Fourth Airborne Geoscience Workshop

The Embassy Suites Hotel
La Jolla, California
January 29–February 1, 1991

AIRBORNE GEOSCIENCE
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Summary Minutes February 1991

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An Interagency and Interdisciplinary Forum on the Scientific Results and Future Needs of Airborne Research

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EXECUTIVE SUMMARY

General Overview

The Fourth Airborne Geoscience Workshop (AGW) was held January 29 through February 1, 1991, at the Embassy Suites Hotel in La Jolla, California. The Workshop was hosted by the National Aeronautics and Space Administration (NASA) and co-sponsored by the National Oceanic and Atmospheric Administration (NOAA), the National Science Foundation (NSF) with the National Center for Atmospheric Research (NCAR), the U.S. Geological Survey (USGS), the Office of Naval Research (ONR), and the Air Force Geophysics Laboratory (AFGL). The Airborne Geoscience Workshops are planned and implemented by the Steering Group on Airborne Geoscience, a panel composed of prominent domestic and international facility managers and scientists representing agencies that operate aircraft as instrument platforms for acquiring scientific data. These Workshops are held every 2 years to permit sufficient time for reasonable progress to be made and to minimize competition with other scientific meetings at which results may be presented. Every effort was made to engender a positive atmosphere for information exchange, and the Fourth AGW more than adequately accomplished this objective. In comparison with the previous Workshop, attendance was up considerably, poster renderings nearly doubled, the agenda and theme had greater balance, and the level of enthusiasm remained high, even in the waning moments of the proceedings.

The general theme for the Fourth Airborne Geoscience Workshop revolved about global environmental change. Over 170 individuals participated in the presentations and ensuing discussions about the many agency activities using airborne platforms and sensors in support of the U.S. Global Change Research Program (GCRP). The U.S. GCRP has been developed as a central component of the U.S. Government's approach to global change and its contribution to worldwide efforts. An all-encompassing U.S. plan has been developed by the Committee on Earth and Environmental Sciences (CEES), which continues as the interagency coordinating group for the program. The U.S. GCRP was established as a Presidential initiative in the FY90 budget, making it a particularly relevant topic for the present Workshop.

The direct administration of the research program is the responsibility of less than a dozen U.S. Government agencies. Representatives from four of the agencies with active airborne research programs participated in the Workshop through keynote speeches and subsequent discussion. Each representative provided a glimpse of respective agency activities relative to the U.S. GCRP and, more particularly, the agencies' airborne research activities in global environmental change. Airborne platforms provide critical *in situ* observations of environmental parameters, test of future observational concepts, and calibration and support for space-based measurements of the Earth's global environment. Field campaigns seek to further understanding of Earth processes on local and regional scales, which can then be combined with satellite data and possibly incorporated into larger scale models of the environment. The Workshop presentations allowed participants to obtain the latest information on experiment results, flight opportunities, instrumentation, and future plans in airborne geoscience to support global change research, with the intent of fostering fruitful agency and international collaboration.

The organizational structure of the Workshop was the responsibility of the Steering Group on Airborne Geoscience. The Workshop opened on the morning of Tuesday, January 29th, with a general session featuring a welcome address and the five keynote speeches. The first of four panel sessions took place on Wednesday morning, with poster previews on Tuesday and Thursday afternoons. See Appendix A for the final agenda of the 4-day Workshop proceedings. The poster presentations and sessions are not covered in these summary minutes. A summary session took place on Friday morning, with highlights provided in the following paragraphs. More detailed coverage of the Session Leaders' summary remarks is offered as Section 4.2.

Specific Issues and Opportunities

The Fourth AGW examined the present-day issues, concerns, needs, and opportunities spanning all disciplines that influence airborne participation in global change research. A vast array of exciting possibilities and actual achievements were described, revealing the interdisciplinary, interagency, and international scope of the campaigns in which aircraft are involved. The growing national and international focus on global change studies provides an excellent opportunity for proaction by the airborne community through the agencies, the National Academy of Sciences (NAS), and the Committee on Earth and Environmental Sciences (CEES). The CEES oversees the U.S. GCRP as a vehicle of the Office of Science and Technology Policy (OSTP), the Executive Branch lead in promulgating global change policy initiatives. U.S. GCRP projects have been coordinated with the World Meteorological Organization (WMO) and the International Council of Scientific Unions (ICSU), so a great deal of planning ensures that U.S. objectives are compatible with global concerns. The program developed by the CEES has been refined by input from both the national and international scientific communities. This preamble underscores the need for the Steering Group on Airborne Geoscience to increase its visibility, both domestically and internationally. By exploiting existing channels, legitimate problems can be brought to the attention of policymakers.

An overriding concern voiced by a number of participants in the Workshop was that the availability of flight time on airborne platforms is decreasing, primarily due to the lessening of agency resources, which is required for all aspects of the airborne geoscience program, and the aging of agency fleets (with little hope for replacement). These concerns are particularly surprising, because they come at a time when airborne observations prove critical in supporting the growing satellite and modeling activities of the global change research community. As is often the case with new interagency initiatives, many Earth science programs pre-dating NASA's Earth Observing System (EOS) are being identified as budget elements in the U.S. GCRP. Unfortunately, no additional monies have been allocated to provide overall maintenance of airborne programs, much less allowing for expansion or upgrades. Demand on resources is ever-increasing, and the capability to satisfy user requests diminishes daily. The Steering Group on Airborne Geoscience suggested that an appropriate avenue be found to forward these concerns to the CEES, whose goal is to "establish an integrated, comprehensive, long-term program of documenting the Earth system on a global scale." The Steering Committee also authored a resolution describing the concerns of the group, documenting the critical nature of the lack of resources. This resolution serves as a tangible reflection of the difficulties facing the airborne geoscience community at large (see Appendix B).

The following points of contention about inadequate platforms were brought up in multiple presentations, and deserve emphasis here (supporting arguments are listed parenthetically; refer to final agenda for speaker placement):

- Critical need for a mid-sized jet to replace the NCAR Sabreliner—perhaps a Gulfstream IV, which has the tremendous range and altitude capability required for atmospheric studies (Shedlovsky, Serafin, Johnson/Smith, Cooper, Pikell)
- Need for a long-duration, high-altitude aircraft for studies of stratospheric processes and access to remote regions (Tuck, Johnson)
- Need for a second NASA DC-8, since this craft has unique operational capabilities but is oversubscribed (McNeal, Hall, G. Vane)
- Need for autonomous craft to alleviate the pilot-endurance problem for extended missions (Serafin, Tuck, Webster, Hall).

The above deficiencies were listed because of the number of times that they were discussed; of course, other important issues were mentioned during the presentations (e.g., need for a standard meteorological instrument package on NASA aircraft). The reader is referred to the body of the text for coverage of these supplementary issues.

A common thread of "communication" ran throughout the Workshop. Since resources are limited, cooperation amongst researchers must improve to ensure that platforms and instruments are utilized to satisfy the objectives of the GCRP, maximizing the utility of the data and the number of scientists that the observations benefit. From the week-long discussions, it became apparent that improved coordination is needed; however, it also became clear that cooperation does exist and that common objectives are being pursued. Competition for flight time will always exist, but infighting must be tempered by a common knowledge of the ultimate objectives of the airborne geoscience community. Across the broad international community, a vigorous infrastructure—both materiel and people—exists to support research in the Earth sciences and, in most areas, only a modest increase in support would make possible major enhancements to the airborne geoscience program. However, any advancement would be jeopardized if investigators are myopically focused on their own programs. Communication entails a broad vision.

1. DAY 1

The first general session of the Workshop took place on Tuesday, January 29, 1991, and featured a welcome address, five keynote speeches, and previews of the posters to be displayed that night at the Faculty Club at the University of California—San Diego (UCSD). The Program Book distributed at registration alleviates the need to cover the 3-minute teasers of the afternoon presenters, so the following paragraphs focus on the invited speakers and consequent discussions stemming from the common theme of global change research.

1.1 Opening Remarks

The welcome address was delivered by Dr. James R. Huning, the Steering Group Chairman and Acting Manager of Research Facilities at NASA Headquarters. Dr. Huning stated that over 170 people were registered with a few individuals still straggling in; fortunately, events in the Persian Gulf did not dissuade people from traveling. All international participants were present, so the core of the airborne geoscience community was represented. He next broached the unifying theme of global change research, stressing that the talks would provide philosophical and programmatic perspectives of agency efforts, with the poster sessions getting into the nitty gritty of available technologies and applications.

Mission to Planet Earth (MTPE) and EOS, its chief contributor, are NASA's most significant contributions to global change research. The ambitious goals of these programs punctuate the vital role of airborne platforms. Should airborne activities remain *status quo* or adapt to help meet the burgeoning requirements of the EOS era? Unfortunately, the demand for flight time remains great and the resources little. Coordination on an interagency and international level must continue if the needed ground truthing and precursor measurements are to be secured. Only by continuing to break down communication barriers can the airborne element of EOS make its own substantial contribution. The poster sessions were specifically designed to facilitate communication on a more active and less formal basis, hopefully yielding more cooperative ventures. Without further ado, Dr. Huning introduced the first keynote speaker.

1.2 Keynote Speakers

The keynote speeches were given by Dr. John Theon, NASA/Earth Science and Applications Division; Dr. Julian Shedlovsky, NSF/Division of Atmospheric Sciences; Dr. Eileen Shea, NOAA/Office of Atmospheric Research (OAR); Dr. Alan Weinstein, Department of Defense (DoD)/ONR; and Dr. Kirill Ya. Kondratyev, USSR Academy of Sciences. Since keynote speakers were not required to provide an abstract for the Program Book, their speeches will receive indepth coverage here.

National Aeronautics and Space Administration

Dr. John Theon prefaced his remarks by stating that budget problems on the Hill demanded Dr. Shelby Tilford's attention and that he sent his regrets. Nonetheless, Dr. Theon was in a unique position to reveal the NASA perspective on global change issues, being the Radiation, Dynamics, and Hydrology Program Office Manager. He briefly overviewed the foundation of the U.S. GCRP—MTPE, and more specifically EOS.

Undoubtedly, humankind is affecting the environment. Inadvertent climate system changes brought about by mass loadings of carbon dioxide (CO_2), chlorofluorocarbons (CFCs), methane, etc., have thrust global change into the limelight. Radiative budget effects (i.e., greenhouse gases and global warming) and ozone depletion in the stratosphere certainly have heightened public awareness; however, climate change goes far beyond these fashionable concerns. The scientific community has to confront the myriad pieces that make up the climate puzzle. Scientists must discern the difference between natural and human-induced change, and decisionmakers must place the pieces in a manner that balances scientific recommendation against the demands of a higher population and an improved standard of living, which are heavily taxing the Earth's resources. This somewhat skewed picture drives environmental policy, though the aforementioned flagrant effects overshadow other parameters that need to be quantified and incorporated into climate models.

