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NASA's Participation in the AVE-SESAME '79 Program

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Abstract

NASA's Marshall Space Flight Center (MSFC) participated with its AVE (Atmospheric Variability Experiment) in a large interagency mesoscale and severe storms experiment identified herein as AVE-SESAME '79 (Atmospheric Variability Experiment-Severe Environmental Storms and Mesoscale Experiment 1979). A primary objective of NASA was to support an effort to acquire carefully edited sets of rawinsonde data during selected severe weather events for use in correlative and diagnostic studies with satellite and radar data obtained at approximately the same times. Data were acquired during six individual 24 h experiments on both the regional and storm scales over a network in the central United States that utilized approximately 20 supplemental rawinsonde sites meshed among 23 standard National Weather Service sites. Included among the six experiments are data obtained between 1200 GMT on 10 April and 1200 GMT on 11 April, encompassing the formation and development period for the tornado-producing systems that devastated Wichita Falls, Tex., and other sections of Oklahoma and Texas. The other dates for which data sets are available are 19-20 and 25-26 April, 9-10 and 20-21 May, and 7-8 June 1979.

1. Introduction and background

Severe storms, to a large extent, appear to be initiated or controlled by mesoscale dynamics. However, the concentration of major research in atmospheric sciences has, in the past, focused on the large and small ends of

the atmospheric scales of motion, and has left a gap in the understanding of phenomena associated with mesoscale systems. It is widely acknowledged that our lack of knowledge about the structure and organization of mesoscale systems forms one of the greatest obstacles to developing a general understanding of severe local storms and their parameterization for numerical and statistical forecast models.

To learn more about the structure and dynamics of mesoscale systems, NASA, in cooperation with NOAA and other government agencies, participated in a field experiment identified herein as AVE-SESAME '79 (Atmospheric Variability Experiment-Severe Environmental Storms and Mesoscale Experiment). One of NASA's primary objectives in this program was to support a continuing effort to acquire carefully edited sets of rawinsonde data during six selected severe weather events for use in correlative and diagnostic studies with satellite and radar data measured at approximately the same times (Kreins, 1979). This activity represents a continuation of a series of similar experiments, conducted during the years 1964-78, under NASA's Atmospheric Variability Experiment (AVE) Program (Hill and Turner, 1977).

A brief description of each of these experiments, including the AVE-SESAME '79 data, is given in Table 1. Figure 1 shows the GOES-East enhanced

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TABLE 1. Summary of NASA's AVE, AVSSE,* and AVE-SESAME '79 experiments.

Experiment	Dates	Observation times, GMT	Experiment size and location	Significant meteorological conditions
AVE 1	19-23 Feb. 1964			
	19	00, 03, 06, 09, 12, 15, 18, 21	Thirty-one rawinsonde stations were used in 18 states stretching from Nebraska, Kansas, Oklahoma, and Texas eastward to the middle Atlantic and southeastern states.	Surface cyclonic system developed over the Gulf of Mexico and moved into the northeastern states accompanied by strong upper-level thermal gradients and winds.
	20	00, 03, 06, 09, 12, 15, 18, 21		
	21	00, 03, 06, 09, 12, 15, 18, 21		
	22	00, 03, 06, 09, 12, 15, 18, 21		
	23	00		
AVE 2	11-12 May 1974			
	11	12, 15, 18, 21	Fifty-four rawinsonde stations encompassing most of the states east of 105° W in the United States.	Complex frontal and upper-level system moved through the Missouri Valley and Midwest and interacted with an active cut-off low over the lower Mississippi Valley. Strong convective activity and horizontal temperature gradients were present.
	12	00, 03, 06, 09, 12		
AVE 3	6-7 Feb 1975			
	6	00, 06, 12, 15, 18, 21	Forty-one United States rawinsonde stations covering most of the states east of 105°W, except for regions near the Canadian border, extreme southern Texas, and southern Florida.	A strong polar air mass moved through the Mississippi and Ohio Valleys accompanied by snowfall in the cold air and convective activity near the frontal system.
	7	00, 06, 12		
AVE 4	24-25 April 1975			
	24	00, 06, 12, 15, 18, 21	Forty-two rawinsonde stations were used within the same area as AVE 3.	A major tornado outbreak occurred from Missouri and Oklahoma eastward into Tennessee and northern Alabama.
	25	00, 06, 12,		
AVSSE 1	27-28 April 1975			
	27	12, 15, 18, 21	Twenty-four rawinsonde stations were used that covered parts of 13 southwestern and southern states from New Mexico and Colorado eastward to Tennessee and Georgia.	Tornadoes and other severe storms occurred primarily in Nebraska and Oklahoma in conjunction with a cold front running through the central plains states and a developing upper-level low over South Dakota.
	28	00, 03, 12		
AVSSE 2	6-7 May 1975			
	6	12, 15, 18, 21	Twenty-three rawinsonde stations covering almost the same area as AVSSE 1.	A major tornado occurred in Omaha, Nebr. Other tornado and funnel activity developed from Oklahoma and Arkansas northward to South Dakota associated with a cold front and dry line.
	7	00, 03, 12		
AVE 5	11-12 June 1977			
	11	00, 12, 15, 18, 21	Twenty-three rawinsonde stations in 15 of the north-central states were used from Montana, Wyoming, and Colorado eastward to Michigan, Ohio, Tennessee, and Alabama.	Tornadoes and other severe storms developed primarily in North and South Dakota associated with a cold front in that region.
	12	00, 03, 12		

