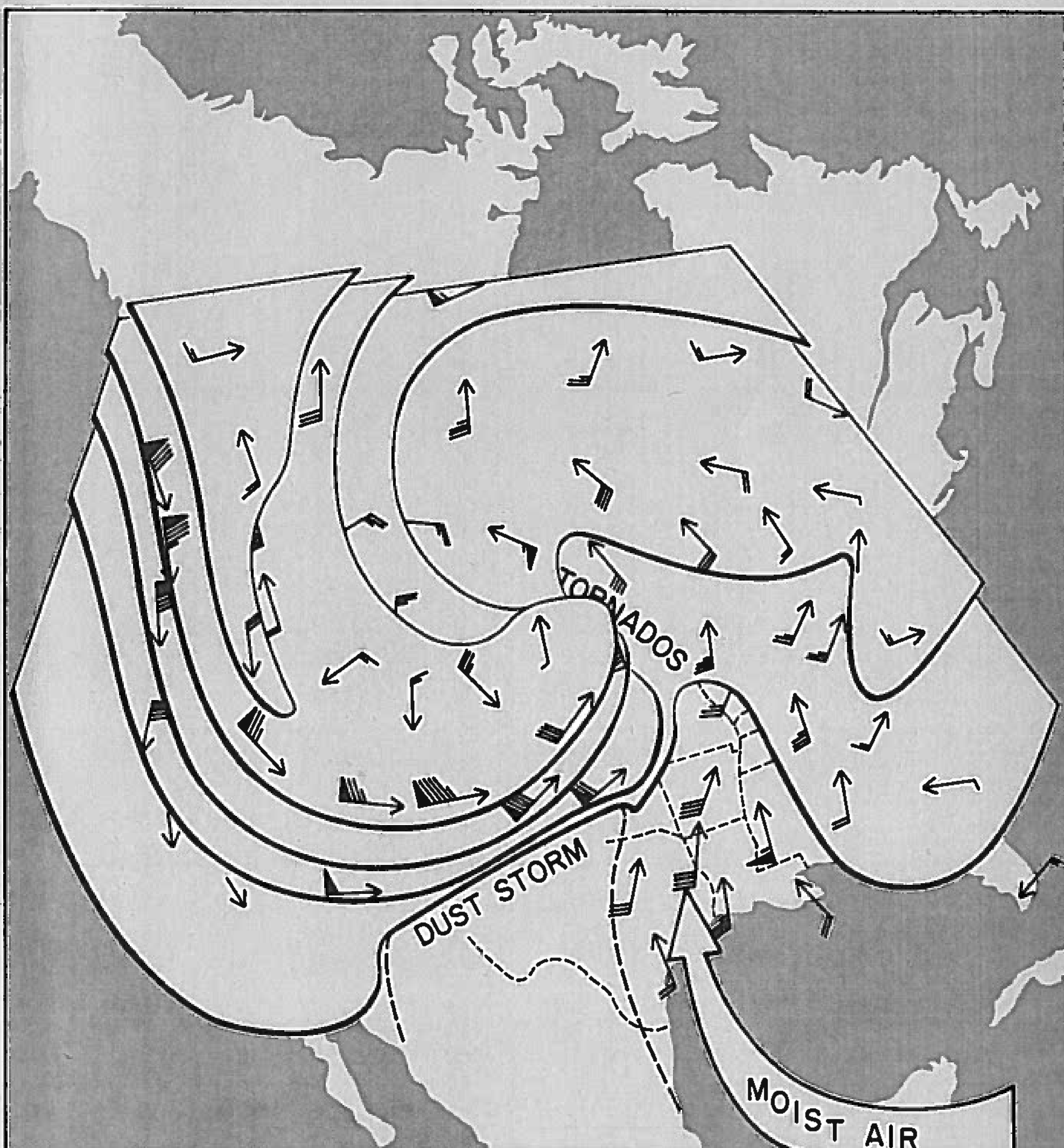
OPERATIONS PLA
Prepared by: Benson Fogle: 7 March 7

PROJECT DUSTORM '75



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1. ABSTRACT

Project DUSTORM, an experiment involving four research aircraft and a number of ground sampling stations, will be conducted by NCAR's Aerosol Project between 7 April and 4 May 1975. This experiment is designed to test Danielsen's concepts of the influence of soil-generated aerosols on the severity of the convective storms which develop in the midwestern and central U.S. during the spring.

2. INTRODUCTION

The Atmospheric Aerosol Project of NCAR is focusing its research on the influences and controls that aerosols exert on the formation and development of weather. The initial effort is to study aerosol's influences on large-scale, organized outbreaks of severe weather (thunderstorms, hailstorms, and tornados) which occur in the midwestern and central United States in the spring.

More than a decade of meteorological research has been conducted under the direction of the Project Leader, E. Danielsen, to identify the large-scale phenomena which both generate the convective stability and trigger its release, and to determine special techniques for predicting the phenomena with sufficient lead-time to direct a combined ground-based and aircraft experiment.

In April of 1972 and 1973 it was proved that major dust storms could be predicted two days in advance. From these two previous experiments the mass of airborne dust, the volume of air affected, and the size distribution of the dust particles versus height were determined.

The first field experiment to test these concepts is scheduled for April/May 1975 in the midwestern/central U.S. The following year, 1976, is to be devoted to data processing and analyzing. A second experiment is scheduled for April/May 1977 in the midwestern/central U.S. This second experiment will likely be on a larger scale and with wider cooperation and involvement of other agencies and university groups.

In 1979 similar field experiments are envisioned for North Africa or Asia where like conditions occur for rapid development of large-scale cyclones in the spring.

These field experiments are of fundamental importance to the Aerosol Project since an early determination is needed of whether or not macroscale motions and aerosols influence the generation of severe storms. The results of the field experiments will determine the specific direction of the theoretical and experimental work of the Aerosol Project.

Background Information on the First Experiment, Project DUSTORM

The first field experiment, code named Project DUSTORM, will involve both research aircraft and ground stations, and will be conducted between 7 April and 4 May 1975. This experiment is designed to test concepts of the influence of soil-generated aerosols on the severity of the convective storms which develop in the midwestern United States during the spring.

These concepts involve a complex chain of events initiated by the coupling of a strong surface heat source and an upper-level momentum source. Solar heating of the soil in the arid southwest destabilizes the air, producing an adiabatic mixing layer to depths of 3-5 km. This destabilization increases the available potential energy in the troposphere and the amplification rate of large-scale wave perturbations. An upper-level jet, propagating eastward across the Gulf of Alaska, supplies the momentum for the large-scale cyclogenesis.

During cyclogenesis, the jet descends rapidly toward the deep mixing layer. Although decelerating during the descent, the air enters the mixing layer at speeds of 60-100 kts. As gusts of this magnitude reach the ground, the arid soil is sandblasted, creating a major dust storm in the southern high plains. NCAR has sampled this dust near the ground and up to heights of 5 km. It consists of disaggregated soil particles, 5-10 μm radius, which contain clay and organic material. The lapse rate in the dust-laden air is adiabatic, the mean winds are 40-60 kts from the west-southeast, and the air near the surface is very dry. As this air moves eastward, it advects over cooler moist air moving northward from the Gulf of Mexico into the midwest. The resulting thermal and moisture stratification produces the convective instability in which convective storms develop. (Fig. 1)

Up to this point, the phenomena are generated by large-scale features in the wind, temperature and moisture fields, and by the unique topographic and soil characteristics of North America. Triggering of the instability by the low-level convergence is also large-scale controlled.

However, the severity of convective storms, the production of copious precipitation, large damaging hailstones, and numerous tornados may be influenced by soil-generated aerosols, suspended in or settling out of the overrunning dry adiabatic air. Danielsen's numerical model of convective storms, which includes hydrometeor growth by stochastic coalescence as well as by vapor deposition, and hail growth following drop freezing by contact nucleation, indicates that the coalescence growth must be initiated quickly in these storms with rapid updraft velocities. If coalescent growth does not predominate in less than 10 minutes, the small droplets all freeze and are carried up into the anvil. Then the cloud functions as a water vapor pump, transferring low-level moisture up to the upper troposphere and lower stratosphere.

