ART. XXVIII. — *A Short Cycle in Weather*; by
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IF a diagram is drawn exhibiting the changes of daily mean temperature in New York City for a few months it will be discovered that these fluctuations occur every three or four days, on an average, but that some have much greater amplitude than others. In the course of four weeks, perhaps, there will be only two or three conspicuous rises and falls. Upon further scrutiny, there will be observed a tendency in these more prominent features of the curve to repeat themselves at intervals of about 27 days. Diagrams marked "Series I," "Series II" and "Series III" are submitted herewith to illustrate that tendency. The left hand vertical marks the true beginning of each cycle; and the right hand one, which is placed at a distance of exactly 27 days, the end; although for greater distinctness the curves are extended three days in each direction beyond the strict limits. In each of the three series, which cover different years, the point at which the second curve is intersected by the left hand vertical is exactly 27 days later than the corresponding point in the curve preceding, and so on through that entire set.

Considering only the general features, and not the minor details of these traces, one finds a sort of repetition of both warm and cold waves in nearly the whole succession. Thus, in Series I (beginning with Aug. 18, 1889, and covering eight cycles in immediate succession) there is a marked rise, **A**, which in the first trace culminates on Aug. 21, and in the second on Sept. 17. Recurrences, more or less distinct, appear on October 12, November 9, December 9, January 3, January 30, February 26 and March 26. In the third, fourth, fifth, sixth, seventh and eighth periods another warm wave, **C**, closely follows **A** at an interval of from four to eight days, the dates of climax being October 20, November 14, December 13, January 6, February 5, and March 5. After **C** has become well developed, the cold wave **E** that followed **A** in the first three cycles becomes inconspicuous for a time. **A** and **C** may be regarded either separately or combined; but one or the other, or both, recur with tolerable regularity. In the first curve of this first series, we find also a rather sustained warm spell, designated "**B**," having maxima on Aug. 31 and Sept. 6 (central point, Sept. 3). The rises of Sept. 26 and of Sept. 30–Oct. 1 (central point Sept. 28) imitate it, although the warmth is not well sustained. Recurrences appear on Oct. 27, Nov. 19–23, Dec. 19, Jan. 13–16, Feb. 12–14 and

SERIES I.

SERIES II.

March 12, 13. Following **B**, much as **C** did **A**, another warm wave, **D**, developed in the third curve on Nov. 2 and 3, and was reproduced Nov. 27 and 28, Dec. 25 and 26, Jan. 20, Feb. 18 and weakly March 18. The second considerable decline of temperature in the first period, **F**, culminated Sept. 11. This was distinctly paralleled on Oct. 8. Nov. 5–6, Dec. 4, Dec. 31, Jan. 28, Feb. 22, and ineffectively March 19, when it had almost merged with **H**, a weak fall which separated **B** and **D** in the last six curves.

In Series II, all within 1892, we have the warm wave **A** culminating Jan. 2 and 29 and Feb. 26. In the fourth, fifth and sixth curves it practically disappears; in the seventh, eighth and ninth, there is a hint of recurrence. Another warm wave, **C**, weak in the first curve, is strong enough in the second to check the reaction after **A**. It recurs weakly in the third curve, but has good parallels in the rest of the series. The first thermal depression after **A** in the first curve of this second set is really made up of two marked cold waves, reaching their greatest severity on Jan. 4 and 10. The former is not well reproduced; but the second, **F**, is apparent right through the whole nine traces. In this series, as in the preceding one, there is a second conspicuous rise in the curve, **B**, manifest at least five times in succession. Whether or not the less distinct elevations **B**², in the other four traces, should be regarded as repetitions of it, these latter are at least recognizable. Another warm wave, **D**, is in nearly every instance inferior in rank to the two or three preceding it in the same cycle (**A**, **C** and **B**); yet it has a certain weak individuality that entitles it to notice. A fifth tendency to warmth, shown in the two peaks grouped as **E** in the first curve, finds a parallel in the next, but none in the third and fourth; and the subsequent imitations are too feeble to count. The warm waves **B** and **D** are at first fairly well separated by a fall in temperature, **G**, but this gradually fails as **D** grows in importance. The reaction, **H**, after both **B** and **D** is in most cases greater than **G** in the first four curves; but in the latter half of this series it fades out of existence gradually, and cannot fairly be identified with **H**² in the eighth and ninth traces.

