TEXAS HIPLEX
INTERIM PROGRESS REPORT

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TEXAS DEPARTMENT OF WATER RESOURCES
POST OFFICE BOX 13087
CAPITOL STATION
AUSTIN, TEXAS 78711

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This report includes a description of both the continued evaluation of 1976-1978 Texas HIPLEX data and evaluation of the 1979 operational season. It includes progress reports on mesoscale data evaluation, development of a synoptic climatology, analysis of satellite radiance data, radar data analyses and interpretation, and operational cloud-sampling and seeding activities.

Analysis of the 1978 mesoscale data indicates findings similar to those of 1976-77 data. Moisture appears to be the primary parameter for establishing a suitable cloud-seeding environment for the Texas HIPLEX area. 1978 satellite imagery and radiance data are currently being analyzed and will be combined with 1976-77 data for a comprehensive analysis. Digitized M-33 (Snyder) radar tapes from 1976-78 are being reduced and analyzed; this activity is scheduled for completion March 31, 1980.

17. KEY WORDS AND DOCUMENT ANALYSIS

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Weather modification research/mesoscale data analysis/satellite cloud imagery/weather radar data analyses/synoptic climatology/rawinsonde observations/precipitation data collection/cloud seeding/ice nuclei sampling

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b. IDENTIFIERS-- High Plains Cooperative Program (HIPLEX)/ Big Spring, Texas

c. COSATI Field/Group

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TEXAS HIPLEX INTERIM PROGRESS REPORT

April 1, 1979 - September 30, 1979

Prepared by the staff of the

Weather Modification & Technology Section

Planning & Development Division

Texas Department of Water Resources

LP-110

October 10, 1979

TEXAS DEPARTMENT OF WATER RESOURCES
1700 N. Congress Avenue
Austin, Texas

October 10, 1979

Dr. Bernard A. Silverman
Acting Chief, Office of Atmospheric
Resources Management
Bureau of Reclamation
Building 67, Denver Federal Center
Denver, Colorado 80225

Dear Dr. Silverman:

Re: Texas HIPLEX Interim Progress Report

In compliance with Amendatory Agreement No. 1 to Contract No. 14-06-D-7587 between the Bureau and the Department, we hereby submit twenty (20) copies of the interim progress report for the Texas High Plains Cooperative Program (HIPLEX). The report discloses and explains all Texas HIPLEX work performed and results achieved during the interim period April 1, 1979 through September 30, 1979.

This report consists of a compilation of individual reports prepared by the Department and each of the Texas HIPLEX participants--Texas A&M University, Texas Tech University, the Colorado River Municipal Water District, Meteorology Research, Incorporated, and North American Weather Consultants, Incorporated. The individual reports consist of three sections which: (1) describe all activity for the Report Period; (2) outline the Work Planned for the next report period; and, (3) provide an Appendix of pertinent information. A Table of Contents and Lists of Tables are provided at the beginning of the report for order and ease of reference. An Executive Summary is included for introduction and orientation purposes.

Please direct any questions concerning this report, or the need for further information, to the Department's Weather Modification & Technology Section of the Planning and Development Division.

Sincerely,

Herbert W. Grubb

Herbert W. Grubb
Director, Planning & Development

EXECUTIVE SUMMARY

In 1974 the Bureau of Reclamation (Bureau) Office of Atmospheric Resources Management entered into a cooperative cost-sharing agreement with the Texas Water Development Board, one of three predecessor water agencies to the Texas Department of Water Resources (TDWR), for the purpose of conducting a long-term, comprehensive atmospheric research and weather modification development program known as HIPLEX. The overall goal of the HIPLEX program is "....establishing a verified, working technology and operational management framework capable of producing additional rain from cumulus clouds in the semi-arid Plains States." In order to achieve this goal, three field-research sites in the U.S. High Plains region were selected by the Bureau. One site was located in Montana, another was situated in Kansas, and a third site was selected to be the Big Spring-Snyder area of Texas. The Texas HIPLEX site has been and continues to be managed by the TDWR under the overall guidance of the Bureau.

To date, the objective of the Texas HIPLEX program has been to understand more fully the cloud and precipitation processes associated with natural and seeded clouds which develop in the High Plains of Texas. This objective is being accomplished through the cooperative efforts of the following institutions and organizations:

Bureau of Reclamation
Texas Department of Water Resources
Colorado River Municipal Water District
Texas A&M University (Department of Meteorology)
Texas Tech University (Atmospheric Science Group)
Meteorology Research, Incorporated
North American Weather Consultants, Incorporated

This report presents the work performed by these organizations during the six-month period from April 1 through September 30, 1979.

The report discusses the Texas Department of Water Resources' continuing role as manager and administrator of the Texas HIPLEX Program. The Department negotiated, awarded, and/or administered eight subcontracts with other Texas HIPLEX participants during the report period. The Department helped develop the 1979 field operations plan and provided staff meteorologists who served as Chief Scientist, Field Program Manager, and Resident Forecaster.

The services provided by the Colorado River Municipal Water District (CRMWD) are discussed. In brief the CRMWD maintained and operated an extensive network of recording and non-recording rain-gages, and provided the services of a rawinsonde operator and a radar meteorologist. In addition, the CRMWD also provided the services of two multi-engine aircraft for the purpose of performing cloud sampling and seeding flights.

The use of Texas A&M University's network of upper-air meteorological measuring instruments (rawinsondes) is discussed. Data from the rawin-sondes are needed to determine the interrelationships between cloud development and the environment. Results of previous years' analyses are also presented.

Additionally, Texas A&M University's work to establish a radar echo/synoptic climatology for the Southern HIPLEX is discussed. Progress on the alleviation of radar bias and a fine-scale seeding analysis is described.

Texas Tech University's work with satellite data is presented. Cloud characteristics derived from satellite imagery and radiance data of Texas HIPLEX clouds are discussed, as well as techniques to extract quantitative cloud information--such as cloud top temperature--from the radiance data. Plans for additional study of real-time LASERFAX satellite photographs, which were collected in-house during the 1979 field program, are also discussed.

The work of North American Weather Consultants (NAWC) on the processing of M-33 radar data for 1976 - 1978 is also presented. Discussed are progress on computer data reduction, software preparation, and the acquisition of additional data.

It is important that these data about West Texas summertime clouds and their environment be collected and studied so that a high level of understanding may be obtained on the cause and effect aspects of cloud behavior, both seeded and unseeded. Only when this level of certainty is reached may the Texas HIPLEX Program progress to a point whereby predicted changes in seeded clouds in the Texas High Plains and their resulting rainfall behavior may be verified.

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SECTION I

WORK PERFORMED DURING THE PERIOD

April 1 - September 30, 1979

TEXAS DEPARTMENT OF WATER RESOURCES

"MANAGEMENT OF THE TEXAS HIPLEX PROGRAM

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Contract Administration

During the reporting period, April 1 to September 30, 1979, the Department negotiated four new contracts and administered four contracts in force (as of April 1, 1979) in support of the 1979 Texas HIPLEX program (Table 1).

Table 1. Contracts Awarded by the TDWR in Support of the 1979 Texas HIPLEX Program

Contract No.	Organization	Period		Purpose
		Begin	End	
14-90027	Colorado River Municipal Water District	1-79	12-79	Operation of raingage network, rawinsonde and radar; equipping and operating Aztec and p-Navajo aircraft
14-90023	Texas Tech University	1-79	8-79	Analysis of 1977 and 1978 satellite data; 76-77 precipitation analysis, and collection of 1979 radar data and real-time satellite imagery
14-90025	Texas A&M University	1-79	8-79	Synoptic climatology for Texas HIPLEX, resolution of the radar bias problem, fine-scale analysis of seeding effects
14-90026	Texas A&M University	1-79	8-79	Analysis of 1978 mesoscale data, development of water budget models, entrainment model, determination of environmental response to convective activity, cloud physics, conduct of field program and Chief Scientist support
14-00013	North American Weather Consultants	8-79	3-80	Analysis of 1976-1978 Texas HIPLEX digital (M-33) radar data
14-00004	Texas Tech University	9-79	12-79	(See 14-90023 above)
14-00005	Texas A&M University	9-79	12-79	(See 14-90025 above)
14-00003	Texas A&M University	9-79	12-79	(See 14-90026 above)

NOTE: The three contracts for the period of September 1979 - December 1979 were extensions of contracts executed and in force earlier in 1979.

1979 Field Program and Meetings at the Big Spring Municipal Airport/ Industrial Park

The 1979 Texas HIPLEX Field Program began on schedule May 21. All daily operations were planned and conducted according to the "HIPLEX 1979-80 Operations Plan, Big Spring-Snyder, Texas" prepared by the Chief Scientist and the TDWR staff prior to the field season and approved by the Bureau.

Daily operations followed the schedule as outlined in the Operations Plan. An early morning designation of mesoscale operational status by the field manager was followed by a morning briefing of representatives from all Texas HIPLEX participating entities, at which time current and forecasted weather conditions, current and anticipated equipment status, and seeding strategy were outlined. When applicable, post-flight debriefings preceded the morning briefings. As needed, the Chief Scientist and/or Project Manager were informed of current weather conditions during the operational period.

106 Belfort recording rain gages were installed jointly by Department and Colorado River Municipal Water District technicians during the first three weeks of May within the Texas HIPLEX Operational Area.

During the field season, various Department staff members served as Project Forecaster and Project Manager, and also shared Chief Scientist duties with Dr. James R. Scoggins of Texas A&M University. A summary of the field season operations is listed as Table 2.

Table 2: Summary of 1979 Texas HIPLEX Field Operations

MONTH/DATE		MESOSCALE DAY		HIPLEX OPERATIONAL DAY			
		Go	No-Go	Mission Performed	No-Mission	Sampling/Recon Only	Tower Fly-By
MAY	21	X			X		
	22		X		X		
	23		X		X		
	24		X		X		
	25		X		X		
	26	X			X		
	27	X			X		
	28	X				X	
	29		X		X		
	30		X		X		
	31		X			X	
JUNE	1	X			X		
	2		X		X		
	3		X		X		
	4	X		(2)			
	5	X				X	
	6		X		X		
	7		X		X		X
	8	X			X		
	9		X		X		
	10		X		X		
	11		X		X		
	12		X		X		
	13		X		X		
	14		X		X		
	15		X		X		
	16		X		X		
	17		X		X		
	18		X		X		
	19		X		X		
	20		X		X		
	21		X		X		
	22		X		X		
	23		X		X		
	24		X			X	
	25		X	(1)			
	26		X			X	
	27		X		X		
	28		X		X		
	29		X		X		
	30		X		X		
JULY	1		X		X		
	2	X*				X	
	3	X		(2)			
	4	X*				X	
	5	X*		(2)			
	6	X			X		
	7	X*				X	
	8		X	(1)			
	9		X			X	
	10		X		X		
	11		X		X		
	12		X		X		X
	13		X		X		
	14	X*	X		X		
	15			(1)			
	16	X	X			X	
	17	X	X			X	
	18	X	X		X		
	19		X		X		
	20		X		X		
TOTALS		14(5)*		9			

*a "partial" mesoscale day; number in parentheses expressed in "Totals" is number of partial mesoscale days conducted.

Two important planning meetings were held prior to opening the 1979 Field Season. On April 26 representatives from each of the entities participating in the 1979 Texas HIPLEX (the Department, Texas A&M University--TAMU, Texas Tech University--TTU, the Colorado River Municipal Water District--CRMWD, Meteorology Research, Incorporated--MRI) met in Austin for the purpose of reviewing and implementing the 1979-80 Operations Plan. On May 29 the Weather Modification Advisory Committee (WMAC) met at the Big Spring Municipal Airport/Industrial Park in the TDWR Meteorological Facility. All WMAC members were given a tour of the facility to enable them to become familiarized with the operation.

The Department's resident meteorologist began HIPLEX forecast support duties May 21. Included in these duties were the issuance of daily 12-hour forecasts; preparation of morning (and afternoon, if necessary) regional surface charts; collection and archiving daily local and regional climatological and facsimile data, and photographing significant cloud development. This activity was performed throughout the two-month field season. Also, the Forecast Decision Tree, which was computerized prior to the season, was used daily to provide a convective prestratification of each forecast period.

In conjunction with normal mesoscale operations during July, two "Rapid scan" satellite imagery days were selected for the Texas HIPLEX Operational Area. This program allows for photographing of the area on 15 minute intervals at ½-mile resolution. These rapid scan sequences were collected on July 17 and 18.

At the close of the season Department staff performed an inventory of all federal property issued to each Texas HIPLEX participant. This inventory was shipped to the Bureau on September 14, 1979.

Reports

The report (LP-99) entitled "Mesoscale Characteristics of the Texas HIPLEX Area During the Summer 1977" was completed in April 1979. This report was submitted to the Department for staff review; copies were shipped to the Bureau on July 16, 1979.

Department report No. LP-97, "Radar Echo Organization and Development in the Mesoscale Environment--A Case Study Approach" by Meteorology Research, Incorporated, was completed and transmitted to the Bureau on May 18, 1979. The work was performed under Contract No. 14-80038. Copies were distributed to all Texas HIPLEX participants.

TEXAS A&M UNIVERSITY

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"A RADAR-ECHO CLIMATOLOGY FOR THE SOUTHERN HIPLEX"

Department of Meteorology
Texas A&M University
College Station, Texas 77843

Texas HIPLEX Interim Progress Report
April 1 through September 30, 1979

Prepared for the
Texas Department of Water Resources
Fiscal Year 1979 Contract Completion Report

By: Dennis M. Driscoll
Principal Investigator

Department Contract 14-90025

ACTIVITY FOR THE REPORT PERIOD

1. Synoptic Climatology of Southern HIPLEX

a. Objective Climatology of Weather Types

The procedure used to delineate weather types from Midland surface and upper-air data (April - September, 1973-1976), and to assign each day of this period to a weather type, consisted of four steps:

(1) Principal components analysis

(2) Multiple regression analysis

(3) Correlation analysis of the regression coefficients obtained in (2).

(4) Objective grouping

The result was generally unsatisfactory in view of the stated objective of obtaining 10 to 30 types, with a reasonable balance among the number of days in the types. After some experimentation with the threshhold value used in step (4), 47 types were produced. The first had 43.4 percent of the days, types 2 to 12 25.8 percent, types 13-47 13.9 percent, and the remaining 16.9 percent were untyped.

The types are differentiated by moisture, and not by synoptic variables such as pressure, and surface and upper-air wind speed and direction. The variables most heavily loaded on the principal components are sky cover, clouds in various levels, 500 mb relative humidity, precipitation, and surface temperature and dewpoint. A composite for each of the first 12 types was made; these composites are differentiated by the above variables. In short, the day-to-day weather at Midland is best distinguished by moisture and moisture-related variables.

b. Subjective Climatology of Weather Types

This classification was based on the position of Midland with respect to features of the surface and 500 mb charts at 1200 GMT, and is shown in the appendix. Of a total of 52 possible types, 13 accounted for nearly 80 percent of the days.

c. Association of the Objective and Subjective Climatologies

There is only a very general correspondence between the two climatologies, although a definitive analysis was not possible because of the few days in objective types 2-12. This is explicable in view of differences in the criteria used to differentiate days and place them in the various weather types. The objective scheme is based almost entirely on temporal moisture variations, whereas the subjective distinguishes among synoptic-scale map patterns which are based on pressure, wind speed and direction, and location with respect to fronts. We believe that this is a significant finding. It suggests that temporal weather variations in Southern HIPLEX are not well represented by synoptic-scale conditions.

d. Association of Radar Echo Parameters with the Climatologies

This association is currently underway. The daily variation of

(1) Initial echoes

(2) Average time required for echoes to grow to a size of 8 kilometers in diameter

(3) Percentage of echoes that grow to a size of 8 km in diameter

(4) Average duration of echoes that never grow to a size of 8 km in diameter

(5) Patterns of echo development

are being associated with the weather types delineated by both the objective and subjective climatologies.

2. Resolution of the Radar Bias Problem

In a previous study of Midland PPI films about 95 percent of the frames were at 250 nautical miles (nm). We expected this would be the case at Amarillo, but here about 25 to 30 percent of the frames are at 125 nm. The frequency count in the 48 squares centered on Amarillo is different for these two ranges; the reasons for this will be explained in the final report. Accordingly, were have had to review the films and record data at the 125 nm range - a procedure that was not necessary with the Midland data. Analysis of the results awaits the completion of this phase, which should take until the end of September.

3. Fine-scale Analysis of Seeding Effects

This was a pilot study to determine the feasibility of using Midland PPI films to ascertain the effects of seeding on a smaller scale than was possible in the initial study. Our analysis of the 50 seeding missions in 1976 has shown this not to be feasible. The details of this investigation will be in the final report.

"MESOSCALE FIELD PROGRAM AND DATA ANALYSIS"

Texas A&M University
Department of Meteorology
College Station, Texas 77843

Texas HIPLEX Interim Progress Report
April 1 through September 30, 1979

Prepared for the
Texas Department of Water Resources
Fiscal Year 1979 Contract Completion Report

Prepared by:
James R. Scoggins, Professor
Alexis B. Long, Assoc. Research Scientist
Steven Williams, Research Assistant
Myron Gerhard, Research Assistant

TDWR Contract No. 14-90026

Section I. Work Performed (April 1-August 31, 1979)

1. Analysis of 1978 Mesoscale Data

The analysis of the 1978 mesoscale data parallels that for the 1976 and 1977 data. Included in the analysis is 19 days with sounding and surface data, and seven days with surface data only. A report similar to those prepared from the 1976 and 1977 mesoscale data is being prepared. All computations have been performed and results for each day analyzed. The daily case studies are approximately 90 percent complete including drafting of the text. Composite analyses of surface and sounding data are nearing completion. Results for several days that were selected as case study days were provided to other investigators during the report period. No problems have been encountered in this research. Results are similar to those obtained from 1976 and 1977 data.

2. Development of Water Vapor Budget Models

The primary purpose of the analysis of the water vapor budget was to examine moisture sources and, therefore, energy sources for convective activity. A triangular area over the Texas HIPLEX area formed by the vertices of 3 rawinsonde stations (Robert Lee, Post, and Midland) was used in the analysis. Balloon drift was determined to be negligible, so this area remains constant with height. The volume for which the water vapor budget equation was evaluated was the triangular area between 850 and 300 mb.

Sounding data taken at 3-h intervals from 1500 GMT to 0300 GMT on selected days during the summers of 1976 and 1977 were used. Coverage extended to 0600 GMT on certain days during the summer of 1977. Results from nine days during the summer of 1976 appear in a final report prepared by Scoggins et al., (1978) (TDWR Report LP-65). Results from 10 days during the summer of 1977 also appear in a final report by Scoggins et al., (1979) (TDWR Report LP-99).

Although temporal changes in the water vapor budget have shown fascinating results, the determination of water vapor budget models provides a general approach in understanding the energy sources of convective activity. Results from 1976 and 1977 (114 sounding times) were stratified according to the presence, type, depth, and areal coverage of convective echoes over the Texas HIPLEX area using digitized radar data from the National Weather Service at Midland, Texas. The results were first stratified into two major groups: (1) sounding times when no convective echoes were observed; and (2) sounding times when convective echoes were observed. This stratification was independent of the type, depth, and areal coverage of convective echoes. Each term in the water vapor budget equation was averaged for each 50-mb layer and average vertical profiles were constructed for each regime. Results indicate that the largest difference occurs above cloud base.

The type of convective echoes observed were analyzed. For all times that convective activity was observed over the Texas HIPLEX area, results were stratified into three major groups: (1) sounding times when isolated convective cells were observed; (2) sounding times when clusters of convective cells were observed; and (3) sounding times when a distinct line of convective cells was observed. This stratification was independent of the depth and areal coverage of convective echoes. Each term in the water vapor budget equation was averaged for each 50-mb layer and average vertical profiles constructed for each group. Increased water vapor transports were observed for organized lines and clusters of cells.

The intensity or depth of convective echoes was analyzed. For all sounding times during which convective activity was present over the Texas HIPLEX area, results were stratified into three categories: (1) sounding times when tops were less than 6.1 km; (2) sounding times when tops were between 6.1 and 9.1 km; and (3) sounding times when tops were greater than or equal to 9.1 km. The sounding times were stratified according to the highest top observed within the area if one or more stratification conditions were met. Each term in the water vapor budget equation was averaged for each 50-mb layer and average vertical profiles constructed for each category of convection. Results have shown a definite correlation between upward vertical transports of water vapor and the depth of the convection. Large water vapor transports in subcloud layers was found to accompany deep convection.

The effect of the areal coverage of convective echoes was considered. For each sounding times that convective echoes were observed over the Texas HIPLEX area the results were divided into two regimes: (1) sounding times when convective echoes covered 50% or more of the area; and (2) sounding times when convective echoes covered less than 50% of the area. This stratification was independent of the type or depth of convective echoes. Each term in the water vapor budget equation was averaged for each 50-mb layer and average vertical profiles constructed for each regime. The largest differences between these regimes occurred below 550 mb which indicates the importance of increased water vapor transports needed for widespread convection.

The average profiles showed variation with the presence, type, intensity, and coverage, and the corresponding moisture processes within layers. A comparison of these models was made by integrating each term of the water vapor budget from 850 to 300 mb. These results indicate the relative magnitudes of water vapor transports for all the models. A comparison of individual terms in the water vapor budget equation shows that the net horizontal transport of water vapor exceeds other terms in the equation and is the primary moisture source for all categories of convection. In some cases, the net horizontal transport term nearly balances the residual term and, therefore, represents the moisture source for precipitation.

Complete results and the development of these water vapor budget models will appear in a technical report now in preparation. A statistical analysis could not be performed due to the small data set available. However, an explanation of the physical processes for the different models will be given.

3. Development of Model for Entrainment

Limited direct effort was devoted to this task during this report period. However, background information continued to be compiled from publications, concepts formulated, and the sounding and aircraft data for 1979 analyzed and studied. The problem of formulating a model that is physically realistic was greatly enhanced by the 1979 mesoscale sounding data and real-time analysis.

4. Determination of Environmental Response to Convective Activity

Time cross-sections were prepared and analyzed for mesoscale sounding data collected during 1977. Cross sections for the following variables were analyzed: temperature, potential temperature, equivalent potential temperature, relative humidity, mixing ratio, scalar wind speed, and wind direction. Also, the sounding data were plotted on Skew T-log p diagrams and the plots arranged in order of time to permit a visual evaluation of the time changes.

5. Cloud Microphysics - Environment Interactions

Progress was made early in the reporting period toward specifying the approaches to take in analyzing 1978 and 1979 cloud physics data so as to achieve the objective of describing the microphysics of seeded and not-seeded clouds in the Texas HIPLEX area. These approaches also should permit determination of the predominant precipitation mechanism in the area and of how it is altered by silver iodide seeding. Analysis of the cloud physics data collected near the -5C and -10C levels should focus on (1) the concentration of cloud droplets, especially of those larger than 24 μm diameter needed for ice multiplication, (2) the nature of the larger hydrometeors, whether they are raindrops or graupel, and (3) the size and shape of ice particles and their concentrations relative to ice nuclei. The analysis also should focus on the temperature at cloud base and the concentration of cloud droplets there. It will be important to learn how rapidly the sizes of the larger hydrometeors increase with time and to estimate where and when in a cloud the sampled particles originate. When all elements of the analysis are brought together they should provide the comprehensive picture of precipitation formation being sought. Of special interest from the standpoint of establising seeding effects will be the comparative concentrations of ice crystals and graupel in seeded and not-seeded clouds. Dr. Alexis B. Long of Texas A&M University gave a presentation of the approaches to take in analyzing the cloud physics data at a meeting of HIPLEX personnel in Austin on April 26, 1979.

Dr. Long consulted with personnel at Meteorology Research, Inc. in

Altadena, California May 7-8, 1979 on the approaches they were following in their analysis of the 1978 cloud physics data. The interchange helped to develop better ideas in regards to the analysis of the Texas HIPLEX cloud physics data.

Dr. Long traveled to Denver, Colorado May 14-15, 1979 to consult with Pam Hajny of the Bureau of Reclamation on procedures to follow in the field program in processing p-Navajo data. He then spent May 16-18, 1979 at the HIPLEX site in Miles City, Montana where he received training from CIC in the operation of the cloud physics instrumentation being installed there on the p-Navajo. Both visits brought Dr. Long into contact with several key personnel in the HIPLEX family and facilitated later interactions that became necessary for testing and improving the instrumentation and for processing the data.

On April 24, 1979 a formal request was made to the Bureau of Reclamation for certain segments of the 1978 aircraft data. Some of these data arrived about July 1, 1979, and examination of them has begun. A request for the remainder of the data has been made.

Dr. Long flew on the p-Navajo on all its flights in the 1979 field program as primary observer and as operator of the cloud physics instrumentation. He also advised the pilot of suitable clouds for penetration and study, and kept extensive notes during each flight and obtained a number of 35 mm photographs. From these and the flight logs from the other aircraft he developed a comprehensive report entitled "Aircraft Operations in the 1979 Texas HIPLEX Field Program." This was transmitted to TDWR on August 24, 1979. This report contains complete information on each mission flown including problems, AgI dispensed, type of clouds seeded and/or sampled, and other similar information.

Dr. Long worked closely throughout the field season with personnel of the Colorado River Municipal Water District and of the Colorado International Corporation (CIC) in testing and improving specific instruments on the p-Navajo and the real-time data processing and recording equipment. Dr. Long checked all data for quality in the field and shipped the 9-track magnetic data tapes to the Bureau of Reclamation for their processing. He worked with Pam Hajny of the Bureau in correcting the data processing program used at the Bureau, and on a number of occasions he worked with CIC personnel, who wrote the initial version of the program, on making it compatible with the data being collected by the p-Navajo cloud physics instrumentation.

