FIRE II Cirrus
Mission Summary

Date: December 5, 1991
Julian Day: 339
Experiment Day: 23

Summary | Active Sensors | Passive Sensors | Sonde and Sfcmet

Mission Scientist: Pat Minnis
Deputy Mission Scientist: Jay Titlow

Mission Objective:

Cirrus Radiative and Microphysical Properties and Remote Sensing

Mission Description:

Extensive radiative and *in situ* observations (four sorties) were taken in a developing large scale cirrus system in coordination with surface-based remote sensing observations at the Hub and an ER-2 overflight, including an AVRIS scene.

An ER-2/AVRIS underflight of LANDSAT over the Gulf of Mexico along the Louisiana coast was flown wherein a variety of cloud conditions were encountered (clear, cirrus, and cirrus over stratus or middle level cloud).

Weather Synopsis:

Clear at sunrise and not as cold with a rapid influx of light cirrus (spissaitus) from the west during the morning. A surface front sagged through northern Kansas. Coverage and density of cirrus increased through the day. Aircraft and ground-based sensors estimated bases in 10 km range with tops extending to 12.5 km. During the late afternoon, multilayered features covered the sky with all stations in Kansas reporting high level clouds. No low or middle level clouds passed over Coffeyville, but some low clouds were visible in the distant southern sky during the afternoon. Afternoon temperatures warmed to the mid 50's with moderate southerly breezes.

Synoptic Situation:

The large-scale ridge anchored on the west coast continued to flatten out. Upper level flow (300 mb) was from the WNW at about 80 knots. A small upper level trough passed through the area early in the morning. Main feature responsible for the widespread cirrus cover was an upper level low that formed 24 to 36 hours previously off of southern Baja. The low moved steadily east and north into the north Mexican coast by midday. The large cirrus shield connected with the low spread east-west from the southern California coast to Missouri with a northern extent of northern Colorado and Kansas. This feature was not well-forecast by the models, probably because of its tropical origins. The upper low low did not form in the usual manner of cutting off from a deep trough over the western US. Instead, formation was much like a dying hurricane moving north from the lower Mexican west coast.

Aircraft	Depart	Land	Notes
NASA ER-2	08:33 CST	15:03 CST	LANDSAT mission over Gulf followed by Hub mission - cirrus on both and transits
NCAR Sabreliner	09:28 CST	12:00 CST	Racetracks from Hub to SW
UND Citation	11:56 CST	14:23 CST	Step pattern between Hub and Parsons
NCAR Sabreliner	14:05 CST	16:28 CST	Racetracks from Hub to SW
NCAR King Air	14:28 CST	17:25 CST	Could only reach cloud bases to SW

Satellite	Hub Overpass Time	Zenith Angle	Azimuth Angle	RAOB
NOAA-11	21:08:18	19.70	258.20	yes
	09:32:47	29.22	102.16	yes
NOAA-12	13:36:23	57.14	97.62	yes
	00:56:23	45.44	70.74	yes

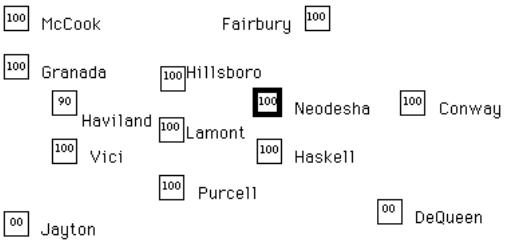
Rawinsonde Operations:

- Inner NWS stations (Type A): Routine @ 12 and 00 UTC
- Outer NWS stations (Type B): Routine @ 12 and 00 UTC
- Hub CLASS station: Soundings at 12, 18 and 19 UTC, plus
  - satellites overpasses at 14, 21, 01 and 10 UTC
  - with ice replicator on 21 UTC sonde
- Remote CLASS stations: Sonde at 12 UTC to complete previous night case.
- Hub GSFC/WFF station: Launches @20, 22, 00, 03 and 06 UTC
- CSU Parsons station: Launches @ 14, 16, 18, 21, 01, and 06 UTC

FIRE Profiler Status:

- CSU 405 MHz @ Parsons: Continuous operation (14 hrs with RASS)
- PSU 50 MHz @ Coffeyville: Continuous operation with RASS
- NOAA 405 MHz @ Coffeyville: Not operational

NWS Wind Profiler Status:



SPECTRE Operations:

Afternoon and evening observations of variable cirrus clouds were made.

