LAW OF WEATHER AND STORMS.

By the Right Rev. Bishop Bromby, D.D.

[*Read on Monday, 13th October*, 1873.]

Great progress has been made of late years in ascertaining the limits and directions of winds, the result of widely-extended observations at sea and on land, which have been collected and reduced by Meteorological Societies in England. The first duty of those who wish to aid the labours of such societies (and few objects can be more philanthropic), is to register the readings of the barometer and the wind-force, and the direction of such force. What is next wanted is to examine and compare these phenomena, and draw practical inferences from them, for both farming and shipping interests. I am glad to find that not only Dr. Hall, in the interests of vital statistics, but our Curator has for some time past registered some portion at least of these important statistics, but not all that is necessary. A hasty glance at these statistics confirms, and a comparison with those of Sydney and Melbourne goes still further to confirm, a general principle. Examining the observations made at Melbourne for eight years, I find the prevailing wind from October to March, *i.e.*, during the summer months, is *southerly ;* from April to September, *northerly.* Now, this statement is but another form of saying that the Australian coast is subject to a prevailing alternation of land and sea breezes, with this peculiarity, however, that instead of being day winds and night winds, they are summer winds and winter winds. When the continent to the north is over-heated during the summer months there is a prevailing indraught from the sea; and during the winter there is a prevailing return wind from the land. If I go to Sydney, which is on the east coast, the other conditions being the same, I should expect sea and land breezes, of the same duration, and when I examine the statistics, I find W. wind from April to September, E. from October to March, calculated upon the average of six years' observation. To compare Tasmania, it must be borne in mind that observations made at Hobart Town are liable to mislead the observer. The proximity of our mountain range will cause a deflection of most winds in the direction of the chain. Captains of our ships know that the wind in our harbour will be no security for the wind's direction down the Channel or at Cape Pillar. The *true* wind blowing on the higher eminences must be distinguished from the *surface* winds of the valley. Tasmania lies upon the northern edge of the great world-circling west trade-wind. In the summer months when our land is heated (to say

nothing of the vaster land of Australia) I should expect at Hobart Town a turning of this westerly wind northward, drawn towards the heated land, *i.e.*, I should expect it to blow from the the S.W. For the converse reason, in the winter months I should look for the N.W. What are the facts? If we examine our own statistics, extended over 30 years, we do find the N.W. prevailing during the winter, but though the S.W. seldom or never prevails, yet the south wind more or less modifies or overcomes the usual westerly wind for the summer months, especially in January and February. But what is the reason for the frequent prevalence of an east wind in the summer months in Bass' Straits helping on the "Pioneer" on its outward voyage to Circular Head? The situation of our island at the extreme S.E. of the Continent so that it may almost be regarded as a continuation of the east coast of Australia, leads me to refer this easterly summer wind to the indraught of the wind from the sea to the east coast of Australia, felt, as I have shown, in summer at Sydney. But why it behaves like a deadly sirocco, as it beats upon the promontory of Circular Head, blighting the fruit trees and cabbages, and producing feverish heat and determination of the blood to the head, inflammatory attacks, opthalmia, and I know not what besides, is a problem for which I have no satisfactory solution to offer. I will draw your attention to another peculiarity of our local winds. When the hot blasts of Australia reach our island (which happily is of rare occurrence) they pass over the northern and midland portions and precipitate themeselves upon the southern coasts. I do not know whether any explanation of this peculiar phenomenon has been given. I apprehend, however, the true solution is to be found in the analogy of everyday occurrence on a larger scale within the tropics in their relation to the poles. The heated land of Australia heats in turn the air, and expanding its bulk, lessens its specific gravity, and causes it to ascend. The air over the Straits would rush in to supply the deficient pressure at the surface, while the ascending lighter column would pass southwards, until when sufficiently condensed and heavier, it would descend to the lower stratum. This crisis of equalised temperature seems to occur when the upper stream of heated air approaches our southern coast, and meets our colder southern ocean. Strzelecki observed that while the hot wind blew from the north at the top of Ben Lomond, 5,000 feet high, it was not felt 2,000 feet high on the windward side of the same mountain.

