Executive Summary
of the
CLOUD IMPACTS ON DOD OPERATIONS AND SYSTEMS 1991 CONFERENCE (CIDOS - 91)

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9-12 July 1991
The Aerospace Corporation
El Segundo, California

COVER   DMSP Multispectral Cloud Analysis

Multispectral imagery from Defense Meteorological Satellite Program polar orbiting satellites was used operationally in support of Operations Desert Shield and Desert Storm. This multispectral image was taken just prior to Desert Storm.

The cover image is an 8-bit composite of the visible ($0.4-1.1\mu$m) and infrared ($12.2-12.8\mu$m) channels from the Operational Linescan System (OLS) on the DMSP satellites. The technique of combining channels to form a multispectral image was developed at the Satellite Meteorology Branch of the Phillips Laboratory, Geophysics Directorate. The Phillips Laboratory staff worked closely with Harris Corporation and The Aerospace Corporation to transition the multispectral display technique from the laboratory to an operational capability at Air Force Global Weather Central (AFGWC). The technique was available for use at AFGWC prior to Operation Desert Storm and was used in direct support of the multinational forces operating in the Kuwaiti theatre thereafter.

The multispectral DMSP imagery was constructed by loading the OLS visible channel data to control the red and green color guns of the display device, and the infrared to control the blue color gun. Enhancements and cloud type-color relationships were achieved using backup table techniques. In the chosen lookup table, the low clouds appear yellow while the high clouds appear white if they are optically thick. Optically thin clouds appear more blue-white. Land generally appears darker than the clouds and highly reflective backgrounds such as sand tend to give the land a slight yellowish tint. Water appears dark blue except in areas of sunglint, where the water appears whiter. The multispectral display technique preserves almost all of the dynamic range of the data. Information compression allows the two 8-bit images to be overlaid without losing the 16-bit fidelity on 8-bit image display devices.

For additional discussions on the analysis and display of multispectral data, see the papers by the Phillips Laboratory, and the Harris and Aerospace Corporations.

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EXECUTIVE SUMMARY OF THE CLOUD IMPACTS ON DoD OPERATIONS AND SYSTEMS 1991 CONFERENCE (CIDOS-91)

Editors

D. D. Grantham
J. W. Snow

18 December 1992

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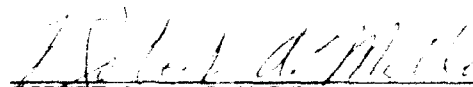
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Directorate of Geophysics
AIR FORCE MATERIEL COMMAND
HANSCOM AIR FORCE BASE, MA 01731-5000

"This technical report has been reviewed and is approved for publication"

DONALD D. GRANTHAM, Chief
Atmospheric Structure Branch

ROBERT A. McCLATCHEY
Atmospheric Sciences Division

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13. ABSTRACT (Maximum 200 words)

The Tri-Service Cloud Modeling Program was established by OUSDR&E and is chaired by the Phillips Lab. Geophysics Directorate/GPA. As a part of this program, the CIDOS conference is held at 18-month intervals. This forum was attended by about 140 researchers and DoD systems designers/users to exchange information on requirements and ongoing research for cloud effects on weapon, communications and surveillance systems. The theme of CIDOS-91 was "Clouds - The First Order Impact for Defense and Climate Change." Two Keynote addresses were presented: "Cloud Forecasting: The Challenge During Operation Desert Storm," by LtCol Gerald Riley, Staff Weather Officer to DS Field HQ; and, a review of the "International Satellite Cloud Climatology Project" by Dr. W.B.Rossow, NASA, Director ISCCP. The latter keynote emphasized the need for greater exchange of cloud data between the civilian and military communities, especially in light of the Congressional Strategic Environmental Research & Development Program (SERDP). Three working groups deliberated on the topics: Better Customer Interface; New Model/Database Requirements; and, the development of a new DoD Clouds Handbook. The recommendations from the working groups and the CIDOS Executive Committee will be submitted to OUSDR&E and will form new statements of need to the tri-service agencies.

The Proceedings of CIDOS-91 are published in a separate PL Technical Report.

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CIDOS EXECUTIVE COMMITTEE

*COL Grant C. Aufderhaar, USAF
Office of the Under Secretary of Defense (Acquisition)

*Mr. Donald D. Grantham
Phillips Laboratory
Air Force Systems Command

*Dr. Andreas K. Goroch
Naval Oceanographic and Atmospheric
Research Laboratory

*Mr. Roberto Rubio
U.S. Army Atmospheric
Sciences Laboratory

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Environmental Technical
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Dr. Gerald L. Geernaert
Applied Research and Technology
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* Steering Committee Member

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CONTENTS

PREFACE

This document is the Executive Summary of the Cloud Impacts on DoD Operations and Systems, 1991 Conference (CIDOS-91), held at El Segundo, California on 9-12 July 1991. The CIDOS-91 Conference was unclassified with oral sessions at Aerospace Corporation and poster sessions at the nearby Ramada Inn. This executive summary of the CIDOS conference is being distributed to approximately 300 members of the CIDOS community, and the Proceedings of CIDOS-91 will be distributed separately.

CIDOS-91 was the eighth conference of the DoD cloud impacts community. The first workshop was convened in 1983, under the name Tri-Service Clouds Modeling Workshop. In 1988, the name of the workshop was changed to Cloud Impacts on DoD Operations and Systems (CIDOS) to reflect more accurately the intent and purpose of the clouds community as a resource for defense-related problems and issues of greater scope and magnitude. The primary purpose of the CIDOS community is to evaluate, through atmospheric sciences, the impacts of clouds on weapons, sensors, and military operations. Linked with the primary purpose, a secondary purpose is to recommend procedures and courses of action for exploiting or mitigating those important operational and programmatic effects due to clouds. CIDOS-91 was organized with an emphasis on nonmilitary applications of the Defense Meteorological Satellite Program (DMSP) and the availability of data and the application of CIDOS community research results to civil programs, such as climate change studies.

The first two and a half days of the conference were devoted to presentations, both oral and poster. During this time, five sessions were organized and convened on the following topics: (1) Program Reviews, (2) Databases (DoD-Civilian Transfer and Applications Emphasis), (3) Systems and Sensors (Ground, Airborne, and Satellite), (4) Models, Simulations, and Applications, and (5) Cloud Detection, Retrieval, and Display Techniques. The full agenda is presented as Appendix A.

On the afternoon of the third day, three workshop meetings convened. The topics addressed by the working groups were (1) User Needs, (2) Cloud Data Users Handbook, and (3) Models and Databases. On the last day the chairman of each workshop presented a summary report and the executive committee met to assign duties and formulate initial plans for the next CIDOS meeting.

Acknowledged is the outstanding support and cooperation of all session chairmen and presenters during CIDOS-91. The conference was sponsored by COL Grant C. Aufderhaar of the Office of the Under Secretary of Defense (Acquisition), hosted by the DMSP Office, Los Angeles, California, and organized by the Science and Technology Corporation, Meetings Division.

Donald D. Grantham
Chairman
CIDOS Steering Committee

PART 1. EXECUTIVE STATEMENT

Cloud Impacts on Defense Systems

COL. Grant C. Aufderhaar, USAF

Assistant for Environmental Sciences

Office of the Under Secretary of Defense (Acquisition)

The importance of the impact of clouds on military operations and weapon system performance, defensive and offensive, was clearly demonstrated during "Desert Storm." Issues included significant cloud impacts on smart weapons performance and serious limitations on providing timely bomb-damage assessment to the command and control systems. These results indicate how important the accomplishments of DoD-sponsored research on clouds were throughout the planning and employment of the wide variety of Desert Storm missions on land and sea and in the air. The need for such research and efforts to transfer this research to operational service is recognized by the research and development community, but not always by the operating forces. Bridging this gap between the research and development and the operating communities is a specific function to be addressed by the Cloud Impacts on DoD Operations and Systems (CIDOS) community and at this 1991 conference. These CIDOS conferences provide a key mechanism to communicate the role clouds research has on military operations and weapon effectiveness and increase our ability to support the defense development community.

The recent experiences in the Middle East have revealed several shortcomings in our capability to use current research and development products and have identified specific requirements for additional research. Under the category of shortcomings is the inability of our present equipment and techniques in translating the flood of environmental data from satellites into directly useful information for battle commanders. This is both a technology and a research problem. The technology aspect is to update present field systems to process the required information quickly and into the language of the operator. The research aspects involve providing the "instructions" to the systems on what required environmental information is needed

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and how to extract the relevant operational support information from the available megabytes of data.

One of the high priority needs for direct research is the improved forecasting of mid-level cloud layers encountered by aircraft engaging ground targets from the 7,000-15,000 ft level. Supporting research on mid-level cloud forecasting involves not only improved cloud detection and characterization but also improved understanding of atmospheric dynamics. For cloud detection there is a need to develop new techniques using existing sensors, both ground and satellite based. Scientists at CIDOS-91 reported the need to improve present cloud characterization to include water vapor, ice, and liquid water content variables. Finally, better understanding of the dynamic processes that generate clouds and precipitation requires more fundamental research. Advancements from improved understanding of the dynamics and cloud characteristics will speed the development of improved cloud forecasting methods.

The CIDOS community has the ability to make significant advances in all of these areas; however, these capabilities will need to be shown to the research sponsors in the 1990s to be high priority and a good investment to improve military operational efficiency and systems effectiveness. This is the challenge for the CIDOS investigators.

