

moisture takes place more easily and in greater quantity than on unwooded ground." Ebermayer thus considers the effect of woods on evaporation to be practically *nil*, otherwise he could not have failed to see the relation between this and the precipitation. He goes on to say that "in level regions of uniform character, the influence of forests on rainfall is at any rate very small, and they have no effect on the proportional distribution through the year. With increase of elevation above the sea, the importance of the effect of woods on the rainfall increases, and the woods are therefore of more value in mountains than on plains. \* \* \* The cutting down of forests will at any rate affect principally the rainfall in the summer months only."

A special committee of the Royal Academy of Vienna, reporting in 1874 upon Wex's deductions, said: "The question of the influence of forests upon the amount of precipitation has for some time engaged the attention of naturalists. Such an influence has been asserted partly from theoretical considerations and partly on account of the entire change presented by the climatic relations of the countries in which the forests have disappeared. \* \* \* It is probable that such influence exists, but while, on the one hand, its consequences may be over-estimated, on the other hand, there is want of direct proof." The commission consequently concluded that an influence of the woods upon the rainfall is probable, although direct observation does not give sufficient evidence to determine its extent or even positively its existence.

TO BE CONTINUED.

## TORNADOES AND DERECHOS.

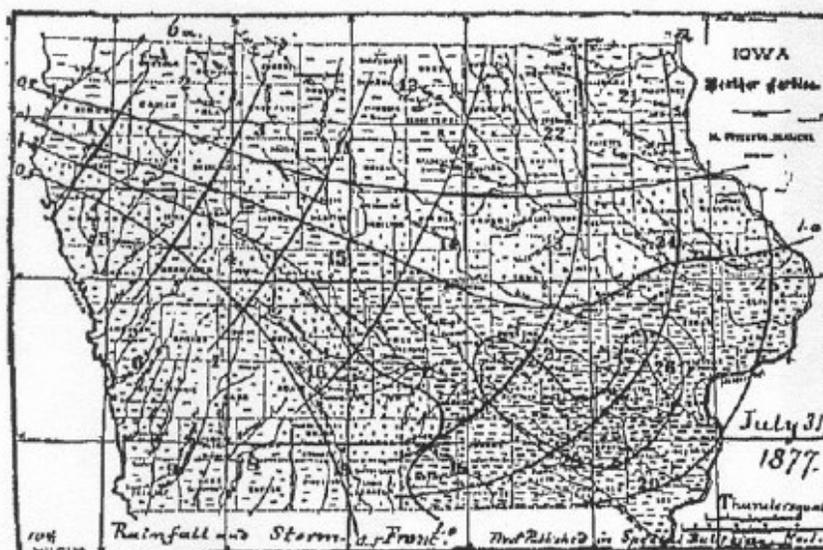
BY DR. GUSTAVUS HENRICHS,  
Director Iowa Weather Service.

I almost regret having accepted the editors' invitation to contribute an article to the AMERICAN METEOROLOGICAL JOURNAL on Tornadoes. This regret is not due to a lack of material; for we have had a few notable phenomena of this kind in Iowa during the thirteen years since the Iowa Weather Service was

founded, and during which it has been managed by me. Indeed, according to Signal Service authority,\* Iowa is credited with over a hundred tornadoes for this period of time; but fortunately for our people, a goodly number of these tornadoes have never existed outside of the archives and publications of the Signal Service, and a great many others were simulations. The real difficulty of writing on this subject consists in the fact that two radically different phenomena are described and officially catalogued under the name of tornado. Although I have years ago called attention to this fact, the practice is still continued. While this very fact makes it practically imperative to publish a brief article on this subject, I cannot help regretting that my contribution will necessarily have many characteristics of a preliminary publication. But at the present time, when so many rush into print at very short notice, I may be permitted to present an outline of the mechanism of our most notable atmospheric disturbances, the tornadoes and derechos, a subject which has occupied my attention for many years.

