Southwest Area Monsoon Project

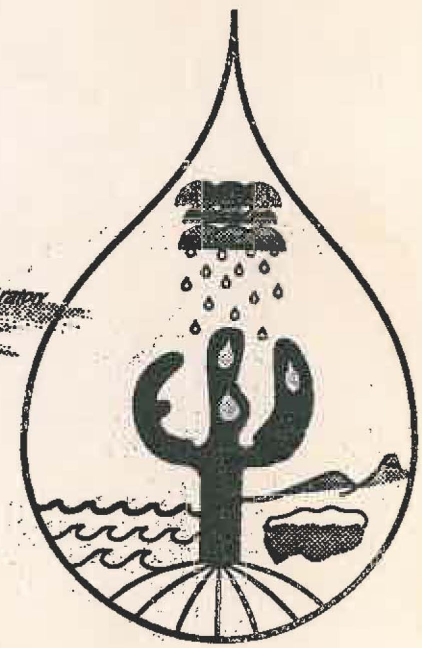
and

Miscellaneous Information

SW Area Monsoon Project

Operations Plan

National Severe Storms Laboratory



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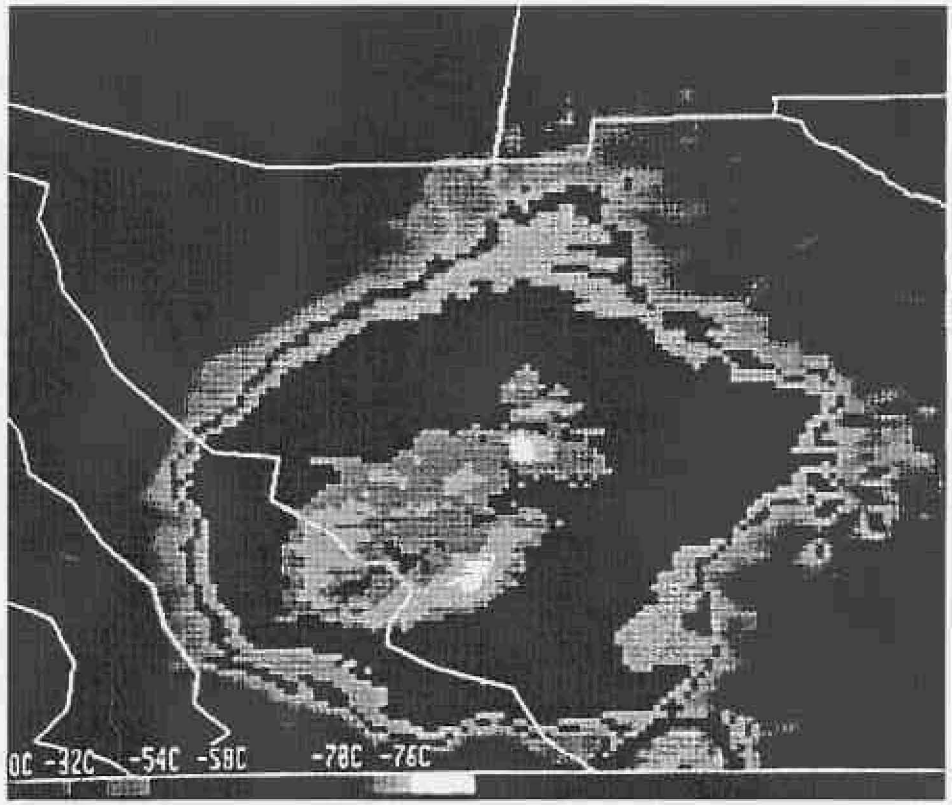
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SW Area Monsoon Project *(SWAMP)*

1. Introduction

The SW Area Monsoon Project (SWAMP) is a cooperative project between forecasters and scientists of the National Weather Service (Phoenix Forecast Office, Tucson Service Office, Western Region Headquarters, and the National Severe Storms Forecast Center), the NESDIS Satellite Applications Laboratory, the National Severe Storms Laboratory, the University of Colorado's Cooperative Institute for Research in the Environmental Sciences (CIRES), Arizona State University, University of Arizona, the Salt River Project, and the Mexican Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE). The project has three major scientific focuses: 1) Central Arizona thunderstorm environments; 2) Monsoon structures and moisture fluxes; and 3) Mexican convective systems. Extensive use of NOAA's P–3 aircraft (operated by personnel from the Aircraft Operations Center/NOAA, Miami) is planned and approximately 85 flight hours have been made available to support this project from 9 July to 7 August, 1990. The aircraft will fly to Arizona on Friday, 6 July, and will be based at the Phoenix Sky Harbor International Airport. All forecasting and project strategy/mission decisions will be made at the National Weather Service Forecast Office (WSFO) at the airport. AOC will maintain a separate briefing and staging facility at the Fixed Base Office (FBO) where the P–3 will be parked. A small computer system will be set up in that facility to examine data tapes and perform limited analyses from data collected during SWAMP.

2. Project Personnel

The primary SWAMP personnel and their affiliations are shown in Table 1.

Table 1. SWAMP Project Coordinators

Title	Person	Affiliation
Overall Project Leader	Robert Maddox	NOAA/NSSL
P–3 Chief Scientist and Aircraft Position Coordinator	David Jorgensen	NOAA/NSSL
Forecast Coordinator	Ken Howard	NOAA/NSSL
Upper Air Sounding and NSSL2 Coordinator	Les Showell	NOAA/NSSL
NWS Coordinator	Norman Hoffman	NOAA/Phoenix WSFO
Western Regions Logistic Coordinator	Larry Dunn	NOAA/NWS WR Scientific Service Division
Mexican Pibal/Rainfall Coordinators	Sergio Reyes/Mike Douglas	CICESE/CIRES
SSMI and AVHRR Coordinators	C. Hayden/R. Rabin	NESDIS/NSSL
AOC Coordinator	Jack Parrish	NOAA/Aircraft Operations Center (AOC)
NSSFC Coordinator	Jack Hales	National Severe Storms Forecast Center
Heat Island Coordinators	Dan Phillips/Randy Cerveny	Salt River Project/Arizona State University
Tucson Activities Coordinator	Bob Gall	University of Arizona
Communications Coordinator	Gary Skaggs	NOAA/NSSL
Data Manager	José Meitín	NOAA/NSSL

The SWAMP Project Coordinator is responsible for overall day-to-day management of the project, use of resources, and assignment of personnel. The P–3 Chief Scientist has overall responsibility for the scientific data collection by the P–3 aircraft including in-flight specification of flight patterns, through consultation with the P–3 Flight Director. Prior to a flight, the flight track planning will be done through coordination between the Principal Investigators (PIs), the Project Forecasters, the P–3 Chief Scientist, and the AOC Coordinator. The Data Manager is responsible for coordinating the archive and quality control of all specialized data sets produced for SWAMP including P–3 data, Phoenix and Tucson WSR-74C digitized radar, data from the national lightning ground-strike detection network, etc. The Upper-Air and NSSL2 Coordinator is responsible for planning and coordinating deployment of NSSL's mobile lab and the release of MCLASS soundings. The NWS Coordinator acts as the liaison between SWAMP operations and the WFSO personnel and arranges for participation of NWS staff in the forecasting and daily decision briefings. The Heat Island Coordinators act as liaison between SWAMP, the Salt River Project, and Arizona State University. They will be responsible for archiving surface mesonet data for the project period and coordinating participation of ASU students in the project. The NSSFC Coordinator is the liaison between SWAMP and the National Severe Storms Forecast Center in Kansas City. The Forecast Coordinator is responsible for scheduling forecast support to SWAMP and daily forecast briefings for the PIs, NWS staff, P-3 scientists, and AOC Coordinator, and also archiving satellite data, forecast products and guidance. The Western Region Coordinator will assist in the logistics required to bring several special capabilities (FAIS, radar operations, etc.) into place at Phoenix for the project. The Mexican Pibals/Rainfall Coordinators will be responsible for siting, training and operating these special data gathering efforts during SWAMP. They will also ensure that these data are processed and incorporated into the SWAMP data base. Pibal wind data will be transmitted via facsimile to Phoenix as appropriate to support forecast operations. The SSMI/AVHRR Coordinators will ensure that special supportive satellite data sets are archived at NESDIS in Madison, Wisconsin. The Tucson Activities Coordinator will arrange participation of two U. of A. students, schedule their training to support WSR-74C radar data recording, and also coordinate all activities with LLP. The LLP Tucson area lightning data will be made available to SWAMP scientists via the Tucson Activities Coordinator. The Communications Coordinator will plan and oversee all aspects of communications required in support of field operations during the project–including collaboration with AOC regarding communications with the P-3 aircraft.

3. Objectives

The project has three exploratory goals for data gathering cases; a) Central Arizona thunderstorm environments; b) Monsoon structures and moisture fluxes; and c) Mexican convective systems and environments.

During a planning meeting, conducted in Phoenix during December 1989, these general goals for the SWAMP Project were specified as follows:

a) Central Arizona Thunderstorm Environments

- Investigate mountain/desert local environments and the Arizona-scale meso-environment to help understand why on specific days monsoon thunderstorms do, or do not, move from the mountains into the Phoenix area, within apparently similar large-scale settings, on two to four intensive study case days.
- Explore ways to discriminate between severe and non-severe thunderstorms (mainly high wind storms that appear similar on radar) that occur over the Salt River Valley during the Project.
- Reduce National Weather Service (NWS) Phoenix's False Alarm Rate (FAR), and increase it's Probability of Dectection (POD) and Critical Success Index (CSI) in the NWS Warning Verification Program. End results will be attained by increasing meteorological watch, by anticipating and/or reacting to severe episodes in a more timely manner, and by improving on the quality and

quantity of information that is made available to the person making the decision in the warning process. Also verify and evaluate severe and significantly severe (as per, Jack Hales, SELS) events.

- Use the forecasts, warnings, and verfications during SWAMP for pre-NEXRAD/post-NEXRAD skill evaluation at the Phoenix forecast office.
- Document the mesoscale four-dimensional thermodynamic structure of the Phoenix heat island, especially during nighttime hours, for at least four case periods.
- Gather ground-based and P-3 radar data coincident with SSMI overflight times whenever possible.

b) Monsoon Structures and Moisture Fluxes

- Determine the large-scale structures (u, v, T, rh, p′) of the western edge of the Monsoon boundary in the middle and lower troposphere for one or two cases.
- Determine the vertical and horizontal signs and approximate magnitudes of moisture flux divergence over northwestern Mexico and the southwest U.S. for several specific cases.

c) Mexican Convective Systems and Environments

- Document the characteristics of the preconvective environment over northwest Mexico for two to four cases.
- Determine the evolution of internal precipitation and kinematic structures for several MCSs over northwestern Mexico.
- Qualitatively characterize the nature of lightning activity within Mexican convective storms utilizing LLP and visual P-3 observations.
- Gather P-3 radar data of MCS and storm structures coincident with SSMI overflight time whenever possible.

Each major activity is described in more detail in the following sections.

3.1 *Central Arizona Thunderstorm Environments*

The Salt River Valley, and particularly the metropolitan Phoenix area, at times represents a puzzling thunderstorm forecast challenge to NWS forecasters. Once the general moist monsoon flow has setup over Arizona (usually by July 10th), thunderstorms are an almost daily occurrence over the mountains. The diurnal cycle within the Valley, and nearby mountains to the north and east, e.g. the Mogollon Rim, appears to have a pronounced effect on the evolution of convective storms. On many days the storms that develop over the mountains do not propagate into the low desert, but rather dissipate as they move away from the high terrain. When storms do move into Phoenix, they are often severe with strong outflows and usually occur during the late evening or early night, giving Phoenix a distinct nocturnal maximum of thunder and rainfall during the monsoon. These different thunderstorm scenarios occur within weakly baroclinic large-scale settings that often appear basically similar. The reasons for the observed thunderstorm characteristics in the Salt River Valley are not well known, primarily due to the dearth of observations available to diagnose boundary layer, as well as mid-tropospheric processes and we hope to gather research data sets on both thunderstorm event and non-event daysin the Phoenix area. The P-3 aircraft can sample the evolving thermodynamic structure from the low desert to the rim during afternoon and evening hours. These data, coupled with sounding data from a fixed MCLASS unit at the WSFO and the mobile laboratory (NSSL2), along with recorded radar data and surface mesonet (PRISMS) data, will provide a unique basis for studying the diurnal evolution of the local thunderstorm environment. A map showing possible deployment locations for remote soundings is shown in Section 5.

In addition to these aspects of the thunderstorm forecast problem, it is known that a substantial heat island is present over the Phoenix metro area during much of the year. The effect of the heat island during the summer monsoon (a period of relatively high humidity as well as heat) is to cause high power demands to persist well into, or through, the night. The four dimensional character and mesoscale structure of this urban heat island have not been well documented. The mesoscale surface network, coupled with the frequent soundings taken by the MCLASS units, provides the opportunity to observe the evolution and structure of the heat island during SWAMP. The NSSL2 mobile lab will be used during four special heat island periods to gather east-west and north-south transects through the heat island during the night and early morning hours. A map of an example of how NSSL2 may gather data during one of these traverses in shown in Section 5. It is also postulated that the heat island, and its attendant circulations, affects the character of the thunderstorm environment over the valley. For example, during a test of the MCLASS capabilities this fall, the heat island core was characterized by reduced humidities to heights as great as 2,000 m above the surface.

Investigators of the data gathered in support of this objective will likely include: R. Balling and R. Cerveny (ASU), J. Hales and a number of NWS meteorologists, D. Phillips and J. Skindlov (SRP), R. Maddox, K. Howard, and C. Crisp (NSSL).

3.2 Monsoon Structures and Moisture Fluxes

One of the most pronounced climatic aspects of the SW United States in the summer is a large-scale flow regime commonly referred to as the Southwest Monsoon. The SW monsoon is one of the most important aspects of summertime weather over large portions of the western half of the United States since the occurrence of substantial precipitation is directly linked to the intensity and persistence of monsoon episodes. The moist monsoon flow often appears to fuel convective episodes over the central and northern Rocky Mountains and the associated moisture plume occasionally intrudes into the westerlies and can extend eastward as far as the Great Lakes region. It appears that the summer and fall precipitation climatology of large portions of the country (SW deserts, Great Basin, Rockies, Central and Southern Plains) are linked directly to the SW U.S. Monsoon. The interface, or "monsoon front", between the moist flow of the monsoon and the large-scale, dry subsiding zone over the eastern Pacific is often very distinct. A large number of convective events tend to occur within or near the western boundary of the monsoon circulation. The monsoon is thus of direct relevance to NOAA and its mission of understanding mesoscale processes; understanding regional climate and climate change; and improving weather forecast services over the United States.

During SWAMP, the P–3 will be used to collect in-situ and some limited dropwindsonde data (over water) to document wind and pressure fields and the strength and extent of the gradients of temperature and moisture across and along the western boundary of the monsoon interface. Special patterns will be flown to investigate the interface (saw-tooth climbs and descents) as well as large-scale aspects of the overall monsoon circulation. In addition, special rawinsonde releases will be obtained from a number of Mexican and U.S. upper-air stations to help define the monsoon circulation. Estimates of moisture flux will be supported by these data plus special pibal wind data from northwestern Mexican stations (see Section 5.2 for details). The actual sites in Mexico where pibal stations will be established will depend on the availability of personnel to make observations. Mexican Weather Service personnel will make the required observations at all but a few sites where no surface observations are presently made. At these sites personnel from CICESE will make the desired observations. The daily pibal strategies will be determined in coordination with the SWAMP PIs and will coincide with P-3 monsoon boundary and moisture flux flights.

As part of an extended Mexican research program, scientists from a number of institutions will be studying the water budget and hydrologic balance over northwestern Mexico (EBA–Estudio del balance de Agua). The first field program in those studies (Transportes atmosféricos Verano en el desierto Sonorense–TRAVASON VERANO 1990) will occur simultaneously and in close coordination with SWAMP. It is planned that the observations taken in this component of SWAMP will prove equally useful to both projects. Further, the detailed precipitation data gathered in TRAVASON VERANO-90 will enhance the SWAMP data base.

Investigators for this objective will likely include R. Gall and J. Zehnder (University of Arizona), S. Reyes (CICESE, Ensenada, Mexico) and other Mexican scientists, M. Douglas (CIRES/NSSL), C. Hayden (NESDIS/SAL), and R. Maddox, R. Rabin, and K. Howard (NSSL).

3.3 Mexican Convective Systems and Environments.

During July and August, the northwestern states of Mexico frequently experience very large, apparently intense (as indicated by the satellite-observed cloud top temperatures colder than -70° C) mesoscale convective systems (MCSs–see satellite image inside front cover). Afternoon convection over the Sierra Madre Occidental occurs almost daily, with long-lived MCSs developing from that early convection with a frequency of about 2 per week. It has been shown that a significant portion of the warm season precipitation over the SW U.S. and northern Mexico comes from MCSs and these systems will undoubtedly prove important to the water balance studies over Mexico (the EBA). The MCSs, as well as the orographically organized thunderstorms, apparently provide a mechanism for the vertical transport of moisture that is eventually advected northward by the monsoonal circulation. The latent heat released by these orographic systems may play an important role in driving the subtropical flow regime over western North America during summer. For SWAMP, direct involvement of Mexican scientists working in the EBA (Centro de Investigación Científica y de Educación Superior de Ensenada [CICESE], Comisión Nacional del Agua [CNA], Servicio Meteorológico Nacional [SMN], Instituto Tecnológico de Sonora [ITSON], Universidad Autónoma de Baja California [UABC]) and other institutions will help provide access to in-situ truth data from western Mexico as well as ensuring that the data prove useful to studies underway in both countries.

Even a cursory examination of summertime satellite imagery over northwestern Mexico reveals that MCSs are very frequent, slow moving, and often very large. However, lack of radar and reliable raingage data have prevented documentation of their internal structure. Important scientific questions relate to the internal structure and organization of these systems. Do they exhibit similar circulation and precipitation structures to the previously studied systems in mid-latitudes and/or the tropics? The P–3 data will enable us to begin to categorize these MCSs in the context of other tropical and mid-latitude systems, further generalize the dynamics of MCSs, and aid in the refinement of global and regional climate models. Investigators of data gathered for this objective, are likely to include R. Maddox, D. Jorgensen, B. Smull, and other NSSL scientists, S. Reyes (CICESE) and other Mexican scientists, and M. Douglas (CIRES).

4. Forecasting and Daily Operations

The SWAMP scientific operations base will be the WSFO at the Phoenix Sky Harbor International Airport. The WSFO Conference room will be made available for use as the SWAMP Operations Center. The SWAMP forecasting team will make limited use of WSFO facilities (including AFOS products, radar and satellite data) and a variety of special data links to prepare daily forecasts and next-day outlooks.

The SWAMP forecasting support effort will operate 7 days a week for the full operational period of the experiment (i.e., 8 July through 7 August). Forecasts and briefings will continue, regardless of whether the aircraft is deployed on a mission. The following daily chronology provides a working guide for how SWAMP forecast support will operate on a day-to-day basis assuming a late afternoon P–3 takeoff (TO). **The schedule will be adjusted for earlier P–3 departures.** Some aspects of the program have yet to be worked out and we plan for the forecast team to be flexible, so that the program can function smoothly without every daily detail having to be specified in advance. The typical daily schedule will be as follows:

03:00 MST — Two members of the AM forecast team (NWS student and NSSL forecaster) will prepare and launch a 12 UTC sounding at the PHX MCLASS. After the completion of the flight the sounding will be encoded into AFOS for dissemination.

06:00—10:30 MST — The AM forecast team, augmented by the NWS SWAMP morning forecaster, will perform analyses to forecast probability of occurrence of convective development in central Arizona for that day, and estimates of the location of occurrence, time of development, and speed and direction of movement of thunderstorms over northern Mexico and southwestern US. Note: the general times for the SWAMP forecast shifts will be: *Early AM:* 3:00 AM to noon; *AM:* 6:00 AM to 2:00 PM; *PM:* 1:00 PM to 10:00 PM.

10:30—11:00 MST — Project coordinators, AOC representatives, and the forecast team meet to discuss the outlook for convective development for that day and to review the status of the various program elements. Based on this information the program leaders, will determine if the day should be considered GO or NO-GO for operations, and if it is a GO day, the flight strategies for the P–3 will be determined. The TO time will have already been estimated the previous day. **If the TO has been set to be earlier than 14:00 MST, then the starting time for this briefing will be 3 $^1/_2$ hours prior to the TO.**

Once the SWAMP mission/scientific objectives, and P–3 flight strategies, for the day are determined, the strategy discussions will focus on the other observing system requirements and address:

- Do any of these sites need to have confirmation to take, or to stand down, special observations this afternoon and night?
- Should the NSSL2 be deployed to take special soundings in support of thunderstorm or heat island studies?
- Do U.S. and Mexican sounding sites have to be alerted for possible special releases on the following day?
- Should the Mexican pibal sites be alerted for possible frequent releases on the following day?
- If NSSL2 and Phoenix MCLASS are to operate during the coming 24 hours, what should be the times of release and where should NSSL2 be located at release time?
- Should storm spotters be deployed during the afternoon and, if so, to what areas? (Note spotter reports will come directly to the NWS public forecast area.)

It is important to remember that special data gathering in support of the "Central Arizona Thunderstorm Environments" can be called for regardless of the decisions on P-3 missions. The principal exception being the case where NSSL2 is needed to accomplish an east-west sounding transverse of the monsoon boundary zone. When this occurs NSSL2 will probably operate along Interstate 8 between Tucson and Yuma. The NSSL2 deployment strategies for both thunderstorm studies and heat island monitoring will be developed prior to July 7 and will depend upon system-site behavior.

11:00—11:30 MST The SWAMP outlook weather briefing (OWB) will be given daily to all personnel, and other interested observers, by the project leader, or his designee, regarding the forecast and the operational status of the program. During this briefing the on-duty forecast team leader, or designee, will provide a weather briefing and forecast for the day, and the outlook for the next day. The various project leaders and special program coordinators will also discuss the status of the projects and special programs, **and will fix the TO time for operations the next day,** or will declare the next day a hard down day for P–3 operations.

(The remainder of this section is valid for P-3 GO days with a late afternoon TO.) At least 4 h prior to the tentative TO, the PM Forecast/operations team arrives at PHX WSFO and begins to monitor convective development using AFOS (hourly surface maps, soundings, etc.), radar and satellite looping displays. Update briefings during this period with SELS will be through a phone call between SELS lead forecaster and/or the MESO forecaster (depending on SELS activity) and the SWAMP and WSFO forecaster.

TO - 3 $^1/_2$ h Key P–3 personnel are briefed by forecast/operations team.

TO - 3h Program leaders make final GO or NO-GO decision, or delay the TO.

At TO minus 1 $^1/_2$ h the key aircraft personnel will receive a final briefing (radar and satellite data) and leave for aircraft. Following the departure of the P–3 from Phoenix, communication is established between aircraft and PHX PM forecast/operations team; continual updates of aircraft location, weather, movement of convective system, development of system, etc., are relayed between the operations center and the P–3. Primary functions of the forecast/operations team are to monitor data and relay information about storm location, movement, and any significant changes in storm structure.

The following is the afternoon forecast schedule for all program days.

13:00—22:00 MDT The PM forecast team (NWS Visiting forecasters, NSSL PM forecaster, and NWS student) will work to support the operational activities of SWAMP and/or prepare forecasts and outlooks for the coming day.

15:30—16:00 MDT Project leaders, forecast team and coordinators from the satellite and rawinsonde program or their designees again meet to discuss the 24-36 hour outlook for MCS development and whether the forecast team needs to supply a new outlook based on the 00 UTC data.

16:00 MDT Two members from the PM forecast team will launch the 00 UTC PHX MCLASS sounding. The PM forecast team will continue to monitor the weather in support of any program activities. The PM forecast team is responsible for recording radar data and taking any special soundings requested by NWS. **The heat island phase of the program will be coordinated through the PM forecast team.**

20:00 - 22:00 MDT If it is determined at the afternoon meeting that the 00 UTC data need to be analyzed in order to make a 24-hour forecast for the rawinsonde program, then the forecast team will update the forecast based on 00 UTC data and supply the information to the program leader, or his designee. If data gathering missions are in progress, this shift will extend through the conclusion of operations.

Typically, at the late afternoon meeting (15:30-16:00 MDT), the options for calling a special rawinsonde day for the next day will have been discussed between the program leader and rawinsonde coordinator. Thus, based on the forecast, the rawinsonde coordinator will, or will not, alert the rawinsonde sites for possible soundings the next day. He will also alert the pibal coordinator if needed.

Several briefings and conference calls are anticipated between NSSFC/SELS forecasters and SWAMP operations, particularly on days when storms are expected in central Arizona. The most effective schedule with regard to coordination between SWAMP and SELS forecasters will be generally as follows:

Outlook Briefing: This would best be done about 19 UTC via a telephone/speaker phone call which would include the SELS Lead Forecaster and/or assistant forecaster and the SWAMP operational and Phoenix WSFO forecasters. This briefing would discuss the next day severe storm and MCS potential over the SWAMP area and would include scheduling a time for a planning briefing if needed. Utilizing the upper-air soundings from the SWAMP area and other data that are available, a discussion of the present days convective scenario would be included.

SELS Planning Briefing: This would have been scheduled the previous day to be 3 hours prior to TO-1 $^1/_2$ h. It could be coincident with the outlook briefing (OWB) if appropriate. This should again be through a telephone call between the SELS Lead Forecaster and/or the Meso forecaster (depending on SELS activity) and the SWAMP and WSFO Phoenix forecasters.

Unscheduled Briefings: These would be handled by the SELS Meso Forecaster using AFOS and/or telephone calls. The purpose would be to provide short range guidance on convective trends and/or severe potential for the Arizona portion of the SWAMP project. There would also be an attempt to identify the first evidence of MCS genesis over Arizona and northwest Mexico on those days identified as an MCS flight day. The AFOS header product to send this information will be *SWOMCD* which is already the operational means to communicate to the WSFO.

Forecast Office Procedures. Because a substantial number of people will be participating in the SWAMP project, there will be many visitors to, and heavy traffic in and out of the Phoenix NWS Forecast Office. To minimize distractions to the operational forecast staff and possible disruptions of critical severe weather services to Arizona, it will be necessary to restrict access to the operational forecast area of the WSFO. Those SWAMP participants who will be authorized to enter the operational area for interactions with the duty forecasters include: The Project Leader, P–3 Chief

Scientist, SWAMP duty forecasters, and the NWS student employees. During severe weather situations a Packet Radio operator and an HF base station operator will also be working in the operations area to relay reports from storm chasers to the duty forecasters. **All other SWAMP participants and visitors are restricted to the SWAMP support area in the library of the WSFO.** These people should enter and leave the forecast office through the front entrance (i.e., the main door which faces Buckeye Road). Signs will be posted to direct participants to the SWAMP area. **All SWAMP participants and visitors must also observe the WSFO dress code – i.e., shoes and slacks and a shirt or sport shirt having a collar – shorts will not be acceptable dress in the WSFO facilities.**

5. Mobile Laboratory and Upper-Air Observations

5.1 Mobile Laboratory and Heat Island

NSSL's mobile laboratory (designated NSSL2) will be deployed to Phoenix for SWAMP. An additional fixed-base MCLASS system will be installed outside the Phoenix WSFO to take regular synoptic (00 UTC and 12 UTC) soundings for the duration of SWAMP. The mobile lab operations will be directed by the NSSL2 Coordinator. The Phoenix MCLASS soundings will be taken by the early morning forecaster (12 UTC) and by the afternoon forecaster or assistant (00 UTC). At the OWB, the MCLASS observational strategy will be determined. Prior to the official start of the project, the NSSL2 team will take exploratory soundings at a number of locations (candidates include: Cordes Jct., Carrizo, Red Rock, Payson, Globe, and Apache Junction, see Map #1) to determine system reliability. Communications with NSSL2 will be via amateur radio links, conventional telephone, cellular phone, or VHF with the SWAMP operations base at the Phoenix WSFO.

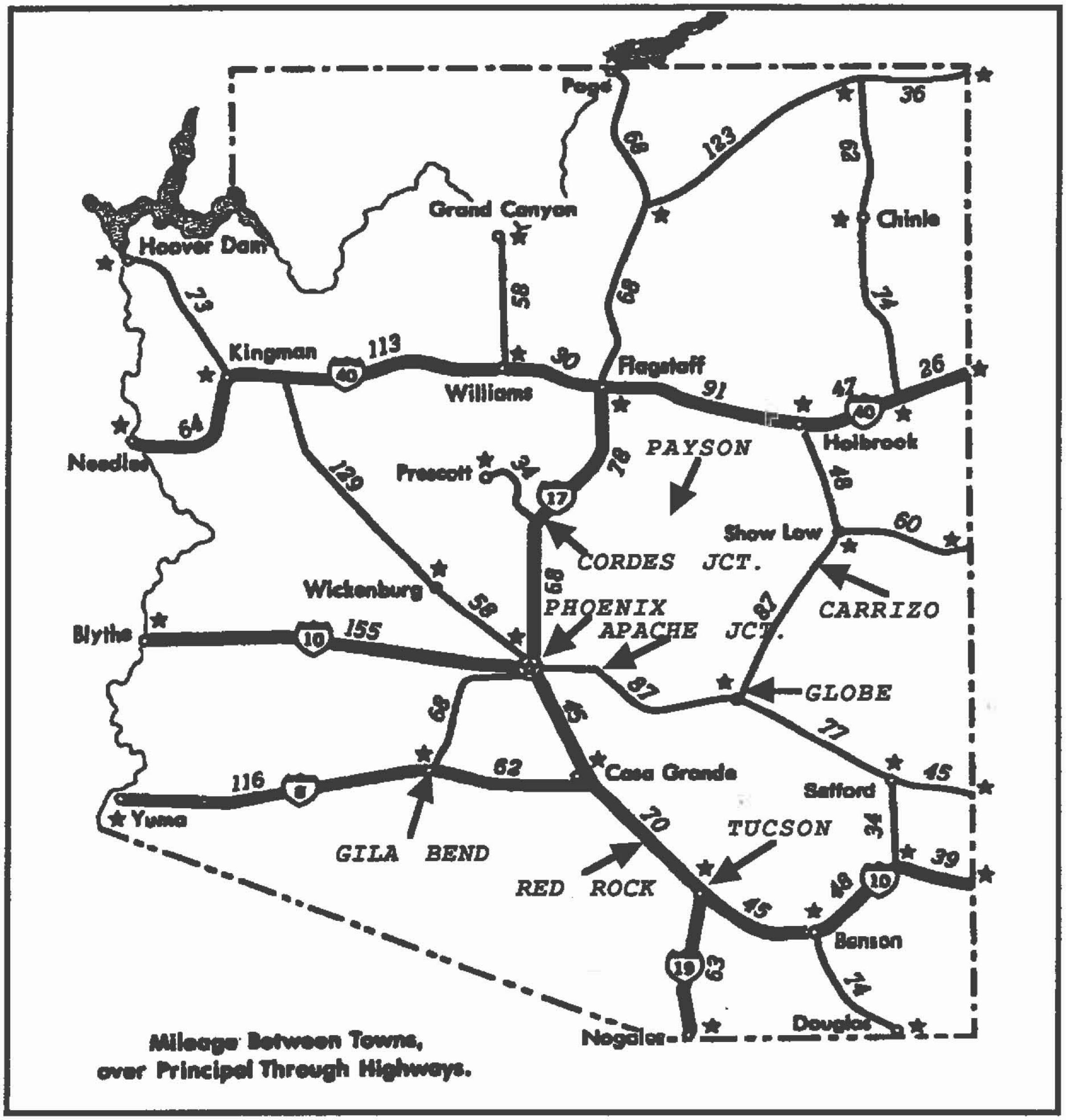
It is anticipated that the majority of NSSL2 launches will be at predetermined sites and times. The placement of the mobile laboratory during the SWAMP project will be determined on a daily basis by the forecast/operations team. Six anticipated NSSL2 operation locations are identified on Map #1. Soundings will also be launched at the NWS Forecast Office in conjunction with soundings taken by NSSL2. Communications will maintained with NSSL2 at all times during experiment days. Repositioning of NSSL2 to alternate locations during a experimental day will be determined by the afternoon forecast team.

Four intensive data gathering missions will be conducted during the SWAMP program to measure the three dimensional characteristics of the heat island over Phoenix. Two preliminary transects across the city have been mapped for the deploying NSSL2 for MCLASS launches (Maps #2). Soundings will be taken simultaneously at the Sky Harbor and predetermined locations along the transects at thirty minutes intervals. The transects have been laid out to allow maximum use of data from the PRISM network surface sites. The maps shows the location of PRISM sites and the location of NSSL2 MCLASS launch sites for the heat Island experiment. The first two heat island experiments will be taken during fair weather conditions with low humidity. Missions will begin with launch at location #1 along the transect at 10:00 PM continuing until 1:00 AM at location #7. A repeat of the transect will begin 3:00 AM with first release at location #8. The transect will end with the last sounding launched at 6:00 at initial starting position of the transect (location 14). A detailed map of the city and surrounding area will be in the NSSL2 van with the locations of each launch site indicated. It is planned that an SRP staff member will serve as 'navigator' during these transects. Two of the missions will be run early in the field program prior to the monsoon beginning. The two remaining missions will be conducted during the monsoon with higher moisture values present over the city. A fifth, optional experiment, could collect soundings during the night within the central portion of one of the transects. Decisions regarding the choice of transects will made prior to each mission. Changes in the strategies for the heat island experiment will be considered after the first run if needed. Again, the heat island work can occur independently of most P-3 missions. If the P-3 flies into Sky Harbor during a heat island intensive observational period, several "missed" approaches could add aircraft in-situ observations to the heat island data base.

5.2 *Upper Air Soundings and PIBALS*

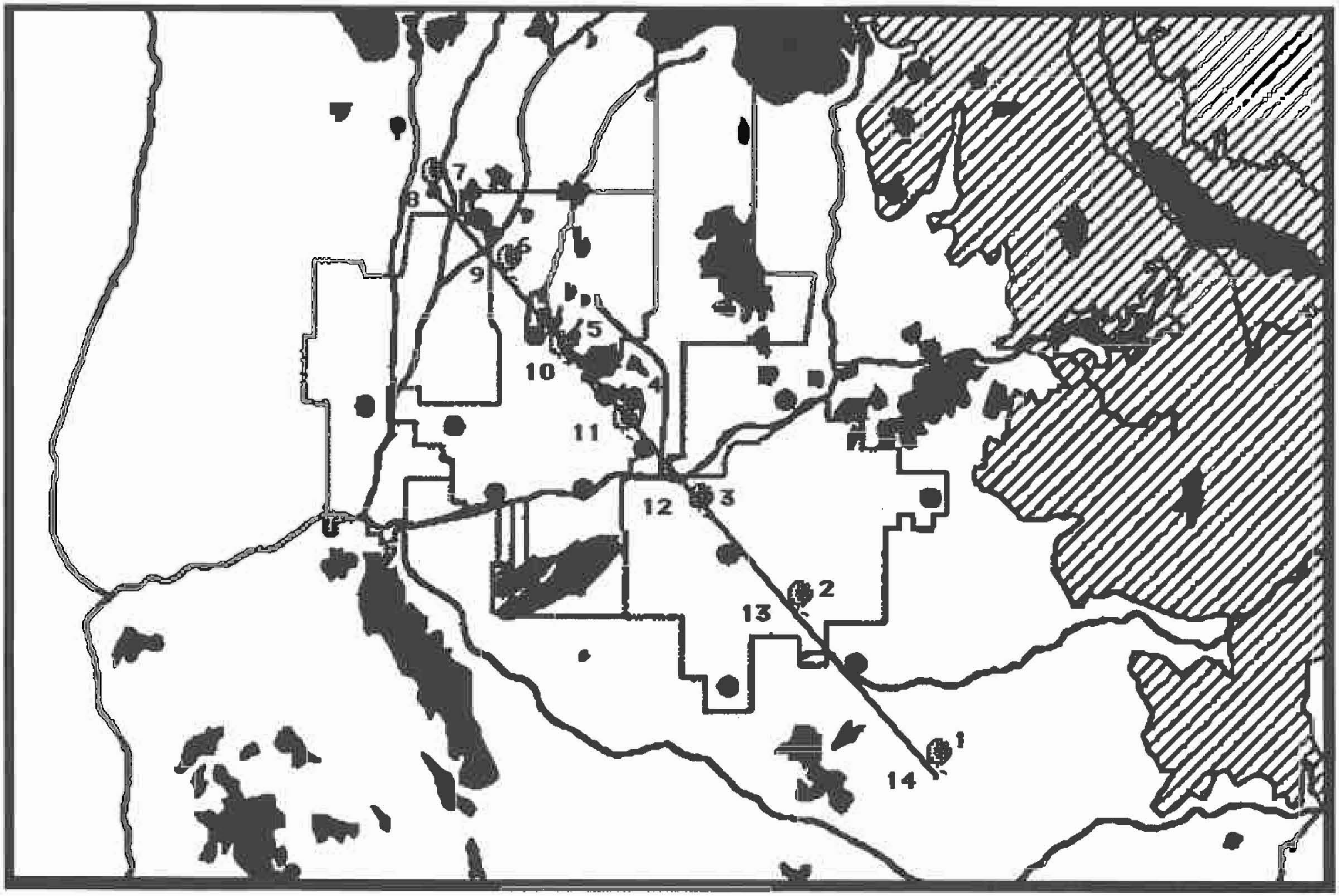
During SWAMP the 00 UTC upper-air soundings will be taken routinely at Guadalupe Island, Mazatlan, Empalme, and Chihuahua. Approximately four to five special support rawindsonde periods will be scheduled during the experiment. During these periods, soundings will be flown at 6 hour intervals (i.e., 00, 06, 12, and 18 UTC) at all participating upper-air locations. (PHX MCLASS, San Diego, Winslow, Tucson, El Paso, Guadalupe Island, Mazatlan, Empalme, and Chihuahua). Termination will be 100 mb, unless the Upper-Air Coordinator requests otherwise. Special soundings will continue until the coordinator notifies all stations to terminate operations; this termination will generally be after 24-hours; however, in an unusual meteorological situation the special soundings might be requested through a 36–48 hour period. All participating upper-air sounding stations will be alerted via an AFOS message ***and*** a phone call from the Upper-Air Coordinator. Close coordination will be maintained between the Phoenix operations center and the Mexican communication center at Mazatlan. The strategies and decisions for special upper-air observations and pibal network operations will also be determined prior to the OWB.

MAP #1. Possible NSSL2 Deployment Sites



Location	Estimated Time from Phoenix
Payson	1:45
Carrizo	3:00
Globe	2:00
Cordes JCT	1:10
Red Rocks	1:10
Tucson	1:45

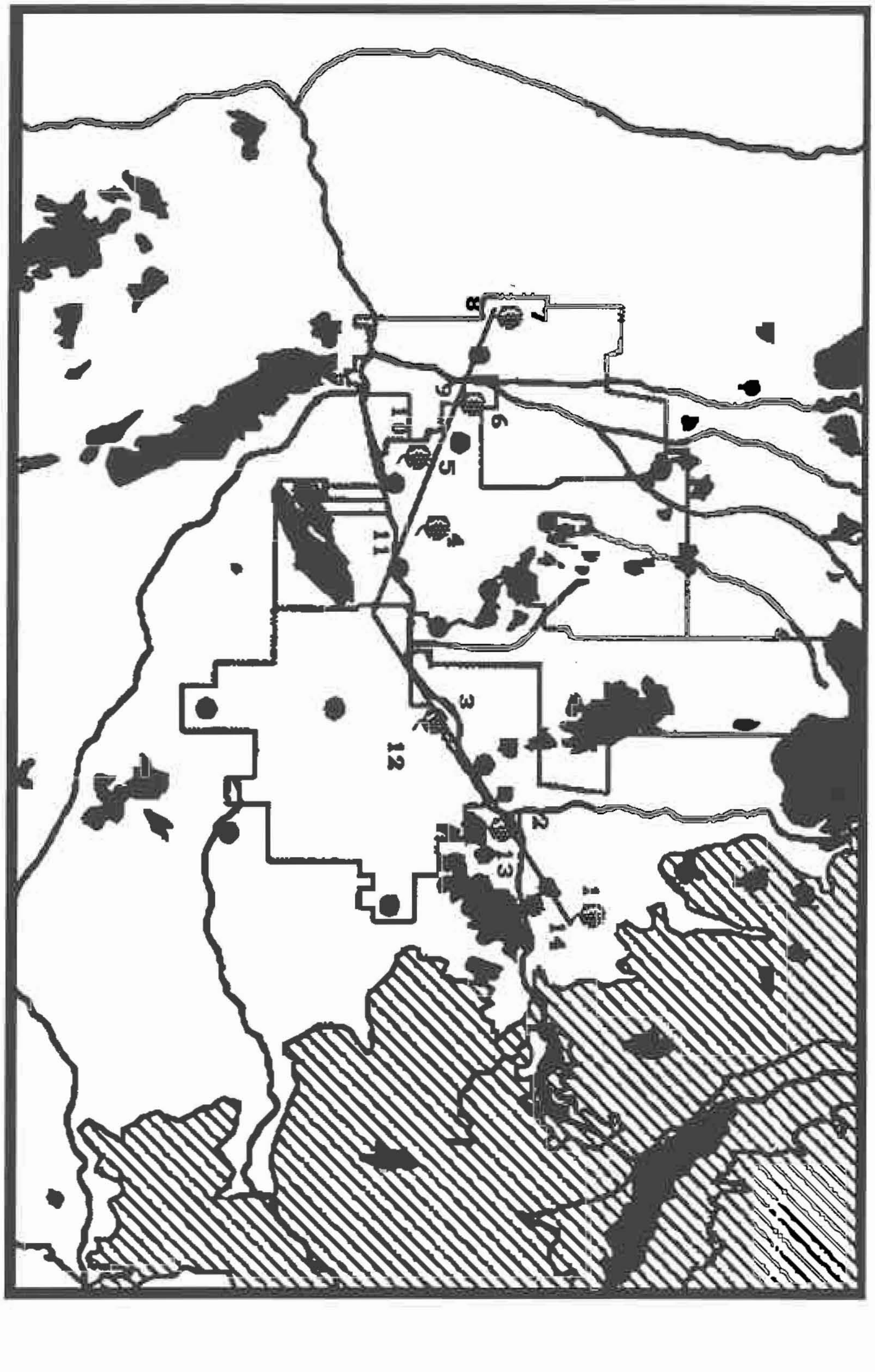
MAP #2 Possible NSSL2 "Heat Island" Transect Launch Locations



M-CLASS launch sites.

PRISMS mesonet sites.

MAP #2. Possible NSSL2 "Heat Island" Transect Launch Locations



M-CLASS launch sites.

PRISMS mesonet sites.

During SWAMP, pilot balloon observations (pibals) will be made at a number of sites in northwestern Mexico. These pibals will supply lower-to-middle level wind observations with a finer horizontal and temporal resolution than possible from the present rawinsonde network. Specifically, these observations will:

- help to specify the wind field in the vicinity of MCSs over the coastal plain of Sonora and Sinaloa.
- provide estimates of the diurnal variation of upper-level winds over northwestern Mexico.
- help to describe the wind field (both mean and synoptic-scale variations) associated with the monsoon circulation over northwestern Mexico during the summer wet season.

The optical theodolites, together with filling devices and pilot balloons, will be shipped to the NOAA NWS Liaison in Laredo, Texas by 1 June. Shortly thereafter the theodolites will be transported to sites in Mexico, for training of Mexican personnel and establishment of the individual sites. The actual sites in Mexico where pibal stations will be established will depend on the availability of personnel to make observations. The sites listed below would be desirable; they are ordered in terms of their relative importance.

1	Hermosillo, Sonora	29.07 N	110.97 W
2	Los Mochis, Sinaloa	25.82 N	108.97 W
3	Ciudad Obregon, Sonora	27.48 N	109.93 W
4	Torreon, Coahuila	25.53 N	103.45 W
5	Cataviña, Baja California	29.87 N	114.95 W
6	La Paz, Baja California Sur	24.17 N	110.42 W
7	Nueva Casas Grandes, Chihuahua	30.42 N	107.92 W
8	San Ignacio, Baja California Sur	27.28 N	112.95 W
9	Hidalgo del Parral, Chihuahua	26.93 N	105.67 W
10	Puerto Peñasco, Sonora	31.30 N	113.55 W

Surface observations are presently made at all of these stations except #5 and #8. It would be desirable to take pibals at the rawinsonde stations of Empalme, Chihuahua, and Mazatlan at the intermediate hours of 18 UTC and 06 UTC.

The theodolites will be deployed to the Mexican sites during June, and should start routine 12 UTC soundings on 28 June. Before the June theodolite deployment, the observers will be introduced to the principles of theodolite operation, calculation of winds, transmission of data, etc. at a training session in Hermosillo. Practice in tracking balloons both in daylight and at night will take place. A precise determination of true north will be made at each site. Local arrangements for the supply of hydrogen gas will be made.

Stations should take 1 morning (12 UTC) sounding from 28 June until 7 July, when routine soundings should be made at 12, 18, and 00 UTC. Soundings at 06 UTC should be made during special requested dates. Routine soundings will end at 00 UTC 10 August. All stations will be requested to make soundings at 09, 12, 15, 18, 21, 00, and 03 and 06 UTC on 2 days during the experiment.

Balloon requirements. Each station will have the following sounding needs: 9 days @ 1 balloon/day, 27 days @ 3 balloons/day, 6 days @ 4 balloons/day, and 2 days @ 8 balloons/day. This schedule requires 130 balloons plus 5 for training and 10% for spares (13). Thus, 148 balloons per station are needed. For 10 stations, a total of 1480 balloons are needed.

Gas requirements. The 100-gm balloons have a volume of 0.34 m^3 when inflated for an ascent rate of 250 m min^{-1}. Approximately 17 balloons can be filled with a standard gas cylinder of 5.9 m^3 volume. **Thus 9-10 cylinders need to be provided to each site before the start of soundings on 28 June.**

The morning (12 UTC) pibal winds should be transmitted operationally to the Mexican Weather Service office in Mexico City, for dissemination. The format should be the standard pilot balloon format (PPBB). A backup procedure will be used if data are not received in the Phoenix WSFO by 15 UTC, whereby stations will be phoned and selected winds orally reported. The specific procedure will be described at each sites' training session.

Theodolites and accessories, together with the raw data, will be collected on return visits to each site to begin after 10 August. A preliminary report on the data collected, as analyzed in the Phoenix WSFO, will be distributed to personnel at each site at that time.

6. P–3 Operations

6.1 Operational Constraints

The Aircraft Operations Center (AOC) of NOAA has developed several rules regarding P–3 flight missions to insure safe operations yet allow maximum flexibility to adjust to changing weather and multiple scientific objectives. These constraints are summarized in Table 2.

Table 2. P–3 Operational Constraints

Constraints	*Limits*
Anticipated next-day takeoff time	Must be specified at least 24 hours in advance
Crew duty day	16 hours
Minimum crew rest between duty days	15 hours
Maximum consecutive mission days	6
Minimum pre-flight preparation time	3 hours

The anticipated next-day takeoff time specifies the start of the crew duty day. The mission **must be completed within 16 hours** of this time including any delays in takeoff. A "hard-down" day must be given after the sixth consecutive mission day, or following 3 consecutive late night missions. A mission day is defined as *an alert day whether or not the aircraft actually flies a mission.* A down day is declared at the OWB for the next day. *The scientific personnel will also adhere to the crew duty day and crew rest operational constraints.*

6.2 *Flight Strategies*

Flight strategies for each of the three major objectives are detailed below.

Monsoon Structures and Moisture Fluxes. The flight strategy for documentation of monsoon interface structure and quantification of horizontal moisture fluxes will be to conduct at least two dedicated missions to describe the large-scale aspects of the SW monsoon (Pattern "A1"). These missions will be conducted on days when the monsoon interface is particularly well-defined (as depicted on water vapor satellite imagery) and will be accomplished as early as possible during the project. It is assumed that 2 days of frequent pibal flights will be coordinated with these flights. Another mission will be devoted to examining the detailed vertical structure of the interface (Pattern "A2") at a location near the U.S. – Mexican border so NSSL2 can be used to gather complementary soundings. This pattern is well-suited to a quasi-two-dimensional (and stationary) monsoon interface. This mission will also be conducted during a relatively quiet convective period (or early in the day) to avoid contamination of the structure by convective processes. In addition, monsoon interface missions (an abbreviated "A2") can be flown as targets of opportunity during an MCS mission or as an alternate mission to document preconvective structures over northwestern Mexico or if MCS evolution does not progress as hoped.

Mexican Convective Systems and Environments. It will not be possible to observe the complete life cycle of a Mexican MCS using a single aircraft. Similarly, it would be a very difficult forecast problem to anticipate MCS development early enough to get the aircraft to sample the undisturbed pre-development state prior to convective storm initiation. Therefore, the MCS strategy will focus on observing the early to mature stage of the system for comparisons to other analyses collected during PRE-STORM, TAMEX, etc. Documentation of forcing mechanisms (such as sea/land/mountain/valley breeze circulations) and the evolution of the boundary layer west of the Sierra Madre Occidental may be attempted in conjunction with the Arizona mission described above. The strategy will usually be to delay takeoff until clear evidence of a major convective development is observed on satellite imagery. Convective storm patterns (B1) will be flown to document the convective kinematics and if MCS genesis occurs, then MCS patterns (B2) will be flown. Omega dropsondes and/or aircraft ascent/descent soundings will be used to document the inflow environment, and the Doppler radar will be used to observe the mesoscale kinematic structure. Should substantial stratiform precipitation develop, then the microphysical survey pattern (B3) could be flown. We will also try to time these flight strategies to assure P-3 radar data coincident with SSMI overflight times (approximately 00 UTC).

Central Arizona Thunderstorm Environments. The P-3 aircraft will be used in two modes to augment the other observing systems being deployed in and around the Salt River Valley. The first set of these patterns (C1 & C3) are designed to sample the evolution of the boundary layer from the low desert to the Mogollon Rim during the late afternoon preconvective environment. Should air traffic control limit the altitude range of the stairstep flight patterns significantly, pattern C3 could be used in place of pattern C1. There are several options possible that would allow this pattern to be flown as part of longer MCS missions to Mexico. The second set of patterns (C2 & C4) are designed to augment the synoptic scale upper-air data to help determine if unresolved short-wave troughs are occasionally associated with propagating thunderstorm systems. These patterns could be rotated to a SW-NE orientation if a disturbance moves across northwestern Mexico toward Arizona. Pattern C2 is the preferred pattern, however, if air traffic control limit the range of altitudes for the stairsteps, then pattern C4 could be substituted for pattern C2. Again there are several options that would allow these missions to be flown as part of a longer MCS flight to Mexico. If strong storms move toward the lower desert, it is anticipated that convective flight strategies would be employed to gather Doppler data within these storms. It is possible that P-3 Doppler data could help provide answers to the severe/non-severe dilemma that often faces Phoenix forecasters. No specific flight strategies are being planned in support of the heat island experiments.

6.3 Flight Patterns

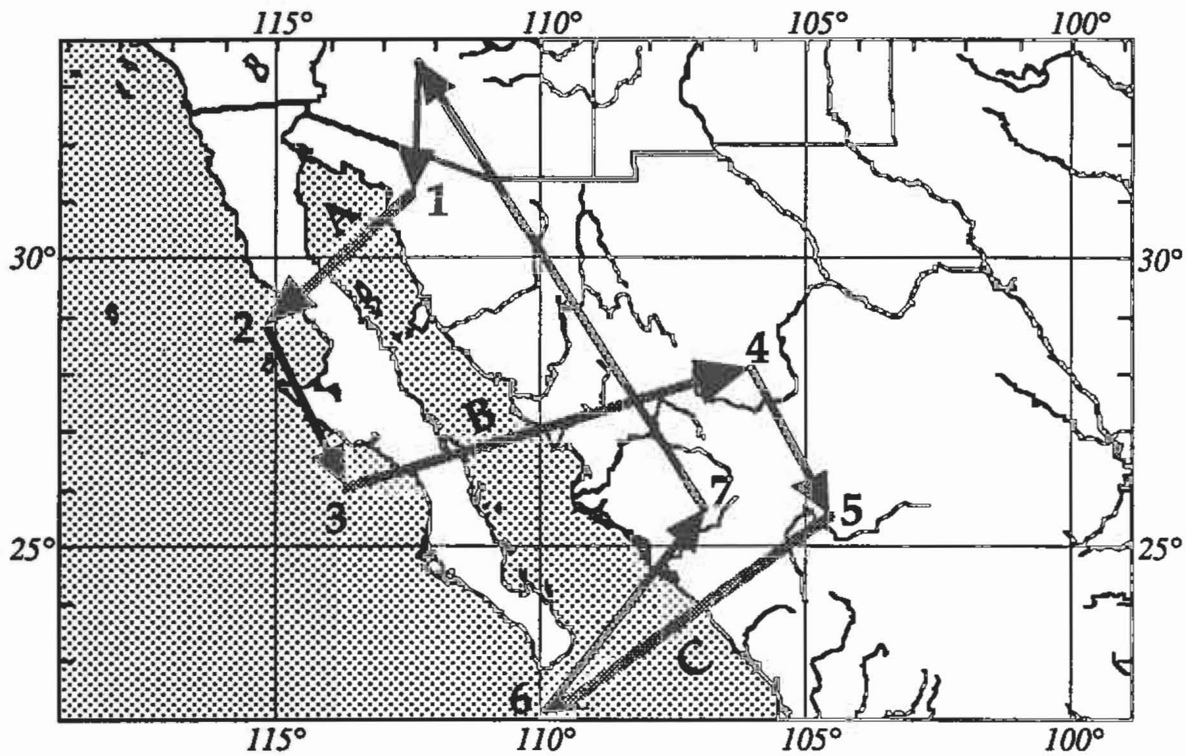
One of the advantages of using the P–3 aircraft to investigate weather phenomena is the ability to adjust flight patterns to fit the pattern of storms and precipitation. This ability makes precise pre-planning of specific flight patterns difficult, and what is shown below are only generic flight patterns showing what typically could be done to address each of the 3 principal scientific objectives. In addition, flight safety requirements specify that the P–3 not penetrate any convective cell where the possibility exists of damage due to turbulence, strong updrafts and downdrafts, and/or damage from hail, graupel, or icing. Due to the unknown nature of MCS structures over northern Mexico or southern Arizona, no penetration of convective features (as evidenced on the nose radar display) will be attempted. Flight paths through extensive "stratiform" precipitation will be a priority for investigation. The flight patterns are grouped by objective and are summarized in Table 3.

Table 3. *Summary of SWAMP mission types.*

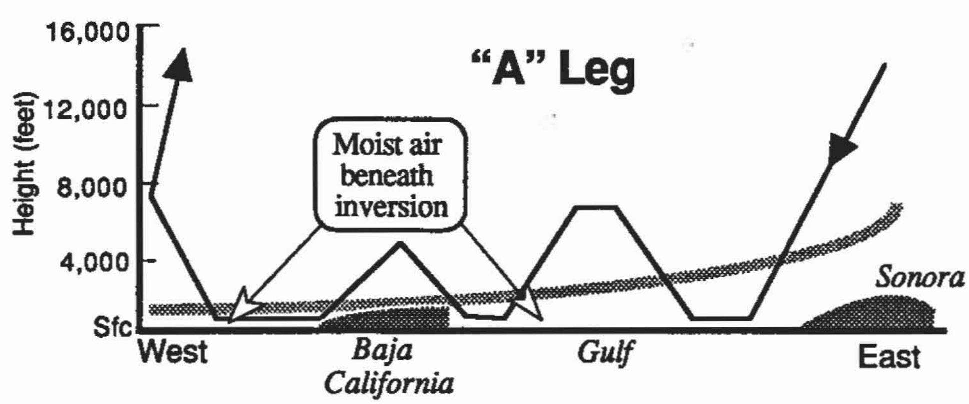
Flight Pattern	Objective	Duration	Description
A1	Document lower tropospheric moisture and wind structure of the monsoon	9 hrs	P–3 performs vertical sawtooth to document monsoon interface at three locations. Normal climb and descent rates are used (1000 feet per minute), although there may be some variation.
A2	Document monsoon interface and northward moisture fluxes	8 hrs	P–3 performs vertical sawtooth where the monsoon interface is best depicted in the water vapor imagery
B1	Examine convective storm structure	3 hrs	P–3 flies down the Sierra Madre Occidental to map convective storm structure.
B1.1	Methodology for the Fore/Aft Scanning Technique (FAST)	5–10 min.	P–3 flies about 10 nm from the center of convective storms.
B1.2	Methodology for pseudo-dual Doppler technique	10–12 min.	P–3 flies two orthogonal legs about 10 nm from the storm center.
B2	Investigation of the structure and dynamics of mesoscale convective systems	6 hrs	Once an MCS develops the P–3 flies Doppler radar patterns around the predominant convective and stratiform precipitation, and collects sounding information (descents/ascents or Ω-sondes) on the inflow side.
B3	Document microphysical structure.	1 hr	Box descent pattern within well developed stratiform rain region.
C1	Boundary layer flights from low desert to rim	3-5 hrs	Aircraft documents afternoon evolution of mixed layer from desert to storm genesis region.
C2	Synoptic scale sounding augmentation	3-5 hrs	Aircraft flies pressure-level patterns to observe the structures between the standard upper air sites.
C3	Document the lower atmospheric structure	3-5 hrs	Alternative to Pattern C1 if sawtooth legs cannot be performed
C4	Synoptic scale sounding augmentation	3-5 hrs	Alternative to Pattern C2 if sawtooth legs cannot be performed

Pattern A1: Monsoon Structure and Fluxes.

Goal: Document the bulk structure of the monsoon interface and provide a quantitative estimate of the northward flux of moisture in the monsoon circulation.

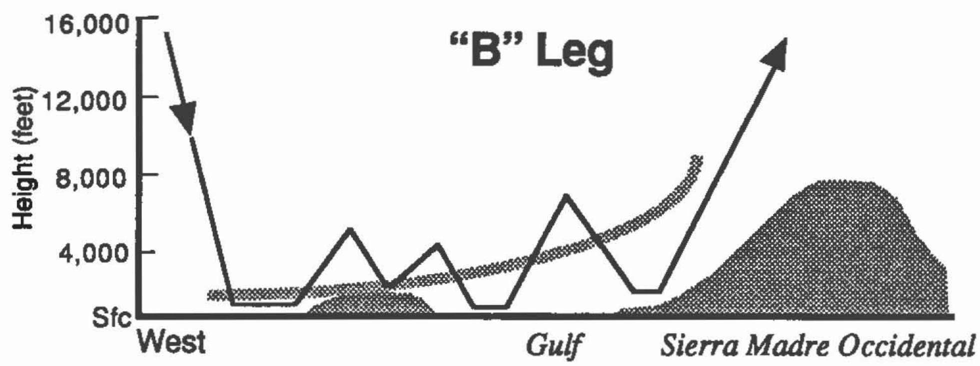


Flight sequence for Leg "A":

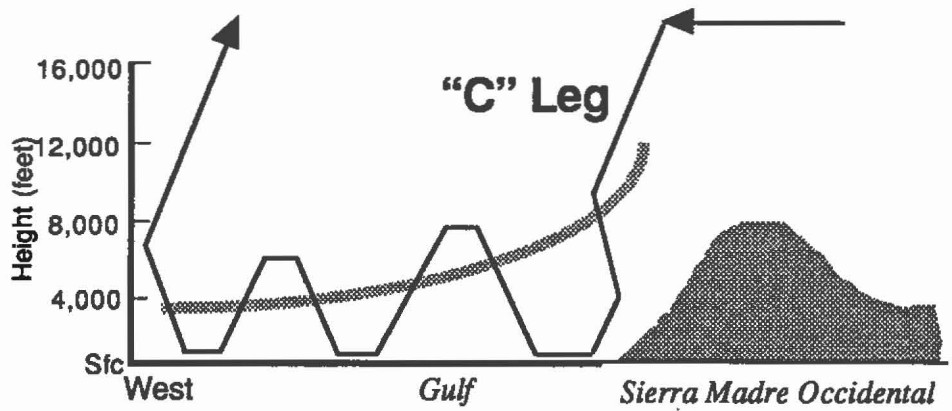


Pattern A1: Monsoon Structure and Fluxes (continued).

Flight sequence for Leg "B":



Flight sequence for Leg "C":



Sequence: For legs "A", "B", and "C", the P-3 climbs and descends at normal rates (~1000 feet per minute). Descents are to the lowest safe altitude (~150 feet over water, ~500 feet over land). *This pattern will be flown only during daylight hours.*

Mobile Lab: The mobile lab is not required for this experiment.

Soundings: 00, 06, 12, and 18 UTC from U.S. and northern Mexican rawinsonde sites. High frequency pibals from the Mexican pibal network.

Nominal Takeoff Time: Morning.

Pattern A2: Monsoon interface and northward moisture fluxes.

Goal: Document the structure and circulations associated with the interface of the monsoon flow with the larger scale environment.

Sequence: Aircraft pattern will be where the monsoon interface is the strongest based on water vapor imagery. Descents are to the lowest safe altitude (~150 feet over water, ~500 feet over land). *This pattern will be flown only during daylight hours.*

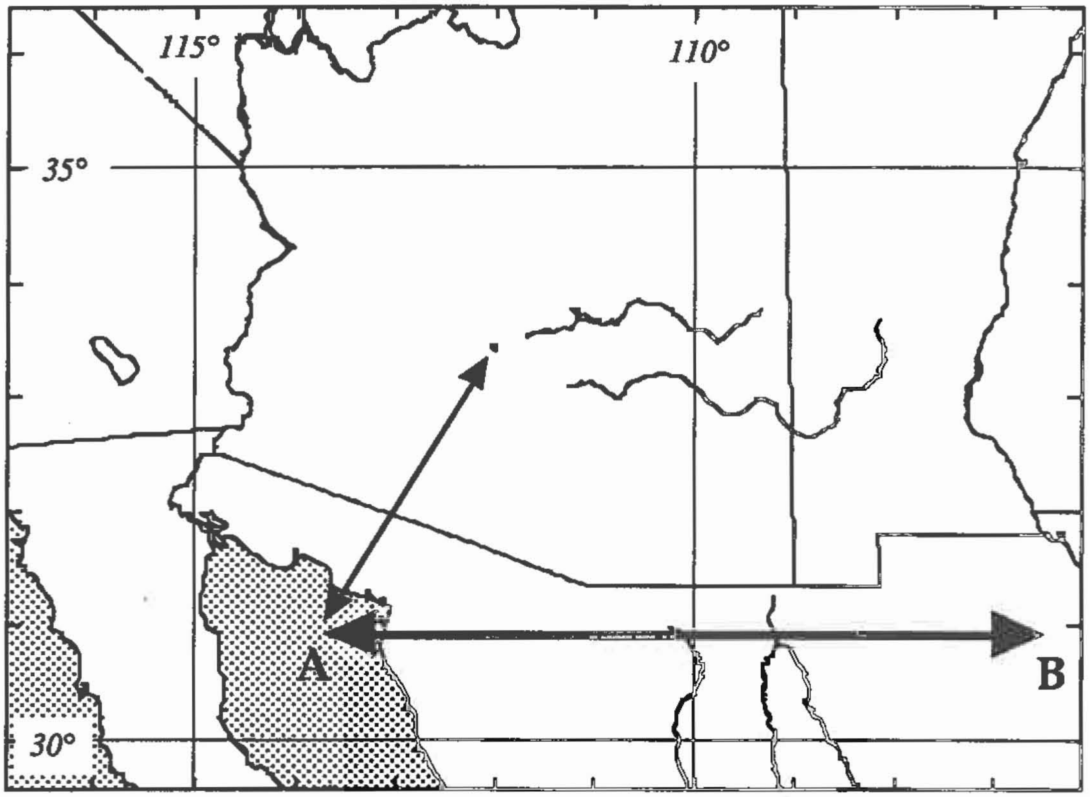
Mobile Lab: The mobile lab will launch soundings near the monsoon interface (within the U.S. only) and may be required to move east-west to get soundings on each side of the interface.

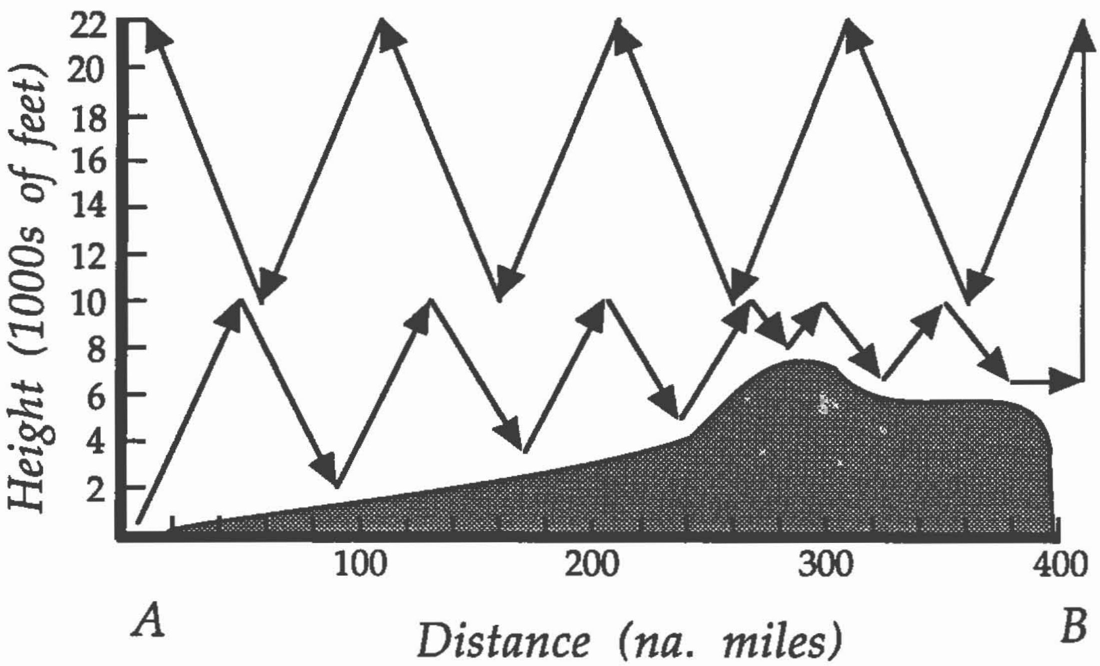
Soundings: 00 UTC, 06 UTC, 12 UTC, and 18 UTC from U.S. and northern Mexican rawinsonde sites. High frequency pibals.

Nominal Takeoff Time: Morning.

Note: Similar flight strategy could be employed to document the early afternoon, preconvective environments from the Gulf of California to the Sierra divide.

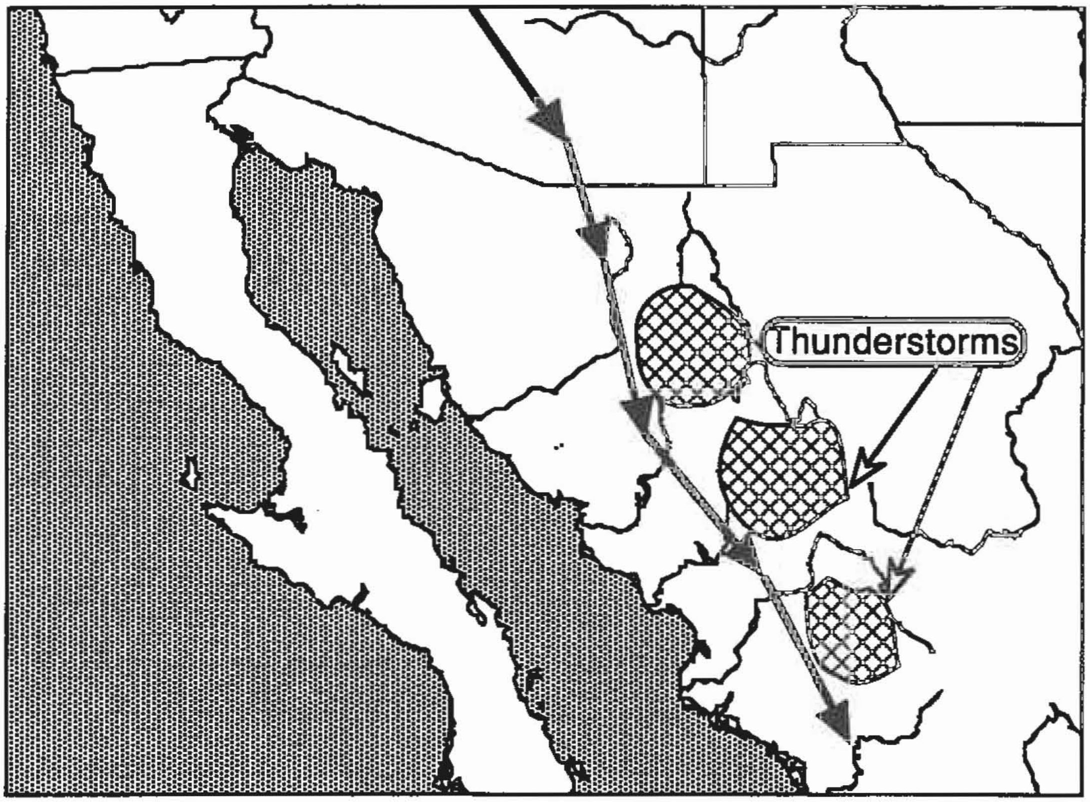
Pattern A2: Monsoon interface and northward moisture fluxes (continued).





Pattern B1. Convective storm survey.

Goal: Survey the distribution of convective storms along the mountains. Gather airborne Doppler data using the FAST scanning technique to examine the basic circulations within the storms.



Sequence: P–3 will fly within ~10 nm of the center of convective storms that are located over the Sierra Madre Occidental mountains. Monitoring of the storms continues until an MCS develops or the convection dies using a north-south oriented flight track. Length of the flight track and exact starting positions are determined by location of the convective storms.

Mobile Lab: The mobile lab is not required for this experiment.

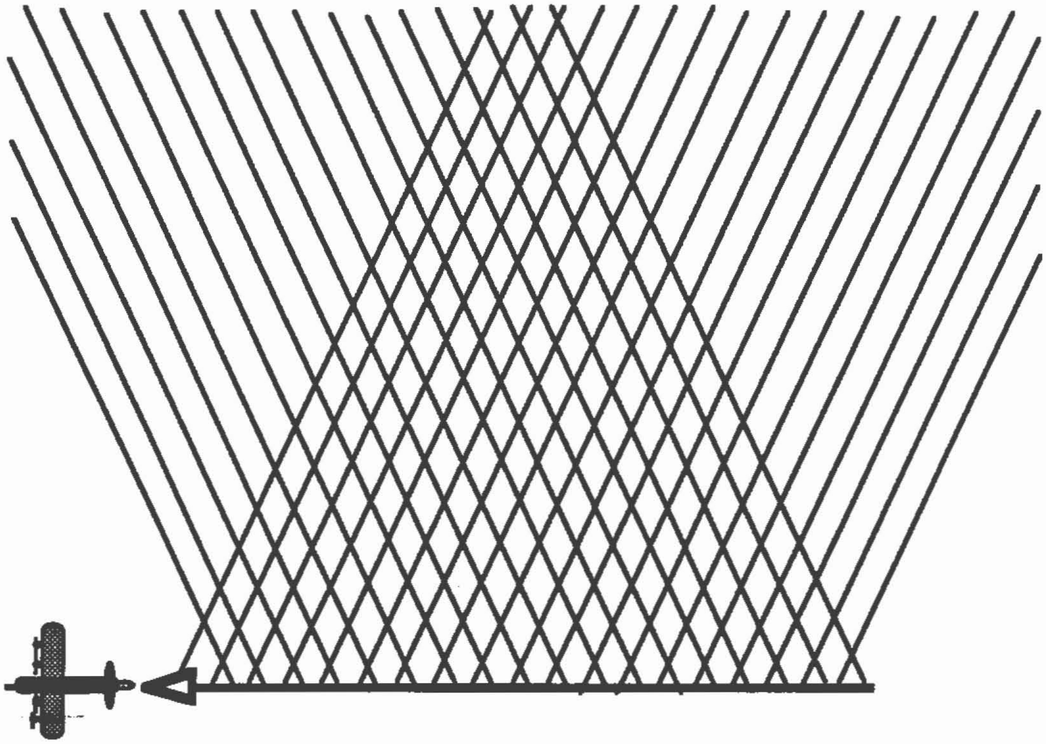
Soundings: 00 UTC and 12 UTC from U.S. and northern Mexican rawinsonde sites. Routine pibals.

Nominal Takeoff Time: Late afternoon (after convection begins as seen on satellite imagery)

Nominal altitude: 15,000 feet

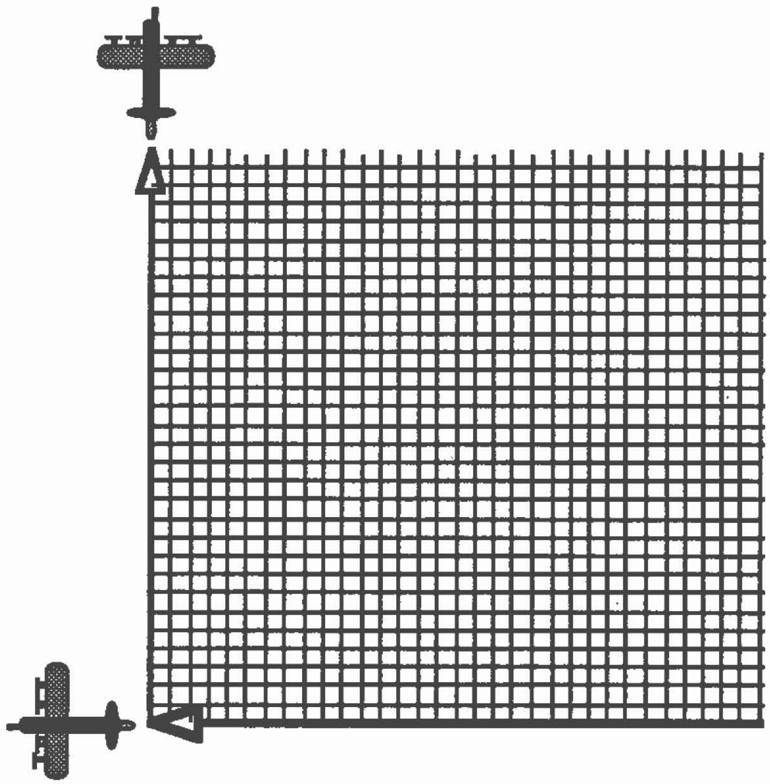
Pattern B1.1. Convective storm investigation using fore/aft scanning technique (FAST).

Goal: Gather airborne Doppler radar data to deduce the 3-dimensional airflow using the "FAST" technique.



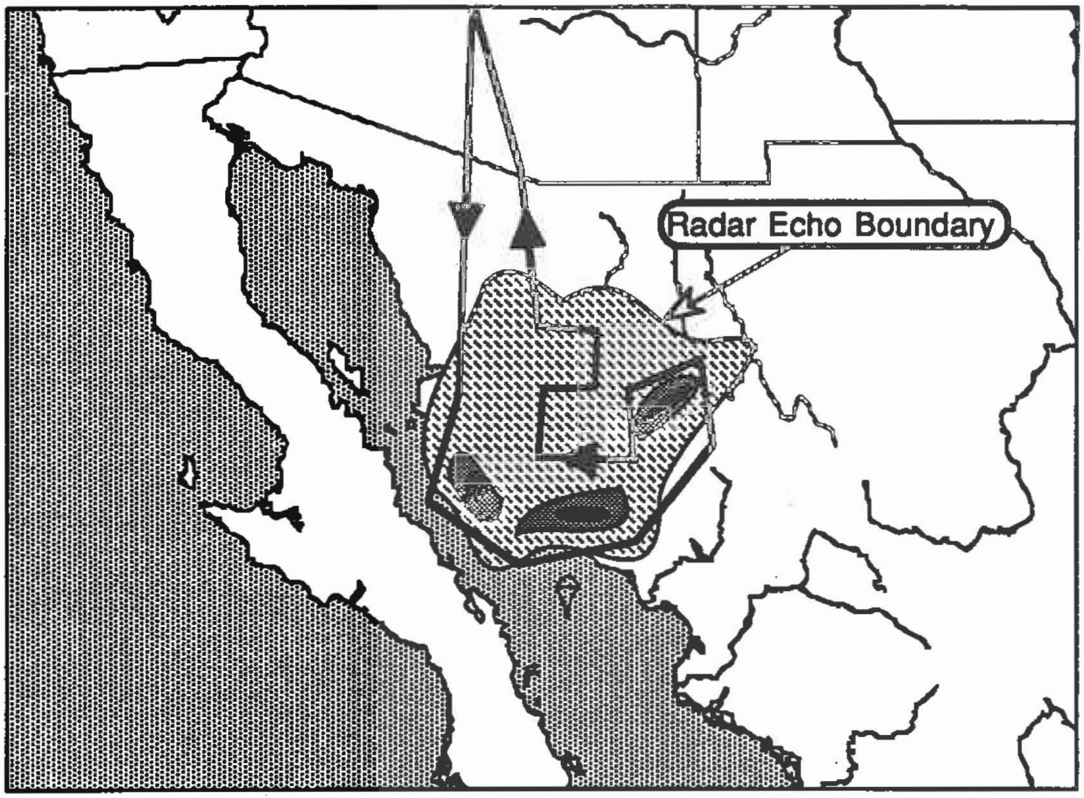
Pattern B1.2. Convective storm investigation using conventional two-leg "L-shape" method.

Goal: Gather airborne Doppler radar data to deduce the 3-dimensional airflow using the "pseudo-dual Doppler technique".



Pattern B2. Investigation of Mexican mesoscale convective systems.

Goal: Document the internal structure and circulations associated with the convective and stratiform parts of the MCS.



Sequence: P–3 will attempt (1) to get on the inflow side (the southwest side) of the system and either drop an Ω-sonde (if over water) or perform a descent/ascent sounding (from/to 20,000 feet); (2) fly patterns relative to the principal convective storms using FAST (straight-line) or conventional dual-Doppler patterns ("L-shaped" patterns with 5 minute legs); (3) locate region of strongest stratiform rainfall and perform FAST or conventional dual-Doppler patterns.

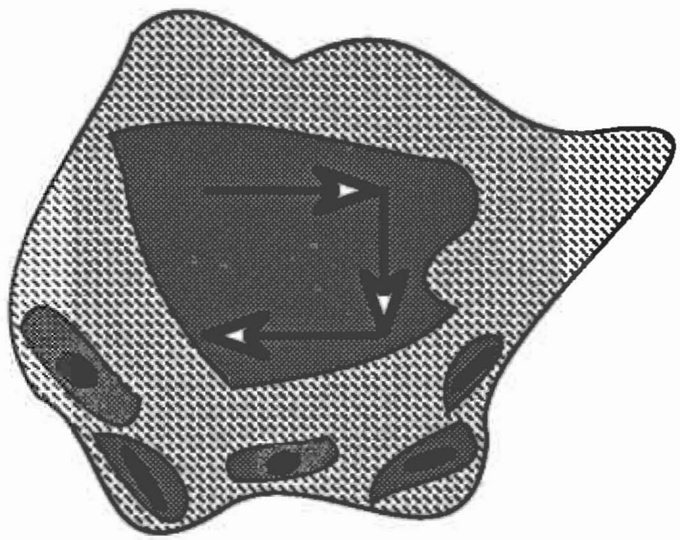
Mobile Lab: The mobile lab is not required for this experiment.

Soundings: 00, 06, 12, and 18 UTC from U.S. and northern Mexican rawinsonde sites. Routine pibals.

Nominal Takeoff Time: Late afternoon (after convection begins as seen on satellite imagery).

Pattern B3. Microphysics pattern in well-developed stratiform rain regions.

Goal: Gather coordinated microphysics and airborne Doppler data to define stratiform region circulations and particle type structure.



Sequence: P–3 will begin box pattern (20 nm legs) at 25,000 feet (or as high as practical) and descend at 1,000 feet per minute. Descent should continue to 10,000 feet. At least three legs of the box should be flown.

Duration: About 15 minutes.

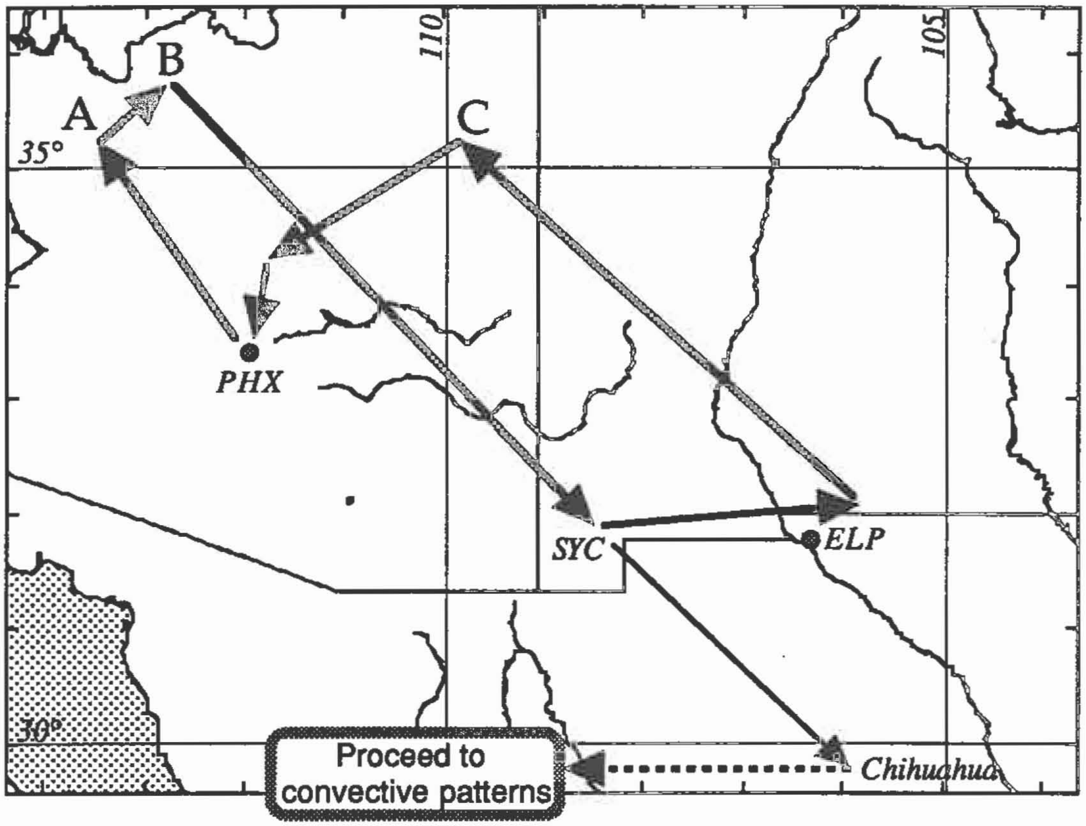
Mobile Lab: NSSL2 is not required for this experiment.

Soundings: 00 UTC and 12 UTC from U.S. and northern Mexican rawinsonde sites. Routine pibals.

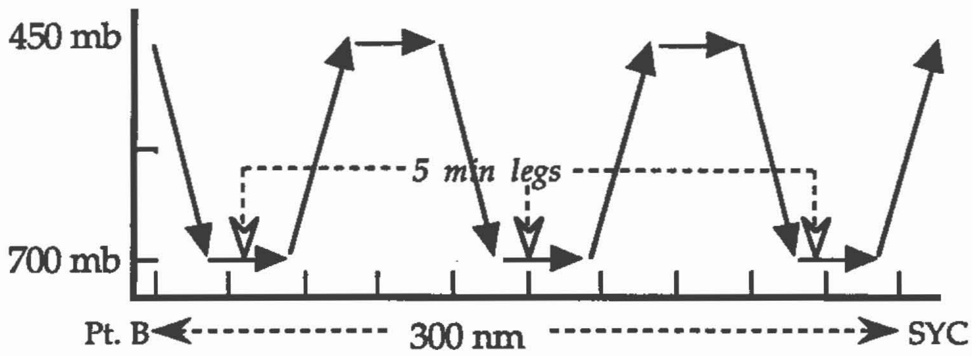
Nominal Takeoff Time: Late afternoon (after convection is evident on satellite imagery).

Pattern C1. Arizona region patterns.

Goal: Document large-scale conditions in support of thunderstorm environment experiments.



Sequence: P–3 will fly from Phoenix to Pt. A at 3,000 feet AGL. From Pt. B to SYC the flight sequence will be:



At SYC, one of two options will be chosen: 1) continue the sawtooth pattern to near Chihuahua, then proceed to convective patterns (Pattern "B"), or 2) fly ELP to Pt. C using the sawtooth pattern.

Duration: 1-2 hours.

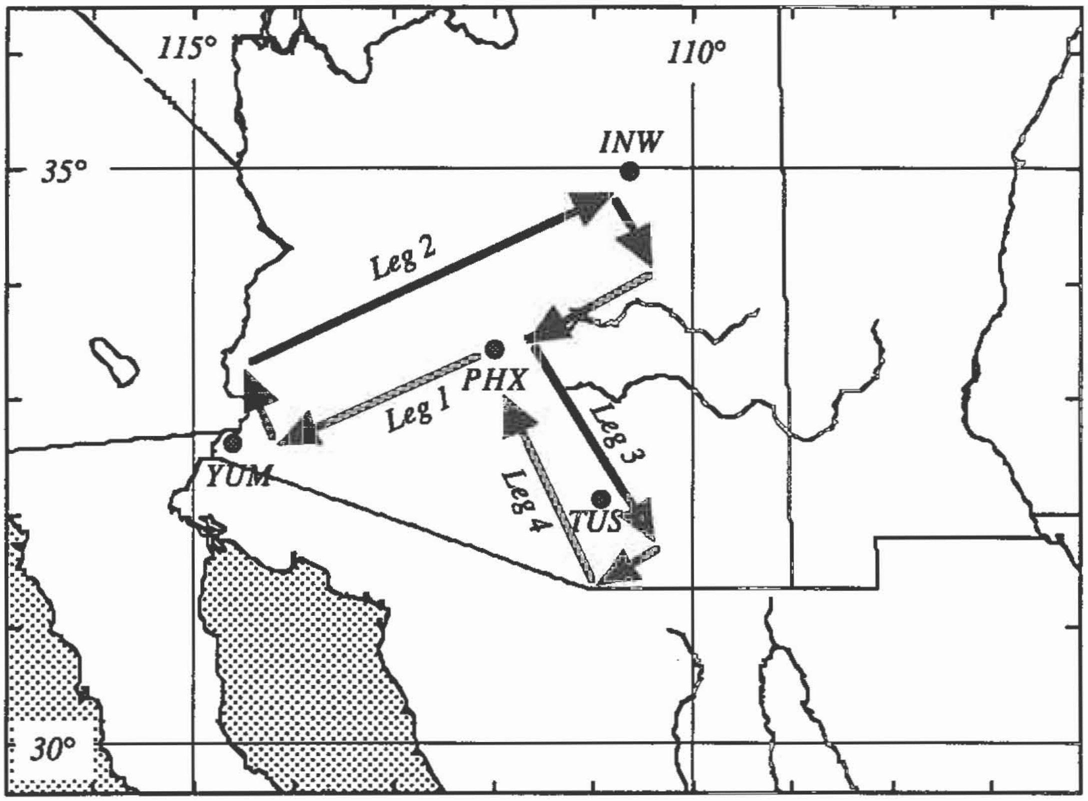
Mobile Lab: The mobile lab will be executing special soundings between the rim and the low desert.

Soundings: 00 UTC and 12 UTC from U.S. and northern Mexican rawinsonde sites. Routine pibals. Additional PHX soundings will be coordinated with NSSL2.