In Series III the same tendency of prominent features to recur is at least equally obvious.

In all three sets of curves, and in those for other years, this apparent disposition to repeat an incident is more conspicuous at some times than at others. At best, it is never very striking; often a stretch of the imagination is required to perceive it. Seldom are all parts of a curve reproduced equally well in the next; some one member, perhaps, failing altogether to return, or even being represented by a reversal. Occasionally a

large rise or fall occurs a little too early or a little too late to be regarded confidently as a repetition in the sense here meant. And if one were to employ this phenomenon as a basis for practical forecasting, he would experience frequent failure. Yet in spite of non-recurrences and regardless of the doubts which may arise as to the reality of the parallel in certain instances, there is still so strong a suggestion of periodicity as to command respect when attention is once directed to it; and, as will appear later, some of the failures and discrepancies are susceptible of reasonable explanation; so that investigation eventually strengthens one's confidence in the genuineness of the phenomenon.

The first half of some of the traces presented herewith resembles the last half, and the resemblance may prove to be more than accidental; so that, judging from this alone, one might believe that the true cycle, if there be one, is 13 or 14 days in length, rather than 27; but in Series III, as in others which might be offered, the latter interval seems to be requisite to make out the full outline; one portion having oscillations either of wider range or greater frequency than the other. Reducing, then, the data embodied in all three series to tabular form, we find that while there is often a variation of a day or two from the exact period, only rarely does the departure amount to three days, one way or the other; and the mean length of the 109

cycles exhibited is 27.046 days, which must, however, be regarded as only an approximate result. A slight change would be effected in this value by omitting from the computation some of the instances which have been employed but which may not properly belong therein. The temperature-curve in our latitudes is a very complicated affair, apparently including not only features that for convenience may be called accidents but also several fairly regular undulations of different lengths, which partially mask each other. But even after free elimination from the evidence here exhibited and from other traces which might be presented, there still remains a residuum hinting strongly at a period of not far from 27 days.

Intervals at which Warm and Cold Waves Recurred.

Series I: 1889-90.		Series II, continued.	
	Date. Interval.		Date. Interval.
A:	Aug. 21, ****	C:	March 1, 28
	Sept. 17, 27		March 26, 25
	Oct. 12, 25		April 23, 28
	Nov. 9, 28		May 18, 25
	Dec. 9, 30		June 13-17, 28
	Jan. 2, 24		July 13-15, 29
	Jan. 30, 28		Aug. 9-11, 27
	Feb. 26, 27	F:	Jan. 10, ****
	March 26, 28		Feb. 6, 27
C:	Oct. 20, ****		March 2, 25
	Nov. 14, 25		March 27, }
	Dec. 13, 29		April 1, }
	Jan. 6, 24		April 25, 27
	Feb. 5, 30		May 21, 26
	March 5, 28		June 18, 28
B:	Centr'l Pt., Sep. 3, ****		July 17, 29
	C. Pt., Sept. 28, 25		Aug. 13, 27
	One peak, Oct. 27, 29	B:	Jan. 14, ****
	C. Pt., Nov. 21, 25		Feb. 8, 25
	One peak, Dec. 19, 28		Mar. 7-10, 29
	C. Pt., Jan. 14, 26		April 4, 27
	C. Pt., Feb. 13, 30		May 2, 28
	March 12, 13, 28	B²:	May 26, ****
D:	Nov. 2, 3, ****		June 22, 27
	Nov. 27-8, 25		July 20, 28
	Dec. 25-6, 28		Aug. 18, 29
	Jan. 20, 26	D:	Jan. 18, ****
	Feb. 18, 29		Feb. 15, 28
	March 18, 28		Mar. 12, 26
E:	Aug. 28, ****		April 8, 27
	Sept. 22, 25		May 4, 26
G:	Oct. 23, ****		June 1, 28
	Nov. 16, 24		June 30, 29
	Dec. 15, 29		July 26, 26
	C. Pt., Jan. 10, 26	E:	C. Pt. Jan. 24, ****
	C. Pt., Feb. 8, 29		Feb. 22, 29
	March 7, 27		Mar. -- --
F:	Sept. 11, ****		April -- --
	Oct. 8, 27		May 9-12, 18
	Nov. 5, 6, 28		June 6, 27
	Dec. 4, 29		July 2, 26
	Dec. 31, 27		July 29, 27
	Jan. 28, 28		Aug. 25, 27
	Feb. 22, 25	G:	Jan. 16, ****
	March 19, 25		Feb. 13, 28
H:	Oct. 30, ****		Mar. 11, 27
	Nov. 26, 27		April 7, 27
	Dec. 24, 28		May 3, 26
	Jan. 17, 24		May 28, 25
	Feb. 16, 30		June 27, 29
	March 16, 28	H:	Jan. 20, ****
			Feb. 17, 28
			March 14, 26
			April 11, 28
			May 7, 26
			June 4, 28
			July 1, 27
		H²:	July 31-Aug. 2, ****
			Aug. 27, 26
Series II: 1892.			
A:	Jan. 2, ****		
	Jan. 29, 27		
	Feb. 26, 28		
	March 23, 26		
C:	Jan. 5, 6, ****		
	Feb. 2, 27		

