Meteorological work in Australia: A Review

By Sir C. Todd, K.C.M.G., M.A., F.R.S, F.R.A.S,
Government Astronomer, Adelaide, S.A.

Report of 5th meeting of Australasian Assoc. for the Advancement of Science. Proceedings of Section A. Held at Adelaide, September 1893.

METEOROLOGICAL WORK IN AUSTRALIA : A REVIEW

By Sir C. TODD, K.C.M.G., M.A., F.R.S., F.R.A.S.,
Government
Astronomer, Adelaide, S.A.

PLATE VI.

The object of the present paper is to place before the Association a brief and succinct account of meteorological work in Australia. Mr. Russell has already told us, in his interesting paper on astronomical and meteorological workers, read before the Association at its first, meeting in Sydney in 1888, what had been done in the early days of the mother colony, and brings the history up to the year 1860, or immediately following the commencement of the active work of the new observatory completed in 1858, an establishment with which he has been associated during the past thirty-four years, and over which he has so honorably presided since his appointment as astronomer in 1870, on the death of Mr. Smalley in July of that year.

It is unnecessary that I should travel over the same ground. My intention is to carry on the history of which Mr. Russell has already given us the opening chapter. Indeed, as regard meteorology but little had been done before the advent of Mr. Scott, the first director of the Sydney Observatory, in 1858, who, Mr. Russell tells me, established twelve meteorological stations, two of which, Brisbane and Rockhampton, were in Queensland, then forming part of New South Wales. Each station was equipped with a standard barometer, dry and wet bulb thermometers, maximum and minimum thermometers, and a rain gauge.

Meteorological stations had previously — in 1840 — been established at South Head, Port Macquarie, and Port Phillip, Victoria being then under the Government of New South Wales. The observations at South Head were kept up, but, I fear, not in a very satisfactory or systematic manner, for fifteen years, or until 1855. At Port Phillip and Port Macquarie they are said to have been discontinued after six years. During Mr. Smaller's tenure of office several stations started by his predecessor, for some reason or other, probably owing to his bad health, were closed or allowed to fall into disuse. These were, however, speedily re-established by Mr. Russell : and I may here mention as showing the active manner in which that gentleman has prosecuted the work commenced by Mr. Scott, that he has now in addition to the Sydney 0bservatory, thirty-five meteorological stations having, barometers, dry and wet

bulb thermometers, maximum and minimum thermometers, and rain gauges; 139 stations furnished with thermometers and rain gauges; and 1,063 stations having rain gauges.

The Sydney Observatory is equipped with continuous self-recording barograph and thermograph, pluviometer and anemograph, made after Mr. Russell's own designs, besides underground thermometers at depths of l0ft., 5ft., 2ft. 6in., and 1in. ; an evaporation tank, or atmometer, &c.; a record, combined with the valuable astronomical work being done, worthy of the oldest colony of the group, which had already gained distinction in its promotion of science by the Dawes Point Observatory, erected in l788, and the celebrated Paramatta Observatory, established in 1821 by Sir Thomas Brisbane.

In Mr. Tebbutt, Mr. Russell has found a most valuable coadjutor. That gentleman has not only carried out an extensive series of astronomical observations entirely at his own cost, but also furnished his observatory with a complete meteorological outfit.

In Victoria there were only broken records of rainfall, temperature, and weather, made chiefly by New South Wales officials in Melbourne, from 1840 to about 1849, and of rainfall up to 1851. In 1854 observations of barometer and temperature for astronomical purposes only, and of rainfall, were made at the Williamstown Observatory, then in charge of Mr. R. L. J. Ellery. Meteorological observations were also made at Melbourne by Mr. Brough Smyth, of the Crown Lands Department, from 1856 to the end of February, 1858, when Professor Neumayer, now director of the Nautical Observatory at Hamburg, commenced systematic observations at the new Magnetic and Meteorological Observatory, at Flagstaff Hill, Melbourne. Dr. Neumayer also established several observing stations at the lighthouses on the coast, and at a few places inland.

On the retirement of Dr. Neumayer in 1863, the Magnetic and Meteorological Department was transferred to the present Astronomical Observatory, then just erected, and placed tinder the direction of the astronomer, Mr. Ellery, in whose hands the institution soon became what it is today — not only a credit to the colony which founded it, but second to none in the Southern Hemisphere. He threw all his energy and skill as a physicist into his work, and early introduced photographic and other systems, by which we obtain continuous records of all variations of terrestrial magnetism, barometric pressure, and changes of temperature, electrical states of the atmosphere, and the direction and force or velocity of the wind, besides thermometers sunk at various depths (3ft., 6ft., and 8ft.) to determine the temperature of the ground; while, as regards astronomy, we have only to visit the observatory to see that it possesses some of the finest instruments in the world.

Besides the Melbourne Observatory, he has established meteorological stations of the second order at Portland, Cape Otway, Wilson's Promontory, Gabo Island, Ballarat (Mount Pleasant),

Bendigo, Echuca, Sale (at the School of Mines), and twenty three stations of the third order, besides 515 rainfall stations judiciously distributed throughout the colony.

In South Australia, thanks to the late Sir George Kingston, father of the present Premier, we have a continuous record of the rainfall in Adelaide from 1839, which that gentleman maintained until 1878.

Meteorological observations, more or less complete, were made at the Survey Office for a number of years, or until I took up the work in November, 1856, when the observatory records commenced under my direction as Government Astronomer.

Since May, 1860, all the observations have been made at the West-terrace observatory. For several years I had no assistant, and having a growing Telegraph Department to look after and control, the area of my work was necessarily restricted, and I labored under many disadvantages; but I early established meteorological stations at Clare, Kapunda, Strathalbyn, Goolwa, Robe, and Mount Gambier, and placed rain gauges at the different telegraph offices. I also introduced the system of publishing daily reports of the weather and rainfall from all stations at the head telegraph office in Adelaide.

We have now meteorological stations, having standard or Board of Trade barometers, dry and wet bulb thermometers, maximum and minimum thermometers, and rain gauges, at Port Darwin, Daly Waters, Alice Springs, Charlotte Waters, Strangways Spring, Farina, Port Augusta, Yongala, Clare, Kapunda, the Agricultural College at Roseworthy, Mount Barker, Strathalbyn, Eucla, Fowler Bay, Streaky Bay, Port Lincoln, Cape Borda, Robe, Mount Gambier, and Cape Northumberland, and 370 rain gauges; at the lighthouses at Cape Borda and Cape Northumberland, and at the telegraph offices at Port Darwin and Alice Springs, the observations are taken every three hours, night and day ; at other stations at 9h. a.m., 3h., p.m., 9h. p.m.; whilst at Alice Springs there is a large evaporation tank similar to the one at the observatory, which it may be convenient here to describe.