Continuing to record the accomplishments of the CIDOS community and the usefulness of this research is, therefore, necessary. To support this concept, the CIDOS community has correctly identified the need for greater user support and the need for improved assistance to the user community. Two identified initiatives to gain greater recognition by the user and improve support are the proposed Cloud Data Users Handbook, and the Cloud Information Reference Library and Archive (CIRLA) system (which was demonstrated at CIDOS-91). Although there is no identifiable DoD cloud research program, the CIDOS community must continue its productivity and efforts to meet the needs of the system development sponsors and operational forces. These continuing efforts will be the basis on which we will be able to generate requirements for the cloud research and development needed to build a more comprehensive and focused program for the future.

PART 2. SYNOPSIS OF PRESENTATIONS

The 1991 CIDOS Conference was the first in the 8-yr history of these conferences where all oral presentations and posters were unclassified. There were eight CIDOS-91 sessions. The first session was a review of programs as they relate to the impact of clouds on DoD systems and on climate change applications. The highlights of the first session included talks on how clouds changed the tactics during "Desert Storm" and the role of clouds on climate change. LT COL Gerald Riley, USAF, described the cloud forecasting problems over Iraq showing the sources of moisture and influence on cloud layer heights. The targets, weapon selection, and aircraft type were altered as the forecast changed. The highest priority research topic on climate change is clouds. The CIDOS-91 attendees were fortunate to hear an excellent address by Dr. William Rossow on the International Satellite Cloud Climatology Project (ISCCP). Using the infrared radiances and reflected radiances measured by environmental satellites, the ISCCP scientists have compiled useful cloud climate data. However, some difficulties do occur in determining cloud layers, subvisible clouds, and diurnal and seasonal variability.

The second oral session addressed the transfer of DoD-funded research to civilian applications. A significant contribution to information transfer of the DoD clouds research effort is the development of CIRLA. Dr. Paul Try described the system which can be queried from almost any personal computer system. The system was demonstrated during the conference.

The third oral session included presentations of ground, aircraft, and satellite systems capable of measuring clouds. The papers ranged from applications data obtained by ground based whole sky cameras to the cloud measurement requirements for the next series of Defense Meteorological Satellite Program (DMSP) spacecraft. One of the more interesting papers was by Mr. Thomas Lee on the tactical application of satellite data during Desert Storm. An added presentation by Mr. Stanley Grigsby with Kuwait oil fire, ground-based photographs, taken very near the fires, was a bonus. He was on an International Red Cross assignment when he photographed the fires and the different smoke plumes.

The fourth oral session consisted of technical presentations on models and a few papers on cloud forecasting. Similarly, the fifth oral session contained technical papers on cloud detection sensors, retrieval algorithms, and display technology. Typical of the high scientific level of these sessions was the presentation by Dr. Edwin Eloranta on measurements of the three-dimensional structure and variability of cirrus clouds, using both satellite-derived data and ground-based lidar.

Each of the oral sessions was accompanied by a poster session. Most of the oral presentations will be included in the Proceedings of CIDOS-91.

PART 3. WORKSHOP SESSION SUMMARIES

The tradition of the DoD clouds meetings has been to convene workshops following the technical sessions. The purpose of these workshops has been to build upon the accomplishments and provide a consensus of the CIDOS community on what continuing research will enhance operational military system performance and provide knowledge on how clouds will impact new system concepts. For CIDOS-91 the workshops had the additional benefit of experiences during Desert Storm and participation from the larger research community addressing similar cloud research problems related to climate change science. The three workshops for CIDOS-91 were organized and chaired as follows:

WORKSHOP A: USER NEEDS

Chairman: Mr. Roberto Rubio

WORKSHOP B: CLOUD DATA USERS HANDBOOK

Chairman: Mr. Donald D. Grantham

WORKSHOP C: MODELS AND DATABASES

Chairman: Dr. Andreas K. Goroch

The chairman of each workshop directed the discussions, kept notes, and summarized the results in the concluding session of the open conference. The following are summary reports as submitted by the respective chairmen.

SUMMARY OF WORKSHOP A

USER NEEDS

Roberto Rubio

U.S. Army Atmospheric Sciences Laboratory

The User Needs Workshop was attended by a befitting mix of approximately 25 scientists from DoD and the private sector. Each participant had either submitted on a prescribed form, or orally, their user requirement(s). Each submission was then addressed individually and openly to allow workshop members to gain a deeper appreciation of the need and its applications. All stated user requirements were subsequently listed and grouped into categories. It was the panel's judgment that significant improvements are needed in (1) Cloud Forecasting, (2) Cloud Observational Analyses, (3) Operational Cloud Data Processing and Dissemination, (4) Cloud Sensing Instrumentation, and (5) Cloud Simulations to Support the DoD Procurement Process.

During the second workshop session, earnest attempts were made to delineate specific and quantitative requirements for each of the five cloud topics. These efforts were hindered by several constraints. First, in some cases absolute spatial, temporal, or microphysical requirements pertain to a specific weapon system and, consequently, are classified. This was an unclassified meeting. Secondly, some specific needs still fall in the realm of unauthorized release of contractually sensitive information. In several instances attendees felt they were not the authorized spokesman for military systems cloud requirements. These and other minor concerns precluded the working groups from listing precise cloud need specifications. Nonetheless, a few quantitative requirements were quoted. These values are described in the discussions of each main category. A natural outcome of this second session was the recommendation that the above constraints be removed at the next CIDOS conference. Therefore, the User Needs Workshop members recommended that CIDOS-93 have (1) classified sessions, (2) more cloud user representation, including invited speakers, (3) invited speakers from DoD agencies officially designated to document cloud-need requirements, such as the

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Air Force Air Weather Service and U.S. Army Intelligence Center and School; and (4) a follow-on User Needs Workshop to build on the foundation established by this CIDOS-91 panel.

From the deliberations the working group delineated five main categories of user requirements. These are reviewed below:

Category 1. Cloud Forecasting

High resolution cloud forecasting capability, on a global extent, was identified as the most important user need. A finer scale of clouds and cloud backgrounds are needed for tactical decision aids and tactical systems applications. Satellite and aircraft surveillance operations require higher spatial resolution cloud forecasts. A thorough review of new forecasting techniques adaptable for operational use should be conducted. This review should include cloud persistence or trajectory technique improvements, statistical methods, and current dynamic cloud models that can predict the genesis of cloud formation. Methods to predict cloud layering and cloud optical depths also must be explored and included in new cloud forecasting techniques. Multispectral remote sensing techniques remain to be fully exploited and incorporated into operational forecasts. Although forecasting refinements are considered important at all altitudes, the need for better cloud prediction is more acute at altitudes below 10,000 ft. Predictions with higher spatial resolution and longer lead times (48 hr for Air Force and Army and 5 days for the Navy) are required. Also, national missile and laser test ranges such as White Sands Missile Range and Kwajalein Test Range, as well as spaceborne surveillance operations, require reliable methods to predict cloud-free lines of sight and cloud-free arcs.

The subtopic of cirrus clouds drew considerable attention. Much more accurate prediction schemes are needed for cirrus clouds in general, but particularly for tenuous and subvisible cirrus clouds. Another subtopic is the requirement for more accurate forecasts of aircraft and naval ship contrail generation. Aircraft contrail forecasting methods are in need of updating, inclusion of the influence of engine exhaust composition and thermodynamic parameters, and improved consideration of synoptic scale upward motion.

Category 2. Cloud Observational Analysis

Methodologies used in cloud observation analysis require implementation of technology that yields sharper definition of cloud physical dimension, i.e., higher spatial resolution. Reliable netted grid analysis to at least 1/8 mesh is considered a good start, but requirements exist for much less than 1-km resolution when point analyses are necessary. Temporal resolution needs to reach a cloud data set every 15 min. The DMSP Block 6 six-hour refresh falls critically short of this practicable requirement and should be reconsidered. The high spatial resolution criteria also apply to observational analysis of contrail clouds, cloud-free line of sight, and cloud-free arcs. Practical techniques and skills are needed to detect, identify, and quantify tenuous and subvisible cirrus clouds. If these can be accomplished with the resolution requirements stated above, so much the better.

With the plethora of satellite data available at Desert Storm, it was established that present procedures burden data acquisition systems and require excessive human interaction. Already a fully automated operational capability is required. The addition of higher spatial and temporal resolution data will make automation a more crucial issue. As part of this automation, methods to reduce recurring biases such as snow and cirrus cloud misrepresentations must be included. Also, the observational analyst frequently responds to the difficult inquiry "How good are the data?" Routines that provide data uncertainty or error bars, variance and confidence levels, and calibration or ground truth information are long overdue. Ultimately, users have to know the impact of cloud data uncertainties on their system or operation. However, first the measurement and analysis uncertainties must be defined and made readily available to the analyst.

Analysts in Desert Storm learned that the aforementioned cloud requirements are particularly important at altitudes of 10,000 ft and below, because aircraft missions were forced to shift to high level attack tactics (above 10,000 ft) to avoid ground fire. From these sorties it was also ascertained that cloud data need to be added to electro-optical tactical decision aids for high level attack.

