and so the precipitation occurs on the Brazilian and Paraguayan slopes of the Andes, while the western slopes in North Chili and Peru are dry. What western rain we do get in Canterbury comes mostly from the south-west, because the South Island lies from south-west to north-east, and its main range runs in the same general direction; therefore the western rains can only, as a rule, reach us by coming round the south end of the Island, and, as the equinoctial winds gyrate from north-west by west to south-west, we thus sometimes get the benefit of the rains carried by the fag-end of western storms. The ordinary south-west, however, is more like a polar than an equinoctial wind, being accompanied by high barometer and low thermometer, and winds from higher latitudes cannot, as a rule, bring heavy annual rainfall because, coming as cold winds, and therefore carrying little moisture to warmer regions, their temperature rises, and so their capacity for holding moisture increases.

The excessive fall at the Bealey is probably, as already observed, owing to its altitude, and the contiguity of a pass (Arthur's, 3,038ft. high) sufficiently low to let much of the north-west weather cross over the Southern Alps.

It has been observed that in England a range of hills 1,500ft. high running athwart the south-west or rainy wind will have the largest precipitation on the eastward or leeward side;

whereas when the range is over 1,500ft. in height the rainfall will be heaviest on the western or windward side. In this colony the 1,500ft. limit will have to be raised to perhaps 3,000ft. or more, on account of the lower latitude. Remembering this, it is not difficult to explain a good many anomalously heavy rainfalls in the colony. In the Rakaia Gorge, *e.g.*, rain comes often heavily from the north-west, admitted presumably over the lower passes or *cols* in the vicinity. So in the neighbourhood of Mount Cook and elsewhere there is seen something similar, as described by Mr. McKay.* Even at the head of Lake Wakatipu the heaviest rainfall is from the north-west, so that some portion of the rainfall which is generally considered to fall almost entirely on the western flanks of the Southern Alps must pass over the lower elevations on the western side and reach the central portion of the range, and even the eastern flanks, in diminished quantity.

Loomis gives the following causes of excessive rainfall:—

(1.) Mountain-sides deflecting prevalent ocean-winds upward, so that much of their vapour is condensed by the cold of elevation.

(2.) The high temperature and great humidity of those winds.

(3.) Proximity of district to sea.

(4.) Influence of storm-tracks.

And as causes of deficient rainfall he mentions—

(1.) Absence of adequate cause to produce strong upward movements of air.

(2.) Chains of mountains between the place in question and the sea, which obstruct the prevalent winds and rob them of their moisture.

In the light of these general principles, it is not difficult to understand most of the local peculiarities as well as general features of the rainfall of New Zealand. Its mountains run along its greatest length—*i.e.*, from north to south—minor ranges deviating only a few points from this direction. The weather coming from the west, the eastern plains are comparatively dry, and the west coast is very rainy.

Dr. Hann confesses "that, on the whole, he has not succeeded in coming to a clear understanding of the winds of these Islands and their causes." He attributes this partly to all the stations being on the coast, and so subject to the disturbances of land- and sea-breezes. But Sir James Hector points out that the influence of mountains and gorges has been still greater in affecting the observations, and thinks the only reli-

* Trans. N.Z. Inst., vol. vii.

able observations as to the winds are those taken from the motion of the clouds. I cannot help thinking, however, that the difficulty of getting reliable observations as to wind in the ordinary ways is less formidable than would appear from our Director's statement; and also that the clouds are no perfectly trustworthy guide, inasmuch as there are often, if not ordinarily, opposing currents of air one above the other, and it is very difficult to say whether the clouds are in the upper or lower stratum. The following quotation from Dove confirms this view: "Although we may admit that the direction of the wind which is given by the drift of the clouds is not affected by so many of the disturbing actions exerted by the surface of the earth on the air which flows over it, yet a material complication is introduced by the fact that the clouds give the direction at times of the lower, at times of the upper, current, while the vane of the weathercock only indicates the point from which the undercurrent is blowing."* Notwithstanding this objection to the suggestion made, there is no doubt that the mountains and gorges of New Zealand do materially affect local wind, and therefore local observations.

Now, what the particular difficulties were that Dr. Hann found while studying the winds of our colony he does not tell us. But, apart from local peculiarities, the characters of the two opposite winds—north-east and south-west—seem to me very perplexing. About the former, particularly at Christchurch, I have already spoken, and, as to the latter, let us bear in mind that, while corresponding to the north-west of the British Isles,—which is not there the wind that brings most rain,—our south-west *is* our great rain-bearer. Our north-west winds, corresponding to the British south-west, should be our great rain-bringers, being equatorial, moisture-laden winds, coming with low barometer to higher latitudes. And I believe they do bring the rain and discharge it heavily in the mountains of our Southern Alps; but they do not discharge it so heavily on the lowlands (even when those lands lie open to them and are not protected as are our Canterbury plains by intervening ranges), because, since New Zealand is 10° or 15° nearer to the equator, the average temperature is much higher than in Great Britain; and, until the cold polar blasts of the south-west commence their struggle with the equatorial current, there does not, as a rule, take place the inevitable heavy precipitation.

