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I. COMMENTARY

Storm Track begins this issue with a nod to Dave Gallaher of Coral Springs, Florida who is a subscriber and chaser as well as a musician and business manager for a small band, "Group Cameron." Professor Dave Jones and I stopped by, on our way west this spring, to visit with Dave and the band at the Viking Motor Lodge in Sunset Hills, Missouri (St. Louis suburb). The band tours and plays across the southeast and Midwest. We had a brief but, nice visit and got to see the band during a practice session. Dave presented the editor with an official band T-shirt (see illustration). If memory serves, the band was planning to do an original composition on storms. Dave's job as business manager keeps him occupied most of the day, and, with evening performances, his main chasing experience has been at night. In one of his letters, several interesting storm encounters were relayed.

Between Joplin and Springfield, Missouri on June 19, 1980,"I ... came close enough to help a spotter pull his car out of a ditch! It seems that the vortex was inside a rain shaft and caught the spotter headed west, spun him back to the east and off the road. I had been watching the cloud base, traveling behind the rain shaft, and had considered driving into it a couple of times. Glad I didn't!"

"Ironically, after several years of chasing in the Midwest, and south with no results (some very near misses), after arriving back home in Ft. Lauderdale, my 10-year old daughter, Kim, came in yelling 'Daddy, there's a tornado cloud outside!'" Scoffing, I went out to find a well-formed funnel about halfway from cloud base to the ground in length, about 1/2 mile west of my home. The whole system was drifting to the S-SE, and I watched for a full 6 or 7 minutes before I had the presence of mind to ask my wife, Jo Anne, to shoot a picture (I did, however, call the emergency number right away)! By the time we shot it, it had shrunk to the final rope-stage and withdrew shortly after that. I do find it rewarding that after two fruitless years, a goad visual (and harmless!) storm was delivered to my door!!"

Good luck to Dave with the big vortex and the "good vibes."

II. ROSTER

III. LETTERS TO THE EDITOR

Roy Britt has brought to ST's attention information on a photo lab that produces laser prints from slides; Laser Color Laboratories, P.O. Box 8000, Department M, Fairview Drive, West Palm Beach, Florida 33407. For those unfamiliar with the process, laser light is used to create superb prints of very rich/deep colors (almost giving a three dimensional effect). Roy says that Laser Color will send "a large amount of information." ST notes that you can send cropping instructions with your slide(s). Prices range from $14.75 for 8X10 to $36.50 for 16X20 (add 10% for shipping and handling). Of course, your choice should be sharp/clear slides for optimum printing/enlargement.