It consists, first, of a brick tank, lined with cement; internal measurement, 4ft. 6in. square and 3ft. 2in. deep. Inside this tank is another, made of slate, 3ft. square and 3ft. deep, leaving an intervening space between it and the larger tank of 7in. Both tanks are filled to the same level, or to within 3in. or 1in. of the top, fresh water being added as required. The evaporation is measured by a graduated vertical rod, which is carried by a float placed in a vertical cylinder of copper 4in. in diameter (perforated at the bottom) standing in the inner tank. The rod is graduated to 1/10 of an inch, and is read off by means of a fixed vernier 1/100 of an inch. A rain gauge is placed by the side of the tank, and both the evaporation and the rainfall are read at 9 a.m. and 9 p.m.

As the question of evaporation is an important one in connection with water conservation, I give below the mean evaporation at Adelaide deduced from twenty-three years' observations, and at Alice Springs, in the centre of the continent, during the years 1890. 1891, and 1892.

Evaporation at Adelaide		Evaporation at Alice Springs		
Mean of Twenty-three Years.		1890.	1891.	1892.
	Inches.	Inches.	Inches.	Inches.
January	8.928	—	12.840	14.020
February	7.226	11.200*	13.840	10.550
March	6.035	11.990	11.850	8.720
April	3.599	6.000	5.040	7.180
May	2.131	9.760	4.480	4.660
June	1.382	3.150	2.660	3.950
July	1.461	4.440	3.820	4.210
August	2.029	5.430	5.810	5.690
September	3.017	—	7.780	8.170
October	4.859	11.222	8.225	9.845
November	6.499	11.730	9.265	11.870
December	8.359	13.790	12.940	11.490
Year	55.525	—	98.550	100.355

* Twenty-seven days.

Greatest in one year at Adelaide . . . . . 60.953 inches in 1876.
Least in one year at Adelaide . . . . . 47.392 inches in 1892.
Average rainfall at Adelaide for fifty-four years . . . 21.077 inches.
Average rainfall at Alice Springs for nineteen years . . . . . 11.254 inches.

In Tasmania the Imperial Government established a magnetic and meteorological observatory at Hobart, as part of an international scheme, in charge of Captain Kay, and systematic meteorological observations were conducted from 1841 to 1854, hourly readings being taken until the end of 1848. The results were published, together with the magnetic observations, in four large quarto volumes with a short but interesting and instructive article by the late Professor Dove, then director of the meteorological stations in Prussia. Similar observatories were established at Greenwich, St. Helena, Cape of Good Hope, and Toronto, besides places in Europe, and by Russia in Asia.

From the beginning of 1855, the Imperial Observatory being closed, meteorological observations at Hobart were carried on by the late Mr. Francis Abbott until about the year 1880, when the Government took up the work, which was entrusted to the late Captain Shortt, R.N., who died last year. Captain Shortt proved a valuable coadjutor, and established eight other observing stations besides a number of rain gauges in various parts of the island, of which there are now about fifty-nine.

In Western Australia a meteorological observatory was established by the Government, in connection with the Surveyor-General's office, the work being entrusted to Mr. M. A. C. Fraser, in 1876, since which continuous records have been published. Prior to the date mentioned we have rain and temperature records at Perth from 1860 to 1869, taken by Mr. H. Knight. At present Mr. Fraser has fifteen meteorological stations, exclusive of' Perth, and ninety-one rain gauges. At Perth there is a self-recording barometer, selected by me when in England in 1886. The observations in this colony are very valuable, extending, as they do, from the south coast well into the tropics at Whyndam, Cambridge Gulf.

In Queensland, as has already been stated, meteorological stations were started at Brisbane and Rockhampton by Mr. Scott, the first Government Astronomer of New South Wales. I do not know the exact date, but Mr. Scott arrived in the colony in 1858, and retired in 1862. The instruments were transferred to Queensland on its separation from the parent colony, and for some years the duties of meteorologist devolved on Mr. Edmund MacDonnell, who established several observing stations and a number of rain gauges.

In 1887 Mr. Wragge was appointed, who — with the great ability and energy which characterises him, and which had brought him so much renown in starting, I believe at his own expense, tile high level observatory at Ben Nevis, where he conducted the work tinder difficulties which would have deterred most men — soon effected a complete revolution. Beginning his work on January 1st, 1887, he speedily equipped stations of the several orders all over the colony along the coast round to the Gulf of Carpentaria, and inland to the very western boundary of the colony. He classified his stations under five orders, according to the completeness of their equipment, as follows:— First order, second order, third order, third order A, third order B.

Stations, of the first order are equipped with the following instruments:— Standard barometer, barograph, Stevenson's double--louvred thermometer screen, hygrometers, maximum and minimum self-registering thermometers, thermograph, solar and terrestrial radiation thermometers, earth thermometers, wind compass and rain gauge. The hours of observation of stations of this order are 3 a.m.. 9 a.m., 3 p.m. and 9 p.m. (local time), and also in some instances at the time (depending on longitude) corresponding to mean noon at Greenwich, when synchronous observations are taken at the principal stations throughout the world. The barographs and thermographs are of Richards' construction.

The equipment of stations of the second order is generally the same as above, with the usual exceptions of barograph and thermograph. The observing hours at these stations are 9 a.m. and p.m. (local time).

Third order of climatological stations are supplied with a thermometer screen, hygrometer, maximum and minimum self-registering thermometers, wind compass, and rain gauge. In "A" division the hygrometer is excepted, and in "B" division a rain gauge only is employed. The time of observation at all stations of the third order is 9 a.m., local time.

Following the example of Mr. Ellery, Mr. Russell, and myself, Mr. Wragge commenced the system of publishing daily reports of weather and rainfall, and a synoptic map similar to the map we had for some time been issuing in Adelaide. He also cooperated with us in publishing forecasts of the probable weather during each ensuing twenty-four hours, with this addition, that he issued forecasts not only for Queensland, but also for the other Australian Colonies; and, as these latter were made without regard to those published at an earlier hour by the several local authorities, it has occasionally happened that the two forecasts for the same colony differed from each other. I will not venture an opinion as to the desirableness of this independent action, beyond remarking that supposing the judgment and qualifications of the other meteorologists to be equally good, their local experience, and the possession of more detailed information in regard especially to prognostics, clouds, &c., gives them an advantage, and their forecasts should be of equal value, and be more frequently justified. Of Mr. Wragge's zeal and high qualifications for his special work there can be no two opinions. I regret that his collected observations have not yet been published — from causes, it may be presumed, beyond his control — in such detail as he himself would wish, and which, in the interests of science, we all desire. This is to be regretted, as his stations are so distributed as to represent the climate of all parts of that large colony. There are now in Queensland sixteen stations of the first order, thirty-six of the second order, forty-five of the third order "A," and 398 rain gauge stations, third order " B." Included in the second order are two private stations and five in the third order "A."