Nominal Takeoff Time: Early to late afternoon.

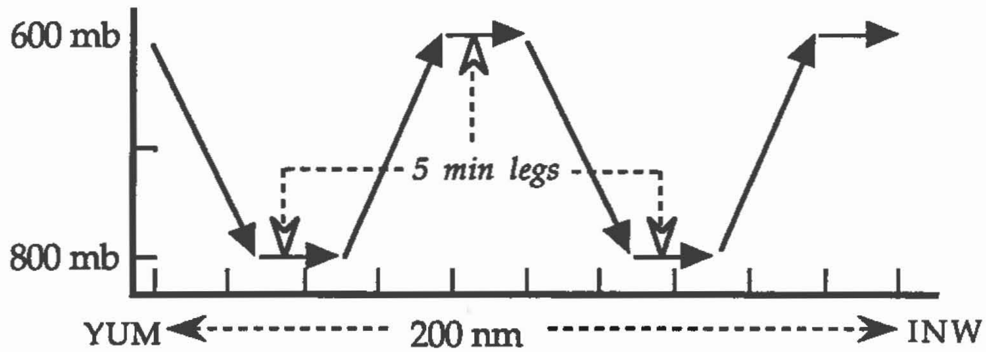
Pattern C2. Arizona region patterns.

Goal: Document large-scale conditions in support of thunderstorm environment experiments.



Sequence: P–3 will fly from Phoenix to YUM at 3,000 feet AGL. The Leg 2 flight sequence will be:

Leg 2:



The Leg 3 sequence is identical to Leg 2 from near PHX to south of TUS. Leg 4 is from near TUS to near PHX at 3,000 feet AGL. At the conclusion of the pattern one of three options will be chosen: 1) repeat the pattern; 2) continue pattern using only the PHX—TUS legs; or 3) begin convective missions (Pattern "B") over Mexico.

Duration: 1-2 hours.

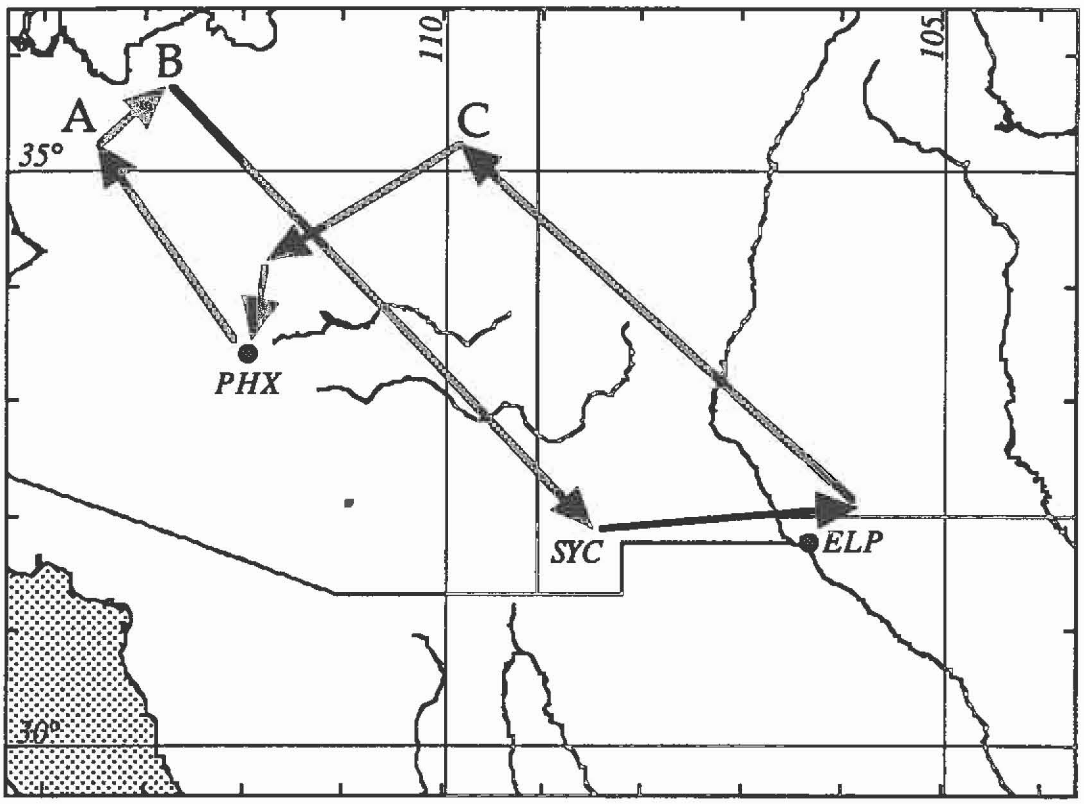
Mobile Lab: The mobile lab will be executing special soundings between the rim and the low desert.

Soundings: 00 UTC and 12 UTC from U.S. and northern Mexican rawinsonde sites. Routine pibals. Additional PHX soundings coordinated with NSSL2.

Nominal Takeoff Time: Early to late afternoon.

Pattern C3. Arizona region patterns.

Goal: Document large-scale conditions in support of thunderstorm environment experiments. This pattern will be flown if it is logistically difficult to complete pattern C1.



Sequence: P–3 will fly the circuit PHX–A–B–SYC–ELP–C–PHX at two altitudes: 10,000 feet PA and 20,000 feet PA, except the first PHX–Point "A" leg will be flown at 3,000 feet.

Duration: 3 hours.

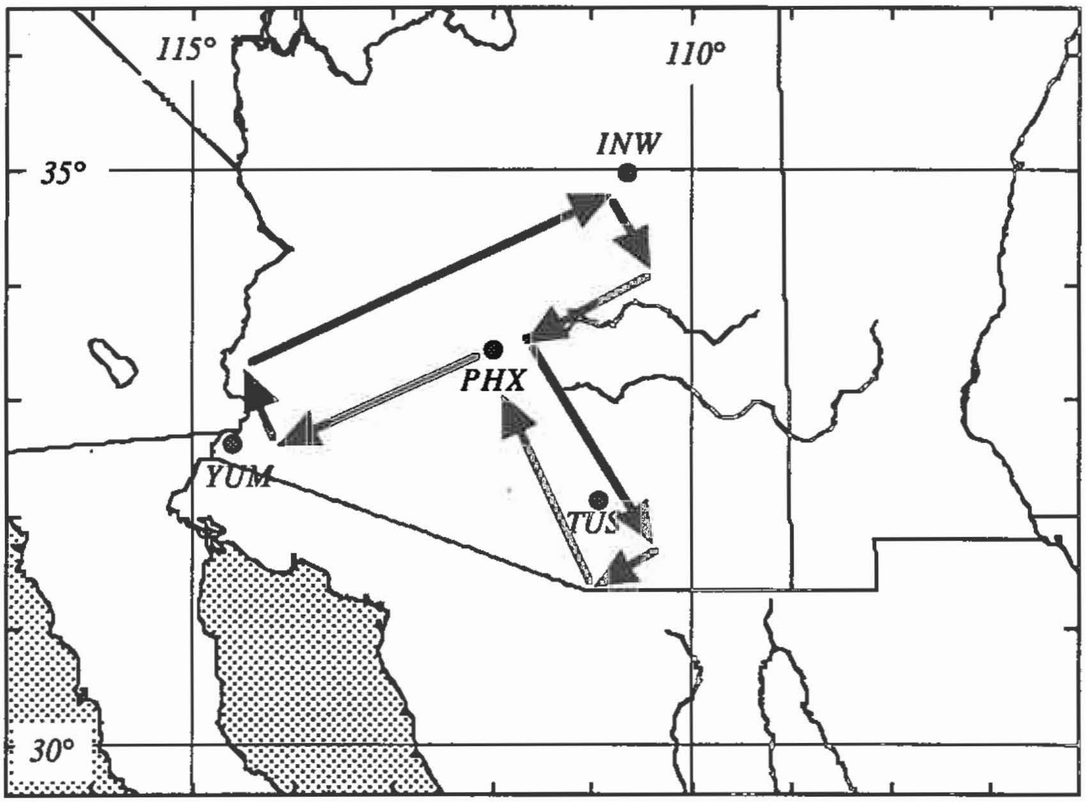
Mobile Lab: The mobile lab will be executing special soundings between the rim and the low desert.

Soundings: 00 UTC and 12 UTC from U.S. and northern Mexican rawinsonde sites. Routine pibals. Additional PHX soundings coordinated with NSSL2.

Nominal Takeoff Time: Early to late afternoon.

Pattern C4. Arizona region patterns.

Goal: Document large-scale conditions in support of thunderstorm environment experiments. This pattern will be flown if it is logistically difficult to complete pattern C2.



Sequence: The P–3 will fly the complete pattern at three altitudes: 3,000 feet AGL, 10,000 feet PA, and 18,000 feet PA.

Duration: 6 hours.

Mobile Lab: The mobile lab will be executing special soundings between the rim and the low desert.

Soundings: 00 UTC and 12 UTC from U.S. and northern Mexican rawinsonde sites. Routine pibals. Additional PHX soundings coordinated with NSSL2.

Nominal Takeoff Time: Early to late afternoon.

6.4 *Scientific Flight Positions*

The operation of the specialized scientific equipment on the P–3 (lower fuselage and tail radar, cloud physics system) is normally performed by the scientific crew. Personnel from AOC monitor the performance and recording of the main data system (in-situ flight-level data). Thus the required scientific positions on the P–3 are as detailed in Table 4.

Table 4. Scientific positions on the P–3.

Position	Number of People	Duties
Chief Scientist	2	Plan flight tracks through coordination with Flight Director Supervise data collection Coordinate with Ops Center & Mobile Lab
Doppler Radar	2	Monitor system performance Maintain tape and event logs Change tapes Help interpret radar displays
Cloud Physics	1	Monitor system performance Maintain tape and event logs Change tapes Help interpret PMS displays
Observers	2	Help interpret meteorology and assist Chief Scientist in mission planning Maintain scientific logs 1 seat reserved for Mexican scientist

6.5 *Instrumentation*

There are four basic data systems on the P–3. These systems include the main data system for the in-situ data, the radar data system, the Ω-sonde data system, and the cloud physics data system. Table 5 lists the instrumentation on the P–3 for SWAMP, its accuracy, resolution, and manufacturer. The sensors that are serviced by the main data system are sampled at a rate of 40 Hz, and then are averaged to yield 1 sample per second.

Table 5. Characteristics of in-situ (main data system) sensors on the P–3.

Parameter	Instrument	Manufacturer	Accuracy	Resolution
Positioning	Inertial Navigation Equipment (INE)	Northrop/Delco	1.5 km (after post-processing)	$8.3x10^{-8°}$
Temperature	Platinum resistance	Rosemount	0.2° C	0.03° C
Dewpoint	Cooled Mirror	General Eastern	0.5° C	0.03° C
Static pressure	Transducer	Garrett	0.2 mb	0.1 mb
Dynamic pressure	Transducer	Garrett, Rosemount	0.1 mb	0.1 mb
Attack pressure	Transducer	Rosemount	0.15%	0.1 mb
Sideslip pressure	Transducer	Rosemount	0.15%	0.1 mb
Absolute altitude	Radar Altimeter	Stewart-Warner (APN-59)	0.01%	1 m
Cloud water	Hot Wire	Johnson-Williams	0.2%	0.1 g m^{-3}
In-cloud temp.	CO_2 radiometer (14 µm)	Barnes/AOC	0.2° C	0.1° C
Sea surface temp.	CO_2 radiometer (9.5-11.5 µm)	Barnes	0.2° C	0.1° C
Ground speed	INE accelerometers	Northrop/Delco	0.5 m s^{-1}	0.06 m s^{-1}
Track angle	INE accelerometers	Northrop/Delco	0.2°	0.005°
Heading angle	INE accelerometers	Northrop/Delco	0.1°	0.005°
Pitch angle	INE accelerometers	Northrop/Delco	0.06°	0.005°
Roll angle	INE accelerometers	Northrop/Delco	0.06°	0.005°

Derived parameters (such as wind) are calculated in post-processing once calibrations and biases are determined and removed. The INE accelerometers are bounded with Omega and LORAN navigation position estimates (for horizontal position) and radar altitude observations (for vertical position) to remove the effects of accelerometer drift.

There are two research radars mounted on the P–3: a horizontally scanning, C-band radar mounted in the lower fuselage (LF), and a vertically scanning X-band radar mounted in the tail (TA). The TA radar has the Doppler capability to estimate radial velocity of precipitation-sized hydrometeors. Table 6 gives information about the P–3 radar systems.

Table 6. Characteristics of the P–3 airborne radars.

Parameter	*LF Radar*	*TA Radar*
Transmitter frequency	5370 ± 6.7 MHz	9315 ± 11.6 MHz
Transmitter wavelength	5.59 cm (C-band)	3.22 cm (X-band)
Transmitter pulse width	1800 m	150 m
Pulse repetition frequency	200 s^{-1}	1600 s^{-1}
Peak transmitter power	70 kW	60 kW
Receiver dynamic range	80 dB	80 dB
Gain, main beam	37.5 dB	40 dB
Gain, first side lobe	23 dB down	23 dB down
Horizontal beam width	1.1°	1.35°
Vertical beam width	4.1°	1.9°
Antenna stabilization range	± 10°	± 25°
Antenna stabilized against	pitch and roll	pitch and drift
Maximum range	384 km	76 km
Nyquist velocity		12.89 m s^{-1}
Antenna rotation rate	4 RPM	8 RPM

The Knollenberg Particle Measurement System (PMS) records the output from their 2-D and FSSP probes on a separate data system. The characteristics of the 2-D probes are given in Table 7. The PMS forward scattering spectrometer probe (FSSP) detects the cloud droplet spectrum for 0.5 µm to 45 µm with the data recorded in 2 s intervals on the same tape as the 2D data.

Table 7. Characteristics of the PMS probes.

Parameter	*2D-P*	*2D-C*
Size range	6.4 mm	1.6 mm
Resolution	200 microns	50 microns
Ice/water discrimination	No	Depolarizer

6.6 *Communications*

One of the biggest uncertainties concerning P–3 operations over Mexico is the anticipated lack of consistent scientific communications. When the P–3 is within line-of-site of the operations base at Phoenix (~100 nm) the VHF radio can be used. However, when the aircraft is beyond VHF range, HF communications will be attempted. HF radio suffers from a number of problems associated with precipitation static and radio wave skip. A dedicated HF operator will be stationed at the Phoenix Operations Base and possibly at NSSL in Norman to relay weather information to the P–3. In cases where communications cannot be established, the P–3 will have alternate missions to perform (e.g., monsoon interface studies instead of MCS mission if convection dies).

6.7 Scientific Personnel

The scientific positions on the P–3 will normally be filled by personnel from NSSL. There should be ample opportunity for training of other scientists during SWAMP to fill one or more of the key positions, therefore there should be considerable flexibility in the assignment of duties during SWAMP. Table 8 shows initial job assignment possibilities.

Table 8. Possible P–3 personnel.

Position	*MCS Missions*	*Monsoon Missions*	*Arizona Studies*
Chief Scientists (2)	Jorgensen *and* Smull	Jorgensen *and* Smull	Jorgensen *and* Smull
Radar Scientists (2)	Watson *and* Bartels	Watson *or* Bartels	Watson *or* Bartels
Cloud Physics (1)	Schuur *or* Hunter *or* Fredrickson	*Not Required*	*Not Required*
Observers (2 or 3 will be selected from persons available for each mission)	Maddox Howard Crisp Showell Douglas Hunter Stensrud NWS Observers Media Observers	Gall Douglas Reyes Maddox Fredrickson Skaggs McCollum Forsyth Krider Zehnder Other Mexican Scientists Media Observers	Hoffman Hales Dunn Krider Balling Cerveny Phillips Skindlov Stensrud Smart Zehnder Other Mexican Scientists Other NWS observers Media Observers

7. Data Management and Dissemination

The general philosophy for SWAMP will be to disseminate all calibrated data sets freely to interested Principal Investigators as soon as the data are validated. The data management procedures that will be followed for each main data set are detailed below. The P–3 and MCLASS data sets will be checked and archived at NSSL/MRD in Boulder, CO. The SWAMP data manager is Mr. José Meitín. A mission summary and data inventory document will be prepared within 3 months of the project's completion.

P–3. The P-3 flight-level data set will be processed at AOC to produce an archived data set (called the AOC "standard tape") that will reside at NSSL/MRD. Copies of the flight level data for selected cases will be made available on an ASCII tape to interested scientists. The Doppler radar, cloud physics, and Ω-sonde data sets will not be routinely processed to produce an archived data set due to the high volume of data produced. The original tapes will be stored at NSSL/MRD. A data processing facility exists at NSSL/MRD for complete processing and analysis of all P–3 data and will be made available to all SWAMP investigators.

MCLASS. The MCLASS soundings will be routinely reprocessed to improve the quality of the wind observations due to low-quality LORAN signal generally in Arizona. The archived data set will reside at NSSL/MRD in a standard format and will be made available to all interested investigators. Post-processing should be completed within 3 months of the conclusion of SWAMP.

Satellite data. Real-time AVHRR data (Global Area Coverage, approximately 4 km resolution) received at the Space Science and Engineering Center in Madison, Wisconsin will be selectively archived and used to produce estimates of vegetation cover during most of July and August 1990. Analyses will be performed for clear periods (as determined from GOES visible imagery) on a weekly basis. The influence of vegetation cover on ground temperature, atmospheric water vapor, and subsequent development of small cumulus clouds will be explored by comparison of vegetation patterns with infrared and visible data from GOES and with analyses of atmospheric moisture and topographical features. It is anticipated that some initial comparisons can be made in near-real time on the McIDAS in Madison, Wisconsin. All GOES data are routinely archived at SSEC (to a cassette tape), but it will be cost effective to save a few interesting cases directly on 9-track magnetic tape. Digital satellite data may also be saved to tape in Madison, as a back-up for the archival procedure in Boulder, if the need arises.

Precipitable water will be estimated from satellite data during intensive data collection periods. The purpose of these estimates will be to define the large-scale horizontal distribution of water vapor associated with the monsoon, determine the origins of moisture in Arizona, and to verify satellite estimates of precipitable water with in-situ observations. Total precipitable water and the fractional amounts contained in 3 atmospheric layers (roughly surface-850 mb, 850-500 mb, and 500-300 mb) will be estimated in cloud free areas over land and ocean areas in the vicinity of the southwest U.S. and northwest Mexico from the VAS sounder on the GOES satellite. These calculations can be made in near-real time at a 3-hour time interval. Microwave data from the SSMI instrument on the polar orbiting DMSP satellite will be used to estimate total precipitable water over ocean area including the Gulf of California nearly twice a day. The estimates are valid in both clear and cloudy regions and can greatly augment the VAS measurements over water. These data must be ordered for post-processing unless a real-time data source can be identified.

Mexican Pilot Balloons (PIBALS). Immediately after the field phase of the experiment, visits will be made to each theodolite site, to retrieve the theodolites and to collect the manual recorded data. The forms on which the pilot balloon elevation and azimuth angles are recorded will be photocopied, and one copy will remain at each site. Copies of all of the original sheets will also be deposited at

CICESE in Ensenada and CNA in Hermosillo. The data will then be transferred from the handwritten sheets to diskette in Boulder, where each sounding will be checked for obvious errors. All soundings will then be sorted into files by time. The exact procedure for wind computation has yet to be determined. A complete pilot balloon data set will be available within ~3-6 months of the end of the observational phase of SWAMP. The data will be made available in both diskette form and in a hard copy document describing the data set and individual soundings to all interested investigators.

The Coordinators of the other SWAMP data sets (Rainfall, satellite, Lightning, supplemental upper-air, radar, PRISMS mesonet, and forecasts with guidance products) will work with the Data Manager to develop processing, archive and access statements that can be distributed in the mission summary and data inventory report that will be distributed following the completion of the field phase of SWAMP.

Appendix

PROJECT FORMS

The following forms should be filled out by the P–3 radar crew during SWAMP missions and daily by the SWAMP forecasters. They will become part of the permanent data archive.

SWAMP

P-3 CHIEF SCIENTIST CHECKLIST

Flight Number _______________

Flight Crew:

Scientific Crew	*AOC Crew*
Chief Scientist________________	Flight Director __________________
Doppler Radar ________________	AC Commander __________________
Cloud Physics _________________	Pilot ___________________________
Observer ___________________	Data Tech______________________
Observer ___________________	Sys Engineer____________________
Others ______________________	
___________________________	
___________________________	
___________________________	

Mission Briefing (including proposed flight plans):

____

____

____

____

____

____

____

Mission Summary:

*Takeoff Time:*__________UTC *Landing Time:* ___________ UTC
Official Mission Duration: ________hr (from Flight Director)
Number of Magnetic Tapes Used: Radar:______ Cloud Physics: _____
*Number of Sondes Dropped:*_______

SWAMP

P-3 RADAR OPERATOR CHECKLIST

Flight Number _______________

Operator(s): __________________ __________________________

Confirm Software Settings: TA: 32 pulses Fastest RPM Tilt 0° (non FAST mode) Threshold on dBm

LF: 32 pulses Fastest RPM Threshold on dBm

Equipment status prior to takeoff:

Brief description of problems encountered during flight:

Radar Data System Tape Log

Tape #	*Time On*	*Time Off*	*Mode (FAST or Cont)*	*Comments*

SWAMP

P-3 CLOUD PHYSICS OPERATOR CHECKLIST

Flight Number _______________

Operator(s): ___________________ ___________________________

Confirm PMS Settings: FSSP range 4. Recording rate MAX.

Equipment status prior to takeoff:

Brief description of problems encountered during flight:

PMS Data System Tape Log

Tape #	*Time On*	*Time Off*	*Mode*	*Comments*

SWAMP

THREE HOUR FORECAST FOR ARIZONA

(Prepare first forecast at 21 UTC and again every 3 hours for as long as the operations continue, if needed, 3 hour outlooks of activity over Mexico may also be made)

Lead Forecaster________________________
Time______UTC
Valid Period_________

1. Draw and describe (use mesonet map) the current convective situation, include severity, movement, coverage and trend.

2. Draw and describe your forecast of expected convective development. Include movement, severity, and changes in intensity and coverage.

3. Coordinate these forecasts with the NWS Duty Forecaster.

OUTLOOK FORECAST FOR SWAMP OPERATIONS AREA

(Complete these forecasts daily prior to OWB and in evening from 00 UTC data when required)

Lead Forecaster____________
Time_____________UTC

1. Draw and describe convective activity expected over the SWAMP program area for the following periods (18-23 UTC, 00-06 UTC, 07-12 UTC and 18-06 UTC tomorrow). Use seperate maps for each period.

SWAMP Phone List

Operations Center .... ?
Message Phone .... ?
AOC Operations .... ?
Phoenix WSFO .... ?

Visiting Scientific Personnel

Name	Affiliation	Dates	Hotel	Room	Phone
D. Bartels	NSSL (Boulder)	7/7—8/8	Camelback		
S. Bennett	OAR (Washington)	intermittent	Camelback		
E. Brandes	NSSL (Norman)	intermittent	Camelback		
D. Carpenter	NWS (SLC)	7/7—7/11	Camelback		
S. Chandler	NSSL (Boulder)	7/21—8/8	Camelback		
C. Crisp	NSSL (Norman)	7/7—8/8	Camelback		
R. Cylke	NWS (RNO)	7/11—7/16	Camelback		
M. Douglas	CIRES (Boulder)	intermittent	Camelback		
L. Dunn	NWS (SLC)	7/16—7/20	Camelback		
D. Forsyth	NSSL (Norman)	6/29—7/11	Camelback		
S. Fredrickson	NSSL (Norman)	7/7—8/8	Camelback		
R. Gall	U. of Arizona	7/11—7/27*	Camelback		
J. Hales	NSSFC (Kansas City)	7/21—8/8	Camelback		
R. Hasimoto	CICESE	7/21—8/8	Camelback		
K. Howard	NSSL (Boulder)	6/25—8/8	Camelback		
S. Hunter	NSSL/CIMMS (Norman)	7/7—8/8	Camelback		
D. Jorgensen	NSSL (Boulder)	7/5—8/8	Camelback		
R. Maddox	NSSL (Norman)	7/7—8/8	Camelback		
J. Meitín	NSSL (Boulder)	7/7—8/8	Camelback		
D. McCollum	NSSL/OU (Norman)	7/7—8/8	Camelback		
S. Reyes	CICESE (Ensenada)	7/7—7/18	Camelback		
J. Sanchez	IMTA/CNA	7/21—8/8	Camelback		
T. Schuur	NSSL/CIRES (Boulder)	7/7—8/8	Camelback		
L. Showell	NSSL (Norman)	6/29—8/8	Camelback		
G. Skaggs	NSSL (Norman)	6/29—8/8	Camelback		
K. Smith	NRC/NSSL	7/21—8/8	Camelback		
B. Smull	NSSL (Boulder)	7/7—8/8	Camelback		
D. Stensrud	NSSL (Norman)	intermittent	Camelback		
I. Watson	NSSL (Boulder)	7/7—8/8	Camelback		
M. Webb	NWS (ABQ)	7/7—7/11	Camelback		
J. Zehnder	U. of Arizona	7/27—8/8*	Camelback		

* intermittently in Tucson some evenings and weekends

AOC Personnel

Name	Title	Room	Phone
Jack Parrish	AOC Project Coordinator		
Phil Bogert	Flight Director		
David Turner	Aircraft Commander		
Phil Kennedy	Pilot		
Nelson Flurry	Flight Engineer		
Shawn White	Navigator		
Ted Jomes	HF Radio		
Al Goldstein	Electronics Engineer		
Terry Lynch	Electronics Tech.		

Local Area Personnel

Name	Affiliation	Dates Available	Work Phone	Home Phone
Robert Balling	Arizona State University, Tempe			
Norm Hoffman	National Weather Service, Phoenix			
Randy Cerveny	Arizona State University, Tempe			
Mike Franjevic	National Weather Service, Phoenix		379-6444	
Dan Phillips	Salt River Project, Phoenix		236-2879	946-4172
Jon Skindlov	Salt River Project, Phoenix		236-2819	967-0403
NWS Contact	NWS WBO Tucson			
NSSFC Contact	NSSFC Forecast Coordinator		FTS 836-3646	
Jack Hales	NSSFC		FTS 836-3646	
Students	to be supplied by Cerveny and Gall			

Motel Addresses

AOC Personnel	NSSL & Other Personnel
Residence Inn of Phoenix	Scottsdale Camelback Resort and Spa 6302 East Camelback Road Scottsdale, AZ 85251 (602) 947-3300

THE PHOENIX GAZETTE Wed., June 20, 1990

Monsoon mystery lures scientists

arge-scale study f storms planned

Clay npson
E PHOENIX GAZETTE

Arizona's monsoon — those muggy, erable and mysterious weeks of July August — will be the focus of what scientist calls "the biggest weather ject in the U.S. this summer."

Personnel from five agencies in the ited States, including Arizona State iversity and Salt River Project, and from Mexico will take part in a study inning July 8 called SWAMP — thwest Area Monsoon Project — to find out exactly how the "monsoon" works.

Scientists will use a variety of high-tech equipment, including a reconnaissance plane normally used to trace hurricanes in the Atlantic. The plane will be based at Sky Harbor International Airport for the month-long study.

Norm Hoffman, acting Phoenix area manager for the National Weather Service, said SWAMP will focus on three areas: the structure of monsoon storms, the flow of warm air into the upper atmosphere over Mexico's Sierra Madre and the central Arizona thunderstorm environment.

"We want to know why the storms develop over the mountains and move over the cities ... and why sometimes they just develop over Phoenix," Hoffman said.

"What we don't understand is the environment in which monsoon thunderstorms develop, and what the situation is and why they develop over one area one day and don't develop the next day."

Hoffman also said SWAMP would be "one of the first projects where research and operational meteorologists will work together." That means some of the data researchers gather could have an immediate effect on local weather forecasts.

Randy Cerveny, a professor of geogra-

See ■STORMS, Page A10

STORMS

From A1

in ASU's climatology labora- said SWAMP would be "the est weather project in the U.S. summer."

t is intriguing how much we t know about the monsoon," aid. "We want to find out what es the monsoon tick."

e and other researchers are ng t' year's monsoon season s ou. be a little more lively last year's, when Arizona yed a relatively peaceful sum- , monsoon-wise.

We don't want anyone to get d, but we're hoping for a very ve monsoon season this year," aid.

erveny's role in SWAMP will to lead a group of ASU eorology students on storm ses, dashing to areas where vy storms are predicted to see ther they develop as forecast.

le also will study the urban t island effect, by which night- e lows seem to get warmer y year as a city's growing anses of concrete retain the ing heat of the day.

We know that the urban heat nd exists horizontally, but we 't know how tall it is, how big a t dome this city puts out," veny said.

n addition to the reconnais- ce airplane, Cerveny said, AMP researchers will bring in phisticated tornado-chasing ve- e t. Oklahoma to follow nsoon storms on the ground.

RP has contributed money to project and will supply some npower, according to SRP me- rologist Dan Phillips.

'Our operational interest is in ping to understand why thunderstorms come into the Valley some nights and not other nights," Phillips said.

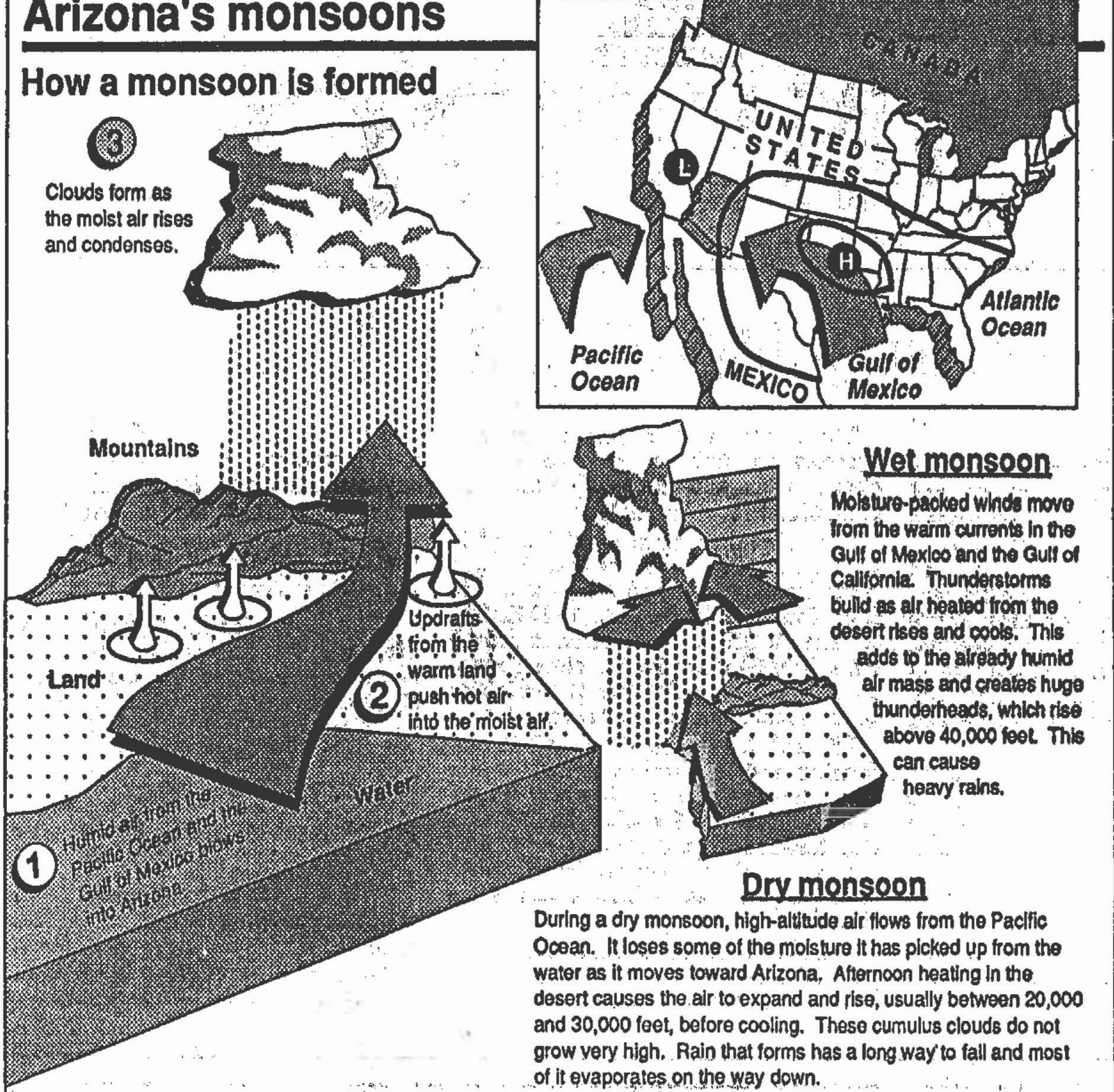
SWAMP data will help the utility plan its power loads and watershed management.

Cerveny said information gathered by SWAMP also should be of use to forecasters on the Great Plains, where predicting tornadoes is a spotty — and lifesaving — art.

The Southwestern climate can contribute to severe weather as far away as the Great Lakes, said Robert Maddox, director of the National Severe Storms Laboratory in Norman, Okla.

Includes information from The Associated Press.

Arizona's monsoons



La Verne Harris / THE PHOENIX GAZETTE

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL WEATHER SERVICE
Forecast Office
PAB 500
P. O. Box 52025
Phoenix, Arizona 85072-2025

March 10, 1992

Dear Colleague,

On June 10-12, 1992, we will convene the 4th Arizona Weather Symposium. The symposium will be co-hosted by the National Weather Service (Phoenix Office) and Central Arizona Chapter of the AMS. The National Severe Storms Laboratory, the Salt River Project, and Arizona State University's Office of Climatology are sponsoring the event.

We invite your participation and support in this year's symposium. We look forward to the opportunity to share information from research and forecast studies related to local and regional weather across the Western U.S. We hope that you will join us.

The Symposium is an excellent opportunity for operational forecasters and research meteorologists to share ideas and discuss Western U.S. applied research and forecast challenges. It will be held at the beautiful Mountain Shadows Resort and Country Club in Scottsdale, Arizona. See enclosures for more information.

If you wish to attend, please return the attached pre-registration form by May 1, 1992.

Sincerely

David M. Carpenter

David M. Carpenter DMIC
NWS WSFO Phoenix AZ

Shawn Bennett

Shawn Bennett
Applied Research Meteorologist
NSSL WSFO Phoenix AZ

Enclosures

Carl Put you in to attend Len

4TH ARIZONA WEATHER SYMPOSIUM
June 10-12, 1992, Phoenix, Arizona

LOCATION Marriott's Mountain Shadows Resort and Country Club
5641 East Lincoln Drive
Scottsdale, AZ 85253
(602) 948-7111

PROGRAM COMMITTEE Shawn Bennett, Chair

Bob Maddox	Ken Mielke	Jon Skindlov
Randy Cerveny	Ken Howard	Tony Haffer

PRELIMINARY SYNOPSIS OF SESSIONS

Jun 10 Wed	9:00 am	Registration Begins
	1:30 pm	Session 1: Western Region Forecast Studies/Challenges
	3:00 pm	Coffee Break
	3:30 pm	Session 1 (Continued): Western Region Forecast Studies/Challenges
	5:00 pm	Sessions End for the Day
	6:00 pm	Reception (cash bar)
	7:00 pm	Banquet
	8:00 pm	Keynote Speaker: Dr. Ron Alberty, Director, NEXRAD OSF (tentative)
Jun 11 Thurs	7:30 am	Registration Continues
	8:30 am	Session 2: SWAMP: Convection/Heavy Precipitation
	10:00 am	Coffee Break
	10:30 am	Session 2 (Continued): SWAMP: Flash Flooding/Lightning
	12:01 pm	Symposium Luncheon
	1:30 pm	Session 2 (Continued): SWAMP: Moisture Sources/Advection
	3:00 pm	Coffee Break
	3:30 pm	Session 2 (Continued): SWAMP: Case Studies
	5:00 pm	Sessions End for the Day
	5:30 pm	Icebreaker (cash bar)
	5:30 pm	Poster Session: Studies relating to Arizona and the Western US
	7:00 pm	Sessions End for the Day
Jun 12 Fri	8:30 am	Registration Ends
	8:30 am	Session 3: Regional Scale Studies
	10:00 am	Coffee Break
	10:30 am	Session 3 (Continued): Local Scale Studies
	12:01 pm	Lunch Break
	1:30 pm	Session 4: NSSL2 Demonstration
	3:00 pm	Symposium Ends

4TH ARIZONA WEATHER SYMPOSIUM
JUNE 10-12, 1992
MARRIOTT'S MOUNTAIN SHADOWS RESORT AND COUNTRY CLUB
PHOENIX, ARIZONA

GENERAL INFORMATION

The program for the Symposium will tentatively feature the following sessions: Western Region Forecast Studies; Southwest Area Monsoon Project (SWAMP) Studies; Regional Scale Process Studies; and Local Scale Process Studies. These sessions will be held at Marriott's Mountain Shadows Resort and Country Club on June 10-12, 1992. A program synopsis is attached.

ACCOMMODATIONS

A block of rooms at Marriott's Mountain Shadows Resort and Country Club has been set aside for the 4th Arizona Weather symposium at the special rate of $72/single or double occupancy, plus tax. For hotel reservations/call or write Marriott's Mountain Shadows Resort and Country Club 5641 East Lincoln Drive, Scottsdale, AZ 85253. Tel: (602) 948-7111. Brochure enclosed. Reservations should be made by May 1, 1992. Be sure to state that you are with the 4th Arizona Weather Symposium.

REGISTRATION

Registration includes admission to all sessions, exhibits, coffee breaks and the symposium luncheon. Registration does not include the banquet. The registration desk will be open for symposium registrants at 9:00 am, Wednesday, June 10, 1992 through 8:00 am, Friday, June 12, 1992. All persons must register. A complete 3-day symposium registration is $50.00, students are $20.00. One-day registration is $25.00, students are $10.00. Pre-registration can be made in check/money order/travelers check to the 4th Arizona Weather Symposium. A pre-registration form is enclosed.

LOCAL HOST

The National Weather Service Forecast Office Phoenix, Arizona, the Central Arizona Chapter of the American Meteorological Society, Office of Climatology, Arizona State University, and the Salt River Project are serving as local co-hosts.

TRAVEL INFORMATION

Southwest and America West are the official airlines for the symposium. Make your reservations early to take advantage of the many low fares available. Marriott's Mountain Shadows Resort and Country Club is located north of Phoenix Sky Harbor Airport in Scottsdale and can be reached by the Sky Harbor Super Shuttle Service for $10.00. If more than one person is traveling: $10.00 first person, $5.00 for each additional person. Shuttle reservations can be made by calling (602) 244-9000.

KEYNOTE ADDRESS

Dr. Ron Alberty, Director, NEXRAD Operational Support Facility, Norman, OK will address the 4th Arizona Weather Symposium.

BANQUET

A banquet featuring the keynote speaker will be held Wednesday, June 10, 1992 at 7:00 pm. A reception (cash bar) will precede the banquet at 6:00 pm. Tickets for the banquet are $25.00.

INQUIRIES

Contact Shawn Bennett or Dave Carpenter at FTS 261-4607 or Commercial (602) 379-4607, or write National Weather Service Forecast Office, PAB 500, P.O. Box 52025, Phoenix, AZ 85072-2025, or e-mail OMNET/s.bennett.

PRE-REGISTRATION FORM

4TH ARIZONA WEATHER SYMPOSIUM
JUNE 10-12, 1992
MARRIOTT'S MOUNTAIN SHADOWS RESORT AND COUNTRY CLUB
PHOENIX, ARIZONA

____

Name

____

Affiliation/Address

____

City/State/Zip Code

____

Daytime Phone

		Amount Regular (Student)
1.	3-day registration	$ 50.00 ($20.00)
2.	1-day registration	$ 25.00 ($10.00)
3.	Banquet	$ 25.00 ($25.00)
	Total enclosed	$______________

Please remit to:

Shawn Bennett, Program Chairman
National Weather Service Forecast Office
PAB 500
P.O. Box 52025
Phoenix, AZ 85072-2025

FAX: Comm. (602) 267-8051

Geography 965-2224 | S965-9011 3 Kerveney ASU Office Climat -6265

SRP

John Lovegrove - warning preparedness meteorologist

Steve Sybill compiled data — daily reports available thru-out season.

7-10-90 Maricopa

7-21-90 Maricopa

7-25-90 Maricopa

- 80 - events during 90 monsoon

- 6 weather related fatalities in state

8:30-9:00 Jack Hales

washes & data / → most of documented reports are in metro areas

50 knots ≥ -1990 distribution of wind reports

-1990 hail distribution

-1990 Significant severe 60 knots or ≥ 2" hail wind damage

OVERHEADS

- 1990 Flash Flood Reports distribution

- average watch equal 25,000 sq. mi.

* Cerveny - storm verification w/ ASU lab

1) verification

2) damage evaluation

3) student experience

4) develop real-time data base

5) increase public awareness

storm chasers report

-Disaster assistance, requires that a mitigation team look at damage on a State level.

* Matching federal funds
SRP

{Radar signiture or air mass structure, rate of movement is not a factor in AZ monsoon, what is causing wind development

DWOOPLER will allow you to see internal structure of the storm

Data Collection Jose Martine

Data Collection 10:05 Jose Martine Howard

+ Data is in very different forms. Following is available

- soundings - Martin
- satellite imagery -
- visibile imagery
- water vapor -

Howard

SWAMP aircraft Data severe storms lab
In Situ Data in Boulder Martin
Radar Systems (software fr. HP)
Cloud Physics Systems
Dropsound System
Digitized Radar
Mexican Pilot Bloon set.

10:55 Mike

Publications

1 - Main overview of data
2 - Baloon exper. sounding
3 - Upper-wind observing networks

* Maddox will have copies of Mexican data,

national (geophysics / symposium / monsoon) in Puerta Vearta 11-15 November

DATA SETS CONTINUED Mexico

- Surface mesonet -
- Rainfall (surges mexico)
- Lightning
- Digital Synoptic Products
- Forecast Operations

Jose Martin
(303) 497-6341
FTS 320-6341
NSSL, Boulder

Hourly precip data for entire U.S.

Reconvene @ 1:00

Conference Room 2107B

WORKING DRAFT

SW AREA MONSOON PROJECT FORECASTING RESEARCH WORKSHOP

June 13/14, 1991

Salt River Project/New NWS Forecast Office
Phoenix, Arizona

Thursday 13 June

8:00 -8:30 am	Coffee	
8:30 - 9:00 am	Welcome, Housekeeping, Brief Workshop Overview	Carpenter Maddox, Franjevic
9:00 - 10:00 am	Review of the 1990 Severe Weather Season in Arizona	Hales/Lovegrove
	ASU severe storm intercept	Cerveny
	Other severe weather perspectives	Participants
10:00 - 10:30 am	Break	
10:30 - Noon	Overview of SWAMP data bases (about 10 min. each, except last general issue)	
	* Sounding archive	Howard/Showell
	* Satellite archive	Howard
	* Aircraft data	MRD staff
	* Radar data	Meitin
	* PIBAL data	Douglas
	* General archive data, additional data needed, data management, and access procedures	Meitin/Howard
Noon - 1:30 pm	Lunch	
1:30 - 3:00 pm	Initial looks at case data (about 20 min. each)	
	The 1990 Monsoon	Ten Harkle/Howard
	Composite analyses	Howard/Ten Harkle
	Pibal wind analyses	Douglas
	Upper-level deformation	Vasquez
3:00 - 3:30	Break	
3:30 - 5:00	Continued first looks at case data (about 20 min. each)	
	Lightning strike analyses	Watson
	August 2 aircraft data case	Bartels

Upper-tropospheric forcing during SWAMP	Dunn
Moisture surges	Douglas

Friday 14 June 1991

8:00 - 8:30 am	Coffee	
8:30 - 10:30 am	Continued first looks at case data (about 20 min. each)	
	July 20 aircraft data case	Schurr/Smull
	Thunderstorm propagation - the "RIM" event	Hales
	Heat island structure	Phillips/Skindlov
	Diurnal wind cycles in the Salt River Valley	Stensrud
	Diurnal cycles in moist static stability	Maddox and Stensrud
	Other forecast office projects	Carpenter
10:30 - 11:00 am	Break	
11:00 - noon	General discussion of additional research opportunities, potential collaborations, COMET proposals, data requirements, etc	Participants
Noon - 1:30 pm	Lunch	
1:30 - 2:30 pm	Tour of new NWS Office	

2:30 pm Meeting formally adjourned - informal discussions continue as appropriate

* Travel for NWS participants will be scheduled and coordinated by Western Region SSD - please get in touch with Ken Mielke.

* Lodging for out-of-towners during the workshop will be at the Doubletree - Barbara Brown has reserved a block of rooms for this meeting. Information on the rates, making reservations, etc. are attached for your information.

* The presentations are envisioned as being **VERY INFORMAL** first looks at work underway, or in formative stages. If any one has questions or concerns, please give me a call.

* Finally, please note: The Phoenix Chapter of the AMS has scheduled an evening meeting at Monti's on the 13th. One of our SWAMP participants, Jack Hales, will be the speaker and we hope that workshop attenders will plan to have dinner with the local AMS.

DRAFT DRAFT DRAFT

C H DAVIS

THE SOUTHWEST AREA MONSOON PROGRAM (SWAMP)

DAILY OPERATIONS SUMMARY

José G. Meitín, Jr. (303) 497-6341
(FTS) 320-6341

National Severe Storms Laboratory / BOULDER
June 1991

noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / Environmental Research Laboratories

THE SOUTHWEST AREA MONSOON PROGRAM (SWAMP).

DAILY OPERATIONS SUMMARY

José G. Meitín, Jr.

Mesoscale Research Division
National Severe Storms Laboratory
Norman, Oklahoma and Boulder, Colorado
June 1991

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1. Introduction

The South West Area Monsoon Program (SWAMP) is a cooperative project between forecasters and scientists of the National Weather Service (Phoenix Forecast Office, Tucson Office, Western Region Headquarters, and the National Severe Storms Forecast Center), the NESDIS Satellite Applications Laboratory, ERL's National Severe Storms Laboratory, the University of Colorado's Cooperative Institute for Research in the Environmental Sciences (CIRES), Arizona State University, the University of Arizona, the Salt River Project, and the Mexican Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE). The project has three major scientific objectives: 1) Central Arizona thunderstorm environments; 2) Monsoon structures and moisture fluxes; and 3) Mexican convective systems. The SWAMP Project Director is Dr. Robert Maddox (NSSL). The TRAVASON Scientific Director is Dr. Sergio Reyes (CICESE). NOAA's P–3 Orion aircraft (operated by personnel from the Aircraft Operations Center / NOAA, Miami) was flown during thirteen missions (approximately 85 flight hours were available to support this project) from 9 July to 7 August, 1990. The aircraft was based at the Phoenix SkyHarbor International Airport. All forecasting and project strategy / mission decisions were made at the National Weather Service Forecast Office (WSFO), Phoenix. The WSFO was also the site of the SWAMP Operations Center during all missions. Similarly, the TRAVASON / SWAMP Operations Center was located at Hermosillo, Sonora for coordination of Mexican operations.

2. Forecast Operations

Appendix A contains a daily summary of weather events, operational decisions, special observations and a brief description of P-3 operations for every 24-hr period during the project. Additionally, a 700-mb streamline chart at 1200 UTC and accumulated cloud-to-ground lightning strikes are available as general descriptors of conditions over the SWAMP / TRAVASON experiment region for each day. All hardcopy forecast products, charts, and text used during the field phase of the project are archived at the NSSL, Boulder. During the experiment, digital archives of AFOS products, SAOs, regional and national scale satellite imagery, NMC model output gridded values and other conventional synoptic products were archived in Boulder through a link to the Forecast System Laboratory (ERL) ingest facility.

3. Aircraft Program

Appendix B summarizes the aircraft missions during SWAMP. Flight tracks for individual missions, flight levels flown, mission plans, and tape logs of the airborne systems are included. The 1-sec, *in situ* data for each mission has been calibrated by the Aircraft Operations Center (NOAA) and are archived at NSSL, Boulder. Experimental data from the other data systems onboard the aircraft will be reprocessed on a case-by-case basis.

There are four basic data systems on the NOAA P–3 research aircraft. These systems include the main data acquisition system for the *in situ* data, the radar data system, the omegadropsonde data system, and the cloud physics data system. The sensors that are serviced by the main data system are sampled at a rate of 40 Hz, and then are averaged to yield 1 sample per second. Derived parameters (such as wind) are calculated in post-processing once calibrations and biases are determined and removed. The Inertial Navigation accelerometers are bounded with Omega and LORAN navigation position estimates (for horizontal position) and radar altitude observations (for vertical position) to remove the effects of accelerometer drift.

There are two research radars mounted on the P–3: a horizontally scanning, C-band radar mounted in the lower fuselage, and a vertically-scanning, X-band radar mounted in the tail. The tail radar has the Doppler capability to estimate radial velocity of precipitation-sized hydrometeors. The Knollenberg Particle Measurement System (PMS) records the output from their 2-D and FSSP probes on a separate data system. The PMS forward scattering spectrometer probe (FSSP) detects the cloud droplet spectrum for 0.5 μm to 45 μm with the data recorded in 2 s intervals on the same tape as the 2-D data.

The Mesoscale Research Division of NSSL (Boulder) will make available a research workstation to all scientists interested in collaborative research using SWAMP data sets. All airborne radar, PMS and omegadropsonde data sets are archived at NSSL, Boulder.

4. Digital Radars

Two research radar digitizers from the Hurricane Research Division (HRD) of NOAA / ERL / AOML were installed on the WSR-74 radars at Phoenix and Tucson. The digitizers recorded high resolution data, 1° radial and 1-km gate spacing with 256 reflectivity thresholds. Appendix C presents tables and tape logs of the times data were recorded at each site. These data are archived at NSSL, Boulder.

5. Digital Satellite Data

During the SWAMP field program digital GOES image data were collected and archived at NSSL in Boulder. Because there was only one operational GOES during this period, the satellite was not in a nominal GOES-East or GOES-West position. Rather, it was located over the equator at 99°W (central United States, eastern Mexico) and had a relatively good perspective of the northern Mexico and the southwestern United States. Hourly infrared (8 km spatial resolution) and water vapor (16 km spatial resolution) imagery were collected on the national scale, which includes the entire contiguous 48 states, southern Canada, and northern Mexico (as far south as the southern tip of Baja California). The infrared and water vapor imagery were also archived on the hemispheric scale at reduced temporal and spatial resolutions of 3 hourly (i.e., 00, 03, 06, ... ,21 UTC) and 16 km, respectively. A special visible image sector was created for SWAMP. Coverage extended from northern Arizona (near Flagstaff) to the southern tip of Baja California, and from Guadalupe Island in the eastern Pacific Ocean (120°W) to central Mexico (103°W). These data are available at half-hour intervals at 2 km spatial resolution.

A summary of the SWAMP archive of national-scale infrared and water vapor imagery is given in Appendix D. Data present in the archive are indicated by the thick black line segments. Note that only five image times were missed during the entire program. This inventory for national-scale IR data applies also to the hemispheric IR and water vapor data, but only at the eight times during the day that those data were available (i.e., 00, 03, 06, 09, 12, 15, 18, and 21 UTC) Only two image times of hemispheric IR and water vapor data were missed.

The SWAMP archive of GOES visible digital imagery is also presented in Appendix D. Coverage began before the start of the program at 1900 UTC on 7 July and extended through 15 August. Only 10 visible images were missed during the entire extent of SWAMP. The hatched region in the table corresponds to the evening and nighttime hours when visible imagery are not available. The loss of the 0230 UTC image after 11 July is a consequence of the reduction in visible coverage as the sun retreats southward following the summer solstice.

6. Upper-Air Program

During SWAMP, the 0000 UTC synoptic upper-air soundings were taken routinely from the four northern Mexico rawinsonde stations. Four special observing periods were requested by the SWAMP Operations Center. During these periods, additional soundings were released at 0600 and 1800 UTC from the participating upper-air locations. (San Diego, Winslow, Tucson, El Paso, Guadalupe Island, Mazatlan, Empalme, and Chihuahua. NSSL's mobile laboratories (designated NSSL2 & NSSL3) were deployed to Phoenix during SWAMP. NSSL3 was installed at SkyHarbor Airport as fixed base site during the experiment; providing soundings at regular synoptic observing times and special releases as necessary. The NSSL2 mobile lab was deployed to preselected launch sites for evaluation of the metropolitan heat island around the Phoenix area. Appendix E catalogs all upper-air soundings from the SWAMP period archived at NSSL.

During the experiment, pilot balloon observations (PIBALS) using optical theodolites were made at ten sites in northwestern Mexico. Pilot balloon observations provide low-to-middle level wind observations with a finer horizontal and temporal resolution than is possible with the present rawinsonde network. Pibals were nominally taken at 1200, 1800 and 0000 UTC during the field phase of SWAMP. Occassionally, special pibals were taken at 0600 UTC Appendix E provides a catalog of all pibal data archived at NSSL. Table E1 lists the locations of all the pilot balloon and other upper-air sites participating in SWAMP.

7. Rainfall data

As this publication went to press, NSSL has received a data base of 24-hour rainfall totals for a number of sites in northern Mexico. Additionally, a request has been submitted for 10-min surface data values collected from the metropolitan Phoenix mesonetwork. During SWAMP, a number of digital recording raingages were deployed along the west slope of the Sierra Madre Occidental. These data have not yet been catalogued.

8. Data Management

All research data sets will be archived at the National Severe Storms Laboratory, NOAA. Data will be available upon request to interested SWAMP researchers. Aircraft data can be analysed with the use of the NSSL/MRD workstation. Submit data requests to the SWAMP Data Manager:

José Meitín
NSSL / SSD R/E/NS1
325 Broadway
Boulder, CO 80303

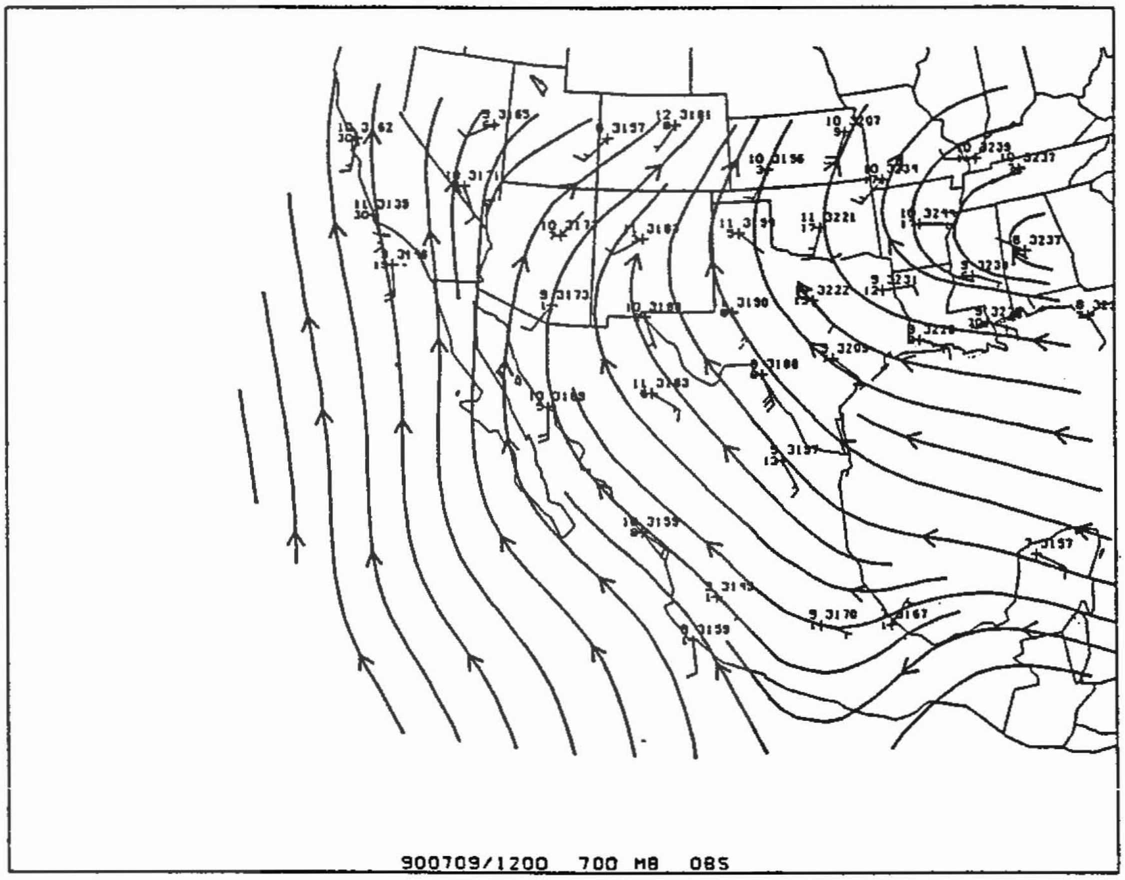
(303) 497-6341

FTS 320-6341
FAX (303) 497-6930
OMNET: NSSL.MRD

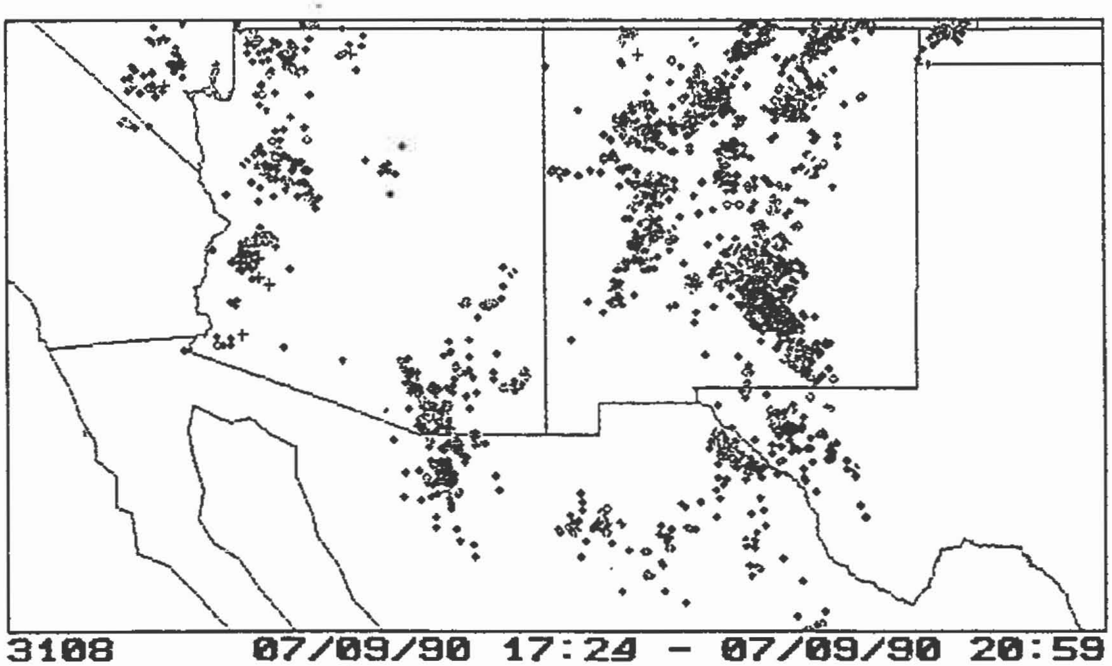
9. Acknowledgments

A project such as SWAMP could not have been successful without the cooperation of a great number of agencies and individuals. We are indebted to the personnel at Phoenix's National Weather Service Forecast Office who were patient enough to allow the SWAMP research staff to invade their cramped quarters at SkyHarbor Airport and remained gracious hosts for the field experiment. The National Water Comission, Mexico (CNA) was responsible for the overall coordination of pilot balloons and upper-air sites in northern Mexico. The staff of the Aircraft Operations Center, NOAA provided their usual professional support during P-3 missions. The dedication, long hours and hard work of hundreds of people is what ultimately determined the high quality of data collected during SWAMP.

Appendix A
Daily Operations



700 mb streamline chart for 1200 UTC, July 9, 1990



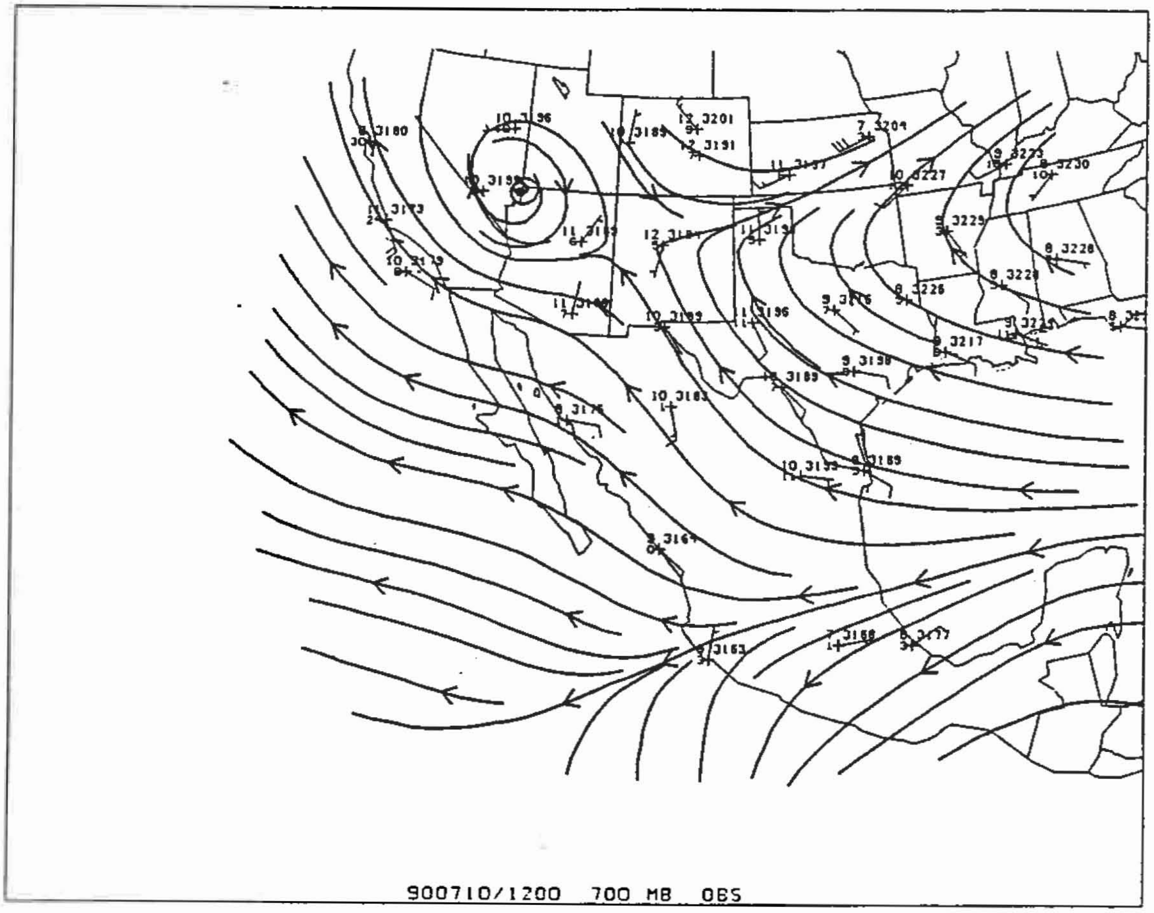
Cloud-to-ground lightning strikes during July 9, 1990

9 JULY 1990 Monday

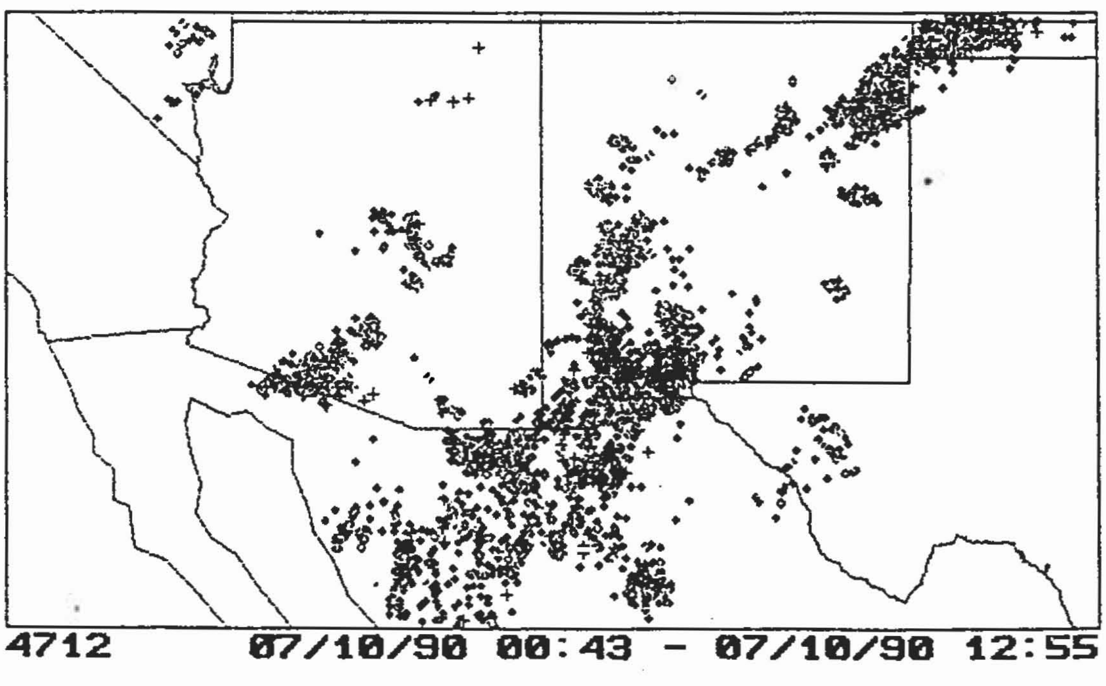
Weather Events: Some drying occurred over northern Arizona with moist, unstable southerly flow continuing in low and middle levels over southern Arizona and New Mexico. Only isolated orographic storms over Arizona. One injury due to lightning occurred in Pinal County. The monsoon interface was located from WSW to ENE to N from northern Baja California to west of the Four Corners region.

P-3 Operations: Mission #1. Flight legs were flown both up and down the Gulf of California and from east to west across Baja California to the mainland, at both high and low altitude. Only a brief encounter was made with exceptionally dry, mid-level air believed to be associated with the west side of the interface. Finished up by gathering cloud physics and radar data on storms over Sonora near the Gulf of California.

Special Observations: Heat island double transect (with soundings taken both at Phoenix and by NSSL2) was performed during the evening and night across the city from SE to NW and then back. Balloon releases began at 9:00 pm (LT) and continued through 6:00 am on the 10th. Special upper-air soundings requested for four U.S. stations at 1800 UTC on the 9th and 0600 UTC on the 10th.



700 mb streamline chart for 1200 UTC, July 10, 1990



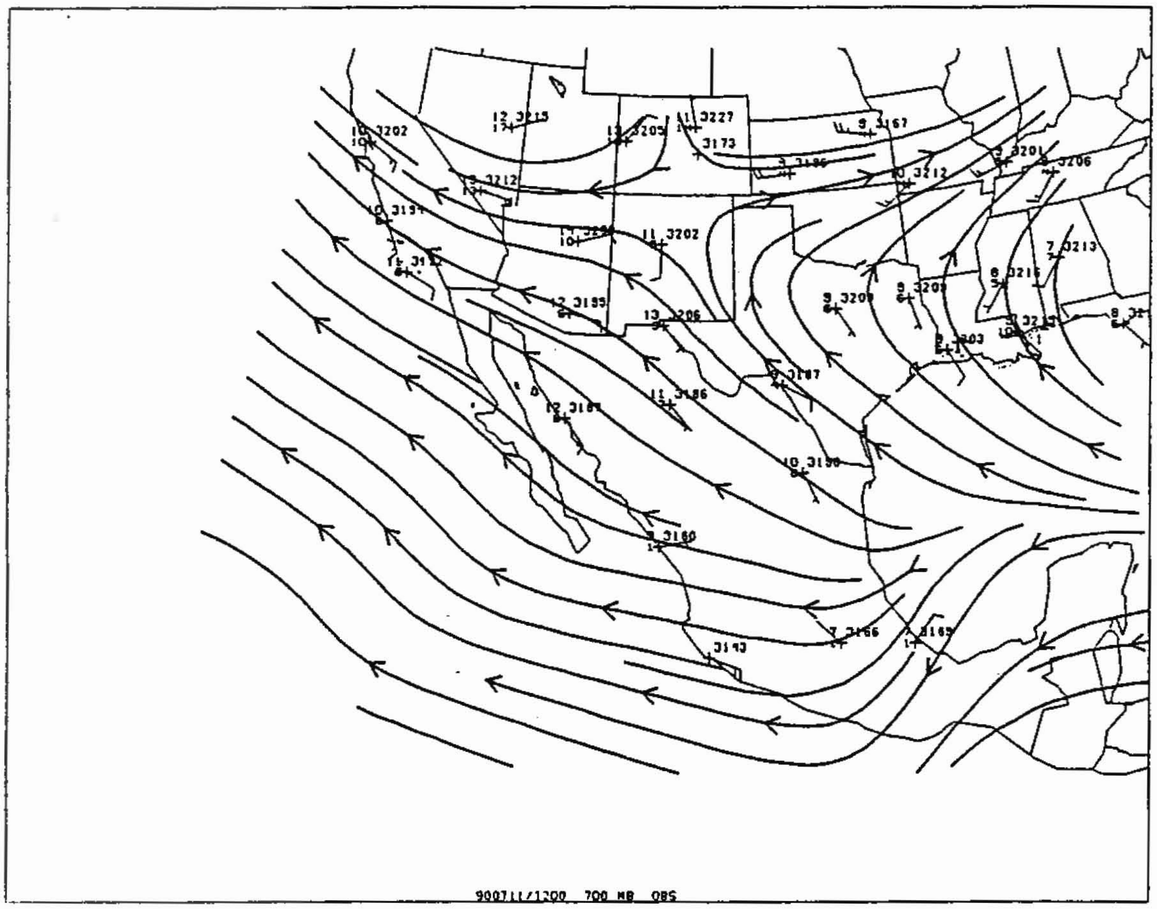
Cloud-to-ground lightning strikes during July 10, 1990

10 JULY 1990 Tuesday

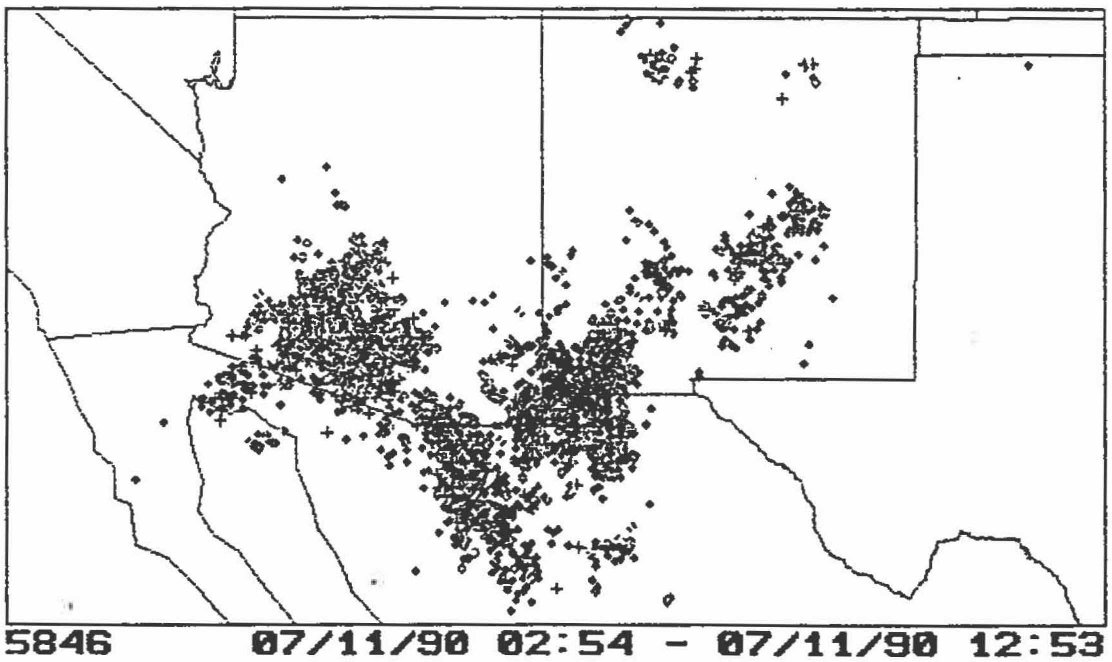
Weather Events: Low-level warming had occurred and a slow moving and very weak easterly disturbance crossed Sonora and Arizona during the evening apparently helping to trigger a classically organized MCS / squall line that moved all the way to the Colorado River Valley by next morning. Storms moved westward off the Superstition Mountains and into the Phoenix area at sunset with very heavy rains, damaging downburst winds, and frequent lightning. The 0000 UTC sounding taken at Phoenix did not support the type and intensity of storms that occurred only 3 to 4 hours later. The MCS left behind a spectacular residual circulation that moved westward across the Yuma area and then triggered new convection over northern Baja California. Flash flooding was again reported in the Tucson area, this time around 7:30 pm (LT).

P-3 Operations: DOWN. Evaluation of data systems after Mission #1.

Special Observations: 0000 and 1200 UTC Phoenix radiosonde.



700 mb streamline chart for 1200 UTC, July 11, 1990



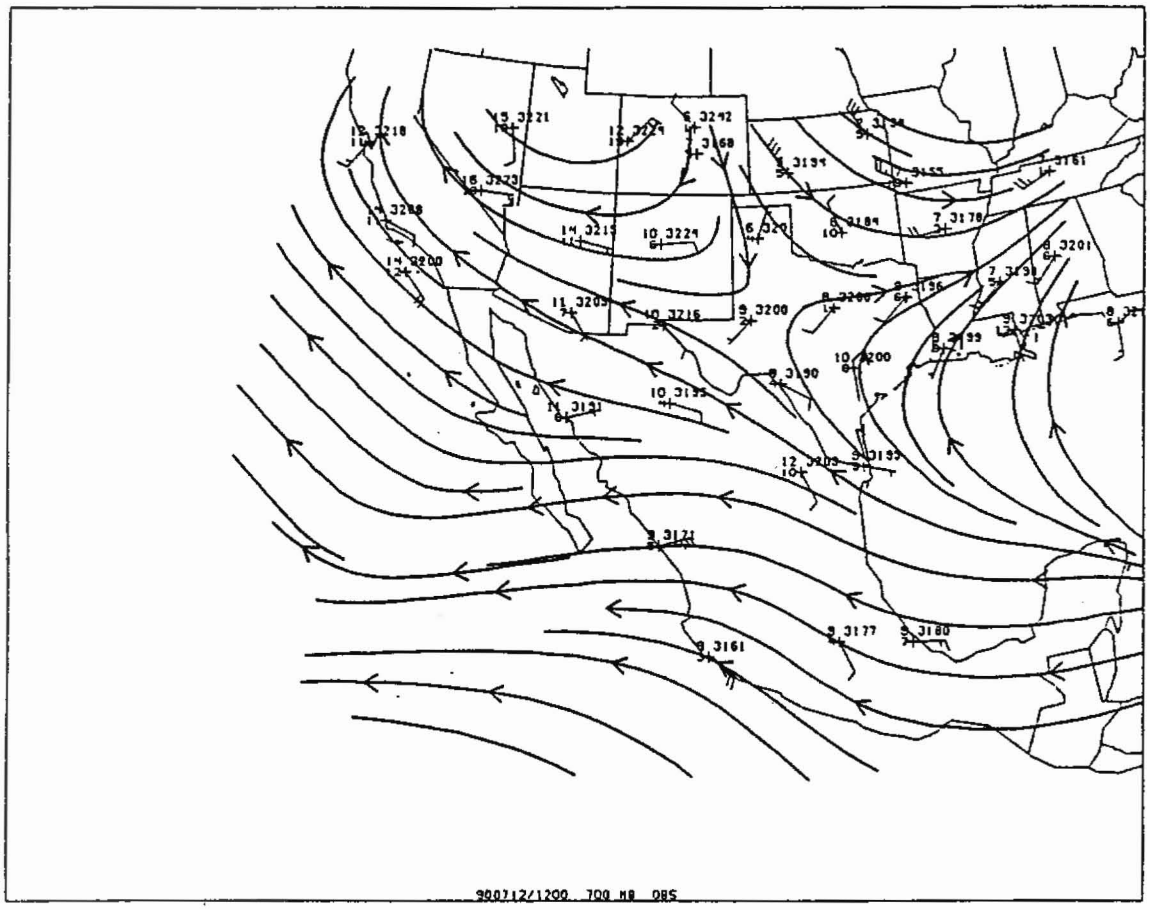
Cloud-to-ground lightning strikes during July 11, 1990

11 JULY 1990 Wednesday

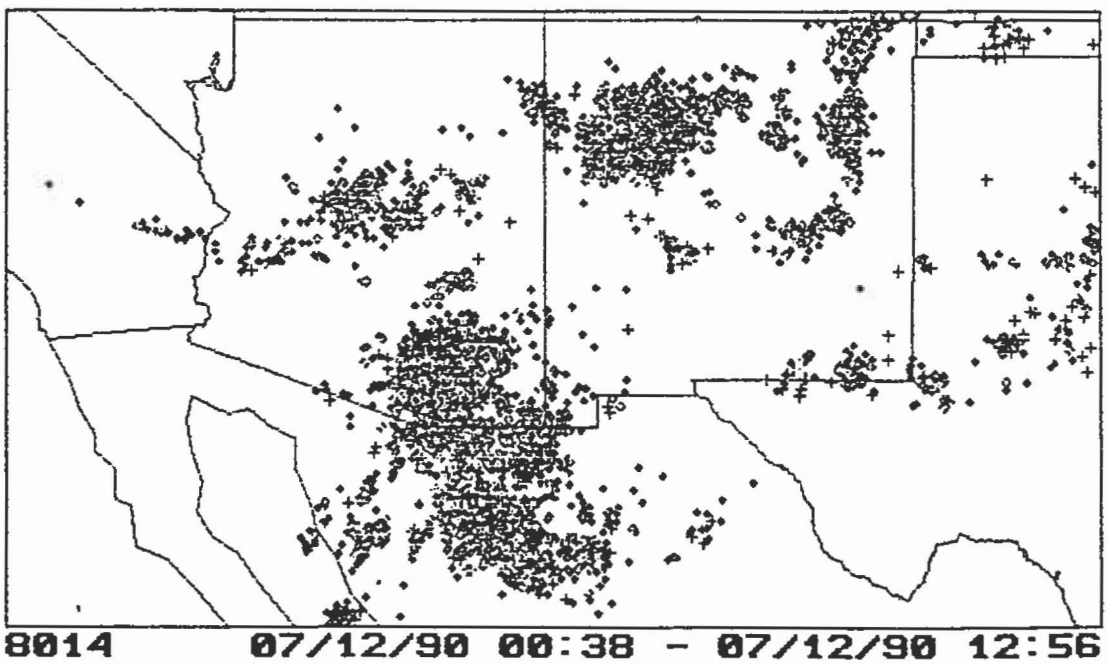
Weather Events: An inverted trough in the low and middle level flow oriented from Empalme across Arizona west of Phoenix at morning sounding time. Primarily afternoon / evening orographic storms over Arizona. Some thunderstorms produced damaging winds in the Tucson area around 9:10 pm (LT). Air mass in NW Mexico was very unstable and several large convective systems developed during afternoon and evening. Next several days appear to be favorable for substantial storm activity over Arizona and special upper-air soundings were alerted for 1800 and 0600 UTC for 48-hour period beginning at noon on Thursday, 12 July.

P-3 Operations: Mission #2 Aircraft took off at about 6:00 pm, passed a bow-echo shaped feature south of Nogales, and ultimately collected data on an MCS, late in its lifecycle, located at about 25°N. Another system developed north of this MCS at about 10:00 pm and the aircraft flew through it gathering data on its return to Phoenix.

Special Observations: Mid-afternoon and evening special rawinsondes, No 0000 UTC at PHX.



700 mb streamline chart for 1200 UTC, July 12, 1990



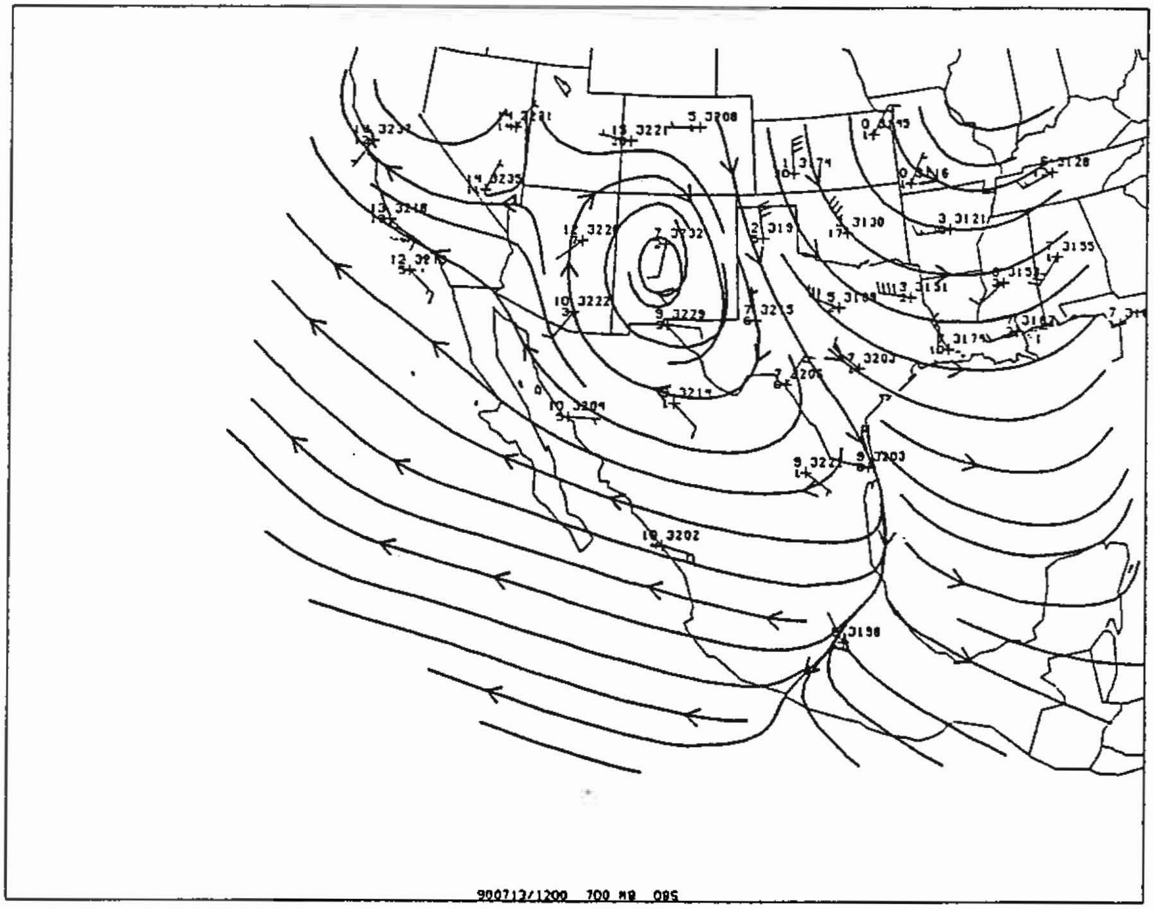
Cloud-to-ground lightning strikes during July 12, 1990

12 JULY 1990 Thursday

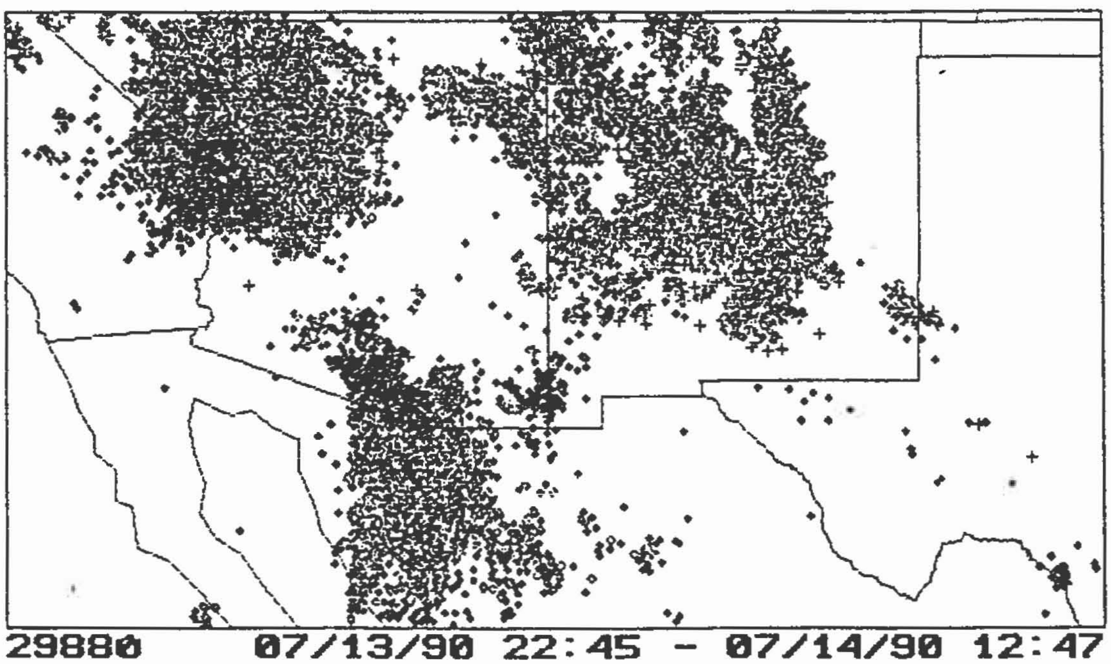
Weather Events: Storms again developed in NW Mexico. A moderately strong easterly flow of moist, unstable air was now set up over much of Arizona. A strong and apparently organized MCS formed over the northwestern mountains at mid-afternoon and produced a pronounced outflow southward into the lower desert. There were many wind damage reports from this outflow, some close to the northwestern suburbs of Phoenix (e.g., New River). Outflow went thru Phoenix at mid-afternoon and may have stalled just south of the Salt River. Late afternoon storm formed ESE of Apache Junction and moved westward producing a highly damaging downburst in the Casa Grande area (heavy damage with many power poles down and injuries: 3 hurt when a concession stand blew apart in Casa Grande; 12 other injuries around Casa Grande - all around 8:00 pm; 9 people were injured in Maricopa County in over-turned mobile homes). As this storm moved westward, it evolved into a large area of strong storms situated just to south of SkyHarbor Airport from about 9 to 11:00 pm. Finally, storms organized west of Tucson after dark and moved rapidly westward, moving across the Yuma area with damaging winds around local midnight.

P-3 Operations: Mission #3 Aircraft takeoff around 9:00 pm and found that systems in Mexico had formed early and moved rapidly westward (influenced by a large-scale disturbance) so that data were gathered in decaying stratiform areas. Aircraft then flew into Arizona, west of Tucson, and collected data well to the rear of the MCS moving across the Yuma area. Doppler radar data were sub-standard for this flight, possibly due to cabin overheating prior to takeoff.

