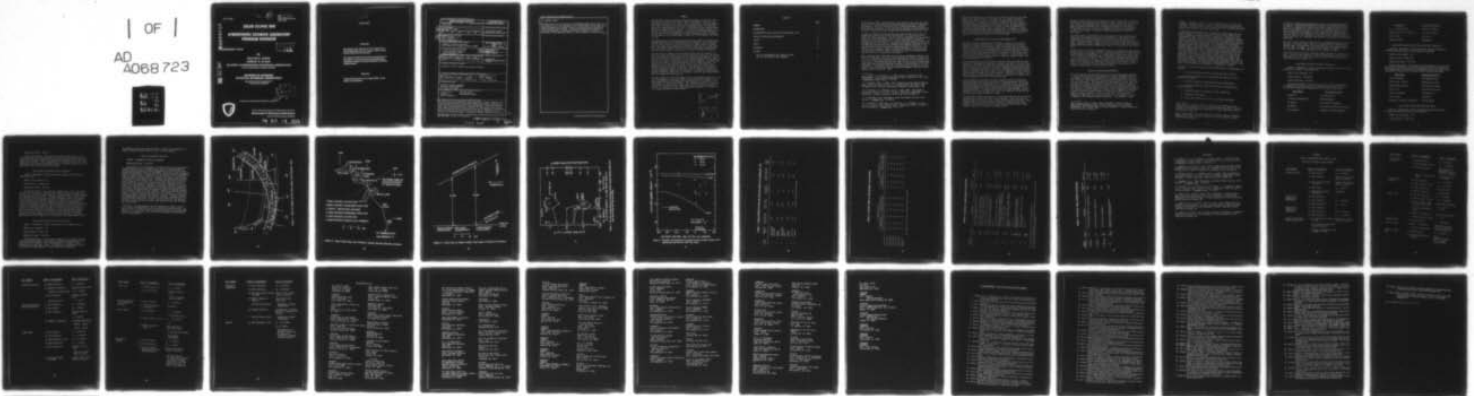


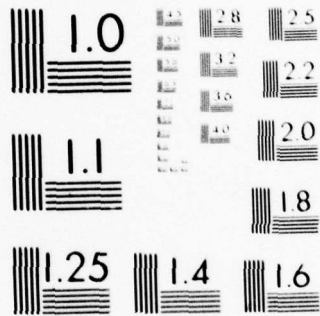
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SOLAR ECLIPSE 1979

ATMOSPHERIC SCIENCES LABORATORY PROGRAM OVERVIEW

FEBRUARY 1979

LEVEL II

By

MELVIN G. HEAPS

ROBERT O. OLSEN

US ARMY ATMOSPHERIC SCIENCES LABORATORY

WHITE SANDS MISSILE RANGE, NM 88002

WARREN W. BERNING

PHYSICAL SCIENCES LABORATORY

NEW MEXICO STATE UNIVERSITY

LAS CRUCES, NM 88003

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The 1979 solar eclipse provides a unique opportunity to better understand the interrelationship of many factors which influence the chemical, physical, and electrical structure of the earth's middle atmosphere. An eclipse provides a day-"night"-day transition on the time scale of a few minutes, thus allowing the rapid processes which affect the electron and ion chemistry to be monitored, while assuring that the bulk properties of the neutral atmosphere vary in a regular and predictable manner. Experimental findings from past eclipses have		

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indicated that a very rapid electron attachment/detachment process exists in the D-region which is not reproduced in our present models and yet needs to be explained because of its potential impact on Army communication systems and nuclear weapons effects studies. To better understand these properties of the middle atmosphere, the Atmospheric Sciences Laboratory is helping to coordinate a field experiment program for the 26 February 1979 solar eclipse.

SUMMARY

The 1979 solar eclipse provides a unique opportunity to study the inter-relationship of many factors which control the chemical, physical, and electrical structure of the earth's middle atmosphere. Past measurements have shown the presence of an electron attachment process and possible electron storage mechanism which are of importance to Army communications and nuclear weapons effects studies. To correctly model and predict the effects of such electron processes, a broad and interrelated data base is needed; therefore, the Atmospheric Sciences Laboratory (ASL) is helping to coordinate a field measurements program for the 26 February 1979 solar eclipse.

In cooperation with the National Research Council (NRC) of Canada and the National Aeronautics and Space Administration (NASA), a field experiment site has been selected in the Red Lake area of western Ontario, Canada. This area offers the advantages of necessary land area for a rocket program, reasonable support facilities to reduce logistical considerations, and maximum duration of eclipse totality at the altitudes of interest.

The main areas of emphasis for ASL participation are the variations in electron density and electrical structure during the course of the eclipse. But a more thorough understanding of such phenomena also demands a knowledge of the sources of ionization in the middle atmosphere and the identity and time variations of the ions and minor neutral species. To gather this type of data, ASL is sponsoring several types of rocket payloads. Two payloads, to be flown from the large rocket range, will measure both photon and particle ionization sources, electron density, and densities of several neutral species. Four small rocket probes will be used to measure atmosphere temperature and pressure. In addition a ground-based partial reflection sounder will be operated to provide continuous monitoring of D-region electron densities.

The ASL program is being coordinated with the experimental programs of the Air Force Geophysics Laboratory (AFGL), NASA, and NRC of Canada. Thus, many complementary and supplementary measurements can be provided to all participants at major cost savings. This cooperative effort is then able to provide a broad spectrum of data which can be used to substantially further our knowledge of the middle atmosphere and predict its effect on Army communications and radar systems.

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On 26 February 1979, a total eclipse of the sun will occur over the north-western tier of the United States and the Canadian provinces of Manitoba and Ontario. This will be the last total eclipse observable from the North American continent in this century and presents a unique opportunity to mount a coordinated field program without formidable logistical costs.

Interest in monitoring solar eclipses has grown in the last 15 years as experimental methods have become available for in situ probing of the middle and upper atmosphere. The first direct measurements of the D-region during an eclipse were carried out in 1963¹ and showed a (heretofore unexpected) very large decrease in electron densities below 75 km near the maximum phase of the eclipse. Subsequent and improved measurements during the 1966 and 1970 eclipses have confirmed the anomalous behavior of the electron density while tentatively identifying some of the positive ions present in the D-region. Army involvement during past eclipse programs has centered on both the chemical and physical state of the middle atmosphere as well as its electrical structure.²⁻⁵

Major questions which have been raised by past experimental findings, and are still unanswered, concern the rapid decrease in D-region electron densities at totality and an anomalously large positive ion to electron density ratio. The implications are that there exists an as-yet-undetermined rapid electron attachment/detachment process in the D-region of the middle atmosphere. This process needs to be determined and its effects incorporated in Army communication systems prediction computer codes and nuclear weapons effects simulation codes.