#### HISTORY OF THE DERECHO.

2. Even before organizing the first State Weather Service in this country, I had noticed some of the peculiarities of the storm

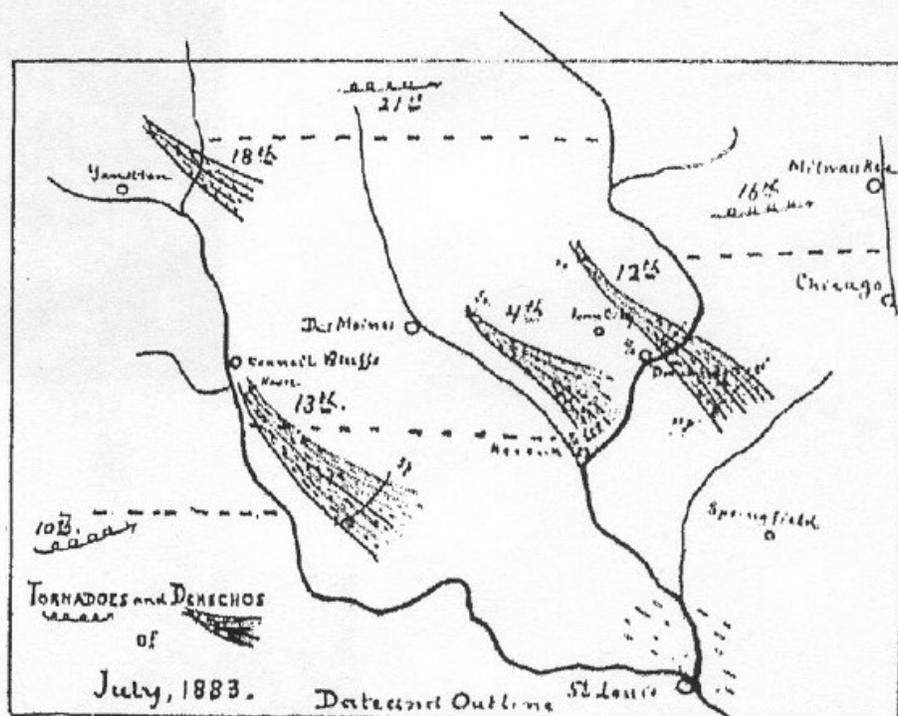


which I now propose to call the *Derecho*. The first publication of the map of such a storm was that of July 31, 1877, in the Special Bulletin, No. 1, a quarto sheet, printed in two colors—

\* Finley: "The Tornadoes of Iowa." Washington, 1888. Table III.

map red, storm details in black—by use of the electric pen. The descriptive part was reprinted on pages 30 and 31 of the Iowa Weather Report for 1877; the map was afterwards re-drawn to obtain a photo-electrotype, which was first published in my "Annual," issued for New-Year, 1882, and reprinted on page 12 of the Iowa Weather Report for 1882, and is inserted above. A brief characteristic description accompanies this map. A more elaborate characteristic of these storms was given in the June Bulletin of 1881, pp. 34-35, and reprinted on pages 272 and 273 of the Iowa Weather Report for 1881, under the name of "Iowa Squalls." It was also furnished the newspapers of Iowa in July, 1881, and thus widely made known in Iowa.

3. In the first publication of 1877 I used no specific name, while in these latter publications of 1881 and 1882 I employed the term "Squall" to designate this storm. I used the term also in describing the storms of this character of July, 1883, before the American Association for the Advancement of Science at Minneapolis in August, 1883, where I exhibited the corresponding general map (here inserted) of these storms and



the tracings of the self-registering instruments of my observatory, since reprinted in the Iowa Weather Report for 1883, on page 120, and before that in my third biennial Report (administrative), of October, 1883.

4. I have always been inclined to consider the storms here referred to as a specifically distinct form of atmospheric disturbance. When first recognizing the same, I supposed it to be described in some of the meteorological works or journals.

The admirable paper of Dr. W. Koeppen in Hann's *Zeitschrift* (Vol. XIV, 1879, pp. 457-478,) induced me temporarily to adopt the name of "Squall" for these storms, for want of anything better, and because I did not yet feel inclined to assume the responsibility of introducing a new term, though I generally specified the same as Iowa squalls.

5. But after continued study and comparison of personal observations in the field and in the observatory, as well as after the charting of a great many of these storms in Iowa, and considering the continued confounding of the same with the tornado, I have for a long time deemed it both wise and necessary to introduce a specific term for the truly specific phenomenon under consideration. Since the "Twister of the Prairies" has been named the *tornado*, I propose to call the peculiar "Straight Blow of the Prairies" the *derecho*; (Spanish, in analogy with the word tornado).

6. It may be objected that the term squall might answer, and that a new term is superfluous. In that case the term tornado should also be discarded, and the more general term of "cyclone" used for all allied phenomena, from a waterspout and a dust-whirl raising withered leaves into the air, to the grand circulatory motions traversing the seas and continents. Such looseness in the use of terms is but the outgrowth of superficiality in thought and knowledge. Nothing is more necessary in science than the recognition of specific forms of phenomena and the application of specific terms to the same. Upon further study, generic relations of these specific forms may properly be indicated by more general terms. The *derecho* is as

thoroughly marked a specific atmospheric disturbance as is the tornado.