6. Conduct of Mesoscale Field Experiment

Preparation for the 1979 mesoscale field experiment began in February 1979 and continued with several trips to the HIPLEX area for site selection of both rawinsonde and surface stations. Arrangements and letters of confirmation were sent to all parties concerned. Maps of both rawinsonde and surface station site locations are shown in Figs. 1 and 2.

The selection and training of rawinsonde operators continued in April 1979. The training sessions included both classroom instruction and field experience to familiarize the operators with both the equipment and operational procedures. Instruction in the handling and usage of TI-59 programmable calculators also was included to prepare the operators for real time data processing. Prior to the start of the field program, each operator had participated in several balloon launches and coding of the data. One key to the success of the 1979 mesoscale field experiment was the training and readiness of new rawinsonde operators prior to the start of the field program.

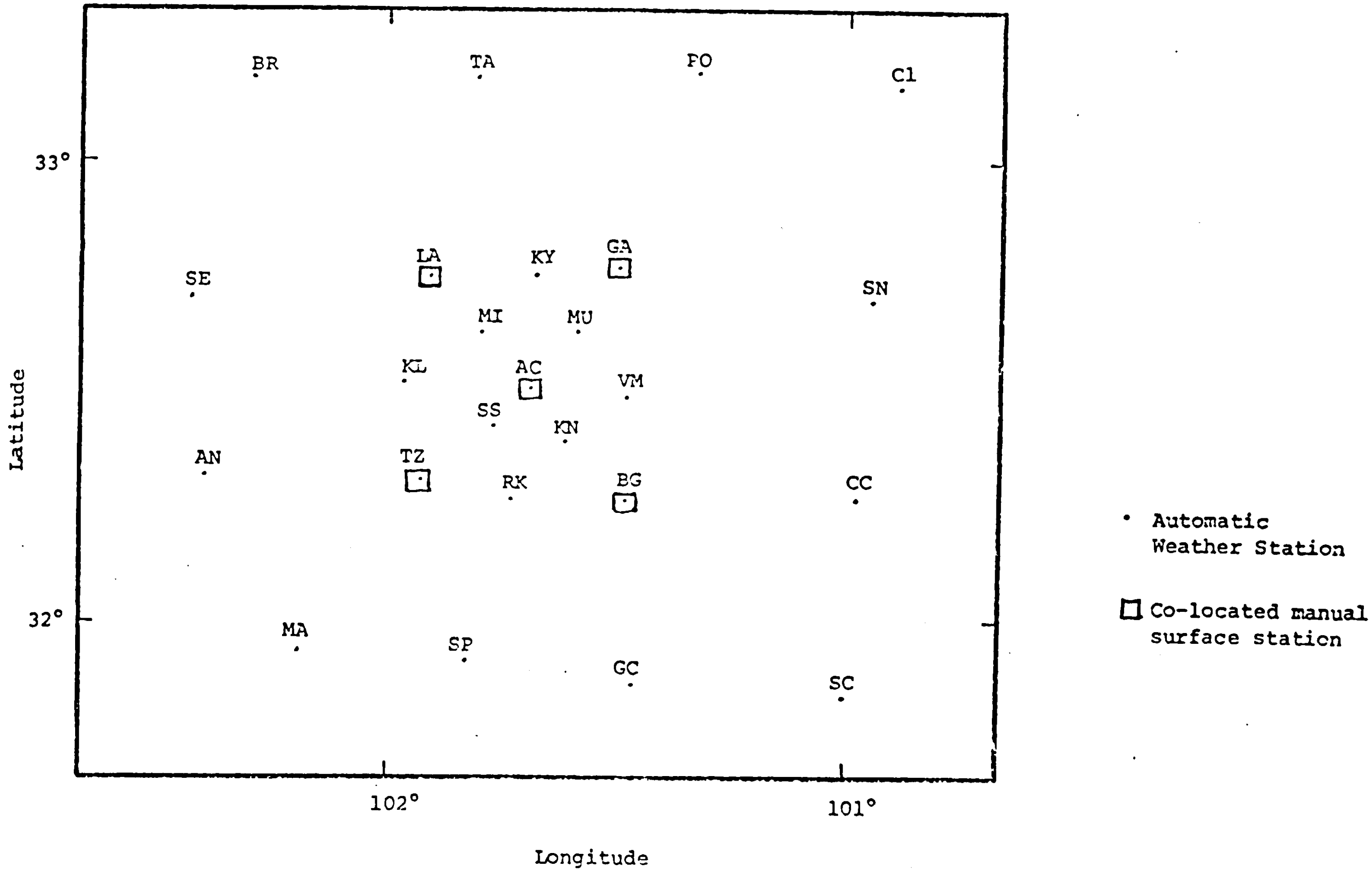

Fig. 1. Locations of surface stations during 1979 Texas HIPLEX field program.

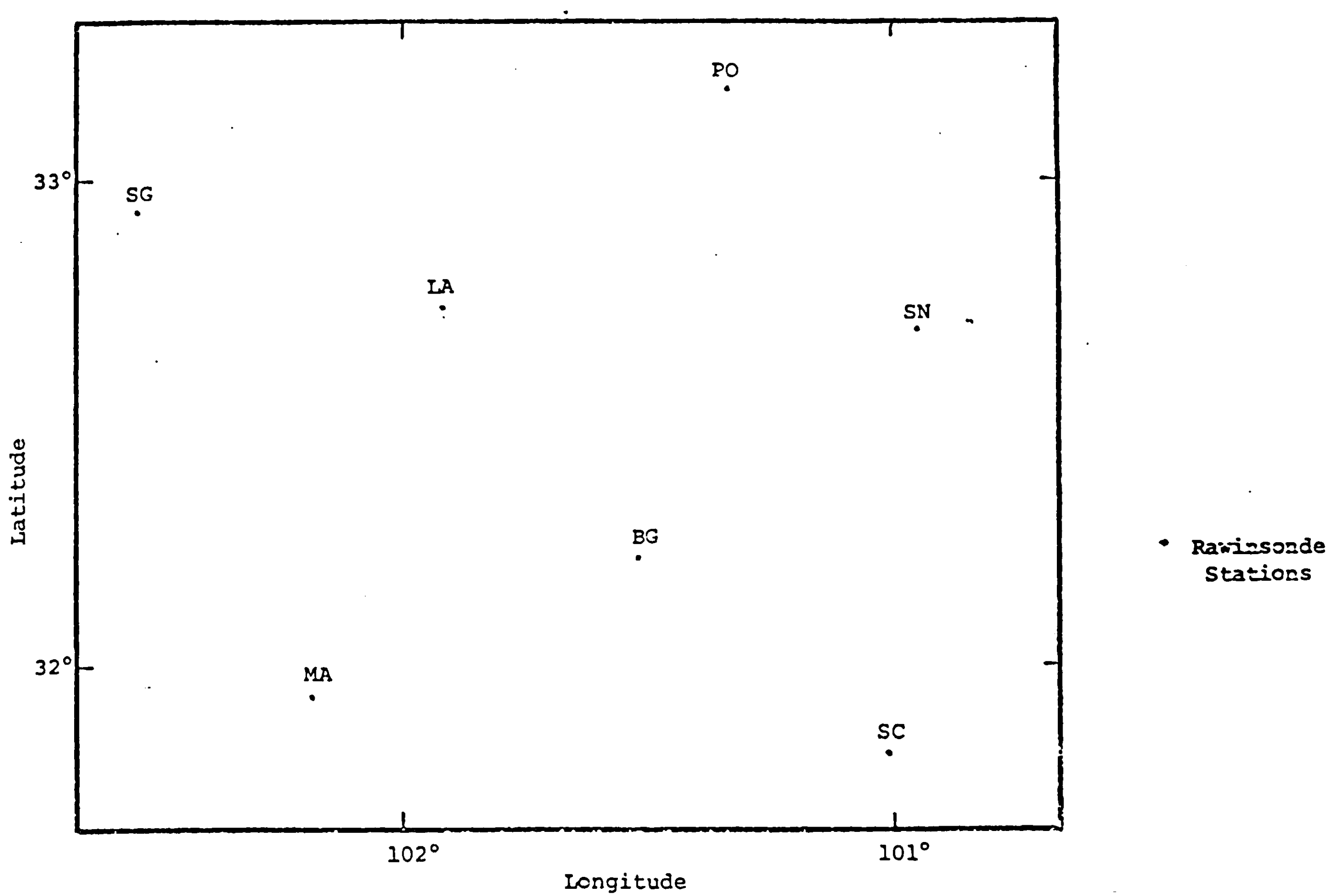

Fig. 2. Locations of rawinsonde sounding stations during 1979 Texas HIPLEX field program.

The TI-59 programmable calculator programs used in the reduction and analysis of HIPLEX rawinsonde data during the 1979 field program were documented for future use. The documentation for each program includes a general description, list of equations used, complete listing of program steps, outline of programming methods, identification of storage registers, program user instructions, a field testing procedure, and pertinent notes and comments useful for the execution of the programs. The seven programs documented include:

(1) Contact interpolation program;

(2) Psychrometric program,

(3) Thermodynamic calculations program;

(4) Height interpolation program;

(5) Wind computation program;

(6) Kinematic parameters program; and,

(7) Stability indices program.

Preparation for real time data processing also continued in April 1979 with the development of TI-59 calculator programs and the acquisition of nine TI-59 programmable calculators from the Texas Department of Water Resources. These programs include: (1) a contact interpolation program to aid the operator in determining 50-mb interval data; (2) a baroswitch setting program; (3) a psychrometric program to calculate relative humidity and dew point; (4) a temperature and relative humidity program which calibrates temperature and relative humidity computations according to the baseline data; (5) a thermodynamic program which computes temperature, dew point, relative humidity, mixing ratio, ascent rate of the balloon, and geopotential height of the balloon at any desired pressure level; and (6) a wind program which computes wind direction and wind speed from 30-s elevation and azimuth angle data. These programs were used by personnel at each rawinsonde station for the reduction of data at 50-mb intervals frmm 850 to 400 mb. These data were then called into Big Spring less than an hour following balloon release for data analysis purposes. TI-59 programmable calculators also were used by personnel in Big Spring to analyze these data. Programs were developed to compute parameters such as stability indices, velocity divergence, moisture divergence, vertical motion, vertical flux of moisture, and precipitable water. Data called in from every station also were used to construct Skew-T diagrams, constant pressure maps of temperature, dew point depression, height, and the wind field. The real time data were used in analyses, for forecasting, and as a quality check of the data received.

The rawinsonde network was expanded to seven rawinsonde stations this year. Four rawinsonde units were obtained on loan from the National Aeronautics and Space Administration in Huntsville, Alabama. Five of the seven rawinsonde stations were operated by Texas A&M University, and one by the Colorado River Municipal Water District in Big Spring. Soundings were purchased from the National Weather Service at Midland. Texas A&M University personnel also were assigned to Big Spring and Midland for real time data processing purposes. Six hundred twenty four soundings were taken on 23 days during May, June, and July. A complete list of these days and a sounding inventory is available in the 1979 HIPLEX data inventory document under preparation by the Bureau of Reclamation.

The surface network was expanded to 25 automatic weather stations during 1979. In addition, five colocated manual surface stations were installed to collect comparative data. The locations of these stations are shown in Fig. 1. These manual stations consisted of a hygrothermograph and microbarograph housed in a standard instrument shelter located less than 10 m from the automatic stations. Chart changes and calibrations on these instruments were conducted weekly. Values of temperature, relative humidity, and pressure were extracted at 1-hr intervals, keypunched, error checked, and archived for future use. In addition, Texas A&M University personnel attended training sessions and instruction in the installation, calibration, and maintenance of the automatic weather stations. Texas A&M University personnel installed and maintained these stations, and provided transportation for servicing as well as dismantling and packaging the equipment following termination of the field program. Data from the automatic weather stations were archived by the Bureau of Reclamation. The period of data archived for both the automatic and manual surface stations were June 20-July 20, 1979. A data inventory of these stations will be included in the 1979 HIPLEX data inventory document under preparation by the Bureau of Reclamation.

Either during or following the field program all rawinsonde data were sent to Texas A&M University for processing. All soundings were keypunched for computer processing. The first stage of processing the ordinate and angle data has been completed. Radar data were obtained for the period of the field program from the National Weather Service at Midland. These data were digitized onto 13 x 13 grids of the Texas HIPLEX area, keypunched, error checked, and archived. Preparations for the computer contouring of the radar data have been completed.

7. Chief Scientist

The Chief Scientist continued to assist with the management, planning, and conduct of the Texas HIPLEX program. The Operations Plan for the 1979 field program was prepared, coordination effected for the field program, a draft plan for 1980 prepared, and several weeks spent in Big Spring during the field program. Other activities included numerous discussions with TDWR personnel on various topics, discussions and meetings on the instrumentation package for the p-Navajo, coordination with Bureau of Reclamation personnel on data processing procedures and approaches, and arranging and presiding at a meeting of all Texas HIPLEX subcontractors.

COLORADO RIVER MUNICIPAL WATER DISTRICT

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COLORADO RIVER MUNICIPAL WATER DISTRICT

Progress Report

April 1 - September 30, 1979

Prepared for;

United States Department of the Interior
Bureau of Reclamation
Office of Atmospheric Resources Management

By:

Colorado River Municipal Water District
Post Office Box 869
Big Spring, Texas 79720

Contract No. 14-90027

The Colorado River Municipal Water District began its obligation under Texas Department of Water Resources Contract No. 14-90027 on January 1, 1979, fulfilling and adhering to each and every obligation contained under Tasks 1, 2 and 3 of that Contract. Services performed under these Tasks during this contractual period included the operation of a recording raingage network, aircraft support, and the purchase of a cloud physics data system. In addition, rawinsonde and radar operations were conducted to support activities being conducted by Texas A&M and Texas Tech Universities.

The following information is provided to describe the work and services performed under each Task of Contract No. 14-90027 for the reporting period April - September 1979.

PRECIPITATION GAGE NETWORK

The raingage network used in the Texas HIPLEX Operation during the 1979 season consisted of 106 Belfort Recording Gages capable of recording up to 12 inches of rainfall on a seven-day chart.

The gages are spaced on a grid pattern over most of a four-county area (Borden, Scurry, Mitchell and Howard) and also four gages in Dawson County. Eighty-one of the gages are placed in the grid pattern at 10 km spacing with the other 25 added in the center portion of the grid to form a dense pattern at 5 km spacing when considered with the other 81 gages.

The gages were serviced at 7-day intervals - charts removed and replaced, clocks wound and gages inspected for proper operation. Each gage was calibrated at the beginning of the season, again during the HIPLEX program.

The 106 recording-gage network is supplemented by a 81 fence-post gage network generally located in the same area as the recording gages. These are read after each rainfall day. All charts and fence-post gage readings are entered on forms supplied by the Bureau and forwarded to Texas Tech University for processing. Daily rainfall totals are also recorded on forms developed by CRMWD and furnished to TDWR, TAMU, the BREC and others for their information.

The recording raingage network operated well during the entire 1979 season with a minimum loss of data due to clock failure. Vandalism occurred on several occasions resulting in theft of buckets from the gages. Two of the gages were damaged by gunfire ruining the shell of one but not interfering with its operation. The other case caused total loss of the gage except for the clock and drum.

The recording gage network operation was completed on September 30th, 1979, and all charts, including mid-season and end of season calibration charts, were delivered to Texas Tech University for data processing.

Beginning October 1st, 1979, a program of winterization was begun, and all gages will be monitored during the winter season to control vandalism.

AIRCRAFT SUPPORT

During the period May 21 - July 21, 1979, the CRMWD flew two specially equipped aircraft in support of the State and Federally sponsored Texas HIPLEX Program.

These aircraft consisted of a high-performance, all-weather turbocharged pressurized Navajo (N7335L) and a Model "D" Piper Aztec. Shown on Table 1 are the performance characteristics of these aircraft.

TABLE 1

AIRCRAFT PERFORMANCE AND EQUIPMENT CHARACTERISTICS

P-Navajo N7335L

Twin 425 H.P. Turbocharged Engines
Service Ceiling - 29,000 Ft.
Rate of Climb - 1700 Ft. per Min.
Cruise Speed - 245 M.P.H. @ 64% Power
Weather Radar
Deicing Boots
X-Ponder/Encoder
2 - Nav. Comm. 360 Channel Transceivers
DME
ADF
3-Axis Auto Pilot

Aztec 13816

Twin 210 H.P. Non-turbocharged Engines
Service Ceiling - 17,000 Ft.
Rate of Climb - 1,000 Ft. per Min.
Cruise Speed - 190 M.P.H.
DME
ADF
Transponder
2 - 360 Channel Dual Transceivers

Each aircraft was equipped with certain silver iodide cloud seeding pyrotechnic devices for the purpose of conducting cloud base and cloud top seeding experiments. In addition to the materials dispensed, the CRMWD, as outlined in Task 2, also provided for the services of the personnel necessary to operate these aircraft and their systems. Provided below is a list of those people and their functions.

Mr. Alan Roberts, Chief Pilot
Mr. Steve Gabrick, Pilot
Mr. Leon Anderson, Pilot
Mr. Thomas Heffner, Meteorological Observer
Mr. Richard Halfmann, Alternate Observer

Complete pilot resumes are shown in Appendices A and B.

All aircraft missions were conducted within the designated 1979 Texas HIPLEX experimental area. A complete list of all operational, calibration and tower fly-by flights conducted by each aircraft is shown in Tables 2 and 3. Although electrical problems were encountered with the Navajo's alternator and transponder, it can be said that most flights were conducted without mechanical difficulty to the aircraft and in an orderly fashion.

Under Task 3 - Aircraft Instrumentation of Contract No. 14-90027, the CRMWD purchased, with Federal funds provided for in this Contract, an airborne cloud physics sensing and recording system. This instrumentation was purchased from the Colorado International Corp. (CIC) and installed on the Water District's P-Navajo for use in the 1979 Texas HIPLEX Program. Appendix C of this report contains a "letter of agreement" between the CIC and the CRMWD for the purchase of those instruments shown in Task 3. The following instruments were replaced by CIC with suitable substitutes and with the approval of TDWR: (1) Lyman Alpha Device, (1) Sony 7-inch Cathode Ray Tube and (2) Sony Audio Cassette Recorders.

Amendment No. 1 to this Contract was issued to the CRMWD to cover those expenses accrued in flying the P-Navajo to Miles City, Montana, where the data system was installed and calibrated and the aircraft FAA certi-

TABLE 2

1979 TEXAS HIPLEX NAVAJO FLIGHT SUMMARY

AIRCRAFT	DATE	MISSION	HOURS	AgI (gms)
P-Navajo	5-13-79	Miles City for Instrumentation	5.9	-0-
P-Navajo	5-18-79	Instrumentation Calibration	3.5	-0-
P-Navajo	5-20-79	Return from Miles City	4.3	-0-
P-Navajo	5-27-79	Instrumentation Check	.7	-0-
P-Navajo	6-3-79	Instrumentation Check	2.5	-0-
P-Navajo	6-4-79	HIPLEX Operation	1.6	80
P-Navajo	6-4-79	HIPLEX Operation	1.9	-0-
P-Navajo	6-5-79	HIPLEX Operation	1.0	-0-
P-Navajo	6-7-79	HIPLEX Tower Fly-by	1.0	-0-
P-Navajo	6-7-79	Speed Runs - Instrument Test	.8	-0-
P-Navajo	6-8-79	Instrumentation Check	1.3	-0-
P-Navajo	6-13-79	Instrumentation Check	.3	-0-
P-Navajo	6-22-79	Instrumentation Check (IPC)	1.0	-0-
P-Navajo	6-22-79	IPC & Flare Rack Test	.6	-0-
P-Navajo	6-24-79	HIPLEX Operation	1.5	-0-
P-Navajo	6-25-79	Instrumentation Check	1.0	-0-
P-Navajo	6-25-79	HIPLEX Operation	3.1	450
P-Navajo	6-26-79	HIPLEX Operation	1.1	-0-
P-Navajo	6-26-79	HIPLEX Operation	1.2	-0-
P-Navajo	7-2-79	HIPLEX Operation	1.0	-0-
P-Navajo	7-3-79	HIPLEX Operation	1.5	-0-
P-Navajo	7-3-79	HIPLEX Operation	2.0	330
P-Navajo	7-4-79	HIPLEX Operation	1.0	-0-
P-Navajo	7-5-79	HIPLEX Operation	3.5	150
P-Navajo	7-5-79	HIPLEX Operation	.6	-0-
P-Navajo	7-7-79	HIPLEX Operation	1.2	-0-
P-Navajo	7-8-79	HIPLEX Operation	1.7	-0-
P-Navajo	7-9-79	HIPLEX-MESO Mapping	1.1	-0-
P-Navajo	7-12-79	HIPLEX - Tower Fly-by	1.2	-0-
P-Navajo	7-15-79	HIPLEX-Operations	1.6	-0-
P-Navajo	7-16-79	HIPLEX Operation	1.0	-0-
P-Navajo	7-17-79	HIPLEX Operation	1.8	-0-
		TOTAL:	53.5	

TABLE 3

1979 TEXAS HIPLEX AZTEC FLIGHT SUMMARY

AIRCRAFT	DATE	MISSION	HOURS	AgI
Aztec	5-28-79	HIPLEX Operation	1.9	-0-
Aztec	6-4-79	HIPLEX Operation	1.9	240
Aztec	6-5-79	HIPLEX Operation	1.5	-0-
Aztec	6-24-79	HIPLEX Operation	2.9	-0-
Aztec	6-26-79	HIPLEX Operation	1.0	-0-
Aztec	7-3-79	HIPLEX Operation	1.1	-0-
Aztec	7-3-79	HIPLEX Operation	1.7	-0-
Aztec	7-5-79	HIPLEX Operation	1.3	-0-
Aztec	7-5-79	HIPLEX Operation	1.8	-0-
Aztec	7-8-79	HIPLEX Operation	1.3	180
Aztec	7-9-79	HIPLEX Operation	1.9	-0-
Aztec	7-15-79	HIPLEX Operation	.6	-0-
		TOTAL:	18.9	

fied. Due to the very short time available to adequately bench check, interface and install the data system, the data system, following its installation, required many days of detailed calibration and debugging attention.

Although it cannot be said with certainty until the 9-track data tapes are processed, it appears as though the system only provided 65% useable data from May 21 through July 7, 1979, and 93% from July 8 through July 21, 1979. Shown in Appendices D and E are memorandums from Dr. Long, who served as the primary operator of the data system during the 1979 field program. The memorandums reflect the inefficient operation of the data system prior to July 3, followed by its improved operating mode during the field program's sixth week.

In summary, we feel the aircraft operations were performed well and the cloud physics data system, in spite of its failures and operational problems, will provide some useful micro-physical cloud data from 1979 and will prove its usefulness during the 1980 field season and in subsequent years.

RAWINSONDE OPERATIONS

Mr. Harold Hancock arrived in Big Spring, Texas, on April 1, 1979, to begin his duties as the rawinsonde operator for that site. During the 1979 field program, a total of 104 rawinsondes were launched, with 93 of these soundings being made in support of the TAMU Mesoscale Program. All sounding data have been processed and archived through the CYBER-74 in Denver, Colorado.

During the first week of September, Mr. Hancock returned to El Paso to continue his data analysis study of inter- and intra-state HIPLEX sounding data.

FPS-77 RADAR

The FPS-77 radar was operated from the Big Spring airport and was the responsibility of CRMWD personnel. Primarily, the system operated to support aircraft operations prior to "take-off" and to serve as a backup system in the event the skywater radar failed during an operational event.

There was only one instance when the skywater radar failed and on this occasion physical records were maintained regarding cloud number, echo intensity, azimuth, elevation, range and cloud top height.

This Interim Progress Report is respectfully submitted by the CRMWD for the Department's approval and acceptance for work and services performed in accordance with TDWR's Contract No. 14-90027, Tasks 1, 2 and 3.

TEXAS TECH UNIVERSITY

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Atmospheric Science Group
Texas Tech University
Lubbock, Texas

Texas HIPLEX Interim Progress Report
April 1 - September 30, 1979

Prepared for the
Texas Department of Water Resources
Fiscal Year 1979 Contract Completion Report

By: Donald R. Haragan, Professor and Co-Principal Investigator
Jerry Jurica, Associate Professor and Co-Principal Investigator
Colleen A. Leary, Assistant Professor and Co-Principal Investigator

Contract Number IAC(78-79) 2104
TDWR Contract No. 14-90023

Section I. Activity for the Report Period

Task 1. Analysis of 1977 Satellite Radiance and Rainfall Data. Research during the report period dealt with the case study days June 22, 24, 27 and July 8, 1977. As described in the last interim report, two problems which had to be dealt with were (1) the misalignment of consecutive data records caused by non-uniform start times for the records and (2) the presence of very strong spatial gradients in some of the data. These two matters were dealt with as follows. It was judged that the only reliable and complete solution to the misalignment problem would be a line-by-line adjustment of the data. Such a task would have been both very time-consuming and very expensive in computer costs. Further, the effect of misalignment would be greatest for the smallest clouds, but would not significantly alter the deduced properties of larger clouds. Therefore, it was decided to use the data as received. At this time it appears that the only serious consequence will be the inability to trace motions of small convective clouds because of their substantial distortions.

Regions of strong gradients were initially interpreted as containing bad data points by the correction algorithms, leading to unwarranted smoothing of the data. A detailed review of the data correction procedure has been performed, and the modified technique now preserves these features in the data while still locating and correcting spurious values.

