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STRATCOM-VIII SCIENTIFIC OBJECTIVES AND MISSION ORGANIZATION

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STRATCOM-VIII

SCIENTIFIC OBJECTIVES

and

MISSION ORGANIZATION

Compiled by

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STRATCOM-VIII Scientific Objectives

ABSTRACT

STRATCOM (STRATospheric COMposition) is a long term, multi-purpose program for integrated, correlated measurements of stratospheric parameters related to composition, thermodynamics, and radiative balance, primarily by the use of balloon-borne instruments. The eighth operation in this series took place in late September, 1977, with large balloons launched from the Holloman Air Force Base in New Mexico, and ground observations and small rockets and balloons from the nearby White Sands Missile Range. The prime objective of the STRATCOM-VIII effort is the study of stratospheric photochemistry, with emphasis on the ozone-NO_x-ultraviolet flux interactions, but also including members of the chlorine, water vapor, and carbon-containing families. Secondary objectives include (1) study of the balloon environment, (2) comparison of independent measurements of ozone and of NO, (3) development of new sensor systems and (4) some measurements for exploratory purposes.

The prime platforms are two large balloons: VIII-a has a payload consisting mostly of instruments for in-situ measurements; VIII-b has a payload mostly of instruments for remote measurements. It was planned that VIII-a would be launched at sunrise and remain aloft for about 33 hours; VIII-b would be launched a few hours after the launch of VIII-a so that both will be observing during sunset. In addition, simultaneous aircraft, rocket, and small balloon flights, and ground based measurements were planned.

The actual flights took place on September 28-30, with the flight

of the VIII-b balloon for the observation of sunset on September 28, and the VIII-a balloon for a 24-hour period of observations beginning just after sunrise on the 29th. Most, but not all, systems and instruments performed as planned, and it is believed that data are available to achieve most of the planned scientific and engineering objectives. The emphasis on photochemistry in the 35 to 40 km region is greater than anticipated, and observations are more complete for sunset than for sunrise.

This report is a discussion of the planned instruments and objectives, and a summary of the flight operations partly for the mutual information of those participating and partly for the wider scientific community.

INTRODUCTION

Although the stratosphere has been studied for a number of years, interest in that region has recently intensified. Man's activities on the surface of the earth and in the stratosphere itself may result in long-term changes in the stratosphere, which, in turn, may have an effect at the earth's surface. The problems are varied and may be posed in terms of aerosol content, carbon dioxide content, or NO and chlorine content, but the real concern is about any resultant changes in the ozone content and the temperature profiles.

Because of the great variability in the distribution of many of the trace species in the stratosphere, and our less-than-complete understanding of the photochemistry and transport, a definitive and detailed characterization of the stratosphere has proven difficult. One of the several possible approaches to this problem is to obtain vertical profiles of many parameters simultaneously at a particular place. From an engineering and operational viewpoint this is a difficult task. However, it was partly for the purpose of finding ways of overcoming such difficulties that the STRATCOM series of operations has been established.

The STRATCOM (STRATospheric COMposition) series of balloon-borne investigations was initiated in 1968 by the Army's Atmospheric Sciences Laboratory (ASL) at White Sands Missile Range (WSMR) under the direction of Dr. Harold N. Ballard. In 1971, the AEC's Sandia Laboratories, including Dr. Frank P. Hudson as theorist, became a major participant. Over the years, a number of other laboratories have sponsored experimenters, with the University of Texas at El Paso currently providing integration and operations support. In 1976, NASA provided a modest portion of the overall support for STRATCOM-VII. For STRATCOM-VIII, scheduled for fall 1977, the NASA contribution has increased, and now includes several NASA supported experiments. A summary of the STRATCOM program, its history, purposes, organization, and participants, may be found in Appendix

This report focuses on STRATCOM-VIII. Launch of two large balloons occurred September 28 and 29, 1977 at Holloman Air Force Base (32^{o}N latitude) in New Mexico during the fall turn-around period for stratospheric winds. Related flights and observations were made from nearby sites in the White Sands Missile Range. This report emphasizes the scientific objectives of the mission, and includes a preliminary description of flight operations.

MISSION COMPLEMENT

The organizers of the STRATCOM-VIII effort, Harold Ballard and Frank Hudson, in consultation with the Upper Atmospheric Research Office at NASA Headquarters, have tried to ensure that certain parameters critical to the understanding of stratospheric structure and photochemistry will be well defined, that the sensor systems are complementary, being neither unduly duplicative nor grossly unrelated, and that there is some room for the unanticipated, for serendipity.

Most, but not all, of the sensor systems included in the STRATCOM-VIII effort have had previous successful flight experience, so that there was a high degree of expectation that good data on the ozone and NO content and uv fluxes, and on various other trace constituents can be obtained for use in the study of the stratospheric photochemistry. This was an opportune time for a comparison of a variety of sensors and techniques for the measurement of ozone in the stratosphere. Finally, since the various experimenters are not funded by a single entity, but by a number of different agencies, there are objectives specific to each sensor.

The STRATCOM-VIII effort involves a complex series of measurements during a 36-hour period. See Table 1 and Fig. 1. Most measurements will be made between morning and evening of the first day. Included are:

Balloon VIII-a (in-situ and remote sensors)	21.7×10^6 ft^3
Parachute drops from balloon VIII-a (three)	
Balloon VIII-b (remote sensors)	11.6×10^6 ft^3
Rocket flights (four different payloads)	

Meteorological rocket flights (10)

Meteorological balloon flights

Rawinsondes (15)

Ozonesondes (2 types)

U-2 aircraft (remote and in-situ sensors)

Ground measurements

Meteorological

Ozone

Ionospheric

Tracking and telemetry

The parameters to be measured and the various instruments are cross-referenced in Table 2.

Table 1. Instruments and Systems

Platform	Instrument/System	Person	Organization
VIII-a Basic System			
	Balloon Design	Arthur Korn, Code LCB	AFGL
	Flight Control	Duke Gildenberg	AFGL/HAFB
	Balloon Launch support	Joseph Koehly	AFGL/HAFB
	Mechanical structure	Hector Carrasco Gustavo Cordova John Whitacre	UTEP
	Payload integration	Miguel Izquierdo Svi Salpeter Preston Herrington	UTEP Sandia
	Control and telemetry	Miguel Izquierdo Preston Herrington	UTEP Sandia
	Power Supply	Claude Tate	ASL
	State of Health Instruments Package temperatures Levelness indicator Magnetometers Other payload monitors	Preston Herrington	Sandia
Experiments			
	UV filter photometer	Bach Sellers	Pan
	UV spectrometer	Bernard Zak James Mentall, Code 624	Sandia NASA/GSFC
	UV spectrometer (skylight)	Rex Megill K. D. Baker Larry Jensen Jagir Randhawa	USU ASL
	Filter photometers (2)	Rex Megill	USU
	UV filter photometer ozone sonde	Arlin Krueger David Wright, Code 912 Peter Simeth	CSU NASA/GSFC SenTran
	Chemiluminescent ozone sonde (2)	Jagir Randhawa	ASL

Platform	Instrument/System	Person	Organization
	Dasibi ozone monitor	John Ainsworth, Code 624	NASA/GSFC
	Cryogenic sampler	Richard Lueb Leroy Heidt	NCAR
	Gas chromatograph	Robert Woods Leroy Heidt Richard Lueb	Sandia NCAR
	Water vapor sensors (Al_2O_3)	Philip Goodman	Pan
	Air temperature sensors	Harold Ballard	ASL
	Air pressure sensors	Harold Ballard	ASL
	IR Pyranometer (nadir)	Robert Rubio	ASL
	Visible Pyranometer (nadir)	Robert Rubio	ASL
	Nikon camera (nadir)	Robert Rubio Claude Tate	ASL
	Blunt Probe Kr Lamp Gerdien Condenser	Jack Mitchell Les Hale	UTEP Penn
	Wind Anemometer	Carlos McDonald	UETP
	Apex plate payload: Air Temperature sensor Balloon skin temperature	Carlos McDonald	UTEP
	Pyranometer, IR and visible Lyman-alpha intensity Levelness indicator Humidity sensor	Robert Rubio	ASL
	Water vapor sensor (Al_2O_3)	Philip Goodman	Pan
	Parachute drop no. 1 Chemiluminescent NO sonde	Rex Megill Alan Shaw	USU
	Filter photometers, O_3 and albedo	Rex Megill	USU
	Chemiluminescent ozone detector	Jagir Randhawa	ASL
	Parachute drop no. 2: Krypton lamp-Gerdien Condenser	Leslie Hale Charles Croskey	Penn
	Parachute drop no. 3: Al_2O_3 water vapor sensor	Philip Goodman	Pan

Platform	Instrument/System	Person	Organization
VIII-b	IR spectrometer	David Murcray John Williams	U. Denver
	IR radiometers(air temp)	David Murcray Don Snider Robert McClatchey	U. Denver ASL AFGL
	Air temperature sensors	Harold Ballard	ASL
	Structure, telemetry, integration, power	David Murcray	U. Denver
Super Loki rocket	UV filter photometer ozone sonde	Arlin Krueger David Wright Charles Manion	CSU NASA/GSFC NASA/WFC
Arcas rocket	Chemiluminescent ozone sonde	Jagir Randhawa	ASL
Arcas rocket	Gerdien condenser	Jack Mitchell	UTEP
Super Loki rocket	Blunt probe	Jack Mitchell	UTEP
Data sonde rocket	Meteorological data	Stan Kubinski	ASL
Radiosonde balloon	Meteorological data	Stan Kubinski	ASL
Small balloon	MAST ozone sonde	Jagir Randhawa	ASL
Small balloon	ECC ozone sonde	Charles Manion	NASA/WFC
U-2 Aircraft	Senior contact	Leo Poppoff	NASA/ARC
	IR spectrometer	David Murcray	U. Denver
	SAS-II (NO, NO_2, O_3)	Max Loewenstein M/S245-5 Walter Starr	NASA/ARC
	Cryogenic sampler	Edward Inn James Vedder Bennett Tyson	NASA/ARC
	Aerosol impact collector	Neil Farlow Guy Ferry Ken Snetsinger	NASA/ARC
	Water vapor overburden	Peter Kuhn	NOAA/ERL

Platform	Instrument/System	Person	Organization
Ground	Dobson ozone spectrophotometer	Jagir Randhawa	ASL
	Filter UV photometer	Peter Simeth	SenTran
	Pyranometer-visible	Robert Rubio	ASL
	Partial reflection ionosonde C-3 Ionosonde	Robert Olsen	ASL
	Meteorology, forecasting	Duke Gildenberg	AFGL/HAFB
	Meteorology, post flight analysis	John Bujnach	UST
	Tracking	Alton Duff Tillman Powell	ASL
	Data acquisition and reduction	Miguel Izquierdo Edward Avila George Holmack	UTEP WSMR
	Missile Range support	Robert Jones Leland Robertson	WSMR ASL
	Photochemical modeling	Frank Hudson José Serna	DOE PSL
	Model, balloon environment	Richard Davis, M/S 474	NASA/LaRC
	Scientific publications	Edith Reed,Code 624	NASA/GSFC
	Overall management	Harold Ballard	ASL

ORGANIZATIONS

AFGL	Air Force Geophysics Laboratory Hanscom Air Force Base, Massachusetts 01731
AFGL/HAFB	Detachment 1, Balloon Branch Air Force Geophysics Laboratory (AFCS) Holloman Air Force Base, New Mexico 88330
ASL	Atmospheric Sciences Laboratory US Army Electronics Command White Sands Missile Range, New Mexico 88002
CSU	Department of Atmospheric Sciences Colorado State University Fort Collins, Colorado 80523
DOE	Environmental Research Department of Energy Washington, D. C. 20545
NASA/ARC	Space Sciences Division Ames Research Center Moffett Field, California 94035
NASA/GSFC	Goddard Space Flight Center Greenbelt, Maryland 20771
NASA/LaRC	Langley Research Center Hampton, Virginia 23665
NASA/WFC	DO-PMOB-PMS (ASRP) Wallops Flight Center Wallops Island, Virginia 23337
NCAR	National Center for Atmospheric Research P. O. Box 3000 Boulder, Colorado 80303
NOAA/ERL	Atmospheric Physics and Chemistry Laboratory NOAA Environmental Research Laboratories Boulder, Colorado 80303
Pan	Panametrics, Inc. 221 Crescent Street Waltham, Massachusetts 02154
Penn	Ionosphere Research Laboratory Pennsylvania State University University Park, Pennsylvania 16802

PSL	Physical Sciences Laboratory New Mexico State University Las Cruces, New Mexico 88001
Sandia	Division 9226 Sandia Laboratories Albuquerque, New Mexico 87115
SenTran	SenTran Company 2705 de la Vina Street Santa Barbara, California 93105
UDenver	Department of Physics and Astronomy University of Denver Denver, Colorado 80208
UTEP	Electrical Engineering Department University of Texas at El Paso El Paso, Texas 79968
UST	Institute for Storm Research University of St. Thomas Houston, Texas 77006
USU	Center for Research in Aeronomy Utah State University Logan, Utah 84322
WSMR	White Sands Missile Range New Mexico 88002

