GEORGIA INSTITUTE OF TECHNOLOGY — OFFICE OF CONTRACT ADMINISTRATION

PROJECT ADMINISTRATION DATA SHEET

[X] ORIGINAL [ ] REVISION NO. _____

Project No. G-35-631 (R5968-0A0) GTRC/~~GTF~~XXX DATE 7 / 1 / 85

Project Director: R. G. Roper School/~~Lab~~XXXX Geo. Sci.

Sponsor: National Science Foundation

Type Agreement: Grant ATM-8512176

Award Period: From 6/15/85 To 6/15/86 (Performance) 9/15/86 (Reports)

Sponsor Amount:	This Change	Total to Date
Estimated:	$	$ 15,000
Funded:	$	$ 15,000

Cost Sharing Amount: $ N/A Cost Sharing No: N/A

Title: Travel Funds for Attendance of U. S. Scientists at the First Globment Symposium, Dushanbe, U.S.S.R., August 19-24, 1985

ADMINISTRATIVE DATA

OCA Contact John Schonk x4820

1) Sponsor Technical Contact:

William Sharp
National Science Foundation
AAEO/ATM
Washington, DC 20550

202/357-7619

2) Sponsor Admin/Contractual Matters:

Lee. A. DeHerrera
National Science Foundation
DGC/AAEO
Washington, DC 20550

202/357-9621

Defense Priority Rating: N/A Military Security Classification: N/A

(or) Company/Industrial Proprietary: N/A

RESTRICTIONS

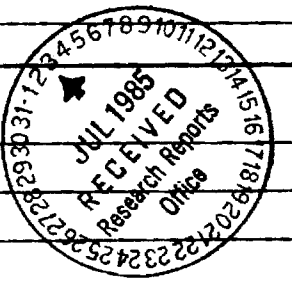
See Attached NSF Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval – Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with GIT

COMMENTS:

No Funds may be expended after 6/15/86.



SPONSOR'S I. D. NO. 02.107.000.85.121

COPIES TO:

Project Director
Research Administrative Network
Research Property Management
Accounting
Procurement/GTRI Supply Services
Research ~~Security~~ Services
Reports Coordinator (OCA)
~~Research Communications~~ (2)
GTRC
Library
Project File
Other A. Jones

FORM OCA 85-28S

GEORGIA INSTITUTE OF TECHNOLOGY OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

Date 7-1-87

Project No. G-35-631 School/~~Lab~~ Geo. Sci.

Includes Subproject No.(s) N/A

Project Director(s) R.G. Roper GTRC /~~GIT~~

Sponsor National Science Foundation

Title Travel Funds for Attendance of U.S. Scientistis at the First Globment Symposium, Dushanbe, U.S.S.R., August 19-24, 1985

Effective Completion Date: 12/15/86 (Performance) 3/31/87 (Reports)

Grant/Contract Closeout Actions Remaining:

- [X] None
- [ ] Final Invoice or Final Fiscal Report
- [ ] Closing Documents
- [ ] Final Report of Inventions
- [ ] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other

Continues Project No. Continued by Project No.

COPIES TO:

Project Director
Research Administrative Network
Research Property Management
Accounting
Procurement/GTRI Supply Services
Research Security Services
Reports Coordinator (OCA)
~~Legal Services~~

Library
GTRC
~~Research Communications (2)~~
Project File
Other Duane H.
Angela DuBose
Russ Embry

FORM OCA 69.285

G-35-62

NATIONAL SCIENCE FOUNDATION
Washington, D.C. 20550

FINAL PROJECT REPORT
NSF FORM 98A

PLEASE READ INSTRUCTIONS ON REVERSE BEFORE COMPLETING

PART I–PROJECT IDENTIFICATION INFORMATION

1. Institution and Address	2. NSF Program	3. NSF Award Number
Georgia Institute of Technology Georgia Tech Research Corporation Atlanta, GA 30332	ATMOS. SCIENCES (AERONOMY)	ATM-8512176
	4. Award Period From 6/15/85 To 12/15/86	5. Cumulative Award Amount

6. Project Title
Travel Funds for the Attendance of U.S. Scientists at the First GLOBMET Symposium, Dushanbe, U.S.S.R., August 19-24, 1985

PART II–SUMMARY OF COMPLETED PROJECT *(FOR PUBLIC USE)*

The First GLOBMET Symposium was held at the Lenin Tajis State University in Dushanbe, Tajicistan, U.S.S.R., from August 19 through 24, 1985. GLOBMET (The Global Meteor Observations System) was founded under the auspices of SCOSTEP (The Scientific Committee on Solar-Terrestrial Research) as a component of MAP - The Middle Atmosphere Program. While the atmospheric dynamics data from the system are of primary interest to MAP, GLOBMET also encompasses the astronomical observations of meteoroids, and the physics of their interaction with the earth's atmosphere. While the majority of meteor research is carried out in the Soviet Union, which was represented by over one hundred participants, the conference was attended by scientists from nine other nations, including the eight from the U.S.A. whose travel to and from the U.S.S.R. was financed by this grant.

In addition to presentations, posters and discussions on atmospheric dynamics in the neighborhood of the mesopause (prevailing winds, tides, gravity waves, and turbulence) meteor orbits, cometary associations - especially of the streams associated with Comet Halley, time was spent on both radio and optical observation techniques, data reduction and analysis, and the archiving of both geophysical and astronomical data. An overview of the meeting has been published in the Middle Atmosphere Program Newsletter for December, 1985, and in EOS for October 14, 1986. Fifty seven papers presented at the symposium are being edited by the principal investigator for publication as a conference proceedings in a Middle Atmosphere Program Handbook, to appear in early 1987. Funds provided under this grant were also used by the principal investigator to present GLOBMET data at the XXVIth COSPAR Assembly in Toulouse, France, June 30-July 11, 1986, for incorporation in the upcoming COSPAR International Reference Atmosphere.

PART III–TECHNICAL INFORMATION *(FOR PROGRAM MANAGEMENT USES)*

1. ITEM *(Check appropriate blocks)*	NONE	ATTACHED	PREVIOUSLY FURNISHED	TO BE FURNISHED SEPARATELY TO PROGRAM	
				Check (√)	Approx. Date
a. Abstracts of Theses	X				
b. Publication Citations	X				
c. Data on Scientific Collaborators			X		
d. Information on Inventions	X				
e. Technical Description of Project and Results				X	2/87
f. Other *(specify)*					

2. Principal Investigator/Project Director Name *(Typed)*	3. Principal Investigator/Project Director Signature	4. Date
R. G. Roper		11/18/86

NSF Form 98A (5-78) Supersedes All Previous Editions

Form Approved OMB No. 99R0013

FINAL TECHNICAL REPORT
GT/PROJECT NO. G-35-631

THE FIRST GLOBMET SYMPOSIUM, AUGUST 19-24, 1985, DUSHANBE, TAJICISTAN, U.S.S.R.