Special Observations: Special upper-air soundings were taken U.S. stations at 1800 and 0600 UTC. NSSL2 released two afternoon soundings near Globe and then moved westward to Apache Junction and released a final sounding just to the north of the Casa Grande downburst storm (the infamous "*Storm from Hell*"). The crew also videotaped the storm as the downburst developed in association with a very heavy rain shaft. Soundings were taken at PHX in coordination with the mobile laboratory.



700 mb streamline chart for 1200 UTC, July 13, 1990



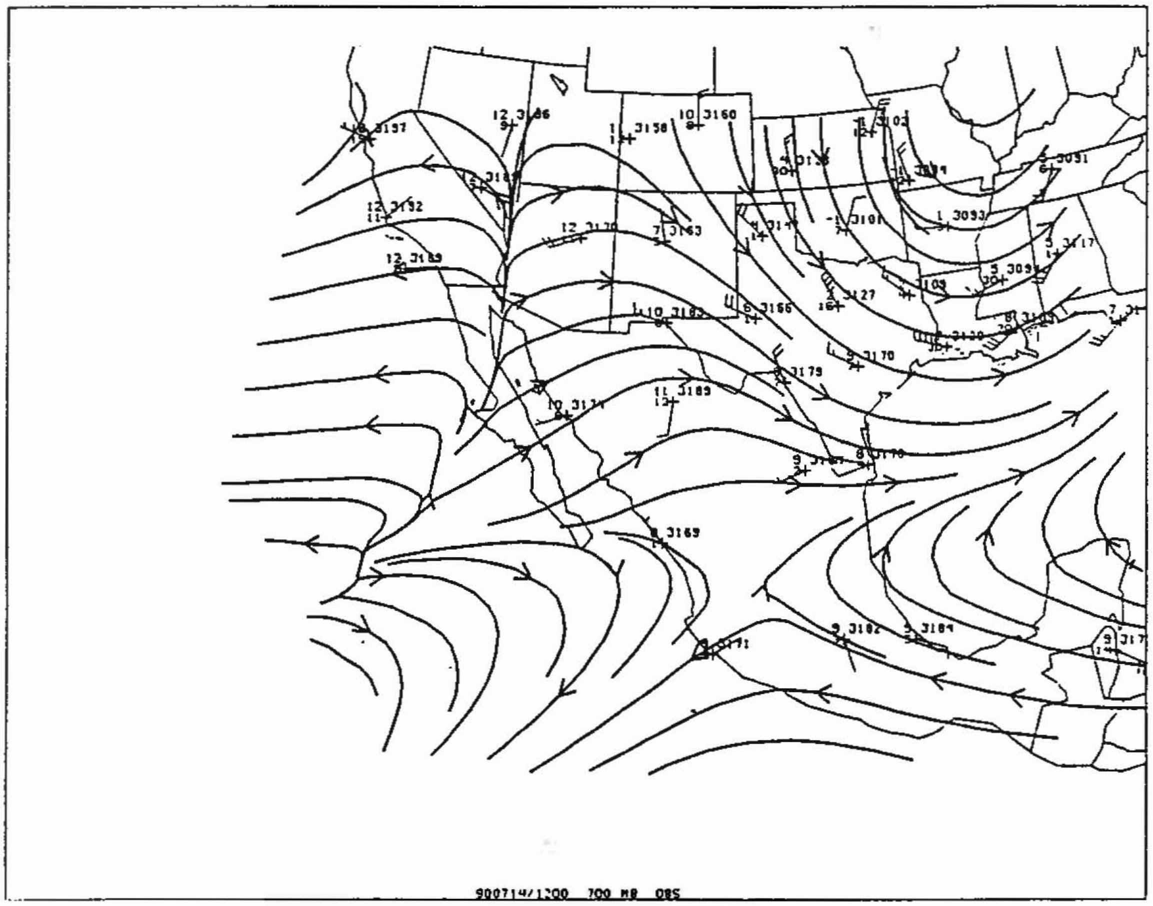
Cloud-to-ground lightning strikes during July 13, 1990

13 JULY 1990 Friday

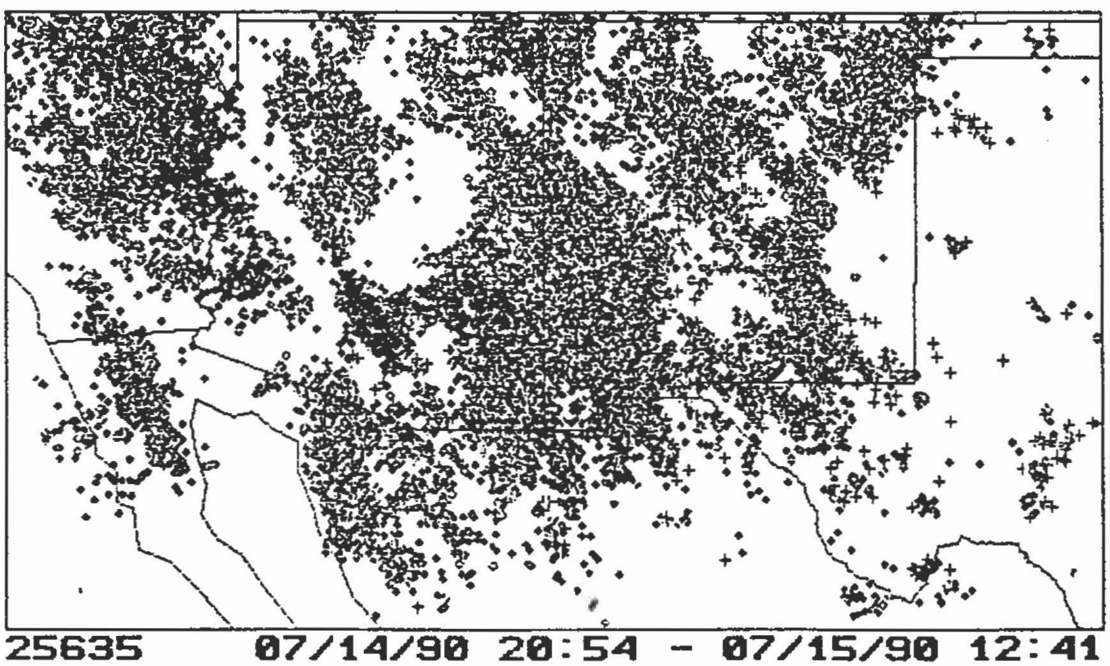
Weather Events: Storms through early morning hours in extreme western New Mexico produced morning flash flooding in Arizona, west of Gallup (there were six reported fatalities with this event). Mid-level drying had occurred over southwestern Utah. West end of a strong surface cold front trails into southern Arizona. Very large afternoon MCS formed over northwestern mountains of Arizona and built westward. Heavy rains and flash flooding reported southwest of Flagstaff with one fatality in Yavapai County. The outflow from this system triggered a second MCS over southern Nevada. This new system moved westward initially and then weakened into a smaller area of storms that moved southeastward into Arizona's low deserts. Wind damage in the Bullhead City area at 8:50 pm (LT).

P-3 Operations: DOWN (air conditioner repairs)

Special Observations: Special upper-air observations continued at U.S. weather service sites thru 0600 UTC on the 14th. Special sounding series in the evening at PHX.



700 mb streamline chart for 1200 UTC, July 14, 1990



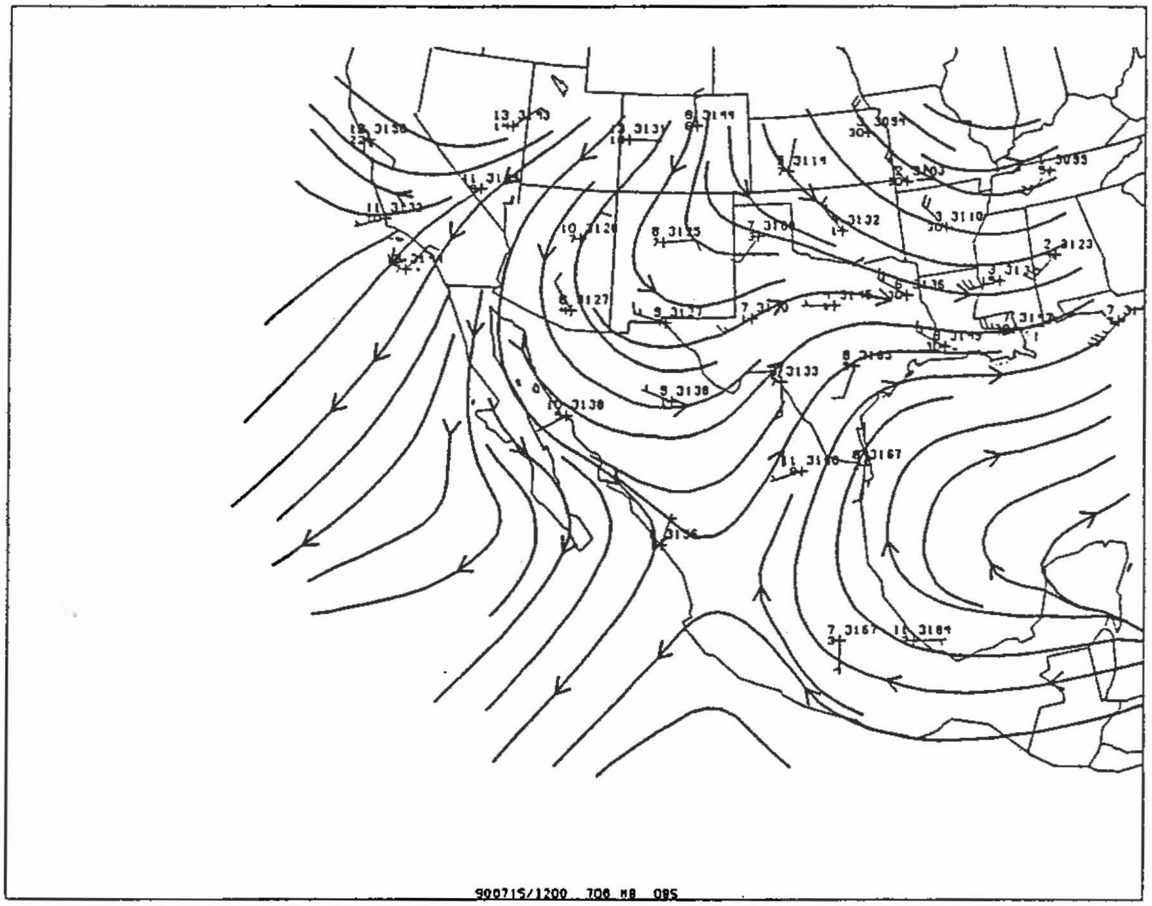
Cloud-to-ground lightning strikes during July 14, 1990

14 JULY 1990 Saturday

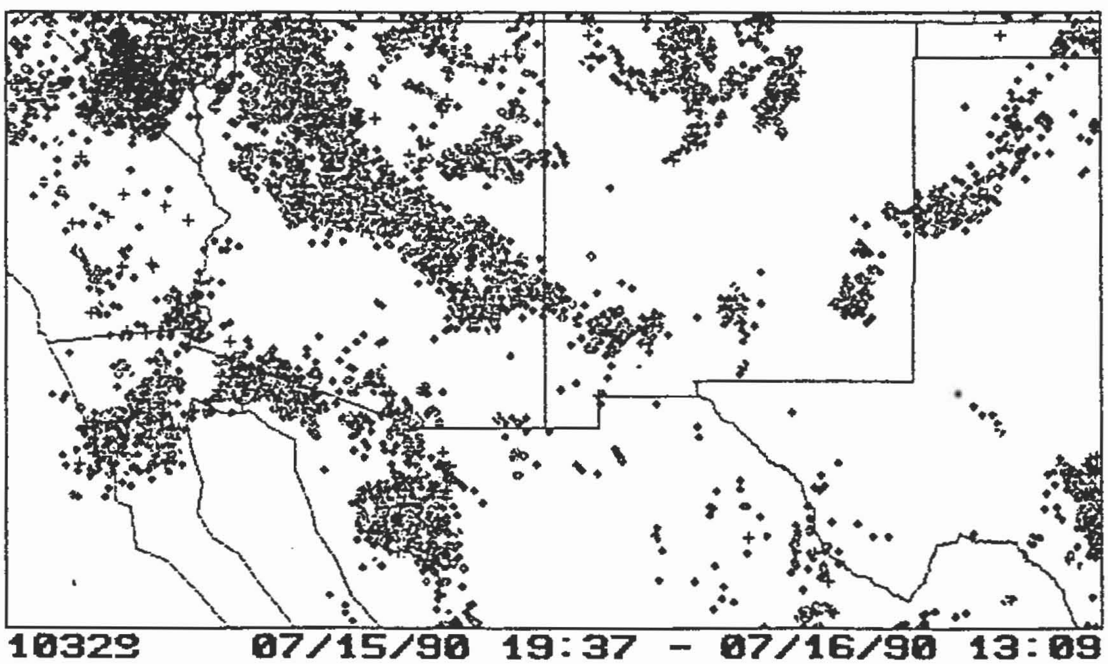
Weather Events: Mid upper-level trough passed across Arizona with winds becoming northwesterly to northerly; low levels continue very moist. Cloudy, cool air covered the low deserts at sunrise and storms developed at midmorning, northeast of Yuma, and continued into early afternoon. The net result was that the lower elevations of Arizona were essentially covered by a cool mesohigh and storms occurred primarily around its periphery in the mountains. Strongest activity was very persistent over the region near Flagstaff / Grand Canyon. Numerous reports of flash flooding in Santa Cruz County, west of Ft. Huachuca, around 7:00 pm. A large, β-scale MCS formed over northern Baja California, south of San Diego, then another very strong system over northern Mexico. Impressive storms also formed over the San Juan Mountains in Colorado and over the Sierra Nevada Mountains in California / Nevada. The storms from the Yosemite National Park area moved southeastward through the night, redeveloping several times and moved into the Phoenix metropolitan area at sunrise with some locally heavy rains, particularly on the south side of the Salt River.

P-3 Operations: Mission #4. Flew a box pattern along airways over Arizona and gathered some Doppler radar data on quasi-stationary storms near Flagstaff and then over eastern Arizona and down to the Tucson area. NOAA aircraft had to fly along airways because of transponder and radio problems.

Special Observations: Mobile lab deployed to Aguila and launched special afternoon soundings in coordination with rawinsonde releases at Phoenix.



700 mb streamline chart for 1200 UTC, July 15, 1990



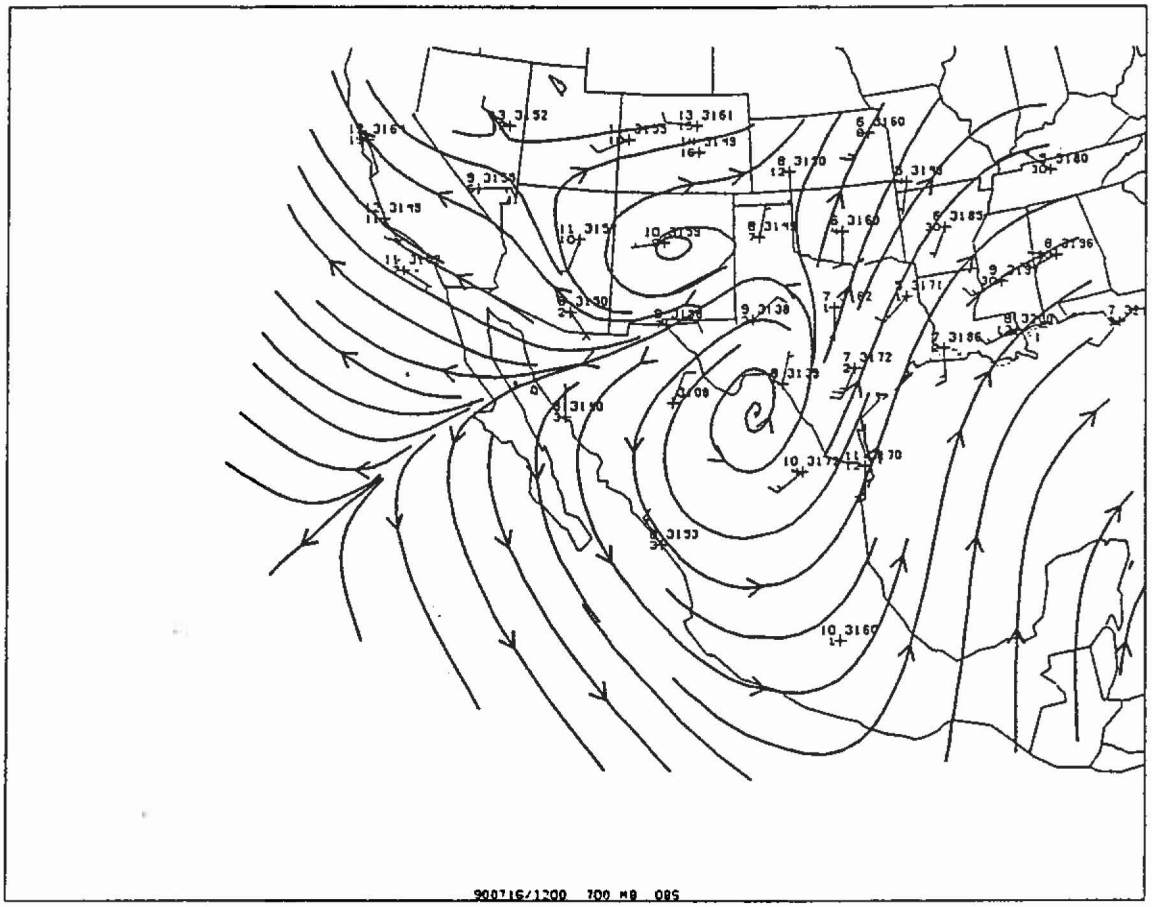
Cloud-to-ground lightning strikes during July 15, 1990

15 JULY 1990 Sunday

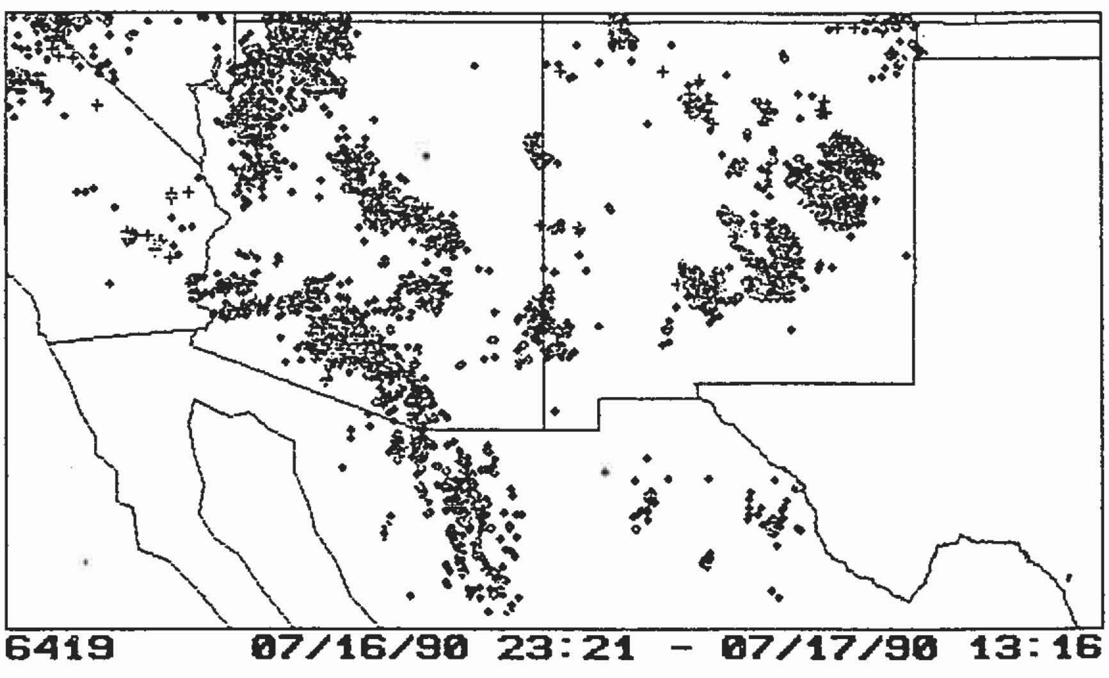
Weather Events: Moist, unstable northwesterly flow regime with storms produced heavy rains at sunrise. Flash flooding in Maricopa County around 1:00 am (LT); early morning significant flooding in Pima County / Tucson. Thunderstorms, heavy rains, and a funnel cloud near Prescott about 3:45 pm. The cool, cloudy air and a weak cold trough in the westerlies almost overhead combined to produce coolest day of project (max temp 91°F within 3°F of coolest max temperature for date). Drying anticipated in Arizona and Mexico will be affected by northwesterly flow aloft.

P-3 Operations: DOWN (radio / transponder testing).

Special Observations: Several special upper air soundings at PHX released ahead of, within and behind the early morning MCS.



700 mb streamline chart for 1200 UTC, July 16, 1990



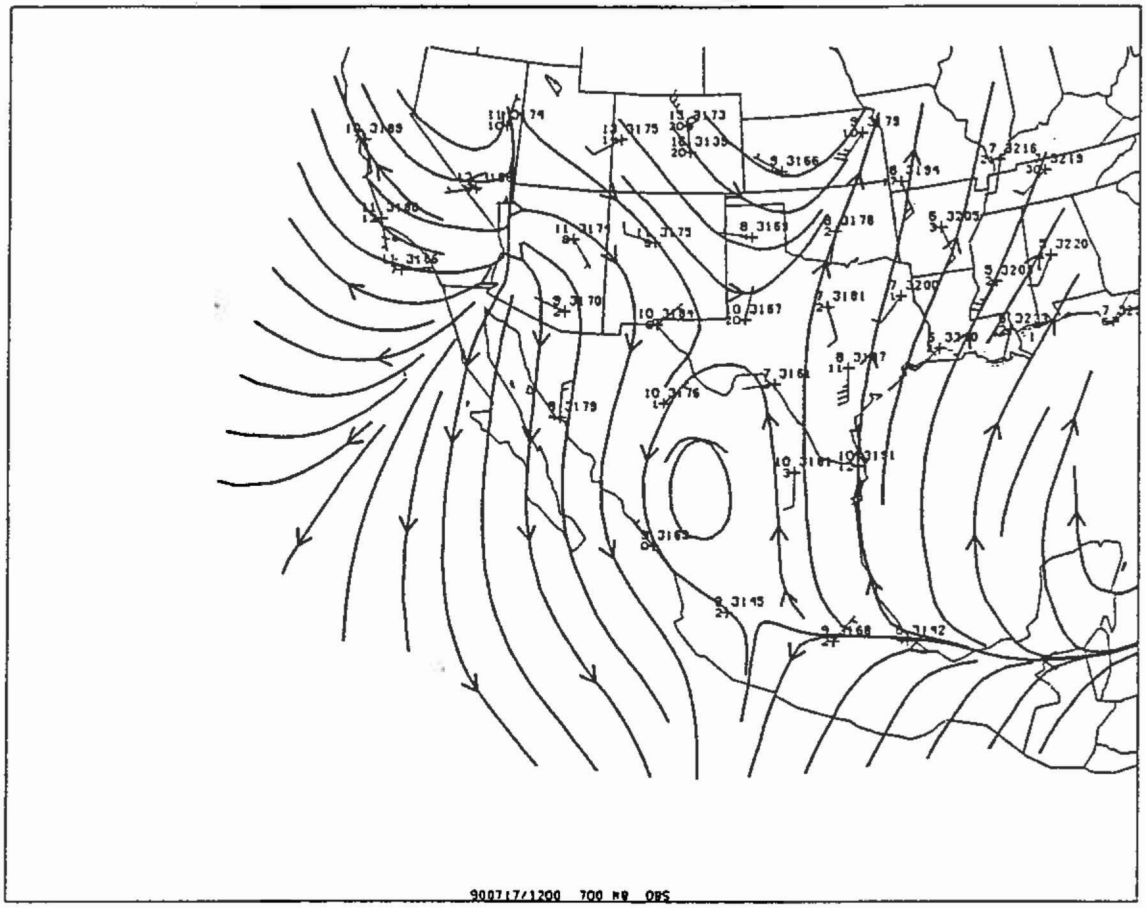
Cloud-to-ground lightning strikes during July 16, 1990

16 JULY 1990 Monday

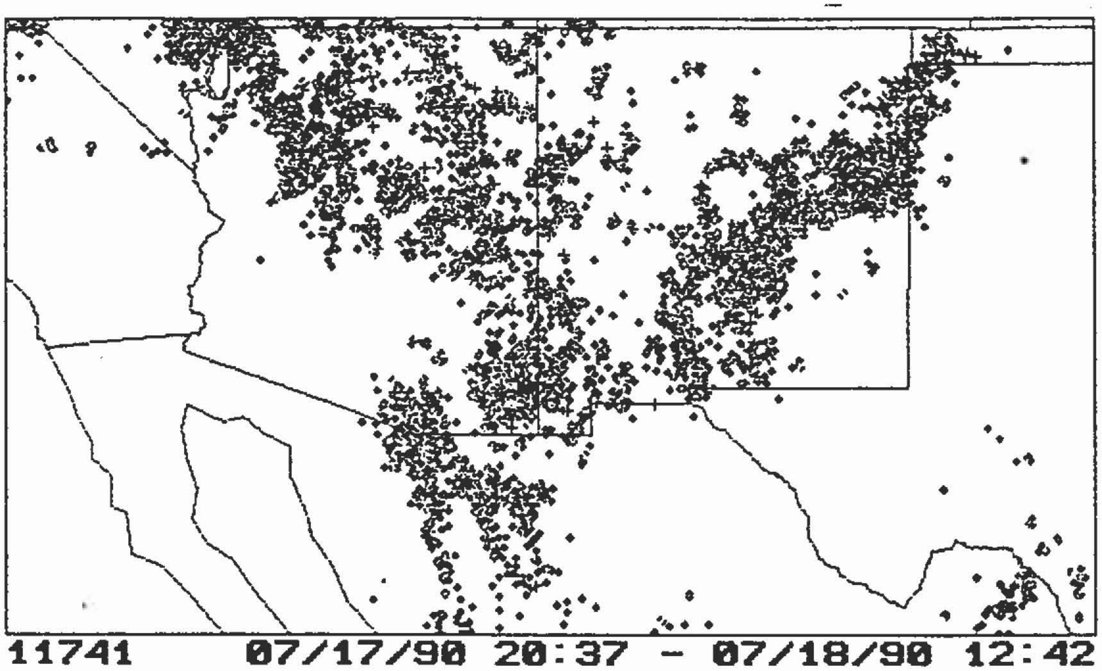
Weather Events: Moist, unstable conditions remain eventhough flow has become northwesterly. Convergence zone lies NW-SE across Arizona. Afternoon storms again lead to locally heavy rains at sites in the Valley of the Sun. Storms formed over McDowell Mountains at 4-5:00 pm (LT) sent large outflow across the metropolitan Phoenix area and was captured well in the PRISM surface mesonet data - intense evening storms appeared to develop along this outflow to the south of SkyHarbor Airport. Once again, flash flooding was reported in the Tucson area around 6:00 pm. A tornado was reported at 1:35 pm near Pierce, in Cochise County.

P-3 Operations: DOWN

Special Observations: Mobile lab deployed to Gila Bend during afternoon. Several special soundings released at PHX.



700 mb streamline chart for 1200 UTC, July 17, 1990



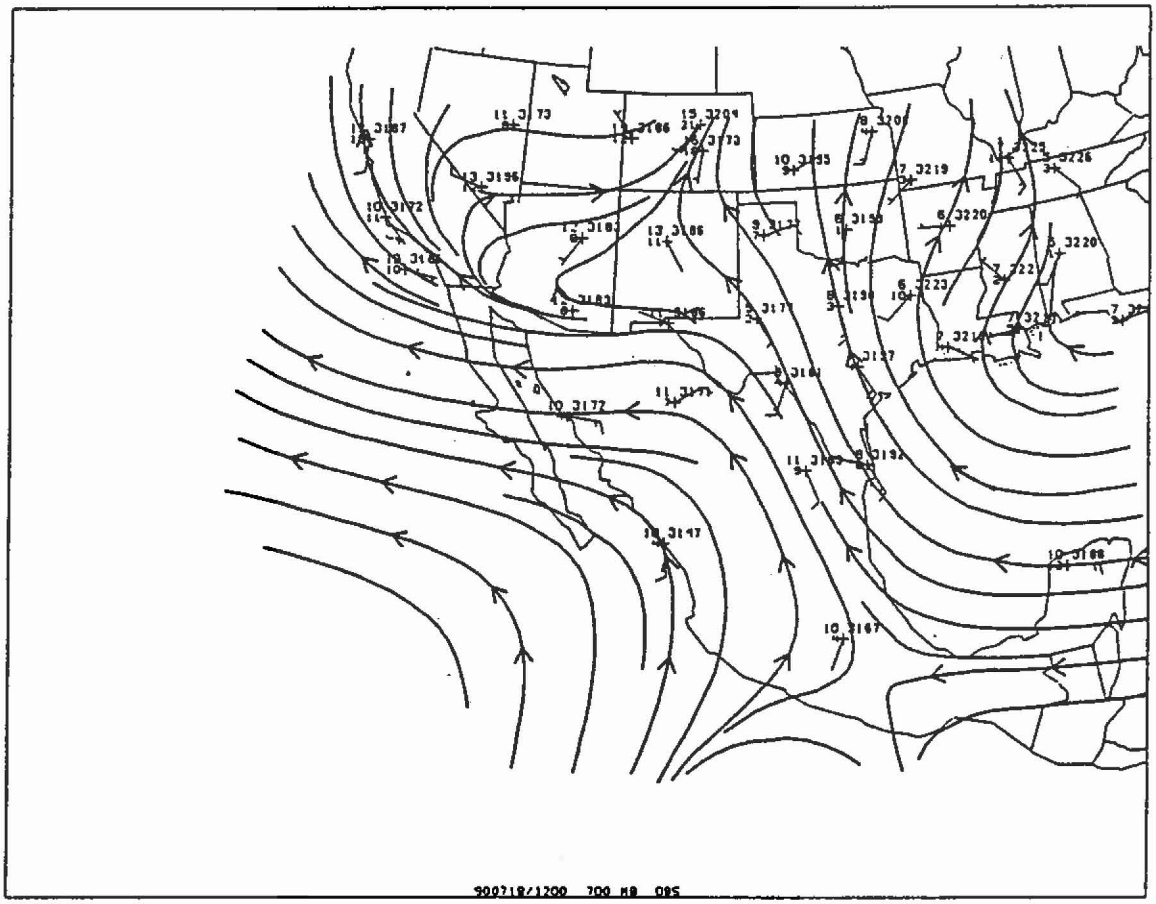
Cloud-to-ground lightning strikes during July 17, 1990

17 JULY 1990 Tuesday

Weather Events: A distinct dry slot is present over central Arizona to Sinaloa. An inactive convergence zone extends across Arizona from Las Vegas-Kingman-to west of Tucson. Some easterly wind component has returned to New Mexico / Sonora. Storms exist over the mountains with some hail reported over the Mogollon Rim. Storms present over northwestern Mexico.

P-3 Operations: Mission #5, to Mexico with takeoff at about 11:30 am (LT). Aircraft monitored very strong convection over Mexico and also the entire, brief lifecycle of a small mesoscale system over Sonora (from towering cumulus stage to dissipating stratiform).

Special Observations: Coordinated special soundings at Gila Bend (NSSL2) and PHX during the afternoon and evening.



700 mb streamline chart for 1200 UTC, July 18, 1990

NO CHART AVAILABLE

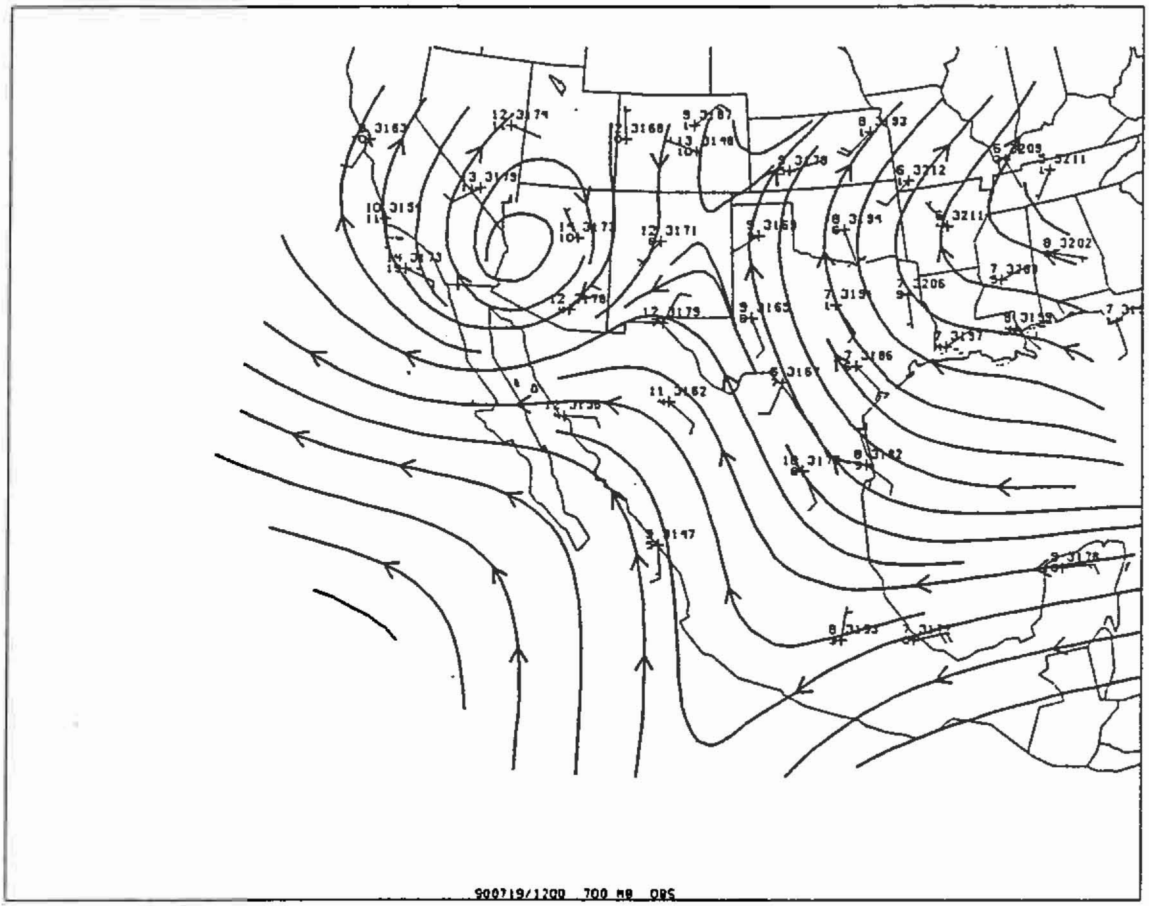
Cloud-to-ground lightning strikes during July 18, 1990

18 JULY 1990 Wednesday

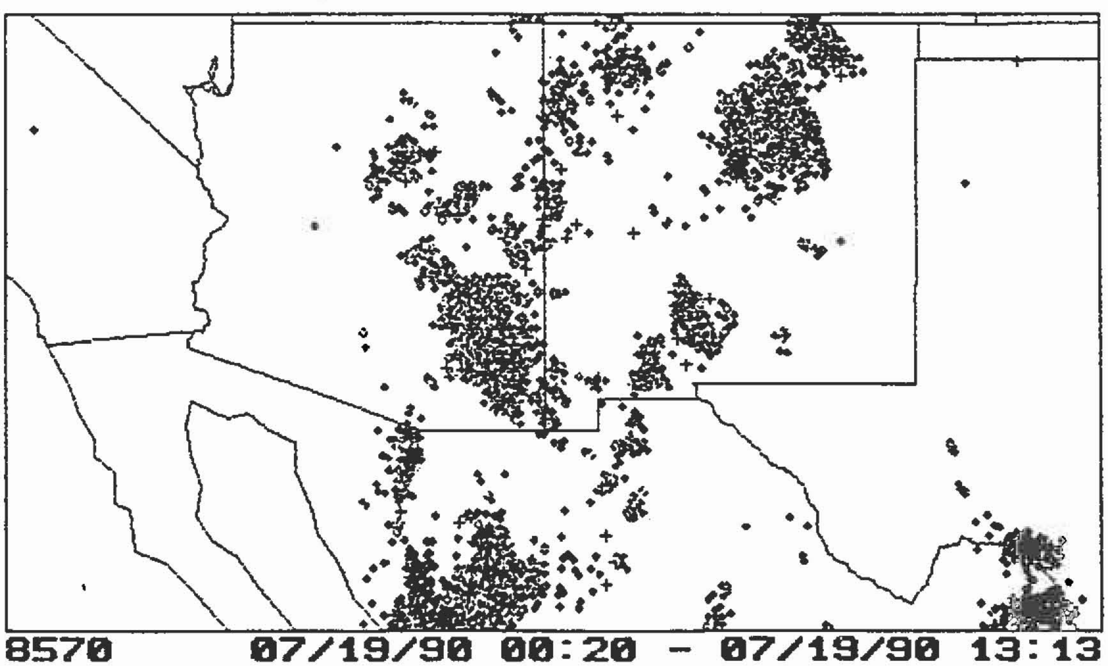
Weather Events: Isolated storms present on the Mogollon Rim and in southeastern part of Arizona. Inactive convergence zone continues Cedar City-Flagstaff-west of Tucson. Some drying and stabilization occurred; winds aloft are north to northeasterly. Nighttime MCS present over Mexico; the 1200 UTC sounding at Empalme indicates much improved CAPE (higher instability) and more easterly winds. Strong winds and $^3/_4$" hail reported in Green Valley, Pima County at about 5:45 pm (LT). Storms on Rim sent outflow down through the Phoenix area after sunset; no convection but complications for heat island mission.

P-3 Operations: DOWN

Special Observations: Requested special soundings in Mexico 18 July / 1800 and 19 July / 0600 UTC. Special evening soundings at PHX. NSSL2 Heat island mission but with only one transect leg (E to W) because of outflow - experiment terminated at 11:30 pm (LT).



700 mb streamline chart for 1200 UTC, July 19, 1990



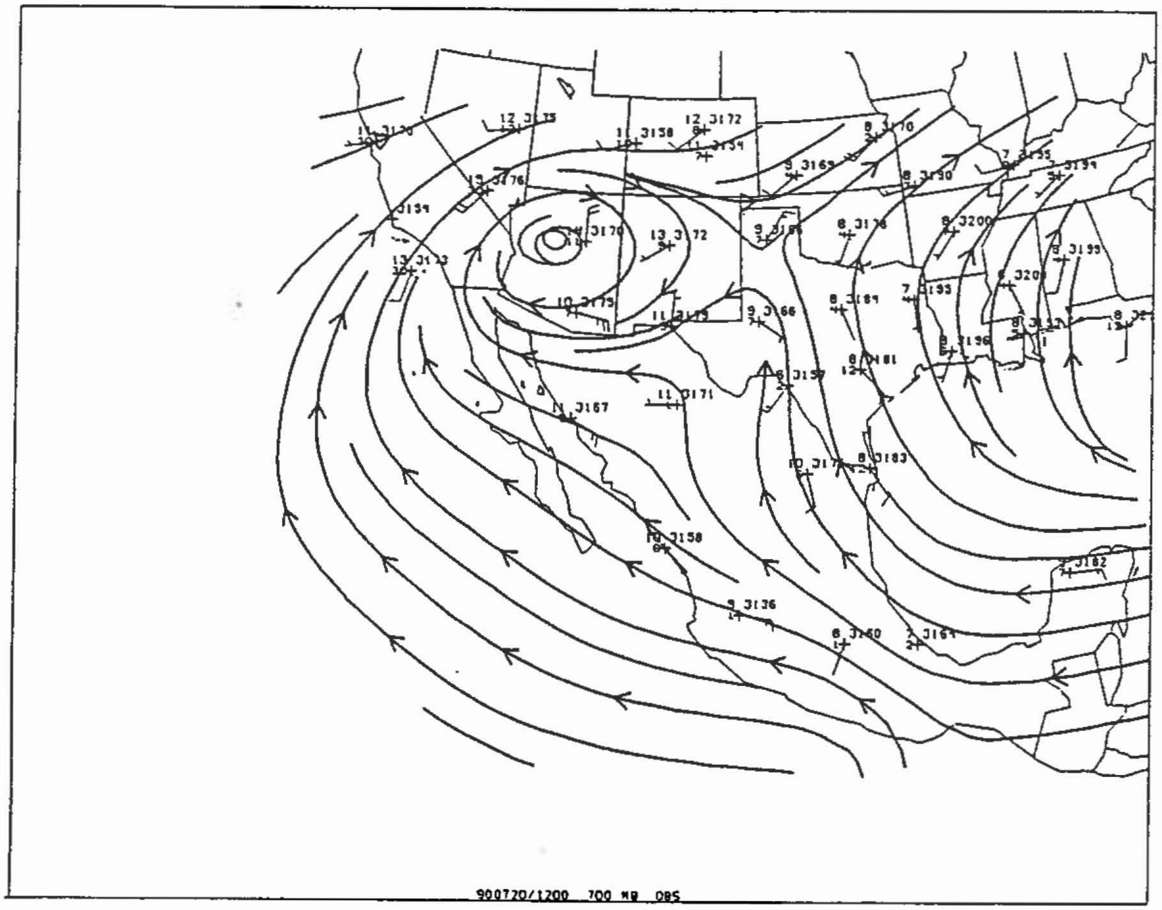
Cloud-to-ground lightning strikes during July 19, 1990

19 JULY 1990 Thursday

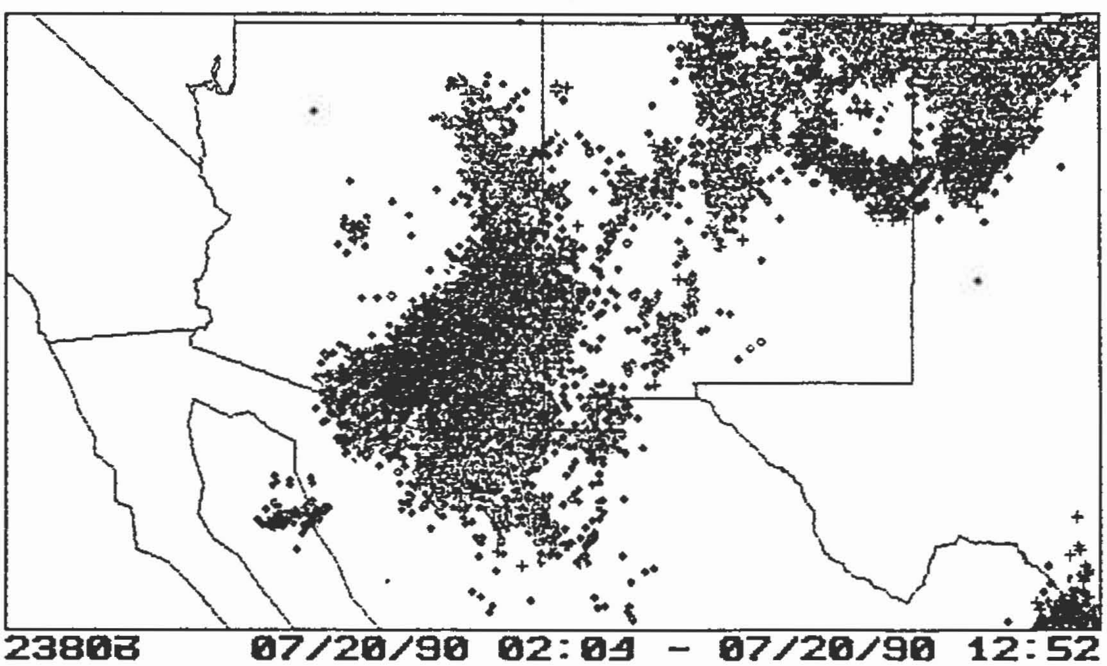
Weather Events: Mid-level anticyclone located over northern Arizona with moderate easterly flow across southern Arizona. Major MCS present over Mexico (≈27°-28°N) during late night; 1200 UTC Empalme sounding shows deep easterlies and extremely large CAPE. Gulf surge evident during early morning at Yuma; later in the day at Blythe and Needles. The storms on the Mogollon Rim stayed out of the Phoenix area and did not generate outflow into Valley of the Sun. Hail to 3/4" reported at St. Johns, Apache County at 6:50 pm.

P-3 Operations: Mission #6 flown over Mexico. Captured large, intense cell with flanking line structure and the mature phase of a very strong and highly organized MCS south of Douglas, Arizona.

Special Observations: 0000 and 1200 UTC Phoenix radiosonde



700 mb streamline chart for 1200 UTC, July 20, 1990



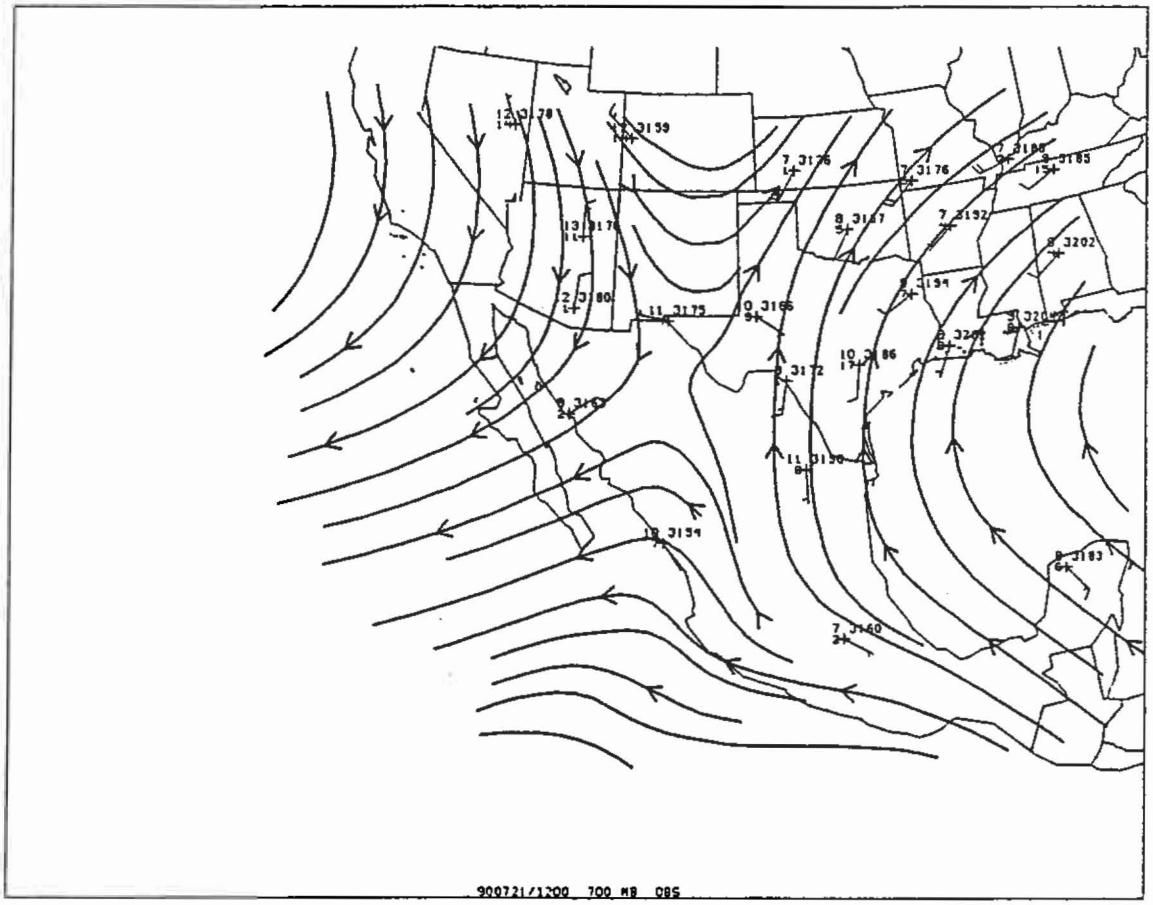
Cloud-to-ground lightning strikes during July 20, 1990

20 JULY 1990 Friday

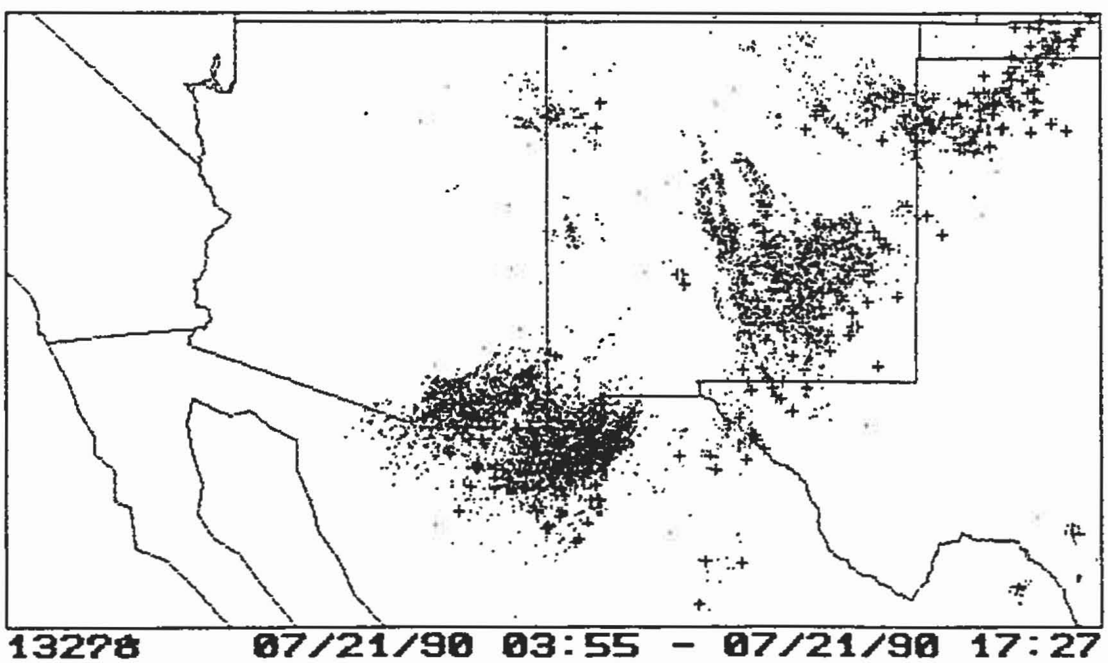
Weather Events: Strong afternoon and evening storms continue over Mexico. A mid-level anticyclone is located near Prescott with northerly flow over central and eastern Arizona and southerly flow over west portion of the state. Thunderstorms occurred from the Mogollon Rim southward across Arizona. Early morning flash floods and wind damage reported in Pima County / Tucson.- one fatality in the flooding.

P-3 Operations: DOWN

Special Observations: 0000 and 1200 UTC Phoenix radiosonde.



700 mb streamline chart for 1200 UTC, July 21, 1990



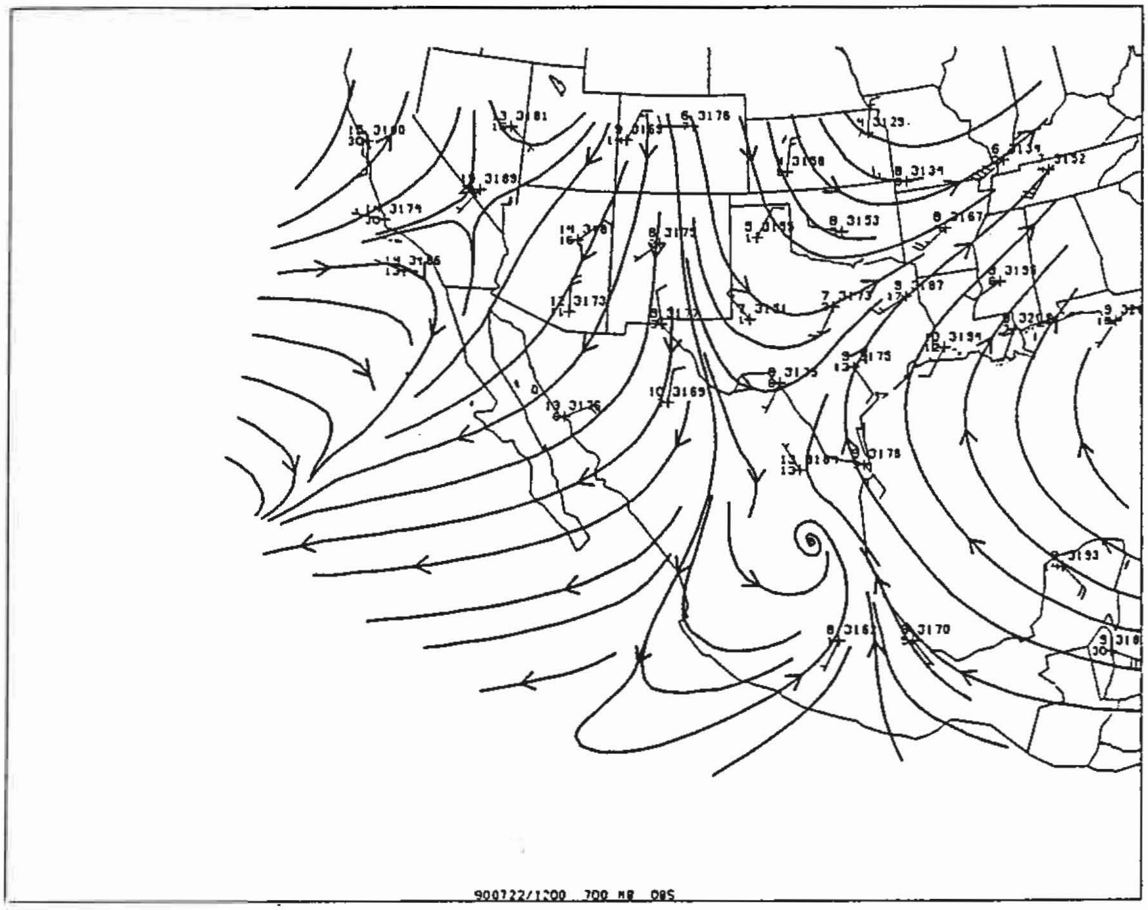
Cloud-to-ground lightning strikes during July 21, 1990

21 JULY 1990 Saturday

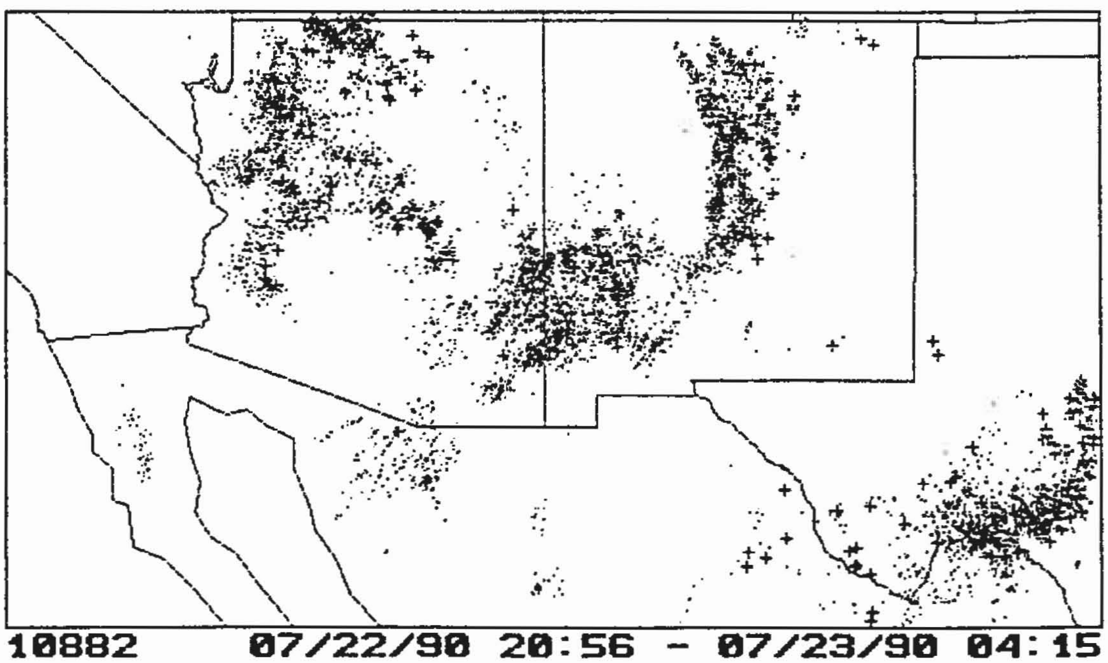
Weather Events: A mid-level anticyclone continues near Prescott; a weak upper-level short wave brushed northern Arizona in the evening. Tornado and downed power lines in Williamson Valley, Yavapai County around 11:30 am (LT). Strong storms over the Mogollon Rim moved into northern Valley (PHX) in the late afternoon. These were the most severe storms to move into the Phoenix area during the entire project. (See ASU storm chaser report). Deer Valley Airport had damage at 7:25 pm to hangars and 10 aircraft - estimated at $1M; north Phoenix had flash flooding, wind damage and estimated 60-80 mph gusts at about 8:30 pm. Very large late night / early morning MCS over Sonora; may have left behind some residual circulation.

P-3 Operations: Mission #7: flew a full-duration flight to measure moisture flux and large-scale monsoon flow structure. Takeoff at 6:05 am. Passed by small squall line system near Nogales. Performed vertical sawtooth patterns, both southeastward down the Gulf of California and E-W-E from the Pacific Ocean across Baja California to the slopes of the Sierra Madre Occidental. May have encountered remnant cyclonic circulation from earlier MCS near 28°N / 112°W. Measured rapid midlevel drying near Mexico / Arizona border, suggestive of boundary.

Special Observations: The mobile lab (NSSL2) was deployed to Yuma and released several soundings in coordination with PIBAL launches there. Sounding series at PHX preceding, during, and after the severe thunderstorm events. Video was taken of the severe storm over the northern valley by the Arizona State University storm chase team and a special detailed document of the damage was prepared by the team.



700 mb streamline chart for 1200 UTC, July 22, 1990



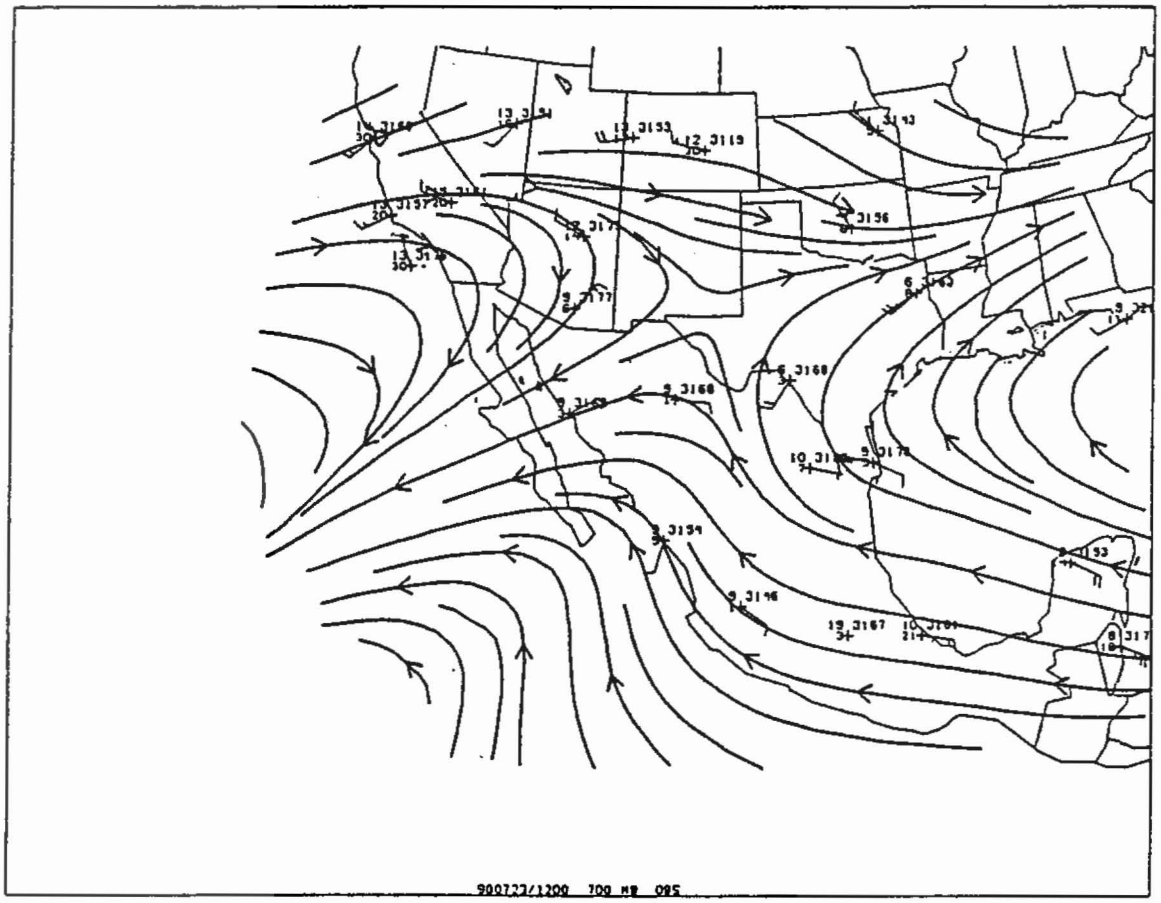
Cloud-to-ground lightning strikes during July 22, 1990

22 JULY 1990 Sunday

Weather Events: Moderately strong northerly flow persists over Arizona with moisture and instability values still high. Storms on Mogollon Rim moved southward at sunset with outflow moving across Phoenix at about 7:00 pm (LT). These storms appeared to split with activity moving toward Tucson to the east of Phoenix and also over the low desert to the west. Flash flooding in Payson around 5:00 pm after ≈1.9" of rainfall in little more than an hour. Tuba City, Coconino County had gale force, thunderstorm winds, sandstorm, and wind damage about 6:00 pm.

P-3 Operations: DOWN

Special Observations: 0000 and 1200 UTC Phoenix radiosonde



700 mb streamline chart for 1200 UTC, July 23, 1990

NO CHART AVAILABLE

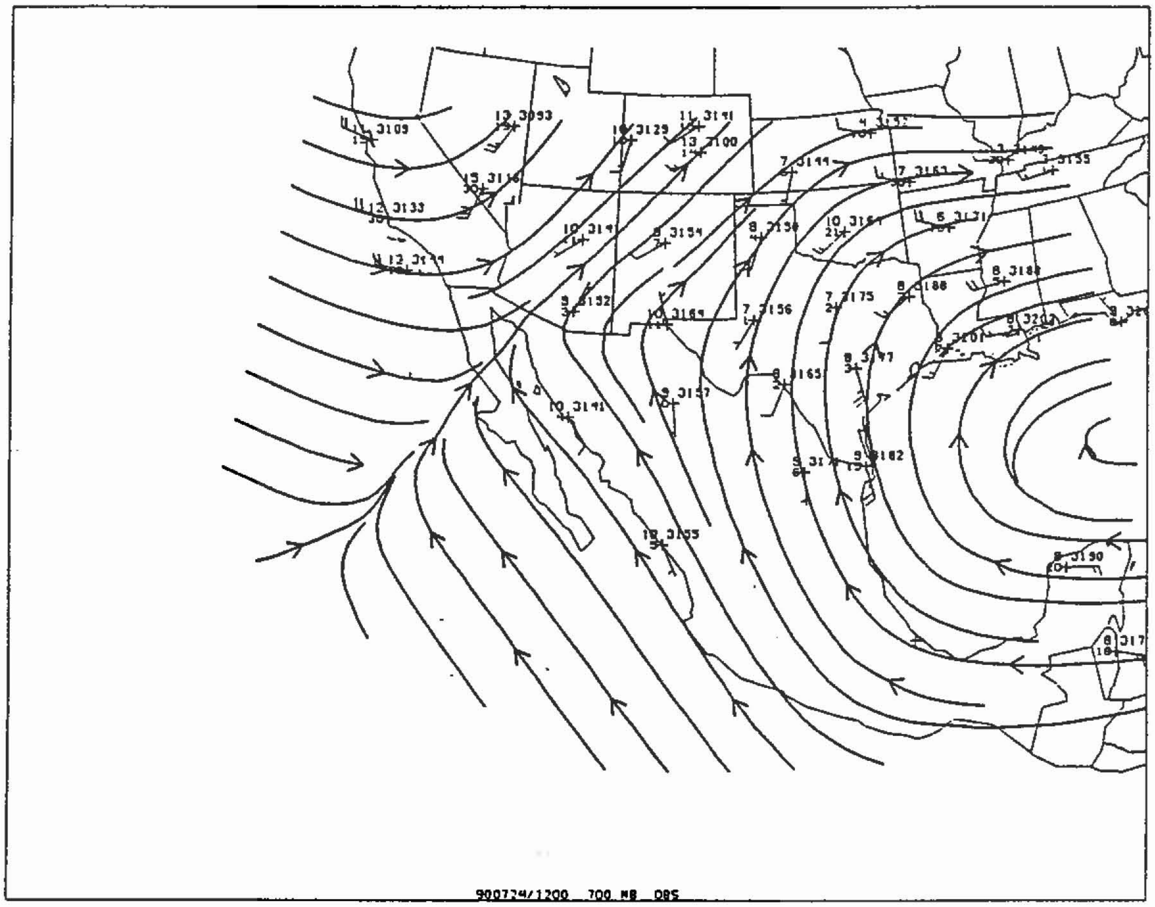
Cloud-to-ground lightning strikes during July 23, 1990

23 JULY 1990 Monday

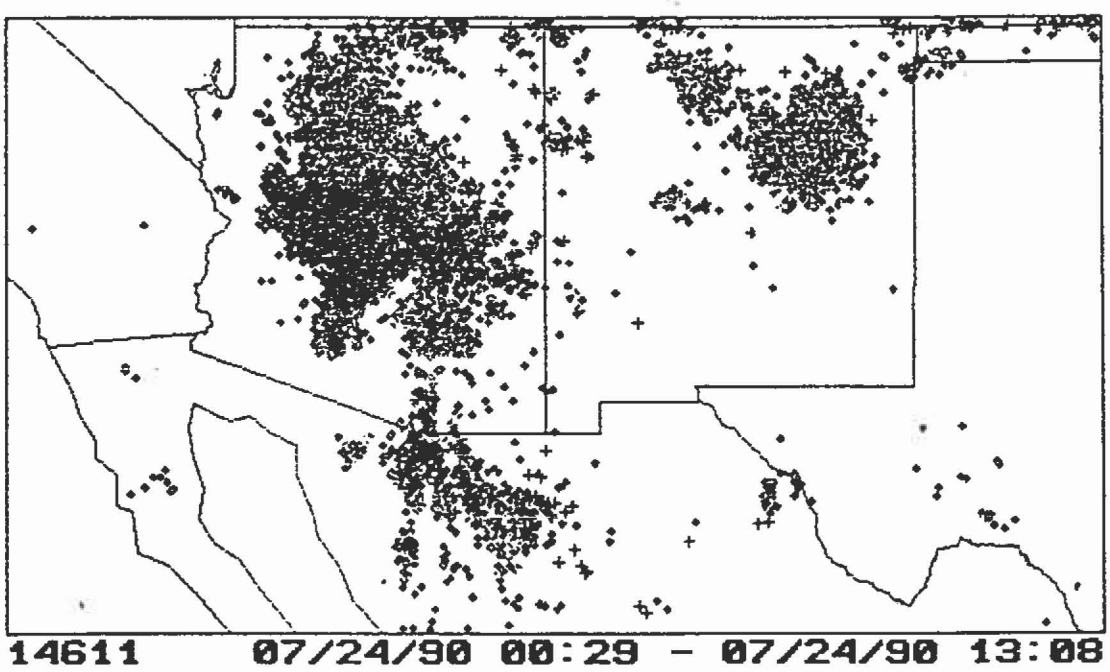
Weather Events: The early morning storms to the east and southeast of Phoenix generated very strong outflow down the Salt River Valley at sunrise - East gusts of 40 to 50 mph with reduced visibility and blowing dust. Morning sounding was considerably drier and more stable but shortwave will brush Arizona during afternoon and evening. A pronounced dry slot exists over the central part of the state. Strong storms stayed on Mogollon Rim during the afternoon. At dark, there is only one small cell over the low desert, near Wickenburg. The storms in the mountains generated nighttime outflow that triggered a large MCS after 11:00 pm; this system again moved across northern metropolitan area with damaging winds and very heavy rains well after local midnight (≈3:00 am on 24 July). Rain amounts of 2-4" were reported. Four people were rescued from vehicles that had been swept away in the flooding.

P-3 Operations: DOWN

Special Observations: Coordinated afternoon and evening soundings between PHX / NSSL2 with the mobile lab stationed at Santa Maria Crossing for two soundings and at Wickenburg for last evening sounding. Requested special rawinsonde at 2100 UTC from INW, TUS, and FHU. Two early morning special soundings at PHX (on the 24th) ahead of the MCS show rapid moistening below 600 mb immediately prior to advance of storms across the Phoenix area.



700 mb streamline chart for 1200 UTC, July 24, 1990



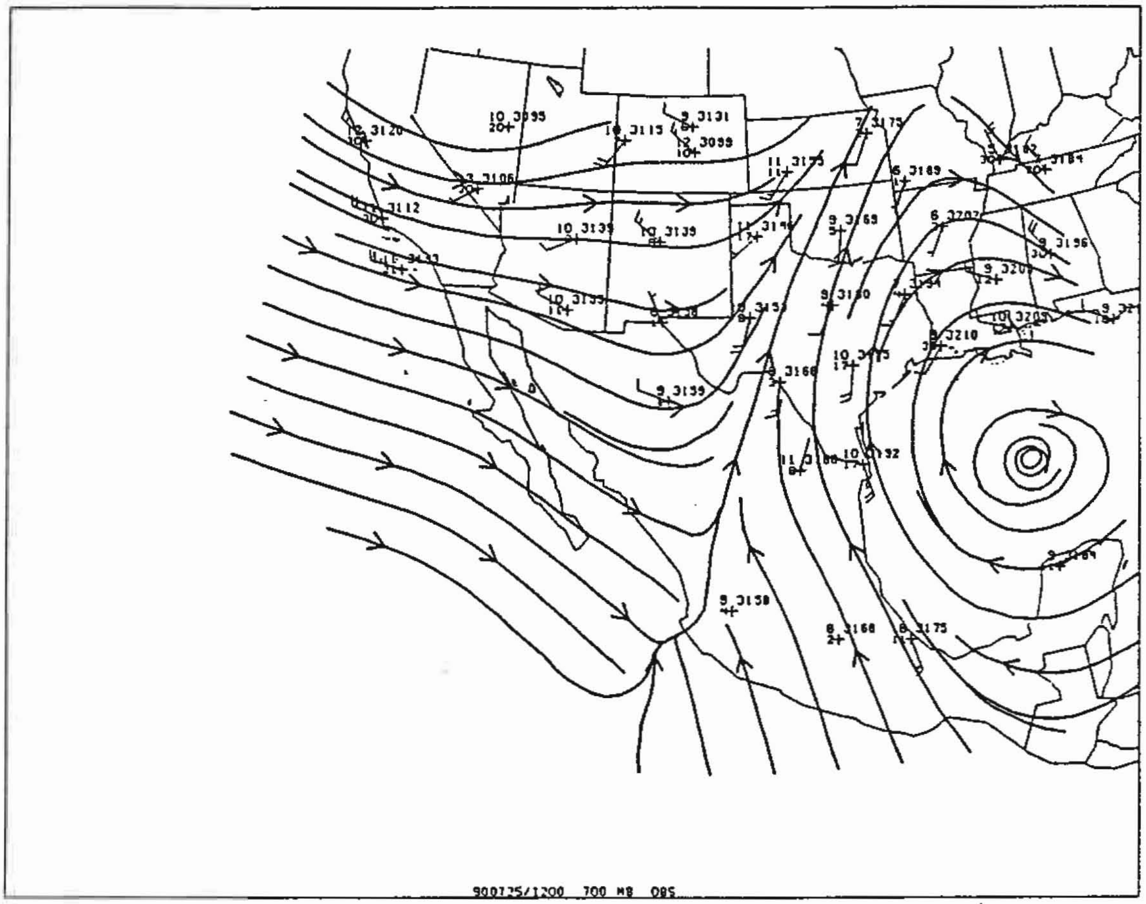
Cloud-to-ground lightning strikes during July 24, 1990

24 JULY 1990 Tuesday

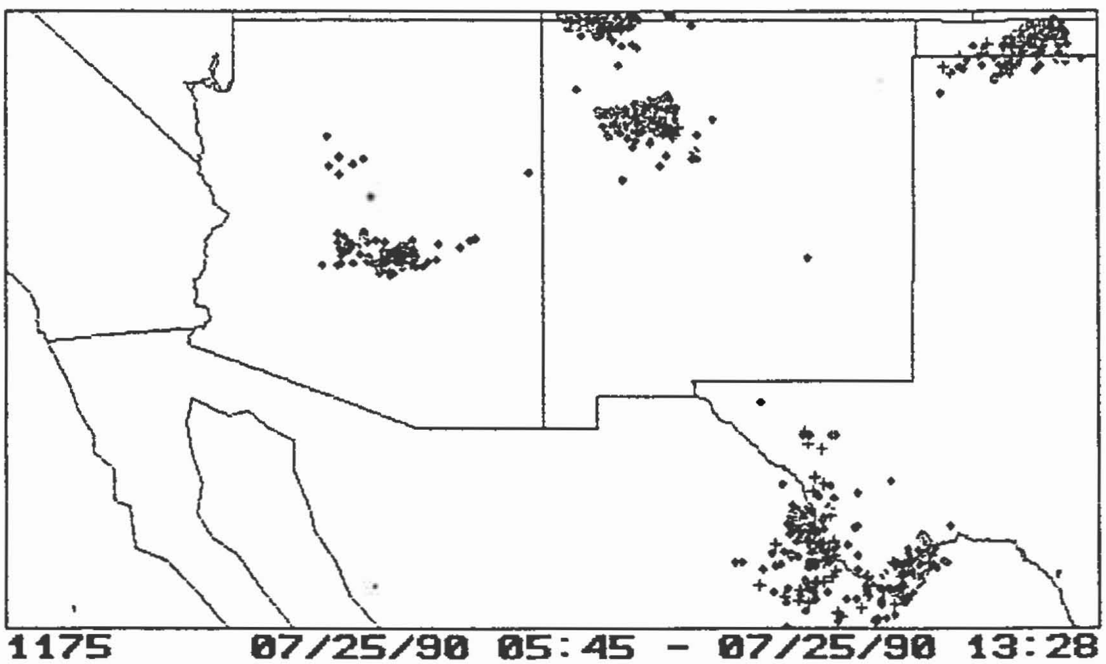
Weather Events: The morning MCS left cool outflow air over Salt River Valley. The systems continued strong after sunrise and propagated south-southeastward toward Tucson area. The rains produced significant flooding in Pima County with amounts of up to 3.55". MCS left distinct (in satellite imagery) outflow boundary over the desert to the west of Phoenix. Strong vertical wind shear but little hope of reaching convective temperatures - only two storms formed along old outflow - the first one moved east-southeastward and dissipated at sunset. The second developed after dark immediately to the west of Phoenix and moved east-northeastward. This storm persisted, seemingly in a near supercell mode, through the night. Storm appeared to hug foothills and avoided metropolitan area except for the far northern suburbs (Cave Creek / Carefree). Produced very heavy rains, wind damage and tennis ball-sized hail after local midnight (i.e., technically on the 25th). This was the ONLY storm in Arizona during the night and appeared very innocuous on satellite imagery.

P-3 Operations: DOWN

Special Observations: 0000 and 1200 UTC Phoenix radiosonde



700 mb streamline chart for 1200 UTC, July 25, 1990



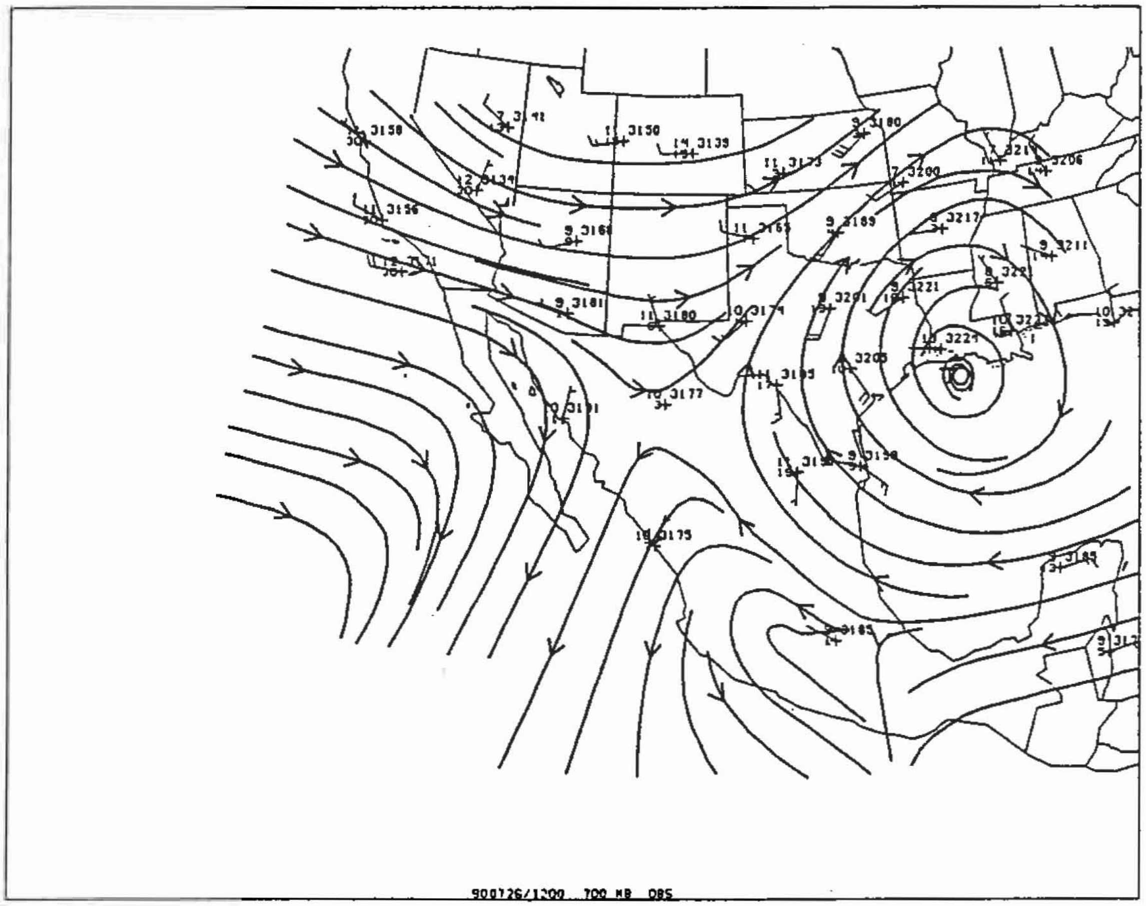
Cloud-to-ground lightning strikes during July 25, 1990

25 JULY 1990 Wednesday

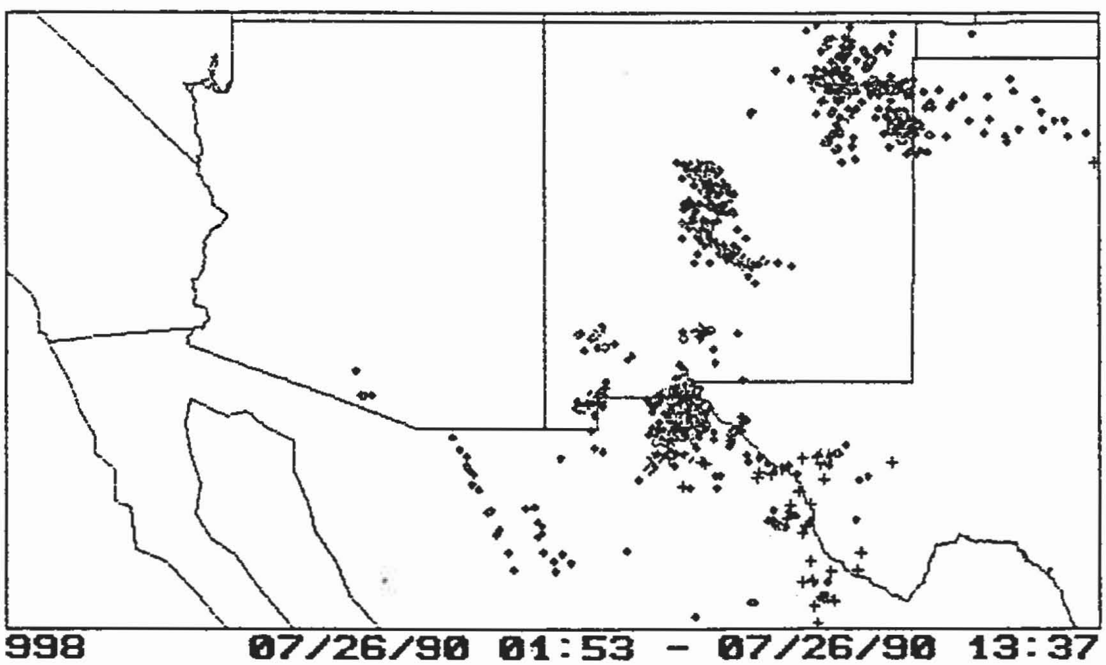
Weather Events: Drying continues in northwesterly flow. Only some isolated late afternoon cells in southern and southeastern Arizona.

P-3 Operations: DOWN

Special Observations: Mobile laboratory heat island double transect (E to W and return) mission during night and early morning, 9:00 pm to 5:00 am (LT) with several special PHX soundings preceding start. Zone of convergence observed between diurnal easterlies over the city and intruding southwesterly winds west of downtown Phoenix.



700 mb streamline chart for 1200 UTC, July 26, 1990



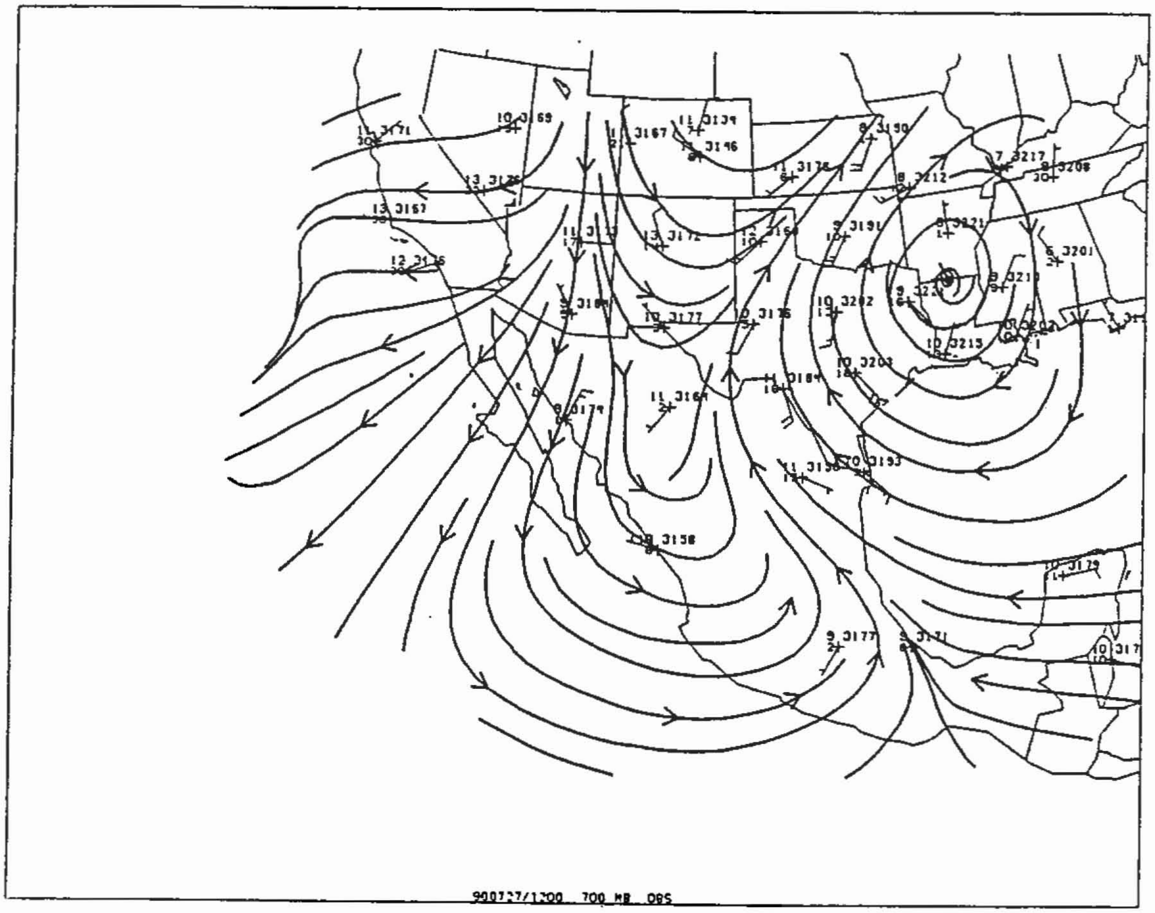
Cloud-to-ground lightning strikes during July 26, 1990

26 JULY 1990 Thursday

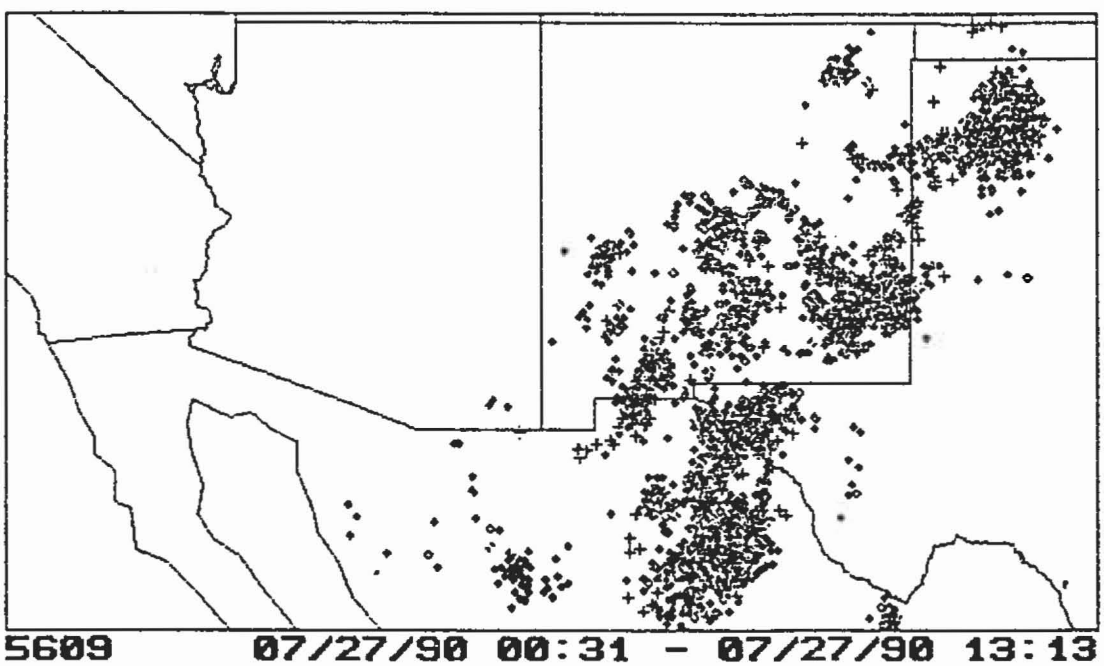
Weather Events: Very substantial drying now in place. Virtually no thunderstorms and very few clouds in Arizona during entire day.