The GCRP is interagency and international in scope, with NASA one of the principal players. Satellites are NASA's primary platforms to secure data; however, aircraft contribute significantly by exploring the details of reactions (e.g., Freons), providing *in situ* measurements, and calibrating spaceborne sensors. Aircraft study local and regional processes that help in extrapolating to global scales. Subtle changes occurring on an annual basis build up over time, and a data and information system (DIS) proves essential to process and house time series of data, yielding trends from which a predictive capability can emerge.

Mission to Planet Earth is the <u>key</u> element of the GCRP and is composed of EOS, Earth Probes, geostationary satellites, and low inclination orbiting platforms (e.g., ADEOS). Obviously a major undertaking, Earth science support is scaling up and will eventually consume about half of NASA's entire budget. Field and satellite measurements will be integrated by EOSDIS into useful data to provide accurate information for policymakers and regulators. EOSDIS comprises 60 percent of the EOS budget.

Though the launch of EOS-A is years away, EOS science is well established. EOSDIS pathfinder data sets are being processed from existing data, much of which involves aircraft observations. Cross-calibration of data and simultaneous measurements refine the data; only through congruity can scientists accurately determine fluxes (e.g., air-sea interactions). Though placing all eggs in one basket with a large platform concept, simultaneity and cost-effectiveness (i.e., Titan IV launch) outweigh inherent risk. Aircraft will assist in technology development and verification for this primarily space-based observing system.

National Science Foundation

Dr. Julian Shedlovsky addressed NSF involvement in the GCRP, technology development issues, and ideas on the current NSF budget. As indicated by CO_2, ozone, and deforestation problems, humans have a significant affect on the global environment (e.g., African Sahelian desert). NSF is helping to isolate anthropogenic from natural change through long-term observations. NSF's Global Geosciences Program (GGP) attempts to minimize the scientific uncertainty surrounding Earth as a composite system. Founded in 1987, the GGP is NSF's main contribution to the GCRP. Dr. Shedlovsky went on to list the seven elements that comprise the program:

- Biogeochemical dynamics
- Ecosystem dynamics
- Dynamics of the hydrosphere
- Geosystems dynamics
- Arctic system sciences
- Earth history
- Geosystems data bases.

These categories are linked by dynamic processes, involving local and short-term fluctuations. Extrapolating these data to intermediate scales (i.e., decades to centuries) to further understanding of the climate system and biogeochemical cycles highlights the importance of easily accessible geophysical data bases that are transparent to the end user.

The well-coordinated interagency oversight that CEES supplies to the U.S. GCRP maximizes the capability for data to be manipulated into a predictive capacity, hopefully resulting in sound policy decisions. CEES activities ensure multilateral coordination; indeed, its program has been endorsed by global change researchers as a model for interagency cooperation.

Sharing the NASA perspective, Dr. Shedlovsky stated that an interdisciplinary global approach proves meaningless without a DIS to process the observations into integrated data sets. Aircraft measurements thus play a substantial role in ground truthing/verification and in data collection in general. Twenty-eight percent of the $954M global change research budget (FY91 $) has ground-based applications; however, with the approach of the EOS era, the gap between satellite and aircraft funding will widen. Satellites are expensive, but the airborne contribution remains an integral part of NSF studies. Geosciences cover 90 percent of NSF involvement in the U.S. GCRP and consumes 20 percent of its total operating budget.

Aircraft contribute vital information on moisture fluxes, heat transport/momentum, cloud microphysics, motion and particle fields, and trace gases; yet, heightened performance specifications must be actively pursued (i.e., replace NCAR Sabreliner, perhaps with a Gulfstream).

Unfortunately, the Federal deficit is still soaring, which affects each agency's total budget. Expectations must take this difficult budget climate into account. Obviously, the sustained commitment required to meet GCRP objectives affects flight opportunities. Program planning must be tempered by the reality of constrained resources. Dr. Calvin Swift/University of Massachusetts then queried if these budget limitations were responsible for the success rate of proposals going down. Dr. Shedlovsky responded that costs are up compared to the consumer price index and with that retired from the podium.

National Oceanic and Atmospheric Administration

The third keynote speaker was Dr. Eileen Shea of NOAA/OAR. She expanded on the goal of the GCRP, relying on the ever-popular CEES science priorities and research objectives charts. NASA and NSF may have been the original leaders in the global change realm, but the CEES got NOAA more actively involved, as evidenced by their substantial contribution to a variety of documents, especially the grey book which was first published in 1989. This CEES publication (i.e., *Our Changing Planet*) accompanies the release of the President's annual budget and should be available the week after adjournment of the Workshop. The U.S. definitely needed a fairly aggressive research program, funding, and a mechanism for interagency collaboration. All this was secured under the auspices of the CEES, and now the program is well underway and in robust health. The ramp of funding scales up dramatically over the next few years; of course, the budget deficit (e.g., Persian Gulf expenses) will affect its rate.

Dr. Shea chose to examine the non-abridged version of the GCRP goal. Key words that she noted included predictive (not enhanced knowledge), interactive (cross-disciplinary/fluxes and connections), and social (the human dimension), which in tandem help provide the science basis for international and national policy. Science priorities were requested by the Office of Management and Budget (OMB), a stipulation that normally throws bureaucrats into a tizzy; however, such steps prove necessary to establish funding emphases. Of course, the broad base of science cannot be compromised if a comprehensive, interdisciplinary treatment of Earth system processes is to be achieved. As such, funding for specific projects is ranked according to the following, no matter where mounted on the priorities graphic:

1) How project contributes to broad science
2) How project discerns differences between natural and human-induced change
3) How project distributes cost between agencies/international organizations, both public and private
4) How project contributes to understanding of focused process studies.

Establishing an interdisciplinary regime necessitates new funding mechanisms and institutional organization, blurring traditional boundaries for both discipline and management orientations. A new information service must emerge based on the overarching driver of climate system change. Of course, discrete elements contribute to the global change vision, but investigators must force themselves from a myopic reliance on discipline-specific study. NOAA started early by initiating their Climatic and Global Change Program in FY89. NOAA strives to achieve reliable projections on seasonal to interannual scales, to provide useful simulations on scales of decades to centuries, and to differentiate natural and human influences. These operational research objectives complement NASA studies, minimizing duplication of effort while supporting large-scale observation networks. Of course, any contribution hinges on the availability of funds. Though NOAA's global change budget escalated from $18 to $47M (FY91 $), Congress only gave the agency half of its request. Their decision was based on actual appropriations rather than anticipated expenditures.

Several questions resulted from Dr. Shea's presentation. Warren Johnson/NCAR asked how a project on the bottom of column #1 of the science priorities chart compared to the top of column #3. Dr. Shea responded that on a project-by-project basis evaluations are made based on the likelihood of substantial science return. Alan Weinstein/ONR chimed in that scientists would never establish priorities again if they were cut off at the knees by an arbitrary ranking system.

F.J. Lampietti/EG&G asked of the possible role of industry. Dr. Shea stated that industry was actively involved with individual projects, but that the broader question of industry's role in defining research needs is referred to a special working group that reports to the CEES. Dr. Shedlovsky reiterated that industry normally supports individual investigators, while agencies must maintain the health of all disciplines, not focusing solely on certain facilities. Dr. Theon welcomed science contributions from industry, as well as academic and the public sector, which could be achieved through the normal channels of Requests for Proposals (RFPs), solicitations, research announcements, and so on—especially regarding hardware configurations.

Office of Naval Research

Dr. Alan Weinstein stated that the purpose of a keynote speech is to inspire the audience for the rest of the meeting. So he broached the subject of coordination and participation, a subject that should be germane to the entire audience. Normally, the rates of performers (i.e., scientists) to bureaucrats (i.e., money managers) is about 1 to 10; however, he was pleased to note that the makeup of the Workshop appeared to be somewhat closer to 50/50. This figure certainly indicates that the main purpose of the Workshop was achieved (i.e., to foster interaction between those who do and those who facilitate the doing).

He went on to state that DoD is involved in GCRP activity, though belatedly, primarily through the participation of ONR in CEES activities. However, DoD's initial stance was to participate in the GCRP in so much as the studies that furthered their agency's needs provided ancillary information of benefit to the global change research community at large, and vice versa. DoD's contribution was derived from existing programs, so he deemed the DoD a "contributory agency" through ongoing studies under the purview of the Navy, Army, and Air Force. The main problem was that DoD could not get Congress to allocate research funding. In effect though, DoD does not even deal with Congress (i.e., no Congressional Affairs Rep).

In November 1989, a shift in policy manifested itself in the "First Tuesday Symposium," chaired on this occasion by Dr. Tom Malone. Basically, DoD could no longer ignore global change issues, because relations among nations no longer were predicated solely on military might (security) and economic vigor; rather, environmental perturbations now played a significant role in diplomatic relations. In the summer of 1990, DoD reevaluated its position and determined that limited, focused global change research may be identified, though it still must support DoD interests which involve primarily seasonal and shorter observations (i.e., time scales of a month or less).

ONR became the CEES representative from DoD since 75 percent of the approved and funded programs were under ONR direction. These eight programs (6 ONR/2 CRREL) total $6.3M in FY92, so DoD realigned itself from a peripheral, contributory participant to a substantial role in global change research. Program elements now support DoD mission requirements on a tactical and regional scale. The specific programs involve ocean measurements, high-latitude dynamics, regional resolving models, boundary layer dynamics, and ocean ecological dynamics. Out of these science objectives emerged the Strategic Environmental Research and Development Program, which encapsulates the DoD component for global change studies and involves the only new dollars allotted by DoD to the U.S. GCRP. Funded projects remain focused on regional and smaller scales of events that have an impact on operational effectiveness. Proposals received priority based on the following criteria.

- Enhance existing programs
- Capitalize on near-term opportunities via a one-time investment
- Executable during the proposed period
- Provide a mix of near-term and out-year deliverables.

Various initiatives will be publicized through the normal channels after release of the FY92 budget. With that, Dr. Weinstein concluded his remarks in hopes that DoD participation in the GCRP yields observations of benefit to the research community.

VIP Keynote

Academician Kirill Ya. Kondratyev—Counsellor of Directorate, Institute for Lake Research, and Soviet Chairperson for the Joint Working Group on Earth Sciences—gave the final keynote address of the morning session. He started his address concerned that he was both a VIP and keynote speaker; however, in his role as Very Intellectual Paratrooper, he did not feel compelled to inspire the audience, as did Dr. Weinstein. Rather, he was poised to depress everyone with his perspective on the state of the planet. He commenced with brief ruminations on global change research, and continued by addressing the specifics of what observations are needed, the appropriate mechanisms to secure needed data, and the airborne remote sensors' role in focused field campaigns.