Besides the stations in Queensland, Mr. Wragge tells me he has Supplied instruments for two stations of the first order in New Guinea, for one in New Caledonia, one in Fiji, and one in Norfolk Island, and two others of' the second order in New Guinea

In New Zealand, I learn from Sir James Hector, that from 1853 meteorological reports were included in the yearly volume of statistics issued by the Registrar-General, but the observations were of irregular character, and possessed little value until 1859, when the work was taken up in a more systematic manner. Observers were appointed at Wanganui, Auckland, Napier, New Plymouth, Wellington, Nelson, Christchurch, and Dunedin, each being supplied with a set of standard instruments. The service appears to have been placed, in the first instance, under the supervision of Dr. Knight, the Auditor-General, bus in 1867 it

was transferred to Dr. (now Sir James) Hector, under whose skilful management great improvements were introduced. The principal stations are supplied with mercurial Fortin barometers, dry and wet bulb and self-registering maximum and minimum thermometers, solar and terrestrial radiation thermometers, Robinson's anemometers, and rain gauges. The height of every barometer above sea-level has been ascertained, and every reading, as in the other colonies, is reduced to sea level and 32° Fahr.

At present there are eight stations, viz., Te Arohu, Taranaki, Russell, The Bluff, Wellington, Lincoln, Hokitiki, and Dunedin, equipped as above, except Te Aroha, which has an aneroid; and seventy-nine rain stations.

To facilitate the transmission Of daily weather reports Sir James Hector has prepared a series of isobaric maps, which fairly represents all the different types of weather. These maps are numbered in consecutive order, and stereotyped copies are supplied to each station, so that all that is necessary is for the head office to telegraph to each office the number of the map to be posted up for the information of the public. In the same manner typical maps of the pressure in Australia have been prepared, with the assistance of Mr. Russell, of Sydney. The reports from a few selected stations, a brief description of the weather, and the number of the map are daily exchanged between Wellington and Sydney (representing Australia); the New Zealand reports being transmitted by telegraph to the head office in each of the other colonies.

Spread throughout the colonies we have 357 meteorological stations more or less completely equipped, and 2,575 rain gauges.

It will be seen that, excepting the magnetic and meteorological observatory at Hobart, established in 1841, which was an Imperial institution, systematic observations under the auspices of the Colonial Governments date, speaking approximately, from about 1858, a date which closely coincides with that given by Professor Waldo (1860) as marking a definite epoch in the development of the modern science of meteorology. The investigation of the law of storms, by Buys Ballot, Dove, and others, and the researches of Ferrel, then just commenced, on the theory of atmospheric motions, cleared the way to further advances; and, later on, the utilisation of the electric telegraph. which is to the meteorologist what the telescope is to the astronomer, in extending his field of view over large areas of the earth's surface, enabled the observer to mark and watch the birthplace of storms, track their course and rate of translation. The same means informed him of the general distribution of pressure, and, knowing the laws governing the circulation of air currents round regions of high and low barometers, he soon felt himself justified in issuing warnings of coming gales and the probable state of the weather some hours in advance. He was no longer confined to his own particular locality, laboriously compiling statistics and studying local prognostics; he could look far around

him, see storms a thousand or more miles distant, and tell people with a considerable amount of confidence when they might be expected and what would be their force. This is the great function of modern meteorology. But, like everything else, it took time. It required money from the State, which was not always readily forthcoming; it required, moreover, a complete and extensive organisation of skilled observers, all working on the same lines and with the same objects in view. It had also to win the confidence of a sceptical public, which still placed confidence in quack weather prophets, who, like Moore and Saxby, could tell them what the weather would be all the year through, according to the phases of the moon. Confidence, we are told, is a plant of slow growth. So it is, and so it should be if progress is to be made on a sound, solid, lasting basis.

So long ago as 1854 Admiral Fitzroy advised the Home Government to establish a meteorological office, with a view to the issue of weather forecasts and storm warnings to all the principal ports of the kingdom. This suggestion was ultimately adopted, and a Meteorological Department, under the Board of Trade. was organised, over which Admiral Fitzroy presided until his death, and storm warnings were issued as proposed. Leverrier, at Paris, also commenced the publication of daily weather bulletins.

On the death of Admiral Fitzroy the Government invoked the aid of the Royal Society, which resulted in the appointment of a standing committee to superintend the meteorological work undertaken by the Board of Trade.

The functions of the Committee were divided into three great branches:—

I. Ocean Meteorology —The object of this branch is to deduce the meteorology of all parts of the ocean from observations made by ships. The surface of the ocean is conventionally portioned off by line of latitude and longitude into a vast number of sections, and the meteorology of each section is discussed as though it were an independent district. The issue of instruments to ships is also undertaken by this branch.

II. Telegraphic Weather Information. —This branch of the functions of the Committee comes most prominently before the public, but it must not therefore be assumed that it is the most useful or important part of their work.

III. Land Meteorology of the British Isles. —The new feature of this branch consists in the establishment of seven land observatories, provided with self-recording instruments. Its object is twofold: first, to give accurate data for a discussion of the law of storms and weather changes; and, secondly, to ascertain meteorological constants,

thereby performing with great precision for the land stations that which is accomplished with moderate precision by branch I. for the entire ocean.

On the recommendation of the Committee, Mr. R. H. Scott, F.R.S., was appointed director of the meteorological office, Capt. Toynbee, R.N., as marine superintendent, and Mr. Balfour Stewart as director of the Kew Observatory.

Shortly after, the storm warnings, which had been temporarily suspended, were resumed, and daily forecasts have been issued up to the present time with a very fair amount of success. It soon became evident, however, that concerted action to secure uniformity of systems and a more complete organisation was urgently necessary and, on the invitation of Dr. Bruhns of Leipzig, Dr. Wild of St. Petersburg, and Dr. Jelinck of Vienna, a meeting, of meteorologists was convened and held at Leipzig in 1872. The invitation stated that "the development of interest in meteorological investigation in modern times among all civilised nations has brought into prominence a requirement which has long been felt. viz.. that of greater uniformity of procedure in different countries." This was followed by congresses at Vienna in 1873, at London in 1874, at Rome in 1879, the last being at Munich in 1891.

In the United States, where they have done more, perhaps, than any other country, a very complete system was organised in charge of the Chief Signal Officer, no expense being spared, and for many years three synoptic weather charts were issued daily.