P-3 Operations: Mission #8 was coordinated with heat island soundings - minimum altitude about 6000 ft MSL. Takeoff at 11:06 pm (LT). Midlevel difluence observed over Phoenix, together with mobile lab observed confluence may be acting to deepen moisture. No clear connection of higher moisture values over Salt River Valley was indicated with flow from Gulf of California.

Special Observations: Mobile Lab (NSSL2) heat island double transect executed during the night.



700 mb streamline chart for 1200 UTC, July 27, 1990



Cloud-to-ground lightning strikes during July 27, 1990

27 JULY 1990 Friday

Weather Events: Very dry and suppressed over Arizona. Unusual westerly flow in place well to the south over northern Mexico with very unusual convective patterns.

P-3 Operations: DOWN

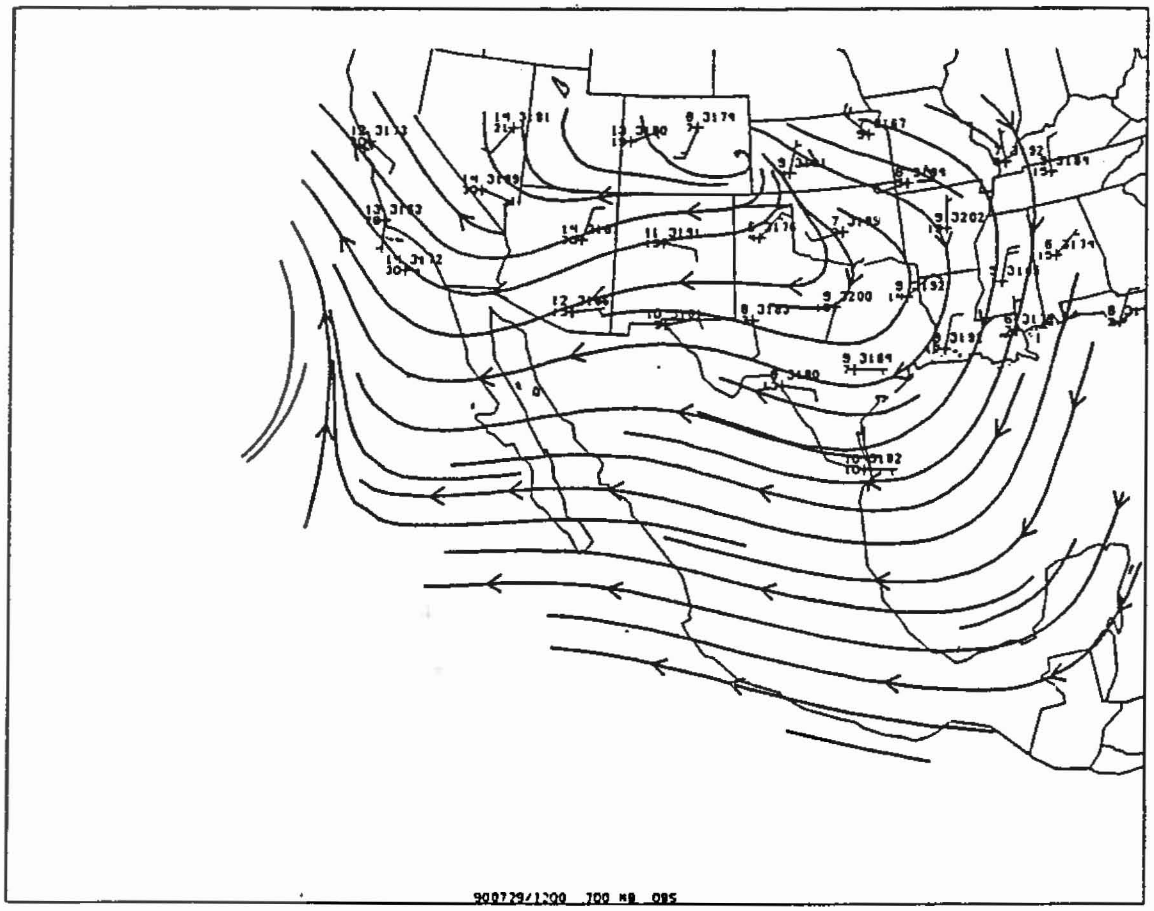
Special Observations: None after termination of the heat island experiment.

28 JULY 1990 Saturday

Weather Events: Very dry and suppressed conditions continue. Weak frontal zone is going to back into Southwest U.S. from the southern Plains during next two days. Weak afternoon thundershowers over White Mountains and eastern Mogollon Rim during very late afternoon.

P-3 Operations: DOWN

Special Observations: None.



700 mb streamline chart for 1200 UTC, July 29, 1990

NO CHART AVAILABLE

Cloud-to-ground lightning strikes during July 29, 1990

Chihuahua, Chihuahua
28°42'N 106°04'W
elev 1429 meters
76225

01 JULY	1115	SYNOP
02 JULY	1113	SYNOP
03 JULY	1115	SYNOP
04 JULY	1115	SYNOP
05 JULY	1115	SYNOP
06 JULY	1115	SYNOP
07 JULY	1115	SYNOP
07 JULY	2355	SYNOP
08 JULY	1115	SYNOP
08 JULY	2315	SYNOP
09 JULY	1115	SYNOP
09 JULY	2315	SYNOP
10 JULY	1115	SYNOP
10 JULY	2315	SYNOP
11 JULY	1115	SYNOP
11 JULY	2315	SYNOP
12 JULY	1115	SYNOP
12 JULY	2315	SYNOP
13 JULY	1115	SYNOP
13 JULY	1815	SPECIAL
13 JULY	2315	SYNOP
14 JULY	0615	SPECIAL
14 JULY	1115	SYNOP
14 JULY	1715	SPECIAL
14 JULY	2313	SYNOP
15 JULY	0615	SPECIAL
15 JULY	1115	SYNOP
15 JULY	2315	short flight
15 JULY	2350	second release
16 JULY	1115	SYNOP
16 JULY	2315	SYNOP
17 JULT	1115	SYNOP
17 JULY	2315	SYNOP
18 JULY	1115	SYNOP
18 JULY	1815	SPECIAL
18 JULY	2315	SYNOP
19 JULY	1115	short flight
20 JULY	*0000	MISSING
20 JULY	1115	SYNOP
20 JULY	2315	SYNOP
21 JULY	1115	SYNOP
21 JULY	2315	short flight
21 JULY	2355	second release
22 JULY	1115	SYNOP
22 JULY	2315	SYNOP
23 JULY	1115	SYNOP
23 JULY	2315	SYNOP
24 JULY	1115	SYNOP
24 JULY	2315	SYNOP
25 JULY	1115	SYNOP
25 JULY	2315	SYNOP
26 JULY	1115	SYNOP
26 JULY	2320	SYNOP
27 JULY	1115	SYNOP
27 JULY	2315	SYNOP
28 JULY	1115	SYNOP
28 JULY	2315	SYNOP
29 JULY	1115	SYNOP
29 JULY	2315	SYNOP
30 JULY	1115	SYNOP
30 JULY	2355	SYNOP
31 JULY	1115	SYNOP
31 JULY	2315	SYNOP
01 AUG	1115	SYNOP
01 AUG	2315	SYNOP
02 AUG	1115	SYNOP
02 AUG	2315	SYNOP
03 AUG	*1200	MISSING
03 AUG	2315	SYNOP
04 AUG	1145	SYNOP
04 AUG	2315	SYNOP
05 AUG	1145	SYNOP
05 AUG	2315	SYNOP
06 AUG	0515	SPECIAL
06 AUG	1115	SYNOP
06 AUG	1815	SPECIAL
06 AUG	2315	SYNOP
07 AUG	0615	SPECIAL
07 AUG	1115	SYNOP
08 AUG	0000	MISSING
08 AUG	1115	SYNOP

Guadalupe Island
Baja California Sur
28°53'N 118°18'W
elev 6 meters
76151

28 JULY	2315	SYNOP
29 JULY	1200	SYNOP
29 JULY	2330	SYNOP
30 JULY	1115	SYNOP
30 JULY	2330	SYNOP
31 JULY	1115	SYNOP
31 JULY	2315	SYNOP
01 AUG	1115	SYNOP
01 AUG	2315	SYNOP
02 AUG	1115	SYNOP
02 AUG	2315	SYNOP
03 AUG	1115	SYNOP
03 AUG	2315	SYNOP
04 AUG	1115	SYNOP
04 AUG	2315	SYNOP
05 AUG	1115	SYNOP
05 AUG	2315	SYNOP
06 AUG	0600	SPECIAL
06 AUG	1115	SYNOP
06 AUG	1800	SPECIAL
06 AUG	2315	SYNOP
07 AUG	0515	SPECIAL
07 AUG	1115	SYNOP
08 AUG	1115	SYNOP

Mazatlan, Sinaloa
23°12'N 106°25'W
elev. 4 meters
76458

07 JULY	2320	SYNOP	22 JULY	1116	SYNOP
08 JULT	1110	SYNOP	22 JULY	2317	SYNOP
08 JULY	2315	SYNOP	23 JULY	1118	SYNOP
09 JULY	1122	SYNOP	23 JULY	no obs	equip probl
09 JULY	2320	SYNOP	24 JULY	1118	SYNOP
10 JULY	1125	SYNOP	24 JULY	2323	SYNOP
10 JULY	2321	SYNOP	25 JULY	1150	SYNOP
11 JULY	1125	SYNOP	25 JULY	2319	SYNOP
11 JULY	2335	SYNOP	26 JULY	1130	SYNOP
12 JULY	1130	SYNOP	26 JULY	2330	SYNOP
12 JULY	2320	SYNOP	27 JULY	1125	SYNOP
13 JULY	0515	SPECIAL	27 JULY	2319	SYNOP
13 JULY	1125	SYNOP	28 JULY	1116	SYNOP
13 JULY	1740	SPECIAL	28 JULY	2319	SYNOP
13 JULY	2319	SYNOP	29 JULY	1118	SYNOP
14 JULY	0550	SPECIAL	29 JULY	2319	SYNOP
14 JULY	1135	SYNOP	30 JULY	1135	SYNOP
14 JULY	1721	SPECIAL	30 JULY	2325	SYNOP
14 JULY	2322	SYNOP	31 JULY	1118	SYNOP
15 JULY	1125	SYNOP	31 JULY	no obs	equip. failure
15 JULY	2318	SYNOP	01 AUG	no obs	personnel failure
16 JULY	1130	SYNOP	01 AUG	2330	SYNOP
16 JULY	2330	SYNOP	02 AUG	1117	SYNOP
17 JULY	1118	SYNOP	03 AUG	0000	MISSING
17 JULY	2328	SYNOP	03 AUG	1118	SYNOP
18 JULY	1116	SYNOP	04 AUG	0000	MISSING
18 JULY	1750	SPECIAL	04 AUG	1116	SYNOP
18 JULY	2318	SYNOP	05 AUG	0000	MISSING
19 JULY	1120	SYNOP	05 AUG	1118	SYNOP
19 JULY	1730	SPECIAL	06 AUG	0000	MISSING
19 JULY	2320	SYNOP	06 AUG	1116	SYNOP
20 JULY	0516	SPECIAL	06 AUG	1820	SPECIAL
20 JULY	1128	SYNOP	06 AUG	2318	SYNOP
20 JULY	2316	SYNOP	07 AUG	0516	SPECIAL
21 JULY	1130	SYNOP	08 AUG	1118	SYNOP
21 JULY	2321	SYNOP			

El Paso, Texas
31°48'N 106°24'W
elev 1193 meters
72270

09 JULY	0000	SYNOP
09 JULY	1200	SYNOP
09 JULY	1800	SPECIAL
10 JULY	0000	SYNOP
10 JULY	0600	SPECIAL
10 JULY	1200	SYNOP
11 JULY	0000	SYNOP
11 JULY	1200	SYNOP
12 JULY	0000	SYNOP
12 JULY	1200	SYNOP
12 JULY	1800	SPECIAL
13 JULY	0000	SYNOP
13 JULY	0600	SPECIAL
13 JULY	1200	SYNOP
13 JULY	1800	SPECIAL
14 JULY	0000	SYNOP
14 JULY	0600	SPECIAL
14 JULY	1200	SYNOP
15 JULY	0000	SYNOP
15 JULY	1200	SYNOP
16 JULY	0000	SYNOP
16 JULY	1200	SYNOP
17 JULY	0000	SYNOP
17 JULY	1200	SYNOP
18 JULY	0000	SYNOP
18 JULY	1200	SYNOP
19 JULY	0000	SYNOP
19 JULY	1200	SYNOP
20 JULY	0000	SYNOP
20 JULY	1200	SYNOP
21 JULY	0000	SYNOP
21 JULY	1200	SYNOP
22 JULY	0000	SYNOP
22 JULY	1200	SYNOP
23 JULY	0000	SYNOP
23 JULY	1200	SYNOP
24 JULY	0000	SYNOP
24 JULY	1200	SYNOP
25 JULY	0000	SYNOP
25 JULY	1200	SYNOP
26 JULY	0000	SYNOP
26 JULY	1200	SYNOP
27 JULY	0000	SYNOP
27 JULY	1200	SYNOP
28 JULY	0000	SYNOP
28 JULY	1200	SYNOP
29 JULY	0000	SYNOP
29 JULY	1200	SYNOP
30 JULY	0000	SYNOP
30 JULY	1200	SYNOP
31 JULY	0000	SYNOP
31 JULY	1200	SYNOP
01 AUG	0000	SYNOP
01 AUG	1200	SYNOP
02 AUG	0000	SYNOP
02 AUG	1200	SYNOP
03 AUG	0000	SYNOP
03 AUG	1200	SYNOP
04 AUG	0000	SYNOP
04 AUG	1200	SYNOP
05 AUG	0000	SYNOP
05 AUG	1200	SYNOP
06 AUG	0000	SYNOP
06 AUG	0600	SPECIAL
06 AUG	1200	SYNOP
06 AUG	1800	SPECIAL
07 AUG	0000	SYNOP
07 AUG	1200	SYNOP
07 AUG	1800	SPECIAL
08 AUG	0000	SYNOP
08 AUG	0600	SPECIAL
08 AUG	1200	SYNOP

Empalme, Sonora
27°57'N 110°48'W
elev. 12 meters
76256

01 JULY	1115	SYNOP
02 JULY	1115	SYNOP
03 JULY	1115	SYNOP
04 JULY	1115	SYNOP
05 JULY	1115	SYNOP
06 JULY	1115	SYNOP
07 JULY	1115	SYNOP
08 JULY	1115	SYNOP
08 JULY	2315	SYNOP
09 JULY	1115	SYNOP
09 JULY	2315	SYNOP
10 JULY	1115	SYNOP 500mb
10 JULY	2315	SYNOP
11 JULY	1115	SYNOP
11 JULY	2315	SYNOP
12 JULY	1115	SYNOP
12 JULY	2315	SYNOP
13 JULY	1115	SYNOP
13 JULY	1815	SPECIAL
13 JULY	2315	SYNOP
14 JULY	0614	SPECIAL
14 JULY	1115	SYNOP
14 JULY	2315	SYNOP
15 JULY	0615	SPECIAL
15JULY	1115	SYNOP
15 JULY	2330	SYNOP
16 JULY	1115	SYNOP
16 JULY	2315	SYNOP
17 JULY	1115	SYNOP
17 JULY	2315	SYNOP
18 JULY	1115	SYNOP
18 JULY	1815	SPECIAL
18 JULY	2315	SYNOP
19 JULY	1115	SYNOP
19 JULY	2825	SPECIAL
19 JULY	2315	SYNOP
20 JULY	0615	SPECIAL
20 JULY	1115	SYNOP
20 JULY	2315	SYNOP
21 JULY	1115	SYNOP
21 JULY	2315	SYNOP
22 JULY	1115	SYNOP
22 JULY	2335	SYNOP
23 JULY	1115	SYNOP
23 JULY	2315	SYNOP
24 JULY	1115	SYNOP 389mb
24 JULY	2315	SYNOP
25 JULY	1115	SYNOP
25 JULY	2335	SYNOP
26 JULY	1115	SYNOP
26 JULY	2315	SYNOP
27 JULY	1115	SYNOP
27 JULY	2315	SYNOP
28 JULY	1115	SYNOP
28 JULY	2315	SYNOP
29 JULY	1115	SYNOP
29 JULY	2315	SYNOP
30 JULY	1115	SYNOP
30 JULY	2315	SYNOP
31 JULY	1115	SYNOP
31 JULY	2315	SYNOP
01 AUG	1115	SYNOP
01 AUG	2315	SYNOP
02 AUG	1115	SYNOP
02 AUG	2315	SYNOP
03 AUG	1115	SYNOP
04 AUG	2315	SYNOP
04 AUG	1115	SYNOP
04 AUG	2315	SYNOP
05 AUG	1115	SYNOP
05 AUG	2320	SYNOP
06 AUG	1115	SYNOP
07 AUG	1115	SYNOP

San Diego, California
32°49'N 117°08'W
elev 124 meters
72290

08 JULY	0000	SYNOP	23 JULY	1200	SYNOP
08 JULY	1200	SYNOP	24 JULY	0000	SYNOP
09 JULY	0000	SYNOP	24 JULY	1200	SYNOP
09 JULY	1200	SYNOP	25 JULY	0000	SYNOP
09 JULY	1800	SPECIAL	25 JULY	1200	SYNOP
10 JULY	0000	SYNOP	26 JULY	0000	SYNOP
10 JULY	0600	SPECIAL	26 JULY	1200	SYNOP
10 JULY	1200	SYNOP	27 JULY	0000	SYNOP
11 JULY	0000	SYNOP	27 JULY	1200	SYNOP
11 JULY	1200	SYNOP	28 JULY	0000	SYNOP
12 JULY	0000	SYNOP	28 JULY	1200	SYNOP
12 JULY	1200	SYNOP	29 JULY	0000	SYNOP
12 JULY	1800	SPECIAL	29 JULY	1200	SYNOP
13 JULY	0000	SYNOP	30 JULY	0000	SYNOP
13 JULY	0600	SPECIAL	30 JULY	1200	SYNOP
13 JULY	1200	SYNOP	31 JULY	0000	SYNOP
13 JULY	1800	SPECIAL	31 JULY	1200	SYNOP
14 JULY	0000	SYNOP	01 AUG	0000	SYNOP
14 JULY	0600	SPECIAL	01 AUG	1200	SYNOP
14 JULY	1200	SYNOP	02 AUG	0000	SYNOP
15 JULY	0000	SYNOP	02 AUG	1200	SYNOP
15 JULY	1200	SYNOP	03 AUG	0000	SYNOP
16 JULY	0000	SYNOP	03 AUG	1200	SYNOP
16 JULY	1200	SYNOP	04 AUG	0000	SYNOP
17 JULY	0000	SYNOP	04 AUG	1200	SYNOP
17 JULY	1200	SYNOP	05 AUG	0000	SYNOP
18 JULY	0000	SYNOP	05 AUG	1200	SYNOP
18 JULY	1200	SYNOP	06 AUG	0000	SYNOP
19 JULY	0000	SYNOP	06 AUG	1200	SYNOP
19 JULY	1200	SYNOP	06 AUG	1800	SPECIAL
20 JULY	0000	SYNOP	07 AUG	0000	SYNOP
20 JULY	1200	SYNOP	07 AUG	0600	SPECIAL
21 JULY	0000	SYNOP	07 AUG	1200	SYNOP
21 JULY	1200	SYNOP	07 AUG	1800	SPECIAL
22 JULY	0000	SYNOP	08 AUG	0000	SYNOP
22 JULY	1200	SYNOP	08 AUG	0600	SPECIAL
23 JULY	0000	SYNOP	08 AUG	1200	SYNOP

Tucson, Arizona
32°07'N 110°56'W
elev 787 meters
72274

07 JULY	0000	SYNOP	23 JULY	2100	SPECIAL
08 JULY	1200	SYNOP	24 JULY	0000	SYNOP
09 JULY	0000	SYNOP	24 JULY	1200	SYNOP
09 JULY	0600	SPECIAL	25 JULY	0000	SYNOP
09 JULY	1200	SYNOP	25 JULY	1200	SYNOP
09 JULY	1800	SPECIAL	26 JULY	0000	SYNOP
10 JULY	0000	SYNOP	26 JULY	1200	SYNOP
10 JULY	0600	SPECIAL	27 JULY	0000	SYNOP
10 JULY	1200	SYNOP	27 JULY	1200	SYNOP
11 JULY	0000	SYNOP	28 JULY	0000	SYNOP
11 JULY	1200	SYNOP	28 JULY	1200	SYNOP
12 JULY	0000	SYNOP	29 JULY	0000	SYNOP
12 JULY	1200	SYNOP	29 JULY	1200	SYNOP
12 JULY	1800	SPECIAL	30 JULY	0000	SYNOP
13 JULY	0000	SYNOP	30 JULY	1200	SYNOP
13 JULY	0600	SPECIAL	31 JULY	0000	SYNOP
13 JULY	1200	SYNOP	31 JULY	0200	SPECIAL
13 JULY	1800	SPECIAL	31 JULY	1200	SYNOP
14 JULY	0000	SYNOP	01 AUG	0000	SYNOP
14 JULY	0600	SPECIAL	01 AUG	1200	SYNOP
14 JULY	1200	SYNOP	02 AUG	0000	SYNOP
15 JULY	0000	SYNOP	02 AUG	1200	SYNOP
15 JULY	1200	SYNOP	03 AUG	0000	SYNOP
16 JULY	0000	SYNOP	03 AUG	1200	SYNOP
16 JULY	1200	SYNOP	04 AUG	0000	SYNOP
17 JULY	0000	SYNOP	04 AUG	1200	SYNOP
17 JULY	1200	SYNOP	05 AUG	0000	SYNOP
18 JULY	0000	SYNOP	05 AUG	1200	SYNOP
18 JULY	1200	SYNOP	06 AUG	0000	SYNOP
19 JULY	0000	SYNOP	06 AUG	0600	SPECIAL
19 JULY	1200	SYNOP	06 AUG	1200	SYNOP
20 JULY	0000	SYNOP	06 AUG	1800	SPECIAL
20 JULY	1200	SYNOP	07 AUG	0000	SYNOP
21 JULY	0000	SYNOP	07 AUG	0600	SPECIAL
21 JULY	1200	SYNOP	07 AUG	1200	SYNOP
22 JULY	0000	SYNOP	07 AUG	1800	SPECIAL
22 JULY	1200	SYNOP	08 AUG	0000	SYNOP
23 JULY	0000	SYNOP	08 AUG	0600	SPECIAL
23 JULY	1200	SYNOP	08 AUG	1200	SYNOP

Winslow, Arizona
35°01'N 110°44'W
elev 1487 meters
72374

08 JULY	1200	SYNOP
09 JULY	0000	SYNOP
09 JULY	1200	SYNOP
09 JULY	1800	SPECIAL
10 JULY	0000	SYNOP
10 JULY	0600	SPECIAL
10 JULY	1200	SYNOP
11 JULY	0000	SYNOP
11 JULY	1200	SYNOP
12 JULY	0000	SYNOP
12 JULY	1200	SYNOP
12 JULY	1800	SPECIAL
13 JULY	0000	SYNOP
13 JULY	0600	SPECIAL
13 JULY	1200	SYNOP
13 JULY	1800	SPECIAL
14 JULY	0000	SYNOP
14 JULY	0600	SPECIAL
14 JULY	1200	SYNOP
14 JULY	2100	SPECIAL
15 JULY	0000	SYNOP
15 JULY	1200	SYNOP
16 JULY	0000	SYNOP
16 JULY	1200	SYNOP
17 JULY	0000	SYNOP
17 JULY	1200	SYNOP
18 JULY	0000	SYNOP
18 JULY	1200	SYNOP
19 JULY	0000	SYNOP
19 JULY	1200	SYNOP
20 JULY	0000	SYNOP
20 JULY	1200	SYNOP
21 JULY	0000	SYNOP
21 JULY	1200	SYNOP
22 JULY	0000	SYNOP
22 JULY	1200	SYNOP
23 JULY	0000	SYNOP
23 JULY	1200	SYNOP
23 JULY	2100	SPECIAL
24 JULY	0000	SYNOP
24 JULY	1200	SYNOP
25 JULY	0000	SYNOP
25 JULY	1200	SYNOP
26 JULY	0000	SYNOP
26 JULY	1200	SYNOP
27 JULY	0000	SYNOP
27 JULY	1200	SYNOP
28 JULY	0000	SYNOP
28 JULY	1200	SYNOP
29 JULY	0000	SYNOP
29 JULY	1200	SYNOP
30 JULY	0000	SYNOP
30 JULY	1200	SYNOP
31 JULY	0000	SYNOP
31 JULY	1200	SYNOP
01 AUG	0000	SYNOP
01 AUG	1200	SYNOP
02 AUG	0000	SYNOP
02 AUG	1200	SYNOP
03 AUG	0000	SYNOP
03 AUG	1200	SYNOP
04 AUG	0000	SYNOP
04 AUG	1200	SYNOP
05 AUG	0000	SYNOP
05 AUG	1200	SYNOP
06 AUG	0000	SYNOP
06 AUG	0600	SPECIAL
06 AUG	1200	SYNOP
06 AUG	1800	SPECIAL
07 AUG	0000	SYNOP
07 AUG	0600	SPECIAL
07 AUG	1200	SYNOP
07 AUG	1800	SPECIAL
08 AUG	0000	SYNOP
08 AUG	0600	SPECIAL
08 AUG	1200	SYNOP
09 AUG	0000	SYNOP
09 AUG	1200	SYNOP
10 AUG	0000	SYNOP

NSSL2 Mobile Laboratory
SWAMP Project
Arizona

Ascent #	Date	Time (UTC)	Project	Site
46	6/26/90	23:09:08	Winslow/Dual Trk	
47	6/27/90	11:02:57	INW/Dual Track	
48	6/27/90	20:49:37	Winslow	
49	6/27/90	23:21:53	INW/Dual Track	
50	6/28/90	11:02:19	INW/Dual Track	
51	7/02/90	21:20:42	PHX SWAMP	
52	7/03/90	18:07:46	PHX SWAMP	
53	7/05/90	18:46:51	PHX SWAMP	
54	7/07/90	22:04:20	PHX SWAMP	
55	7/10/90	04:03:21	Heat Island	33°15'N 111°40'W Queen Creek
56	7/10/90	04:30:39	SWAMP Heat Island	33°17'N 111°42'W mile 5 of Higly Road and Superstition Express
57	7/10/90	05:13:01	SWAMP Heat Island	33°22'N 111°50'W Mesa Community College
58	7/10/90	05:50:57	SWAMP Heat Island	33°30'N 112°00'W Thomas Road Mall
59	7/10/90	06:23:21	SWAMP Heat Island	33°33'N 112°10'W Christown Mall
60	7/10/90	07:06:39	SWAMP Heat Island	33°38'N 112°14'W
61	7/10/90	09:53:05	SWAMP Heat Island	33°38'N 112°14'W
62	7/10/90	10:26:15	SWAMP Heat Island	33°33'N 112°10'W Christown Mall
63	7/10/90	10:57:24	SWAMP Heat Island	33°30'N 112°00'W Thomas Road Mall
64	7/10/90	11:38:41	SWAMP Heat Island	33°22'N 111°50'W Mesa Community College
65	7/10/90	12:10:36	SWAMP Heat Island	33°17'N 111°42'W 1/2 mile off Higly Road 110
66	7/10/90	12:48:56	SWAMP Heat Island	33°15'N 111°40'W Queen Creek
67	7/12/90	21:29:58	SWAMP	Gila County Fairground NE of Globe, AZ
68	7/12/90	22:59:56	SWAMP	NE of Globe, AZ
69	7/13/90	01:59:57	SWAMP	Apache Junction
70	7/14/90	19:02:07	SWAMP	Aguila, AZ
71	7/14/90	20:59:47	SWAMP	Aguila, AZ
72	7/14/90	22:59:42	SWAMP	Aguila, AZ
73	7/15/90	01:04:25	SWAMP	Aguila, AZ

74	7/15/90	03:00:01	SWAMP	Aguila, AZ
75	7/16/90	23:00:38	SWAMP	Gila Bend, AZ
76	7/17/90	02:00:08	SWAMP	Gila Bend, AZ
77	7/17/90	11:00:04	SWAMP	Gila Bend, AZ
78	7/17/90	12:59:02	SWAMP	Gila Bend, AZ
79	7/17/90	17:05:45	SWAMP	Gila Bend, AZ
80	7/17/90	19:59:59	SWAMP	Gila Bend, AZ
81	7/17/90	22:59:59	SWAMP	Gila Bend, AZ
82	7/19/90	03:59:35	SWAMP Heat Island 2	Apache Junction
83	7/19/90	04:33:34	SWAMP Heat Island 2	33°25'N 111°41'W East Mesa
84	7/19/90	05:06:18	SWAMP Heat Island 2	33°25'N 111°45'W Mesa
85	7/19/90	05:41:39	SWAMP Heat Island 2	33°26'N 111°53'W East Tempe
86	7/19/90	06:20:33	SWAMP Heat Island 2	33°28'N 112°10'W West Phoenix
87	7/19/90	06:51:37	SWAMP Heat Island 2	33°29'N 112°20'W Goodyear
88	7/19/90	07:25:51	SWAMP Heat Island 2	Buckeye, AZ
89	7/20/90	23:36:50	SWAMP	Apache Junction
90	7/21/90	00:59:59	SWAMP	Buckeye, AZ
91	7/21/90	02:01:19	SWAMP	Gila Bend, AZ
92	7/21/90	04:03:31	SWAMP	Eloy, AZ
93	7/21/90	18:32:54	SWAMP	Yuma, AZ
94	7/21/90	20:43:41	SWAMP	Yuma, AZ
95	7/23/90	19:59:59	SWAMP	93 & Santa Maria River
96	7/23/90	22 59:59	SWAMP	93 & Santa Maria River
97	7/24/90	01:59:58	SWAMP	Wickenburg Airport
98	7/24/90	03:28:26	SWAMP	12 mi SE Wickenburg, Hwy 74
99	7/26/90	03:59:15	SWAMP Heat Island 3	Apache Junction
100	7/26/90	04:33:23	SWAMP Heat Island 3	Apache Junction
101	7/26/90	05:05:11	SWAM Heat Island 3	Mesa, AZ
102	7/26/90	05:37:11	SWAMP Heat Island 3	33°26'N 111°53'W Price Road & Salt River
103	7/26/90	06:14:48	SWAMP Heat Island 3	33°28'N 112°10'W 43rd & I-10
104	7/26/90	06:47:27	SWAMP Heat Island 3	33°29'N 112°20'W Litchfield & I-10
105	7/26/90	07:19:51	SWAMP Heat Island 3	33°26'N 112°35'W Buckeye
106	7/26/90	08:54:10	SWAMP Heat Island 3	33°26'N 112°35'W Buckeye
107	7/26/90	09:40:27	SWAMP Heat Island 3	133°29'N 112°20'W Litchfield & I10
108	7/26/90	10:10:21	SWAMP Heat Island 3	33°28'N 112°10'W 43rd & I-10

109	7/26/90	10:47:53	SWAMP Heat Island 3	33°26'N 111°53'W Price Road & Salt River
110	7/26/90	11:25:51	SWAMP Heat Island 3	33°25'N 111°45'W Lindsey and Adobe
111	7/26/90	11:56:29	SWAMP Heat Island 3	33°25'N 111°41'W University & Bush
112	7/26/90	12:28:41	SWAMP Heat Island 3	33°25'N 111°32'W Apache Junction
113	7/27/90	03:50:13	SWAMP Heat Island 4	33°28'N 112°10'W 42nd Ave. & I-40
114	7/27/90	04:27:31	SWAMP Heat Island 4	33°21'N 111°59'W Ahwatukee
115	7/27/90	04:56:20	SWAMP Island 4	33°27'N 111°50'W Mesa Community College
116	7/27/90	05:33:08	SWAMP Heat Island 4	33°30'N 111°53'W Indian School and Hay
117	7/27/90	06:01:46	SWAMP Heat Island 4	33°31'N 112°01'W 20th & Camelback Rd
118	7/27/90	06:56:21	SWAMP Heat Island 4	33°28'N 112°10'W 43rd & I-10
119	7/27/90	07:27:27	SWAMP Heat Island 4	33°21'N 111°59'W Ahwatukee
120	7/27/90	07:57:04	SWAMP Heat Island 4	33°27'N 111°50'W Mesa Community College
121	7/27/90	08:37:14	SWAMP Heat Island 4	33°30'N 111°53'W Indian School and Hay
122	7/27/90	09:01:53	SWAMP Heat Island 4	33°31'N 112°01'W 20th & Camelback Rd
123	7/27/90	09:43:41	SWAMP Heat Island 4	33°28'N 112°10'W 43rd & I-10
124	7/27/90	10:12:35	SWAMP Heat Island 4	33°21'N 111°59'W Ahwatukee
125	7/27/90	10:39:55	SWAMP Heat Island 4	33°27'N 111°50'W Mesa Community College
126	7/27/90	11:05:55	SWAMP Heat Island 4	33°30'N 111°53'W Indian School & Hay
127	7/30/90	14:13:52	SWAMP	Mogollon Rim
128	7/30/90	16:06:08	SWAMP	Mogollon Rim
129	7/30/90	17:59:25	SWAMP	Mogollon Rim
130	7/30/90	20:01:09	SWAMP	Mogollon Rim
131	7/30/90	23:00:28	SWAMP	Mogollon Rim
132	7/31/90	00:59:43	SWAMP	Mogollon Rim
133	8/01/90	01:56:29	SWAMP	Pinnacle Rd, East of Pima Rd
134	8/01/90	03:58:38	SWAMP	Pinnacle Rd, East of Pima Rd
135	8/01/90	19:49:57	SWAMP	Florence
136	8/01/90	20:31:35	SWAMP	Florence
137	8/01/90	22:59:01	SWAMP	Florence
138	8/02/90	01:00:07	SWAMP	Florence
139	8/02/90	02:52:47	SWAMP	Florence
140	8/02/90	04:57:15	SWAMP	Florence

Phoenix, Arizona (NSSL3)
32°26'N 112°01'W
elev 337 meters
72278

02 JUL	2200	Training	15 JUL	0000	Synoptic
03 JUL	1800	and testing	15 JUL	0200	Special
05 JUL	1846		15 JUL	0400	Special
05 JUL	2200		15 JUL	1200	Synoptic
05 JUL	2200		15 JUL	123?	Special
06 JUL	2100		15 JUL	1800	Special
07 JUL	0300		15 JUL	2100	Special
07 JUL	2000		16 JUL	0000	Synoptic
07 JUL	2200		16 JUL	0300	Special
08 JUL	0000	Synoptic	16 JUL	1200	Synoptic
08 JUL	1200	Synoptic	16 JUL	1800	Special
08 JUL	1828	Special	17 JUL	0000	Synoptic
09 JUL	1200	Synoptic	17 JUL	0300	Special
09 JUL	1800	Special	17 JUL	1200	Synoptic
10 JUL	0000	Synoptic	17 JUL	1500	Special
10 JUL	0400	Heat Island #1	17 JUL	1800	Special
10 JUL	0440	Heat Island #2	17 JUL	2100	Special
10 JUL	0513	Heat Island #3	18 JUL	0000	Synoptic
10 JUL	0551	Heat Island #4	18 JUL	0300	Special
10 JUL	0623	Heat Island #5	18 JUL	1200	Synoptic
10 JUL	0706	Heat Island #6	18 JUL	1800	Special
10 JUL	0859	Heat Island #7	18 JUL	2100	Special
10 JUL	0953	Heat Island #8	19 JUL	0000	Synoptic
10 JUL	1026	Heat Island #9	19 JUL	0400	H.I. #1
10 JUL	1057	Heat Island #10	19 JUL	0430	H.I. #2
10 JUL	1138	Heat Island #11	19 JUL	0500	H.I. #3
10 JUL	1210	Heat Island #12	19 JUL	0530	H.I. #4
10 JUL	1242	Heat Island #13	19 JUL	0630?	H.I. #5
11 JUL	0000	Synoptic	19 JUL	0700	H.I. #6
11 JUL	1200	Synoptic	19 JUL	0730	H.I. #7
11 JUL	2200	Special	19 JUL	1200	Synoptic
12 JUL	0300	Special	19 JUL	1800	Special
12 JUL	1200	Synoptic	19 JUL	2100	Special
13 JUL	0000	Synoptic	20 JUL	0000	Synoptic
13 JUL	0300	Special	20 JUL	0200	Special
13 JUL	0600	Special	20 JUL	0400	Special
13 JUL	1200	Synoptic	20 JUL	1200	Synoptic
14 JUL	0000	Synoptic	20 JUL	1800	Special
14 JUL	0200	Special	20 JUL	2100	Special
14 JUL	0300	Special	21 JUL	0000	Synoptic
14 JUL	0400	Special	21 JUL	0200	Special
14 JUL	0600	Special	21 JUL	0300	Special
14 JUL	1200	Synoptic	21 JUL	0500	Special
14 JUL	2000	Special	21 JUL	1200	Synoptic
14 JUL	2200	Special	21 JUL	1800	Special

21 JUL	2100	Special
22 JUL	0000	Synoptic
22 JUL	0300	Special
22 JUL	0600	Special
22 JUL	1200	Synoptic
22 JUL	1800	Special
22 JUL	2200	Special
23 JUL	0000	Synoptic
23 JUL	0300	Special
23 JUL	1200	Synoptic
23 JUL	1800	Special
23 JUL	2100	Special
24 JUL	0000	Synoptic
24 JUL	0100	Special
24 JUL	0300	Special
24 JUL	0700	Special
24 JUL	0900	Special
24 JUL	1200	Synoptic
24 JUL	1600	Special
24 JUL	1900	Special
24 JUL	2100	Special
25 JUL	0000	Synoptic
25 JUL	0300	Special
25 JUL	1200	Synoptic
25 JUL	1800	Special
25 JUL	2100	Special
26 JUL	0000	Synoptic
26 JUL	0300	Special
26 JUL	0400	H.I.#1
26 JUL	0430	H.I.#2
26 JUL	0500	H.I.#3
26 JUL	0530	H.I.#4
26 JUL	0600	H.I.#5
26 JUL	0630	H.I.#6
26 JUL	0700	H.I.#7
26 JUL	0900	H.I.#8
26 JUL	0930	H.I. #9
26 JUL	1000	H.I. #10
26 JUL	1030	H.I. #11
26 JUL	1100	H.I. #12
26 JUL	1130	H.I. #13
26 JUL	1200	H.I. #14
26 JUL	2100	Special
27 JUL	0000	Synoptic
27 JUL	0400	H.I. #1
27 JUL	0430	H.I. #2
27 JUL	0500	H.I. #3
27 JUL	0530	H.I. #4
27 JUL	0600	H.I. #5
27 JUL	0700	H.I. #6
27 JUL	0730	H.I. #7
27 JUL	0800	H.I. #8
27 JUL	0830	H.I. #9
27 JUL	0900	H.I. #10

27 JUL	0930	H.I. #11
27 JUL	1000	H.I. #12
27 JUL	1030	H.I. #13
27 JUL	1100	H.I. #14
28 JUL	0000	Synoptic
28 JUL	1200	Synoptic
28 JUL	0000	Synoptic
28 JUL	1200	Synoptic
30 JUL	0000	Synoptic
30 JUL	0300	Special
30 JUL	1200	Synoptic
30 JUL	1500	Special
30 JUL	1700	Special
30 JUL	1900	Special
30 JUL	2100	Special
31 JUL	0000	Synoptic
31 JUL	0200	Special
31 JUL	0300	Special
31 JUL	0500	Special
31 JUL	1200	Synoptic
31 JUL	2100	Special
01 AUG	0000	Synoptic
01 AUG	0300	Special
01 AUG	0500	Special
01 AUG	1200	Synoptic
01 AUG	0700	Special
01 AUG	1900	Special
01 AUG	2100	Special
02 AUG	0000	Synoptic
02 AUG	0200	Special
02 AUG	0400	Special
02 AUG	0600	Special
02 AUG	0800	Special
02 AUG	1200	Synoptic
02 AUG	2200	Special
03 AUG	0000	Synoptic
03 AUG	0200	Special
03 AUG	0500	Special
03 AUG	1200	Synoptic
03 AUG	0400	Special
04 AUG	0000	Synoptic
04 AUG	0300	Special
04 AUG	0400	Special
04 AUG	1200	Synoptic
04 AUG	2100	Special
05 AUG	0000	Synoptic
05 AUG	0300	Special
05 AUG	1200	Synoptic
05 AUG	2200	Special
06 AUG	0000	Synoptic
06 AUG	0200	Special
06 AUG	0400	Special
06 AUG	0600	Special
06 AUG	1200	Synoptic

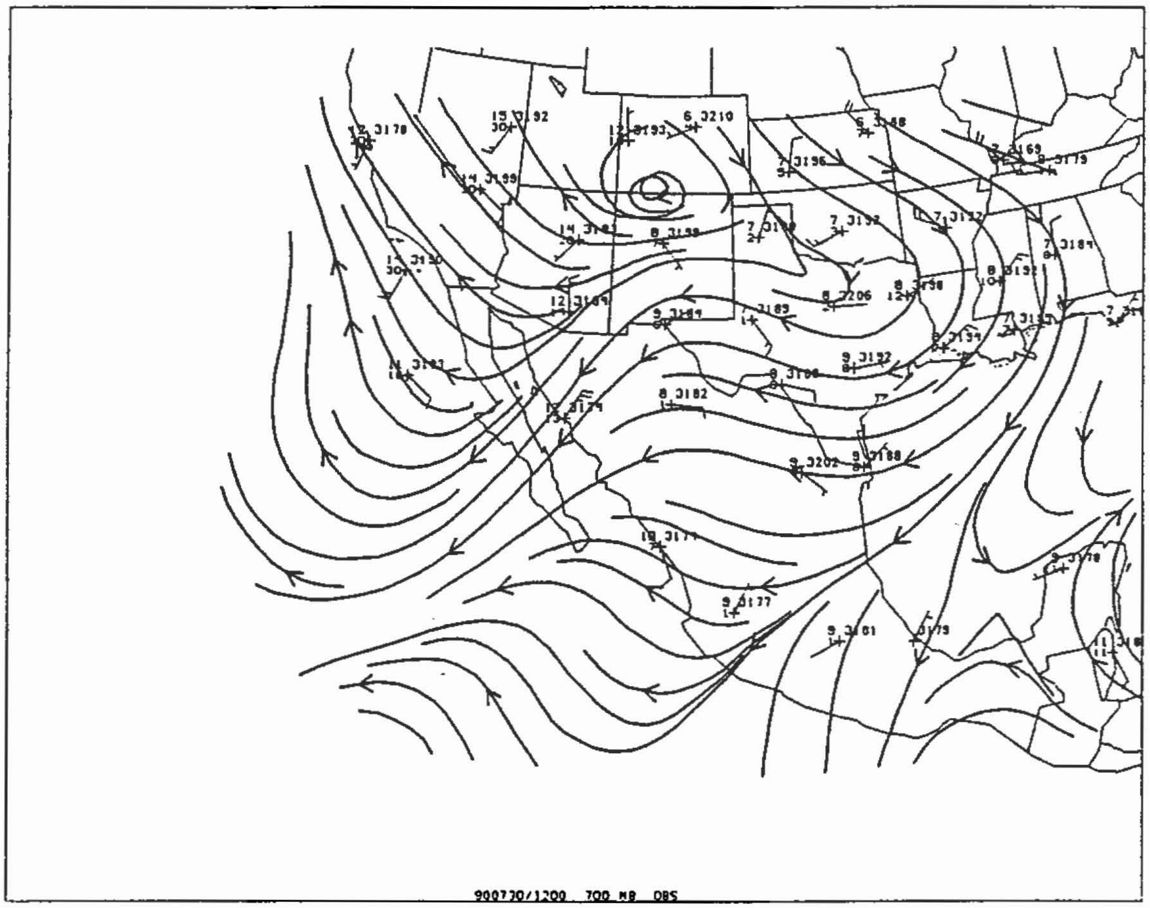
06 AUG	1800	Special
06 AUG	2200	Special
07 AUG	0000	Synoptic
07 AUG	0200	Special
07 AUG	0400	Special
07 AUG	0600	Special
07 AUG	1200	Synoptic
07 AUG	1800	Special
07 AUG	2200	Special
08 AUG	0000	Synoptic
08 AUG	0200	Special
08 AUG	0400	Special
08 AUG	0600	Special

29 JULY 1990 Sunday

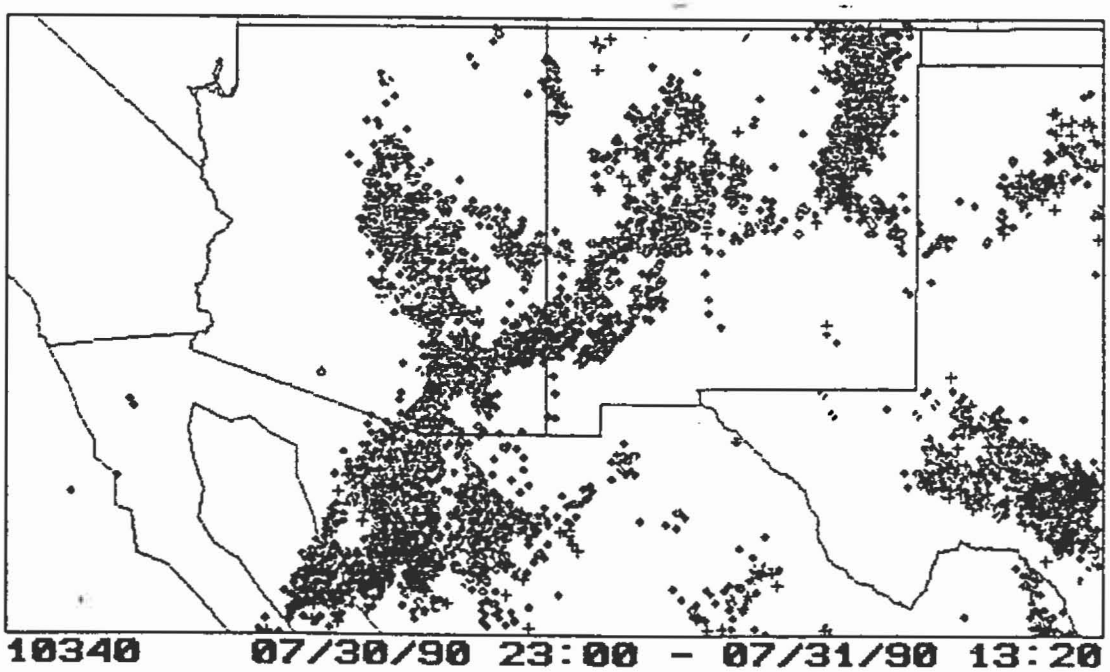
Weather Events: Some cooling and destabilization has taken place at mid-levels over West; lower levels have experienced moistening. Thunderstorms formed on Mogollon Rim and White Mountains much earlier in afternoon. Outlook for Monday is for fairly active day in the West. Increasing 700-500 mb lapse rates, combined with mid-level moisture, increases prospects for microbursts in central Arizona also.

P-3 Operations: Mission #9, a combined moisture structure / flux and MCS flight over the Sea of Cortez and Sonora, probably collected the best observations of the monsoon boundary during the project. Takeoff at 6:06 pm. Aircraft proceeded down the Gulf of California from Mexicali. An omegadropsonde in the northern Gulf showed extremely shallow moist layer (≈30 mb). South of 29°N / 113°W porpoise pattern between 1000 to 10,000 feet to 25.5°N / 110°W and then returned between 8000-15,000 feet. Data appear to indicate that boundary sloped over the cool air with height, *i.e.*, toward the southeast. Aircraft monitored disorganized convection near Hermosillo and a small, but intense bow-shaped line on return south of Nogales.

Special Observations: One evening special sounding at PHX. Mobile lab deployed to Mogollon Rim for coordinated sounding series PHX / NSSL2 on Monday.



700 mb streamline chart for 1200 UTC, July 30, 1990



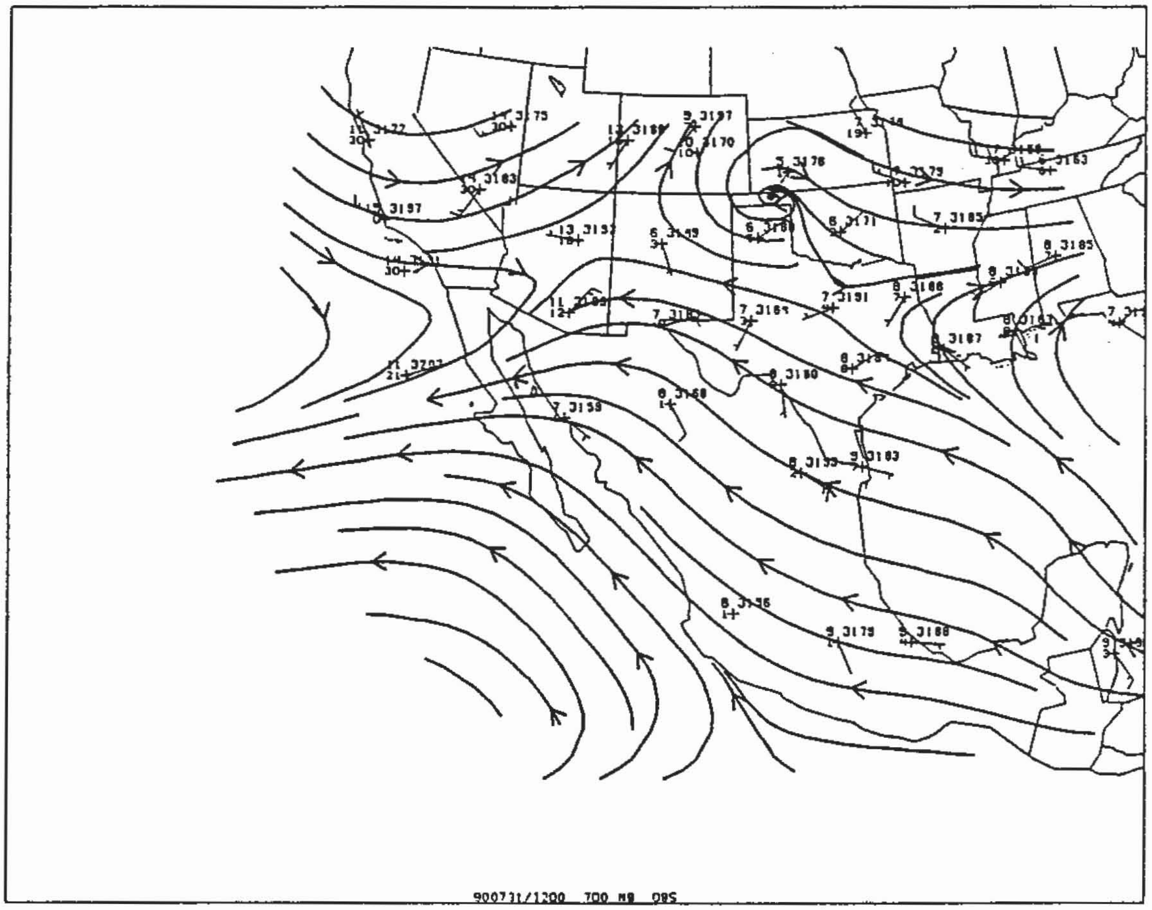
Cloud-to-ground lightning strikes during July 30, 1990

30 JULY 1990 Monday

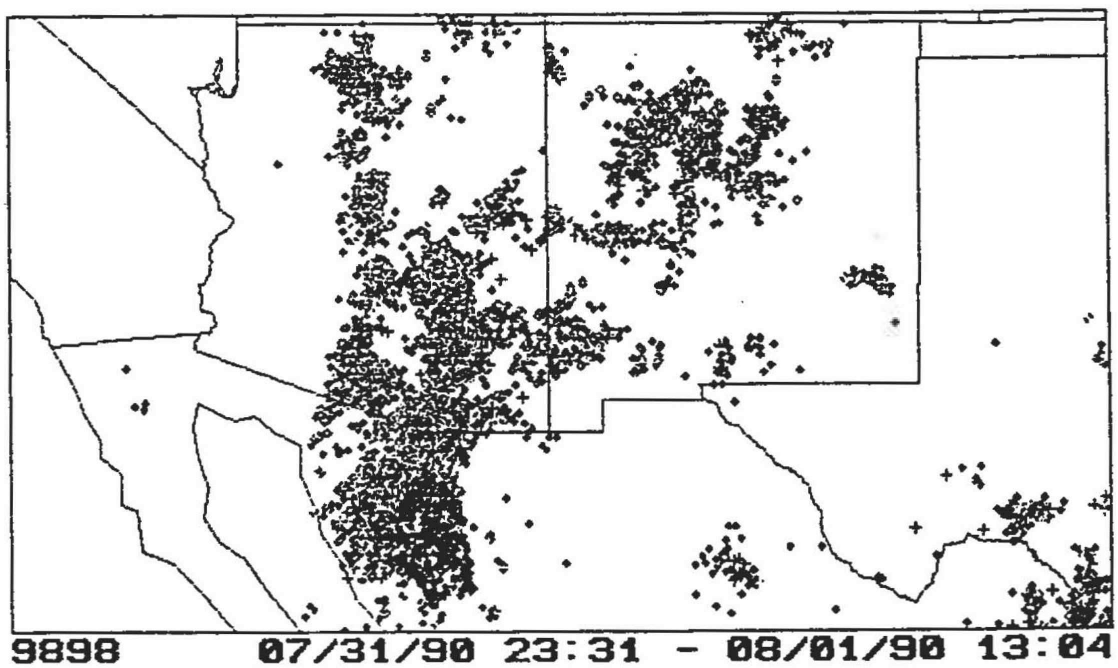
Weather Events: Storms formed over the Mogollon Rim and White Mountains again. Soundings series taken on Rim. Initial developments appeared to be over position of the mobile lab, but did not intensify until they moved south of Rim. Cool, upslope outflow from these first storms appeared to trigger another period of storm development over the Rim area. The storms moved off the mountains to near Phoenix and sent very strong outflow and haboob right across SkyHarbor airport as NOAA aircraft was in takeoff queue. This system appeared to take on classical MCS structures and moved rapidly westward to Colorado River Valley ("bare bones" MCS with stratiform precipitation region and rear inflow but no hard new convection on gust front after it moved across Phoenix). Quite a bit of wind damage in metropolitan area: wind damage and trees down in east Mesa about 7:42 pm (LT); damaging winds at Apache Junction about 6:35 pm.

P-3 Operations: Mission #10. Plan was to work storms in southeastern Arizona, but takeoff was delayed by the local events - note that SkyHarbor Airport was closed temporarily but after the worst of the outflow and duststorm was well past. Aircraft eventually flew a pattern well to the rear of a rapidly moving MCS. Very turbulent flight in weak residual stratiform area. Finished with a trip around the eastern half of the Phoenix heat island mission pattern.

Special Observations: Coordinated soundings between Phoenix and NSSL2 (on the Rim) Obtained an extensive afternoon and night soundings series at PHX through the life of the outflow / MCS event. Video was recorded as the outflow moved across the SkyHarbor Airport area.



700 mb streamline chart for 1200 UTC, July 31, 1990



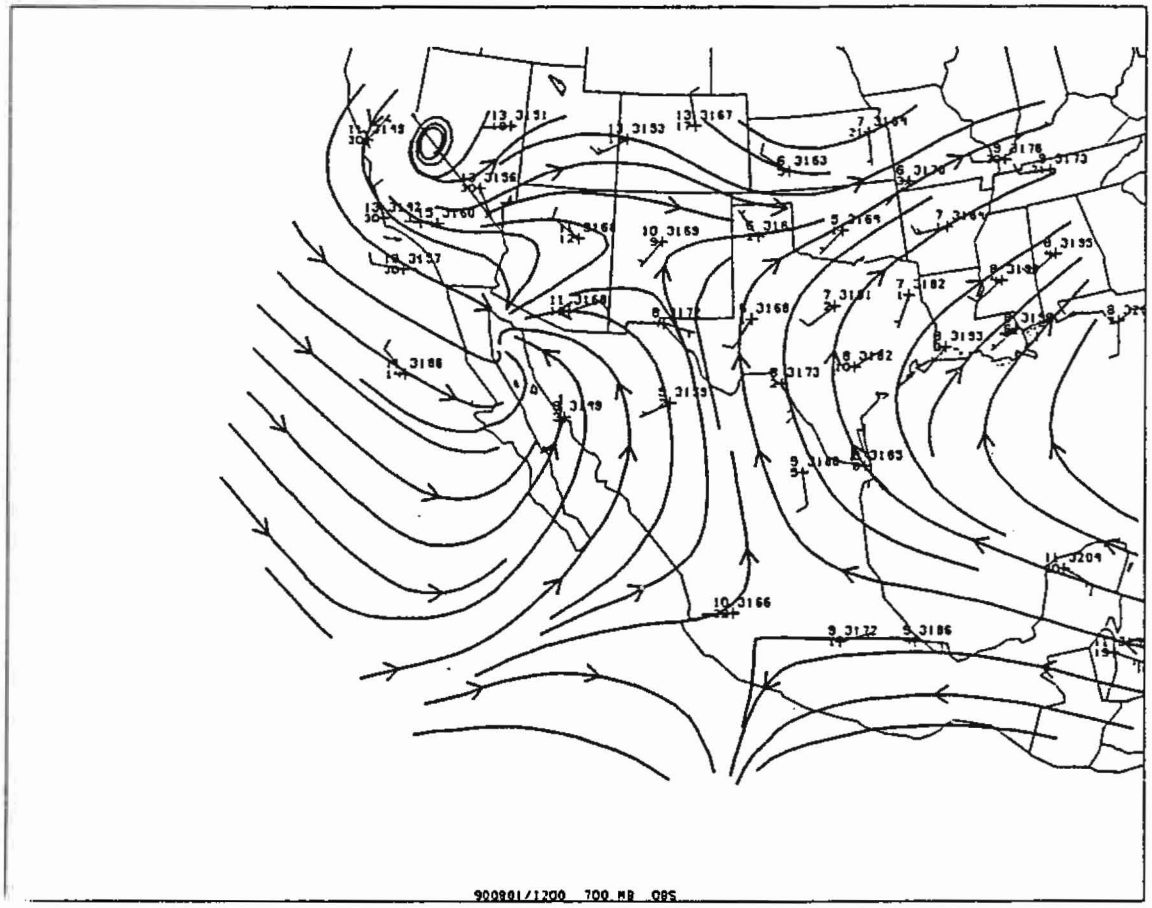
Cloud-to-ground lightning strikes during July 31, 1990

31 JULY 1990 Tuesday

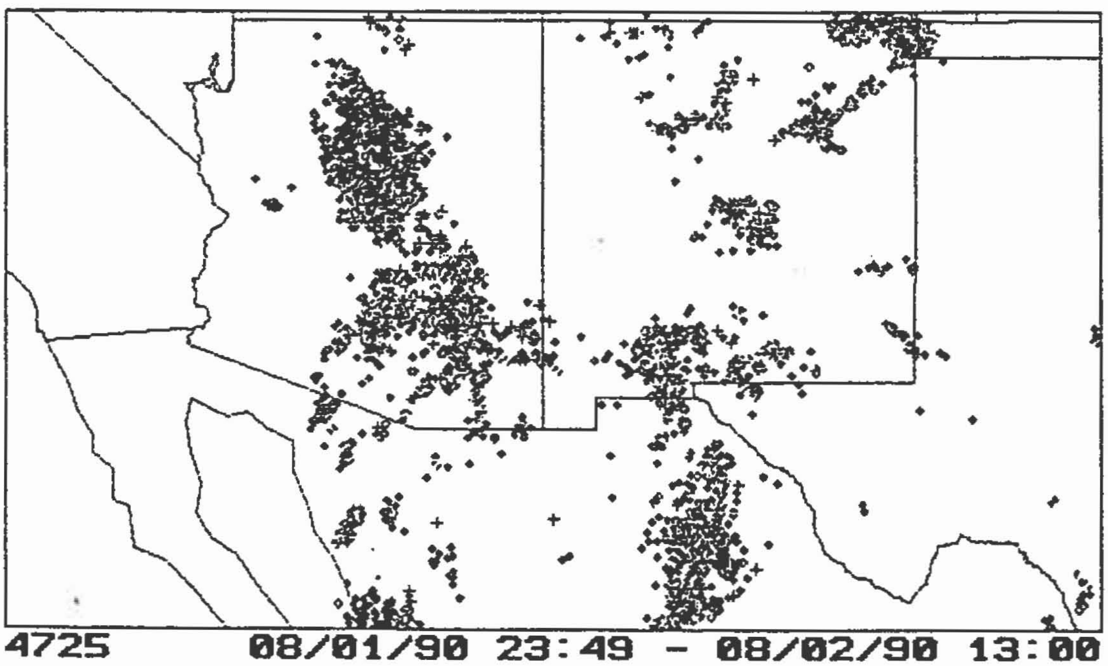
Weather Events: Convective system over Mexico appeared to help generate a moisture surge from the Sea of Cortez. Storms again moved from mountain genesis regions into the east Valley and sent outflow across the metropolitan area at ≈9:00 pm (LT). A severe storm developed near sunset northeast of Scottsdale and moved southward across the Mesa area with 3/4" hail and measured gust to 60 kt; several aircraft were damaged. Wind damage reported in Tucson area around 8:00 pm. Weak convection continued through the night and outflow again appeared to move far to the west. Heavy storms also in the Tucson area.

P-3 Operations: Mission #11 was flown to observe MCS over northern Sonora and adjacent Gulf of California in order to use omegadropsondes to determine effects of system upon flow over the Gulf. Intense convection to the east of SkyHarbor Airport and gust front / wind shear alerts delayed takeoffs until about 9:00 pm. Observed westward propagating system south of Nogales with trailing stratiform rain region. Encountered another line to the west with 3-4 large cells trailed by substantial stratiform rain area. This MCS dissipated as it approached the Gulf of California but new development on W-E line along the southern edge of stratiform precipitation area. Characterized as major tropical squall near Isla Tiburón. This south side convection exhibited about a 45° slope with roots in shallow stratocumulus that extended out over the Gulf. Small hail was encountered as Doppler radar data were gathered on these storms. Three dropsondes were deployed around this storm area (one over the low-level inflow region in the Gulf).

Special Observations: Coordinated evening sounding series between PHX and mobile lab (NSSL2) positioned on Pinnacle Peak Rd. Mobile lab took soundings in the vicinity of where severe cell developed. Video also available.



700 mb streamline chart for 1200 UTC, August 1, 1990



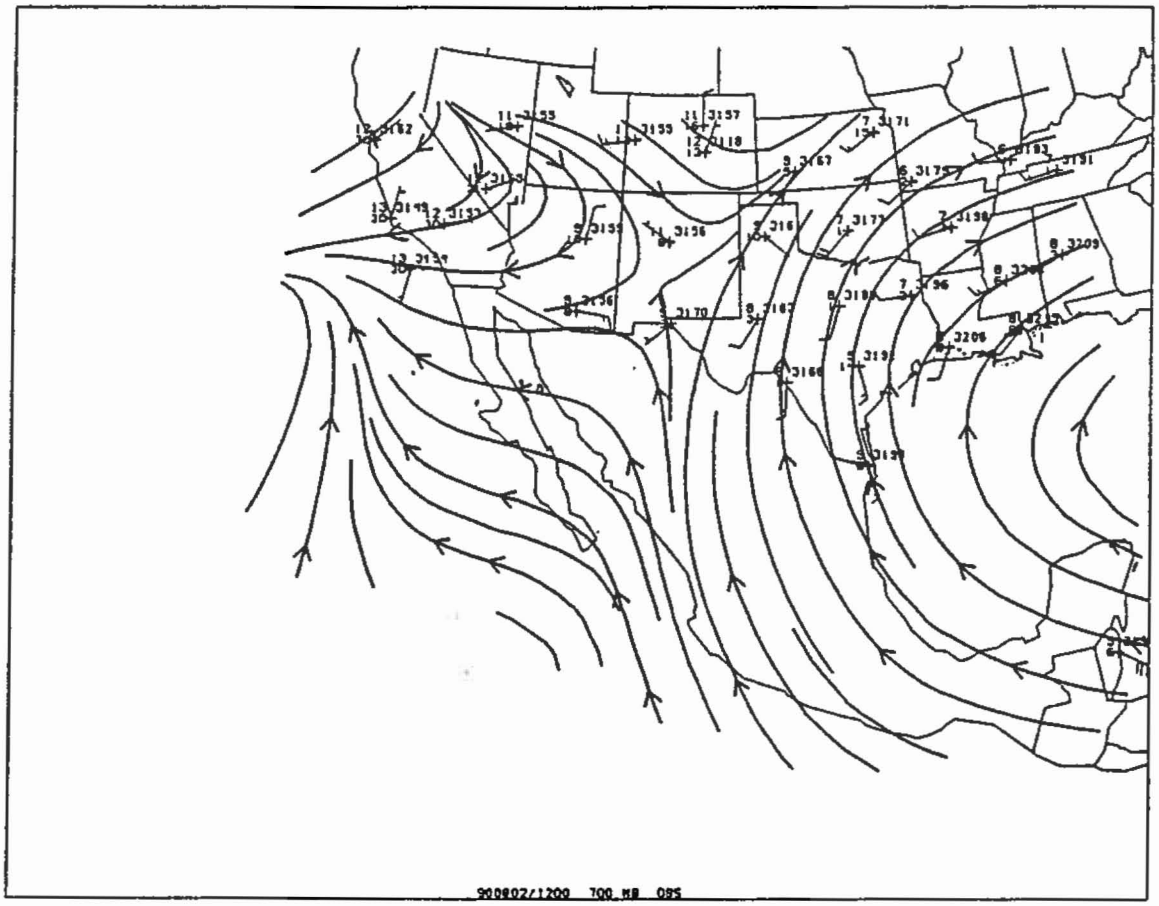
Cloud-to-ground lightning strikes during August 1, 1990

1 AUGUST 1990 Wednesday

Weather Events: Storms develop earlier in the day. Middle and upper level short wave trough is approaching from the west. Storms initially existed over the Mogollon Rim and mountains but weaken early in the evening. Strong storms with heavy rains and high winds develop before sunset in the Casa Grande / Florence area. Some flash flooding in southern Valley of the Sun. Flash flooding in Benson, Cochise County, about 3:30 pm (LT) and in Coolidge, Pinal County about 9:25 pm. Mesoscale outflow again appears to move almost to the Colorado River Valley.

P-3 Operations: Mission #12. Aircraft initially worked in Prescott / Flagstaff area and then flew south as intense storms developed to the south of Phoenix. Doppler radar data collected both around short, intense lines and in residual stratiform rainfall just to the south of SkyHarbor Airport. Flight finished with a leg around the eastern heat island pattern. Cool outflow from these storms led to Phoenix's lowest observed temperature during the project - a bone-chilling 76°F.

Special Observations: Mobile lab released a coordinated sounding series at Florence, right in area of storm development and where aircraft flew. Excellent coordinated sounding series between PHX and NSSL2.



700 mb streamline chart for 1200 UTC, August 2, 1990

NO CHART AVAILABLE

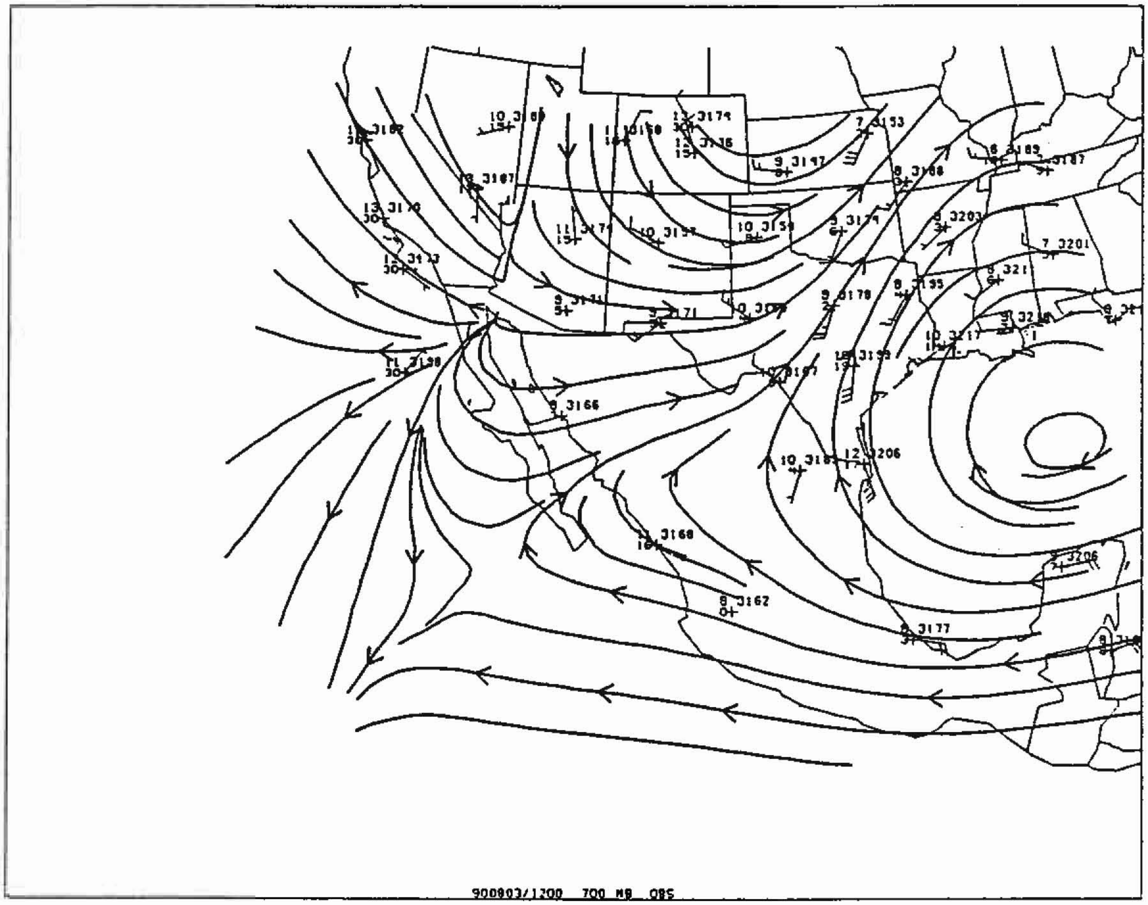
Cloud-to-ground lightning strikes during August 2, 1990

2 AUGUST 1990 Thursday

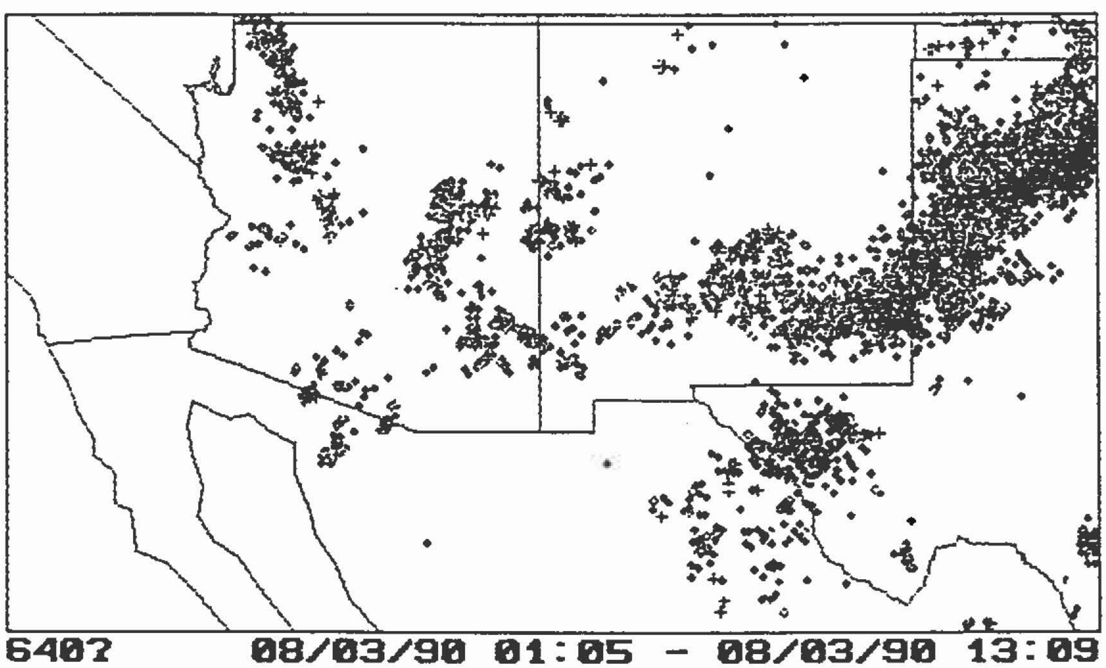
Weather Events: Intense storms developed by noon time over low mountains to northwest. Very intense storm produced strong outflow and damaging winds northwest Phoenix suburbs to the Wickenburg area. Brief gust front tornado documented by mobile lab. Funnel cloud also reported near Big Bug Mesa in Prescott area of Yavapai County. After early burst of convective activity, only afternoon / evening storms existed in the Tucson area and isolated over the mountains; another isolated storm south of Kingman.

P-3 Operations: Mission #13 to collect data on the moisture structure over northern portion of the Sea of Cortez and then return across U.S. border to monitor storms in Arizona. Storms were too small and isolated to work effectively and mission concluded after flying another eastern half trip around the heat island pattern.

Special Observations: Mobile laboratory was scheduled to release special soundings in the Wickenburg area; however, a tire blowout damaged electrical system. Crew was able to videotape the decay phase of the short-lived "*gustnado*" and several haboob. Rawinsonde sounding series at PHX; NSSL2 unavailable for remainder of experiment period.



700 mb streamline chart for 1200 UTC, August 3, 1990



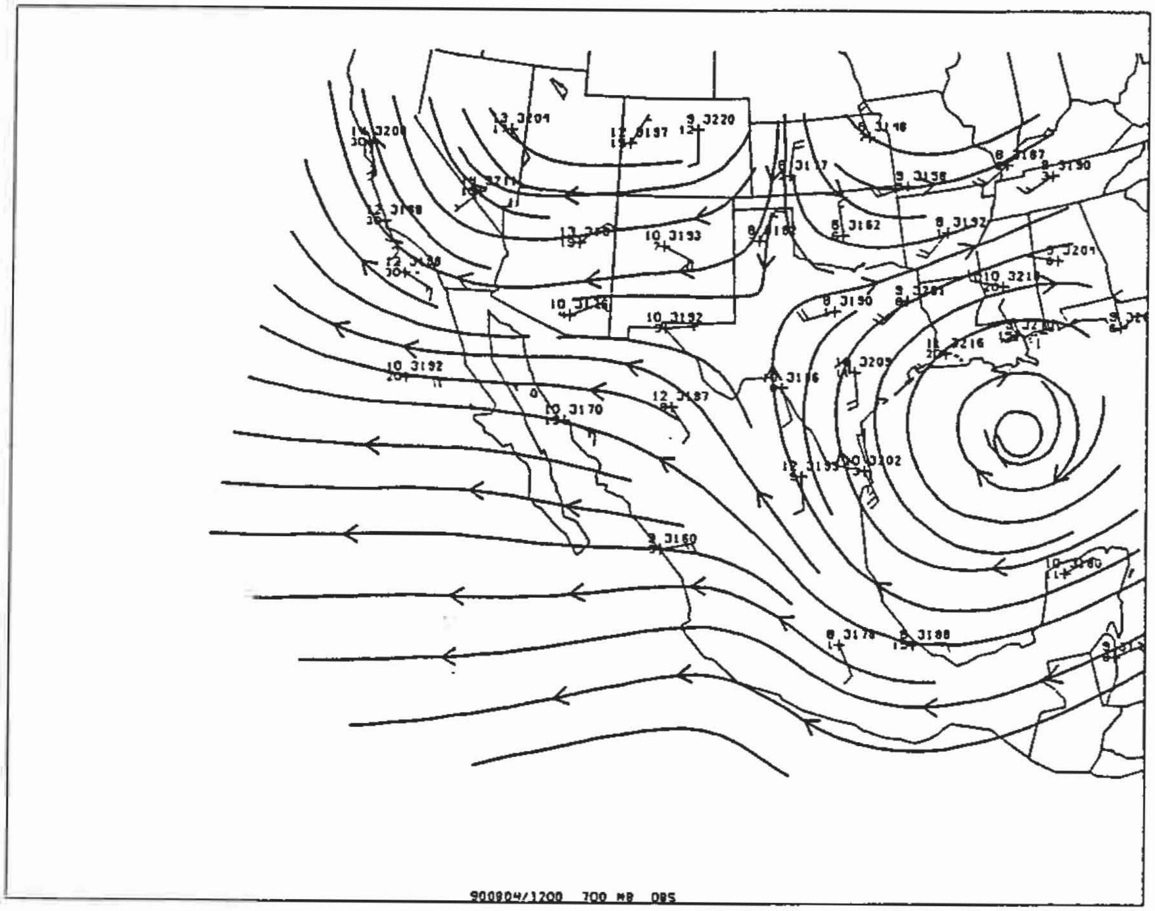
Cloud-to-ground lightning strikes during August 3, 1990

3 AUGUST 1990 Friday

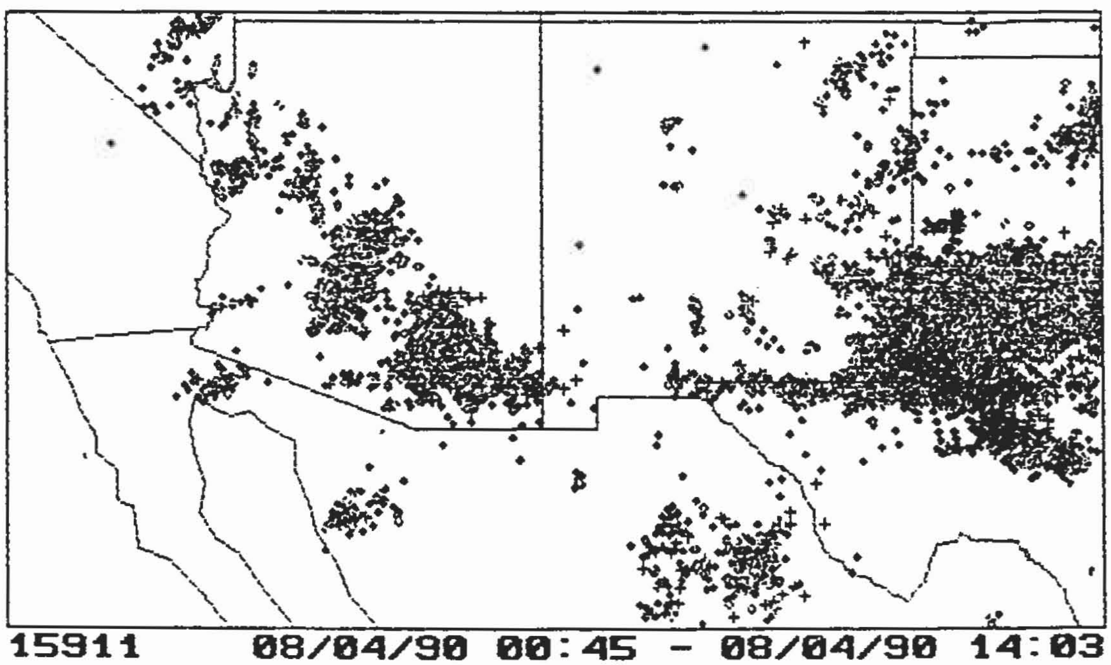
Weather Events: Storms developed very late over the White and then Superstition Mountains. Redeveloped into an intense line that moved across Phoenix metropolitan area from 8:00 to 10:00 pm (LT) producing heavy rains and some wind damage. Damage reported in Phoenix at about 9:30 pm and in Carefree at about 10:30 pm. Flash flooding and wind damage were reported in the Tucson area at 8:05 pm.

P-3 Operations: DOWN

Special Observations: Special soundings at PHX released ahead of line of thunderstorms.



700 mb streamline chart for 1200 UTC, August 4, 1990



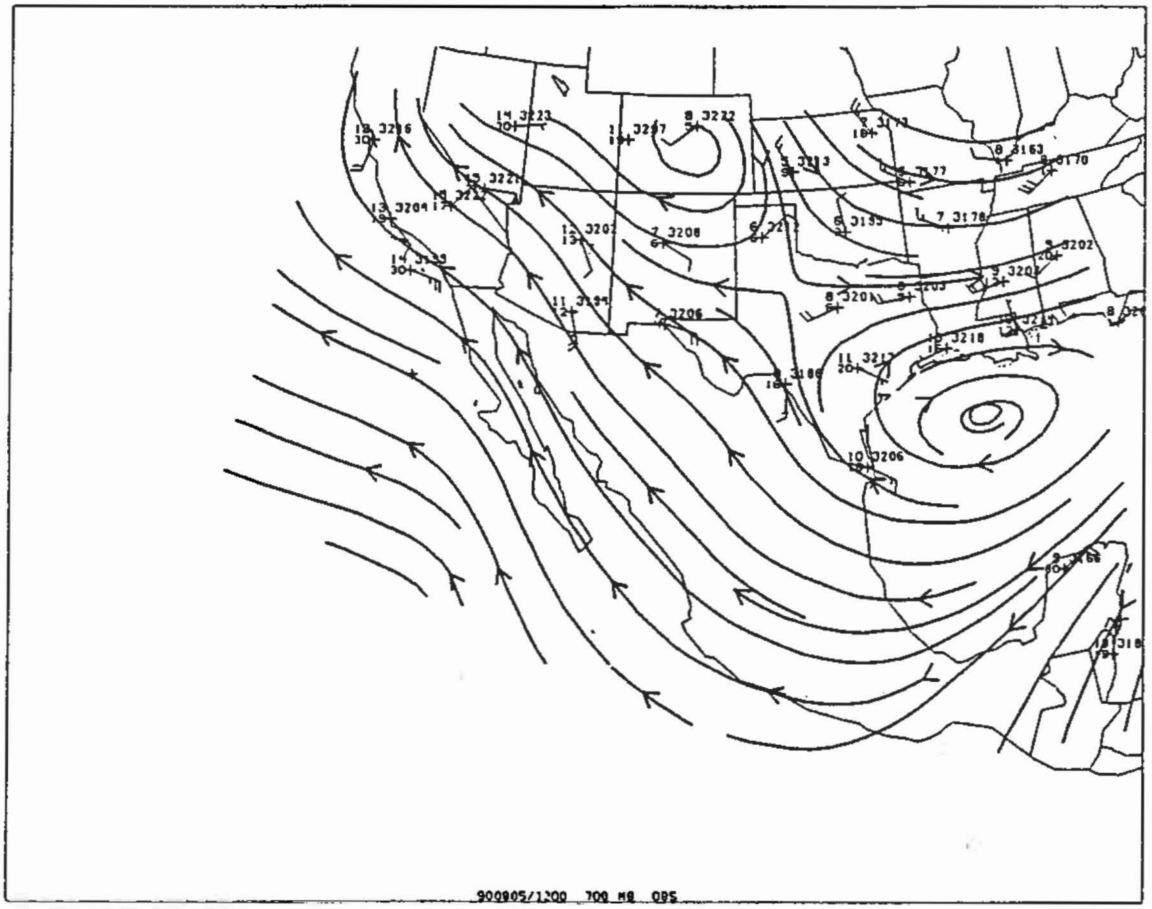
Cloud-to-ground lightning strikes during August 4, 1990

4 AUGUST 1990 Saturday

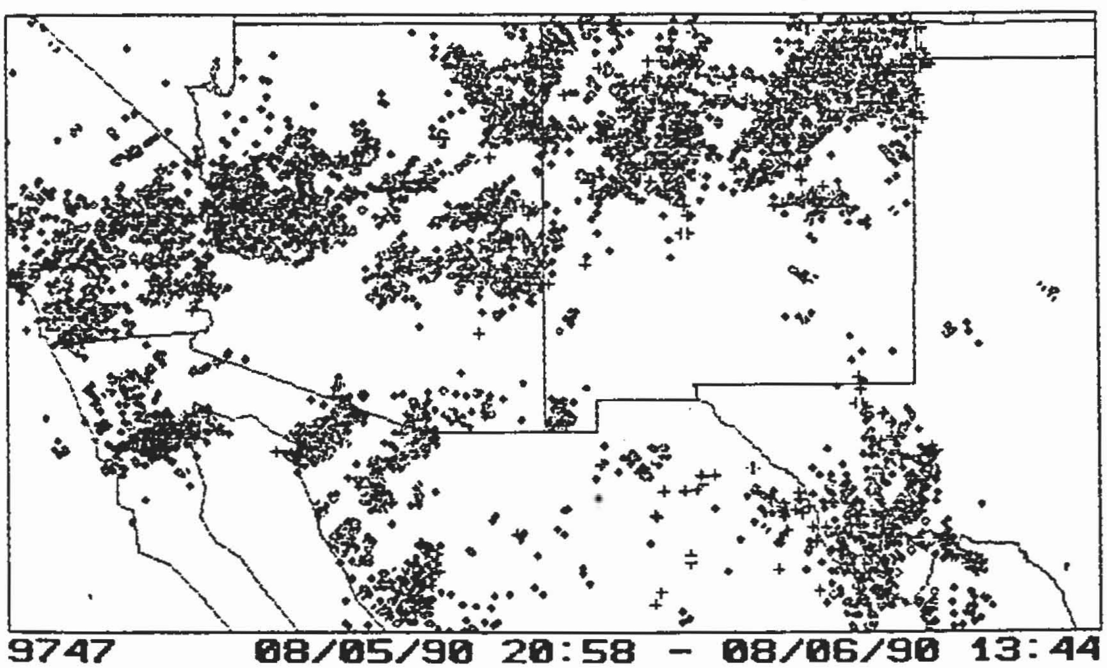
Weather Events: Thunderstorms over Mogollon Rim and White Mountains by midday. Middle level flow has become easterly again. No reports were received of significant storms in Arizona.

P-3 Operations: DOWN. All allocated flight hours expended.

Special Observations: 0000 and 1200 UTC Phoenix radiosonde.