By
R. G. Roper

Research Supported by
THE ATMOSPHERIC SCIENCES SECTION (AERONOMY)
NATIONAL SCIENCE FOUNDATION

Under
Grant No ATM85-12176

Contract Period June 15, 1985 - December 15, 1986

July, 1987

GEORGIA INSTITUTE OF TECHNOLOGY
A UNIT OF THE UNIVERSITY SYSTEM OF GEORGIA
SCHOOL OF GEOPHYSICAL SCIENCES
ATLANTA, GEORGIA 30332

The First GLOBMET Symposium

August 19-24, 1985

Dushanbe, Tajicistan, U.S.S.R.

R. G. Roper (editor)
School of Geophysical Sciences
Georgia Institute of Technology
Atlanta, GA 30332

Being a summary of reports submitted by
the eight scientists who attended the Symposium
with financial support under

Grant No. ATM85-12176

(Georgia Tech Project No. G-35-631)

Atmospheric Sciences Section (Aeronomy)

National Science Foundation

July, 1987

CONTENTS

THE FIRST GLOBMET SYMPOSIUM

R.G. Roper
School of Geophysical Sciences,
Georgial Institute of Technology,
Atlanta, GA 30332

The First GLOBMET Symposium was held in Dushanbe, Tajicistan, U.S.S.R., August 19-24, 1985, under the sponsorship of SCOSTEP (the Scientific Committee on Solar-Terrestrial Physics), IAGA (the International Association of Geomagnetism and Aeronomy), ICMUA (the International Commission on the Meteorology of the Upper Atmosphere), the Soviet Geophysical Committee of the Academy of Sciences of the U.S.S.R. and the Institute for Astrophysics, Tajic Academy of Sciences.

GLOBMET (the Global Meteor Observation System) was first proposed by the Soviet Geophysical Committee (by B.L. Kashcheyev and V.A. Nechitailenko), and was accepted by the Middle: Atmosphere Program Steering Committee as a MAP Project in 1982. While the atmospheric dynamics data from the system are of primary interest to MAP, GLOBMET also encompasses the astronomical radio and optical observations of meteoroids, and the physics of their interaction with the earth's atmosphere.

In addition to more than one hundred Soviet participants, the conference was attended by scientists from nine other nations, including eight from the U.S.A.

During the opening ceremony, the attendees were greeted by Mr. Usmanov, the Deputy Prime Minister of the Republic of Tajicistan; Professor Asimov, President of the Tajic Academy of Sciences; Professor Ovezgeldyev, Chairman of the Soviet National Committee for GLOBMET; and Professor Babadzhanov, Proctor of the Lenin Tajic State University and prior director of the Astrophysical Observatory. This ceremony firmly established the atmosphere of conviviality which was continued throughout the meeting.

With some 46 oral and 30 poster presentations, the review which follows emphasizes invited papers, with an overview of the other contributions.

The first scientific session of the symposium consisted of four invited papers presented by members of the GLOBMET Panel. Roper opened with a review of currently operating radio meteor systems, with emphasis on meteor wind radars, but also including the proposed three station Georgia Tech Radio Meteor Facility, which is designed to measure meteoroid orbits as well as both large and small scale parameters of the mesopause level wind field. He discussed the relative merits of beam antennas versus all sky (dipole) systems, with the latter producing not only a somewhat greater height coverage but also a greater radiant distribution for orbit measurement. Roper also referenced the Soviet Hydrometeorological Service "Cyclone" radar (Lysenko), the ST/MST radar as a meteor radar (Avery), the MU radar as a meteor radar (Fukao) and the Newcastle radar (Keay).

Babadzhanov then discussed what is currently known about the dynamics of meteor streams, emphasizing both evolutionary theories and observational evidence. The role of gravitational and non-gravitational perturbations were discussed in the context of the concrete examples provided by the Gemenid, Quadrantid and Perseid streams. Estimated lifetimes for these streams were presented, as determined from a mathematical model of the structure and shape of meteor streams versus time.

Ovezgeldyev followed with a presentation on the spectra and aeronomy of meteor trails, using the meteor-atmosphere interaction as a unique phenomenon for the study of elementary gaseous processes, such as atomic and molecular oscillations, excitation and ionization, dissociation, recombination, ion-molecular reactions, and so on. The collision processes involved cannot be simulated in the laboratory (the average meteoroid has a velocity of a few tens of kilometers per second). The lines and bands of observed meteor spectra are a combination of radiation from both incoming meteor atoms and molecules, and those of the ambient atmosphere. Many species and reaction schemes have already been identified, and efforts are being made to improve both the observational instrumentation, and the reduction, analysis and interpretation schemes. Special emphasis was placed on the importance of metallic and other meteor ions to the aeronomy of the middle atmosphere.

The collection of data and exchange of information was addressed next by Nechitailenko, who emphasized the need for validation and editing of data during the reduction and interpretation process, and that the algorithm for achieving this should be standardized, if possible, and, if not, should be readily available to users of the data. He suggested the development of a meteor data indexing system, to establish criteria of compatability, homogeneity and representativeness of any given data set, and the requirement for standarized formats for international data exchange, as have already been proposed for wind reporting by the GLOBMET Panel.

The opening paper of the session on "Dynamics of Atmospheric Processes in the Meteor Zone," which was to have been presented by Portnyagin, was withdrawn due to the absence of the author. This was especially unfortunate in that Portnyagin has been in the forefront of the measurement and interpretation of mesopause level winds for almost two decades.

The results from the meteor wind radar at Shigaraki, near Kyoto, Japan, which has been operating almost continually since 1979, were presented by Kato. Prevailing winds, tides, gravity waves with periods of a few hours, and some long term means for the lunar tide were discussed—the thermal tides in the context of global observations, as exemplified by the ATMAP (Atmospheric Tides in the Middle Atmosphere Program) project. This was followed by a paper by Kashcheyev on the dynamics of the equatorial meteor region. While this is "old" data (from the period August, 1968 to July, 1970) taken on a Soviet expedition to Mogadishu, Somalia (2°N, 45°E), it is very important because it is the only long term data set from the equatorial regions. The equatorial lower thermosphere is

characterized by predominant easterlies, a diurnal tide greater in amplitude than the semidiurnal, a two day component, and, on occasion very large wind speeds (greater than 150 m/sec).