¹L. G. Smith, C. A. Accardo, L. H. Weeks, and P. J. McKinnon, 1963, "Measurements in the Ionosphere During the Solar Eclipse of 20 July 1963," J Atmospheric Terrest Phys, 27:803-829

²H. T. Lootens, and W. A. Dean, 1970, "D-Region Electron Density Measurements During the Solar Eclipse of 12 November 1966," BRL Report 1464, US Army Ballistic Research Laboratories, Aberdeen Proving Ground, MD

³H. N. Ballard, J. S. Randhawa, and W. L. Webb, 1968, "Stratospheric Circulation Response to a Solar Eclipse," R&D Report, ECOM-5189, US Army Atmospheric Sciences Laboratory, White Sands Missile Range, NM

⁴J. S. Randhawa, 1968, "Mesospheric Ozone Measurements During a Solar Eclipse," J Geophys Res, 73:493-495

⁵H. N. Ballard, R. Valenzuela, M. Izquierdo, J. S. Randhawa, R. Morla, and J. F. Bettle, 1969, "Solar Eclipse: Temperature, Wind, and Ozone in the Stratosphere," J Geophys Res, 74:711-713

The desired outcome of a research plan to measure response of the atmosphere to a solar eclipse is the production of improved atmospheric models with which to predict atmospheric response under a variety of disturbances. In developing a research program for the solar eclipse, principal interest centers upon the behavior of the ionized regions at altitudes below 100 km which are of concern to Army HF communication systems and nuclear weapons effects predictions. Therefore, to better understand and define the middle atmosphere and its electrical structure, ASL is assisting in coordinating and mounting a basic field experiment program to study the 26 February 1979 solar eclipse.

DESCRIPTION OF ECLIPSE PATH AND LAUNCH SITES

The solar eclipse of 26 February 1979 begins at dawn over the Pacific Ocean west of Puget Sound and will terminate at sunset over northern Greenland. Because of the northerly path of totality and the calendar date of occurrence, solar elevation angles for observing sites along the totality path will not exceed 26 degrees, a factor of importance in planning for eclipse related experiments. The portion of the eclipse path which lies over North America is shown in figure 1. Particulars for the eclipse path at equally spaced points (in time) are given in table 1 for the numbered points in figure 1.

Early consideration of the scientific objectives deriving from the major concern for understanding atmospheric response dictated a site for rocket experiments for which the solar elevation angle was near its maximum value. This constraint arises because the earth's atmosphere between the sun and point of measurement provides a filter for incoming solar radiation which blocks or decreases the energy input into the atmosphere and thus modifies the atmospheric response of primary interest. Referring to figure 1 and table 1, the solar elevation angle attains its maximum value between north-eastern Montana and the shore of the Hudson Bay.

In the absence of existing and suitable sounding rocket installations, operating safety constraints imposed by existing population centers and rural populations are exceedingly severe. Combining safety, the equally restrictive logistic problems and the eclipse totality requirements for the rocket measurements quickly removed all but a few potential sites for rocket operations. In cooperation with NRC of Canada and NASA, several potential sites were surveyed, with final site selection settling on the Red Lake area in western Ontario, Canada.

Six physically separate locations in the Red Lake area will be used during various phases of the 1979 solar eclipse program. Three locations are near Red Lake itself and are more closely associated with the small rocket program, while the three remaining locations are approximately 30 km southeast of Red Lake and are associated with the large rocket program. Figure 2 shows these locations in greater detail.

The small rocket launch site is located just north of the town of Cochenour and will be utilized by ASL and the NRC of Canada. About 2 km south is the small rocket instrumentation and tracking site, located at the physical plant of Cochenour-Willans Mine. Additional buildings at the Cochenour-Willans Mine are to be used as the "command center" for the coordination of the eclipse program. The partial reflection sounder is located in Balmertown.

The large rocket instrumentation site and launch site are located approximately 30 km southeast of Red Lake and Balmertown. The launch site is separated from the instrumentation site about 6 km on an east-west line across the Chukuni River. These sites are to be used by ASL, the AFGL, and NASA. Somewhat further southeast on the main highway is the rocket booster storage and large rocket assembly area located in a building at the Griffith Mine.

Because of the small angle (26 degrees) that the sun makes with the horizon during totality in the Red Lake area, and hence because of the rather oblique shadow through the atmosphere, it is advantageous to have the rocket launch sites located on the southern edge of the area of totality at ground level, as is illustrated in figure 3. This allows the lower ionosphere above the rocket launch sites to be along the center line of totality, thus enabling the in situ sampling to be done where the duration of the total eclipse is longest. The specifics of the onset and duration of the eclipse at the small and large rocket sites are given in table 2.

SCIENTIFIC NEEDS AND REQUIREMENTS

The basic objective of the 1979 solar eclipse field measurements program is to provide the necessary measurements to improve the understanding of the chemical and physical properties of the middle atmosphere. Of particular interest is the electrical structure and variations in electron density of the D-region. Data from previous measurements, such as those from the 1966 solar eclipse illustrated in figure 4, have shown a significant decrease in electron concentration during the short time about totality. (In figure 4, 2C denotes second contact or onset of totality and 3C denotes third contact or end of totality.) Ideally one's knowledge of atmospheric processes should be complete enough to simulate and predict such variations in electron density. Using a current model of the pertinent atmospheric chemistry,⁶ the data from figure 4 is shown again in figure 5 along with the simulated electron densities. The disparity is most

⁶D. W. Hoock, and M. G. Heaps, 1978, "DAIRCHEM: A Computer Code to Model Ionization-Deionization Processes and Chemistry in the Middle Atmosphere," ASL Internal Report, US Army Atmospheric Sciences Laboratory, White Sands Missile Range, NM

dramatic. Detailed studies^{7,8} of this phenomenon have concluded that it cannot be explained by the currently known, conventional gas phase chemistry. The data indicate that a rapid electron attachment/detachment process exists which is not well understood.