Series III: 1886.

	Date.	Interval.
A:	Jan. 4,	****
	Jan. 28,	24
	Feb. 25,	28
	March 25-6,	28
B:	Jan. 17-21,	****
	Feb. 13-19,	28
	March --	--
	April 10-13,	55

	Date.	Interval.
D:	Jan. 12,	****
	Feb. 5,	24
	March 1,	24
	Mar. 27-9,	27
E:	Jan. 24,	****
	Feb. 20,	27
	March 20,	28
	April 16,	27

That these and kindred oscillations in New York City are, in the main, representative of temperature-changes over the greater part of the United States becomes evident when one compares the curves for that place with those for St. Paul and St. Louis. Indeed, one may go beyond the Rocky Mountains for this purpose, although at first sight the result is a little unsatisfactory. The four traces presented in Series IV (covering

August, 1891), are offered rather to illustrate than to demonstrate the close general parallel between temperature-curves for stations in almost the same latitude, in a chain reaching nearly or quite across the continent. Were the testimony of five years instead of a single month offered the resemblance would still hold good. Indeed, probably no meteorologist would question it. It should be observed, however, that in point of time, there is a sensible difference between places widely separated in longitude, in which respect these curves are unlike traces of magnetic storms, which exhibit deflections all around the globe at practically the same instant of time. But a conspicuous rise in temperature at New York is apt to be a day or two behind that at St.

Louis, fully two days behind St. Paul, and sometimes nearly a week behind Utah. The eastward progress of warm and cold waves across the continent is one of the most familiar phenomena in meteorology. There is, in Series IV, for instance, a rise (A) at Salt Lake City, culminating there on Aug. 4, at St. Paul on the 8th, St. Louis the 10th, and New York the 10th

and 11th. That these are intimately related appears from this fact: Such phases of the weather are associated with winds from lower latitudes, bringing warm air upon the scene; these southeasterly, southerly or southwesterly winds constituting part of a system always to be found about a region of low barometric pressure and prevailing on the eastern or southern sides of such depressions. When, therefore, one of these areas approaches a place from the west, and is passing, with its center north of the station, these warm winds dominate; and when the depression has gone far enough to the eastward to permit the northwesterly and northerly winds of its western half to sweep over the spot, air from higher and colder latitudes is transported thither, and the temperature falls. These latter winds are also characteristic of the front of a high pressure system, such as usually follows the low area; and a study of these alternate "lows" and "highs" is the foundation of modern meteorology. A map showing the distribution of air pres-