The visible radiance data represent the albedo of the observed area, and have been converted to albedo values using a modified version of the technique developed for the June 22, 1976 case study, and previously reported on. Figure 1 shows the relation used between visible data

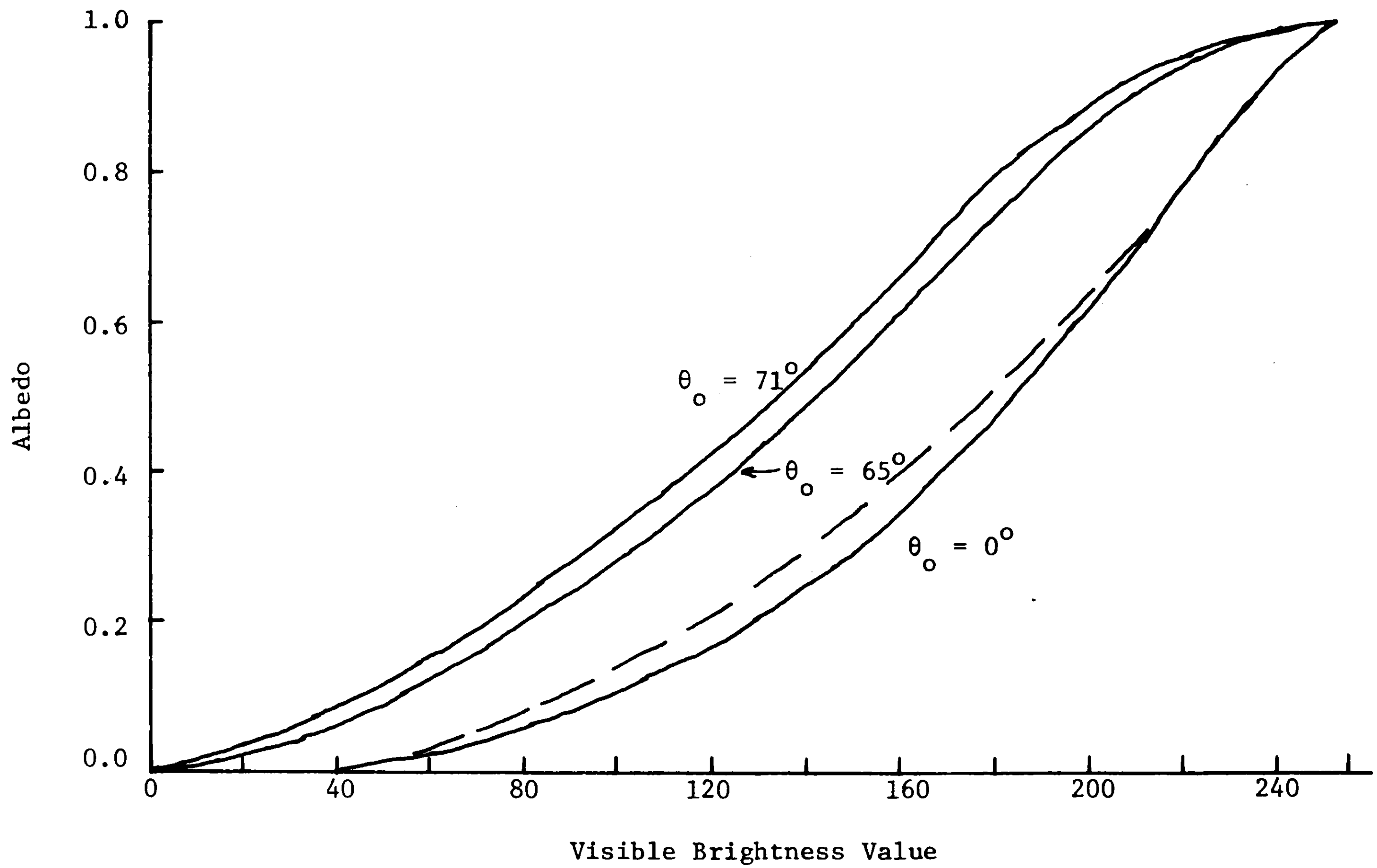

Figure 1. Albedo versus visible radiance data brightness value. The dashed curve is for zero solar zenith angle as used for 1976 data.

brightness values and albedo for several solar zenith angles. Also shown for comparison is the curve previously applied to 1976 data for a solar zenith angle of zero. Figures 2, 3 and 4 demonstrate the application of these relationships to the location of high reflectivity regions within a cloudy area. Figure 2 is the GOES-WEST visible photo for 2030 GMT on July 8, 1977. Figure 3 shows the unenhanced visible image reconstructed from the radiance data for 2015 GMT on July 8, 1977 using the ADVISAR (All Digital Video Imaging System for Atmospheric Research) at Colorado State University (CSU). The use of color enhancement to identify high albedo regions of the clouds is demonstrated in Figure 4.

The visible data are analyzed in detail for an area approximately 315 x 315 km centered at Big Spring, Texas. One set of results gives cloud-by-cloud summaries of properties such as size, mean brightness, etc. A partial listing of a sample output is given in Table I. Figure 5 shows the use of these results to compare percent cloud cover over the study area on the four case study days.

Task 2. Analysis of 1977 and 1978 Satellite Data. The principal emphasis in this task is on the integration of satellite, rainfall and radar data into a consistent understanding of the cloud system. Figure 6 shows the isohyetal pattern produced from the raingage data for the period 2015-2030 GMT on July 8, 1977. Superimposed are several radial lines drawn from the location of the M-33 radar at Snyder. In Figure 7 is shown a vertical cross-section of the radar echo pattern along the 250^{o} radial. The rainfall maximum of 0.89" corresponds well with the radar reflectivity maximum noted at a distance of 40 km. The dashed curve shows

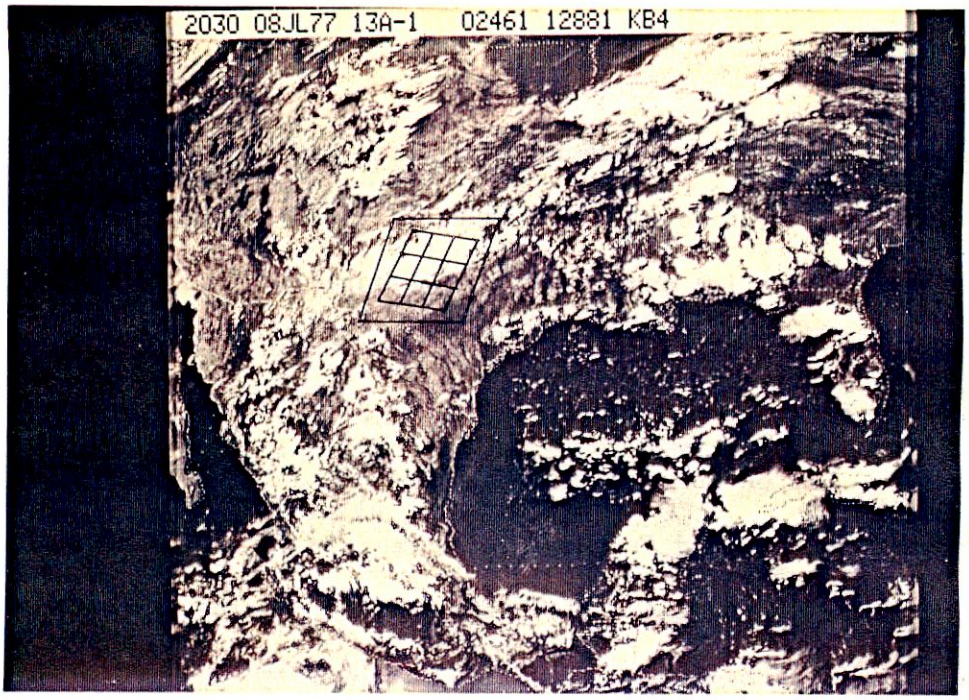

Figure 2: GOES-WEST visible photo for 2030 GMT on July 8, 1977.

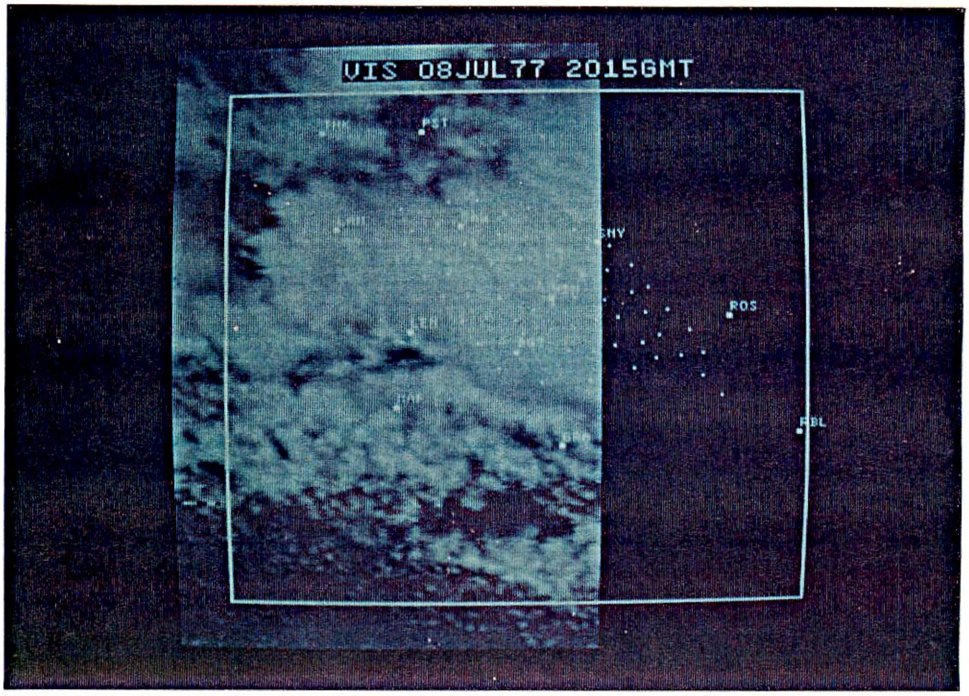

Figure 3: Unenhanced visible image reconstructed from the radiance data for 2015 GMT on July 8, 1977 using the ADVISAR at Colorado State University.

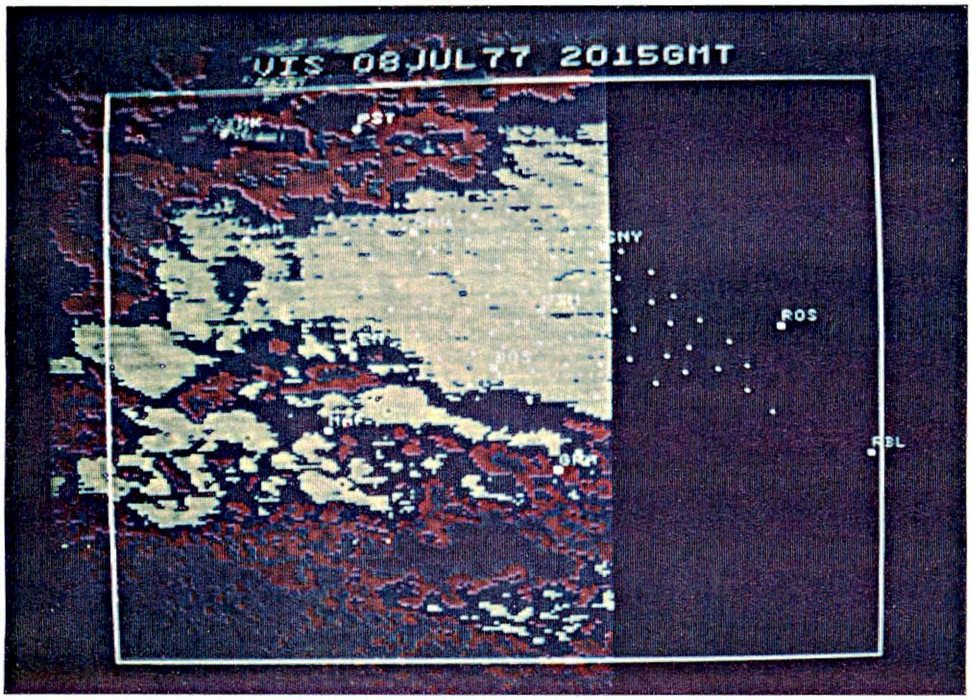

Figure 4: Color-enhancement of Figure 3, identifying high albedo regions of clouds

Table I

Summary of Visible Radiance Data Set
for 1815 GMT on 22 June 1977

	Number Of Points	Percent	Mean Value
Cloud	44,011	94.3	174
Non-Cloud	2,645	5.7	113
TOTAL	46,656	100.0	171

Cloud Number	Cloud Size	Mean Value	Variance	Center	Maximum Value
1	43,788	175	315.1	(133,121)	228
2	7	131	7.8	(22,171)	136
3	31	145	178.7	(24,213)	176
4	17	133	26.8	(24,225)	144
5	19	136	32.0	(22,232)	148
6	5	131	9.0	(34,220)	136
7	5	132	6.4	(35,228)	136
8	4	133	27.0	(36,234)	140
9	10	129	3.4	(40,233)	132
10	44	131	11.3	(44,229)	140

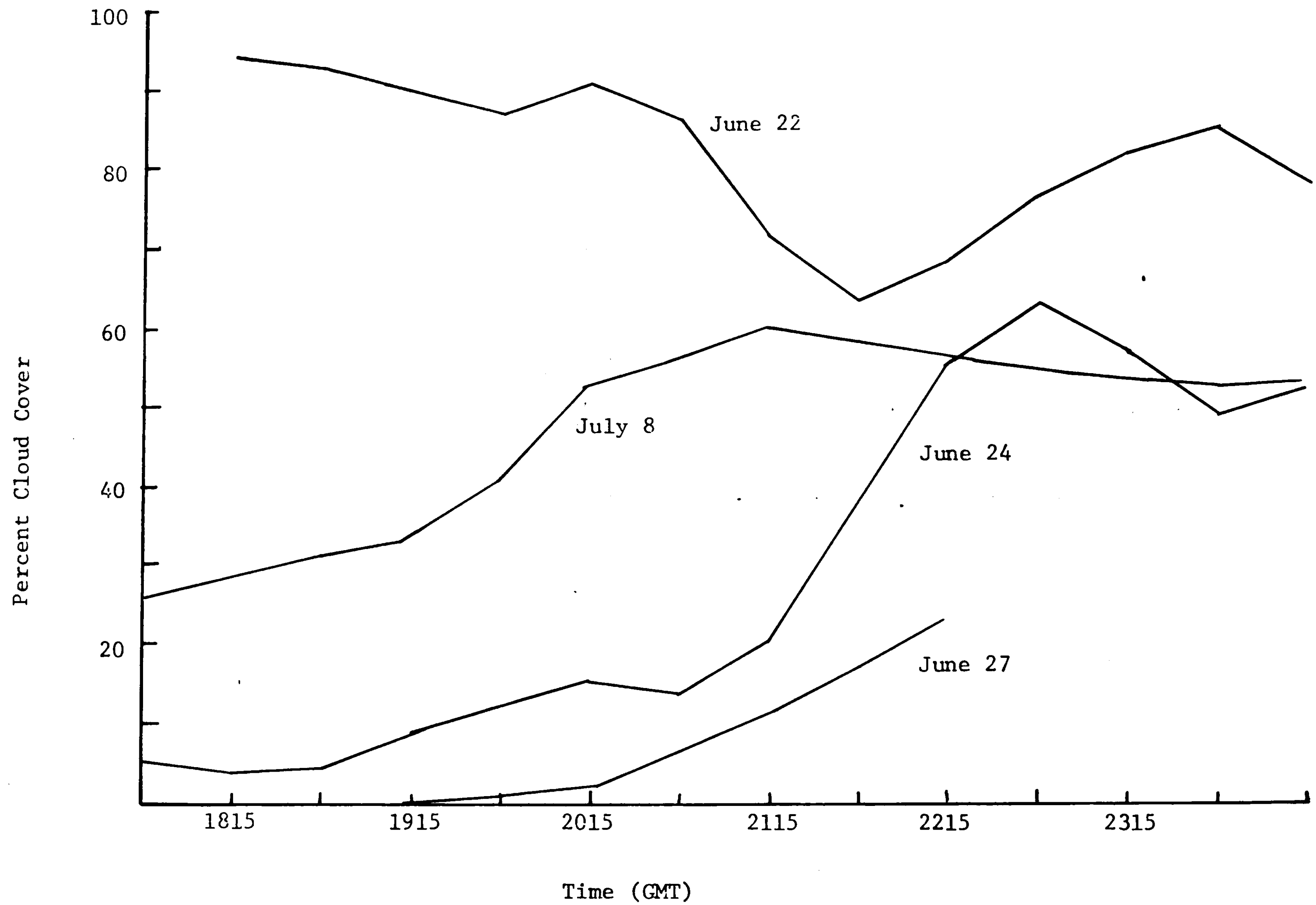

Figure 5. Percent cloud cover over the study area versus time of day for June 22, 24, 27 and July 8, 1977.

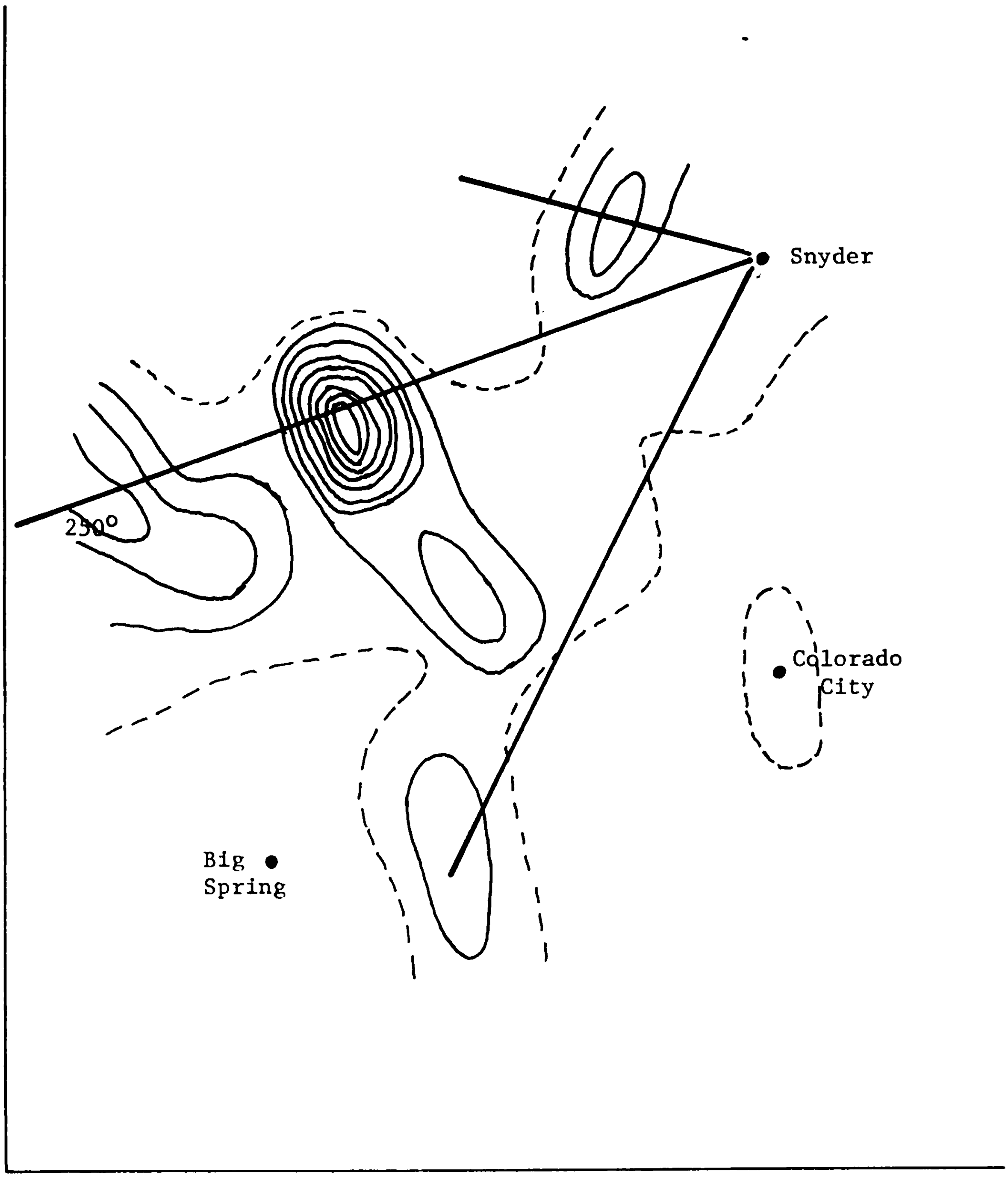

Figure 6. Isohyets over the Texas HIPLEX raingage network for the period 2015-2030 GMT on July 8, 1977. Also shown are several radial lines from the location of the M-33 radar.

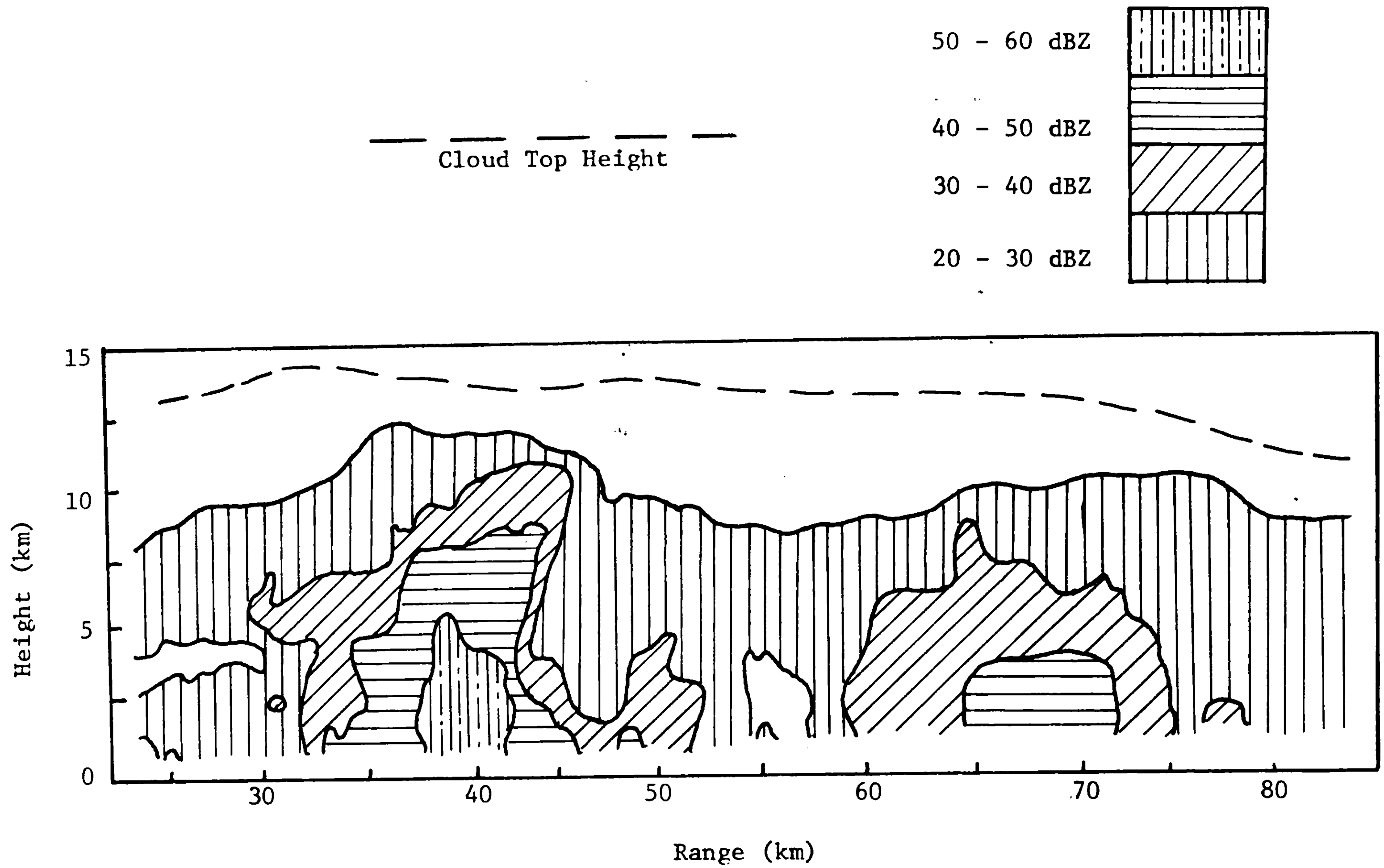

Figure 7. Vertical cross-section of M-33 radar reflectivity measured along a radial 250° from north. Also shown are the satellite-derived cloud-top heights.

cloud-top heights derived from the infrared satellite radiance data. These are obtained by comparing the cloud-top temperature inferred from the infrared radiance data with the vertical temperature profiles from rawinsonde data obtained by Texas A&M. The agreement is considered to be good, keeping in mind that the satellite data represent the physical cloud top while the radar data represent only the precipitation-sized particles within the cloud region.

It has been judged to be highly desirable to develop a technique for estimation of rainfall from satellite radiance data. An approach has been developed by Oliver and Scofield for the qualitative use of satellite photographs to this end. An effort to adapt the principles of their method to quantitative data has been made, and a computer algorithm is under development at this time.

The analysis of visible and infrared satellite photographs obtained during the 1978 field program is continuing. When completed, these results will be combined with and compared with results obtained for the 1976 and 1977 field programs.

Task 3. Rainfall Analysis. Tables II and III show rainfall periods for 1977 and 1978. Tabular values give the date and time of rainfall and the total water received over the network during periods when five or or more gages received rain. A new period begins whenever 15 minutes with no rain is recorded. Total water was derived by first constructing a network of triangles, computing the average rainfall over each triangle and then summing over the entire network.