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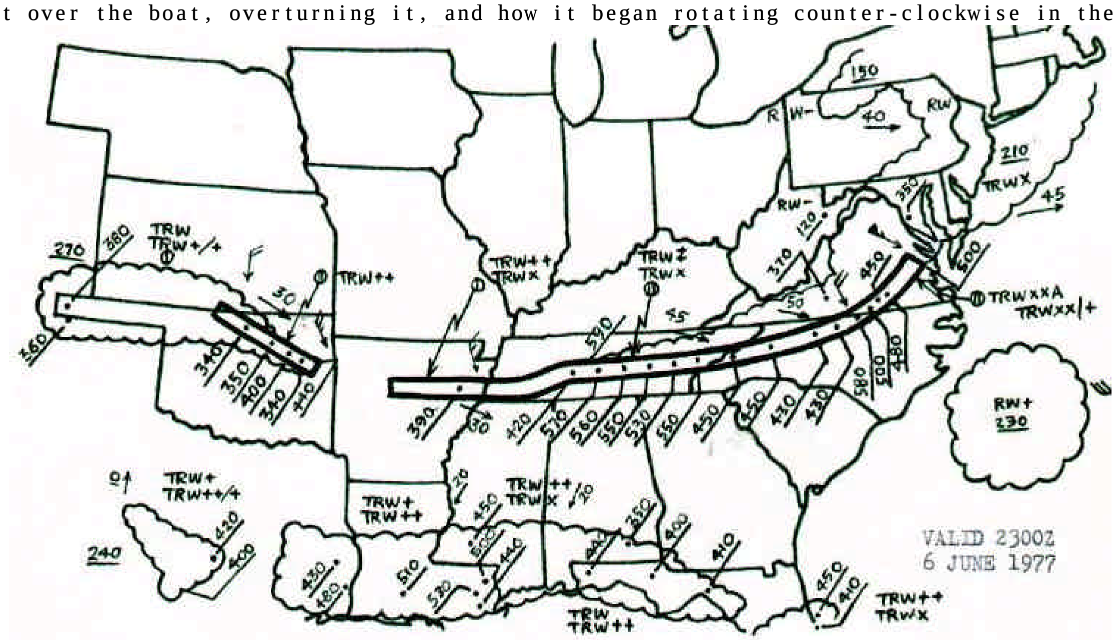
Jan Curtis sent me an interesting letter some time back on a remarkably long squall line of June 6, 1977. "The afternoon was quite hot and humid for that time o. year. I was the Navy forecaster in Norfolk, Virginia. At 2PM, the GOES satellite showed an intensifying line of thunderstorms in the extreme western part of the state. It must have impressed someone in Kansas City, because the National Weather Center issued a severe T-storm warning for a very large area over the middle Atlantic States. By 4PM, the largest squall line ever depicted on NWC's radar fax chart, stretched from Arkansas to New York. The average height of the line was well over 40,000 ft with many cells in excess of 50,000 ft. Needless to say, the telephone didn't stop ringing. Everyone wanted to know if it was really going to gust to 80 knots. I replied by saying that this line was moving eastward at 60 knots, and that several hooked echoes were clearly evident (almost on a continuous basis). I had a free moment to call home. My sister was visiting me at my beach front condo on Chesapeake Bay in Virginia Beach. Luckily, she was home. I warned her to yell out to the people on the beach to seek shelter immediately. Just then, the gust front hit my station. Gusts reached 98 MPH at Norfolk International Airport, 3 miles to the east, within a minute. My sister asked, "What are you talking about? The sun was shining brightly." There was no hint of danger. Suddenly, the phone went dead.

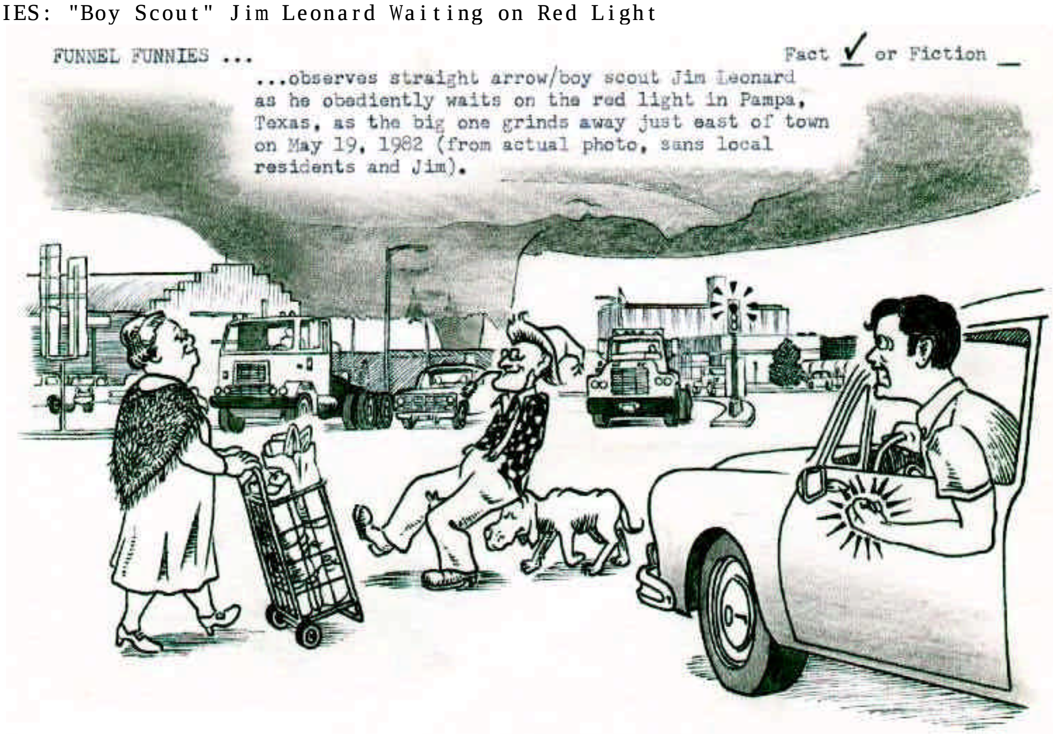
Several windows in my building shattered, when gusts fluctuated by more than 40 knots within seconds. The city was in total confusion. Trees and power lines were downed everywhere. But the city made national news that day when the 60 foot fishing boat Dixie Lee overturned in Chesapeake Bay, only 300 yards from shore. Thirteen of the 26 passengers on board drowned. I was later asked to testify during the Coast Guard's investigation of this serious accident. An apparent tornado/ waterspout was the probable cause for the disaster. The survivors told an unbelievable account of how a 15 foot (tidal) wave swept over the boat, overturning it, and how it began rotating counter-clockwise in the water."