sure on the morning of Aug. 7, 1891, is submitted, and the positions successively occupied by its center from the 3d to the 10th indicated thereon. It will thus be seen that Utah came under the fullest influence of the warm winds of this system on Aug. 4, St. Paul on the 8th, and New York on the 10th. Its effect at the last named place and at St. Louis seems to have been heightened by the passage of a similar area from Manitoba to the St. Lawrence Valley on Aug. 9-11. The high

pressure area overlying Utah, Idaho and Oregon on the 7th is associated with the cold wave (**B**) felt at Salt Lake City on that day, at St. Paul and St. Louis on Aug. 12, and New York Aug. 13-15; its effect being increased somewhat east of the Mississippi by another high pressure area from British America, which merged with the first one on Aug. 10-11. By the time that the warm wave **A** had reached St. Paul the cold wave **B** was affecting Salt Lake City; so that here, as in many other instances, the curve for the former station reverses that for the latter. But the reversal is only apparent. Upon making the proper time allowance, the parallel is found to be very close; and, with easily explicable exceptions, it holds good the year round. When, however, any low or high area changes its size or shape materially, or follows such a route as not to present in an equally advantageous way its warm or cold winds, to a series of stations, the parallel fails; or if it exists, is accidental, not logical. Exceptions occur, for instance, when low areas or "storms" come into the United States from the north east of the Rocky Mountains, or from the Gulf of Mexico, by way of Tennessee to the lower Lakes, or skirt the Atlantic seaboard without coming inland at all, having originated in the West Indies.

The influence of one of these tropical storms is revealed in Series IV. The cold wave **C** was well defined at St. Paul and St. Louis, but almost imperceptible in New York. This was because its progress was obstructed and its intensity reduced by the abnormal delay for five days (Aug. 21-25) of a depression directly ahead of it. This delay in turn seems to have been due to a slight high pressure barrier along the seaboard, raised, like snow in front of a plow, by the famous Martinique cyclone. That storm, crossing the Windward Isles on Aug. 18, 1891, advanced slowly to the Bahamas, recurved there on the 23d and 24th, and then crept off to the northeastward. Had this interfering depression approached the Carolina coast more nearly, no doubt a very different effect would have been produced. The inland storm would have merged with it, escaping quickly to the ocean; the northerly winds in the front of the anticyclone over the Mississippi Valley would have quickly reached the coast, and would have been intensified. Indeed, while this particular high pressure area was retarded until it almost died out, the next one after it, though insignificant in the west, was rendered more boisterous and chilly by the suction of the West India storms, which, by the 29th, was off Nova Scotia. That is the day on which New York experienced the cold wave marked **C**³.

The deflection of a low area, whose center has kept north of St. Paul and St. Louis, but which goes out onto the ocean south

of New York City, is another occasional cause of discrepancy in the parallel.

But the general uniformity of storm tracks is conspicuous enough in spite of these freaks to produce a strong resemblance between the temperature curves for the four stations specified, and for intermediate ones; and they will therefore be found to exhibit much the same periodicity as is observed in New York City. And since the same laws of storm movement and wind direction prevail in Europe and Asia as in America, and in the Southern as in the Northern Hemisphere, subject to certain local modifications, it is probable that the tendency of certain weather changes to recur at intervals of 27 days, observed in this country, may be found to exist in corresponding latitudes elsewhere.*

If, as seems to be the case, the immediate cause of warm and cold waves is wind-direction, then the intensity of the former must be proportional to the size and depth of the barometric depressions, and to the breadth and height of such anticyclones as happen to be adjacent thereto on the south. The greater the heaping up of air in the latter and the greater the rarefaction in the former, the steeper will be the gradient between the two systems, and the wider and stronger the sweep of the atmospheric currents. Examination of the daily weather maps for the three periods covered by the temperature curves in Series I, II and III, ought to show whether or not this is a sound conclusion. Such scrutiny does, on the whole, warrant confidence in the existence of such a relation. But the inquiry is more complicated than might be supposed. Were all storms symmetrical or even similar in shape and size, and were their routes always the same, and were high pressure areas also alike in dimensions and movement, the investigation would be very simple; but such differences exist among lows and among highs, and such are the distortions of figure in instances, that the comparison does not yield entirely harmonious results. One encounters occasional anomalies.