Table II

1977 Rainfall

Period	Date	Rain Began (CDT)	Rain Ended (CDT)	Total Water (Acre-feet)
1	1 June	0145	0930	41,136
2	1 June	0945	1045	76
3	1 June	1100	1130	
4	2 June	0845	0900	
5	10 June	1945	2130	2,170
6	10 June	2200	2215	
7	11-12 June	2200	0415	50,364
8	12 June	0430	0530	99
9	12 June	0615	0630	
10	13-14	2245	0030	11,661
11	14 June	0045	0130	
12	18-19 June	2115	0115	
13	19 June	0145	0200	
14	20-21 June	2230	0615	95,389
15	21 June	0645	0715	
16	21 June	1145	1200	
17	21 June	1715	2015	1,503
18	21-22 June	2030	0145	15,492
19	22 June	0215	0230	
20	22 June	0300	0330	
21	22 June	0600	0615	
22	22 June	0715	0745	
23	22 June	0930	1000	
24	22 June	1215	2215	52,987
25	22 June	2230	2330	139
26	22-23 June	2345	0215	283
27	23 June	0230	0245	
28	23 June	0300	0800	4,896

Period	Date	Rain Began (CDT)	Rain Ended (CDT)	Total Water (Acre-feet)
29	23 June	0830	0900	
30	23 June	1330	2030	40,653
31	23 June	2045	2100	
32	23 June	2115	2130	
33	23 June	2215	0000	581
34	24 June	0015	0030	
35	24 June	0230	0530	1,979
36	24 June	0600	0615	
37	24 June	0645	0700	
38	24 June	0715	0730	
39	24 June	0900	1100	632
40	24 June	1115	1130	
41	24 June	1215	1230	
42	24 June	1315	1330	
43	24 June	1415	1445	
44	24 June	1700	1745	
45	24-25 June	2000	0030	20,648
46	25 June	0045	0100	
47	25 June	0845	1200	1,885
48	25 June	1215	0115	111
49	25 June	1330	2145	27,961
50	25-26 June	2200	0115	4,038
51	26 June	0145	0200	
52	26 June	0330	0345	
53	26 June	0400	0430	
54	26 June	1615	1645	
55	26 June	1700	1715	
56	26 June	2130	2145	
57	26 June	2200	2215	
58	26 June	2230	2245	
59	27 June	1045	1100	

Period	Date	Rain Began (CDT)	Rain Ended (CDT)	Total Water (Acre-feet)
60	28 June	0445	0500	
61	28 June	1315	1330	
62	28 June	1345	1400	
63	28 June	1545	1615	
64	1 July	0400	0430	
65	1 July	1630	1700	
66	8 July	1230	1930	66,095
67	8 July	2000	2015	
68	8 July	2030	2045	
69	8 July	2115	2130	
70	8 July	2230	2315	
71	8-9 July	2345	0015	
72	9 July	0315	0345	
73	9 July	0415	0430	
74	9 July	0445	0800	1,078
75	9 July	0815	0830	
76	9 July	1500	1515	
77	9 July	1545	1700	
78	9 July	2000	2030	
79	21 July	1230	1300	
80	21 July	1315	2230	35,909
81	21 July	2315	2345	
82	22 July	0100	0115	
83	22 July	0130	0215	90
84	22 July	0230	1230	118,128
85	22 July	1245	1330	107
86	22 July	1345	1445	
87	26-27 July	2330	0100	1,650
88	27 July	0115	0145	
89	27 July	0800	0845	
90	27 July	1515	1630	

Period	Date	Rain Began (CDT)	Rain Ended (CDT)	Total Water (Acre-feet)
91	27 July	1645	1700	2,307
92	27 July	1915	1930	
93	27 July	2000	2015	
94	28 July	0145	0245	
95	28 July	0800	0845	
96	28 July	0900	0915	
97	28 July	0930	0945	
98	28 July	1345	1715	7,410
99	29 July	0045	0100	
100	29 July	0230	0245	
101	29 July	0300	0800	12,897
102	29 July	0815	0915	1,111
103	29 July	1030	1045	
104	29 July	1445	1945	8,832
105	29 July	2000	2045	87

Table III

1978 Rainfall

Period	Date	Rain Began (CDT)	Rain Ended (CDT)	Total Water (Acre-feet)
1	31 May, 1 June	2100	0300	103,644
2	2 June	0145	0430	1,181
3	2 June	0630	0645	
4	2 June	0745	1430	39,130
5	2 June	1645	1700	
6	2 June	1715	0000	15,820
7	3 June	0400	0500	
8	5 June	0130	0745	4,402
9	5 June	1615	2200	72,630
10	6 June	0200	0315	718
11	6 June	0330	0345	
12	6 June	0500	0615	452
13	6 June	0645	0700	
14	6 June	0800	1500	36,574
15	6 June	2030	2145	1,698
16	6 June	2200	2215	
17	7 June	1800	1845	167
18	13 June	1345	1545	1,015
19	14 June	1600	1615	
20	28 June	1800	1830	
21	28 June	1845	2145	573
22	29 June	2130	2200	
23	20-30 June	2230	0115	1,784
24	30 June	1130	2130	21,944
25	30 June	2215	2230	
26	30 June	2315	2330	
27	1 July	1245	1730	8,130
28	1 July	1745	1815	
29	2 July	1415	1430	
30	2 July	1645	1800	

Period	Date	Rain Began (CDT)	Rain Ended (CDT)	Total Water (Acre-feet)
31	2 July	2045	2230	517
32	3 July	1345	1400	
33	3-4 July	1500	0200	62,497
34	15 July	1615	1900	5,965
35	20 July	1315	1330	
36	20 July	1400	1415	
37	20 July	1445	1600	364
38	20 July	1615	1645	
39	22 July	1345	1900	22,577
40	23 July	0115	1045	9,741
41	23 July	1330	2115	51,660
42	23 July	2130	2145	
43	24 July	1345	1630	2,953
44	24 July	1715	1730	
45	24 July	1745	1830	
46	26 July	1515	1545	3,810
47	26 July	1900	1915	
48	26 July	2130	2200	
49	26-27 July	2215	0215	8,684
50	27 July	0345	0400	
51	30 July	0400	0430	
52	30 July	0445	0500	
53	30 July	1445	1830	5,432
54	31 July	1700	1730	

Analyses of two case studies for 1977 are now underway. The two periods are 22 June and 8 July. Total water received in the network has been computed as a function of time and is shown in Figure 8 for each station. The value plotted at a given time represents rainfall occurring during the previous 15-minute interval. Figures 9 and 10 show sequences of maps with 15-minute time resolution for each of the two periods. The broken isohyet represents .01 inches of rain while solid contours are drawn for each 0.1 inch. Research emphasis is now on the 8 July case study. In this instance, a line of intense convective rainfall formed in association with the passage of a cold front through the rainfall network. High surface temperatures coupled with moist unstable air produced rainfall rates exceeding 3.5 inches per hour for a short period of time. Total precipitable water varied from 3.30 gm cm^{-2} to 4.00 gm cm^{-2} over the area.

Mesoscale analysis of these cases, including integration of surface, upper air, radar and satellite data is now underway. It is anticipated that the 8 July analysis will be completed by the end of the next quarter.

Task 4. Radar Data Collection for the 1979 Field Experiment. On each day during the 1979 HIPLEX season when convective echoes were present, the SKYWATER radar was used to record digital radar. In addition, 16mm movies of the color television display were obtained to supplement the digital data collected on magnetic tape.

Table IV lists the four scanning modes in which the digital radar data were recorded. The two aircraft modes were employed when HIPLEX

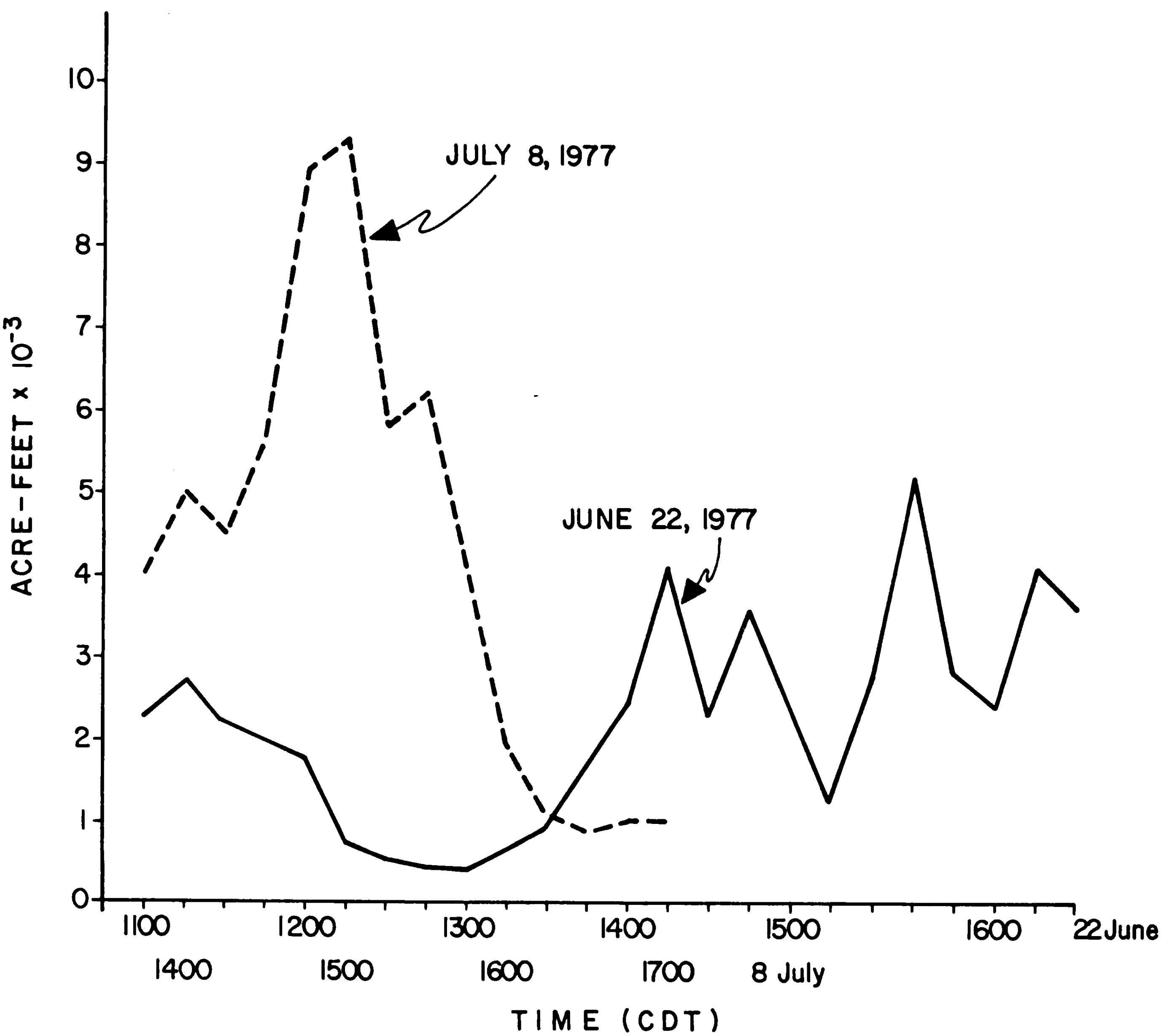

Figure 8. Total Network Precipitation as a function of time (acre-feet).