A coordinated set of measurements is needed to improve models of atmospheric response to various disturbances, both natural and man-made. Credible models are needed whether the concern is a decrease in the stratospheric ozone shield or serious impairment in radiowave communications. The extremely rapid loss of electrons at second contact during the 1966 eclipse raises the possibility of an electron storage mechanism over a broad altitude regime rather than permanent electron removal through electron-ion recombination. As a consequence, reinstatement of sunlight would release the stored electrons and provide a degraded or markedly changed environment for the transmission of radio signals from ELF to HF frequencies. Such a phenomenon was observed after the high altitude nuclear tests in the Pacific in 1958. High altitude nuclear events are not required; large-yield surface bursts will produce the same effect but at even lower altitudes than observed in 1958. Thus, predictive models of atmospheric response have practical application to real problems today. Significantly, only the measurements taken during an eclipse have shown the phenomenon of rapid electron loss which is completely unexplained by existing models of atmospheric response.

To provide a sufficient data base the following types of measurements are required.

- a. Electron density variations in the period about totality
- b. Positive and negative ion composition and densities in the period about totality
- c. Ionizing radiations (background and eclipse modulated)
- d. Density of important minor neutral species (background and eclipse modulated)
- e. Possible presence of aerosols and their properties
- f. Temperature and density
- g. Direct and scattered solar flux at selected wavelengths

⁷M. G. Heaps, F. E. Niles, and R. D. Sears, 1978, "Modeling the Ion Chemistry of the D-Region: A Case Study Based Upon the 1966 Total Solar Eclipse," ASL-TR-0015, US Army Atmospheric Sciences Laboratory, White Sands Missile Range, NM

⁸M. G. Heaps, 1978, "The 1979 Solar Eclipse and Validation of D-Region Models," ASL-TR-0002, US Army Atmospheric Sciences Laboratory, White Sands Missile Range, NM

To make the necessary measurements and yet provide the needed redundancy and backup, a coordinated experimental program has evolved between ASL and AFGL, as Department of Defense participants, NASA and NRC of Canada. While such a program necessarily reflects the interests and desires of various researchers and groups, it has been possible to plan an experimental program to take advantage of this composite of information and at the same time test the credibility of certain critical data by virtue of their acquisition by independent experimenters using differing experimental techniques.

Two rocket launch sites have been set up to accommodate the various rocket payloads. The large rocket launch site located near the Chukuni River, approximately 30 km southeast of the Red Lake area, will handle payloads for ASL, AFGL, and NASA. The small rocket launch site located in the Red Lake area will handle payloads for ASL and NRC of Canada.

Short descriptions of the ASL sponsored rocket payloads are given below. Table 3 gives a brief resume of all large rocket payloads to be flown from the large rocket site, and table 4 gives a resume of the payloads to be flown from the small rocket site.

Large Rocket Payload ASL-SE79A₁ (Payload A)

Sponsor: Atmospheric Sciences Laboratory through the Physical Sciences Laboratory, New Mexico State University.

Number to be Launched: one

Launch Vehicle: Nike-Orion

Sampling Altitude: 60-120 km

Payload Description: The principal mission of this rocket payload is provision of altitude profiles of important minor neutral species. The parameters measured are indicated in the following tabulation:

<u>Measurement</u>	<u>Instrument/Technique</u>
O density	UV resonance lamp
O density (comparative)	5577Å ^o photometer
O ₃ density	UV absorption photometer
NO density	UV resonance scattering photometer
OH excitation	Cryogenic infrared radiometer

<u>Measurement</u>	<u>Instrument/Technique</u>
$O_2(^1\Delta_g)$ concentration	Infrared radiometer
Lyman-alpha flux (O_2 density)	Ionization chamber
Solar aspect	Sun sensor
Magnetic aspect	Magnetometer

Large Rocket Payload ASL-SE79B₁ and A12.9A1 (Payload B₁)

Sponsors: Atmospheric Sciences Laboratory through the Physical Sciences Laboratory and Air Force Geophysics Laboratory

Number to be Launched: one

Launch Vehicle: Nike-Orion

Sampling Altitude: 40-120 km

Payload Description: The principal mission objectives for this payload are an electron density profile, photoionization and photodissociation energy input and a profile of mesospheric density and temperature. The parameters measured are indicated in the following tabulation:

<u>Measurement</u>	<u>Instrument/Technique</u>
Electron density	RF impedance probe
Solar X-rays (1-10 ⁰ Å)	Proportional counter
Precipitated electrons	Scintillation counter
Cosmic rays	Scintillation counter
Solar UV radiation	Photometers (2)
Solar aspect	Sun sensor
Atmospheric density, temperature	Falling sphere

Small Rocket Payload ASL-SE79E (payload E)

Sponsor: Atmospheric Sciences Laboratory through the Physical Sciences Laboratory, New Mexico State University

Number to be Launched: four

Launch Vehicle: Super Arcas

Sampling Altitude: 60-90 km

Payload Description: The principal scientific objectives for these rocket payloads are the measurement of electron density profiles and solar Lyman alpha radiation input to the mesosphere during the eclipse and under noneclipse conditions. These measurements will complement the large rocket experiments and provide more frequent samples of electron density and solar Lyman alpha than would otherwise be possible.

Small Rocket Payload ASL-SE79F (payload F)

Sponsor: Atmospheric Sciences Laboratory through the University of Texas at El Paso

Number to be Launched: six

Launch Vehicle: Super Arcas

Sampling Altitude: 30-85 km

Payload Description: The scientific objective for these rocket payloads is the measurement of positive and negative electrical conductivity, ion mobility, and charge number density in the atmospheric interval sampled. The experimental device used is a Gerdien condenser lowered by parachute (at subsonic speeds) after ejection from the rocket carrier. The operating arrangement of the Gerdien condenser is such that the atmospheric sample to be measured flows at a determined velocity (given by the fall rate of the instrument) through a pair of concentric cylindrical electrodes. In the arrangement used here the inner electrode serves as the charge collector. A voltage applied between the inner and outer electrodes produces an electric field which accelerates the charged particles toward the collecting electrode. The resulting current of collected charged particles, in the presence of a varying voltage, provides information about the electrical conductivity, ion mobility, and charge number density.

Small Rocket Payload ASL-SE79M (Payload M)

Sponsor: Atmospheric Sciences Laboratory and Air Weather Service

Number to be Launched: ten

Launch Vehicle: Super Loki

Sampling Altitude: 30-70 km

Payload Description: The scientific objectives for these rocket payloads are the measurement of winds and of atmospheric temperature in the altitude interval sampled. The instrumentation is carried in a dart launched by the Super Loki rocket. At apogee the instrumentation sensors are ejected and measurements are taken on descent by parachute.

In addition to the rocket borne payloads, a ground based experiment to measure D-region electron densities will also be conducted.