Thus the warm wave **A** in the first curve of Series I was associated with a barometric depression whose center was moving eastward over Ontario on Aug. 21, 1889. This was the most conspicuous low area that had crossed the country for ten days, and it had no equal for nearly a fortnight afterwards. The warm wave was correspondingly preëminent. This is a

* Something of this sort, noted at Innsbruck and Paris by Nervander, and by Buys Ballot at Harlem, Danzig and Zwanenburg, is mentioned at page 80, in "Die wichtigsten periodischen Erscheinungen," by Herman Fritz, of Zurich, who himself contributes further data of the same kind on pages 396-8. exhibiting a single or double oscillation in temperature at several other European stations, four points in the Arctic regions and one in Africa.

clear case, and most of the principal rises of temperature exhibited in all these traces were similarly associated with more than usually intense storms, whose centers kept north of New York while passing eastward to the Atlantic. The warm wave **A**, in the sixth curve, Series I, culminating on Jan. 2, 1890, however, was not related to a deep depression but to a shallow one. But as the pressure over Georgia at that time was exceptionally high, the necessary gradient existed for an extensive movement of air from the warm southwest. This instance is typical; and several other apparent exceptions may be explained by similar situations. After all, it is not the actual barometric readings, but the contrasts, which explain wind force. These cases of high pressure over the South Atlantic or East Gulf States, moreover, suggest the possibility that not only are rapidly moving high and low areas intensified at times, but that the sub-permanent high pressure area which in an almost continuous belt extends around the globe along the 30th parallel of latitude, is also subjected to an occasional intensification. The warm wave **B**, in the first curve, Series II, culminating in New York on January 14, 1892, was as conspicuous as any exhibited in the whole set of traces; yet it had no precedent at St. Paul or St. Louis. This was because the storm to which it was related, instead of coming across the continent near the northern frontier, entered from the Gulf of Mexico and pushed up to the St. Lawrence Valley by a route which brought New York under the influence of its southerly winds; while places west of the Alleghanies were not so affected. On May 18 and 19, 1892, a storm of exceptional intensity prevailed over Lake Michigan, and came eastward on the two following days. New York, however, had a cold wave, not a warm one, in consequence. This was because a high pressure area over New England and the British Provinces obstructed the advance of the storm along its proper route—the St. Lawrence Valley—and forced it to reach the ocean by dipping down toward the Virginia coast. The metropolis, therefore, experienced strong northeasterly winds instead of southerly ones. Thus, the failure of the temperature-curve to rise at the expected time is explained; and the recurrence of storm activity when the 27-day period required it, really happened.

Most severe cold waves, in like manner, may be shown to be associated with the strong northwesterly winds prevailing between a very deep depression which has just passed and a moderately high pressure area behind, as on Sept. 22, 1889. (**E**, second curve, (Series I) or between a moderate low and a big high, as on Oct. 23, 1889 (**C**, third curve, Series I), or between a low and a high that are both very intense, as on Feb. 21, 1890 (**F**, eighth curve, Series I). But sometimes, as on Dec.

15, 1889 (G, fifth curve, Series I), the cause seems to be inadequate to the effect; and again, as on Jan. 10, 1892 (E, first curve, Series II), the results are not quite as great as possibly one might expect. In the former case, however, with only a moderate high and a shallow low, there was a great intensification of the storm after it passed out on the Atlantic, beyond the range of the weather maps, but while it was still near enough to affect the coast by increasing the gradient and wind force; and in the latter, with an exceptionally large anticyclone over New Brunswick, the fall would undoubtedly have been greater had not the temperature already been greatly lowered by a previous high pressure area, and by a storm going out to sea south of New York City.