These papers were followed by contributions related to the solar cycle dependence of long term variations in mesopause level circulation, extensive observations of lower thermospheric winds over Europe and Asia, the relationship of such circulations to the occurrence of midwinter stratospheric warmings, and the possible forcing of these motions by tropospheric meteorology.

Presentors on Wednesday morning continued the discussion of the previous afternoon's topics, with additional material on tidal winds. In the afternoon, Gavirlov presented an overview of the current state of the art in gravity wave theory, prior to presentations on lower thermospheric turbulence, the role of fragmentation in the interaction of meteoroids with the atmosphere, and an invited paper by Mathews which considered some aspects of metallic ion chemistry and dynamics in the meteor region. These were followed by presentations on meteor trail spectra, fireball end heights, and a film on the dynamics of magnetic storms.

Thursday's papers concentrated on the astronomical aspects of meteor science. Belkovich discussed the importance of global observations of the meteor flux, and was followed by Ceplecha's review of many years involvement with photographic fireball networks. Voloschchuk presented data from about two decades of observations from Kharkov of the temporal and three dimensional structure of the meteor complex in the vicinity of the Earth's orbit, and Simek a method for improving the statistics of meteor shower data analysis from long term observations. Further papers on observations of the Eta-Aquarid and Orionid meteor showers, the density of the incident meteoroid flux and the modelling of sporadic and shower meteoroid distribution followed.

Thursday afternoon's session covered predictions relative to the "Valec" Fireball fall and the relationship of the Eta-Aquarids and Orionids to the orbit of Halley's comet.

Friday morning's session was entitled "Methodological Problems; Techniques and Facilities for Studying Meteors and the Middle Atmosphere." Avery and Fukao, in separate papers, presented some results of meteor wind determinations from MST radar facilities. The concept of MENTOR (Meteor Echoes—No transmiters, Only Receivers) which proposes to use the Colorado Wind Profiler Network of ST radars was presented by Roper, and Keay discussed the new Newcastle (Australia) meteor patrol radar. A paper on lidar sounding of the meteor zone was followed by Meisel's discussion of the reception of various beacon transmiters by amateur radio operators as a data source for meteor rate studies, and a paper by McIntosh on the archiving of a data base as part of the International Halley Watch. Papers on the treatment of data from radar observations of meteor showers and the technical problems of spaced image intensifier observations completed the formal presentations.

Thursday afternoon was highlighted by a panel discussion which included summary presentations by session chairmen. In addition to contributions to GLOBMET, involvement of the radio meteor community in the international programs such as the Halley Watch, ATMAP (the Atmospheric Tides in the Middle Atmosphere Project) and GTMS—the Global Thermospheric Mapping Study, of which the URSI/IAGA CTOP (Coordinated Tidal Observations Program) is an important facet, was discussed. The proliferation of such programs has greatly increased the need for standardized formats for data exchange. Further emphasis was put on the need for continuous observations, both of winds and meteoroid fluxes and associated astronomical parameters. This is now relatively easily achieved; because the rapid advances in the techniques of automatic recording. There is still much work to be done on the number densities and mass distributions associated with both daytime and nighttime showers and sporadics. While meteor radiant measurements are not as accurate as optical, the ability to measure during the daytime, and continuously independent of cloud cover or moonlight more than offsets this limitation.

The formal program ended with a closing ceremony in which the participants thanked the sponsors and organizers and, in particusimultaneous translations in English or Russian for the whole program.

The formal presentation program was greatly enhanced by the poster sessions, for which time out from the oral presentations was arranged on Wednesday and Thursday afternoons. One must compliment the Soviet scientists for the amount of time it must have taken to present all their poster texts and figure captions in English. It was here that the "nitty gritty" of the session topics could be discussed in more detail than could be accommodated in the formal sessions, and the significance of the Soviet contributions to an area receiving little attention elsewhere could be fully appreciated.

Extended abstracts of nearly all of the presentations and posters will appear in a forthcoming issue of the MAP Handbook.

CHAPTER I

INTRODUCTION

This report is sent as requested to summarize my attendance in Dushanbe at the First GLOBMET Symposium. It highlights the "main results" of participating in this gathering. Some background is given concerning earlier contacts with the meteor radar program because this context gives significance to the Dushanbe results.

My first contact with the Meteor Radar community was in 1979 at the IUGG General Assembly in Canberra, Australia. Because of anticipated involvement with MAP data, I attended a Joint Working Group meeting devoted to planning the start of systematic collection of meteor wind radar data. At that time there seemed to be little agreement about standard data formats, standard data collection procedures, standard data processing algorithms to derive common results, standard data exchange formats, or plans for systematic collection of reduced data at an archiving and dissemination facility. These typical needs of all data collecting programs usually are not considered in detail until the more immediate problems of instrument development, deployment and operation are solved.

I told the Working Group about WDC-A experiences with international data exchange of data on magnetic tape, especially USA-USSR exchange, and suggested that they coordinate with appropriate WDC's for help with data handling problems. At that time most meteor radar operations were planned to determine neutral winds in the Middle Atmosphere region and the group thought the appropriate data centers would be those serving meteorological disciplines (e.g. in the U.S. the National Climate Data Center in Asheville, NC). In my NOAA trip report and in discussions with the Director NGDC, I discussed this contact but did not actively follow-up. MAP Handbook and Newsletter articles later gave

more meteor radar program information but I only followed it marginally.

By the time of the IAGA Scientific Assembly in Edinburgh (1981), agreement had been reached on most instrumental problems and special workshops were planned to share experience with processing meteor radar data to derive winds and other parameters. GLOBMET was emerging but still without planning for coordinated data collection and dissemination - perhaps because no large volume of data existed - meteor radar still was a research area. Talks with John Gregory and Rex Megill were main sources of information on current operations and plans for further meetings to "iron out formats".

At the IUGG General Assembly in Hamburg (1983) substantial progress in the meteor radar field was evident by comparison of papers there with those from earlier meetings and at the Working Group discussions. Activity of the ICSU Panel on World Data Centers' Task Group on Guide Revision was discussed and the need for a Meteor Radar section of the new Guide. The GLOBMET group acted to meet this need and a draft document was produced describing standard data collection, formatting, and exchange but the ICSU Guide revision effort stalled and no iterations followed by which GLOBMET expertise could combine with WDC experience to refine their proposals. WDC-B2 (Moscow) announced that two new staff were added to work with MAP data, including meteor radar data. WDC-A for STP seemed to have stabilized after drastic reductions in 1981 to the STP data services area of the National Geophysical Data Center (NGDC) but there were no new resources to devote to meteor radar or other MAP data.