Turning again to Australia, we found the same need for uniformity and cooperation between the colonies, and, at the instance of Mr. Russell a conference was held at Sydney in 1879, which was attended by the following delegates:— Mr. Russell. Government Astronomer, New South Wales; Mr. Ellery, Government Astronomer. Victoria; Mr. Todd, Government Astronomer, South Australia; Sir James Hector, K.C.M.G., Inspector of Meteorological Stations, New Zealand.

After discussion the following resolutions were arrived at:—

I. That, in view of the great importance which a better knowledge of the movement and origin of strong gales and storms on our coastlines and neighboring seas is to the shipping and commercial interest generally, it is desirable to secure, as far as possible, co-operation in all the Australasia Colonies for the investigation of storms, as well as for agricultural and general climatological purposes.

II. That, with the view of giving effect to the foregoing resolution, similar observations and the same form of publication should, as far as possible, be adopted throughout the colonies.

III. That, in order effectively to carry out the objects of the Conference, as affirmed in the foregoing resolutions, it is desirable to establish first-class meteorological stations

in certain well-selected positions in the several Australasian Colonies, including New Zealand, in addition to those existing.

IV. That the definition of the work of a first-class station, given in the preface to the New Zealand Meteorological Report for 1873, be adopted, viz.:— "The observations taken are limited to those for determining atmospheric pressure, maximum and minimum daily temperature of atmosphere, and of insolation and radiation, the average daily amount of moisture, the rainfall and number of rainy days, the force and direction of wind, and amount and character of cloud."

V. That the instruments at each first class station consist of a mercurial barometer, of either the standard or Board of Trade form; thermometers of new or approved patterns, compared with standards as frequently as possible; rain-gauges of 8in. collecting diameter, and wind-gauges of any approved form. The local hours of observation to be 9 a.m., 3 p.m., and 9 p.m. Beaufort's scale of wind to be adopted. The observations to be recorded in equivalents and pressure.

VI. That it is very desirable to obtain the co-operation of the Government of Tasmania, and to persuade them to establish a station at the public expense at Hobart Town.

VII. That it is desirable to secure the co-operation of the Governments of Western Australia, New Zealand, and Tasmania in the system of weather telegrams, which now embraces the colonies of South Australia, Victoria, New South Wales, and Queensland.

VIII. That, in the opinion of this Conference, it is desirable that weather telegrams and forecasts shall, in all cases, depend upon the observations used for general meteorological and climatological statistics, and be under the direction of the head of the meteorological department in each colony.

IX. That this Conference, having been informed that the Eastern Extension Telegraph Company will charge half rates for the transmission of weather reports through the cable connecting Australia and Tasmania, and probably also the cable to New Zealand, recommend that the cost of such reports be defrayed by the participating colonies in equal proportions; and that, in the opinion of this Conference, such cost need not exceed in the aggregate £350 per annum.

X. That, in the opinion of the Conference, this expenditure is justified by the extreme importance to the shipping interest of early information of the approach of dangerous easterly and westerly gales.

XI. That the several Governments be requested to cause precedence to be given to the regular weather telegrams and special storm reports.

XII. That, in the opinion of this Conference, there should be established in each of the colonies, upon a high mountain peak, a meteorological observatory for the special study of winds and other meteorological phenomena; and that the most desirable positions for them would be the following:—

South Australia ..	Mount Lofty ..	About 2,5OOft. above sea-level.
New South Wales .	Kiandra	" 4,600ft. "
New Zealand	Tauhara Taupo.	" 4,600ft. "
Ditto	Mount Herbert..	" 4,000ft. "
Tasmania	Mt. Wellington.	" 4,000ft. "
Victoria	Mount Macedon	" 3,500ft. "

XIII. That the revision of the present telegraph weather code be referred to Messrs. Russell and Ellery, with a view to its simplification and extension.

XIV. That the interchange of weather statistics, in carrying out the suggestions of this Conference, between the different Australasian stations; should be in the form of a diagram ; and that this should not interfere with the printing of statistics by the different colonies in any way they like.

XV. (1) That the monthly graphic records for interchange Shall consist of curves, showing barometer, velocity and direction of wind, temperature, humidity, rainfall, with remarks upon weather, especially with reference to storms and atmospheric disturbances; and that specific forms be prepared and distributed to the co-operating colonies.

(2) That the mean humidity curve be derived from the means of maximum and minimum of wet and dry bulb thermometers.

(3) The barometer curve to be constructed from barographic records, so as to depict the turning points.

(4) The temperature curve to represent maximum and minimum and mean for each day.

(5) The velocity and direction of the wind to be deduced from the anemometer.

XVI. That, in the transmission of telegrams, the reports be generalised from the local weather reports. For New Zealand the following sub-division into districts is recommended for convenience of reporting:—

A . . . . N.E. aspect	North Cape to East Cape.
B . . . . N.W. aspect	Cape Maria to West Cape (exclusive of Cook Straits).

C . . . . S. aspect . . . . West Cape to Moeraki.
D . . . . S.E. aspect . . . . Moeraki to East Cape (exclusive of Cook Straits).
E . . . . Cook Straits . . . . Comprising Wanganui, Wellington, Cape Campbell, and Cape Farewell, Nelson.

A code to be framed to express the weather in each of above aspects in general terms, according to the judgment of the reporter, thus :—

Aspect.	Wind and Weather.	Rain.	Sea.

No remark to indicate absence of phenomena.

XVII. That the telegrams furnished to Melbourne by Tasmania should conform with those between the Australian Colonies.

XVIII. (1) That weather telegrams from the Australian Colonies shall comprise :—

1. Barometer reduced to 32° F, and sea-level
2. Dry bulb
3. Humidity
4. Maximum and minimum
5. Direction and velocity of wind
6. State of weather
7. Rainfall
8. Sea disturbances,

with a synoptical report of the weather generally.

(2) And that within New Zealand the same system should be adopted.

XIX. That the extreme importance of the weather system proposed be strongly urged upon the Queensland Government, with a view to obtain their more active co-operation.

XX. That Australia be divided into six meteorological areas for transmission of reports to New Zealand, viz., Western Australia, South Australia, Victoria, New South Wales, and Queensland; South Australia being divided into two districts, tropical and extra-tropical.

XXI. That weather telegrams be written on paper of a special color, so as to be readily distinguishable in the offices.

XXII. That the solar radiation thermometers should be blackened bulb thermometers in vacuo, and should be exposed on an open space at an elevation of 4ft. 6in. from the surface of the ground, supported by a post carrying two light arms.