Our rains do not come with a low glass, neither the north-easterly nor south-westerly. With the latter, of course, the barometer almost invariably rises. The quarter of low glass in the Southern Hemisphere is north-west, and it is presum-

* "Law of Storms," p. 152.

ably thence that the greater part of our cyclones approach us, just as 90 per cent. of those of the British Isles come from the south-west.

Now, what are these cyclones which are accompanied by low barometer, high wind, and heavy rain? They are simply eddies and whirlpools—not upright, but inverted and sloping—formed in the broad stream of the equatorial current of air as it passes on to polar regions. And here it will be fitting to make some remarks on what Loomis refers to as the influence of storm-tracks in producing heavy rains. If it be true, as Mr. Russell, the Meteorologist of New South Wales, says, that nine-tenths of the rain of a country is brought by cyclonic disturbances, it is clearly of the greatest importance to a knowledge of New Zealand weather that we should, if possible, ascertain what are the prevailing paths that cyclonic disturbances with us take.

Dove doubts whether there be such a thing as a polar storm—*i.e.*, a storm coming with its usual accompaniments of rain and low barometer from higher latitudes to lower. Our experience, however, in Australia and New Zealand seems to show that south-west storms are very frequent: but are these polar storms? They may be equatorial storms diverted from their course, having first started south-eastwards from sub-tropical starting-places, but subsequently drifted into aërial channels skirting anticyclonic areas, and thus doubled to some extent backwards; or, as already suggested, they may be the result of a contest between the warm north-west and the cold polar wind, which by lowering the temperature of the equatorial wind as it gradually masters it, causes the heavy precipitation which characterizes a good deal of south-west weather. In any case they come to us and the southern points of Australia, apparently, from the south-west. Their centres sometimes pass over these Islands; and thus places on the east coasts—Dunedin and Wellington, *e.g.*—will get south-east storms, for the rain, it must be remembered, does not come from the quarter indicated by the path of lowest pressure. When the centre passes to the north of New Zealand, as Sir James Hector observes, north-east storms of wind and rain will come along the east coast, and hence, probably, the heavy north-east rains of Nelson.

But cyclones from west and north-west, accompanied by heavy rains from west and south-west, would seem to be much more usual than those from the south-west. Sometimes storms have been traced from Mauritius to New Zealand, skirting the huge anticyclone that generally rests over Australia, carrying rain to the southern points of that land, passing over Bass's Straits and Tasmania to New Zealand in twenty-four hours, striking against our Southern Alps with

deluges of rain on the west coast, and then sheering off eventually to the south-east. Even the south-west storms that pass through Bass's Straits and skirt the coasts of New South Wales are considered by Mr. Todd, of South Australia, to turn when they reach the Tropic and make off to New Zealand in the south-east, communicating their motion to or being taken up, I presume, by the return trades. But probably very many of our north-west storms have an independent origin near the coast of Queensland.

We know that cyclones are always formed and travel along by the sides of an anticyclone. Now, anticyclones are not erratic, rapidly-moving twenty-miles-an-hour creatures like cyclones, but decidedly sluggish, some of them hanging for months indifferently over sea or land almost motionless. Certain latitudes are particularly anticyclonic. In the Southern Hemisphere such a one in the winter season extends north-west of New Zealand, from about 20° to 35° south latitude, brooding over the greater part of Australia and a belt of contiguous ocean. Just north of New Zealand this belt becomes thinner, and, as a consequence, the cyclones formed south of Australia and Tasmania come to the North Island from the south-west, and bring the copious winter rains, which are a marked feature in that portion of the colony. Much of this is also seen in the South Island; but in Wanganui, Taranaki, and Auckland Dr. Hann has calculated the frequency of south-west in winter as 26 per cent. (greatest of all); in autumn, 25 per cent. (also greatest); in spring, 21 per cent. (second); and in summer, 18 per cent. (second).