Two important GLOBMET-related events happened in Spring 1985: (1) The first tape of meteor wind data was received at WDC-A for STP from WDC-B2; and (2) I was invited to participate in the First GLOBMET Symposium and to be one of 8 U.S. scientists attending the meeting under a grant obtained by Professor Roper, co-organizer of the symposium. The new data tape, in the GLOBMET standard format, was copied to Roper in anticipation of his looking at the contents and reviewing their correctness and utility and identifying any needed changes in

format or data contents. At WDC-A, we know only that these tapes can be copied for user requests and have no experience to support an evaluation of the meteor wind radar data significance or quality.

FIRST GLOBMET SYMPOSIUM - DUSHANBE, USSR

From August 19-25 I was in Dushanbe attending the First GLOBMET Symposium and having my first uninterrupted tutorial introduction to the details of meteor radar observations and meteor wind determinations. The most important feature of this meeting for me was the opportunity provided to meet with most of the key sources and users of meteor radar data. I learned in detail about the current level of need for standard data exchange, had an opportunity to request final input for the revived ICSU Guide revision section on Meteor Radar data collection, processing and exchange through the WDC system, and obtained a commitment for a final draft by December 1985. It appears that WDC-A for STP will be able to cope with receiving processed MR-data and when we have acquired a representative data base, it will be advertised through the STP Newsletter and direct mailing of announcements to our list of some 3,600 names in the STP/MAP communities.

The opportunity for personal, one-on-one interactions with many persons in the meteor radar community was excellent for it gave many of them their first contact with a representative of the WDC community. For example, Dr. Susan Avery reported on use of MST radar data to study meteor winds and she was not informed about the WDC system, its existing STP data holdings, or the possibility of meteor radar data being exchanged through WDCs.

Contacts with Ceplecha (Ondrejov Observatory, Czechoslovakia) and Cevaloni (Bologna, Italy) were important because they were completely new names to me and may become important data sources.

Contacts with V. Nechitailenko and E. Kharin, WDC-B2 (Moscow), to learn about their meteor radar data holdings, handling plans, and the recent

reorganization within the Soviet Geophysical Committee and WDC-B2 were important because of their potential impact on future exchanges with WDC-A.

Lagutin's report on using LIDAR sounding in the meteor zone seemed potentially important although about a completely different technique than meteor radar data and it is important to find out more about this method and the data generated by it in different countries and the extent to which it will complement and/or independently validate meteor radar data.

Meisel's report on the systematic observations by amateurs was of special interest because our data center has long experience with amateur efforts from the American sunspot observing network. If properly organized and if their output is quality-controlled, such networks can produce much good data.

McIntosh's report on the International Halley Watch data collection, processing and archival plans was interesting. I must learn more about the FITS (Flexible Image Transfer System) standard tape data format. However, their plan to have a completed data archive only by 1989 (four years after the roughly 6-month Halley passage) illustrates the difficulty and time required to build a comprehensive data base. I was surprised that they use a digital data format in which dates are given by MO/DA/YR. This is contrary to the old European standard (DA/MO/YR) and has generally been replaced among all computer-oriented data collecting bodies by the standard YR/MO/DA (e.g. today is 85/09/12).

Colin Keay was surprising when he stated that the Newcastle meteor radar would not be used for meteor wind observations (did I misunderstand) in his lifetime. My expectation before the GLOBMET symposium was that some of the papers would be related to meteor burst radio communications but except for the possible use of meteor count rates, orbits, and ablation information given in some of the papers it seemed that all reports were addressed to neutral wind measurements. Is Keay using the Australian meteor radar for communications studies? Is he the only one doing this? [The Newcastle radar is designed for Astronomical use - particularly meteor count rates. Ed.]

Mathews' comment that if the meteor radar groups waited until data were published in journals it "will be 10 years until they are available" was not encouraging. This presents a challenge to the data services community which we must meet if GLOBMET and the larger meteor radar community are to make reasonable progress based on general availability of data and results.

FURTHER COMMENTS

Potential for conflict among plans to archive:

(1) Incoherent Scatter Radar data;
(2) MST Radar data;
(3) ST Radar data; and
(4) Meteor radar data.

For example, in U.S. (1) is at NCAR and supported by NSF. (2) is collected by NOAA, an agency which has internal data centers, and by university groups which may be NSF-funded and want to put their data at NCAR.

This has some potential for diminishing the international sharing of data through the WDC system. On the other hand, use of the MR data (at WDC's) by communications researchers as well as for wind studies is likely to focus on the WDC system where such data have been retained since ~1957. Quantity of data, number of requests received, format of data, and cost of acquisition (possible exchange) all are important.

Need to have at WDC's:

(1) Catalogs of data held at collecting institutions, regional centers, and special program centers. If any of these are of temporary lifetime, plans must be made for generation of standard data summaries and decision made about what to hold for the future.

(2) If data held at WDC's, then description of type, frequency, format, etc. must be written quickly for ICSU Guide. Also coordination needed between meteorology and ionospheric data centers.

September 12, 1985. Joe H. Allen

CHAPTER II

The GLOBMET Symposium held in Dushanbe, 18-26 August was interesting for me in two ways. Firstly, as a means of learning about the Soviet efforts in studying atmospheric dynamics in the meteor zone and secondly as an opportunity to learn about meteor astronomy.

I was impressed with several of the Soviet papers in dynamics. In particular I was interested to see a strong two-day oscillation in the equatorial region as reported by B. V. Kalchenko and B. L. Kascheyev. This result is important for our tidal experiments at Jicamarca and gives us further information for determining the best method for analyzing data for tides. The satellite analyses presented by Koshelkov revealed similar features of the circulation presented by other scientists. I was surprised that his comparison between geostrophic winds and actual winds was good at high latitudes. Other workers have shown discrepancies at latitudes north of ~70° due to strong ageostrophic components in the wind field.

Of the younger Soviet scientists present at the Symposium (not many!) I was most impressed with the gravity wave work of Gavrilov. He had one oral presentation and several poster presentation describing the modeling studies of the propagation characteristics of gravity waves. He also had a poster paper that showed results of a statistical study of gravity wave characteristics in the meteor zone. Although this later presentation was terse, it did seem to show momentum flux values in the upper mesosphere that were quite large in winter (-60 ms^{-1} day^{-1}) and significantly smaller in summer (10 ms^{-1} day^{-1}). It is interesting that there is such a dramatic difference between the two solstices. However, the time resolution of the radiometer data was not mentioned so we have no idea of the frequency distribution of the observed gravity waves.

