THUNDERSTORMS AND THE THUNDERSTORM PROJECT

Roscoe R. Braham, Jr.

Professor Emeritus, University of Chicago
Scholar in Residence, North Carolina State University

Ed. Dr. Braham, senior analyst for the Thunderstorm Project, delivered the keynote address at the NWA Annual Meeting in Cocoa Beach, Florida on Monday, 2 December 1996. This is his edited version of that presentation. The 21st NWA Annual Meeting was held in conjunction with the 50-year Reunion of The Thunderstorm Project. In February 1996, Dr. Braham gave a presentation on this subject to the 18th Conference on Severe Local Storms. It was printed in the August 1996 Bulletin of the American Meteorological Society, Volume 77, Number 8, 1835-1845.

1. Introduction

Thank you: Wes Junker, Col. Adang, Gen. Lewis, Mr. Lavin, distinguished guests, Ladies and Gentlemen. I appreciate this opportunity to kick-off the NWA Annual Meeting and Conference on Thunderstorms by recalling a few details of the Thunderstorm Project of 1946-1949. Those of us who took part in that project, and who are here to celebrate the 50th Anniversary of our Florida Operations, express our sincere appreciation to Mr. Kevin Lavin and the Officers of the National Weather Association for making your Annual Meeting a venue for our celebration.

It would be more appropriate if this talk were given by Dr. Horace R. Byers, who was director of the Thunderstorm Project. Unfortunately his physical condition prevents him from traveling. I talked with him recently and received a letter from him last week in which he sends his best wishes. He goes on to say, "The Thunderstorm Project was not just another program of research. It was a project with a goal, and that goal was to understand the inner workings of the most common and nonetheless serious mesoscale disturbances of the atmosphere, threatening the safety of air travel and the lives of many people. It was an endeavor vigorously carried out by outstanding and dedicated workers...." But that carries us ahead of our story.

In the years prior to and during World War II the aviation industry, both civilian and military, was expanding rapidly. The airplane of choice in commercial aviation was the Douglas DC-3; unpressurized, carrying 28 passengers and a crew of 3. Standard cruising altitudes were less than 12,000 ft. Navigation devices and flight instrumentation were primitive by today's standards. In those years aviation was very vulnerable to adverse weather. Thunderstorms were widely recognized as aviation's most serious weather hazard.

In August 1940, a commercial DC-3 went down in a thunderstorm near Lovettsville, Virginia, killing Senator Lundeen from Minnesota. In July 1943, an American Airlines DC-3, flying at its assigned cruising altitude of 2,000 ft msl, crashed during thunderstorm conditions near Bowling Green, Kentucky. These were not the first, nor the last, commercial airliners to go down in encounters with thunderstorms, but they must have caught the attention of Congress.

Scientific and Aeronautics advisory groups of this period had already recognized that the safety of aviation required research to learn more about thunderstorms. Two of these groups were the subcommittee on Meteorological Problems of the National Advisory Committee on Aeronautics (predecessor group to NASA) and the Meteorological subcommittee of the Air Transport Association (an association of commercial air carriers).

You will recognize names of many of the meteorologists who served on these committees: Mr. C. E. Buell, American Air Lines; Mr. Joe George, Eastern Air Lines; Dr. Ross Gunn, Naval Research Lab.; Prof. Henry Houghton, MIT; Col. Arthur Merewether, U. S. Air Force; Capt. Howard Orville, U. S. Navy; Dr. Reichelderfer, Chief of the U.S. Weather Bureau; Dr. C-G Rossby, University of Chicago; Maj. A. F. Spilhaus, Signal Corp.; and Maj. Harry Wexler, Army Air Force.

These people were among the Pioneers of Meteorology in this country. They helped focus attention on the need for scientific studies and helped to galvanize the Congress and the Weather Bureau into action that led to the Thunderstorm Project.

In Jan 1945, Mr. Bulwinkle of North Carolina introduced into the House of Representatives a Bill identified as H.R. 164 which authorized and directed the Chief of the Weather Bureau to provide safety in aviation and to direct an investigation of the causes and characteristics of thunderstorms. Section 1 of this Bill reads,

> *Be it enacted by the Senate and the House of Representatives of the United States of America in Congress assembled, That the Chief of the Weather Bureau is authorized and directed to investigate fully and thoroughly the internal structure of thunderstorms, particularly the degree of turbulence within such storms, and the development, maintenance, and magnitude of downdrafts with a view to establishing methods by which the characteristics of particular thunderstorms may be forecast....*

Sections 2 and 3 of H.R. 164 authorized appropriations for such a study and authorized the cooperation of other departments and independent agencies in it.

It was into this background that the Thunderstorm Project was born. It could hardly have come at a more propitious time. The end of World War II meant that for the first time suitable airplanes and large amounts of other equipment, and large numbers of trained personnel, were available for a major meteorological research effort.