XXIII. That radiation thermometers be placed over grass.

XXIV. That the following subjects for experiment be referred to each member of the Conference, for future consideration and report :—

1. Shade temperature.
2. Swinging thermometer and thermometer sheds in use.
3. Standards to be swung with 2ft. 6in. string during sunshine and after sunset.
4. Observations to determine the difference in humidity, by self-registering maximum and minimum thermometers, and by other methods.
5. The best method of measuring the velocity and pressure of wind.
6. Whether any better method than black bulb thermometers can be devised for measuring the direct effect of the sun.
7. As to the best method of determining spontaneous evaporation.

XXV. That, as investigation of the Newcastle tide-gauges has shown that such instruments give valuable indications of distant earthquakes, gales, and sea disturbances, it is desirable, in the opinion of the Conference, that self-registering tide-gauges be established in as many convenient places as possible on the coast, in connection with the meteorological departments of the different colonies.

XXVI. That the foregoing minutes be adopted as the report of this Conference on the various matters referred to it, and that the chairman be requested to report to the Government of New South Wales.

A second conference was held at Melbourne in April, 1881, the same gentlemen being present. Among other resolutions, it was agreed —

That daily isobar maps, on the system adopted in Europe and America, should be issued by the head office in each colony.

That, with a view to the instrumental readings being referred to one uniform standard, a complete set of standard instruments, viz., barometer, thermometer, solar thermometer, and anenmometer, be purchased for circulation between the then four chief stations, viz., Melbourne, Sydney, Wellington, and Adelaide.

That the New South Wales Government should move the Queensland Government to co-operate by transmitting daily reports from Brisbane, Rockhampton, Cooktown, Normanton, and Cloncurry.

The Governments of New Caledonia and Fiji were also to be moved to have regular observations taken and published, on the Australian system.

A third conference was held at Melbourne in September, 1888, at which all the colonies were represented :— Mr. Ellery, Victoria, Mr. Russell, New South Wales; Sir James Hector, K.C.M.G., New Zealand; Mr. C. L. Wragge, Queensland; Sir John Forrest, K.C.M.G.. Western Australia; Captain Shortt, Tasmania; Mr. Todd, South Australia.

A number of important subjects were discussed at this Conference, which I need not here particularly specify.

Amongst other things it was agreed — Mr. Wragge dissenting — that each head office should restrict its forecast, as a rule, to its own colony, and that the colonies should exchange their forecasts by telegraph, so that they might be published in a complete form in the daily papers.

The object of the Conference in arriving at this decision was to secure the publication of the local forecasts at the earliest possible hour; and, further, to avoid the issue of conflicting forecasts, which it was thought would confuse the public, and create a want of confidence in the system.

I may say here that, in Adelaide, we publish our forecasts for South Australia shortly after 1 p.m., in time for insertion in the afternoon papers, frequently including the forecasts for Victoria and New South Wales, supplied by Mr. Ellery and Mr. Russell. The forecasts, which apply to the twenty-four hours ending at 6 p.m. on the following day, and a short description of the weather generally, are posted in the hall of the General Post Office, at Port Adelaide, Largs Bay, and several other ports and towns in the colony.

As the outcome of these conferences we now have a daily (Sundays excepted) interchange of weather telegrams between all the Australian Colonies, including Tasmania and New Zealand.

In all there are about eighty selected reporting stations, besides which nearly every telegraph station reports at 9h. a.m. to the head office the direction of the wind, the state of the weather, and the rainfall, which are also posted in a collective form at the General Post Office for public information.

From these data isobar and weather charts are compiled nearly all the colonies, together with the forecasts to which I have referred.

At Adelaide, where, as I have already said, we have issued daily isobar maps since 1882, we exhibit a diagram showing the barometric curve at selected stations along the south coastline from Albany to Cape Howe during the month, which enables persons to see at a glance the westerly progressive march of coastal depressions; and we have recently added a map which shows the distribution of rain in the colony on each wet day.

We also publish monthly a statement of the rainfall at every station throughout the colony, compared with the average of the corresponding month deduced from previous years, accompanied

by a complete discussion of the characteristics of the month in regard to temperature, pressure, the passage of "highs" and "lows," and the weather generally, in which comparisons are made between the month under review and previous seasons, attention being drawn to any abnormal features that may have presented themselves.

The annual volumes give in detail the observations at Adelaide. the principal results at outstations, and maps showing in graduated tints the general distribution of' rainfall during the year.

An examination of the daily isobar maps extending over a period of eleven years shows that, while we have an infinite variety of details, there are several well-marked types which are frequently recurring.

No two maps of the same type, perhaps, may exactly agree or resemble each other, but the type to which they belong is at once recognised. We can thus classify our maps into their respective types

I have selected seven well-marked types to accompany this paper (see Plate VI.).

MAP No. 1-FEBRUARY, 18TH, 1890,

Shows the ordinary summer high pressure over the south coast, having its maximum about latitude 45°, which is further south than usual, covering Tasmania, with gradual falling gradients northwards to the usual low pressure conditions of the tropics.

The map indicates a cyclonic centre to the north-west of Australia, where the barque Dorunda reports the barometer down to 29.47, in longitude 114° E. and latitude 15° S.

This cyclone was moving westward when encountered by the Dorunda, and probably passed through the S.E trade belt; then recurving to the eastward, may possibly be identical with a south coast depression which appeared off the Leeuwin on the morning of the 24th, but if so it had greatly lost its energy.

The weather corresponding to this map was — Fine, except on and near the cast coast from Cape Howe to the Gulf of Carpentaria, where the weather was everywhere cloudy and unsettled. with rain, heavy rains falling on the coast. Over the whole of Australia the winds were south-east, and strong from the east through Bass's Straits.

Following, we had general and heavy continuous rains for several days in both Queensland and, New South Wales, the isobar charts showing a V-shaped depression gradually extending south-ward into Queensland from the Gulf of Carpentaria. whilst the high pressure to the south became split up into two parts by a northerly low pressure extension towards our south coast. In Queensland and northern New South Wales many heavy floods were reported, Townsville (Queensland) having over 19in. of rain in three days.

MAP No. 2 - JANUARY 14TH, 1891,

Shows a tropical "low" in the Gulf of Carpentaria, working its way southwards over Queensland, whilst to the south is a "high," having its maximum, 30.2in., over Tasmania, the south coast of Victoria, and part of New South Wales between two "lows." one approaching from the west and south of the Leeuwin, and the other to the east, covering southern New Zealand.

With this map we had fine weather over Tasmania, Victoria, South Australia, and Western Australia; cloudy to gloomy and very unsettled throughout Queensland and New South Wales, with rain, very heavy in former colony.