Partial Reflection Experiment

Sponsor: Atmospheric Sciences Laboratory

Sampling Altitude: 60-90 km

Description of the Experiment: The partial reflection experiment is ground based and has as its experimental objective the measurement of D-region electron density profiles throughout the eclipse and for background electron density profiles throughout the eclipse and for background noneclipse conditions. In operation, a low frequency (several megahertz) radar is used to transmit pulses of radiation vertically. Echoes back-scattered from the D-region of the ionosphere are received and recorded as functions of pulse transit time. Circular polarization of the transmitted radiation is utilized, and pulses of both right and left hand polarization are employed. Because of the earth's magnetic field, the index of refraction of the ionosphere is different for the two polarization modes. The relative intensities of the waves partially reflected from a given altitude within the ionosphere contain information concerning the electron density at the altitude. This partial reflection technique can be used to measure the density of free electrons, in the ionosphere as a function of altitude from 50 to 100 km. A single frequency of 2.666666 MHz is employed. The partial reflection experiment will be located in Balmertown, near the small rocket launch site, and operated continuously for a period of several days before, during, and following the solar eclipse.

In addition to the measurements detailed above and in tables 3 and 4, other sources of complementary data are available from satellites. The appendix lists the specific physical properties which are to be measured along with the applicable rocket payloads and appropriate complementary satellite measurements.

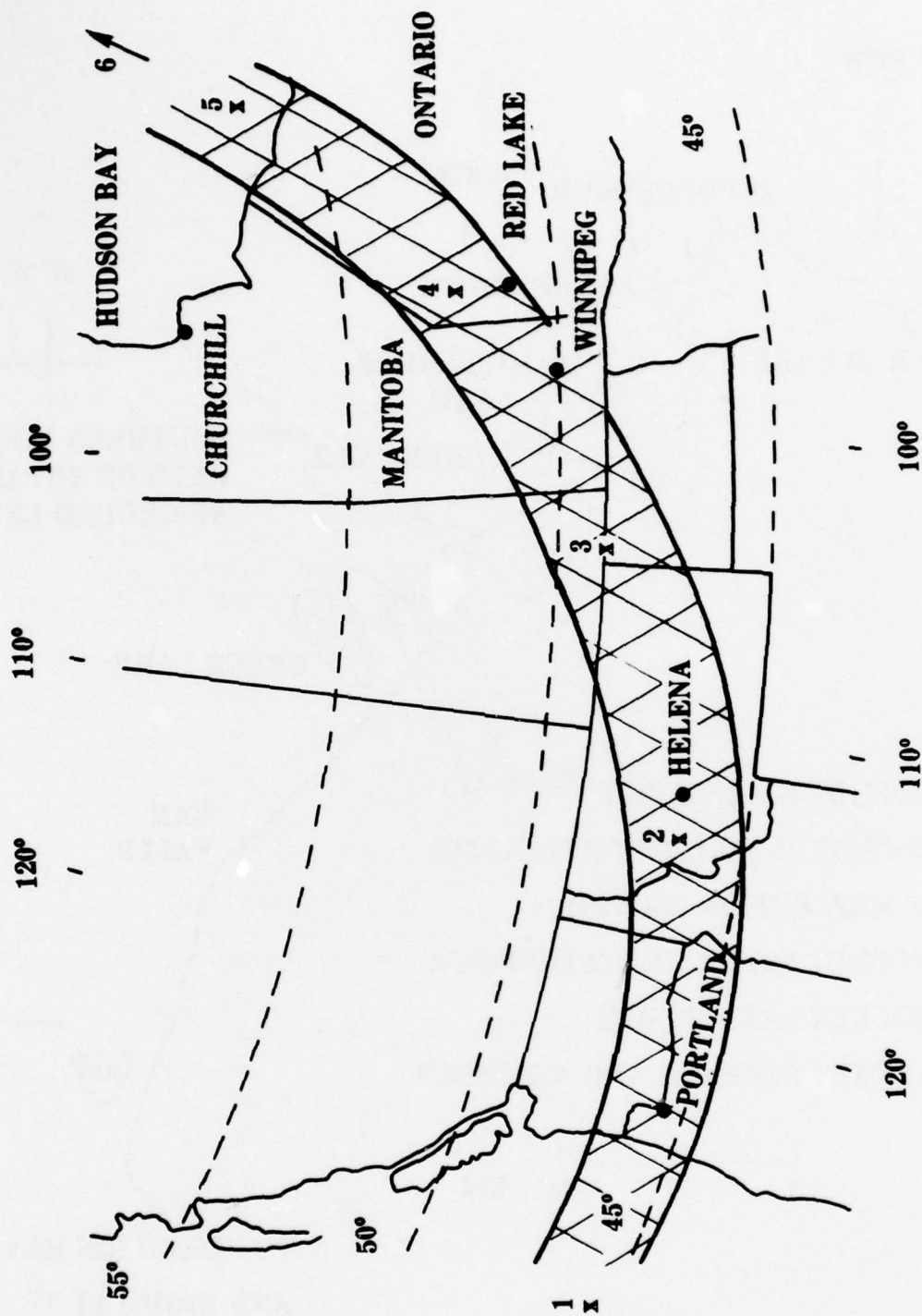


Figure 1. Path of totality for the solar eclipse of 26 February 1979.