He discussed the infamous CEES science priorities chart, with supporting documentation annotated (see Appendix C1 for reference list). Though he deemed study of the role of clouds as the purpose of his life, he proposed combining the second and the third columns (i.e., Biogeochemical Dynamics and Ecosystem Dynamics), and making this merger the highest priority for global change research. Our planet is constructed on a very delicate balance, with minute variations having a profound impact. The issue of global warming proves mere noise when confronted with the awesome repercussions of a carbon cycle run amok. The land biosphere no longer acts as a sink, but a contributor, with biological consumption of carbon by the oceans the only thing saving us from ecological catastrophe. Belief that man is creating a new biosphere for the planet as an element of nature is unfounded, because nature established conditions that remained somewhat pristine until this century. The present tendency of humankind to treat the biosphere as an afterthought will produce irreversible consequences that will destroy the planet in mere centuries. Our main purpose now must be to conserve the biosphere for generations to come.

This vision inextricably links the natural and social sciences. Prior to this century, biodiversity kept everything in balance; now, humankind is overrunning the planet. Overpopulation threatens life as we know it, and only by reducing our numbers can the biosphere be saved. Acad. Kondratyev posed the following solution: 1-child families. Reducing population by this arbitrary means will help offset the incremental contribution each body makes to the destruction of the biosphere. As it is, humans already overpopulate the globe.

Biospheric dynamics thus assumes a critical role in global change research. Of course, science must be pursued through existing data sources and observation systems; unfortunately, the research community has never taken care of integrating satellite and conventional data sources. Ground observations support a myriad of programs, but these efforts remain disjoint. Acad. Kondratyev recommended that conventional platforms be concentrated on energy zones, where the observations are most intense (e.g., Earth radiation budget). By focusing programs on such anomalies, limited resources can be optimally deployed, data more easily validated, and results achieved more cost-effectively. Concrete results can then be extrapolated to the global environment, rather than multiple campaigns conducted throughout the globe linked only by discipline.

Acad. Kondratyev continued by outlining remote sensing requirements and the inadequate facilities that presently existed. To optimally employ a Global Climate Observational System demands coordination amongst components, but more importantly what these components would actually be. Accuracy and sensitivity of measurements must be addressed, because in many instances too many channels of operation generate a data glut that does not substantially contribute to research. International partners must join forces to optimally plan an observational system, including justification for accuracy. Since all investigators are competing for aircraft, some means of oversight must be developed to establish priority, yielding a more cost-effective approach and heightening the utility of data generated.

The first step involves the choice of an ecologically significant area of the globe upon which to concentrate the efforts of global change researchers. Of course, satellite and conventional configurations would be necessary. Airborne platforms would provide *in situ* observations and calibration data for the orbiting platforms (e.g., atmospheric correction). Acad. Kondratyev invited participation in two experiments currently being planned by the Soviets: 1) Ladoga Lake, a study located just north of Leningrad that focuses on the meteorology, chemistry, and biology of this watershed region, and 2) a Urals Sea experiment, analyzing the first decaying sea in the world through desert aerosol studies. The former takes place in 1992, and could serve as a precursor to a like venture on the Great Lakes region. The latter is a collaboration with the British. Of course, any other international participation would be welcomed. Acad. Kondratyev concluded that only through narrowly defined priorities can humankind save the planet, perhaps starting with atmosphere and climate studies since questions already exist and layman interest revolves about such high-visibility issues (e.g., global warming). Finally, political complications must be ignored if the sweeping international cooperation needed to bring about a Global Climate Observational System is to be realized.

1.3 Poster Session

The afternoon poster session was chaired by Dr. S. Harvey Melfi/GSFC, who did a superlative job in keeping the speakers within their 3-minute time limits. Each poster presenter was given the opportunity to summarize the content of his/her display, piquing the audience's curiosity through a couple of viewgraphs and an invitation to drop by and check out the poster. Rather than address the onslaught of information presented in the January 29th afternoon session, the reader is referred to the poster abstracts listed in alphabetical order in the Fourth Airborne Geoscience Workshop Program Book. Readers must consult their own brains for sensory information concerning the poster displays.

2. DAY 2

The morning session for Wednesday, January 30, 1991, was dedicated to agency activities in airborne geoscience. The format allowed 20 minutes for each speaker, with questions after each presentation. Robert McNeal/NASA HQ served as Session Leader. Time was also allocated for a general panel discussion at the conclusion of the morning session, which proved unnecessary since pertinent questions immediately followed each talk . The afternoon session concentration involved platform and instrument developments. Though the Session Leader (Warren Johnson/NCAR) limited speakers to 12 minutes apiece, the "technology session" left no time for a panel discussion at day's end. Paul MacCready , the featured luncheon speaker, spoke of "Unusual Vehicles for Fun, Profit, and Science." His talk was warmly received by the Workshop participants, providing a welcome respite from the technically oriented material of the panel sessions.

Since abstracts were provided by most speakers prior to the Workshop (see Program Book), this section of the summary minutes focuses on the issues and discussions that arose from each of these presentations.

2.1 Agency Activities in Airborne Geoscience

National Aeronautics and Space Administration

NASA possesses a vigorous applications and science program, as will be discussed later in the text. Dr. Robert McNeal chose to shy away from specific programs to discuss existing NASA capability in the context of short-term objectives and management of facilities. NASA employs aircraft in three ways: 1) Ground/air truth for satellites to validate/verify space remote sensing measurements; 2) technology development and improvement, with a particular emphasis on EOS; and 3) focused campaigns to meet specific objectives, especially in the Earth sciences (e.g., land processes mesoscale investigations). Airborne platforms include the ER-2, DC-8, C-130, and Electra, among others, with FY91 flight hours approximating the following: 600 (ER-2), 500 (DC-8), and 300 (C-130). A new approach has been implemented over the past year to help minimize resource constraints. In years past, the user submitted flight requests that proposed certain science objectives and justification for the aircraft needed in meeting these requirements. Program managers would then determine the merits of the proposal and procure hours at a very subsidized rate. Now, in-house managers are charged a user fee (once again heavily subsidized) to help reduce the burden on airborne geoscience coffers at NASA HQ. The success of this method is currently being evaluated.

NASA has to split flight time between four major field campaigns and test flights for prototype instruments, including but not limited to EOS. [Note: The Earth Science and Applications Division (ESAD) has to satisfy requests from all of the Office of Space Science and Applications, not just ESAD.] ESAD maintains a rolling 3-year flight plan, stressing the need for advanced coordination. Investigators need assurance that slots are available, while management must build in enough flexibility to take care of emergencies. Obviously, requests far exceed available flight time, so resources are carefully husbanded in a manner that maximizes science benefits, while being fair to all disciplines. Every discipline warrants attention, and needs access to facilities and results. Problems arise in who and what defines science utility.

Discussion

Several questions arose from Dr. McNeal's presentation. First and foremost, has NASA considered adding aircraft since flight time is so valuable and the results attained from campaigns so exciting? Dr. McNeal responded that the problem obviously stemmed from funding. The funds come from Research and Analysis (R&A) dollars, which are limited in supply. ESAD cannot get a separate line item request by OMB. Dr. Theon added that EOS Principal Investigators (PIs) are adequately funded for underflights and that significant growth in R&A programs has been placed in the projected budget. A question arose about specific targets of opportunity (i.e., oil spills, volcanoes), to which Dr. Huning responded that sufficient flexibility has been incorporated into planning activities to cover such events. He continued that flight time availability was not really a problem. As a matter of fact, aircraft are not fully utilized. The problem is that user requests exceed *funded* hours by a factor of 2 to 3. Dr. Kakar mentioned that ESAD has skirted the issue internally by funding more operational hours in support of EOS instrument development through the program manager user fee (i.e., ~200 hours for LAWS and ~80 hours for TRMM).

National Oceanic and Atmospheric Administration

The priorities of NOAA remain forecasting activities of the National Weather Service (NWS), studies of climate and global change, and coastal ocean studies. Dr. Robert Mahler/Environmental Research Laboratory (ERL) discussed NOAA's capabilities, primarily with regard to their P-3s (2700-mile range, 10-hour endurance, 23,000-foot+ altitude), by dividing the topic into geographic distinctions: Climate feedback studies (air quality/ecosystem response on local scales), hurricane research in the Gulf Atlantic region (precipitation events), and Arctic studies (ozone hole/gas and aerosols/ice processes).

NOAA plans to meet university and interagency science requirements by planning only on short time scales of 3 to 5 years, allowing flexibility in schedule and changing science priorities. This approach also ensures that the agency works within allocated resources. He reiterated Dr. Shea's point that though the FY91 budget allocated $47M in "new money" for NOAA global change research, that sum only totaled half of its budget request. So NOAA must carefully coordinate global change efforts with those of other agencies to ensure a robust program of study. For example, the Antarctic Ozone Hole Experiment uses NASA platforms to house NOAA instruments; furthermore, certain instruments of the EOS core complement will contribute to NOAA's operational measurements. Forty percent of the new money will be spent outside of the agency, so NOAA is working within a highly constrained budget environment—not only the airborne geoscience element, but the whole agency.

Budgets must realize air chemistry, radiation budget, precipitation process, and Arctic studies in such a way that they all are mutually supportive. Linkages are key in the global change research era, with deficiencies in any component affecting other disciplines. He supports the coordinating role filled by the CEES, but stressed that interagency cooperation through such a mechanism is still evolving and remains an experiment as yet.

Discussion

In response to a question about the availability of a salinity instrument, Dr. Mahler responded that institutional funds for research and proposals are easy to secure relative to tangible goods. Basically, it is hard to get money for the actual hardware through the agency infrastructure. Dr. Serafin raised an issue that became one of the prevailing issues of the Workshop: Is there a mechanism to replace airborne platforms (in this case the P-3) once its design lifetime has been surpassed? Dr. Mahler responded that the lifetime of a P-3 is on average 35 years and that no mechanism currently exists to procure replacement craft.

National Center for Atmospheric Research

Dr. Robert Serafin seized upon the capital equipment replacement problem. Available aircraft are becoming obsolete, most notably the Sabreliner. The Sabreliner's payload, height, and longevity specifications are all subpar, with no real means for remediating the problem. Thus, acquisition of a new mid-sized research aircraft has become the highest priority for NCAR. Preliminary studies reveal that the Gulfstream IV more than adequately fits the bill.

Unfortunately, NCAR has no real power to hasten the process, since it is not a Government agency. NCAR is operated by 58 universities, with NSF its principal sponsor; its research emphases are determined by the entire spectrum of users. Data from the broad community is used in development of four-dimensional models of atmosphere-ocean interaction, and active remote sensing plays a critical role in determining signatures of atmospheric variables. Since satellite measurements are not always cloud-free, airborne platforms are absolutely necessary to hone models. Workshops (not just the AGW) help streamline interagency endeavors through improved communication, development of specific programs of study, and increased international participation.

