J. P. Finley: The First Severe Storms Forecaster[1]

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second of a two-part series

1. Finley's theories on tornadoes and tornado forecasting

Finley's career as a military meteorologist is notable for his continuing struggle to convince the Signal Corps that tornadoes could be predicted. When Finley departed from the Weather Bureau in 1892 to become a full-time infantry officer, he left behind a base of concepts that would be mulled over through the years by those interested in severe storms. His works would be cited as additional information became available with the advent of upper-air observations and reconstructed theory.

Finley proposed that the topography of the Great Plains was most conducive for the meeting of contrasting air masses that contributes to tornado formation. He also recognized the presence of "an elongated barometric trough" in storm systems that produced the tornadoes. Figure 1 is a map from Professional Paper No. 7 (Finley, 1884a). Finley used this map to substantiate his argument that severe storms occurred at the juncture of conflicting temperature and wind fields. A conventional frontal analysis of today has been superimposed to show that these contrasting temperature and wind fields were the result of an instability line (a line of thunderstorms) in the warm sector of a surface cyclone. Finley was correct in his assessment of the location of tornado formation, since a strong instability line often causes a reduction in temperature and a shift in the wind field that can last for several hours.

A methodical worker, Finley began in 1877 to compile a list of all published reports of tornadoes dating back to 1794. This list provided a base for an extensive climatology on tornadoes, which would grow during the years of his investigations and would be cited often by contemporary and future researchers in the field of severe local storms. Finley's data included a distribution of tornadoes by state, month, time of day, path length and width, translation, estimates of wind speed, and many other characteristics of tornadoes. Along with this climatology Finley set forth suggestions for a method of investigation after the occurrence of a tornado (known today as a tornado survey), and provided safety precautions for those who found themselves in the path of a tornado. He also suggested the construction of tornado cellars or caves for persons living in regions frequented by tornadoes and the ringing of church and school bells "in some peculiar manner" to forewarn the approach of a tornado (Finley, 1884b). Although they were not the focus, embryo rules for tornado prediction also appeared. They included Finley's tenet on contrasting air masses, the frequent occurrence of tornadoes in the southeast quadrant of a low-pressure system, a knowledge of the areas with maximum tornado frequency for each state, and insight into the occurrence of tornadoes in certain regions of the country, in certain months of the year. Finley's compilation appeared in 1882 but was suppressed "on account of many typographical errors" (Finley, 1888a).

In 1884 the suppressed publication on tornado characteristics was finally published as Professional Paper Number 7 of the Signal Service. It was also in 1884 that Finley received unexpected support from *Science* (Davis, 1884a), which published a figure showing the average of three sets of charts depicting the surface pressure, temperature, and wind patterns of large tornado outbreaks that occurred on 19 February, 11 March, and 25 March 1884 (Fig. 2 here). The charts had been prepared by Finley and released by the Signal Corps. In the discussion of the figure, the editor pointed out the position of the tornadoes in relation to the cyclone center (southeast) and the warm and cold winds. He continued, "with longer and more detailed study, the smaller storms may, a few years hence, be predicted with as much accuracy as the larger ones are now."

A following issue of *Science* contained an article by Finley (1884c) in which he reported on the progress of his tornado investigations. He listed a series of relationships he observed from the information sent him by the tornado reporters and a study of the daily weather maps for the past year. Although he stated that these were the principal "results" of this study, they were in fact the first formal listing of rules for tornado prediction.

1. That there is a definite portion of low pressure within which conditions for the development of tornadoes are most favorable; and this has been called the "dangerous octant."
2. That there is a definite relation between the position of tornado regions and the region of high contrasts in temperature, the former lying south and east.
3. That there is a similar relation of position of tornado regions and the region of high contrasts in dewpoint; the former being, as before, south and east.
4. That the position of the tornado regions is to the south and east of the region of high contrasts of cool northerly and warm southerly winds—a rule that seems to follow from the preceding, and is of use when observations of temperature and dew-point are not accessible.
5. The relation of tornado regions to the movement of upper and lower clouds has been studied, and good results are still hoped for.

[1] An unabridged version of this paper appears in NOAA Technical Memorandum ERL NSSL-97.