But I wish to interest the Society not so much with the wind as with the whirlwind—not the zephyr but the *storm*.

Will no member of this Society utilise the observations already registered, together with those daily presented in *The Mercury* for the purpose of aiding science to the benefit, sooner or later, of our mercantile marine? I have no qualifications, and, if I had, no time. But, from the wish to stimulate others, I desire to offer a few, and, I hope, useful, if not very original, remarks. Perhaps the seed may fall upon the soil of one of our A.A's. who has distinguised himself as a student of natural philosophy. I am myself content to point out to the enquirer the gain that science has already made. We now know that the general character of storms over the world is circular, or, more strictly, elliptical. A storm is but the name for the behaviour of the atmosphere attempting "to flow in upon a central area (to use Buckan's words) of *low* pressure in an inmoving spiral course." But as we find that such inflow does not, as we might expect, *increase* the deficient pressure, Buckan concludes that within and about the centre of the storm there is a vast ascending current arising into the upper regions of the atmosphere, and then flowing over to the right and left. These storms or hurricanes are never known to cross the equator, but they always move obliquely from their starting point towards one or other of the poles.

Again, we may accept it as the most fundamental axiom of the science of "weather prophecy" that the direction and intensity of the wind depends, not so much upon the state of the barometer in any given place, as upon the *barometric gradient.* By this is meant that if the barometer stands at a different height in two localities near to each other, such difference in atmospheric pressure will produce disturbance, and the *amount* of such disturbance will depend upon two things—the *difference* as indicated by the barometer in the two places, and the *proximity* of the places one to the other. I may illustrate this by the gradient of an inclined plane, which depends not only upon the height but the length of base of the triangle. In this exaggerated analogy the height represents the barometric differences in two places, while the base represents the distance between the two places themselves. The violence of the storm will depend upon the angle of inclination, *i.e.*, the ratio between the height and base, which in the language of trigonometry might be conveniently called the tangent of the angle of inclination.

If every other rule is of doubtful trustworthiness, in the science of weather prediction, this fundamental principle of the barometric gradient has been fully established. The advent as well direction of the storm has been familiarly expressed by Ballot's law, "Stand with your back to the wind, and the barometer will be lower on your left hand than on

your right." This roughly-stated principle will account for the great storms of the Northern Hemisphere, the hurricanes of the West Indies, and the typhoons of China, all circular, and moving from right to left, contrary to the hands of a watch; as well as those of the Southern Hemisphere, which, true to the contradictory spirit of the antipodes, have a reverse circular movement. True to this law of Ballot's, a westerly gale is never experienced in Ireland and in the British Isles without many hours forewarning, in the fact that the pressure at the north of Scotland is a half-inch less than in the south of England.

From a study of the law of rotatory storms in Europe, English observers now know that cyclones go in pairs, but in opposite directions, like two cog-wheels in machinery. Thus, if the barometic readings in Central England be lower than in Central France, then England experiences on her eastern and southern coasts a true cyclone, while in France a secondary or anti-cyclonic storm will be experienced; the one rolling round a barometric minimum, the other round the barometric maximum.

I think that observations are needed for the purpose of establishing the truth of this reversion of Professor Ballot's law, so that in Australia we must *face* the wind instead of turning our backs to it, whenever the barometer will be lower on our left hand than our right, though perhaps this is nothing more than we should expect as the converse proposition which makes our rotatory storms follow the hands of the watch from left to right, and not as in the other hemisphere from right to left. We need also to register the results of other observations for which our insular position, and yet not distant proximity to a large continent, gives us useful conditions. These are, then, the points for the scientific observer to bear in mind. Can he establish, with any approach to mathematical certainty, the ratio between the violence of a storm and the extent of the area of barometric depression? When the area is small, do the storms follow rapidly; and when large, more slowly? Can the *rate* of approach be estimated by the extent of such area? If the barometer read lower at Hobart Town than at Launceston, we ought to expect more sudden as well as more dangerous storms; but if the difference was observed between Hobart Town and Melbourne we ought to expect them to be less rapid in their approach, but to last a longer time. To a great extent, we might expect that observations made in England in relation to her position towards the Continent, would be analogous to those made in Tasmania in her relation to Australia. Whenever increased pressure occurs in England *following* a corresponding increase of pressure on the