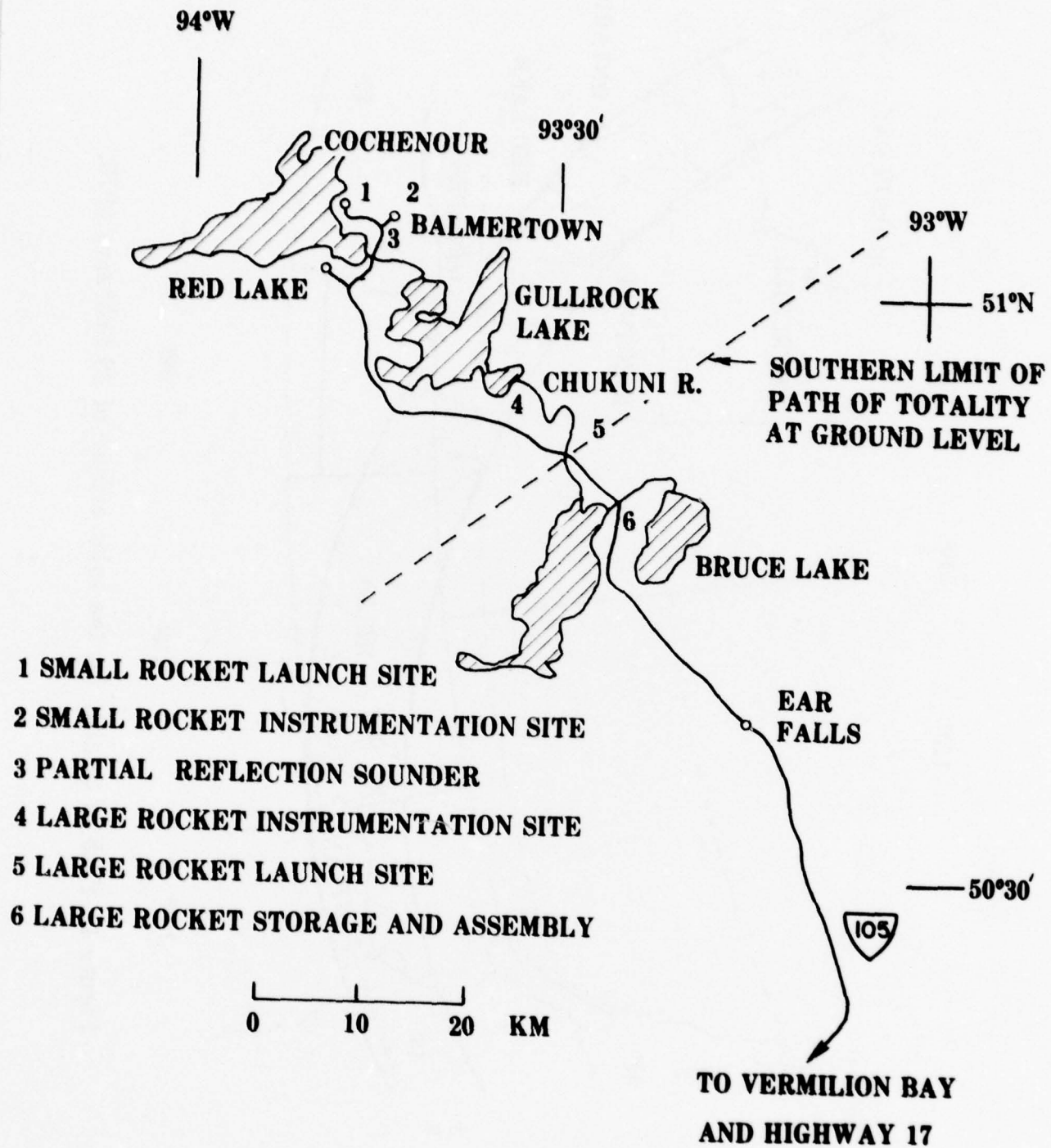


Figure 2. Map of Red Lake area, Ontario, Canada, showing field site locations.

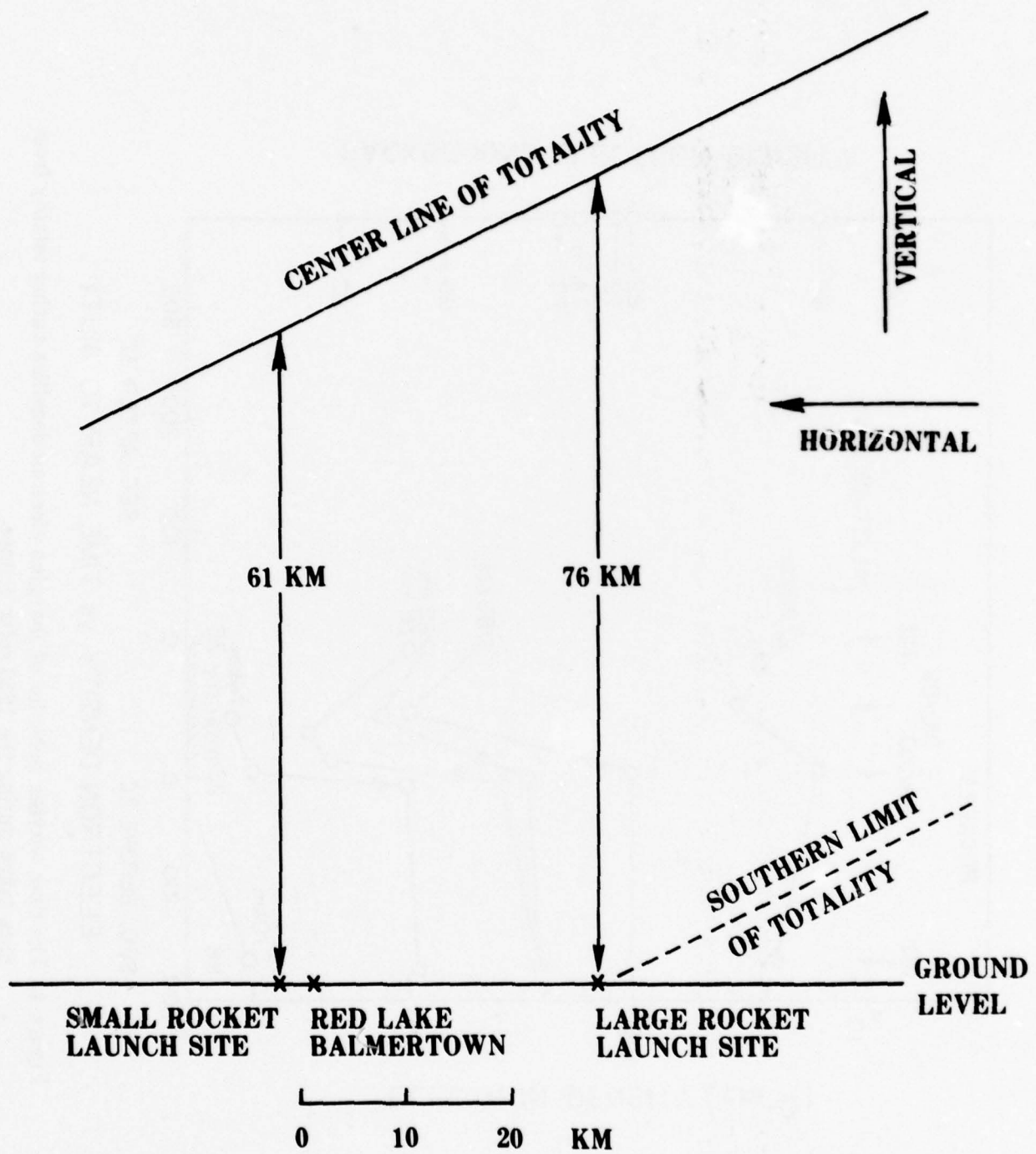


Figure 3. Center line of eclipse totality with respect to field site locations.