TABLE 1—continued.

Experiment	Dates	Observation times, GMT	Experiment size and location	Significant meteorological conditions
AVE 6	27–28 May 1977	00, 12, 15, 18, 21 00, 03, 12	Twenty-two rawinsonde stations covering an area from South Dakota to Texas and eastward to Illinois and Alabama.	Severe thunderstorms occurred in Missouri, Tennessee, and Oklahoma.
AVE 7	2–3 May 1978	00, 12, 15, 18, 21 00, 03, 12	Twenty-four rawinsonde stations covering an area approximately the same as AVE 6.	Severe thunderstorms, tornadoes, hail, snow, and flooding occurred over Texas and Louisiana in association with strong disturbances aloft over the southern Rockies.
AVE–SESAME 1	10–11 Apr 1979	12, 15, 18, 21 00, 03, 06, 09, 12	(See Fig. 3a)	Major tornado outbreak in Texas and Oklahoma and general thunderstorm activity over the midwestern United States occurred in conjunction with a strong cyclone centered over eastern Colorado.
AVE–SESAME 2	19–20 Apr 1979	12, 15, 18, 21 00, 03, 06, 09, 12	(See Fig. 3a)	A tornado outbreak stretching from North Dakota to Texas and major flooding in southeast Texas occurred in advance of a cold front located along the eastern slopes of the Rocky Mountains.
AVE–SESAME 3	25–26 Apr 1979	12, 15, 18, 11 00, 03, 06, 09, 12	(See Fig. 3a)	Since the thunderstorms occurred in Missouri and Illinois along a cold front in the midwestern United States, general thunderstorm activity was located in the Mississippi River Valley and eastern plains States.
AVE–SESAME 4	9–10 May 1979	12, 15, 18, 21 00, 03, 06, 09, 12 (supplemental sites at other times)	(See Fig. 3b)	Thunderstorms stretched from the Great Lakes southward into Texas along an advancing cold front. Tornadoes and hail occurred in Texas, Oklahoma, and Kansas.
AVE–SESAME 5	20–21 May 1979	12, 15, 18, 21 00, 03, 06, 09, 12 (supplemental sites at other times)	(See Fig. 3b)	Thunderstorms occurred from the Appalachians westward into Oklahoma and Texas along a cold front. Several tornadoes occurred in west Texas.
AVE–SESAME 6	7–8 June 1979	12, 15, 18, 21 00, 03, 06, 09, 12 (supplemental sites at other times)	(See Fig. 3b)	Widespread thunderstorm activity, causing locally heavy rains, occurred from the Great Lakes into Texas in association with a cold front located in the midwestern United States.

* Atmosphere Variability and Severe Storms Experiment (same as AVE measurements).

FIG. 1. GOES-East enhanced infrared satellite imagery for 0230 GMT on 3 May 1978.

infrared satellite imagery for 0230 GMT on 3 May 1978, a time period during AVE 7. The concurrent analysis of Manually Digitized Radar data is shown in Fig. 2 for 0235 GMT on 3 May. The squall line and precipitation shield in Texas and Oklahoma seen in Figs. 1 and 2 represents only one of many deep and intense synoptic and mesoscale weather disturbances captured during past Atmospheric Variability Experiments.

2. AVE-SESAME '79 program

The new AVE-SESAME '79 data contain higher spatial and/or temporal resolution than most prior AVE data sets and will be used to examine the fundamental mesosynoptic processes responsible for the formation and development of severe convective activity associated with phenomena such as tornadoes, damaging winds, hail, floods, turbulence, etc., that affect property and personal safety. A second objective is to compile a data set for investigating atmospheric variability and associated severe storm development with emphasis on the determination of mechanisms for the formation and prediction of severe storms.