IV. BULLETIN BOARD/COMMERCIAL MARKET -$- FOR PICTURES

V. CAMERA TIPS

FUNNEL FUNNIES: "Boy Scout" Jim Leonard Waiting on Red Light



VI. TRAVEL TIPS

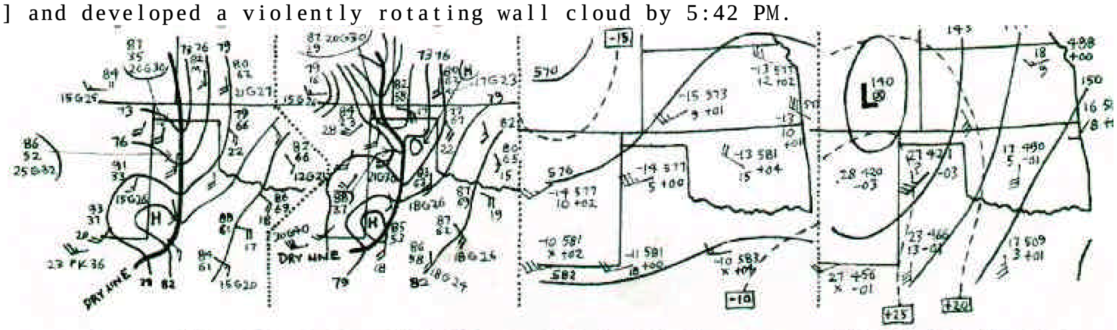
VII. FEATURE #1

CORRECTION: ST erred twice in its July 31, 1982 issue. The May 9 tornado near Dawn, Texas was photographed by Tim Marshall, as described, not Jim Leonard. Also, Eric Rasmussen was not at the Altus tornado but at the Plaska, Texas one, along with Tim. [Storm Track CD-ROM editor's note: This is fixed.]

Resuming our summary of this year's chase reports to ST, we pick up on Wednesday, May 19, 1982, which by sunset had entered the record books as a standard by which to measure all other chase days. "The best day I've ever seen." said Tim Marshall of Texas Tech U., Lubbock. He, Roy Britt and Bobby Yudnick (sp?) comprised one chase vehicle, which virtually ran through seven 50 ft rolls of 8mm movie film and four rolls of 35 mm slides. Eric Rasmussen, Bruce Jensen and Mark Mabey were also taking pictures south of the storm, and Neal Rasmussen (Eric's brother) was photographing from 10 miles SE. Unknown at that time to the other Texas Tech chase teams, Jim Leonard was in the area, filming on his own. He also took superb pictures (slides and movies). At one point, he was sighted by a chase team, but they didn't know who he was. Since then, they have been in contact and are busily exchanging information and pictures (Hey! For those of you who are shy, this is a great way to meet people!). The Texas Tech team did a very thorough job, taking extensive minute-by-minute measurements locally from the chase vehicle on surface pressure, wind direction/speed, temperature and wet bulb readings. 'Without further elaboration, here is Tim Marshall's own account.

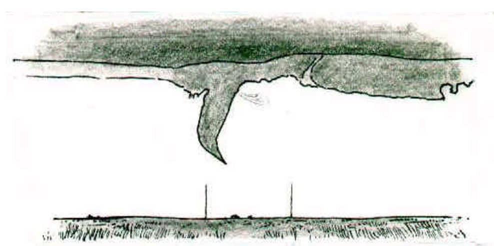
Pampa, Texas tornadoes of 5/19/82
By Tim Marshall

The Texas Tech Tornado Intercept Team ... observed six tornadoes from a supercell thunderstorm near Pampa, Texas" on May 19. "The storm initially developed ahead of a dryline bulge southwest of Borger, Texas and moved slowly eastward at 15 MPH. The storm had an extensive rain free base at 5:30 PM [all times CDT] and developed a violently rotating wall cloud by 5:42 PM.