Category 3. Operational Cloud Data Processing and Dissemination

Cloud sensing systems currently generate vast amounts of data, some superfluous. Neither hardware, software, nor human resources are available to handle all information entering a central collection point. As an example, during Desert Storm, DMSP Special Sensor Microwave/Imager (SSM/I) data frequently overflowed the collection center. The user community needs faster and more efficient methods of ingesting data and intelligently filtering and applying quality control techniques based on user accuracy requirements. Means of achieving faster dissemination of processed data to tactical users continues to be a fundamental need. Although today improved engineering can resolve some of these deficiencies, in the long term, particularly to accommodate higher resolution data, novel technology is required. Exploitation of new data compression techniques such as fractal geometry and octree coding is encouraged. High speed optical signal processing techniques should be considered also. Ultimately, this equipment will have to be lighter, more compact, and capable of performing in-theater reception, high speed processing, and rapid dissemination to tactical users.

Category 4. Cloud Sensing Instrumentation

Enhanced cloud sensing capabilities must be accomplished with complementary ground based and spaceborne, long range, remote sensors. Since the launching of sufficient satellites to measure the required high resolution data is cost prohibitive, satellite cloud sensors must be improved to extend sensing range, enhance spatial resolution, perform better identification of cirrus clouds and their properties, properly discriminate between snow and clouds, and enhance accuracies. Better utilization of modern multispectral sensor technology is needed. Sponsorship of microwave cloud sensing techniques should continue.

Lidar has the potential to fill some data voids within the user's needs. These voids need to be identified and a plan developed to tailor and reliably quantify lidar data to fill these voids. Efforts to develop the Whole Sky Imager nighttime capability should continue along with exploration of methods to enhance cloud spatial resolution.

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The subjects of the user's required cloud data accuracies, measurement accuracies, satellite ground truth verification, and ground remote sensor in situ truth verification are all obviously related and heavily interdependent. Yet at CIDOS meetings, these subjects are normally addressed independently of each other. Again, a plan to begin coordination of these related issues is sorely needed. Establishment of a session at CIDOS-93 and a workshop dedicated to this discipline is submitted for consideration by the CIDOS steering committee.

Category 5. Cloud Simulations to Support the DoD Procurement Processes

This subject clearly falls under the purview of the Cloud Models Workshop. However, it is briefly reported here for two reasons. First, there is a group of users such as concept developers, system designers, and system evaluators who are part of the DoD procurement process. These users are concerned with cloud effects on a given future system, for example, those responsible for performing the cost operation effective analysis (COEA) on Army or Air Force systems. The second reason for including this subject here is to make the community and Models Workshop group aware of this need and recommend that at the CIDOS-93 Conference the Models Workshop include this topic and make further recommendations. The User Needs Workshop concluded that personnel involved in systems procurement processes require cloud simulation models that are "user friendly" and capable of running, in reasonable time, on a small mainframe. The generally known requirements are cloud dimensions and definitions or specifications of cloud microphysical parameters and radiative transfer properties that affect system operation. At present, database systems such as CIRLA and Atmospheric Properties System and "engineering level" models, like those in the Electro-Optical Systems Atmospheric Effects Library (EOSAEL), are available to address this requirement partially. However, further coordination with specific systems developers and evaluators is necessary before proceeding to delineate exact model, climatology, or database requirements.

SUMMARY OF WORKSHOP B

CLOUD DATA USERS HANDBOOK

Donald D. Grantham

Geophysics Directorate

Phillips Laboratory, Air Force Systems Command

For many years, the CIDOS *steering committee and its predecessor groups recognized* the need to consolidate what is known about clouds and cloud data (observations and data sets) and communicate this knowledge to the users. The CIDOS conferences have been an effective mechanism to fulfill this need; however, the information transmittal has been limited to attendees and readers of the published proceedings. At CIDOS 89/90, a specific recommendation was made to establish a working group to develop guidance to prepare a Cloud Data Users Handbook. This handbook would be designed to provide useful information on clouds to military planners, system developers, engineers, and operational users, and also serve as a source document for the environmental expert, such as Air Force staff meteorologists.

Purpose of Cloud Data Users Handbook

The purpose of the Cloud Data Users Handbook is to provide to the DoD *user* an aid in identifying (1) the *cloud-related parameters* that require consideration when addressing the effectiveness of *military systems*, (2) *the available sources of cloud data*, and (3) *the methods* for applying these data to typical problems of system operation. The users were identified to be (a) professional meteorologists, such as the Air Force staff meteorologists assigned to system commands; (2) nonmeteorologists, particularly engineers designing new systems; and (3) analysts, technical or operations analysts involved in analyzing cloud data.

Contents of Handbook

For the purpose of this handbook clouds are defined to be visually observable natural clouds (water or ice) and subvisible cirrus. Cloud parameters include optical characteristics and physical properties over a range of values applicable to various cloud types.

It was suggested that the handbook contain two levels of detail to best satisfy the broad range of users: one level tai.u.red for nonmeteorologists and the other for professional meteorologists. Major characteristics of the handbook will include cloud observation information, and for different problems, discussions on cloud considerations and methods or techniques for applying available data to the problem.

A table of contents for the handbook was proposed as follows:

CHAPTER	COMMENT*
I. Introduction	Who is the book for and for what purpose?
II. Background	Cloud definitions, how observations are made, sample types of problems.
III. Cloud Characteristics	Distribution, microphysics (range of physical properties, values, and parameterizations).
IV. Type or Class of Problems and Cloud Considerations	A matrix relating the typical military mission with the cloud characteristics that affect it.
V. Sources of Data and Databases	Types of data, available analyses.
VI. Simulation and Modeling Methods	Explanation of methods and techniques and how to use them.

Appendices:

A. Acroynms and Definitions

B. Cloud Characteristic Details

C. References and Bibliography

* Each chapter would contain two levels of detail, one for quick and easy understanding by nonmeteorologists and the other, sufficient explanation to allow a more indepth understanding by staff meteorologists (i.e., "cookbook" and reference book).

SUMMARY OF WORKSHOP C
MODELS AND DATABASES

Andreas K. Goroch

Atmospheric Directorate

Naval Oceanographic and Atmospheric Laboratory

The workshop started by reviewing recommendations from the previous CIDOS workshop and indicating those that were successful. These success stories would then serve as the model for the development of current recommendations. The presentations at this conference showed three success stories from the previous conference recommendations: (1) the characterization of cirrus clouds, (2) the development of cloud models and databases for the user community, and (3) the further refinement of CIRLA, the library of database locations and contents.

Development of Cirrus Models

One of the major recommendations of the CIDOS-91 Conference was that several applications required physical characterization of cirrus clouds. At least five papers were presented at this conference on new cirrus cloud characterizations, ranging from detailed physical radiative transfer models of propagation through a population of ice crystals to statistical parameterizations, to the development of multispectral cirrus visualization techniques.

Development and Publicizing of Cloud Databases

Several different CIDOS-89/90 recommendations dealt with the need for the development of cloud models and databases, which would serve as an engineering cookbook of physical characteristics of various types of clouds. At the present conference, a new effort was described for the development of a cloud handbook providing a summary of physical cloud characteristics associated with different atmospheric and environmental conditions. In addition, this conference included several papers describing the current conventional databases (RTNEPH, ISCCP) as well as the archiving of Whole Sky Imager data.

Development of Library of Database Locations and Contents

After the previous conference, an effort was started under Strategic Defense Initiative sponsorship on the summarization of cloud databases available for development of applications. This effort was described at the conference, and discussion followed on the utility and possible improvements of the CIRLA program.

Actions Recommended at CIDOS-91 on Models and Databases

The three cases described demonstrate that the information transfer resulting from the conference can result in improved program development without necessarily a directly funded effort by other users. These samples seem to show that the distribution of the proceedings is sufficient to identify work efforts by major users that have potential for subsequent application by other users.

Encouraged by the implementation of recommendations from previous CIDOS workshops, the participants of the Models and Databases Workshop deliberated on what actions are now needed for advancing cloud modeling and database development for enhancing the operations of defense systems. They then grouped their findings into the following sets of primary and secondary recommendations.

Primary Recommendations

1. <u>Include water vapor, liquid water content, and water phase in measurement programs</u>.

The role of water vapor and water phase (ice type or water) is found to be a component necessary to the understanding of cloud characteristics. This function is particularly important for remote sensing and in the analysis of electro-optical system performance, where the absorption and scattering of the various types of ice in the atmosphere have a significant effect, in addition to the effects of the cloud itself.

2. <u>Improve cloud forecast capability by funding cloud physics analysis in cloud environment</u>.

Cloud forecasting has been undergoing a certain neglect over the past decade or two. Recent uses of cloud data, as well as events in the Persian Gulf, have demonstrated the importance of

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understanding physical mechanisms in clouds with the goal of better forecasts of cloud occurrence. The consensus among workshop participants was that the emphasis on research in these physical mechanisms should be increased. In addition to this general recommendation, participants also proposed several specific efforts that should be pursued.

A. Develop short range (<6 hrs) and medium range (6-48 hrs) cloud forecast.

The Persian Gulf War demonstrated the importance of knowing cloud cover both in the short range and medium range: the former for tactical field operations, the latter for theater planning. A strong effort should be made to develop these two scales of forecasts of cloud cover, cloud type, and cloud characteristics.

B. Provide physical parameters quantitatively related to applications requirements rather than generic names (e.g., cirrus).