Several phenomena could be responsible for triggering coalescence: It has been proved that microscale turbulence and electric charge increase the collection efficiency. Thus they may contribute or be of primary importance. But first, the possibility will be examined that giant land- or sea-generated aerosols, upon being wetted, trigger coalescent growth. It is of special interest, therefore, to determine whether aerosols with radii greater than 25 μm are present to enter the cloud via the main updraft or by entrainment.

The ice nucleating properties of the smaller clay and organic particles are also worth examining. Being smaller, they remain in suspension and enter the cloud via entrainment. Finally, there is a need to determine the condensation nucleating abilities of stratospheric aerosols, i.e., aerosols produced by gas-to-particle formation in the stratosphere. Aerosols which originate in the stratosphere also enter the storms by entrainment when the convective clouds penetrate the layer of stratospheric air produced by tropopause folding. From many isentropic analyses it is known that the folded tropopause is destroyed by mixing into cumulus clouds.

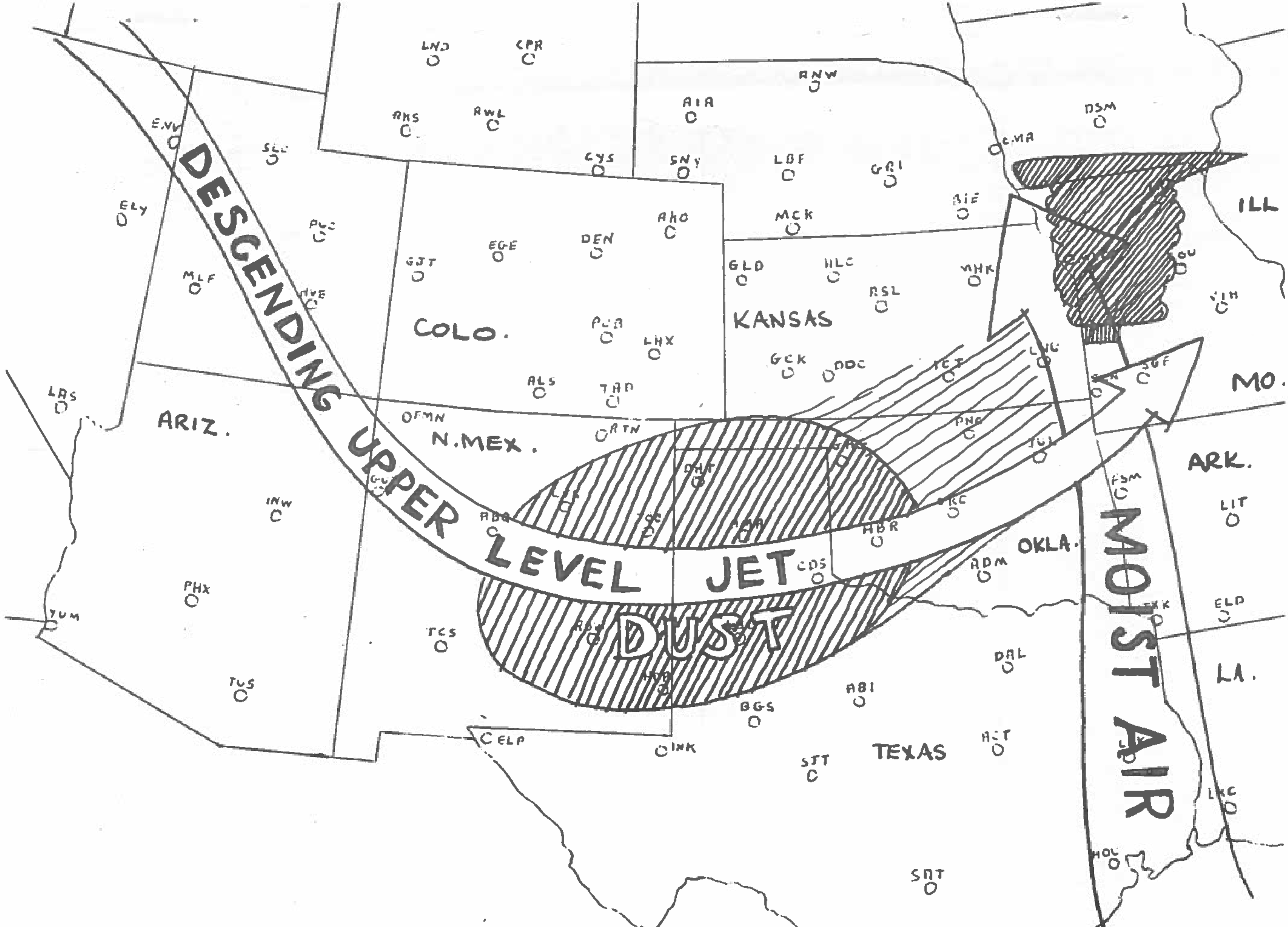

FIGURE 1: LARGE SCALE CONDITIONS FOR THE PRODUCTION OF MESOSCALE SEVERE WEATHER.

Other areas of study are the rate at which hail grows and its final size and number distribution; the downdrafts hail creates by mass loading and evaporation, which may depend directly on the clay and organic aerosols; and the degree of supersaturation in the cloud and the release of latent heat which may be modulated by the stratospheric aerosols.

3. OBJECTIVES

3.1. Major Objectives

The major objectives of Project DUSTORM are to determine whether:

1. The large airborne soil particles (bigger than 10 microns) enter the severe convective storms and trigger coalescent growth upon being wetted.

2. The small particles, particularly the clay and organic matter, control drop freezing and therefore production of hail.

3. The stratospheric aerosols, when mixed into the growing cumulus, control the supersaturation and release latent heat by the formation of new cloud droplets.

3.2. Other Objectives

1. Determine the size, number distribution, and vertical flux of dust for different wind speeds and soil conditions. (Gillette)

2. Test hypothesis that wind erosion causes breaking up of soil aggregates. (Gillette)

3. Measure the transport of dust from soil erosion area. (Gillette)

4. Determine the nucleating capability of vegetative matter. (Schnell)

5. Determine the chemical fractionation of dust as it is generated and transported. (Delany)

6. Study the hydrogen/deuterium ratio in hailstones from severe storms. (Knight)

7. Study structure of dust layers in the dry air being mixed into the severe storms, and study suspension of dust when the heating is cut off from the ground. (Fernald)

8. Determine characteristics of aerosol particle formation in stratospheric air as it moves into the troposphere. (Mohnen)

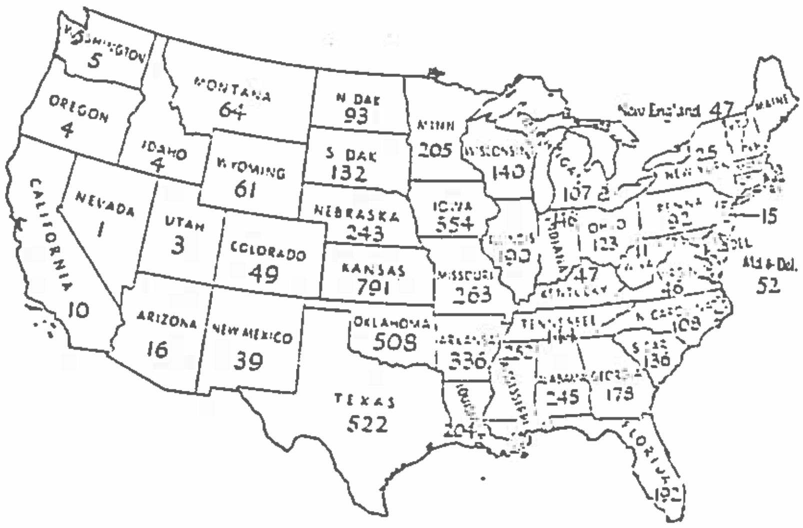

Figure 2. The statistically most probable area for severe storms. Number of tornadoes, by states, reported in the 37.5 yr period ending with June, 1953. (From official records of the U.S. Weather Bureau).