6. The study of the relation of tornado regions to the form of barometric depressions seems to show that tornadoes are more frequent when the major axis of the barometric troughs trend north and south, or north-east and south-west, than when they trend east and west.

Finley's rules for the prediction of tornadoes appeared in print again when the *American Meteorological Journal* sponsored a contest for prize essays on tornadoes in 1888. Finley won first place in the contest with his essay, but political overtones (the imminent transfer of the weather service to civilian control), the continuing conflict between the military and civilian meteorologists of the Signal Corps, plus the low esteem in which Finley was held by his superiors, negated the opportunity to put into practice the routine issuance of tornado predictions for the public.

Finley was not lacking for critics. There were those who took exception to a particular statement or portion of Finley's publications, and there were those who entirely ignored his scope of work and postulations. Finley's most outspoken adversary was Professor H. A. Hazen, a civilian employee of the Signal Corps. Hazen, a brilliant and well-educated man, had been recruited by Gen. W. B. Hazen (no relation) to work in the study room in May 1881, having been assistant in meteorology and physics under Professor Elias Loomis at Yale University. Hazen's activities and investigations in the study room ranged from the proper exposure of thermometers, atmospheric electricity, balloon ascensions, and psychrometry to the study of thunderstorms and tornadoes. It was the latter that led him into controversial exchanges over tornado postulation with Finley.

After the abolition of the study room in 1886 by order of the secretary of war, Hazen was assigned to the records division as an assistant to Finley. The strained relations that existed between the military and civilian meteorologists at the central office of the weather service in Washington are exemplified in the public exchange between Finley and Hazen in the *American Meteorological Journal.* Hazen, in a letter to the editor, questioned who was first to mention the fact that tornadoes do not occur at the center, but rather in the southeast quadrant of an area of low pressure. He continued that credit on this point had been given to Finley's Professional Paper Number 7 (1884a) but pointed out that "the author [Finley] considers that tornadoes occur in the southwest quadrant of the low area" (Hazen, 1888a). Hazen followed with an extract of an article that appeared in the *Washington Post* for 30 March 1884, in which Hazen stated that tornadoes occur in the southeast quadrant of a low-pressure area. He concluded that "it may be wise to give it [the article] a more permanent form for reference." Finley, outraged, responded in a subsequent issue of the journal (Finley, 1888a). He methodically listed his publications between 1881 and 1883 stating that tornadoes form in the southeast or south-and-east of the low-pressure area. He explained that the original Professional Paper Number 7 of 1882 contained many typographical errors and had to be suppressed. The corrected edition of 1884 did not eliminate all the errors, among them the use of the word *southwest* where it should have been *southeast*.

Hazen retreated from his position, announcing in a following article that his priority existed in the claim of "definite

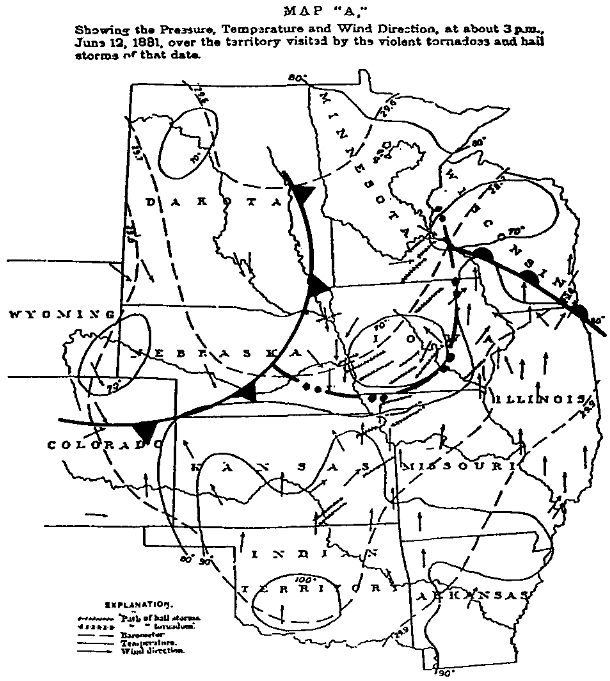

FIG. 1. Finley's surface weather map for June 12, 1881. Fronts and stability line have been added to depict present-day map analysis (Finley, 1884b).