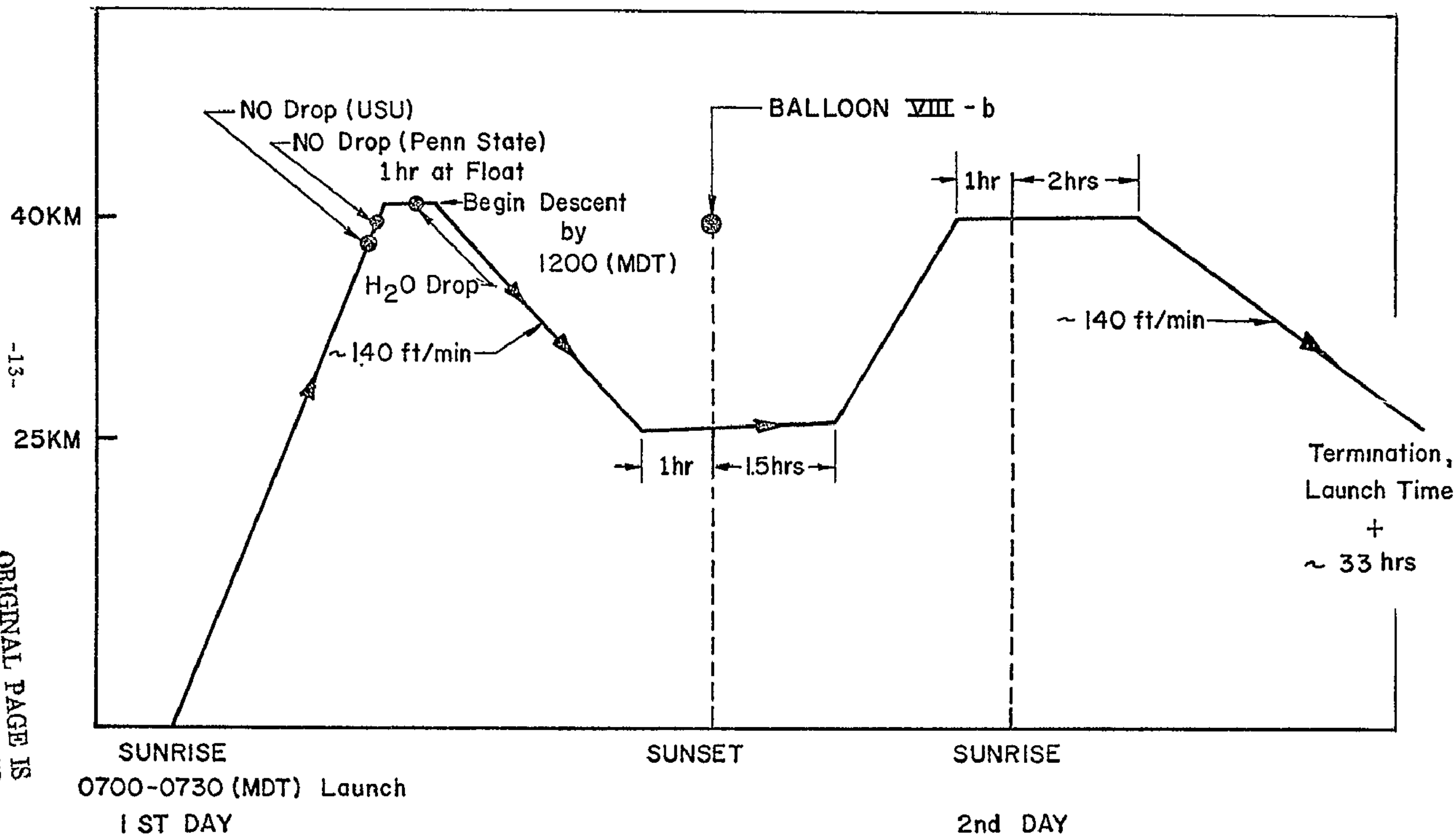


FIGURE 1. STRATCOM VIII-a Flight Profile (Planned)

Parameter	Balloon VIII-a: Package temperatures (San)	Levelness indicator (San)	Magnetometers (San)	UV filter photometer (Pan)	UV spectrometer (San/GSFC)	UV spectr skylight (USU)	Filter photometers (USU)	UV filter photo O_3 (CSU/GSFC/Sen)	Chemilum O_3 (ASL)	Dasibi O_3 (GSFC)	Cryogenic sampler (NCAR)	Gas chromatrograph (San/NCAR)	Water vapor-Al_2O_3 (Pan)	Air temp thermistor (ASL)	Air pressure (ASL)	IR/visible pyranom. (ASL)	Nikon camera (UTEP/ASL)	Blunt probe (UTEP/Penn)	Gerdien Condenser (UTEP/Penn)	Kr lamp (Penn/UTEP)
O_3 overburden				X	X		X	X												
O_3 in-situ									X	X										
H_2O											X		X							
CO_2											X									
CO											X									
NO																				
NO_2																				
HNO_3																				
N_2O											X									
N_2O_5																				
$CFCl_3$											X	X								
CF_2Cl_2											X	X								
$ClONO_2$																				
CCl_4												X								
CH_3Cl												X								
$CHCl_3$, CH_3CCl_3												X								
CH_4											X									
H_2											X									
Sky flux						X														
Earth flux							X									X	X			
Lyman alpha																				
solar UV				X	X															
air temp.														X						
air pressure															X					
aerosols																				
conductivity																		X	X	
ion mobility, ρ																			X	
attitude		X	X			X											X			
status param.	X																			

Parameter	Apex plate: Air temp thermistor (UTEP)	Balloon skin temp. (UTEP)	Pyranometer (ASL)	Lyman-alpha (UTEP)	Humidity, resistance (UTEP)	Water vapor, Al_2O_3 (Pan)	Parachute drops: Chemiluminescent NO (USU)	Chemiluminescent O_3 (ASL)	Filter photometers (USU)	Kr lamp Gerdien (Penn)	Water vapor, Al_2O_3 (Pan)	Balloon VIII-b: IR spectrometer (UDen)	IR radiometers (UDen/ASL/AFGL)
O_3 overburden									X			X	
O_3 in-situ								X					
H_2O					X	X					X	X	
CO_2													
CO													
NO							X			X		X	
NO_2												X	
HNO_3												X	
N_2O												X	
N_2O_5												/	
$CFCl_3$													
CF_2Cl_2												/	
$ClONO_2$												/	
CCl_4													
CH_3Cl													
$CHCl_3$, CH_3CCl_3													
CH_4												X	
H_2													
Sky flux			X										
Earth flux									X				
Lyman alpha				X									
solar UV													
air temp.	X												X
air pressure													
aerosols													
conductivity										X			
ion mobility, ρ										X			
attitude													
status param.		X											

Parameter	Rockets: UV filter photo O_3 (CSU/GSFC/Sen)	Chemiluminescent O_3 (ASL)	Gerdien (UTEP)	Blunt probe (UTEP)	Small balloons: MAST O_3 (ASL)	ECC O_3 (WFC)	U-2 aircraft (ARC): IR spectrometer (UDen)	SAS-II (ARC)	Cryogenic sampler (ARC)	Aerosol collector (ARC)	H_2O overburden (NOAA/ERL)	Ground: Dobson O_3 (ASL)	Partial refl ionos (ASL)	C-3 ionosonde (ASL)	UV filter photo. O_3 (Sen)
O_3 overburden	X						X					X			X
O_3 in-situ		X			X	X		X							
H_2O											X				
CO_2															
CO															
NO								X							
NO_2								X							
HNO_3							X								
N_2O							/		X						
N_2O_5															
$CFCl_3$							X		X						
CF_2Cl_2							X		X						
$ClONO_2$															
CCl_4							/		X						
CH_3Cl									/						
$CHCl_3$, CH_3CCl_3									/						
CH_4							X								
H_2															
Sky flux															
Earth flux															
Lyman alpha															
solar UV															
air temp.															
air pressure															
aerosols										X					
conductivity			X	X											
ion mobility, ρ			X										X	X	
attitude															
status param.															

Table 2. Parameters to be Observed.

(3) In the early afternoon, balloon VIII-a will descend slowly to about 25 km. During the descent, cryogenic samplers will collect 7 air samples which will later be analyzed for fluorocarbons (CFM's), N_2O, CO, CO_2, CH_4, H_2, and H_2O. Simultaneously, an on-board gas chromatograph will be operating to provide data on halogen compounds: CCl_4, methyl chloride, chloroforms, and CFM's. If the gas chromatograph is not ready for this flight, a second cryogenic sampler will be flown, increasing the total number of air samples to 14.

(4) Meanwhile, also in the afternoon of the first day, balloon VIII-b will be launched, so that the altitude profile of various constituents may be observed remotely during sunset. The spectral range to be observed is expected to provide data for NO, NO_2, N_2O, HNO_3, O_3, and possibly on N_2O_5 and $ClONO_2$.

(5) If the flights occur before October 1, it is planned at about the time of the parachute drops that one and possibly two U-2 aircraft containing stratospheric sensors will fly from the Ames Research Center to the WSMR vicinity, with a loiter time of about one hour. The IR spectrometer on the U-2 covers a spectral range chosen to obtain data on HNO_3, CH_4, CFM's, and N_2O. An additional sensor will be used to capture aerosols for later examination. The chemiluminescent sensor (SAS-II) will be used for NO, NO_2, and O_3 and a cryogenic sampler will be used to collect air samples for analysis for N_2O, CFM's, CCl_4, and, possibly, $CHCl_3$ and CH_3CCl_3. These measurements will be at altitudes in the vicinity of 20 km.

(6) Two scientific rocket flights for ozone altitude profiles are planned, one including the in-situ chemiluminescent ozone sonde, the

other a filter photometer for ozone overburden, probably in mid-morning of the first day.

(7) Two scientific rocket flights related to atmospheric electrical conductivity, ion mobility and ion density are planned for the afternoon of the first day. One payload is a Gerdien condenser and the second a blunt probe.

(8) Structural parameters (pressure, air temperature, and winds) will be observed from balloon VIII-a by temperature and pressure sensors, from VIII-b by pressure and an IR temperature sensor, and from flights of meteorological rockets and balloons.

(9) After sunset, ballast will be released from balloon VIII-a so that it will again rise to well above 30 km. Through the night, ozone will continue to be measured by two different techniques. Just prior to sunrise the next day, the ozone solar uv instruments will resume operation, providing data on the uv flux and the ozone overburden. Descent will begin in mid morning, with the gas chromatograph again providing data on a number of halogen compounds.

The set of data resulting from these operations should be highly valuable for checking the ability of a photochemical model to produce altitude profiles of the various trace species consistent with the observed uv fluxes and trace species, over the diurnal cycle. A model expressly for this purpose, that is, for the computation of the distributions of trace species for specific places and times, has been constructed by F. Hudson, and will be used with these data.

Post flight comment:

Most of these operations relating to photochemistry occurred as planned. Significant deviations are as follows:

Because the balloon remained at float altitude for a period longer than planned most of the data is between 30 and 40 km. Data is not available from the first parachute drop. The gas chromatograph was replaced by an additional cryogenic sampler. Since only one U-2 was available, the U-2 cryogenic sampler and the H_2O radiometer were not flown; the SAS-II, the IR spectrometer and the aerosol collectors were flown as planned. Balloon VIII-b was launched September 28, observing the sunset immediately preceeding the launch of balloon VIII-a. Data transmission from Balloon VIII-a ended shortly after sunrise, 24 hours after launch, with the balloon at about 30 km altitude.

Balloon environment

Two aspects of the balloon environment are important to experimenters: (1) the thermal history of instrumentation, and (2) the composition and temperature perturbations to the atmosphere in the immediate vicinity of the balloon. Data on both aspects will be obtained from balloon VIII-a.

Since the balloon will be aloft for 33 hours, it will experience a wide range of solar irradiation; its nighttime ascent will provide data on the effects of changing air temperature and densities. Temperature sensors are located in a number of the experimental packages of varying internal power dissipation and external configurations. Considerable care has been taken in the design and construction of the VIII-a main payload to minimize perturbations to the environment, by the use of pressure tight containers and surface finishes which minimize outgassing.

For the study and measurement of the thermal environment in the immediate vicinity of the balloon, data is obtained both on the skin temperature of the balloon and on the air temperature. Skin and air temperatures are measured near the apex plate of the balloon, along with a pyranometer to measure the radiation input. On the main payload, suspended about 200 m below the balloon, are additional air temperature sensors, a pressure sensor, and two pyranometers to measure the upwelling radiation.

For studies of water vapor emission from the balloon and payload, several sensors are strategically located. Two types of water vapor sensors will be located on the apex plate at the top of the balloon;

additional water vapor sensors are located on the main payload. An Al_2O_3 water vapor sensor is being dropped from the main payload after the balloon has reached its peak altitude. The data from the drop sonde together with the observations during the various ascents and descents should give a good indication of the history and shape of the water vapor cloud surrounding the balloon and payload.

A model has been developed at Langley Research Center which describes air temperatures in the vicinity of the balloon. The water vapor problem is more complex, and its description thus far has been largely empirical.

Post flight comment:

Full data on the environment of balloon VIII-a is available for about the first five hours after launch (after which apex plate telemetry was lost) which can be used to define the initial conditions near the balloon and their rate of change. No data will be available for studies dependent on the comparison of cloud shapes during slow descent and ascent. Excellent information is expected regarding the environment of the main payload as it remained at float altitude for over 20 hours and regarding the perturbations to the balloon environment due primarily to changes in solar zenith angle.

Comparison of techniques

The STRATCOM-VIII effort is unique in the large number of platforms, mostly balloons and rockets, planned for flight in a short period of time. The closeness of the flights is limited by the availability of telemetry frequencies, ground stations, and tracking capabilities. This effort does provide the opportunity for the comparison of techniques, not only among balloon-borne systems, but also among rocket, aircraft, and ground based systems. Among the comparisons, the prime emphasis in the effort is the comparison of techniques for the measurement of ozone; most of these techniques have been widely used. Several systems for NO will also be used, but these have a shorter history of experience. The results of two cryogenic air sampling systems, prepared and analyzed by different groups, and the results from a balloon-borne gas chromatograph are expected to be complementary to each other.

A. Ozone

The VIII-a balloon is the principal platform for ozone sensors, and includes three in-situ (two identical chemiluminescent sondes and the Dasibi ozone monitor), and four remote (the CSU/GSFC filter photometer, the USU filter photometer, the Panametric filter photometer, and the Sandia/GSFC spectrometer). A second type of remote measurement of ozone can be obtained from the IR solar absorption spectrometer of the VIII-b balloon; during ascent the ozone is deduced from the change in overburden, and during sunset, from the absorption as a function of elevation angle. Auxiliary launches provide additional vertical profiles and range: The parachute dropped NO-sonde includes a USU filter photometer for ozone and an engineering model of the chemiluminescent ozone sonde. Standard meteorological-type rocket payloads, one with the chemiluminescent ozone monitor and one with the uv filter photometer, will be flown; these rockets will extend the altitude range well above the balloon maximum altitude of about 40 km. The Mast and the ECC balloon borne ozone sondes will provide additional profiles of ozone in the troposphere and lower stratosphere. Finally, the total ozone will be monitored from the ground with the Dobson spectrophotometer. There is a faint possibility that the Nimbus-4 BUV ozone spectrometer may obtain data in the vicinity of the STRATCOM-VIII flights. There have been previous "fly-offs" among tropospheric balloon sondes, among rocket sondes, and among satellite instruments, but none with the heavy emphasis on the balloon systems in the stratosphere.

