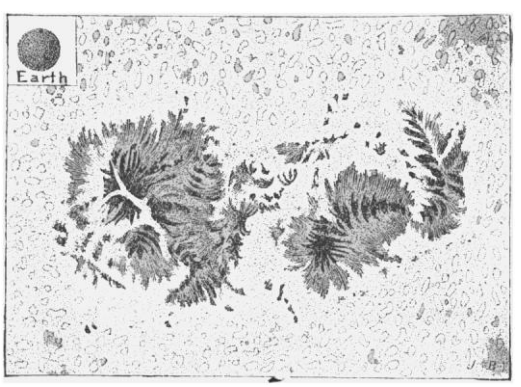
SUN-SPOTS AND THE EARTH.

"If dusky spots are varied on his brow,
And, streaked with red, a troubled color show;—
That sullen mixture shall at once declare
Winds, rain, and storms, and elemental war."
DRYDEN.

ONE of the most interesting questions of modern astronomy is whether sun-spots produce any effect upon terrestrial affairs, and, if so, of what nature is their influence, and how extensive?

It is an important question too; for, if they really do exert any thing like a commanding authority, then our knowledge of the laws that regulate their extent and frequency will give us a power of prediction, in respect to coming seasons, of the greatest value in all agricultural and commercial operations.

It was ascertained long ago (first by our own Henry), that as a sun-spot is darker, so also it is



SUN-SPOT AS SEEN JUNE 30, 1883

cooler, than the bright surface of the sun. According to the observations of Professor Langley, the black nucleus or *umbra* of a spot emits only about fifty-four per cent as much heat as an equal area of the normal surface; and the *penumbra*, the shaded fringe around the nucleus, about eighty per cent. If, then, any considerable portion of the solar surface were ever covered by the spots, we should reasonably expect a notable falling-off in the sun's light and heat, and an unmistakable effect upon climates and the weather.

It has been found, however, that, even in the most extreme cases yet observed, the portion of the sun's surface actually occupied by the spots is relatively very small, seldom amounting to a five-hundredth of the whole, and then only for a few days at a time. The direct temperature effect of sun-spots is therefore still more minute, never reaching a thousandth of the sun's whole heat.

But while their direct effect is thus insensible, it does not seem impossible, nor even improbable, that the spots might be indicative of an abnormal condition of things upon the sun's surface, such as would seriously affect the earth's revenue of heat. We might suppose, for instance, that they are symptoms of a general chilling of the solar surface, or, on the other hand, that they are caused by some ebullition from beneath the surface, which would, on the whole, raise the temperature instead of lowering it, and so compensate, or even overbalance, the effect of their darkness.

In regard to this, it is now only possible to say that the change, if any, is too slight to be detected by our present means of observation. It is earnestly to be hoped, that before long some apparatus and method of observation may be devised delicate enough to deal with the problem; but at present they do not exist, and no one knows with certainty whether the sun's radiation is increased or diminished when sun-spots are most prevalent.

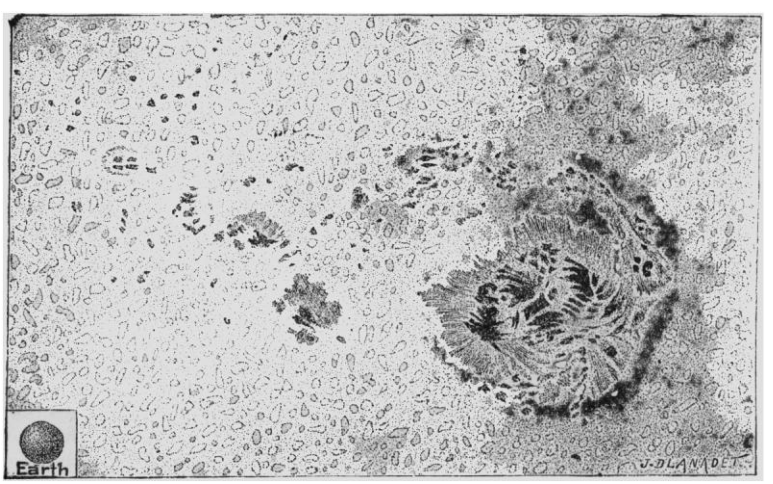
A priori, then, we have no reason for expecting any perceptible effect of sun-spots upon the earth's conditions. But, on the other hand, it would not do to assume that they have none; that a variation in the sun's heat, even too small to be directly measurable, may not *indirectly* produce very important consequences by disturbing some nicely adjusted equilibrium. The gentlest touch of a child's finger may depress a key, and fire a mine. It is easy to imagine many ways in which an extremely slight change in the temperature might occasion, if it did not strictly cause, such alterations in the cloudiness, or in the direction and velocity of winds, as would seriously modify the climates and the fertility of large regions of the earth. The question is simply one of fact.