9. Determine the vertical concentration profiles and physical characteristics (e.g., size distribution and radiative properties) of aerosols in stratospheric air. (Grams, Patterson)

10. Evaluate applicability of mass/visibility relationships for estimating dust concentrations associated with wind erosion. (Gillette, Patterson)

4. SAMPLING TIME AND REGION

4.1. Time Period for Experiment

The period 7 April to 4 May 1975 has been scheduled for Project DUSTORM. This period was selected to include those times when severe storms in the midwest most often occur.

4.2. Most Probable Sampling Days

The highest probability sampling days during the above period are 19-21 April and 27-28 April.

4.3. Most Probable Zone of Severe Storms to be Measured

The statistically most probable area for severe storms is shown in Fig. 4.3.1. Severe storms of interest for this experiment may, however, develop in states just east of this zone (Ohio, Kentucky, and Tennessee).

4.4. Duration of Sampling Episodes

Two sampling episodes are planned. The main sampling period during each of these two episodes will be from approximately 11:00 a.m. to 8:00 p.m. However, most of the ground stations will begin operation prior to 11:00 a.m. and may continue on after 8:00 p.m. Combined air and ground measurements may be resumed on the following day if the storm continues.

5. MEASUREMENTS TO BE MADE

5.1. Airborne Measurements

A. Wyoming Queen Air - will sample the air both outside the severe storm clouds and at their base. It will operate out of Kansas City or St. Louis.

Instruments:

- o Rich 100 (Environment 1) CN counter.
- o Knollenberg scattering probe and optical array (0.2-20 μm).

- o Knollenberg 20-imaging optical array (5 μm-75 μm).
- o Mie fluorescent particle counter (1 to 5,000 particles/liter).
- o Hydrometeor detector (500 μm-3,000 μm) descriminates water/ice.
- o Decellerator replicator (replicates ice crystal).
- o Multistage impactor (0.1).
- o Millipore, nuclepore filters.
- o Precipitation collector.

B. NCAR Queen Air - will monitor the aerosol in the dust generation region. It will operate out of Amarillo, Texas, during the sampling episodes.

Instruments:

- o Rich 100-CN counter (0 to $3x10^8$ particles/liter).
- o Ozone KI sensor.
- o Single stage jet impactor for size/number distribution of particles > 0.6 μm radius (oil).
- o Variable slit impactor for size/number distribution of particles > 10 μm radius (oil).
- o High volume multistage impactors (Delbag, Fiberglass).
- o "Teakettle" bulk filter collector (Fiberglass, Delbag, Millipore).

C. NCAR Sabreliner - will follow dust as it is advected eastward toward the line of severe weather which is generated by the same large-scale cyclogenesis that produces the dust storm. A probable base of operation is in the general area of Wichita, Kansas.

Instruments:

- o Ozone KI sensor.
- o Knollenberg double-barrel laser scattering probe (0.1 μm to 1.5 μm; 1 μm to 10 μm).
- o Knollenberg optical array (6-75 μm).
- o Single stage jet impactor (for aerosol size/number distribution).
- o "Samovar" bulk filter collector (Fiberglass, Delbag, Millipore).
- o "Samovar" duplex (Fiberglass, Delbag).

TABLE 1 : AEROSOL COLLECTORS FOR DUSTORM '75

INSTRUMENT	AIR/GND STATION	FLOW RATE OR UNITS	COLLECTING SURFACE OR CONT.	MEASUREMENT
A. Single Stage Impactors				
1. Jet Impactor	Sabreliner	12 lpm	Oil coated slides	Size/No. distribution.
2. Jet Impactor	NCAR QA	12 lpm	Oil coated slides	Size/No. distribution.
3. Variable Slit Impactor	NCAR QA	34 lpm	Oil coated slides	Size/No. dist. of Supergiant Aerosols; SEM and microprobe analysis of supergiants.
4. Round-jet, 1 hole, 6 stage	WYO QA	12 lpm	Oil coated slides	Size/No. distribution.
B. Large Impactors				
1. Weathermeasure 5 stage	NCAR QA	566 lpm	Fiberglass (FG)	Size/Mass dist. of organic. Char. of org.
2. Weathermeasure 5 stage	NCAR QA	566 lpm	Delbag (DB)	Size/Mass dist. of mineral. Al/SI. Metals
3. Andersen 2000 5 stage	Ground	566 lpm	FG/DB	C/Si, Al/Si, size dependence of organic/mineral.
C. Small Filters				
1. Round 4.7 cm filters	WYO QA	12 lpm	Millipore(MP)&NP	Size/No. dist. of aerosols.
2. Round 4.7 cm filters	Ground	12 lpm	MP & Nucleopore(NP)	Size/No. dist. of submicron aerosols. SEM analysis
D. Bulk Filters				
1. Percolator	Electra	5,000 lpm	I.P.C.	SO_4, radioactivity, NO_3.
			M.P.	Ice nucleation characteristics.
			N.P.	SEM and microprobe analysis.
2. Teakettle	NCAR QA	3,000 lpm	F.G.	Organic characteristics.
			D.B.	Al/Si, mineral, oxygen isotope.
			M.P.	Ice nucleating characteristics.
3. Samovar	Sabreliner	10,000 lpm	F.G.	Organic characteristics.
			D.B.	Al/Si, mineral, Si/Na.
			M.P.	Ice nucleation characteristics.
4. Samovar Duplex	Sabreliner	6,000 lpm	F.G.	C/Si
5. Windmill	Ground	12,000 lpm	D.B.	Size/Mass dist. of soil aerosol, mineral, metals, Si/Al char. of soil, ice nuc. char.
			F.G.	Size/Mass dist. of organic, char. of organics.
6. Hi Volumes x 3	Ground	6,000 lpm	D.B.	Mass determination.
E. Bulk Collectors				
1. Bagnold catcher	Ground	grams	Plastic bags	Characteristics of soil.
2. Shovel	Ground	kilograms	Coffee cans	Characteristics of soil.
F. Hydrometeor Collection				
1. Cloud water collection	WYO QA	20 cm^3	Plastic bags	D/H, ice nucleation characteristics.
2. Saturated air	WYO QA	4 l.	S.S. Cylinder	D/H
3. Hail	Ground	Hstones	Hailcatcher	D/H, microscopic determination of hail embryos.

TABLE 2 : AEROSOL DETECTORS FOR PROJECT DUSTORM 1975

INSTRUMENT	AIRCRAFT	COMMENTS
A. Condensation Nuclei		
1. Saxena Variable Supersat CN Counter	Electra	
2. Gardner	Electra	
3. Rich 100 (press. Aircraft Design)	Electra	0 - 3 x 10^8 particles/liter
4. Rich 100	Queen Air	0 - 3 x 10^8 particles/liter
5. ---	Sabreliner	---
6. Rich 100 (Environ. 1)	WYO Queen Air	0 - 3 x 10^8 particles/liter
B. Aerosol (0.2 µm to 10 µm)		
1. Knollenberg Double Barrel Scatt. Probe	Sabreliner	0.2 - 20 µm
2. Knollenberg Scatt. Probe	WYO Queen Air	0.2 - 20 µm
3. Climet	Electra	Size and No. distribution.
C. Big Aerosols (greater than 10 µm)		
1. Knollenberg Optical Array	Sabreliner	5 - 75 µm
2. Knollenberg Optical Array-2D Imaging	WYO Queen Air	5 - 75 µm
D. Aerosol Characteristics		
1. Polar Nephelometer	Electra	Aerosol refractive index, size distrib.
2. Vertical Lidar	Electra	Aerosol mixing ratios
3. Mie Fluorescent Particle Counter	WYO Queen Air	1 - 5000 particles/liter
E. Hydrometeors		
1. U. Wash/U. Wyo. Polarisation Det.	WYO Queen Air	500 µm - 3000 µm. Ice/Water discrim.
2. Decellerator Replicator	WYO Queen Air	Replicates ice crystal in soot or lexane/oil.

D. NCAR Electra - will monitor the stratospheric aerosols which are transported into the mid-troposphere during the tropopause folding. It will operate out of the Jeffco Airport (Colorado).