The domains of current programs (e.g., TOGA/COARE) are immense, and the multiscale, multidisciplinary observations desired significantly increase requirements for an aircraft with sufficient payload, range, and endurance. The U.S. GCRP has not provided funds for capital acquisition of such a craft; rather, 60 percent has been allocated for data processing/acquisition and 40 percent for the spaceborne component. Not a cent has been earmarked for *in situ* aircraft, which proves a serious deficiency in planning. Dr. Serafin proposed drafting a resolution to address this issue; with the credibility of 170 AGW participants behind it, perhaps the document would make an impression upon targeted decisionmakers. Warren Johnson took the action of refining the text, soliciting comments from fellow Steering Committee members at the Thursday luncheon (see Appendix A for the luncheon attendees and B for the draft resolution).

Discussion

A barrage of questions followed. Dr. Theon mentioned that a line item in the Presidential budget allows for purchase of a remotely piloted craft for stratospheric research. In response to a best-case scenario query, Dr. Serafin said that ideally one replacement craft per decade and a supercomputer upgrade every 3 years should be included in agency and planning strategies. Gregg Vane mentioned that JPL airborne programs have to scrape together existing monies to support EOS. Though EOS needs aircraft observations, the EOS budget has not earmarked adequate funds to promote this activity (e.g., NO_2 simulators for EOS a big problem). Dr. Shea added that in the NOAA FY92 budget submission to OMB a specific line item for Facilities Management squeaked by. NOAA plans to exploit this opening by funneling as many science dollars into it as its budget will allow.

Department of Defense

Dr. Alan Weinstein gave a very brief overview of DoD activities in airborne geoscience. DoD basic research funds are split between three branches of the military: Air Force, Army, and Navy. The Air Force focuses on high-altitude and tropospheric studies; the Army on electromagnetic (EM) propagation, snow and ice, and mesoscale meteorology; and the Navy on ocean-related programs (~90% oceanography, ~10% meteorology). At present, the relatively small DoD projects are embedded in larger programs, employing the aircraft of other agencies. For the most part, DoD plays an ancillary role and is not directly involved in the aircraft campaign portion of joint studies. In summary, DoD does have a large environmental research program, but does not deploy its own aircraft. Instead, heavy interaction with the aircraft owners (i.e., NASA, NOAA) fills this void. As would be expected, proposals to participate in such ventures through DoD grants are rated by scientific merit.

Discussion

Dr. Janice Boyd/Naval Research Laboratory (NRL) felt that actual DoD flight activities were misrepresented. NRL makes substantial use of aircraft, primarily in the development of ocean numerical models. The NRL owns four research P-3s, which are presently operated on a cost-reimbursable basis. In the future, funded flight hours will come out of research budgets. Whatever the case, Navy researchers have easier access to the P-3 than do most investigators. If you pay for the fuel, you get a plane.

Department of Energy

Dr. Allen Mason stated that DOE maintains a fleet of aircraft equipped for regularly scheduled research ventures, and to respond to national emergencies. These aircraft are either owned by various national laboratories or are contracted out to the laboratories for specific research programs. In addition to aircraft, a limited number of programs incorporate balloons for atmospheric sampling and measurement of atmospheric motions. Two offices within the DOE manage its airborne campaigns—Office of Energy Research and Office of Environmental Health and Safety—with seven laboratories under their purview: Battelle/Pacific Northwest Laboratory, Brookhaven National Laboratory, Lawrence Livermore National Laboratory, Environmental Measurements Laboratory, Sandia National Laboratories, Los Alamos National Laboratory, and EG&G Energy Measurements, Inc. (contractor). These laboratories analyze data for studies ranging from atmospheric radiation transport to fates of energy-related pollutants to satellite reentry radioactive plumes. Rather than rehash the research emphases of each institution and the fleet of nine DOE aircraft here in the summary minutes, Robert Leifer's comprehensive abstract, located on pages 21-22 of the AGW Program Book, will have to suffice. DOE platforms are available to all users on a cooperative basis.

Canada

Drs. Ian McPherson and Leon Bronstein split their time in an effort to address both the atmospheric chemistry studies of the National Research Council and the synthetic aperture radar (SAR) applications being developed at the Canada Centre for Remote Sensing (CCRS). Ian McPherson/Institute for Aerospace Research (IAR) listed available aircraft and presented a graphic of ever-increasing flight hours over the 1979 to 1990 time frame. Initially, atmospheric programs focused on weather modification, cloud physics, and storm research; however, as environmental concern over industrial pollution mounted, research emphases evolved into acid rain and gaseous flux studies. A cursory glance at current flight hours and funding revealed the following programmatic breakdown: 46% air quality, 48% CO_2 flux, and 6% weather. With regard to global change research, Dr. McPherson indicated that the NRC Twin Otter was scaling up from purely local measurements to regional observations. Leon Bronstein briefly discussed the concept of SAR imaging and gave performance specifications of the CCRS Convair 580 aircraft. He stressed that the CCRS is involved in sensor development in the visible, infrared, and microwave wavelengths (both passive and active), but that CCRS notoriety still stems from development of SAR systems (e.g., polarimetric SAR and digital pushbroom imagers). The Ontario Centre for Remote Sensing, with whom he is directly affiliated, also conducts studies on a provincial rather than Federal scale, such as forest regeneration, wildlife habitat, and annual crop determination, for the immediate benefit of Ontario residents.

Discussion

Dr. Mahler queried whether weather modification studies were scaled down due to political implications, to which Dr. McPherson responded in the affirmative (cloud seeding uncertainties). Dr. Huning then asked about investigator funding in Canada. No formal mechanism exists, nor an annual evaluation of flight requests for that matter. Their unregimented system involves a phone call or correspondence to either McPherson or Bronstein, depending on discipline, with selected investigators only responsible for operating costs. Al Riedler/Northrop Corporation wondered whether all the necessary speed and altitude regimes were covered in the Canadian fleet, to which Dr. McPherson responded that his hangar was a museum with most aircraft capable of only 10,000-foot altitude or lower. In response to a question posed by Bob Grossman/University of Colorado, a basic sensor complement stays with each craft, minimizing downtime, and an instrument development capability exists in the form of a laboratory, metal shop, and installation personnel onsite at IAR.

Europe

Dr. Anne Jochum gave a very comprehensive overview of airborne facilities available in Europe, all without the benefit of her prepared viewgraphs which were in her lost luggage. She acknowledged that European geoscience activities had an atmospheric science bias, but that that in itself was not a detriment; rather, atmospheric research would be the European airborne community's chief contribution to the GCRP. She sees global change research consisting of:

- Observing systems from space
- *In situ* field experiments and modeling (regional)
- Parameterization of subscale.

She continued by listing the various organizations involved in airborne geoscience, highlighting their research interests and available aircraft and instrumentation in support of the above global change research areas. Countries covered included Switzerland, Federal Republic of Germany, United Kingdom, Netherlands, Poland, Sweden, Turkey, and the Soviet Union. She also pointed out major new developments in existing and recently acquired aircraft (e.g., ARAT Fokker-27 and Dornier Do-228), and outlined the major field campaigns to be conducted over the next few years. Her viewgraphs were hailed as an exhaustive resource worthy of retention by the airborne community at large. Since so many copies of her presentation were requested, they have been rekeyed and included as Appendix C2.

Discussion

Bob Grossman detected a lack of gust probe/boundary layer/turbulence instrumentation in Dr. Jochum's overview. Was this an oversight? No, the European community currently focuses its attention elsewhere. A comment was made that Eastern Europe was not well-represented, to which Acad. Kondratyev responded that the "socialist camp" had previously used the Soviet fleet. The new world order has dissolved such a heavy reliance, with the affected countries now establishing their own airborne facilities.

2.2 Platforms and Instrument Developments

Mid-Sized Jet

Dr. Warren Johnson/NCAR kicked off the technology session by reemphasizing the need for a mid-sized jet to replace the Sabreliner. He listed several milestones in the evaluation process, such as the February 1982 and April 1987 NCAR Aircraft Fleet Workshops. In February 1989, the document entitled *Airborne Geoscience: The Next Decade* reaffirmed the need for a mid-sized jet platform. So the scientific justification for such a capital acquisition is well-founded. The Gulfstream-class airplane seems the best alternative, though the -IIB and -III would have restrictions placed on it because of an excessive decibel level. The Gulfstream is two to three times larger than the Sabreliner and improves on the altitude, range, and endurance specifications that the airborne community finds so desirable. Dr. Ronald Smith/Yale

University added a few comments, though he felt this question was close to being overstudied. Science benefits would be immense, because improved specifications would greatly increase the portion of the atmosphere and the area of land, sea, and ice surfaces that could be directly observed. Such a craft would be heavily used and in great demand.

Airborne Hyperspectral Imaging

Dr. Alex Goetz/University of Colorado spoke of a new form of remote sensing. Instead of using the normal seven channels, as with a Thematic Mapper, hyperspectral instrumentation employs in excess of 200 bands simultaneously. This technology has been under development at the Jet Propulsion Laboratory (JPL) for the past 10 years. With the delay of the HIRIS facility instrument to EOS-B, aircraft platforms must fill the gap. More information on physical properties could be collected routinely if the bands utilized were contiguous. Hyperspectral imaging accomplishes this by compositing images in 11 km x 11 km data frames that are 11 registered spectral bands deep. Atmospheric correction proves important, because water vapor dominates half of the entire visible spectrum. JPL has developed a means to calibrate its hyperspectral imaging system to within a precision of 3 percent, far surpassing the accuracy of conventional methods. Radiosondes are not nearly as accurate. In response to a question about flight plans for the coming year, Dr. Goetz referred the question to Dr. Wickland, who responded that the issue was currently under evaluation.

Very High Altitude, Unmanned Aircraft

Dr. Adrian Tuck/NOAA mentioned two craft that prove ideal for stratospheric studies: Boeing Condor (wing span of 200 feet) and the Aurora Perseus (82,000-foot altitude capability). Balloons, satellites, and rockets are not at their best for lower stratosphere/upper troposphere studies. The ER-2 and DC-8 have been successfully deployed in support of such research (e.g., Arctic Polar Ozone Mission), but their range does not allow the indepth sampling necessary. This particular experiment revealed a phenomenon whereby ozone-depleted pockets of air peel off from the vortex and are flung into the mid-latitudes. The ER-2 performed magnificently, but could only get to the edge of the vortex. An unmanned drone could pierce the vortex, without requiring superhuman endurance by the pilot with regard to flight time and temperature (i.e., vortex reaches -150°F, since reactions minimized by the effect of sunlight/warming). Furthermore, nitrogen reactions in the 20- to 30-km range play a significant role, but are poorly understood. The basic science requirements for such an "air-breathing satellite" include an altitude of up to 100,000 feet, extended range, subsonic speeds, payloads up to 3,000 lb, and the ability to withstand temperature extremes. Given adequate funding, such a capability could exist within 3 years.