Since, however, it has been discovered that there is a somewhat regular, though unexplained, increase and decrease in the number and extent of the sun-spots (with a period of about eleven years), we are in a position to investigate the subject statistically. It is only necessary to compare the tabulated data relating to the spots with those relating to temperature, barometric pressure, magnetic disturbance, rainfall, height of water in rivers, — every thing, in fact, that fluctuates in our terrestrial affairs: we may even justifiably and properly include in our inquiries such matters as the price of grain and stocks, financial crises, and epidemic diseases. If in any case we find that in a sufficiently long run


THE SUN
COMPILED FROM SEVERAL DATES
Scale of miles
0
100
200
300
400
500
600
700
800
869000 miles.
Harvard College Observatory 1873.
J H Bufford's Sons New York Boston & Chicago

the variations in the sun-spot data correspond exactly to those relating to the element under examination, we shall be compelled to admit some sort of a causal connection; and that, even if the nature of the connection is inscrutable.

Numerous such comparisons have been made during the past twenty-five years. So far the results must be pronounced indecisive, except as regards the effects of solar disturbances upon terrestrial magnetism. Here all the investigations agree in showing an intimate connection, the mechanism of which is, however, still unknown. When sun-spots are numerous and active, we always have magnetic storms upon the earth, manifested by the aurora-borealis and by strong disturbance of our compass-needles.



SUN-SPOT AS SEEN JULY 25, 1883.

The investigations in regard to other elements have, as Professor Langley says, "nearly every one brought out some result which might be plausible if it stood alone, but which is apt to be contradicted by the others." For instance: Dr. Gould in South America, and Mr. Stone at the Cape of Good Hope, think they have detected a slight lowering of temperature, amounting to one or two degrees, at the time of sun-spot maximum; while at Edinburgh, Smyth reaches a similar conclusion, except that the minimum temperature follows the sun-spot maximum at an interval of about two years. On the other hand, Chambers, from twenty-eight years' observations in India, finds a *rise of temperature* coinciding with the sun-spot maximum; and, in opposition to all the others, Jelinek of Prague, from all the observations he could collect in Germany up to 1870, obtained a purely negative result. Discrepancies of the same sort appear in the results of other investigators, with reference to the rainfall and the height of rivers in different parts of the earth; though, on the whole, they seem to show a slight increase in the rainfall (one or two per cent) at or near the time of spot-maximum.

It is to be remarked, however, that these discrepancies and contradictions by no means disprove the reality of sun-spot influence. It is quite possible, and even likely, as Dr. Gould and others have pointed out, that slight changes in the sun's radiation might be felt mainly by their effect in disturbing atmospheric currents, and so altering the distribution of heat and moisture, rather than by any general effect. In this case, the effects in neighboring regions would evidently be exactly opposite in character.

As matters stand, it is clear, in the first place, that a much longer period of observations will be needed to settle the question decisively as to the reality of sun-spot influence; and, in the next place, that, if the influence is real, it is only slight, and so masked by other effects as to be difficult of detection. There can be no reasonable expectation that the ordinary variations in the state of the solar surface will prove to be dominant, or even very important, in terrestrial meteorology, or in human conditions that depend upon climate and the weather.

THE INSECTS OF THE YEAR.

"Fairy bands
Sailing, 'mid the golden air,
In skiffs of yielding gossamer."
HOGG.

THE seasonal appearance of insects varies. Some species are found during several months, others at all times of the year; some vary in date of appearance with the earliness or lateness of the