Atmospheric circulation systems on the regional, meso, local, and convective scales involve very complex physical processes, including important contributions from the underlying geography, intense heat release, and nonlinear interactions between the larger and smaller scales. Because the important physical processes, scientific methods/techniques, and the state of knowledge are all scale-dependent, the AVE-SESAME '79 experiments were conducted using two different observational networks. Three of the six experiments were conducted in April within a regional-scale network and three in the May-June period within the storm-scale network.

The regional-scale experiments (see network in Fig. 3a) consisted of 24 h periods of observation involving 23 National Weather Service (NWS) rawinsonde sites and 17 supplemental rawinsonde sites taking measurements at 3 h intervals during three severe weather outbreak days in April. Rapid scan visual and infrared imagery was acquired by GOES satellites, and TIROS-N and NIMBUS-G data were also obtained during certain periods of these experiments.

FIG. 2. Analysis of Manually Digitized Radar Data for 0235 GMT on 3 May 1978.

Special conventional and Doppler radar and aircraft measurements were obtained during thunderstorm development periods from stations located in the experiment area. Note that special rawinsonde data were acquired during the formation, development, and dissipation stages of the major tornado-producing systems that devastated Wichita Falls, Tex., and areas in Oklahoma and Texas on 10–11 April 1979.

The enhanced infrared satellite imagery at 2330 GMT on 10 April (Fig. 4) shows the cold cloud tops over Texas and Oklahoma that less than 1 h later were associated with the tornadic thunderstorms responsible for the Wichita Falls, Tex., tornado. A small and moderately cold cloud line located in west central Texas (running from southwest to northeast) eventually developed into a long line of severe thunderstorms that moved eastward into central Texas. Some of the tremendous number of severe weather reports that occurred during the 24 h period between 1200 GMT on 10 April and 1200 GMT on 11 April 1979 during AVE–SESAME 1 are plotted in Fig. 5.

The storm-scale experiments consisted of three 24 h periods of observations involving approximately 23 National Weather Service rawinsonde sites (some as regional scale) taking measurements at 3 h intervals, and about 20 supplemental rawinsonde sites taking measurements at 1.5 and/or 3 h intervals during severe weather events closer to Oklahoma (see Fig. 3b). Special satellite, radar, aircraft, surface, and conven-

FIG. 3. Rawinsonde station networks: (a) AVE–SESAME '79 regional-scale and (b) storm-scale.

tional measurements were acquired as in the regional-scale experiments but the primary measurement area of interest was focused on Oklahoma.

All rawinsonde data will be reduced by the NASA–AVE technique, which will include a quick-look assessment and documentation of each experiment (Fuelberg, 1974). This data reduction technique is designed to extract every meaningful and accurate measurement taken during each rawinsonde flight. Analysis of the temporal and spatial continuity of the individual soundings insures a final data set with internal consistency. Each data set obtained from the six experiments will be provided upon request, by NASA's Marshall Space Flight Center, to all investigators and the scientific community in hard copy form and/or on magnetic tape.

FIG. 4. GOES-East enhanced infrared satellite imagery for 2330 GMT on 10 April 1979.

3. Potential research areas

The number of potential scientific studies that could be conducted using the data available from these experiments is high. Some possibilities are:

- 1) Examine conditions that lead to the severe and unusual weather events throughout the experiment day. This would include diagnostically calculated and numerically predicted vertical motion (lifting mechanisms), kinematic parameters, convective instability, air structure, etc.
- 2) Perform studies of budgets of energy (transformations included), moisture, and vorticity to determine the source of energy for the storms and mechanisms responsible for the release of the latent energy.
- 3) Relate satellite observations to results from various analyses to determine what can be learned from satellite data about the conditions established from 3 h and 1.5 h rawinsonde data.

FIG. 5. Severe weather reports that occurred during the 24 h period between 1200 GMT on 10 April and 1200 GMT on 11 April 1979 in the south-central United States.

- 4) Investigate the role of the jet stream in the formation of convective activity.
- 5) Develop improved storm forecast capability through the development of models of severe storms and their environment that use space technology and conventional ground-based data sources.
- 6) Perform correlative analyses of the satellite and ground measurements to determine the critical atmospheric variables or storm severity indicators that may be required for future sensor system developments.

These are only a few of the possibilities. Research results from the utilization of these AVE-SESAME '79 data sets will be documented and made available to the scientific and application user communities in studies relating to the understanding and knowledge of severe weather. Reports involving analysis of other AVE and AVSSE (Atmospheric Variability and Severe Storms Experiment) data sets are currently available from NASA.

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