Airships

Dr. Ted Blanc/Naval Research Laboratory (NRL) broached the subject of airship utility by discussing the problem of calibrating a scatterometer. Six steps are involved: Variety of accessible oceanic environments, distortions stemming from the observing platform, measurement limitations, sensor inaccuracy, appropriateness of measurement altitude, and sufficiency of measurement duration. To guarantee precision, the sampling platform should be at most 5 to 10 m above the ocean surface. Even the most insane pilot cannot fulfill such a requirement; however, airships prove ideal platforms. An airship can be used as a skyhook to dangle scatterometry instrumentation. Plus, the bulk of the calibration issues are satisfied (e.g., unaffected air space four blimp diameters below the craft, float along with air mass, etc.). Airships are a well-established technology, since they were used extensively during World War II through the 1960s, and their owners do not mind dangling parcels from the gondola to calibrate the instrumentation onboard. At present, vehicles are leased from the private sector. The first flight of NRL's dangling scatterometer is slated for April 1991. In the ensuing discussion, Don Lenschow/NCAR mentioned the utility of airships in cloud entrainment studies and in investigating the canopy over land.

Ultralights

Dr. Richard McCreight/Oregon State University discussed the effectiveness of an ultralight as an airborne observatory. The instrumented single-seater craft weighs less than 254 lb, flies between 25 to 50 mph, needs only a 70-foot runway, has a 100-mile range/3-hour endurance, and has performed in all weather conditions. Though not recommended for the novice pilot, Dr. McCreight has taken his craft up to 14,000 feet on a couple of occasions. The ultralight is field-portable, with no fixed base of operation; range is not an issue since takeoff can take place right at the study site. Fully loaded (i.e., flight and computer/instrument expenses), the ultralight costs about $10/hour to operate. For the cost of 1 hour of DC-8 time ($4700 in FY90 $), you could buy your own ultralight! The instrument complement of the Oregon State craft includes a thermal radiometer, spectrometer, and audiovisual equipment, all of which can be calibrated in flight, with pixel resolution from a km to a m or less. Science utility is also great in that observational schemes are easier to develop and underflights of larger platforms to independently verify data sets proves a breeze. A two-seater (300-mile range, 4-hour endurance) is currently under development.

Airborne Oceanography

Dr. John Bane/University of North Carolina spoke of the airplane's role in oceanographic research. Expendable and remote sensors need to be taken to a specific target region and deployed over a large area in a short time. The speed of an aircraft deployment far exceeds the capabilities of ships, increasing the number of *in situ* probes dramatically. An aircraft can accomplish in mere hours what takes days for a ship, easing the task of establishing data time series and deriving 3-D synoptic maps of highly transient oceanic events. Ocean profiles change rapidly on the mesoscale (e.g., eddies), so aircraft-deployed sensors could greatly enhance oceanic research; unfortunately, aircraft techniques are limited by the number of available sensors. At present, demand by the oceanic community is not too great, but that can be attributed to a lack of certain types of remote and expendable sensors (e.g., AXCTD and AXPogo are not air-deployable). Should the capability be developed, it would certainly be embraced by oceanographers. Existing air-deployable probes have proven very accurate.

Airborne Turbulent Flux Measurements

Dr. Donald Lenschow/NCAR discussed the varied applications of airborne flux measurements in clear convective boundary layer, cloud-capped boundary layer, clear stably stratified atmospheric, and convective cloud transport studies. Advances in airborne remote sensing technology has heightened the accuracy of air velocity and species concentration measurements, which in turn hone the models to determine fluxes. Flux determination has evolved beyond mere eddy correlation. Radome, laser, and doppler radar systems all contribute, since no one instrument can measure flux—hence the simultaneity issue being the crux of the EOS-A single platform approach. Airplane motions (i.e., yaw) can be factored out with a high degree of efficiency due to advances in inertial navigation systems (INSs). In tandem with Global Positioning System (GPS) data, mean wind measurements can be inferred, which are key to all scientific disciplines. In response to the question "why pursue flux improvements?," Dr. Lenschow noted that improved INS/GPS and species measurement technologies and new approaches for air motion sensing serve as a precursor to the data assimilation requirements of the global change research era.

Airborne Lidar Research

Dr. S. Harvey Melfi/GSFC gave an overview of developments in lidar research. Goddard recently conducted the Convective Waves Experiment (COWAX), which investigated the role of organized convection within the planetary boundary layer (PBL) in generating gravity waves in the troposphere. Resultant data should yield significant insight into the physical mechanisms of tropospheric circulation. After presenting a number of theories on how gravity waves form, he discussed how Electra flight experiments help determine gravity wave signatures. Checking aerosol levels with instrumentation onboard the Electra allows researchers to determine the height of the PBL; height variation as a function of distance helps define the gravity field. Results of these lidar measurement campaigns indicate that gravity waves are strongly correlated with convection in the PBL. However, to validate such a conclusion, 3-D measurements are needed. GSFC's Large Aperture Scanning Airborne Lidar (LASAL) will provide such information in the near future, with several flights planned on the Wallops Flight Facility P-3.

SAR Measurements

Dr. Jacob van Zyl/JPL gave one of the more visually stimulating presentations thanks to the color output of the JPL AIRSAR. Standard processing involves 12 spectral channels that have been composited in a three-frequency, fully polarimetric mode. Standard images are usually 3 km x 3 km, with investigators scanning the output to determine the study site location. Once accomplished, finer resolution can be secured. Two special modes are also available: Along-Track Interferometry and Cross-Tracking Interferometry. However, only C, L, and P bands are utilized for these special applications. The process investigators must employ to secure data involves a user request to NASA Headquarters with all the requisite scientific justification for the sortie; flight hours from negotiations with pertinent NASA and JPL officials; and identification of a funding mechanism to cover SAR processing fees. This procedure resulted in 30 flights during CY90. Dr. van Zyl closed his talk by showing a sample of synoptic processing. This method yields a 10-km swath, but only employs three channels and is not yet fully operational. Producing a synoptic frame takes about 5 hours. In response to a question about deriving physical properties out of the imagery, Dr. van Zyl responded that that is up to the investigator. JPL merely provides the radar and processed image.

Airborne Doppler Radar

Dr. David Jorgensen/NOAA described a doppler radar system mounted to the tail of the NOAA P-3. This system scans both forward and aft, yielding a pseudo-dual beam output, which proves a boon when measuring horizontal wind fields. By flying from point A to point B and shifting the orientation of the scanner mid-flight, one is left with a criss-crossed hatching of diamond-shaped transects. The investigator then determines the intersection points to derive horizontal wind speed. The most time-consuming aspect of processing involves removing the velocity of the platform and antenna biases, both of which can be accomplished by using the ground as a reference point. This method has many advantages over the standard L pattern currently employed. The wind field measured is much larger since the plane is not zigging and zagging, and the need to assume a stationary air mass no longer exists. Such a presumption makes previous data suspect, since a variable as transient as wind obviously does not remain static while the plane reorients itself. Of course, the accuracy of the NOAA P-3 method is predicated on a steady-handed pilot flying in a straight line.

Laser Measurements

Dr. Christopher Webster/JPL discussed how airborne infrared laser technology contributes to polar stratospheric chemistry research. Atmospheric models of general circulation patterns are limited by uncertainties about cloud radiative feedback. In the lower atmosphere, air is heated/cooled by land, but what about the stratosphere, particularly as manifested in the polar vortex? Dr. Webster proceeded to explain the extraordinarily complex interactions between active chlorine, nitrogen, hydrogen, etc., that takes place in polar stratospheric clouds. Without getting into too much detail, suffice it to say that as the extreme cold which contains the vortex in the polar night and winter dissipates in the spring (i.e., sunlight) O_3 is released, which in turn depletes stratospheric ozone. Researchers need high-latitude observations from airborne platforms to analyze the budgets, vertical profiles, daytime ratios, and temporal variation of the elements that participate in the catalytic chemical cycle that destroys ozone. In the mid-latitudes, BLISS (a tunable diode laser absorption spectrometer) performs adequately. Normally, balloons are employed in the 30- to 40-km range, but a bit of maneuverability would improve research results. ALIAS has flown successfully on the ER-2. Researchers collected 200 Mb of data for every 10-hour flight during the 10-week polar campaign (four flights/week). Removing the endurance problem associated with a manned vehicle would further improve the quality of the data. An Aurora Perseus drone seems the logical choice to deploy ALIAS 2.

Cloud Physics

Dr. William Cooper/NCAR spoke of the inability to make good predictions about cloud processes, a deficiency that makes global climate modeling a virtual impossibility. Many hypotheses exist, but without quantitative measurements validation seems unlikely. Observations of droplet growth, ice crystals, water drops, precipitation processes, entrainment, electrification, cirrus, and climate must be collected *in situ* if any advances are to occur. At a recent Air Chemistry Workshop, steps to garner said observations were identified:

- Expand complement of standard instruments
- Develop and exploit remote sensing from airborne platforms
- Renew efforts to improve existing measurements.

Dr. Cooper was the first to admit that progress has been slow to nonexistent; however, a number of limitations have been holding cloud physicists back. First and foremost, the airborne community needs a cloud-penetrating jet. Furthermore, existing instruments do not provide adequate coverage of dynamical fields at fine scales. He stressed that researchers must look beyond the microphysics of the problem and face the fact that additional instrumentation is needed. Dr. Weinstein asked about the role of small aircraft in cloud campaigns. Dr. Cooper responded that such observatories would be well-suited for cloud studies, but that problems stem from large campaigns throwing everything into the field, leaving inadequate reserves for other investigators. Dr. Cooper recommended that the scientific method be used to narrow the focus of large field campaigns to more efficiently deploy existing resources.

Airborne Passive Microwave Measurements

Dr. Calvin Swift/University of Massachusetts gave an overview of the Electronically Steered Thinned Array Radiometer (ESTAR). This passive microwave instrument has been pieced together from a variety of sources, most notably the trusses that secure it to the bomb bay. Though the racks are spares from other programs, the radiometer itself is all brand new hardware. This large instrument has a 1-m aperture supporting a pair of antennae whose combined output measures reflectivity of the surface. For example, brightness diminishes with dry conditions, so longer wavelengths indicate minimal soil moisture. ESTAR also detects the difference between fresh and brackish water; since saline conditions are colder, the instrument detects the difference in returned signals. Hardware weight and bulk are a direct function of aperture size.

Airborne Data Collection

Mr. Alan Goldstein/NOAA had the undesirable task of giving the final presentation in a marathon session. His talk, "Matching Recording Techniques with Aircraft Data Collection Requirements," compared available recording media and data compression techniques (i.e., boxcar, sliding window, autoregressive, and dual slope). He then went on to discuss computer topologies for both single and multiple processor configurations. Finally, he stressed the importance of leaving sufficient flexibility in a system once the design has been frozen to allow room for expansion with advances in technology. Since his subject matter was highly technical and beyond the comprehension of this particular minute-taker, individuals should contact Mr. Goldstein directly for further information (see Appendix A for current address).

