THE VALUE AND USES OF METEOROLOGY.

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This article is an explanation in simple terms of the practical uses and benefits to be derived from meteorology, which may be defined as that part of natural science dealing with the factors influencing weather and climate.

The study of weather and climate is important to people in many spheres of activity. At first sight it may appear that such people as agriculturists, aviators and mariners are the only ones vitally concerned with this subject, but merchants, engineers, contractors, medical officers, insurance men, caterers, leaders of defence forces and many others are among those who find a knowledge and the study of weather conditions essential in their respective callings. A few instances will be cited to illustrate the importance of meteorology and the correlations between meteorology and the various interests operating in this Territory.

At the chief town in each of the various administrative districts of the Territory there is a climatological station where barometric pressure, temperature, humidity, wind, visibility, cloud and other weather phenomena are recorded. In addition, there are some 60 stations which forward to this office in Rabaul, immediately after the close of each month, particulars of their rainfall records on a form, which also makes provision for notation of wind direction and force, cloud scale and any other available information, such as thunderstorms, dew, &c. When received by the central bureau at Rabaul these particulars are transferred to a permanent register and are then available on application.

For historical purposes it is interesting to note that climatic changes have occurred from one geological epoch to another. Geology teaches us that there have been great changes in the world's climatic conditions since its earliest formation (in pre-Cambrian period) through the various geological epochs—Palaeozoic, Mesozoic, Tertiary and Quaternary.

Remains of plant and animal life are amongst evidence of these climatic changes. The presence and disappearance of ice-fields and the transformation of forest and desert also support such changes.

Many theories are propounded regarding the causes of climatic changes, but so far a satisfactory solution is still awaiting authoritative acceptance. However, these changes become scarcely appreciable within our own life-cycle unless we can refer to records registered by instruments.

Through the courtesy and assistance of various observers stationed throughout the Territory it is possible, where the records cover a sufficiently lengthy period, to determine the climate of the different localities and its effect on agriculture and other kindred callings.

There is, of course, a difference between weather and climate. Weather is the meteorological condition for the 24 hours ensuing. Climate is the average weather condition over a number of years. The weather changes so frequently and is notoriously capricious in its behaviour during the course of a year, but its constancy or average over a period of years will enable a description to be made of the "climate" of a selected place, and at the same time act as a guide

to what may be expected of the average behaviour of the weather. Accurately recorded weather conditions for a month or so are practically valueless, and the recordings must be continued over a lengthy period to have any marked value.

Meteorology is not an exact science. The movement of the various atmospheric factors follows no set plan, so that a vast field of research and future study lies ahead for students of meteorology, particularly in its application to this Territory.

As climatic factors vary in different localities it is obviously necessary to record them at as many places as possible, and wherever private rain gauges are installed the central bureau would greatly appreciate receipt of such further records as observers may care to submit.

It is a natural function and duty of this office to publish from time to time such information as it is able to collect by the co-operation of observers, and it should be noted that already considerable climatic data has been published in previous issues of this *Gazette*. It is hoped that the published information proves its usefulness and will lead to a more accurate knowledge of the various climates to be found in this Territory.

Agriculture.

Dr. Bryce, formerly Director of Agriculture in New Guinea, and now directing the agricultural welfare of Nigeria, stressed the importance of climate on agriculture in the following words:—

> The influence of climatic factors on the crop yield is of course recognized by everyone. Of equal and in some instances of greater importance is the influence of climatic factors on the incidence of fungus diseases and insect pests. It has been stated by Sir E. J. Russell that the loss to agricultural crops in Britain through the ravages of fungi and insects is probably at least 10 per cent. of the total value of the crops, or some £12,000,000 per annum. 'The saving fact seems to be that the pest does harm only when three sets of conditions happen to occur together: the pest must be present in the attacking state; the plant must be in a sufficiently receptive state; and the conditions must be favorable to the pest.' The chief conditions that favour the pest or otherwise are climatic, and a sound knowledge of the local climate is frequently of great aid in devising means of combating the pests and diseases. For example, 'in the Sudan some degree of control over the cotton thrips has been effected by giving the plant protection against the drying north wind and so maintaining a rather more humid atmosphere—a condition in which the plant flourishes more than the pest.' A knowledge of the climatic and essential seasonal conditions which favour the boll weevil of cotton in the United States has led to alterations in the cultivation of the crop in order to obtain a quick-growing and early-maturing variety in infested districts, a line of investigation which seems at present to offer the most hopeful means of controlling the pest.