I was most impressed with the data base management movement in the Soviet

Union. This movement seems to be largely the result of Nechitailenko's efforts. It seems to me that the Soviets are more aware of the need for a data base than we are. Of course the major drawback in using their data is the lack of height resolution. However, I did seem to hear that several of their radars would soon be able to produce wind profiles. That is encouraging.

I was somewhat disappointed in the meteor astronomy aspects of the symposium, probably because of my unfamiliarity with the subject. A few more tutorials would have been good for me. I still don't know why there is such a keen interest in studying meteors in their own right (i.e. radiants, distributions, etc.). Presumably knowledge regarding planetary objects can be deduced. I found the most interesting paper to be the historical development of the study of fireballs by Ceplecha.

The presentation by western bloc scientists were excellent. I was particularly interested in the attempt by the Japanese to determine whether the meteor echoes observed with the MU radar were in the mainlobe or sidelobes of their antenna pattern. This is a crucial point that needs to be resolved if we are to continue using the MST (ST) radars for meteor detection. I had several conversations with S. Fukao regarding additional experiments to resolve this question. In addition, discussions with J. Mathews and D. Meisel concerning the analysis of randomly spaced data were useful to me since I have a graduate student also working on this problem.

Overall I felt that the exchange of scientific information at the Symposium was good. I certainly returned to the States with several new ideas.

September 25, 1985 S. K. Avery

CHAPTER III

Abstracts of the presentations at the first GLOBMET Symposium are available in English, as are some of the complete manuscripts, so a detailed description will not be given. Rather, this report deals with my individual impressions of the meeting.

There was a total of five sessions, as follows:

1. Dynamics of atmospheric processes in the meteor zone
   5 invited papers, 12 contributed, 10 posters
   7 of the presentations were from outside USSR

2. Physics of interaction of meteors with the earths atmosphere
   2 invited papers, 10 contributed, 7 posters
   4 of the presentations were from outside USSR

3. Meteor flux, structure of meteor complex
   5 invited papers, 4 contributed, 3 posters
   2 of the presentations were from outside USSR

4. Structure and evolution of meteor showers
   5 contributed papers, 5 posters
   2 of the presentations were from outside USSR

5. Methodological problems, techniques and facilities for studying meteors and middle atmosphere
   4 invited papers, 6 contributed, 5 posters
   7 of the presentations were from outside USSR

As is evident, the major participation was from the USSR. I am conversant only with the scientific fields of Session 1, so my remarks are confined to it.

The GLOBMET Symposium organizers are to be congratulated on having arranged that three different scientific communities came together at this meeting: those concerned with the dynamics of meteors themselves (Ovezgeldyev); scientists involved in meteor measurements (Portnyagin, Cevolani, Roper, etc); and dynamical meteorologists concerned with atmospheric structure, tides and waves (Koshelkov, Gavrilov, etc.).

I got the impression that these communities have not previously discussed their scientific results at a meeting of this kind. The proceedings will be of

great interest to the MAP community.

The network of meteor radars in the USSR is the most extensive in the world. However, these radars have generally no height discrimination, so the tidal results all refer to some average altitude in the middle of the meteor region. This is a great handicap in the identification of tidal modes, for example, where the vertical wavelength must be known. It was strongly stressed to the Soviet scientists that every effort should be made to incorporate height determination in their radars.

The papers themselves were highly variable in quality. The theoretical review papers were excellent, particularly those by Gavrilov and Koshelkov, but I had the impression that some of the experimental analysis papers were pushing the data further than I would like to see.

I believe that the major benefits from this Symposium will be to the USSR scientists who were able to hear from outside visitors (Roper, Keay, Fukao, Avery, Mathews, etc.) some of the more recent and exciting results from incoherent scatter and MST radars, as well as from meteor radar.

January 21, 1986 S. A. Bowhill

CHAPTER IV

The GLOBMET meeting reinforced for me several prior conclusions or suspicions. Scientifically, I have always found that the "workshop" environment, with just single sessions, to be scientifically more valuable than, for example, the AGU meetings. Furthermore, a range of topics sufficient to be considered interdisciplinary greatly enhances the interest in the workshop and enhances the possibility of scientific "cross-fertilization". The GLOBMET meeting satisfied both these requirements for me personally. For example, I met Professor David Meisel (SUNY Geneseo) and became interested in his "passive" meteor radars. I have raised $2000 from Lawrence Livermore National Laboratories, and a student is now building the system.

The meeting also confirmed for me my suspicions that the Russian peoples are without any basic animosity toward US citizens and that "our" mutual difficulties are at a "government" level. Our Russian hosts were friendly, courteous, and so helpful as to be sometimes almost overwhelming. The people we met on the streets were friendly toward and curious about us.

Unfortunately, the apparent state of Russian science, in my area of atmospheric/ionospheric research, is fairly poor. However, several of the scientists (e.g. V. Stepenovich and O. Alimov) were extremely interested in my talk (Some Aspects of Metallic Ion Chemistry and Dynamics in the Mesosphere and Thermosphere), and I ended up giving away all my personal copies of my published papers which I had with me in order to finalize my talk.

I will conclude with some suggestions. First, I found that more translators were needed for informal discussions. The workshop environment demands that just formed ideas get discussed and this is not always possible in the formal session format. Secondly, I believe "we", and I am not sure who "we" are, should host a few of the Russian scientists on extended trips to the US. Such arrangements need to be made, in my view, at some level above individual

academic institutions. I would happily assist in making these arrangements. Also, I strongly encourage another GLOBMET meeting and suggest a neutral, accessible venue but that the size of the meeting remain in the 100-200 participant range.

Finally, while realizing the apparent political sensitivity of the issue to both the US and USSR, I strongly urge mutual discussions of deep space observations of cometary bodies which could pass near to or impact the earth-moon system.

I thank our Russian hosts, in particular V. A. Nechitailenko and P. B. Babadzhanov, and Professor Roper for an excellent meeting. I also thank the NSF, Georgia Institute of Technology, and my academy department, (Electrical Engineering and Applied Physics) at Case for the financial support necessary to enable me to participate in this meeting.

September 25, 1985 J. D. Mathews

CHAPTER V

PROFESSIONAL RESULTS FROM ATTENDANCE AT GLOBMET

Since my principle interest in the meeting was in the area of meteoric astronomy, I will concentrate my comments and recommendations on this subject. My recommendations will be given in upper case letters.

