The 1956 Tornado Research Airplane Project Data

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ABSTRACT

The purpose of this article is to describe the project and its objective, the kinds of flights that were made, and to summarize the kinds of data available to researchers. A summary of the flight areas, dates, times, and levels is shown in tabular form. A sample data sheet shows the data presentation. These data may be borrowed from the U. S. Weather Bureau, Washington 25, D. C.

1. Introduction

DURING the spring and summer of 1956, a specially instrumented airplane served as an observational platform for providing some of the much needed facts about the causes and characteristics of tornadoes and their environmental conditions. The airplane was an F-51 which was owned and operated by Mr. James M. Cook, Jacksboro, Texas, under contract with the Weather Bureau. The purpose of this flight reconnaissance was, as stated in the contract, "To make observations of temperature and humidity gradients in both the horizontal and vertical plane, as well as other meteorological elements required by the Weather Bureau which were within the scope and performance of the airplane. Observations are required when feasible and practicable before, during and after the occurrence of severe atmospheric disturbances such as thunderstorms or tornadoes." It should be noted that all of these observations were planned for the season's operations and not necessarily for the same storm system.

During the last week of July, fifteen flights were made in cooperation with the Office of Naval Research and the New Mexico Institute of Mining and Technology. The objective of this flying was to correlate temperature, humidity and visual observations with electric field measurements (measured by two airplanes and at the ground) and ground-based radar. About the middle of August, six flights were made in cooperation with the University of Wisconsin and Project Prairie Grass. The purpose of these flights was to obtain horizontal samples of temperature and humidity in the vicinity of the operations base at O'Neill, Nebraska.

The first flight, a test flight, was made at Dallas, Texas, on 26 April 1956. Flying continued from this time through August, and, altogether, 107 flights were made. Flights were numbered each time the plane took off, even though there were as many as three flights in one day. Thirty-three flights were conducted in and around some 36 tornado and severe thunderstorm forecast areas, and there were a few flights in the vicinity of activity when no forecast was issued. Except for two-minute losses during referencing, almost all temperature, humidity, and pressure data are available for these flights. On quite a number of these flights, the airplane obtained either horizontal or vertical samples of the tornado's environment at or near the time of tornado occurrence. In some of these flights the pilot was informed of the tornado location and of the associated thunderstorm cell through communications with tower personnel.

2. Instrumentation

The instrumentation of the airplane included a Naval Research Laboratories axial-flow vortex thermometer [1] loaned by the Navy, a modified version of the Weather Bureau's infra-red hygrometer [2], a modified version of the VGH (velocity, gust, height) recorder [3] furnished by the National Advisory Committee for Aeronautics, a Kollsman recording pressure altimeter, several cameras, an Ampex tape (voice) recorder, an electric field meter, two two-channel Brown recorders, and the required associated gear. All instruments were checked and calibrated on the ground. Additional checks of recorded temperature, humidity, and pressure altitude were made at landing and take-off times. Flight tests were made to determine possible variations in temperature during level flight in connection with variations in airplane attitude or speed. Four flights were made in the vicinity of radiosonde ascents; three of them were spiral climbs around the instrument itself. Data regarding the accuracy and response of the instruments are microfilmed with the original records.

3. Operations

A summary of 72 of these flights that might be of interest to researchers is shown in table 1. (There were 35 other flights, including 11 test flights, 18 ferry flights at variable altitudes, and six flights that were cut short by aircraft or meteorological instrument troubles.) In this tabulation, the Weather Bureau's Severe Local Storm Warning Center (SELS) forecast-area numbers refer to those issued prior to the flight, during flight, or later during the afternoon or early evening which were over or near the flight tracks. Since most of the forecast areas were issued after the flight briefing, particularly on the first flight of a day, the areas flown and forecast areas issued do not necesarily correspond. The number of tornadoes shown here refers to those listed in the Climatological Data, National Summary [4], which occurred within 100 miles of the flight track and no more than 6 hours after the flight time.

After the probable activity area was determined (or the actual activity area in the case of flights later in the day) the flight briefer then planned the operations for the day, which might include several flights. The air time of each flight was limited to three hours, at 240 knots true air speed, plus a reserve of one hour, so it was necessary for the flight briefer to consider: 1. the location of airports with 100 octane gasoline; 2. the current and expected weather over the flight area (ceilings, visibility, winds at flight altitude, etc.); 3. navigational aids such as Air Defense Command radars, radio navigation facilities, etc.; 4. the location of Weather Bureau radars (for later study); 5. Airways Route Traffic Control regulations (IFR or VFR flight plans); and 6. Air Defense Identification Zone. These considerations sometimes contributed to the lack of correspondence between flight areas and forecast areas. At the termination of each flight away from Kansas City the pilot called the briefer for further instructions. Indirect, in-flight contacts from the pilot to SELS or from SELS to the pilot were effected through Weather Bureau and/or Civil Aeronautics Authority communications.