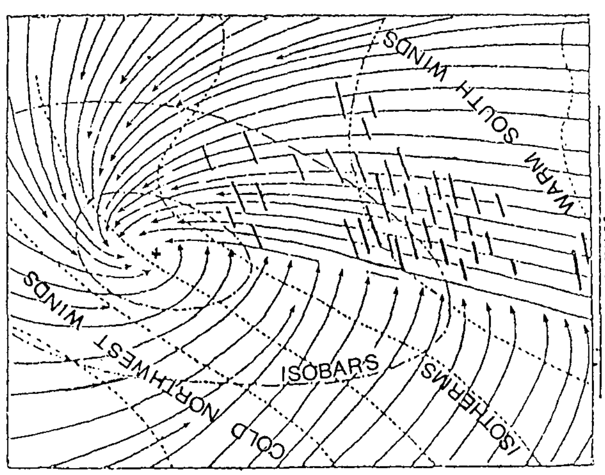

FIG. 2. Interpretation of Finley's tornado formation with respect to the surface low-pressure and wind field (after Davis, 1884a).

mention and emphatic calling attention" to this particular law of tornado development (Hazen, 1888b). He added that tornadoes occur to the southeast of a storm center from 300 to 600 miles away and where there are absolutely no northerly winds and no contrasts of temperature. Finley, still smarting from Hazen's original article, countered with "this is too low a standard by which to judge my rights in the matter . . . Of all the ways of retreating from an indefensible position, the method adopted by Prof. Hazen is both unique and original. He makes a claim which he is not entitled to" (Finley, 1888a). Since the existence and life cycle of instability or squall lines was not fully recognized by the meteorological community at that time, both parties were partially right. Hazen was looking at the broad synoptic pattern under which tornadoes form, while Finley was basing his postulation on the manifestations of the squall line.

Although Finley won the battle about who was first to recognize the fact that tornadoes occurred in the southeast quadrant of a low-pressure system, Hazen remained undaunted and continued to criticize Finley whenever the opportunity presented itself. Hazen published a book on tornadoes (Hazen, 1890) which not only highly criticized Finley's efforts in the field of tornado investigation but also disputed the writings of prominent theorists in the field of tornado and thunderstorm formation (Professors James P. Espy, William Ferrel, and William M. Davis). Besides denouncing once more Finley's stand that tornadoes form at the juncture of hot south winds and cool northerly winds, he challenged many others of Finley's observations. Hazen wrote that there was no rotation in the tornado, no updraft—"the apparent drawing up of water from a pond cannot be regarded as evidence of an uprush [updraft]," and he denied that the tornado roar was caused by the wind.

While Finley, along with others, rejected the once-popular theory that tornadoes were caused by atmospheric electricity, Hazen attributed the depluming of fowls to "the supposition that an electric charge threw off the feathers, and this seems the only way of explaining the stripping of clothes from a person [caught in a tornado]." Hazen chided Finley for making no effort to classify tornadoes as to violence or extent, "but [he] would take any funnel-shaped cloud, whether it reaches the earth or is seen in the clouds, and give it a county, date, time of occurrence, direction of motion, shape of cloud, and width of path." Finley considered the tornado a meteorological event to be recorded, no matter how weak or strong, and he came to the realization that the tornado was not the rare and special event it was believed to be at the time.

Another vocal critic of Finley was Dr. Gustavus Hinrichs, director of the Iowa Weather Service, who in an invited article for the *American Meteorological Journal* (Hinrichs, 1888) rebuked Finley for his method of compiling tornado statistics.

What riled Hinrichs was a paper on tornadoes in Iowa by Finley (1888b). Hinrichs stated in his article that "a goodly number of these tornadoes have never existed outside the archives and publications of the Signal Service, and a great many others were simulations." He accused Finley of confusing the tornado with violent thunderstorm outflow (i.e., downburst) winds and combining both storms in one set of statistics. He wrote that "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." Hinrichs proceeded to methodically dissect and discredit Finley's list of Iowa tornadoes by citing information he had gathered on individual storms during his 13 years as director of the Iowa Weather Service. He concluded that Iowa averaged one notable and one minor tornado event per year stating, "Our record averaging one real tornado a year is bad enough, and needs no amplification by professional tornado manufacturers." However, Hinrichs's list of notable tornadoes included not only single devastating tornadoes but also multiple tornadoes (tornado outbreak) that caused widespread havoc on a single day. Thus, Hinrichs was referring to the number of tornado days while Finley listed individual storms. Both viewpoints are acceptable and the practice today is to record both.