A perusal of the article submitted by the economic botanist in this issue will reveal to the reader the stress laid on the particular weather conditions in relation to the diseases of coco-nuts. Similar importance is attached to the welfare of other crops in relation to rainfall and other climatic factors, for unless the planter is aware of the climate of a particular area it would merely be gambling with his fortunes if he ventured on a planting scheme in which the generally known weather conditions are likely to have an adverse effect on the particular crop chosen.

Some varieties of crops require a short growing season and others a long one. For instance, to cite the case of cotton, which may prove a particularly remunerative crop now war has broken out, it is possible to grow long stapled cotton successfully where the crop has a long growing season or where it can be irrigated when rain has ceased falling. So that a prospective planter of this crop would choose the variety of cotton best suited to the particular climate of his settlement.

When reliable information is available for a particular district for reference at a central bureau the intending settler may be supplied with advice on the suitability and prospects of any particular crop with a greater degree of accuracy and certainty. For instance, in the Gazelle Peninsula he would not sow a grain crop in October when he knows the length of time it takes to mature will require it to be harvested in the middle of the wet season. Any experienced planter will, therefore, make good use of his available climatic records and their variability.

The Governments of Germany, Holland and the United States of America in particular make a keen study of climate and use this knowledge to the best advantage, and we might well follow them in this respect.

An examination of the rainfall records of Rabaul and Manus indicates, at a glance, that the latter town receives nearly twice as much rainfall as Rabaul, and that Rabaul has a distinct dry season which is essential to the success of some crops, whereas it would be detrimental to attempt to cultivate a similar crop at Manus, which experiences no regular dry season.

To cite another instance, a case has just come to notice of a plantation on the mainland which was recently abandoned simply because of unsuitable soil and climatic conditions in that district. The coco-nuts on this plantation thrived at first but later succumbed. Had inquiries been made and advice sought regarding the average climatic conditions of this area over a period of years such a costly mistake could have been averted.

Generally speaking rain is essential for growth of leaf and wood and sunshine for profuse blossoming and good setting of seed. Many insects are badly affected by excessive rain, particularly bees and flies, which become fungus-ridden and perish under such conditions, while lack of rain or sunshine retards vegetative growth and causes the plants to wither and die.

Aviation Weather Service.

Aviation services regard as essential a knowledge of weather conditions along the route over which they operate, especially prevailing weather at landing places. In response to the writer's questions when discussing the value of weather advices with a flying-boat captain, he emphatically stated, "It is sweet music to our ears to hear the actual prevailing weather conditions." Weather, apparently, has a marked psychological effect on aviators, and it greatly relieves their minds to receive aeradio advice of the weather they are likely to encounter and especially that prevailing at their next landing place.

It is interesting to note that at all airports of call on the air mail route from Sydney to Rabaul trained officers are stationed to make available weather messages for the information of aircraft. Prior to departure from each aerodrome *en route* the pilot signs a form on which is indicated weather conditions between points of departure and ports of call.

As a guide to the most favorable altitude at which to fly weather observers inform the pilots of the strength and direction of winds in the higher atmosphere. These are ascertained by the aid of pilot balloon observations, which are carried out by tracing through a theodolite and noting at fixed intervals of time the track and movements of suitably coloured rubber balloons filled with hydrogen. These balloons are so light in comparison with their size that they immediately adjust themselves to the speed and direction of wind flow in the various layers of the

atmosphere. By taking advantage of favorable winds not only is there a saving in time gained by an increase in speed but also a great saving in petrol consumption.