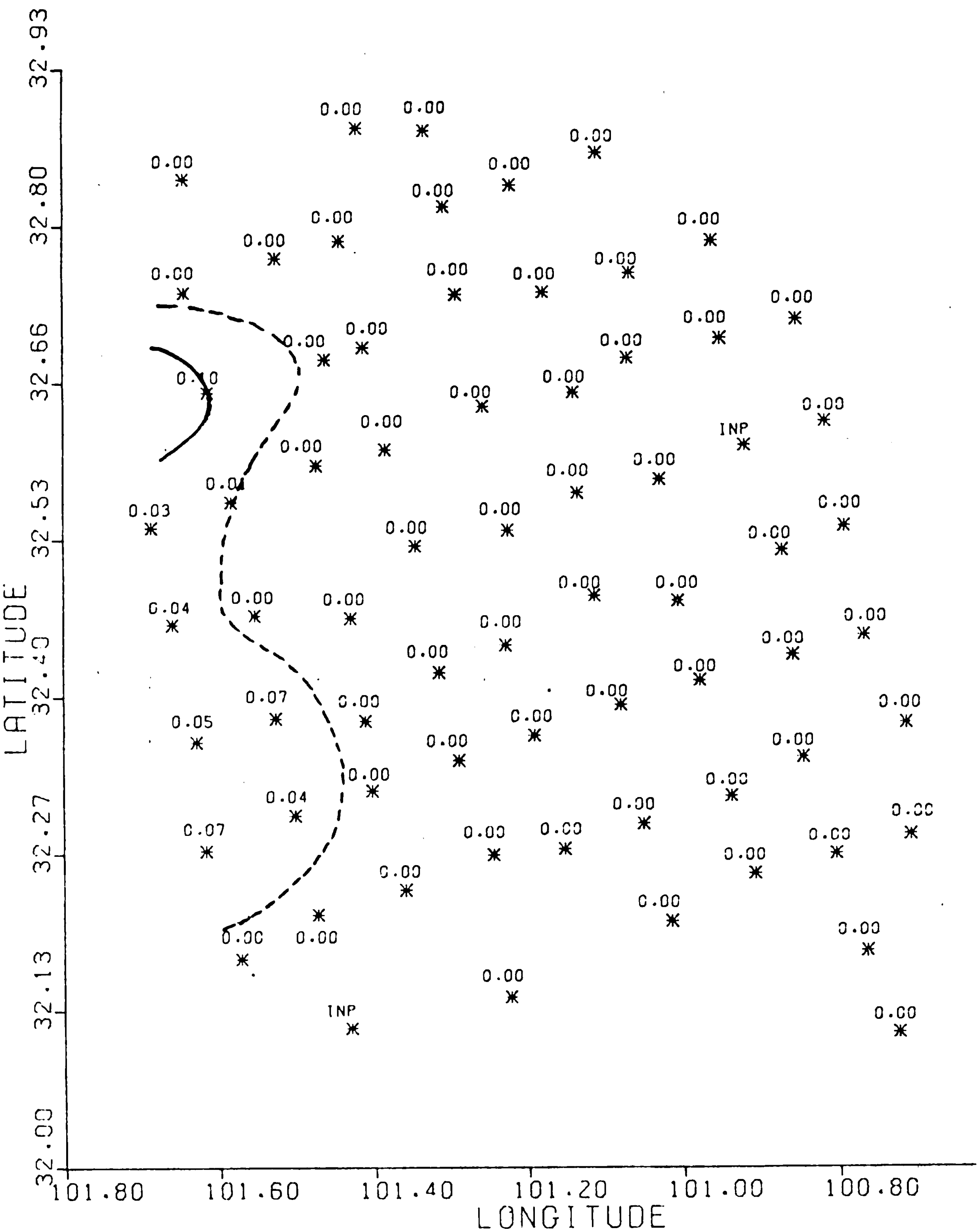

Figure 9a. Rainfall for 22 June 1977
1300 - 1315 CDT

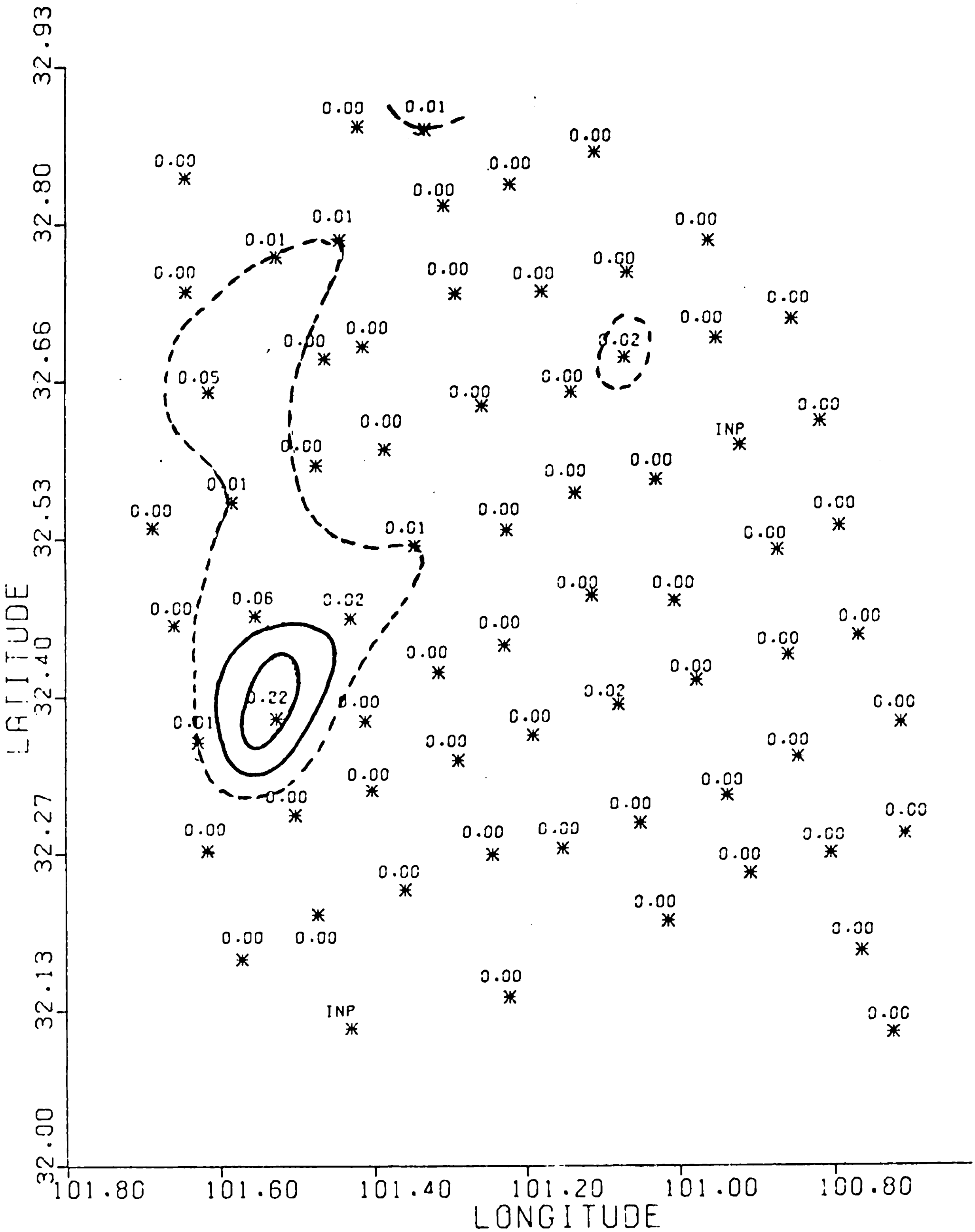

Figure 9b. Rainfall for 22 June 1977
1315 - 1330 CDT

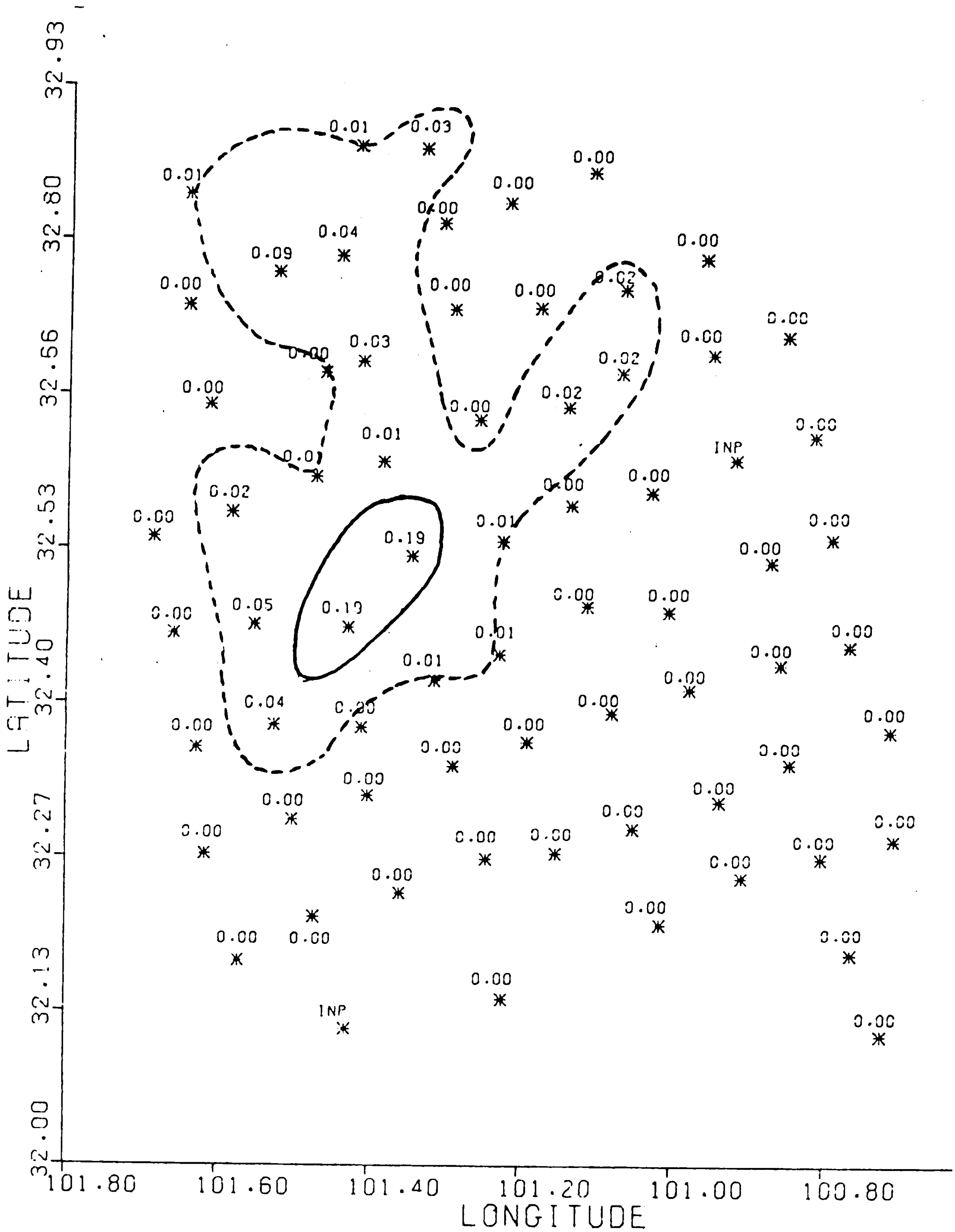

Figure 9c. Rainfall for 22 June 1977
1330 - 1345 CDT

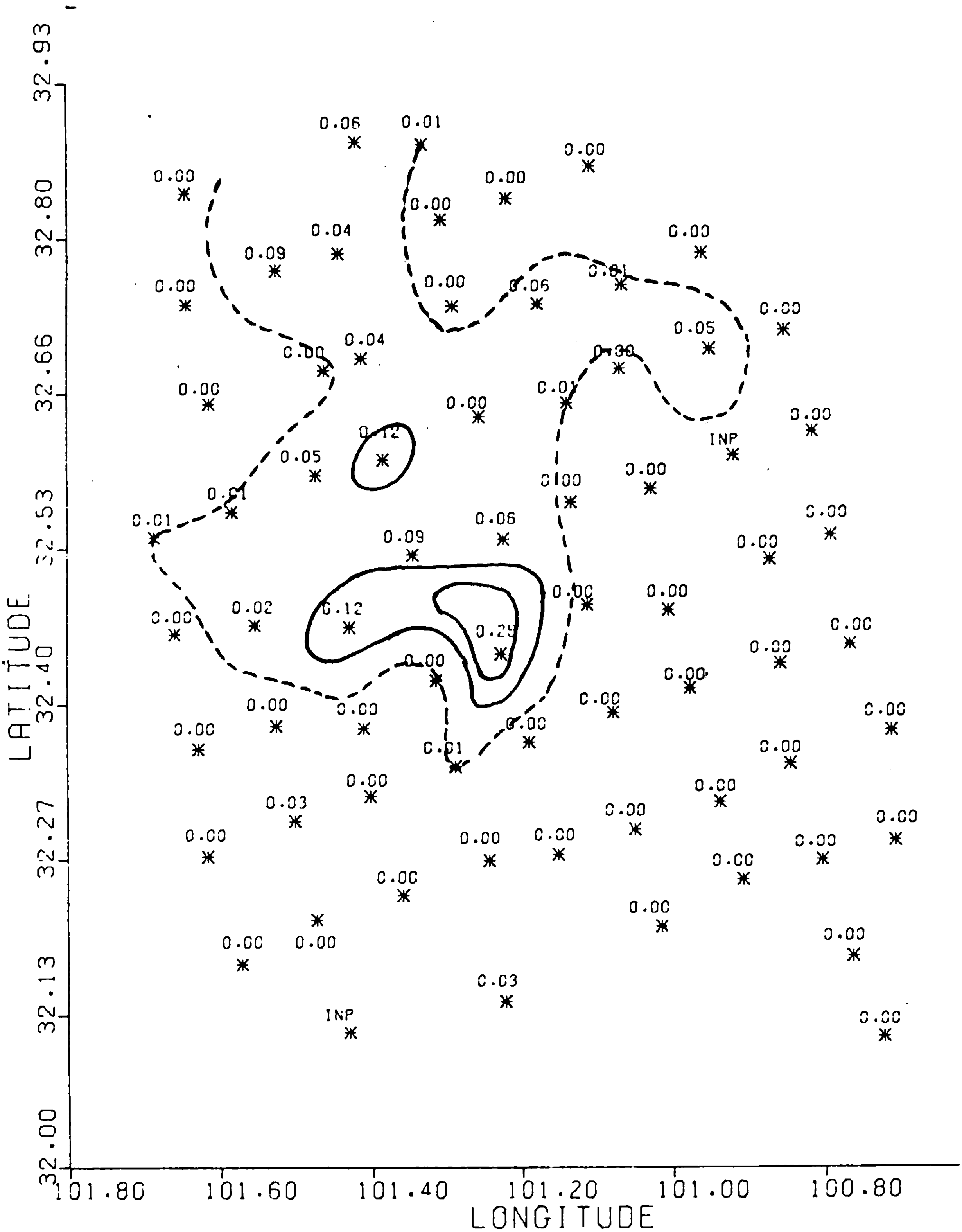

Figure 9d. Rainfall for 22 June 1977
1345 - 1400 CDT

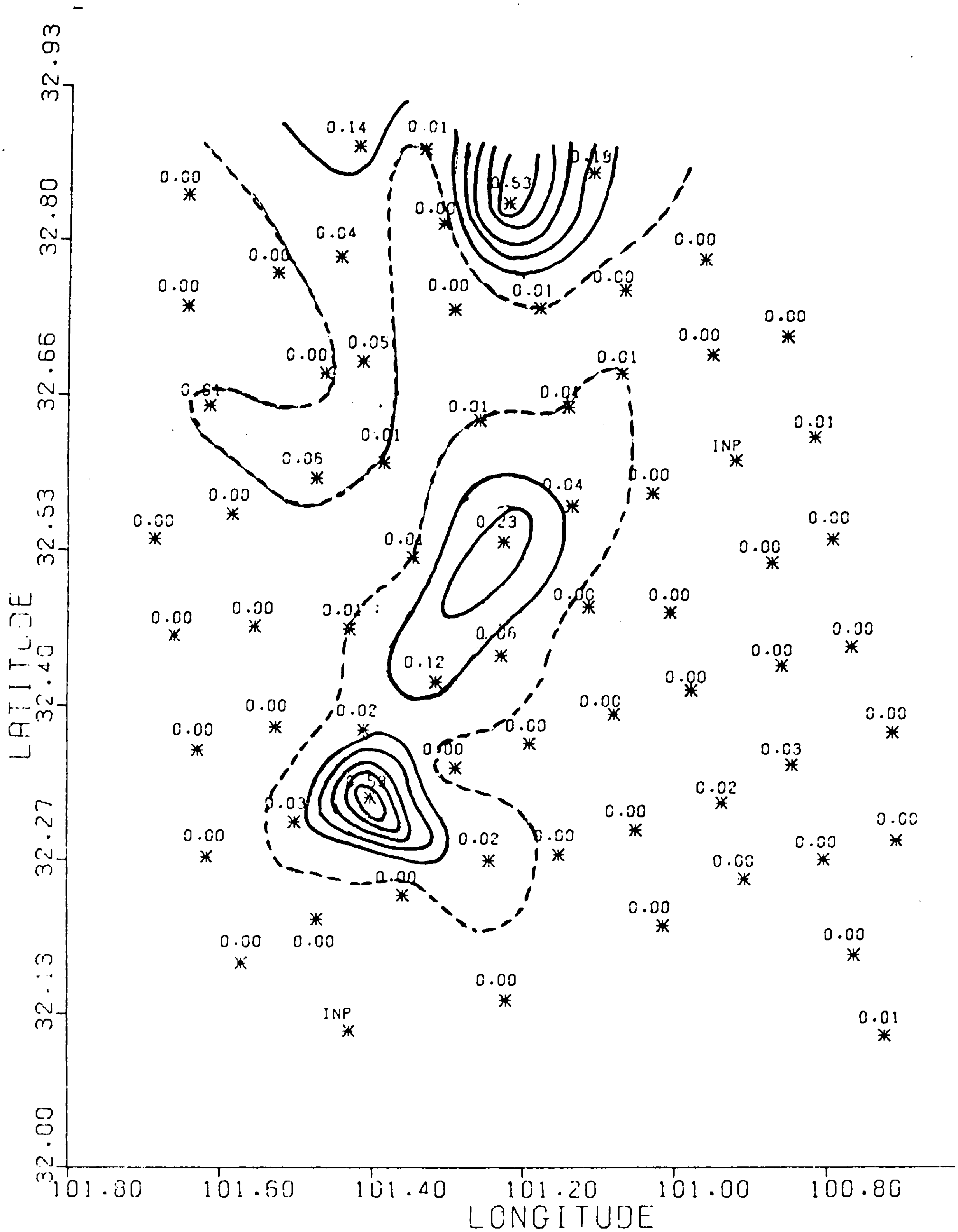

Figure 9e. Rainfall for 22 June 1977
1400 - 1415 CDT

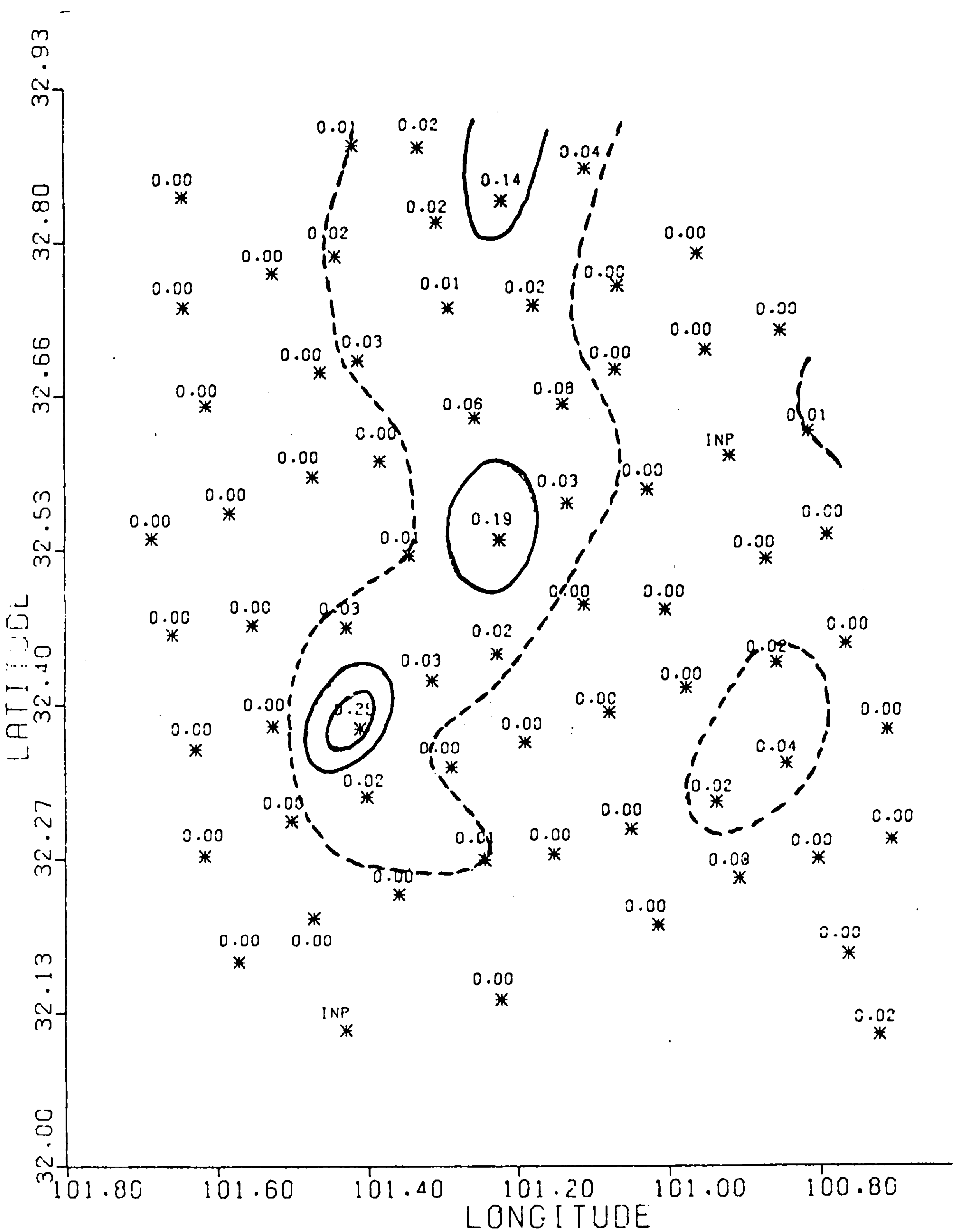

Figure 9f. Rainfall for 22 June 1977
1415 - 1430 CDT

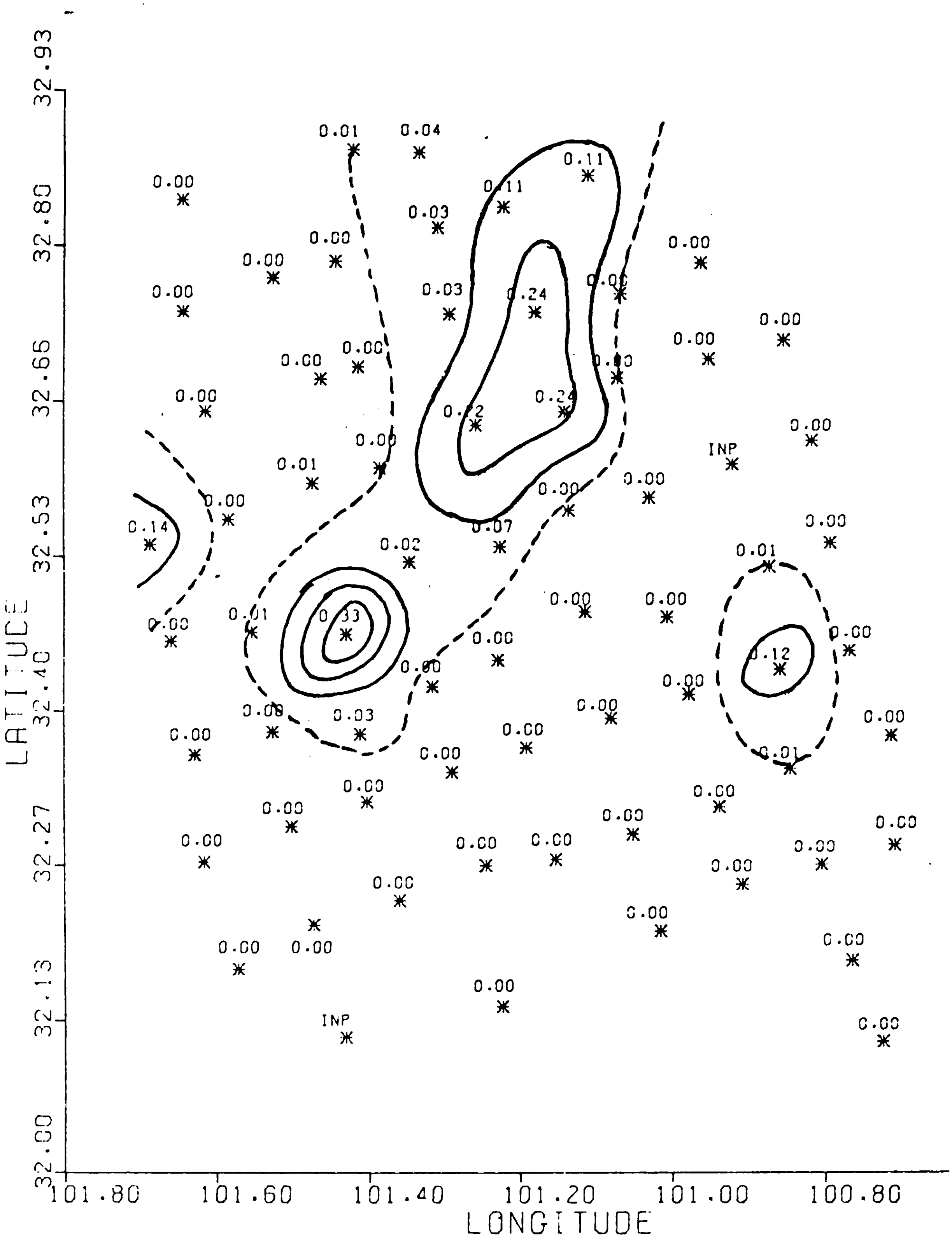

Figure 9g. Rainfall for 22 June 1977
1430 - 1445 CDT

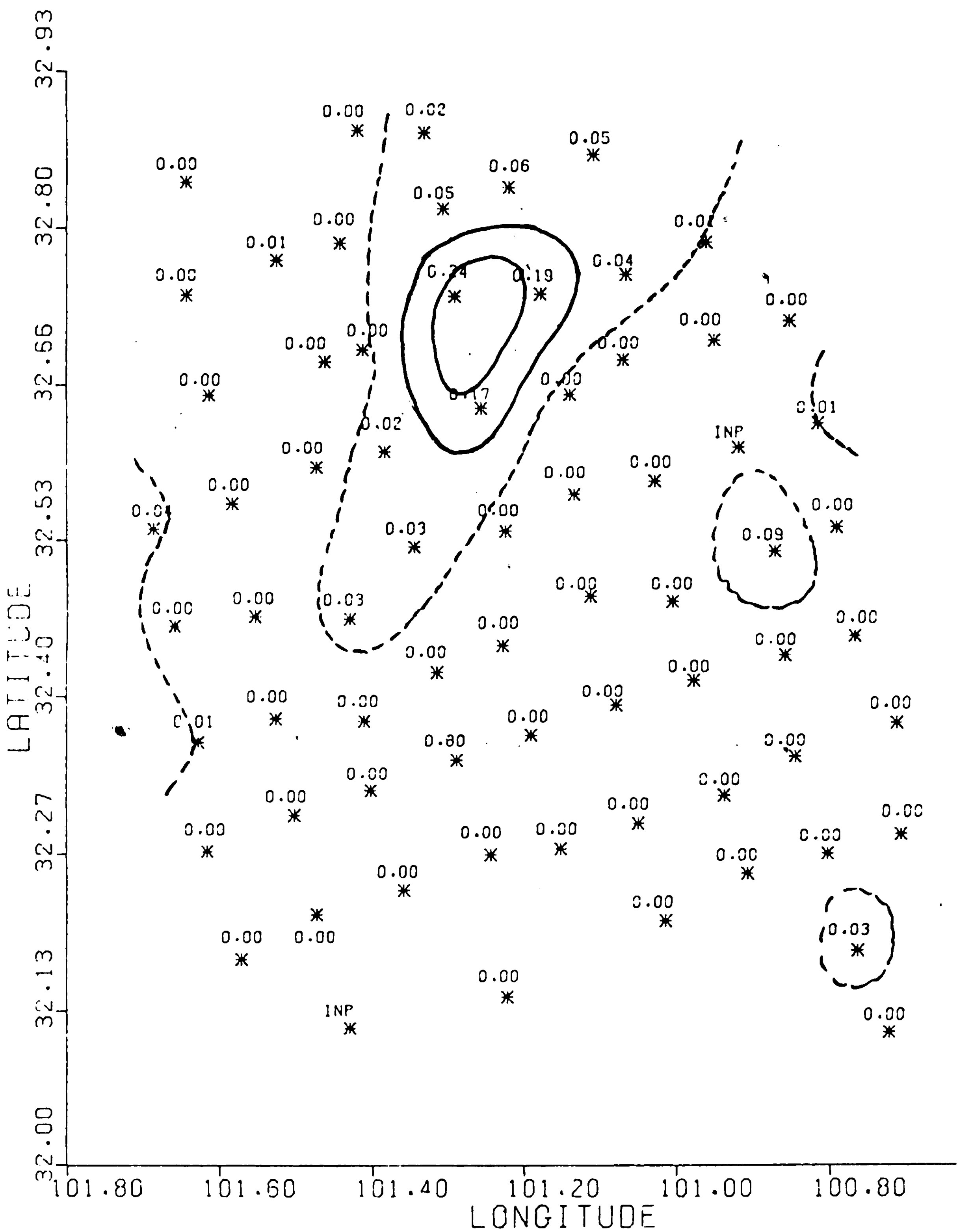

Figure 9h. Rainfall for 22 June 1977
1445 - 1500 CDT

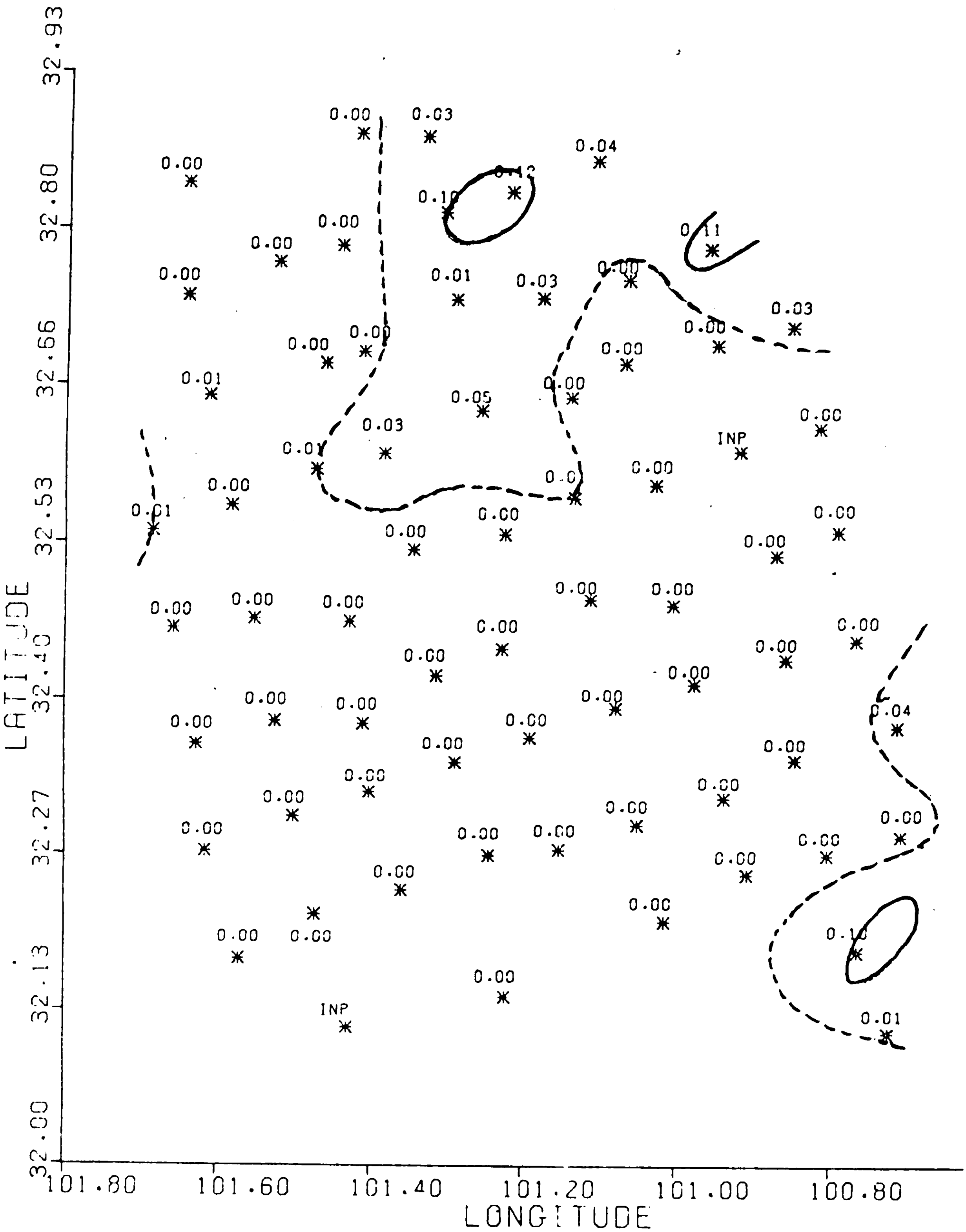

Figure 9i. Rainfall for 22 June 1977
1500 - 1515 CDT

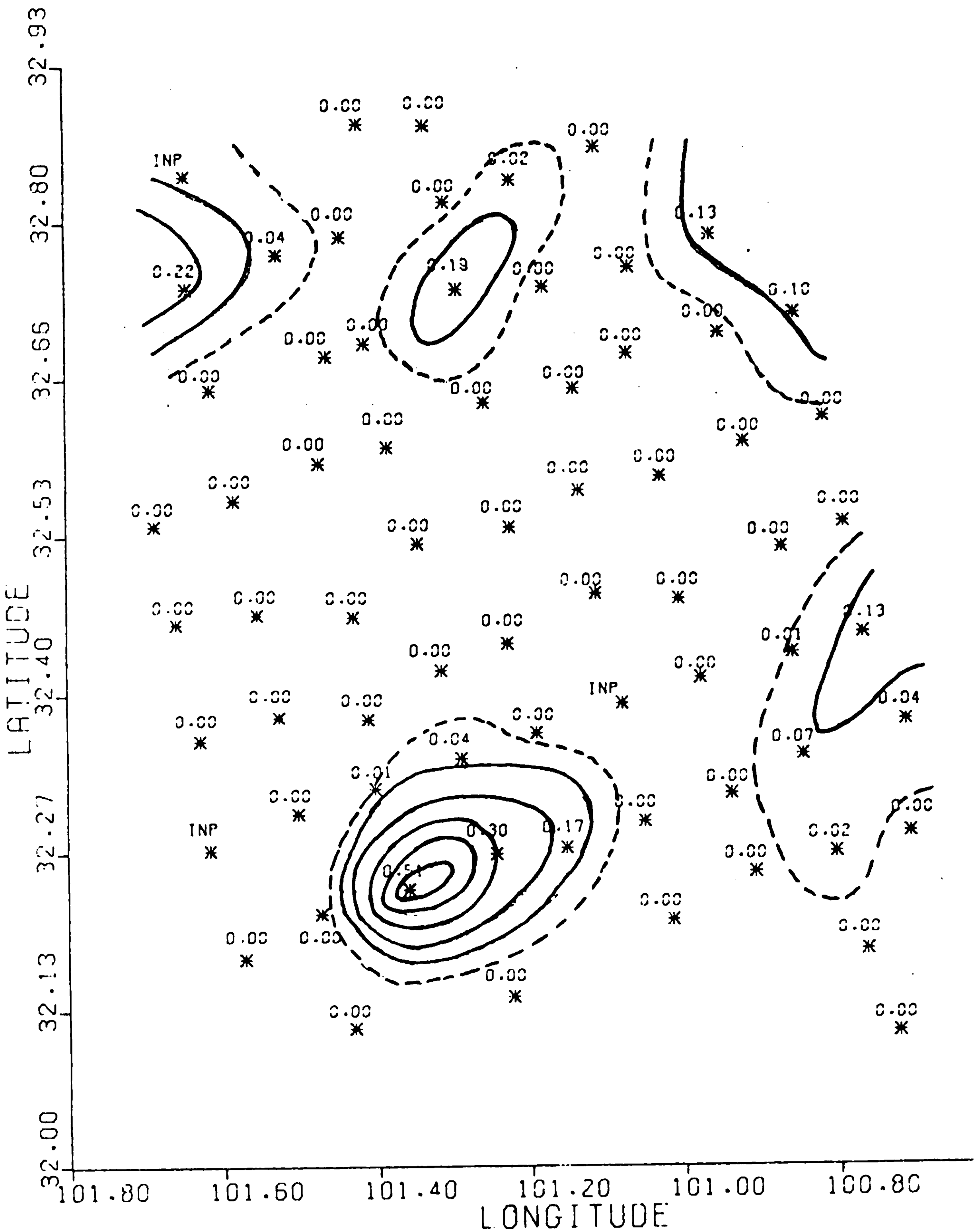

Figure 10a. Rainfall for 8 July 1977
1330 - 1345 CDT

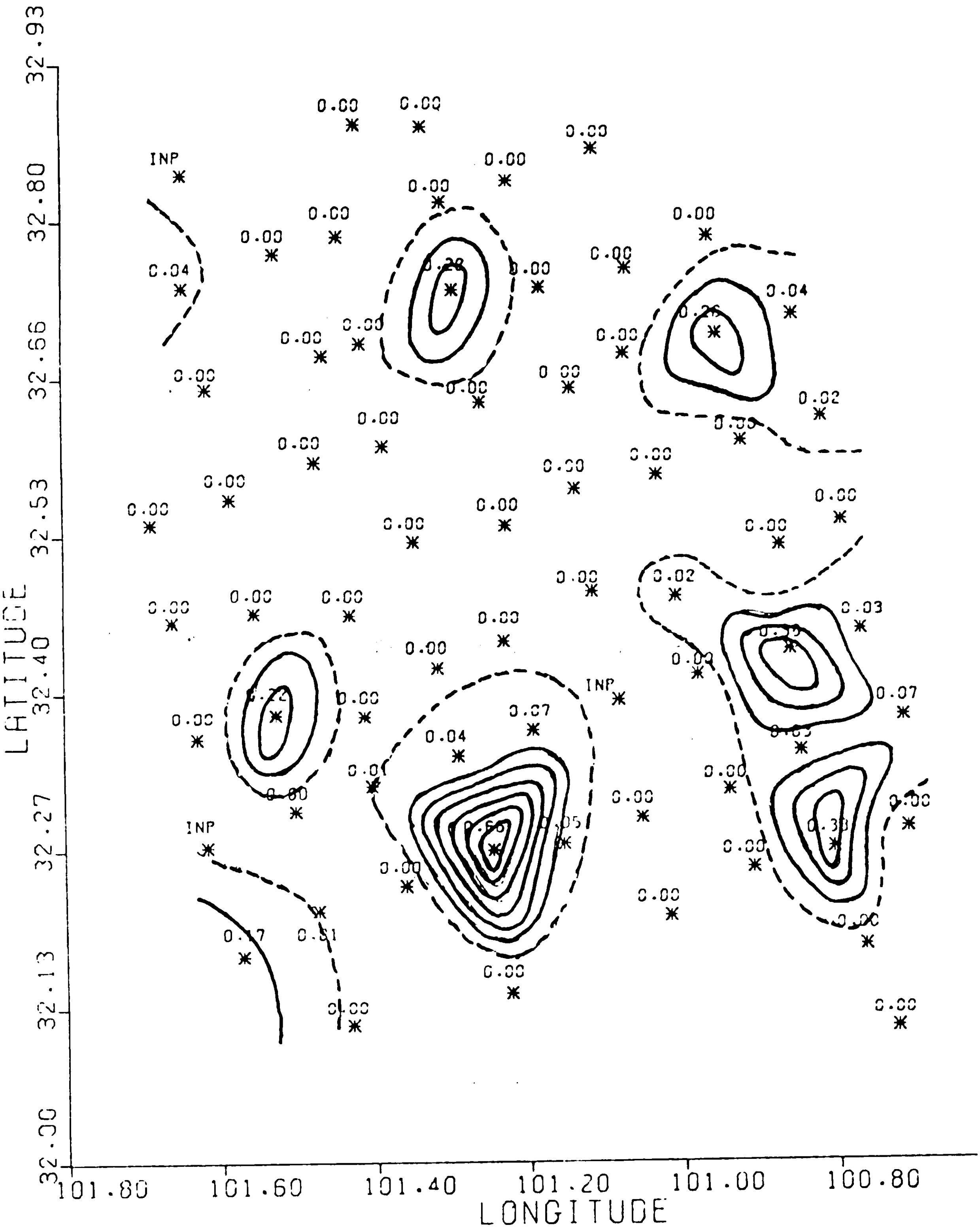

Figure 10b. Rainfall for 8 July 1977
1345 - 1400 CDT

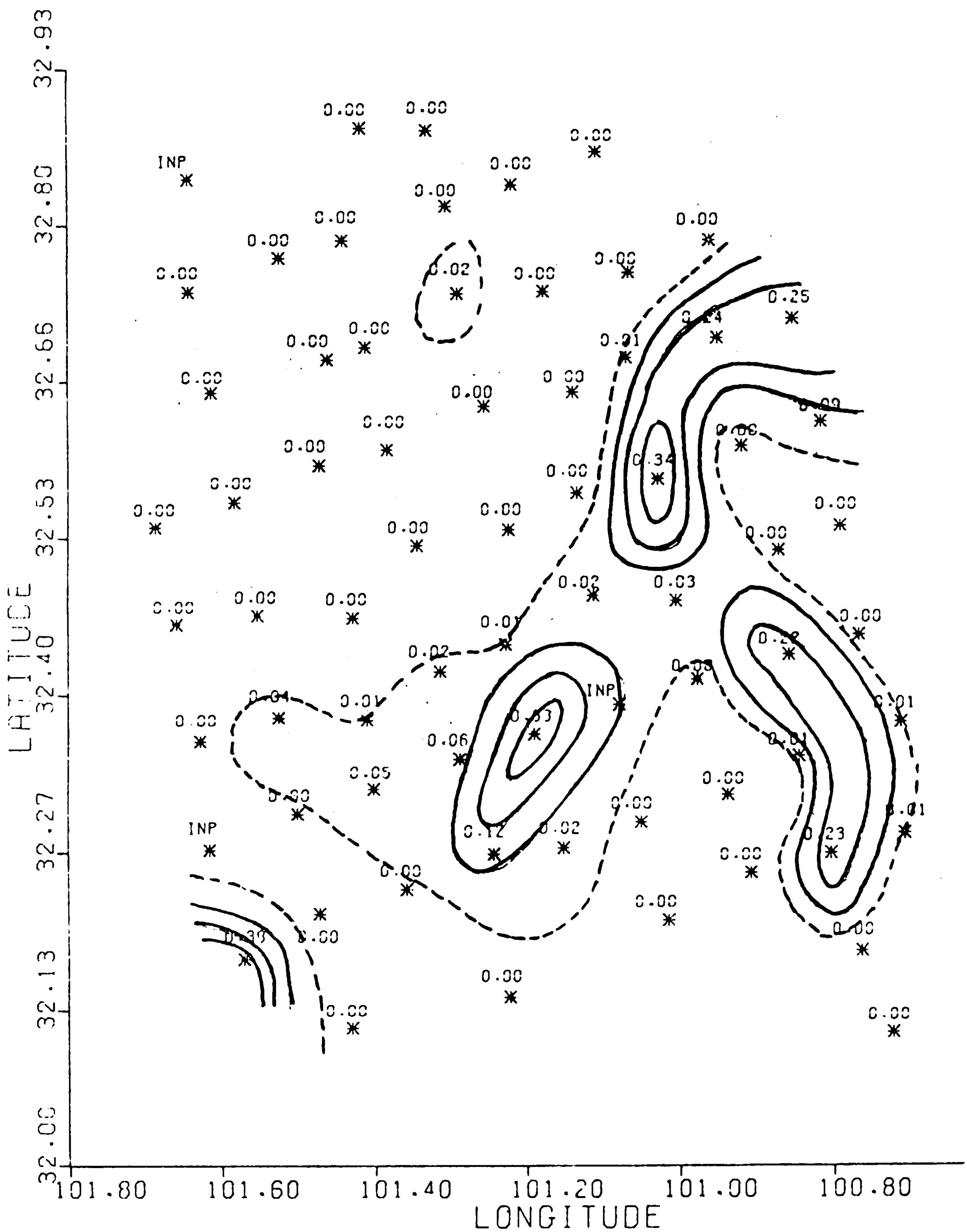

Figure 10c. Rainfall for 8 July 1977
1400 - 1415 CDT

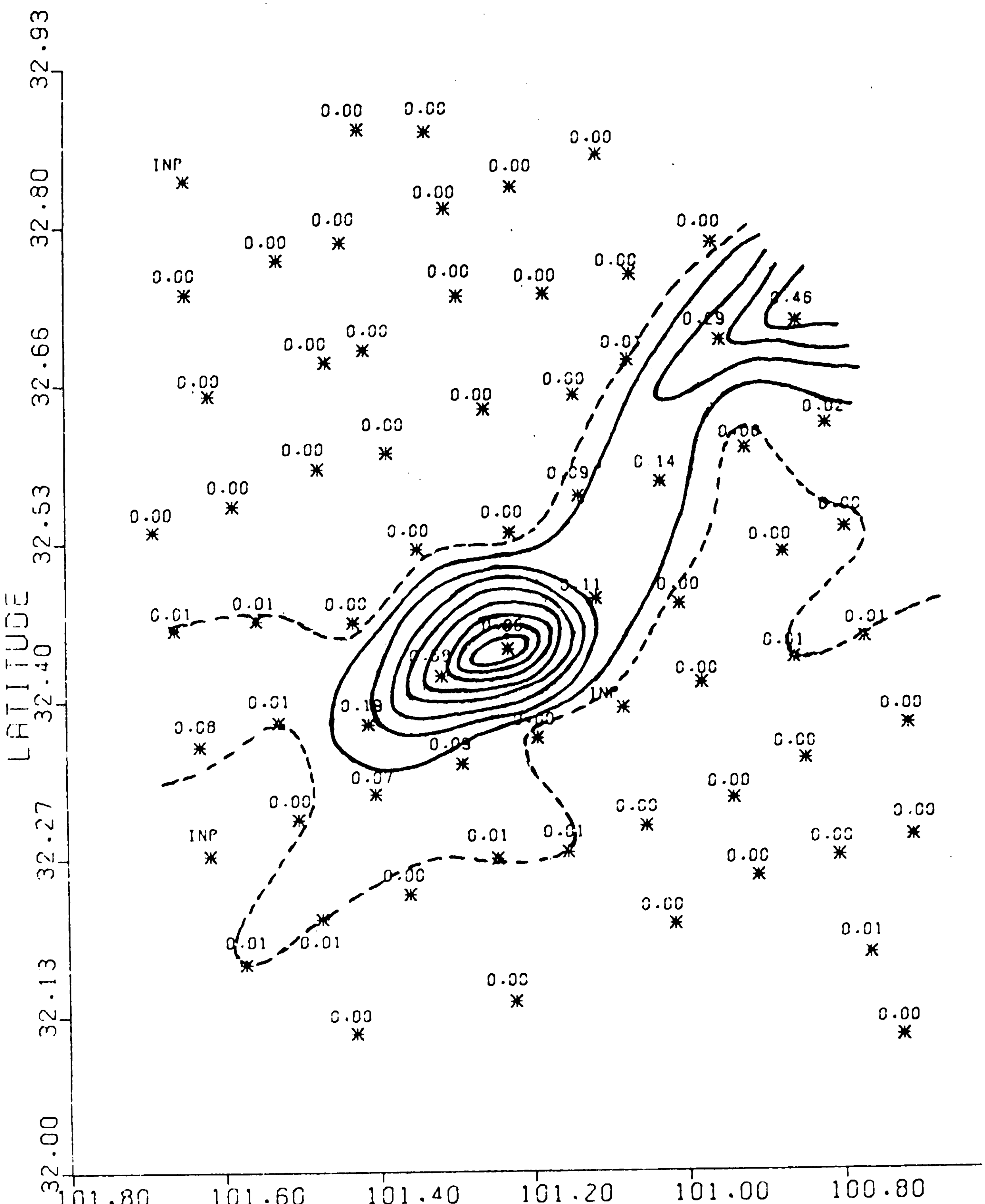

Figure 10d. Rainfall for 8 July 1977
1415 - 1430 CDT

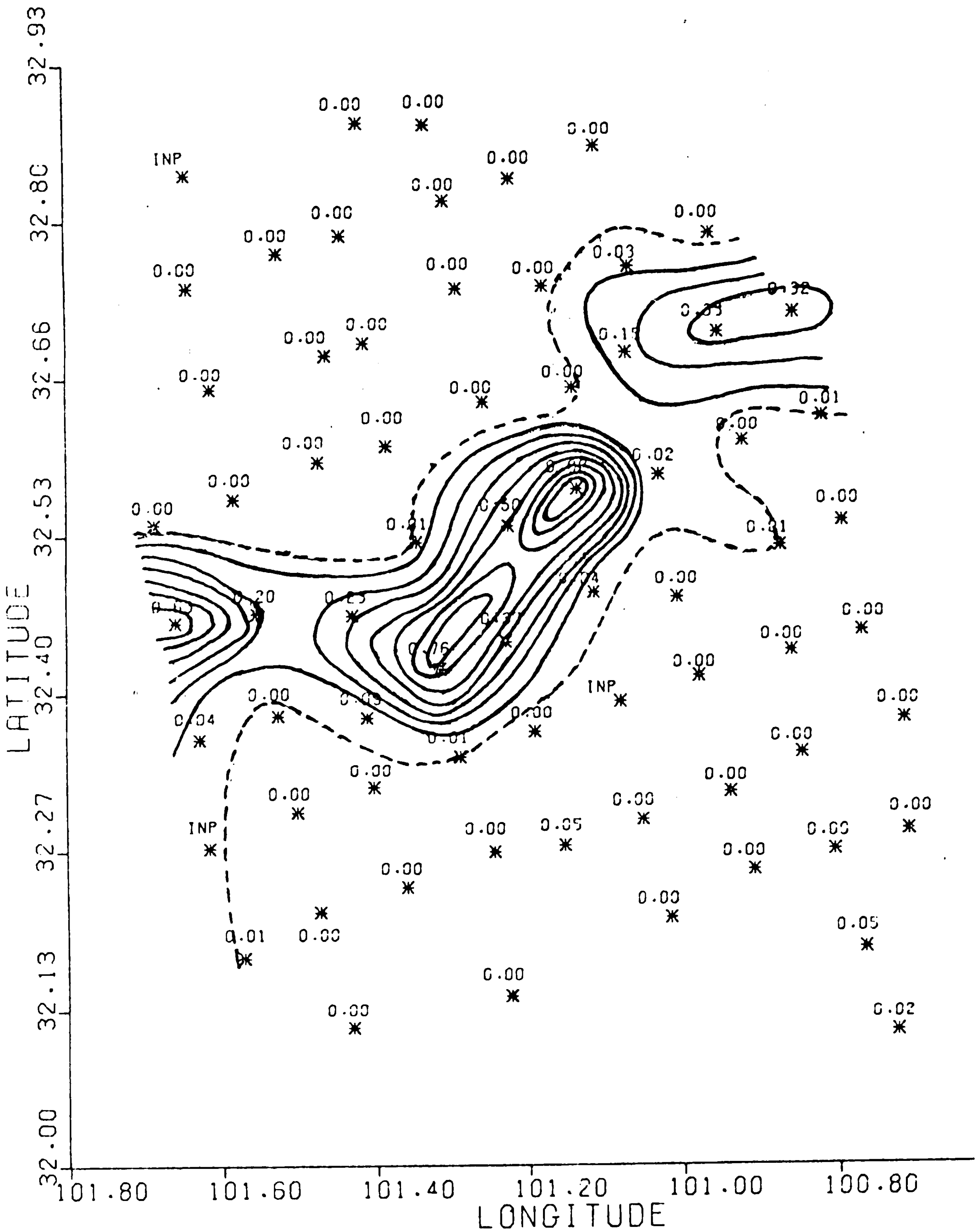

Figure 10e. Rainfall for 8 July 1977
1430 - 1445 CDT

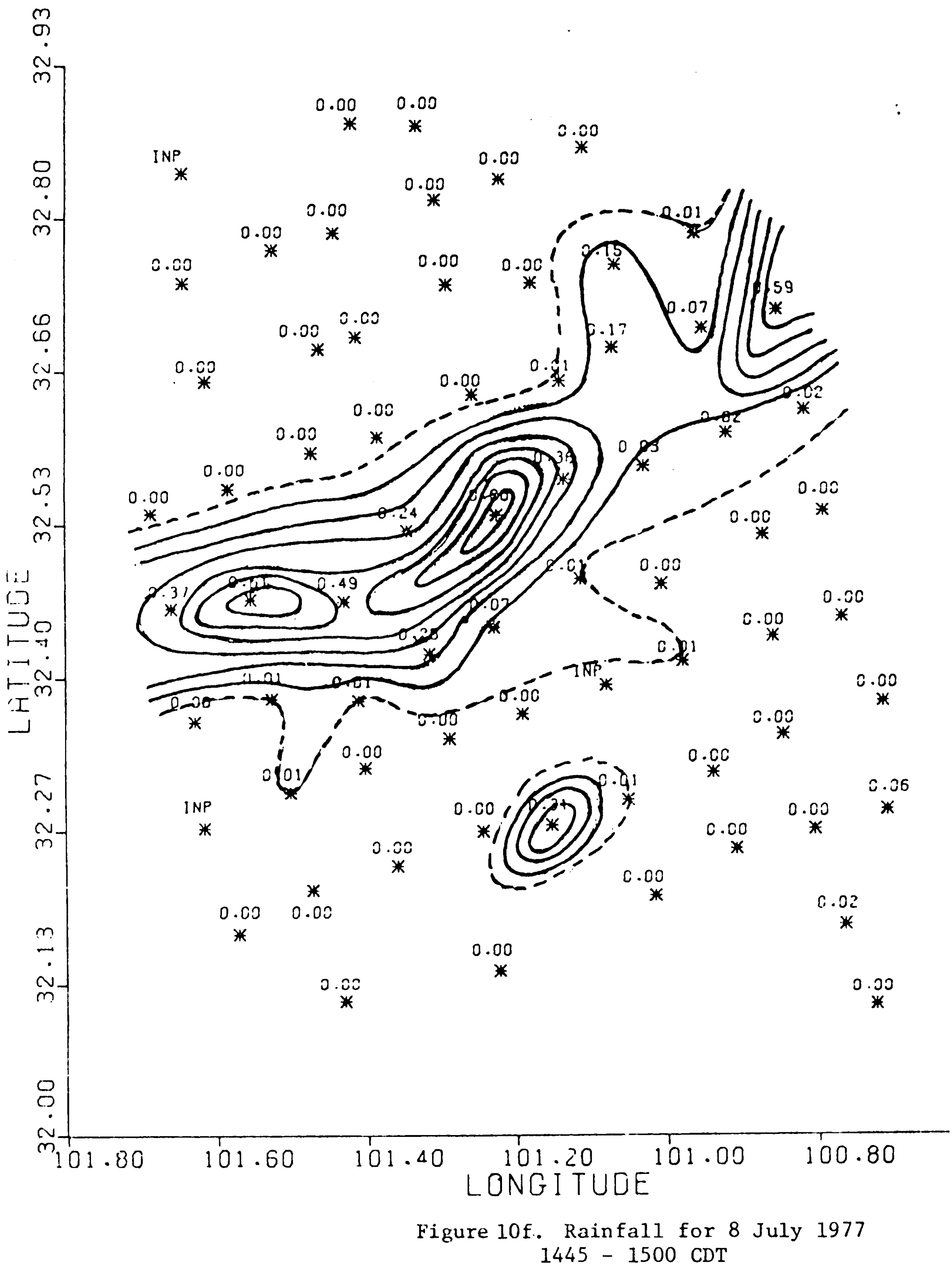

Figure 10f. Rainfall for 8 July 1977
1445 - 1500 CDT

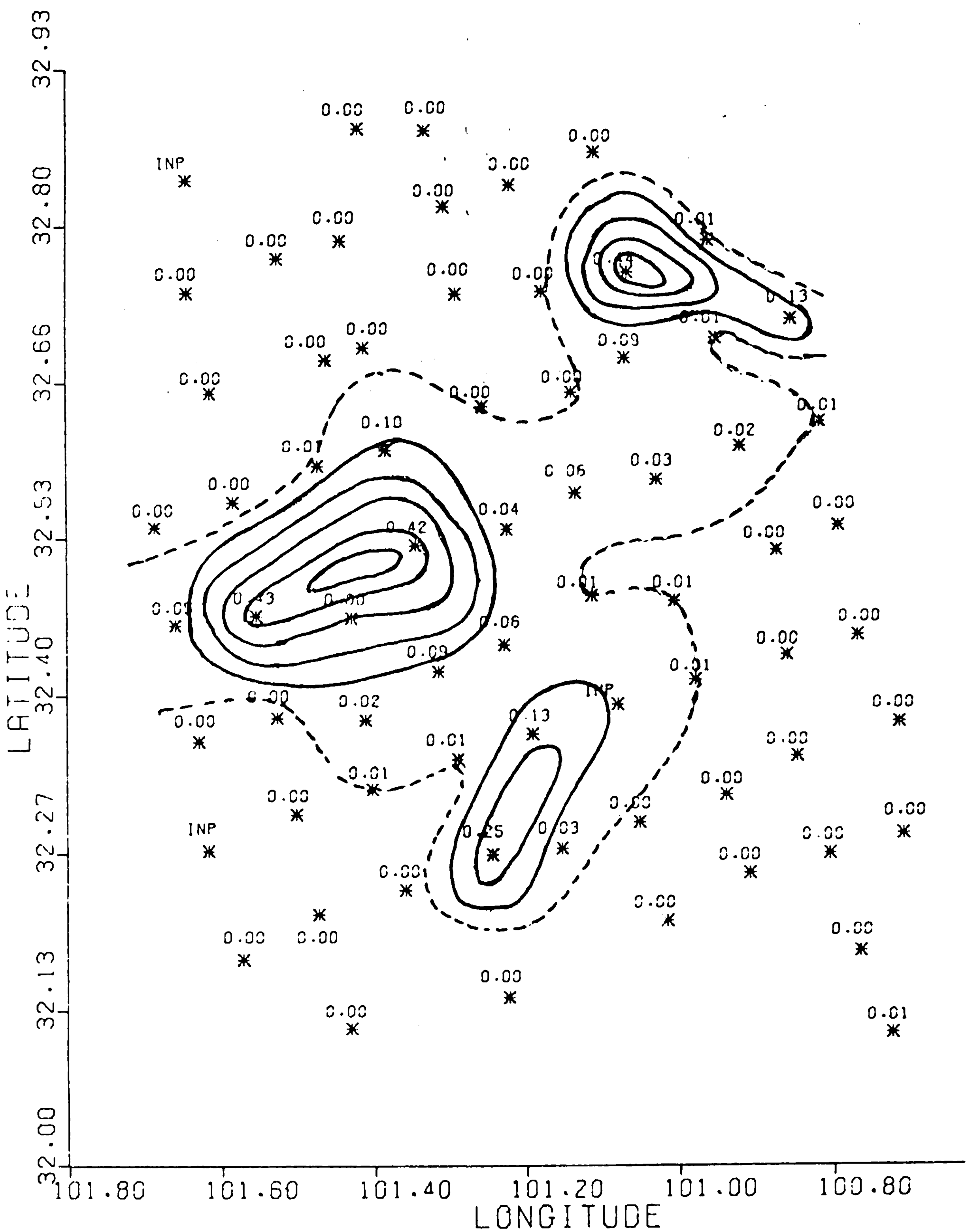

Figure 10g. Rainfall for 8 July 1977
1500 - 1515 CDT

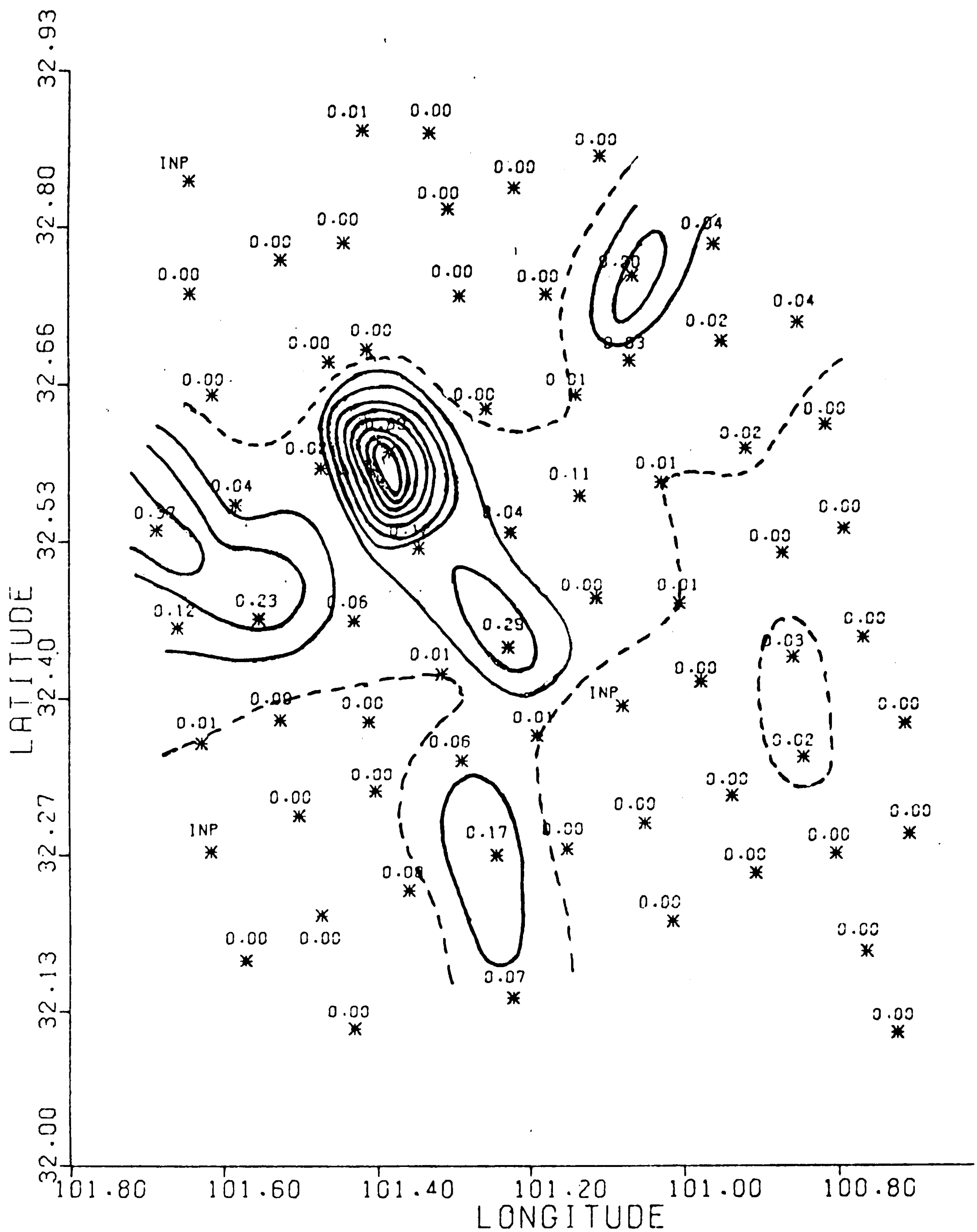

Figure 10h. Rainfall for 8 July 1977
1515 - 1530 CDT

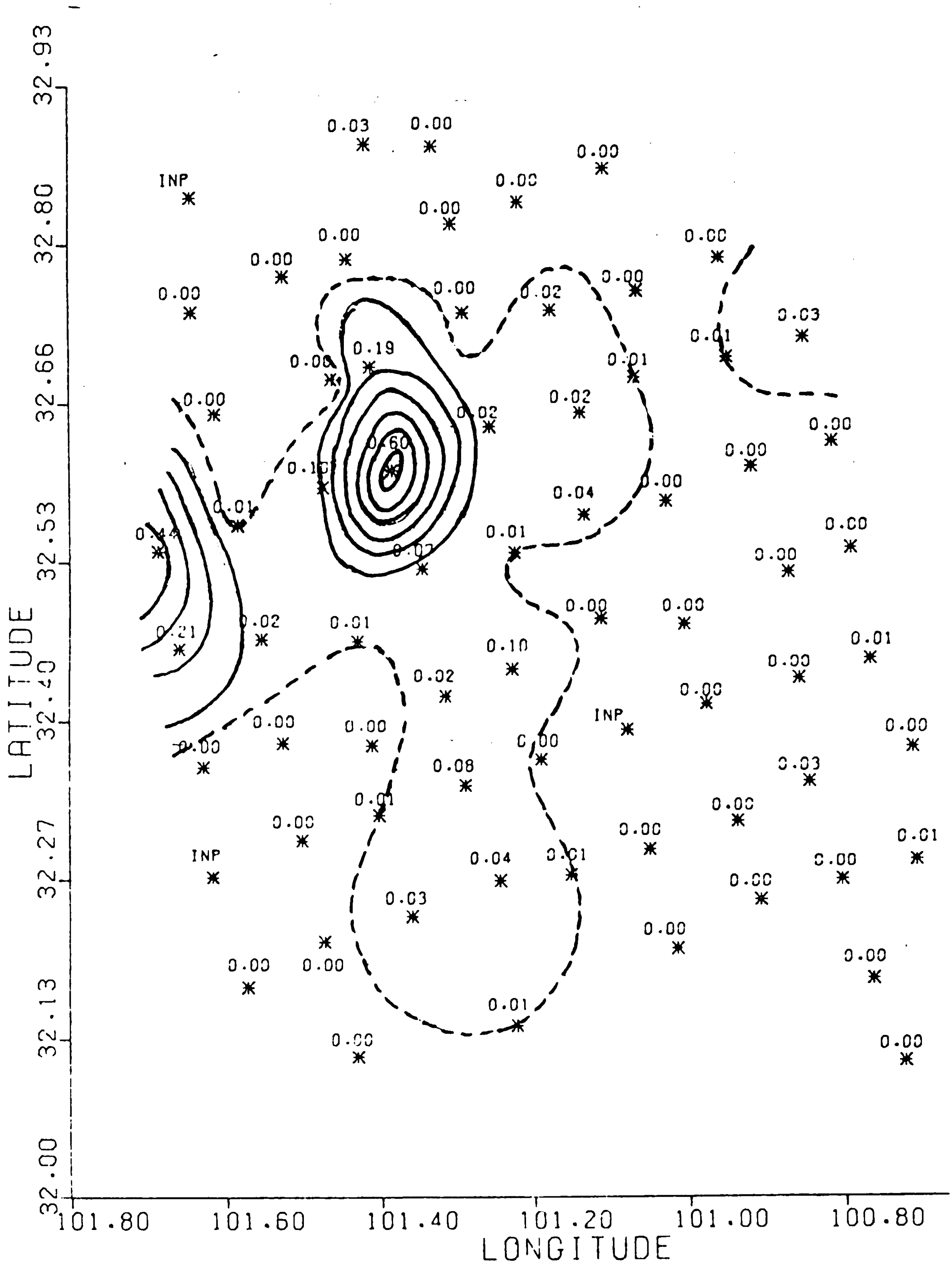

Figure 10i. Rainfall for 8 July 1977
1530 - 1545 CDT

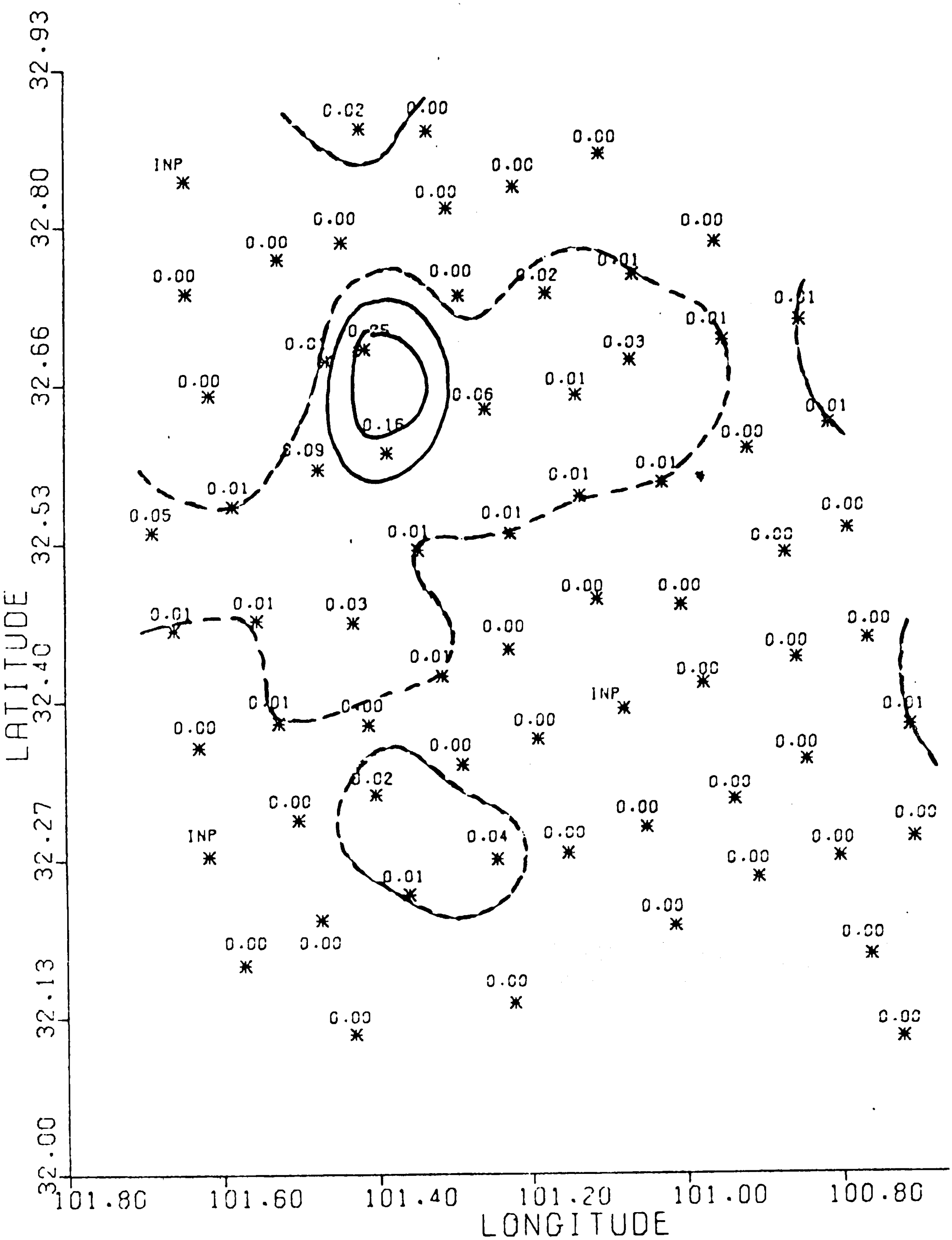

Figure 10j. Rainfall for 8 July 1977
1545 - 1600 CDT

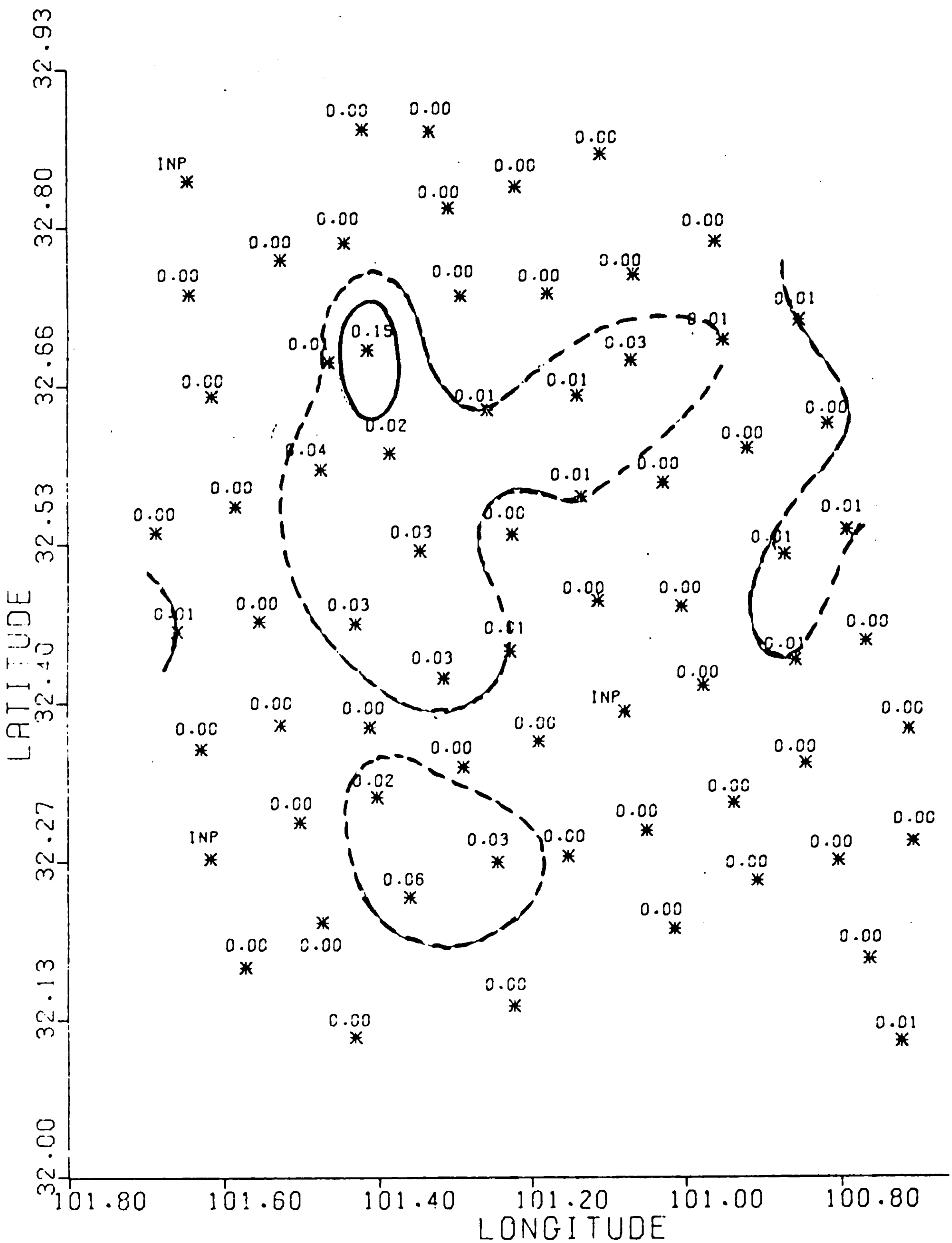

Figure 10k. Rainfall for 8 July 1977
1600 - 1615 CDT

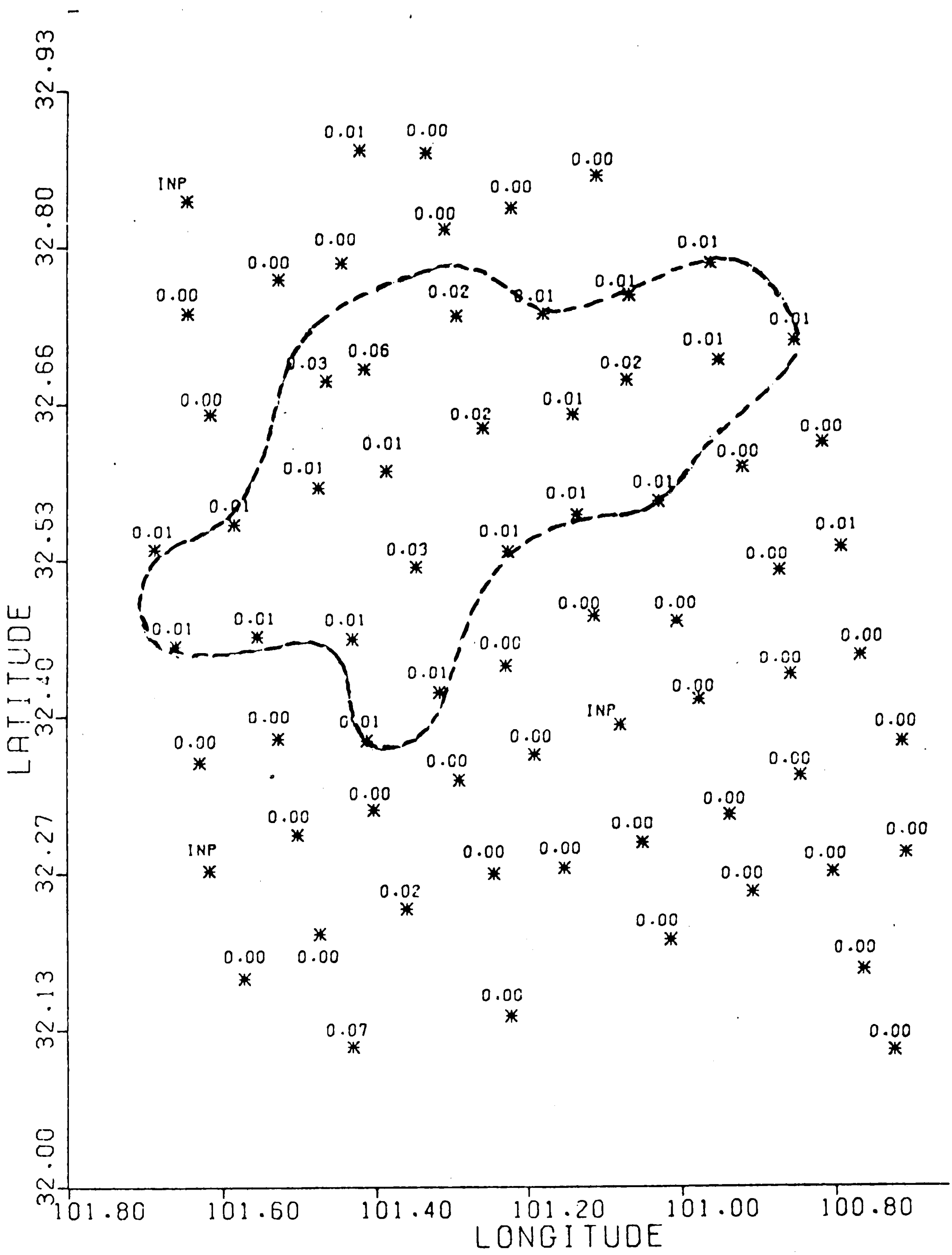

Figure 101. Rainfall for 8 July 1977
1615 - 1630 CDT

Table IV

SKYWATER RADAR

TEXAS HIPLEX SCANNING MODES

1979

	Monitoring (MON)	Z/R (ZR)	Aircraft Far Out (ACF)	Aircraft Close In (ACC)
PRF	414	414	414	414
RANGE INTERVAL	1 Km	0.5 Km	0.5 Km	0.5 Km
RANGE DELAY	10 Km	10 Km	10 Km	10 Km
<u>A-SCAN</u>				
Samples	16	16	16	16
Elevation	1°	0.5°	1°	1°
<u>B-SCAN</u>				
Samples	16	32	8	8
Start	2°	1°	2°	2°
Stop	12°	3°	12°	20°
Steps	1°	0.5°	0.5°	1°
TIME INTERVAL	10 Min	5 Min	5 Min	5 Min

cloud treatment missions were in progress. If the clouds to be treated were more than 50 km from the radar, the Aircraft Far Out mode was employed, while if the clouds to be treated were located within 50 km of the radar, data were recorded using the Aircraft Close In mode. When aircraft flew near cloud base to collect data for comparing radar reflectivity to rainfall rate, the ZR mode was used. Data was recorded in the Monitoring mode when the HIPLEX aircraft were not engaged in a mission. Table V lists the times for which digital radar data was recorded in each of the four scanning modes. Table VI lists the times for which 16 mm color photographs were obtained.

During aircraft operations, radar observations were made available whenever possible for guidance in the deployment of aircraft for cloud monitoring and treatment. Video tape recordings of the color television display, which showed the positions of HIPLEX aircraft made it possible to discuss aircraft operations during debriefings with reference to changing echo patterns. Table VII lists the times for which video tapes made during the field project were saved for later analysis.

Weekly calibration tapes were mailed to the Bureau. Digital data tapes were all mailed to the University of North Dakota where they were edited with little or no delay after they were received. Processing through the University of North Dakota's RADPROC programs has also been completed on all 172 tapes.