3. DAY 3

The morning session for Thursday, January 31, 1991, focused on selected field projects. The format for the "acronym session" allowed 20 minutes for each speaker, with questions after each presentation. Alan Weinstein/DoD served as Session Leader. Once again, a general panel discussion was scheduled, and was actually exercised this go round. The afternoon session, chaired by Dr. James McFadden/NOAA, consisted of poster previews, which will not be covered in these summary minutes thanks to the Program Book abstracts. The popularity of the poster sessions has increased dramatically over the years. The poster tally for the Fourth AGW leapt to 85, an increase of ~30 presenters over its immediate predecessor. However, one cannot fully appreciate the utility of poster sessions unless tasked with compiling the minutes!

Since abstracts were provided by most speakers prior to the Workshop (see Program Book), this section of the minutes focuses on the issues and discussions that arose from the field project presentations.

3.1 Selected Field Projects

TOGA-COARE

Dr. Joachim Kuettner/NCAR provided details about the Tropical Ocean Global Atmosphere (TOGA) program and, more specifically, one of its primary components—the Coupled Ocean-Atmosphere Response Experiment (COARE). COARE, a focused subelement of the overarching 10-year monitoring program, will provide indepth analyses of El Niño Southern Oscillation (ENSO) events. ENSO events are triggered when the Western Pacific warm pool moves east. This pool encompasses the warmest part of the world and plays a critical role in the sea surface energy balance. Rainfall measurements indicate that almost .5 m of freshwater is added to the pool each year, because precipitation exceeds evaporation by a factor of 2. If researchers understood how the warm pool is generated, maintained, and displaced, and how it contributes to the circulation of ENSO phenomena, they could hone existing climate models, allowing a predictive capability for ancillary processes. Research efforts will focus on superclusters (i.e., clouds from 1000 to 2000 km in diameter that buck the norm by moving west to east).

The science goals of COARE are to describe and understand the principal processes for coupling of the warm pool, atmospheric convection, oceanic response, and the multiple scale interactions that affect other regions. Ships, buoys, and aircraft will participate in an intense 4-month data collection campaign, with contributions coming from a vast array of international partners (i.e., Australia, People's Republic of China, France, Federal Republic of Germany, Indonesia, Japan, Korea, New Zealand, Taiwan, U.S., and USSR). Aircraft requested for the campaign include: NCAR Electra, NASA DC-8, NASA ER-2, two NOAA P-3s, and an Australian Cessna 340A. Aircraft will help chase down the unpredictable El Niño events. International partners are contributing ships, buoys, and a dedicated telecommunications satellite.

Airborne Arctic Ozone Expedition

Dr. James Margitan/JPL briefly covered the Antarctic and Arctic ozone missions to date, then spoke of future efforts. He mentioned that Total Ozone Mapping Spectrometer (TOMS) measurements indicate that the hole extends beyond the Antarctic continent and that it exhibits temporal behavior. In addition, the chlorine reactions take place at 40 km, then circulate down to 20 km where the hole has formed. Several air campaigns have verified these findings, with the DC-8 and ER-2 making substantial contributions. In fact, the Antarctic Ozone Hole Experiment was the first research deployment of the NASA DC-8. The ER-2 has the unique ability to enter the vortex and to achieve high enough altitudes to compare both the active and reservoir phases of CFC-induced ozone depletion. The Airborne Arctic Stratospheric Expedition revealed that no Arctic ozone hole is present; this pole is warmer and more dynamic than the isolated Antarctic air mass. ER-2 and DC-8 measurements showed that denitrification was not as extensive and that there was little dehydration, respectively; however, significant chemical perturbations were present, just not of the magnitude found in the Antarctic.

With the dissipation of chlorofluorocarbons in the atmosphere, the Antarctic ozone hole should close up by 2075. The question remains whether it will get worse before it gets better. To determine the course of remediation, researchers need to analyze a complete vortex cycle. Intensive 6-week studies prove inadequate. As such, two expeditions are planned. The Arctic expedition involves six 2-week deployments of the ER-2 and DC-8 spanning the October 1991 to April 1992 time frame. The Antarctic mission has a similar deployment over the April to November 1993 period. These campaigns will achieve a high degree of visibility as part of International Space Year (ISY) activities.

ASTEX

Dr. Bruce Albrecht/Pennsylvania State University gave an overview of the Atlantic Stratocumulus Transition Experiment (ASTEX). Stratocumulus clouds are an excellent reflector of solar radiation, and could play a significant role in counterbalancing the greenhouse effect. Theoretically, a 4 percent increase in stratocumulus cover could minimize the impact of global warming induced by increased concentrations of CO_2 in the atmosphere. Certain processes need to be better understood to determine the effect of cloud type and amount on the atmosphere and ocean, as follow: Cloud-top entrainment instability, diurnal decoupling and clearing due to solar absorption, drizzle and transition to horizontal inhomogeneous clouds, mesoscale circulation, and episodic strong subsidence. The first experiment (FIRE) took place in 1987 off of the California coast, but cloud cover and logistical hassles plagued the project. A second FIRE is scheduled for June 1992, off the coast of South America. Cloud composition at this site will be far more complex, so multiple boundary layer aircraft will be needed. The proposed aircraft include the UK C-130, University of Washington's C-131A, NCAR Electra, NASA ER-2, NOAA P-3, and ARAT F-27. These long-range aircraft will provide measurements of cloud mean structure, turbulence, radiation, cloud microphysics, chemistry, and cloud-top properties. Details have yet to be hammered out, because investigators are in the process of developing an operations plan.

High-Resolution Remote Sensing

The remote sensing program at ONR uses various platforms to determine how oceanic and atmospheric processes affect electromagnetic backscatter and emission. Primarily using the all-weather, no-light capabilities of microwave imaging, ONR strives to establish ocean sea-truth for incorporation into numerical climate models. Not to be outdone by his colleagues, Dr. Charles Luther introduced the acronym SAXON-FPN, a joint US/FRG experiment. Based on the NORDSEE tower 60 miles out in the North Sea, the experiment involved airborne synthetic and real radar measurements taken over the tower intercompared with tower-based radar observations. The intent was to better understand radar backscatter over a broad range of wind speeds and sea states, and determine how SAR resolution is degraded by steep waves and strong winds. Surface truthing allows researchers to identify sources of clutter, which can then be factored out of climate models. The ultimate goal is to develop radar as a scientific instrument to quantify air-sea interaction processes, thereby improving physically based models. The High-Resolution Remote Sensing Experiment, a joint program with the Naval Research Laboratory, is slated to take place off the coast of Cape Hatteras. A pilot program is currently underway, with the experiment proper to take place in 1994. The ERS-1, blimps, aircraft, ships, and fixed buoys will all participate in a study of eddies and eddy structure associated with the Gulfstream. An exact experiment site has yet to be determined.

MACs

Dr. Diane Wickland/NASA HQ outlined the development of the Multisensor Airborne Campaign (MAC) concept, then gave brief synopses of existing and future field projects. Several factors led to the creation of these special land processes investigations:

- To acquire comprehensive multisensor data sets for well-studied field sites
- To add a strong remote sensing science component to disciplinary field projects
- To promote strong interactions among scientists within a discipline
- To establish precursor EOS data sets.

The 1990 MACs started with one terrestrial physics program, which evolved into two ecology and two hydrology experiments: A Forest Ecosystem Dynamics MAC (FEDMAC), the Oregon Transect Ecosystem Research (OTTER) Project, MACHYDRO (Pennsylvania), and Monsoon '90 (Arizona). The latter two studied the role of soil moisture in the hydrological regime. As do all MACs, these studies started off with an individual approaching NASA management. The investigator is instructed to develop a data plan and experiment methodology, then the research proposal is peer-reviewed. If the science content warrants, additional participants become involved. This ensures work of the highest quality, and collaboration with NASA-sponsored scientists greases the mechanism for allocating funds. MACs work within the existing fiscal budget, except for data system costs, and the enhanced visibility of such projects does garner priority in the aircraft reservation queue.

GEWEX

Dr. Deborah Vane/JPL described the components of the Global Energy and Water Cycle Experiment (GEWEX), an international program sponsored by the World Climate Research Program (WCRP). The fluxes of water and energy are key global change parameters, which are poorly understood. A predictive capability about the elements that drive the water cycle would certainly go a long way towards honing global change models (GCMs). GEWEX is a continental-scale project that seeks to develop and improve macroscale models by addressing key deficiencies in our understanding of the hydrologic regime. Clouds and precipitation; partitioning between soils, groundwater storage and runoff; and evaporation and related water and energy fluxes are the physical foci of GEWEX. The Mississippi Basin serves as the primary study site, since it is already heavily instrumented and encompasses several GCM squares. Substantial international participation is required; collaboration with existing programs such as the International Geosphere-Biosphere Program (IGBP) will help keep costs in check. Full use of operational and archived data allows researchers to compare data sets and develop time series evaluations upon which to test and validate consequent GCMs. With accurate models, scientists can extrapolate anticipated climate conditions from instrumented to non-instrumented regions, and these pieces can be aggregated to generate a global picture. Airborne sensors will make specialized measurements and serve as precursors to the instrumentation onboard EOS-A, slated for launch in the fourth quarter of 1998.

GTE

Dr. Robert McNeal/NASA HQ presented an overview of the Global Tropospheric Experiment (GTE), a program attempting to quantify anthropogenic impacts to the global troposphere. The ongoing study has been implemented in three phases: 1) Improve the capability to measure trace gases and aerosols, and develop optimal field measurement strategies; 2) conduct airborne and ground-based field campaigns to further understanding of the contributing processes; and 3) perform global-scale satellite studies of tropospheric chemistry and dynamics. The field campaigns involve a suite of planes, including but not limited to the ER-2, Electra, and CV-990. The purpose of these campaigns is to determine fluxes/boundary layer exchange (ABLE), to perform instrument intercomparisons (CITE), and to map global-scale species distributions (PEM). The mission type for each of these research thrusts has been listed parenthetically. The overarching goal for these subelements of GTE is to determine the global distribution/transportation of certain trace chemicals, thus revealing how regions as vast as continents affect global climate. For example, tropospheric ozone measurements have been derived by subtracting SAGE from TOMS data, obviously leaving a great margin for error. Though highly inaccurate, one can detect from a few crude calculations that North America and Asia contribute dramatically to tropospheric ozone concentrations. Biomass burning in the Amazon rain forest has created a plume that disperses contaminants in the tropical Atlantic. In 1992, the DC-8 and Electra, along with numerous international craft, will study this phenomenon. Phase 3 must await the launch of EOS-A.