Post flight comment:

Of the 16 ozone sensors to be flown on the various platforms, almost all provided data as needed for the comparison of techniques. Only those on the first parachute drop (a chemiluminescent sonde and a uv filter photometer) did not result in data; however similar instruments on the main gondola did provide data. The MAST balloon sondes provided a tropospheric ozone profile on September 29 and a profile up to 10 mbar in the stratosphere on September 30. Nimbus-IV, with the BUV instrument, did not happen to be near HAFB during the days of flight. A late addition to the ozone-sensitive instruments is a ground based filter photometer for total ozone using filters at the "Dobson" wavelengths.

B. Nitric Oxide:

The remote sensing of NO with an infrared spectrometer (balloon VIII-b) has been done for several years; likewise, the U-2 aircraft-borne SAS-II chemiluminescent instrument has had considerable flight experience. The parachute dropped chemiluminescent sonde is a new system. There is limited experience with the Krypton lamp-Gerdien condenser system. In the STRATCOM-VIII flights, the simultaneous observations by the various systems will permit comparison of data from three different techniques and represents a major step in the engineering and proof of the parachute drop system.

Post flight comment:

The comparison of the NO techniques was partially successful. On September 28, the IR solar absorption spectrometer on balloon VIII-b and the in situ SAS-II instrument on the U-2 both provided optimum data for comparison with each other. On the next day, the chemiluminescent NO dropsonde failed to provide data; the Kr lamp-Gerdien condenser drop sonde and the SAS-II instrument on the U-2 were both satisfactory.

C. Cryogenic samplers and in-situ gas chromatography:

These systems on balloon VIII-a and the U-2 are comparable in the sense that, for both, gas chromatography is used in the analysis of the contents of the collected samples; hence both techniques provide values on the CFM's, N_2O, CCl_4, and some other species. Since one sampler and the gas chromatograph are on balloon VIII-a, collecting in the 25 to 40 km range, and the other is on the U-2, at least 5 km lower, the data will not be simultaneous in place; the U-2 data may be used to extend the balloon data to a lower altitude. The balloon-borne version of the gas chromatograph is new; this flight should confirm the considerable engineering accomplishment.

Post flight comment:

The gas chromatograph was not ready and was replaced by a second cryogenic sampler. The U-2 cryogenic sampler was not flown because only one U-2 was available. Hence the prime use of the sampler data will not be in comparisons but will be in the photochemical studies.

Engineering and exploratory

There are some instruments in the STRATCOM-VIII campaign which are included not so much because their data are needed to fulfill the major objectives, but for other reasons. Two infrared radiometers, at the 4.3 and 15 micron emission lines of CO_2 are being flown to check their ability to measure air temperatures accurately. The radiometer data will be compared with balloon and rocket-borne in-situ temperature measurements. A Lyman-alpha sensor (121.6 nm) is being flown as part of the Apex package on balloon VIII-a. If, perchance, it should observe substantial Lyman-alpha emission, the other data from the STRATCOM-VIII flights will be needed to define the circumstances under which such Lyman-Alpha emissions can penetrate to balloon altitudes. Both a blunt probe and a Gerdien condenser are included for conductivity measurements. There have been some little understood changes in conductivity near sunset/sunrise which need study. It has been the experience of past STRATCOM efforts that one cannot completely predict which of the data will be the most interesting and valuable.

Post flight comment:

As might be expected, almost all the instruments which did not provide useful data were among those which were included primarily for initial evaluation: the gas chromatograph was not flown; the NO dropsonde system is new; the chemiluminescent ozone instrument included on the NO sonde is new; of the two new IR radiometers the 4.3 micron instrument did not provide data, the 15 micron instrument did; the loss of data from the apex package did not permit Lyman-alpha data through high noon, as desired. Satisfactory data were obtained from the conductivity instruments on the main payload.

EXPERIMENT OBJECTIVES

Each of the experimenters was asked to provide a statement regarding the scientific objectives pertaining to his participation in the STRATCOM-VIII effort and a brief description of his instrument and its expected accuracy. The responses, somewhat edited, are included in this section. In general, these objectives relate primarily to the use of data from a single sensor and complement the Mission Objectives outlined in the previous section.

The instruments are arranged alphabetically according to the organization of the responsible scientist.

Atmospheric Sciences Laboratory

Air temperature sensors	Ballard
Air pressure	Ballard
Ozone instruments	Randhawa
Pyranometers	Rubio
Camera	Rubio/Tate

Colorado State University

Filter ozone sensor (ROCOZ) (with GSFC, SenTran, and WFC)	Krueger

NASA/Ames Research Center

Aerosol impact collector	Farlow
Cryogenic sampler	Inn
SAS-II (NO_x family)	Loewenstein

NASA/Goddard Space Flight Center

Dasibi ozone monitor	Ainsworth
UV spectrometer (with Sandia)	Mentall

National Center for Atmospheric Research

Cryogenic sampler	Lueb
Gas chromatograph (with Sandia)	Heidt

NOAA/Environmental Research Laboratory		
	Water vapor radiometer	Kuhn
Panametrics, Inc.		
	Water vapor sensors	Goodman
	UV filter spectrometer	Sellers
Pennsylvania State University		
	Kr lamp-Gerdien condenser	Hale
SenTran		
	Filter photometer (ground)	Simeth
University of Denver		
	Thermal emission spectrometer	Murcray
	Solar absorption spectrometer	
	IR radiometers for air temperature (with ASL and AFGL)	
University of Texas at El Paso		
	Apex package	McDonald
	Anemometers	McDonald
	Blunt probe and Gerdien condensers	Mitchell
Utah State University		
	Sky spectrometer	Baker
	Filter photometer	Megill
	Chemiluminescent NO drop sonde	Shaw

Air temperature

Balloon VIII-a

Balloon VIII-b

Harold N. Ballard
Atmospheric Sciences Laboratory
US Army Electronics Command
White Sands Missile Range
New Mexico 88002

Instrument:

A coupled pair of identical film-mounted spherical bead thermistors serve as air temperature sensors aboard both Balloons VIII-a and VIII-b. The VIII-a payload will be reeled downward approximately 200 m beneath the balloon. The thermistor mounts are arranged in such a way so that when solar radiation is incident in a direction which is perpendicular to one film, then the direction of the incident solar ray is parallel to the second film. As the payload rotates during the flight (its rotation rate relative to the earth's magnetic field is sensed by a magnetometer), the temperature of each sensor will vary depending on the orientation of the film surfaces with respect to the sun. The maximum difference in the temperatures recorded by the two identical sensors gives an experimental determination of the maximum solar radiation correction to the temperatures recorded by the film-mounted thermistors; the lesser of the two temperatures is taken to represent the atmospheric temperature (all other corrections being negligible). During the times of the flight when the thermistors and film mounts are totally shaded from directly incident solar radiation, and during the night, no correction need be applied to the recorded temperatures. Thus accurate ($\pm$ 1°C) measurements of the atmospheric temperature can be made throughout the course of the flight without recourse to theoretical corrections to the observed temperatures.

Objectives:

1. To measure the detailed temporal and spacial variations in the meteorological parameters of temperature, pressure, and density (derived) at times of darkness, sunrise, and daylight, the daylight variations to be related to the measured uv solar flux. Implicit in this objective is the determination of the diurnal tidal temperature variation at altitudes above 30 km.

2. To serve as a tool for obtaining detailed information concerning the balloon and payload behavior.

3. To provide background data for temperature-dependent experiments.

Air pressure

Balloon VIII-a

Harold N. Ballard
Atmospheric Sciences Laboratory
US Army Electronics Command
White Sands Missile Range
New Mexico 88002

Instrument:

The pressure measurement is made by a Model 830J Rosemont sensor which utilizes the principle of a changing pressure to change correspondingly the capacitance of the pressure sensitive element. The sensor's range is stated to be from zero to 100 Torr (14 km); however, the sensor will not be activated until an altitude of 20 km (41 Torr) is reached during the balloon ascent. The resolution of the sensor is specified by the manufacturer as infinitisimal; however, associated electronic and pressure read-out systems limit the resolution to 4.4×10^{-2} Torr. Thus in the vicinity of an altitude of 30 km the pressure resolution corresponds to an altitude resolution of approximately 33 meters.

Objective:

To provide data for use in conjunction with the air temperature data for study of atmospheric structure.

Ozone instruments

Chemiluminescent ozonesonde
Balloon VIII-a main gondola
(two identical instruments)
Balloon VIII-a drop sonde No. 1
Arcas rocket drop sonde

Jagir Randhawa
Atmospheric Sciences Laboratory
US Army Electronics command
White Sands Missile Range
New Mexico 88002

MAST balloon sonde

Dobson spectrophotometer

Instruments:

1. The chemiluminescent ozonesonde to be flown with the STRATCOM balloon flight consists of two main parts:

a. A constant-volume sampling pump made from TEFLON is used for the intake of the air sample. Sample is drawn at the rate of 200 milliliters per minute.

b. Ozone is detected by the chemiluminescent process (Rhodamine - B). Ozone molecules in the air sample flow over the detector and the photons produced by the destruction of ozone molecules on the chemiluminescent material are monitored by the photomultiplier tube, the output signal from which is transmitted to the ground receiver.

2. A sketch of the balloon ozonesonde is shown below. The instrument is calibrated under simulated flight conditions in the laboratory and is capable of measuring ozone concentration with an uncertainty of ±10% of the actual concentration.

In addition to the two ozonesondes on the main payload and an experimental unit in dropsonde no. 1, the following experiments will be performed during the day of the balloon launch:

1. A rocket-borne chemiluminescent ozone sonde will be deployed to measure ozone profile from 60 to 15 km.

2. A chemical ozonesonde (Mast) will be launched on a small balloon to measure ozone concentration up to 30 km.

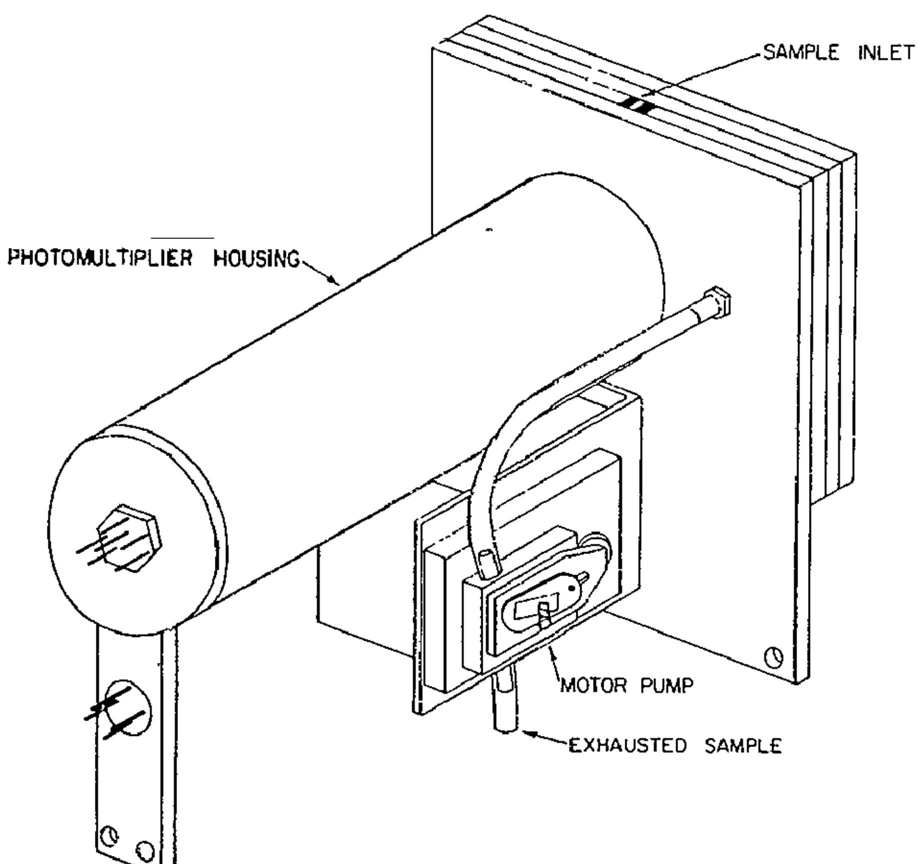
3. Dobson spectrophotometer will be in operation during the day of the balloon flight and will measure the total ozone present in the atmosphere.

Objectives:

1. Determination of ozone concentration in the troposphere and stratosphere.

2. Measurement of diurnal variation of the ozone density in the stratosphere and its importance to ozone photochemistry.

3. Comparison of ozone concentrations measured with other techniques on the same balloon.



BALLOON OZONESONDE

Pyranometers

Balloon VIII-a
Main gondola
Apex package

Robert Rubio
Atmospheric Sciences Laboratory
U. S. Army Electronics Command
White Sands Missile Range
New Mexico 88002

Instruments:

Visible pyranometer: This instrument to measure shortwave radiation is an Eppley Precision Spectral Pyranometer, Model PSP, with two concentric dome windows which provide a 180° field of view and a wavelength transparency of 0.28 to 2.8 micrometers. This radiometer comprises a circular multi-function thermopile with an approximate sensitivity of 8 mv/cal cm^{-2} min^{-1} and a one second time response. One instrument is mounted on the apex plate of the balloon and a second is on the main gondola, pointed earthward. The expected performance of 8.5% accuracy is based as follows:

Temperature	0.5%	
Linearity	0.5%	
Cosine response	0.5%	
Calibration	1.0%	
Non-levelness	8.0%	(due to balloon top plate wobble)

Infrared Pyranometer: This instrument is an Epply Precision Pyrgeometer with two concentric dome windows which provide a 180° field of view but which have a wavelength transparency of 4 to 50 micrometers. The Pyrgeometer sensor is a thermopile detector with an approximate sensitivity of 5 mv/cal cm^{-2} min^{-1} and a two second response time. It is mounted on the main gondola, pointed earthward. The expected performance of 5% accuracy is based on the following:

Temperature	1%
Linearity	2%
Calibration	2%

A correction for levelness and cosine response is not applicable since it is observing diffused radiation.