TORNADO AND DERECHO DESCRIBED.

7. By giving a descriptive definition of these two forms of prairie storms the above position will be completely established.

8. The *tornado*, or "twister of the prairies," is a powerfully lifting column of violently revolving air, describing a narrow path of destruction as it moves along the earth's surface in a northeasterly direction; it is surmounted by a cloud, from which the column seems to hang down. Its track is generally marked by stakes driven into the ground beyond where it has destroyed buildings, these stakes being the longer fragments into which the tornado has torn such buildings.

9. The *derecho*, or "straight blow of the prairies," is a powerfully depressing and violently progressing mass of cold air, moving destructively onward in slightly diverging straight lines, (in Iowa) generally towards the southeast, with its storm-cloud front curving as the storm-lines diverge. The barometer bounds upwards and the thermometer falls greatly under the blow of this cold air of the upper strata suddenly striking the ground. The *derecho* will blow a train of cars from its track, unroof, overturn and destroy houses; but it does not twist the timbers into splinters and drive these firmly into the hard soil of the prairie.

10. Both of these prairie storms are markedly intermittent in their character. The *tornado* at intervals in its path draws in lateral currents of destructive violence, and frequently rises in the air, and thus interrupts its path of destruction. The *derecho* in its forward and downward sweep also strikes with exceptional violence at considerable intervals of time and space apart.

11. The forward motion of the tornado is small in comparison to the rotary motion that causes its destructive effects. The forward motion of the *derecho* averages about twice the progressive motion of the tornado; but the most destructive effects of the *derecho* are due to the locally more violently down and forward striking masses of the same.

12. The entire track of a tornado may be compared to the

storm-front of the derecho at a given instant of time, though the length of the storm-front of a derecho generally largely exceeds the length of a tornado track. As the storm-front of the derecho sweeps onward and spreads laterally over the prairies, it is plain that the derecho is by far the most extensive of these two prairie storms. Per contra, the tornado, in its narrow track, is by far the most intensive of these two storms.

13. Both the tornado and the derecho are violent disturbances in the atmosphere whereby a highly unstable equilibrium is suddenly changed into a stable equilibrium. Both storms last but a very short time at any given point, and both are followed by a refreshing, comparative calm, free from oppressive sultriness that preceded them.

14. Heavy rain, thunder and lightning, and hail may be associated with either of these storms.

15. Mechanically speaking, the tornado is due to the local up-rushing of the hot and moist southeasterly stratum into the cold and dry northwesterly stratum above the same, while the derecho results by the cold and dry northwesterly striking obliquely downward, and displacing the hot and moist southeasterly current, generally by striking under the same.

16. The annual period of these two storms is very marked, and has a strong bearing on the mechanical causation of the same. In the cold months, neither of these storms occur. Sudden heated and moist spells in April may cause tornadoes in Iowa, and for this State the rising tornado season continues for three months, ending about July 4th, being most intense in June. Meanwhile, derechos may have occurred, and for mid-summer (say July and August) they are the only storm forms by which the unstable equilibrium of the atmosphere is suddenly restored to a stable equilibrium in Iowa. In September and October we may again have the tornado form in Iowa, while I know of no authenticated tornado having occurred in Iowa during the five months from the beginning of November till the beginning of April.

17. The tornado months of Iowa are for the rising season, April, May and June; and for the falling season, September and

October, as I have repeatedly shown in official publications of the Iowa Weather Service. The danger in May and September is not serious.

18. Tornadoes, therefore, appear to form only in a moist, heated stratum of moderate height, while the *derecho* forms by preference when this stratum is the highest.

19. It is well known that severe tornadoes occur in the southern States during the winter season, and in Minnesota during our midsummer. These facts harmonize with the annual period in Iowa.

20. I shall at another time consider the general mechanism of the more extended storms or cyclones proper.

21. At this place I may be permitted to make the following comparisons:

The most notable storms of Iowa are the blizzard, the tornado, and the *derecho*. The *blizzard* is a winter storm, and progresses from the northwest till it generally sweeps over the entire State and adjacent parts of the Northwest. Its cold air is surface air of colder regions.

The *derecho* is a summer storm, in its mode of progress and in some other features resembling the blizzard, but in comparison is very much restricted in its extent, and confined to definite limits; its cold air comes down from higher strata of the atmosphere, and not from a higher latitude simply. During three months (April to June) of the rising, and two months (September, October,) of the falling season, we may have *tornadoes* in Iowa.