Subsequent weather. — The "low" shown over the gulf country of Queensland passed slowly southwards, and on the morning of the 17th lay over the Riverina districts of New South Wales. Very heavy and general rains continued all over the eastern colonies, and heavy floods resulted in many parts of Queensland and New South Wales, and stormy conditions affected the east coastline. The "high" shown off the south coast moved eastward, as the "low" worked its way southward from northern Queensland.

MAP No. 3 - MARCH 12TH, 1891,

Is a very important type. It shows a tropical cyclonic "low" approaching the east coast between Sydney and Brisbane from the north-east, a not infrequent occurrence in the summer. A "high" lies to the south-east, with compact gradients, the maximum pressure, about 30.4, embracing the whole of New Zealand.

Another "high" is seen pushing its way over Western Australia, whilst a "low" lies to the south of Victoria.

This map and No. 2 deserve careful study, as the conditions they indicate affect, largely the weather on the east coast of Queensland and New South Wales generally, bringing heavy flood rains in both colonies, the rains frequently extending well into the interior, occasionally reaching the north-eastern districts of South Australia.

In this instance the weather was stormy, with heavy seas and strong southerly gales along the New South Wales and South Queensland coasts; fine inland and throughout all southern, central, and western Australia, with some cloud along the coast between Kangaroo Island and the Leeuwin.

The first indications we had of the approach of this disturbance was on the morning of the 7th, when the barometer on the Queensland coast commenced to fall, with freshening south and south-east winds. By the morning of the 13th it had become merged into the low pressure waves shown off Tasmania, and passed south of New Zealand during the following night. The weather, as it progressed, was very coarse and bad on the east coast, with heavy rains; but the rains were confined to the coastal districts, and the reports on the 14th show heavy weather to the

south of New Zealand, with strong south-west gales. Two days after this, the "high" shown on the map of the 12th to the westward of Perth had moved eastward and covered the whole continent, with its centre (30.45) off Kangaroo Island (S.A.).

MAP No. 4, FEBRUARY 5TH, 1890, AND MAP No 5, MAY 27TH, 1893,

Show low pressure valleys stretching across the continent connecting the tropical and south low pressure belts. These are frequently productive of good general rains ; the winds on the east side of the trough are northerly, and southerly on the west side- strong if the valley is narrow and nipped up between two "highs" with steep gradients on either side.

With No. 4 map the weather was cloudy and unsettled in the rear or west side of the low pressure trough, with showers all along the coastline of Western Australia ; in advance of the low pressure valley it was partially clouded in central and north Australia, gloomy and sultry in South Australia with steady rain falling over the northern areas, very hot (95° at Eucla) over the head of the Great Australian Bight, fine and warm in Victoria and Tasmania, cloudy in eastern Queensland and north-east parts of New South Wales, and thundery in Central Queensland.

The maps for the previous day or two show that the formation of the valley of low barometers was preceded by a general taking off of pressure over the interior of Western Australia on the 3rd.

Next morning, the 4th, the valley was very well defined, the weather chart for that date being almost identically the same as that on the 5th. Splendid general rains set in over South Australia during the afternoon and evening of the 4th, extending from Strangways Spring's to the Mount Lofty Ranges. Subsequent maps show that as the isobars moved eastward the low pressure valley or trough underwent considerable modification, though the valley-like depression was clearly marked in each map.

The heavy steady rains which fell in advance of the valley in South Australia did not, however, extend to the eastern colonies, and its effect on the weather in New South Wales and Victoria was to produce sultry and oppressive conditions, which culminated later on in heavy thunderstorms and rains over a large part of both colonies.

The weather with No. 5 map was cloudy to gloomy in southern West Australia, with heavy showers on south coast, fine and clear in the north. All over South Australia (nearly across the continent), Victoria, Tasmania, and the western half of New South Wales it was cloudy to gloomy, and threatening with rain falling in the northern areas of youth Australia, and in places in the other colonies; in Queensland fine but cloudy.

This map shows a slightly different trough formation to No. 4. In the latter the valley ran north and moth across Australia. In this the axis lies north-west and south-east.

The maps immediately preceding the 27th show an ordinary low pressure wave advancing eastwards along the Southern Ocean, with a "high" over the continent, gradually retreating before it to the eastwards. On the 26th signs of a valley forming were very marked, and on the next day we have the trough shown in map No. 5.

The subsequent weather charts are very interesting. The 28th being a Sunday no chart was issued, but on the 29th we find that a well-marked cyclonic depression had developed over South Australia, the centre lying between Adelaide and Port Augusta, and the Barrier Ranges in New South Wales, whilst a large high pressure area lay over New Zealand and the ocean between those islands and the Australian coast, and another "high" overlapped the south-western portion of the continent. This low pressure Centre then passed southwards to between Kangaroo Island and Lacepede Bay, thence down the coast over Tasmania, and off towards New Zealand.

Splendid rains fell all over this colony, Victoria, and Tasmania, extending well inland over the northeast districts of South Australia into western and central Queensland. In South Australia it was one of the heaviest, if not the heaviest, general rainstorm of which we have records. The bulk of the rain fell between 9 a.m. on the 27th and 9 a.m. on the 30th, and during that period we find that in South Australia heavy rains fell everywhere south of Alice Springs; in New South Wales light to heavy rains fell almost generally; also in Queensland, especially in the centre and west; whilst in Victoria and Tasmania there was a copious rainfall throughout.

I doubt if so extensive a rainstorm has been experienced since records began. The drought over our north-eastern country, western and central Queensland, was broken up, and practically more than half the entire continent participated in the downpour, which was certainly as beneficial as it was extensive.

MAP No. 6, JUNE 22ND, 1893,

Is a typical winter map, an anticyclonic area resting over the interior, with its maximum extending from the Great Australian Bight to the centre of the continent, and in a long loop from Western Australia to near the coast range in Queensland, whilst over the Southern Ocean we have the usual low pressure belt.

The weather was mostly fine and clear in Western Australia; in South Australia dry south-east winds were blowing in the interior from Lake Eyre to the north coast, and the weather was cloudy fine to gloomy, and in parts foggy, with misty rain over southern districts. On the Victorian coast it was cloudy and showery, and fine and clear inland there and in New South Wales; fine but more or less cloudy in Queensland and the Northern Territory. There were frosts in early morning in Victoria and southern Queensland.

Subsequent Maps show that the "high" gradually increased in energy till the 1st of July; then decreased slightly during the next day or two, the centre of the anticyclone remaining stationary over the southern part of South Australia. Very cold frosty nights were experienced inland over South Australia and New South Wales, the thermometer on grass at the Sydney Observatory on the morning of the 4th reading 24° - the lowest reading there in thirty-five years.