Objectives:

1. To obtain the variation of the earth and atmosphere's thermal radiation and of the scattered and reflected solar radiation, both as a function of altitude, solar zenith angle, earth albedo (cloud cover), and atmospheric content of O_3 and H_2O.

2. To study the transformation of radiative energy within the earth-atmosphere system using the pyranometer data and data from other instruments on Balloon VIII-a.

Camera

Balloon VIII-a

Robert Rubio
Claude Tate
Atmospheric Science Laboratory
U.S. Army Electronics Command
White Sands Missile Range
New Mexico 88002

Instrument:

Camera: Nikon Model F2AS with DS-1 automatic aperture control

Motor driven film transport MD-11, set at M-1

Lens: Nikon 16 mm full frame fisheye, 170° viewing angle, nadir

Speed set at 1/125 second

Film: Kodak Ektachrome MS-64, 250 frame pack, frame size: 35 mm square.

The film transport was keyed to the telemetry clock such that the time between exposures was about 5 minutes.

Objective:

To observe cloud structure, primarily as an aid in the interpretation of data from the nadir viewing pryanometers.

UV filter photometer ozone sonde (ROCOZ) Balloon VIII-a	Arlin J. Krueger Department of Atmospheric Science Colorado State University Fort Collins, Colorado 80523
Super Loki Dart rocket	David U. Wright, Code 912 Goddard Space Flight Center Greenbelt, Maryland 20771
ECC balloon sonde	Peter Simeth SenTran Company 2705 de la Vina Street Santa Barbara, California 93105
	Charles Manion DO-PMOB-PMS (ASRP) Wallops Flight Center Wallops Island, Virginia 23337

Instruments:

The ROCOZ optical ozone sonde determines the vertical ozone profile from measurements of the height gradient of relative solar irradiance in three narrow UV bands of about 3-4 nm width. The center wavelengths of these bands are selected for optimum sensitivity to ozone in adjacent height regions over the height range 20 to 60 km for rocket applications and 20 to 40 km for the STRATCOM balloon application. A fourth narrow band at a wavelength with a low ozone absorption coefficient is also included to monitor extraneous sources of signal change, such as Rayleigh attenuation. The nominal center wavelengths for the four channels and corresponding height regions for rocket instrument are as follows:

Channel	Center wavelength, nm	Altitude region, km
0	320	reference
1	304	20 - 35
2	283	32 - 47
3	255	45 - 60

For the STRATCOM balloon instrument, the center wavelengths for channels 2 and 3 chosen as appropriate for altitudes below 40 km because the balloon cannot reach altitudes where 255 nm data are useful. The STRATCOM center wavelengths and approximate altitude ranges are as follows:

Channel	Center wavelength, nm	Altitude region, km
0	319.7	reference
1	305.2	25 - 34
2	300.1	29 - 38
3	287.8	35 - 40

The 287.8 nm channel is also designed to observe ozone changes above the balloon ceiling altitude during the course of the experiment.

The ozone sonde operates over solar zenith angles from 0 to 84°. A flat plate diffuser with approximately Lambertian angular response is used as the first optical element such that acceptable signal levels are obtained at the detector over this range of angles. This diffuser was selected because light from the horizon is minimized and because such measurements are directly amenable to radiative transfer calculations.

The light from the diffuser plate passes through a beamsplitter and then through narrow-band interference filters mounted in a filter wheel. Visible and infrared light transmitted by the interference filter is removed with a broadband UV-filter. A quartz lens focuses light from the diffuser plate on a UV enhanced silicon photodetector. The lens also limits rays passing through the interference filter to 8.5° from the normal.

An amplitude modulation of the optical signals, caused by changes of the angle of incidence of sunlight on the diffuser, is removed in the following manner. A small percentage of the light from the diffuser plate is redirected by a 45° beamsplitter to a second photometer similar in construction to the primary UV-photometer, but sensitive to a fixed band near 375 nm. The output of this photometer feeds into the X input (denominator) of the dividing circuit. The output of the UV-photometer connects to the Z input (numerator). Changes in light input level (pendulation, rotation, or partial shading of the diffuser plate) affect both divider input signals equally and therefore, are cancelled in the dividing circuit. In the rocket instrument the output of the dividing circuit is commutated into four sample and hold circuits which are updated when their corresponding narrow-band filter is lined up with the UV-optical assembly. Each sample and hold circuit provides a 0-5 volt output signal to the telemetry system.

The compensation signal which is proportional to the input light level is also transmitted to the ground since it provides information about pendulation and rotation of the sonde.

A sixth output signal is derived from the thermistor which monitors the temperature of the UV-optical assembly. A Super Loki-Dart vehicle is used to deliver the ozone sonde to an altitude of 65 to 70 km. The actual measurements are made while the instrument package is descending on a 7 ft. starute (parachute). The measured data are transmitted to a ground station via an 8-channel PCM telemetry system (carrier = 1680 MHz). Because of telemetry channel limitations in the STRATCOM balloon gondola, the four UV channels are transmitted serially.

The instrument is designed such that the calibration is dependent only on effective ozone absorption coefficients for the UV filters. These coefficients are computed using detailed measurements of the filter transmission characteristics. The ozone densities are calculated directly from the flight measurements of attenuation in each kilometer of height change.

References

Krueger, A. J., P. Simeth, B. Ellefson, W. R. McBride, M. E. Hills, C. A. Flanagan, W. Gammill, D. U. Wright and S. Park, "Design of an Optical Ozonesonde for the Super Loki-Dart Rocket", NASA TP in preparation.

Krueger, A. J. and G. M. Foster, "Regular Rocket Ozone Sounding Data Report, March, April and May, 1976" available from ASRP, Code 912, GSFC, Greenbelt, Md. 20771, August 1976.

Krueger, A. J., G. M. Foster and D. U. Wright, "Scheduled Rocket Ozone Sounding Network Data - Quarterly report for the Period June, July and August, 1976" available from ASRP, Code 912, GSFC, Greenbelt, Md. 20771, February 1977.

Krueger, A. J., "The Mean Ozone Distribution from Several Series of Rocket Soundings to 52 km at Latitudes from 58°S to 64°N", PAGEOPH, 106-108, 1272-1280, 1973.

ECC balloon-sonde

The Electrochemical Concentration Cell uses an iodine-iodide redox electrode concentration cell for measurement of ozone from the surface to about 35 km altitude. Prior to flight it is calibrated in an absolute sense by comparison with a Dasibi ozone monitor. Total ozone deduced from the flight of such calibrated instruments matches total ozone values observed simultaneously with a Dobson spectrophotometer.

Objectives:

1. Simultaneous determination of the vertical ozone profile with measurements of other parameters and constituents important to ozone photochemistry.
2. A potential improvement in effective ozone absorption coefficients for the ozonesonde filters from coincident measurements of the solar spectrum.
3. A comparison of solar irradiances and ozone concentrations with other techniques on the same balloon.

One ozone sensor will be on the balloon VIII-a package for ozone profile data between the tropopause and ceiling altitude, for sampling of changes in the ozone above the balloon at ceiling, and for profile data during the daytime during the vertical maneuvers.

An additional ozonesonde will be on a Super Loki-Dart rocket launched from WSMR in conjunction with the balloon experiment. This has the advantages of extending the altitude range of the ozone profile to about 60 km and providing some information about spatial variations in ozone below the balloon ceiling.

A small balloon borne electrochemical (ECC) ozone sonde will be flown to provide a measure of tropospheric and lower stratosphere ozone by yet another method.

Aerosol Collector
U-2 Aircraft

Neil H. Farlow
Guy V. Ferry
Ken G. Snetsinger
Space Science Division
NASA/Ames Research Center
Moffett Field, CA 94035

Instrument:

The aerosol samples are obtained by a device which places collecting surfaces into the airstream below the wing and beyond the boundary layer. The collecting surfaces are specially made thin films supported on electron microscope screens, and thin (75 µm dia) palladium wires that are carbon-coated to prevent spreading of fluid particles. Impaction of aerosol particles larger than 0.01 µm is effected because of the aircraft's speed in the stratosphere. Collection surfaces are projected from, and returned to, a vacuum sealable flight module that is processed before and after flight under clean room conditions. Because of the sealable module design, collected samples are returned to the laboratory vacuum-sealed from the stratosphere without exposure to moisture in the lower atmosphere. Special treatment of the flight-exposed grids can then be made in controlled environmental chambers.

Objective:

Aerosol size distributions, physical state and chemical composition will be obtained at three altitudes (15, 18, 21 km) beneath the flight path of STRATCOM-VIII. Results will be compared to similar findings obtained throughout the previous year in tropical, temperate and polar regions. Of particular interest will be the continuing search for sea-salt fragments and NO_x/aerosol reaction products in stratospheric aerosols.

Cryogenic (LN_2) samplers

U-2 aircraft

Edward C. Y. Inn
James F. Vedder
Bennett J. Tyson
Atmospheric Experiments Branch
NASA/Ames Research Center
Moffett Field, CA 94035

Instrument:

Large volume collection with flow-through cryogenic (LN_2) samplers on board the NASA U-2 aircraft. Recovered samples analyzed by gas chromatograph-electron capture method. The sampling and analytical system have been successfully used in Alaska, Hawaii and Panama for similar measurements.

Objective:

To measure mixing ratios of halocarbons, N_2O, methane and other possible constituents in the lower stratosphere (up to 21.3 km). Data from these measurements will be intercompared with those from other experiments of STRATCOM-VIII measuring the same constituents. Data will also provide midlatitude mixing ratio profiles of these constituents as part of our meridional survey of profiles in the northern hemisphere.

Chemiluminescent NO, NO_2, and O_3 sensors
SAS-II
U-2 aircraft

Max Loewenstein
Walter L. Starr
Atmospheric Experiments Branch
NASA/Ames Research Center 245-5
Moffett Field, CA 94035

Instrument:

The Ames in situ stratospheric air sampler, SAS II, collects real-time data on NO, NO_2, and O_3 as part of an overall NASA program for stratospheric studies.

The air sampler system weighs 230 kg and is specially designed to be mounted in the instrument bay of the U-2 high altitude research aircraft. The stratospheric air sample enters the system through a ram scoop on the aircraft. Each instrument consists of an NO/O_3 chemiluminescence sensor; for ozone, the roles of first and second reactant in the NO sensor are reversed; in the case of NO_2 the sensor is preceded by a high temperature converter to dissociate these molecules to NO, at least partially. Light from the chemiluminescent reaction is detected by cooled photomultipliers operated in pulse counting mode. The chemiluminescence signals, along with a variety of pressures, temperatures, and system diagnostic measurements, are recorded on magnetic tape for later analysis.

A bottle of NO-in-N_2 calibration gas is carried on flights to allow periodic calibration of the NO sensors. The O_3 sensor and the NO_2 converter efficiencies are calibrated in the lab both before and after a flight operation.

The sampler has two modes of operation:

1. Automatic - In this mode, three minutes each are provided for measure, calibration, and null (zeroing) for each of the four constituent channels. The system is fully automatic in this mode.

2. Manual - In this mode, after three minutes of calibration and three minutes of null, a measurement period of arbitrary length can be selected by the pilot. At the end of the measurement period the calibration and null are repeated.

The system can be switched from one mode to the other at any time during the flight.

Objectives:

To measure concentrations of odd nitrogen species and ozone in the lower stratosphere. Measurements are made <u>in situ</u> at U-2 flight altitudes up to 21 km.

The data are used to test predictions of atmospheric models that are in use or under development at Ames Research Center, as well as to check the predictions of other atmospheric models.

Dasibi ozone monitor
Balloon VIII-a

John Ainsworth, Code 624
Goddard Space Flight Center
Greenbelt, Maryland 20771

Instrument:

The Dasibi ozone monitor contains a 0.71 meter absorption tube irradiated by the 253.7 nm mercury line from a uv lamp. The tube is alternately filled with a sample of the ambient atmosphere and with a sample of the ambient atmosphere from which all of the ozone has been removed (scrubbed). The instrument compares the absorptions of the consecutive samples to obtain the ambient ozone concentration. An important feature of the instrument is its ability to ensure that the total photon flux is the same for the consecutive measurements. The laboratory instrument has been modified to obtain greater resolution and accuracy in the measurement of ozone by operating the instrument at its maximum sensitivity and by measuring the zero reference associated with each ozone measurement. For stratospheric use, the instrument is placed in a pressurized container to prevent arcing of its high voltage components.

Objectives:

1. To obtain ozone measurements simultaneously with those from instruments based on other principles. For good comparisons, this should be over as great an altitude range as possible, both ascending and descending, both by day and by night.

2. To look for the detailed changes in the in-situ ozone content during the sunrise and/or sunset periods, preferably during a near-40 km portion of the flight. These transient changes may reflect the build-up and decay of ozone production processes.

3. Although data above the tropopause are of prime interest, it is desirable to obtain data from the tropopause to near ground level (either ascent or decent) partly to compare the results with the other ozone data to be obtained in this region, and partly to evaluate certain engineering changes in the instrument.

UV spectrometer
Balloon VIII-a

James Mentall, Code 624
Goddard Space Flight Center
Greenbelt, Maryland 20771

Bernard Zak
Sandia Laboratories.
Albuquerque, New Mexico 87115

Instrument:

The ultraviolet scanning spectrometer is an 1/8 meter Fastie-Ebert instrument manufactured by Ray Lee Instruments. Equipped with a 3600 1/mm holographic ruled grating, it has a measured resolution of 1.1 nm. The grating is driven by means of a cam and scans from about 190 to 290 nm in 3.6 sec. The dispersed photons are detected with an EMR 510F solar blind (CsTe photocathode) photomultiplier which has a nominal long wavelength cutoff of 320 nm. Although scattered light in the instrument is less than 1 part in 10^{-4}, it was necessary to place an interference filter in front of the entrance slit to obtain solar spectra down to about 30 km. This reduces the scattered light at 250 nm by more than 2 orders of magnitude while reducing the signal by a factor of 10. The efficiency at 240 nm (zero solar zenith angle) is 4.5×10^{-8} counts/photon.