In a different area, Finley was challenged on his verification statistics for tornado prediction. G. K. Gilbert, a geologist, stated that, although Finley's work showed "encouraging progress," he wished to point out a fallacy in that Finley assumed that verifications of predictions of a rare event could be classed with verifications of the predictions of frequent events, without any system of weighting. He noted that the occurrence of tornadoes in any one of the districts indicated by Finley is highly exceptional and that their non-occurrence is the rule. This consideration was overlooked in Finley's verification system. By using dualistic prediction (conditions favorable and unfavorable for tornado activity) Finley achieved a 96.6-percent degree of success. He showed that excluding all Finley's non-occurrence predictions and using only his positive predictions gave Finley a 23-percent degree of success at predicting tornadoes (Gilbert, 1884).

Professor Hazen later challenged both Finley's and Gilbert's tornado verification schemes (Hazen, 1887). Hazen's answer was a weighting system. Hazen took Finley's tornado predictions for June 1885 and found them to be 49 percent correct. Surprisingly, this appears to be in defense of Finley. However, Hazen's concluding remarks include the statement, "It seems probable that the division of the country into districts, in each of which predictions are to be made, is hardly wise."

Finley did have his supporters. Among them was W. M. Davis, a professor of meteorology at Harvard University. Davis published an in-depth discussion of these charts (Davis, 1884b). He noted that it was possible that "the larger cyclonic circulation carries cool air over warm air, and thus produces the distinctly unstable atmospheric equilibrium necessary for the development of violent local storms." He continued, "this relation has already been more or less distinctly perceived . . . but has never had such proof as it finds in Mr. Finley's tornado charts of this year."

Support for Finley also came from a different sector of the academic field but only after he had been replaced by General Hazen as the Signal Corps authority on tornadoes. Alexander McAdie, a doctoral candidate at Clark University in Worcester, Massachusetts, won second prize in a contest on tornadoes sponsored by the *American Meteorological Journal.* In his essay McAdie rebuked the Signal Corps for not openly predicting the possibility of tornadoes and accused the weather service of "cloaking" the fact under the term "severe local storms." He added, "Nor can the commotion and alarm of a community fearful of misdirected prediction, be fairly weighed against the benefits and advantages to a community warned of the likelihood of a tornado, in that section or county, within a given time."

McAdie challenged the Signal Corps to reissue (prepare) a special chart that he called "The Tornado Chart," which was begun in July 1886 and, after two years, was discontinued for reasons not made public. The charts were prepared to assist the indications officer in locating areas of possible severe-local-storm formation. They included the 10 features or parameters listed by Finley (1886) with regions of northerly and southerly winds distinguished by heavy carbon lines (a suggestion of Finley's and one that hints of frontal analysis).

The tornado chart was quite similar to the present-day composite chart prepared by severe-storms forecasters using surface and upper-air parameters that are conducive to formation of severe local storms.[2]

2. Finley, the meteorological consultant

After his final retirement from the military, Finley became a private meteorologist, and in 1920 he established the National Storm Insurance Bureau in New York City. (This company later was renamed the National Storm and Aviation Insurance Bureau.) Using the vast accumulation of climatological data he had amassed over the years, he provided insurance underwriters with assessments of risk to life, property, and crops from tornadoes, windstorms, and hail for all areas of the country. He also provided storm-track frequencies, maximum and minimum rainfall values, and descriptions of weather conditions that increased risk to crops from insects and disease. He was well known throughout the insurance field, as his publications and lectures before various insurance groups attest (Finley, 1925). Finley also became a charter member, charter fellow, and contributing member of the American Meteorological Society. In the late 1920s he became interested in aviation weather and wrote numerous weather surveys following aviation disasters.