The Thunderstorm Project seems to have been the first large-scale, multi-agency meteorological project mandated and funded by Congress. According to one report which I have seen, the Air Force gave this project a priority second only to the Bikini Bomb tests which were then in progress.

For the Fiscal year beginning July 1945, Congress included $185,000 in the Weather Bureau appropriations to begin this study of thunderstorms. The Chief of the Weather Bureau at that time was Dr. Francis W. Reichelderfer. He selected Dr. Horace R. Byers, at the University of Chicago, as Director of the new project. He also appointed an advisory committee with several of the persons I have already mentioned. In addition, there were: Mr. Alan Bemis, MIT; Dr. J. Bjerknes, UCLA; Mr. H.T. Harrison, USWB; Comdr. R.H. Maynard, US Navy; Dr. R.V. Rhode, NACA; and Dr. E.J. Workman, Univ. of New Mexico.

Dr. Reichelderfer had previous experiences with thunderstorms. In 1923, as a US Navy Lieutenant, he, along with Lt. Lawrence won the US National Balloon race because their balloon was drawn into a thunderstorm which carried their flight farther than any others in the race. Dr. Reichelderfer also became involved with thunderstorms as a forecaster for the transatlantic flights of the German Zeppelin airships.

Can you imagine flying in the vicinity of thunderstorms in balloons and airships, filled with hydrogen and trailing ropes and antennae?

In the brief time available this morning I will touch upon three aspects of the Thunderstorm Project: the research plan, major scientific findings, and the people who carried out this project.

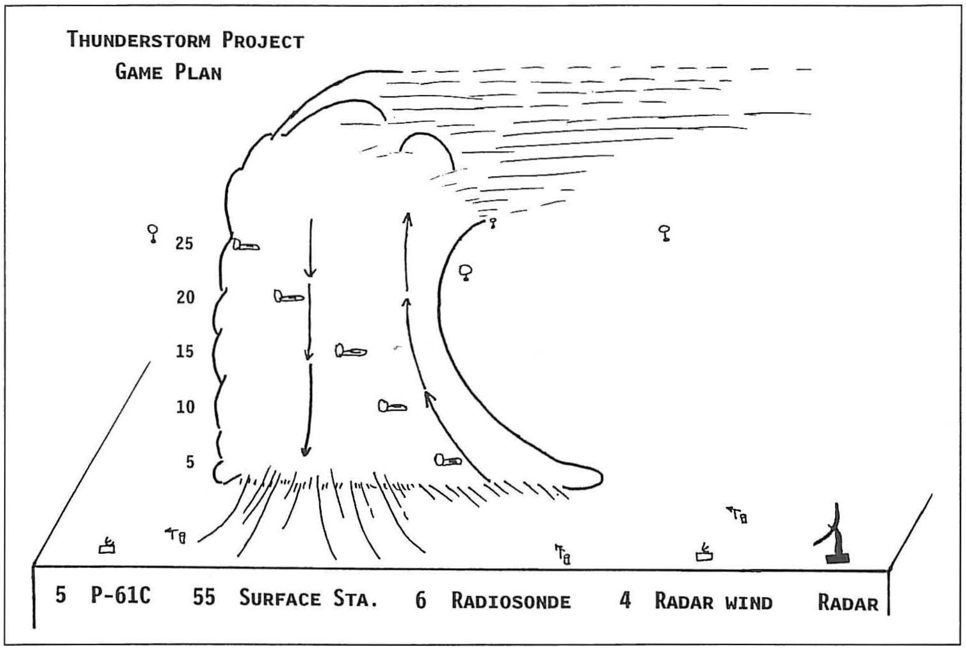


Fig. 1. Sketch showing the deployment of various equipment used to probe thunderstorms on The Thunderstorm Project.

2. The Research Plan

As we revisit the Thunderstorm Project please remember that we are going back into a time before computers were commonplace. A time when weather maps were hand plotted from data received over land-line teletypes or radio. Charts from recording weather instruments were read and recorded manually. Radiosonde flights were reduced from Speedomax records by manually picking off the significant and mandatory levels, and worked up with the help of special slide rules. (Such as that invented by John Bellamy who is here this morning.) Calculations were carried out on hand-cranked adding machines and slide rules.

The Thunderstorm Project research plan (Byers et al. 1946) called for a vertical stack of five airplanes to make nearly simultaneous penetrations through thunderstorms as they passed over a surface network of recording weather stations. The environment around storms was to be documented by taking measurements at radiosonde stations and radar-wind stations located