22. Careful study of facts will readily reveal a corresponding periodicity for other parts of our country.

As in Iowa, so in a belt passing east and west through the Mississippi Valley, the tornado season will be found to be interrupted by a midsummer spell of no tornadoes, during which more or less marked and extensive *derechos* will result from the upsetting of the unstable equilibrium produced by the sun's heat.

But it will be impossible to establish this conclusion until we shall have reliable data of actual tornadoes from these regions.

Lists giving all sorts of storms and mere cloud phenomena, inextricably mixed up with genuine tornadoes, cannot form the basis of any scientific study whatever.

23. Having now presented an outline of the most important forms of the destructive summer storms of our prairies, we are ready to enter upon the more critical and special consideration of the same. In this paper we shall mainly devote our attention to tornadoes, using our knowledge of the derecho merely to recognize and remove such storms from the tornado lists before the public. In a future paper I shall endeavor to give more complete description of derechos from the abundant material which I have at hand.

#### FINLEY'S TORNADOES IN IOWA.

24. The climate of Iowa has been most outrageously maligned both by thoughtless or sensational newspaper correspondents and by official and semi-official publications of the Signal Service in ascribing to Iowa an excessive tornado frequency. Both of these ever-grinding tornado mills for Iowa have furnished



MAP SHOWING THE LOCATIONS OF TORNADOES WHICH HAVE OCCURRED IN THE ABOVE STATES BETWEEN FEBRUARY 23, 1875 AND OCTOBER 20, 1891. TAKEN FROM THE RECORDS OF THE SIGNAL SERVICE BUREAU OF THE UNITED STATES ARMY.

abundant material for frightening people from settling in Iowa, and for coaxing residents of Iowa into the thriving tornado insurance institutions of both the East and the West. The more pretentious advertising sheets of these companies are embellished by truly frightful maps, "taken from the records of the

Signal Service Bureau of the United States Army," which show the valleys of the Missouri and Mississippi in the latitudes from 35 to 45 degrees to be an almost unbroken mass of dark tornado patches. See the cut reproducing one page of a tornado advertisement of the Phoenix, of Brooklyn, N. Y., of 1882 or 1883.

25. These publications have recently been followed up by John P. Finley's tornado maps for the several states, which are worse than even the sensational advertisements of the tornado insurance concerns.

As the author's position in the Signal Corps is given under his name on the title-page, and as in the preface he assures us that "the information presented in this manual is the result of many years of labor, collated under the supervision of the Government, and published with the permission of the Chief Signal Officer of the Army," the tables and maps are intended to be taken by the public as deserving confidence, as exposition of facts.

26. If this were not already bad enough, the author, Lieutenant John P. Finley, in the same preface to his Iowa Tornadoes, intimates that the tornado story has not been half told; for he says: "It cannot be assumed that the accompanying tables contain the record of every tornado that has actually occurred in the State of Iowa during the past fifty-one years, but it may be said that all available sources of information have been exhausted."

27. The trouble is that these sources of information "have been exhausted" without using scientific criticism, and the result is the publication of Iowa tornadoes that had no existence whatever in fact. There are long drawn tornado tracks on Finley's map along which a tornado never traveled.

While it is perfectly true that for lack of data of observation no one can record and map all tornadoes that may actually have occurred, it is certainly improper to publish as tornadoes other storms or entirely harmless phenomena.

28. I here give a reduced copy (half size of the original) of Finley's tornado map of Iowa, referred to. I have added the order number from his Table III, so far as I was able to iden-



29. It sounds almost like irony when the card of the publisher of this map says that "Every person will be interested in ascertaining where he can go to escape them" (the tornadoes). For the map shows only a few counties in middle southern Iowa as really free from tornadoes,—that is, the land of the so-called "Hairy Nation." Next to that, the northeast of Iowa is the most free from Finley's tornadoes.

30. The county of Johnson, in which is located this Central Station, and where I have resided for nearly thirty years, seems to be specially threatened by tornadoes, according to Finley's map. For in addition to tornado 9 (August 15, 1858), the entire county is shown to have been traversed by the track of No. 2 (June 17, 1843), which is drawn through six counties and is over one hundred miles long, in an unbroken straight line. Neither of these Signal Service tornadoes ever occurred in fact.