So many of the apparent exceptions to the rule may be reasonably explained away, that one is justified in believing that the few remaining ones would disappear with more careful analysis, or in the light of conditions on land and sea contiguous to the United States but not represented on the ordinary charts. There is strong reason, therefore, to believe that, in the main, if not entirely, the temperature phenomena here exhibited are directly related to the distribution of air pressure, and that the atmosphere, owing either to the increased operation of the cause or causes (whatever they may be) which originate storms, or to the supplementary influence of some other cause, is persuaded periodically to arrange itself in high and low pressure areas of more than usual intensity.

The fact that the periodicity observed in the United States has also been noticed in Europe and in the Arctic regions leads one to suspect that the exciting cause is cosmical and not terrestrial. The 27-day period imperfectly revealed in the weather corresponds nearly to that of the sun's rotation. There are tremendous disturbances on that orb which appear to us as spots and prominences. And a relation between these solar storms and auroras and other phenomena in terrestrial magnetism has long been believed to exist. So that it is natural to seek for a connection between important meteorological episodes and the reappearance, by the sun's revolution upon its axis, of spots, faculæ, prominences, or something else even more permanently located upon that immense globe. It is not surprising to find, therefore, that nearly 20 years ago Broun suspected the existence of certain meridians* on the sun which might be particularly potent in exciting auroras and magnetic storms. Buys Ballot, it will be remembered, referred the fluctuations which he observed to "heat holes" or areas of higher or lower temperature on the solar surface. In line with these ideas was the belief of Prof. Spoerer that cer-

* *Encyclopædia Britannica*; article on Terrestrial Magnetism, Section 86.

tain regions on the sun were predisposed to spottedness, although this theory still lacks confirmation. As early as 1883 we find Henry C. Maine, a journalist and amateur astronomer, trying to connect atmospheric storms with solar disturbances. For nearly ten years, in "The Rochester Democrat and Chronicle," he has been printing paragraphs every few days in illustration of this supposed relation. By or before 1889, however, he had concluded that the influence exerted was electrical, and proceeded from the sun's "streamers," but without indicating exactly what he meant by this term.* Mr. Maine, like some other observers, has noticed frequent coincidences between disturbances of the magnetic needle and the outbreak of severe terrestrial storms somewhere on the globe. Dr. M. A. Veeder, of Lyons, N. Y., long a student of auroral phenomena, has also been led by his own researches to think that there are certain solar meridians, or permanent sites, that disturb the earth's magnetism, and affect our weather. He and Mr. Maine further believe that the excitement, magnetic and meteorological, is produced, chiefly if not exclusively, when the solar storm or more permanently located region of influence is coming into view on the sun's eastern limb by rotation; the former gentleman confining the effect rather to the first two or three days after such reappearance, while the latter extends the interval at least to a meridian passage.

These intuitions of American and foreign students contain unquestionably much of value, even if the precise truth has not yet been ascertained. But either in quantity or manner of presentation, or both, the testimony thus far offered to the public has not been adequate to secure general acceptance for these interesting theories by men trained to strict scientific methods; nor have official bureaus, with all their enterprise and sense of responsibility, felt warranted in utilizing these suspicions for practical forecasting. The International Meteorological Conference in Munich in 1891, however, advised that all such Government institutions give special attention to the relations between meteorology and terrestrial magnetism. Upon his return to Washington, Prof. M. W. Harrington, Chief of the United States Weather Bureau, secured for this purpose the services of Prof. Frank H. Bigelow, whose original and valuable contributions to the study of solar physics and whose exhaustive and ingenious methods of investigation inspired much confidence in his ability to unravel this mystery, if there be one to unravel. Prof. Bigelow's inquiry is not yet completed; and the result of his work thus far has not been made public to any great extent. Yet in a pamphlet from his pen, issued by the Weather Bureau last

* Frank Leslie's Illustrated Weekly, Aug. 31, 1889.