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Aircrew/Mission Scientist Debrief Notes:

- PROLOG: At 0600 CST, the decision was made to fly an ER-2 mission over the Gulf of Mexico in conjunction with the 1550 UTC Landsat overpass since it appeared that Kansas would be devoid of clouds. A surface mapping mission (AVRIS) over southern Texas was scheduled to follow the Landsat overpass portion of the flight.
- GENERAL, A.M.: After the 0400 CST clearing event that had ended the previous night's mission, we were surprized by improving cirrus conditions to the southwest after 0700. The Sabreliner was placed on standby at 0830 for a 1000 takeoff to seek cirrus in Oklahoma. Conditions continued to improve as evidenced in the satellite imagery and upwind soundings. During the 0900 weather briefing, a takeoff time of 0930 was set. Cirrus were visually sighted to our southeast at this time. All surface instruments were asked to turn on as soon as possible - most everyone was still asleep after the previous night's mission. The CO2 lidar was turned on near 1000 and reported very thin cirrus at 12 km. Because of the developing conditions, the ER-2 flight plan was modified to bring it over the Hub between 1200 and 1330 instead of performing the Texas AVRIS mission. A decision was made to use the Citation to support the ER-2 mission with microphysical observations at the Hub. Cirrus clouds continued to develop from the moisture being advected by the upper level low off of Baja. Cirrus were observed into central Oklahoma by 0930. At approximately the same time, the upper level dry zone was pinched off over Kansas area by convergence of the southern and northern moist areas over Colorado. This produced conditions for cirrus development starting at the Rockies in southern Colorado. The streamers from that area were thin but continuous in the GOES photos all the way to Wichita by 1000. The Parsons lidar was up at 1112 and observed cirrus at 11-12 km.
- NCAR SABRELINER, #1: The Sabreliner took off at 0930 and ran a racetrack pattern between PER (~Ponca City) and Coffeyville (255deg. heading). At 1007, thin cirrus were reported above 31K' with bases at 33K' over the Hub. Cloud base was much lower to the southwest (37K'). Eight legs were flown. The first 6 legs were mostly in thin cirrus at 35-37K'. The last 2 legs were in thicker cloud with lots of small crystals observed near cloud top and some bullets and columns. Good spectral optical depth measurements were obtained (TDDR). Energy budget measurements (fluxes) were deemed less useful because of the thin and broken conditions. Landed at 1200.
- NASA ER-2: The ER-2 passed over the northern portion of the northern Landsat box in the Gulf. Clear conditions, cirrus, and cirrus over stratus were observed. This should be a very successful LANDSAT underpass mission in terms of the scene and the radiative and lidar measurements.