Instruments:

- o Rich 100 CN counter.
- o Gardner CN counter.
- o Royco counter.
- o Saxena variable supersaturation CN counter (DRI).
- o Lidar
- o Polar nephelometer.
- o Ozone - KI sensor--Kombyr type.
- o Ozone - Chemiluminescent sensor.
- o Ion counters.
- o Lyman alpha water vapor sensor.
- o Climet aerosol counter (0.4 μm to 1.5 μm).
- o Percolator bulk filter collector (IPC, Millipore, Nucleopore).

5.2. Ground Stations Measurements

A. Plainview, Texas - Operators: Gillette and Dolan)

Instruments:

- o "Windmill" bulk filter collector (Delbag, Fiberglass).
- o High volume Anderson 2000 multistage impactor (Delbag, Fiberglass).
- o Vertical flux apparatus for wind determination.
- o Bagnold catcher-impactor for total soil movement (flux).
- o Shovel and coffee cans for bulk soil samples.

B. Plains, Texas - Operator: M. Thompson

Instruments:

- o High volume sampler using microsorban filters.
- o MRI portable weather station (wind, temperature, humidity).

C. Woodward, Oklahoma - Operator: E. McIlvain

Instruments:

- o High volume sampler using microsorban filters.
- o Weather station (wind, temperature, humidity).

D. Oklahoma City, Oklahoma - Operators: Kiang, Fernald, Frush, Ray, and Walker

Instruments:

Same sampling equipment as at Plainview, PLUS:

- o Sonic anemometer.
- o NCAR lidar.
- o 500-meter instrument tower.
- o 10 CM radar.
- o Droplet disdrometer and precipitation collector.
- o High volume sampler using microsorban filters.

E. Big Springs, Texas - Operators: Gillette, Dolan, and Schnell

Instruments:

- o Wind tunnel.
- o Simulate dust uptake and transport.

F. Urbana, Illinois - Operator: R. Semonin

Instruments:

- o Droplet disdrometer (Ill. State Water Survey) and precipitation collector.

G. St. Louis, Missouri - Operator: Debold

Instruments:

Same as for Urbana, Illinois.

H. Other Ground Stations

Hail collection in hailswath zones. (C. and N. Knight)

5.3. Data Analyses, Laboratory and Numerical Experiments

Presence of large aerosols will be determined in flight by visual readout of the scopes depicting the size distribution sensed by the Knollenberg probes. If large aerosols are present and are captured by the high volume filter systems, they will be tested in the laboratory for their wetability. After these tests, their effects on the coalescent growth will be determined in Danielsen's time-dependent numerical model of a cumulus cloud.

A variety of laboratory experiments will be conducted to determine the ice nucleating capability of the smaller clay and organic aerosols. Samples of these aerosols will be prepared to test separately their contact, immersion, and sublimation nucleation efficiency as a function of size and ambient temperature. Once again, these experimental results will be incorporated into the cloud model to test for their effects on hail growth.

The stratospheric aerosols will be counted in flight under very high supersaturations and under realistic variable supersaturations which exist in a cloud. Again, many analyses will be made of these aerosols to determine their size distribution, phase, shape, and composition. Project DUSTORM offers the first opportunity to sense these particles by both remote and <u>in situ</u> sensors and to capture them for laboratory analyses.

All of the inertial platform, vane and meteorological data obtained by aircraft will be filtered (Fourier low-pass filters) to pass the large-scale and mesoscale features which can be compared and related to radiosonde data. To make these comparisons, the radiosonde data will have to be processed in detail. Special effort will be directed toward identifying the horizontal and vertical wavelengths of internal gravity waves.

An attempt will be made to analyze small-scale turbulence after the signal-to-noise ratio in the high frequency oscillations have been determined. Of particular interest is the small-scale turbulence in the convective clouds because of its influence on droplet coalescence.

Another source of data which will be valuable for severe storm diagnoses is the 10 CM radar data (NOAA weather radar) and the 22.5 CM radar data (FAA aircraft reconnaissance radar). Arrangements are being made to obtain magnetic tapes of pertinent data. NSSL has offered to loan to us any of their radar data processing programs.

The NCAR vertical lidar will be used to verify the advection aloft of the dust-laden air. This dry air overrunning the moist air establishes the convective instability. The temporal variations in height of the upper boundary of the dust layer will be used to study gravity waves and shearing instability breakdowns. It is thought that this instability maintains the turbulence in the dust-laden air after it loses contact with the hot soil.

Finally, rain and hail samples will be obtained at the ground, which will be analyzed for evidence of dust. Particular interest will be directed toward examining the hail embryos for dust particles and determining the number of frozen drops versus graupel embryos.

6. ORGANIZATIONS AND GROUPS PARTICIPATING IN PROJECT DUSTORM

6.1. Univ. of Wyoming, Dept. of Atm. Sciences (Veal, Cooper, Marwitz, Vali)

This group will operate the Wyoming Queen Air aircraft in the severe storms area, measuring aerosol parameters adjacent to and inside severe storm clouds. Dr. Marwitz will monitor the severe storms using the FAA 22.5 CM aircraft reconnaissance radar at Kansas City and advise DUSTORM participants of the location and nature of the storms.

6.2. State Univ. of New York at Albany (SUNY)--Atm.Sci. & Res. Center (Mohnen, Hogan, Grahek)

This group will operate various aerosol instruments on the Electra.

6.3. Denver Research Institute (Saxena)

Dr. Saxena will operate a variable supersaturation Condensation Nuclei counter on the Electra.

6.4. Univ. of Oklahoma (Walker)

Dr. Walker will have his Sonic Anemometer at the Oklahoma City station in operation during the experiment.

6.5. Illinois State Water Survey (Semonin)

Semonin will collect bulk rainwater samples at Urbana, Illinois, and St. Louis, Missouri.

6.6. NCAR/NHRE Group (C. and N. Knight, Moore)

Will be collecting hail associated with severe storms for determination of the hydrogen/deuterium ratio.

6.7. NCAR/FOF (Fernald, Frush)

Will operate the NCAR ground-based lidar at the Oklahoma City station. They will monitor the dust intrusion into the severe storm area, looking at the vertical fluctuation of the dust, and how it varies with time and at the fluctuations of the top edge of the dust layer.

6.8. NCAR/UAP (Grams, Patterson, Wyman)

Will operate the lidar, polar nephelometer, and Climet aerosol detector on the Electra, test IR-transparent slides as aerosol collectors on the Sabreliner, and make visibility observations at the Plainview, Texas ground station.

7.A. PERSONNEL PARTICIPATING IN PROJECT DUSTORM

Aerosol Project	(NCAR Ext.)
Cardamon, Laura	681
Danielsen, Ed	660
Davis, Bill	427
Deaven, Dennis	683
Delany, Tony	322
Dolan, Gerry	664
Ellison, Cathy	461
Gillette, Dale	463
Gitlin, Sonia	698
Haagenson, Phil	468
Kiang, C. S.	661
Roper, Nat	253
Schnell, Russ	647
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Wartburg, Art	646

NHRE Project	
Browning, Keith	431
Knight, Charlie	684
Knight, Nancy	684
Moore, Howard	688

FOF/ATD	
Frush, Chuck	216
Serafin, Bob	77-740
Stockton, Bruce	216

Upper Air Project	
Fernald, Fred	245
Grams, Gerry	495
Patterson, Ed	338
Wyman, Clyde	218

RAF/ATD	
Adkisson, Ted	78-45
Brown, Ed	78-34
Brun, Jacques	78-35
Burris, Bob	78-59
Rodi, Al	78-34

RAF/ATD (Cont.)	(NCAR Ext.)
Covington, Jim	78-43
Friesen, Dick	78-55
Garrelts, Dick	78-35
McQuade, Tom	78-43
Newcomer, Lloyd	78-40
Orum, Pete	78-42
Reynolds, Matt	78-53
Taylor, Dick	78-53
Zinser, Bill	78-41

Other NCAR Personnel	
Fogle, Ben	205
Johnson, Diane	260

Univ. of Wyoming (FTS: 307/778-2220)
Phone: 307/766-3245 or 307/742-2435

Cooper, Al
Marwitz, John
Vali, Gabor
Veal, Don

State Univ. of NY, Albany (FTS: 518/712-4411)
Phone: 457-4604 or 377-6477 (airport)

Grahek, Frank
Hogan, Austin
Mohnen, Volker (home: 374-2807)

Denver Research Institute

Saxena, Vin (753-3361)

Illinois State Water Survey Dept.