Task 5. Real-Time Satellite Support for the 1979 Field Program. Dr. Jurica was stationed at the field operations center in Big Spring for the duration of the field program. Laserfax equipment was installed by the Bureau and produced around-the-clock GOES imagery at 30-minute intervals. The principal responsibilities were to provide real-time support to the mesoscale and HIPLEX operational day decision process, to participate in the daily weather forecast briefing, to assist in the initial deployment of aircraft, and to contribute to aircraft mission debriefings when appropriate. The operation, on the whole, was a success, due in large part to the very reliable performance of the Laserfax equipment. In addition, an opaque projector was generously loaned to us for the duration of the project by Howard College. This permitted the satellite imagery to be effectively displayed and discussed during the daily weather briefings.

Table V

INVENTORY OF DIGITAL RADAR DATA

Calendar Date	Original Tape Label	A-file Name	Mode	Start Time (GMT)	End Time (GMT)
20 May 1979 /	T9140 A#	AT0140V	ACC	212641	220145
"	T9140 B#	"	ACC	220622	224530
"	T9140 C#	"	ACC	225256	2330
"	T9140 D#	"	ACC	233318	000743
"	T9141 A#	AT9141B	ACC	010021	011135
27 May 1979*	T9147 A	AT9147P	MON	154420	172820
"	T9147 B	"	MON	173417	192834
"	T9147 C	"	MON	193414	212910
"	T9147 D	"	MON	213413	232842
"	T9147 E	"	MON	233415	011000
"	T9148 A	"	ACC	011128	014043
"	T9148 B	"	MON	014447	034930
"	T9148 C	"	MON	035510	042410
28 May 1979*	T9148 D	AT9148T	ACF	191732	194942
"	T9148 E	"	ACF	195333	202305
"	T9148 F	"	MON	202540	220940
31 May 1979	T9151 A	AT9151S	MON	181855	185436
"	T9151 B	"	ACC	185740	193152
"	T9151 C	"	ACC	193248	200158
"	T9151 D	"	ACC	200315	203226
"	T9151 E	"	MON	203636	223056
"	T9151 F	"	MON	223635	003056
"	T9152 A	"	MON	003217	021639
"	T9152 B	"	MON	021745	031341

\# Indicates 16 mm movie of the color television display <u>not</u> available for the time period of this tape

* Indicates a mesoscale day

/ Indicates a rapid scan day

Calendar Date	Original Tape Label	A-file Name	Mode	Start Time (GMT)	End Time (GMT)
1 June 1979*	T9152 C	AT9152P	MON	151902	170712
"	T9152 D	"	MON	171005	183322
"	T9152 E	AT9152S	MON	185558	204019
"	T9152 F	"	MON	204610	224019
"	T9152 G	"	MON	224558	003503
"	T9153 A	"	MON	003717	020131
2 June 1979	T9153 B	AT9153O	MON	140740	154201
"	T9153 C	"	MON	154740	173202
"	T9153 D	"	MON	173740	192201
"	T9153 E	"	MON	192740	212202
4 June 1979*	T9155 A	AT9155R	MON	172117	175538
"	T9155 B	"	ACC	175739	182649
"	T9155 C	"	ACC	182753	190202
"	T9155 D	"	ACC	190309	193643
"	T9155 E	"	ACC	193742	201151
"	T9155 F	"	ACC	201257	204206
"	T9155 G	"	MON	204427	213849
"	T9155 H	"	ACC	214126	220221
"	T9155 J	"	ACC	220520	223929
"	T9155 K	"	ACC	224030	230944
"	T9155 L	"	MON	231225	005654
"	T9156 A	"	MON	010000	024300

* Indicates a mesoscale day

Calendar Date	Original Tape Label	A-file Name	Mode	Start Time (GMT)	End Time (GMT)
5 June 1979* /	T9156 B	AT9156T	MON	192900	201420
"	T9156 C	"	ACC	201604	205013
"	T9156 D	"	ACC	205116	210524
"	T9156 E	"	MON	210659	222512
"	T9156 F	"	ACC	222512	224921
"	T9156 G	"	ACF	225107	231540
"	T9156 H	"	MON	231743	010205
7 June 1979 /	T9158 A	AT9158U	MON	205300	223719
8 June 1979* /	T9159 A	AT91590	MON	141124	155545
"	T9159 B	"	MON	160124	174545
"	T9159 C	"	MON	175124	192555
"	T9159 D	"	MON	193728	212150
"	T9159 E	"	MON	212535	230955
"	T9159 F	"	MON	231418	005839
"	T9160 A	"	MON	005957	014500
"	T9160 B	"	MON	015204	025634
9 June 1979*	T9160 C	AT91600	MON	145115	163530
"	T9160 D	"	MON	164109	181830
21 June 1979*	T9172 A #	AT9172U	MON	203400	222821
"	T9172 B #	"	MON	223400	002822
23 June 1979	T9175 A	AT9175B	MON	013218	022640
"	T9175 B	AT9175E	MON	043806	051236

* Indicates a mesoscale day
\# Indicates 16 mm movie of the color television display not available for the time period of this tape
/ Indicates a rapid scan day

Calendar Date	Original Tape Label	A-file Name	Mode	Start Time (GMT)	End Time (GMT)
8 July 1979	T9189 A#	AT9189U	MON	203921	205340
"	T9189 B#	"	ACC	205929	212842
"	T9189 C#	"	ACC	213325	220235
"	T9189 D	AT9189X	ZR	232640	003222
"	T9190 A	"	MON	003700	022300
"	T9190 B	"	MON	023009	030430
9 July 1979	T9190 C	AT9190P	MON	153938	172800
"	T9190 D	AT9190V	ZR	210314	211154
"	T9190 E	"	ACC	211525	213550
"	T9190 F	"	ACC	214008	214931
"	T9190 G	"	ZR	215222	222107
"	T9190 H	"	MON	222428	000852
"	T9191 A	"	MON	002035	020456
"	T9191 B	"	MON	021050	034512
12 July 1979	T9193 A	AT9193Q	MON	163424	182846
"	T9193 B	"	MON	183341	201802