STORMS

Dr. Richard Dirks/NCAR stated that this program had been under discussion for about a decade; however, CEES recently gave the go-ahead to develop a plan as a national initiative. In giving this mandate, CEES also changed the name to the U.S. Weather Research Program. This 10-year program has been endorsed by the CEES Atmospheric Subcommittee, been briefed at OMB, and been presented to the President's science advisor. As with all large programs, OMB requested science priorities, ranked as follows:

- Mesoscale weather systems
- Study of scale interactive processes
- Hydrometeorological links
- Physical and biogeochemical interactions.

Researchers will be focusing on the multiscale nature of weather in an attempt to improve local and regional forecasting capabilities. Investigators can then extrapolate research results to national and global scales. Conceptual plans for field studies stem primarily from the #2 priority, with a 15-state area in the central U.S. the domain of the first experiment. Observing systems consist of satellites, radars, surface meteorological stations, commercial aircraft, and information processing equipments. Aircraft requirements entail participation of the NCAR Electra, NCAR Sabreliner, NCAR King Airs, NOAA P-3s, NASA DC-8, and anything else that planners can get their hands on. New facilities sought include an over-the-horizon communications capability, high-altitude dropwindsondes (over land), airborne dual beam scanning doppler radar, GPS, and a mid-sized high-altitude jet. Since this program lists all capital acquisitions that the airborne community has been after for years, its #1 strategic priority is to maximize the benefit from the Government's multi-billion dollar investment in modernization.

3.2 Panel Discussion

A general discussion followed, prompted by the Session Leader's query about how to handle the data morass resulting from large multisensor campaigns. Dr. Weinstein wondered if integrated data systems would be the most efficient and timely means of getting the data to the users, and if so how? Dr. Albrecht stated that the ASTEX program intends to analyze the data real-time through existing networks, not dump it in an archive to be dredged up later. Dr. Kuettner added that TOGA/COARE plans include a dedicated telecommunications satellite that would transmit both voice and data streams in real-time to participating centers. A real-time modeling effort in the field will also speed access of fully documented data sets to participating scientists within 3 months.

Such an ambitious schedule brought up the issues of data compatibility and quality assurance. Dr. Wickland stated that EOSDIS Version 0 involves the implementation of certain data standards in its processing, distribution, and archiving activities. Evolutionary EOSDIS elements will be developed with the necessary standards and interfaces required for EOSDIS to function as part of the U.S. and international global change research data system. Though compatible formats may be too much to ask, a common data policy (i.e., access, cost, etc.) is being sought for the entire international suite of data. Pathfinder data sets, which include airborne observations, will help refine the process, but she stressed that there is a learning curve. Wherever feasible, existing infrastructure will be used, and the system will evolve from there. Drs. Vane and Dirks mentioned that planners for the programs that they described are working closely with EOSDIS prototypers to ensure compatibility.

Dr. McNeal stated that GTE data will be available in various formats, and wondered if inclusion of value-added evaluations (i.e., metadata) would unduly slow up the process. Turning around just raw data would limit the magnitude of the data management activity. Taking the perspective of the archivist, Jack Sherman/NOAA mentioned that the average time for oceanographers to provide data sets, complete with development algorithms, to the National Oceanographic Data Center (NODC) was 7 years from the point of collection! So archives cannot be faulted for their several-month turnaround time. A general consensus was reached that only accurate data sets be archived. Researchers need the assurance that the data they are manipulating are precise. Technology advances make it possible to ship around huge data sets on a number of media, but what is the benefit? Quality control must be the highest priority for all investigators, because field campaigns prove worthless if the data product generated is suspect.

4. DAY 4

The final session took place on Friday, February 1st, with over half of the registrants in attendance. Such perseverance did not go unnoticed by the AGW Chairman, who recognized the enthusiasm and vitality of the meeting participants. This high degree of participation has made the Fourth AGW an unqualified success, and the mandate to foster interaction amongst all the disciplines associated with airborne observations easily satisfied.

On a more serious note, concern surrounding the availability of platforms and the lack of commitment by agency decisionmakers to allocate funds for replacement craft took the form of a resolution, which was drafted by Robert Serafin and Warren Johnson, and discussed at the Steering Group Luncheon. The draft resolution is attached as Appendix B, so details will not be given here; however, whatever governing body is targeted (perhaps the CEES), the credibility of the presenter and the very significance of the document increases with the concurrence of the Workshop participants. The Steering Group encourages attendees to review the resolution and forward their comments with the enclosed questionnaire to the attention of the Executive Secretary, Mr. Bernard Nolan, at the following address:

Earth Science Support Office (ESSO)
600 Maryland Avenue, SW
Suite 440
Washington, DC 20024
fax: (202) 479-2743

The final session gave facility managers the opportunity to describe the capabilities of their respective fleets. The format allowed 10 minutes for each speaker, with questions after each presentation. Gregg Vane/JPL served as Session Leader. Finally, James Lawless/NASA Ames Research Center (ARC) provided summary impressions of the Workshop, and Jim Huning adjourned the meeting.

4.1 Overview of Facilities Used in Support of Airborne Geoscience Programs

National Center for Atmospheric Research

Dr. Lawrence Radke/University of Washington gave an overview of the NCAR aircraft, which include a King Air, Sabreliner, Electra, and Schweitzer (glider), based in Boulder, Colorado. All are heavily instrumented, but can easily accommodate user equipment. His graphics were somewhat dated, so he explained that the nose booms had been replaced by multi-hulled radomes. The outfitted craft are capable of providing state parameter, global positioning, 3-D wind field, radiation, humidity, cloud physics, air chemistry, and electric field measurements through a number of instrument packages (e.g., lidar, soundings). Onsite personnel have the expertise to help project scientists with experimental design, as well as operational and flight planning. NCAR is funded primarily through NSF, but other users can secure flight time on a non-interference, cost-reimbursable basis. In response to a question posed by Barney Nolan/ESSO, user requests are reviewed and hours allocated on a 6-month cycle. Warren Johnson added that aircraft downtime for each project ranges from about 2 to 3 weeks for hardware installation and a week to demount the equipment, for a total of about a month for each major campaign.

NASA Ames Research Center

Mr. Warren Hall recently became Chief of the ARC Science and Applications Aircraft Division. Though not a radical departure from the management philosophy of his predecessors, he stressed the service bureau aspect of facility operations at Ames. He views the Ames fleet as an element of NASA, a support division rather than a discrete research organization. The customer and NASA Headquarters define the science and mission purpose, with Ames personnel helping to maximize the science return through their extensive experience in operational planning. This orientation entails more indepth review cycles to ensure the air worthiness of the aircraft and flight instrumentation. The Ames fleet consists of the ER-2, C-141A, DC-8-72, C-130B, Learjet-24, and two helicopters. At present, none of the planes are aloft as much as they could be. Of course, demand for flight time is overwhelming; the problem remains lack of funding. However, Mr. Hall stressed that the fixed costs associated with ground personnel could be reduced substantially with an increase in the number of flights. The ER-2 seems to be the aircraft of choice lately. Ames has two available for investigator use, actually three since one is on loan from the Air Force. As such, one ER-2 can be dedicated solely to polar ozone studies, with efforts underway to develop an autonomous capability to free the craft from the strictures imposed by a human operator. Also, a second DC-8 dedicated to sustained missions is being sought.

This is where the AGW fits in. A strong science rationale supported by a unified user community can help further such airborne initiatives; unfortunately, efforts to influence superiors in agency hierarchies often go unheeded. So, Mr. Hall suggested that Workshop participants petition their Congressional representatives. Constituent pressure recently revitalized an $87M program for the State of California, with direct benefits to Ames, so such methods should not be discounted. Several investigators wondered why NASA tends not to provide basic instrumentation, specifically meteorological packages (e.g., temperature, humidity, etc.). Mr. Hall responded that facility instruments are available; Earl Peterson added that programs were underway to remedy any deficiencies, and guidance from the user community would be most appreciated. In response to a query from Lawrence Radke, an automated ER-2 could be operating within 2 to 3 years, if $1.5M can be found and if the Air Force can be convinced to share this burden.

NASA Wallops Flight Facility

Dr. Roger Navarro explained that the Wallops Island-based fleet consists of six craft: Electra, Sabreliner, P-3, Skyvan, and two UH-1 helicopters. In addition, a long-range P-3B will be available in the spring of 1992 (see *Airborne Geoscience Newsletter 90-3*). These craft support a wide range of users, with ~600 hours/year currently funded. To reserve flight hours, investigators should contact Wallops Flight Facility (WFF) personnel to compare objectives and establish requirements. If the researcher needs a NASA sponsor to secure funding, WFF personnel will make every effort to find a collaborator with similar research objectives and/or discipline orientation. This can prove tricky at times, because WFF is not funded directly by one NASA office; rather, support comes from a myriad of sources at GSFC. Obviously, finding a sponsor should be the highest priority for independent investigators, since flight fees range from $650 to $2700 per hour. This "walk-on" approach yields substantial benefits in scheduling. For most studies, WFF can respond in a timely fashion if the desired instruments are available, eliminating the need to reserve craft eons in advance. Flexible scheduling and rapid response certainly benefit researchers who study transient or specific targets of opportunity (e.g., oil spills). As with Ames, Dr. Navarro stressed that Wallops is a support center dedicated to maximize the science return of agency-wide initiatives. In response to concerns about resource-restricted endeavors, Dr. Navarro assured independent investigators that no standby charges are assessed. Only actual flight hours are charged, with incremental hikes of 5 to 10 percent levied if contractor overtime proves necessary.

Jet Propulsion Laboratory

As Session Leader, Dr. Vane took the opportunity to insert himself into the morning agenda. JPL has no aircraft of its own, except for a Beechcraft King Air used to transport people to and from Ames (i.e., cannot cut holes in it). As such, JPL relies heavily on the Ames fleet to house their instruments, whether operational or under development. The overriding objectives for the JPL Airborne Instruments Program Office are to provide testbeds for future spaceborne instruments, and algorithm development and simulation; provide ground truth and information for atmospheric correction by underflying satellites; and provide high-quality data for research in Earth science on a routine basis. He listed operational instruments and those under development, provided a brief description of the applications for each, and discussed the fiscal resources required to support all of the above. Dr. Vane voiced profound concern about the apparent lack of support for airborne global change research. He finds it odd that airborne observations serve as precursor observations for EOS data sets, yet are virtually overlooked in the Mission to Planet Earth scheme as it presently exists. Even when observations have been made, processing the measurements into usable, verifiable data sets proves a challenge. The utility of the data diminishes with time, yet virtually insurmountable funding dilemmas stymie processing efforts. Furthermore, as funding scales up for the EOS era, a concurrent increase for airborne geoscience activities is nowhere to be seen, thereby restricting and even descoping development efforts. Joachim Kuettner picked up on the inadequate resources theme to attack decisionmakers' lack of commitment to the airborne geosciences. The DC-8 is used in all important atmospheric chemistry campaigns, so how come there is only one available for the entire airborne community? And the one DC-8 available does not even have a basic meteorological instrument package! Obviously, effort needs to be expended in fostering interaction with the broader scientific community, not just internal bickering about how the airborne geoscience community is overlooked.