User requirements have advanced sufficiently that quantitative cloud information is required; qualitative cloud information such as alto-stratus or cumulus humilis is no longer sufficient. Cloud characterization would now include such variables as drop size distribution, water phase, liquid water content, water vapor density, and index of refraction of cloud components.

3. Invite program managers and planners to review relevant program plans.

One of the most important forms of guidance of future research direction is the interest and funding availability in different subjects by DoD agencies. There was general concurrence that the conferees would find very valuable a series of presentations by program managers and planners outlining in general terms the future directions of their cloud-related programs. These presentations would stimulate research community interest and provide the planners and managers with a certain amount of feedback for the refinement of their plans.

Secondary Recommendations

The conferees considered the following to be important recommended actions. These should be implemented with somewhat lower priority than the primary recommendations.

1. Develop means for in situ cirrus clouds measurement.

Although remote measurements and modeling of cirrus clouds have increased, and have been quite successful, the physical measurements of cirrus cloud characteristics have decreased. Substantial measurements of cirrus characteristics have been conducted in the past using the RB-57 aircraft, but currently no means is available for extended hydrometeor measurement in the stratosphere. An airplane or balloon would provide data required for wide ranging detailed observations of ice crystal distributions and composition.

2. Define required horizontal cloud scales for DoD operations.

Currently several scales of cloud analysis are available, usually defined by the limitations of the equipment. The requirements of the user may in fact be different and ought to be documented for development of applications.

3. Include cloud characterization in DoD field programs.

Many electromagnetic and electro-optical related field programs archive only rudimentary cloud information, such as that found in standard observations and pilot reports. It is becoming clear that clouds are having a large impact on atmospheric transmission, and more detailed information should be provided. Among examples of such detail are cloud base, cloud height, extent of multilayers, optical depth, and cloud motions.

4. Encourage DoD platforms of opportunity during field programs.

Large scale field programs are almost always limited in the number of ships available to support surface measurements. The conferees agreed the field programs and the DoD would benefit if Navy vessels on maneuvers, with certain flexibility (such as training or reserve duty), were to participate in the measurement program.

5. Improve cataloging of data in CIRLA.

The access to the CIRLA database was found to be adequate, although relatively few attendees had actually used the system. It was suggested that the utility of the CIRLA would be improved if a data management system, such as that in a relational database, were available. This capability might enable users to be more efficient in finding the correct course to the required data.

PART 4. EXECUTIVE COMMITTEE REPORT

After the closing session of CIDOS on 12 January 1991, the executive committee met at Aerospace Corporation, El Segundo, California. The meeting was convened by the chairman of the steering committee, Mr. Donald Grantham. Representatives of all three services and others participated, including

> Mr. Donald D. Grantham, Chairman, Air Force
> Mr. Roberto Rubio, Army
> Dr. Andreas K. Goroch, Navy
> Dr. Gerald L. Geernaert, Navy
> Dr. John S. Bohlson, Aerospace Corp
> Dr. Paul D. Try, Science and Technology Corp.

A general discussion followed noting the high quality of presentations and posters at CIDOS-91 and the achievements of the DoD clouds community such as the on-line capability of CIRLA.

The CIDOS-91 Conference was organized with a purpose to emphasize DMSP and civilian use of DoD cloud data and research results, particularly considering first order impact for climate change studies. The purpose of CIDOS-91 was achieved and this conference's technical presentations were judged by the committee to have reached a higher level of science excellence.

There was a focused discussion on user needs that were identified during CIDOS-91. The following topics were included:

- Radiance structure and variability
- Cirrus structure
- Cloud detection and automated displays
- Short-term forecasting (0–6 hr) for tactical applications (weapon system performance)
- Digitizing and archiving DMSP data
- Interagency database management

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The user needs discussion led to suggestions for the agenda of the next clouds conference, to be known as CIDOS-93. There was agreement that CIDOS-93 will be organized around the military missions related to cloud impact needs on (1) tactical or battle area, (2) surveillance, and (3) communication.

The CIDOS-91 Conference was unclassified, a fact that precluded discussions on specific DoD needs. There was agreement at the executive committee meeting that the next CIDOS conference will return to the format that includes classified sessions.

It was agreed CIDOS-93 will be held in mid-1993 and will be hosted by the Army, perhaps at Ft. Belvoir, Virginia. The restructured CIDOS executive committee will be

COL Grant C. Aufderhaar, DoD   Dr. Gerald L. Geernaert, Navy
Mr. Donald D. Grantham, Air Force   Dr. J. William Snow, Air Force
Mr. Roberto Rubio, Army   CAPT Herbert P. Colomb, Navy
Dr. Andreas K. Goroch, Navy   LTCOL Roger C. Whiton, Air Force
MAJ Frank P. Kelley, Air Force

RECOMMENDATIONS

Based on the workshop reports and discussions during the executive committee meeting, numerous technical recommendations were made. Several emerged from Desert Storm to require priority attention, such as cloud forecasting in tactical scenarios. Other priority recommendations include expand CIRLA; accelerate preparation of the cloud handbook; increase emphasis on cirrus clouds; consider water vapor, liquid water content, and water phases in measurements; improve cloud simulation models; and develop better automated cloud displays.

The list of recommendations compiled during the executive committee meeting included the above and many more. The random order partial listing of recommendations follows:

- Archive selected Air Force nephanalysis data

- Consider adding data catalog to CIRLA

- Upgrade DMSP archive capability

- Archive water vapor, liquid water content, and ice information with cloud data sets

- Investigate incorporating CIRLA into INTERNET

- Develop improved cloud forecasts

- Inform cloud science community that CIDOS-93 will emphasize cloud forecasting

- Measure in situ cirrus cloud characteristics

- Encourage development of platforms and sensors for field experiments

- Develop modern (new) cloud detection and measurement techniques necessary for 4D determination of water vapor, liquid water content, and ice in clouds.

- Develop cloud characterization (handbook) for user (staff meteorologist clients)

- Expand efforts to describe cloud impact (CIDOS results) and plans by program managers, sponsors, and operational forces

- Encourage climate modelers to consider cloud radiation, physical properties, and processes

CLOUD IMPACTS ON DOD OPERATIONS AND SYSTEMS 1991 CONFERENCE (CIDOS-91)

The Aerospace Corporation
Building A1, Room 1062
El Segundo, California
9-12 July 1991

Theme

CLOUDS: THE FIRST ORDER IMPACT–FOR DEFENSE AND CLIMATE CHANGE APPLICATIONS

AGENDA

TUESDAY, 9 JULY 1991

0730 - 0830   **REGISTRATION**
The Aerospace Corporation, Building A1, Room 1062

0830 - 1000   **SESSION I: INTRODUCTION AND PROGRAM REVIEWS**
Chairperson: COL Grant C. Aufderhaar, Military Assistant for Environmental Sciences, Deputy Defense Research and Engineering, Research and Advance Technology, Environmental and Life Sciences

Conference Chairman
Donald D. Grantham, Geophysics Directorate, Phillips Laboratory, Air Force Systems Command

Welcome by Host
Discussion of DOD Assets for Environmental Monitoring
Joseph Straus, The Aerospace Corporation

Sponsor Introductory Address
COL Grant C. Aufderhaar, Military Assistant for Environmental Sciences, Deputy Defense Research and Engineering, Research and Advance Technology, Environmental and Life Sciences

Keynote Address
Cloud Forecasting: The Challenge During Operation Desert Storm
LT COL Gerald Riley, 3WS/CC, Air Weather Service

1000 - 1030   **COFFEE BREAK**

1030 - 1200   **PROGRAM REVIEWS**

Army
Robert Rubio, U.S. Army Atmospheric Sciences Laboratory

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<u>Navy</u>
    CAPT Herbert P. Colomb, Jr., Assistant Chief of Staff for Operations, Naval Oceanography
    Command
<u>Air Force</u>
    J. William Snow, Geophysics Directorate, Phillips Laboratory
<u>Strategic Defense Initiative Office--Cloud Impacts on GBL</u>
    Donald D. Grantham, Geophysics Directorate, Phillips Laboratory
<u>Defense Meteorological Satellite Program</u>
    COL John A. Goyette, Defense Meteorological Satellite Program SPO Director

1200 - 1330   **LUNCH BREAK (DMSP & Aerospace Tours)**

1330 - 1415   **Keynote Address**
                 Analysis of Cloud Observations From Weather Satellites for the International Satellite Cloud Climatology
                 Project
                     Dr. William B. Rossow, NASA Goddard Institute for Space Studies, Director ISCCP

1415 - 1715   <u>**SESSION II: DATABASES (DOD-CIVILIAN TRANSFER AND APPLICATIONS EMPHASIS)**</u>
                 Chairperson: **Dr. Gerald Geernaert**, Office of Naval Research

1500 - 1530   **COFFEE BREAK**

        ORAL PRESENTATIONS

                 Cloud Information Reference Library and Archive (CIRLA)
                     Paul D. Try, and **Donald D. Grantham[1]**, Science and Technology Corporation and [1]Geophysics
                     Directorate, Phillips Laboratory

                 A Global Environmental Database System
                     Roland E. Nagle, Computer Sciences Corporation

                 Cloud Base, Top, and Thickness Climatology From RAOB and Surface Data
                     CAPT Kirk D. Poore, U.S. Air Force Environmental Technical Application Center