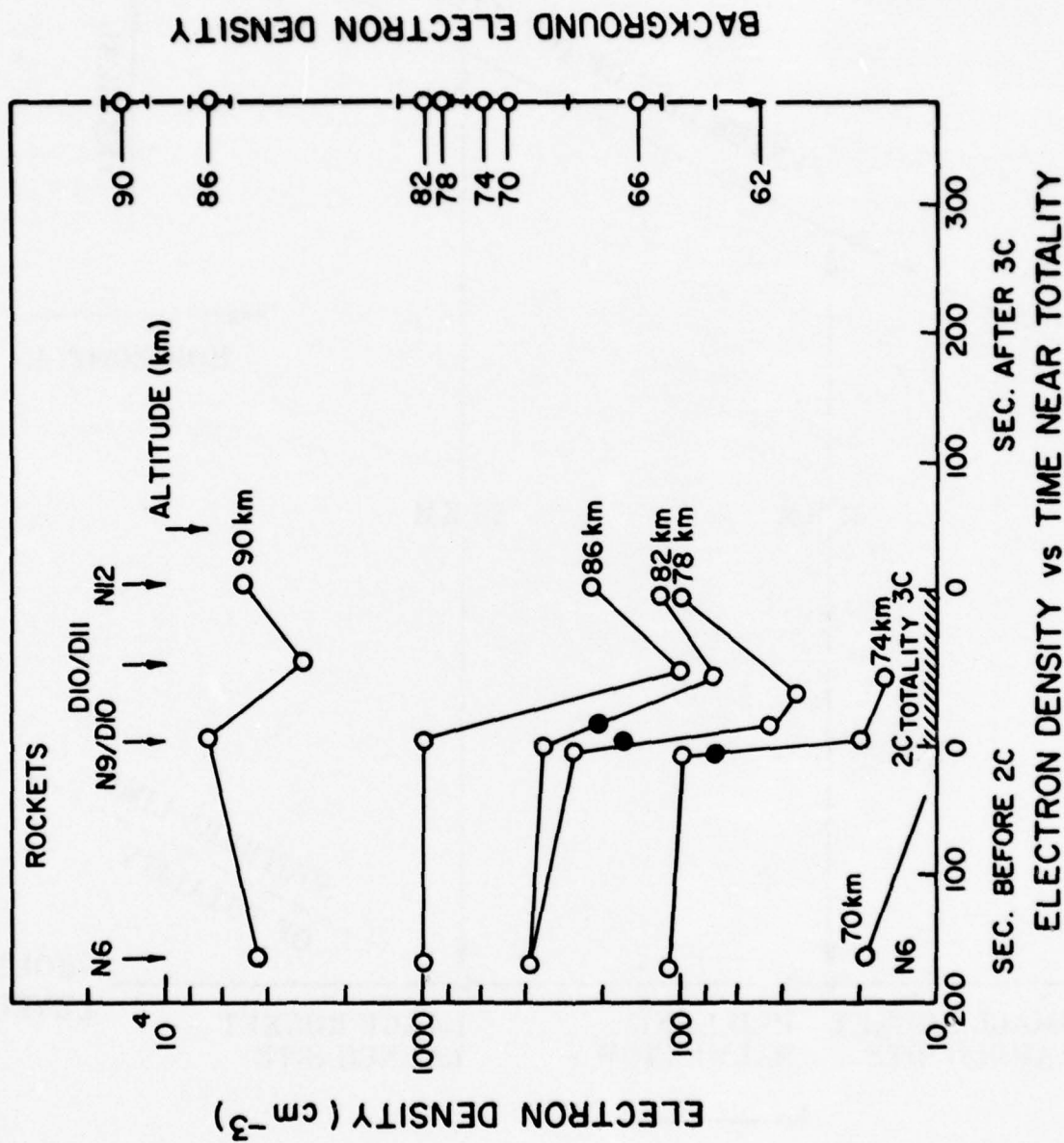


Figure 4. The time varying behavior of D-region electron densities during totality from data taken during the 1966 solar eclipse.