Changnon, Stan
Debold, (618/224-9881)
Semonin, Dick (217/333-4967)

FAA

Current, Ron (KC, Ks.) (913/782-5300, ext. 215)
(home: 913/492-9519)
Florea, Tom (Denver) (303/837-2211; home-757-3430

<u>NSSL (Nat. Severe Storms Lab)</u>
Phone: Direct FTS=8-405/231-4916

Golden, Joe
Kessler, Ed
Wilkes, Kenneth

<u>NSSFC (Nat. Severe Storms Forecasting Ctr.)</u>

Pearson, Allen (KC, Missouri) (816/374-3426)
-5476)
-5203)
(Home: 913/631-7857)

<u>Bureau of Reclamation (Denver)</u>

Politte, Fran (234-3091)

<u>Other</u>

Cressman, George (Director, National Weather Service, NOAA)
Hammett, Paul (Direct FTS: 8-816/374-3226)
Howard, Don (Dir. FTS: 8-801/524-5138)
McIlvain, Ernest (FTS: 405/231-4011; Phone: 256-7449)
Ray, Peter
Thompson, C. Merle (FTS: 214/749-1011; Phone: 806/456-3703)
Walker, Gene

7.B. RESPONSIBILITIES OF VARIOUS PERSONNEL

<u>Cardamon, Laura</u>: Administrative Assistant to project leader. In addition to normal secretarial duties, assists in liaison, coordination, and communications.

<u>Cooper, Al</u>: Scientist manning equipment on the Wyoming Queen Air during second sampling episode.

<u>Cressman, George</u>: Director, National Weather Service.

<u>Current, Ron</u>: Arranged for John Marwitz to use the 22.5 CM radar in Kansas City, Kansas.

<u>Danielsen, Ed</u>: Aerosol Project Leader. Overall planning and supervision of project and experiment. Makes forecasts, decides when sampling episodes will be conducted.

<u>Davis, Bill</u>: Involved in data analysis and interpretation after the experiment is over.

<u>Deaven, Dennis</u>: Will prepare program for processing radiosonde data for forecasts and for processing data collected during the experiment. Will also assist in forecasting operations.

Debold, ______: (Ill. State Water Survey) Will set up and operate a droplet disdrometer at St. Louis, Missouri.

Delany, Tony: Involved in the design, construction, installation, and operation of the aerosol collecting instruments on board the Sabreliner, Electra, and Queen Air. Will operate instruments on Sabreliner during experiment. Afterwards, will be responsible for analysis of samples. Has HV multistage impactor at Plainview ground station. Interest is on fractionation and chemistry of dust.

Dolan, Gerry: Prior to the experiment, will take part in instrumenting the aircraft and in setting up the ground stations. During the experiment, will work with Gillette at the Plainview and Big Springs stations.

Ellison, Cathy: Will provide programming and secretarial support of project as required. Also will serve as courier to pick up radiosonde data from Bureau of Reclamation in Denver.

Fernald, Fred: Will prepare, set up, and operate the NCAR lidar at Oklahoma City site with Frush.

Florea, Tom: With the FAA in Denver. Tom is our main contact man at the FAA. He is trying to arrange for a special radio frequency allocation for the experiment.

Fogle, Ben: Prepare operations plan. Assist project leader with coordination and liaison.

Frush, Chuck: Will prepare, set up, and operate the NCAR lidar at Oklahoma City with Fernald.

Gillette, Dale: Responsible for the overall planning and supervision of the ground sampling stations at Plains, Plainview, Woodward, and Oklahoma City. Also will conduct wind tunnel simulation of dust transport at Agricultural Research station at Big Springs, Texas. In March will set up ground stations. His interest is in the dust size distribution and aggregate structure. (Will operate Plainview ground station during tests.)

Gitlin, Sonia: Currently getting the microprobe ready for analysis of the samples in May. Will take part in analyzing the samples.

Golden, Joseph: (NSSL) Interested in photogrametry of storm. Will have two mobile field photo units in operation 15 April-June.

Grahek, Frank: Will prepare SUNY instruments and install them on the Electra (March 10-31).

Grams, Gerry: Scientist in charge of the lidar, nephelometer, and Climet particle counter operations on the Electra. (Will fly on Electra during tests.)

Haagenson, Phil: Will monitor service A hourly surface weather reports during experiment and prepare meteorological surface maps. Also investigating backup systems for meteorological data. Will assist in forecasting during experiments. Will test computer programs before experiments. Works on program to process data. Coordinate preparation for handling all data to be obtained in experiment. After experiment will do large-scale analysis of parameters leading to dustorm outbreak to help determine if severe storm outbreaks are associated with dust.

Hammett, Paul: Contact man on radiosonde data system in Kansas City.

Hogan, Austin: Will assist Mohnen in preparations for test and will man SUNY instruments on the Electra during the experiment.

Howard, Don: Contact man on radiosonde data system in Salt Lake City.

Johnson, Diane: Responsible for public relations and publicity for the experiment.

Kessler, Ed: Director of National Severe Storms Lab (NSSL) in Norman, Oklahoma.

Kiang, C. S.: Will operate station at Oklahoma City during the experiment.

Knight, Charlie: Will collect and analyze hailstones associated with severe storms.

Knight, Nancy: Will collect and analyze hailstones associated with severe storms.

Marwitz, John: Will monitor severe storms using FAA 22.5 CM radar at Kansas City.

McIlvain, Ernest: (U.S. Southern Great Plain Field Station) Will operate station at Woodward for Gillette.

Mohnen, Volker: Scientist in charge of SUNY effort. Will have the following instruments on the Electra: a variable supersaturation condensation nuclei counter (if he can get it ready in time), Rich 100 cn counter, Gardner cn counter, Royko aerosol counter, two ion chambers, and an ozone chemiluminescent sensor.

Moore, Howard: Will fly on the Sabreliner operating the "Samovar" sampler during the experiment.

NCAR Aircraft Personnel: Perform usual well-known functions (see sheet on aircraft personnel).

Patterson, Ed: Will go to the Plainview, Texas station two days prior to the experiment to make visibility observations. Responsible for getting dye laser for airborne lidar operational.

Pearson, Allen: Director of the NSSFC in Kansas City.

Politte, Fran: Contact man for weather data tapes at the Bureau of Reclamation in Denver.

Ray, Peter: With NOAA in Oklahoma City. Involved in Sonic Anemometer Operations.

Rodi, Al: Coordinator for the three NCAR aircraft during the experiment.

Saxena, Vin: Responsible for the DRI variable supersaturation condensation nuclei counter on board the Electra. Will man the equipment during the experiment.

Schnell, Russ: Will operate aerosol sampling equipment experiments on NCAR Queen Air. After sampling experiment is done, will join Gillette at Big Springs to participate in wind tunnel tests. Will analyze aircraft and ground aerosol collections to test ice nucleating properties.

Semonin, Dick: (Ill. State Water Survey) Will set up and operate droplet disdrometer at Urbana, Illinois. Will provide another one for C. S. Kiang to set up at Oklahoma City site.

Snyder, Jim: Responsible for setting up HF communications capability on NCAR aircraft as a backup. Not involved during the experiment.

Thompson, C. Merle: Operator for ground station at Plains.

Vali, Gabor: Scientist on Univ. of Wyoming Queen Air.

Veal, Don: Project Leader of Univ. of Wyoming group.

Walker, Gene: Prof. of Engineering at Oklahoma Dept. of Eng. Supervises Sonic Anemometer Operations at Oklahoma City station.

Wartburg, Art: Generally involved with instrumenting the three NCAR aircraft. Working with Delany in preparing sampling instruments for aircraft and will operate some of these on the Electra during tests. Interface with Saxena of DRI in preparing and installing CN counter on Queen Air and with SUNY group on getting their instruments installed on the Electra. Will install ozone instrument on Sabreliner and Queen Air and train observers.