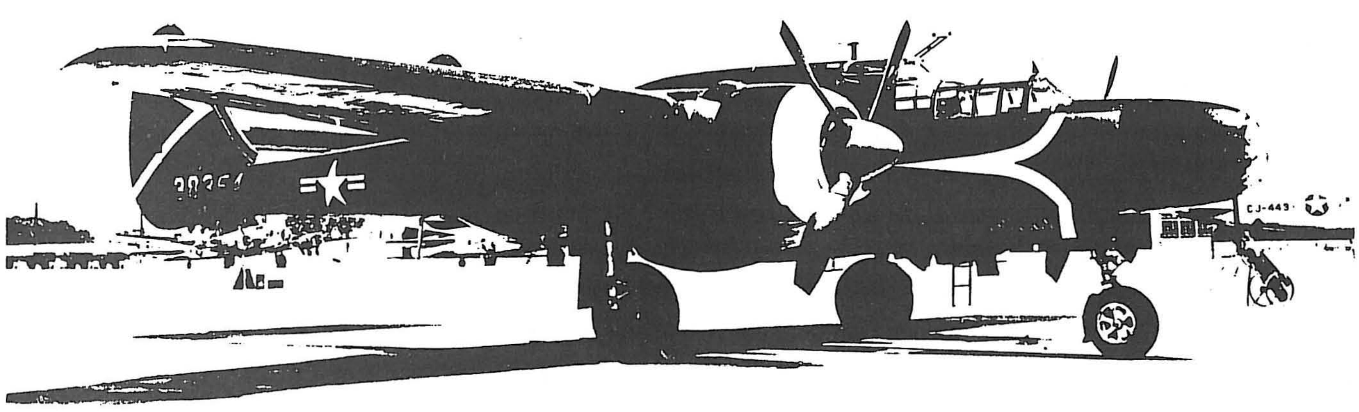


Fig. 2. P-61 Black Widow airplane used on the Thunderstorm Project.

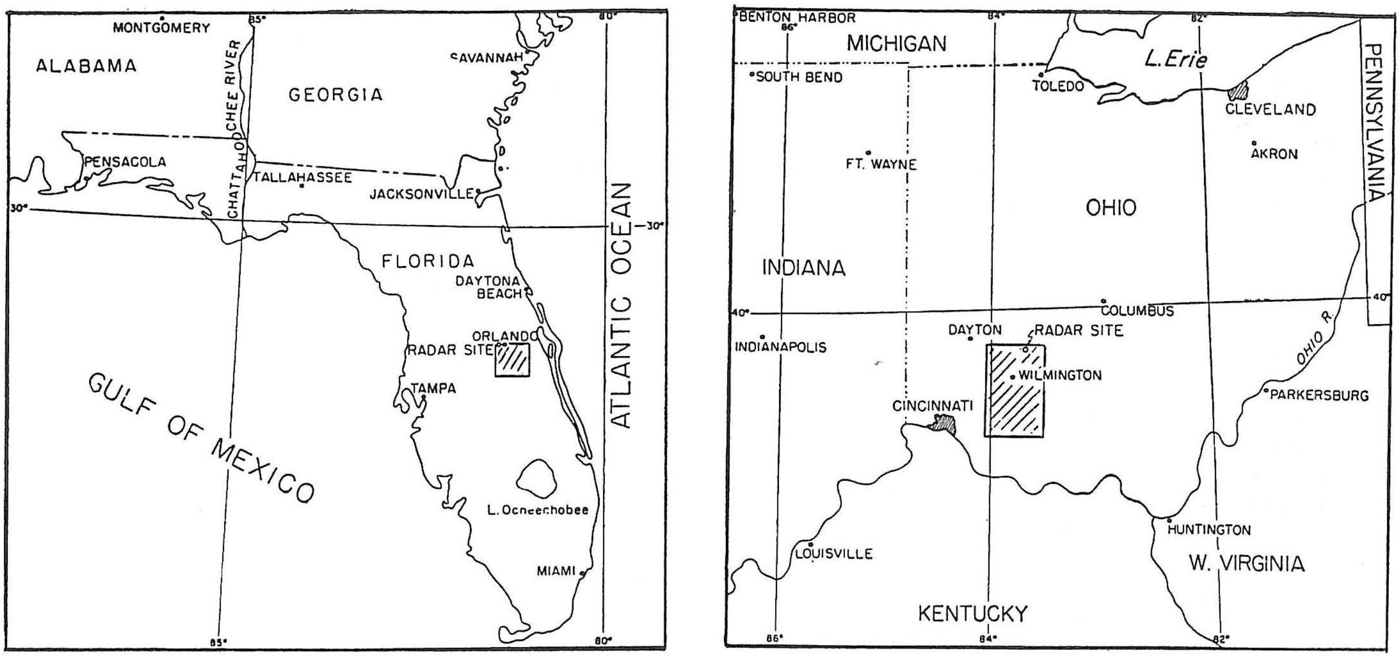


Fig. 3. Maps showing locations of the Thunderstorm Project surface networks in Florida and Ohio.

around the perimeter of the surface network. The storms were to be detected and monitored by a large surface radar which also would provide control for the planes and balloon releases (Fig. 1).

For storm penetrations, the Army Air Force provided 10 Northrup P-61C type airplanes, commonly known as the Black Widow (Fig. 2). These fighter-type planes were built to withstand strong maneuvering loads, and thus were judged to be rugged enough to fly through thunderstorms.