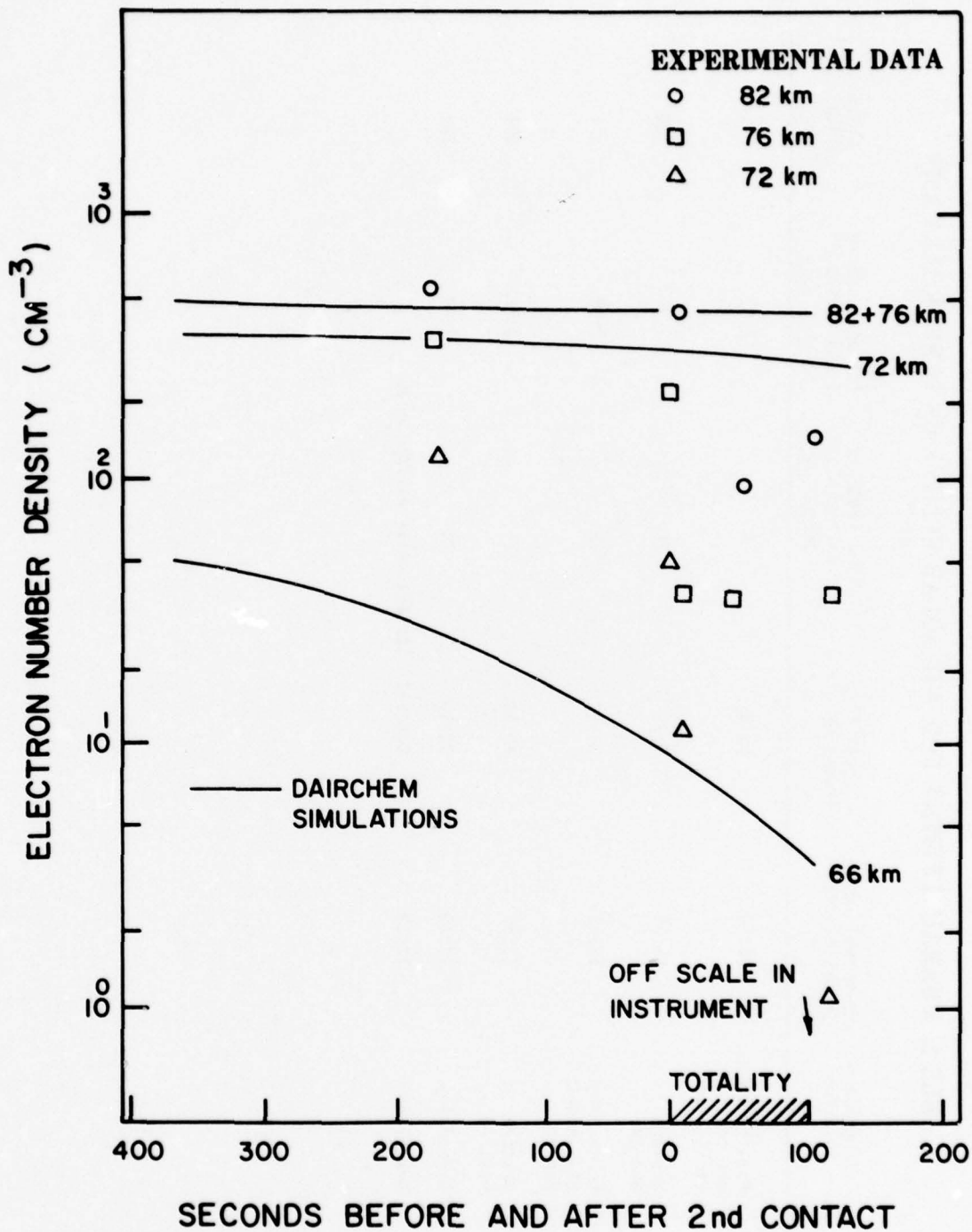


Figure 5. Computer code simulations of D-region electron densities compared with experimental data from the 1966 solar eclipse.

TABLE 1. CHARACTERISTICS FOR THE SOLAR ECLIPSE ON 26 FEBRUARY 1979

Map Location	Geographic Location	Universal Time (hours:minutes)	Local Time (hours:minutes)	Sun Angle (from Horizon) (deg)	Eclipse Duration (minutes:seconds)	Shadow Width (km)
1	Pacific Ocean off coast of Washington	16:10	8:10	5	2:02	249
2	Western Montana	16:25	9:25	20	2:36	303
3	North Dakota US-Canadian Border	16:40	10:40	24	2:49	314
4	Western Ontario	16:55	10:55	26	2:52	304
5	Hudson Bay	17:10	12:10	24	2:47	283
6	Greenland	17:39	Central	(total)	solar eclipse ends	

TABLE 2. ECLIPSE TIMES AT THE ROCKET LAUNCH SITES

	SMALL ROCKET SITE			LARGE ROCKET SITE		
	Ground Level (hours:minutes:seconds*)	Center Line (61 km) (hours:minutes:seconds*)	Center Line (76 km) (hours:minutes:seconds*)	Ground Level (hours:minutes:seconds*)	Center Line (76 km) (hours:minutes:seconds*)	Center Line (76 km) (hours:minutes:seconds*)
First Contact	15 42 09	15 42 09	15 42 21	15 42 21	15 42 21	15 42 21
Second Contact	15 53 04	16 52 30	16 54 06	16 54 06	16 52 41	16 52 41
Eclipse Maximum	16 53 56	16 53 56	16 54 08	16 54 08	16 54 08	16 54 08
Third Contact	16 54 48	16 55 22	16 54 10	16 54 10	16 55 35	16 55 35
Fourth Contact	18 08 28	18 08 28	18 08 40	18 08 40	18 08 40	18 08 40
Duration of Totality	00 01 44	00 02 53	00 00 00	00 00 00	00 00 02	00 00 02

*Time given is Universal Time: subtract 6 hours for Local Time

TABLE 3. PAYLOADS - LARGE ROCKET LAUNCH SITE

Payload Designation	Sponsor	Measurement	Altitude Range (km)	Launch Time
A	ASL	Solar Lyman alpha radiation. Number densities of O_3 , O_2 , NO , OH , and $O_2(^1\Delta_g)$.	60-120	$T_2 - 25$ min
B ₁	ASL AFGL	Neutral atmosphere density and temperature. Electron density. Solar X-ray flux ($<10\text{\AA}$). UV flux (1216\AA , 2050\AA). Ionizing radiations.	40-120	$T_2 - 25$ min
G	AFGL	Infrared emissions at $3.0\mu\text{m}$, $9.6\mu\text{m}$, and $10.6\mu\text{m}$.	70-120	$T_2 - 3$ min
C ₁	AFGL	Composition and relative density of positive and negative ions. Total ion densities.	50-100	T_2
C ₂	AFGL	Same as C ₁ .	50-100	$T_2 + 45$ min
B ₂	AFGL	Neutral atmosphere density and temperature.	20-100	$T_2 + 55$ min
N-1	NASA	Composition and relative density of positive ions. Electron density. Direct and scattered solar fluxes at certain wavelengths. Ionizing radiation.	70-120	$T_2 - 2$ days
N-2	NASA	E and F region electric fields.	100-250	$T_2 - 2$ min
N-3	NASA	Neutral and ion composition. Electron density and temperature. Airglow. Photoelectrons. Photoionization.	100-180	$T_2 - 2$ min
N-4	NASA	Same as N-1.	70-120	$T_2 - 1.5$ min
N-5	ARO* ONR NASA	Aerosol properties. Electron attachment/detachment coefficients. Ion conductivities and densities.	35-85	$T_2 - 2.5$ min
N-6	NASA	Same as N-1, except for negative ion in place of positive ions.	70-120	$T_2 + 1$ min
N-7	ARO ONR NASA	Same as N-5.	35-85	$T_2 + 12$ hr or $T_2 - 12$ hr

*ARO - US Army Research Office; ONR - Office of Naval Research.

T_2 is the time of second contact, i.e., the beginning of totality which lasts 2 min 52 sec at its fullest extent. Launch times are approximate.