The symposium started off with four excellent review papers:

Roper: On meteor radars

Babadzhanov: Dynamics of Meteor Streams

Ovezgeldyev: Meteor Spectra

Nechitailenko: Meteor Information Data Banks

From Roper's review it is obvious that the main concentration of meteor radars is in the U.S.S.R., but that several of the most sophisticated installations are outside the U.S.S.R. and more are needed especially in North America.

Babadzhanov described an attempt at unifying several of the well-known annual showers, by a single dynamical mode. The results are not convincing, however, and indicate that in spite of several decades of radar meteor observing of the major showers, the dynamics of meteor streams are still not well understood at least in terms of conventional astronomical theories.

Ovezgeldyev described the spectroscopy and aeronomy of meteor trails obtained with photographic and TV imagery. He indicated that there are many unresolved problems when the excitation of the visible trail is compared to the ionization detected by radio scatter.

Nechitailenko indicated the problems of unifying the immense amount of data collected by USSR scientists and making it available to the world community on a data exchange basis. The difficulty of combining material obtained at widely divergent locations and with different types of equipment does not yet appear to be near solution.

The problem of wave excitation from meteor wake turbulence was addressed in a poster paper by Jandieri and Kevanishvili. This work and several others in the poster session seems to indicate that a better definition of the spectrum of mesospheric turbulence as measured by meteor trail doppler motions is needed. THIS IS ONE POSSIBLE AREA OF WORK WHICH SHOULD BE EMPHASIZED FOR THE PROPOSED NEW GIT RADAR SYSTEM.

J. Mathews described the apparent migration of heavy ions into the ionosphere. Since these have come from the mesosphere due to turbulent transport, a detailed study of the turbulence is reinforced. Since sporadic-E phenomena is often cited as manifestation of the effect of wind shear on meteor ions, it seems that a reinvestigation of Es occurrence in the same area as mesospheric wind and meteor trail turbulence would be of interest. AN Es PATROL OPERATED IN CONJUNCTION WITH THE NEW GIT RADAR MIGHT YIELD SOME INTERESTING RESULTS. (In particular, it would be of interest to establish that Es occurs when there is some interruption or enhancement of the vertical transport.)

The paper by Babadzhanov et. al. (given by Novikov ?) explored the role of fragmentation in both radio and visual meteor studies. Certainly this parameter was of great interest in the Harvard project during the 1950's and is of continued interest particularly for astronomical studies. WHILE THE PROPOSED GIT RADAR CANNOT GET AS DETAILED FRAGMENTATION DATA AS THE HARVARD PROJECT, THE THREE STATION VELOCITIES AND TIMES OF ARRIVAL AT EACH HEIGHT CAN BE USED TO DERIVE APPROXIMATE DECELERATION PARAMETERS FOR EACH METEOROID. THUS A METEOROID DENSITY CLASS CAN BE ASSIGNED FOR EACH OBJECT IN A MANNER INDEPENDENT OF THE END-HEIGHT, MASS, AND VELOCITY RELATIONSHIP.

On August 22 Belkovich reviewed the astronomical problems of GLOBMET. He cited several problems that are yet unsolved. In particular, if the large bulk of meteoric material comes from ejection from comets conforming with the Whipple model, how does one invert the observed stream properties to obtain the details of the three-dimensional structures around the sun? Also is the sporadic meteor

flux an equilibrium configuration? Why is there a limit of 0 to 130 degrees in the elongations of slow meteors? The only thing that seems in a satisfactory state is the determination of the exponent of mass distribution. IT SEEMS THAT PERHAPS ONE SHOULD SEEK A DIRECT SOLUTION OF THIS PROBLEM IN TERMS OF A THEORY BASED ON TIME-SERIES ANALYSIS OF THE DATA AS PROPOSED IN MY PAPER.

The paper by Simek demonstrated how difficult it is to derive flux data with a single radar at a single frequency. He confirmed that the Czech radar is operated (like the one at Ottawa) only during major showers. This means that the new proposed GIT radar would be one of the few outside the U.S.S.R. to be operating continuously for the purpose of obtaining astronomical information. Colin Keay's would be another one. THIS SHOULD BE EMPHASIZED FOR THE PROPOSED GIT RADAR SYSTEM. IN PARTICULAR, THERE IS NO GOOD COVERAGE OF MINOR METEOR STREAMS.

The papers in the poster session all reinforce the above perceptions that while there are a large number of investigations and investigators involved in the interpretation of the meteor data along traditional astronomical leins, no one is looking at the problems in terms of random processes (i.e. time-series analysis) as I proposed doing. The nearest to what I have in mind is the Monte-Carlo approach described by Kulikova. THE NEED FOR DATA IN SUPPORT OF A UNIFYING METHODOLOGY SHOULD BE EMPHASIZED. IT IS AGAIN APPARENT THAT NO ONE IS ADDRESSING THE TIME-SERIES ANALYSIS ASPECT OF THE PROBLEM.

Several papers addressed the problems of dealing with the Halley-related showers. Most indicate that no enhancement of the showers due to the passage of the comet can be expected, but this does not mean that they are not going to be of interest. IT IS QUITE LIKELY THAT ONCE THE HALLEY "MANIA" IS OVER, THERE WILL BE MUCH REDUCED INTEREST IN THESE SHOWERS.

At the meeting there was plenty of opportunity to make contacts with other meteor astronomers. In particular contacts with Belkovich, Hajduk, Ceplecha, Babadzhanov, Getman, Bronshten, Simek, Keay, Revelle, Novikov, Ovezgeldyev, and

Nechitailenko were extremely valuable for the astronomical viewpoint. There is no doubt that a dual S.U.N.Y. - G.I.T. effort could contribute greatly to the GLOBMET program. WHAT HAS NOT BEEN RESOLVED IS WHY THERE IS STILL SUCH INTENSE INTEREST IN METEORS IN THE USSR AND VIRTUALLY NONE IN THE U.S.????? (I could get no information on this from any of the Soviet participants.)

URSI (including the U.S. Nat. Comm.) really has no place to fit radio meteor work in any of its commissions. Is there anyway we could get them to sponsor some sort of radiometeor subcommittee?

If Susan Avery gets bogged down with her "black box" program, someone should pick it up.

It seems that the MENTOR program could be made to work with the MIT optical program in New Mexico. OF PARTICULAR INTEREST WOULD BE A FAINT METEOR MAGNITUDE-IONIZATION CORRELATION STUDY. The data rates would be low but perhaps worth trying.