700 mb streamline chart for 1200 UTC, August 5, 1990



Cloud-to-ground lightning strikes during August 5, 1990

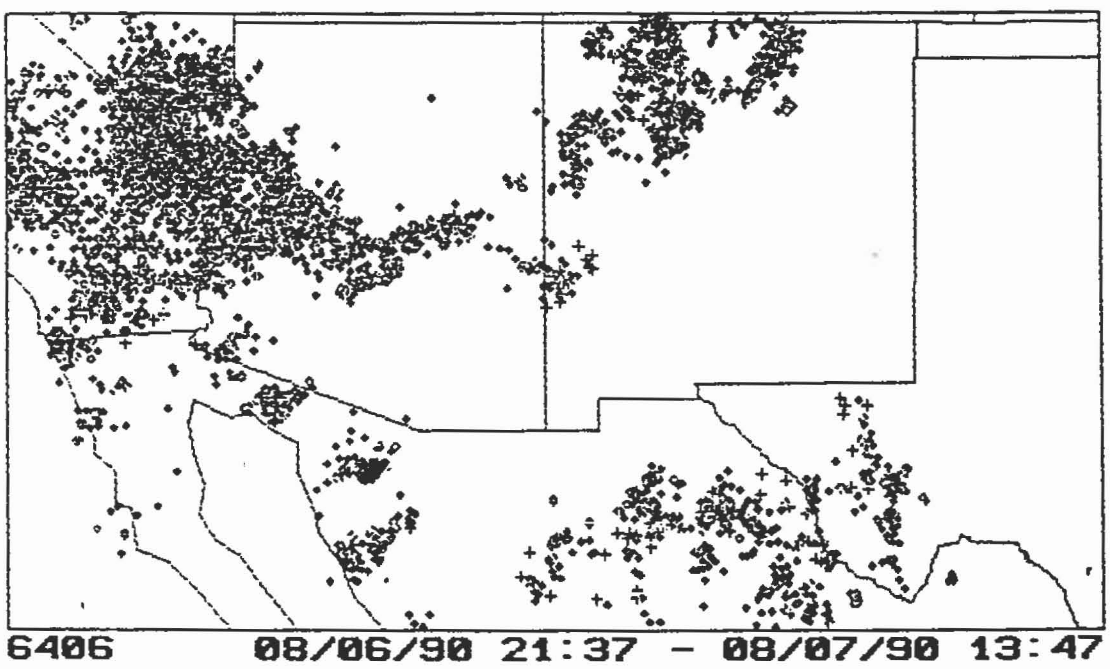
5 AUGUST 1990 Sunday

Weather Events: Thunderstorms produced damaging winds at Williams Air Force Base near Tucson at 4:55 pm (LT). Extensive wind damage occurred in the Lake Havasu City region of Mohave County around 6:30 pm. Damaging winds and power lines down in the Parker to Ehrenburg area of Lapaz County around 7:00 pm with many traffic accidents due to blowing dust along Interstate 10.

P-3 Operations: Research aircraft unavailable.

Special Observations: 0000 and 1200 UTC Phoenix radiosonde. Special soundings called for at U.S. and Mexican weather service sites.

700 mb streamline chart for 1200 UTC, August 6, 1990



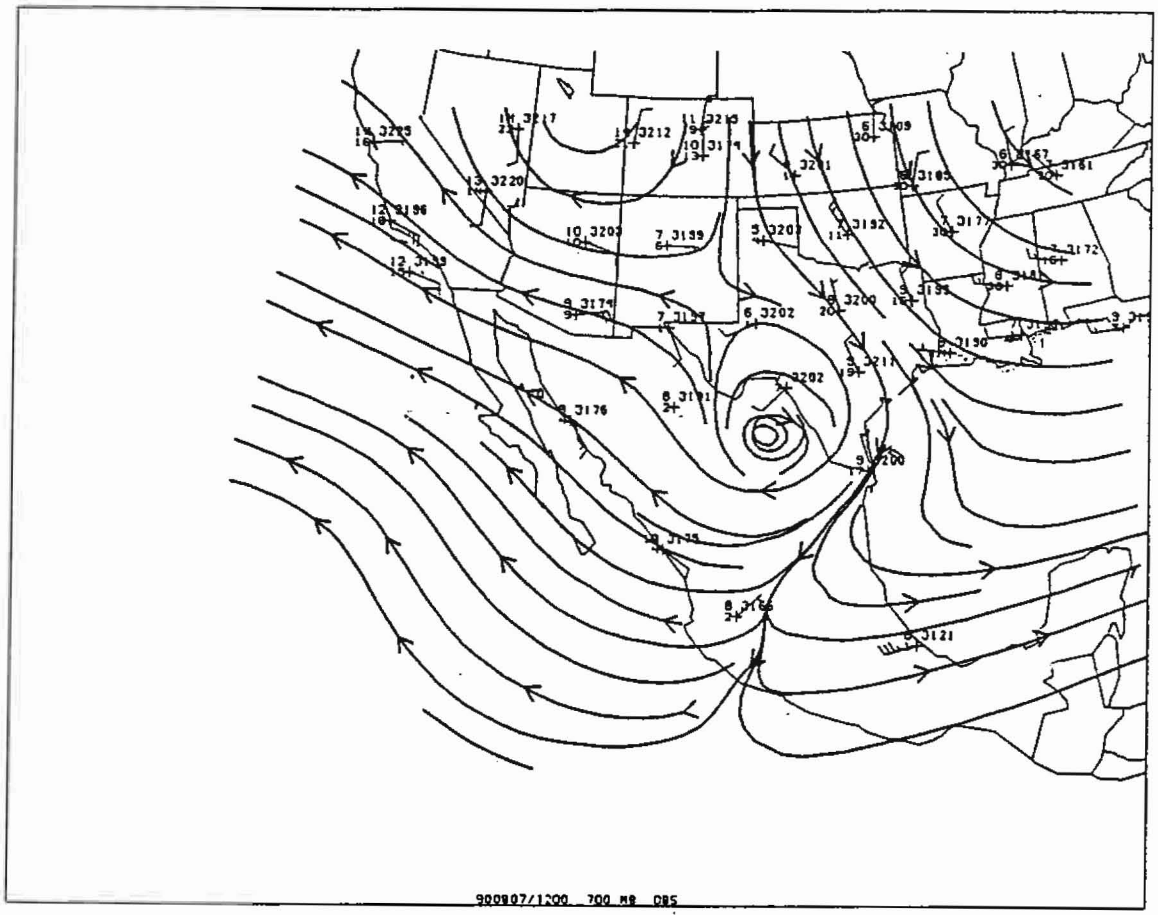
Cloud-to-ground lightning strikes during August 6, 1990

6 AUGUST 1990 Monday

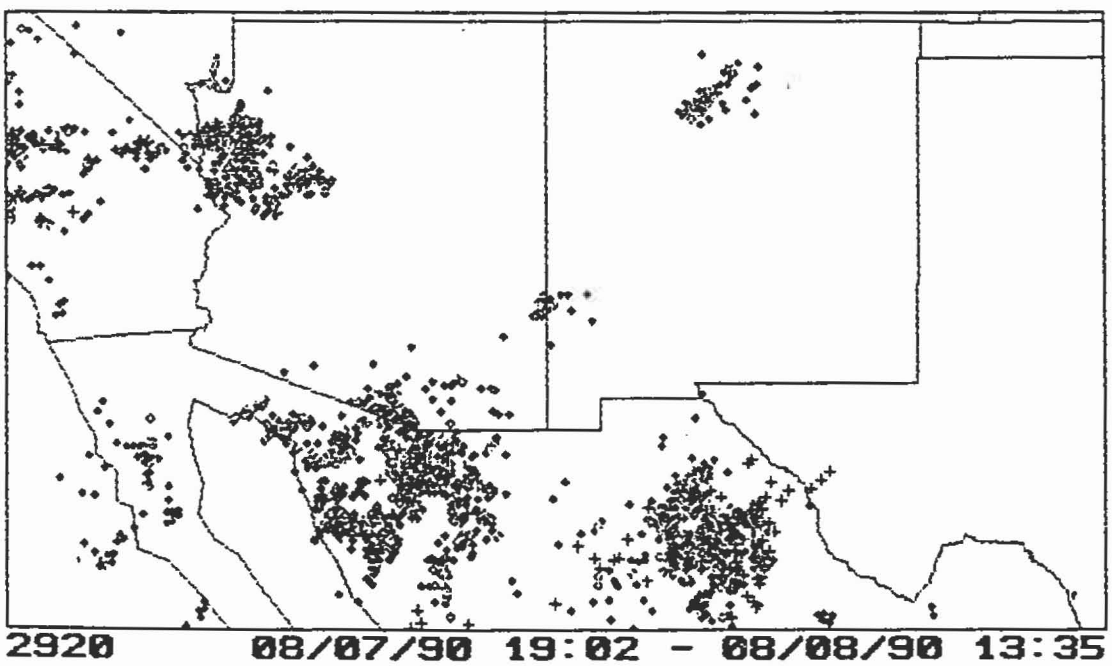
Weather Events: There were numerous storms which produced damaging downburst winds throughout Arizona. At 4:35 pm (LT) damage reported at Luke Air Force Base near Phoenix to 12 aircraft and two trailers with estimate of $1M damage. Damage in west Phoenix at 5:50 pm. Damage and power lines down again in Parker / Ehrenburg at 7:35 pm. Damage at Lake Havasu City and also Bullhead City in Mohave County at 4:25 pm reported two house trailers blown over.

P-3 Operations: Research aircraft unavailable. All flight hours used.

Special Observations: 0000 and 1200 UTC Phoenix radiosonde. Special soundings called for 0600 and 1800 UTC at U.S. and Mexican weather service sites.



700 mb streamline chart for 1200 UTC, August 7, 1990



Cloud-to-ground lightning strikes during August 7, 1990

7 AUGUST 1990 Tuesday

Weather Events: No significant weather reported in Arizona.

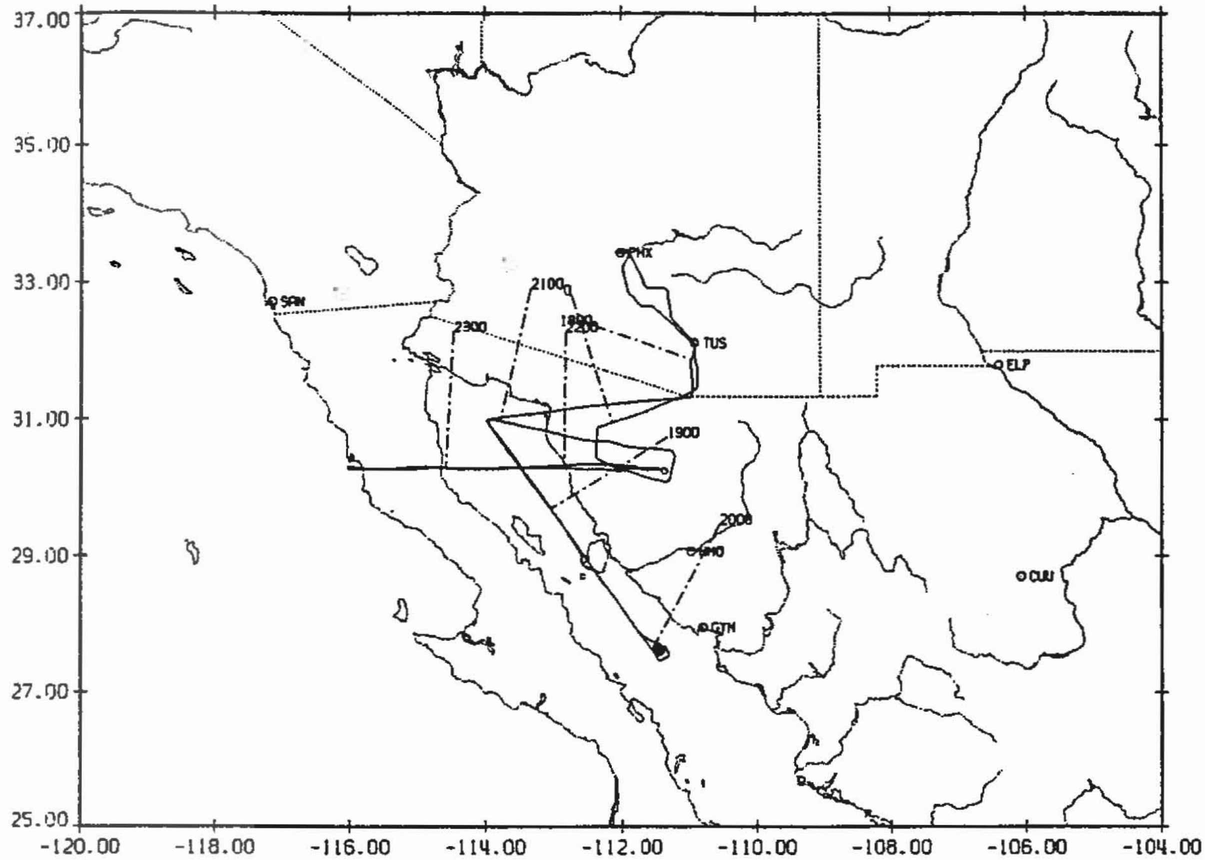
P-3 Operations: Research aircraft unavailable. All flight hours used.

Special Observations: 0000 and 1200 UTC Phoenix radiosonde.

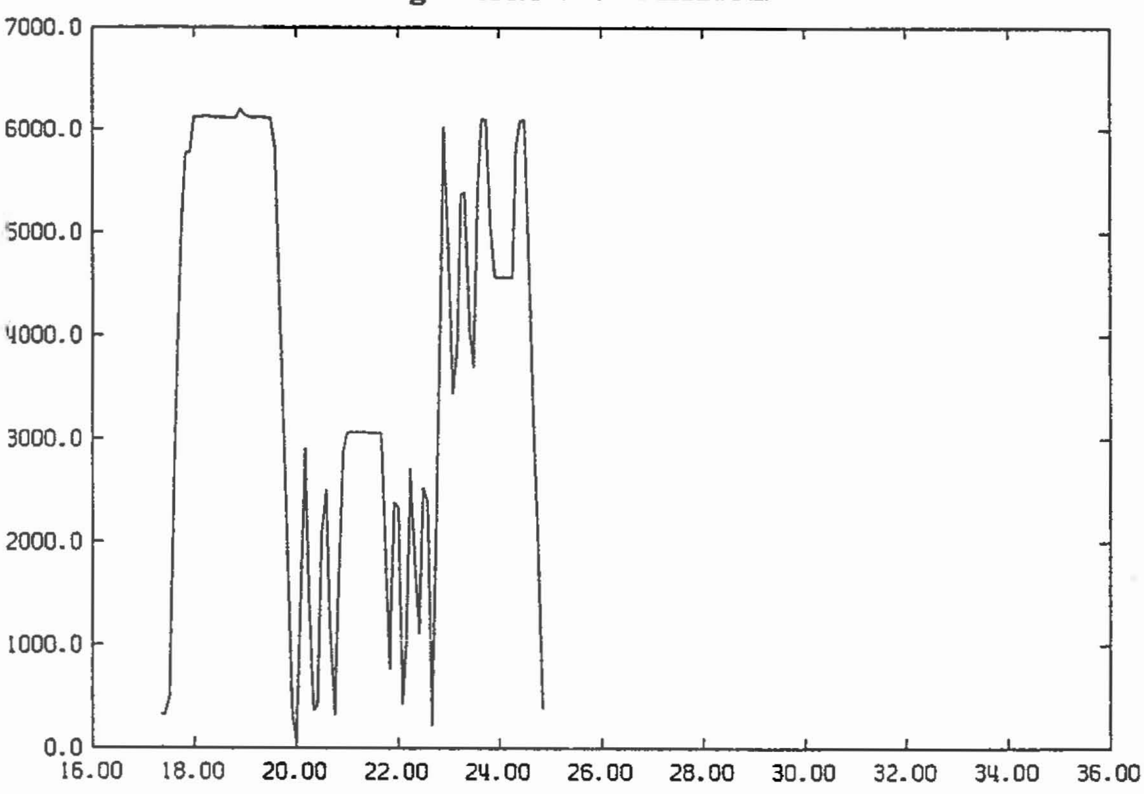
Appendix B
Mission Summaries

SWAMP Aircraft Flight Summary

Mission Number	Date	Take Off	Return
		(Time in UTC)	
1	9 July 1990	1729	0050
2	12 July 1990	0110	0733
3	13 July 1990	0334	0834
4	14 July 1990	2218	0348
5	17 July 1990	1804	0006
6	20 July 1990	0015	0550
7	21 July 1990	1320	2100
8	27 July 1990	0606	1036
9	30 July 1990	0106	0702
10	31 July 1990	0355	0547
11	1 August 1990	0358	0738
12	2 August 1990	0138	0702
13	3 August 1990	0036	0451



Flight track for Mission #1



Flight levels (pressure altimeter) for Mission #1

Mission 1 Summary
Monday July 9, 1990

Staffing:

P-3:	Chief Scientist:	Jorgensen / Smull
	Radar:	Watson / Bartels
	Cloud Physics:	Schuur
	Observers:	Reyes, Sipple, Anderson (NWS)
	Media:	TV 5 (2)

Operations Center: Howard, Skaggs, Meitín

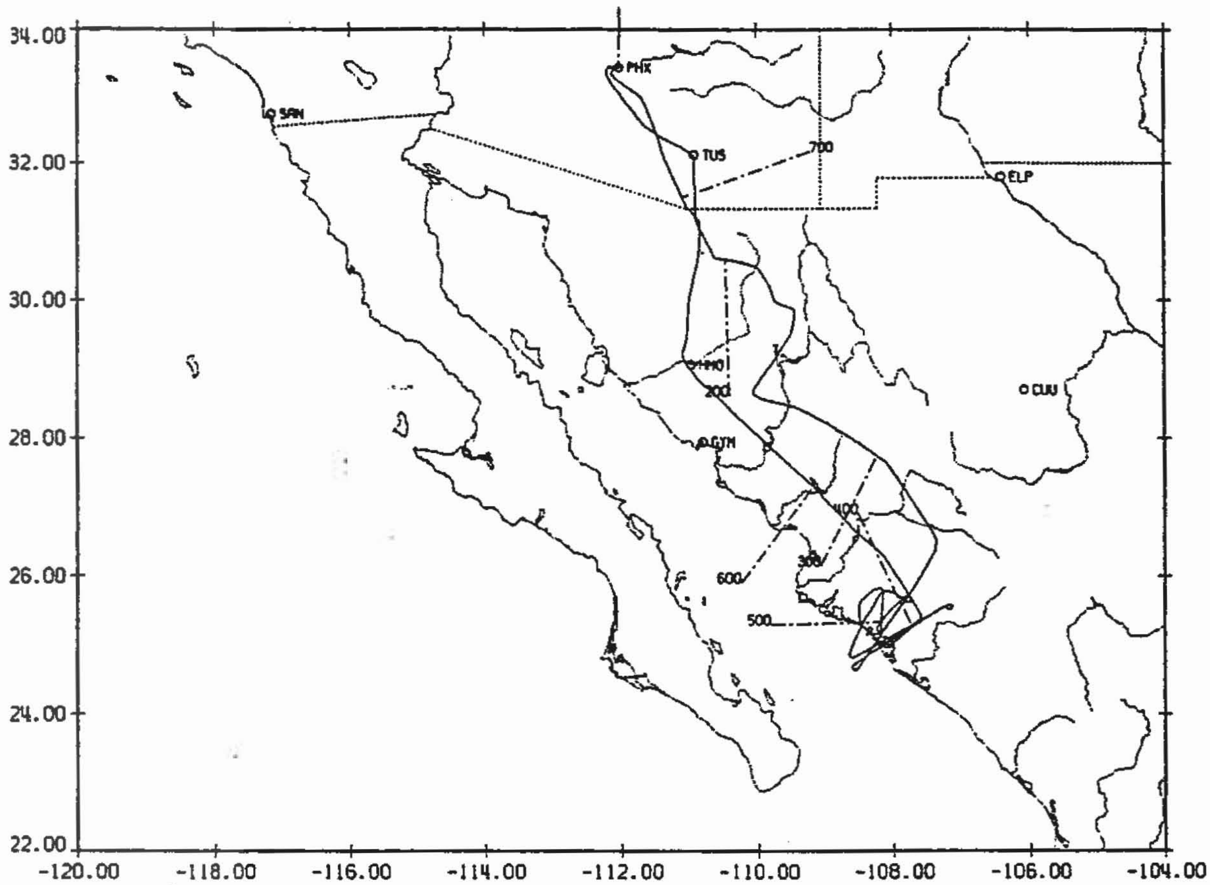
Mission Description:

Plan is to do pattern A1 (large scale "A" monsoon pattern) with 1) omegadropsonde, at north end of Gulf of California; 2) level flight SE down Gulf of California to point "B", did descent sound; 3) 0-10,000 ft porpoise, NW back up the Gulf to point "A"; 4) E-W transects at 0-10,000 ft and 10-20,000 ft along 30°N; 5) sample convective systems with FAST scans as opportunity arises; 6) if time allows, ferry home via Yuma.

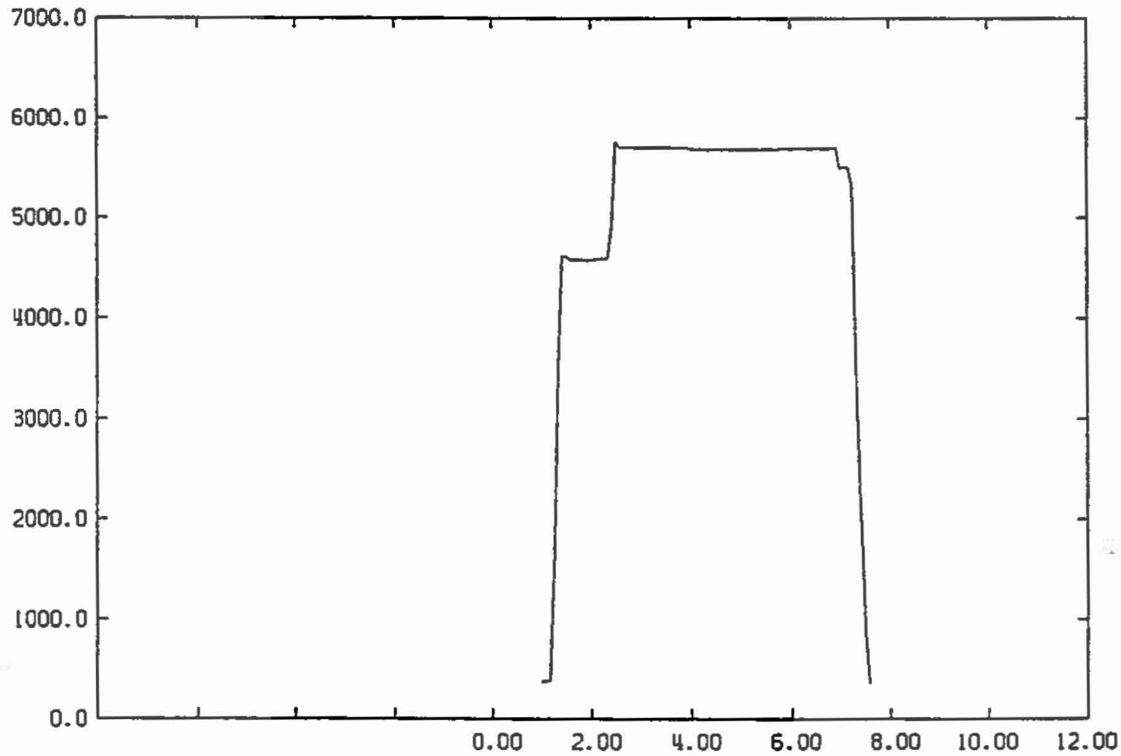
Mission Summary:

Takeoff Time: **1729 UTC** Landing Time: **0050 UTC**
Official Mission Duration **7.6 hr**
Number of Magnetic Tapes Used: Radar: **2** Cloud Physics: **2**
Number of Sondes Released: **2**

Cloud Physics Log			**Radar Log**		
Tape #	On	Off	Tape #	On	Off
1	2131	2351	1	1732	2200
2	2353	2354	2	2215	0026



Flight track for Mission #2



Flight levels (pressure altimeter) for Mission #2

Mission 2 Summary

Thursday July 12, 1990

Staffing:

P-3:	Chief Scientist:	Jorgensen / Smull
	Radar:	Watson / Bartels
	Cloud Physics:	Schuur / Hunter
	Observers:	Reyes, Bjorem, Sims, Perfrement, Sturm (NWS)
	Media:	None
Operations Center:	Howard, Skaggs, Meitín	

Mission Description:

Convection was present along Sierra Madre Occidental at planning time; plan is to track SE in anticipation of possible MCS development. Track A-B at 15,000 ft for FAST. Point A: 30.8°N, 110.2°W; Point B: 26.0°N, 107.5°W. Plan to release omegadropsonde and / or descent soundings ahead (W or SW) of convection.

Mission Summary:

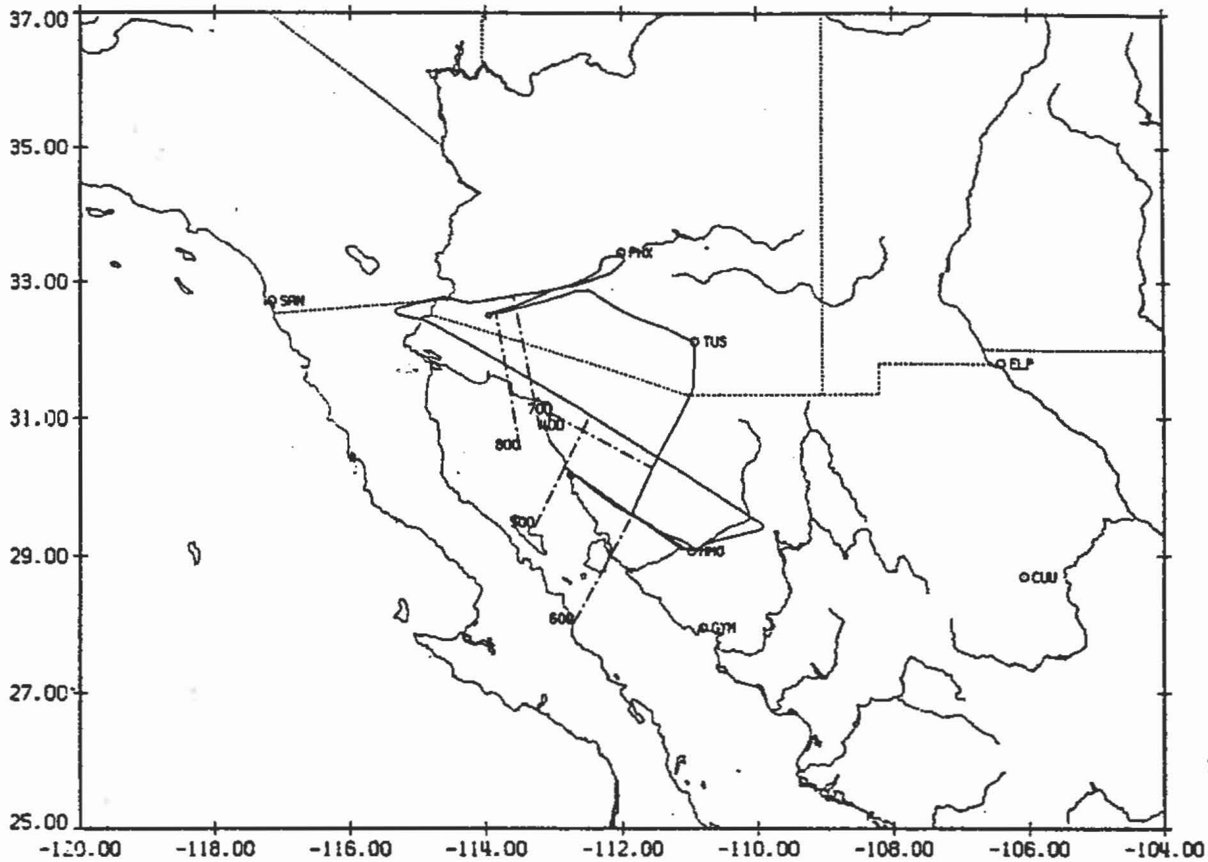
Takeoff Time: **0110 UTC** Landing Time: **0733 UTC**
Official Mission Duration **6.7 hr**
Number of Magnetic Tapes Used: Radar: **7** Cloud Physics: **16**
Number of Sondes Dropped: **3**

Cloud Physics Log

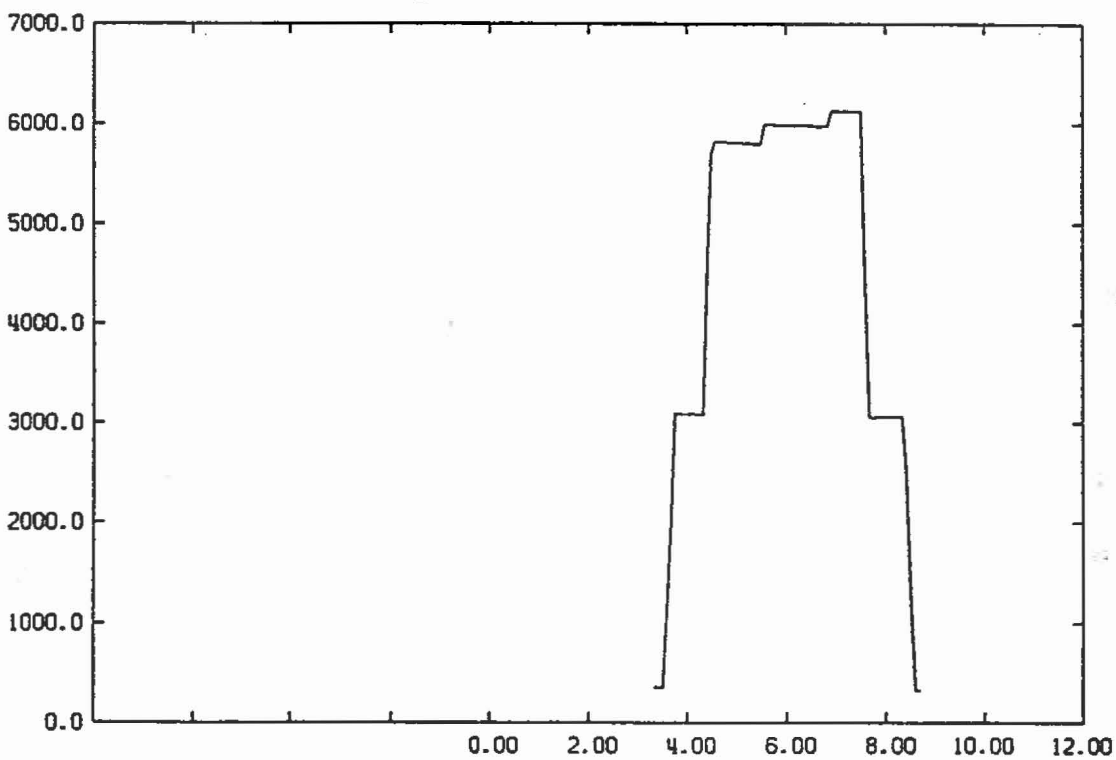
Tape #	On	Off
1	0140	0233
2	0235	0240
3	0250	0256
4	0256	0337
5	0338	0356
6	0356	0403
7	0403	0412
8	0412	0417
9	0420	0426
10	0453	0458
11	0458	0504
12	0504	0517
13	0517	0522
14	0522	0527
15	0528	0627
16	0627	0633

Radar Log

Tape #	On	Off
1	0127	0227
2	0227	0336
3	0336	0412
4	0412	0446
5	0446	0520
6	0520	0636
7	0636	0715



Flight track for Mission #3



Flight levels (pressure altimeter) for Mission #3

Mission 3 Summary

Friday July 13, 1990

Staffing:

P-3:	Chief Scientist:	Jorgensen / Smull
	Radar:	Bartels / Watson
	Cloud Physics:	Schuur
	Observers:	Gall , Hoffman, Vazquez (NWS)
	Media:	Shane
		Parmoon, Pool (Tucson *TV9*)

Operations Center: Howard, Skaggs, Meitín

Mission Description:

Plan is to split flight into two parts: first, Mexican MCS, then file flight plan to cross U.S. border at ≈0700 UTC to work any "targets of opportunity" over southern Arizona. Track out of PHX will be at 700 mb to the vicinity of Yuma to survey desert boundary layer. After crossing south of border into Mexico, soundings (2) will be taken to sample low-level MCS inflow prior to beginning Doppler radar patterns.

Mission Summary:

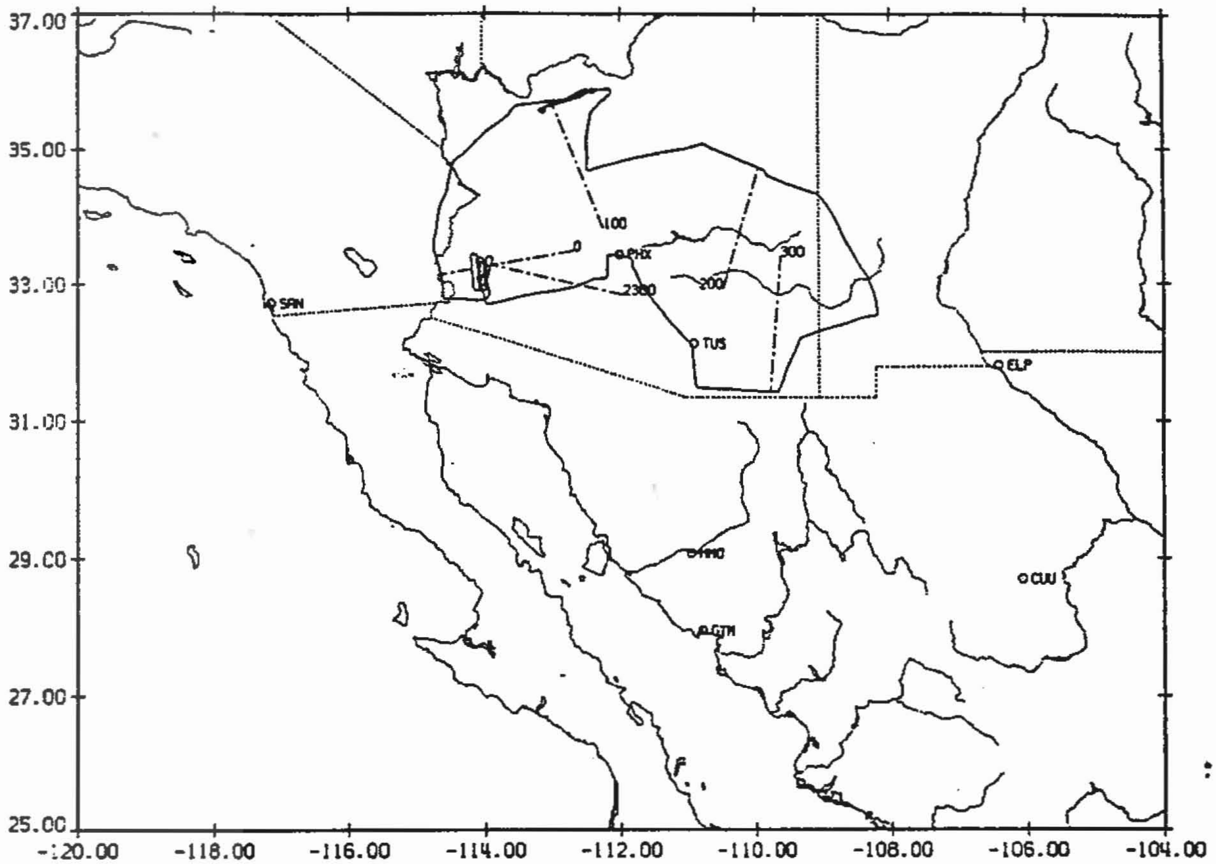
Takeoff Time: **0334 UTC** Landing Time: **0834 UTC**
Official Mission Duration **5.4 hr**
Number of Magnetic Tapes Used: Radar: **4** Cloud Physics: **15**
Number of Sondes Dropped: **2**

Cloud Physics Log

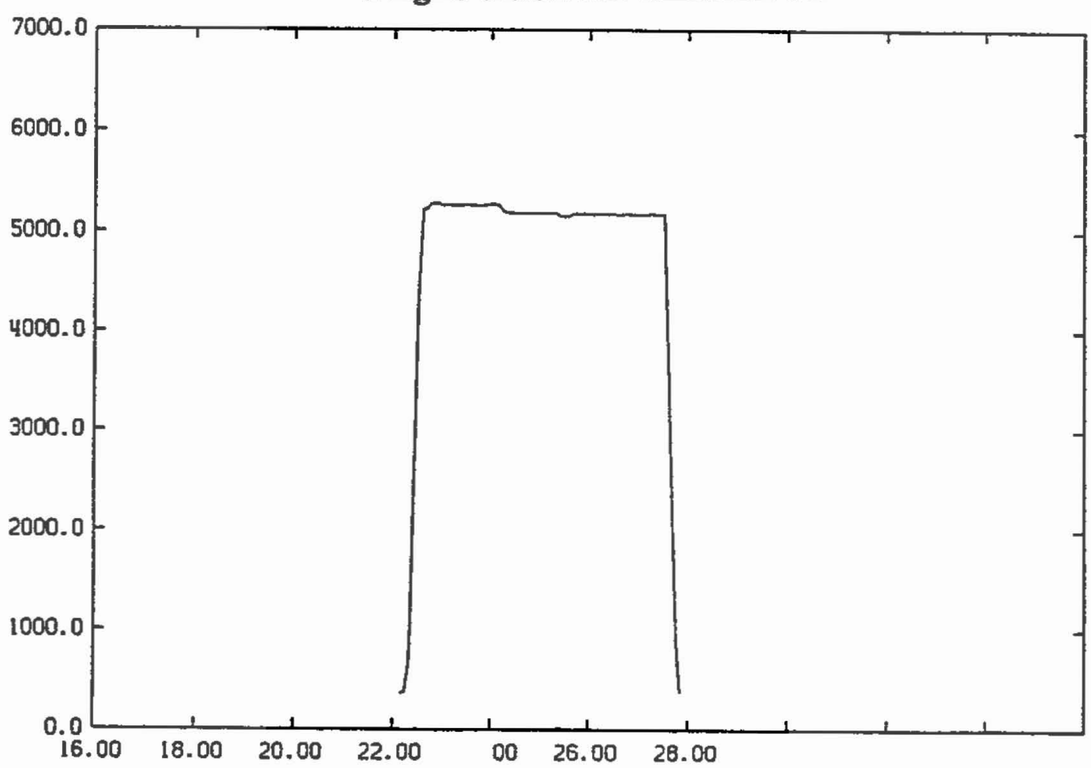
Tape #	On	Off
1	0342	0347
2	0347	0352
3	0357	0402
4	0402	0436
5	0436	0441
6	0441	0447
7	0603	0608
8	0608	0616
9	0616	0621
10	0621	0626
11	0626	0633
12	0634	0638
13	0642	0647
14	0647	0653
15	0653	0654

Radar Log

Tape #	On	Off
1	0339	0445
2	0452	0607
3	0607	0656
4	0713	0824



Flight track for Mission #4



Flight levels (pressure altimeter) for Mission #4

Mission 4 Summary

Saturday July 14, 1990

Staffing:

P-3:	Chief Scientist:	Jorgensen / Smull
	Radar:	Watson / Bartels
	Cloud Physics:	Schuur / Hunter
	Observers:	Douglas, Rowe, Houle (NWS)
	Media:	Aguilar, Stocks (*TV12*, NBC)

Operations Center: Howard, Skaggs, Meitín

Mission Description:

Monitor the central Arizona thunderstorm environment. Set up a circuit for PHX-YUM-GEN-SJN-SVC; then shuttle between GCN-->SJN-->SVC; repeat 2-3 times, breaking off for Doppler radar work, if applicable.

Mission Summary:

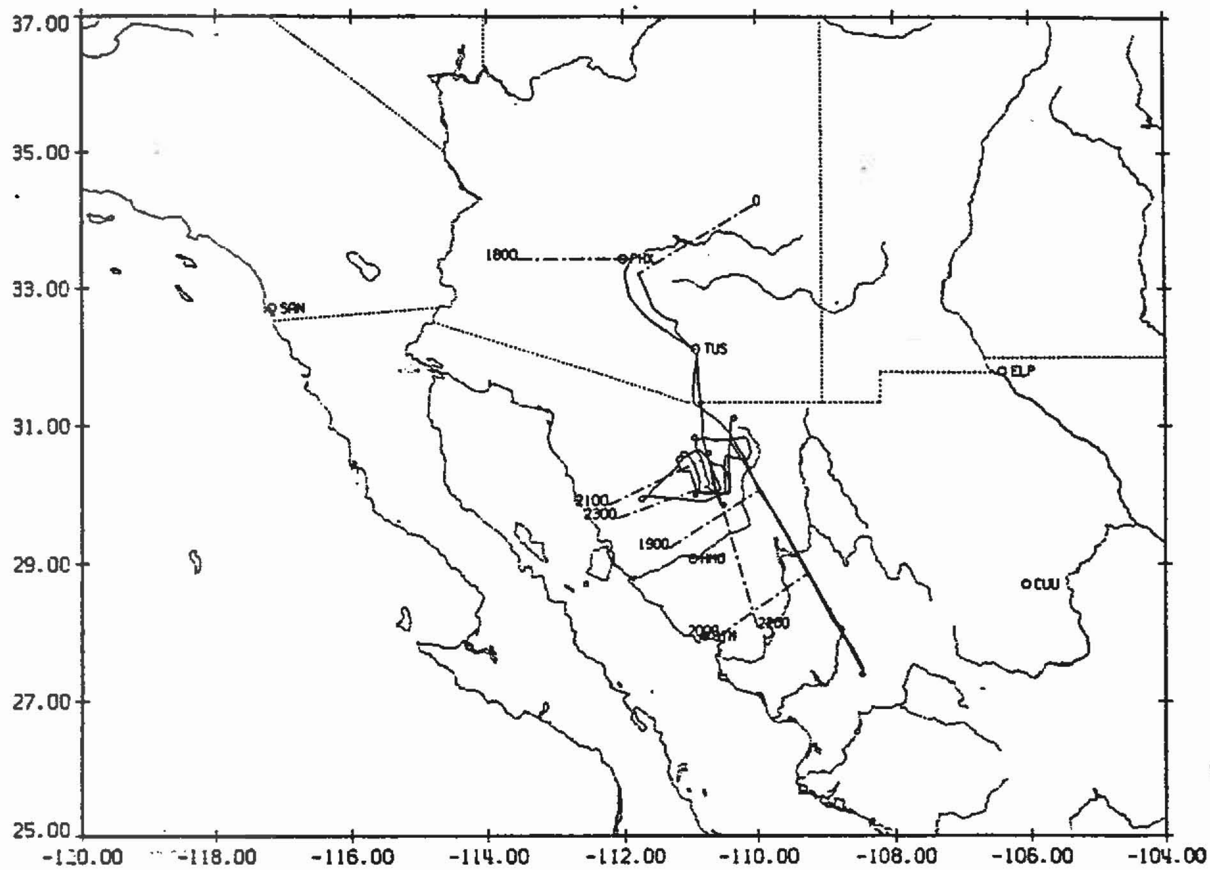
Takeoff Time: **2218 UTC** Landing Time: **0348 UTC**
Official Mission Duration **5.8 hr**
Number of Magnetic Tapes Used: Radar: **3** Cloud Physics: **8**
Number of Sondes Dropped: **0**

Cloud Physics Log

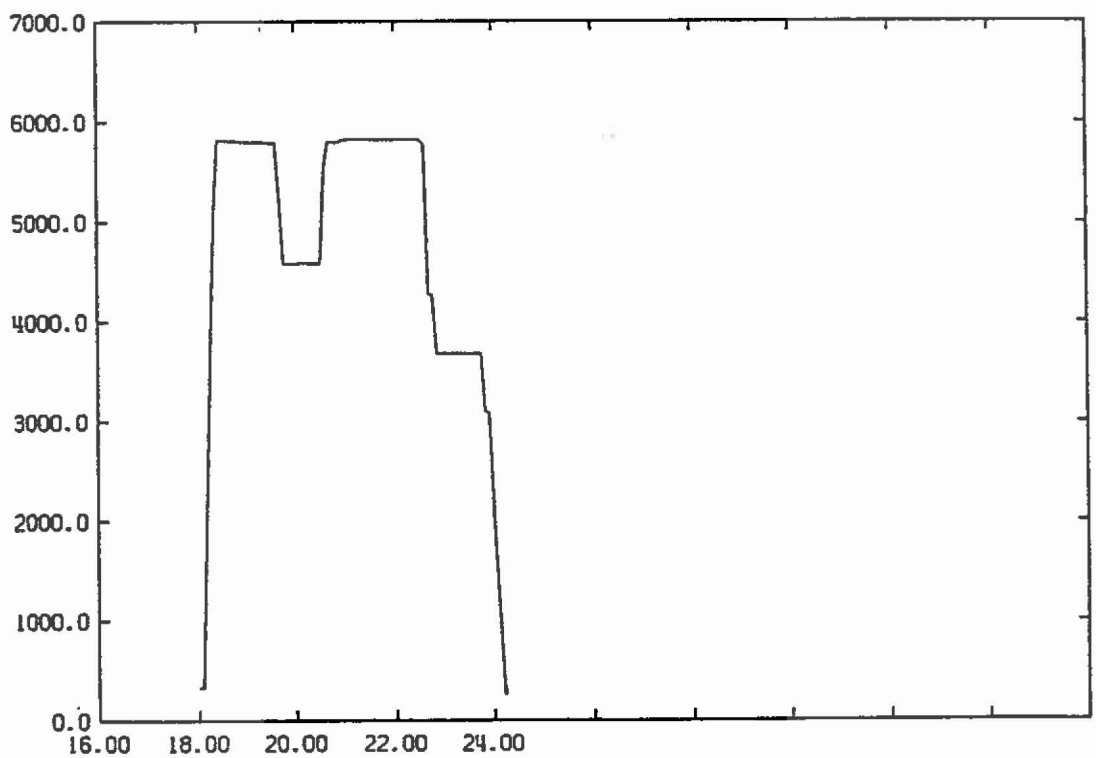
Tape #	On	Off
1	2233	2241
2	2241	0057
3	0057	0107
4	0107	0126
5	0129	0137
6	0137	0203
7	0203	0209
8	0209	0214

Radar Log

Tape #	On	Off
1	2221	0134
2	0134	0232
3	0232	0337



Flight track for Mission #5



Flight levels (pressure altimeter) for Mission #5

Mission 5 Summary

Tuesday July 17, 1990

Staffing:

P-3:	Chief Scientist:	Smull / Watson
	Radar:	Bartels / Schuur
	Cloud Physics:	Hunter
	Observers:	Jorgensen, Douglas, Lovegrove
	Media:	Hicks, Person, Barash (CNN)

Operations Center: Howard, Skaggs, Meitín

Mission Description:

Sample the pre-convective environmnet and the intense convective stage of MCS. Proposed plan is to fly from point **A** (31°N, 110.5°W) to point **B** (27.5°N, 108.5°W) and monitor convective development along the high terrain. As convection develops follow guidance from Operations Center which showed two regions of convection, select best flight pattern and monitor progress through its lifecycle.

Mission Summary:

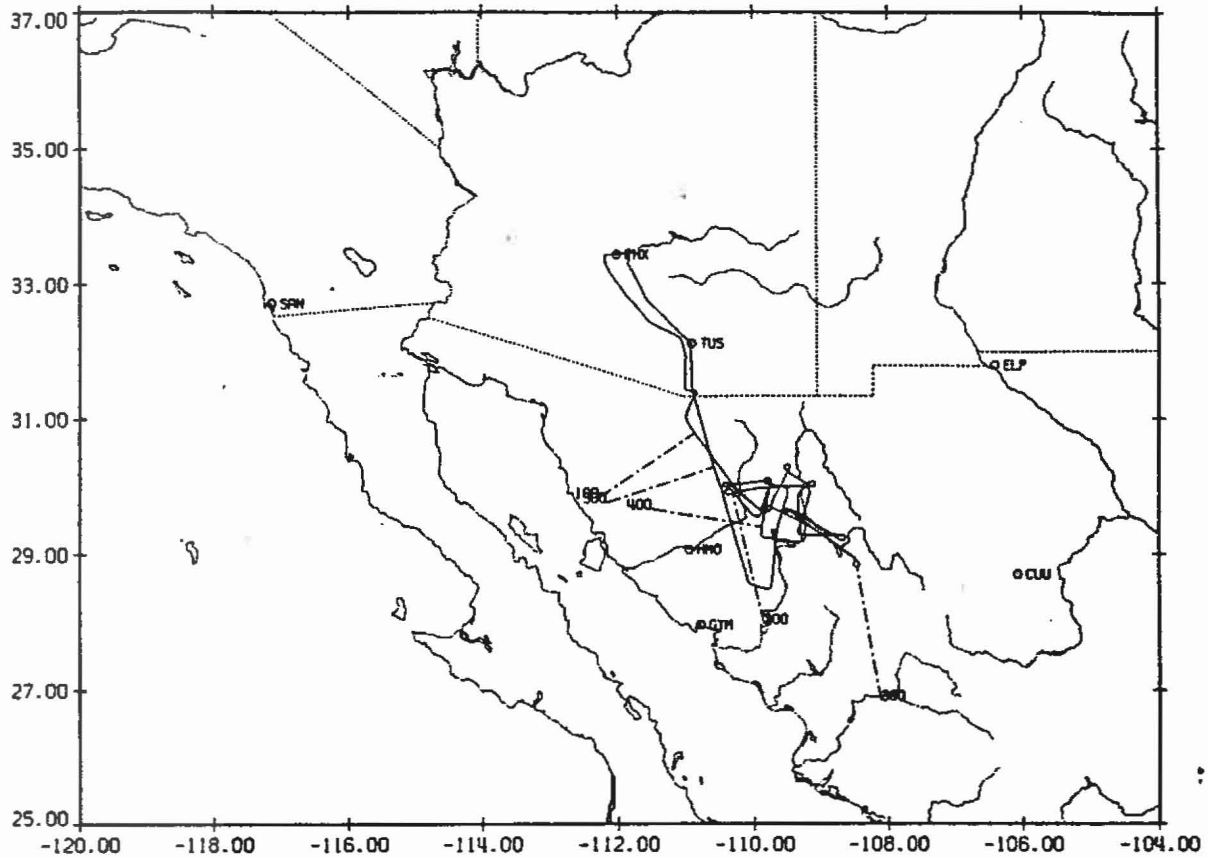
Takeoff Time: **1804 UTC** Landing Time: **0006 UTC**
Official Mission Duration **6.2 hr**
Number of Magnetic Tapes Used: Radar: **5** Cloud Physics: **3**
Number of Sondes Dropped: **1**

Cloud Physics Log

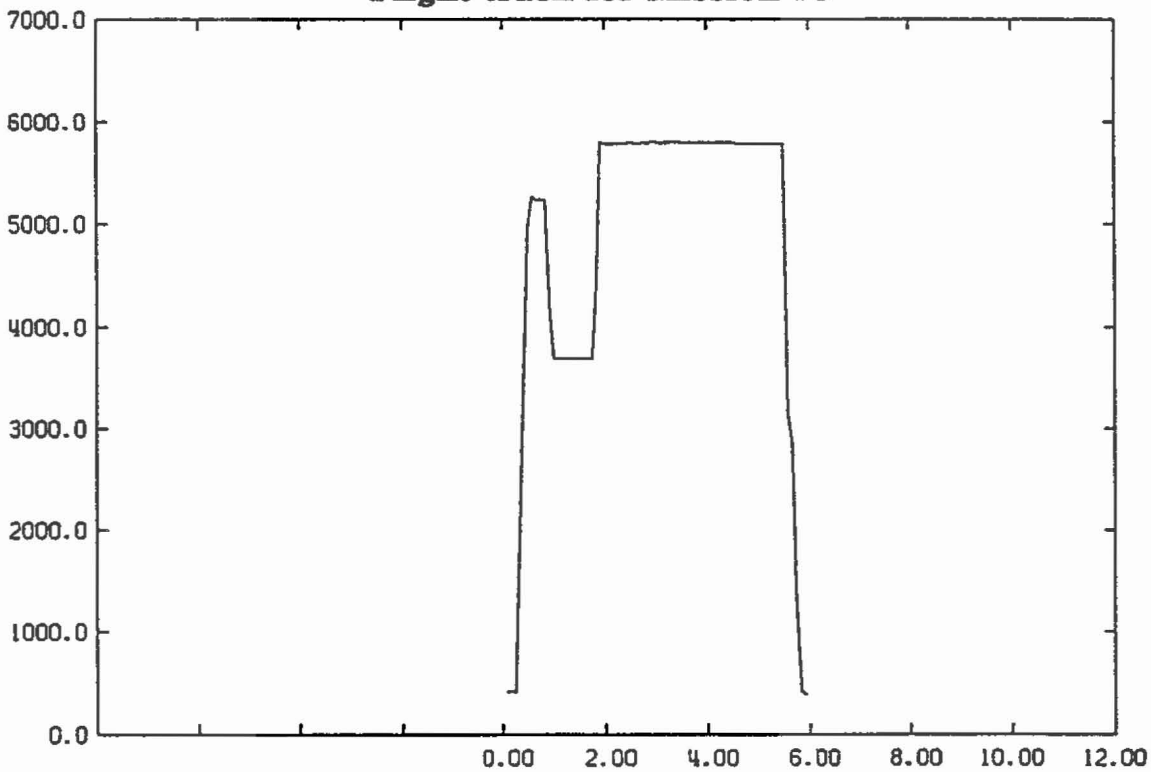
Tape #	On	Off
1	2106	2112
2	2128	2246
3	2259	2259

Radar Log

Tape #	On	Off
1	1809	2042
2	2042	2138
3	2138	2243
4	2243	2333
5	2333	2352



Flight track for Mission #6



Flight levels (pressure altimeter) for Mission #6

Mission 6 Summary

Friday July 20, 1990

Staffing:

P-3:	Chief Scientist:	Watson / Smull
	Radar:	Bartels / Schuur
	Cloud Physics:	Hunter
	Observers:	Jorgensen,Gall, Zehnder, NWS (2)
	Media:	TV10 (2)

Operations Center: Howard, Skaggs, Meitín

Mission Description:

At takeoff time, deep convection was already organized in meso-ß scale systems along and just east of Sierra Madre Occidental. Plan is to fly from point A (31°N, 111°W) to point B (27.5°N, 109°W) at 12,000 ft and return at 20,000 ft to survey these systems as well as conduct transect across W-E monsoon boundary provided it hasn't been obliterated by the convection south of Nogales. Attempt a release of omegadropsonde in the MCS inflow region. Strong convective activity was encountered, with some cells oriented N-S in a bow pattern. Due to 115°F temperature at takeoff, absolute maximum duration is 6 hours.

Mission Summary:

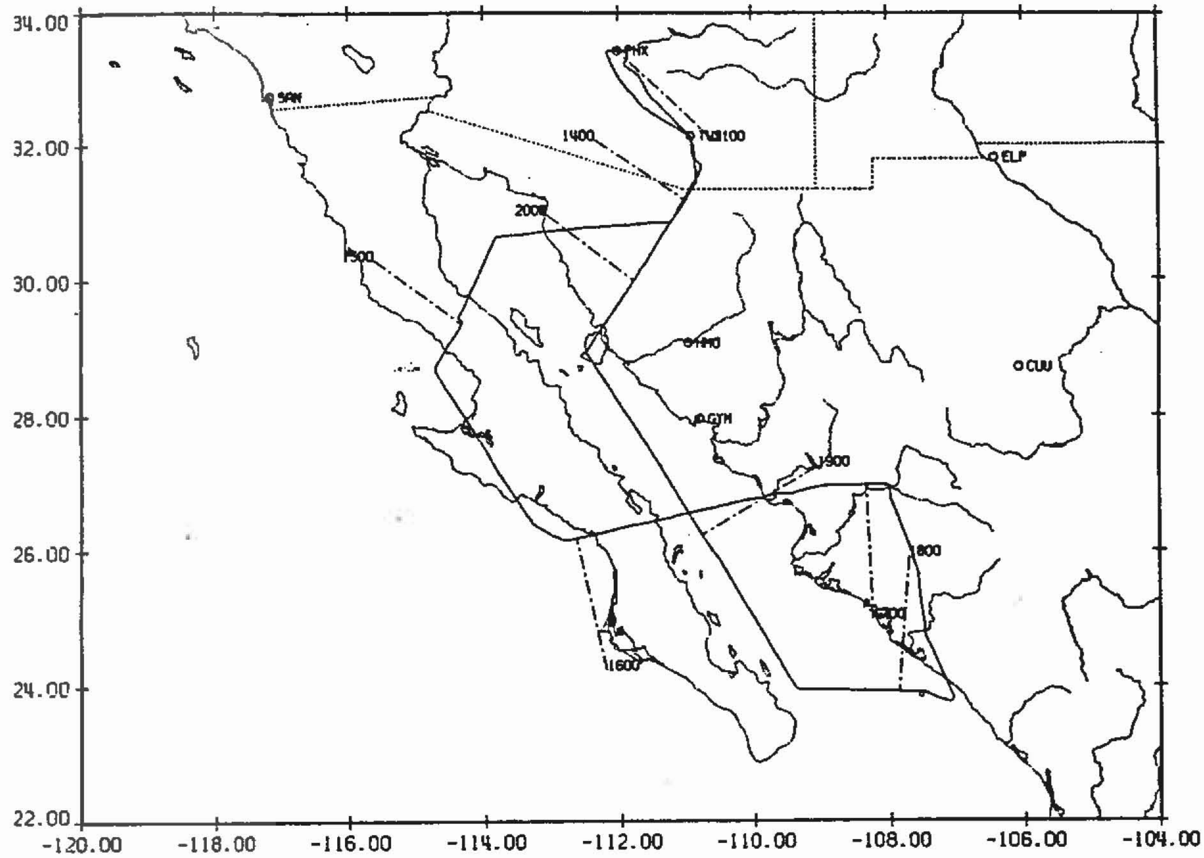
Takeoff Time: **0015 UTC** Landing Time: **0550 UTC**
Official Mission Duration **5.9 hr**
Number of Magnetic Tapes Used: Radar: **8** Cloud Physics: **9**
Number of Sondes Dropped: **4**

Cloud Physics Log

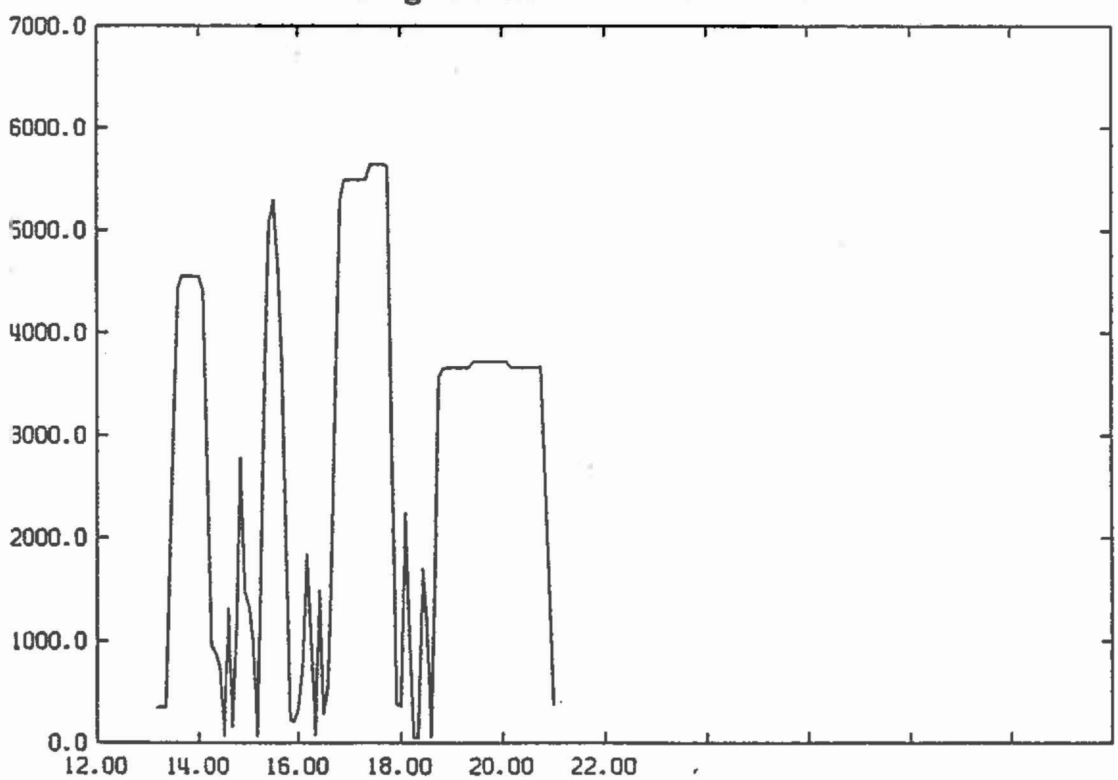
Tape #	On	Off
1	0154	0159
2	0201	0236
3	0246	0252
4	0254	0303
5	0305	0311
6	0313	0347
7	0349	0354
8	0419	0425
9	0427	0430

Radar Log

Tape #	On	Off
1	0020	0128
2	0134	0206
3	0206	0237
4	0237	0309
5	0309	0337
6	0340	0408
7	0408	0440
8	0440	0532



Flight track for Mission #7



Flight levels (pressure altimeter) for Mission #7

Mission 7 Summary

Saturday July 21, 1990

Staffing:

P-3:	Chief Scientist:	Douglas / Jorgensen
	Radar:	Bartels / Howard
	Cloud Physics:	Meitín
	Observers:	Smull, Dunn, Shilito (NWS), Gall, Hasimoto
	Media:	None

Operations Center:

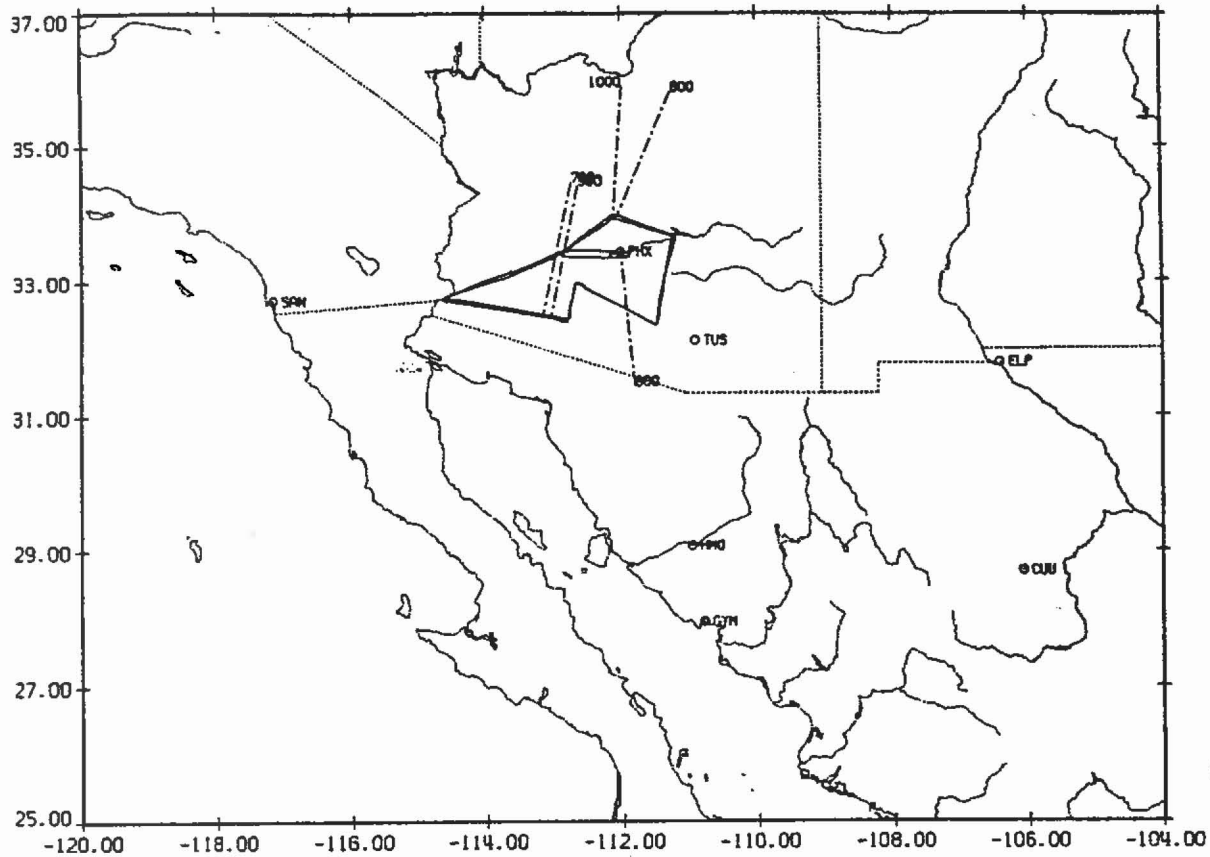
Mission Description:

Large-scale monsoon boundary-layer pattern with potential option for sampling decaying MCS circulation in northern Gulf of California.

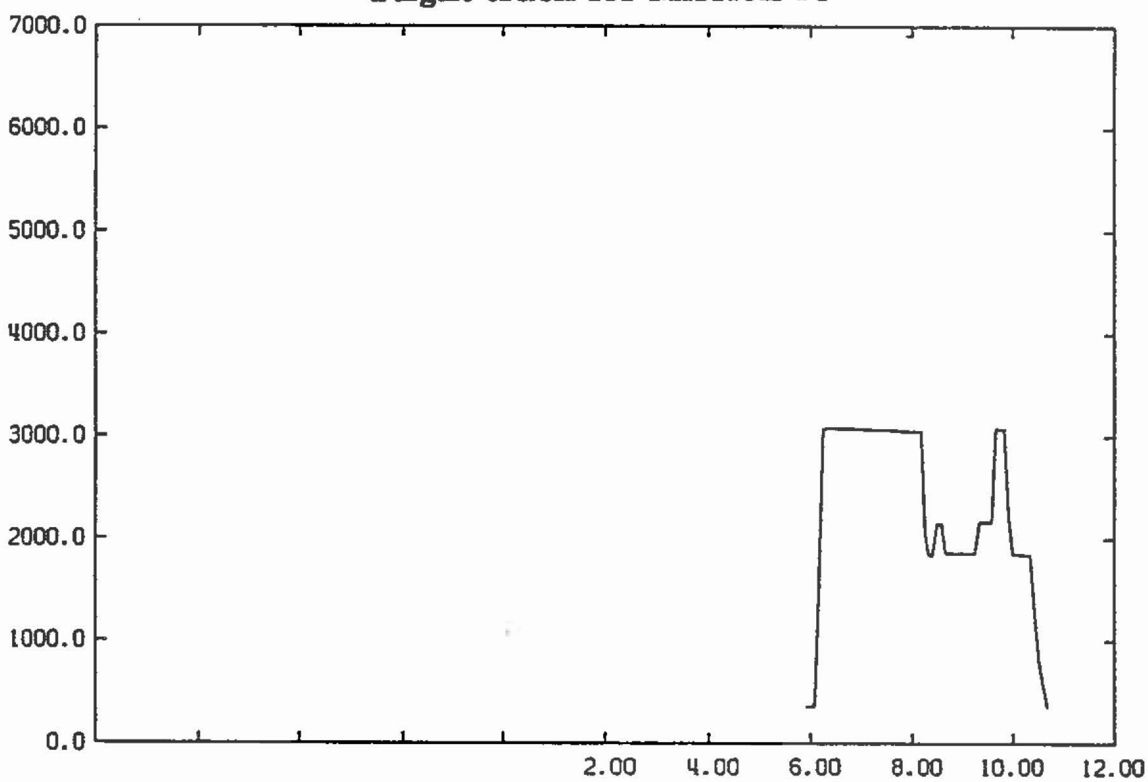
Mission Summary:

Takeoff Time: **1320 UTC** Landing Time: **2059 UTC**
Official Mission Duration **8.0 hr**
Number of Magnetic Tapes Used: Radar: **1** Cloud Physics: **0**
Number of Sondes Dropped: **1**

Cloud Physics Log			Radar Log		
Tape #	**Time**	**Time**	**Tape #**	**On**	**Off**
			1	1327	2051



Flight track for Mission #8



Flight levels (pressure altimeter) for Mission #8

Mission 8 Summary

Friday July 27, 1990

Staffing:

P-3:	Chief Scientist:	Jorgensen / Smull
	Radar:	Brandes / Skaggs
	Cloud Physics:	
	Observers:	J. Wilhite, I. Reinink (SRP), M. Stouffer (State of AZ), T. Lamarche, T. Donaldson (Maricopa County Flood Control), J. Sanders (NWS)
	Media:	L. Carlson KJZZ, Natl Public Radio

Operations Center: Meitín, Howard

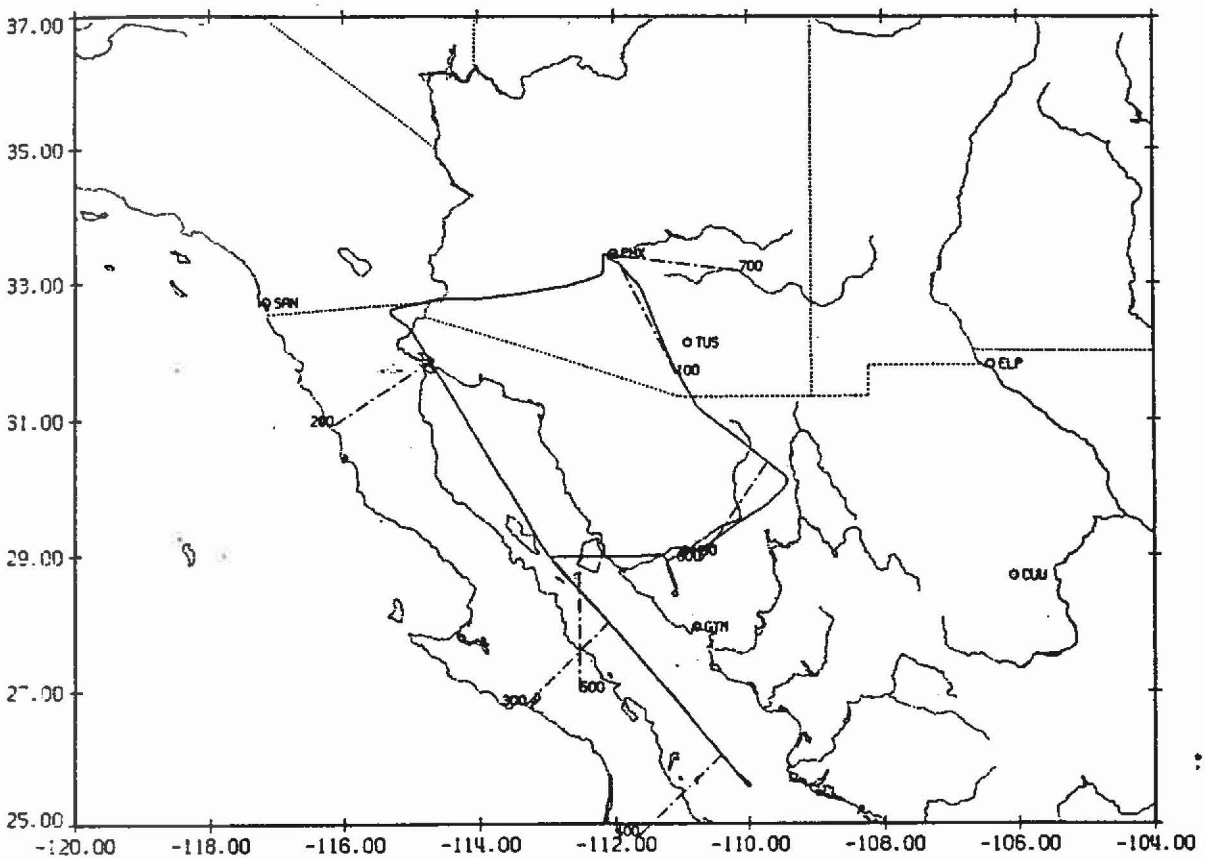
Mission Description:

Metropolitan Phoenix Heat Island. Central Arizona mission in support of heat island.

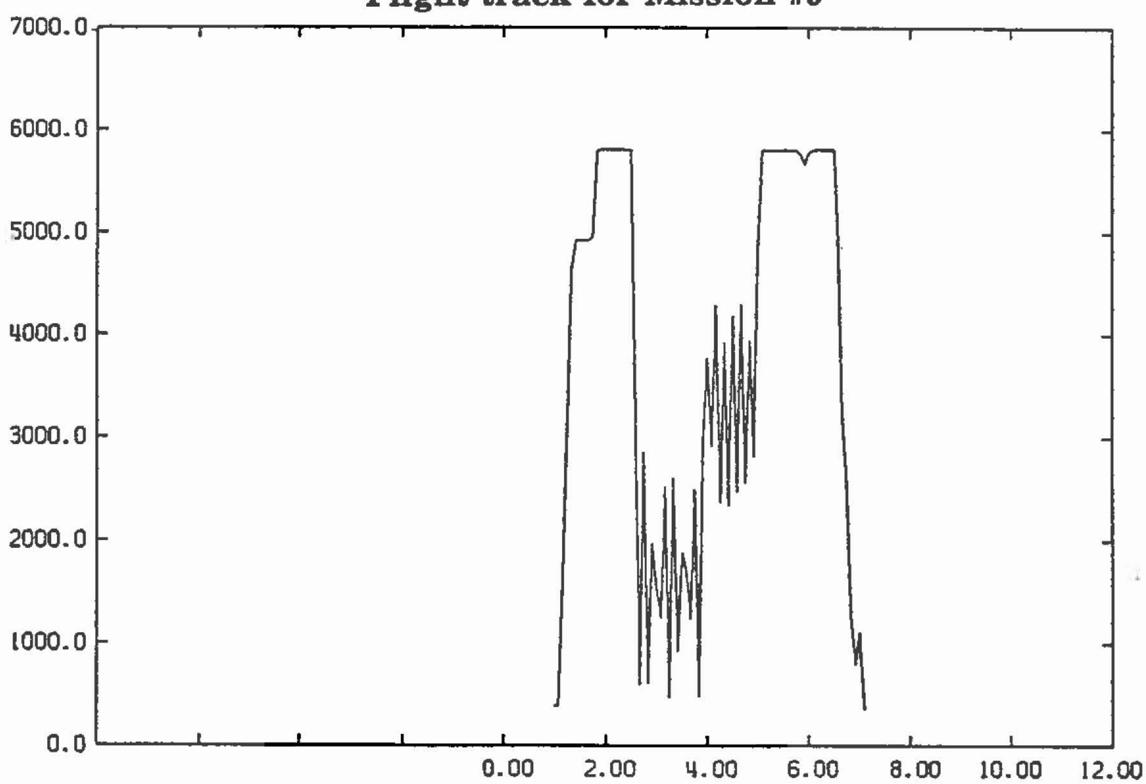
Objectives are (1) to sample low to mid-tropospheric thermodynamic structure and winds under essentially clear air conditions in support of mobile lab observations surrounding the Phoenix metropolitan area, and (2) to test the hypothesis that evening-time southwesterly winds on the west side of Phoenix associated with the heat island may be tapping the Gulf of California (*i.e.*, acting as an important source of moisture for convection over the valley).

Mission Summary:

Takeoff Time: **0606 UTC** Landing Time: **1036 UTC**
Official Mission Duration **4.8 hr**
Number of Magnetic Tapes Used: Radar: **0** Cloud Physics: **0**
Number of Sondes Dropped: **0**



Flight track for Mission #9



Flight levels (pressure altimeter) for Mission #8

Mission 9 Summary

Monday July 30, 1990

Staffing:

P-3:	Chief Scientist:	Smull / Brandes
	Radar:	Bartels / Schuur
	Cloud Physics:	Fredrickson
	Observers:	Sanchez (Mexico), Zehnder (U of Az) McCollum (NSSL), Mathewson (NWS)
	Media:	Krolar (TV3) / Story (Arizona Republic)

Operations Center:

Mission Description:

Two-fold objectives for this mission: (1) To document the monsoon interface over the central Gulf of California, and (2) Spend any remaining flight time documenting MCS organized into meso α scale.. Cross border southbound at Mexicali, release omegadropsonde in northern Gulf, proceed to point A (29°N/113°W) and porpoise 1000-10,000 ft to point B (25.5°N/110°W), reciprocal track porpoise 8000-15,000 ft back to point A. Then with guidance from SWAMP Operations Center, use any remaining time (likely <1h) to work MCS activity in northern Mexico.

Mission Summary:

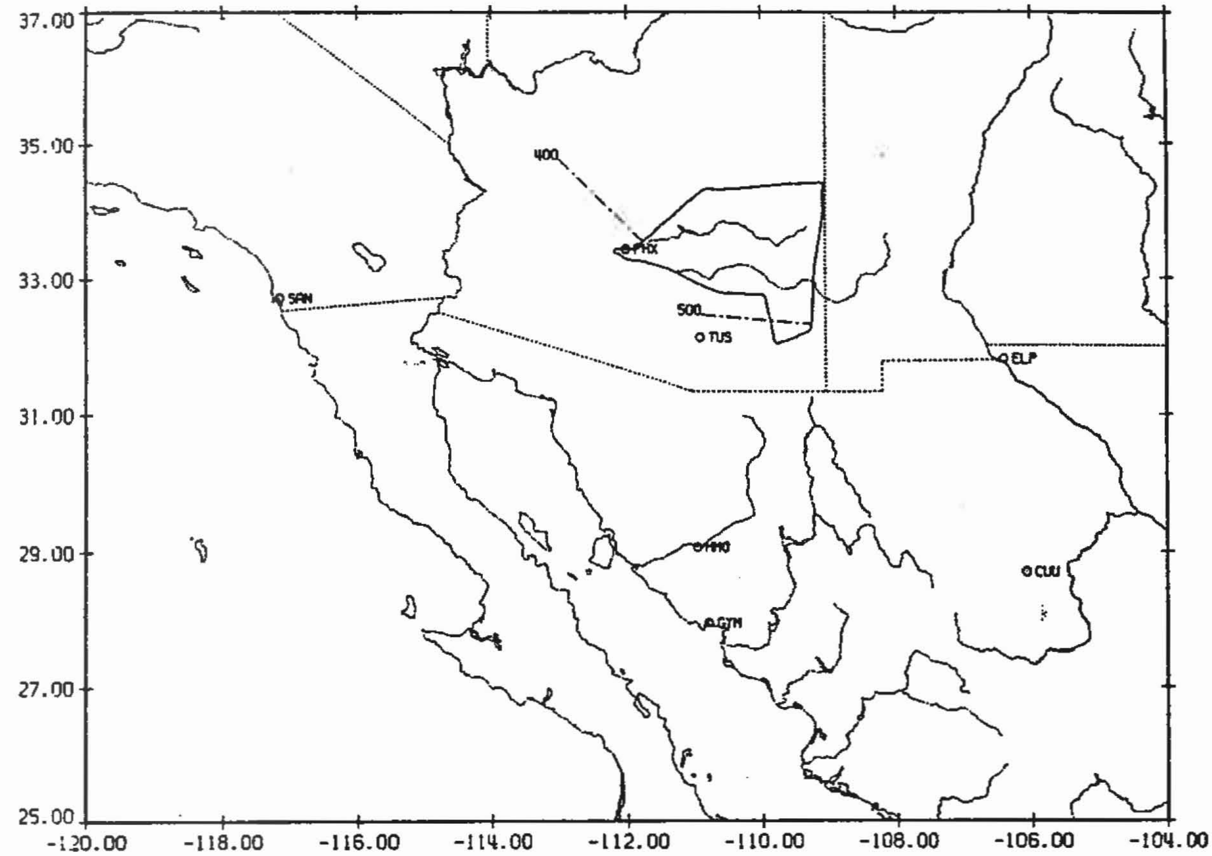
Takeoff Time: **0106 UTC** Landing Time: **0702 UTC**
Official Mission Duration **6.2 hr**
Number of Magnetic Tapes Used: Radar: **2** Cloud Physics: **0 ***
Number of Sondes Dropped: **1**

Cloud Physics Log

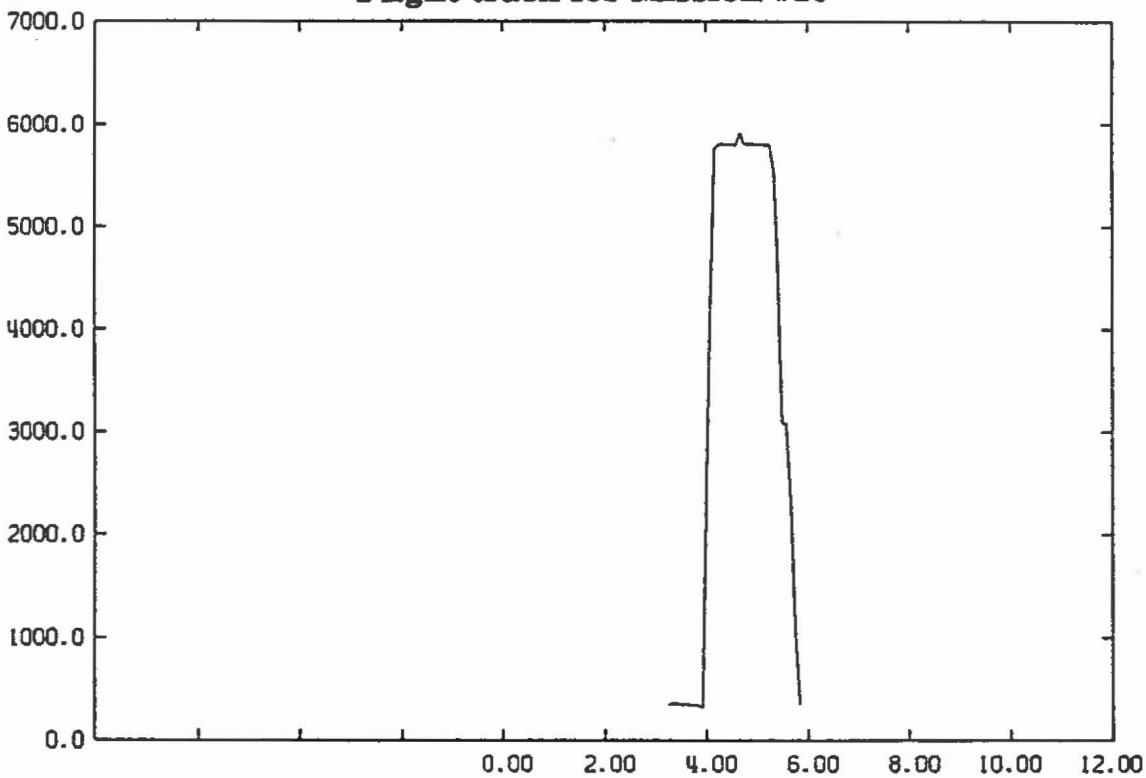
Tape #	On	Off
1	Drive Problems	

Radar Log

Tape #	On	Off
1	0110	0604
2	0604	0640



Flight track for Mission #10



Flight levels (pressure altimeter) for Mission #10

Mission 10 Summary

Tuesday July 31, 1990

Staffing:

P-3:	Chief Scientist:	Jorgensen / Smull
	Radar:	Schuur / Bartels
	Cloud Physics:	Fredrickson
	Observers:	Watts (ITSON)
	Media:	J. Stewart (2), (NBC Tucson)
Operations Center:	Meitín, Howard, Skaggs	

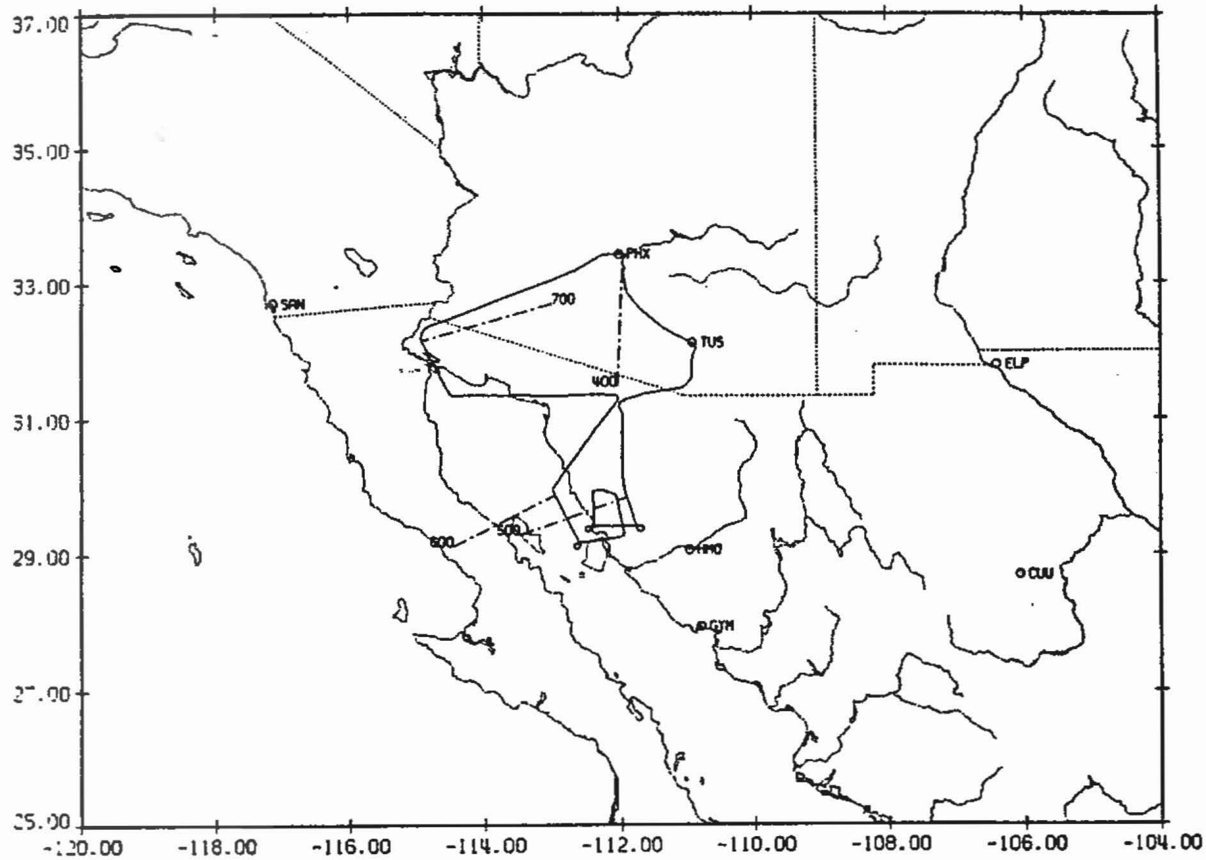
Mission Description:

Plan for central Arizona thunderstorms mission. Takeoff was delayed due to *haboob* at SkyHarbor Airport. Monitor rapidly moving MCS which generated some residual stratiform rainfall. Latter portion of flight dedicated to eastern portion of Phoenix heat island pattern.