Although originally built as night-fighters, several of these planes were converted to weather reconnaissance duty. The P-61s carried a crew of two or three. These planes had what engineers would call a stiff wing which allowed more accurate measurements of the storms' turbulence.

One of our project P-61s is currently being restored by the Smithsonian Air and Space Museum. Another is in the Air Force Museum at Wright-Patterson AFB near Dayton Ohio. Here in the front of the room is a model of a P-61 thunderstorm research plane. This model was made especially for our reunion gratuitously by Peter Espada, a model builder in the Washington D.C. area. Many of his models are in the Smithsonian collections. Maybe this one will be there some day.

Engineers at NACA Langley Field equipped the planes to measure airplane responses to turbulence and vertical air currents. The planes themselves were the sensors of storm turbulence and updrafts and downdrafts, hence the need for a stiff wing. But, as we all know, pilots can induce aircraft accelerations and altitude changes by the way they handle the controls. To obtain valid measurements, NACA Engineers requested that pilots trim their planes for straight and level flight before entry into the storm, and to use a minimum of control inside the storm. Roughly this translated into attitude but not altitude control. Airplane engine power settings and the movements of all control surfaces (elevators, ailerons, rudder) were continuously recorded, and the pilots panel was photographed. The planes were equipped with transponders so that they could be tracked through the storms.

Portions of flight records where there was evidence for pilot's actions which would compromise the data were discarded and not used in the analysis.

I have here a short piece of oscillograph record such as that used by the NACA engineers to deduce storm turbulence and up and downdrafts.

The planes penetrated the thunderstorms at five different levels, 5,000 ft apart (5, 10, 15, 20, and 25,000 ft). The objective was to obtain the maximum number of traverses through each storm and to sample storms in all stages of development. No storm was to be avoided because it appeared too large or too violent. Storms were detected and followed, and the airplanes controlled and vectored, using a large ground radar located near the operations area. Continuous photography of the radar scopes provided information about the storms as well as locations of the planes.

Most of you will recall that the project was located near Orlando, Florida during the summer of 1946. The surface network was located around St. Cloud, on the south side of East Lake Tohopekaliga. The airplanes were based at Pinecastle AFB, which now is part of a commercial airport south of Orlando. The large ground radar was located just north of Orlo Vista (Fig. 3).

After the summer of 1946, the project was moved to Wilmington, Ohio for research operations during the summer of 1947. These locations were selected on the basis of thunderstorm frequencies and the locations of large military airbases and large military radars capable of supporting the project.

In 1986, the State of Florida erected a highway marker near the site of the 1946 operations (Fig. 4).

The environments around thunderstorms were documented by taking measurements from six SCR 658 radiosonde stations and four SCR 584 radar-wind stations located around the perimeter of the surface network. The SCR 584, a 10-cm, 250 kw radar, was used to track balloon-borne corner-reflectors to measure winds aloft. These radars were also used as a back-up to the large 10 cm ground radar. The project had four SCR 584 radars in 1946 and five in 1947.

During the two seasons combined, the Project made 824 radiosonde flights and 503 radar-wind flights. We found that we could track up to six different radiosonde instruments simultaneously by using a 3 megacycle frequency separation on the radiosondes. Thus, by making simultaneous releases from 6 radiosonde stations and 4 or 5 radar-wind stations, and by inflating the balloons for identical ascent rates, we obtained temperatures, dewpoints and winds at several points at each level around cumulus clouds and thunderstorms. These data allowed us to calculate divergences and horizontal cloud in-flow.

In the surface network we had 55 surface weather stations where rainfall, station pressure, temperature, dewpoint, wind direction and wind speed were recorded using an expanded time resolution, so that measurements could be timed to within 1 or 2 minutes.

In the analysis of the surface data, emphasis was given to pressure, temperature and wind fields; such things as the meso-low under the updraft, the meso-high under the downdraft, the relation between surface rainrate, surface pressure anomalies, and surface wind divergence. Several studies detailed the thunderstorm outflow or gust front, as well as rain temperature and the humidity dip.

Some of the project advisors were of the view that it was not possible to make meaningful measurements of air temperatures inside of clouds. In spite of this advice we tried. Pat Harney built a simple housing to shield the temperature element from contact with large cloud drops and rain. We tested it in the cloud and icing tunnels at Wright-Patterson Air Force Base, and mounted one on each of the planes. In spite of the crude nature of our air temperature system we could easily see that the updrafts were warm, and the downdrafts cold, with respect to the storm environment. The temperature housing mounted over the pilot's canopy can be seen in Fig. 2.

To explore smaller cumulus clouds the project employed an instrumented AT-6 and an instrumented Kytoon.