Finley returned to his native Michigan in 1932 and opened the National Weather and Aviation School in Ann Arbor. A 1939 brochure for the school stated, "the work covers the fields of theoretical and applied meteorology and climatology. Particular attention given to weather forecasting, especially in its vital relation to aviation. Instruction by correspondence" (Finley, 1939). The brochure also indicated that statistical compilations, weather surveys, and investigations would be conducted in the commercial, agricultural, industrial, and social fields. Finley was now 85 years old. Four years later, on 24 November 1943, at the Percy Jones Hospital in Battle Creek, Michigan, John Park Finley died. He was survived by his two daughters of his wife Julia (who died during 1930s), and by his second wife Flora C. Finley. The situation of his brother, Dr. Mark F. Finley, at the time of John Finley's death, has not been determined. John Park Finley's obituary appeared in the 26 November 1943, edition of the *Ann Arbor* [Michigan] *News*.

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[2] Finley left the Weather Bureau and active involvement in meteorology in 1892 and served as a military administrator. He did not completely divorce himself from his interest in meteorology, however. He wrote and gave lectures on the typhoons and monsoon season for the area of the Philippines. A note he sent to the *Monthly Weather Review* (MWR), which appeared in the February 1909 issue, listed meteorological terms in English, Spanish, Malay, and two Moro dialects. He had translated one of the latter into both English and Arabic, but the Arabic was omitted from the MWR note (Abbe, 1909). Finley retired from the military in 1920.

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The major portion of the material in this paper was obtained from Finley's publications, the "Finley Papers" (National Archives) and the Reports of the Chief Signal Officer of the Army. These references are listed here in generic form. A complete listing appears in NSSL Tech Memo No. 97.

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announcements (*continued from page 1505*)

meetings of interest

29–30 January 1986. NASA's Goddard Space Flight Center will be hosting its second annual Pilot Climate Data System (PCDS) Workshop on 29–30 January 1986 at the Goddard Space Flight Center in Greenbelt, Maryland. For further information contact Dr. Paul Smith, Code 634, Goddard Space Flight Center, Greenbelt, Maryland 20771; telephone 301-344-5876, or Mrs. Mary Reph at the same address; telephone 301-344-5037.

13–16 February 1986. The first national conference on technology literacy in America will be held on 13–16 February 1986 in Baltimore, Maryland. The conference is sponsored by the Science through Science, Technology, and Society (S-STS) Project supported by the National Science Foundation (NSF). Speakers who are scheduled to address the conference include: Governor Richard Lamm of Colorado; Eric Bloch (director of the NSF); John Gibbons (head of the Office of Technology Assessment); James Rutherford (head of science education for the American Association for the Advancement of Science); and Jeremy Rifkin (citizen activist). Workshops will be held emphasizing curriculum materials and instructional methods. Tutorials will also be held for educators on all levels. Complete program, registration, and accommodations information is available from Ernest Hawk, TLC Coordinator, 164 Chambers Building, University Park, PA 16802; telephone 814-865-9951.

April–October 1986. The Society for the Advancement of Material and Process Engineering (SAMPE) announces conferences scheduled for 1986. From 7 to 10 April 1986, SAMPE will sponsor the 31st International Symposium/Exhibition on Materials Sciences for the Future in Las Vegas, Nevada. On 10–12 June 1986, the Seventh international SAMPE conference, entitled "High Tech—The Way to the Nineties," will be held in Munich, Federal Republic of Germany. The 18th international conference, entitled "Materials for Space—The Gathering Momentum," is scheduled to take place on 7–8 October 1986 in Seattle, Washington.

14–17 April 1986. The American Society of Mechanical Engineers (ASME) solar-energy conference will take place at the Grand Hotel, Anaheim, California, on 14–17 April 1986. For further information contact the ASME Meetings Department, 345 East 47th Street, New York, NY 10017; telephone 212-705-7795.

23–27 June 1986. The Conference on Precision Electromagnetic Measurements (CPEM) will take place on 23–27 June 1986 at the National Bureau of Standards, Gaithersburg, Maryland. The conference is sponsored by the U. S. National Bureau of Standards, the IEEE Instrumentation and Measurement Society, and the Union Radio Scientifique Internationale. Papers will be presented describing original work covering the theory, design, performance, simulation, or application of electromagnetic standards, measurements, techniques, instruments, or systems. Deadlines for submission of papers is 1 February 1986. Abstracts of papers should be sent to Norman B. Belecki, Technical Program Chairman of CPEM '86, National Bureau of Standards, B146, Metrology, Gaithersburg, MD 20899; telephone 301-921-2715.

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