14 July 1979*	T9195 A	AT9195P	MON	152826	172247
"	T9195 B	"	MON	172842	185310

# Indicates 16 mm movie of the color television display not available for the time period of this tape

* Indicates a mesoscale day

Calendar Date	Original Tape Label	A-file Name	Mode	Start Time (GMT)	End Time (GMT)
15 July 1979	T9196 A	AT9196U	MON	200853	210322
"	T9196 B	"	ACF	210903	213333
"	T9196 C	"	ACF	213753	220225
"	T9196 D	"	MON	220707	235129
"	T9196 E	"	MON	235628	014048
"	T9197 A	"	MON	014527	031948
"	T9197 B	"	MON	032429	035851
16 July 1979*	T9197 C	AT9197S	MON	182810	202231
"	T9197 D	"	MON	202842	222305
"	T9197 E	"	MON	223100	233528
"	T9197 F	"	ACF	234719	001152
"	T9198 A	"	MON	002309	005500
17 July 1979*/	T9198 B	AT91980	MON	144803	163223
"	T9198 C	"	MON	163731	182152
"	T9198 D	"	MON	182813	195233
"	T9198 E	"	ZR	200140	205019
"	T9198 F	"	ACC	205327	210800
"	T9198 G	"	ACC	211505	214406
"	T9198 H	"	ACC	214850	221758
"	T9198 J	"	MON	222233	000654
"	T9199 A	"	MON	001148	015610
"	T9199 B	"	MON	020139	025610

* Indicates a mesoscale day
/ Indicates a rapid scan day

Caldendar Date	Original Tape Label	A-file Name	Mode	Start Time (GMT)	End Time (GMT)
18 July 1979*/	T9199 C	AT91990	MON	144837	164320
"	T9199 D	"	MON	165431	184853
"	T9199 E	"	MON	185500	204922
"	T9199 F	AT9199V	MON	212356	231816
"	T9199 G	"	MON	232337	011758
"	T9200 A	"	MON	012544	030005
19 July 1979	T9200 B	AT92000	MON	143359	161846
"	T9200 C	"	MON	162515	181935
"	T9200 D	"	MON	182752	202213
"	T9200 E	AT9200U	MON	205414	224836
"	T9200 F	"	MON	225426	004847
20 July 1979	T9201 A	AT92010	MON	145008	164437
"	T9201 B	"	MON	165008	171510

* Indicates a mesoscale day
/ Indicates a rapid scan day

Table VI

INVENTORY OF 16MM MOVIE FILM

Reel Number	Julian Day	Start Time (GMT)	End Time (GMT)	Calendar Day
1	146	1422	1433	26 May
"	"	1912	2012	"
"	147	1534	2400	27 May
"	148	0000	0420	"
"	"	1916	2209	28 May
2	151	1840	2400	31 May
"	152	0000	0314	"
"	"	1419	2400	1 June
"	153	0000	0201	"
"	"	1408	2122	2 June
"	155	1721	2400	4 June
"	156	0000	0243	"
"	"	1855	2305	5 June
3	158	2124	2237	7 June
"	159	1350	2400	8 June
"	160	0000	0257	"
"	"	1350	1505	9 June
"	"	1522	1816	"
4	175	0132	0233	23 June
"	"	0438	0512	"
"	"	1947	2400	24 June
"	176	0000	0034	"
"	"	1639	2400	25 June
"	177	0000	0127	"
"	"	1444	2246	26 June

Reel Number	Julian Day	Start Time (GMT)	End Time (GMT)	Calendar Day
5	183	2137	2137	1 July
"	184	0314	0511	2 July
"	"	1806	2400	3 July
"	185	0000	0251	"
"	"	1844	2324	4 July
"	186	1435	2318	5 July
6	186	2333	2400	5 July
"	187	0204	0258	"
"	"	1820	2400	6 July
"	188	0000	0219	"
"	"	1453	1909	7 July
"	"	2254	2400	"
"	189	0000	0037	"
"	"	2322	2400	8 July
"	190	0000	0304	"
"	"	1539	1722	9 July
"	"	2103	2400	"
"	191	0000	0025	"
"	"	0114	0345	"
"	193	1634	2018	12 July
"	195	1524	1901	14 July
7	196	2012	2400	15 July
"	197	0000	0359	"
"	"	1828	0000	16 July
"	198	0023	0102	"
"	"	1447	0000	17 July
"	199	0000	0256	"
"	"	1449	2400	18 July
"	200	0000	0300	"
"	"	1434	2026	19 July

Reel Number	Julian Day	Start Time (GMT)	End Time (GMT)	Calendar Day
8	200	2054	2400	19 July
"	201	0000	0048	"
"	"	1450	1715	20 July

Table VII

INVENTORY OF RADAR VIDEO TAPES

SUMMER 1979

Calendar Day	Tape Number	Julian Day	Start Time (GMT)	End Time (GMT)
May 27	1	148	005509	015732
May 31	2	152	144559	145601
June 4	3	155	153440	153536
June 4	3	155	152527	153145
May 28	3	148	153510	154045
June 4	4	155	193136	203344
June 5	5	156	222150	232300
June 8	6	159	215827	230128
June 8	7	159-60	230827	001100
June 25	8	176	144351	150944
June 25	9	176	195634	205905
June 25	10	176	210245	220531
June 26	11	177	200201	201400
July 19	12	200	144140	144455
July 2	12	184	032715	042623
July 3	13	184	214500	224811
July 3	14	185	003246	013526
July 3	15	185	014546	024600
July 4	16	185	210242	220720
July 5	17	186	165216	175505
July 5	18	186	201719	211947
July 7	19	188-89	234146	003830
July 9	20	190	212000	222255
July 15	21	196	211655	221830
July 15	22	197	003116	012449
July 15	22	197	022650	023547
July 16	23	197-98	225800	004405
July 17	24	198	204849	214940
July 17	25	160	145637	150540
July 17	25	198	145610	150600

Calendar Day	Tape Number	Julian Day	Start Time (GMT)	End Time (GMT)
July 17	25	199	000030	004345
July 18	26	199-200	231825	002126

NORTH AMERICAN WEATHER CONSULTANTS, INC.