One of the little known aspects of the Thunderstorm Project was the use of gliders to explore cumulus clouds and thunderstorms. The Soaring Society of America provided pilots for three US Army Pratt Reed TG-32 two-place gliders under contract to the Weather Bureau. This group flew a total of 141 flights, several of which were into mature stage thunderstorms. On 25 July 1946, Paul Tuntland set a new national altitude record for two-place gliders by spiraling up inside a thunderstorm updraft. Some of you will recall that Paul was later killed while soaring in the Sierra Wave.

3. Major Scientific Findings

From the two summers' combined operations, a total of 179 storms were selected for detailed study. The P-61s flew a total of 76 thunderstorms evenly divided between Florida and Ohio for a total of 1362 storm penetrations and over 70 hours inside thunderstorm clouds. The maximum radar top of a storm flown was 56,000 ft, the modal height was between 35 and 40,000 ft.

In general, there was little difference in maximum heights reached by thunderstorms in Florida and Ohio, however storms in Florida contained much less hail, weaker updrafts and downdrafts, and had less severe turbulence than storms in Ohio.

As directed by Congress, several studies focused on the effects of thunderstorms on aircraft in flight (Braham et al. 1948; Braham and Pope 1949). At mid-levels the maximum updraft was about 5,000 ft min^{-1}. The maximum downdraft measured at 5,000 ft was about 2,100 ft min^{-1}. Fifty eight percent of the downdrafts at 5,000 ft in

Fig. 4. Thunderstorm Project marker in St. Cloud. Florida, with several of the participants in the 50th anniversary reunion. Front row, L-R: Bob Fett, Harold Dubach, John Neumann, Reggie Regelson, Harry Moses, Roscoe Braham, Harry Hamilton, and John Bellamy. Back row, L-R: Charles Lucas, Charles Nevins, Betty Lucas, John Bledsoe, marker, Harry Wheaton, Danzy Williams, Robert Muffly, Alden Clemons, William Chassee, Werner Baum, David Atlas, Fred Pope, and William Jenner.

Ohio displaced a P-61 by more than 500 ft. Measurable downdrafts were found as low as 500 feet above ground level in Ohio.

The P-61 crews reported hail on about 10 percent of the passes at mid-levels. Occasionally the hail was large enough to produce 2-3 inch dents in prop spinners and leading edges of cowling and control surfaces.

Twenty one times the planes were struck by lightning.

Storm turbulence and vertical air motion data were reduced and analyzed at the NACA Langley Lab. Analyses of other kinds of data, and the integration of airplane data with sounding data and surface measurements were carried out in Chicago during the winter of 1946-47 and from the fall of 1947 through May 1949.

During the winter of 1946 in Chicago, I constructed a device which allowed us to position aircraft data in three-dimensions, superimposed on a map of surface weather data. Using this device, and with the help of Mary Ellen Thomas, a Navy aerologist assigned to the project, it became apparent that the thunderstorms which had been flown in Florida typically were composed of a small number of individual convection cells. Each of these went through a life cycle which could conveniently be divided into three stages: beginning with a cumulus congestus dominated by an updraft; then transitioning into a mature stage containing both an updraft and a downdraft. After about 20-30 minutes this transitioned into a final stage containing only a weak downdraft (Figs. 5 and 6).

I first presented this model of thunderstorms at the Spring Meetings of the American Meteorological Society in Washington D.C. in April 1947. Later it was published in my Masters Thesis at the University of Chicago, and in the Journal of Meteorology in 1948 (Braham 1948; Byers and Braham 1948). However, because of the much wider distribution of the 1949 Thunderstorm Project Final Report, which I was honored to co-author with Prof. Byers, that is the reference most commonly cited for this finding (Byers and Braham 1949). Now it seems that this model of the internal structure and circulation in thunderstorms has become such an integral part of meteorological knowledge that it is often used without reference to its origin.

Although the cell model of a thunderstorm was developed on the basis of data collected in Florida, it was found to be applicable to Ohio storms as well.

There were many other studies of thunderstorm phenomena. Mid-level inflow into thunderstorms was clearly recognized, and its magnitude calculated. Entrainment of outside air was shown to be a fundamental part of cumulus dynamics setting the stage for double-