Wilkes, Kenneth: Operations director for ground-based operations in Norman, Oklahoma for NSSL.

Wyman, Clyde: Will prepare lidar and nephelometer for operations on the Electra and will operate them during the experiment.

8. GROUND STATION OPERATIONS

Dale Gillette of the Aerosol Project has made arrangements to establish near-surface measurements at four stations in and downwind of the dust generation region (see table below). Small 6 m towers will be installed in Plainview, Texas to obtain dust samples for vertical flux determinations. Multistage impactors and high volume bulk filters will collect dust for later analysis. Ken Wilkes of NSSL has given his permission to set up one station at their site near the 500 m tower at Oklahoma City. The tower is instrumented for meteorological data at three levels. In addition, the University of Oklahoma will be operating a sonic doppler system in April at the same site, and Fernald and Frush of NCAR's FOF will operate a ground-based lidar at the Oklahoma City site. If the dust reaches this site, we will have an excellent opportunity to determine the horizontal and vertical velocity fluctuations which keep the dust in suspension.

Table 8.1. Gillette's Ground Stations

Plainview: Operated by Gillette and Dolan

- "Windmill" high volume bulk filter collector (Delbag, Fiberglass).
- Andersen 2000 high volume multistage impactor (Delbag, Fiberglass).
- Vertical flux apparatus for wind determinations.
- Bagnold catcher--impactor for total soil movements (flux).
- Patterson's optical measurements.

Oklahoma City: Operated by C. S. Kiang

- High volume sampler with microsorban filters.
- NCAR lidar--Fernald and Frush.
- Sonic anemometer--Walter and Ray (Un. of Oklahoma and NOAA).
- 500 m instrumented tower.
- Droplet disdrometer and precipitation collector.
- 10 cm radar.

Plains: Operated by C. M. Thompson

- Instrumented with high volume sampler and with MRI weather station.

Woodward: Operated by McIlvain

- Instrumented with same basic equipment as at Plains.

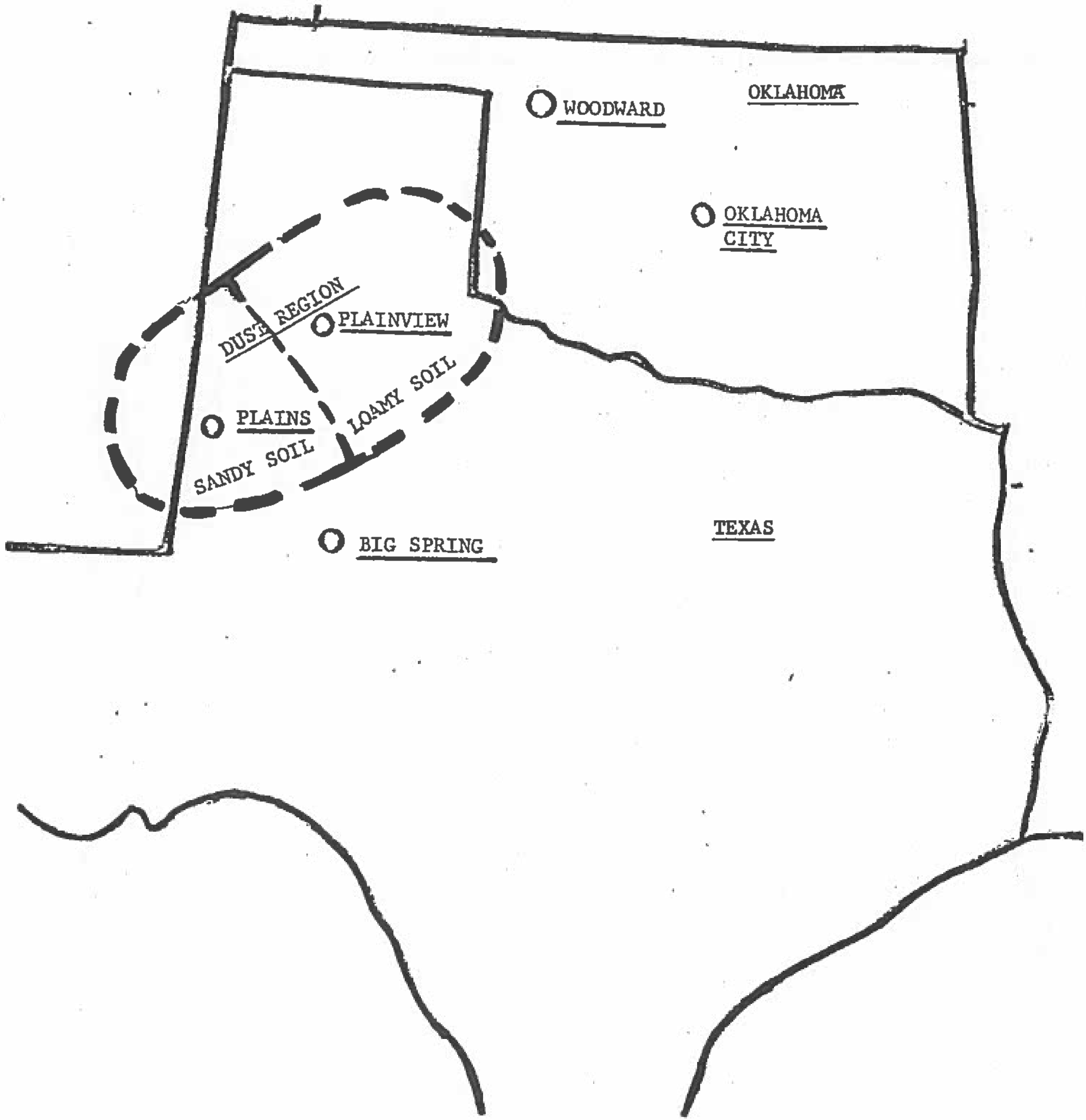

Figure 3: Location of Dust Sampling Stations.

Big Springs: D. Gillette, G. Dolan, and R. Schnell will conduct wind tunnel tests simulating dust transport at the Bureau of Reclamation station there.

Precipitation and Bulk Water Collection

Dick Semonin of the Illinois State Water Survey will participate in Project DUSTORM by making disdrometer measurements of the precipitations and bulk water samples at three sites: St. Louis, Urbana, and Oklahoma City.

Hail Collector

Sample site dependent on location of hail swath.

9. AIRCRAFT OPERATIONS

9.1. Aircraft Participating in DUSTORM

Four aircraft will participate in Project DUSTORM--the University of Wyoming Queen Air, the NCAR Electra, the NCAR Sabreliner, and the NCAR Queen Air.

The NCAR Queen Air will make measurements in the dust-generation region; the Sabreliner will follow the dust as it is advected eastward toward the line of severe weather, which is generated by the same large-scale cyclogenesis that produces the dust storm; the Electra will monitor the stratospheric aerosols which are transported into the mid-troposphere during the tropopause folding, and the Wyoming Queen Air will sample the air outside the storm clouds and at the storm cloud base.

9.2. Aircraft and Flight Plans

Each aircraft will follow a separate flight plan. When conditions are favorable for large-scale cyclogenesis, the crews will be alerted. The day before the experiment the NCAR Queen Air will be deployed to western Texas, the Sabreliner and Wyoming Queen Air to eastern Kansas. On the first day of the experiment the NCAR Queen Air will take samples at low and intermediate altitudes in the dust-generation region, i.e., over the Texas Panhandle. The Sabreliner will ascend to 15,000 feet MSL and fly southwest until it intercepts the dust. Then it will turn and follow the dust as it advects eastward. The objective is to trace the large soil particles detected by the Knollenberg optical array to the west of the line of developing cumulus. If necessary, the Sabreliner will descend to stay with the large particles. If they reach the line of convective clouds, the Sabreliner will turn and monitor the north-south limits of the dust. The Sabreliner will be in communication with Danielsen, Marwitz, and the Wyoming Queen Air.