                 Global Coverage and Seasonal Changes in Cirrus Clouds
                     Donald Wylie and **W. Paul Menzel[1]**, University of Wisconsin-Madison and [1]NOAA/NESDIS Satellite
                     Applications Laboratory

                 RTNEPH Total Cloud Cover Validation Study
                     CAPT Ronald P. Lowther, Mark T. Surmeier, CAPT Richard W. Hartman, Charles R. Coffin, and
                     CAPT Anthony J. Warren, U.S. Air Force Environmental Technical Applications Center

                 Status of the Whole Sky Imager Network Database
                     Richard W. Johnson, **Thomas L. Koehler**, and Janet E. Shields, University of California, San Diego

                 Spiral Cloud Identification Using Hough Transforms
                     Sailes K. Sengupta, Andreas K. Goroch[1], and **Rabindra Palikonda**, Naval Oceanographic and
                     Atmospheric Research Facility and [1]Naval Oceanographic and Atmospheric Research Laboratory

Poster Session II – 2 minute overview by authors

Poster Session V – 2 minute overview by authors

1800 - 1930   **ICEBREAKER – POSTERS FOR SESSIONS II AND V**
                El Segundo and Hawthorne Rooms, Ramada Inn

POSTERS FOR SESSION II: <u>DATABASES (DOD-CIVILIAN TRANSFER AND APPLICATIONS EMPHASIS)</u>

Demo of Cloud Information Reference Library and Archive (CIRLA)
Paul D. Try, and Donald D. Grantham[1], Science and Technology Corporation and [1]Geophysics Directorate, Phillips Laboratory

Database of Coincident Lidar and Satellite Observations of Thin Cirrus Clouds
M. Paz Ramos-Johnson and R. Gary Rasmussen, The Analytic Sciences Corporation

Cumulative Frequency of Skycover Below Selected Altitude Levels In Various Climatic Regions
Oskar Essenwanger, University of Alabama in Huntsville

July Climatology of Marine Stratocumulus Clouds
Patrick Minnis, David F. Young[1], and **David R. Doelling[1],** NASA Langley Research Center and [1]Lockheed Engineering and Sciences Corporation

Lidar Observations of Tropical Cirrus Clouds Revisited–Applications of a Proposed Kwajalein Lidar Facility
Edward E. Uthe, SRI International

Rayleigh and Raman Lidar Measurements in Greenland
J. Meriwether, P. Dao, R. Farley, LT R. McNutt, **Gilbert Davidson[1],** and W. Moskowitz[1], Geophysics Directorate, Phillips Laboratory and [1]PhotoMetrics, Inc.

POSTERS FOR SESSION V: <u>CLOUD DETECTION, RETRIEVAL, AND DISPLAY TECHNIQUES</u>

The Three-Dimensional Spatial Structure of Cirrus Clouds Determined From Lidar and Satellite Observations
Edwin W. Eloranta, Donald W. Wylie, and W. Wolf, University of Wisconsin-Madison

Multispectral Imagery on the Satellite Data Handling System for AFGWC Support to Desert Shield/Desert Storm
Earl S. Barker, **Bruce H. Brooks,** and Bruce H. Thomas, Harris Corporation/Aerospace Corporation

Retrieving Atmospheric Temperature Profiles From Simulated DSMP Sounder Data With A Neural Network
Charles T. Butler, R. Van Meredith, and Ari Rosenberg[1], Physical Sciences Inc. and [1]McDonnell Douglas Electronic Systems Co.

Multispectral Aircraft Data and the Snow/Cloud Discrimination Problem
Michael Brandley, Richard DeJulio, Robert Drake, **Steven Westerman,** and Steven Yool, Lockheed Missiles & Space Company

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A New Instrument For Water Vapor Sounding: SSM/T-2
   Vincent J. Falcone and Michael K. Griffin, Geophysics Directorate, Phillips Laboratory

A New Water Vapor Attenuation Correction for the Air Force Global Weather Central RTNEPH (Real-Time Nephanalysis)
   Thomas M. Hamill and CAPT Norman H. Mandy[1], Atmospheric and Environmental Research, Inc. and [1]Air Force Global Weather Central

WEDNESDAY, 10 JULY 1991

0800 - 0830   **REGISTRATION**
   The Aerospace Corporation, Building A1, Room 1062

0830 - 1200   **SESSION III: SYSTEMS AND SENSORS (Ground, Airborne, and Satellite)**
   Chairperson: MAJ Frank P. Kelly, Defense Meteorological Satellite Program SPO, Space Systems Division

0945 - 1015   **COFFEE BREAK**

ORAL PRESENTATIONS

Tactical Nephanalysis (TACNEPH) Program Overview
   Ronald G. Isaacs and Gary B. Gustafson, Atmospheric and Environmental Research, Inc.

Tactical Satellite Signatures from Desert Storm Using NOAA Multispectral Data
   Thomas F. Lee, Naval Oceanographic and Atmospheric Research Laboratory

Using Clouds to Track Surface Ships
   Richard Siquig, Arunas Kuciauskas, and Nahid Khazenie[1], Naval Oceanographic and Atmospheric Research Laboratory and [1]University of Texas

Cloud Remote Sensing Requirements for DMSP Block 6
   David L. Glackin and MAJ Frank P. Kelly[1], The Aerospace Corporation and [1]AWS-DMSP Liason Office

NWP Impact of Cloud Top and Boundary Layer Winds From a Satellite Borne Lidar: An Observing System Simulation Experiment
   Ronald G. Isaacs, C. Grassotti, M. Mickelson, R.N. Hoffman, J.-F. Louis, and T. Nehrkorn, Atmospheric and Environmental Research, Inc.

Imaging Systems for Automated 24-Hour Whole Sky Cloud Assessment and Visibility Determination
   Janet E. Shields, Richard W. Johnson, and Thomas L. Koehler, University of California, San Diego

The Impact of Clouds on a Time-Dependent Ground-to-Space Viewing System: A Cloud-Free and Cloudy Arc Analysis
   Gary J. Thompson and Vance A. Hedin, Logicon/RDA

Smoke Plumes From Kuwaiti Oil Fires as Atmospheric Experiment of Opportunity
   Ernest Bauer, Institute for Defense Analyses

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Poster Session III – 2 minute overview by authors

1200 - 1330   **LUNCH BREAK (DMSP and AEROSPACE Tours)**

1330 - 1715   **SESSION IV A: MODELS, SIMULATIONS, AND APPLICATIONS**
Chairperson: **LT COL Roger C. Whiton**, Environmental Technical Applications Center

1500 - 1530   **COFFEE BREAK**

NOTE: Session IV B will be on Thursday, 11 July 1991

ORAL PRESENTATIONS

Operational Forecasting with a 3-D Cloud Model at Kwajalein Atoll
Dan Rusk and Mark Bradford, Aeromet, Inc.

Spectral-Spatial-Temporal Cloud Physics
John Malick, FSI Inc.

Specular Scattering From Cirrus Clouds: A First-Order Model
Joe Shanks, Fred Mertz, Chris Blasband, Tom Kassal[1], Photon Research Associates, Inc. and [1]Grumman Aerospace Corporation

Cloud Scene Simulation Modeling
Maureen E. Cianciolo and R. Gary Rasmussen, The Analytic Sciences Corporation

CFLOS4D Accuracy Assessment Using Whole Sky Imager Data
Kenneth B. MacNichol and **Steven R. Finch**, The Analytic Sciences Corporation

Infrared Radiances from Structured Clouds
E.P. Shettle, R.G. Priest, and I.B. Schwartz, Naval Research Laboratory

Remote Sensing of Cirrus Cloud Parameters From Satellite Data
S.C. Ou, K.N. Liou, and W.M. Gooch, Liou and Associates

Poster Session IV – 2 minute overview by authors

1800 - 1930   **ICEBREAKER – POSTERS FOR SESSIONS III AND IV**
El Segundo and Hawthorne Rooms, Ramada Inn

POSTERS FOR SESSION III: **SYSTEMS AND SENSORS (Ground, Airborne, and Satellite)**

Use of a Learjet 36 for Cloud and Weather Characterization
Ray Harris-Hobbs and Michael Bellmore, Aeromet, Inc.

Assessment of Cloud Effects on High Altitude Observatory (HALO) Aircraft Operations
Paul Weckler and Dana Swift, Aeromet, Inc.

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Whole Sky Cloud Imagery Under Both Day and Night Illumination Levels
  Richard W. Johnson, Jack R. Varah, and Eugene M. Zawadzki, University of California, San Diego

Cloud Remote Sensing Concepts With Millimeter Wave Radar
  David L. Glackin and Gregory G. Pihos, The Aerospace Corporation

Site Specific Cloud Field Analysis In Support of the Department of Energy Atmospheric Radiation
Measurement (DOE/ARM) Program
  Ronald G. Isaacs, D. Johnson, and W.-C. Wang[1], Atmospheric and Environmental Research, Inc. and
  [1]Atmospheric Sciences Research Center

Integrated Oceanographic Tactical Aid (AID)
  Andreas K. Goroch, Michael J. Pastore, and Larry Miller[1], Naval Oceanographic and Atmospheric
  Research Laboratory and [1]Planning Systems, Inc.