east coast, a sudden irruption of wind may be expected from the S.E., to the confusion of the fishing fleet from the Tyne to the Humber. If the pressure is abnormally high over France, a cyclonic gale (as Scott shows in a paper lately published) will pass over England, the direction of the wind depending upon what edge the observer is happening to stand. If the area of continental pressure be very large, the diameter will be larger also, and the result will be that the greater part of England will stand upon the southern edge, feeling the force of a western gale.

Again, the sweeping hypothesis has been lately started by very trustworthy and scientific observers ; that barometric depression depends altogether upon vapour pressure, or rainfall. The larger rainfall upon the coasts of Australia affords favourable opportunity for testing the accuracy of this hypothesis. It would be well, too, for the interest of both science and shipping to register observations how far some storms are due to a *rise*, instead of a fall, in the barometer. As some again depend upon variations of temperature, not between one locality and another, but between one stratum of the atmosphere and a higher one, it is important to register the relative readings of the thermometer on Mount Nelson and other elevations.

Once more, it is equally important to bear in mind that storms arise from an attempt to force a way between two opposite currents ; that our island, when at rest, lies straight in the path of a great western trade wind ; and that, according to Mr. Meldrum's paper, read before the British Association, upon observations made at the Mauritius, the east winds in such conflicts always lie on the polar side of the westerly. Our duty will be, as soon as we can, not only to register, as we are now doing, the variations of weather, *i.e.*, the movements of our local atmosphere, but to notice the coincidence with larger cosmical phenomena, for the purpose of establishing their physical relation one to another. The connection between the Earth's magnetism and the greater activity of the Sun's energy, revealed by the solar spots, has been for some time past suspected and now established. I have observed, as you may also have, the coincidence between the Aurora Australiensis and the Aurora Borealis. The most splendid exhibition of the former I have witnessed in Tasmania, occurred upon the night of 24th September, 1872. I looked out for records of the corresponding Aurora in the Northern Hemisphere, and found them duly noticed in *The Times*, to which newspaper I communicated the fact of the coincidence of our own, whose brilliancy had been witnessed in New Zealand as well as here. Some important questions remain

to be answered. Do these Auroræ occur most frequently during the greater frequency of maximum sun-spots, and secondly, which portions of the Earth are most affected by the greater activity of the Sun's energy which they represent? When speaking of the return of the Sun's spots I need only add that the shortest estimate of these cosmical gales or sun-spot periods is 11 years, or according to some, 33 or even 69 years, in order to show that meteorological records, to be trustworthy guides in the science of weather prediction, must be extended over long periods of time, and that, therefore, we cannot begin too early to record our observations. In a word, for the sake of science and for the sake of its practical results, it is very important to register phenomena within our reach for comparison all over the world. The atmosphere round the Earth, like the ocean, is one fluid, and effects observed in one place of the globe are to be traced, if we could only trace them, to causes in another. Excessive evaporation in Europe may be, and probably is, accompanied by corresponding precipitation in other countries and in another hemisphere. In this new sense "a touch of nature makes the whole world kin." Evaporation may not be the cause of storms, but storms and evaporation spring from the same cause. That cause is proximately heat, producing less atmospheric pressure and consequently greater evaporation. But why is one year's heat greater than the heat of many preceding years, and why is there, as there can be no doubt there is, a periodicity in the weather and in weather storms? It has been satisfactorily shown among others, by that excellent observer at the Mauritius, Mr. Meldrum, that cyclones and consequent rainfall show a periodicity, corresponding to the return of the maximum frequency of sun-spots. The value of Mr. Meldrum's observation and hypothesis communicated to the British Association, which I have read with interest and commend to your reading, will depend upon confirmatory investigation in Australia, while the establishment of the law in the Southern Hemisphere will not only carry with it a direct scientific advantage of its own, but must prove to be a most profitable contribution to the pursuit of science in the Old World and in America.