  Patchy thin cirrus was observed over Dallas at 45K' at 1121 on transit to the Hub. Four orbits of a 170 km N-S racetrack were flown with one leg over the Hub ans one leg over Parsons. A 15-minute AVRIS scene was taken over Parsons and Coffeyville in addition to the earlier 10-minute scene over the Gulf in conjunction with LANDSAT. The ER-2 left at 1330 for Houston. An additional 10 minute AVRIS scene was taken over good cirrus on the way to Houston.
- UND CITATION: A step-up line pattern was flown between Parsons and Coffeyville in 1K' altitude increments from 35K' to 41K' in coordination with the ER-2 overflight. The tropopause was observed at 12.4 km MSL at -63.6deg.C. Cloud base was near 300 mb and cloud top at 12.2 km. Ice particles were generally small, between 50 and 150 um, but somewhat larger near cloud base. An under-sun was observed near cloud base on the last leg. The cirrus were judged to be the most uniform seen yet with variations in crystal concentration from 6 to 30 per liter.
- GENERAL, P.M.: The Wisconsin VIL was turned on at ~1300 and took beautiful pictures. Cirrus base was near 9 km with tops near 12 km. There should be some simultaneity between the VIL and the ER-2 mapping between 1300 and 1330 CST. At 1345, cloud base was at 10.2 km with tops to 12.2 km at Parsons. The Sabreliner flew a second mission to coordinate with the VIL scan pattern. A NW-SW flight line between Oswego (~Parsons) and Ponca City was flown. The CO2 lidar reported bases at 10 km and tops at 12.5 km with a relative continuous return in the vertical. The King Air took off at 1426 to run a line pattern between Parsons and the Hub. The Utah lidar reported cirrus returns between 9 and 12 km at 1516. All surface instruments continued to operate up to 1800 CST. Many of the instruments operated into the night as the cirrus system continued to pass overhead.
- NCAR SABRELINER, #2: The second Sabreliner mission was a radiation mission using a racetrack pattern passing to the north side of the VIL scan plane. Four legs were flown at 29K' to measure cloud extinction. Very little crystal fallout was observed. Cloud base was at ~31K'. Two legs were then run at 9.5 km passing in and out of the cloud base which appeared to be fallout. The next leg was at 9.7 km in thin wispy banded cirrus. One leg was run at 10 km inside the cloud most of the time. The cloud was variably thick with total obscuration of the surface at times. Good microphysics slides were obtained. A leg at 10.6 km started in very thin cirrus moving into thicker clouds well below cloud top. Hexagonal crystals were seen in the video display. The final leg was flown at 11.85 km (-61.7deg.C) still below cloud top. There appeared to be two layers: a thin one above and thick one below obscuring the ground.
- NCAR KING AIR: A spiral sounding to was flown to just above cloud base at 31K'. Extremely dry air was found below the cloud. A few low-level clouds were observed to the south near 5K'. Three legs were flown between Parsons and the Hub at 31K' (9.1 km) passing through fall streaks interspersed with clear sections below true cloud base. One leg was flown at 30K' where smaller areas of fall streaks were encountered. The next leg was flown at 29K' with no particle encounters. Cirrus was overhead throughout. Another leg at 30K' passed through fall streaks again. The last leg at 31K' was within the cloud at all times alternating between areas of small particles and large-particle fall streaks. A spiral down sounding was then made over the Hub. Particles were observed to 28.5K'. Middle levels had continued to dry during the flight and the boundary layer topped at 1.1 km. Landed at ~1720 CST.

Significant Hardware Problems:

- None other than continuing RASS problems.

Highlights of FIRE Operations:

- An excellent LANDSAT underflight mission was flown by the ER-2 with good cloud conditions ranging from clear sky to variable cirrus to cirrus over a stratus undercast within the scene. A well-matched LANDSAT and AVRIS data set was obtained with the GSFC lidar as cloud truth.
- An excellent coordinated ER-2 remote sensing mission over the Parsons-Coffeyville area coordinated with extensive *in situ* microphysical profiling observations by the Citation and VIL cloud mapping observations.

- Nearly seven (7) hours of *in situ* microphysical measurements taken over the Hub in conjunction with extensive surface-based active and passive remote sensing observations of an unobscured and strongly developing cirrus cloud system.
- A good NOAA-11 overpass case was obtained (~ 28deg. view angle) in conjunction with VIL cloud mapping and extensive measurements by other active and passive systems on the ground as well as airborne microphysical measurements from the Sabreliner and King Air.