Battlefield Obscuration From the Kuwait Smoke Plume
  E.H. Holt, R.A. Sutherland, D.W. Hoock, Dorothy Bruce, John Grace, S.A. Luces[1], W.D. Ohmstada[2],
  and R.A. Pielke[3], and R.L. Walko[3], U.S. Army Atmospheric Sciences Laboratory, [1]Physical Science
  Laboratory, New Mexico State University, [2]Certified Consulting Meteorologist, [3]Colorado State University

Thermal Infrared Spectroscopy of Natural and Artificial Clouds
  David K. Lynch, John A. Hackwell, Ray W. Russell, and Mark A. Chatelain, The Aerospace Corporation

POSTERS FOR SESSION IV: MODELS, SIMULATIONS, AND APPLICATIONS

  A Numerical Model for the Prediction of Hydrometeors in the Tactical Environment
  Roland E. Nagle, Computer Sciences Corporation

  A Massively Parallel Implementation of the MASS Model for Operational Use
  Robert Sladewski and Mark Bradford, Aeromet, Inc.

  Statistics of IR Cloud Changes–A Modelling Approach
  Lawrence R. Thebaud, Morton S. Farber, Stewart J. Hemple, and Jerry Tessendorf, Arete Associates

  Visual Translucent Algorithm (VISTA)
  Albert R. Boehm, ST Systems Corporation

  Validation of a Cloud Scene Simulation Model Using AVHRR Multi-Spectral Imagery
  Fred Mertz, Chris Blasband, Leif Hendricks, Rob Francis, and Dave Anding, Photon Research
  Associates, Inc.

  Simulation of Whole-Sky Imager From Satellite for Cloud-Free Arc Estimates From Space
  Donald L. Reinke and Thomas H. Vonder Haar, METSAT, Inc.

  Tropical Storm Cloud Analysis Using SSM/I Imagery
  Morton Glass and Gerald W. Felde, Geophysics Directorate, Phillips Laboratory

0800 - 0830   **REGISTRATION**
The Aerospace Corporation, Building A1, Room 1062

0830 - 0930   **SESSION IV B: MODELS, SIMULATIONS, AND APPLICATIONS**
Chairperson: **LT COL Roger C. Whiton**, Environmental Technical Applications Center

ORAL PRESENTATIONS

Cirrus Clouds in Infrared Targeting Models—A Statement of Modeling and Experimental Needs
R.C. Vik, W.T. Kreiss, Edward E. Uthe[1], W.M. Cornette[2], J.G. Shanks[2], and W.A. Lanich[3], Horizons Technology, Inc., [1]SRI International, [2]Photon Research Associates, Inc., and [3]Wright Laboratories

SSMI Operational Analysis for Thunderstorms
LT COL Charles R. Holliday and CAPT Keith H. North, Air Force Global Weather Central

Strategic Air Command Contrail Formation Study
CAPT Jeffrey L. Peters, Third Weather Wing

0930 - 1230   **SESSION V: CLOUD DETECTION, RETRIEVAL, AND DISPLAY TECHNIQUES**
Chairperson: **Dr. J. William Snow**, Geophysics Directorate, Phillips Laboratory, USAF Systems Command

1005 - 1030   **COFFEE BREAK**

ORAL PRESENTATIONS

TACNEPH Single Channel and Multispectral Cloud Algorithm Development
Gary B. Gustafson, Jean-Luc Moncet, Ronald G. Isaacs, Robert P. d'Entremont[1], James T. Bunting[1], and Michael K. Griffin[1], Atmospheric and Environmental Research, Inc. and [1]Geophysics Directorate, Phillips Laboratory

Cloud Type Identification and Classification Using Spatial Statistical Texture Measures
Nahid Khazenie and Kim A. Richardson, Naval Oceanographic and Atmospheric Research Laboratory

The Three-Dimensional Spatial Structure of Cirrus Clouds Determined From Lidar and Satellite Observations
Edwin W. Eloranta, Donald W. Wylie, and W. Wolf, University of Wisconsin-Madison

Visible Scattering and Infrared Extinction in Clouds Calculated From Satellite and Lidar Data Comparisons
Donald W. Wylie, Edwin W. Eloranta, and Christian Grund[1], University of Wisconsin-Madison and [1]NOAA Environmental Research Laboratory

Parameterization of Visible and Infrared Window Radiances for Cloud Simulation and Satellite Retrievals
Patrick Minnis, Patrick W. Heck[1], and David F. Young[1], NASA Langley Research Center and [1]Lockheed Engineering and Sciences Corporation

The Positive Identification of Optically Thin, Cirrus Clouds in Nighttime Multispectral Meteorological Satellite Data by Automated Cloud Detection and Typing Algorithms
Keith D. Hutchison, Jerry Mack, Russel McDonald, and Grey Logan, Lockheed Austin Division

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Simulated Composite Color Imagery For Real-Time Cloud Analysis
Larry W. Thomason and Robert P. d'Entremont[1], NASA Langley Research Center and [1]Geophysics Directorate, Phillips Laboratory

Air Force Global Weather Central's (AFGWC) New Surface Temperature Analysis and Forecast Model (SFCTMP)
James H. Cramer and Thomas M. Hamill[1], Air Force Global Weather Central and [1]Atmospheric and Environmental Research, Inc.

Polar Cloud Classification Using AVHRR Imagery: A Neural Network Approach With Bootstrap Validation
Sailes K. Sengupta, R.M. Welch, Andreas K. Goroch[1], Rabindra Palikonda, and N. Rangaraj, Naval Oceanographic and Atmospheric Research Facility and [1]Naval Oceanographic and Atmospheric Research Laboratory

1230 - 1400   **LUNCH BREAK**

1400 - 1530   **SESSION VI: INITIAL INDIVIDUAL WORKSHOP MEETINGS**

Workshop A: User Needs
Chairperson: **Mr. Robert Rubio**

Workshop B: Cloud Data Users Handbook
Chairperson: **Mr. Donald D. Grantham**

Workshop C: Models/Databases
Chairperson: **Dr. Andreas K. Goroch**

1530 - 1600   **COFFEE BREAK**

1600 - 1730   **SESSION VII: FINAL INDIVIDUAL WORKSHOP MEETINGS**

EVENING OPEN

FRIDAY, 12 JULY 1991

0830 - 1000   **SESSION VIII: PLENARY – WORKSHOP RECOMMENDATIONS**
Chairperson: Donald D. Grantham, Geophysics Directorate, Phillips Laboratory

1000 - 1030   **COFFEE BREAK**

1030 - 1200   **SESSION IX: EXECUTIVE SESSION**

1200   **CIDOS-91 ADJOURNS**

APPENDIX B
List of Attendees

A

Adams, Allen
Defense Meteorological Satellite Program
Space Systems Division
SSD/MWA
P.O. Box 92960
LAAFB, CA 90009-2960
Telephone: 213/336-4090

Aufderhaar, Grant C.
Assistant for Environmental Science
Office of Undersecretary for Defense
(Acquisition)
Pentagon, Rm 3D129
Washington, DC 20301-3080
Telephone: 703/695-9604

B

Babcock, Michael R.
SAC/DOWA
Offutt AFB, NE 68113-5001
Telephone: 402/294-2681

Barker, Earl
Harris Corporation
Government Information Systems Division
301 N. Washington
Bellevue, NE 68005
Telephone: 402/292-2048

Bassi, Joseph P.
SSD/WE
PO Box 92960
Los Angeles AFB, CA 90009-2960
Telephone: 213/543-0304

Battalino, Terry E.
Pacific Missile Test Center
Geophy Division
Code 3253
Point Mugu, CA 93042

Bauer, Ernest
Institute for Defense Analysis
Science and Technology Division
1001 N. Beauregard Street
Alexandria, VA 22311
Telephone: 703/578-2873

Belfiore, Jr., James S.
AER, Inc.
840 Memorial Drive
Cambridge, MA 02139
Telephone: 617/547-6207

Bennett, William H.
Aerojet Electronic Systems Division
1100 West Hollyvale Street
PO Box 296
Azusa, CA 91702
Telephone: 818/812-1321

Blasband, Chris
Photon Research Associates, Inc.
9393 Towne Center Drive
Suite 200
San Diego, CA 92121-3016
Telephone: 619/455-9741

Boehm, Albert R.
ST Systems Corporation
109 Massachusetts Ave
Lexington, MA 02173
Telephone: 617/377-2971

Bohlson, John S.
The Aerospace Corporation
Mail Stop M3/716
2350 E. El Segundo Blvd
Los Angeles, CA 90245-4691
Telephone: 213/336-0012

Brewer, Richard D.
Science Applications International Corporation
10260 Campus Point Drive
M/S 34
San Diego, CA 92121
Telephone: 619/546-6084

Brooks, Bruce H.
Harris Corporation
Government Information Systems Division
301 N. Washington
Bellevue, NE 68005
Telephone: 402/292-2048

Brooks, Tom
ITT Aerospace
Communications Division
1919 W. Cook Road
P.O. Box 3700
Fort Wayne, IN 46801
Telephone: 219/487-6701

Bunting, James
GD/PL
Satellite Meteorology Branch
Atmospheric Sciences Division
Hanscom AFB, MA 01731-5000
Telephone: 617/377-3495

Burger, Harry L.
GRC
5383 Hollister Avenue
Santa Barbara, CA 93160
Telephone: 805/964-7724