On the basis of a prediction of the dust's trajectory and the onset of convection, the Wyoming Queen Air will be sent to monitor a convective cloud to the east of the axis of the dust. It will make a vertical sounding about 20-30 km upwind of the cloud. Then it will proceed at low altitude to the main updraft region and monitor the air and aerosols near cloud base. John Marwitz of the University of Wyoming will be flown to Kansas City to the FAA regional center, where he will have access to the radar displays of the 22.5 cm FAA radar (including severe weather radar echoes and specific aircraft positions) and, by facsimile, access to certain of the 10 cm WSR-57 radar. Marwitz will be able to maintain close contact with the aircraft via FAA communication facilities.

Jim Snyder will supply an HF system which will be transmitted from a tower in northeast Boulder. Transmissions will be received by the Electra and relayed to the other aircraft by VHF, giving us an opportunity to talk directly to the aircraft without going through the FAA. The Sabreliner and the Wyoming Queen Air will be able to communicate with each other by VHF, air-to-air.

The Electra will be based at Jeffco Airport near Boulder. On the day of the experiment it will ascend to 18-20,000 feet MSL and fly southeast to Amarillo, Texas. Its objective is to locate the layer of stratospheric air, whose boundaries, wind, and temperature differences will be predicted. Ozone measurements will provide additional detecting capability in flight. When the boundaries are determined, the Electra will turn downwind and take samples near the warm boundary of the layer. These samples will be completed after a 180° turn and an upwind flight (see flight patterns in Fig. 9).

The same type of sampling will be repeated in the center and near the cold boundary of the layer. These flights will supply direct information of the stratospheric aerosols in a relatively dry environment (near warm boundary) and a relatively moist environment (near cold boundary).

After completing the sampling missions the Electra will ascend a few thousand feet, fly southeast in the low stratosphere and then return to Jeffco. These measurements will provide data for assessing possible changes in the stratospheric aerosols due to mixing with tropospheric air; as an example, the possible formation of new aerosols when the air becomes moist.

If the large-scale cyclogenesis is a major development, operations will continue on the following day. Since the convective lines develop, breakdown and redevelop, the most probable locations will be forecast and the Sabreliner and the Wyoming Queen Air will be redeployed if necessary.

AIRCRAFT : QUEENAIR- UN. WYOMING (DUSTRM #1)
Number of Flights Requested : Four - Two each episode
Duration of Each Flight : 4 hours
Base of Operation : Kansas City
Average Flight Radius from Base: 200 km- 120 n. mi.
Desired Flight Altitude : Vertical Ascents
Time of Day for Flights : Afternoon - 1 pm to 8 p.m.

Flight Patterns: Vertical Ascent adjacent to severe storm cloud from base to top, then descend to base level, fly into base and make slight vertical ascent, then return to base.

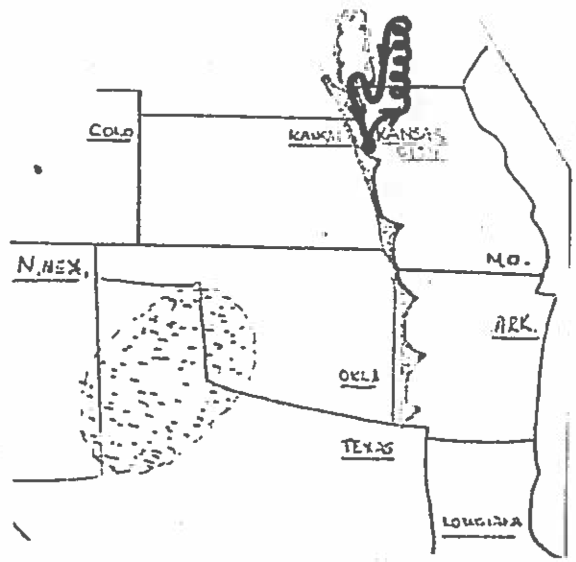

Figure 4 A.

AIRCRAFT : ELECTRA- NCAR (DUSTRM #2)
Number of Flights Requested : Four- Two each episode
Duration of Each Flight : 6 hours
Base of Operation : Jeffco, Colo.
Average Flight Radius from Base: 1500 km.
Desired Flight Altitude : 18,000 feet
Time of Day for Flights : Afternoon

Flight Patterns: Fly southeast at 18$\pm$ 1 K ft. across stratospheric layer which can be identified by wind shear, temperature gradient, and ozone readings. Return to layer , fly along southern boundary for a while, then reverse direction and fly along the middle of the intrusion, then reverse direction and fly along the northern boundary a while, and finally ascend to sample the stratospheric air at higher altitudes on the way back to base.

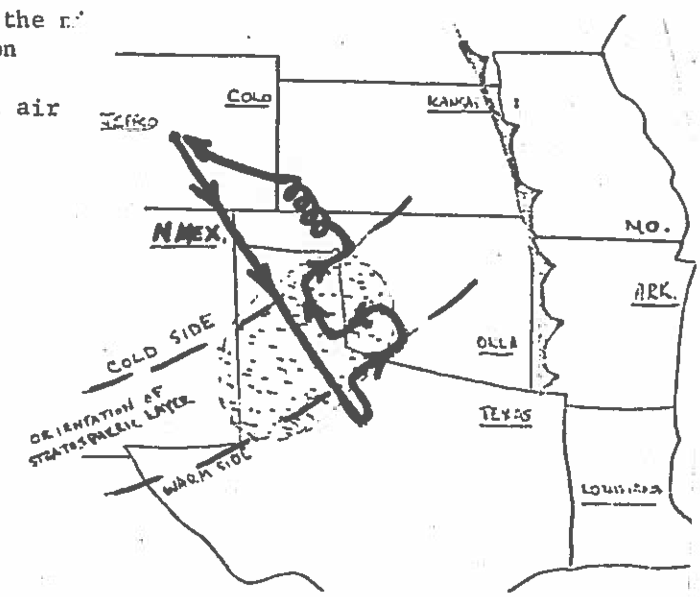

Figure 4 B.

AIRCRAFT : QUEENAIR- NCAR (DUSTRM # 3)
Number of Flights Requested : Four , Two each Episode
Duration of Each Flight : Four Hours
Base of Operation : Big Springs
Average Flight Radius from Base: 200 km or 120 n mi.
Desired Flight Altitude : 10 - 15 K ft.
Time of Day for Flights : Afternoon

Flight Patterns: Fly NE at abt 15 K ft MSL in dust volume. Then return to midpoint after descending to 10 Kft MSL. Then fly perpendicular course at 10 Kft MSL to edge of dust. Ascend to 15 Kft MSL and reverse course across dust volume.

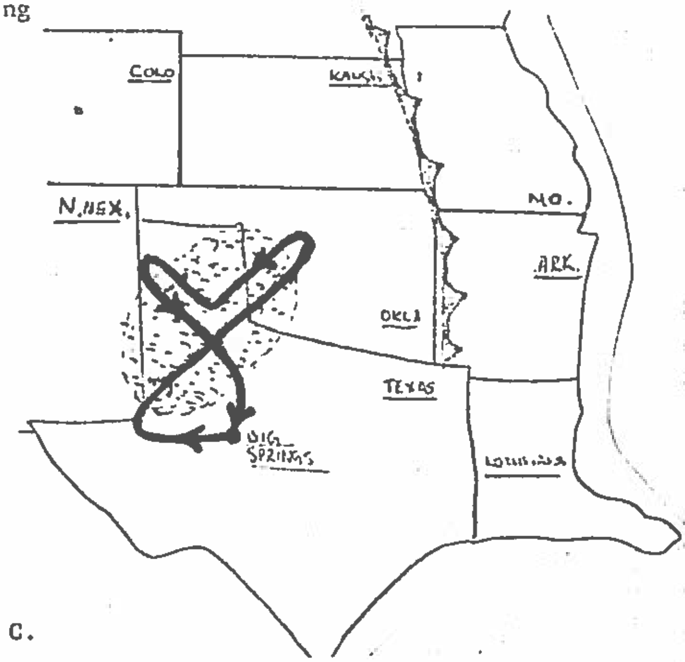

Figure 4 C.