Data from the flights were processed within a few days of the flying and the pilot was de-briefed after each day's operation. With this information at hand, frequent discussions were held between the SELS operational and research personnel to review the objectives of this research. Thus, the objectives of individual flights were varied from time to time in order to insure a comprehensive coverage of a number of different kinds of situations, or storm settings; a variety of flight types; and flights at different stages of the storm cycle. Also, flights were dispatched into low confidence tornado forecast areas, or even in cases where the forecasters were agreed upon a no-tornado forecast, in order to obtain data in these situations for comparison.

4. Data

For most uses of these data, and for ease and simplicity of data reduction, it was felt that data at one-minute intervals (about four miles at the average flying speed) would suffice and data were tabulated accordingly. Of course, the original records are available for more detailed study where this is necessary. A sample data sheet is shown in table 2. This data sheet shows some of the locations of the airplane (check points), time (CST), temperature in degrees C, reference correction to temperature (none was ever needed during these flights) and absolute humidity, pressure, absolute humidity ordinate, corrected (for reference) absolute humidity ordinate, absolute humidity, mixing ratio, dew point, photographs from the special events camera (when taken), ADF bearing, OMNI bearing, compass heading, air speed and remarks. ADF and OMNI bearings were frequently missing because the pilot's head obscured the instrument panel from the time-lapse camera. Unfortunately, it was impossible to correct this during the season's operations because of lack of space.

After each flight, the briefer wrote up a summary of the flight. Information in this summary included the purpose of the flight, general area, date, time, pilot briefing, and some of the interesting aspects of weather, data obtained, etc.

From the voice recorder tape, a transcript was typed of the pilot's comments. With use of data from the photopanel record and the transcript, a flight track was prepared which includes times of reliable locations along the flight path.

The "flight package" for all 107 flights that is now available on microfilm includes the four items described above. That is, a flight summary, data tabulation at one-minute intervals, a voice transcript, and a flight track. From these data it is possible to renavigate the track in possibly a little more detail than shown on the original flight track and also to check the reduction of the original absolute humidity ordinate value to dew point.

The strip charts on the two Brown recorders were fed at the rate of two inches per minute. Temperature was recorded in black and humidity in red on one chart with 140 ordinates. Temperature may be read directly from the chart since each space corresponds to 1C and the zero point is at the 90th ordinate. Temperature values increase with ordinate values. Absolute humidity values were converted from corrected (reference drift) ordinate values through a calibration graph and increase with decreasing ordinate values. Below about 600 mb the temperature trace is on

TABLE 1. A summary of 72 tornado research airplane flights. In column 8, severe thunderstorm forecasts are indicated in parenthesis.