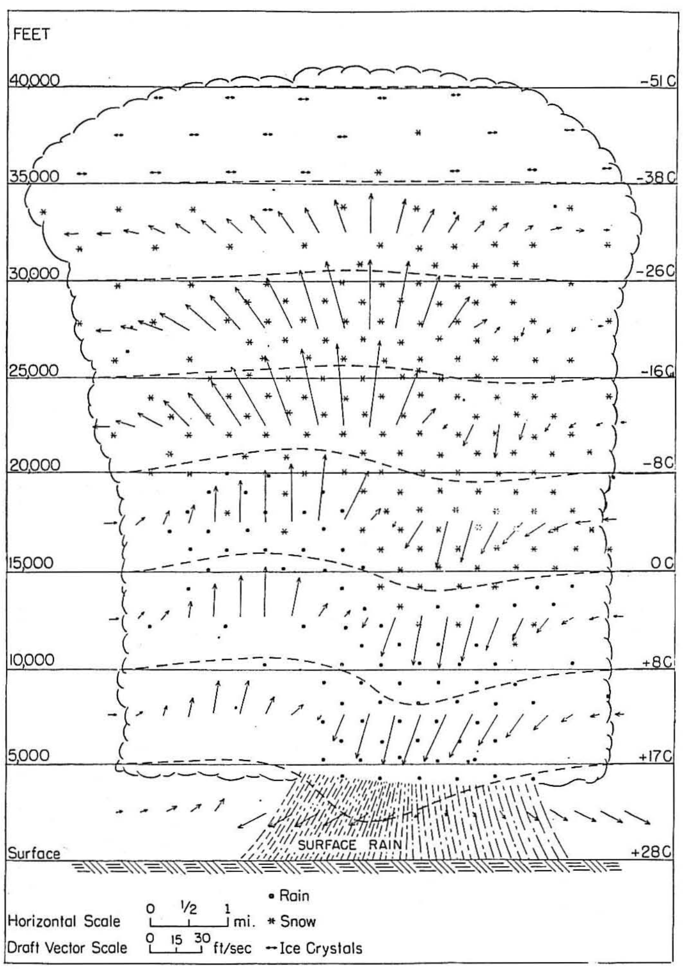


Fig. 5. Mature stage of the three-stage model of updraft/downdraft circulations in a thunderstorm cell.

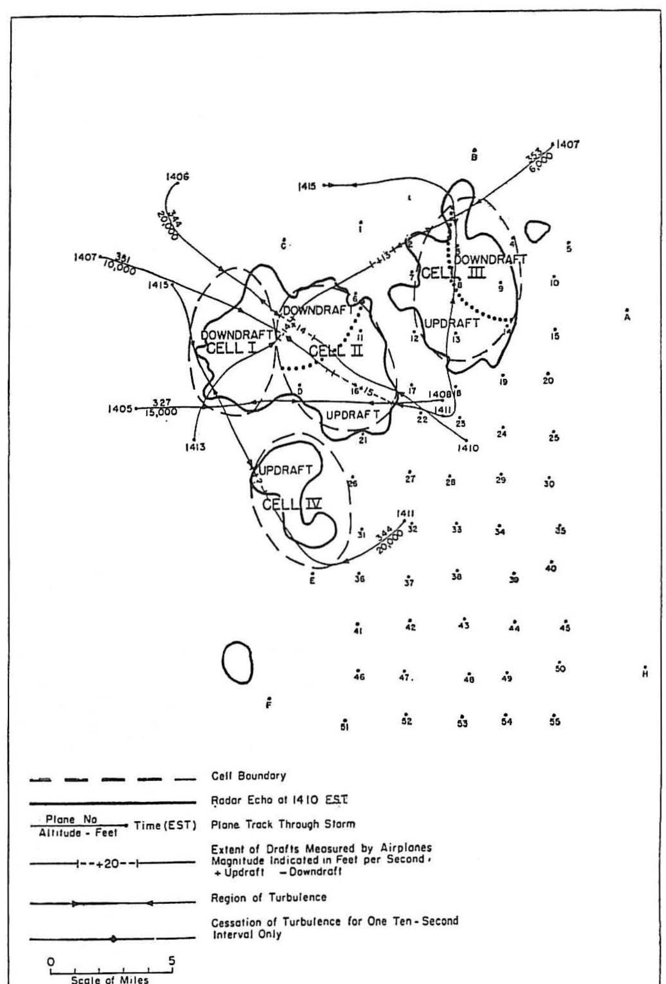


Fig. 6. Horizontal cross section showing cells in various stages of development in thunderstorm of 14 August 1947.

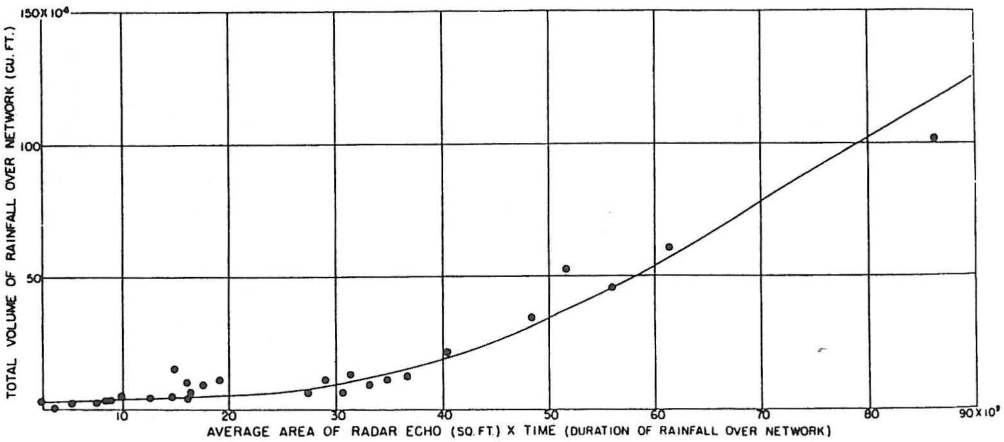


Fig. 7. Relation between time integral of echo area and surface rainfall for several 1946 thunderstorms in Florida.

action energetics, with warm updrafts and cold downdrafts in thunderstorms. The tilt and movement of thunderstorms were related to the vertical shear in the environmental wind. The water and energy budgets of typical Ohio thunderstorms were calculated. The surface meso-low and meso-high, and the gust front along the leading edge of the downdraft outflow were described. The diurnal distribution of thunderstorms over the peninsula of Florida was related to the role of sea breezes from both sides of the peninsula.