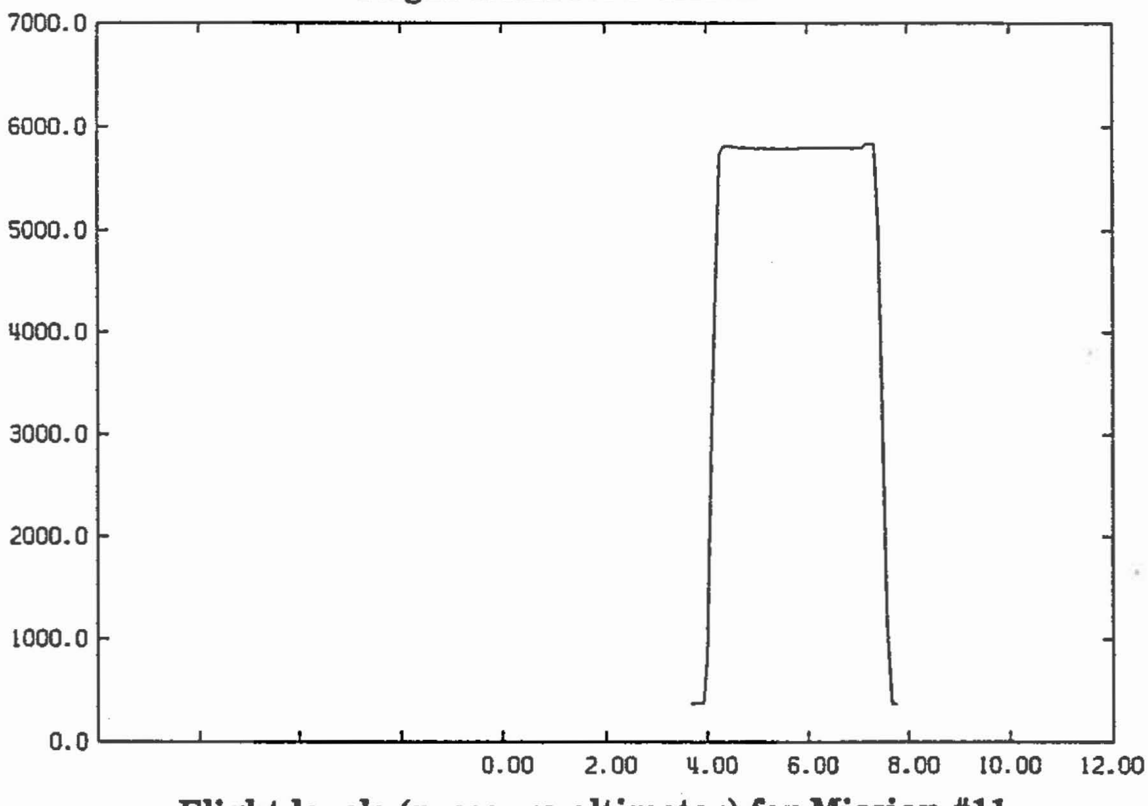
Mission Summary:

Takeoff Time: **0355 UTC** Landing Time: **0547 UTC**
Official Mission Duration **2.7 hr**
Number of Magnetic Tapes Used: Radar: **1** Cloud Physics: **0**
Number of Sondes Dropped: **0**

Cloud Physics Log			Radar Log		
Tape #	**On**	**Off**	**Tape #**	**On**	**Off**
1	System inoperative		1	0401	0527



Flight track for Mission #11



Flight levels (pressure altimeter) for Mission #11

Mission 11 Summary

Wednesday August 1, 1990

Staffing:

P-3:	Chief Scientist:	Jorgensen / Smull
	Radar:	Bartels / Schuur
	Cloud Physics:	Fredrickson
	Observers:	Stensrud, Douglas, NWS Staff
	Media:	None
Operations Center:	Meitín, Howard	

Mission Description:

Plan to monitor mesoscale system over northern Sonora by using omegadropsondes to determine the effects of MCS on the flows over the Gulf of California. Encountered some hail around southern convective line which had redeveloped along the edge of an earlier region of stratiform rainfall.

Mission Summary:

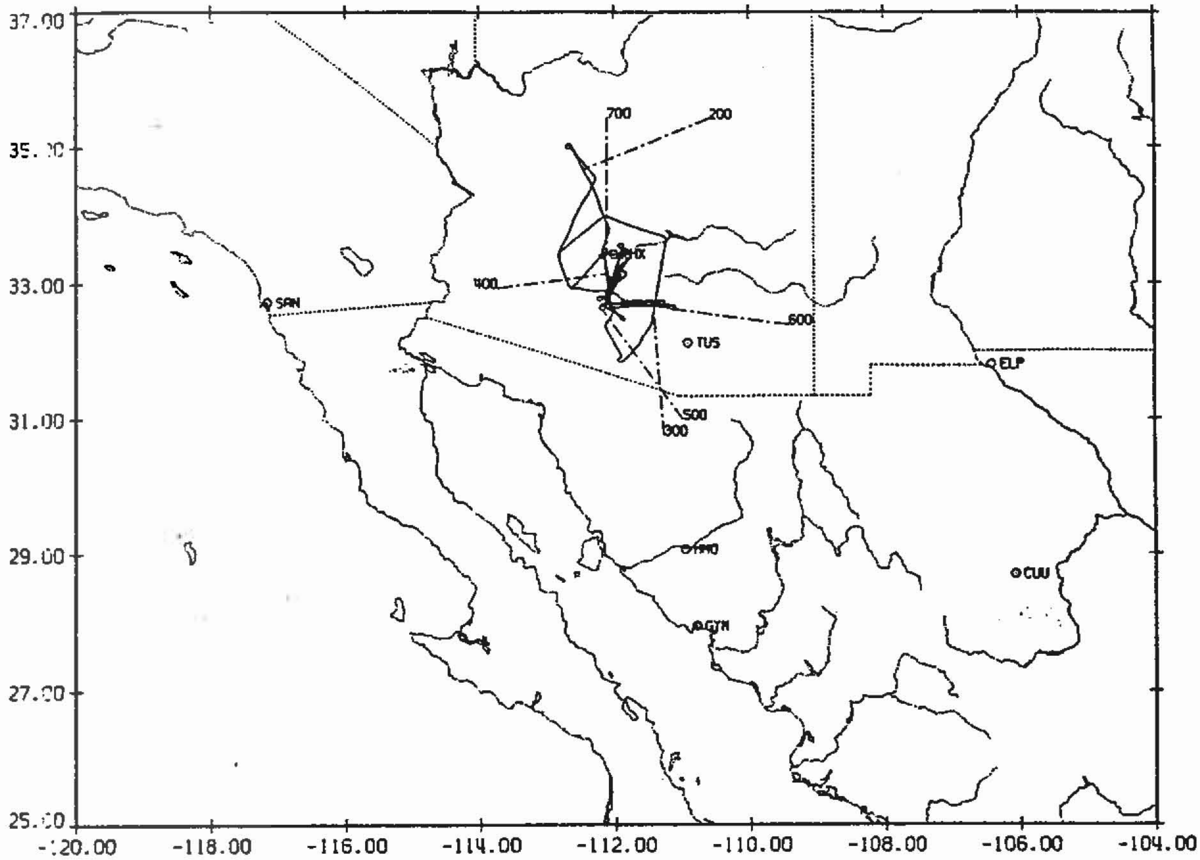
Takeoff Time: **0358 UTC** Landing Time: **0738 UTC**
Official Mission Duration **4.2 hr**
Number of Magnetic Tapes Used: Radar: **4** Cloud Physics: **6**
Number of Sondes Dropped: **3**

Cloud Physics Log

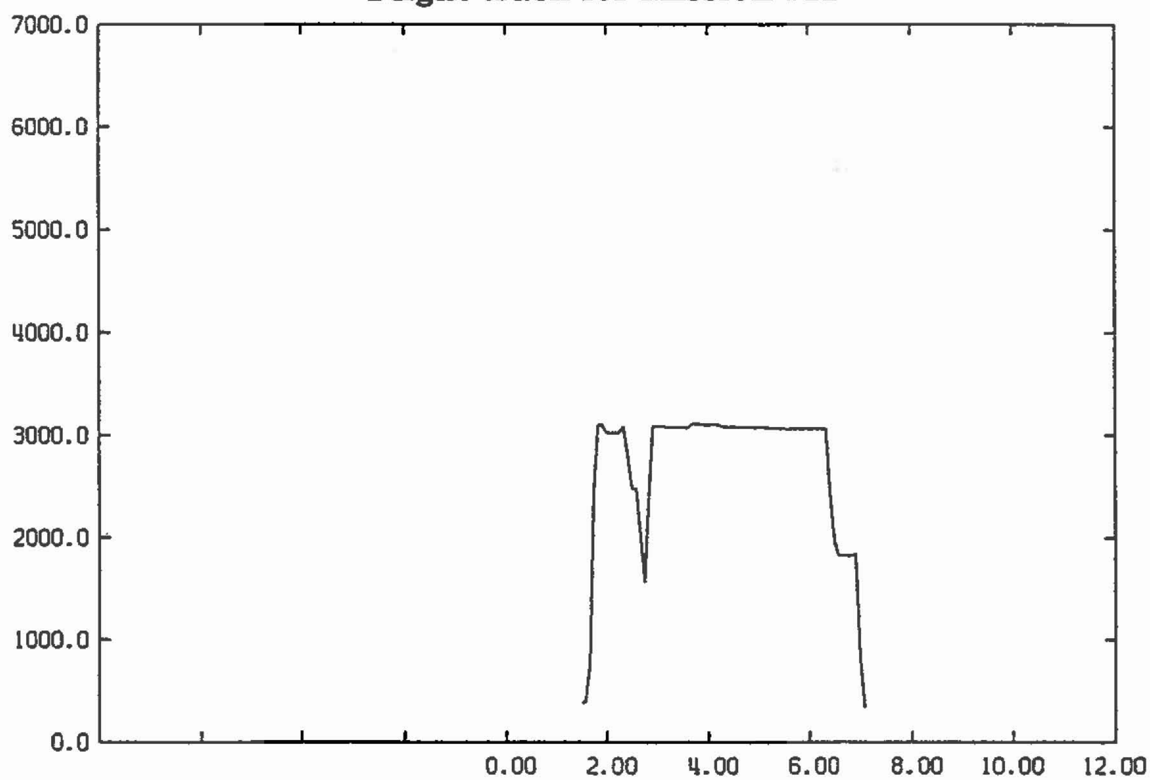
Tape #	On	Off
1	0339	0429
2	0450	0455
3	0458	0503
4	0507	0515
5	0532	0534
6	0642	0651

Radar Log

Tape #	On	Off
1	0411	0452
2	0452	0529
3	0529	0633
4	0633	0728



Flight track for Mission #12



Flight levels (pressure altimeter) for Mission #12

Mission 12 Summary

Thursday August 2, 1990

Staffing:

P-3:	Chief Scientist:	Jorgensen / Smull
	Radar:	Schuur / Bartels
	Cloud Physics:	Fredrickson
	Observers:	Sanchez (Mexico) / Stensrud / Haffer (NWS) Skindlov (SRP)
	Media:	Tyler, Dixon (Fox TV)
Operations Center:	Meitín, Howard	

Mission Description:

Began with monitoring mission over northern Arizona, in the Prescott/Flagstaff area until convection developed south of Phoenix.into a small, active line with a residual stratiform rain area.

Mission Summary:

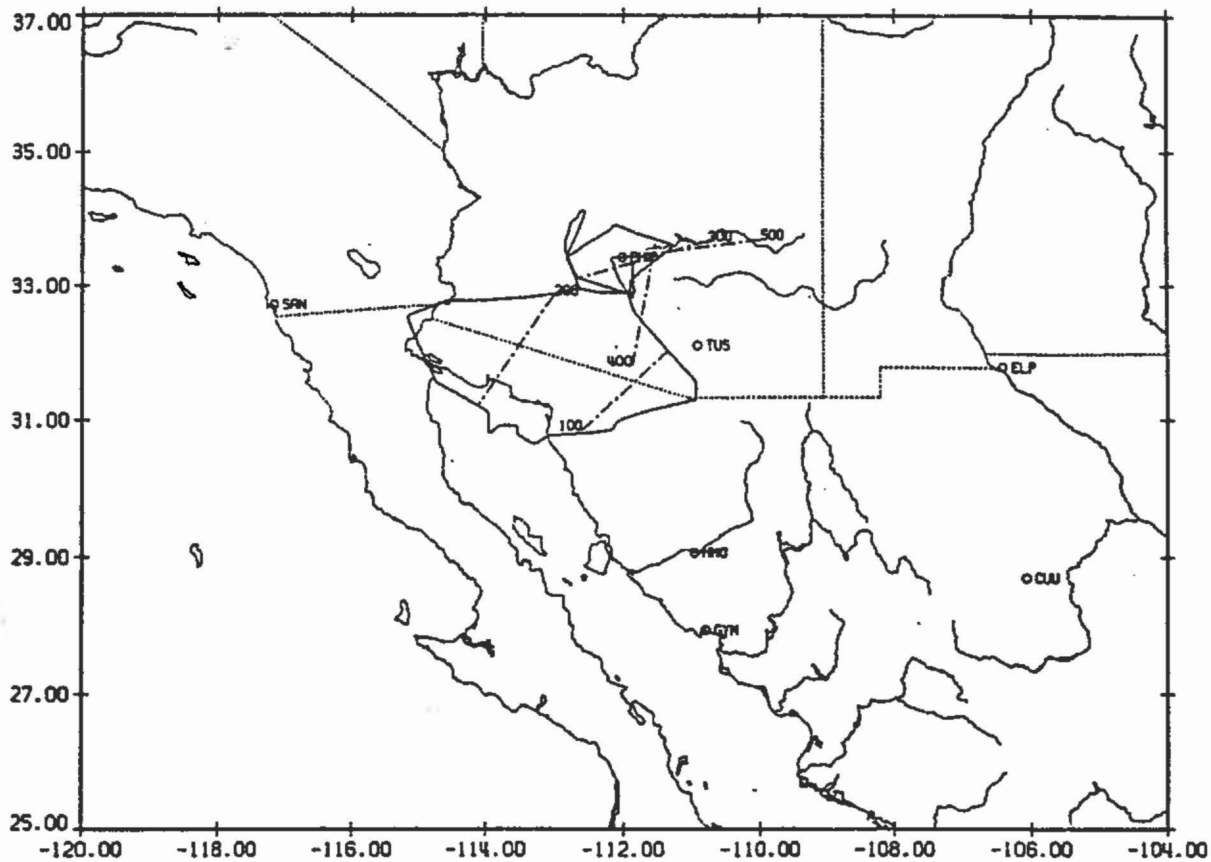
Takeoff Time: **0138 UTC** Landing Time: **0702 UTC**
Official Mission Duration **5.8 hr**
Number of Magnetic Tapes Used: Radar: **7** Cloud Physics: **1**
Number of Sondes Dropped: **0**

Cloud Physics Log

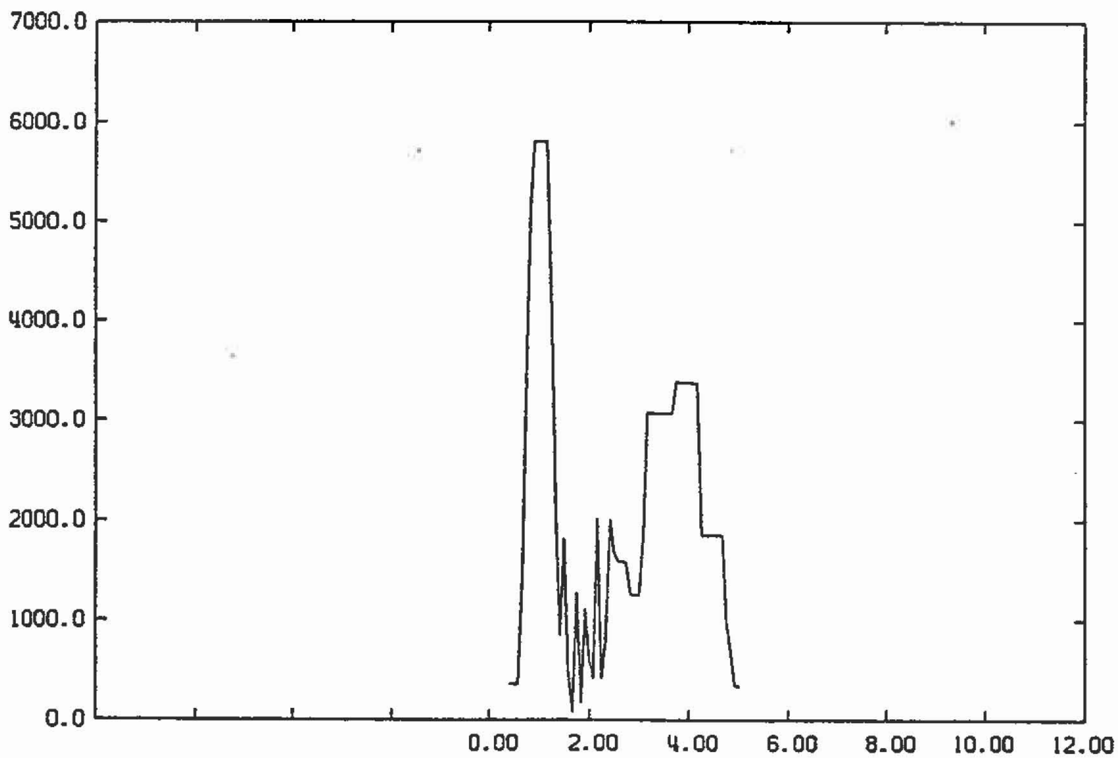
Tape #	On	Off
1	0119	0605

Radar Log

Tape #	On	Off
1	0141	0304
2	0304	0347
3	0347	0424
4	0424	0457
5	0457	0534
6	0534	0612
7	0612	0650



Flight track for Mission #13



Flight levels (pressure altimeter) for Mission #13

Mission 13 Summary

Friday August 3, 1990

Staffing:

P-3:	Chief Scientist:	Jorgensen / Smull
	Radar:	Schuur / Bartels
	Cloud Physics:	Fredrickson
	Observers:	Maddox, Douglas, Breckenridge (NWS)
	Media:	none

Operations Center: Howard, Skaggs, Meitín

Mission Description:

Plan to observe Gulf Surge / moisture structure over northern Gulf, then cross into U.S. for possible convective activity in southern Arizona.

Mission Summary:

Takeoff Time: **0036 UTC** Landing Time: **0451 UTC**
Official Mission Duration **4.7 hr**
Number of Magnetic Tapes Used: Radar: **2** Cloud Physics: **0**
Number of Sondes Dropped: **0**

Cloud Physics Log			Radar Log		
Tape #	**On**	**Off**	**Tape #**	**On**	**Off**
	none		1	0038	0316
			2	0322	0443

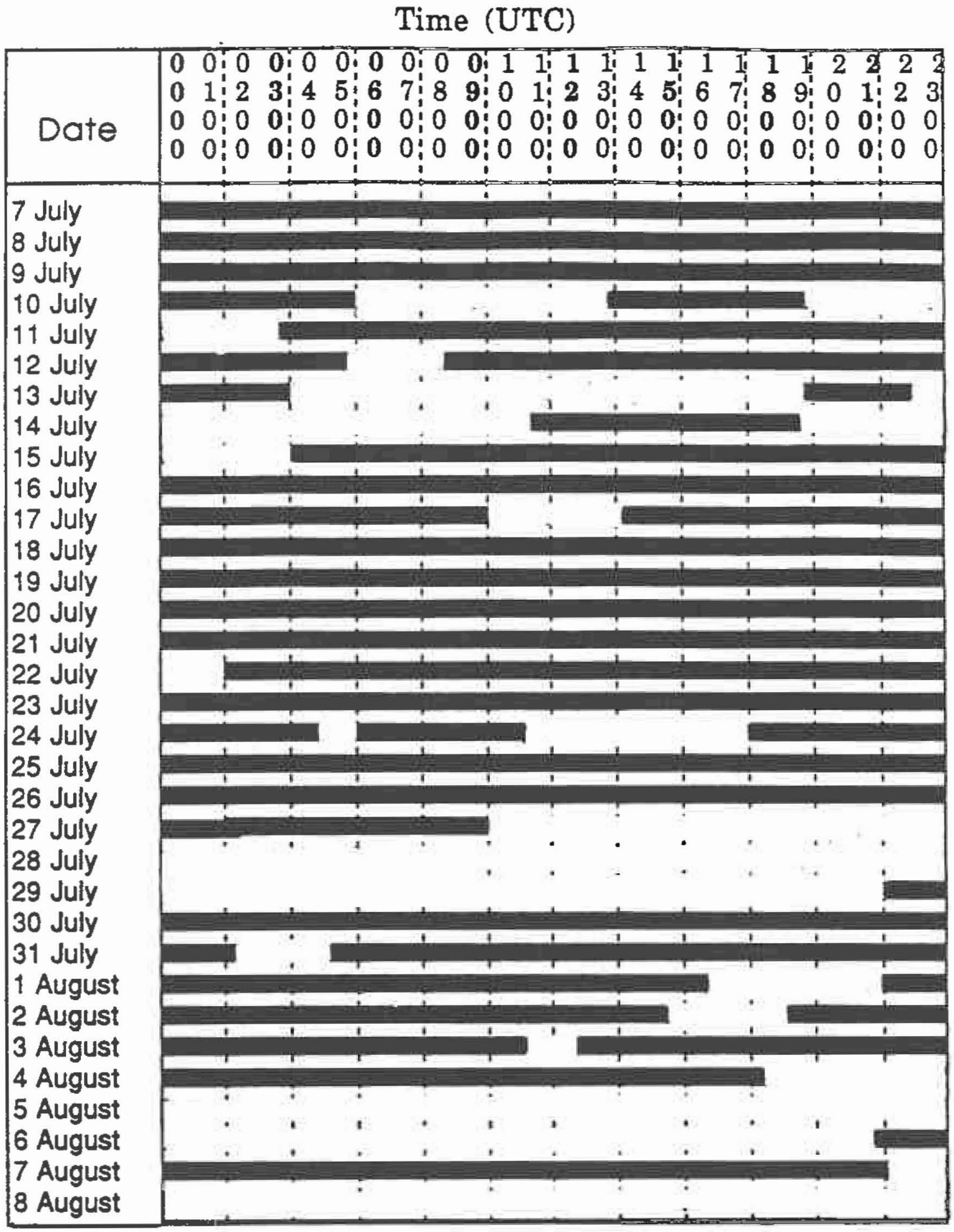
Appendix C
National Weather Service Digital Radar Data

WSR-74 digital radar

Phoenix, Arizona
33° 26.00' North, 112° 01.00' West

	Start time (UTC)		End time (UTC)	
Tape 1				
file 1	6 July 90	1438	10 July 90	0541
file 2	10 July 90	1336	10 July 90	1852
file 3	11 July 90	0315	12 July 90	0521
file 4	12 July 90	0806	13 July 90	0311
file 5	13 July 90	1932	13 July 90	2201
file 6	14 July 90	1121	14 July 90	1829
file 7	15 July 90	0402	15 July 90	1203
file 8	15 July 90	1212	15 July 90	1909
file 9	15 July 90	1931	17 July 90	0959
file 10	17 July 90	1429	22 July 90	0037
file 11	22 July 90	0203	24 July 90	0421
file 12	24 July 90	0649	24 July 90	1033
Tape 2				
file 1	24 July 90	1719	27 July 90	0937
file 2	29 July 90	2213	31 July 90	0153
file 3	31 July 90	0444	1 Aug 90	1608
file 4	1 Aug 90	2137	2 Aug 90	1459
file 5	2 Aug 90	1838	3 Aug 90	1040
file 6	3 Aug 90	1241	4 Aug 90	0344
file 7	4 Aug 90	0359	4 Aug 90	1758
file 8	6 Aug 90	2141	6 Aug 90	2311
file 9	7 Aug 90	1706	7 Aug 90	2105

Phoenix WSR-74 digital radar data inventory for SWAMP



WSR-74 digital radar

Tucson, Arizona

32° 07.20' North, 110° 53.00' West

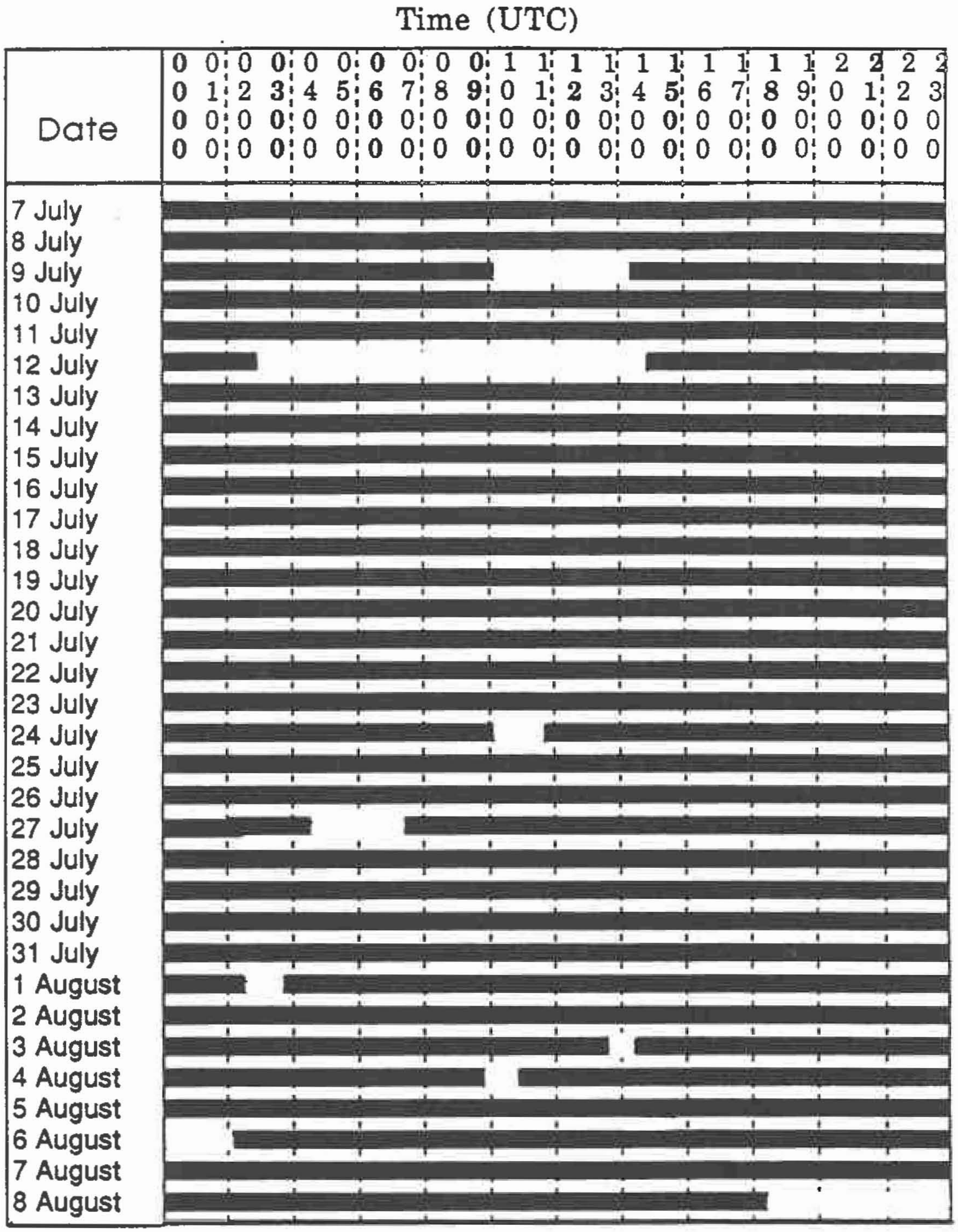
	Start time (UTC)		End time (UTC)	
Tape 1				
file 1	6 July 90	2020	9 July 90	1001
file 2	9 July 90	1416	11 July 90	0148
file 3	11 July 90	0203	11 July 90	0456
file 4	11 July 90	0519	12 July 90	0232
file 5	12 July 90	1438	13 July 90	0113
file 6	13 July 90	0134	13 July 90	0350
file 7	13 July 90	0402	14 July 90	2357
file 8	15 July 90	0011	15 July 90	0150
file 9	15 July 90	0227	17 July 90	0023
file 10	17 July 90	0032	17 July 90	1515
Tape 2				
file 1	17 July 90	1526	17 July 90	1641
file 2	17 July 90	1703	18 July 90	0407
file 3	18 July 90	0413	18 July 90	2139
file 4	18 July 90	2150	19 July 90	1602
file 5	19 July 90	1609	20 July 90	0105
file 6	20 July 90	0112	20 July 90	0506
Tape 3				
file 1	20 July 90	0512	21 July 90	0551
file 2	21 July 90	0622	23 July 90	0410
Tape 4				
file 1	23 July 90	0415	23 July 90	0756
file 2	23 July 90	0825	23 July 90	1339
file 3	23 July 90	1350	24 July 90	0859
file 4	24 July 90	1043	24 July 90	1133
file 5	24 July 90	1205	24 July 90	2106
file 6	24 July 90	2118	24 July 90	2129
file 7	24 July 90	2136	25 July 90	2101

WSR-74 digital radar

Tucson, Arizona
32° 07.20' North, 110° 53.00' West

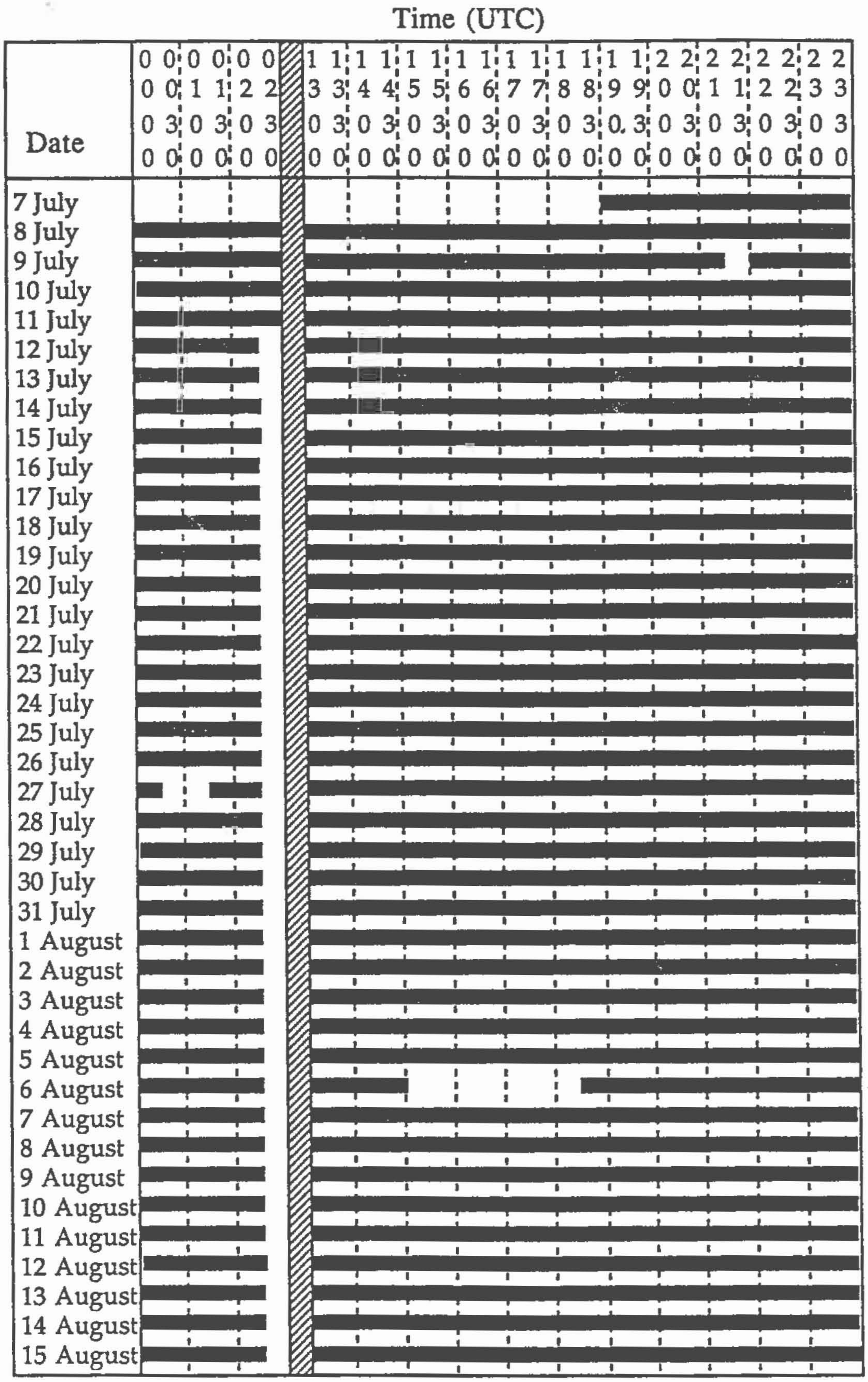
		Start time (UTC)		End time (UTC)	
Tape 5					
	file 1	25 July 90	2113	26 July 90	0838
	file 2	26 July 90	0844	27 July 90	0406
	file 3	27 July 90	0715	28 July 90	0136
	file 4	28 July 90	0145	28 July 90	1430
Tape 6					
	file 1	28 July 90	1436	29 July 90	1409
	file 2	29 July 90	1414	30 July 90	0821
	file 3	30 July 90	0828	31 July 90	0048
Tape 7					
	file 1	31 July 90	0054	1 Aug 90	0145
	file 2	1 Aug 90	0306	1 Aug 90	2209
	file 3	1 Aug 90	2223	2 Aug 90	1621
Tape 8					
	file 1	2 Aug 90	1626	2 Aug 90	1731
	file 2	2 Aug 90	1739	3 Aug 90	1240
	file 3	3 Aug 90	1405	4 Aug 90	0939
	file 4	4 Aug 90	1037	5 Aug 90	0523
	file 5	5 Aug 90	0530	5 Aug 90	0936
Tape 9					
	file 1	5 Aug 90	0942	6 Aug 90	0021
	file 2	6 Aug 90	0209	6 Aug 90	2107
	file 3	6 Aug 90	2122	7 Aug 90	1631
	file 4	7 Aug 90	1643	8 Aug 90	0135
	file 5	8 Aug 90	0202	8 Aug 90	1747

Tucson WSR-74 digital radar data inventory for SWAMP



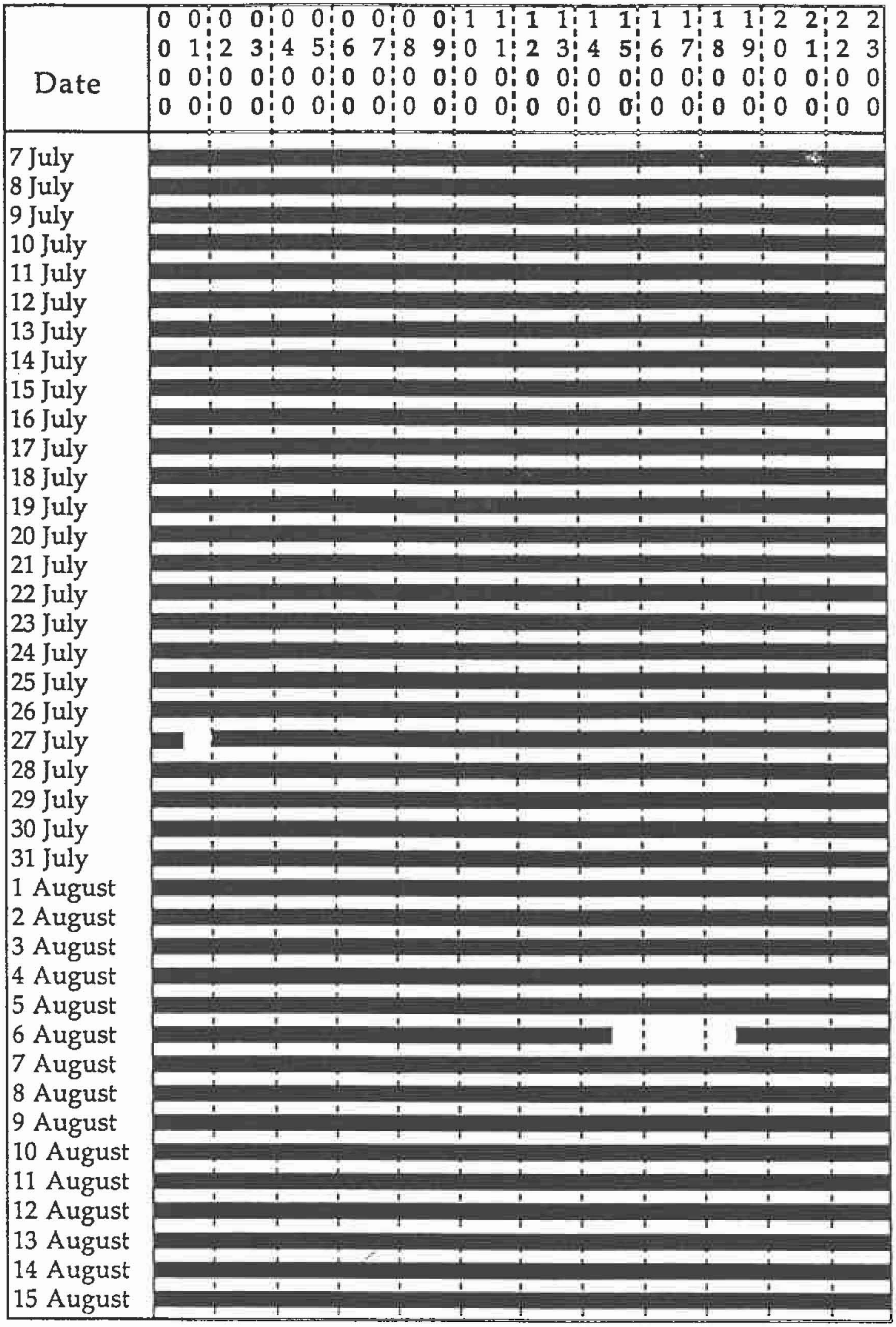
Appendix D
Digital Satellite Imagery

GOES visible data inventory for SWAMP



GOES infrared and water vapor data inventory for SWAMP

Time (UTC)



Appendix E
Upper-Air Soundings

SWAMP Upper-Air Station Network

Station Name	Station ID	Location Lat	Location Long	Station Type
Altar		30°47'N	111°43'W	PIBAL
Chihuahua	CUU	28°42'N	106°04'W	RAWIN
CICESE		Mobile		PIBAL
El Paso	ELP	31°48'N	106°24'W	RAWIN
Empalme	GYM	27°57'N	110°48'W	RAWIN
Guadalupe Isl.	ISG	28°53'N	118°18'W	RAWIN
Hermosillo	HMO	29°06'N	110°56'W	PIBAL
La Paz		24°06'N	110°23'W	PIBAL
Los Mochis		25°51'N	109°00'W	PIBAL
Mazatlan	MZT	23°12'N	106°25'W	RAWIN
NSSL2	NS2	Mobile		RAWIN
Nuevo Casas Grandes		30°26'N	107°54'W	PIBAL
Ciudad Obregón		27°27'N	109°58'W	PIBAL
Ordaz		27°23'N	113°20"W	PIBAL
Parral		26°57'N	105°37'W	PIBAL
Phoenix	PHX	32°26'N	112°01'W	RAWIN
San Diego	SAN	32°49'N	117°08'W	RAWIN
Torreon		25°23'N	103°30'W	PIBAL
Tucson	TUS	32°07'N	110°56'W	RAWIN
Winslow	INW	35°01'N	110°44'W	RAWIN
Yuma		32°35'N	114°30'W	PIBAL

Altar, Sonora
30°47'N 111°43'W
elev. 398 meters

JUL 05 0600	JUL 06 1200	JUL 06 1800	JUL 07 0000	JUL 07 0600
JUL 07 1200	JUL 07 1800	JUL 08 0000	JUL 08 1200	JUL 08 1800
JUL 09 0000	JUL 09 1200	JUL 09 1800	JUL 10 1200	JUL 10 1800
JUL 11 0000	JUL 11 1200	JUL 11 1800	JUL 12 0000	JUL 12 0600
JUL 12 1200	JUL 12 1500	JUL 12 1800	JUL 12 2100	JUL 13 0000
JUL 13 1200	JUL 13 1800	JUL 14 0000	JUL 14 1800	JUL 15 0000
JUL 16 0000	JUL 16 1200	JUL 17 0000	JUL 17 0600	JUL 17 1200
JUL 17 1800	JUL 18 0000	JUL 18 1200	JUL 18 1800	JUL 19 0000
JUL 19 1200	JUL 19 1800	JUL 20 0000	JUL 21 0000	JUL 22 0000
JUL 22 1200	JUL 22 1800	JUL 23 0000	JUL 23 1800	JUL 24 0000
JUL 24 1200	JUL 24 1800	JUL 25 0000	JUL 25 0600	JUL 25 1200
JUL 25 1800	JUL 26 0000	JUL 26 1200	JUL 26 1800	JUL 27 0000
JUL 27 0600	JUL 27 1200	JUL 27 1800	JUL 28 0000	JUL 28 1200
JUL 28 1800	JUL 29 0000	JUL 29 1200	JUL 29 1800	JUL 30 0000
JUL 30 1200	JUL 30 1800	JUL 31 0000	JUL 31 1800	AUG 01 0000
AUG 01 1200	AUG 01 1800	AUG 02 0000	AUG 02 1200	AUG 02 1800
AUG 03 0000	AUG 03 0600	AUG 03 1200	AUG 03 1800	AUG 04 0000
AUG 04 1200	AUG 04 1800	AUG 05 0000	AUG 05 1200	AUG 05 1800
AUG 06 0000	AUG 06 1200	AUG 06 1800	AUG 07 0000	AUG 07 1800
AUG 08 0000	AUG 08 1200	AUG 08 2100	AUG 09 0000	AUG 09 0300
AUG 09 0600	AUG 09 1200	AUG 09 1500	AUG 09 1800	AUG 09 2100
AUG 10 0000	AUG 10 0300	AUG 10 1800	AUG 10 2100	AUG 11 0000
AUG 11 0300	AUG 11 1800	AUG 12 0000	AUG 12 0300	AUG 12 1800
AUG 13 0000	AUG 13 0300	AUG 13 0600	AUG 15 0000	AUG 15 1500
AUG 16 1800				

Hermosillo, Sonora
29°06'N 110°56'W
elev. 200 meters

JUL 10 0000	JUL 10 1200	JUL 10 1800	JUL 11 0000	JUL 11 0600
JUL 11 1200	JUL 11 1800	JUL 12 0000	JUL 12 0300	JUL 12 0900
JUL 12 1200	JUL 12 1500	JUL 12 1800	JUL 12 2100	JUL 13 0000
JUL 13 1800	JUL 14 1200	JUL 14 1800	JUL 15 0000	JUL 15 0600
JUL 15 1800	JUL 16 0000	JUL 16 1200	JUL 16 1800	JUL 17 0000
JUL 17 1800	JUL 18 0000	JUL 18 1200	JUL 18 1800	JUL 19 0000
JUL 19 0600	JUL 19 1200	JUL 19 1800	JUL 20 0000	JUL 20 1200
JUL 20 1800	JUL 21 0000	JUL 21 0600	JUL 21 1800	JUL 22 0000
JUL 22 1200	JUL 22 1800	JUL 23 0000	JUL 23 0600	JUL 23 1200
JUL 23 1800	JUL 24 0000	JUL 24 1200	JUL 24 1800	JUL 25 0000
JUL 25 0600	JUL 25 1200	JUL 25 1800	JUL 26 0000	JUL 26 1200
JUL 26 1800	JUL 27 0000	JUL 27 0600	JUL 27 1200	JUL 27 1800
JUL 28 0000	JUL 28 1200	JUL 28 1800	JUL 29 0000	JUL 29 0600
JUL 29 1200	JUL 29 1800	JUL 30 0000	JUL 30 1200	JUL 30 1800
JUL 31 0000	JUL 31 0600	JUL 31 1200	JUL 31 1800	AUG 01 0000
AUG 01 1800	AUG 02 0000	AUG 02 0600	AUG 02 1800	AUG 03 0000
AUG 03 0600	AUG 03 1200	AUG 03 1800	AUG 04 0000	AUG 04 0600
AUG 04 1200	AUG 04 1800	AUG 05 0000	AUG 05 1200	AUG 05 1800
AUG 06 0000	AUG 06 0600	AUG 06 1200	AUG 06 1800	AUG 07 0000
AUG 07 1200	AUG 07 1800	AUG 08 0000	AUG 08 0600	AUG 08 1200
AUG 08 1800	AUG 09 0000	AUG 09 1200	AUG 09 1800	AUG 10 0000
AUG 10 0600	AUG 10 1200	AUG 10 1800	AUG 11 0000	AUG 11 1200
AUG 11 1800	AUG 12 0000	AUG 12 0600	AUG 12 1200	AUG 13 0000
AUG 13 1800	AUG 14 0000	AUG 14 0600	AUG 14 1200	AUG 15 0000
AUG 15 1800				

La Paz, Baja Calif. Sur
24°06'N 110°23'W
elev. 20 meters

JUL 10 1200	JUL 10 1800	JUL 11 1200	JUL 11 1800	JUL 12 0000
JUL 12 0600	JUL 12 1800	JUL 12 2100	JUL 13 0000	JUL 13 0300
JUL 13 0600	JUL 13 1200	JUL 13 1800	JUL 14 0000	JUL 14 0600
JUL 14 1200	JUL 14 1800	JUL 15 0000	JUL 15 1200	JUL 15 1800
JUL 16 0000	JUL 16 0600	JUL 16 1200	JUL 16 1800	JUL 17 0000
JUL 17 1200	JUL 17 1800	JUL 18 0000	JUL 18 0600	JUL 18 1200
JUL 18 1800	JUL 19 0000	JUL 19 1200	JUL 19 1800	JUL 20 0000
JUL 20 0600	JUL 20 1200	JUL 20 1800	JUL 21 0000	JUL 21 1200
JUL 21 1800	JUL 22 0000	JUL 22 0600	JUL 22 1200	JUL 22 1800
JUL 23 0000	JUL 23 1200	JUL 23 1800	JUL 24 0000	JUL 24 0600
JUL 24 1200	JUL 24 1800	JUL 25 0000	JUL 25 1200	JUL 25 1800
JUL 26 0000	JUL 26 0600	JUL 26 1200	JUL 26 1800	JUL 27 0000
JUL 27 1200	JUL 27 1800	JUL 28 0000	JUL 28 0600	JUL 28 1200
JUL 28 1800	JUL 29 0000	JUL 29 1200	JUL 29 1800	JUL 30 0000
JUL 30 0600	JUL 30 1200	JUL 30 1800	JUL 31 0000	JUL 31 1200
JUL 31 1800	AUG 01 0000	AUG 01 0600	AUG 01 1200	AUG 01 1800
AUG 02 0000	AUG 02 1200	AUG 02 1800	AUG 03 0000	AUG 03 0600
AUG 03 1200	AUG 03 1800	AUG 04 0000	AUG 04 0600	AUG 04 1200
AUG 04 1800	AUG 05 0000	AUG 05 0600	AUG 05 1200	AUG 05 1800
AUG 06 0000	AUG 06 1200	AUG 06 1800	AUG 07 0000	AUG 07 0600
AUG 07 1200	AUG 07 1800	AUG 08 0000	AUG 08 1200	AUG 08 1800
AUG 09 0000	AUG 09 0600	AUG 09 1200	AUG 09 1800	AUG 10 0000
AUG 10 1200	AUG 11 1200	AUG 11 1800	AUG 12 0000	AUG 12 1200
AUG 12 1800	AUG 13 0000	AUG 13 1200	AUG 13 1800	AUG 14 0000
AUG 14 1200	AUG 14 1800	AUG 15 0000	AUG 15 1200	AUG 15 1800
AUG 16 0000				

Los Mochis, Sonora
25°51'N 109·00'W
elev. 24 meters

JUL 09 1800	JUL 10 0000	JUL 10 0600	JUL 10 1800	JUL 11 0000
JUL 11 1200	JUL 11 1800	JUL 12 0000	JUL 12 0900	JUL 12 1200
JUL 12 1800	JUL 12 2100	JUL 13 0000	JUL 13 0300	JUL 13 0600
JUL 13 1200	JUL 13 1800	JUL 14 0000	JUL 14 1800	JUL 15 0000
JUL 15 0600	JUL 15 1200	JUL 15 1800	JUL 16 0000	JUL 16 1200
JUL 16 1800	JUL 17 0000	JUL 17 0600	JUL 17 1200	JUL 18 0000
JUL 18 1800	JUL 19 1200	JUL 20 0000	JUL 20 1200	JUL 20 1800
JUL 21 0000	JUL 21 0600	JUL 21 1200	JUL 21 1800	JUL 22 0000
JUL 22 1200	JUL 23 1800	JUL 24 0000	JUL 24 1200	JUL 24 1800
JUL 25 0000	JUL 25 1230	JUL 25 1800	JUL 26 0000	JUL 26 1230
JUL 26 1800	JUL 27 0000	JUL 27 1300	JUL 27 1800	JUL 28 0000
JUL 28 1230	JUL 28 1800	JUL 29 0000	JUL 29 1240	JUL 29 1800
JUL 30 0000	JUL 30 1230	JUL 30 1800	JUL 31 0000	JUL 31 1240
JUL 31 1800	AUG 01 0000	AUG 01 1200	AUG 01 1800	AUG 02 0000
AUG 02 1250	AUG 02 1800	AUG 03 0000	AUG 03 1250	AUG 03 1500
AUG 03 1800	AUG 03 2100	AUG 04 0000	AUG 04 1230	AUG 05 0000
AUG 05 1800	AUG 06 0000	AUG 06 1245	AUG 06 1800	AUG 07 0000
AUG 07 1255	AUG 07 1800	AUG 08 0000	AUG 08 1230	AUG 08 1800
AUG 09 0000	AUG 09 1300	AUG 10 0000	AUG 10 1245	AUG 10 1800
AUG 11 1230	AUG 11 1800	AUG 12 0000	AUG 12 1800	AUG 13 0000
AUG 13 1230	AUG 13 1800	AUG 14 0000	AUG 14 1800	AUG 15 0000
AUG 15 1245	AUG 15 1800			

N. Casas Grandes, Chihuahua
30°26'N 107°54'W
elev. 1478 meters

JUL 25 1200	JUL 25 1800	JUL 26 0000	JUL 26 1200	JUL 26 1800
JUL 27 0000	JUL 27 1200	JUL 27 1800	JUL 28 0000	JUL 28 1200
JUL 28 1800	JUL 29 0000	JUL 29 1200	JUL 29 1800	JUL 30 0000
JUL 30 0600	JUL 30 1200	JUL 30 1800	JUL 31 0000	JUL 31 0600
JUL 31 1200	JUL 31 1800	AUG 01 0000	AUG 01 0600	AUG 01 1200
AUG 01 1800	AUG 02 0000	AUG 02 0600	AUG 02 1200	AUG 02 1800
AUG 03 0000	AUG 03 0600	AUG 03 0900	AUG 03 1200	AUG 03 1800
AUG 04 0000	AUG 04 0600	AUG 04 1200	AUG 04 1800	AUG 05 0000
AUG 05 1800	AUG 06 1200	AUG 07 1800	AUG 08 0000	AUG 08 0600
AUG 08 1200	AUG 08 1800	AUG 09 0000	AUG 09 0600	AUG 09 1200
AUG 09 1800	AUG 10 0000	AUG 10 0600	AUG 10 1200	AUG 10 1800
AUG 11 0000	AUG 11 0600	AUG 11 1200	AUG 11 1800	AUG 12 0000
AUG 13 0000	AUG 13 1800	AUG 14 0000	AUG 14 1200	AUG 14 1800
AUG 15 0000	AUG 15 1200	AUG 15 1800	AUG 16 0000	

Ciudad Obregón, Sonora
27°27'N 109°58'W
elev 70 meters

JUL 10 1242	JUL 10 1756	JUL 10 2415	JUL 11 1440	JUL 11 1818
JUL 12 0052	JUL 12 0633	JUL 12 0917	JUL 12 1234	JUL 12 1512
JUL 12 1810	JUL 12 2115	JUL 13 0000	JUL 13 0558	JUL 13 1816
JUL 14 0011	JUL 14 0610	JUL 14 1244	JUL 14 1800	JUL 15 0000
JUL 15 1257	JUL 16 1815	JUL 17 0000	JUL 17 1250	JUL 17 1815
JUL 18 0007	JUL 18 1200	JUL 18 1800	JUL 19 0000	JUL 19 1250
JUL 19 1900	JUL 20 0000	JUL 20 0610	JUL 20 1200	JUL 20 1800
JUL 21 0002	JUL 21 1200	JUL 21 1835	JUL 22 0021	JUL 22 0600
JUL 22 1845	JUL 23 1250	JUL 23 0000	JUL 24 0600	JUL 25 0010
JUL 25 1200	JUL 25 1800	JUL 26 0006	JUL 26 0620	JUL 26 1200
JUL 26 1805	JUL 27 0005	JUL 27 1200	JUL 27 1815	JUL 27 1855
JUL 28 0600	JUL 28 1200	JUL 28 1800	JUL 29 0035	JUL 29 1800
JUL 30 0000	JUL 30 0600	JUL 30 1200	JUL 30 1800	JUL 30 1830
JUL 31 1244	JUL 31 1800	AUG 01 0600	AUG 01 1200	AUG 01 1820
AUG 02 1245	AUG 02 1800	AUG 03 0000	AUG 03 0600	AUG 03 0900
AUG 03 1200	AUG 03 1500	AUG 03 1810	AUG 03 2058	AUG 04 0008
AUG 04 0300	AUG 04 0600	AUG 04 1240	AUG 04 1808	AUG 05 0610
AUG 05 1330	AUG 05 1800	AUG 06 0007	AUG 06 1245	AUG 06 1800
AUG 07 0000	AUG 07 0600	AUG 07 1252	AUG 07 1840	AUG 08 0000
AUG 08 1054	AUG 08 1254	AUG 08 1830	AUG 09 0022	AUG 09 0600
AUG 09 1245	AUG 09 1820	AUG 10 0013	AUG 10 1255	AUG 10 1813
AUG 11 1845	AUG 12 0030	AUG 12 1430	AUG 12 1800	AUG 13 0015
AUG 13 0600	AUG 13 1200	AUG 13 1807	AUG 14 0046	AUG 14 1250
AUG 14 1800	AUG 15 0015	AUG 15 0600	AUG 15 1200	AUG 15 1800
AUG 16 0000				

Ordaz, Baja Calif Sur
27°20'N 113°20'W
elev. 70 meters

JUL 11 0600	JUL 11 1800	JUL 12 0000	JUL 12 0300	JUL 12 0600
JUL 12 0900	JUL 12 1200	JUL 12 1500	JUL 12 1800	JUL 12 2100
JUL 13 0000	JUL 13 0300	JUL 13 1200	JUL 13 1800	JUL 14 0000
JUL 14 0600	JUL 14 1200	JUL 14 1800	JUL 15 0000	JUL 15 0600
JUL 15 1200	JUL 15 1800	JUL 16 0000	JUL 16 1200	JUL 16 1800
JUL 17 0000	JUL 17 0600	JUL 17 1200	JUL 17 1800	JUL 18 0000
JUL 18 0600	JUL 18 1200	JUL 18 1800	JUL 19 0000	JUL 19 0600
JUL 19 1200	JUL 19 1800	JUL 20 0000	JUL 20 0600	JUL 20 1200
JUL 20 1800	JUL 21 0000	JUL 21 1200	JUL 21 1800	JUL 22 0000
JUL 22 1200	JUL 22 1800	JUL 23 0000	JUL 23 0600	JUL 23 1200
JUL 23 1800	JUL 24 0000	JUL 24 1200	JUL 24 1800	JUL 25 0000
JUL 25 0600	JUL 25 1200	JUL 25 1800	JUL 26 0000	JUL 26 1200
JUL 26 1800	JUL 27 0000	JUL 27 0600	JUL 27 1200	JUL 27 1800
JUL 28 0000	JUL 28 1800	JUL 29 0000	JUL 29 0600	JUL 29 1200
JUL 29 1800	JUL 30 0000	JUL 30 1200	JUL 30 1800	JUL 31 0000
JUL 31 0600	JUL 31 1200	JUL 31 1800	AUG 01 0000	AUG 01 1200
AUG 01 1800	AUG 02 0000	AUG 02 0600	AUG 02 1200	AUG 02 1800
AUG 03 0000	AUG 03 0600	AUG 03 1200	AUG 03 1800	AUG 04 0000
AUG 04 0600	AUG 04 1200	AUG 04 1800	AUG 05 0000	AUG 05 1200
AUG 05 1800	AUG 06 0000	AUG 06 0600	AUG 06 1800	AUG 07 0000
AUG 07 1200	AUG 07 1800	AUG 08 0000	AUG 08 1200	AUG 08 1800
AUG 09 0000	AUG 09 1800	AUG 10 0000	AUG 10 1200	AUG 10 1800
AUG 11 0000	AUG 11 1200	AUG 11 1800	AUG 12 0000	AUG 12 1200
AUG 12 1800	AUG 13 0000	AUG 13 1800	AUG 14 0000	AUG 14 1200
AUG 14 1800	AUG 15 0000			

Hidalgo del Parral, Chihuahua
26°57'N 105°37'W
elev. 1744 meters

JUL 26 0000	JUL 28 0000	JUL 28 1200	JUL 28 1800	JUL 30 1800
JUL 31 0000	JUL 31 1800	AUG 01 0000	AUG 01 0600	AUG 01 1200
AUG 02 0600	AUG 02 1200	AUG 02 1800	AUG 03 0000	AUG 04 0000
AUG 04 1200	AUG 04 1800	AUG 05 0000	AUG 06 0000	AUG 06 1200
AUG 06 1800	AUG 07 0000	AUG 07 1200	AUG 07 1800	AUG 08 0000
AUG 08 0600	AUG 08 1800	AUG 09 0000	AUG 09 1200	AUG 09 1800
AUG 10 0600	AUG 10 1800	AUG 11 0000	AUG 11 1800	AUG 12 0600
AUG 12 1800	AUG 13 0000	AUG 13 0600	AUG 13 1200	AUG 13 1800
AUG 14 0600	AUG 14 1200	AUG 14 1800	AUG 15 0000	AUG 15 0600
AUG 15 1200	AUG 15 1800			

Torreon, Coahuila
25°23'N 103°30'W
elev. 1123 meters

JUL 20 1800	JUL 21 0000	JUL 21 1200	JUL 21 1800	JUL 22 0000
JUL 22 1200	JUL 22 1800	JUL 23 0000	JUL 23 1200	JUL 23 1800
JUL 24 0000	JUL 24 1800	JUL 25 0000	JUL 25 1200	JUL 25 1800
JUL 26 1800	JUL 27 0000	JUL 27 1800	JUL 28 0000	JUL 28 1200
JUL 28 1800	JUL 29 0000	JUL 30 1800	JUL 31 0000	JUL 31 1200
JUL 31 1800	AUG 01 0000	AUG 01 1200	AUG 01 1800	AUG 02 0000
AUG 02 1200	AUG 02 1800	AUG 03 0000	AUG 03 1200	AUG 03 1800
AUG 04 0000	AUG 04 0600	AUG 04 1200	AUG 04 1800	AUG 05 0000
AUG 05 1200	AUG 05 1800	AUG 06 0000	AUG 06 1200	AUG 06 1800
AUG 07 0000	AUG 07 1200	AUG 07 1800	AUG 08 0000	AUG 08 1800
AUG 09 0000	AUG 09 1200	AUG 09 1800	AUG 10 0000	AUG 10 1200
AUG 10 1800	AUG 11 0000	AUG 11 1200	AUG 11 1800	AUG 12 0000
AUG 12 1200	AUG 12 1800	AUG 13 0000	AUG 13 1200	AUG 13 1800

Yuma, Arizona
32°35'N 114°30'W
elev. 40 meters

JUL 09 1200	JUL 10 0000	JUL 10 1200	JUL 11 0000	JUL 11 1200
JUL 12 0000	JUL 12 1200	JUL 13 0000	JUL 13 1200	JUL 14 0000
JUL 14 1200	JUL 15 0000	JUL 15 1200	JUL 16 0000	JUL 16 1200
JUL 17 0000	JUL 17 1200	JUL 18 0000	JUL 18 1200	JUL 19 0000
JUL 19 1200	JUL 20 0000	JUL 20 1200	JUL 21 0000	JUL 21 1200
JUL 21 2100	JUL 22 0000	JUL 22 1200	JUL 23 1200	JUL 24 0000
JUL 24 1200	JUL 25 0000	JUL 25 1200	JUL 26 0000	JUL 26 1200
JUL 27 0000	JUL 27 1200	JUL 28 0000	JUL 28 1200	JUL 29 0000
JUL 29 1200	JUL 30 0000	JUL 30 1200	JUL 31 0000	JUL 31 1200
AUG 01 0000	AUG 01 1200	AUG 02 0000	AUG 02 1200	AUG 03 0000
AUG 04 0000	AUG 06 0000	AUG 06 1200		

JUL 06 1990

Mr. Norman Hoffman, Swamp Project Coordinator
National Weather Service
2633 E. Buckeye Road
Phoenix, Arizona 85034

Dear Mr. Hoffman:

Thank you for your information concerning the Southwest Area Monsoon Project, SWAMP. As we discussed by phone, we are interested in having staff attend your 11:00 AM briefing sessions during this monsoon season.

Briefing attendance will better inform us as to daily climatic conditions and alert our staff to possible flood warning situations within Maricopa County. Advance storm information will also be useful by allowing us time to send teams to measure real time discharges on County watersheds.

I understand that the possibility also exists that extra seating may be available on the aircraft which will be flying the SWAMP missions. I would like to request that a space for a Flood Control District staff member be added to your list of additional interested parties for these flights. Please notify Joe Rumman or Dave Johnson at 262-1501 if a vacancy is available so they can notify interested staff. I assume that there may be little advance notice with regards to vacant seats, however the opportunity to fly one of these missions would be greatly appreciated. As suggested I will also contact Jose Meitin next week regarding the flight schedule.

Thank you for your attention in this matter and I look forward to meeting you in the near future.

Sincerely,

Carol H. Davis
Hydrologist

Coor: ~~JMR~~
Info: DR ~~AMM~~ JT RWC

File: CHD

FLOOD CONTROL DISTRICT
of
Maricopa County

3335 West Durango Street • Phoenix, Arizona 85009
Telephone (602) 262-1501

D. E. Sagramoso, P.E., Chief Engineer and General Manager

AUG 08 1990

Mr. Jon A. Skindlov
Salt River Project
Water Resource Operations Services
P.O. Box 52025
Phoenix, Arizona 85072-2025

Dear Mr. Skindlov:

Thank you for stopping by. Enclosed is a list of our telemetry rain gauges and their approximate locations. Since we last spoke, we have installed four additional sites which are not shown. Three of the new gauges are located within the foothills of the McDowell Mountains and the fourth will be at 35th Avenue and Baseline Road. If you would like any additional information, please call me at 262-1501.

Sincerely,

Carol H. Davis
Hydrologist

Enclosure

CHD/eal

Info: JMR

File: Hydrology (CHD)

FLOOD CONTROL DISTRICT
of
Maricopa County

3335 West Durango Street • Phoenix, Arizona 85009
Telephone (602) 262-1501

D. E. Sagramoso, P.E., Chief Engineer and General Manager

AUG 08 1990

Mr. Sherman Fredrickson
National Severe Storms Lab
1313 Halley Circle
Norman, Oklahoma 73069

Dear Mr. Fredrickson:

Thank you for taking the time to visit the Flood Control District. Enclosed you will find a list of our telemetry rain gauges and their approximate locations. Since your visit, we have installed four additional gauges which are not on this list. Three are located northeast of Phoenix in the foothills of the McDowell Mountains and the fourth is located near our office at 35th Avenue and Baseline Road. If you have any questions, please call me at (602) 262-1501.

Sincerely,

Carol H. Davis
Hydrologist

Enclosure

CHD/eal

Info: JMB

File: Hydrology (CHD)

Kevin Stewart \ Denver Flood Control & Urban
Ben Urbanos * / 1-303 455-6277

Received basic standard IGA fr. USGS
Tied conditions to IGA w/a letter
USGS good for data collection but not analysis.
- Alot of their data was not clean
USGS was sloppy w/data collection & maintenance
- Make sure you verify data on regular basis
because once it is published its all over
- Began to put IGA together in 1969
was not completed until 1971
- Out of 30 sites only 6 had clean reliable
data
CLEAN defined: no irrigation, latterals
or good controls
+ They suggest for Urban Watershed 1 gauge
per square mile.

~~Rainfall~~

Average annual rainfall for Maricopa County is

Recorded Telemetry Rainfall

Rainfall ~~[illegible]~~ Table 1.
* Data recorded from FCD telemetry gauges

7/24	Paradise Valley	2.25"	4 hrs
7/24	Dreamy Draw Dam	2.01"	4 hrs
8/14	Skunk Creek East I-17	2.40"	2.0 hr.
8/15	Adobe Dam	2.64"	2.5 hr
8/14	King's Ranch	2.09	2hr
8/14	Magma FRS	1.97	good
8/14	Buckeye FRS 1	2.20	good
8/15	South Mountain Pk	2.05	good
9/3	New River Dam	3.39"	14 hrs
9/3	New River Glendale	2.33"	6 hrs
9/3	New River Bell	2.95	12 hrs
9/3	Bloody Basin	2.05	6 hr
9/3	ACDC, 67th Ave	3.50"	3 hr good

Monsoon 90
Rainfall Data

July 24, Gauge # 6629 (McKellips TBW) stage showed a peak reading on July 24th at 0900 of 3.5'

New River at Glendale aug 14-15 showed approx 24 hour rainfall of 4.17
2.72
1.45"

Peak stage New River at Glendale (#1523 gauge) of
3.6' at 1200 on 8/15
4.0 at 1600 on 8/14

— For Laveen Rainfall
Holly Acres 8/14-15 = 1.38"
.47"
.91"

Agua Fria @ Buckeye 8/14-15 = 5.12"
− 4.65"
.47"

— FCD aug 14 & 15 3.90
− 1.20
2.88
+ .20
3.08

ACDC 67th Ave on 8/15/90
Rainfall - #1510 recorded 1.97 TOTAL for storm
Approximate flow

#1520 New River Glendale Sept. 4+3 precip Total 6.50 / 4.17 / 2.33" — Stage 1523 - 6.7' on 3rd
#1530 New River at Bell Sept. 4+3 precip Total 6.02 / − 3.07 / 2.95" — 1533 STAGE 4.1' 3rd

2630	8/14	Skunk Ck East I-17	2.72	2hrs	65
2650	8/15	Adobe Dam	2.64	2.5 hrs	
1510	9/3	ACDC 67th Ave	3.50	3 hrs	
1625	8/14	Buckeye FRS	2.20		
	8/15	S. Mt. Park			

2.82
2.49
.33

2.82
2.72
.10

100
50
50

100
4

2.82
2.64
.18

2.82
2.49
.33

100
50
50

2.82
2.49
.33

100
50
50

2.82
2.72
.10

Refer:

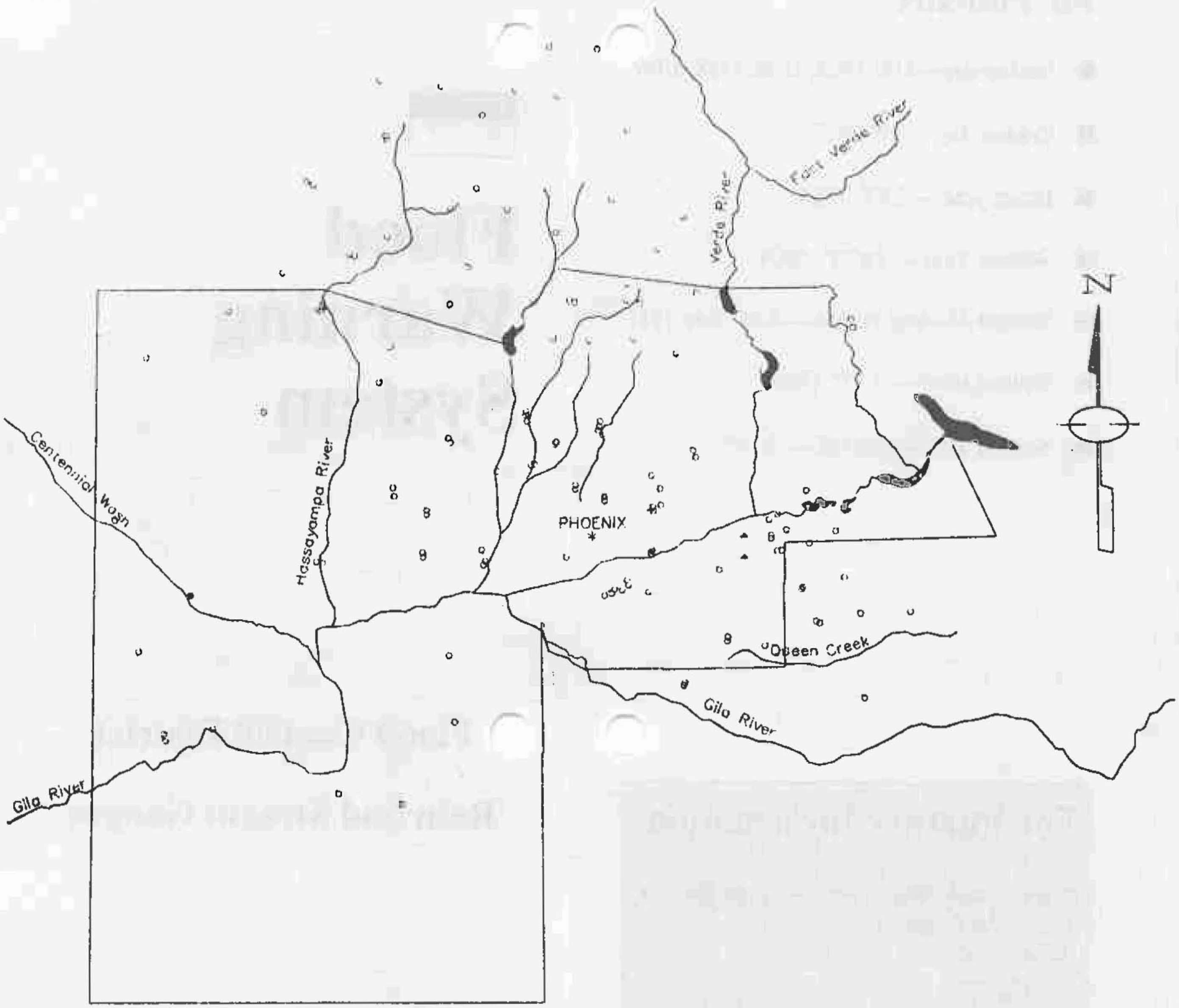
'AZ CLIMATE SUMMARY' VOL. 17, NUMBER 04 SEPT, 1990
OFFICE OF THE STATE CLIMATOLOGIST
DEPT. OF GEOGRAPHY, ASU, TEMPE, AZ 85287-1508

'WEEKLY CLIMATE BULLETIN', CLIMATE ANALYSIS CENTER
UNITED STATES DEPT. COMMERCE
NATIONAL WEATHER SERVICE - NATIONAL METEORLOGICAL CENTER
- NO. 90/36, Sept. 8, 1990
- NO. 90/33, August 18, 1990

'AZ Water Supply Outlook, Oct. 22, 1990'
Soil Conservation Service
US Department of Agriculture
201 E. Indianola Ave, Suite 200
Phoenix, Arizona 85012

Maricopa County Department of Civil Defense and Emergency Services
'AFTER-ACTION REPORT'
Storm/Floods - Summer 1990

Satellite Imagery from the Geostationary Operational Earth Satellite (GOES) Data Collection System



Telemetered Gauge Locations

Flood Warning System

The District's flood warning system provides current, or "real time," information about rainfall and runoff in Maricopa County.

The telemetered rain and stream gauges send information via radio waves to computers at the Flood Control District and the National Weather Service.

The District uses the information to monitor the conditions at our dams and channels to provide for their safe operation.

The Weather Service uses this information to put out its flash flood warnings and advisories. The Maricopa Water District uses the information for the operation of Waddell Dam.

The system is especially valuable after a storm. The computer data can be used to reconstruct the storm to show the origin of problems, help with design of future flood control sturctures, and provide records for other analyses. The data is also used to calibrate computer models of the watershed and floodplain delineation studies. The District shares this information with other agencies.

By the end of 1990, the District will have approximately 123 telemetered rain gauges and 47 telemetered stream gauges in Maricopa and neighboring counties.

Volunteers

The District actively recruits volunteers to report rainfall at their homes.

The District supplies and installs the large capacity gauges, and the volunteers mail the information into the District offices.

This information is used to build a history of rainfall in Maricopa County.

The data is also integrated into the weather records maintained by the District and is analyzed for reconstruction of rainfall events and for design of future structures.

Rain Gauges

You may have a small gauge.

Attach the rain gauge to a wall, fence, or post or stick it in the ground away from buildings or trees.

Following a major storm the District may need more information about the storm in certain areas and would like to be able to call you to see if you recorded the storm. Please give us your name, address, and phone number.

Weather Information for Phoenix

- Hottest day—118° 1925, 1929, 1958, 1989
- Coldest day — 16° 1913
- Driest year — 2.82" 1956
- Wettest Year — 19.73" 1905
- Wettest 24-Hour Period — 4.98" July 1911
- Wettest Hour — 1.72" 1966
- Normal Yearly Rainfall — 7.11"

For Further Information

Flood Control District of Maricopa County
3335 West Durango
Phoenix, Arizona 85009
602 262-1501

Flood Warning System

Flood Control District

Rain and Stream Gauges

HOW FLOODS CAN BE CONTROLLED

Upstream Detention

Flood control dams, sometimes called floodwater retarding structures (FRS), collect floodwater and release it slowly to minimize damage. These reservoirs are normally empty.

Channel Improvements

This method increases the capacity of natural waterways to convey floodwater. This is done by clearing plants and other obtsructions and by excavation, channel lining and building dikes and levees. In some cases flood channels may be built where there are no natural streams.

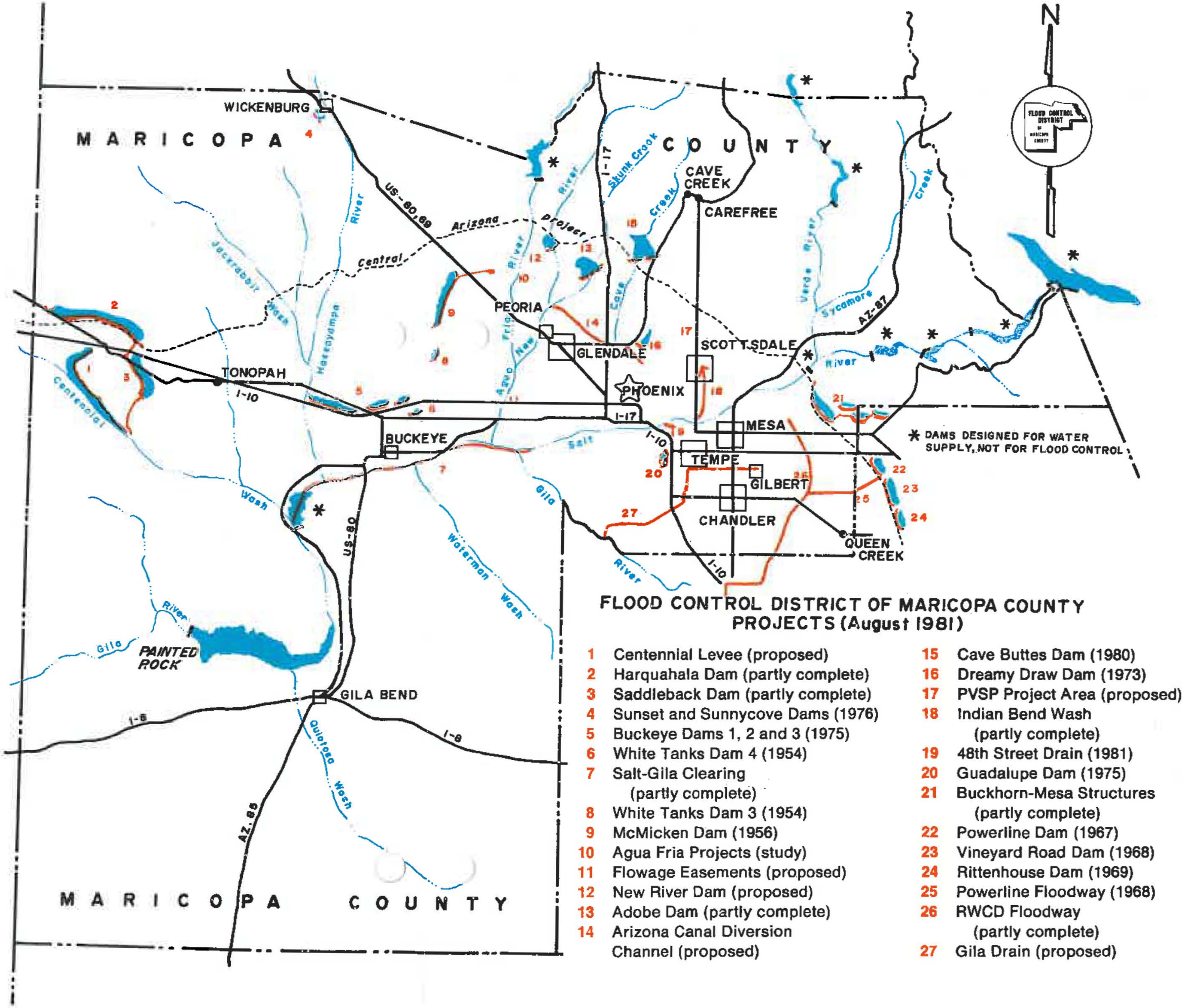
Floodplain Management

This method controls the use of and construction in floodplains to reduce flood damages. Under Arizona law, this responsibility rests with county, city and town governments.

Combination of Methods

Most often, effective flood control uses all of the preceding methods.

Incidentally—Flood control project land can often be used for outdoor recreation when county or city parks departments sponsor the recreation uses.



OF MARICOPA COUNTY

WHERE THE MONEY COMES FROM

Federal agencies pay the construction costs on federal projects. Land rights and relocations on federal projects are paid from the flood control tax on real property and half of these costs are reimbursed by the State.

Local (nonfederal) projects are funded by a variety of State, Flood Control District, County and city cost sharing arrangements.

WHAT ELSE NEEDS TO BE DONE

Flood control on the Salt and Gila main stems is very high in priority. We see this as a federal project, possibly with the District as the local sponsor.

Flood control needs on the Agua Fria main stem must be evaluated and a plan implemented. This could be done as a federal project or, more quickly, as a Flood Control District project with special State funding assistance.

Detention basins and channels are being built by cities and towns, sometimes with District and State cost sharing arrangements. This process must continue.

As major flood control systems are completed, the District can focus on control of smaller watersheds and major storm drains.

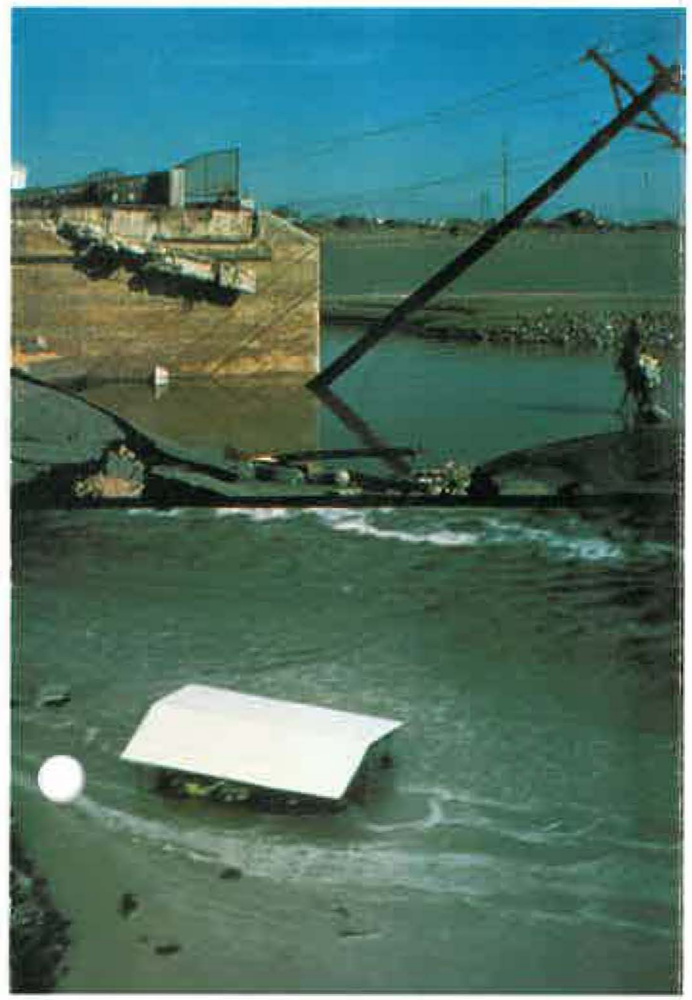
Intensive enforcement of floodplain regulations must become a common practice of all communities.

For more information contact

FLOOD CONTROL DISTRICT
of Maricopa County
3335 West Durango
Phoenix, Arizona 85009

(602) 262-1501

Flood Control District of Maricopa County



FLOOD CONTROL DISTRICT

WHO WE ARE

The District, founded in 1959, is a municipal corporation and political subdivision of the State of Arizona. The District is governed by the Board of Directors with the advice of the Citizens' Flood Control Advisory Board. The Directors are also Supervisors of Maricopa County.

WHAT WE DO

The purpose of the District is to provide flood control facilities to prevent the flooding of property and the endangering of lives within Maricopa County.

In fulfilling its purpose, the District

1. Acts as the local sponsor of federal flood control projects designed and constructed by the Army Corps of Engineers and the Soil Conservation Service. The District acquires the necessary rights-of-way and relocates facilities and people affected by the projects.
2. Plans and constructs flood control projects alone or in cooperation with State and local organizations.
3. Maintains and operates completed structures.
4. Assists in providing early warning of potential floods and provides technical leadership during flood emergencies.
5. Provides technical guidance related to floodplain management on a reimbursable basis.

FILE NO.	NAME	DESCRIPTION	CARD

MARICOPA COUNTY
HIGHWAY DEPARTMENT

3027C Zion, Ill. U. S.

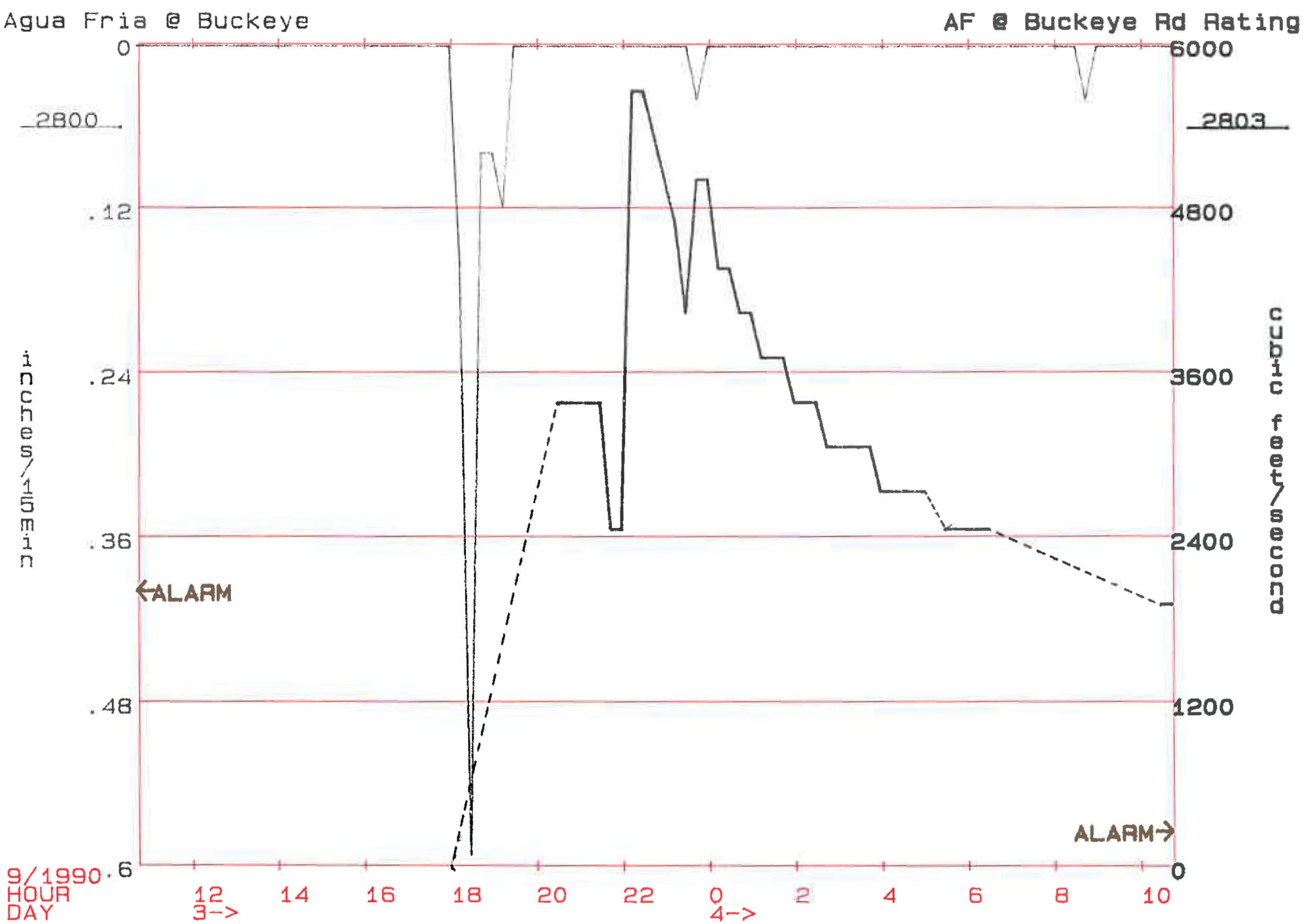
FILE NO.	NAME	DESCRIPTION	CARD

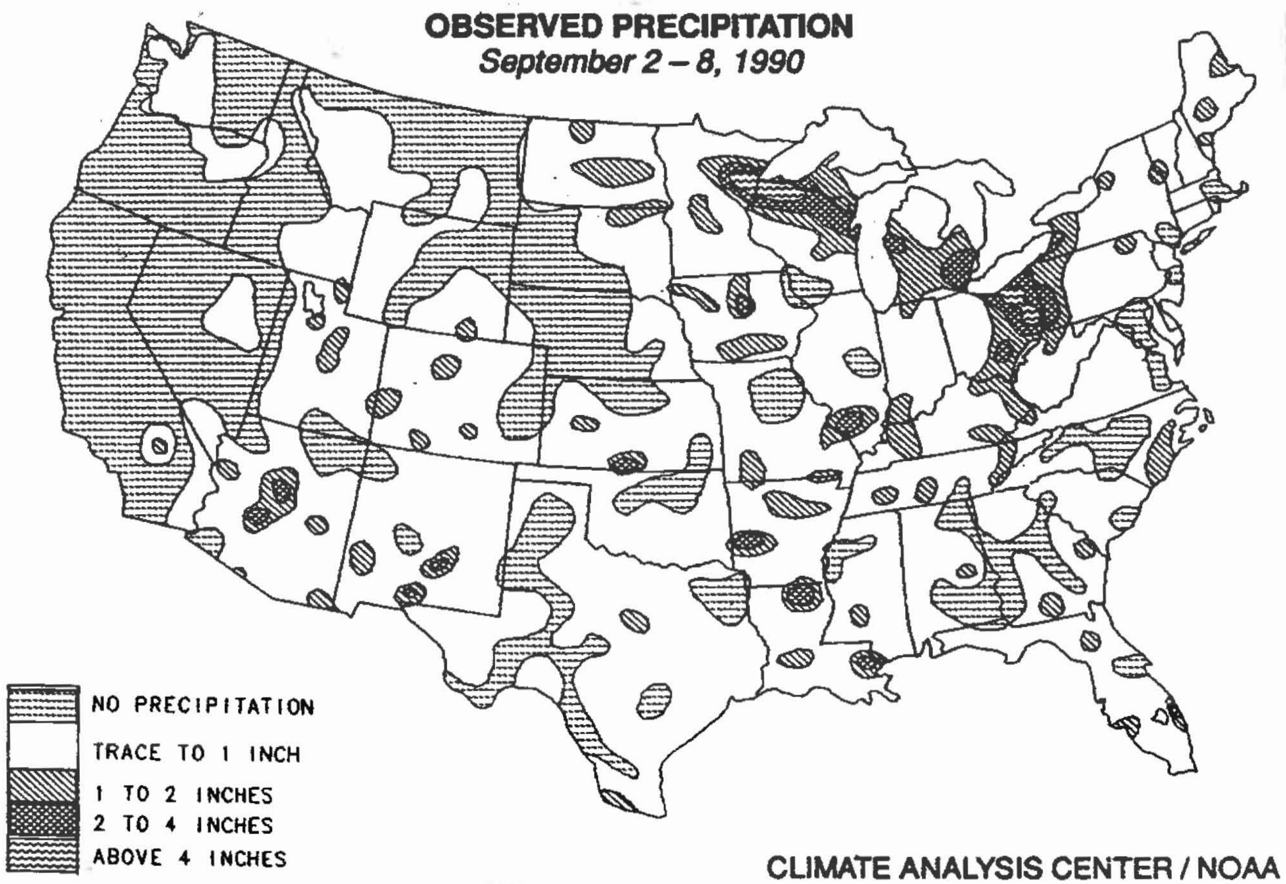
MARICOPA COUNTY
HIGHWAY DEPARTMENT

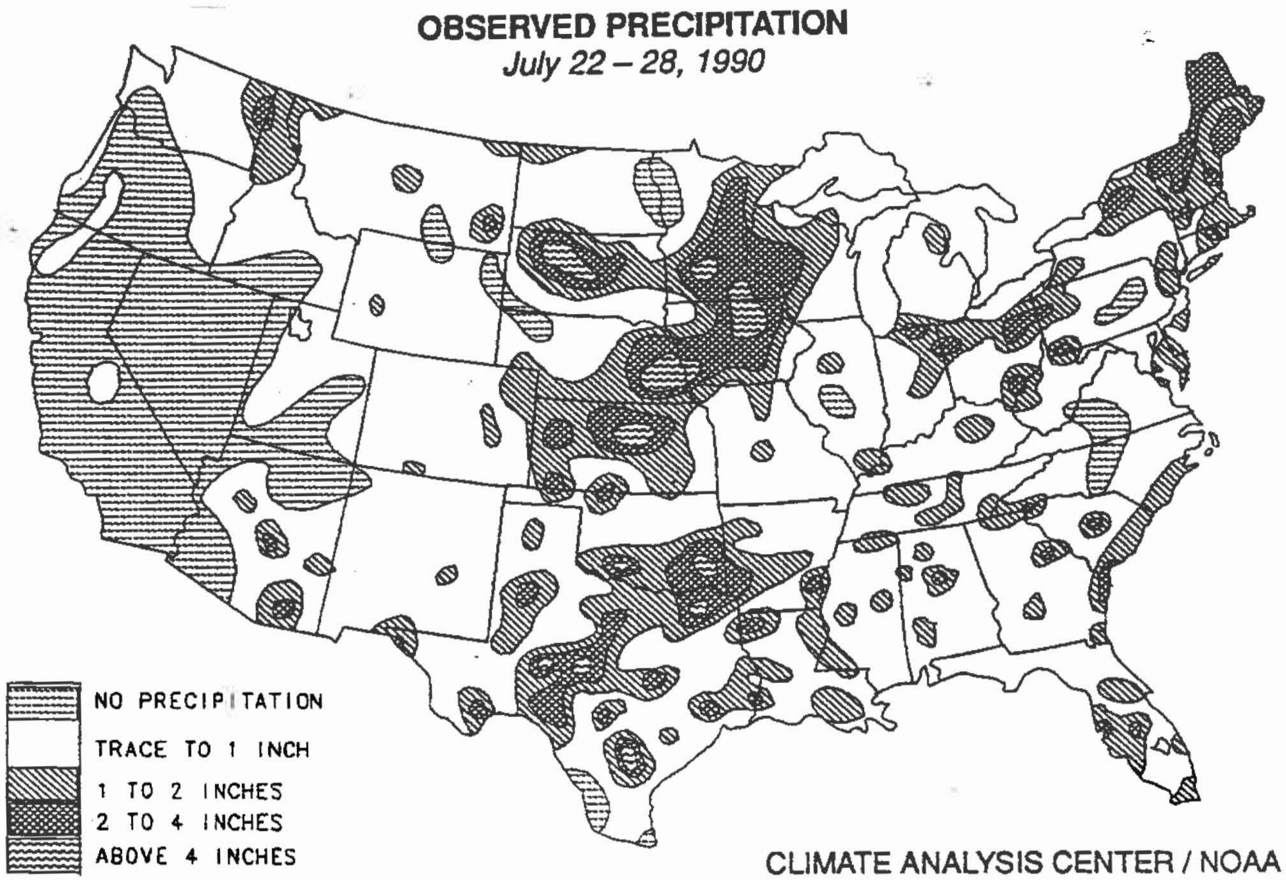
3027C Zion, Ill. U. S.