AIRCRAFT : SABERLINER- NCAR (DUSTRM # 4)
Number of Flights Requested : Four- Two each Episode
Duration of Each Flight : Four hours.
Base of Operation : Wichita, Kansas
Average Flight Radius from Base: 500 km
Desired Flight Altitude : 5 to 15 Kft
Time of Day for Flights : Afternoon& Evening

Flight Patterns : Ascend to determine top of dust layer at 15-20 Kft, flying southwest into dust generation region.Then descend to 2000 ft below dust top and fly Northeast, descending if necessary to stay in dust. Approach but remain behind thunderstorm line. Then turn south and fly to west of line at altitude determined by the top of the dust layer. Then turn and fly back at lower altitude to suitable airport for refuéling.

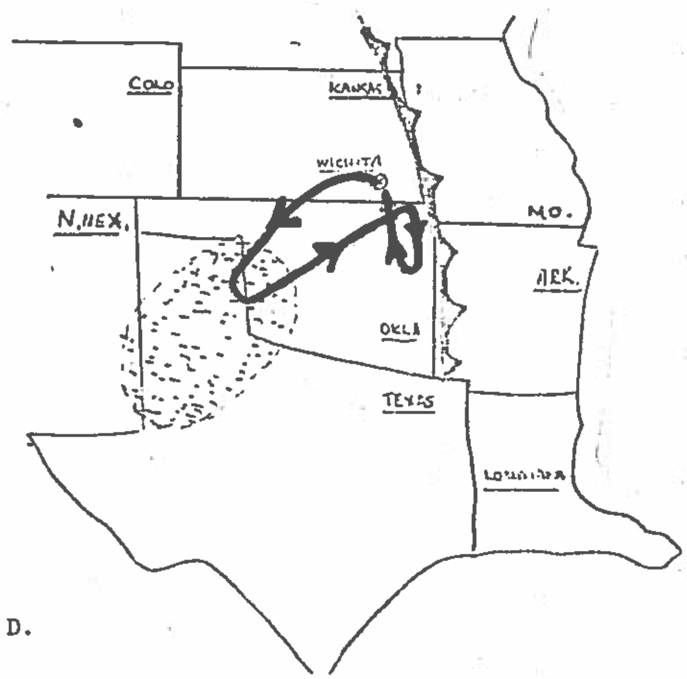

Figure 4 D.

Several meetings have been held with officials of the FAA at the Denver Regional Center to acquaint them with Project DUSTORM's objectives and flight requirements. Their cooperation is absolutely essential and we are pleased to acknowledge their enthusiastic support.

9.3. Personnel Associated with Aircraft Operations

DUSTORM #1 - Wyoming Queen Air

Veal, Don	Pilot; Head of Depart.
Cooper, Al	Scientist
Vali, Gabor	Scientist

DUSTORM #2 - NCAR Electra

Zinser, Bill	Pilot
Covington, Jim	Co-pilot
Adkisson, Ted	Flight Engineer
Brun, Jacques	Instrument Engineer
Garrelts, Dick	Instrument Engineer
Reynolds, Matt	Instrument Engineer
Taylor, Dick	Instrument Engineer
Grams, Gerry	NCAR Scientist
Hogan, Austin	SUNY Scientist
Saxena, Vic	DRI Scientist
Wartburg, Art	NCAR Support Scientist
Wyman, Clyde	NCAR Technician

DUSTORM #3 - NCAR Queen Air 306-D

McQuade, Tom	Pilot
Burris, Bob	Co-pilot
Friesen, Bob	Instrument Engineer
Schnell, Russ	NCAR Scientist

DUSTORM #4 - NCAR Sabreliner

Newcomer, Lloyd	Pilot
Orum, Pete	Co-pilot
Brown, Ed	Instrument Engineer
Delany, Tony	NCAR Scientist
Moore, Howard	NCAR Scientist
Rodi, Al	Coordinator for NCAR Aircraft

10. HAIL COLLECTION

The Knights have made plans to collect hailstones associated with the severe storms occurring during Project DUSTORM. They have arranged for a small aircraft to standby at the Boulder airport during the operation period (7 April to 4 May) and to fly them to their probable sampling area on the day before the severe storm is predicted to occur. They plan to catch the hailstones associated with the storms before the stones hit the ground, and will rely on Marwitz to predict the best sampling site. On the day following the severe storm and hailfall, the Knights will collect hailstones from those local citizens who gathered them in response to the radio and TV requests to do so. The Knights are interested in the hydrogen/deuterium ratio of the water in the hailstones. Danielsen is interested in whether large hailstones have dust nuclei.

11. COMMUNICATIONS

When conditions appear favorable for a severe-storm outbreak, all personnel will be alerted by telephone. This will be approximately three days prior to the storm. All personnel will receive an update forecast on the morning of each of the following three days (SD-2, SD-1, and Sample Day). Those aircraft and personnel deployed on SD-2 and SD-1 will receive their update forecasts at their field sites by telephone. During the experiment, when the aircraft are aloft, the primary communication links with Danielsen at NCAR will be through Snyder's HF system in Boulder to the Electra. The Electra will communicate with the other aircraft directly via VHF. In addition, Marwitz at Kansas City will have direct communication with all participating aircraft (except possibly the NCAR Queen Air) via VHF using the FAA system, and he will have good communication with Danielsen at NCAR via regular telephone.

12. FORECASTING OPERATIONS

Danielsen, along with Haagenson and Deaven, will make forecasts of the outbreak of severe storms using radiosonde data obtained twice daily from the Bureau of Reclamation in Denver, plus surface weather data obtained from NOAA in Boulder. Past experience has shown that an outbreak of severe storms can be forecast two to three days in advance. These forecasts will be made at NCAR and results will be communicated to participating personnel by telephone.

13. SCHEDULES

13.1. Weekly-Monthly Schedules

March 1: All Machine work done on sampler for aircraft.

March 15: Electra returns from NORPAX missions.

March 24
to 29: All aircraft instrumented.

March 31: Test fly instruments.

April 7: Experiment period begins. Everything ready by now.

- o Publicity operations prepared. All contacts made.
- o All aircraft instrumented and ready.
- o Communications setup functional and backup ready.
- o Standby personnel ready to fill in as necessary.
- o Preparations for HAIL CATCH made, and for getting them back to NCAR.
- o Marwitz arrangements made.
- o Specific frequency assigned for aircraft operations.
- o Ground stations all set up and personnel trained.

May 4: Last day of period for experiment.

13.2. Daily Schedule Beginning April 6

1700: Ellison picks up weather data from Bureau of Reclamation in Denver Federal Center and brings to NCAR.

2100-2400: Deaven processes data for forecast.

0200: Danielsen, Deaven and Haagenson make analysis and forecast.

0600: Danielsen makes decision on basis of analysis and forecast.

0800: Ellison picks up second tape at Federal Center and returns it to NCAR.

If forecast looks good, Danielsen schedules tentative sample day three days away. All personnel are alerted by Laura. Countdown begins.

13.3. Sample Day 1

All personnel not on station go to stations. Marwitz to Kansas City. TV stations and radio stations broadcast alert for hail collection. Aircraft deployed.

13.4. Sample Day

Sample according to plans (see Sec. 9.2. and Figs. 9.1-9.4). Danielsen makes last-minute adjustments as required on basis of Marwitz observations.

13.4.A. Sampling Schedule for Ground Stations

Routine. No detailed schedule required.

14. PUBLICITY, PUBLIC RELATIONS

Publicity and public relations for this experiment will be handled by Diane Johnson of NCAR's Information Office. CBS News is planning to do a short feature on the experiment for national television in late March --early April. Diane will handle the interface with them and will obtain copies of their footage for showing on local TV stations in the experimental area if time permits. She will also prepare news releases and contact local radio and TV stations and newspapers to ensure good news coverage of the operation, and will assemble lists of county agents in the experimental area and determine from them which radio stations are the best for making the requests for hail collections.

15. DATA EXCHANGE

Each investigator will try to complete the analysis of his data and make the results available to other participants in the experiment in as timely a manner as possible. The time scale for data analysis will range from a few days (for the ground-based lidar, for example) to months (analysis of hail samples).

16. POST EXPERIMENT REPORT

A brief post experiment summary report of the results of the experiment will be issued by July 1975.