1956 Flight Log

Flight No.	Area	Date	Flight Type	Time Off	Time On	Flight Level	Sound-ings	SELS Forecast Number(s)	Tornadoes	Remarks
3	DAL-OKC-DAL	4/28	OPN	1420	1612	Variable	1	93.95	9	Sounding SE of TSTN with Tornadoes
4	DAL-ACT-AUS	4/29	OPN	1332	1538	700 mb–12,000	1	(100)	(2" Hail)	Primarily test flight
5	AUS-ACT-DAL	4/29	OPN	1641	1734	14,000	0	(100)	(2" Hail)	Primarily test flight
8	DAL-TUL	5/6	OPN	1149	1359	9–10,000	3	111	(Hail)	Low-confidence area
9	TUL-MKC	5/6	OPN	1520	1709	9–11,000	1	—	—	High sferics area
10	MKC-DDC-DAL	5/8	OPN	1631	1935	6–10,000	1	116	—	
11	DAL-ONA	5/10	Ferry	1357	1557	700 mb	—	—	3	Ferry to forecast area
12	ONA-PSD-MKC	5/10	OPN	1655	1929	Variable	—	121, 122	5	Flight near Tornado—High sferics
14	DAL-DDC-MKC	5/13	Ferry	1104	1333	700 mb	—	136	3	Crossed cold front
15	MKC-RST	5/13	OPN	1537	1737	13–18,000	1	135	—	Little activity in area
16	RST-MKC	5/14	Ferry	1020	1152	700 mb	—	—	—	
19	MKC-DAL	5/22	Ferry	1809	1959	850 mb	—	—	1	
20	DAL-OKC	5/23	OPN	1424	1536	14,000	1	146, 147, (148)	8	Sounding E of TSTN with Tornado
21	OKC-TUL-DAL	5/23	OPN	1645	1848	Variable	2	146, 147, (148)	6	Sounding W & M of squall line
22	DAL-DLF-LBB	5/24	OPN	1028	1312	700 mb	—	—	(Funnels)	Low confidence area
23	LBB-DLF-DAL	5/24	OPN	1442	1723	700 mb	—	—	(Hail)	
24	DAL-ANA	5/25	OPN	1242	1513	700 mb	1	(149), 150, 151	4	Sounding TSTN
25	AMA	5/25	OPN	1702	1937	Variable	1	150, 151, 152	2	Activity sampling
29	DAL	6/1	Raob	0901	1023	27,000	1	—	—	Good comparison
34	TOP-DEN-SCT	6/5	OPN	0956	1211	700 mb	1	(182)	1	
35	SCT-RAP-PIR	6/5	OPN	1439	1648	850–700 mb	—	181	—	No activity in area
36	PIR-HON-MKC	6/5	OPN	1724	1924	700 mb	—	181	—	No activity in area
38	MKC-DEN-SCT	6/10	OPN	1015	1254	850–800 mb	—	—	—	
39	SCT-LBF	6/11	OPN	1022	1319	800–700 mb	—	—	—	Excellent line sampling
40	LBF-LBF	6/11	OPN	1441	1656	800–700 mb	—	—	—	
41	LBF-SCT	6/11	OPN	1759	1845	800 mb	1	—	—	
43	MKC-MSN	6/14	OPN	1120	1326	700 mb	—	192	—	No activity
44	MSN-MKC	6/14	OPN	1538	1744	700 mb	—	192(193)	—	No activity
45	MKC-AMA	6/16		1053	1356	700 mb	—	195	—	Activity north of flight track
46	AMA-DDC-DAL	6/16		1556	1839	700 mb	1	195	—	Activity north of flight track
48	DAL-MKC	6/22		1043	1316	850, 700 mb	—	214	2	
49	MKC-GRI	6/27		1230	1511	Variable	1	(229)	1	Sounding behind very severe squall line
50	GRI-MKC	6/27		1633	1729	Variable	—	(229)	—	Activity sampling
51	MKC-PIR	6/29		1032	1301	700 mb	—	232, (233)	—	No activity this flight
52	PIR-MKC	6/29		1442	1647	13,000	1	232, (233)	1	
53	MKC-HBR-DAL	7/1		1349	1631	700 mb	2	(240)(242), 245	2	Soundings ahead of line of building cumulus
54	DAL-MKC	7/5		1245	1552	700 mb	1	(258), 260	3	
55	MKC-DEN	7/7		1039	1251	700 mb	—	267	1	Activity several hours after flight
56	DKN-CDR-SCT	7/7		1501	1735	700 mb	—	—	—	
58	TOP	7/9		0842	1024	252 mb	1	—	—	Raob. good comparison
65–79	SOR	7/23-30		Flights in cooperation with the ONR and New Mexico School of Mines						
80	DAL-SCT	8/2		0851	1200	700 mb	1	(326)	—	Early sampling
81	SCT	8/2		1420	1722	Variable	2	(326)(327)	—	Soundings ahead of line of TSTNS
82	SCT	8/3		1305	1433	Variable	1	—	—	No activity
83	SCT	8/4		1452	1613	Variable	1	—	—	Sounding taken on NE edge of TSTN
84	SCT-MKC	8/5	Ferry	1203	1411	700 mb	1	—	—	
85–90	GRI	8/8-12		Flights in cooperation with University of Wisconsin and Project Prairie Grass						
93	DAL-MKC	8/21	Ferry	1343	1526	700 mb	—	—	—	No activity
95	TOP	8/22		0859	1007	302 mb	1	—	—	Raob: close comparison
103	MKC-DDC	8/29		1341	1456	700 mb	—	366	—	Encountered line
104	DDC-MKC	8/29		1610	1802	850 mb	1	366	—	Sounding east of weak line structure
106	TOP	8/30		0941	1057	366 mb	1	(368)	—	Raob: excellent comparison
107	MKC-DAL	8/31		1507	1707	850 mb	—	373	3	

the upper portion of the chart and the humidity trace is on the lower part. Referencing was usually automatic every 15 minutes on both of these traces. Pressure altitude and electric field meter data were recorded on the other chart. Altitude, or pressure, taken from a standard atmosphere curve, was reported linearly with a full-scale (100 ordinates) deflection corresponding to 2000 feet. At this point the recorder pen dropped back to zero. After each flight these two rolls were synchronized from the hack marks and taped together. These charts have been microfilmed.

TABLE 2. A sample data sheet. The following abbreviations have been used: *T* for temperature; *AH* for absolute humidity; *Ref* for reference; *Pres* for pressure; *Ord* for ordinate; *Corrd* for corrected; *Comp* for compass; and *ADF* and *OMNI* refer to bearings.