8/15/90 1:30 p.m. New River at Grand Avenue

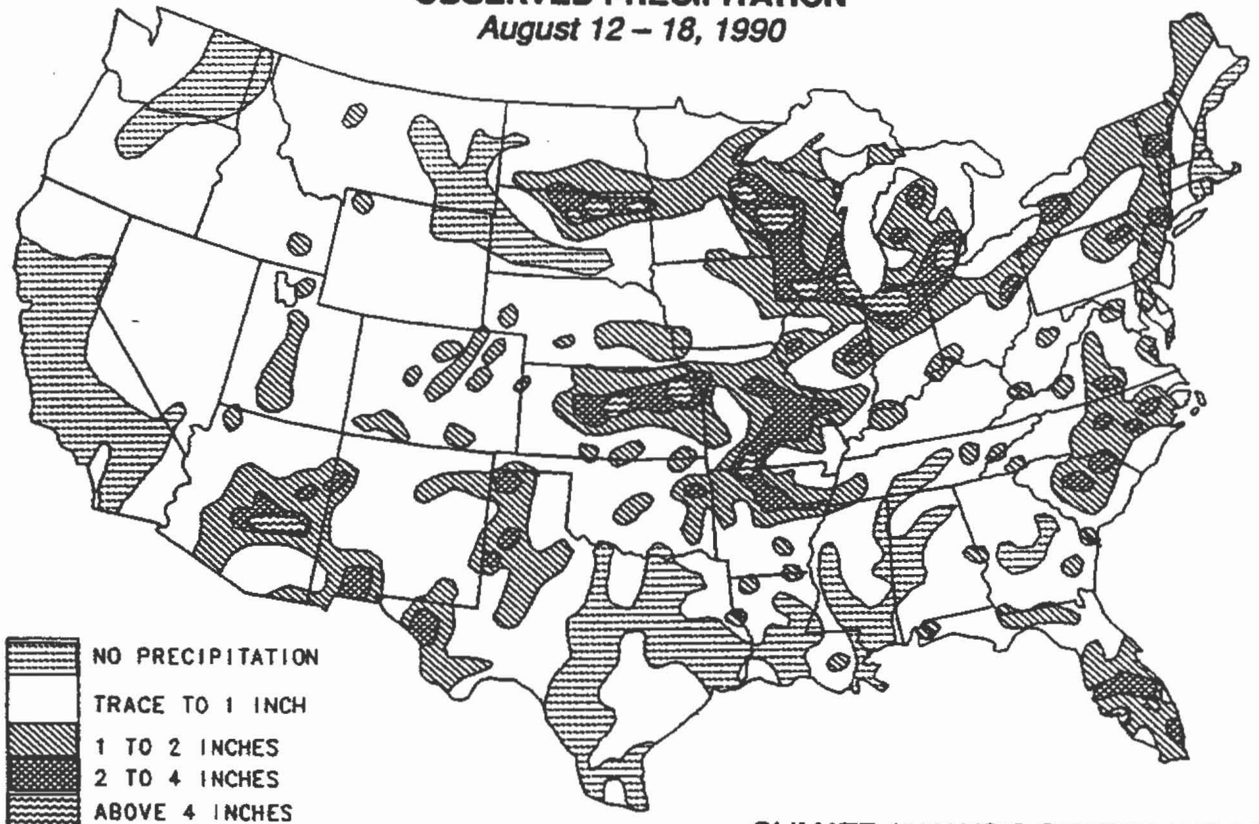
photo
4
Channelization
of New River


Agua Fria @ Buckeye
AF @ Buckeye Rd Rating
0
2800
.12
.24
.36
.48
.6
6000
2803
4800
3600
2400
1200
0
inches/15min
cubic feet/second
←ALARM
ALARM→
9/1990
HOUR
DAY
12
3->
14
16
18
20
22
0
4->
2
4
6
8
10


OBSERVED PRECIPITATION
September 2 – 8, 1990
NO PRECIPITATION
TRACE TO 1 INCH
1 TO 2 INCHES
2 TO 4 INCHES
ABOVE 4 INCHES
CLIMATE ANALYSIS CENTER / NOAA


OBSERVED PRECIPITATION
July 22 – 28, 1990
NO PRECIPITATION
TRACE TO 1 INCH
1 TO 2 INCHES
2 TO 4 INCHES
ABOVE 4 INCHES
CLIMATE ANALYSIS CENTER / NOAA

OBSERVED PRECIPITATION
August 12 – 18, 1990



CLIMATE ANALYSIS CENTER / NOAA

Jeanette M. Hardiman
Program Analyst

Sierra-Misco, Inc.
Environmental Products

916 363-4271
~~(916) 929-8864~~, (800) 422-5111
1900 Point West Way, Suite 208
Sacramento, CA 95815
TELEX NO. 275945 SMBK UR
FAX: (916) 929-2959

Wholly owned
Subsidiary of
First Generation
Resources
Capital Corporation

Flood Control District Structures Status Report

Peak Gauged Impoundments / Flows

Date of Event: SEPTEMBER 14-15, 1990

STRUCTURE	CAPACITY A/F	STAGE HEIGHT FT.	SPILLWAY CREST ELEV / HEIGHT FT.	DETENTION BASIN USED / AVAIL A/F	DETENTION BASIN % FILLED	INFLOW = RELEASES CFS
WEST COUNTY						
SADDLEBACK FRS	42	0.3	(no spillway) DAM-- 1193/22	1.1 / 41	3	14
BUCKEYE #1	8,185	0.0	1080/22	0 / 8,185	N/A	N/A
WHITE TANKS #3	2,655	0.0	1210/24	0 / 2,655	N/A	N/A
WHITE TANKS #4	2,250	0.6	1050/14	.2 / 2249	<1	4
MCMICKEN DAM	23,800	0.0	1354/27	0 / 23,800	N/A	N/A
CENTRAL COUNTY						
NEW RIVER DAM	43,520	0.0	1488/72	0 / 43,520	N/A	N/A
ADOBE DAM	18,350	0.0	1378/38	0 / 18,350	N/A	N/A
CAVE BUTTES DAM	46,600	.04	1657/168	1 / 46,599	<1	14
DREAMY DRAW DAM	317	0.0	1405/43	0 / 317	N/A	N/A
EAST COUNTY						
GUADALUPE FRS	298	4.3	1274/27	3.6 / 294	1	17
SPOOKHILL DAM	866	5.5	1582/14	401 / 465	46	1620
SIGNAL BUTTE DAM	1,356	0.0	unkwn/<39	0 / 1,356	N/A	N/A
APACHE JUNCT. DAM	552	1.5	unkwn/<22	1.6 / 550	<1	20
RITTENHOUSE DAM	4,060	0.1	1598/15	.09 / 4,059	<1	1
VINEYARD DAM	4,310	0.9	1575/12	1.7 / 4,308	<1	20

Flood Control District Structures Status Report
Peak Gauged Impoundments / Flows

Date of Event: SEPTEMBER 14-15, 1990

STRUCTURE	CAPACTIY A/F	STAGE HEIGHT FT.	SPILLWAY CREST ELEV / HEIGHT FT.	DETENTION BASIN USED / AVAIL A/F	DETENTION BASIN % FILLED	INFLOW = RELEASES CFS
NORTHWEST COUNTY						
SUNSET FRS	55	0.0	2142/20	0 / 55	N/A	N/A
SUNNYCOVE FRS	218	0.0	2179/40	0 / 218	N/A	N/A

COMMUNITY RATING SYSTEM
ACTIVITY 610: FLOOD WARNING PROGRAM
INTRODUCTION

Maricopa County, Arizona occupies approximately 9200 square miles in central Arizona. The topography ranges from mountains to low desert. The Phoenix metropolitan area is located within a large valley in the southern portion of the county.

Maricopa County is subject to two distinct rainy seasons. The monsoon season which occurs from July to September is typified by increased humidity and high summer temperatures. The majority of winter precipitation occurs from January to March. These storms are usually of longer duration than the monsoon storms.

The Flood Hazard

Several major watercourses bisect Maricopa County and the Phoenix metro area. These include the Salt and Gila Rivers which flow in a general southwest direction and the Agua Fria River which flows north to south. All three of these rivers have water conservation dams located on them upstream of the metro area and are therefore relatively dry for much of the year. During a large storm these rivers can carry flow from localized runoff and or released water from dams or irrigation canals. Flow in these rivers can cause the closure of roads and bridges and the evacuation of businesses and residences located within the floodplain.

In addition to these major water courses, numerous smaller rivers and streams are located in and around the populated areas of the County. During the summer monsoon season these streams are highly susceptible to flash flooding.

Irrigation canals and laterals are used not only for farming but also for residential irrigation of lawns and citrus within the County. Overtopping or breaching of these canals can and has occurred.

The majority of floodplain property including the floodway is privately owned in Maricopa County. Many of the properties were developed in the floodplain prior to the development of floodplain regulations and therefore post regulation to prevent recurring flood losses is often difficult.

The Flood Threat Recognition System

Initial flood threat recognition is based upon visual observations and weather forecast information from the National Weather Service. When the National Weather Service forecasts significant rainfall the District sends a staff member to the daily briefing. If a weather watch or warning is issued, the Chief Engineer of the District is notified by the Weather Service. The Flood Control District also operates and maintains its own telemetry flood warning system known as a ALERT (Automated Local Evaluation in Real Time) system. Operation of the system allows the user to monitor rainfall and stream flow amounts at key locations. Color radar is also used by District staff to track the development and movement of storms.

In addition to technical equipment, the Flood Control District also has teams of trained field personnel who monitor the effects of storm runoff in the field. Other municipal, county and state agencies also coordinate with the District by phone and radio during a potential strong storm or flood event.

Flood Warning Times

Flood warning times depend on many variables including storm location, intensity, duration and topography.

Flash floods typically occur from a high intensity rainfall of short duration and there may be little to no warning, depending on the location of the storm. These are often characteristic of the monsoon rains and can produce a great deal of inconvenient street flooding.

Storms large enough to produce flooding on major water courses within the County often take many hours to develop. Flood warning times could vary from hours to days, allowing sufficient time to complete evacuations when necessary.

Operational releases from dams and canals are monitored and timed to prevent increased flooding when possible. Breaches or overtoppings are often suspected ahead of occurrence allowing evacuation or mitigation efforts to be taken.

As required by the State of Arizona, evacuation plans due to a dambreak are available for all flood control structures within Maricopa County. These evacuation plans include estimated flood warning times, depths and velocities of flood waters.

How Flood Warnings are Disseminated and to Whom

The initial dissemination of flood warnings to the public is the responsibility of the National Weather Service. Evacuation plans, notification to smaller municipalities, governmental agencies, police and other emergency agencies is primarily the responsibility of the Arizona State Department of Civil Defense and Emergency Services. Prior to public notification the Flood Control District plays a major role in the collection of real time rainfall and runoff storm data.

Telemetry precipitation gauges located throughout the County relay information via microwave towers back to computers at the Flood Control District. At the District a dedicated phone line relays this information to the local office of the National Weather Service. Flood Control District staff from the Hydrology Divisions Special Projects Branch monitor the incoming data. If predetermined rainfall frequencies or runoff volumes for an area are exceeded or rapid impoundment of water behind flood control structures occurs additional Flood Control District staff are notified in the following order:

Hydrology Division Chief
Chief of Operations and Maintenance Division (notifies FCD field observation teams)
Deputy Chief Engineer
Chief Engineer and General Manager

During this time the National Weather Service and Arizona Department of Civil Defence and Emergency services are notified by the Deputy or Chief Engineer so that coordination with other emergency service agencies can begin.

Equipment, Maintenance and Testing

The Flood Control District currently operates and maintains 102 telemetry rain gauges throughout Maricaopa County. It also operates approximately 39 stage gauges some of which are recording gauges.

The telemetry gauges are programmed to check in twice in a 24 hour period. If they do not check in within 48 hours a hydrometeorological technician will visit the site and correct any problems. Recording gauges are serviced once a month and all of the gauges are serviced at least twice a year.

Drill Procedures

Practice drills with regards to the telemetry equipment are completed before and during installation and also at least twice per year on each gauge if it continues to function correctly.

Evacuation drills in which the Flood Control District is involved related to flood emergencies are organized on a annual basis by the National Weather Service in cooperation with the Arizona Department of Emergency Services and Civil Defense.

Staff Responsibilities

Officially Flood Control District staff become involved in a flood emergency in the order shown below, however during a emergency situation the majority of the district staff is involved and their help is greatly appreciated.

1. The impending storm is monitored by hydrologists in the Special Projects Branch of the Hydrology Division.

2. The US Weather Service may notify the District if a weather watch or warning has been issued.

3. If significant rainfall and runoff occur additional Flood Control District staff are alerted. This includes:

Chief Hydrologist

Chief of Operations and Maintenance,(sends field inspectors to designated locations in the field to monitor flood water and the condition of Flood Control District structures.

Deputy Chief and Chief Engineer and General Manager of the Flood Control District.

Department of Civil Defense and Emergency Services.

At present the primary duty of the Flood Control district is to operate and maintain its flood control structures and to assist the Arizona Department of Civil Defense and Emergency Services. An evaluation of public needs during a flood emergency is currently underway to determine if the District should take a more active role in the dissemination of public warnings.

FLOOD CONTROL DISTRICT
of
Maricopa County
3335 West Durango Street • Phoenix, Arizona 85009
Telephone (602) 262-1501

D. E. Sagramoso, P.E., Chief Engineer and General Manager

MEMO TO: Board of Directors

VIA: Roy A. Pederson, County Manager
A. W. Collins, Assistant County Manager/
Public Works Director and County Engineer

FROM: D. E. Sagramoso

SUBJECT: PERFORMANCE OF FLOOD CONTROL DISTRICT STRUCTURES DURING AUGUST 1990 MONSOON STORMS

The Arizona Canal Diversion Channel (ACDC) transported flows of up to 5 feet in depth and the East Maricopa Floodway (EMF) registered depths of 4 feet during intense thunderstorms occurring throughout the County August 14 and 15. Such flows were indicative of the storm's impact throughout the Phoenix Metropolitan Area as streams and channels filled with runoff from rainfall amounts in excess of 2 inches.

At the height of the storm, 16 feet of water was impounded behind Dreamy Draw Dam, 14 feet behind Cave Buttes Dam and 9 feet at Adobe Dam, all North Phoenix structures. While effectively detaining such flows, these structures were by no means full, as less than 2 percent of their reservior capacities were utilized. In Eastern Maricopa and Northern Pinal counties, 6 feet of water was detained behind Rittenhouse Dam and 3.5 feet behind Spook Hill Dam. Guadalupe Dam had 5.5 feet by 7:00 a.m. on the 15th.

During the two-day storm, peak stream flows of 5 feet were recorded in Centennial Wash; 4-foot flows were observed in the Gila River at Highway 85, in New River at Glendale Avenue and in the EMF at Elliot Road; 3.5 feet of water flowed in the Hassayampa River at Wickenburg; 3 feet in Vekol Wash at Interstate 8 and in Cave Creek at Cave Creek Road; and 2 feet in the Salt River at 24th Street and in Sauceda Wash located in Gila Bend. Additionally, flows in Indian Bend Wash measured 2.7 feet at McKellips Road by late afternoon on the 15th.

A peak discharge of 2500 cubic feet per second (cfs) was reported on the Agua Fria at Buckeye Road, 1300 cfs in Sauceda Wash, 1000 cfs in Cave Creek at Cave Creek Road, 833 cfs from Adobe Dam, 814 cfs from Spook Hill Dam, 200 cfs from Cave Buttes Dam and 135 cfs from Dreamy Draw Dam. Stormwater in the Sossaman Drain in Mesa was measured at 3 feet and overtopped the canal at 9:00 a.m. on the 14th, flooding portions of Guadalupe Road.

Water in the ACDC reached a depth of 5 feet at 43rd Avenue at 11:15 a.m. August 14, with 3 feet of water recorded in the unlined portion near 67th Avenue. Flows at the 67th Avenue location were estimated at 4,000 cfs.

The maximum rainfall amount recorded by a District gauge August 14 was 2.44 inches at Mount Ord during the 36-hour period ending August 14 at 3:.00 p.m. Mount Ord is in the Mazatzal Mountains northeast of Bartlett Reservoir. Other 36-hour rainfall amounts included 2.4 inches at New River and I-17, 2.3 inches at the Buckeye FRS, 2.09 inches at King's Ranch east of Apache Junction, and 1.85 inches at the Magma FRS northeast of Florence.

Significant amounts of rainfall were reported the morning of August 15 between midnight and 7:00 a.m. at Adobe Dam (2.17 inches), at White Tanks #4 west of Goodyear (1.73 inches), at Dreamy Draw Dam in northeast Phoenix (1.61 inches), and at Queen Creek (1.38 inches).

D. E. Sagramoso

Copy to: FCD Advisory Board Members
Civil Defense

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Group Name	Date	Time
ACDC Network	10/11/90	1335

Sensor #	1510	6645	6610
StatType	dif	dif	dif
DataType	precip	precip	precip
Units	in	in	in
720 hours			
9/30/90	4.57	1.54	1.77
8/31/90	3.98	1.89	3.19
8/ 1/90	0.59	0.98	3.19
7/ 2/90	0.00	0.00	0.04
TOTALS:	9.13	4.41	8.19

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Group Name	Date	Time
McDowell Mountain	10/11/90	1335

Sensor #	85	90	95	6650	6655
StatType	dif	dif	dif	dif	dif
DataType	precip	precip	precip	precip	precip
Units	in	in	in	in	in
720 hours					
9/30/90	1.57	1.38	1.02	0.91	1.38
8/31/90	1.89	2.09	2.24	1.69	1.97
8/ 1/90	1.18	—	—	0.98	0.75
7/ 2/90	0.75	—	—	0.28	—
TOTALS:	5.39	3.46	3.27	3.86	4.09

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Group Name	Date	Time
Southwest Valley	10/11/90	1335

Sensor #	70	2800
StatType	dif	dif
DataType	precip	precip
Units	in	in
720 hours		
9/30/90	2.68	2.28
8/31/90	1.14	0.67
8/ 1/90	2.76	2.72
7/ 2/90	0.20	0.00
TOTALS:	6.77	5.67

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Group Name	Date	Time
Upper Hassayampa	10/11/90	1334

Sensor #	7	36	40	45	50	3610
StatType	dif	dif	dif	dif	dif	dif
DataType	precip	precip	precip	precip	precip	precip
Units	in	in	in	in	in	in
720 hours						
9/30/90	2.95	3.11	2.09	1.06	1.54	2.09
8/31/90	0.75	2.83	3.54	0.35	3.07	0.67
8/ 1/90	1.18	4.29	5.24	0.16	3.90	2.68
7/ 2/90	0.12	0.04	1.77	0.00	0.20	0.24
TOTALS:	5.00	10.28	12.64	1.57	8.70	5.67

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Group Name	Date	Time
Lower Hassayampa	10/11/90	1335

Sensor #	30	35	3630	3635	635
StatType	dif	dif	dif	dif	dif
DataType	precip	precip	precip	precip	precip
Units	in	in	in	in	in
720 hours					
9/30/90	1.34	1.89	1.22	1.30	1.02
8/31/90	0.55	0.55	1.26	1.26	0.24
8/ 1/90	2.01	2.20	2.52	2.13	0.75
7/ 2/90	0.35	0.08	0.20	0.16	0.00
TOTALS:	4.25	4.72	5.20	4.84	2.01

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Group Name	Date	Time
South Mountain	10/11/90	1335

Sensor #	6500	6510	6530	75	5900	65	6550
StatType	dif	dif	dif	dif	dif	dif	dif
DataType	precip	precip	precip	precip	precip	precip	precip
Units	in	in	in	in	in	in	in
720 hours							
9/30/90	0.98	1.38	0.91	2.05	0.79	0.91	______
8/31/90	2.23	3.93	1.97	2.48	2.25	0.00	______
8/ 1/90	1.69	1.14	2.24	0.91	1.06	______	______
7/ 2/90	0.04	0.04	0.04	0.04	0.00	______	______
TOTALS:	5.00	6.54	5.16	5.47	4.13	0.91	______

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Group Name	Date	Time
Southeast Valley	10/11/90	1335

Sensor #	80	5615	5650	5660	5605
StatType	dif	dif	dif	dif	dif
DataType	precip	precip	precip	precip	precip
Units	in	in	in	in	in
720 hours					
9/30/90	1.30	1.54	0.16	1.06	1.02
8/31/90	0.98	3.74	0.94	2.36	1.10
8/ 1/90	0.35	0.51	0.55	2.60	0.16
7/ 2/90	0.04	0.20	0.08	0.24	0.20
TOTALS:	2.68	5.98	1.73	6.26	2.48

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Group Name: Cave Crk/Carefree — Date: 10/11/90 — Time: 1334

Sensor #	2500	2510	2600	2610	2615	2625	2520
StatType	dif	dif	dif	dif	dif	dif	dif
DataType	precip	precip	precip	precip	precip	precip	precip
Units	in	in	in	in	in	in	in
720 hours							
9/30/90	1.28	2.52	2.20	5.00	2.99	3.46	1.73
8/31/90	0.47	1.69	4.17	0.75	0.47	0.51	1.93
8/ 1/90	0.43	1.06	1.65	2.32	3.82	2.09	0.24
7/ 2/90	0.24	1.38	1.69	0.12	0.31	0.24	0.59
TOTALS:	2.52	6.65	9.72	8.19	7.60	6.30	4.49

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Group Name: Far West County — Date: 10/11/90 — Time: 1334

Sensor #	620	625	630	670	640	660	1620
StatType	dif	dif	dif	dif	dif	dif	dif
DataType	precip	precip	precip	precip	precip	precip	precip
Units	in	in	in	in	in	in	in
720 hours							
9/30/90	0.28	1.50	0.39	0.87	0.12	0.43	1.06
8/31/90	2.01	3.07	1.65	0.67	1.54	0.98	1.50
8/ 1/90	1.18	0.51	3.03	0.79	2.40	0.83	0.43
7/ 2/90	0.08	0.08	0.04	0.00	0.00	0.00	0.04
TOTALS:	3.54	5.16	5.12	2.32	4.06	2.24	3.03

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Group Name: Upper Agua Fria — Date: 10/11/90 — Time: 1334

Sensor #	20	3510	4600	4605	4610	4625
StatType	dif	dif	dif	dif	dif	dif
DataType	precip	precip	precip	precip	precip	precip
Units	in	in	in	in	in	in
720 hours						
9/30/90	1.61	1.18	3.62	3.11	2.76	2.95
8/31/90	1.65	1.38	1.38	0.79	0.87	1.50
8/ 1/90	3.31	1.61	4.41	3.74	2.36	2.99
7/ 2/90	0.28	0.04	0.08	0.31	0.55	0.24
TOTALS:	6.85	4.21	9.49	7.95	6.54	7.68

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Group Name: Lower Agua Fria — Date: 10/11/90 — Time: 1334

Sensor #	15	4510	4530	4615	4620	4635
StatType	dif	dif	dif	dif	dif	dif
DataType	precip	precip	precip	precip	precip	precip
Units	in	in	in	in	in	in
720 hours						
9/30/90	2.01	2.24	0.00	2.44	2.76	1.73
8/31/90	0.55	1.85	0.83	0.91	2.36	2.08
8/ 1/90	1.42	2.39	4.57	3.46	4.53	2.72
7/ 2/90	0.20	1.51	0.67	0.08	0.00	0.20
TOTALS:	4.1[illegible]	8.70	6.06	6.89	9.65	7.32

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Group Name	Date	Time
Indian Bend Wash	10/11/90	1332

Sensor #	6625	6630	6635	6640	5	55
StatType	dif	dif	dif	dif	dif	dif
DataType	precip	precip	precip	precip	precip	precip
Units	in	in	in	in	in	in
720 hours						
9/30/90	0.75	0.39	1.54	0.79	1.10	0.55
8/31/90	1.18	1.42	2.64	2.36	0.00	0.00
8/ 1/90	0.39	1.26	0.43	2.72		
7/ 2/90	0.08	0.00	0.08	0.20		
TOTALS:	2.40	3.07	4.69	6.06	1.10	0.55

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Group Name	Date	Time
North Valley Structures	10/11/90	1332

Sensor #	6620	2630	2640	2650	2700	2605
StatType	dif	dif	dif	dif	dif	dif
DataType	precip	precip	precip	precip	precip	precip
Units	in	in	in	in	in	in
720 hours						
9/30/90	0.91	2.60	0.91	0.43	3.94	1.61
8/31/90	1.10	3.15	2.17	4.06	1.65	1.26
8/ 1/90	0.39	1.97	0.59	2.17	0.91	1.69
7/ 2/90	0.00	0.08	0.00	0.00	0.00	0.47
TOTALS:	2.40	7.80	3.66	3.55	6.50	5.04

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Group Name	Date	Time
Trilby Wash/McMicken	10/11/90	1332

Sensor #	1600	1605	1610	1520	1500	1530
StatType	dif	dif	dif	dif	dif	dif
DataType	precip	precip	precip	precip	precip	precip
Units	in	in	in	in	in	in
720 hours						
9/30/90	1.54	2.24	1.85	4.09	2.32	3.58
8/31/90	0.43	0.87	0.39	2.28	3.62	1.85
8/ 1/90	0.39	0.59	1.02	1.26	0.59	0.79
7/ 2/90	0.08	0.20	0.08	0.35	0.00	0.12
TOTALS:	2.44	3.90	3.35	7.99	6.54	6.34

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Group Name Date Time

Far East Valley 10/11/90 1333

Sensor #	5600	5605	5610	5700	5800
StatType	dif	dif	dif	dif	dif
DataType	precip	precip	precip	precip	precip
Units	in	in	in	in	in
720 hours					
9/30/90	1.97	1.69	1.46	0.87	0.51
8/31/90	1.61	2.72	1.42	1.02	2.70
8/ 1/90	0.35	0.75	1.18	0.39	2.52
7/ 2/90	0.05	0.43	0.31	0.04	0.12
TOTALS:	4.02	5.59	4.37	2.32	5.91

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Group Name Date Time

Southwest County 10/11/90 1333

Sensor #	510	60	600	605	610	615	520	530
StatType	dif	dif	dif	dif	dif	dif	dif	dif
DataType	precip	precip	precip	precip	precip	precip	precip	precip
Units	in	in	in	in	in	in	in	in
720 hours								
9/30/90	0.83	2.05	1.97	1.97	1.81	0.59	1.34	0.87
8/31/90	0.31	2.32	1.06	1.65	0.63	1.57	0.43	1.22
8/ 1/90	0.43	1.65	1.69	1.81	1.73	0.63	0.47	3.90
7/ 2/90	0.00	0.20	0.00	0.00	0.20	0.04	0.00	0.13
TOTALS:	1.57	6.22	4.72	5.43	4.37	2.83	2.24	6.12

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Group Name Date Time

Apache Junction 10/11/90 1333

Sensor #	5620	5625	5630	5635	5640	5645
StatType	dif	dif	dif	dif	dif	dif
DataType	precip	precip	precip	precip	precip	precip
Units	in	in	in	in	in	in
720 hours						
9/30/90	2.09	1.73	0.87	2.40	1.69	1.42
8/31/90	1.18	2.32	1.09	2.17	1.14	1.69
8/ 1/90	0.71	0.55	0.20	0.51	0.35	0.20
7/ 2/90	0.24	0.28	0.12	0.12	0.51	0.18
TOTALS:	4.21	4.88	3.07	5.20	3.70	3.46

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Group Name Date Time

Far West Valley 10/11/90 1333

Sensor #	1615	1625	1630	1635	6520	6540
StatType	dif	dif	dif	dif	dif	dif
DataType	precip	precip	precip	precip	precip	precip
Units	in	in	in	in	in	in
720 hours						
9/30/90	1.38	1.38	1.22		2.52	1.57
8/31/90	1.81	3.54	2.05		1.69	1.30
8/ 1/90	0.12	0.16	0.94	0.63	2.32	1.14
7/ 2/90	0.04	0.04	0.00	0.20	0.12	0.00
TOTALS:	3.35	5.12	4.21	0.83	6.65	4.02

MARICOPA COUNTY DEPARTMENT OF CIVIL DEFENSE
AND EMERGENCY SERVICES

AFTER-ACTION REPORT

STORM/FLOODS - SUMMER 1990

I. BACKGROUND/WEATHER

A. In 1990, the Phoenix metropolitan area experienced the most damaging monsoon season in several years. The rains, which were heavier than usual, caused wide spread flooding of residential areas, erosion of roads, overtopping of canals, and other property damage such as loss of vehicles by inundation; lightening strikes caused a number of residential and commercial building fires; and winds caused severe damage to aircraft, buildings, manufactured homes, trees, etc.

B. A complete re-cap of the July and August Storms is at enclosure 1.

C. In the late afternoon Monday, September 3, the most violent weather of the 1990 monsoon season hit the Phoenix metropolitan area. Strong thunderstorms moved through the valley with wind gusts of 60 to 80 miles per hour and dropped as much as 3.82 inches of rain in some areas. The storms caused the temperature to drop from 98 degrees at 5:00 p.m. to 80 degrees an hour later.

6:00 PM 3rd

At 5:15 p.m. a tornado touched down north of Union Hills Drive between Seventh Street and Seventh Avenue - no damage reported from the tornado.

59th Avenue between Glendale and Northern Avenues was like a river with water running as much as 20 inches deep. The intersection of 51st Avenue, Bethany Home Road and Grand Avenue resembled a lake.

Waves of water swept across Union Hills Drive and Seventh Street where the flooding was at least three feet deep.

Underpasses on the Black Canyon Freeway (I-17) from Peoria Avenue north to Union Hills Drive were flooded, although I-17 remained open.

About 15,000 Arizona Public Service customers were without power at the height of the storm, including 8,000 who lost service in northwest Phoenix when the Loma Vista substation was flooded.

Salt River Project officials said about 20,000 customers in the east valley lost power when 17 power poles were knocked down.

II. SUMMARY OF EVENTS

A. Peoria Situation

The night of Monday, September 3, Peoria had opened their EOC because of the storm related problems they were having. That evening, the partial evacuation of the Sun Grove Nursing Home went well with the patients being transported to various other nursing homes by ambulance. It had been necessary to evacuate people from several homes. The Red Cross was contacted to open a shelter in the Community Center and they had 25 people spend the night. The following morning, the city set up an assistance center at the Community Center to help residents in the area.

On Wednesday, Fire Chief Fusco, Neil Harrison (from the Red Cross), and the City Manager, Dennis Fredrickson, and Ruth Aud of this Department, toured the areas that had been flooded to see if Peoria should declare an emergency. With the damage estimates received from the public side and the business and private sector damages surveyed, it was decided the city would declare. A council meeting was called for Thursday afternoon, September 6th.

B. Glendale Situation

C. County Situation

1. County Departments

a.	Highway Department	$273,855
b.	Parks & Recreation Department	$ 10,000

2. Unincorporated Areas

a. Buckeye Irrigation Company — $ 35,000

b. Roosevelt Irrigation District

1. Business — $200,000

2. Private — $800,000

3. Wittman

a. Public — $ 1,000

a. Business $ 12,000

3. School Districts

a. Glendale High School District $ 30,000

b. Glendale Community College $ 60,000

4. Private/Nonprofit Organizations

American Graduate School of International Management ~~School~~ $750,000

D. Peoria Declaration

1. Date of Declaration - Sept 6, 1990

2. Damage Estimates

a. Public Sector

1. City Buildings - $ 25,000

2. Infra-structure - $ 31,000

3. Peoria Schools - $ 135,000

b. Business Sector -

Commercial/Industrial $1,709,500

c. Private Sector -

Residential $ 517,000

E. Glendale Declaration

1. Date of Declaration - Sept 3, 1990

2. Damage Estimates

a. Public Sector

1. Supplies and Equipment - $ 31,898

2. Overtime $ 10,947

b. Business Sector

c. Private Sector

F. County Declaration

1. Date of Declaration - September 6, 1990 to cover period July 8 through Sept 10.

2. Damage Estimates - Enclosure 2

a. Public Sector

1.	Cities/Towns	$2,412,618
2.	County/Other	$ 574,855
		$2,987,473

b. Business Sector

1.	Cities/Towns	$ 187,000
2.	County/Other	$ 247,000
		$ 434,000

c. Private Sector

1.	Cities/Towns	$1,610,000
2.	County/Other	$1,550,000
		$3,160,000

G. A State Proclamation was initially signed on July 27th because of storm damages (wind and flooding) in Mohave, Gila, Pima and Yavapai Counties. Maricopa County was added to the State Proclamation on September 7, 1990.

1. Other Counties included in the State Proclamation are:

INCIDENT PERIOD	COUNTIES	DECLARATION DATE
08 - 24 JULY 90	Mohave	23 July 90
	Gila	25 July 90
	Pima	26 July 90
	Yavapai	26 July 90

12 - 21 AUG 90	Pinal	20 Aug 90
	Graham	24 Aug 90
30 AUG - 05 SEP 90	Coconino	03 Sept 90
	Maricopa	06 Sept 90
	Yavapai	11 Sept 90

2. The purpose of the State Proclamation is to make all of the State's resources available to cope with the disaster or other situation which has arisen. It is also a necessary pre-requisite to requesting a Presidential Declaration.

3. Prior to requesting a Presedential Declaration, it is necessary to request Federal and State (FAST) Team(s) from the Federal Emergency Management Agency (FEMA) Region IX. These Teams survey the disaster site(s) in order to verify the estimates of damages incurred and to determine if the damages and their impact on the quality of life of the community are sufficient for the Governor to request a Presidential Declaration.

H. The Arizona Division of Emergency Services initiated a request for FAST Teams on September 10.

I. Prior to the arrival of the FAST Teams, this Department requested damage survey assistance on an "as needed" basis from the Assessor's Office and the Building Safety Division. The names and telephone numbers of the designated personnel were included in our "list of contacts" but the need to use their assistance did not arise.

J. 1. The FAST Teams from FEMA Region IX arrived in Phoenix on morning of September 12 and received an In-Briefing at the offices of the Arizona Division of Emergences (ADES).

2. FAST Team Composition varied with the type of team. Public Damage Teams had 2 FEMA representatives and 1 ADOT representative. The Individual Assistance Teams were composed of a representative of FEMA, a representative of the Small Business Association (SBA) and a representative of the county

K. FAST Team Activities in Maricopa County

1. Public Damage Team (1)

2. Individual Assistance Teams (2)

3. Staff Assistance Provided - Ruth Aud, Warren Leek and Royce Pettit of this Department assisted the Individual Assistance Teams.

4. Inclusive Dates of Survey - September 12-17, 1990.

5. Jurisdiction Contacts - see attached

6. County Contacts - see attached

7. Team Procedures

   a. Visited jurisdictions that indicated large damages.

   b. Telephoned jurisdictions with lesser damages and after telephonic verification of types of damages, accepted estimated dollar figures originally submitted.

   c. Met with Highway Department and Flood Control District Representatives to discuss and verify information.

III. FAST Team Out-Briefing Results

A. Presidential Declaration?

1. Public Assistance

75% Federal - 25% Jurisdiction/Agency

2. Individual Assistance

B. Non-Presidential?

1. State Assistance Only to Public Sector

a. 30% State - 70% Jurisdiction/Agency

IV. Presidential Declaration (Tentative)

V. Disaster Application Centers (DAC) (Tentative)

A. Purpose

B. Selection

C. Location(s)

D. Notification of Jurisdictions, Public, Businesses

1. Radio/TV Announcements

2. Posters

E. Make-up of DAC

1. Federal Agencies Represented

2. Governor's Authorized Representative (GAR)

F. Duration

VI. Lessons Learned - see attached

VII. Attachments

A. Event Log

B. Documents referred to in Event Log

C. Packet Distributed to FAST Team Members

INCLOSURE 1

RECAP OF STORMS

On Tuesday, July 10, the first of the monsoon storms hit. It caused approximately $50,000 damage to an apartment complex and an undetermined amount of residential damages in the City of Goodyear. This storm also caused $25,000 - $50,000 wind damage in Phoenix, and a lightening strike in Scottsdale set fire to a residence. Several thousand homes and businesses were without electric power for several hours after the storm.

An early morning thunderstorm on Sunday, July 15, resulted in street flooding and road closures in Peoria, west Phoenix, and other west valley locations. The Rubbermaid plant in Goodyear sustained $20,000 - $50,000 damages to its fire protection system and landscaping.

On Saturday night, July 21, a powerful storm hit northwest Phoenix. Some of the more heavily damaged areas included the general vicinities around 25th Avenue and Butler, 19th Avenue and Bell Road, and 35th Avenue and Beardsley. Typical damages in these areas included large sections of roof tiles/shingles blown away, mature trees uprooted or broken, roof-mounted air conditioners blown down, wooden fences blown over, and windows broken. A mobile home was destroyed and another severely damaged in the vicinity of 27th Avenue and Deer Valley Road. Approximately 65,000 homes and businesses were blacked out at various times during the storm. APS sustained about $350,000 in damages to lines and poles. Deer Valley estimated nearly $1 million due to damages to 10 aircraft, doors blown off hangars, and damages to other buildings. Substantial flooding also occurred in northwest Phoenix.

On Tuesday, July 24, another major thunderstorm hit the Phoenix metropolitan area. In Scottsdale, three vehicles were swept away by floodwaters in Indian Bend Wash. In Phoenix, lightening-caused fires did an estimated $100,000 damage to an apartment complex near 35th Avenue and Indian School Road, and $30,000 damage to another apartment complex at 35th Avenue and Dunlap. Winds blew the roof off of a Circle K at 35th Avenue and Union Hills. Several homes were flooded due to localized street flooding and lack of adequate drainage and six homes near 4th Avenue, north of Dunlap were flooded - due partially to on-going construction of the ACDC. Several major street intersections were flooded in northwest Phoenix.

The night of July 24, Fountain Hills experienced a thunderstorm in which lightening struck a house and caused an attic fire. Damages estimated at $20,000.

On Monday night, July 30, a thunderstorm hit eastern Maricopa County. Mesa Insulation, a business located one-half mile north of the intersection of Center Street and Southern Avenue in Mesa sustained $10,000 - $20,000 in damages when it was struck by "tornado-like" winds. A 90' x 26' section of metal roof was ripped from a three sided storage building. The roof landed in the lot behind its original location. Many locations in Mesa reported loss of electrical power during the storm.

On Tuesday evening, July 31, a storm passed through Mesa and Chandler. Lightening caused some power outages and palm tree fires, but no major damage was reported.

On Monday, August 6, a thunderstorm-associated microburst hit in the vicinity of Luke Air Force Base. The base sustained over $1 million damage as a result of toppled structures, trailers, poles, signs, and roofs, along with minor damage to 12 jet fighter aircraft. Two trailers at the JJ Trailer Park, near the intersection of Glendale Road and Dysart Road, were heavily damaged - one lost its roof and the other was blown off its foundation.

On Tuesday evening, August 11, a heavy storm caused street flooding in northwest Phoenix and loss of electric power in the West Valley, Mesa, and Tempe. Interstate 10 was closed from the town of Buckeye to the California state line from 7:30 p.m. to 8:30 p.m.

ON Wednesday night, August 12, a storm caused brief losses of electric power for up to 1000 APS customers, but no major damage was reported.

A slow, steady rain which lasted most of the day Tuesday, August 14, and Wednesday morning, August 15, resulted in heavy flooding in several Valley locations. Some specific areas were:

- Approximately 20 homes and the Baptist Church were flooded in Laveen when rain flowing into the irrigation canal alongside of Dobbins Road caused it to overfill and to overtop.

- On the Gila River Indian Reservation, more than 30 people were evacuated as a result of their homes being flooded.

- The Auto Zone store at 43rd Avenue and Indian School Road had the roof collapse and the store flooded to a depth of four inches.

- The Rock Haven Motel, near the intersection of 51st Avenue and Bethany Home Road, had flood water as deep as three feet in some rooms. Occupants were evacuated.

- Ironwood Apartments, near 9th Avenue and Butler Drive, had 21 units flooded.

- East of the town of Buckeye, approximately 20 homes between Baseline Road and the Buckeye Canal were flooded when the canal overtopped. The damage to the canal is estimated at $20,000; the dollar value of the damage to the homes is unknown.

- North of the town of Buckeye, the Roosevelt Canal overtopped in several places causing an estimated $200,000 damage to the canal system. Damage to the surrounding area as a result of flooding of homes, washed-out irrigation ditches, etc. is estimated at approximately $800,000.

- In the city of Phoenix, locations at which homes were flooded include 43rd Avenue and Buckeye Road, 7th Avenue and Glendale Avenue, and 7th Avenue and Dunlap Avenue. An apartment was flooded at I-10 and Bell Road.

- In El Mirage, Dysart Road was washed out between Greenway and Thunderbird Roads when a farm levee gave way. Repairing this damage along with several other small road repairs cost the city approximately $10,000.

MARICOPA COUNTY DEPARTMENT OF CIVIL DEFENSE
AND EMERGENCY SERVICES

1990 MONSOON FLOODS LIST OF CONTACTS

COUNTY AGENCIES

1. Flood Control District
   3335 West Durango, Phoenix

   Bob Payette — 262-1501 or 269-4730

2. Highway Department
   3335 West Durango, Phoenix

   Gary Lasham — 233-8668

3. Parks and Recreation
   ~~335~~ West Durango, Phoenix
   3355
   Howard Gilmore — 272-8871

CITIES/TOWNS

1. Avondale
   525 North Central Ave

   Public Works - Don Bratke — 932-1909

2. El Mirage
   14405 North Palm St

   Scott Lind — 972-8116

3. Fountain Hills
   MCSO Fountain Hills Substation, 16833 North Saguaro Blvd

   Pat Harvey, Streets Supt — 837-2003

4. Glendale
   7505 North 55th Avenue

   Galen Shirley — ~~843-7600~~
   931-5614

CITIES/TOWNS (Cont)

5. Goodyear
   119 North Litchfield Rd

   Public Works - Lynn Kartchner 932-1637

6. Litchfield Park
   214 West Indian School Rd

   Dennis Tinberg 935-5033

7. Mesa
   13 West First St

   Dave Nichols 644-3523

8. Peoria
   8311 West Washington St

   Mike Fusco 979-7067

9. Phoenix
   251 West Washington St (Downtown Phoenix)

   Steve Charvat 495-2077

10. Scottsdale
    9065 East Via Linda

    Marc Eisen 391-5666

11. Surprise
    12604 Santa Fe Drive

    Gilbert Balcome 583-8225
    RANDY YINGLING 977-8369

PRIVATE SECTOR/BUSINESSES

1. American Graduate School of International Management
   59th Avenue and Greenway Road

   VP for Business Affairs -
   Lee Stickland 978-7145

   Director of Physical Plant -
   Robert Watts 978-7224

PRIVATE SECTOR/BUSINESSES (Cont)

2. Buckeye Irrigation Company
   205 East Roosevelt Avenue, Buckeye

   Gary Colvin 247-7623

3. Roosevelt Irrigation District
   103 West Baseline Road, Buckeye

   Stan Ashley 935-4271

AMERICAN RED CROSS - 1510 East Flower Street

Liz Pabst 264-9481

COUNTY AGENCIES - THESE AGENCIES WILL PROVIDE DAMAGE SURVEY ASSISTANCE UPON REQUEST.

1. Assessor's Office

   Neal Wolfe 495-8738 or 261-5960

   Ellen Moore 495-8738

2. Building Safety

   Dale Graf 262-9692

LESSONS LEARNED
SUBMITTED BY RUTH AUD

1. We need to find ways to obtain information regarding damage after a storm.

    a. Contact each place where you think flooding could have occurred when surveying an area.

    b. Get address, name, telephone number, and damages incurred.

    c. Contact Red Cross for individuals requiring immediate assistance.

    d. Stay in contact with Red Cross so that duplicate surveys are not conducted.

    e. See if we can get media help in promoting the need for information from the public. We know there were more people affected - but they didn't inform the Red Cross, their city/town, or us.

    f. Information on people who had to leave their homes. We can get numbers from the Red Cross on how many in shelters or put up in temporary housing, but we don't know how many others were dislocated. (FEMA Teams are looking for IMPACT - which is numbers of people affected and to what extent)

2. City must keep their people informed of what is going on. Residents of Peoria were prepared to answer questions posed by the FEMA Teams because the city had conducted city meetings and the newspapers had provided extensive coverage.

3. The city's and county must keep up-to-date records on expenses incurred as a result of the storm.

   a. City can allow the expenses from Public Building(s) under construction which received damage and city had to meet a $5,000 deductible on its insurance.

   b. City will get allowance for use of city owned equipment to repair damages.

   c. City should keep track of all expenses including extra garbage containers placed in hard hit areas, extra pick-ups, etc.

   d. FEMA Teams are looking at the <u>impact</u> of all expenses on the existing maintenance budgets. Care should be taken to insure that these dollar figures are extracted and made available, when requested.

4. Estimates on businesses should have any damage that would be covered under their insurance policy subtracted from their total price and reflect only uninsured losses.

5. We need to understand how FEMA evaluates the damages.

   a. Floodwaters needed to be high enough inside to affect the electrical outlets to be considered as damaged. If it doesn't reach that height, damage is reflected as affected but habitable. Minor damage was designated when a $5,000 grant would fix the damage; over that amount was designated as major damage; and destroyed would have to be quite extensive damages.

   b. FEMA also is looking at price ranges of affected homes and the IMPACT of the damages. Carpeting that needs to be replaced in a $100,000 home does not have the impact of $15,000 damage to a $40,000 home.

6. The folders with maps, listing of contact names and telephone numbers were extremely useful. The addresses for the various contacts should also be included in the list.

7. The Red Cross damage survey sheets were used extensively by the Team and they found them to be quite accurate. A listing of names and addresses of people who had complained to the city was provided by the City of Glendale. The team felt that some people complained and there was no real damage. They wanted to see verified damages.

8. The cellular telephones proved to be extremely beneficial.

DATE: November 5, 1990
TO: Carol Davis
Maricopa Flood Control District

Carol:

1. Attached are the radar observations taken for a storm event from about 10:30 am (MST) to 10:00 pm (MST) on August 3, 1990.

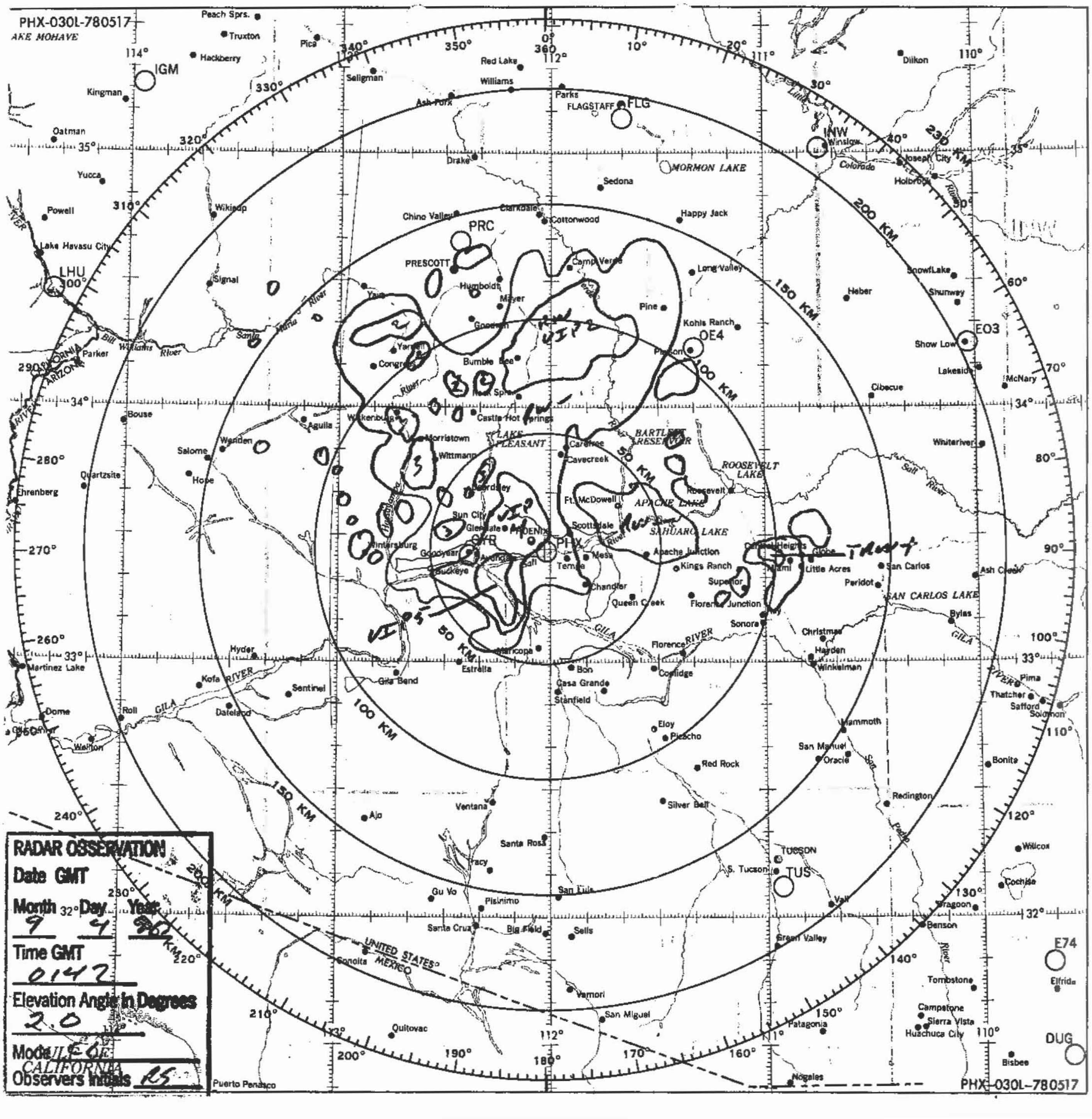
2. For your info., I've included a little conversion chart I use for Z time.

3. Following are the monthly precip. values at the airport for Aug. and Sept. 1990.

Month	Total precp.	Departure from norm.	Yr. cum.
Aug 1990	2.70"	+1.68"	5.97"
Sep 1990	1.11"	+0.47"	7.08"

Please call if we can help you with anything else.

Rose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FLAGSTAFF
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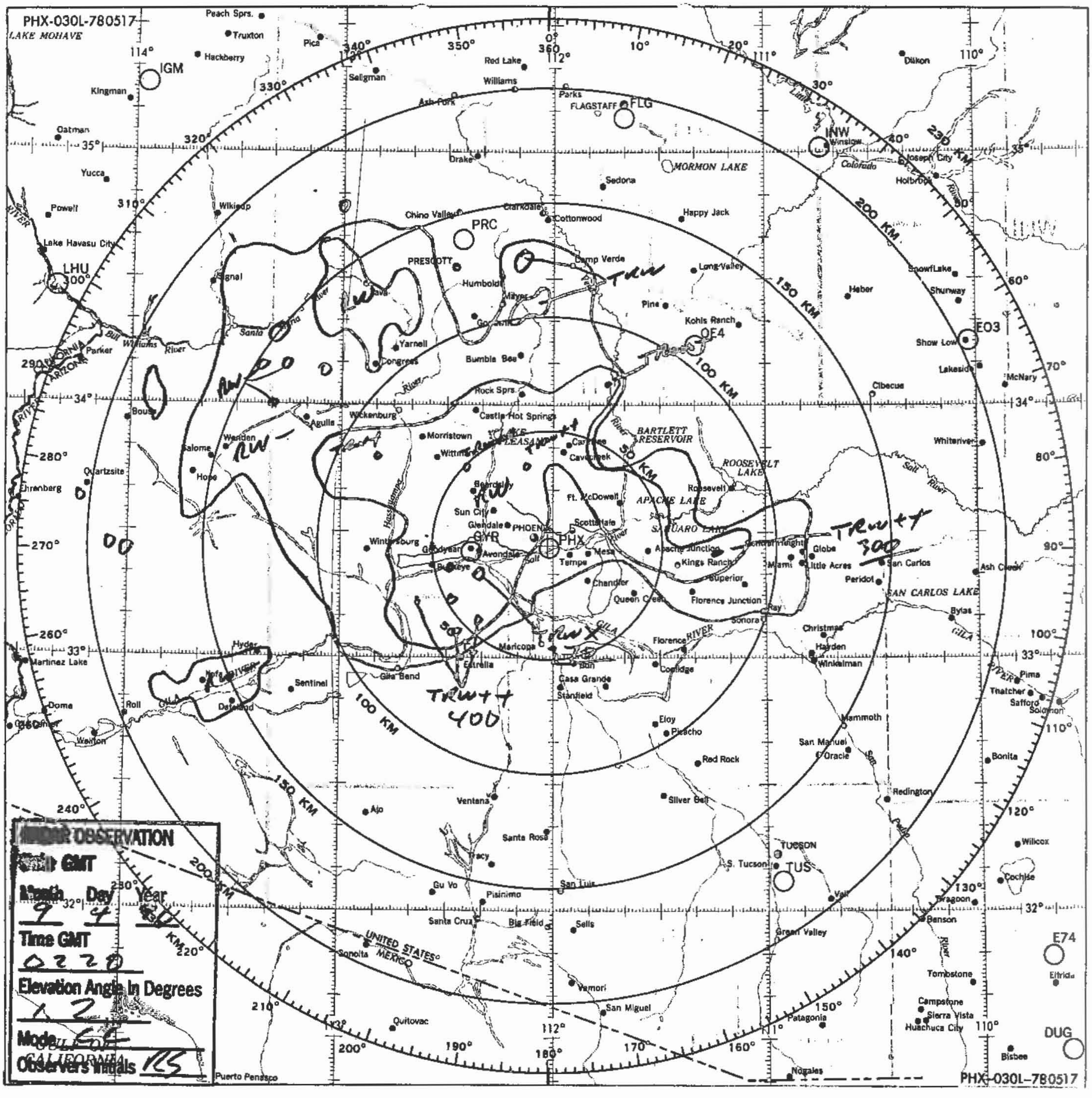
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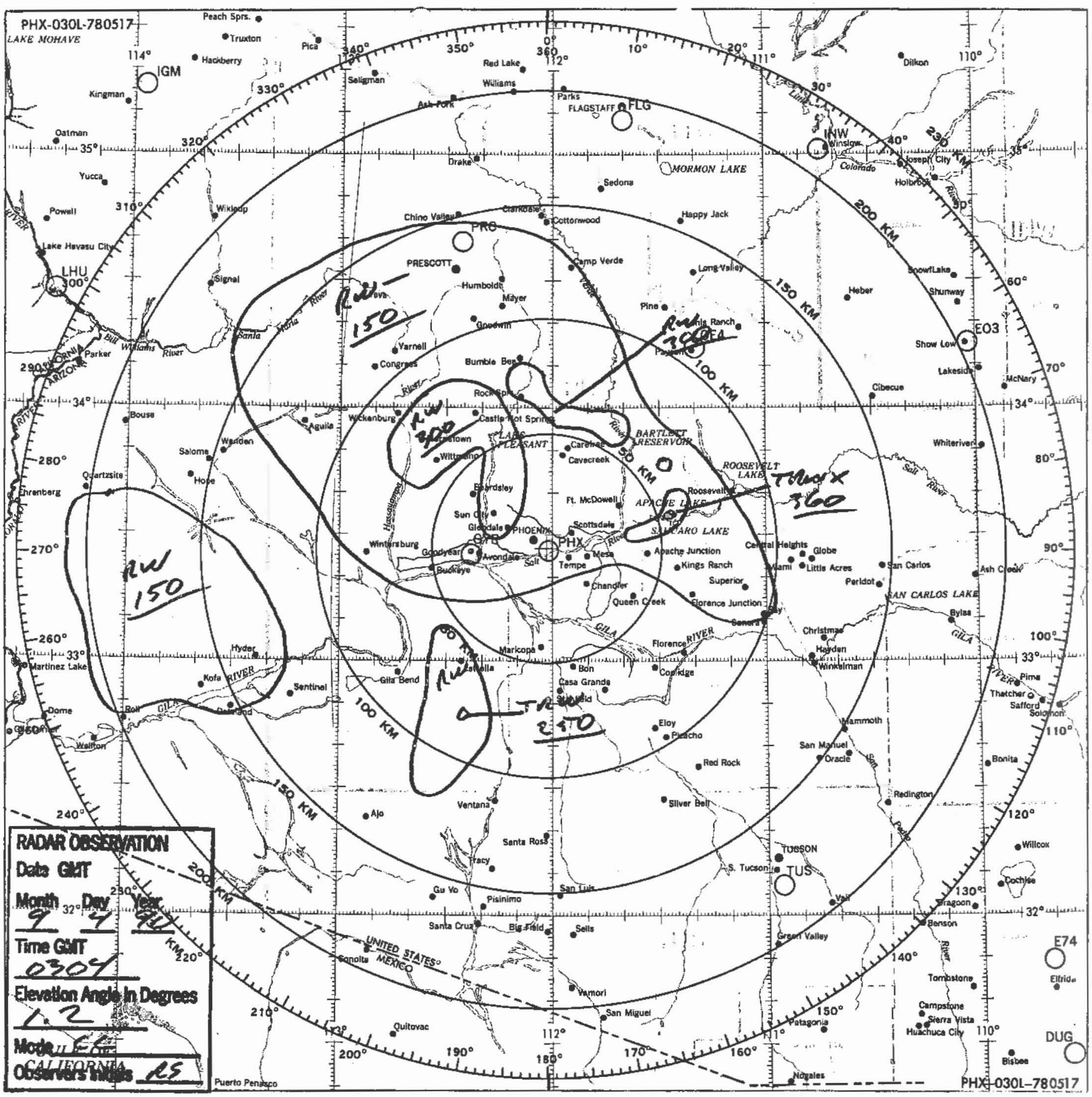
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Humboldt
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Clarkdale
Cottonwood
Camp Verde
Sedona
Flagstaff
Williams
Ash Fork
Seligman
Drake
Parks
Happy Jack
Long Valley
Pine
Payson
Heber
Show Low
Snowflake
Shumway
Lakeside
McNary
Holbrook
Joseph City
Winslow
Dilkon
Cibecue
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San Carlos
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Kings Ranch
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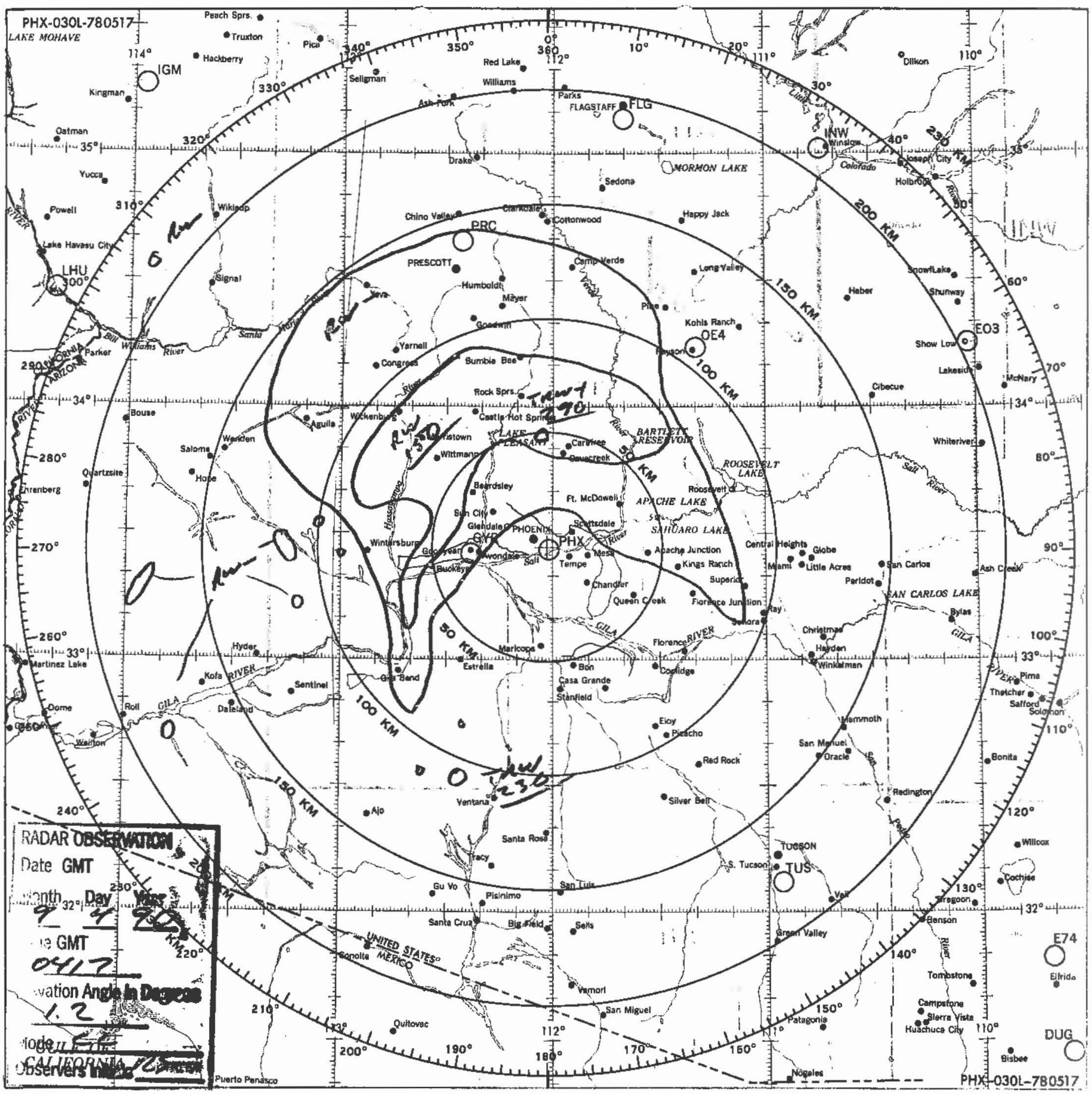
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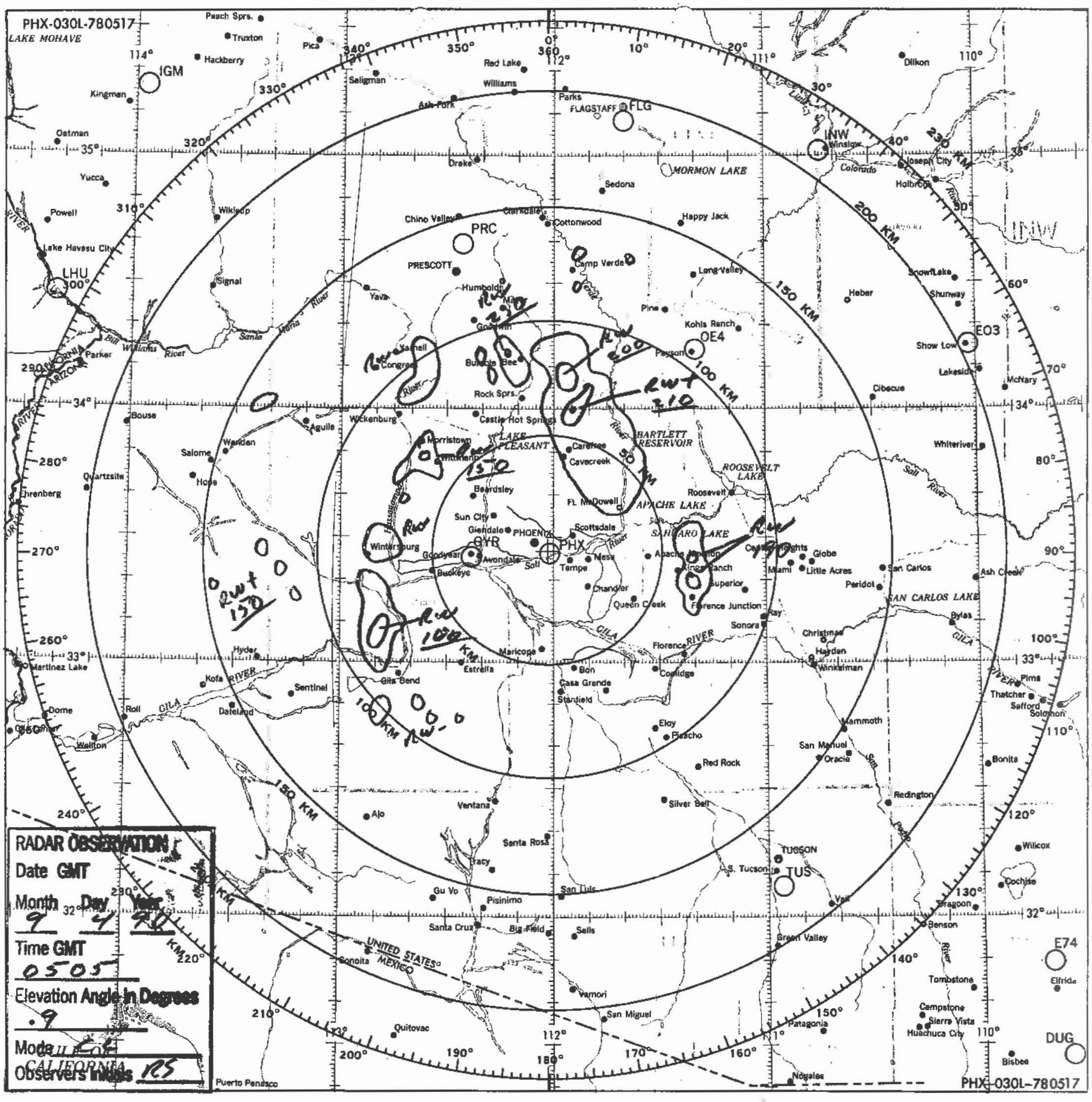
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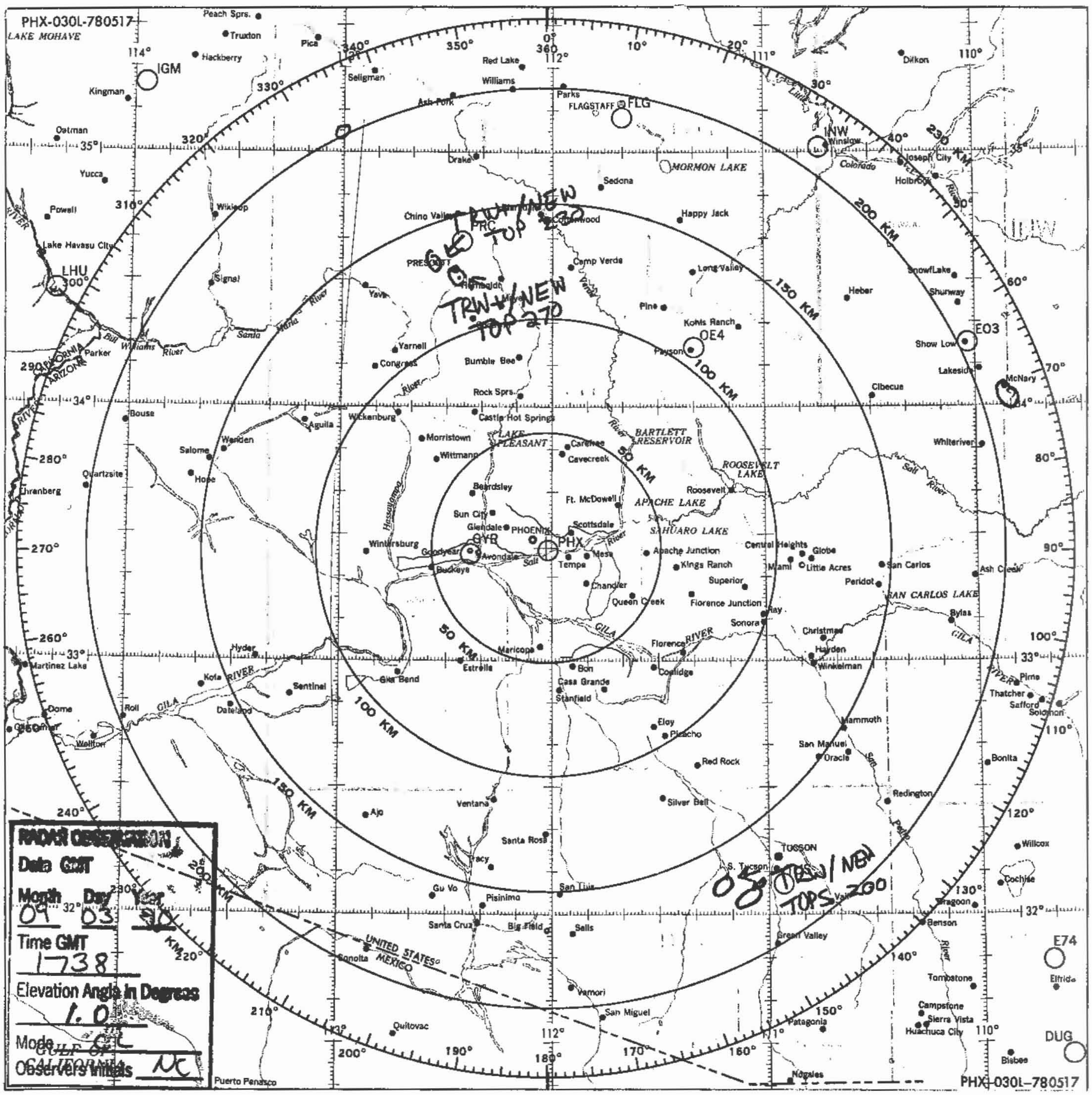
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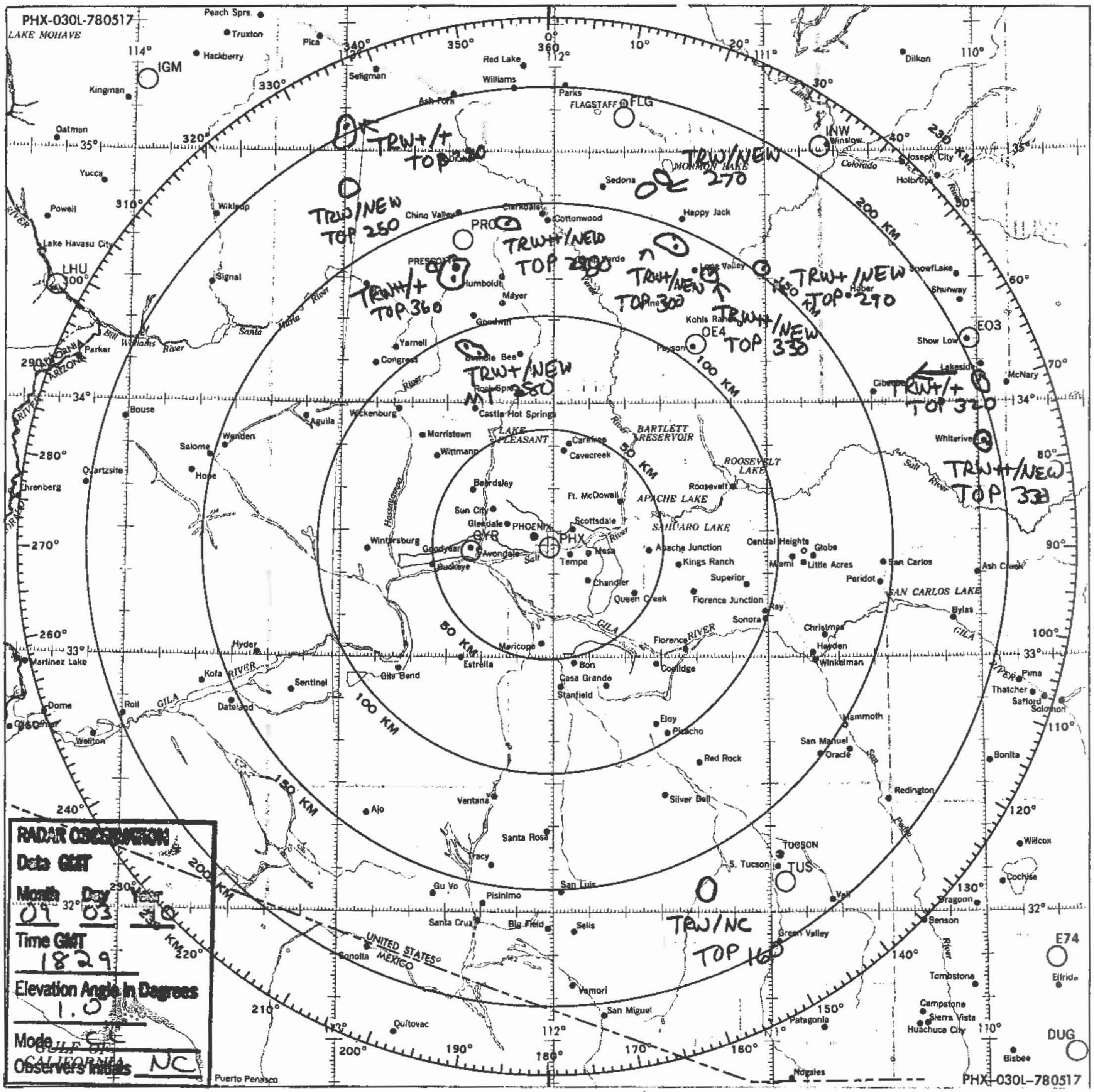
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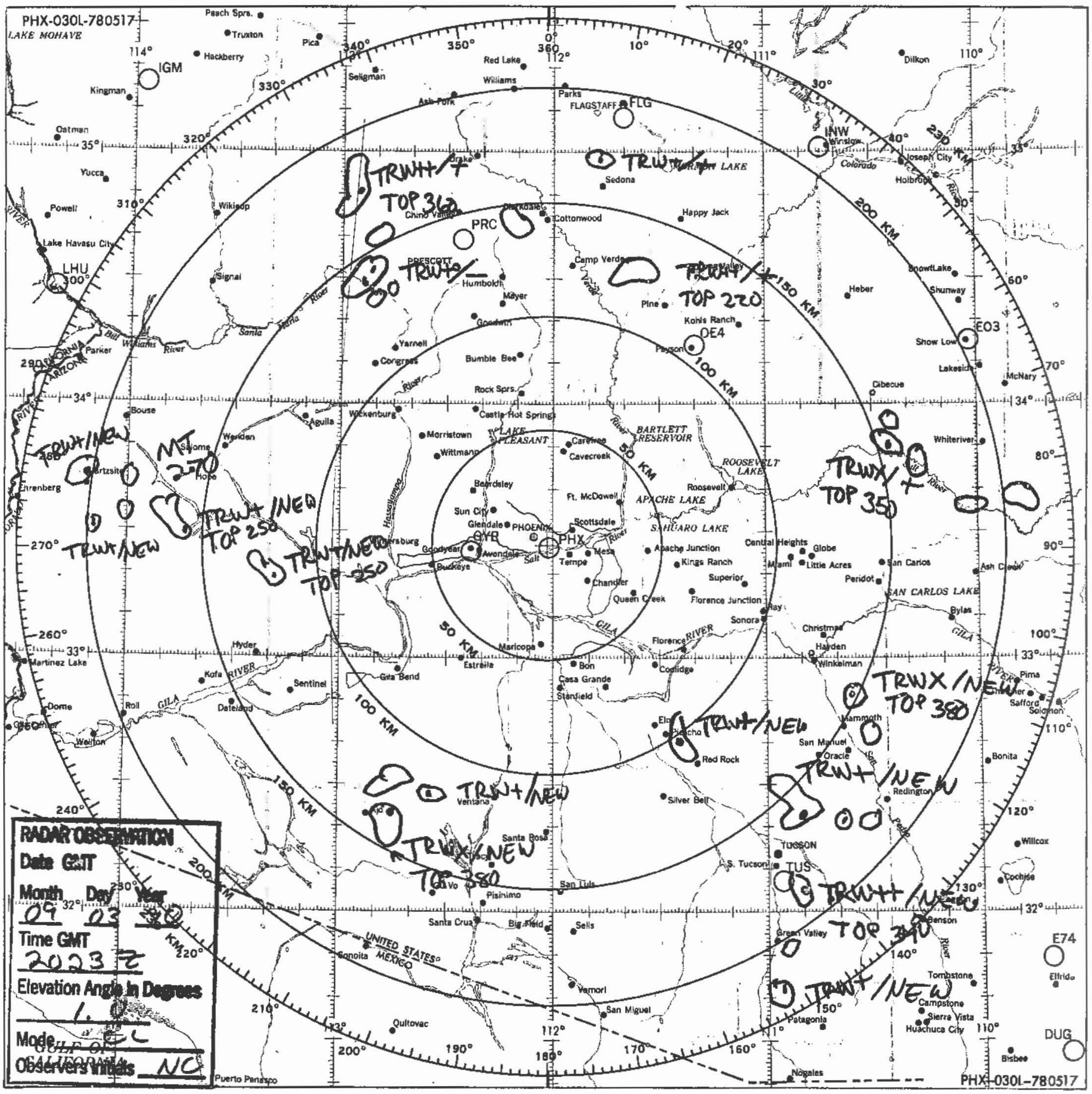
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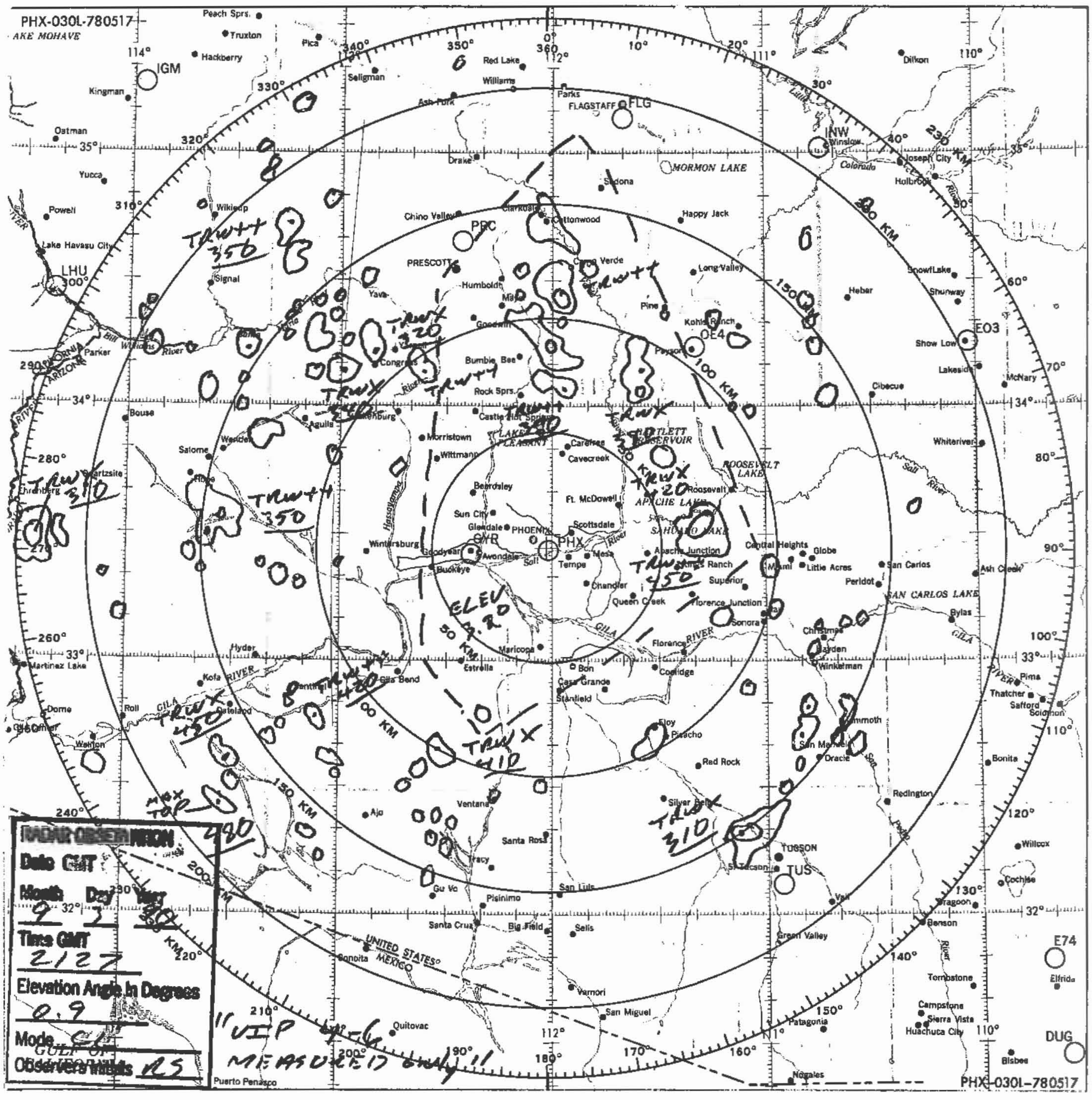