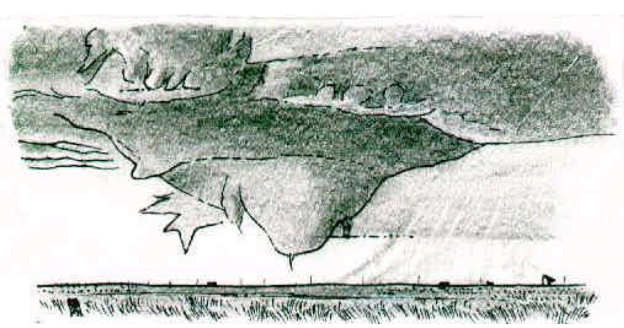


Surface 1700 CDT   Surface 1800 CDT   500 mb 00Z Thursday   850 mb 00Z Thursday
Space limitations this issue preclude larger maps, but these will give you a general idea.

At 5:48, striations were visible under a rain free base, moving rapidly toward the wall cloud. At about this time, a positive lightning bolt, struck between the updraft and the ground (one of several this day). "By 5:58, a rope shaped tornado dipped toward the ground just southwest of Skellytown, Texas and traveled eastward through the 6666 Ranch. The tornado only lasted two minutes and damage was minimal.



Then the storm appeared to go through a transition stage as another cell had merged from the south, and the circulation expanded and intensified," doubling the rain free base. "Two minutes later, at 6:09, another rotating wall cloud developed just west of Pampa. The wall cloud was ragged and wedge shaped, and at times had a laminar appearance." At Film Site #1 from 6:13 to 6:18, the pressure dropped from 29.87 to 29.79, with a mostly easterly wind at, 30 to 40 Kts. At 6:14, lightning became so intense that Tim's chase team returned to the shelter of the car for continued filming.

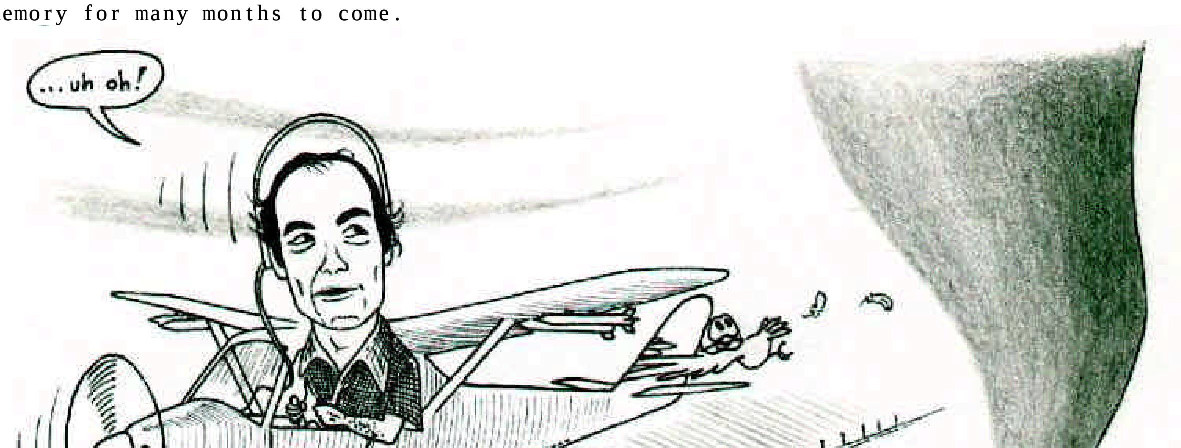


By 6:19,,a large funnel developed as rotation intensified. Several subvortices were noticed rotating around the circulation at cloud base. At 6;23, a V-shaped tornado formed four miles west of Pampa. The tornado quickly became obscured in dust and was nearly stationary. The 6:26 surface pressure at Film Site #2 jumped from 29.80 to 29.88 in one minute, and winds shifted from 100 deg at 30 kts to 270 deg at 5 kts. During this time period, I had to stop filming to wipe the rain off my movie camera lens.