31. Again, the apparently terrible track of No. 13, drawn over one hundred and twenty miles in an unbroken straight line through six counties, runs within ten miles of Johnson county; and by the way, this No. 13 is in Table III credited to May 22, 1873, a tornado which is very carefully described by Sergeant James Mackintosh, whose valuable report may be found on pages 1047 to 1097 of the Chief Signal Officer's Report for 1873. From the data there given I have plotted the track of this tornado, as will be found on my map (§ 74); it forms a most remarkable, curved track, entirely confined to the two counties of Keokuk and Washington. It measures, at most, sixty miles in length, from beginning to end. It is strange indeed that Lieutenant Finley, while "exhausting all available sources" of the Signal Service, should have overlooked the report of his fellow officer, and converted a most remarkably curved tornado-track of less than sixty miles into a straight track of over twice that length, and running clear through three additional counties in which no tornado occurred at all at that time! It is, indeed, mortifying to be compelled to point out such outrageous blunders, which seem to have but one result, namely, that of causing sensational fright to our own people, driving them into expon-

sive tornado insurance, and to scare eastern people from coming to Iowa.

32. Further, the tornado track corresponding to Nos. 64 and 65, and extending in a straight line unbroken for a distance of one hundred and forty miles southeastward, strikes our county of Johnson in its southwestern corner. These numbers answer to the date of June 17, 1882, the Grinnell tornado, about which further on; but it may be said right here, that there was no tornado track like the one represented at all, that no tornado traversed the whole or part of Iowa county, just west of Johnson, and that of course no tornado occurred in Johnson county on that date. The little tornado track, No. 83, some twenty miles long, also has a threatening course towards Johnson county, but as the same has nothing but a thunder-storm for its basis, we shall say nothing further about it.

33. The tornado track, No. 81, one hundred miles in length, comes also within ten miles of Johnson county; it has been drawn through six counties, traversing two of these completely. The corresponding date is July 4, 1884. On that date there was a minute tornado in Hardin county, recorded as No. 78 in the table of Finley, and entered under this number on his map. But there was no tornado whatever to correspond to track No. 81; this hundred-mile tornado track which indicates that many miles of devastated territory, destroyed houses, killed and maimed people, is one of the many meteorological calamities that have fortunately never existed outside of the Signal Office at Washington, and it is greatly to be regretted that they have not been confined to the same.

34. By thus considering the pretended tornado tracks in and around Johnson county, and showing not only how utterly devoid of value the Signal Service tornado map is, but also how grossly and absurdly everything has been magnified, even in absolute conflict with the official published reports of the special investigators of the Signal Corps in the field, we may be excused from further general consideration of this tornado map and tornado table of the Signal Service.

hasty examination of the data in question, and with a view to calling the attention of meteorologists to this important point. If there is a constant relation between the movements of the upper air currents, and the velocity of translation of storm centres, as the writer believes, a definite elucidation of the relation would add very greatly to the importance and value of the observations of upper clouds in advance of storm centres.

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## TORNADOES AND DERECHOS.

[CONTINUED.]

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BY DR. GUSTAVUS HINRICHS,  
Director Iowa Weather Service.

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35. I shall only refer to a couple of systematic errors, because they undoubtedly permeate and vitiate the entire statistical and geographic work on tornadoes now carried on by the Signal Service.

36. It seems to have become a settled practice at the Signal Office to catalogue reputed tornadoes, with a view of obtaining as long and extended a list as possible at any cost to scientific value of the result.

The method adopted by the Signal Service in drawing up their tornado list, if applied to the record of meteorites, would require a separate entry for each meteorite of a shower. What an absurd list we should have for showers like that of Amana, Iowa (February 12, 1875), not to mention the shower of Pultusk.

37. The only truly scientific method of tornado record will be by *date*, as is practiced in regard to meteorites. Everything pertaining to track and multiplicity of tornadoes, should remain matter of detail; it will give abundant room for study, indeed.

38. Let us now apply this principle to the notable tornado date of April 14, 1886. By reference to my special Bulletin, reprinted on page 72 of my Iowa Weather Report for 1886, it will be seen that tornadoes visited twelve counties of western Iowa, and that the tracks form, at most, three parallel lines on which tornadoes started at two or three different points, at dif-

ferent times. At most, some six separate tornadoes may be distinguished for this date in Iowa.

Now, in Finley's Table III, and correspondingly on his map, we have nineteen distinct entries, namely, numbers 96 to 114, inclusive. In this list Carroll county figures twice; the one tornado being timed at 5 p. m., the other at 5:05 p. m.; the one traveling northeast, the other is said to have traveled north-northeast.

Taylor county is favored with four distinct tornado entries for that day, all traveling northeast, or N. N. E., or N. 40° E.; one being credited to the "afternoon," another to 8 p. m., and two to 8:30 p. m.; the width of path is given at 150 feet, 260 feet, 300 to 500 feet, and 1,320 feet. There is no evidence whatever that there was more than one single tornado in Taylor county on that evening; there is no reason to credit that county with four "great demons of the air," to use the phrase whereby Finley's book is seeking the public.