In a seminal paper, published in the 1948 Transactions of the American Geophysical Union, Dr. Byers and several project scientists showed how RHI radar data could be used to measure the amount of rain falling on the ground from convective storms. Figure 7 gives the rainfall measured by raingages in the surface network against the time-integral of 10-cm radar echo volume (Byers and Collaborators 1948). Considering the nature of our radar, it is surprising how accurately we were able to map surface precipitation amounts using radar data.

The RHI radar data obtained on the Thunderstorm Project were also used by Lou Battan to show that the coalescence process was responsible for precipitation initiation in many mid-latitude summertime convective clouds, even though the cloud tops may have been many thousands of feet above the freezing level (Battan 1953).

In my view, one of the most important findings of the Thunderstorm Project was the demonstration that radar could be used to detect, and guide airplanes around, the most dangerous parts of thunderstorms. Today this is routine; but we must recall that during World War II radar was new, highly classified, and essentially limited to the military. Military planes carried small radars for locating ships, submarines, and other airplanes. Large ground radars, such as we used on this project, were in use for airplane and missile tracking. Our project showed that severe turbulence and strong up/down motions were concentrated within the thunderstorm cells, while the interstitial cloud was essentially free of turbulence and that it was possible for an adequately trained pilot, in a suitable plane, to penetrate thunderstorms while minimizing the risk of encountering severe turbulence and strong vertical motions.

Our 1362 storm penetrations were made without an accident. This is not to suggest that thunderstorm flying is not hazardous. Thunderstorms are very dangerous. But, we showed that it was possible for an adequately trained pilot, in a suitable airplane with proper equipment, and with radar guidance, to penetrate many thunderstorms while minimizing the risk of encountering severe turbulence and strong vertical motions. There is no question but that this demonstration helped to further motivate industry in the development of weather radars suitable for aircraft use.

In an important study, NACA scientists analyzed the airplane data to see how the total variance in aircraft gust loads was partitioned between altitude within the storm, planes, and pilots. There was a clear indication that the frequency of encountering gusts stronger than about 20 ft s^{-1} increased with altitude in thunderstorms, was independent of which plane made the measurements, but was very dependent upon which pilot was flying (Press 1948).

There are several important aspects of thunderstorms which the Project did not recognize. We did not recognize a weak echo vault, or a supercell, even though they may have been present in the data. Also very little progress was made on the electrical aspects of thunderstorms. Low-level wind shear was recognized as a potential hazard for landing aircraft, but we did not dwell on the transition of the industry into heavy jets where low-level shear would became a major problem. Perhaps we were fortunate that our Florida and Ohio operations were outside the region of frequent, very large hail else our pilots might have experienced even greater hazards.

4. Thunderstorm Project Participants

Now I want to turn briefly to the people who were involved in carrying out the project. Earlier I mentioned some of those who were involved in planning and setting up this project.

I have identified about 180 persons who contributed in a substantial way to the Thunderstorm Project. An impressive fraction of these people rose to positions of leadership and prominence in American meteorology; some are sitting in this room today.

The Air Force awarded the Distinguished Flying Cross to pilots and other aircrew members for their participation in the project.

Surface and upper-air measurement operations and analysis of most of the data were carried out mainly by a group of young meteorologists fresh out of the military. They found in this project an exciting way to transition from military to civilian meteorology.

I am often asked how was it possible to accomplish so much in so little time, considering the state of instrumentation available at that time? I reply that the full credit goes to the project staff, many of whom are here today. The Thunderstorm Project was successful because its participants were eager to learn, willing to work, and dedicated to developing a career in meteorology. And, our military background had conditioned us to the importance of working toward common goals.

Those of you who were still with the project in Chicago during its final months will recall how our press-date for printing the Final Report at the Government Printing Office loomed ever larger. So we agreed to work a double shift, going in from about 9 until 5, going home for supper and returning to work until midnight or 1 am. In those days, there was no such thing as overtime or "comp" time. There was a job to do and we got it done.

At this point I will stop and we will watch a short Air Force movie of our 1947 operations in Ohio. Dan Smith has converted the film to video. I haven't seen it yet, so lets look at it together.