By 6:30, the tornado was encircled by rain, which lasted for ten minutes. After the rain subsided, a tall, uniform-column shaped tornado was still observed. The tornado roped out and dissipated at 6:55. During the twenty-two minutes the tornado was on the ground, it had moved only 1.5 miles. The tornado damage path extended northeastward and then curved back to the northwest. The tornado had demolished a residence and several oil tanks. The residence was moved westward across a farm road, and the entire floor was deposited in an open field with debris scattering to the northwest. Several oil tanks were damaged and completely covered with mud. Trees in the area were stripped of large branches. Another circulation developed over Pampa and moved eastward at 6:41, as a large cumuliform wall cloud developed. The wall cloud was rotating cyclonically and several small anticyclonic funnels were observed moving north around the periphery of the updraft." At about, this time, and at repeated intervals, Tim drove under and out of the wall cloud's edge, experiencing almost instantaneous wind speed changes from 20 Kts to 60 Kts inflow. Apparently, and along an invisible boundary (as if an extension of the wall to the ground), the strong surface inflow abruptly drew up into the outer edge of the wall, and lighter inflow continued thereafter (at ground level) into the core of the meso-low.

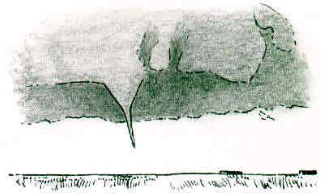
A third tornado developed four miles east of Pampa at 6:53 PM and moved slowly northeastward through a wheat field. The tornado was V-shaped and rapidly widened into a column-shaped vortex. The condensation rapidly dissipated at 6:56, but the circulation continued northeastward and transformed into a wide tornado with three condensated subvortices at 6:58. The subvortices formed on the southern periphery of the circulation and moved around the east side, dissipating on the north side. At 7:02 PM, an anticyclonic funnel developed out of the eastern periphery of the updraft and extended halfway to the ground. At 7:04 PM, a lightning bolt hit a utility pole next to the car.

At the same time, Stirling Colgate of the Los Alamos National Laboratory was approaching this storm from the south, attempting to fly close enough in a Cessna 210 to fire small instrumented/ transmitting rockets into the vortex. The objective (thus far thwarted over many attempts) is to record data on pressure, temperature, electrical fields and ionization. What, happened next has been pieced together from several informants. Flying alone at, about 2,000 ft and to within about one mile of the tornado, Stirling fired two rockets (near misses), before he found himself in a critical situation. Unlike close passes at many other storms, he was suddenly caught in a powerful inflow wind that was beginning to pull him backwards, tail first into the tornado, despite his 120 kt forward air speed. Fortunately, he was able to drop to a lower elevation into weaker inflow. Suspecting tail damage from a secondary vortex circling the main one, he managed to land in a field or on a county road. Neither pilot, nor plane suffered structurally, although ST guesses that Stirling will carry that memory for many months to come.

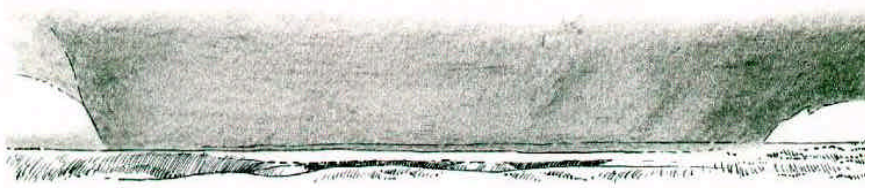


The anticyclonic funnel at 7:02 previously mentioned "moved northward and dissipated a few minutes later. Meanwhile, the large cyclonic vortex completely filled in with condensate and turned westward, becoming encircled with rain. At approximately 7:06, the tornado turned back towards the southeast and struck the Pampa Industrial Park. The tornado levelled the Cudd Pressure Services facility and Halliburton Services facility. The Cudd Pressure Services facility consisted of two buildings: a prefabri- cated metal building and an office building. The Halliburton Services facility consisted of five prefabricated metal buildings. Damage to the Industrial Park exceeded three million dollars. The tornado continued eastward, crossing Rt. 30 six miles east of Pampa and roped out at approximately 7:15. A semi-truck was tipped over on a Department of Public Safety vehicle; no injuries occurred. The tornado lasted 22 minutes, and the path was a clearly defined loop.