Cass county is credited with two tornadoes (No. 97 and 107), both at 4 p. m., the one going N. E. and the other N. N. E.; the one making a track 100 to 350 feet wide, the other 1,320 feet wide. Does Finley have any evidence that Cass county on that day and at that hour was being devastated by two distinct tornadoes? So far as I know, there was only one tornado in Cass county at that time, and neither the interest of science nor that of the people of Cass county calls for the manufacture of additional "demons of the air" by the officers of the Signal Service at Washington.

In concluding this subject, I only add that Audubon county gets three and Fremont county two tornadoes (99, 112), in the list. Seven other counties get one each.

39. The tornadoes of June 17, 1882, are credited with only two entries in Finley's table, namely, for Poweshiek county (No. 64, the Grinnell tornado), and Boone county (No. 65); but on Finley's map we find that remarkable straight track of one hundred and forty miles in length, traversing six counties. Of course, there was no such a track at all; but, per contra, real

tornadoes should have been credited to Story and Jasper counties also, if they are to be denoted by counties at all.

40. The most remarkable tornado date of April 21, 1878, is credited by Finley with three distinct entries (Nos. 28, 29 and 31), and their tracks on the map are also nearly correct, being probably taken from my published description and map. But this record is in conflict with the county plan, which under No. 29 would require the mention of Woodbury, Ida and Sac, as well as Monona and Buena Vista; under No. 31, Sac and Calhoun should be credited, as well as Crawford and Pocahontas.

41. After looking at this important subject from all sides, I see no reason to deviate from the method of making a specific entry for actual tornadoes only by the *date* of the same, reserving every further particular to the description.

42. We will next examine the official tornado record for Iowa, before us, in order to strike from the same all storms that were not tornadoes at all, but especially derechos. To complete this work would require more time and space than at hand; for it takes more research and pains to prove the fallacy of an entry of this kind than simply to put that entry down on the tornado list and print it. I shall therefore restrict myself to some of the more notorious cases.

43. For August 6, 1877, at 2:30 A. M., we find a tornado (No. 25) credited to Pottawattamie county, about which it is said that it traveled towards the southeast. This was, in fact, a north-west gale, and is described on page 27 of my Weather Report for 1877.

44. Buchanan county is credited with a tornado (No. 44), having traveled northeastward at 4:30 P. M., on May 25, 1880. The observer at Independence records only a heavy thunder-storm at 5 P. M. My Bulletin gives no tornado.

45. A most notable derecho occurred late on June 28, 1881. It was fully described in my June Bulletin of that year (pp. 34, 35), under the heading "Iowa Squalls"; see also Report for 1881, pp. 272, 273. The map of this derecho was published in my Annual for New-Year, 1883, and Report for 1882, p. 12. The same is inserted on next page.



This derecho was very severe in Cherokee county, which may account for the fact that this county is credited by Finley with a big tornado (No. 56) for this date. The hour given is 4 P. M., which is earlier than the derecho; but all that is said is that the cloud was of funnel form,—its "path" is left blank.

46. The widest path of destruction of any tornado in Iowa, namely, the extraordinary width of 5,280 feet, is credited to the tornado (No. 67) which is said to have traversed Buchanan county in a northeasterly direction at 5:27 P. M. on June 22, 1882. The track of this tornado is drawn over 25 miles diagonally in Buchanan county, on Finley's map, as will be seen from our photo-copy thereof (in § 28.)

This was a regular derecho, and is mentioned as a squall in my Press Bulletin, No. 110, issued to the press of the State on July 4, 1882, and reprinted in the Report for 1882, on page 97.

Evidently, the tornado track drawn by Finley is simply the derecho-front about the instant when the storm struck Independence. This derecho extended far beyond Independence southeastward, even reaching beyond Iowa City. There was no tornado in Iowa on that day. Even the newspaper reporters state that it was a straight blow. What a sad day it would have been for the people of Independence and Buchanan county if this "Signal Service Tornado" had been a real tornado and cut that swath of destruction five thousand feet wide and twenty-five miles long!

47. Tornadoes Nos. 68 and 69, credited respectively to Sioux and Dallas counties, for June 24, 1882, were only manifestations of the derecho of that date, mentioned in the same Bulletin.