Butler, Charles T.
Physical Sciences Inc.
635 Slaters Lane
Suite G-101
Alexandria, VA 22314
Telephone: 703/548-6410

C

Champion, Kenneth S.W.
PL/LY
Hanscom AFB, MA 01731-5000
Telephone: 617/377-3033

Cianciolo, Maureen E.
TASC
55 Walkers Brook Drive
Reading, MA 01867
Telephone: 617/942-2000

Cole, Julet C.
Science and Technology Corporation
101 Research Drive
Hampton, VA 23666
Telephone: 804/865-7604

Colomb, Jr., Herbert P.
Naval Oceanography Command
Stennis Space Center, MS 39529-5000
Telephone: 601/688-5003

Comoglio, Ronald L.
Det 1, 2WS (ASD/WE)
WPAFB, OH 45433-6503
Telephone: 513/255-2207

Cowles, Kelly A.
Jet Propulsion Lab
MS 161-135
4800 Oak Grove Dr
Pasadena, CA 91109
Telephone: 818/354-9176

Cramer, James H.
HQ AF6WC/SDDC
Offutt AFB, NE 68113
Telephone: 402/294-5744

Crandall, Winston K.
PL/WE
Kirtland AFB, NM 87117
Telephone: 505/846-4722

D

d'Entremont, Robert P.
GD/PL
Satellite Meteorology Branch
Atmospheric Science Division
Hanscom AFB, MA 01731-5000
Telephone: 617/377-2983

Davidson, Gilbert
PhotoMetrics, Inc.
4 Arrow Drive
Woburn, MA 01801
Telephone: 617/938-0300

Davidson, John D.
SSD/WE
Los Angeles AFB, CA 90009-2960
Telephone: 213/363-3769

De Lorenzo, Robert
The Aerospace Corporation
2250 E. El Segundo Boulevard
MS M3/717
El Segundo, CA 90245-4691

Dickinson, Lee G.
Lockheed Missiles and Space Co
Department 85-72, Bldg 154
PO Box 3504
Sunnyvale, CA 94088-3504
Telephone: 408/742-4956

Doelling, David R.
Lockheed Engineering and Sciences Corporation
144 Research Drive
Hampton, VA 23666
Telephone: 804/766-9052

Dunmire, Jr., Thomas B.
Ballistic Missile Organization (BMO)/WE
Norton AFB, CA 92409-6468
Telephone: 714/382-2643

E

Eloranta, Edwin W.
University of Wisconsin
Department of Meteorology
1225 West Dayton
Madison, WI 53706
Telephone: 608/262-7327

Essenwanger, Oskar M.
University of Alabama
Department of Mathematics
MDH 204
Huntsville, AL 35899
Telephone: 205/895-6296

F

Farber, Morton S.
Arete Associates
P.O. Box 6024
Sherman Oaks, CA 91413
Telephone: 818/501-2880

G

Geernaert, Gerald L.
Office of Naval Research
Code 1241
800 N. Quincy Street
Washington, DC 22217
Telephone: 703/696-6462

Glass, Morton
GD/PL
Satellite Meteorology Branch
Atmospheric Sciences Division
Hanscom AFB, MA 01731-5000
Telephone: 617/377-2946

Gleiter, R.F.
The Aerospace Corporation
PO Box 92957
Los Angeles, CA 90009
Telephone: 213/336-5573

Gold, Terry L.
Defense Meteorological Satellite Program
Space Systems Division
SSD/MWBA
P.O. Box 92960
LAAFB, CA 90009-2960
Telephone: 213/336-4332

Gooch, Willis
University of Utah
Department of Meteorology
819 WBB
Salt Lake City, UT 84112
Telephone: 801/581-8991

Goroch, Andreas K.
Naval Research Laboratory-Monterey
Code 421
Monterey, CA 93943-5006
Telephone: 408/647-4725

Goyette, John A.
Defense Meteorological Satellite Program
Space Systems Division
SSD/MW
P.O. Box 92960
LAAFB, CA 90009-2690
Telephone: 213/336-4333

Grantham, Donald D.
GD/PL
Air Force Systems Command
Hanscom AFB, MA 01731-5000
Telephone: 617/377-2982

Griffin, Michael K.
GD/PL
Satellite Meteorology Branch
Atmospheric Sciences Division
Hanscom AFB, MA 01731-5000
Telephone: 617/377-2961

Grigsby, Stanley H.
NRL - BDC
7638 Kingsbury Road
Alexandria, VA 22310
Telephone: 202/404-7832

Gustafson, Gary B.
AER, Inc.
840 Memorial Drive
Cambridge, MA 02139
Telephone: 617/547-6207

31

H

Hackwell, John
The Aerospace Corporation
PO Box 92957
Los Angeles, CA 90009
Telephone: 213/336-6041

Hamill, Thomas M.
AER, Inc.
840 Memorial Drive
Cambridge, MA 02139
Telephone: 617/377-2694

Hanks, Zarak
NSWC
Code K44
Dahlgren, VA 22448
Telephone: 703/663-8856

Hauth, Floyd F.
OFMC
6010 Executive Boulevard
Suite 900
Rockville, MD 20852
Telephone: 301/443-8704

Holliday, Charles R.
AFGWC/WFM
Offutt AFB, NE 68113
Telephone: 402/294-5451

Humphrey, Charles H.
Visidyne, Inc.
10 Corporate Place
South Bedford Street
Burlington, MA 01803
Telephone: 617/273-2820

Huntley, Jack E.
USAETL
CEETL-GL-AE
7701 Telegraph Road
Fort Belvoir, VA 22060-5546
Telephone: 703/355-2840

Hutchison, Keith D.
Lockheed Missiles and Space Co
6800 Bourleson Road
T2-30, Bldg 310
Austin, TX 78744
Telephone: 512/386-1678

Hutchison, William A.
General Research Corporation
300 Continental Blvd
Suite 550
El Segundo, CA 90245
Telephone: 213/640-1661

I

Isaacs, Ronald G.
AER, Inc.
840 Memorial Drive
Cambridge, MA 02139
Telephone: 617/547-6207

J

Jensen, Jimmy A.
Harris Corporation
Government Information Systems Division
301 N. Washington
Bellevue, NE 68005
Telephone: 402/292-2048

Johnson, Richard W.
University of California
Marine Physical Lab
San Diego, CA 92093-0701
Telephone: 619/534-1772

K

Kelly, Frank P.
Defense Meteorological Satellite Program
Space Systems Division
SSD/MWBA
P.O. Box 92960
LAAFB, CA 90009-2960
Telephone: 213/336-4469

Koehler, Thomas L.
University of California
Marine Physical Lab
Scripps Institute of Ocanography
San Diego, CA 92152-6400
Telephone: 619/534-1771

Kreiss, William T.
Horizons Technology, Inc.
3990 Ruffin Road
San Diego, CA 92123-1826
Telephone: 619/292-8331

Kriese, Willis D.
Boeing Aerospace and Electronics
MS 87-08
PO Box 3999
Seattle, WA 98124-2499
Telephone: 206/773-9951

Kuciauskas, Arunas
Naval Research Laboratory
Airport Road
Monterey, CA 93943-5006

Kwok, Munson A.
The Aerospace Corporation
MS M5-753
PC Box 92957
Los Angeles, CA 90009
Telephone: 213/336-5441

L

Lapp, Marshall
Sandia National Labs
Division 8350A
PO Box 969
Livermore, CA 94551-0969
Telephone: 415/294-2435

Lee, Thomas F.
Naval Research Laboratory
Monterey, CA 93943-5006
Telephone: 408/647-4797

Liou, Kuo-Nan
University of Utah
Department of Meteorology
Salt Lake City, UT 84112
Telephone: 801/581-3336

Louapre, Merlin E.
Aerojet Electronic Systems Division
1100 West Hollyvale Street
PO Box 296
Azusa, CA 91702
Telephone: 818/812-1261

Luces, S.A.
Physical Science Lab (NMSU)
P.O. Box 30002
Las Cruces, NM 88003-0002
Telephone: 505/522-9480

M

Mandy, Norman H.
Meteorological Models Section
AFGWC
Offutt AFB, NE 68113
Telephone: 402/294-4273

McClatchey, Robert A.
GD/PL
SES-O4
Division Director
Hanscom AFB, MA 01731-5000
Telephone: 617/377-2975

Mendenhall, Laurence D.
Geodynamics Corporation
21171 Western Ave
Suite 100
Torrence, CA 90501
Telephone: 213/320-2300

Miller, E.L.
The Aerospace Corporation
PO Box 92957
Los Angeles, CA 90009
Telephone: 213/336-0008

Miller, Thomas E.
Defense Meteoroogical Satellite Program
Space Systems Division
PO Box 92960
Los Angeles, CA 90009-2960
Telephone: 213/336-4400

Minnis, Patrick
NASA LaRC
MS 420
Hampton, VA 23665
Telephone: 804/865-5669

Moe, Osborne K.
Space Systems Division/WE
Los Angeles, CA 90009-2960
Telephone: 213/363-5176

Mohr, Duane L.
Det 1, HQ AWS
Pentagon
Washington, DC 20000
Telephone: 703/614-1772

Musto, Steven E.
DET 3, HQ AWS
Onizuka AFB, CA 94088
Telephone: 408/752-6310

N

Nagle, Roland E.
Computer Sciences Corporation
c/o Naval Research Laboratory
Monterey, CA 93943-5006
Telephone: 408/647-4715