The flight spectrometer was mounted in a hermetically sealed container with a blackened shield above the entrance aperture to block reflections from the balloon overhead. A conical diffuser allowed the solar spectra to be obtained from near zenith to about 90°. The instrument sensitivity drops rapidly as the solar zenith angle increases from 15 to 30°. For the STRATCOM-VIII flight, the solar zenith angle at local noon is about 35°. At this angle, the sensitivity of the system is about 20% of that for an overhead sun. At sunrise and sunset the efficiency is about 3% of maximum.

Objective:

The purpose of this flight is to measure the uv irradiance as a function of wavelength (from 190 to 290 nm), time, and altitude. This data is for use as an input to the model of stratospheric chemistry developed by Frank P. Hudson, and also for comparison with the radiation transport model developed by J. Collins. In addition, ozone column densities are derived from the data which will be compared with in-situ ozone-sonde measurements and with the chemical models.

Of most interest in this experiment is the spectral region below 240 nm. Radiation in this region is capable of dissociating chlorofluoromethanes (CFMs) and hence enters directly into the question of ozone destruction by CFM dissociation products.

Cryogenic samplers

Balloon VIII-a

Richard Lueb
Leroy Heidt
National Center for Atmospheric Research
P. O. Box 3000
Boulder, Colorado 80303

Instrument:

The instrument is a low temperature air sampling system consisting of stainless steel cylindrical sample containers cooled to liquid Ne temperatures and with appropriate motor driven valves and control circuitry. The instrument is described in reference 1 and techniques for the analysis of the collected samples are discussed in references 2 and 3. For minimum contamination it is planned that the gas inlet line extend about 3 m below the payload and that samples be taken while the payload is descending at a rate of 30 to 80 meters per second.

Objective:

To measure the content of H_2, H_2O, CH_4, CO, CO_2, N_2O, $CFCl_2$ and CF_2Cl_2 in the stratosphere at altitudes from 25 to 40 km.

References:

1. Lueb, R. A., D. H. Ehhalt, and L. E. Heidt, "Balloon-Borne Low Temperature Air Sampler", Rev. Sci. Instrum., 46, 702-705, 1975.

2. Heidt, L. E. and D. H. Ehhalt, "Gas Chromatographic Measurement of Hydrogen, Methane, and Neon in the Air", J. Chromatogr., 69, 103-113, 197

3. Moore, H., "Isotropic Measurement of Atmospheric Nitrogen Compounds", Tellus, XXVI, 169-174, 1974.

Water vapor radiometer

U-2 aircraft

Peter Kuhn
NOAA/Environmental Research Laboratories
Boulder, Colorado 80303

Objective:

To compare water vapor over-burden and in-situ water vapor mixing ratio inferred from airborne (U-2) infrared radiometer with balloon borne in-situ water vapor instruments.

Instrument Description:

The airborne water vapor radiometer is a chopper type referencing the sky emission against a radiation source resulting in an output proportional to the water vapor over-burden. The radiometer pass band is 270-520 cm^{-1}.

The radiant power observed at the airborne radiometer from the zenith sky emission is expressed by,

$$N{\downarrow}_o = k(sV_o - V_e) + N_R - \int_\nu B(\nu,T)\ \phi(u)\ \ _X(\nu)\ d\nu$$

where $N{\downarrow}_o$ = observed radiance ($w\ cm^{-2}\ sr^{-1}$)

- k = the instrument system calibration constant, combining effects of the radiometer's field of view, optical collecting powers, the pyroelectric detector responsivity and the system electronic gain ($w\ cm^{-2}\ sr^{-1} V_o^{-1}$)
- s = instrument attenuation factor
- V_o = the radiometer output signal voltage
- V_e = the offset voltage
- N_R = instrument reference blackbody radiance
- B = Planck radiance ($w\ cm^{-2}\ sr^{-1}$)
- ν = frequency (cm^{-1})
- T = the monitored instrument housing o-temperature (°K)
- X = spectral transmittance of the detector system

The minimum detectable signal for the radiometer is 2.0 x 10^{-7}w cm^{-2} sr^{-1}.

Bibliography:

Kuhn, P. M., L. P. Stearns, and M. S. Loiko, Latitudinal profiles of stratospheric water vapor, Geophys. Res. Letters, 2, 6, 227-230, 1975.

Kuhn, P. M., M. S. Loiko, and E. V. Petersen, Water Vapor: Stratospheric injection by thunderstorms, Science, 174, 1319-1321, 1971.

Kuhn, P. M., Zonal profiles of atmospheric water vapor, NOAA Tech. Rep., ERL 319-APCL 33, U. S. Dept. Comm., Boulder, Co., 11pp, 1975.

Water vapor sensors (Al_2O_3)
Balloon VIII-a and
dropsonde no. 3

Philip Goodman
Panametrics, Inc.
221 Crescent Street
Waltham, Massachusetts 02154

Instrument:

Water vapor sensors to be flown are of the newly-developed Aquamax® type. These sensors are fabricated by thin film techniques by deposition upon silicon substrates. Production methods developed by the semiconductor industry are employed with the result that much greater uniformity and quality control can be achieved for these sensors than was previously possible for sensors fabricated from aluminum foil.

These sensors have a planar configuration with bonding pads that lead to an underlying metal layer and to a thin, water vapor permeable overlaying Au layer. Sandwiched between the two metal layers is a thin porous dielectric layer so that the entire structure functions as a leaky capacitor whose impedance is determined by the sensor's ambient water vapor pressure.

Such sensors exhibit very rapid response times and respond to frost points from saturation down to at least as low as -110°C. Accuracy at low frost points is estimated as ± 3°C and is largely limited by calibration uncertainties.

Objectives:

a) The STRATCOM flight series is designed to provide a continuous series of measurements of stratospheric parameters and of stratospheric chemical species. The principal objective is to generate data which can be utilized to improve stratospheric models and, hence, our understanding of stratospheric aeronomic processes. The H_2O molecule is an important participant in stratospheric photochemical reactions.

b) Water vapor also plays an important role in influencing the net energy balance between incoming solar radiation and energy reradiated by the earth. Through such thermal effects it can influence circulation patterns.

(c) Under favorable circumstances, water vapor serves as a tracer of transport processes. Water vapor data obtained during flight can be utilized, in conjunction with other data, to derive information concerning such processes.

(d) Data obtained by numerous other instruments carried by STRATCOM are influenced by the presence of water vapor. A knowledge of the actual local environment water concentration can permit corrections to be made to such data, thereby providing greater accuracy in these other measurements.

(e) In view of the importance of water vapor per se in stratospheric processes as well as the indirect influence it may have upon other measurements, it is planned to measure the concentration at three locations on the experimental package. In addition, a fourth sensor will be installed on a drop sonde to measure the ambient water vapor profile during descent from maximum altitude.

UV filter photometer (UVS)

Balloon VIII-a

Bach Sellers
Frederick A. Hanser
Jean Hunerwadel
Panametrics, Inc.
221 Crescent Street
Waltham, Massachusetts 02154

Instrument:

The Panametrics ultraviolet spectrophotometer uses a filter wheel and a uv photomultiplier to obtain the incident uv flux in 10 spectral regions between 220 and 400 nm. It is similar to the instrument flown on previous STRATCOM balloons except that a conical diffuser has been added so that light is received from all azimuths and from a zenith angle of 20° to more than 90° (light scattered from the overhead balloon is blocked by a shield). The precise position of the optical axis is deduced by use of data from the levelness and magnetometer sensors; the solar zenith angles needed for data analysis are calculated as a function of location (radar data) and time. Intensity is measured up to 4 orders of magnitude down from the unattenuated solar flux. The 12 positions of the filter wheel are sampled at 1 second each during ascent of the balloon and at 10 seconds each during float. The filters are as follows:

Wheel position	Center wavelength	Effective bandwidth
1	220 nm	15 nm
2	287	2
3	292	2
4	298	2
5	307	2
6	312	2
7	322	2
8	330	2

Wheel position	Center wavelength	Effective bandwidth
9	371	26
10	402	28
11	Calibration checks - 2 light levels and 6 voltage lev	
12	Dark current measurement	

Other information:

Power consumption	Electronics	19W (1 sec/sample)	9W (10 sec/sample)
	Heaters	62W	
	Max. total	81W	or 71W

Heaters are used to control the internal temperature at + 20°C with the external temperature as low as -70°C.

Weight: 10.5 pounds; with insulation: 15 pounds

Size: 6" dia. x 10" deep cylinder; with insulation: 12" dia. x 15" deep

Objectives:

The altitude dependence of the uv flux is being measured for the following purposes:

1. For use in photochemical calculations of reaction rates related to the various stratospheric species being measured as part of the STRATCOM effort.

2. For use in verification and development of radiation transport models.

3. For use in determining ozone overburden as a function of altitude to be compared with similar data from other instruments. In addition, the measured variations of the overburden can be used to calculate local ozone densities for comparison with in-situ measurements.

4. The measurements in the 220 nm window will give an indication of the variability of the ultraviolet solar flux and its relationship to the daily sunspot number (Rz), its 27-day average, and/or solar flares.

Kr lamp-Gerdien condenser
Balloon VIII-a
Dropsonde No. 2

Leslie C. Hale
Charles L. Croskey
Ionosphere Research Laboratory
Pennsylvania State University
University Park, PA 16802

The effects of ionizing radiation on the atmosphere are measured by a Gerdien condenser. This parachute-borne drop-sonde complements similar measurements made on the balloon gondola. Measurements are made over a wide altitude range in a relatively short time, with known flow conditions providing uncontaminated sampling. Objectives are:

(a) The determination of NO densities from the change in positive electrical conductivity produced by the lamp.

(b) Measurements of an additional enhancement in negative conductivity produced by photo-detachment of electrons from aerosol particles.

(c) Species differentiation from an analysis of charged particle mobilities--This objective will only be obtained if a very stable parachute is used with an angle of attack variability (swinging) of at most a few degrees.

The accuracy of the NO determination by this method has not yet been thoroughly evaluated, and the STRATCOM-VIII flight will allow comparison with the more generally accepted chemiluminescent technique. The potential of the photo-ionization technique is seen as a relatively simple means for determining variability over a wide altitude range.

UV filter photometer

Ground observations of total ozone.

Peter Simeth
SenTran Company
2705 de la Vina Street
Santa Barbara, California 93105

Instrument:

The filter photometer is a four channel instrument similar in construction to the ROCOZ rocket-borne photometer except that the filters were chosen to correspond to the lines used by the Dobson spectrophotometer, namely, at 332.5, 311.5, 325.5, and 305.5 nm. The field of view was about 3°; it was manually pointed to the sun.

Objective:

To obtain a comparison of the performance of this instrument with that of the ASL operated Dobson spectrophotometer for the measurement of total ozone content.

IR Spectrometer (Thermal emission)

U-2 aircraft

David G. Murcray
Department of Physics & Astronomy
University of Denver
Denver, Colorado 80208

Molecular radiation (thermal emission) from the atmosphere is measured with a liquid-helium-cooled, spectral radiometer. Calculations involving recorded signal strengths, black body calibrations and molecular parameters yield the overburden of various constituents (HNO_3, CH_4, O_3, F11, F12, etc.).

The radiometer is mounted in the right wing tank of the U-2 looking at right angles to the flight path and 13° above the horizon with a field of view of 1° vertical and 4° horizontal. Radiation enters through a zinc selenide window, is scanned by a grating spectrometer, and imaged through a beam splitter onto two copper-doped germanium detectors covering the 3-7 and 6-14 micron spectral regions. Forty-two second scans with a resolution of 2 cm^{-1} are taken continuously during each flight with all data recorded on a digital tape recorder for subsequent analysis.

Simultaneous flights of the U-2 and the Balloon VIII-b instruments will provide correlated measurement of certain spectral regions and should enable an improvement in the interpretation of the thermal emission spectral data.

IR Spectrometer (solar absorption)

Balloon VIII-b

David G. Murcray
Dept. of Physics and Astronomy
University of Denver
Denver, Colorado 80208

For the flight this fall, emphasis is on the oxides of nitrogen. On the STRATCOM-VIII-b balloon, the one-and-a-quarter meter Czerny-Turner IR grating spectrometer will be used to measure solar absorption spectra during sunset in the spectral regions 4.9 to 6.2 microns and from 6.5 to 8.3 microns. This wavelength coverage would give data on NO, NO_2, N_2O, HNO_3, O_3, H_2O, CH_4, and possibly on CF_2Cl_2 and $ClONO_2$. During ascent vertical profiles deduced from overburden measurements will be obtained for O_3, H_2O, CH_4, and N_2O. Thus this instrument covers some of the molecules measured by the in-situ techniques for intercomparing and also provides data not obtained by instruments on the VIII-a balloon.

IR radiometers for air temperature

David Murcray
Dept. of Physics and Astronomy
University of Denver
Denver, Colorado 80208

Balloon VIII-b

Don Snider
Atmospheric Sciences Laboratory
US Army Electronics Command
White Sands Missile Range

Robert McClatchey
Air Force Geophysics Laboratory
Hanscom Air Force Base
Massachusetts 01731

The purpose is to measure atmospheric limb infrared radiance from the STRATCOM VIII-b balloon during ascent, and to compare the temperature derived from these measurements to that measured by rocket and rawinsondes. In order to make the interpretation of the data as unambiguous as possible, the spectral regions in which the radiance will be measured will correspond to the "blackest" part of the 4.3 micrometer and the 15 micrometer CO_2 bands. Since horizontal temperature gradients are much smaller than vertical temperature gradients, the radiometers will be pointed toward the horizon rather than in the vertical or nadir. Thus the radiation entering the radiometers will come from a layer that is more nearly uniform in temperature, and will not require the use of inversion algorithms to infer an atmospheric temperature profile. The radiance measured by the filter radiometers will be related directly to the atmospheric temperature through the Planck black body function.