MAP No. 7, JULY 14TH, 1893,

Is another typical winter map showing an extended series of low pressure waves passing in rapid succession easterly along the south coast-one rounding the Leeuwin, another to the west of Tasmania, while a third is over southern New Zealand, with its centre to the south of the island. A moderate "high" covers Australia from west to east.

The trend of the low pressure isobars on the south coast is a very general feature. Reaching up northwards into Victoria, they curve abruptly southwards, rounding Tasmania to the south, and then recurring northwards up the east coast. In many maps this is much more marked. The same feature may be seen in maps 3 and 6. This abrupt northerly extension east of Tasmania frequently gives rise to strong southerly winds on the New South Wales coast.

The weather was cloudy to threatening and showery in West Australia; cloudy to gloomy and threatening, and in a few places showery, with squalls on coast, in South Australia, Victoria, and Tasmania; fine and clear in north-east New South Wales, unsettled in west; cloudy to gloomy in south and east parts of Queensland, clear in centre and north-west districts.

This map was taken at random from several during a long spell of cyclonic conditions, lasting from the 8th to the 24th, and clearly shows the rapid succession of V-shaped depressions along the south coastlines. With each depression unsettled weather and rain passed along the south coast of the continent. The "low" shown off the Leeuwin when it reached the Bight passed inland over South Australia, causing the rains to be heavier and more general than when the previous depression passed along the south coast further to the south.

Leaving the maps, and speaking generally, I would point out that in both the Northern and Southern Hemispheres is a belt or zone of high pressure separating the tropical and polar zones of low pressure at the latitude where the return trade and polar winds descend towards the surface of the earth.

The southern belt passes over the extra-tropical or temperate parts of Australia. It is made up of long loops, or anticyclonic areas, being broken up at intervals by low pressure intrusions from the tropics and northerly extensions of V-shaped depressions from the south. When these join they form a barometric trough or valley, effecting a complete rupture of the anticyclonic belt. The position

or latitude of this anticyclonic belt depends on the time of the year, and varies in different years. Normally, during the winter the crest of the "high" lies over the interior, approximately about latitude 29° or 30° (vide map 6). North of this the continent is swept by the dry south-east trade winds, whilst to the south we have, in South Australia, a prevalence of dry northerly (north-east to north-west) winds, varied by strong west and south-west winds as coastal depressions pass from west to east, with rain and squally weather. On the east coast west winds prevail during the winter.

The character of our winter season, in South Australia especially, depends very closely on the position of this wall, as it were, of high barometers, which plays a very important part in Australian climate. If it lies too far south, or near the coast, the winter over the southern districts of the colony (I am speaking of South Australia) is dry, but we may, and occasionally do, have under these conditions good rains in the north, due to the extension of tropical depressions bringing rain over the interior of Queensland, New South Wales, and South Australia east of Lake Eyre and the Flinders Range.

On the other hand, if the anticyclonic areas keep more to the north, the southern or coastal V depressions extend further inland, at times being felt as far as the tropics, and we have copious rains all over the colony, as well as in Victoria and western New South Wales. As the depressions pass the winds veer from north-east and north to north-west, west, and south-west. Steady rains set in with the wind at north-east to north, heaviest at north-west, and break up with heavy showers and squalls at south-west,. sometimes accompanied by heavy thunderstorms, while the wind is north-west to south-west.

As the summer advances the high pressure belt retreats, and usually lies a little to the south of the coast, with its maximum pressure about latitude 37° to 40°, and the whole of the interior of Australia is then well within the equatorial belt of low pressure.

On the north coast, and for some distance inland, the winds are north-west, monsoons rains setting in at the end of October and lasting till the end of March or April, the heaviest rain being in December, January, and February, in which months the average at Port Darwin is 10.420, 14.782, and 13.009 inches, respectively.

The southerly reach of the north-west monsoon depends on the pressure in the interior, which is frequently very uniform, hut when a barometric valley (vide maps 4 and 5) is formed the rains may extend almost without a break right across the continent, being in some years very heavy and general in South Australia. On the east coast summer rains are frequent and heavy, especially when tropical "lows" pass down from the north and north-east (vide naps 2 and 3).

In South Australia the prevailing wind in summer is south-east, varied by hot, dry, northerly winds, as coastal "lows" approach

from the west, followed on their retreating side by a sudden shift of wind to south-west and a rapid fall of temperature as the depression passes, the thermometer at times falling 30° or 40° in a few hours. I have known a fall of 20° in almost as many minutes.

From what I have said you will see that we have, as weather conditions:—

1st. A continual series of anticyclonic areas, which in the winter pass over the interior, covering the whole or greater part of the continent, with gradual falling gradients from the centre, while in the summer they pass along or near the south coast.

2nd. Cyclones, disturbers of the peace, but bringing fruitful rains; sometimes, alas ! disastrous floods. These are mostly of tropical origin, and, starting on a west to south-west course, they re-curve south of the trade belt, and move to the south-east. Some-those approaching from the north-east of Australia-strike the east coast of Queensland; others enter by the Gulf of Carpentaria, and, passing inland, shed rains over the western interior of Queensland and New South Wales; others pass over the interior from the north-west; whilst others again pass to the west of Australia, and ultimately, rounding the Leeuwin, appear as a south coastal disturbance.

3rd. Northerly extensions of the antarctic low pressure, which, passing along the south coast, give us our winter rains, and, on their retreating side, south-westerly gales.

Taking the five years 1888 to 1892, Mr. Russell, in a recent paper to the Royal British Meteorological Society, states that on the average about forty-three high pressure areas pass over us during the year, and that they are more frequent in summer than in winter.

Their general movement, as with cyclones, is from west to east, curving to the south-east, no doubt dying out as they reach higher latitudes. Mr. Russell makes their average rate of motion to be about 400 miles a day, passing over Australia in seven or eight days in summer and nine or ten in winter. My own observations lead me to the conclusion that anticyclonic areas seldom retain their general outlines and energy for any great length of time; both are continually varying, according to surrounding conditions. For instance, our Weather charts may show an anticyclone on the west coast pushing its way inland, and in a few days covering nearly the whole of the continent; but by that time it will very frequently have greatly increased in energy, and the central pressure may be 30.5in. or more, although no such pressure may have passed over the west coast; it gets built up over the land. This is especially noticeable when there is a deep "low" adjoining, say, off the coast to the south-east, the increased pressure in the anticyclone being probably due to the upper outflow of air from the neighboring "low," or cyclone.

An anticyclone is fitful and uncertain in its movements; it may remain stationary, or nearly so, over the interior for days together, and then suddenly split up, or contract, or show diminished pressure; and then, perhaps, make a rapid forward move, and again come to a standstill, after which it will pass off to the south-east and in a few days appear over New Zealand. The movements of cyclonic areas are more marked and regular, though by no means uniform. Taking the south coastal depressions, of which about sixty pass during the year, I find they travel on the average at the rate of 25 miles an hour.