TABLE 4. PAYLOADS - SMALL ROCKET LAUNCH SITE

Payload Designation	Sponsor	Measurement	Altitude Range (km)	Launch Time
E (4 payloads)	ASL	Solar Lyman alpha radiation. Electron density.	60-90	T ₂ - 1 week to T ₂ + 1 day
F (6 payloads)	ASL	Positive and negative ion conductivities.	30-85	T ₂ - 1 week to T ₂ + 1 day
M (10 payloads)	ASL AWS	Neutral density and temperature.	30-70	T ₂ - 1 week to T ₂ + 1 day
NRC-1	NRC (Canada)	Vacuum UV of solar corona and prominences. Ozone density. Electron density.	35-120	T ₂ - 1 min

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APPENDIX
 TYPES OF MEASUREMENTS AND SOURCES OF DATA
 FOR THE 1979 SOLAR ECLIPSE PROGRAM

<u>DATA ELEMENT</u>	<u>SOURCE OF MEASUREMENT</u>	<u>TIME OF MEASUREMENT</u>
Electron Density	(1) ASL Payload A	T_2 - 25 minutes
	(2) NASA Payloads	Several times during course of eclipse
	(3) Small Rocket Payload (4 each)	Several times during course of eclipse
	(4) NRC Payload	T_2 - 1 minute
	(5) Ground-based Partial Reflection	continuous
Positive Ion Composition and Density	(1) AFGL Payload C_1	T_2
	(2) AFGL Payload C_2	T_2 + 45 minutes
	(3) NASA Payload N-1	T_2 - 2 days
Negative Ion Composition and Density	(1) AFGL Payload C_1	T_2
	(2) AFGL Payload C_2	T_2 + 45 minutes
	(3) NASA Payload N-6	T_2 - 1.5 minutes
Positive and Negative Charge Conductivity	(1) ASL Small Rocket Payload (6 each)	Several times during course of eclipse
	<ul style="list-style-type: none"> · Can provide ion mobilities and ion densities · Provides information to low altitudes (~30 km) 	

<u>DATA ELEMENT</u>	<u>SOURCE OF MEASUREMENT</u>	<u>TIME OF MEASUREMENT</u>
Precipitating Electrons	(1) ASL Payload B ₁	T ₂ - 25 minutes
	(2) NASA Payloads N-1,N-4	T ₂ - 1.5 minutes
	(3) NOAA-5 Satellite	Approximately 24 samples per day at latitude of interest
	· 1500 km circular polar orbit	· Directional flux E > 140 kev
Precipitating Protons	(1) ASL Payload B ₁	T ₂ - 25 minutes
	(2) NASA Payloads N-1,N-4	T ₂ - 1.5 minutes
	(3) NOAA-5 Satellite	as noted above
	(4) TIROS-N Satellite	as noted above
Solar X-Rays	(1) ASL-AFGL Payload B ₁	T ₂ - 25 minutes
	(2) NASA Payloads, N-1,N-4	T ₂ - 1.5 minutes
	(3) GOES-1, GOES-2, SMS-1 and SMS-2 Satellites	Continuous monitoring · 0.5 - 3 Å · 1 - 8 Å
	· All in geosynchronous orbits	
Bremsstrahlung	(4) SOLRAD 11B Satellite	Continuous monitoring
	· 115000 km circular orbit	· 1 - 8 Å
Bremsstrahlung	(1) ASL Payload B ₁	T ₂ - 25 minutes
Galactic X-Rays	(1) HEAO - 1 Satellite	Continuous mapping; discrete sources and diffuse background
	· 450 km circular orbit	
Galactic Cosmic Rays	(1) ASL Payload B ₁	T ₂ - 25 minutes
	(2) Ground-based Neutron Monitors	Hourly Available through WDC-A; Calgary station nearby

<u>DATA ELEMENT</u>	<u>SOURCE OF MEASUREMENT</u>	<u>TIME OF MEASUREMENT</u>
Extreme Ultraviolet	(1) NASA Payload N-3	T_2 - 2 minutes
	(2) SOLRAD 11B Satellite	Continuous monitoring
	· 115000 km circular orbit	· 170 - 1050 Å
	(3) AE-E Satellite	Frequent spectral scans
	· 250-390 km orbit	· $\lambda > 140$ Å
Direct and Scattered Solar Ultraviolet	(1) ASL Payload B ₁	T_2 - 25 minutes
	(2) NRC Payload	T_2 - 1 minute
	(3) AE-E Satellite	Frequent spectral scans
		· $\lambda < 1850$ Å
	(4) SOLRAD 11B Satellite	Continuous monitoring
		· 1080 Å - 1350 Å
		· 1175 Å - 1800 Å
Lyman Alpha	(1) ASL Payload A	T_2 - 25 minutes
	(2) ASL Payload B ₁	T_2 - 25 minutes
	(3) NASA Payloads N-1,N-4	T_2 - 1.5 minutes
	(4) NASA Payload N-3	T_2 - 2 minutes
	(5) AE-E Satellites	Frequent spectral scans
		· Specific measurement at 1216 Å
	(6) ASL Small Rocket (4 each)	Several times during course of eclipse

<u>DATA ELEMENT</u>	<u>SOURCE OF MEASUREMENT</u>	<u>TIME OF MEASUREMENT</u>
Lyman Beta	(1) NASA Payload N-3	T_2 - 2 minutes
	(2) AE-E Satellite	Frequent spectral scans * Specific measurement at 1026 \AA
Infrared Radiation from Atmospheric Molecules	(1) AFGL Payload G	T_2 - 3 minutes
	(2) USU Field-Widened Interferometer	Continuous
Minor Neutral	(1) ASL Payload A	T_2 - 25 minutes * $O, O_3, NO, OH, O_2(^1\Delta_g)$
	(2) NASA Payloads, N-1, N-4	T_2 - 1.5 minutes * O_3
	(3) DMSP-F2 Satellite (Block 5)	Early morning and local noon scans * O_3 through stratosphere * H_2O through stratosphere
Atmospheric Density	(1) AFGL Payload B_1	T_2 - 25 minutes
	(2) AFGL Payload B_2	T_2 + minutes
	(3) Rocket Payloads equipped with Lyman alpha detectors	Several times during course of eclipse * Altitude profiles of Lyman alpha radiation can provide (through calculation) altitude profiles of $[O_2]$, and hence, total density.

<u>DATA ELEMENT</u>	<u>SOURCE OF MEASUREMENT</u>	<u>TIME OF MEASUREMENT</u>
Atmospheric Temperature	(1) AFGL Payload B ₁	T ₂ - 25 minutes
	(2) AFGL Payload B ₂	T ₂ + 55 minutes
	(3) ASL Small Rocket Payload (10 each)	Several times during course of elcipse
	(4) DMSPF-2 Satellite (Block 5)	Early morning and local noon
	· 850 km circular orbit	· Temperature through stratosphere
Atmospheric Temperature	(5) TIROS N Satellite	Approximately 30 samples per day at latitudes of interest
	· 500 km circular orbit	· Temperature through stratosphere
Aerosols	(1) NASA Payloads, N-5,N-7	T ₂ - 2.5 minutes
		T ₂ + 12 hours
		· Instrumented with flashing visible and UV lamps and a collecting electrode. Parachute deployed

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