August, he declared that he felt able to show that a real relation does exist between magnetic and meteorological phenomena.

This assurance and the facts adduced in the present article suggest the following questions:

(1) What is the sun's exact synodical rotation-period? This needs to be determined accurately before we can make it the basis of comparison with terrestrial phenomena. The testimony of spots, magnetic storms, auroras, and spectroscopic observation of the sun's motion at the limbs is conflicting and diverse, yielding results all the way from 26 to 29 days. The mean time required for spots to reappear on the solar disc has been estimated at the Greenwich Observatory to be $27\frac{1}{4}$ days; but as yet we are not justified in regarding even this as final or representative of the whole orb.

(2) If the periodicity in terrestrial weather be due to the return, by the sun's rotation, of some important solar feature, is that feature a spot, facula or prominence, liable to develop in any longitude, and seldom existing for much more than three or four rotation-periods, or is it a permanent center or site? In the former case, the recurrence of any particular weather incident could only be counted upon a few times; in the latter it might be predicted not only months, but even years in advance. In the traces here reproduced, for instance, a warm wave, like *C* in Series I, will appear, without any immediate precedent, and subside after a few appearances. In some such cases purely terrestrial and local interferences can be discerned: in others, the reason for subsidence is not apparent. This would seem to favor the notion that a short-lived solar disturbance was the agent. On the other hand, the traces in Series I represent a minimum of the 11-year sunspot cycle, while Series II represents a period, which, according to Dr. Rudolph Wolf (whose "sunspot numbers" are widely accepted as a standard), exceeded in evidence of solar activity the last maximum stage.* Yet the periodicity of the temperature-changes is about as distinct and the amplitude nearly or quite as great, in one series as in the other.

(3) If the exciting influence is associated with one or more permanent sites, is the occasional subsidence and revival observed in its effects due to variations in the energy itself, to unequally advantageous positions resulting from the inclination of the sun's axis, or to some unequal terrestrial masking or interference? Perhaps an answer to this can be found more easily when the following question is disposed of:

* The mean of Wolf's monthly numbers from Sept. 1, 1889, to March 31, 1890, is 3.5; for the year 1883, 62.8: for 1884, 63.3: for the first nine months of 1892, 74.0.

(4) Is this exciting influence thermal or magnetic? Dr. Kœppen, a division officer of the North German Weather Service, believes that as between the maximum and minimum stages of the 11-year sunspot cycle, there is enough difference in the heat received from the sun to be sensible at the earth's equator, and to have an effect on the general circulation of the air.* This is in conflict with the view that the variations in solar radiation are too slight to be appreciable; but if it were true of the 11-year cycle, it might also hold good for shorter periods. Fritz's evidence of a 27-day temperature oscillation at Vivi on the Congo for a single year, is inadequate to prove this. But were a similar phenomenon noticed at a dozen or more widely separated equatorial stations, the fact would possess great significance; since along the Equator there are no cyclonic systems passing, with winds coming first from a warmer and then from a cooler quarter. Moreover, Lockyer has presented some spectroscopic evidence of the occurrence of great changes from year to year in the temperature of spots,† which has not yet been followed up to a satisfactory conclusion. The discovery of a "heat pole" on the sun, such as Buys Ballot believed in, would harmonize well with a periodical temperature oscillation outside the range of moving high and low pressure systems, and also with the thermo-dynamic theory of storm formation and intensification, of which Espy, Abbe and Ferrel have been such able expounders, but against which a fresh revolution has recently broken out in meteorological circles. On the other hand, great magnetic storms have long been regarded, but without much proof, as precursors of weather changes; and in many isolated instances, like the great typhoon which smote Mauritius on April 29, 1892, notable atmospheric disturbances have been immediately preceded by exceptional agitation of the needle. Dr. Meldrum, for forty years Secretary of the Meteorological Society of Mauritius, has long believed such coincidences to be significant, and he is not alone in that belief.

* Hann's "Klimatologie," p. 707.

† "Chemistry of the Sun," pp. 310-24.