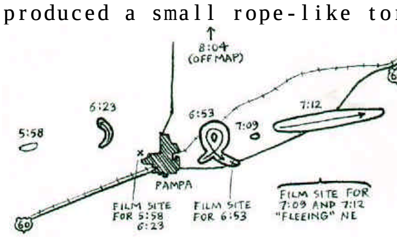
At 7:09, a small anticyclonic tornado developed at the intersection of the inflow band and the northeast periphery of the updraft, about eight miles northeast, of Pampa. The tornado was needle shaped and had a small debris cloud at. the point, which lasted only a few minutes. At about this time, the storm began to pick up speed and move east-southeastward, producing a fifth tornado.



At 7:12, a maxi-tornado developed ten miles northeast of Pampa and moved eastward. The tornado struck several farm residences and knocked down power lines. Some residences lost roofs and occasional exterior walls. The tornado appeared as a dark wedge shape, and the damage path averaged a mile in width.



The tornado crossed Rt. 60 about 12 miles northeast of Pampa and dropped off the Caprock, traveling for several more miles through sparsely populated ranchland. The chase team encountered baseball-size hail, which broke the windshield and damaged the exterior of the vehicle about five miles southeast of Miami, Texas. The tornado then dissipated around 7:40 PM about seven miles south of Miami, after lasting 28 minutes. The storm complex moved eastward, and no more tornadoes were observed with that cell. A flanking line was then observed extending northwest from the storm complex and, at 8:04, produced a small rope-like tornado, which was short lived, about ten miles west-northwest of Miami."



Interestingly, no roar was heard from any of the tornadoes this day. Also noteworthy on the mile wide tornado was the apparent absence of a wrapping gust front. Tim's chase vehicle traversed north, west and then south around the supercell. Except for moderate evaporative cooling around the base, no strong downdraft was encountered, which so large a storm might be expected to generate. Tim said the storm resembled a large rotating barrel, and the classic flanking line just wasn't there. This raises some interesting questions about the possibility of different formative mechanisms for tornadoes, where wrapping downdrafts (Lemon, Doswell; 1979) may not be the principal driving force for large scale rotation. This will be discussed and illustrated in a future ST.

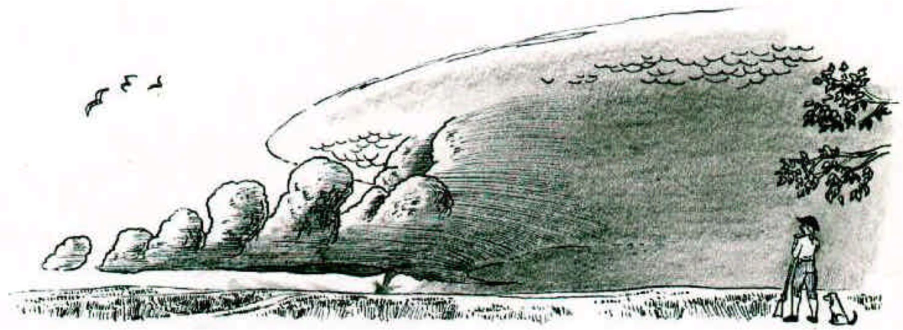
The editor has seen the movies and original slides taken both by Tim Marshall and Roy Britt. These are first class, high contrast pictures and rank among the best one day's collection -if not. the best- that I have ever seen. This was a once-in-a-lifetime storm, and Bob, Bruce, Eric, Jim, Mark, Roy and Tim were there. They share something now that the rest of us can hardly imagine. Fifty years hence, several gray haired little old men will gather around a cracker barrel in a small neighborhood bar, somewhere on the fringes of Lubbock, and recall "the storm of '82," . . . and nobody will believe them!