Apex Plate Payload, Balloon VIII-a
balloon skin temperature
air temperature
water vapor
Lyman-alpha radiation
pyranometer

Carlos McDonald
Electrical Engineering Department
University of Texas at El Paso
El Paso, Texas 79968

The Top Package is mounted above the apex plate located on top of the balloon. Its main purpose is as follows:

(1) To provide temperature and water vapor emission information of the balloon for the purpose of estimating thermal and water vapor contamination by the balloon in the surrounding environments, and

(2) to serve as an instrumentation platform for experiments requiring an upward clear view, such as albedo measurements, etc.

At the present time, the Top Package is designed to telemeter the following parameters:

a. balloon skin temperature at two points using bead thermistors

b. air temperature using an STS film-mounted thermistors

c. atmospheric water vapor using an Al_2O_3 film capacitor sensor from Panametrics, Inc.

d. atmospheric water vapor using a radiosonde resistance-type humidity sensor,

e. UV radiation in the hydrogen Lyman-alpha range (121.5 nm) using a gas ionization chamber,

f. IR radiation in the 0.2-2.8 micron range using a pyranometer,

g. levelness indicator.

Anemometers

Balloon VIII-a

Carlos McDonald
Electrical Engineering Department
University of Texas at El Paso
El Paso, Texas 79968

Instrument:

The anemometer is based on the use of bead thermistors exposed to the air flow and operated in a constant temperature mode. Matched thermistors operating at different temperatures are used to eliminate the dependence on ambient temperature and radiation. Air density dependence is accounted for by the use of an enclosed reference pair of thermistors. The reference pair also serves as a densitometer. Calibration is based on the measurements of the difference in power as a function of velocity of wind and Reynolds number at atmospheric pressures and by calibrating the reference pair as a function of density.

Objective:

Three identical instruments are arranged as a 3-axis wind anemometer for monitoring the air flow relative to the instrument platform. These measurements may provide information regarding the Lagrangian characteristics of the balloon and on boundary layer phenomena.

Conductivity measurements:
Blunt probe
Gerdien condenser
Krypton lamp-Gerdien condenser

John D. Mitchell
Electrical Engineering Department
University of Texas at El Paso
El Paso, Texas 79968

Balloon VIII-a
Arcas rocket (Gerdien condenser)
Super-Loki rocket (blunt probe)

Leslie C. Hale
Charles L. Croskey
Ionosphere Research Laboratory
Pennsylvania State University
University Park, PA 16802

Useful information about stratospheric electrical conductivity and its associated altitude, temperature, and sunrise variations have been obtained from the previous STRATCOM experiments and we are continuing these studies on STRATCOM VIII. The instrument package will be a blunt probe and a Gerdien condenser with a krypton discharge ionization lamp to study the effects of ionizing radiations on the atmosphere.

In addition, we will conduct two different rocket experiments for measuring electrical conductivity, ion mobility, and ion density in conjunction with the balloon flight. The rocket experiments, launched from the Small Missile Range at White Sands, will measure electrical conductivity in the upper stratosphere as well as in the altitude region of the balloon flight.

UV spectrometer (skylight)
Balloon VIII-a

K. D. Baker and Larry Jensen
Center for Research in Aeronomy
Utah State University
Logan, Utah 84322

This instrument measures the scattered light from the atmosphere in the wavelength region from 3100 Å to 2000 Å with a resolution of approximately 3 Å. The instrument does not have active solar pointing, however, a sun sensor is employed to facilitate the determination of the instrument line-of-sight relative to the sun's position. The instrument scans between zenith and the horizon at a fixed azimuth with respect to the payload structure.

Filter photometer
Balloon VIII-a
Balloon VIII-a dropsonde No. 1

Rex Megill
Center for Research in Aeronomy
Utah State University
Logan, Utah 84322

These are two small instruments to (1) measure the direct solar flux with filters at wavelengths of approximately 292.5nm, 297.5nm, and 300.0nm from which ozone overburden may be determined, and (2) measure the albedo by looking downward at wavelengths of approximately 300.0nm, 350.0nm, 400.0nm, and 450.0nm.

One pair of these instruments are planned for the main gondola of balloon VIII-a; a second pair is planned for the chemiluminescent sonde to be dropped by parachute.

Chemiluminescent nitric oxide sonde
Balloon VIII-a dropsonde No. 1

Alan Shaw
Center for Research in Aeronomy
Utah State University
Logan, Utah 84322

This parachute drop sonde, to be released from balloon VIII-a includes:

1. A chemiluminescent sonde for the measurement of nitric oxide during the descent on parachute.
2. A chemiluminescent ozone detector, based on the instrument of Jagir Randhawa of the Atmospheric Sciences Laboratory at WSMR.
3. Two small filter photometers, similar to those on the main gondola, to (1) measure the direct solar flux at wavelengths of approximately 292.5nm, 297.5nm, and 300.0nm from which ozone overburden may be determined, and (2) measure the albedo by looking downward at wavelengths of approximately 300.0nm 350.0nm,400.0nm, and 450.0nm.

PRELIMINARY FLIGHT DESCRIPTION

A description of the planned flight and observations included in the STRATCOM-VIII effort is given in the Introduction of this report. All of the different types of platforms were used, with almost all of the planned instruments. Some adjustments in schedule were made to accommodate available equipment and support, but not to the extent that the objectives of the missions were seriously compromised. Approximate times for the various launches are given in Table 3. Not included are a few small balloons and rockets from which no useful data were obtained; the back-up payloads which were flown successfully later in the period are included.

The instruments on each platform were as given in Table 1 of the Introduction. On Balloon VIII-a the gas chromatograph was replaced by a second cryogenic sampler. For the U-2 aircraft, the SAS-II, the infrared spectrometer, and the impact aerosol collector were selected for use on both flights.

A picture of the Balloon VIII-a payload is given in Figure 2. The basic aluminum frame was 3 meters long, 1.2 meters high and 0.7 meters wide. To provide a suitable environment for in-situ measurements of the atmosphere, the payload was reeled down so that it was about 200 meters from the balloon, the experiments and instruments were generally in pressurized containers, the payload was assembled with a minimum of tape and other materials containing volatiles, the crash pads were aluminum honeycomb instead of corrugated cardboard, and the effluent from the cryogens were gathered in a "garbage dump" line and emitted about 3 meters to the side of the payload.

The actual flight profile of Balloon VIII-a is given in Figure 3. The inability to valve helium or to dump ballast did not permit the planned descent to 25 km for the collection of air samples and the observation of sunset. These samples and data were obtained at the float altitude and are considered to be very useful, although for somewhat different purposes than originally intended. Both the VIII-a and the VIII-b balloons remained in the vicinity of the launch site at Holloman Air Force Base, at no time exceeding a distance of 130 km.

Almost all of the instruments provided useful data, and it appears that the major objectives of a comparison of ozone measurement techniques and a near simultaneous measurement of many stratospheric species along with the incident solar radiation will be substantially as planned. However, the operation was not perfect; a list of the major problems in systems and operations follows:

Balloon VIII-a:

1. It was not possible to change the altitude of the balloon due to a failure of the system to command the release of helium and ballast.

2. The telemetry signal from the apex plate package weakened and was not useful after the initial four or five hours of flight.

3. The ability to command the experiments gradually diminished and was lost about 18 hours after launch. This resulted in an inability to turn on the sensors which looked at solar radiation for the sunrise period and in an inability to switch to the second battery pack, resulting in the termination of payload telemetry about 24 hours after launch, shortly after sunrise.

Platform	Time (MDT)	Date (1977)	Location
Balloon radio sonde	0700	Sept. 22	HAFB
Loki data sonde	1215*	"	SMR
Loki data sonde	1200*	23	"
Balloon radio sonde	0030	24	HAFB
Balloon radio sonde	0635	"	"
Loki data sonde	1100*	"	SMR
Balloon radio sonde	0001	25	HAFB
Balloon radio sonde	0600	"	"
Loki data sonde	1100*	"	SMR
Balloon radio sonde	0001	26	HAFB
Balloon radio sonde	0700	"	HAFB
Loki data sonde	1000*	"	SMR
Balloon radio sonde	1200	27	HAFB
Loki data sonde	1205*	"	SMR
Balloon radio sonde	0900	28	HAFB
Balloon radio sonde	1300	"	"
Balloon VIII-b	1351	"	"
Super-Loki data sonde	1427*	"	SMR
U-2 aircraft in vicinity	1845	"	
Termination of Balloon VIII-b		"	
Balloon radio sonde	2100	"	HAFB
Balloon radio sonde	0200	29	"
Mast ozone sonde	0230	"	SMR
Balloon radio sonde	0615	"	HAFB
Balloon VIII-a	0707	"	"
Parachute drop no. 1 #	0915	"	
Parachute drop no. 2	0932	"	
ECC ozone sonde	1025	"	SMR
U-2 aircraft in vicinity	1045	"	
Parachute drop no. 3	1045	"	
Balloon radio sonde	1200	"	HAFB
ARCAS ozone sonde (ASL) #	1207*	"	SMR
Super-Loki ROCOZ	1222*	"	"
Mast ozone sonde #	1230	"	"
Super-Loki data sonde	1330*	"	"
Super-Loki blunt probe	1445*	"	"
ARCAS Gerdien condenser #	1519*	"	"
ARCAS ozone sonde (ASL)	1620*	"	"
Balloon radio sonde	1800	"	HAFB
Loki data sonde	2010*	"	SMR
Balloon radio sonde	0600	30	HAFB
Loki data sonde	0702*	"	SMR
Mast ozone sonde	0800	"	SMR
Loki data sonde	1200*	"	"
Termination of Balloon VIII-a	1330	"	

Notes:
*A balloonradio sonde was simultaneously launched at the Small Missile Range.
#Performance of vehicle or payload was seriously substandard.
HAFB - Holloman Air Force Base
SMR - Small Missile Range
The Balloon radio sondes and the Loki/Super-Loki data sondes are for meteorological data.