On all aerodromes it is of paramount importance that a pilot should know the exact direction and approximate velocity of the wind at ground level, particularly when landing, and a wind direction indicator is always installed for this purpose. This may take the form of the usual wind sock which blows out from a pole in the direction of the wind, or in more modernly equipped airports, a wind vane is attached to a large white arrow which is easily visible from the air to mark the wind direction. Smoke fires are also of assistance at actual ground level itself, especially on aerodromes which have only a one-way runaway.

Aeroplanes usually land into the wind, but on narrow runaways it sometimes becomes necessary to land partly or completely across wind. In these cases drift has to be counteracted by depressing the wing tip of the machine into the direction from which the wind is blowing, thereby offsetting the possible drift by a corresponding amount of side-slip into the wind, hence the necessity for knowledge of direction and velocity.

Although not within the scope of services provided by this Territory, it may be mentioned that at many air force depots a special 'plane, which co-operates with weather bureaux, is sent up daily to a height of 25,000 feet to ascertain atmospheric conditions at various altitudes.

In passing it may be noted that, since we have so many aerodromes and landing places at high altitudes in this Territory, with decreased barometric pressure associated with increasing height and a more rarified atmosphere, an increased runaway is required for taking off and landing. The length of the run for take-off is increased by 15 per cent. at 2,000 feet, 25 per cent. at 3,000 feet and 50 per cent. at 5,000 feet.

The information given by weather observers for the benefit of aircraft comprises—

(*a*) Barometric readings (essential for night flying or when flying "blind" through cloud or fog).
(*b*) Humidity.
(*c*) Direction and force of surface wind.
(*d*) General remarks upon present weather.
(*e*) Total amount of cloud in tenths of sky cover.
(*f*) Type and amount of low clouds with direction of movement.
(*g*) Type and amount of middle clouds with direction of movement.
(*h*) Estimated height of the base or underside of low clouds.
(*i*) Horizontal visibility.
(*j*) Upper winds.

This information can be condensed, coded and transmitted by radio to aircraft in flight.

The most feared factors as far as aviation is concerned are thunderstorms and fog. Low clouds over a landing place often present difficulties to aviators, and in this respect observers can proffer welcome advice by giving information as to the location of any clear spaces where the 'plane might come through.

Vast amounts are spent annually on aviation meteorology, and from press reports within the past few months we learn that Pan American Airways, in conjunction with their Trans-Pacific Air Service, provided for over 100,000 francs expenditure on their aviation meteorological service at Noumea in our neighbouring territory.

In the United States of America, the Department of Agriculture, which controls the weather services of that country, has submitted $990,000 as their requirements to be expended on research, while its actual cash appropriation to maintain the existing aviation weather service for the fiscal year ending 30th June, 1940, is $3,700,000.

In connexion with the Trans-Atlantic Air Service it may be mentioned that the French steamer *Carime* (6,400 tons) was engaged cruising in the Atlantic Ocean during 1937-38 specifically as a meteorological and radio station collecting valuable information on the atmospheric conditions of the Atlantic, and just prior to the outbreak of hostilities a co-operative plan was arranged for exchange of weather data collected by various ships crossing the Atlantic for the benefit of shipping and aviation.

Health.

A knowledge of climatology in relation to different localities is essential to the medical profession not only from a general public health point of view, but to aid its officers to diagnose causes of ill-health and which places to recommend to their patients requiring either a bracing or sedative sanitorium.

In selecting healthy or unhealthy localities the general concern of the medical officers regarding a place is to obtain information as to the exposure, elevation and drainage.

Exposure refers to what degree a particular locality is open to or sheltered from the sun or winds and the influence of modifying forces such as sea or mountains and the effects of these forces on a locality. The penetration of the sun's direct rays assists the bactericidal powers, whereas low-lying, inland valleys will be liable to mists and perhaps produce detrimental effects on the patients.

Elevated altitudes are usually associated with purer air and feelings of personal buoyancy as a result of the rarer atmosphere and its lesser moisture content than stations on the littoral or sheltered valleys where there is usually a greater range of temperatures.