VII. FEATURE #2

HISTORY OF THUNDERSTORM FORECASTING
Part VI: The Thunderstorm (to 1900)

By John F. Weaver

Most events, which manifest themselves as sudden and violent. deviations from the more normal behavior of nature, turn out, to be simply local adjustments to broader scale changes. Thus, if two large plates of the earth's crust are slowly drifting past each other over the centuries, and the two should 'stick' at some spot for a time (while the forces on the plates continue), eventually the jam will release with a little jerk, and the drift will go on. To the humans living nearby, that 'jerking loose' represents a potentially disastrous earthquake, throwing them to the ground, leveling their fragile structures, and entering their history books as an incident of great importance. Such is the case with the severe thunderstorm. In reality, what are thunderstorms except the result of transferring a portion of the earth's surface heat into the atmosphere? Or rather, random 'bubbles' of convection which spring up and disappear as part of the process. And a few of these bubbles may create miniscule eddies in their wake, as they rise. Perhaps tornadoes are nothing more than just that. However, to us these tiny circulations are of great importance. Furthermore, as impossible as it sounds, the thunderstorm forecaster must take on the job of alerting the rest of us when one of these random little eddies is about to occur.



It is a difficult, decision as to where the history of thunderstorm forecasting (as opposed to forecasting in general) begins. Aristotle deduced a few facets of the thunderstorm's nature. For example, he realized that the upper atmosphere is cooler than the air near the surface, that cooling causes air to 'turn to water,' and that this process produces clouds. However, Aristotle's deductions concerning storms were, when considered in total, more wrong than right. Uncountable proverbs permeate 'weather lore' regarding the forecasting of rain and thundershowers. However, weather lore is simply a collection of regional climatology, and, as has been "pointed out in previous sections, climatology breaks down when used to predict weather on a day to day basis. As the old proverb goes: 'Climatology is what is expected ...Weather is what happens instead.' At what point then should our history begin? I think I shall (arbitrarily) revert to my argument in the first section; namely, that once the motivating force for a natural event is understood, then true prediction becomes possible. And since this approach wasn't taken until the time of the Renaissance, it is there that I shall begin this part of the story.

Even after we've established the period in which the history begins, the 'first' relevant discovery is difficult to identify. Was the development of meteorological instrumentation (beginning in 1450 A.D.) the true debut of modern thunderstorm forecasting? Perhaps. When van Helmont, in 1635, showed that water vapor was a gas different from air, did we begin to understand enough to predict more accurately? Probably not. What about Boyle's work in the 1650s or Isaac Newton's laws of motion (1687)? Well, all of these discoveries, as well as many others, were probably requisite to the beginnings of scientific meteorology, of which thunderstorm forecasting is a small subset. However, if I were to have to choose one event, a discovery that applied to the most unique characteristic of the thunderstorm, my choice would be Joseph Black's discovery (in the 1670s) that condensing water gives off heat. Latent heat. This knowledge gave us the mechanism of buoyantly driven convection.

As was mentioned in an earlier section, it required the latter half of the 1700s and the early part of the 1800s to begin to evolve a conception of the general nature of the vertical structure of the troposphere. With this knowledge and with careful observation of many thunderstorms, it wasn't long before meteorologists began to understand storms a little better. In 1841, James P. Espy of the Franklin Institute wrote a book entitled 'The Philosophy of Storms,' which was, by any definition, the first work to logically and scientifically describe the mechanism by which the thunderstorm forms and maintains itself. Some of the more important points made with regard to thunderstorms include:

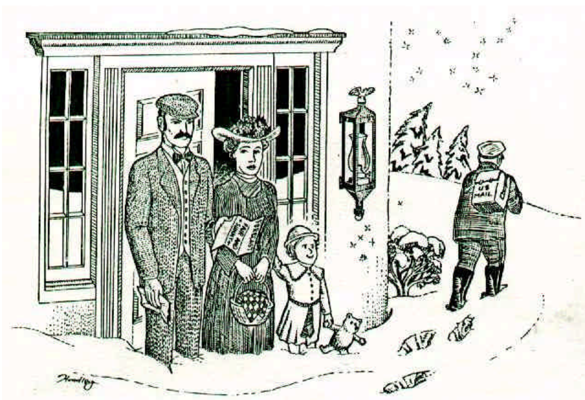
1. The thunderstorm forms when ascending currents carry vapor laden air to higher altitudes. Expansional cooling then causes condensation to form and latent heat to be released. This, in turn, causes the updraft air to be buoyant relative to its environment.
2. The height of the cloud base depends, therefore, on the dewpoint depression.
3. Environmental air continues to 'feed' the storm throughout its lifetime.
4. There is often a lowered cloud base under the most intense updraft (which he felt was due to a relative pressure deficit beneath the updraft).
5. The nearby environment is 'stabilized' by the storm.
6. The upper, drier environment mixes with the storm (which he deduced from the shape of congestus clouds).
7. Moist air can be forced to form clouds if it is moved to higher terrain by advection.
8. Hail is formed only if the updraft is strong enough to carry raindrops above the freezing level.
9. Storm motion is governed by the flow aloft.
10. Rain-cooled air produces downdrafts and outflow boundaries. Often, new convection will form via forced lifting at these outflow boundaries.
11. Fog is a cloud on the ground.
12. Following a 'cold wave' (i.e., cold front passage), convection is suppressed due to stabilization of the lower layers of the atmosphere.