The anticyclone which hugs the Tropic of Capricorn more or less right round the earth during the winter season, and is especially marked, as we should expect, over the central mass of Australia, thins out and changes its character completely as summer approaches over the three great masses of land in the Southern Hemisphere. The mean pressure over Australia falls from 30·2in. in July to 29·8in. in January. The anticyclone north of New Zealand and east of Australia contracts to a comparatively small area, and only affects or hangs over the extreme northern tip of our colony. It leaves a continuous belt of low pressure from the southern seas well into the tropics. Now is the season—spring and summer—when the north-west cyclones blow most persistently, their direction being given by the sides of the great anticyclone. These cyclones, born as would appear mostly between the anticyclone and the coast of Queensland, in the neighbourhood of the Tropic of Capricorn, strike New Zealand from north to south, but heaviest in the middle of the South Island; and are drawn, if they do not previously exhaust themselves, by the coast-line and the mountain-range, through and over which

they break here and there, down towards the extreme south of the colony, and then pass on to the south-east or turn up the east coast as south-west storms. Dr. Hann has calculated the percentage of frequency of north-west weather in Hokitika to be 23 in summer and 20 in spring, but very much less in autumn and winter. Between the winter and summer solstices of the Southern Hemisphere the path of the cyclones that affect New Zealand will be found probably to change gradually from south-west to north-west, and in the opposite season of the year it will move again to the south-west.

Such, apparently—*i.e.*, from the south-west and north-west—are the main paths of the cyclones which produce our most characteristic weather. But this presentment is only of the general tendency as regards barometric pressure and the climate that it produces; and in our latitude, we must remember, irregular barometric fluctuations are so common as to defy any perfectly and universally accurate general statements. "Shifting areas of high and low pressure" continuously cross and sometimes recross our Islands, and the configuration of the country, its varying elevation, and the alternation of water- and land-surfaces, interfere with the prevailing types of weather and produce all kinds of unexpected local modifications. Into a full and complete examination of these it would be impossible on this occasion to enter.

The main difference between the rainfall of the two Islands of New Zealand lies in the fact that the North Island, being almost subtropical, is subject, as already said, to the heavy winter rains that accompany the descent of the return trades between latitudes 30° and 40° (Scott, p. 331), whereas the South Island is in the zone of rain at all seasons, as pointed out by Dr. Hann and Mr. Scott. Here rain therefore depends on the irregular succession of barometric depressions and anticyclones, and these are most frequent on the west coast in spring and early summer. Summer rains are more frequent on the east side and in the interior; but these depend on secondaries, which come in the most unexpected manner, puzzle the weather prophet, and have very little, if anything, to do with the general character of the weather.

The even distribution of rain throughout the year in most parts is the grand feature of the New Zealand climate—the cause of its constant verdure and great productivity. Local circumstances, we repeat, modify the general weather considerably: not so much local development of heat, for that does not seem to be so important as is usually supposed, though the flow of air from the hot equator to the poles is the primary cause of cyclonic development; but the geographical features of a neighbourhood largely affect its climate. For example, Mount Egmont, in Taranaki, probably largely in-

creases the rainfall of the country immediately around it; for, if rain be caused by the chilling of air charged with moisture, and this chilling can be brought about by (1) currents of such air ascending, or (2) striking against cold ground, or (3) mixing with air of lower temperature, it is easy to see how the moisture-laden winds from the ocean striking against a peak 8,000ft. high and close on the shore must be obliged to precipitate largely their precious burden.

There are many other special and interesting questions in connection with the rainfall that it would be well worth our while to investigate, such as—the influence of neighbouring oceanic currents, the proportion of our rainfall which is carried into the sea by our impetuous rivers, the average number of days in the year when rain comes at the several seasons and in the different districts, the time of maximum rainfall, the cycles of dry and wet years, the precise localities and periodicity of droughts and excessive rainfall, the heaviest daily falls recorded, the monthly rain-probability for different districts, the relation between indigenous forest and rainfall, &c.

The subject of weather is a very important one, and one which is not, as far as New Zealand is concerned, by any means worked out, or even, as yet, well understood. Indeed, this remark need not be limited to New Zealand. Weather-saws, smacking of bygone times, are plentiful enough, and a species of forecasting was probably practised in ages rendered to us indistinct by the mists of antiquity; but systematic forecasting, founded on isobaric charts (Buchan's) and accurate knowledge of physical phenomena, is a science of yesterday, if, indeed, it be a science at all as yet. It is, however, not quite true now that "the wind bloweth where it listeth, and man cannot tell whence it cometh or whither it goeth," for patient and skilful workers have long been gathering meteorological facts, and, according to the Baconian inductive method, building theories thereon, many of which must be considered as incontestably established. What we have to do in respect to our colony is to make exact observations, gather accurate statistics, and examine them by the light of the general principles which have been worked out for us by such men as Dove, Loomis, Hann, Buchan, Scott, Abercrombie, Ley, and Ferrel. Thus, and only thus, we may hope to understand the weather to which we are subject.