WORK PERFORMED

Regarding the North American Weather Consultants, Incorporated (NAWC) digitized radar data analysis done under Department Contract No. 14-00013, preliminary work performed consisted of data processing, software development, and the acquisition of additional data.

It was determined that a number of the radar tapes supplied to the University of North Dakota (UND) by Meteorology Research, Incorporated (MRI) for processing contained an excessive number of errors. Those tapes must be corrected by MRI before UND is able to process the Texas HIPLEX data. Timely receipt of the corrected data should allow for an October completion date by UND.

NAWC has received some data from UND, including the unsorted (U) file for all 1976 and three days of 1977, as well as the equivalent reflectivity (dBz) file for 1977. These files may be read on the NAWC computer.

A few composite and echo top PPI presentations have been received from the Bureau by NAWC on microfiche. Additional microfiche records will follow as UND analysis continues.

NAWC has begun software development for use in producing hourly radar rainfall maps. Information on map scale and coverage was obtained via telephone conversation with Texas Tech University and Department personnel.

Additional data has been or is currently being acquired for use in fulfilling the requirements of this contract. Among these data are:

--HIPLEX data inventories for 1976 - 1978

--Texas HIPLEX data tabulations for 1976 - 1978

--Seeding logs from CRMWD for 1976 - 1978

--Data tape containing Texas HIPLEX rawinsonde and mesonet data for 1976 - 1978

--National Weather Service, Midland Air Terminal, rawinsonde data for 1976 - 1978, and

--National Weather Service, Midland Air Terminal, radar data for 1976 - 1978.

SECTION II

WORK PLANNED FOR THE PERIOD

October 1, 1979 - March 31, 1980

TEXAS DEPARTMENT OF WATER RESOURCES

Management of the Texas HIPLEX Program & Support Studies

Activities in support of the Texas HIPLEX Program planned for the next reporting period (October 1, 1979 - March 31, 1980) by the Department staff are:

Continued administration of the 1974 agreement between the Department and the Bureau including the review of proposals, negotiation and execution of contracts between the Department and various HIPLEX-related subcontractors;

Distribution of the funds in support of various subcontractors services, including State appropriations and monies obligated to the Texas Program during Federal Fiscal Year 1980 by the Bureau of Reclamation;

Coordination of data-analysis activities by subcontracting organizations which include the development of a synoptic climatology of the Texas HIPLEX region, analysis of mesoscale data for 1978-79, development of various water budget and entrainment models, an examination of satellite-precipitation-cloud characteristics, and analyses of M-33 radar and cloud physics data;

Planning and coordination with the Bureau in developing the 1980 HIPLEX Operations Plan for field experiments to be conducted at Big Spring;

Sponsorship of and participation in meetings and planning sessions with the Chief Scientist, HIPLEX participants, and the Weather Modification Advisory Committee;

Further refinement of the Forecast Decision Tree and the Rainshower Occurrence model, documenting and summarizing the 1979 Texas HIPLEX field season, analysis of the 1979 rawinsonde data for all HIPLEX sites, and coordination of the analysis of 1976-78 digitized M-33 (Snyder) radar data tapes; and,

Preparation of Texas HIPLEX monthly and interim progress reports.

"Texas HIPLEX Field Operations Summary--1979"

Department staff is preparing a technical report which will fulfill the responsibility of documenting the daily HIPLEX operations conducted in the Big Spring - Snyder area during 1979. Completion of this document is anticipated in November.

TEXAS A&M UNIVERSITY

Page

"A Synoptic Climatology for the Southern HIPLEX" 110

"Mesoscale Field Program and Data Analysis" 111

"A Synoptic Climatology for the Southern HIPLEX"

This task will be completed after associations are made between radar echo parameters and the objective and subjective climatologies. This should be done by mid-September.

Resolution of the Radar Bias Problem

Analysis will begin about the first of October, after data acquisition at the 125 nm range is complete.

Fine-scale Analysis of Seeding Effects

This task has been completed.

"Mesoscale Field Program and Data Analysis"

1. Analysis of 1978 Mesoscale Data

The analysis of mesoscale conditions for each day selected for study will be concluded. A report similar to LP-65 and LP-99 will be completed and submitted to the Texas Department of Water Resources for printing. We expect this task to be completed by the end of October.

2. Development of Water Vapor Budget Models

A technical report documenting average vertical profiles and developmental procedures of water vapor budget models for various classifications of convective activity is in preparation and should be completed by mid-November.

3. Development of Model for Entrainment

The preliminary model formulated several months ago will be revised based primarily upon results from the 1978 and 1979 field programs, and evaluated by comparisons with observed cloud behavior. The model and results will be documented in the final contract report.

4. Determination of Environmental Response to Convective Activity

Several case-study days on which squall lines, isolated convective echoes, and clusters of convective echoes were observed during 1976-1978 will be chosen for in-depth analysis. The time cross sections will be analyzed and interpreted to determine the influence of the storms in each category on the environment as a function of intensity and distance from the storms. Emphasis will be placed on temperature, moisture, and wind since these are the basic fields used in the computation and interpretation of numerous physical processes. In addition to cross sections of the basic variables, numerical computations will be made to show in a more quantitative manner the influence of the storms on their environment.

5. Cloud Microphysics - Environment Interactions

Analysis of the 1978 and 1979 cloud physics data will begin. Most of the analysis effort will be concentrated on the more accessible 1978 data. However, analysis of the 1979 data will commence as soon as they are made available by the Bureau of Reclamation. Hopefully this will be before the end of the year.

6. Conduct of Mesoscale Field Experiment

Work is currently in progress for the computer contouring of the radar data, and the final error checking of sounding ordinate and angle data. Once this is completed, the soundings will be computed. Constant pressure maps will be prepared and analyzed to check spatial continuity of the data, and time cross sections will be prepared and analyzed to check temporal continuity of the data. Once this is done and the final data set is completed, 25-mb sounding data will be computed and a data report prepared. All soundings except those for Big Spring will be coded in the Bureau of Reclamation format, the data placed on magnetic tape, and the tape carried to Denver where a computer programmer from TAMU will assist Bureau personnel with the processing and archival of the soundings.

7. Chief Scientist

It is expected that at least two meetings will be arranged for discussing scientific results and exchanging ideas, and for discussing plans for 1980. Also, the 1980 program plans and budget will be revised and implemented.

TEXAS TECH UNIVERSITY

Task 1. Tabulations and diagrams of satellite-derived cloud properties will be prepared for the four 1977 case study days.

Task 2. Comparisons of satellite, raingage and radar analyses will be performed for the 1977 case study days. One aspect of particular interest will be differences in spatial and temporal resolution of the different data sources, and their relative advantages or disadvantages.

Development of a technique for rainfall-estimation from satellite radiance data will continue. Sample data sets will be tested for which raingage data are available as verification.

The analysis of 1978 satellite imagery is expected to be completed. A comparison with 1976 and 1977 results will be undertaken.

Task 3. Precipitation analyses of case studies from the 1977 data will be completed. Emphasis will be placed on the July 8 case, utilizing all data sources (radar, satellite, mesoscale, rainfall) in order to relate storm rainfall to mesoscale events. The M-33 radar data is being used to detect precipitation type (stratiform or convective), downdraft structure and mesoscale organization.

Task 4. Task 4 has been completed.

Task 5. All Laserfax photographs obtained during the 1979 field season will be catalogued and archived. A data report consisting of photos acquired on each mesoscale day will be prepared.

NORTH AMERICAN WEATHER CONSULTANTS, INC.

October 1979 - March 1980

A work plan for the reduction and analysis of M-33 (Snyder) Texas HIPLEX radar data of 1976 - 1978 by North American Weather Consultants, Incorporated under Department Contract No. 14-00013 is currently being prepared by NAWC and will be distributed in early October.

SECTION III

PERSONNEL

TEXAS DEPARTMENT OF WATER RESOURCES

John T. Carr, Jr.	Chief, TDWR Weather Modification and Technology Section
William Alexander	Meteorologist/Forecaster at Big Spring
George Bomar	Meteorologist
Betty Flentge	Secretary
William Hanshaw	Rain-Gage Technician
Mike Henderson	Economist
Thomas Larkin	Meteorologist
Robert Riggio	Meteorologist
Keith Topham	Computer Program Analyst

TEXAS A&M UNIVERSITY

Synoptic Climatology for the Texas HIPLEX Area

Dennis Driscoll	Principal Investigator
Judson W. Ladd	Research Assistant

Analysis of Mesoscale Data & Chief Scientist Support

James R. Scoggins, Professor	Principal Investigator and Chief Scientist
Alexis B. Long, Associate Research Scientist	Data Analysis and Aircraft Observer
Steven F. Williams, Research Assistant	Data Analysis
Nick Horvath, Research Assistant	Data Analysis
Myron Gerhard, Research Assistant	Data Analysis and Processing

Texas A&M University (continued)

Meta Sienkiewicz, Research Assistant	Data Analysis and Processing
Nine-Min Chou, Research Assistant	Data Processing
Bruce Burdick, Research Assistant	Rawinsonde Operator and Data Processing
John Rod, Research Assistant	Rawinsonde Operator and Data Processing
Steve Bishkin, Research Assistant	Rawinsonde Operator and Data Processing
Tim Deegan, Research Assistant	Rawinsonde Operator and Data Processing
Robert Cohen, Research Assistant	Rawinsonde Operator and Data Processing
Phil Zamora, Research Assistant	Rawinsonde Operator and Data Processing
Dan Neville, Research Assistant	Rawinsonde Operator and Data Processing
Dan Tschoepe, Research Assistant	Rawinsonde Operator and Data Processing
Kip Etheridge, Research Assistant	Rawinsonde Operator and Data Processing
Bill Babb, Research Assistant	Rawinsonde Operator and Data Processing
Jerry Guynes, Research Assistant	Rawinsonde Operator and Data Processing
Gordon Grant, Research Assistant	Rawinsonde Operator and Data Processing
Karen Hood, Student	Technician and Data Processing
Tammy Chisum, Student	Technician and Data Processing
Mara Djuric, Student	Data Processing

COLORADO RIVER MUNICIPAL WATER DISTRICT

HIPLEX Raingage, Rawinsonde and Seeding Aircraft Support Programs

Owen H. Ivie	General Manager, Colorado River Municipal Water District
R.A. Schooling	Coordinator and Supervisor
John R. Girdzus	Radar Meteorologist
Alan Roberts	Cloud Seeding Aircraft Pilot
Steven Gabrick	Cloud Seeding Aircraft Pilot
Leon Anderson	Cloud Seeding Aircraft Pilot
Harold R. Hancock	Rawinsonde Technician
Jill Odom	Assistant to the Rawinsonde Technician
Thomas Hefner	Observer in Seeding Aircraft
Richard Halfmann	Raingage Technician/Alternate Observer

TEXAS TECH UNIVERSITY

Satellite-Derived Cloud Climatology and Real-Time Satellite Radar Support Program

Donald R. Haragan	Principal Investigator
Jerry Jurica	Principal Investigator
Colleen A. Leary	Principal Investigator
George Huebner	Associate Investigator
Shih-Cheng Chao	Research Assistant
Patricia L. Jackson	Research Assistant
Michael LePage	Research Assistant
Eric Pani	Research Assistant

Texas Tech University (continued)

David H. Spears	Research Assistant
Debrajean Kerr	Secretary II
Don Williams	Research Associate
James Holman	Research Associate

NORTH AMERICAN WEATHER CONSULTANTS

Analysis of 1976-78 Digitized M-33 Radar data from Snyder

Jack Kidd	Principal Investigator
Joe Sutherland	Meteorologist
Douglas Hughes	Senior Programmer
Robert Elliott	Scientific Advisor
R. Rao Kandurkuri	Head of Computer Services
Don Griffith	Managerial Support

SECTION IV

APPENDICES

APPENDIX A

"A 1979 Texas HIPLEX Forecast Decision Tree"

LIST OF TABLES

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2	Summary of 1979 Texas HIPLEX Forecast Decision Tree Performance	129

APPENDIX A

"A 1979 TEXAS HIPLEX FORECAST DECISION TREE"

The State of Texas and the U.S. Bureau of Reclamation jointly sponsored a scientific weather modification endeavor known as the Texas High Plains Cooperative Program (HIPLEX). HIPLEX is a program designed to assess the feasibility of enhancing precipitation over the semi-arid High Plains region of Texas through the application of cloud-seeding techniques from an airborne platform. This assessment is being accomplished by conducting a controlled cloud-seeding experiment. The HIPLEX cloud-seeding experiment requires the use of detailed and specific weather forecasts designed to take advantage of every cloud-seeding opportunity and to gather the maximum of meteorological data.

The use of available computer analyses and cloud models in conjunction with standard teletype and National Meteorological Center (NMC) facsimile data is quite helpful in providing support to the forecast effort, but climatological features unique to the region require specially tailored forecasting techniques; therefore, based on these local and regional climate-influencing features, a Forecast Decision Tree (FDT) was developed by the Department staff and was initially used during the 1979 HIPLEX field season in the Big Spring-Snyder area of Texas. The performance of the Decision Tree during its first season is summarized on these pages.

Design

Each forecast day during the three previous seasons (1976-1978) was post-stratified according to its Convective Index (CI). The CI is assigned a number value which ranges from "one" (clear or cirrus) to "nine" (widespread precipitation with overcast nimbostratus embedded

TABLE 1. Class Definitions of the Convective Index*

Class No.	Definition
1	Clear or cirrus and non-precipitating mid-level altocumulus or altostratus
2	Mid-level clouds with virga or RW-; no low level clouds
3	Non-precipitating low level convective clouds (i.e., stratocumulus to small congestus)
4	Towering cumulus with virga but no rain reaching the ground
5	Towering cumulus with light rainshowers which developed within the operational area either randomly or in lines; no cumulonimbus observed
6	Similar to 5 with cumulonimbus and thunderstorms which developed within the operational area in addition to the towering cumulus
7	Mesoscale cumulonimbus system which developed W-SW of the operational area due to upslope and/or dry line-sfc trough and moved across operational area as a line of thunderstorms or rainshowers
8	Mesoscale cumulonimbus system which developed along a synoptic feature (i.e., front or short wave aloft) and moved across operational area as a line of thunderstorms and rainshowers
9	Widespread precipitation from overcast nimbostratus with embedded thunderstorm-bearing cumulonmibi

*Alexander, W.O. and Riggio, R.F.; A Texas HIPLEX Forecast "Decision Tree." Texas Department of Water Resources, 1978, p. 4.

with thunderstorm-bearing cumulonimbi) (Table 1). Data from 1200 Greenwich Mean Time (GMT) rawinsonde launches at Midland for each forecast day were analyzed to determine the most effective predictor variables for each CI. It was determined that the single most dominant factor in predicting precipitation over the Texas HIPLEX operational area is the presence of a mechanical or dynamic forcing feature. Another important factor is the degree of saturation of the air mass. This is determined by a temperature-moisture analysis[1].

The FDT incorporates results of the above analyses into a logical stepwise decision tree. This model pre-stratifies each day according to anticipated CI. The FDT was programmed for computer use and loaded into the Bureau of Reclamation computer system for access at the Big Spring HIPLEX Meteorological Facility during the 1979 field season. Accordingly, forcing mechanisms and atmospheric characteristics may be quantified and loaded into the model to arrive at a pre-stratification of the day's weather by the combined use of input data from these sources: the 1200 GMT Midland rawinsonde data; the fine-mesh computer data; the NMC facsimile data; and, the high-resolution satellite imagery data available in-house via Harris LASARFAX.

1979 FDT Performance

The 1979 field season marked the first regular use of the FDT as a standard forecasting tool for the Texas HIPLEX program. During the 1979 season (May 21 through July 20), a total of 59 forecasts were made for HIPLEX purposes using the FDT model to pre-stratify each day for its convective type.

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1 Alexander, W.O. and Riggio, R.F. A Texas HIPLEX Forecast "Decision Tree." Texas Department of Water Resources, 1978, pp. 9-14.

The pre-stratified CI describes the vertical, and partially horizontal, extent of cloud development anticipated over the operational area during the forecast period, 1200 to 2200 Central Daylight Time (CDT). As shown in Table 1, CI 1 through CI 4 describe a no-rain (non-operational) type of day and CI 5 through CI 9 describe a rain (operational) day. On this basis, forecast verification is accomplished using a binary hit-miss routine. Of the 59 forecasts issued during the 1979 field season, 53 were hits and 6 were misses (89.8% correct). Table 2 summarizes the FDT's performance during the 1979 Texas HIPLEX season.

Summary

The Decision Tree appears to have performed well during the 1979 field season, but obvious areas of needed improvement exist. For example, the CI 9 situation may not be suitably defined because there are only 3 CI 9 days for the 1976 to 1978 period. Also, the term "subsidence"--which is used as a branch-point in the FDT in the non-forcing CI 5 situation--is non-quantitative, possibly ambiguous, and needs a clearer definition. These two areas appear to be most responsible for much of the error in pre-stratification and for one missed forecast.

Studies need to be conducted to develop further an objective scheme to identify synoptic and subsynoptic forcing features, the principal rain-inducing elements of the Texas HIPLEX area. Four of the six missed forecasts during the 1979 field season occurred largely because of errors in judging the effect of forcing action in the operational area.

These areas of inadequacy will be studied by Department staff in the coming months. At the conclusion of this study, a second generation of FDT is expected to be derived for use during the 1980 Texas HIPLEX field season.

TABLE 2. Summary of 1979 Texas HIPLEX Forecast Decision Tree Performance

Date	May CI(F)*	May CI(V)*	May ΔCI*	June CI(F)	June CI(V)	June ΔCI	July CI(F)	July CI(V)	July ΔCI
1				8	9	1	1	1	0
2				9	9	0	7	7	0
3				3	3	0	6	7	1
4				6	6	0	7	7	0
5				6	6	0	6	6	0
6				5	4	1	6	6	0
7				4	4	0	6	6	0
8				7	7	0	6	3	3
9				-	-	-	6	6	0
10				3	1	2	3	1	2
11				1	1	0	1	1	0
12				1	1	0	3	7	4
13				1	1	0	1	1	0
14				1	1	0	3	3	0
15				1	1	0	6	3	3
16				1	1	0	6	9	3
17				2	2	0	6	6	0
18				3	3	0	9	6	3
19				5	2	3	9	6	3
20				3	6	3	5	5	0
21	8	8	0	5	5	0	5	5	0
22	4	4	0	-	-	-			
23	3	3	0	-	-	-			
24	4	3	1	6	5	1			
25	3	3	0	5	6	1			
26	8	5	3	6	6	0			
27	8	8	0	3	3	0			
28	6	6	0	1	1	0			
29	3	3	0	6	6	0			
30	3	3	0	3	1	2			
31	8	8	0						

*CI(F)--Forecasted (pre-stratified) CI
CI(V)--Verified (post-stratified) CI
ΔCI--error

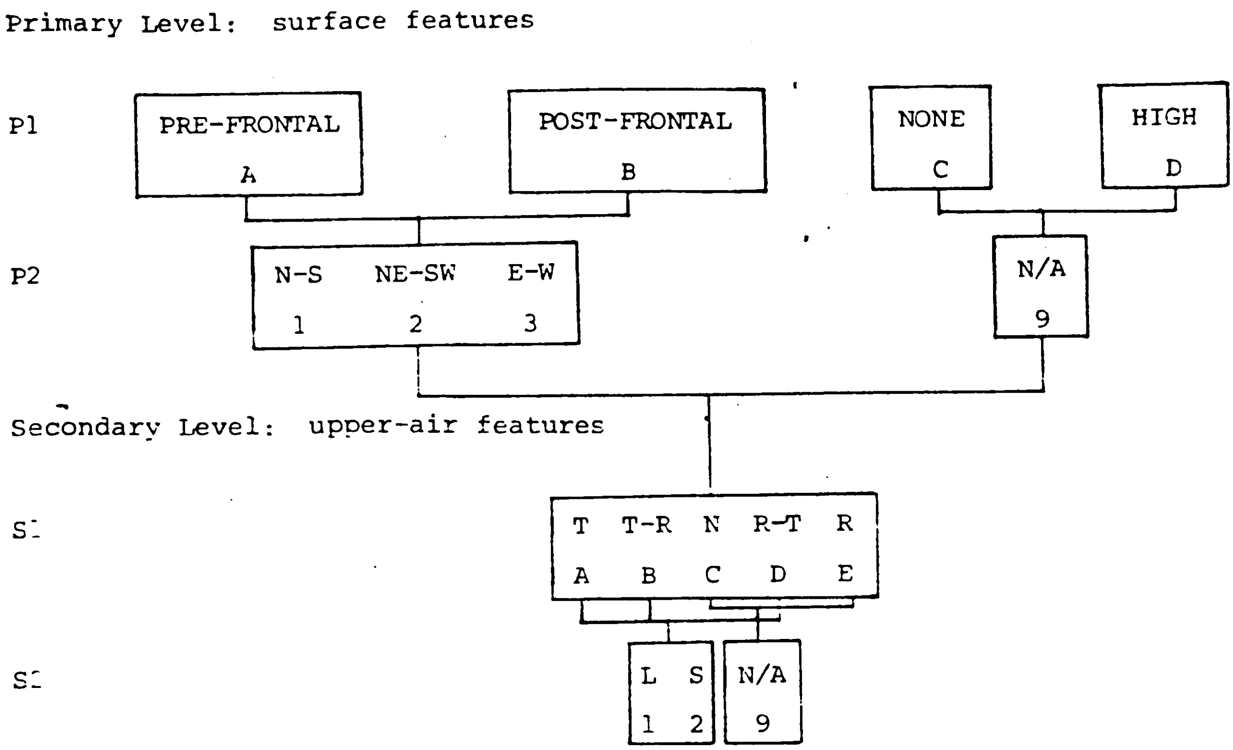
APPENDIX B

"The Subjective Synoptic Climatology"

APPENDIX B

Texas A&M University -- 14-00005

The subjective synoptic climatology: A scheme for assigning days of 52 weather types in accordance with the position of Midland with respect to features of the surface and 500 mb charts at 1200 GMT.



Legend:

- N/A -- not applicable
- T -- trough positioned over station
- T-R -- station positioned between a trough to west and ridge to east
- N -- no upper-air feature indicated
- R-T -- station positioned between a ridge to west and trough to east
- R -- ridge positioned over station
- L -- long wave feature
- S -- short wave feature

Type	No. of Days	Percent	Type	No. of Days	Percent
C9D1	114	16.0	B2D1	24	3.4
C9B1	106	14.9	C9A1	20	2.8
C9C9	90	12.6	A2A1	16	2.2
C9E9	55	7.7	B2B1	16	2.2
A2B1	40	5.6	B1B1	14	2.0
A2C9	33	4.6	D9D1	14	2.0
A2D1	24	3.4		566	79.4