With regard to other scales of action, Espy suggested that the forced upward motion near the center of extra-tropical cyclones helps convection to form there, and that the additional, buoyantly-driven upward motion of thunderstorms might (conversely) help intensify the cyclones. All in all, not a bad set of deductions from a fellow that had only the most limited amount of data to work from.

On February 9, 1870, the United States Weather Bureau was created by an act of Congress and was put under the control of the U.S. Signal Service. By 1878, 284 field stations were telegraphing weather reports to Washington, D.C. three times a day. The weather observations were collected by military personnel at each station, who soon became some of the most knowledgable observational meteorologists of all time. One of these, a Sergeant James Park Finley became fascinated with severe thunderstorms and tornadoes, and wrote several definitive articles on the subject during the 1880s. Among the many important, characteristics noted by Finley were the following:

1. Tornadic storms seem to form on boundaries separating warm from cold air masses;
2. These boundaries (and, therefore, severe storms) usually occur near the center of extra-tropical cyclones;
3. Severe storms most often occur between four and six PM; and
4. A large-scale circulation in the surface wind field is normally present, and it is likely that the severe storm converges this broad, gentle circulation into a small, violent one when the tornado is formed.

These findings constitute but a few of Finley's observations and form a set of important, contributions to the science of thunderstorm forecasting. Notice also, that Finley talked about 'fronts' (in all but name only) thirty to forty years before the Norwegians 'air mass and frontal analysis' method of forecasting.



Let's pause a moment and look at the thunderstorm forecast process at the end of the nineteenth century. Observations of surface weather conditions were being transmitted to Washington regularly. In Washington, surface weather maps were constructed three times a day. However, there were no facsimile or teletype circuits, so that these finished products could not be transmitted in very convenient format to any field stations. Thus, forecasts for the whole nation were prepared in Washington. By 1901, worded forecasts were being disseminated daily by telephone, telegraph and even by mail to nearly 80,000 users" (illustration).

In out-lying parts of the country, forecast maps could be constructed by plotting the telegraphed positions of lows and highs along with regions of forecast precipitation. This type of forecast, map was appearing in many public places around the nation, before the turn of the century.

The forecasts themselves, were based only on the rudimentary knowledge outlined above. It was known that inclement weather was associated with extratropical cyclones (indicated on maps as lows), and that the deeper the central pressure, the stronger were the accompanying winds. Also, deeper lows generally produced more precipitation. It was known that these systems pulled cold air southward in their rear quadrant and warm air north in front. Thus 'cold waves' could be forecast, as well as periods of unseasonably warm temperatures. Large regions, expected to be generally cloudless in summer, could be expected to develop thundershowers, since it was known that strong heating could provide sufficiently rapid ascending currents of air. Finley showed that stronger storms formed near the center of these systems and along boundaries separating warm from colder air masses, so that these regions could be watched for intense development. Climatologically 'normal' temperatures had been established for most cities, and -in the absence of any significant air mass changes, these could be used to provide guidance on general temperatures. However, in terms of area or intensity- specific thunderstorm forecasts, it is evident that no reliable guidance could be prepared. I would guess that the best one could do at this time was to be aware of approaching weather systems, and then apply as much as was known regarding observational meteorology. In terms of a three to six hour forecast, this method serves fairly well even today, depending on the observer's skill.

The skill of the individual. This, of course, is the problem. Most people that have a vested interest in knowing when severe storms are about to strike don't have the time to learn these skills. Not everyone can learn them. The problem that awaited the twentieth century, then, was how to forecast strong thunderstorm activity so that concerned segments of the public could be alerted in a timely fashion, without requiring considerable training on their part.

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Next ST issue: Weather related poetry, the Borger storm by Al Moller. Also, John Weaver's concluding series/article.