Niday, David H.
General Research Corporation
2659 Townsgate Road
Suite 220
Westlake Village, CA 91361
Telephone: 805/379-2474

O

O'Brien, Arthur E.
The MITRE Corporation
M/S L112
14 Oak Park Drive
Bedford, MA 01730
Telephone: 617/271-5736

Olson, Vernon E.
The Aerospace Corporation
MS M3-716
2350 E. El Segundo Blvd
El Segundo, CA 90245-4691
Telephone: 213/336-6682

Ometz, Denny L.
Westinghouse ESG
Space Division
MS 3K28
P.O. Box 746
Baltimore, MD 21203
Telephone: 301/765-5825

Ou, Szu-Cheng
Liou and Associates
4480 Adonis Drive
Salt Lake City, UT 84124
Telephone: 801/581-8991

P

Palikonda, Rabindra
Naval Research Laboratory
Monterey, CA 93943-5006

Pan, Rosia Y.
Aerojet Electronic Systems Division
1100 W. Hollyvale Stree
Building 160/D5321
PO Box 296
Azusa, CA 91702
Telephone: 818/812-2503

Paul, David J.
LMSC

Peters, Jeffrey L.
3WW/DN
Offutt AFB, NE 68113-5001
Telephone: 402/294-2681

Pihos, Gregory G.
The Aerospace Corporation
P.O. Box 92957
M 4-902
Los Angeles, CA 90009-2957
Telephone: 213/336-7963

Poore, Kirk D.
USAFETAC/ECS
Scott AFB, IL 62225-5438
Telephone: 618/256-3543

Q

Quigley, William W.
Westinghouse Electric Corporation
Electronic Systems Group
PO Box 1521
MS 3K26
Baltimore, MD 21203
Telephone: 301/993-6017

R

Raffensberger, Mark E.
HQ AWS/XTX
Bldg 1521
Scott AFB, IL 62225-5008
Telephone: 618/256-4721

Reinke, Donald L.
METSAT, Inc.
515 South Howes
Ft Collins, CO 80521
Telephone: 303/221-5420

Richard, Jeff V.
Science Applications International Corporation
10260 Campus Point Drive
M/S 34
San Diego, CA 92121-5438
Telephone: 619/546-6403

Riley, Jr., Gerald F.
3d Weather Squadron/CC
Bldg 1130
Shaw AFB, SC 29152-5070
Telephone: 803/668-2430

Robinson, Ian S.
The Aerospace Corporation
MS 4/041
PO Box 92957
Los Angeles AFB, CA 90009-2957
Telephone: 213/336-6142

Rogers, John M.
HQ AFOTEC/WE
Kirtland AFB, NM 87117-7001
Telephone: 505/846-9424

Rossow, William B.
NASA Goddard Institute for Space Studies
2880 Broadway
New York, NY 10025
Telephone: 212/678-5567

Rubio, Roberto
US Army ASL
SLCAS-AA-A
WSMR, NM 88002-5501
Telephone: 505/678-2926

S

Schultz, Ernest G.
GE Astro Space
5933 W. Century Boulevard
Suite 220 (GE)
Los Angeles, CA 90045
Telephone: 213/642-5282

Schurin, Bertram D.
Hughes Aircraft Company
EO/E52/C242
PO Box 902
El Segundo, CA 90245
Telephone: 213/616-6978

Seagraves, Mary Ann
US Army ASL
SLCAS-BW-W
WSMR, NM 88002
Telephone: 505/678-4207

Sengupta, Sailes K.
Naval Research Laboratory
Monterey, CA 93943-5006
Telephone: 408/647-4747

Sentelle, Gary
OL-A/HQ AWS
Buckley AFB, CO 80011
Telephone: 303/341-3406

Shanks, Joseph G.
Photon Research Associates, Inc.
9393 Towne Centre Drive
Suite 200
San Diego, CA 92121
Telephone: 619/455-9741

Shettle, Eric P.
Naval Research Lab
Optical Sciences Division
Code 6522
Washington, DC 20375-5000
Telephone: 202/404-8152

Shields, Janet E.
University of California
Marine Physical Lab 0701
9500 Gilman Drive
La Jolla, CA 92093-0701
Telephone: 619/534-1769

Shimabukuro, Fred
The Aerospace Corporation
PO Box 92957
Los Angeles, CA 90009
Telephone: 213/336-6903

Shoemaker, James D.
Lockheed Missiles and Space Co
9800 S. Sepulveda
Los Angeles, CA 90045
Telephone: 213/670-5250

Siquig, Richard A.
Naval Research Laboratory
Atmospheric Directorate
Code 442
Monterey, CA 93943-5006
Telephone: 408/647-4732

35

Snapp, Michael R.
Pacific-Sierra Research Corporation
1401 Wilson Blvd
Suite 1100
Arlington, VA 22209
Telephone: 703/527-4975

Snow, J. William
GD/PL
Satellite Meteorology Branch
Atmospheric Sciences Division
Hanscom AFB, MA 01731-5000
Telephone: 617/377-3496

Sparrow, Jeanne M.
AER, Inc.
840 Memorial Drive
Cambridge, MA 02139
Telephone: 617/547-6207

Steven, John
The Aerospace Corporation
PO Box 92957
Los Angeles, CA 90009
Telephone: 213/336-5959

Strang, Wayne G.
Defense Meteoroogical Satellite Program
Space Systems Division
PO Box 92960
Los Angeles, CA 90009-2960
Telephone: 213/336-4458

Straus, Joseph
Th⌐ Aerospace Corporation
PO Box 92951
Los Angeles, CA 90009
Telephone: 213/336-

Sugihara, Edna M.
Aerojet Electronic Systems Division
1100 W. Hollyvale Street
Building 160/D5321
P.O. Box 296
Azusa, CA 91702
Telephone: 818/812-2526

T

Tessendorf, Jerry
Arete Associates
P.O. Box 6024
Sherman Oaks, CA 91413
Telephone: 818/501-2880

Thebaud, Lawrence R.
Arete Associates
P.O. Box 6024
Sherman Oaks, CA 91413
Telephone: 818/501-2880

Thomas, Bruce H.
The Aerospace Corporation
DMSP
c/o HQ 1000 Sat Ops Group
Offutt AFB
Omaha, NE 68113-4000
Telephone: 402/291-3140

Thomas, Clement J.
Boeing Aerospace and Electronics
MS 87-08
PO Box 3999
Seattle, WA 98124-2499
Telephone: 206/773-2290

Thompson, Gary John
Logicon RDA
P.O. Box 9377
Albuquerque, NM 87119-9377
Telephone: 505/842-8911

Thorne, Lawrence R.
Sandia National Laboratory
ORG 8300A
Livermore, CA 94551
Telephone: 415/294-2552

Trivett, Heather C.
NSWC
Code K44
Dahlgren, VA 22448
Telephone: 703/663-8335

Try, Paul D.
Science and Technology Corporation
409 3rd Street
Suite 203
Washington, DC 20024
Telephone: 202/863-0012

Twitchell, Paul
Science and Technology Corporation
509 Schley Rd
Annapolis, MD 21401
Telephone: 301/263-8976

U

Uthe, Edward E.
SRI International
333 Ravenswood Avenue
Menlo Park, CA 94025-3493
Telephone: 415/859-4667

V

Vonder Haar, Thomas H.
Cooperative Institute for Research
 in the Atmosphere (CIRA)
Colorado State University
530 South Howes
Ft Collins, CO 80521
Telephone: 303/221-8566

W

Walters, Michael K.
HQ USAF/XOWX
Pentagon
Washington, DC 20330-5054
Telephone: 703/693-8277

Warren, Anthony J.
USAFETAC/DNY
Air Force Global Weather Central
Scott AFB, IL 62225-5438
Telephone: 618/256-5412

Weckler, Paul
Aeromet Inc.
P.O. Box 701767
Tulsa, OK 74170-1767
Telephone: 918/299-2621

Weeks, Lawrence H.
Defense Meteorological Satellite Program
Space Systems Division
SSD/MW-D
P.O. Box 92960
LAAFB, CA 90009-2960
Telephone: 213/336-4334

Weiner, Allen
Det 1, HQ AWS
13940 Antonia Ford Court
Centreville, VA 22020
Telephone: 703/614-1772

Westerman, Steven
Lockheed Missiles and Space Co
B/572 0/6R-23
P.O. Box 3504
Sunnyvale, CA 94088-3504
Telephone: 408/742-6109

Whiton, Roger C.
USAFETAC/DN
Scott AFB, IL 62225-5438
Telephone: 618/256-3902

Whitten, Milton G.
LMSC

Widhopf, George F.
Arete Associates
P.O. Box 6024
Sherman Oaks, CA 91413
Telephone: 818/501-2880

Wylie, Donald P.
University of Wisconsin
1225 W. Dayton Street
Madison, WI 53706
Telephone: 608/263-7458

Y

Yang, T.P.
The Aerospace Corporation
PO Box 92957
Los Angeles, CA 90009
Telephone: 213/336-5891

Yepez, Jeffrey
PL/LYA
Hanscom AFB, MA 01731
Telephone: 617/377-5955

Yoon, Douglas
Logicon RDA
P.O. Box 92500
Los Angeles, CA 90009
Telephone: 213/645-1122