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Instrument Logs

Active Sensors

Active Sensor	UTC Hour																								Notes
	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	
Utah Lidar H										X	X	X	X	X	X	X	X	X	X						
LaRC Laser Ceilometer H	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Wisc HSR Lidar H	X								X	X	X	X	X	X	X										
Wisc Vol Image Lidar								X	X	X	X	X	X	X											
GSFC RAMAN Lidar H								X			X	X	X	X			X	X							
NOAA CO2 Lidar H				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
NOAA Radar H																									NOT OPERATIONAL
PSU Radar H					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
PSU Laser Ceilometer H	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
PSU 50 MHZ Wind Prof H	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
PSU/NOAA 50 MHz RASS H	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
NOAA 405 MHz RASS H																									NOT OPERATIONAL
LaRC Lidar P						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
CSU Wind Prof/RASS P	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	RASS FROM 16 TO 04 UTC
CSU Laser Ceilometer P	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	

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Passive Sensors

Passive Sensor	UTC Hour																								Notes
	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	
NOAA μ-wave Radiometer H	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
NOAA Sun Photometer H																									NO OBSERVATIONS
NOAA H20 Photometer	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
NOAA IR Flux Radiom. H	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
NOAA Dobson Ozone H																									NO OBSERVATIONS
NOAA Surface Ozone H	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
NOAA Trace Gas H							C	F						CF											
PSU μ-wave Radiometer H	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
PSU Sun Photometer H																									LOST DATA
PSU Solar Flux Radiom. H																			X	X	X	X	X	X	LOST DATA BEFORE 6 UTC
PSU IR Flux Radiometers H																				X	X	X	X	X	LOST DATA BEFORE 6 UTC
PSU Sky Video H									X	X	X	X													
Utah IR-Window Radiom. H										X	X	X	X	X	X	X	X	X	X						
Utah Sky Video H					X	X	X	X	X	X	X														
LaRC Video H	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
AFGL Sky Imager H	X	X	X	X	X	X	X	X																	TAPE DRIVE ERROR
Ames Radiometer H		X	X	X	X	X	X	X	X	X	X	X													END MARKS LAST DATA TAKEN DURING MISSION
Denver Solar Radiom. H																									NO OBSERVATIONS
Denver IR-Spectrometers H								X	X	X				X	X	X	X	X							CALIBRATIONS DONE DURING 19 TO 21 UTC
GSFC IR-Spectrometer H													X	X	X	X	X	X	X	X	X	X	X	X	
Wisc. IR-Spectrometer H			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X								
MRI Sun Photometer H			X	X	X	X	X	X																	*MARKS LAST DATA TAKEN DURING MISSION BY MRI AND AMES
MRI IR Radiometer H	X	X	X	X	X	X	X	X																	*

MRI Spectro-Radiom. H					X	X	X	X																	*
MRI Solar Flux Radiom. H	X	X	X	X	X	X	X	X																	*
GSFC Sun Photometer H		X	X	X	X	X	X	X	X	X	X	X													*
CSU Sun Photometer P			X	X	X	X	X																		
CSU IR-Window Radiom. P	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
CSU Solar Flux Radiom. P	X	X	X	X																					
CSU IR Flux Radiometers P	X	X	X	X																					
CSU IR-Spectrometer P				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
CSU Sky Video P			X	X	X	X	X	X			X	X	X												
Ames Spectroradiometer H		X	X	X	X	X	X	X	X	X	X	X													*
Ames 10 μm narrow fov H		X	X	X	X	X	X	X	X	X	X	X													*
CISRO/WPL/PSU IR W. Rad					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	

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Sonde and Surface Meterology

Sonde + Sfc Met Sensor	UTC Hour																							Notes
	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	
NOAA Ozone Sonde H																X									
WFF Sonde H									X		X		X			X			X						
NCAR Cloud Ice Sonde H										X															NOT RECOVERED AS OF 12/6
NCAR/CLASS Sonde H	X		X				X	X		X				X									X		SOME WIND DATA LOSS
NCAR PAMS H										X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
NCAR/CLASS (remote)	X																								
NCAR PAMS (remote)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	IOLA AND ARKANSAS CITY DOWN,
CSU Sonde P			X		X		X			X				X					X						
CSU Sfc Meteor. P	X	X	X	X	X	X	X	X																	
Type A NWS Sondes	X												X												
Type B NWS Sondes	X												X												
PSU Sfc Meteor H																			X	X	X	X	X	X	DATA LOST BEFORE 6 UTC