48. Tornado No. 80 figures very largely on Finley's tornado map, extending for some 70 miles through three counties in the northwest (Sioux, Plymouth, and Cherokee), and is ascribed to July 4, 1884, 5 P. M. There was no such tornado, but only a derecho, in these counties. It is claimed by the papers that a small tornado was seen in these regions on that day, and in my Bulletin for July, 1884, I have admitted this, although upon repeated study of all information I am strongly inclined to doubt that a minor tornado (or perhaps minute tornadoes) did occur. The destructive effects described plainly belong to the derecho only, at least so far as I have seen them. There can be no possible doubt but that the general direction of the "tornado path, No. 80," on Finley's map, only marks the blow of the derecho.

49. Tornado No. 83 figures very prominently on the map in Poweshiek and Iowa counties, for July 23, 1884; it is credited with a path 660 to 2,640 feet wide! So far as I have been able to learn, it was no tornado at all. Its main direction southeastward, as well as great width of path, plainly indicate that a derecho has been mistaken for a tornado.

50. I do not consider it necessary to continue this thankless labor.

What with our western "weather prophets" predicting dire storms from the relative position of the planets, and our Signal Service inventing and publishing immense tornadoes, cutting paths from 2,000 to 5,000 feet wide for thirty and more miles through Iowa, the honest student of the weather in the West has really a hard time of it, and might well be excused if he should become impatient.

51. It will now be necessary to try to eliminate other phenomena, even not *storms*, from the pretended list of 123 tornadoes in Iowa published by Lieutenant Finley under the authority of the Signal Service.

The mass of data is so bulky, and the information so indefi-

nite, that it is difficult to adopt any criterion that will remove all the spurious tornadoes.

52. In 36 cases, nothing is said about the path as to its width, and the only statement made involving the possibility that the record refers to a tornado is the "funnel" cloud-form.

But all who have watched the clouds carefully, especially during storms, will admit that such a statement, especially when coming from storm-frightened people, or anxious tornado reporters, deserves very little confidence. Even the floating detached rain-clouds from which a more or less notable streak of rain seems to descend, is, no doubt, often taken for a tornado cloud; it takes but little imagination, or fear, or desire, to report a tornado, to see a "funnel cloud" in this innocent phenomenon.

The 36 cases of "funnel clouds" without indication of path of destruction, recorded in the tornado list of Iowa, are Nos. 1, 12, 13, 19, 26, 33, 36, 41, 43, 45, 48, 49, 50, 54, 55, 56, 57, 70, 73, 74, 75, 77, 80, 81, 82, 84, 86, 88, 93, 94, 109, 112, 114, 115, 117, 119. This last one is marked a "waterspout," sufficient to let it out of the tornado list without question.

53. Another list of not less than 32 entries fails to indicate that either cloud form or destructive path has been noted; probably every one of these entries should be removed from the tornado list of Iowa. These are Nos. 8, 9, 11, 14, 15, 18, 20, 21, 22, 23, 24, 25, 27, 32, 34, 35, 39, 44, 46, 58, 61, 68, 69, 72, 79, 87, 89, 91, 92, 95, 116, 118.

54. But it must not by any means be supposed that the positive statement of a path of destruction—even one, two, or five thousand feet wide—will allow us to consider the entry properly that of a real tornado. Thus tornado No. 2, said to have traversed Johnson and Cedar counties on June 7, 1843, at 5 p. m., in a direction E. 20° N., as funnel cloud, and to have cut a path a thousand feet wide, has not existed. I have carefully examined the issues of the weekly *Iowa Capital Reporter* for June 3, June 10 and June 17 of 1843, without finding a word about any storm, or cyclone, or tornado, or waterspout, in the same. Now it is not possible that a whirlwind could cut a swath a thousand feet wide through the county in which is located the capital

of a territory, without being mentioned at the time in the weekly paper of that live town.

55. Indeed, I need only refer to § 46 to prove that the record in Finley's table of a path-width of over five thousand feet is no evidence that a tornado has really existed; and I have shown repeatedly that a tornado track of from say 30 to 100 miles in length, drawn on his map, does not give the least assurance that any tornado ever traversed that part of our State.

56. Now, the 36 "funnel clouds" without anything indicating the destructive presence of a tornado, and the 32 entries on Finley's list in which neither funnel-cloud nor path is given to indicate that there was a tornado, aggregate 68 entries, which, no doubt, nearly all should be entirely removed from the tornado list of Iowa.

This is more than half the total number, 123, recorded by Finley.