Porous soils are a factor tending towards a healthy locality, whereas impermeable soils are generally unhealthy and in such cases an engineer may be called in to suggest a suitable drainage scheme to overcome the difficulty.

Meteorology teaches us that the atmosphere is like a blanket preventing the penetration of ultra violet rays so that the higher the elevation and more rarified the air the greater the healing power of such rays. Although Zulus know nothing of the principle of ultra violet rays, they have learned from experience their healing virtues, and it is customary for them to go to the tops of their highest mountains to expose wounds to the sun with beneficial results. At lower levels the ultra violet rays have a beneficial effect from dawn to about 8 a.m., but after that the effect is negligible.

It is therefore necessary for the Health Department to have a knowledge of the various climatic factors including sunshine, rainfall, humidity and temperatures to enable them to deal satisfactorily with matters coming under their jurisdiction.

Engineering.

Meteorology has also many applications to engineering. It may be noted that in connexion with air-conditioning purposes to arrive at an ideal indoor temperature the builder would ascertain the average outdoor temperature and in the case of many coastal New Guinea stations he would probably strive for about 71°F. as an ideal indoor temperature.

Recently an electrical engineer conferred with the department's bureau to ascertain the minimum shade and maximum solar temperatures experienced in Rabaul. This information was necessary to enable him to make allowances in the stress on electric light wires which his company propose to lay in a single span of half a mile from the vulcanological observatory site to a base at the foot of the hills encircling Rabaul.

Ballistics.

At present most people in this Territory are military minded, and from our knowledge of the theory of gunnery and small arms we know that weather conditions have a decisive bearing on the motion of the projectiles during flight from muzzle to target.

Before leaving the factory, .303 service weapons are tested for certain standard conditions which include—

(*a*) Still air—at all points of the projectiles' trajectory.
(*b*) Ground pressure of 30.00 inches of mercury at 32° F. in latitude 45 degrees.
(*c*) Ground temperature of 60° F.

Allowance must therefore be made for any departure from these standard conditions. The longer the range being used the more necessary it will be for adjustments to suit the particular prevailing weather.

For naval gunnery and artillery such other climatic factors as relative humidity and lapse rates must receive consideration.

The effect of wind on the trajectory of a bullet or shell, especially that of a cross-wind, is a factor for which due allowance must be made.

For accuracy of shooting with anti-aircraft and long-range guns, it is necessary to know the equivalent constant wind, which may be defined as the average velocity and direction of wind from the firing point to the top of the trajectory.

The velocity and direction of surface and upper winds are ascertained daily at Rabaul and Salamaua by means of pilot balloon observations. If the presence of cloud prevents a speedy pilot balloon observation, the weather observer may ascertain the strength and direction of ballistic winds by firing a shell to burst at a known height into a patch of clear sky and tracing its smoke drift through the weather observer's theodolite.

Where instruments such as anemometers, wind vanes or pilot balloons are not available to measure the direction and force of surface winds, a due appreciation on the wind's direction and force may be gained by a study of its effect on trees,

grass, smoke and other objects rather than on physical sensations. The annexed universally adopted Beaufort Scale Wind Force Table will enable the observer to discriminate between the various types of wind.

So far as our records show in New Guinea, there is nothing to indicate that winds greater than force seven on the Beaufort Scale have been experienced near ground level, although a wind of 60 miles per hour was registered near the 18,000 feet level a day after the departure of the tourist ship *Strathnaver* from Rabaul—28th August, 1939—when it may be remembered that during this vessel's stay we experienced perhaps our most severe squall for many years. However, this squall was of very short duration.

As altitude increases there is a noticeable rarity in the air which corresponds to a decreased atmospheric or barometric pressure. As the barometer falls, less air resistance is thus offered to a projectile so that at hill stations such as Wau, Edie Creek or Upper Ramu, a rifleman must take into account the rarity of the atmosphere and deduct from his range 1½ yards for every 100 yards. It should be noted that the barometer falls about 1 inch for every 1,000 feet altitude.