September 29, 1985 D. D. Meisel

CHAPTER VI

The First Globmet Symposium was held the week of August 24, 1985 in Dushabe, Tajicistan, U.S.S.R. The meeting brought together specialists from both inside the U.S.S.R. and Soviet Bloc and Western scientists working on the problems associated with processes occurring near the Mesopause.

Specifically the areas of competence included radars for probing this region which includes atmospheric systems (MST, etc.) and Meteor radars as well. In addition, topics such as atmospheric fluid dynamics as well as the physics of meteors and fireballs were also presented by the numerous scientists (more than 100) registered at the conference. Of this number eight U.S. scientists attended the meeting along with scientists from Canada, Australia, Japan and others as well.

The meeting lasted for about three and one half days and was filled with activities almost continuously. We could have really used one or two additional days to fully absorb all the information that was being exchanged at the conference. This has also been true at most other meetings I have attended. However, this exchange was very unique in that even most of the Russians from outside Dushanbe had not seen one another in about 10 years! Some discussion took place following the meeting about the possibility of holding a Second Globmet Symposium in Kazan
in about two or three years. I feel this would be an excellent idea that could help with projects with international scope, such as Globmet, as well as to foster communications between Western and Soviet scientists.

I would like to take the opportunity to acknowledge the support of Dr. M. H. Davis, Atmospheric Processes Direction, Univer. Space Res. Asso. (U.S.R.A.) and of both Dr. Robert Smith and Dr. William Vaughan of the Atmospheric Sciences Division of the Systems Dynamics Laboratory of the NASA Marshall Space Flight Center (MSFC) for making my trip to Dushanbe possible. In

addition, the NSF travel grand acquired by Dr. R. G. Roper of Georgia Tech allowed a significant reduction in the overall costs that U.S.R.A. would otherwise have had to expend in my behalf. This was especially significant in by case since, at the last minute, I accepted an academic position which meant that I would not return to NASA/MSFC following the conference.

With regard to my reaction to the overall meeting, I was impressed with the high quality of the sessions, the concurrent translations from Russian to English and vice versa, etc. We could not have asked for better hosts.

I must bring up a very important point regarding future exchanges within Globmet. As a U.S. scientist I felt I came to Dushanbe to contribute to both the areas considered at the meeting, namely Meteors and Fireballs and Atmospheric Processes occurring in the vicinity of the Mesopause. There were only two other Western scientists who were at Dushanbe and were also active in the meteor physics field. In contrast, most of the Soviet and Soviet bloc scientists at Dushanbe were engaged in various forms of meteor research including the area of meteor radar techniques. If future exchanges are to continue, this obvious imbalance should change so that a more balanced and effective communication can continue. This also brings up the important question of why there are so many Soviet scientists doing meteor research in stark contrast to the situation in the Western world. The answer I have been told by various scientists is that the work goes on primarily due to the interests of the Soviet military. The question that arises then is should this exchange continue to be fostered, if this is the primary motivation.

I believe the answer is that it should be fostered. The totality of atmospheric processes in the vicinity of the Mesopause is sufficiently complex that international cooperation is almost a necessity, i.e. witness the numerous global programs within MAP of which Globmet is a small, but an integral part. If we are to continue to make progress in this area, future exchanges like Globmet must continue. In addition, more Western scientists need to be involved

in the meteor-fireball area as well as in the field of middle atmospheric processes research. The fields are quite complimentary, contrary to current majority Western views on the subject. At this meeting I was able to make contact with almost everyone who is doing significant meteor work. This was certainly not true for the atmospheric case. Many prominent Western scientists who went to Prague did not go to Globmet. Travel costs were not the single largest obstacle that prevented their attendance in Dushanbe. Hopefully, at the next Globmet Symposium the current imbalance of atmospheric workers from the West can be improved.

With regard to personal contacts, I found the meeting very satisfying. I had never met Dr. Bronshten before so my discussions with him were especially important. Also, continuing additional contacts with Dr. Belkovich and Dr. Babadzhanov, Dr. Getman, Dr. Keay, and Dr. Ceplecha, etc. were also very satisfying. These contacts, for areas of common interest, may lead to future collaborative work.

Thus, as far as my own personal research was concerned, I was quite pleased with the conference from an atmospheric research view and from the meteor research presented as well. As I mentioned earlier, there were far more meteor people than atmospheric types at the conference so the feedback on my work was heavily weighted toward the former.

There were two Russian groups working on atmospheric problems that were relevant to the ongoing work at the NASA/MSFC. One group was involved with a quasi-numerical calculation of waves in the Mesosphere from a Tropospheric source, similar to work I have done for NASA/MSFC. A report summarizing this work will be finished shortly with the help of U.S.R.A. As a result of Globmet, two short papers will be submitted to the J.G.R. on the meteor-fireball work and on the atmospheric work as well. A second group were using radiance data from a Soviet satellite system to calculate various Mesospheric parameters (temperature, etc.). This work could compliment the current NASA modeling

efforts regarding the improvements in GRAM (Global Reference Atmosphere Model) for use with various NASA projects (Shuttle, AOTV, UARS, Station, etc.).

Thus, this conference helped me greatly both personally and professionally. The warm friendliness of the Russian people and their traditions and the generally high quality of the work that was presented made this experience very worthwhile. If a second conference does take place, I would be pleased to attend. These people need continued contact from the West, and we need future collaboration on problems requiring international cooperation.

December 20, 1985 D. O. ReVelle

CHAPTER VII

My attendance at the first Globmet Symposium at Dushanbe, USSR was personally very rewarding. It provided my first insight into the real depth of work being carried out in one middle atmosphere field, viz meteor physics and atmospheric processes on the height region of meteor entry. The opportunity to meet a number of lower-level, less-senior scientists who have not been able to travel outside USSR was beneficial. It seems that much of the newer work is being done by these less-travelled people.

My scientific objective in attending the symposium was to determine the level of work attained in USSR on the middle atmosphere region 70-100 km. Although my own work has focussed on MST radar and incoherent-scatter radar methods, the older meteor radar technique that is popular in USSR still has much to offer, particularly for long term studies. It is of interest for me to determine the level of international expertise in the experimental methods themselves and the future scientific potential. This has been prompted by the realization that MST radars have proven quite inadequate for studying the middle atmosphere. Their data is intermittent in height and time, and the cost (capital and operational) is too high for such sparse data.