57. But among the 55 remaining entries we have noticed many entirely false, though both funnel and destructive path are recorded,—such as the tornadoes by which the Signal Service has devastated Johnson county on June 7, 1843 (No. 2), and August 18, 1858 (No. 9). Another lot were simply derechos, although figuring on the Finley list with the widest paths of destruction, up to five thousand feet. It is safe to say that not over one out of four tornadoes that, according to the authority of the Signal Service, have cut a swath of destruction through the plains of Iowa up to a mile in width for a distance of over one hundred miles in length, have ever existed at all. In other words, three-fourths of the tornadoes by which the State of Iowa has been afflicted, according to Lieutenant Finley, are nothing but "Signal Service tornadoes," and have happily never existed outside of the Signal Office at Washington.

58. As the Signal Service publications ought to be taken as authority, the exposition here given of the utter unreliability of the same on the subject of tornadoes is of the utmost importance both to science in general and to our people in particular. The tornado lists for the other States of the Union are, of course, no more reliable than those for Iowa; and accordingly the "Six

Hundred Tornadoes" of the Seventh Professional Paper of the Signal Service probably should be cut down to say one hundred or at most one hundred and fifty.

59. Before closing this, to me very disagreeable work, I am compelled to notice that Finley inflicts on our people quite a tornado danger for midsummer, and also for midwinter. Now, it is of course of the highest importance to the peace of mind of our Iowa people to know whether the Signal Service tornado danger of winter and midsummer exists, or whether they need fear no such visitations during the seven months which I claim to have found free from tornadoes.

60. The pretended winter list gives two cases for November (Nos. 72, in Greene, and 95, in Louisa county), two cases for February (Nos. 16 and 17, both ascribed to Van Buren county), and one case in March (No. 26, in Crawford and Sac); in all, five winter tornadoes.

The pretended midsummer list is much more extensive, comprising five for August (Nos. 9, 25, 59, 122 and 123), and seven for July, after July 4th (Nos. 8, 15, 58, 70, 83, 84, 94); in all, twelve midsummer tornadoes.

61. Now, about Nos. 72, 95, 8, 9, 15 and 58 nothing specific has been said indicating that they may have been genuine tornadoes.

Nos. 26, 70, 84, 94 are merely said to have been funnel-clouds. Nos. 25, 83 and 84 were no tornadoes at all, as we have shown. No. 9 had no existence, not even as a severe storm. This wipes out twelve of the seventeen cases given.

62. Nos. 122 and 123 are insignificant on the face; Nos. 16 and 17, for Van Buren county, refer probably to but *one* case, for the entries are nearly alike, except that No. 16 is *without date* for 1875, while No. 17 gives date February 27, 1876. By turning to my Report for 1876, p. 30, it will be seen that at this time there was but the high northwesterly wind, following a marked low barometer. This opinion was expressed by me at the time, though observer William Craig, of Keosauqua, Van Buren county, speaks of a "tornado"—but as he describes the damage done, I was unable to accept the name of tornado.

63. Of the total 17, only one entry is left, namely, No. 59, August 5, 1881, Clay county. By reference to my Press Bulletin, No. 99, for August, 1881, this will be noticed to have been a derecho (squall), and is more fully described in my Bulletin for August, 1881, pp. 45, 46, reprinted in Report for 1881, pp. 281, 282.

64. I therefore see no reason to fear a tornado during midwinter or midsummer in Iowa, and maintain that periodicity of Iowa tornadoes given above (§ 16, 17).

[TO BE CONTINUED.]

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## DEFLECTION OF HORIZONTAL MOTION DUE TO THE EARTH'S ROTATION.

BY M. W. HARRINGTON.

The demonstration that a deflection of horizontal motion must result from the earth's rotation, and the determination of the direction and amount, have been frequently made, but they are generally of such a character as to require a knowledge of the calculus. Those who are familiar with this branch of mathematics can get a full discussion of the subject in Professor Ferrel's various writings—in the "Astronomical Journal," and elsewhere, but especially in his "Recent Advances in Meteorology,"—and they will find two or three discussions of the subject in previous volumes of this JOURNAL. A highly ingenious demonstration, without calculus, can also be found in German, in Dr. Sprung's "Meteorologie," as well as one with the use of the higher mathematics. As, however, many meteorological readers do not find it easy to read the higher mathematics, and do not possess Dr. Sprung's excellent book, I venture to lay before them a demonstration which is simpler than Dr. Sprung's and which I have not found in my reading in English. It is given by Dr. Günther in his "Lehrbuch der Geophysik," who attributes it to Buff, with modifications by Zöppritz.

Let us suppose that a material point would move in one second from *A* to *D* (Fig. 1) by its own velocity, and that during