Every degree the temperature registers above or under 60° F. the rule is to deduct or add $^1/_{10}$ yard for every 100 yards of range. The following may be quoted as an example. At Edie Creek the range finder reports the distance to the target at 1,600 yards. Barometer records 23.00 inch and thermometer 80° F.

		Deduction.
Barometer	7 x 1½ x 16 =	168
Temperature	20 x $^1/_{10}$ x 16 =	32
Total deduction		200

Corrected elevation sight will therefore be 1,400 yards. Corrections may appear negligible for actual skirmishing conditions likely to be encountered in this Territory with small arm weapons, but it is obvious that for naval gunnery and artillery purposes, when the shell passes through a greater stress of weather factors, a knowledge of barometric pressure, ballistic temperatures and strength and direction of equivalent constant winds will be essential to accuracy of shooting, and in this respect the services of a weather officer or meteorologist can be of great assistance to a gunnery unit.

Summary.

In conclusion it may be stated that meteorology is so closely associated with health, habits, pleasure and various vocations in life that it warrants universal attention.

Meteorology covers such a wide field, and the factors which govern it are so variable in character that a net-work of weather observers is necessary to act as a guide for any intelligent discussion on climate and the probable behaviour of weather.

Illustrations have been given in this article to show the importance and value attached to this branch of science; also the necessity for observers in the various parts of the Territory continuing to submit weather data to a central bureau at the Department of Agriculture in Rabaul.

To quote John Ruskin on meteorology—

One following this science will find himself part of one mighty mind—a ray of light entering into one vast eye—a member of a multitudinous power, contributing to the knowledge and aiding the efforts which will be capable of solving the most deeply hidden problems of nature, penetrating into the most occult causes, and reducing to principle and order the vast multitude of beautiful and wonderful phenomena by which the wisdom and benevolence of the Supreme Deity regulates the course of the times and the seasons, robes the globe with verdure and fruitfulness and adapts it to minister to the wants and contribute to the felicity of the innumerable tribes of animated existence.

TABLE OF THE BEAUFORT SCALE OF WIND FORCE.

Beaufort Number.	Descriptive Title.	Abbreviated Descriptions.*	Specification for use on land.	Average speeds in the open.		
				Miles per hour.	Metres per second.	Feet per second.
0	Calm ..	Calm ..	Smoke rise vertically ..	Less than 1	Less than 0.3	Less than 2
1	Light air ..	Light wind	Direction shown by smoke but not by wind vanes	1–3	0.3–1.5	2–5
2	Light breeze ..		Wind felt on face; leaves rustle; ordinary vane moved by wind	4–7	1.6–3.3	6–11
3	Gentle breeze ..		Leaves and small twigs in constant motion; wind extends light flag	8–12	3.4–5.4	12–18
4	Moderate breeze	Moderate wind	Raises dust and loose paper; small branches are moved	13–18	5.5–7.9	19–27
5	Fresh breeze ..	Fresh wind	Small trees in leaf begin to sway; crested wavelets form on inland waters	19–24	8.0–10.7	28–36
6	Strong breeze..	Strong wind	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty	25–31	10.8–13.8	37–46
7	Moderate gale		Whole trees in motion; inconvenience felt when walking against the wind	32–38	13.9–17.1	47–56
8	Fresh gale ..		Breaks twigs off trees; generally impedes progress	39–46	17.2–20.7	57–68
9	Strong gale ..		Slight structural damage occurs (chimney pots and slates removed)	47–54	20.8–24.4	69–80
10	Whole gale ..	Gale ..	Seldom experienced inland; trees uprooted; considerable structural damage occurs	55–63	24.5–28.4	81.93
11	Storm ..		Very rarely experienced; accompanied by widespread damage	64–75	28.5–33.5	94–110
12	Hurricane ..	Hurricane	.. ..	Above 75	33.6 or above	Above 110

* The abbreviated list of descriptive terms is often used in plain language reports and forecasts.