The meteor radar method has been criticized for low count rate and poor height coverage. Therefore I was interested in learning what technical advances, if any, had been made in recent years. If sufficient technical advances seemed possible, and significant sciences was attainable, I would consider a proposal to place such a radar in Alaska because the MST radar near Fairbanks is due to close at the end of 1986.

A large segment of the meeting was devoted to the physics of meteors, meteor entry,and astronomical aspects of meteor research. This was outside my personal expertise, however there was an obvious strong effort in these areas (28 papers).

The technical advancements received too little attention in my opinion. The most promising paper was given by Professor Keay from Newcastle, Australia. He described preliminary results from a new radar. The meteor count rate was very high compared to older systems. The main improvements are in the data acquisition and signal processing. The data handling equipment is probably not cost-effective to duplicate in the US environment because of the high level of university-built parts. However, the key data acquisition and signal processing components could be emulated with an inexpensive micro or mini computer with hardware arithmetic units. For example, the signal processing algorithms for threshold detection could be transferred to other radars. Given sufficient funds, the meteor radar community should determine the optimum possible performance from a radar. Technical issues did not receive adequate coverage. Considerable gains seem possible and could lead to better scientific utilization.

The two papers by Avery and Fukao on meteor wind observations using MST radars confirmed my prior experiences. That is, MST radars are very poor tools for detection of meteors because the vertical narrow beam antenna results in low count rates.

With regard to MST radars, there was much interest in US results. However, there are apparently no plans for MST radar construction in USSR. There was little USSR interest in incoherent-scatter as a tool for investigating the geophysics of the meteor height region. However I learned of a proposal within USSR for a chain of incoherent-scatter radars, but the funding seems unlikely at this time.

Many of the wind observation papers involved long-term studies including solar cycle effects. There was little effort to link these observations to large-scale numerical models.

The symposium was helpful in outlining the level of science now being done with meteor radars, but the future directions seem uncertain. Concerning the

technical aspects, it is still unclear to me what the optimum system may achieve in performance. The field badly needs a technical boost.

A trip to the field station in the Gissar Valley was profitable. Since I have an interest in the HIPAS heating experiments in Alaska, observation of the USSR heater in a working mode was noteable. I suggested some possible middle atmosphere experiments to Dr. Rubtsov (Station Director) that could be done with his equipment. The heater was said to have an average power of 150kW and an antenna gain of 100, giving an effective radiated power of 15MW. However, from the dimensions of their antenna, I calculate that their antenna gain was only 70. Significant heating effects on ionograms ere observed. Six fixed frequencies from 4 to 6Mhz were available. One other interesting experiment was the vertical rectangular array 8 to 32 Mhz. Dimensions were approximately 5x50 meters and its "over the horizon" capability was demonstrated.

A number of personal contacts were made. The following people specifically requested reprints and other scientific information: Shved, Medvedev, Oras, Kazimirovsky, Rubtsov, Ovezgeldyev and Karimov. Dr. Ovezgeldyev was involved in laser studies of the middle atmosphere and requested information on the research status of US efforts.

The language barrier was a handicap, and the interpreters were essential. This hindered interactions but effective communications were still possible.

At the next Globmet symposium I would like to see a special session devoted to technical aspects, improvements, cost estimates for new systems, and specific details on what performance an ideal meteor radar could achieve. Second, there should be a US representative involved in large-scale (global) modelling to define whether such ideal radar systems could offer a significant improvement in the calibration, use, or development of those models. I suggest M. Schoeberl at NASA.

Overall, I rate the symposium highly for its ability to summarize activities in the meteor and meteor radar fields.

THOUGHTS ON POSSIBLE ACTIONS AND RESOLUTIONS FOR THE GLOBMET COMMITTEE

1. Progress

Although there is much effort apparent from the USSR, the support for meteor research in USA is minimal and unlikely to increase unless positive steps are taken by the GLOBMET committee.

2. Science Goals

It is imperative that a list of science problems, amenable to study via meteor radar, be prepared. These scientific problems should be clearly defined (and not just to "study waves" etc.). The nature of the physical problem should be explained, and reasons why meteor methods should be used instead of other techniques.

3. Image

At least in USA, meteor radar for geophysics applications is viewed as an old method that has already made its contribution, and funds should be directed to new techniques. This should be changed via an "aggressive sales method". The impression of a re-birth of meteor methods should be given by passing new science goals, and/or using new technology to show how the method can be greatly improved. However, application of new technology must permit new science.

4. Technology

There is clearly much room for improved technology, but it is not clear if this is really going to produce significant new science. What is needed is a set of specifications for an "ideal" meteor radar e.g. antenna configuration, transmitter power, etc. Then the approximate performance

(e.g. meteor count rate, height discrimination, etc.) should be stated. This will give geophysics colleagues some idea of possible contributions to science from meteor radars. The questions of count rate, height discrimination and coverage have not been adequately addressed at this Symposium. These are technical areas that are viewed as deficiencies and may be critical to future funding.

5. Cost

Since one of the meteor radar's strengths is continuous long term operation, efforts should be made to totally automate the operation and analysis. This is necessary because manpower will be impossible to fund over the long term and is more expensive in the long term than capital costs for equipment. As a function of time, manpower costs rise at least 5% per year, yet radar equipment, computers, etc. decrease in cost every year. A detailed cost analysis of construction and operation must be done. Can new technology significantly lower the cost of operation and analysis? This should be addressed.

September 20, 1985 B. J. Watkins

APPENDIX

ADDRESSES OF U.S. ATTENDEES

Mr. J. H. Allen, Code D-64
NOAA
Environmental and Data Information Service
325 Broadway
Boulder, CO 80303

(303)497-6323

Dr. S. K. Avery
CIRES
Campus Box 449
University of Colorado
Boulder, CO 80309

(303)492-5694

Dr. S. A. Bowhill, Head
Department of Electrical Engineering
Lowell University
1 University Avenue
Lowell, MA 01854

(617)452-5000 X2320

Dr. J. D. Mathews
Department of Electrical Engineering
Pennsylvania State University
121 Electrical Engineering East Building
University Park, PA 16802

(814)865-6337

Dr. D. D. Meisel
Department of Physics
State University of New York
Geneseo, NY 14454

(716)243-3037

Dr. D. O. Revelle
Meteorology Program
Northern Illinois University
Dekalb, IL 60115

(815)753-6853

Dr. R. G. Roper
School of Geophysical Sciences
Georgia Tech
Atlanta, GA 30332

(404)894-3892

Dr. B. J. Watkins
Geophysical Institute
University of Alaska
903 Koyukuk Avenue North
Fairbanks, AK 99701

(907)474-7479