My time is up, Bob Maddox and others will review the increasing understanding of thunderstorms from the time of the Thunderstorm Project up to the present — suffice it to say that the contributions made since 1949 by many of you in this room truly are mind-boggling. The tools you have developed, and the things that you have learned, make our efforts on the TSP look antiquated indeed. We of the Thunderstorm Project salute each of you. I thank you.

References

Battan, L. J., 1953: Observations on the formation and spread of precipitation in convective clouds. *J. Meteor.*, 10, 311-324.

Braham, R. R. Jr., 1948: Thunderstorm structure and circulation. M.S. Dissertation, Dept. of Meteorology, University of Chicago, 40 pp.

_________, and F. W. Pope, 1949: Further studies of thunderstorm conditions affecting flight operations; Turbulence. Tech. Rep. 105-39, Air Weather Service, Washington, D.C., 31 pp.

_________, H. Moses, L. J. Battan, H. L. Hamilton, and F. W. Pope, 1948: A report on thunderstorm conditions affecting flight operations. Tech. Paper 7, U.S. Weather Bureau, Washington, D.C., 52 pp.

Byers, H. R., and R. R. Braham, Jr., 1948: Thunderstorm structure and circulation. *J. Meteor.*, 5, 71-86.

_________, and R. R. Braham, Jr., 1949: *The Thunderstorm*. U. S. Department of Commerce. 287 pp.

_________, B. G. Holzman, and R. H. Maynard, 1946: A project on thunderstorm microstructure. *Bull. Amer. Meteor. Soc.*, 27, 143-146.

Press, H., 1948: A statistical analysis of gust velocity measurements as affected by pilots and airplanes. Tech. Note 1645, National Advisory Committee for Aeronautics, Langley Field, VA., 12 pp.

More on the Thunderstorm Project Reunion...

Over 50 project returnees and their guests arrived at the Holiday Inn Cocoa Beach Oceanfront Resort in Cocoa Beach, Florida on Saturday, 30 November 1996. Posters, pictures and a P-61C model from their 1946-1949 experiences decorated their hospitality room fueling many hours of reminiscing. On Sunday morning, the group boarded buses and vans for a trip to Saint Cloud, Florida which was the center of the 1946 surface network. They rededicated the historical marker and were feted to a barbecue picnic by the city's Vietnam Veterans Association. On the way back to Cocoa Beach, the group stopped at the Melbourne National Weather Service Forecast Office where Bart Hagemeyer and his staff briefed on thunderstorms continuing to be a challenge and the capabilities of the new equipment being received as part of the NWS modernization. On Monday morning, Dr. Braham started the NWA Annual Meeting keynote session, "Thunderstorm Research and Severe Weather Warnings - A Historical Perspective." The Reunion group was then hosted to a luncheon at the Patrick Air Force Base Officer's Club and escorted on a tour of the Cape Canaveral and Kennedy Space Center area. Those remaining for the week participated in the NWA Annual Meeting activities. Watching the Cape Canaveral launch of a Delta rocket with the Mars Pathfinder probe was an unexpected treat for those braving a chilly northeasterly wind at 0200 local time on two consecutive mornings out on the beach in front of the hotel.

Photographs on page 34 were arranged by Dan Smith, Chief Scientific Services Division, NWS Southern Region Headquarters. He and Dr. Braham initiated the 50th reunion celebration. Picture captions as they are arranged:

Dansy Williams (L) and Reggie Regelson discuss the Florida surface observation network.

Dansy Williams (L) who was chief of the Florida surface network receives the proclamation from the City of St. Cloud. Bob Phillips from the Mayor's office read and presented the proclamation.

John Bellamy (L) and Roscoe Braham in the reunion hospitality room

Roscoe Braham discusses TSP activities with J.B. Kump (L) who rededicated the historic marker on behalf of Congressman Dave Weldon.

Visit to the Melbourne NWS Forecast Office after the picnic

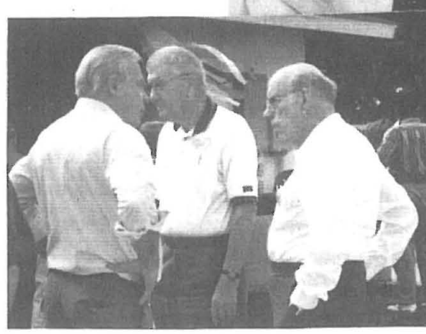
(L-R): Bob Fett, Fred Pope and Bill Jenner

Bill Jenner (L) and Harry Hamilton at the hotel hospitality room

The Melbourne NWS Forecast Office was the first new facility built as part of the NWS modernization program. The office in effect replaces a former Weather Bureau facility which was closed because of budget cuts shortly after the Thunderstorm Project. Melbourne received the second WSR-88D. The office is located in part to provide Doppler weather radar support to the nearby Cape.

Thunderstorm Project
50th Reunion

Florida — December 1996



Picnic in St. Cloud at Lake Tohopekaliga, near site of the surface network headquarters during the TSP Florida phase.

Tour of NWS Office — Melbourne, Florida