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Bouse
Quartzsite
Ehrenberg
Beardsley
Sun City
Glendale
PHOENIX
PHX
GYR
Goodyear
Avondale
Buckeye
Wintersburg
Tempe
Mesa
Scottsdale
Chandler
Carefree
Cavecreek
Ft. McDowell
BARTLETT RESERVOIR
ROOSEVELT LAKE
Roosevelt
APACHE LAKE
SAHUARO LAKE
Apache Junction
Kings Ranch
Superior
Queen Creek
Florence Junction
Florence
Sonora
Central Heights
Globe
Miami
Little Acres
San Carlos
Peridot
SAN CARLOS LAKE
Christmas
Hayden
Winkelman
Payson
OE4
Kohls Ranch
Pine
Heber
Show Low
EO3
Lakeside
McNary
Cibecue
Whiteriver
Winslow
INW
Joseph City
Holbrook
Snowflake
Shumway
Maricopa
Estrella
Bon
Casa Grande
Stanfield
Coolidge
Eloy
Picacho
Red Rock
Silver Bell
Gila Bend
Sentinel
Hyder
Dateland
Roll
Dome
Kofa
Martinez Lake
Wellton
Ajo
Ventana
Santa Rosa
Tracy
Gu Vo
Pisinimo
San Luis
Santa Cruz
Big Field
Sells
TUCSON
TUS
Vail
Green Valley
Sonoita
Vamori
San Miguel
Quitovac
Puerto Penasco
Nogales
Patagonia
UNITED STATES
MEXICO
GULF OF
Mammoth
San Manuel
Oracle
Redington
Bonita
Thatcher
Safford
Solomon
Pima
Bylas
Willcox
Cochise
Dragoon
Benson
Tombstone
E74
Elfrida
Campstone
Sierra Vista
Huachuca City
DUG
Bisbee
Dilkon
50 KM
100 KM
150 KM
200 KM
230 KM
TRW++ 350
TRW+ 320
TRWX
TRW++
TRWX 120
TRW++ 350
TRWX 310
TRWX 450
TRWX 410
TRWX 310
ELEV
MAX TOP 480
Date GMT
Month
Day
Year
Time GMT
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Elevation Angle In Degrees
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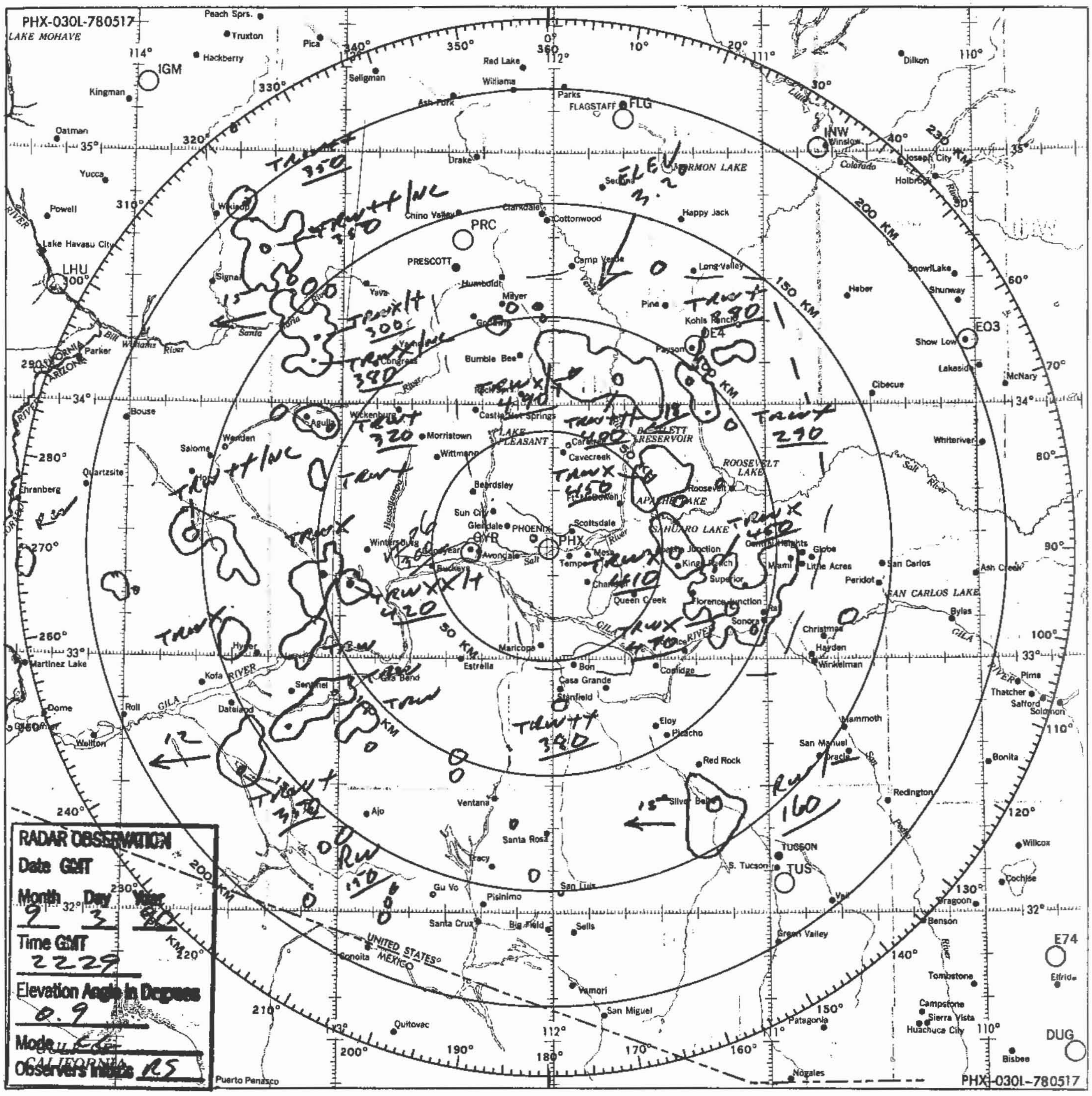
Observers Initials
"VIP 4-6 MEASURED only!!
PHX-030L-780517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Month Day Year
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Time GMT
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PHOENIX
PHX
FLAGSTAFF
FLG
PRESCOTT
PRC
TUCSON
TUS
LHU
IGM
INW
EO3
DE4
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50 KM
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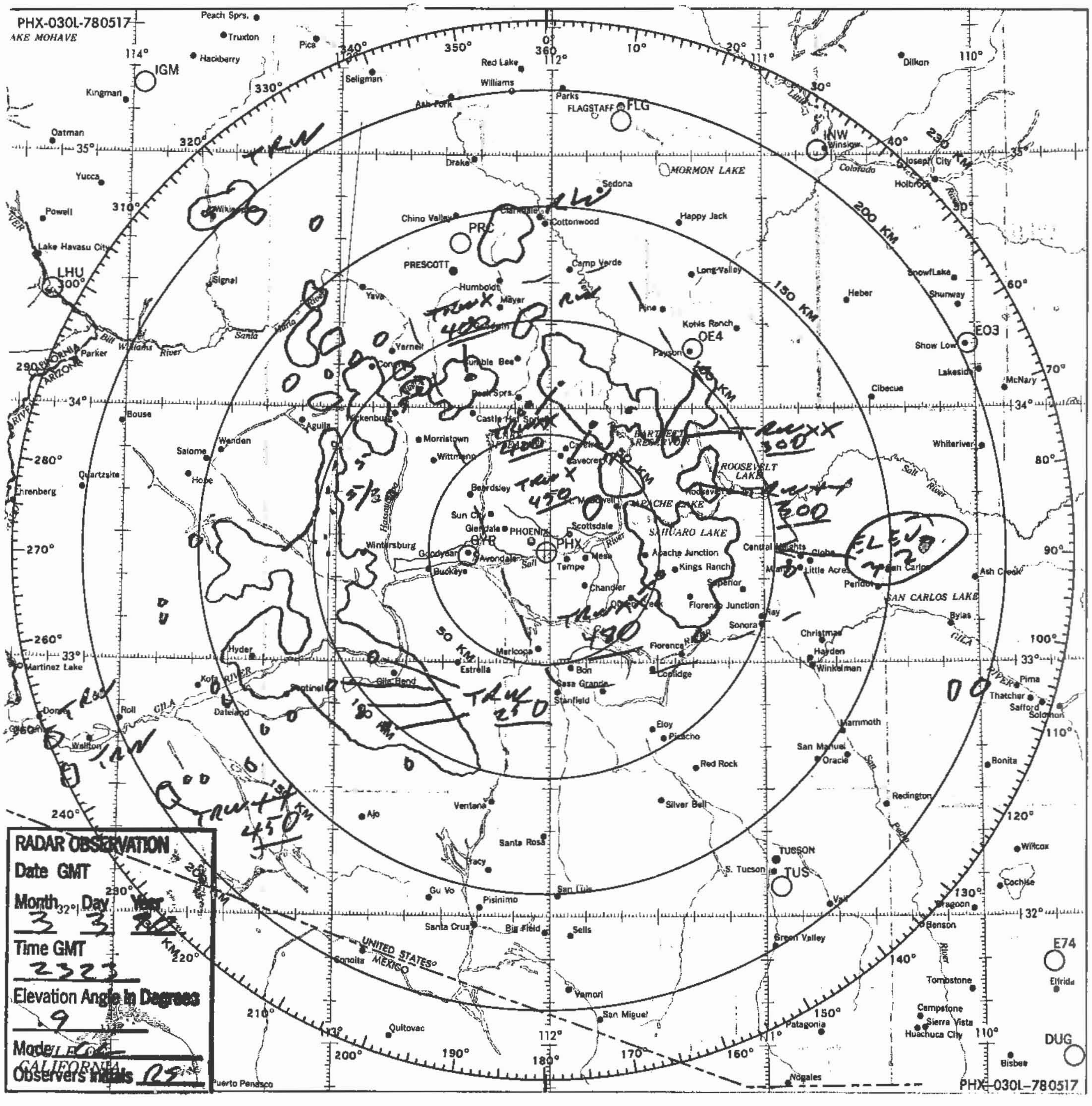
UNITED STATES
MEXICO
PHX-030L-780517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Date GMT
Month Day Year
3 3
Time GMT
2323
Elevation Angle In Degrees
9
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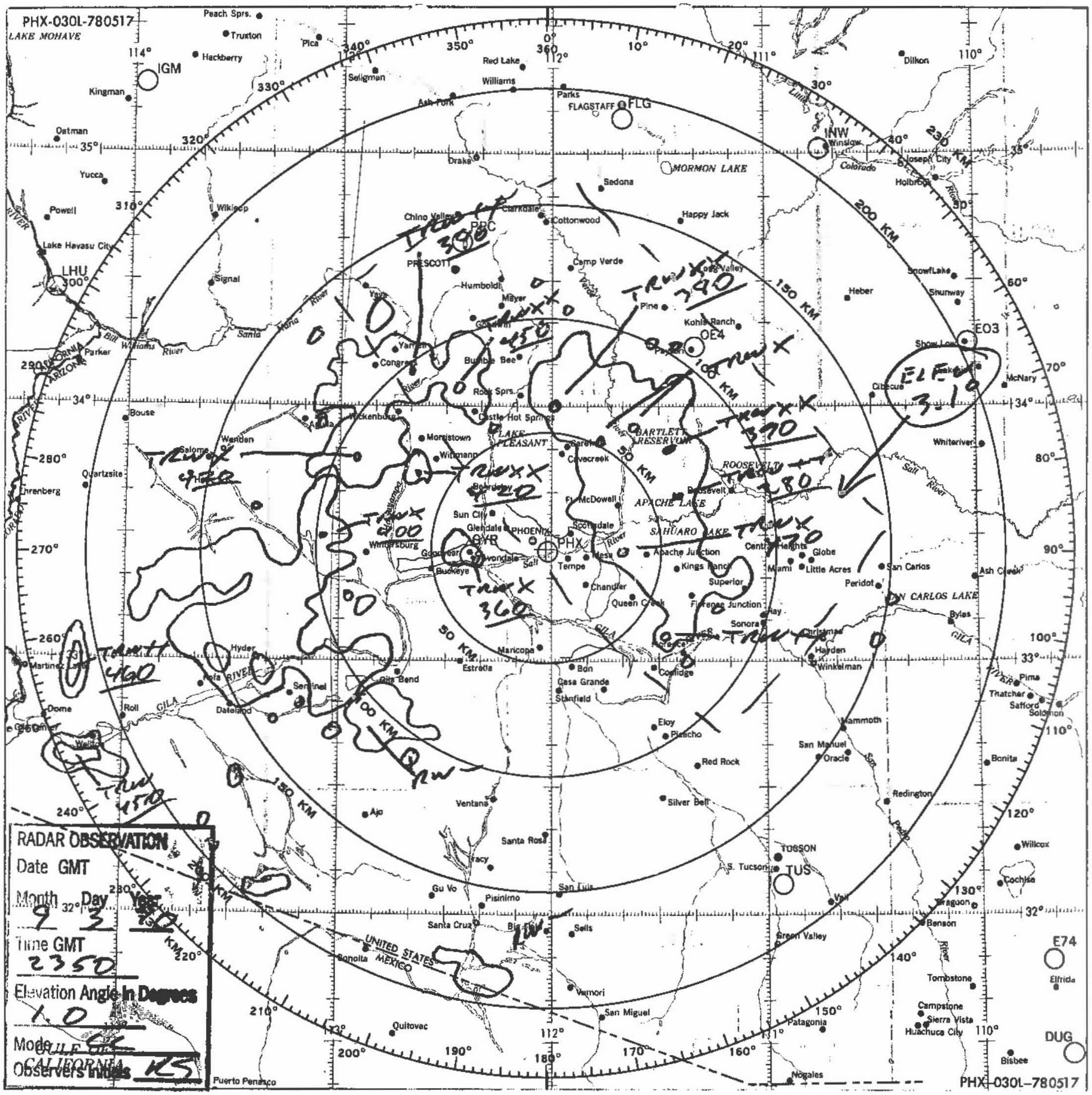
LAKE MOHAVE
Peach Sprs.
Truxton
Hackberry
Kingman
Oatman
Yucca
Powell
Lake Havasu City
LHU
IGM
Seligman
Williams
Red Lake
Parks
FLAGSTAFF
FLG
INW
Winslow
Joseph City
Holbrook
Dilkon
MORMON LAKE
Sedona
Chino Valley
Clarkdale
Cottonwood
PRC
PRESCOTT
Camp Verde
Happy Jack
Long Valley
Humboldt
Mayer
Heber
Snowflake
Shumway
Show Low
EO3
Lakeside
McNary
Payson
OE4
Kohls Ranch
Pine
Parker
Signal
Yava
Yarnell
Bumble Bee
Wickenburg
Aguila
Bouse
Wenden
Salome
Hope
Quartzsite
Ehrenberg
Morristown
Wittmann
Castle Hot Springs
BARTLETT RESERVOIR
ROOSEVELT LAKE
Roosevelt
Cibecue
Whiteriver
Beardsley
Sun City
Glendale
PHOENIX
Scottsdale
PHX
GYR
Goodyear
Avondale
Buckeye
Wintersburg
Tempe
Mesa
Chandler
APACHE LAKE
SAGUARO LAKE
Apache Junction
Kings Ranch
Central Heights
Globe
Miami
Little Acres
Peridot
San Carlos
SAN CARLOS LAKE
Ash Creek
Superior
Florence Junction
Ray
Sonora
Christmas
Hayden
Winkelman
Florence
Coolidge
Maricopa
Estrella
Gila Bend
Sentinel
Hyder
Kofa
Dateland
Roll
Dome
Wellton
Martinez Lake
Casa Grande
Stanfield
Eloy
Picacho
Mammoth
San Manuel
Oracle
Red Rock
Silver Bell
Redington
Bylas
Pima
Thatcher
Safford
Solomon
Bonita
Willcox
Ajo
Ventana
Santa Rosa
Tracy
Gu Vo
Pisinimo
San Luis
Santa Cruz
Big Field
Sells
TUCSON
S. Tucson
TUS
Vail
Dragoon
Benson
Cochise
Green Valley
Sonoita
UNITED STATES
MEXICO
Tombstone
Elfrida
E74
Campstone
Sierra Vista
Huachuca City
Vamori
San Miguel
Quitovac
Patagonia
Nogales
Bisbee
DUG
Puerto Penasco
CALIFORNIA
ARIZONA
50 KM
100 KM
150 KM
200 KM
230 KM


PHX-030L-780517
LAKE MOHAVE
IGM
Kingman
Oatman
Yucca
Powell
Lake Havasu City
LHU
Parker
Bouse
Quartzsite
Ehrenberg
Wenden
Salome
Wickenburg
Congress
Yarnell
Prescott
PRC
Chino Valley
Humboldt
Mayer
Seligman
Williams
Ash Fork
Red Lake
Parks
FLAGSTAFF
FLG
Drake
Sedona
Clarkdale
Cottonwood
Camp Verde
MORMON LAKE
Happy Jack
Pine
Kohls Ranch
OE4
Payson
Heber
Snowflake
Shumway
Show Low
EO3
McNary
Cibecue
Whiteriver
Winslow
INW
Joseph City
Holbrook
Dilkon
Colorado
Little
BARTLETT RESERVOIR
ROOSEVELT
Roosevelt
APACHE LAKE
SAHUARO LAKE
Apache Junction
Kings Ranch
Superior
Miami
Globe
Little Acres
San Carlos
Peridot
SAN CARLOS LAKE
Central Heights
Ash Creek
Bylas
Christmas
Hayden
Winkelman
Pima
Thatcher
Safford
Solomon
Morristown
Wittmann
Beardsley
Sun City
Glendale
PHOENIX
PHX
GYR
Goodyear
Avondale
Buckeye
Wintersburg
Scottsdale
Tempe
Mesa
Chandler
Queen Creek
Florence Junction
Ft. McDowell
Carefree
Cavecreek
LAKE PLEASANT
Castle Hot Springs
Rock Sprs.
Bumble Bee
Maricopa
Estrella
Bon
Casa Grande
Stanfield
Coolidge
Sonora
Ray
Eloy
Picacho
Red Rock
Mammoth
San Manuel
Oracle
Silver Bell
Redington
Bonita
Willcox
Cochise
Dragoon
Benson
TUCSON
TUS
S. Tucson
Vail
Green Valley
Tombstone
Elfrida
E74
Campstone
Sierra Vista
Huachuca City
Bisbee
DUG
Patagonia
Nogales
San Miguel
Vamori
Sells
Big Fields
San Luis
Pisinimo
Santa Cruz
Gu Vo
Tracy
Santa Rosa
Ventana
Ajo
Sonoita
Quitovac
Puerto Penasco
UNITED STATES
MEXICO
Gila Bend
Sentinel
Dateland
Hyder
Roll
Tacna
Dome
Martinez Lake
Wellton
Salt
Verde
Santa Maria River
Bill Williams River
GILA
ARIZONA
CALIFORNIA
50 KM
100 KM
150 KM
200 KM
230 KM
RADAR OBSERVATION
Date GMT
Month Day Year
9 3 80
Time GMT
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Elevation Angle In Degrees
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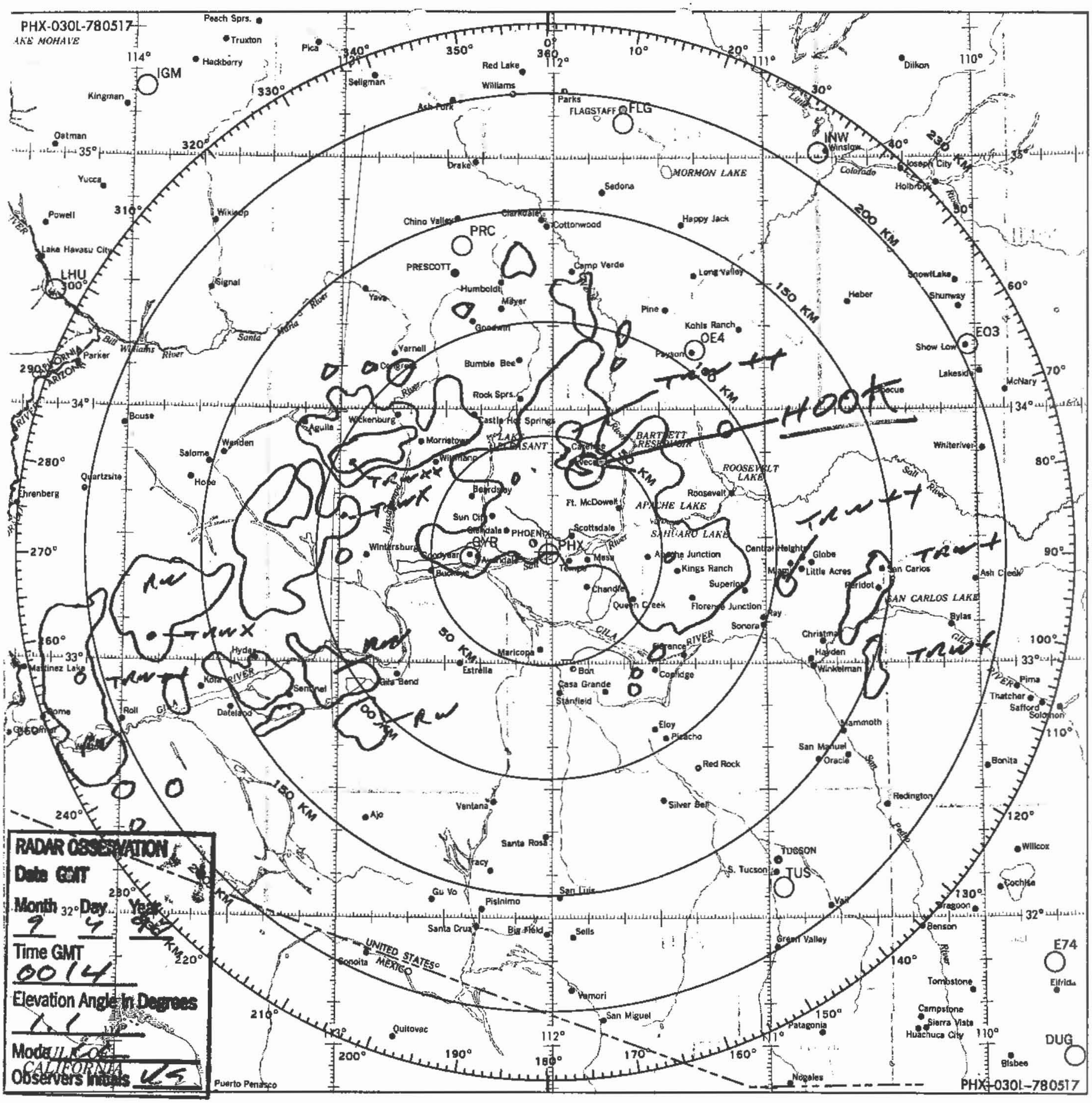
Mode
Observers Initials KS
PHX-030L-780517


PHX-030L-780517
LAKE MOHAVE
RADAR OBSERVATION
Date GMT
Month 9
Day 4
Year
Time GMT 0014
Elevation Angle in Degrees
Mode
Observers Initials
HOOK
TRW++
TRW+
TRWX
RW
50 KM
100 KM
150 KM
200 KM
230 KM
PHX
GYR
PRC
IGM
FLG
INW
LHU
OE4
E03
TUS
E74
DUG
Kingman
Oatman
Yucca
Powell
Lake Havasu City
Parker
Bouse
Salome
Quartzsite
Ehrenberg
Hope
Wenden
Aguila
Wickenburg
Congress
Yarnell
Yava
Bumble Bee
Rock Sprs.
Castle Hot Springs
Morristown
Wittmann
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Wintersburg
Scottsdale
Tempe
Mesa
Chandler
Queen Creek
Ft. McDowell
Carefree
Cave Creek
Apache Junction
Kings Ranch
Superior
Florence Junction
Florence
Coolidge
Casa Grande
Stanfield
Maricopa
Estrella
Gila Bend
Sentinel
Dateland
Hyder
Kofa
Roll
Mohawk
Martinez Lake
Yuma
Gadsden
Ajo
Ventana
Santa Rosa
Tracy
Gu Vo
Pisinimo
Santa Cruz
Big Fields
Sells
Sonoita
Quitovac
Vamori
San Miguel
Puerto Penasco
Nogales
Patagonia
San Luis
S. Tucson
TUCSON
Green Valley
Sahuarita
Red Rock
Picacho
Eloy
Silver Bell
San Manuel
Oracle
Mammoth
Redington
Benson
Tombstone
Elfrida
Bisbee
Campstone
Sierra Vista
Huachuca City
Dragoon
Cochise
Willcox
Bonita
Safford
Solomon
Thatcher
Pima
Bylas
Winkelman
Hayden
Christmas
Ray
Sonora
Kearny
Globe
Miami
Little Acres
Peridot
San Carlos
Central Heights
SAN CARLOS LAKE
Roosevelt
ROOSEVELT LAKE
APACHE LAKE
SAGUARO LAKE
BARTLETT RESERVOIR
LAKE PLEASANT
Payson
Kohls Ranch
Pine
Long Valley
Happy Jack
Camp Verde
Cottonwood
Clarkdale
Sedona
Chino Valley
PRESCOTT
Humboldt
Mayer
Goodwin
Drake
Ash Fork
Seligman
Williams
Red Lake
Parks
FLAGSTAFF
MORMON LAKE
Winslow
Joseph City
Holbrook
Heber
Snowflake
Shumway
Show Low
Lakeside
McNary
Whiteriver
Cibecue
Ash Creek
Dilkon
Pica
Peach Sprs.
Truxton
Hackberry
Wikieup
Signal
Bill Williams River
Santa Maria River
Colorado River
Salt River
Gila River
Hassayampa River
Verde River
San Pedro River
UNITED STATES
MEXICO
CALIFORNIA
ARIZONA
114°
113°
112°
111°
110°
35°
34°
33°
32°
0°
360°
10°
20°
30°
40°
50°
60°
70°
80°
90°
100°
110°
120°
130°
140°
150°
160°
170°
180°
190°
200°
210°
220°
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240°
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280°
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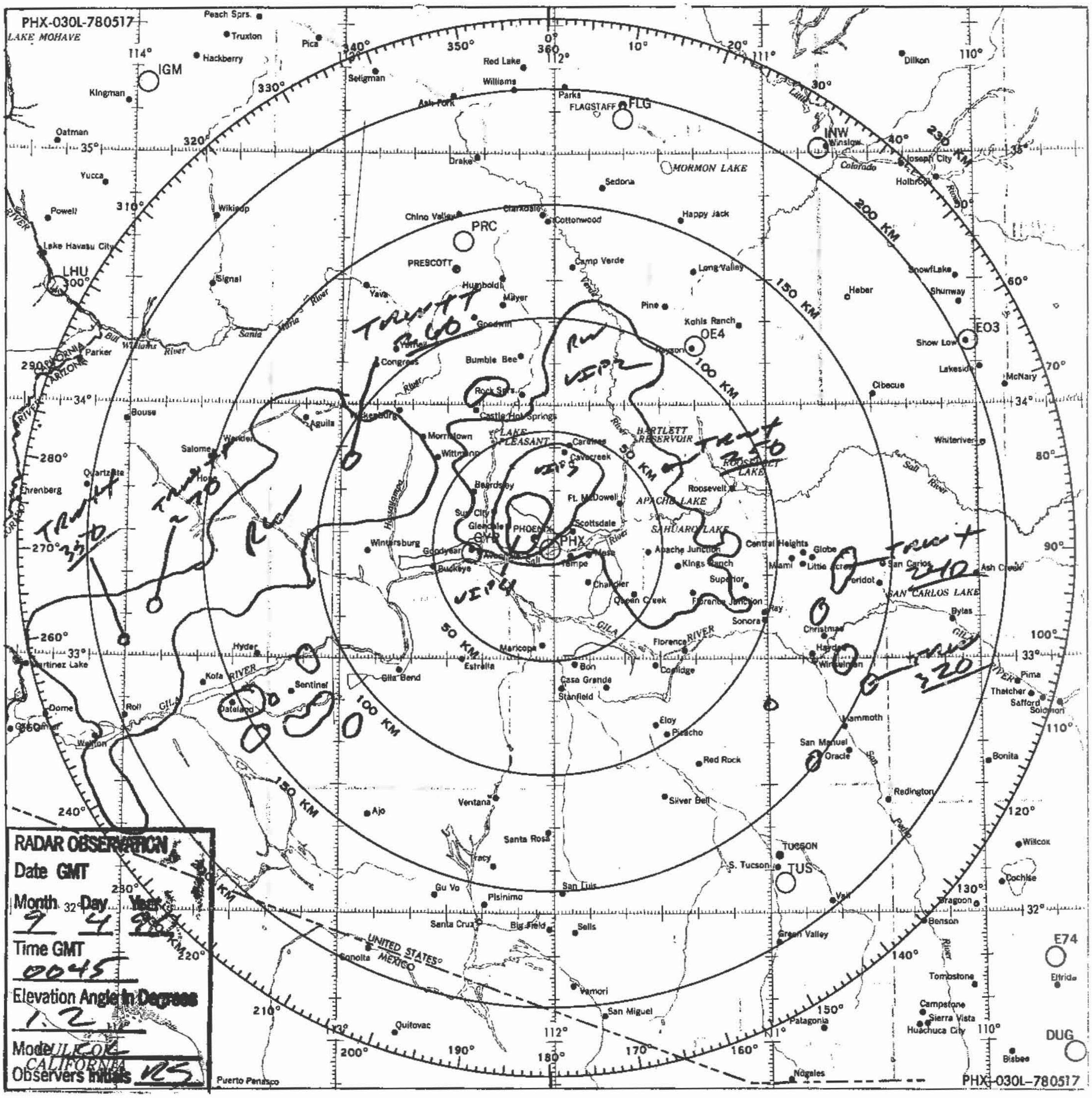
300°
310°
320°
330°
340°
350°


PHX-030L-780517
LAKE MOHAVE
RADAR OBSERVATION
Date GMT
Month Day Year
Time GMT
0045
Elevation Angle in Degrees
1.2
Mode
Observers Initials
PHX-030L-780517

DATE		GAUGE #		INCHES		TIME
7/~~25~~ 24 computer		6640		~~2.28~~ 2.25		4 hrs
7/~~25~~ 24 computer		6610		~~2.07~~ 1.97		4 hrs
7/~~25~~ 24		10	5.66 / 2.09	.55	8:26 / 2:43	6 hrs
9/~~4~~ 3		2700	8.39 - 5.00 = 3.39 →	3.39	20:24 / 6:11	14 hrs
9/~~4~~ 3		1520	6.50 / 4.17 / 2.33	2.32	20:41 / 14:09	6 hr
9/4 3		1530	6.02 / 3.09 / 2.93 →	2.64	20:26 / 8:01	12 hr
9/~~4~~ 3		2610	11.5 / 9.59 / 2.04 →	2.05	21:56 / 15:33	6 hr
9/~~4~~ 3		10		NO BIG DEAL		
9/~~4~~ 3	ALDC	1510	7.83 / 4.33 / 3.50 →	3.50	19:49 / 16:59	3 hr
8/~~15~~ 14		2630	9.41 / 6.69 / 2.72 →	2.40	12:03 / 9:45	2 hr
8/~~16~~ 15		2650	9.88 / 7.32 / 2.64 →	2.32	7:14 / 4:36	2.5 hr
8/15		5605		2.09		2.0 hr
8/15		5800		1.97		
8/15		1625		2.20		
8/16		6510		2.05		

Sensor # 10 FCD Complex Precipitation Gage

DATE	TIME	inches	
08/15/90	12:27:41	0.20	(5)
08/15/90	06:33:53	0.16	(4)
08/15/90	06:06:47	0.12	(3)
08/15/90	05:54:18	0.08	(2)
08/15/90	05:41:43	0.04	(1)
08/15/90	05:31:34	0.00	(0)
08/15/90	05:18:25	3.90	(99)
/15/90	05:11:46	3.86	(98)
08/15/90	05:01:44	3.82	(97)
08/15/90	04:53:56	3.78	(96)
08/15/90	04:43:46	3.74	(95)
08/15/90	04:35:45	3.70	(94)
08/15/90	04:23:38	3.66	(93)
08/15/90	04:14:59	3.62	(92)
08/15/90	04:11:21	3.58	(91)
08/15/90	04:09:26	3.54	(90)
08/15/90	04:05:41	3.46	(88)
08/15/90	03:56:10	3.39	(86)
08/15/90	03:42:33	3.35	(95)
08/15/90	03:33:34	3.31	(84)
08/15/90	03:24:47	3.27	(83)
08/15/90	03:13:15	3.23	(82)
08/15/90	03:07:00	3.19	(81)
08/15/90	03:02:51	3.15	(80)
08/15/90	02:57:56	3.11	(79)
08/15/90	02:55:01	3.07	(78)
08/15/90	02:52:33	3.03	(77)
08/15/90	02:49:42	2.99	(76)
08/15/90	02:45:59	2.95	(75)
08/15/90	02:44:02	2.91	(74)
08/15/90	00:33:21	2.87	(73)
08/14/90	13:45:50	2.87	(73)
08/14/90	12:38:16	2.83	(72)
/14/90	12:29:38	2.83	(72)
08/14/90	11:11:47	2.76	(70)
08/14/90	10:58:01	2.72	(69)
08/14/90	10:52:52	2.68	(68)
08/14/90	10:46:23	2.64	(67)
08/14/90	10:34:31	2.48	(63)
08/14/90	10:33:02	2.44	(62)

Compare monthly TOTALS
FOR Sept. Airport +
Aug. Airport +

Call Tom Hard copy
9.15 for Radar

2.76
1.10
1.66"

11:10 AM
9:40 AM
hrs

08/14/90	10:30:19	2.36	(60)
08/14/90	10:28:34	2.32	(59)
08/14/90	10:27:09	2.28	(58)
08/14/90	10:23:30	2.20	(56)
08/14/90	10:21:12	2.01	(51)
08/14/90	10:19:27	2.13	(54)
/14/90	10:16:30	2.09	(53)
08/14/90	10:14:09	2.05	(52)
08/14/90	10:11:36	2.01	(51)
08/14/90	10:10:13	1.97	(50)
08/14/90	10:08:00	1.93	(49)
08/14/90	10:05:27	1.89	(48)
08/14/90	10:02:17	1.85	(47)
08/14/90	10:00:49	1.81	(46)
08/14/90	09:59:20	1.77	(45)
08/14/90	09:58:02	1.73	(44)
08/14/90	09:55:45	1.69	(43)
08/14/90	09:52:42	1.61	(41)
08/14/90	09:51:23	1.57	(40)
08/14/90	09:49:53	1.54	(39)
08/14/90	09:49:07	1.50	(38)
08/14/90	09:48:12	1.46	(37)
08/14/90	09:47:23	1.42	(36)
08/14/90	09:46:26	1.38	(35)
08/14/90	09:44:28	1.26	(33)
08/14/90	09:43:43	1.22	(31)
08/14/90	09:43:00	1.18	(30)
08/14/90	09:42:03	1.14	(29)
08/14/90	09:40:47	1.10	(28)
08/14/90	02:22:09	1.00	(27)

1.77
1.10
.67" 20min

12:29 2.83
9:40 1.10

~~2.76~~

11:11

10:58 2.72
9:58 1.73
.99

11:11 2.76
9:11 - 1.06
2 hrs - 1.7

Sensor # 10 FCD Complex Precipitation Gage

DATE	TIME	inches	
09/04/90	19:04:06	0.39	(10)
09/03/90	19:22:20	0.39	(10)
09/03/90	19:20:05	0.36	(9)
09/03/90	19:09:59	0.35	(9)
09/03/90	17:08:11	0.31	(8)
09/03/90	17:03:25	0.28	(7)
09/03/90	07:30:26	0.24	(6)

Aug. 14-15

monsoonal moisture and an upper-level disturbance produced locally heavy rains on New Mexico & Arizona; ~~[illegible]~~ High humidities frequent cloudiness and numerous showers and thunderstorms prevented typical daytime heating w/ temperatures averaged more than 5°F below normal

Sept. 3-4

monsoonal showers and thunderstorms dotted desert southwest, occasionally dumping heavy rains producing flash flooding

Sept. 3-4

Classical monsoon pattern steady stream tropical moisture

On Sept. 3rd thunderstorm activity covered most of the state. Hardest hit were parts of northern Maricopa county, Verde Valley & Havasupai Indian Reservation. Maricopa county streets reported w/ five feet of sheet flow. Power outages, trees uprooted winds reached speeds of 68 to 80 mph. A small tornado north side of Phx. A golfer killed by lightning near Apache Junction

Sensor # 10 FCD Complex Precipitation Gage

DATE	TIME	inches	
08/15/90	12:27:41	0.20	(5)
08/15/90	06:33:53	0.16	(4)
08/15/90	06:06:47	0.12	(3)
08/15/90	05:54:16	0.08	(2)
08/15/90	05:41:43	0.04	(1)
08/15/90	05:31:34	0.00	(0)
08/15/90	05:18:25	3.90	(99)
08/15/90	05:11:46	3.86	(98)
08/15/90	05:01:44	3.82	(97)
08/15/90	04:53:56	3.78	(96)
08/15/90	04:43:46	3.74	(95)
08/15/90	04:35:45	3.70	(94)
08/15/90	04:23:36	3.66	(93)
08/15/90	04:14:59	3.62	(92)
08/15/90	04:11:21	3.58	(91)
08/15/90	04:09:26	3.54	(90)
08/15/90	04:05:41	3.46	(88)
08/15/90	03:56:10	3.39	(86)
08/15/90	03:42:33	3.35	(85)
08/15/90	03:33:34	3.31	(84)
08/15/90	03:24:47	3.27	(83)
08/15/90	03:13:15	3.23	(82)
08/15/90	03:07:00	3.19	(81)
08/15/90	03:02:51	3.15	(80)
08/15/90	02:57:56	3.11	(79)
08/15/90	02:55:01	3.07	(78)
08/15/90	02:52:33	3.03	(77)
08/15/90	02:49:42	2.99	(76)
08/15/90	02:46:59	2.95	(75)
08/15/90	02:44:03	2.91	(74)
08/15/90	00:33:21	2.87	(73)
08/14/90	13:45:50	2.87	(72)
08/14/90	12:38:16	2.83	(72)
08/14/90	12:29:38	2.83	(71)
08/14/90	11:11:47	2.76	(70)
08/14/90	10:58:01	2.72	(69)
08/14/90	10:52:52	2.68	(68)
08/14/90	10:46:23	2.64	(67)
[illegible]	10:[illegible]:21	2.[illegible]	([illegible])

08/14/90	10:33:07	2.44	(62)
08/14/90	10:31:37	2.40	(61)
08/14/90	10:30:19	2.36	(60)
08/14/90	10:28:34	2.32	(59)
08/14/90	10:27:09	2.28	(58)
08/14/90	10:23:30	2.20	(56)
08/14/90	10:21:12	2.01	(51)
08/14/90	10:19:27	2.13	(54)
08/14/90	10:16:39	2.09	(53)
08/14/90	10:14:09	2.05	(52)
08/14/90	10:11:36	2.01	(51)
08/14/90	10:10:13	1.97	(50)
08/14/90	10:09:06	1.93	(49)
08/14/90	10:05:27	1.89	(48)
08/14/90	10:02:17	1.85	(47)
08/14/90	10:00:49	1.81	(46)
08/14/90	09:59:20	1.77	(45)
08/14/90	09:58:02	1.73	(44)
08/14/90	09:55:45	1.69	(43)
08/14/90	09:52:42	1.61	(41)
08/14/90	09:51:23	1.57	(40)
08/14/90	09:49:53	1.54	(39)
08/14/90	09:49:07	1.50	(38)
08/14/90	09:48:12	1.46	(37)
08/14/90	09:47:23	1.42	(36)
08/14/90	09:46:26	1.38	(35)
08/14/90	09:44:28	1.26	(32)
08/14/90	09:43:43	1.22	(31)
08/14/90	09:43:08	1.18	(30)
08/14/90	09:42:03	1.14	(29)
08/14/90	09:40:47	1.10	(28)
08/14/90	02:22:09	1.06	(27)
08/14/90	00:43:35	1.02	(26)

8|15 3.90 – 5:18
8|14 – 1.06 – 2:22 – 5:18
2.84
.16
3.00

Sensor # 6010 Dreamy Draw Precip Precipitation Gage

DATE	TIME	inches	
08/15/90	12:26:47	8.70	(221)
08/15/90	07:41:37	8.70	(221)
08/15/90	06:52:42	8.66	(220)
08/15/90	06:24:09	8.62	(219)
08/15/90	06:10:24	8.58	(218)
08/15/90	05:59:04	8.54	(217)
08/15/90	05:46:52	8.50	(216)
08/15/90	05:30:10	8.46	(215)
08/15/90	05:19:47	8.43	(214)
08/15/90	04:49:27	8.35	(212)
08/15/90	04:32:45	8.07	(205)
08/15/90	04:30:53	7.95	(202)
08/15/90	04:29:42	7.87	(200)
08/15/90	04:27:37	7.76	(197)
08/15/90	04:27:09	7.72	(196)
08/15/90	04:25:58	7.64	(194)
08/15/90	04:25:10	7.60	(193)
08/15/90	04:24:35	7.56	(192)
08/15/90	04:23:53	7.52	(191)
08/15/90	04:23:11	7.48	(190)
08/15/90	04:22:43	7.44	(189)
08/15/90	04:22:01	7.40	(188)
08/15/90	04:21:11	7.36	(187)
08/15/90	04:20:29	7.32	(186)
08/15/90	04:20:02	7.28	(185)
08/15/90	04:19:20	7.24	(184)
08/15/90	04:18:52	7.20	(183)
08/15/90	04:18:24	7.17	(182)
08/15/90	04:17:43	7.13	(181)
08/15/90	04:17:09	7.09	(180)
08/15/90	04:15:54	7.01	(178)
08/15/90	04:15:15	6.97	(177)
08/15/90	04:14:27	6.93	(176)
08/15/90	04:13:47	6.89	(175)
08/15/90	04:13:05	6.85	(174)
08/15/90	04:11:33	6.77	(172)
08/15/90	04:09:30	6.69	(170)
08/15/90	00:14:56	6.65	(169)
08/14/90	14:03:31	6.65	(169)
08/14/90	12:35:19	6.61	(168)
08/14/90	12:18:14	6.57	(167)
08/14/90	12:03:48	6.54	(166)
08/14/90	12:03:04	6.50	(165)
08/14/90	11:50:58	6.50	(165)
08/14/90	11:40:35	6.46	(164)
08/14/90	11:30:35	6.42	(163)
08/14/90	11:21:47	6.38	(162)
08/14/90	11:00:47	6.34	(161)
08/14/90	10:27:26	6.22	([illegible])
08/14/90	10:19:49	6.06	(154)
08/14/90	10:17:21	6.02	(153)
08/14/90	10:15:58	5.99	(152)
08/14/90	10:14:00	5.91	(150)
08/14/90	10:11:31	5.83	(148)
08/14/90	10:00:05	5.79	(147)

8.35
6.65
1.7

4:49
4:09
1 hr.

1.78

6.61
5.71
.90"

16/14/90 05:38:45 5.67 (144)

Sensor # 6610 Dreamy Draw Precip Precipitation Gage

DATE	TIME	inches	
09/04/90	20:20:32	9.02	(229)
09/03/90	19:50:40	9.02	(229)
09/03/90	17:31:33	9.02	(229)
09/03/90	17:20:35	8.98	(228)
09/03/90	17:12:36	8.94	(227)
09/03/90	07:44:56	8.90	(226)

3.46 in 3 hrs. > 100 yr return

Sensor # 1510 ACDC @ 67th Ave. Precipitation Gage

DATE	TIME	inches	
09/04/90	15:25:44	7.83	(199)
09/04/90	03:13:52	7.83	(199)
09/03/90	19:49:18	7.83	(199) = 20:00
09/03/90	19:23:07	7.80	(198)
09/03/90	19:10:31	7.76	(197)
09/03/90	18:35:49	7.72	(196)
09/03/90	18:32:00	7.68	(195)
09/03/90	18:21:09	7.56	(192)
09/03/90	18:10:45	7.44	(189)
09/03/90	18:07:17	7.36	(187)
09/03/90	18:04:42	7.32	(186)
09/03/90	18:02:26	7.28	(185)
09/03/90	18:00:11	7.24	(184)
09/03/90	17:57:35	7.20	(183)
09/03/90	17:53:21	7.13	(181)
09/03/90	17:51:40	7.09	(180)
09/03/90	17:50:22	7.05	(179)
09/03/90	17:49:20	7.01	(178)
09/03/90	17:47:44	6.97	(177)
09/03/90	17:46:25	6.93	(176)
09/03/90	17:45:23	6.89	(175)
09/03/90	17:44:26	6.85	(174)
09/03/90	17:43:29	6.81	(173)
09/03/90	17:42:37	6.77	(172)
09/03/90	17:41:26	6.73	(171)
09/03/90	17:40:23	6.69	(170)
09/03/90	17:39:53	6.65	(169)
09/03/90	17:39:24	6.61	(168)
09/03/90	17:38:41	6.57	(167)
09/03/90	17:37:55	6.54	(166)
09/03/90	17:37:18	6.50	(165)
09/03/90	17:36:47	6.46	(164)
09/03/90	17:36:17	6.42	(163)
09/03/90	17:35:50	6.38	(162)
09/03/90	17:35:31	6.34	(161)
09/03/90	17:35:15	6.30	(160)
09/03/90	17:34:57	6.26	(159)
09/03/90	17:34:43	6.22	(158)
09/03/90	17:34:29	6.18	(157)
09/03/90	17:34:16	6.14	(156)
09/03/90	17:33:59	6.10	(155)
09/03/90	17:33:43	6.06	(154)

7.83
4.37
3.46

19:49 - 7.83
~~4.41~~ 4.37
3.42

19:49 - 7.83
~~18:01~~
16:59 - 4.37
3.46
2hrs 50min

09/03/90	17:33:21	6.02	(153)
09/03/90	17:33:11	5.98	(152)
09/03/90	17:32:52	5.94	(151)
09/03/90	17:32:32	5.91	(150)
09/03/90	17:32:10	5.87	(149)
09/03/90	17:31:44	5.83	(148)
09/03/90	17:31:24	5.79	(147)
09/03/90	17:30:57	5.75	(146)
09/03/90	17:30:34	5.71	(145)
09/03/90	17:29:58	5.67	(144)
09/03/90	17:29:33	5.63	(143)
09/03/90	17:28:51	5.55	(141)
09/03/90	17:27:16	5.43	(138)
09/03/90	17:25:30	5.39	(137)
09/03/90	17:23:56	5.35	(136)
09/03/90	17:22:19	5.31	(135)
09/03/90	17:20:55	5.28	(134)
09/03/90	17:19:32	5.24	(133)
09/03/90	17:18:14	5.20	(132)
09/03/90	17:16:53	5.16	(131)
09/03/90	17:15:03	5.12	(130)
09/03/90	17:13:21	5.08	(129)
09/03/90	17:12:19	5.04	(128)
09/03/90	17:11:32	5.00	(127)
09/03/90	17:10:38	4.96	(126)
09/03/90	17:09:47	4.92	(125)
09/03/90	17:08:57	4.88	(124)
09/03/90	17:08:02	4.84	(123)
09/03/90	17:07:21	4.80	(122)
09/03/90	17:06:48	4.76	(121)
09/03/90	17:06:12	4.72	(120)
09/03/90	17:05:39	4.69	(119)
09/03/90	17:05:16	4.65	(118)
09/03/90	17:04:49	4.61	(117)
09/03/90	17:04:19	4.57	(116)
09/03/90	17:03:40	4.53	(115)
09/03/90	17:02:35	4.45	(113)
09/03/90	17:01:10	4.41	(112)
09/03/90	16:59:34	4.37	(111) – 17:00
09/03/90	15:01:59	4.33	(110)
09/03/90	02:50:0	4.33	(110)

Sensor # 2630 Skunk Creek East I- Precipitation Gage

DATE	TIME	inches	
08/15/90	22:44:03	9.96	(253)
08/15/90	10:32:11	9.96	(253)
08/15/90	07:26:01	9.96	(253)
08/15/90	07:04:41	9.92	(252)
08/15/90	06:54:30	9.88	(251)
08/15/90	06:50:50	9.84	(250)
08/15/90	06:46:50	9.80	(249)
08/15/90	06:44:28	9.76	(248)
08/15/90	06:38:26	9.72	(247)
08/15/90	06:21:36	9.61	(244)
08/15/90	06:18:01	9.57	(243)
08/15/90	06:14:47	9.53	(242)
08/15/90	06:10:23	9.49	(241)
08/15/90	06:05:26	9.45	(240)
08/14/90	22:20:18	9.41	(239)
08/14/90	12:03:46	9.41	(239)
08/14/90	11:53:04	9.37	(238)

9.41" − 6.73 = 2.68"

2.82 − 2.49 = .33

2.82 − 2.68 = .14

12:00 9:45 hrs

79 return

[illegible]	[illegible]	[illegible]	[illegible]
08/14/90	11:15:38	9.25	(235)
08/14/90	11:07:49	9.17	(233)
08/14/90	11:04:53	9.13	(232)
08/14/90	11:01:59	9.06	(230)
08/14/90	10:59:23	8.98	(228)
08/14/90	10:57:58	8.94	(227)
08/14/90	10:56:35	8.90	(226)
08/14/90	10:54:46	8.86	(225)
08/14/90	10:52:43	8.82	(224)
08/14/90	10:49:19	8.74	(222)
08/14/90	10:46:36	8.70	(221)
08/14/90	10:45:21	8.66	(220)
08/14/90	10:44:27	8.62	(219)
08/14/90	10:43:41	8.58	(218)
08/14/90	10:42:29	8.54	(217)
08/14/90	10:41:26	8.50	(216)
08/14/90	10:40:10	8.46	(215)
08/14/90	10:39:28	8.43	(214)
08/14/90	10:37:55	8.35	(212)
08/14/90	10:36:07	8.31	(211)
08/14/90	10:34:36	8.27	(210)
08/14/90	10:32:51	8.23	(209)
08/14/90	10:31:12	8.19	(208)
08/14/90	10:29:25	8.15	(207)
08/14/90	10:27:46	8.11	(206)
08/14/90	10:25:12	8.03	(204)
08/14/90	10:18:36	7.72	(196)
08/14/90	10:16:22	7.64	(194)
08/14/90	10:15:10	7.60	(193)
08/14/90	10:10:10	7.48	(190)
08/14/90	10:08:26	7.44	(189)
08/14/90	10:01:42	7.44	(189)
08/14/90	09:57:48	7.36	(187)
08/14/90	09:57:11	7.32	(186)
08/14/90	09:56:35	7.28	(185)
08/14/90	09:56:09	7.24	(184)
08/14/90	09:55:40	7.20	(183)
08/14/90	09:55:12	7.17	(182)
08/14/90	09:54:36	7.13	(181)
08/14/90	09:53:18	7.05	(179)
08/14/90	09:51:49	6.97	(177)
08/14/90	09:51:10	6.93	(176)
08/14/90	09:50:28	6.89	(175)
08/14/90	09:49:40	6.85	(174)
08/14/90	09:47:56	6.81	(173)
08/14/90	09:45:02	6.73	(171)

Sensor # 2650 Adobe Dam Precipitation Gage

DATE	TIME	Inches	
08/15/90	20:04:22	9.88	(251)
08/15/90	07:52:30	9.88	(251)
08/15/90	07:14:05	9.88	(251)
08/15/90	06:52:44	9.84	(250)
08/15/90	06:12:22	9.76	(248)
08/15/90	05:10:45	9.72	(247)
08/15/90	05:08:53	9.69	(246)
08/15/90	05:05:56	9.65	(245)
08/15/90	04:59:06	9.29	(236)
08/15/90	04:57:57	9.25	(235)
08/15/90	04:52:45	9.13	(232)
08/15/90	04:51:35	9.09	(231)
08/15/90	04:50:47	9.06	(230)
08/15/90	04:49:40	9.02	(229)
08/15/90	04:48:49	8.98	(228)
08/15/90	04:48:10	8.94	(227)
08/15/90	04:47:16	8.90	(226)

2.80

9.72"
- 7.24
2.48"

5:10
4:26
45"

4
30
10
44"

9.29"
7.24
2.05

4.59
- 4.26
.33 min

90 year return

2.10
2.05
.05

2.10
1.86
.24

8/15

08/15/90	[illegible]	8.86	(225)
08/15/90	04:46:29	8.82	(224)
08/15/90	04:45:02	8.78	(223)
08/15/90	04:45:39	8.74	(222)
08/15/90	04:45:15	8.70	(221)
08/15/90	04:44:53	8.66	(220)
08/15/90	04:44:30	8.62	(219)
08/15/90	04:44:08	8.58	(218)
08/15/90	04:43:23	8.50	(216)
08/15/90	04:42:58	8.46	(215)
08/15/90	04:42:33	8.43	(214)
08/15/90	04:42:09	8.39	(213)
08/15/90	04:41:46	8.35	(212)
08/15/90	04:41:22	8.31	(211)
08/15/90	04:40:57	8.27	(210)
08/15/90	04:40:32	8.23	(209)
08/15/90	04:40:02	8.19	(208)
08/15/90	04:39:24	8.15	(207)
08/15/90	04:38:44	8.11	(206)
08/15/90	04:37:56	8.07	(205)
08/15/90	04:37:15	8.03	(204)
08/15/90	04:36:36	7.99	(203)
08/15/90	04:36:07	7.95	(202)
08/15/90	04:34:20	7.87	(200)
08/15/90	04:33:27	7.83	(199)
08/15/90	04:32:45	7.80	(198)
08/15/90	04:32:04	7.76	(197)
08/15/90	04:31:31	7.72	(196)
08/15/90	04:31:06	7.68	(195)
08/15/90	04:30:41	7.64	(194)
08/15/90	04:30:10	7.60	(193)
08/15/90	04:29:39	7.56	(192)
08/15/90	04:29:07	7.52	(191)
08/15/90	04:28:07	7.44	(189)
08/15/90	04:27:34	7.40	(188)
08/15/90	04:26:58	7.36	(187)
08/15/90	04:26:11	7.32	(186)
08/15/90	02:59:11	7.24	(184)
08/14/90	19:40:39	7.20	(183)
08/14/90	12:59:16	7.20	(183)
08/14/90	12:30:34	7.17	(182)
08/14/90	11:55:53	7.13	(181)
08/14/90	10:54:31	7.05	(179)
08/14/90	10:38:51	6.97	(177)
08/14/90	10:36:46	6.93	(176)
08/14/90	10:34:45	6.89	(175)
08/14/90	10:33:02	6.85	(174)
08/14/90	10:30:21	6.77	(172)
08/14/90	10:23:33	6.65	(169)
08/14/90	10:21:15	6.57	(167)
08/14/90	10:18:11	6.50	(165)
08/14/90	10:17:16	6.46	(164)
08/14/90	10:15:28	6.42	(163)
08/14/90	10:11:56	6.38	(162)
08/14/90	07:28:48	6.34	(161)

Sensor # 5605 King's Ranch Precipitation Gage

DATE	TIME	inches	
08/15/90	14:29:40	8.62	(219)
08/15/90	06:49:05	8.58	(218)
08/15/90	02:17:56	8.54	(217)
08/15/90	01:54:50	8.54	(217)
08/15/90	01:51:32	8.50	(216)
08/15/90	01:49:35	8.46	(215)
08/15/90	01:47:27	8.43	(214)
08/15/90	01:43:04	8.39	(213)
08/15/90	01:41:17	8.35	(212)

[illegible]	[illegible]	[illegible]	[illegible]
08/15/90	01:23:28	8.27	(210)
08/15/90	01:20:31	8.19	(208)
08/15/90	01:19:35	8.15	(207)
08/14/90	14:06:04	8.11	(206)
08/14/90	10:37:17	8.07	(205)
08/14/90	09:52:27	8.03	(204)
08/14/90	09:33:15	7.99	(203)
08/14/90	09:25:04	7.95	(202)
08/14/90	09:19:10	7.91	(201)
08/14/90	09:14:02	7.87	(200)
08/14/90	09:08:31	7.83	(199)
08/14/90	09:04:56	7.80	(198)
08/14/90	09:00:13	7.76	(197)
08/14/90	08:56:11	7.72	(196)
08/14/90	08:48:12	7.68	(195)
08/14/90	08:40:24	7.64	(194)
08/14/90	08:27:00	7.60	(193)
08/14/90	08:11:58	7.56	(192)
08/14/90	08:00:13	7.52	(191)
08/14/90	07:53:56	7.48	(190)
08/14/90	07:45:58	7.44	(189)
08/14/90	07:41:08	7.40	(188)
08/14/90	07:34:16	7.36	(187)
08/14/90	07:26:20	7.32	(186)
08/14/90	07:18:40	7.28	(185)
08/14/90	06:56:12	7.24	(184)
08/14/90	06:39:57	7.20	(183)
08/14/90	06:30:54	7.17	(182)
08/14/90	05:59:47	7.13	(181)
08/14/90	05:38:40	7.09	(180)
08/14/90	05:22:10	7.05	(179)
08/14/90	05:12:47	7.01	(178)
08/14/90	05:01:32	6.97	(177)
08/14/90	04:52:43	6.93	(176)
08/14/90	04:33:41	6.85	(174)
08/14/90	04:22:32	6.81	(173)
08/14/90	04:16:16	6.77	(172)
08/14/90	04:06:43	6.73	(171)
08/14/90	03:59:45	6.69	(170)
08/14/90	03:49:24	6.65	(169)
08/14/90	03:42:00	6.61	(168)
08/14/90	03:34:35	6.57	(167)
08/14/90	03:23:53	6.54	(166)
08/14/90	03:11:34	6.50	(165)
08/14/90	03:02:32	6.46	(164)
08/14/90	02:55:00	6.42	(163)
08/14/90	02:51:25	6.38	(162)
08/14/90	02:46:59	6.34	(161)
08/14/90	02:43:36	6.30	(160)
08/14/90	02:38:17	6.26	(159)
08/14/90	02:34:29	6.22	(158)
08/14/90	02:27:26	6.18	(157)
08/14/90	02:19:41	6.14	(156)
08/14/90	02:05:51	6.10	(155)
08/14/90	01:59:05	6.06	(154)
08/14/90	01:54:11	6.02	(153)

Sensor # 1625 Buckeye FRS 1 Precipitation Gage

DATE	TIME	inches	
08/15/90	21:06:47	6.06	(154)
08/15/90	09:20:39	6.06	(154)
08/15/90	05:39:53	6.06	(154)
08/15/90	05:08:03	5.98	(152)
08/15/90	04:52:47	5.94	(151)
08/15/90	04:33:18	5.91	(150)
08/15/90	04:23:54	5.87	(149)

08/15/90	[illegible]	5.83	(148)
08/15/90	03:50:04	5.79	(147)
08/15/90	03:03:00	5.75	(146)
08/15/90	02:58:48	5.67	(144)
08/15/90	02:57:06	5.63	(143)
08/15/90	02:55:34	5.59	(142)
08/15/90	02:54:10	5.55	(141)
08/15/90	02:51:04	5.43	(138)
08/15/90	02:50:13	5.39	(137)
08/15/90	02:49:07	5.35	(136)
08/15/90	02:47:26	5.31	(135)
08/15/90	02:45:42	5.28	(134)
08/15/90	02:44:17	5.24	(133)
08/15/90	02:42:10	5.20	(132)
08/15/90	02:36:58	5.16	(131)
08/14/90	21:45:21	5.12	(130)
08/14/90	14:08:46	5.12	(130)
08/14/90	13:35:23	5.08	(129)
08/14/90	13:31:18	5.04	(128)
08/14/90	13:28:56	5.00	(127)
08/14/90	13:27:05	4.96	(126)
08/14/90	13:25:05	4.92	(125)
08/14/90	13:21:02	4.84	(123)
08/14/90	13:19:47	4.80	(122)
08/14/90	13:18:33	4.76	(121)
08/14/90	13:17:14	4.72	(120)
08/14/90	13:15:17	4.65	(118)
08/14/90	13:14:23	4.61	(117)
08/14/90	13:13:28	4.57	(116)
08/14/90	13:12:41	4.53	(115)
08/14/90	13:11:59	4.49	(114)
08/14/90	13:11:17	4.45	(113)
08/14/90	13:10:36	4.41	(112)
08/14/90	13:09:51	4.37	(111)
08/14/90	13:09:00	4.33	(110)
08/14/90	13:08:16	4.29	(109)
08/14/90	13:07:37	4.25	(108)
08/14/90	13:06:53	4.21	(107)
08/14/90	13:06:03	4.17	(106)
08/14/90	13:05:04	4.13	(105)
08/14/90	13:04:09	4.09	(104)
08/14/90	13:03:22	4.06	(103)
08/14/90	13:02:14	3.98	(101)
08/14/90	13:01:44	3.94	(100)
08/14/90	13:01:06	3.90	(99)
08/14/90	13:00:24	3.86	(98)
08/14/90	12:59:38	3.82	(97)
08/14/90	12:59:02	3.78	(96)
08/14/90	12:58:34	3.74	(95)
08/14/90	12:57:45	3.66	(93)
08/14/90	12:57:24	3.62	(92)
08/14/90	12:57:03	3.58	(91)
08/14/90	12:56:36	3.54	(90)
08/14/90	12:56:14	3.50	(89)
08/14/90	12:55:48	3.46	(88)
08/14/90	12:55:18	3.43	(87)
08/14/90	12:54:46	3.39	(86)
08/14/90	12:54:17	3.35	(85)
08/14/90	12:53:51	3.31	(84)
08/14/90	12:52:57	3.23	(82)
08/14/90	12:52:31	3.19	(81)
08/14/90	12:52:03	3.15	(80)
08/14/90	12:51:21	3.11	(79)
08/14/90	12:49:22	2.99	(76)
08/14/90	12:47:01	2.95	(75)
08/14/90	11:42:04	2.91	(74)

35
+13
48

5.08
2.95
2.13

13:35
12:47
48 min

13:17
[illegible]
12:47

4.72
2.95

Sensor # 6510 South Mountain Park Precipitation Gage

DATE	TIME	inches	
08/15/90	14:36:14	6.93	(176)
08/15/90	05:57:22	6.93	(176)
08/15/90	05:34:43	6.89	(175)
08/15/90	05:22:07	6.85	(174)
08/15/90	05:12:09	6.81	(173)
08/15/90	04:50:42	6.77	(172)
08/15/90	04:39:12	6.73	(171)
08/15/90	04:35:09	6.69	(170)
08/15/90	04:32:07	6.65	(169)
08/15/90	04:30:03	6.61	(168)
08/15/90	04:27:33	6.57	(167)
08/15/90	04:25:40	6.54	(166)
08/15/90	04:20:45	6.46	(164)
08/15/90	04:18:54	6.42	(163)
08/15/90	04:14:46	6.34	(161)
08/15/90	04:11:49	6.30	(160)
08/15/90	04:10:05	6.26	(159)
08/15/90	04:07:59	6.22	(158)
08/15/90	04:06:02	6.18	(157)
08/15/90	03:58:51	6.10	(155)
08/15/90	03:56:19	6.06	(154)
08/15/90	03:54:43	6.02	(153)
08/15/90	03:53:08	5.98	(152)
08/15/90	03:51:38	5.94	(151)
08/15/90	03:46:27	5.79	(147)
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08/15/90	03:42:59	5.67	(144)
08/15/90	03:42:11	5.63	(143)
08/15/90	03:41:16	5.59	(142)
08/15/90	03:39:48	5.55	(141)
08/15/90	03:37:58	5.51	(140)
08/15/90	03:36:27	5.47	(139)
08/15/90	03:34:40	5.43	(138)
08/15/90	03:33:18	5.39	(137)
08/15/90	03:31:50	5.35	(136)
08/15/90	03:29:56	5.31	(135)
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08/15/90	03:13:30	4.92	(125)
08/15/90	02:24:20	4.88	(124)
08/14/90	14:12:28	4.88	(124)
08/14/90	13:29:10	4.88	(124)
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08/14/90	09:32:55	4.33	(110)
08/14/90	09:31:59	4.29	(109)
08/14/90	09:30:53	4.25	(108)
08/14/90	09:29:27	4.21	(107)
08/14/90	09:26:19	4.13	(105)
08/14/90	09:25:16	4.09	(104)

[illegible]	[illegible]	[illegible]	[illegible]
08/14/90	09:22:37	4.02	(102)
08/14/90	09:21:17	3.98	(101)
08/14/90	09:20:07	3.94	(100)
08/14/90	09:19:17	3.90	(99)
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08/14/90	07:10:52	3.74	(95)
08/14/90	06:58:29	3.70	(94)
08/14/90	02:00:36	3.66	(93)
08/14/90	01:52:51	3.66	(93)

SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE

201 E. Indianola Ave., Suite 200
Phoenix, Arizona 85012

ARIZONA WATER SUPPLY OUTLOOK

October 22, 1990

SOIL CONS[illegible]N SERVICE
U.S. DEPA[illegible]T OF AGRICU[illegible]

201 E. Indianola Ave., Suite 200

USDA SOIL CONSERVATION SERVICE

ARIZONA WATER [illegible] FALL REPORT

OCTO[illegible]R 22, 1990

ARIZONA WATER SUPPLY OUTLOOK

Donald W. Gohmert, State Conservationist

Prepared by:
Ronald A. Jon[illegible] Water Supply Specialist
Robert [illegible] Range Conservationist

The information contained in this report is intended to present [illegible] overall summary of water [illegible]

[illegible] detailed information [illegible] this report, contact:

Ronald A. Jones, Water Supply Specialist
USDA Soil Conservation Service
201 E. Indianola Avenue, Suite [illegible]
Phoenix, Arizona 85012

All programs and services of [illegible] Conservation Service are offered [illegible] nondiscriminatory basis, without regard to race, color, national origin, religion, sex, marital status, or handicap.

USDA SOIL CONSERVATION SERVICE

ARIZONA WATER CONDITIONS FALL REPORT

OCTOBER 22, 1990

Donald W. Gohmert, State Conservationist

prepared by:
Ronald A. Jones, Water Supply Specialist
Robert S. Carmichael, Range Conservationist

The information contained in this report is intended to present an overall summary of water supply and related water conditions within the state of Arizona during the spring and summer seasons of 1990. If more detailed information is desired on any subject mentioned in this report, contact:

Ronald A. Jones, Water Supply Specialist
USDA Soil Conservation Service
201 E. Indianola Avenue, Suite 200
Phoenix, Arizona 85012

Soil Conservation Service

Arizona Water Conditions Fall Report

October 22, 1990

The 1990 spring and summer seasons in Arizona were generally drier than the same period in 1989 with the exception of June when temperatures reached all time records. Precipitation was variable during the April-June period with some areas being slightly above normal and other areas slightly below normal in each of these months. July was generally above average due to an abundance of thunderstorm activity. August and September were stormy but activity was not uniform over the state. Some areas received abundant rainfall during these months. Streamflow for the April-September period was below the 15 year average although individual streams ran above average in July and September. Reservoir storage within Arizona was below normal on October 1. The reservoirs on the Colorado River had near normal storage for this time of year. The rains of July, August and September helped to recharge soil moisture which had reached extremely low levels in June. Range conditions were generally fair to poor until the thunderstorm season during which time they made a dramatic improvement.

PRECIPITATION AND TEMPERATURE

The [illegible] Arizona [illegible] full of surprises, some welcome some not so welcome.

April: Arizona weather was unsettled in early April. Thunderstorms and showers occurred during the first week. Most of the activity was in central and northern Arizona. Daily precipitation was generally less than half an inch. Temperatures ranged from normal at Douglas and Kingman to 7 degrees above at Phoenix. Most areas had above normal temperatures. The second week was hot and mostly sunny. Temperatures reached the 70's in high country, 80's around 5000 feet, and 90-101 degrees in the deserts. Average temperatures were 4-12 degrees above normal. Most areas received no precipitation. Temperatures cooled quite a bit April 16-18 and winds were strong and gusty. Scattered showers fell in the northern two thirds of the state. Some shower activity continued to April 21 and temperatures increased. Rainfall was generally light and average temperatures during this period were 2-9 degrees above normal. April 22-25 experienced cooler temperatures and increased precipitation. Snow fell at Flagstaff and Mt. Lemmon. Florence received 1.25 inches of precipitation in 45 minutes. Areas around Phoenix received an inch or more at times. The weather cleared and temperatures rose April 26-28 but fell again April 29-30 as a cold storm entered from the northwest. Snow fell in the Grand Canyon area. April generally had above average temperatures statewide with Phoenix having the third warmest April on record. Precipitation was below average in northeastern Arizona, southern and southeastern Arizona, and the White Mountains. Precipitation was above average around the eastern Gila River area, the Mogollon Rim and northwestern Arizona.

Soil Conservation Service

Arizona Water Conditions - Fall Report

October 22, 1990

The 1990 spring and summer seasons in Arizona were generally cooler than the same period in 1989 with the exception of June when temperatures reached all time records. Precipitation was variable during the April-June period with some areas being slightly above normal and other areas slightly below normal in each of these months. July was generally above average due to an abundance of thunderstorm activity. August and September were stormy but activity was not uniform over the state. Some areas received abundant rainfall during these months. Streamflow for the April-September period was below the 25 year average although individual streams ran above average in July and September. Reservoir storage within Arizona was below normal on October 1. The reservoirs on the Colorado River had near normal storage for this time of year. The rains of July, August and September helped to recharge soil moisture which had reached extremely low levels by June. Range conditions were generally fair to poor until the thunderstorm season during which time they made a dramatic improvement.

PRECIPITATION AND TEMPERATURE

The weather in Arizona over the April-September period of 1990 was full of surprises, some welcome, some not so welcome.

April: Arizona weather was unsettled in early April. Thunderstorms and showers occurred during the first week. Most of the activity was in central and northern Arizona. Daily precipitation was generally less than half an inch. Temperatures ranged from normal at Douglas and Kingman to 7 degrees above normal at Phoenix. Most areas had above normal temperatures. April 9-15 was hot and mostly sunny. Temperatures reached the 70's in the high country, 80's around 5000 feet, and 90-101 degrees in the deserts. Average temperatures were 4-12 degrees above normal. Most areas received no precipitation. Temperatures cooled quite a bit April 16-18 and winds were strong and gusty. Scattered showers fell in the northern two thirds of the state. Some shower activity continued to April 21 and temperatures increased. Rainfall was generally light and average temperatures during this period were 2-9 degrees above normal. April 22-25 experienced much cooler temperatures and increased precipitation. Snow fell at Flagstaff and Mt. Lemmon. Florence received 1.25 inches of precipitation in 45 minutes. Areas around Phoenix received an inch of moisture. The weather cleared and temperatures rose April 26-28 but fell again April 29-30 as a cold storm entered from the northwest. Snow fell in the Grand Canyon area. April generally had above average temperatures statewide with Phoenix having the third warmest April on record. Precipitation was below average in northeastern Arizona, southern and southeastern Arizona, and the White Mountains. Precipitation was above average around the eastern Gila River area, the Mogollon Rim and northwestern Arizona.

May: The cold storm of late April continued to cross the state as it produced rain and snow over central and eastern Arizona. Precipitation amounts were .50 to .75 of an inch in the White Mountains and .10 to .25 of an inch in the northeast and southeast with little elsewhere. Average temperatures ranged from 3 degrees below to 5 degrees above normal. May 6-9 was mostly sunny and warm with gusty winds. On May 11 a Pacific storm crossed the state causing a lowering of temperatures and a few showers. By May 12 temperatures rose again and sunshine prevailed. No measurable precipitation was recorded and average temperatures were 1-7 degrees above normal. May 13-19 was generally dry. Average temperatures ranged from 3 degrees below to 5 degrees above normal. Several periods of strong winds occurred which ranged from 25 to 50 miles per hour at various locations. Hot dry weather continued May 20-23. Temperatures reached the upper 70's in the mountains, upper 80's at 5000 feet, and 98-105 degrees in the deserts. A cold front crossed May 23-24 lowering temperatures and producing scattered showers over the north and central sections of the state. May 25-26 was again warm and dry. Average temperatures ranged from 2 degrees below to 6 degrees above normal during May 20-26. May 27 and 28 were unseasonably cold with strong gusty wind and considerable rainfall. About 1 inch was reported in Flagstaff, Bullhead City, and Kingman. Much of the rest of the state received .10 to .50 of an inch. The extreme north and extreme south were dry. Shower activity decreased but temperatures remained lower until month's end. The last week of May averaged 2-6 degrees below normal. The only places where May precipitation was above average were around Kingman, the Mogollon Rim, the White Mountains, and the Window Rock area. Most of the state had above normal temperatures for the month except the western portion from the Grand Canyon to Kingman to Wickenburg to Buckeye.

June: As June began temperatures rose in a continuing spiral to a record breaking heat wave. By June 5 temperatures had reached 116 degrees at Bullhead City and Gila Bend; 115 degrees at Buckeye; 113 degrees at Phoenix, Coolidge and Yuma; 112 degrees at Tucson; and 89 degrees at Flagstaff. Moisture from tropical storm Boris triggered thunderstorms June 8-10 over much of the state with strong gusty wind and locally heavy rain. Temperatures June 3-9 averaged 2-10 degrees above normal. June 10-16 was a period of very little precipitation and moderate temperatures. The air dried out and was sunny while a cold front reduced temperatures. Winds gusted 58 mph at Show Low, 50 mph at Holbrook, 45 mph at Prescott, while winds were 20-35 mph in the south. Temperatures averaged 4 degrees below to 2 degrees above normal. June 17-23 was dry and hot. Temperatures reached 92 degrees at Flagstaff and Grand Canyon, 90 degrees at McNary, 115 degrees at Parker, 114 degrees at Phoenix and Yuma, and 112 degrees at Tucson. Temperatures for this week averaged 1 degree below to 7 degrees above normal. The last week of June was hotter still and many all time records were broken on separate days at various locations. Phoenix hit 122 degrees on June 26 breaking the all time record of 120 degrees set the previous day. The 122 degree mark was also reached at Buckeye, Gila Bend, Youngtown, and Yuma. Tucson hit 117 degrees. Parker reached 120 degrees; Safford 112; Prescott 103; Flagstaff and Grand Canyon, 94 degrees. Widely scattered thunderstorms developed but very little precipitation was produced. Average temperatures for June 24-30 were 5-13 degrees above normal. June as a whole had below average precipitation over the state and above normal temperatures.

July: July was the month the thunderstorm or monsoon season started. At first storms were scattered over the western Mogollon Rim, Central Basin, central and eastern sections, then to the southeast and south central sections. By July 6 local rainfall was becoming heavy - Wickenburg reported 1.50-2.33 inches. On July 7, 1.50-3.00 inches fell in the mountains northeast of Tucson. Storms hit from the Grand Canyon to the White Mountains and along the Colorado River. Average temperatures for the first week were 2 degrees below to 4 degrees above normal with many areas reaching 90-115 degrees. The second week of July brought intense monsoon activity moving around the state. July 8 - storm areas covered Globe to Tucson, Wickenburg to Prescott, and around Quartzite. Rainfall amounts were 1-2 inches. July 10 - a 60 mile wide band of storms stretched from the White Mountains to Nogales with hail and rainfall in excess of 1 inch. Winds of 40-70 mph hit New River and the Phoenix area. July 12 - Yuma received about .50 inch of rain and 50 mph winds. Heavy rain and wind wreaked havoc in Casa Grande. July 13 - thunderstorms hit Flagstaff and northern Yavapai County. Chino Valley received 2 inches of rain with hail and 70 mph wind. Bullhead City got over 1 inch of rain and 70 mph wind. July 14 - storms hit northeastern and southeastern Arizona as well as the area between Flagstaff and Prescott. Average temperatures during this week were 4 degrees below to 1 degree above normal. The intense activity continued through the third week of July. Heavy rain and high winds hit locales all over the state. Storms often dropped 1-3 inches of rain. Local flooding occurred and wind damage was common. Individual storms dropped 2.66 inches at Bisbee, 2.17 inches at Sabino Canyon, and 2.36 inches 20 miles west of Tucson. Prescott, Payson, and the Phoenix area received large amounts of precipitation. Temperatures fluctuated as storms waxed and waned. Average temperatures for July 15-21 were 4 degrees below to 2 degrees above normal. On July 22 Payson received 2 inches of rain and hail. On the 24th the Salt River Valley was deluged with rain which produced street flooding. Winds of 60 mph caused considerable damage. This storm moved south and produced similar flooding in the area from Tucson to Marana. The monsoon activity decreased some after this but local activity continued over the White Mountains and southeastern Arizona. Average temperatures for July 22-28 were 4 degrees below to 1 degree above normal.

August: The first 16 days of August were dominated by thunderstorm activity with the exception of the 7th and 8th. Thunderstorms did not develop in the same areas every day but most areas of the state did have storms during this period. Rainfall intensities were high in some places as evidenced by 1.15 inches in 15 minutes at Benson, 2 inches in 15 minutes in Tucson, .61 inches in 30 minutes at Kingman and 1 inch in 30 minutes at San Luis. On August 14 and 15 central Arizona received 2 to 4 inches of rain. Local flooding was common and severe. Wind gusts caused damage in the Ehrenburg-Parker area. Winds reached 60 mph at Luke Air Force Base, and 70-80 mph in west central Arizona. The 7th and 8th were generally quiet as air stabilized under a high pressure system. Temperatures ranged from 4 degrees below normal to 5 degrees above normal during August 1-11 but averaged 3-8 degrees below normal August 12-18.

Most of the state became dry August 17-26 with some exceptions. A cold front produced clouds and wind over the northern portion of the state around the 19th. On the 20th and 21st heavy rain and hail hit Duncan, Safford, and Willcox. Temperatures averaged 5 degrees below to 1 degree above normal August 19-25.

The monsoon moisture re-entered the state on the 26th. Thunderstorm activity continued to the end of the month over the northern and central mountains, central basin, southern Arizona and the Mexican border. In general August precipitation was above average in northeastern and central Arizona, including most of the Mogollon Rim, and over the northwestern portion of the state. The northeast, southwest, and west central portions of the state received below average moisture. Average temperatures were below normal throughout the state.

<u>September:</u> Thunderstorm activity expanded across Arizona during the first three days of September with locally heavy rains, and strong winds. Winds were recorded up to 88 mph in Maricopa County which knocked down power poles and trees. Local flood waters reached 5 feet in depth. Maricopa County, Verde Valley, and the Havasupai Indian Reservation were the hardest hit. A 12 foot high flash flood devastated the Village of Supai. Precipitation amounts reached 3.60 inches in the northwest Phoenix area, 2.50 inches in Wellton, 2.28 inches at Prescott, 1.34 inches at Kingman. Storm intensity diminished over the next five days to a few scattered showers. Temperatures rose to the 80's in the high country and 105-113 in the deserts. On the 11th Yuma and Phoenix set records for that date with 116 degrees and 112 degrees. Moist air again entered the state and triggered thunderstorms in Pinal and Graham Counties and from Tucson to Nogales. Storms then hit Gila and Maricopa Counties with 50-70 mph wind, heavy rain and hail on the 14th. A short break in storm activity on the 15 and 16 was followed by renewed activity as moisture from tropical storm Norbert crossed the state. On the 17th and 18th strong thunderstorms hit Pinal, Gila, southern Mohave, and northeast La Paz Counties, the Mogollon Rim and White Mountains, the Salt River Valley, Williams, Flagstaff, and Globe. Scattered thunderstorm activity then continued throughout the state through the 24th. Sunny weather prevailed from the 25th to 28th. Light showers hit northern and eastern Arizona on the 29th. Cloud cover expanded across the state on September 30 with rainfall lasting through October 1.

Streamflow:

Streamflow within Arizona was very low during April through June. Runoff increased during the monsoon months of August through September. Even with the abundant thunderstorm activity the runoff for the entire April-September period was well below the 25 year average. Preliminary observed flows, unadjusted for diversions, ranged from 1% of average on the Virgin River at Littlefield to 68% of average on the San Pedro River at Charleston for this six month period. The Salt River ran 40% of average; the Verde River, 61% of average; and the Gila River at Head of Safford Valley, 50% of average. Runoff on the Little Colorado River at Lyman Lake was 9% of average. Table 1 shows the percent of average runoff by months and for the six month period at major Arizona gaging stations.

Table 1
1990

Arizona -Percent of Average Streamflow**

Stream	Apr	May	Jun	Jul	Aug	Sept	Apr-Sept
Salt R.	19	20	26	178	95	69	40
Tonto Cr.	21	19	11	85	34	36	28
Verde R.	26	59	78	176	72	103	61
Gila R. - Calva	6	3	0	19	26	8	10
Gila R. - Solomon (Head of Safford Valley)	19	28	61	106	89	56	50
San Francisco R. - Clifton	18	30	64	92	93	68	51
Little Colorado R. - Lyman	3	0	67	24		30	9
San Pedro R. - Charleston	79	64	30	79	45	115	68
Virgin R - Littlefield	1	1	2	3	2	2	1

**Percent of average based on the 25 year period 1961-1985

The inflow to Lake Powell on the Colorado River was 41% of average for April-September. The Central Arizona Project delivered water through Maricopa and Pinal Counties. Deliveries satisfied demands except for a short period in late June and early July when demands were at their peak. This was within the normal plan of operations of the canal. Scheduled releases from Parker Dam ranged from 10,300-14,200 cfs in April, 7000-15,500 cfs in May, 8400-15,000 cfs in June, 9300-15,200 cfs in July, 10,800-15,300 cfs in August, and 7400-15,200 cfs in September. No shortages were reported by water users having access to the Colorado River below Parker Dam.

Reservoir Storage

Most Arizona reservoirs did not contain enough water to fill normal allotments or demands during the spring and summer season. The increased streamflow during August-September did not significantly change the situation. The Salt River Project announced on October 1 that their 1991 water allotments will be reduced by 17%. On October 1 the Salt River reservoirs were at 42% of capacity with 724,544 acre feet and the Verde River reservoirs were at 23% of capacity with 72,726 acre feet. San Carlos held 44,900 acre feet at 5% of capacity. The allotment to farmers using San Carlos water was only 0.5 acre feet/acre in 1990. Lake Pleasant held 48,700 acre feet on October 1 at 31% of capacity.

In the White Mountains area, Bunch, Tunnel, River, and White Mountain reservoirs did not fill irrigation needs. Lyman Lake supplied most of the irrigation demand but is now essentially drained with less than 7% of capacity remaining. Scott reservoir was low all season. Show Low Lake was only at 2% of capacity on October 1. At Flagstaff, Lower Lake Mary has been dry all season and Upper Lake Mary was at 13% of capacity by mid September. In the Prescott area, Lynx Lake was 40% full; Watson Lake 10%; and Willow Lake 10%. On the Arizona Strip, Short Creek Reservoirs #1 and #2 were dry through early August and empty again by September 1. Shortages were reported in Colorado City. Talkalai Lake on the San Carlos Apache Reservation was reported to be full on October 1. The Shiprock, New Mexico area reported Navajo Reservoir to have an October 1 storage of 169,700 acre feet, about 70% full. Some shortages were reported on the San Juan Projects. Flow into Hogback, Fruitland, and Cudei Canals was maintained all season. Elsewhere on the Navajo Reservation, reservoirs were about half full at Many Farms, Tsaile, Wheatfields, and Round Rock. Early season shortages were reported in these areas.

The combined storage of Lakes Mohave, Havasu, Mead, and Powell on the Colorado River was 38,446,000 acre feet or 72% of capacity on October 1.

Small Empoundments, water hauling

Small impoundments and stock ponds throughout Arizona contained little or no water from April through June. Some exceptions could be found but natural inflow to these structures was limited. Where pumps or windmills were available, groundwater was used to make up deficiencies. In other cases water was hauled for stock use. Water hauling was reported in all parts of the state except along the Colorado River and on the San Carlos Reservation. In the Safford and Willcox areas pipelines were used to transport water, thus reducing the need for hauling, but the shortage of stock water was still apparent.

The monsoon rains of July-September alleviated the situation. Stock ponds and small impoundments caught water and many filled. During these months most stock water supplies were adequate. The

Arizona Strip, Prescott area, Springerville area, Holbrook area and Navajo Reservation did report shortages even during these months.

Groundwater

Groundwater was used in every part of Arizona in the summer of 1990. In most areas of the state groundwater is a major, if not only, supply of domestic water. In areas where large reservoirs are available, the water supply can be a combination of surface water and groundwater, both for domestic and agricultural uses. In 1990 groundwater played a larger role than it has in many years. Groundwater supplemented the short water supply in San Carlos reservoir. Salt River Project started pumping ground water in March to augment their reservoir storage supply. Groundwater supplemented the Central Arizona Project water users during the period of peak demand. Pumps and windmills provided groundwater for stock water. Pumped groundwater provided irrigation water for agriculture in all areas of Arizona. In most cases the supply was adequate, but there were limitations and danger signs.

Groundwater use was regulated by law in the Active Management Areas; Prescott, Phoenix, Tucson, and Pinal. Domestic wells in the Cave Creek area went dry in July. The City of Flagstaff well fields at Lake Mary and Woody Mountain were reliable, but the Inner Basin water tables dropped to very low levels. Some domestic water wells in the Prescott area went dry. Well production was not adequate in the Colorado City area. Well production declined on the Kaibab-Paiute Tribal farm.

Direct Diversion

Water for direct stream diversion was generally in short supply during the 1990 spring and summer season. Direct diversion supplies around Springerville were short or non-existent. The Holbrook area stream supplies were not always adequate. The Fredonia and Colorado City areas reported insufficient diversion water. The Verde River generally provide adequate supplies in Verde Valley. In the Buckeye area, Harquahala and Tonopah Irrigation Districts drew on adequate supplies of Central Arizona Project water. Buckeye and Arlington Irrigation Districts and Paloma Ranch used storm water and effluent flows supplemented by groundwater. In Safford Valley, diversion water was minimal in May, none in June, and limited during July-September. The available supply was not adequate and groundwater was used. Two Indian communities in the Chandler area used director diversion as a primary water source. Both had to supplement with groundwater. In the Shiprock area direct diversion was the only surface water source outside of the San Juan Projects. Runoff is never sufficient and this year was no different. Even flood flows in August were too late to save many crops. Direct diversion was inadequate in the Chinle area during the critical season of April-June.

Diverted flow was near normal most of the growing season on the San Pedro around St. David and Pomerene. Some supplemental groundwater was pumped at St. David. The Colorado River provided normal diversion supplies along the river from Parker to Yuma.

Range Conditions

As spring began ranges were producing below average feed. Fall and winter precipitation was scarce in most parts of the state and many ranches were forced to reduce herd sizes. Ranchers in many areas were participating in the Emergency Feed Program. By May 1 ranges were dry and soil moisture was very low. Range trend monitoring in southern Arizona was showing substantial loss of perennial grass plants from plant communities as a result of the prolonged dry conditions. The worst conditions prevailed toward the end of June.

At the beginning of July monsoon rains arrived and provided much needed moisture over most of the state. Vegetation responded to the rains and by the end of July range conditions over most of the state were much improved. The southern and central parts of the state seemed to receive the most uniformly distributed rains with almost all areas reporting good to excellent production. A report from Prescott indicated the summer rains in that area resulted in the best summer range conditions in twenty years. Conditions in northern Arizona were improved by the beginning of August but rains continued to be spotty in the north country, particularly around Springerville and on the Arizona Strip.

Rains diminished in the period from mid August through mid September but by late September most parts of the state were receiving scattered showers. This late summer moisture helped to spur on the recovery in range conditions.

Adjustments due to water conditions

The commom management decision made due to the lack of sufficient moisture was the reduction of livestock herds. Reductions were reported in the areas around Shiprock, Kayenta, Holbrook, Springerville, Flagstaff, the Arizona Strip, Prescott, Safford, Willcox, Douglas, and Tucson.

Crop production was also affected. Reduction in irrigated acreage was reported around Colorado City. There was a decrease in Indian corn production in the Kayenta area. Shiprock reported a reduction in acreage of corn and truck crops and elimination of a second cutting of alfalfa. In the Springerville area some crop production was 1/3 to 1/2 of normal. Some grain crops were not even planted this year in the Prescott are. Some Pinal county farmers reduced acreage by 1/2 to 1/3 of normal. Safford Valley alfalfa was under irrigated to save water for the cotton crop.

Flood Damage

The 1990 "monsoon" season in Arizona produced an abundance of thunderstorms throughout most of July, August, and September. These storms often produced winds of 50-80 mph and periods of very high intensity rainfall. Hail was often produced and tornadoes were spawned.

Local flooding was a common result often with associated wind damage. Affected were the greater Phoenix area, Casa Grande, Tucson, Wickenburg, Globe, Kingman, Bullhead City; the list of areas suffering flood damage is extensive. The Governor requested that eight Arizona counties be declared disaster areas - Pinal, Pima, Mohave, Yavapai, Coconino, Maricopa, Gila, and Graham.

Level basin fields in the Casa Grande area suffered damage by washouts of field borders and irrigation structures. Flooding in the Bryce area north of Pima damaged the Graham Canal and several irrigation ditches. In the Eden area, floods damaged the Fort Thomas Canal and irrigation ditches. Farm water distribution systems were damaged in the Gila Bend, Buckeye, and Tonopah areas. The Roosevelt Canal and Buckeye Canals broke in several places affecting about 3,000 acres of irrigated cropland. Some light damage was reported in the Aguila area. Agricultural damage around Willcox was slight.

Storm drainage damaged irrigation systems in Wellton-Mohawk. In the Shiprock area there was some flood damage along Walker Creek and floods destroyed all diversions in Cave Creek. The Dodge Nevada Canal near Ashurst was damaged. A flash flood in Cataract Creek and Havasu Creek devastated the village of Supai on the Havasupai Reservation. Fields were destroyed, 7 flumes were taken out, and several miles of channels were clogged with debris. Sixty acres of gardens and crops were flooded and 15 homes damaged.

__Fires__

Numerous fires broke out in Arizona as a result of the extremely dry conditions in the spring. The largest was the "Dude." The Dude fire, rated as the worst fire in Arizona history, broke out on June 25, 1990 and took a week to be contained. Six fire fighters lost their lives, 65 structures were destroyed, and 28,400 acres were totally or partially burned. The burned area is along the Mogollon Rim where steepness of the terrain and the propensity for thunderstorms presents a great danger of future flash floods and erosion.

Sources for Information Contained in the Report Include:

USDA - Soil Conservation Service
USDA - Arizona Agricultural Statistics Service
Laboratory of Climatology, Arizona State University
NOAA - National Weather Service
USDI - Geological Survey
USDI - Bureau of Reclamation
San Carlos Irrigation & Drainage District
Salt River Project
Maricopa Water District
Arizona Republic

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