Table 3. Times of Launch and other Significant Events

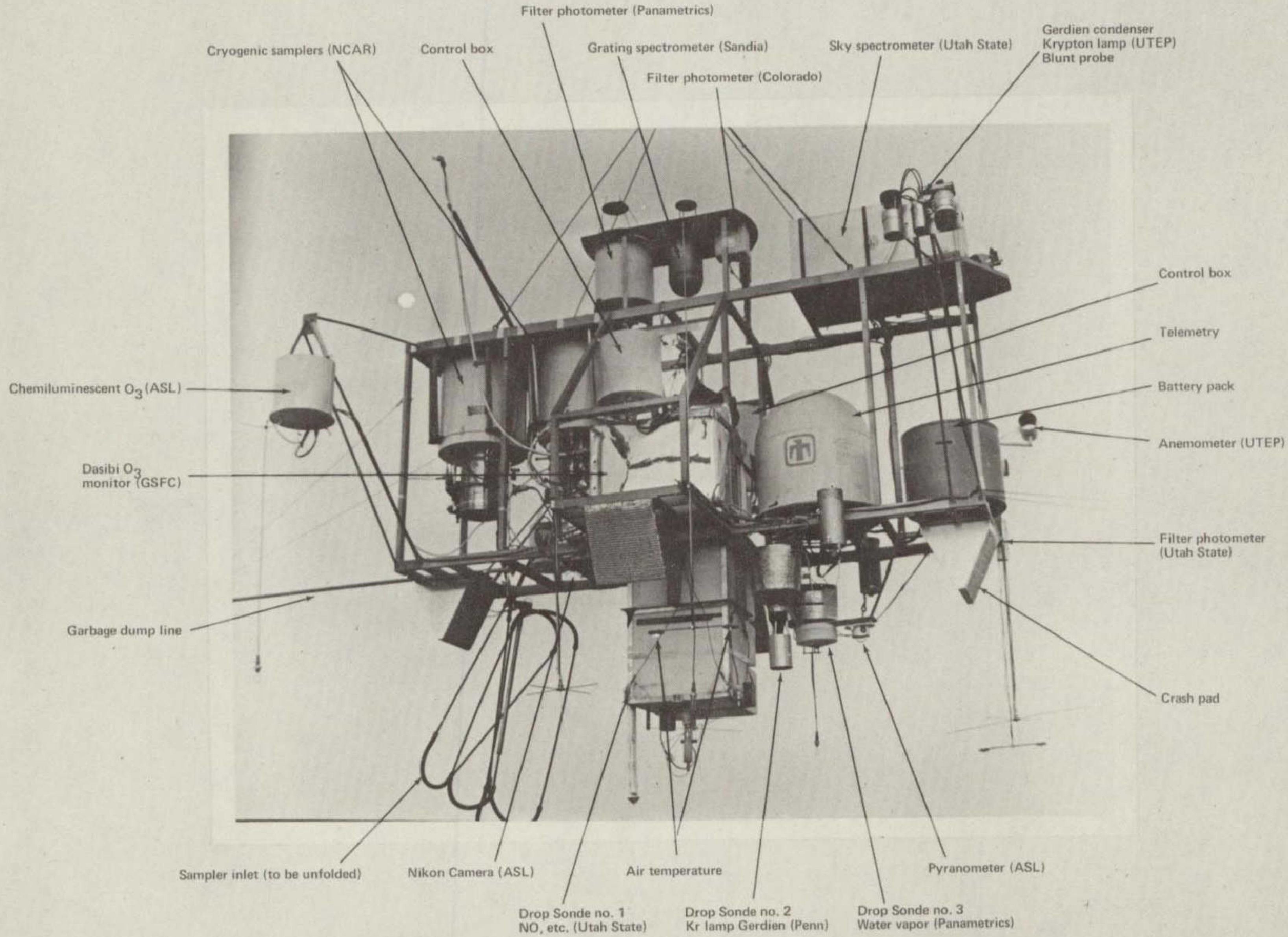


Figure 2. STRATCOM VIII-a Payload

STRATCOM BALLOON VIII—A
HOLLOMAN AIR FORCE BASE, NEW MEXICO

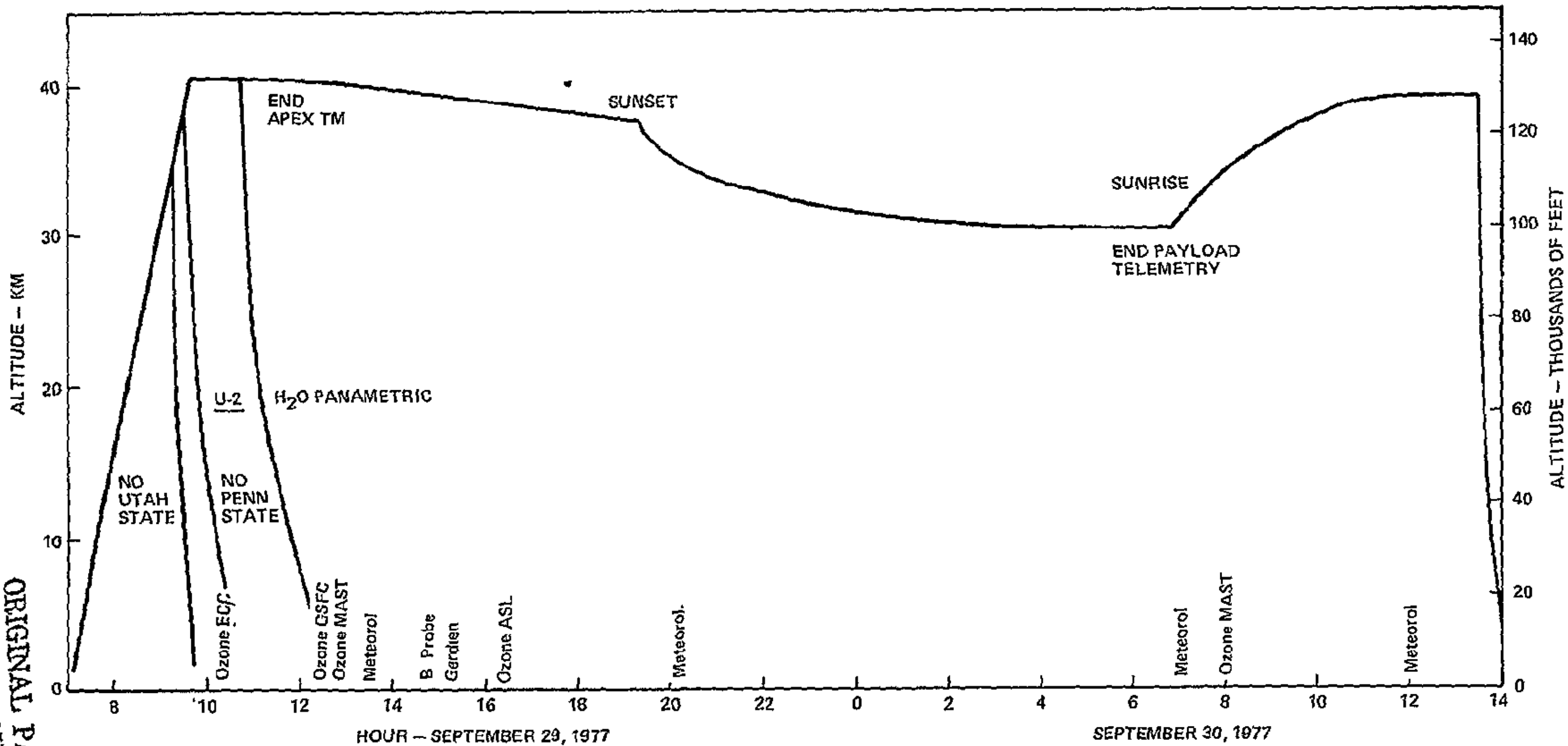


Figure 3. STRATCOM VIII-a Flight Profile (Actual)

4. The tape recorder and the telemetry system in dropsonde no. 1 failed prior to drop. No data were obtained.

5. Drop sondes no. 2 and no. 3 have not yet been recovered; all data were telemetered.

Other Platforms:

1. The payload from Balloon VIII-b was destroyed upon impact due to failure of the parachute to deploy properly. All data, however, was telemetered.

2. The initial flights of the rocket-borne chemiluminescent ozone-sonde the MAST ozone sonde balloons, and one meteorological rocket did not provide the desired data. Back-up instruments were flown and were successful.

3. The Gerdien condenser rocket reached 32 km, short of its expected altitude.

4. The ROCOZ ozone sonde has not yet been recovered; data were telemetered.

Instruments:

Real time looks at telemetered data indicate that almost all instruments were operating as expected. Primarily because the valved descent of Balloon VIII-a did not occur as planned, only about half of the possible 14 cryogenic air samples were collected. There is some indication that the Dasibi ozone monitor did not work as expected after the first 11 hours of flight. One of the air temperature radiometers on Balloon VIII-b did not seem to provide data. On the first of the two U-2 aircraft flights, the infrared spectrometer did not operate properly.

In summary, the STRATCOM-VIII operation was more complex than any of the previous ones, involving more platforms and more sophisticated instruments. In spite of the difficulties noted above, it is believed that data are available to achieve about 80% of the possible scientific and engineering objectives.

APPENDIX I

THE STRATCOM PROGRAM

of

ATMOSPHERIC MEASUREMENTS

Frank P. Hudson

Harold N. Ballard

The STRATCOM Program of Atmospheric Measurements

INTRODUCTION

STRATCOM (STRATospheric COMposition) is a long-term, multi-purpose program for integrated, correlated measurements of stratospheric parameters related to composition, thermodynamics and radiative balance. It is a joint undertaking of several laboratories whose combined scientific, engineering and field capabilities make possible an extensive, high quality program of multiple related measurements in the very complex, highly variable stratosphere. It emphasizes (1) in-situ measurements, since a considerable increase in stratospheric data is the greatest need at present; and (2) correlated measurement of critical parameters, since measurements of related parameters under the same conditions allows sounder interpretations, and leads to a better understanding of atmospheric processes and their roles.

Balloon platforms are used because they are well-suited to the required altitude range, complex payloads, and experimentation times. The series of flights are planned to cover the 10 to 50 kilometer (33,000 to 164,000 foot) altitude range, from 10° to 65° N latitude, at all seasons of the year. Changes in measurements as a function of altitude and at sunrise/sunset are of particular interest. Longer term flights are launched at the stratospheric wind turn-around in spring and fall.

Relationships with other modes of measurement are developed when possible. Important platforms are ground, aircraft, rocket, parachute and satellite.

The principal reason for combining the talents and resources of the several laboratories is to make the required complex operation possible, but some secondary benefits are of considerable importance: (1) the value of each experiment is enhanced because of the availability of measurements, at the same time and place, of related parameters; (2) unification of operational and engineering needs, to serve a number of experiments at one time, effects a large saving in both time and money; (3) the recoverable, reuseable system provides a common background for later parallel experiments under other selected conditions of altitude, latitude, and season for comparative purposes (time and money are again saved); (4) a body of data, acquired under common conditions, is available for direct use in developing and validating models in contrast to the usual use of statistical means of frequently disparate data.

PURPOSES

Each laboratory has its own goals in the program. These range from pure science to development of the operational methods. There is much overlapping goals and many degrees of mutual support. Included are:

(1) Measurements of species densities, solar ultra-violet flux, and thermodynamic properties for basic understanding of atmospheric processes.

(2) Development and validation of photodissociation and chemical kinetic models of the stratosphere.

(3) Determination of natural variations of parameters, and relationship to altitude, latitude, time-of-day, season-of-year, and other time cycles.

(4) Development of understanding of meteorology of the stratosphere.

(5) Study of parameters important to stratospheric pollution from aircraft, fluorocarbon chemicals, and other sources.

(6) Development and calibration of instruments for rocket and parachute payloads can be extended to potential satellite instrumentation.

(7) Study of the perturbed atmosphere for defense studies.

(8) Development of instrumentation, platforms and field operational methods for defense oriented studies.

(9) Development of methods for meso-scale pollution studies in the troposphere.

HISTORY

STRATCOM FLIGHTS	
I.	September 11, 1968
II.	September 22, 1969
III.	September 18, 1972
IV.	October 19, 1973
V.	May 22, 1974
VI.	September 24, 1975
VII.	September 27, 1976
VIII.	September 28, 1977

The sequence of STRATCOM experiments was initiated in 1968 by the Army's Atmospheric Sciences Laboratory (ASL), White Sands Missile Range (WSMR), under the direction of Harold N. Ballard. The first flight in September 1968 carried a payload of 30 kilograms (66) pounds) of instrumentation at an altitude of 50 km, the top of the stratosphere. The principal goals were the study of atmospheric motions, diurnal temperature variations, thermodynamics, and ozone density. A similar flight, with upgraded instrumentation, was made in September 1969. The Aerospace Instrumentation Laboratory, Balloon Branch, of the Air Force Cambridge Research Laboratory provided balloon design, launch operations and flight control for these and later flights; except STRATCOM IV, which was launched at the National Scientific Balloon Facility, Palestine, Texas, under the direction of the NCAR staff. The WSMR facilities provided necessary range support.

In 1971, the AEC's Sandia Laboratories, Albuquerque, NM (SLA) was invited to participate. Experimentally this added mass spectrometry and ultra-violet spectroscopy; and of fundamental importance, made available the extensive instrumentation development and field experimentation experience and facilities of Sandia. At this point, the correlated multi-instrument approach, backed by theory and modeling, was initiated. The September 1972 flight, STRATCOM III, carried 17 instruments, with a payload weight of 260 pounds, to 48.7 kilometers altitude for nine hours of measurement with all instruments functioning successfully.

STRATCOM IV and V, October 1973 and May 1974, were special-purpose flights dedicated to the measurement of stratospheric H_2O and NO.

STRATCOM-VI operation, September 24-26, 1975, returned to the multi-parameter approach. Several laboratories added instruments; the relationship with other measurements programs was enlarged. The extent of the widened base of this effort is indicated by Table I, which is a list of participating agencies and laboratories and of platforms. An ideal flight profile was realized, about 85% instrumentation success was obtained; and an excellent, highly adaptable mechanical/electrical/electronic system, usable for future flights at other altitude ranges, latitudes, and seasons of the year, was developed and proved.

The STRATCOM VI-a balloon was launched from Holloman AFB, New Mexico (32^o N. latitude) at 2357 on September 23, 1975. Peak altitudes of 38.7 km was attained at about 0300 on the 24th. The instruments were turned on intermittently during ascent, and continuously for a period of one hour before to one hour after sunrise. Periodic measurements were made at float altitude and during a slow descent initiated at about 1100. A two-hour measurement period through sunset at about 25 km altitude was followed by an ascent to 36.6 km for a two-hour sunrise measurement period on September 25. The scientific payload was brought down by parachute from 1000 to 1035 with all instruments turned on. Recovery of the intact payload in excellent condition was near Springeville

Table I

STRATCOM VI

FEDERAL AGENCIES

Department of Defense
Energy Research and Development Administration
Department of Transportation
National Aeronautics and Space Administration
National Science Foundation
National Oceanic and Atmospheric Agency

LABORATORIES

Atmospheric Sciences Laboratory - WSMR
Sandia Laboratories - Albuquerque
Air Force Cambridge Research Laboratories, AIL/BB
National Center for Atmospheric Research (NCAR)
Los Alamos Scientific Laboratory (through NCAR)
University of Denver
University of Texas at El Paso
Pennsylvania State University
NASA Ames Research Center
New Mexico State University
Panametrics, Inc. (by contract)

PLATFORMS

Balloon VI-a	15.8 million cu.ft., 1180 lb. payload 34 hour flight, 30 instruments 24-25 September 1975
Balloon VI-b	2.9 million cu.ft.; 500 lb. payload 2 major experiments, 8 hour flight 26 September 1975
U-2 aircraft	18.3 and 21.3 kilometer altitude flight paths, 24 September, NO and O_3 measurements NASA Ames Research Center
NIMBUS-6 satellite	O_3, H_2O and temperature measurements. NASA-Goddard and NCAR (John Gille)
Small rockets (WSMR)	O_3 and temperature, September 24

Arizona. Balloon VI-b was launched at 1500 on September 26 to provide infrared absorption measurements through sunset. The U-2 aircraft flight pattern was at 18.3 and 21.3 km, under Balloon VI-a, on September 24.

The STRATCOM-VII operation, September 28-29, 1976, was again a broadly based series of measurements including the flight of two large balloons and several closely related rocketsondes. This series of measurements were especially interesting since the ascent and decent portions of the Balloon VII-a flight occurred under contrasting conditions of vertical wind, providing data on two quite different stratospheric regimes. Balloon VII-a, carrying 26 instruments, was launched at 0730 MST on September 28 from Holloman Air Force Base. The peak altitude of 39 km was reached before noon for a series of measurements at that altitude. The principal measurements were made during a slow decent to 18km, with measurements at that altitude during sunset. The payload rose to 23 km during the night for a series of measurements at sunrise on the 29th and during the 40 minute parachute descent after cutdown at 1030. The payload was successfully recovered about 20 km north of the launch site. All instruments operated as planned. Balloon VII-b carrying the infrared spectrometer and a Fourier-transform interferometer spectrometer, was launched on September 30 for measurements through sunset. Rocketsonde measurements of ozone, temperature, pressure, and electrical conductivity were made on September 28 in the altitude range of 60 to 10 km.

METHOD

Teams of experienced specialists in the several phases of activity necessary for successful multi-instrumented, in-situ stratospheric measurements have been assembled into a well integrated unit.

The Balloon Branch of the Aerospace Instrumentation Laboratory of the Air Force Geophysical Research Laboratories does the balloon design to suit payload and flight specifications, the launch operation, meteorological analysis, stratospheric wind predictions, and flight control.

The Atmospheric Sciences Laboratory (ASL) of the Army Electronics Command provides overall program direction (Harold N. Ballard); and, with assistance from WSMR groups, meteorological support, pre-launch rocket probing of the stratosphere, radar tracking, mobile support facilities, still-photo documentation, safety and security services; and recovery assistance.