Over the United States the average is about 28.4 miles, ranging from 34.2 in February to 22.6 in August. Over the Atlantic in middle latitudes the average is 18 miles, ranging from 20 in November to 15.8 in July. Over Europe the average is 16.7, ranging from 19 in October to 14 miles in August.

The progress of our south coastal depressions is frequently retarded by anticyclonic conditions ahead or to the east of them, which will sometimes deflect them such a distance to the south as to barely affect the weather in this colony In other cases, after pushing up into the Great Australian Bight, or near Eucla, as a well-marked V, they will, more particularly during the winter, open out and the isobars will run roughly parallel with the coast (or east and west), and we have then long shoots of north-west and west winds, with either no rain or squally showers on the Mount Lofty Ranges and the coast, and fresh westerly winds with rain through Bass's Straits. All these conditions have to be taken into account in framing our daily forecasts. Taking the last four years, the forecasts issued in South Australia have been justified to the extent of 73 per cent., partially justified 20 per cent., and wholly wrong 7 per cent. In connection with this work, I have much pleasure in acknowledging the great and zealous assistance I receive from Mr. Griffiths. Our usual practice is for Mr. Griffiths and myself each to write out independently a forecast. The two are then compared, and adopted if they agree. If they disagree we discuss the conditions very carefully, and decide what the forecast shall be. In my absence this work entirely devolves on Mr. Griffiths.

SEASONAL FORECASTS.

The importance to the farmer, the horticulturist, and pastoralist of knowing beforehand the probabilities of dry or wet winter seasons, and whether the rains will be early or late, or both, has naturally led to a desire for seasonal forecasts. They have them, it is said, in India ; why not in Australia ?

A letter from Mr. Archibald, at one time on the meteorological staff in India, published in Queensland, opened the ball. As the responsibility of issuing such forecasts would not devolve upon himself, he was, perhaps, the more fearless in suggesting what should be done by others. The Postmaster-General of Queensland,

the Hon. Mr. Unmack, expressed a desire that the matter should be discussed at the recent Brisbane Postal and Telegraph Conference, and for this purpose Mr. Russell, and Mr. Ellery, and myself were invited to meet Mr. Wragge. I think we all felt that it was altogether premature to attempt anything of the kind, at all events for the present, and the suggested conference of meteorologists fell through. However desirable such seasonal forecasts may be, to be of any practical value they must be reliable, or at least so far generally verified by the results as to secure the confidence of the community. Frequent or even occasional failure would bring the system into contempt, and do far more harm than good. We have had instances of rashness in the prediction of droughts, which very seriously depreciated property, and we should move cautiously where so many interests are affected. Meteorology is still far from being an exact science, and the phenomena presented to us are so complex as to render the prediction of the weather even a few days in advance very often a matter of considerable difficulty. I have always regarded what we are doing as paving the way to further extensions of the system, with a view to the forecasts covering longer periods. This, however, can only be done by the accumulation and intelligent discussion of the necessary data, and the correlation of weather conditions over considerable areas of the earth's, surface. I have already made some attempts to do this, but much remains to be done.

I may, perhaps, add that, so far as I know, India is the only country which has attempted anything like a systematic issue of seasonal forecasts. These are mainly based on the amount of snow failing during the previous winter on the Himalayas, and the general character of the weather in India during he five or six months preceding the setting in of the south-west monsoon; the chief objects of the forecasts being to give some idea of the probable rainfall during the ensuing monsoon.

DROUGHTS.

Australia, lying between the parallels of 11° and 39° S. has a tropical and sub-tropical climate, with monsoon summer rains on the north coast and winter rains on the south coast, both extending well inland. A great part-all the interior is within the anti-cyclonic region of high pressure and dry south-east winds; it is therefore subject to severe droughts, more or less prolonged. The driest portion appears to be a belt of country reaching from north of the Great Bight and Lake Eyre, or about lat. 30°, to near the north-west coast, which is swept nearly throughout the year by the south-east trade. The climate of the eastern half of the continent is more favorable, as the monsoonal rains extend further south over the coastal ranges, which form the watershed of the large rivers and watercourses running through the interior on the one side, and to the coast on the other.

With regard to the winter rainfall in South Australia, our records appear to show—

1. That in the thirteen years when the mean summer pressure was above the average and the temperature below, the following winter rain was below the average in nine years, above the average in only one year, and about an average in three years :
2. That in the nine years when the summer pressure was below the average and the temperature above, the following winter rain was above the average in seven years, below in only one year, and an average in one year :

From which we obtain the following general rough rule :—

Summer *cool*; with high barometer : winter *dry*.
Summer *hot*, with low barometer : winter *wet*.

As regards the future, if I may venture to make any suggestions, it appears to be desirable that the meteorological observations of the different colonies should be published in a more uniform and systematic manner, in such complete detail as will assist theoretical deductions, and be accompanied by fuller discussion of results, general character of the weather, storms, extent and duration of droughts, and any abnormal conditions that may have occurred during the year. Mr. Russell has done very much in the latter direction in his publications on the climate of New South Wales, and rains, and state of rivers, &c.

We also require normal isobaric and isothermic maps for each month and the year, but the observations as at present published hardly afford sufficient data for these, and many of the stations have been too recently established to furnish more than roughly approximate averages.

New Caledonia would be a valuable reporting station in regard to cyclones approaching the Queensland coast from the east, and I trust the cable now laid will he utilised as early as possible. I would also strongly urge an exchange, by mail, of weather charts and observations with the Cape of Good Hope. Natal, and Mauritius.

CONCLUSION.

I feel that I have trespassed too long on your time, but I have had a considerable stretch of ground to cover. The record I have placed before you—very imperfectly, I fear—is one of which we have have no need to be ashamed. That meteorology should have been taken up so energetically and been so liberally supported by the several Colonial Governments, on whose purse, in building up a new nation, there are so many claims, is not, however, without a sufficient cause. To successfully occupy and establish industries in new countries, a knowledge of climate and the meteorological conditions under which we are to labor is essential to success, as teaching us what we can best and most profitably produce. Situated within and without the tropics, with such a range of

climate, from the snows of Kosciusko to the burning plains of the interior and the humid heat of Port Darwin, we can obtain nearly all that man requires. Our marvellous growth in the past is only a foretaste of the future, and under such sunny skies we should be, as I trust we are, in spite of the clouds of depression which occasionally hang over us—with, however, silver linings not far away—a happy and contented people. The lines have fallen to us in pleasant places, and truly we have a goodly heritage.