TORNADO RESEARCH AIRPLANE DATA
FLIGHT NO. 53 GENERAL AREA MKC-JLN-DAL
DATE 7-1-56 FLIGHT TYPE OPN
TIME CST 1349 TO 1631

Location	Time	Temp	Ref T/AH	Pres	AH Ord	Corrd AH Ord	AH	Mix Ratio	Dew Pnt	Photo	ADF	OMNI	Comp Headg	Air Speed	Remarks
	1428	9.3		699.0	57.5	71.8	3.4	4.0	−4.3						
	29	9.6		699.0	57.0	71.3	3.5	4.1	−4.0		045	224	230		
	30	9.5		697.0	58.0	72.5	3.3	3.8	−4.6		044	222	230	213	
	31	10.0		700.0	57.5	71.5	3.4	4.0	−4.3		043	220	226		
	32	10.0	−21.2/63.5	701.0	57.0	71.8	3.4	4.0	−4.2		043	220	221	214	
	33	10.0		701.0	57.0	71.8	3.4	4.0	−4.2		046	222	223	207	
	34	10.0		700.0	56.0	70.6	3.5	4.1	−4.0		047	222	229	209	
	35	9.9		699.5	59.0	74.4	3.3	3.8	−4.6		047	221	229		
	36	10.1		699.0	56.5	71.2	3.5	4.1	−4.0		047	222	224	212	
	37	10.2		700.5	59.0	74.3	3.3	2.8	−4.6		046	220	221	208	
	38	10.5		700.0	62.0	78.2	2.9	3.4	−6.4		047	221	230	205	3 marks
	39	10.4		699.0	62.0	78.2	2.9	3.4	−6.4		046	220	231		
	40	10.6		700.5	63.0	79.4	2.9	3.4	−6.4						
	41	10.6		701.0	63.5	80.0	2.8	3.3	−6.5		045	219	233		
	42	10.9		699.5	62.5	78.8	2.9	3.4	−6.4		045	219	220	210	
	43	10.6		698.0	63.5	80.0	2.8	3.3	−6.5						
	44	10.5		700.0	63.0	79.4	2.9	3.4	−6.4		034	198	223	208	5 marks
	45	10.9		700.0	63.5	80.0	2.8	3.3	−6.5						
Over Tulsa	46	10.5		700.0	62.5	78.8	2.9	3.4	−6.4		051	052	235		
OMNI	47	10.5	−21.2/63.5	699.0	63.0	79.4	2.9	3.4	−6.4						
	48	11.0		699.0	64.0	80.6	2.8	3.3	−6.5						
	49	11.0		699.0	64.0	80.6	2.8	3.3	−6.5		052	052	234	210	
	50	11.0		702.5	64.0	80.6	2.8	3.3	−6.4						
	51	10.8		697.0	65.0	81.8	2.7	3.2	−7.2		069	052	234	207	
	52	10.5		699.5	65.5	82.5	2.7	3.2	−7.2						
	53	10.9		699.5	66.0	83.2	2.7	3.2	−7.2		133	052	230		
	54	10.9		698.0	65.0	81.8	2.7	3.2	−7.2		136	231	233		
	55	11.0		701.0	64.5	81.2	2.8	3.3	−6.4						
	56	11.0		699.0	64.0	80.6	2.8	3.3	−6.5		136	231	233		
	57	11.0		698.0	63.5	80.0	2.8	3.3	−6.6						
	58	11.0		698.5	64.0	80.6	2.8	3.3	−6.6		135	230	230	210	
	59	11.1		700.0	64.0	80.6	2.8	3.3	−6.5						
	1500	11.2		701.5	63.0	79.4	2.9	3.4	−6.4						
	01	11.1	−21.2/63.5	701.0	63.0	80.0	2.9	3.4	−6.5						
	02	11.7		699.0	61.0	77.5	2.9	3.4	−6.4						
	03	11.8		697.5	63.0	80.0	2.8	3.3	−6.5						2 marks
	04	11.4		700.0	61.0	77.5	2.9	3.4	−6.4						
	05	11.6		702.0	60.0	76.2	3.1	3.6	−5.6		133	228	229		
	1506	11.5		702.0	61.0	77.5	2.9	3.4	−6.3			227	230		

Thus, all meteorological and navigational data are available for further study and analysis. These films (about three 100-ft. rolls) are on file with the Weather Bureau and requests for copies should be sent to the Chief, U. S. Weather Bureau, Washington 25, D. C.

In addition to the above mentioned data, VGH data were obtained and were analyzed by the NACA. The original records are on file there. (These data are not on the records which were microfilmed by the Weather Bureau.) Since most of this flying was outside thunderstorm activity, few structures were sampled which contained turbulence of severe or extreme character. The pilot was unable to obtain photographs of tornadoes, and, because of his many other duties in the vicinity of thunderstorms, had considerable trouble in obtaining correct exposures. Thus, while many of the cloud photographs are interesting, particularly in the time-lapse photos later in the season, it did not seem worthwhile to reproduce them.

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