The Energy Research and Development Administration (ERDA)* assists in program planning and scientific direction (Frank P. Hudson); ERDA's Sandia Laboratories assists in the project engineering; electronic, electrical, mechanical, and thermal design of the integrated payload; and moving picture documentation. The University of Texas at El Paso (UTEP) provides assembly, mobile command/control, telemetric data gathering for the instruments in-flight and some data analysis.

The above laboratories also provide several scientific experiments, and are joined by scientists from other government and university laboratories and contractual support from industrial laboratories. Generally,

*Now, Department of Energy.

each experimenter provides only his basic instrument with specifications of power, command signals, data handling and special requirements. The project engineer directs the design effort in accordance, to integrate the system.

Theory and modeling of solar ultra-violet photodissociation of atmospheric species, and one-dimensional modeling of the chemical kinetics are provided by UTEP/ASL/ERDA. These are used to assist in program planning and later will be used to expand interpretation of experimental results.

The first planning meeting, principally scientific, is held about 6 to 8 months prior to launch. Attendance by a representative from each concerned group is required. Brief presentations are given of each experiment and of pertinent information on balloon design, launch, meteorology, range support, payload engineering, scheduling, field operation, safety and background theory. Understanding and agreement on all phases are sought. The second full-group meeting, principally engineering, is held about four months before launch.

All instruments (accompanied by a technical person) arrive at University of Texas at El Paso five to six weeks before launch for system assembly, and check-out of individual instruments and the full system. All equipment is shipped to the launch site for reassembly, check-out and preparation for flight.

The third meeting of all concerned, principally operational, is held one week prior to expected launch date. A meteorology and operations briefing is held daily awaiting the launch window. Each experimenter is involved with his own equipment, as required, through final preparation and check-out right up to launch time.

After flight termination, recovery is made by ASL/AFGL/Sandia crews. Telemetered data is extracted from the tapes by WSMR and provided to the experimenter in the format requested.

A data meeting is held a few months after the flight for an initial evaluation and exchange of data. In recent years a symposium has been scheduled a few months later for the presentation of initial results.

APPENDIX II

BIBLIOGRAPHY

This is a compilation of papers and published abstracts relating to the STRATCOM program, arranged by year of publication.

1969

Randhawa, J. S., Ozone Measurements from a Stable Platform near the Stratopause Level", J. Geophys. Res., 74, 4588-4590, 1969.

1970

Ballard, H. N., N. J. Beyers, and M. Izquierdo, A Constant-Altitude Balloon Experiment at 48 km. Proceedings, Sixth AFCRL Scientific Balloon Symposium, 27 October 1970, AFCRL-70-0543, L. A. Grass, Editor. pp 33-47.

Ballard, H. N., N. J. Beyers, M. Izquierdo, and J. Whitacre, A Constant-Altitude Balloon Experiment at 48 km. J. Geophys. Res., 75, 3501-3512, 1970.

Reynolds, R. D., and A. L. Wallis, Jr., An Analysis of the Boundary Layer Associated with Floating Balloon Systems, Proceedings, Sixth AFCRL Scientific Balloon Symposium, 27 October 1970, AFCRL-70-0543 L. A. Grass, Editor. pp. 471-476.

1971

Randhawa, J. S., Ozone Measurements near Sunrise, Nature (Phys. Sci.) 233, 101, 1971.

1972

Ballard, H. N., N. J. Beyers, B. T. Miers, M. Izquierdo, and J. Whitacre, Atmospheric Tidal Measurements at 50 km from a Constant-Altitude Balloon, J. Appl. Met., 11, 1138-1149, 1972. Also, ECOM-5417 (US Army Electronics Command).

1974

Ballard, H. N., M. Izquierdo, C. McDonald, and J. Whitacre, Atmospheric Temperatures Measured Near 48 Km by Balloon-Borne Thermistors, Proceedings, Eighth AFCRL Scientific Balloon Symposium, 30 September to 3 October 1974, AFCRL-TR-74-0393, A. S. Carten, Jr., Editor. pp. 401-416.

Herrington, Preston B., Balloon Gondola Measurements, Proceedings, Eighth AFCRL Scientific Balloon Symposium, 30 September to 3 October, 3 October 1974, AFCRL-TR-74-0393, A. S. Carten, Jr., Editor pp 511-516.

Patel, C.K.N., E. G. Burkhardt, and C. A. Lambert, Spectroscopic Measurements of Stratospheric Nitric Oxide and Water Vapor, Science, 184, 1173-1176, 1974.

Woods, R. O., A Cryopump for Balloon-Borne Mass Spectrometer, RSI, 45, 1, pp. 136-137, January 1974.

Woods, R. O., Flight Mass Spectrometry at Sandia Laboratories, SAND74-0175, October 1974 (OUO).

Woods, R. O., Design and Operating Characteristics of a Balloon-Borne Vacuum System, Proceedings, Eighth AFCRL Scientific Balloon Symposium, 30 September to 3 October 1974, AFCRL-TR-74-0393, A. S. Carten, Jr., Editor. pp. 495-509.

1975

Ballard, H. N., F. P. Hudson, Stratospheric Composition Balloon-Borne Experiment, 18 September 1972, ECOM-5554 U.S. Army Electronics Command, Fort Monmouth, N.J., 119 pp. January, 1975, AD-A008021, contains the following papers:

Introduction, H. N. Ballard and F. P. Hudson, pp. 1-9.

Summary of State of Health Measurements, Stratospheric Composition

Balloon Experiment, by P. B. Herrington, pp. 10-13.

Atmospheric Temperatures Measured near 48 Kilometers by Balloon-Borne Thermistors, by H. N. Ballard, M. Izquierdo, C. McDonald, and J. Whitacre, pp. 14-28.

Stratospheric Balloon Pressure Measurements and Derived Density in the 40- to 48-Kilometer Altitude Interval, by R. Rubio and C. L. Tate, pp. 29-41.

Ozone Particle Densities Measured by Chemiluminescent Sensors on a Balloon at 48 Kilometers, by J. S. Randhawa and M. Izquierdo, pp. 42-48.

Solar Ultraviolet Irradiance and Ozone Particle Concentration Observations at 48-Kilometer Balloon-Float Altitude, by R. L. Schellenbaum, pp. 49-58.

A Comparison of Measured and Calculated Ozone Particle Densities During Sunrise, by J. L. Collins and M. A. Ellis, pp. 59-67.

Determination of Neutral Constituent Concentrations in 45- to 60-Kilometer Interval with Rocket- and Balloon-Borne Samplers, by H. N. Ballard, R. W. Byrnes, M. Izquierdo, J. Whitacre, and C. McDonald, pp. 68-80.

Electrical Conductivity Measurements from the September 1972 Stratospheric Balloon Experiment, by J. D. Mitchell and L. C. Hale, pp. 81-89.

Water Vapor Measurements during a 48-km Balloon Flight, by P. Goodman, pp. 90-97.

Solar and Cosmic Radiation Prevailing during the September 1972 Stratospheric balloon Experiment, by R. Rubio, H. N. Ballard, J. Whitacre, and M. Izquierdo, pp. 98-106.

Mass Spectrometer Data, by R. O. Woods, p. 107.

Burkhardt, E. G., C. A. Lambert, and C.K.N. Patel, Stratospheric Nitric Oxide: Measurements During Daytime and Sunset, Science, 188, 1111-1113, 1975.

Collins, J. L., High Latitude Photodissociation Rates, EOS, 56, 996, 1975.

Myers, R. D. and D. K. Werling, Design of a Linear Ramp Current Supply for Balloon Borne Instruments SAND-75-0659, Sandia Labs., Albuquerque, New Mexico, 13 pp.

1976

Ballard, H. N., M. Izquierdo, C. McDonald, and J. Whitacre, Temperature Measurements in the Stratosphere from Balloon-Borne Instrument Platforms, 1968-1975, ECOM-5808, December 1976, 45 p. U.S. Army Electronics Command, Fort Monmouth, New Jersey 07703.

Ballard, H. N., P. B. Herrington, F. P. Hudson, A. O. Korn, The STRATCOM VI Program of Correlated Measurements of Stratospheric Composition and Other Parameters Between 25 and 39 Kilometers Altitude; 24 and 25 September 1975. EOS, 57, 156, 1976.

Gille, J. C., and P. L. Bailey, Stratospheric Observations by Nimbus-6 LRIR Related to STRATCOM VI, EOS, 57, 156, 1976.

Goodman, P., and M. Izquierdo, Water Vapor Concentration in Various Positions in the Balloon Train During the STRATCOM VI-a Flight, EOS, 57, 156, 1976.

Izquierdo, M., C. McDonald, Z. Salpeter and H. N. Ballard, Atmospheric Temperature Measurements During the STRATCOM VIa Flight, EOS, 57, 156, 1976.

McDonald, C., H. Carrasco, M. Izquierdo and H. N. Ballard, Electron Forward-Scatter and α-Particle Absorption Measurements of Atmospheric Density (STRATCOM VI), EOS, 57, 156, 1976.

Mitchell, J. D., C. L. Croskey and L. C. Hale, Electrical Conductivity Measurements in the Middle Stratosphere, EOS, 57, 156, 1976.

Randhawa, J. S., and M. Izquierdo, Ozone Measurements at 48 km, J. Photochemistry, 6, 148, 1976.

Randhawa, J. S., M. Izquierdo, and C. McDonald, Stratospheric Ozone Density as Measured by Chemiluminescent Sensors, EOS, 57, 156, 1976.

Rubio, R., and M. Izquierdo, Measurement of Atmospheric Limb Radiance in the 0.28 to 2.80 Micron Infra-red Region on STRATCOM VIa, EOS, 57, 156, 1976.

Schellenbaum, R. L., B. D. Zak, Ozone Particle Density Derived from Solar Ultraviolet Absorption Measurements in STRATCOM VI, EOS, 57, 156, 1976.

Sellers, B., F. A. Hanser, J. L. Hunerwadel, Solar Ultra-Violet Fluxes in the 200-400 nm. Range Measured on STRATCOM VIa., EOS, 57, 156, 1976.

Williams, W. J., J. J. Kosters, A. Goldman, D. G. Murcray, Simultaneous Stratospheric Measurements of Fluorocarbons and Odd Nitrogen Compounds, EOS, 57, 156, 1976.

Williamson, E., C. McDonald and M. Izquierdo, Earth Albedo Measurements in the 0.28 to 2.80 Micron Region on STRATCOM VIa. EOS, 57, 156, 1976.

Zak, B. D., R. L. Schellenbaum, Stratospheric Solar Ultraviolet Radiation in the Fluorocarbon Dissociation Range: Preliminary Results from STRATCOM VI, EOS, 57, 156, 1976.

1977

Ballard, H. N., M. Izquierdo, F. Hudson and A. Korn, STRATCOM VII - Experiment Description (Balloon Systems, Instruments, Trajectory, Supporting Measurements), EOS, 58, 451, 1977.

Ballard, H. N., J. N. Serna, and F. P. Hudson, Calculation of Selected Atmospheric Composition Parameters for the mid-latitude September Stratosphere, ECOM-5818, May 1977, 41 pp. US Army Electronics Command, Fort Monmouth, N. J. 07703.

Buijs, H., and G. Vail, Measurement of Density Profiles of HF and HCl in the Stratosphere, EOS, 58, 453, 1977.

Carrasco, H., G. Cordoba, Vertical Velocities of the STRATCOM VII-A Balloon Calculated From Radar Data EOS, 58, 451, 1977.

Collins, J. L., Stratcom-related Photodissociation Rates and Solar Flux Intensities ECOM-77-1, February, 1977, US Army Electronics Command, Fort Monmouth, NJ 07703 32 pp.

Gildenberg, D., Analysis of the Meteorological conditions Associated with the STRATCOM VII-A Balloon-Borne Experiment, 28-29 September 1976, EOS, 58, 451, 1977.

Goodman, P., The Water Vapor Environment of the STRATCOM VII-A Flight, EOS, 58, 452, 1977.

Heidt, L., W. Pollock, and R. Lueb, Cryogenic Collection of Whole Air Aboard the STRATCOM VI-A and VII-A Balloon-Borne Experiments, EOS, 58, 452, 1977.

Herrington, P., and R. Meyers, State of Health Measurements Aboard the STRATCOM VII-A Payload, EOS, 58, 451, 1977.

Izquierdo, M., H. Ballard and J. Randhawa, A Qualitative Interpretation of the Ozone Number Density and Temperature Profiles Measured Aboard STRATCOM VII-A as Related to Indicated Atmospheric Vertical Transport, EOS, 58, 452, 1977.

McDonald, C., M. Izquierdo, Z. Salpeter and H. Ballard, Air Temperature History Associated With the STRATCOM VIIA Balloon Flight, EOS, 58, 451, 1977.

Megill, R., K. Montierth, K. Baker and J. Randhawa, Measurement of Scattered UV Flux in the Stratosphere, EOS, 58, 452, 1977.

Mitchell, J.D., K. J. Ho, C. L. Croskey and L. C. Hale, Electrical Conductivity Measurements From the STRATCOM VII Experiment, EOS, 58, 452, 1977.

Murcray, D., A. Goldman, J. Kosters and W. Williams, Stratospheric Distribution of Several Minor Constituents and Pollutants as Determined From Infrared Solar Spectra, EOS, 58, 452, 1977.

Randhawa, J. G., Stratospheric Ozone Density as Measured by a Chemiluminescent Sensor During the STRATCOM VI-A Flight, ECOM-5816, April 1977, 12 pp. US Army Electronics Command, Fort Monmouth, NJ 07703

Randhawa, J., M. Izquierdo, Z. Salpeter and C. McDonald, Stratospheric Ozone Density as Measured by Chemiluminescent Sensors During the STRATCOM VII-A Flight, EOS, 58, 452, 1977.

Rubio, R., C. McDonald, and Z. Salpeter, STRATCOM VII-A Measurements of Shortwave Radiation in the 10-39 km Altitude Interval, EOS, 58, 452, 1977.

Sellers, B., F. Hanser and J. Hunerwadel, Solar UV Flux and Total Ozone Measurements from STRATCOM VII-A, EOS, 58, 452, 1977.

Woods, R. O., In Situ Mass Spectrometry at Stratospheric Altitudes, Atmospheric Technology, No. 9, Fall 1977, in press.