National Oceanic and Atmospheric Administration

Dr. James McFadden gave a brief overview of the NOAA Aircraft Operations Center (AOC) and how it functions. NOAA has 14 aircraft available for research use: P-3 (2), King Air, Citation II, Twin Otter, Shrike Commander (2), Turbo Commander (2), Cessna 210, and four helicopters. All except the P-3s can be reserved on an informal basis, basically one-stop shopping. NOAA personnel take care of all flight aspects of an experiment. They operate, maintain, install, engineer, and fabricate mission equipments; direct the flight and operational phase of the mission; process and validate the data; then provide the data to the user. Access to particular craft can be secured merely by calling the proper flight manager. P-3 reservations are a little different. A formal flight request must be filed (i.e., NOAA Form 56-48) about a year prior to the proposed flight. All flight requests filed by February 15th are forwarded to a NOAA Advisory Council by April 1st, with decisions rendered when the council convenes mid-April. NOAA funds ~400 hours of P-3 flight time for internal researchers or NOAA-sponsored collaborators; additional hours are cost-reimbursable. Fixed costs for the P-3 are $1262 per hour, plus the variable costs of fuel, travel, etc., driving the cost up to $2500 to 3000/hour. In response to a query by Jim Huning, Dr. McFadden stated that over 740 hours of P-3 time were requested for 1991.

Canada

Drs. Bronstein and McPherson once again split time to provide brief overviews of their respective organizations. The CCRS Convair 580 has a 2300-km range at an optimum 6-km altitude. Its primary sensor is a C- and X-band SAR, which is used primarily for applications development (land, ocean, and ice studies) and for regional agricultural assessments. A second craft (i.e., Falcon 20) is owned by industry and is contracted out chiefly for mapping expeditions using an 8-channel, visible pushbroom imager. A third craft (i.e., Piper Navajo) is owned by the Ontario Government and makes observations in the visible realm, using cameras, spectrometers, and thermal line scanners. The Institute for Aerospace Research has a full support capability, including metal shops, laboratories, ground personnel, wind tunnels, etc. The Institute has 10 aircraft in its hangars, four of which are dedicated to the airborne geosciences: Convair 580, Twin Otter, T-33, and Falcon 20. Access to the craft is only a phone call or letter away, given sufficient lead time and collaboration with a Canadian sponsor. If an agency co-investigator cannot be identified, the user must fully reimburse the affected flight agency; however, such an event has yet to occur. In most cases, the investigator is responsible only for direct costs and associated travel. Jim Huning asked about the difference between cooperative and uncooperative cost scales, which turns out to be about a factor of 3. Ian McPherson was quick to point out that small Canadian dollars were at issue, so Canadian resources are relatively cheap to operate.

Germany

Anne Jochum gave an overview of DLR craft, pointing out several reports that the audience could reference for more detail. The *Airborne Geoscience Newsletter Issue 90-2* featured a lead article on airborne geoscience in Germany, so only a cursory treatment will be offered here; back issues of the *AGN* are available by request from the Earth Science Support Office. Dr. Jochum listed the available aircraft, instruments, and sensors, highlighting some of the more interesting developments (e.g., telemetry applications). The Falcon is undoubtedly the premier DLR aircraft, having a new cockpit, inertial navigation system, and data system (both general and payload) recently installed. She also mentioned some broader development activities , which include a Lymanographer, a cryogenic hygrometer, an "automatic" calibration unit (currently receiving a lot of emphasis), flow modeling, and telemetry systems. Certain procedures are in place to ease access to the DLR fleet. DLR's airborne geoscience program is a subelement of the larger spacer science program, so investigations must be justified under a space guise. Most airborne initiatives are cooperative projects, in which case free access is guaranteed; however, if the flight request does not contribute to central DLR objectives, costs must be shared. A few ballpark hourly figures followed: $3000 for the Falcon, $1000 for the

Dornier, and $180 for the motorgliders. See Appendix C2 for explicit programmatic data. With mere seconds to spare, Dr. Jochum introduced Doug Johnson/Royal Aerospace Establishment and flashed a viewgraph describing the capabilities of the British C-130.

France

J.P. Chalon/Centre National de Recherches Météorologiques spoke only of the French aircraft that were fully dedicated to airborne geoscience, plus a couple that had recently been modified. Météo France—a national agency that focuses on meteorology, turbulent exchanges, orographic flows, and cloud development—has two craft: The Piper Aztec and Merlin IV. In addition, four agencies have pooled resources to acquire a Fokker-27: Institut Géographique National, Institut National des Sciences de l'Univers, Centre National d'Etudes Spatiales, and Météo France. This conglomeration forms the cooperative Avion de Recherche Atmosphérique et de Télédétection (ARAT) program (see *AGN 90-3*), which was conceived to further atmospheric sciences and remote sensing studies. The ARAT Fokker-27 has 140 flight hours completely funded for 1991, its first complete year of operation. Mssr. Chalon then discussed the capabilities of several operational sensors: LEANDRE (backscatter lidar), POLDER (reflectance and polarization), PUSHBROOM (multiband scatterometer), and Volothéque (mobile ground-based data system). Finally, he presented the Caravelle and Transelle aircraft. Though primarily for military applications, the former can provide microphysics and electromagnetic measurements, and the latter, larger craft can achieve high enough altitudes to generate astrophysics and physiochemistry data. Bob Grossman asked whether it was possible for individual investigators to gain access to any of the French craft. Mssr. Chalon responded that a number of committees review flight requests, with a bias towards the atmospheric sciences.

Universities

Dr. Paul Smith/South Dakota School of Mines and Technology (SDSMT) described the five aircraft that comprise the university fleet: King Air (University of Wyoming), Armored T-28 (SDSMT), Citation II (University of North Dakota), C-131A (University of Washington), and SPTVAR (New Mexico Institute of Mining and Technology). The first two are sponsored by NSF, and the latter three operate as independents. Rather than get into detail about the capabilities of the craft, Dr. Smith referred the Workshop participants to his abstract, and proceeded to talk of the unique perspective that academia can bring to airborne geoscience. Graduate students spawn innovative ideas, develop them in coordination with faculty advisors, and fly the experiments, all without the benefit of an acronym. These experiments possess a scientific utility, plus fledgling investigators get flight time within months rather than waiting dozens of years for the launch of a satellite or a berth in the Shuttle payload bay. Unfortunately, it's a constant struggle to keep the university aircraft aloft (80% funded, with universities making up the difference). The facility influence proves very inspirational and helps guarantee the next generation of Earth scientists. He followed up his robust resource pool comments by condemning NASA for a lack of institutional commitment to graduate study; however, with the EOS New Start, Global Change Research Fellowships are available to qualified applicants, with grants of $22,000 awarded to 37 individuals in CY90. The number of scholarships will scale up dramatically as the launch of EOS-A grows imminent. Gregg Vane asked why university craft are dedicated to the atmospheric sciences, to which Dr. Smith responded that atmospheric sensors are less expensive to develop.

U.S. Air Force

Paul Pikell/4950th Test Wing presented the Air Force's contribution to airborne geoscience research. A wide variety of craft are available, though they are somewhat old; however, this problem plagues all organizations that operate aircraft as research platforms. The 4950th's mission involves the flight test of aircraft systems; worldwide airborne research and test support; aircraft modification, design, fabrication, and installation; limited manufacturing support; and testing of commercial aircraft for military applications. The fleet is based at Wright-Patterson Air Force Base. The 4950th does not have a test range adjacent to its hangars; instead, they consider the whole world as their test range. In 1990, aircraft were deployed to 75 test sites in the U.S. and to 25 locations abroad. He proceeded by zooming through a number of slides that showed available platforms (see pp. 221-223 of the Program Book), quick to point out the empty space on the tarmac reserved for a mid-sized, high-altitude jet. Securing such a platform should be the #1 priority for the airborne community. He placed a great deal of emphasis on the 4950th's ability to design and install large radomes (e.g., on the Boeing 707). He closed his talk by describing the recent successful intercept of chemical tracers by the Combined Release and Radiation Effects Satellite (CRRES) over the South Pacific, to which Dr. Huning added kudos and gratitude. Workshop participants were referred to the Program Book abstract for information on how to access the craft for future missions.

4.2 Summary Impressions of the Workshop

Panel summations were provided to Dr. James Lawless/ARC by the Session Leaders. The poster sessions will not be covered here, except for the observation that the chocolate fondue was delicious. Rather than paraphrase the comments provided by the general session kingpins, an abridged version of their summary bullets are offered in the following subsections. Dr. Lawless and Acad. Kondratyev's closing comments will wrap up the Workshop proceedings as covered in these summary minutes.

4.2.1 Session Leader Contributions

Global Change Perspectives

For lack of an assigned Session Leader *per se*, Dr. Lawless identified the following items as common themes throughout the keynote speeches:

- Efforts to improve coordination are needed, but agency discussions indicate that cooperation does exist and common objectives are being pursued.
- All agree that facilities are an issue:
  - Number of aircraft
  - Aging aircraft
  - Replacement or expansion philosophy.
- Limited resources are a universal concern.
- Visibility of the Interagency Steering Group must be heightened (e.g., become a CEES advisory body).
- The international community needs to be more tightly coupled to the airborne community's collective activities.

Agency Activities in Airborne Geoscience

Dr. McNeal provided the following items as a summary of his panel:

- Proposals requiring aircraft require more flight hours than are available, but present-day operating funds are inadequate to fly the existing fleet at full capability. Additional operating funds are needed to bring the fleet's flight hours to capacity.
- Full capacity would not resolve serious schedule conflicts (i.e., more than one program having a concurrent need for a unique resource like the DC-8). Until more aircraft are available, careful planning is required to minimize conflicts. Because large interagency, international programs require a lot of advance notice, planning must have a 2- to 3-year horizon.
- Most agencies do not have a separate line item in their budgets to meet the need for a "staking fund" to upgrade and replace aging aircraft, nor to cover any catastrophic losses (e.g., the 990). Big programs like EOS do not have such funds in them, and are not likely to add them; however, by finding research programs now covered by R&D funds, pressure on the larger efforts can be

reduced, enabling them to provide more for equipment upgrades. A study of how to meet the need for upgrades and replacement was urged from the floor.

- The aircraft program, notwithstanding the limited funding, is extremely productive and enjoys broad support in many agencies, although the funding level is short of what could be effectively used.

Platforms and Instrument Developments

Dr. Johnson provided the following items as a summary of his panel:

- With regard to new platforms, it is clear that current interests and plans go well beyond the conventional manned airplanes that constitute the bulk of current fleets. The complex observational demands of planned science projects require that new platform technologies be explored. New research applications are foreseen for:
  - Very high altitude, unmanned aircraft
  - Lighter-than-air aircraft (i.e., airships)
  - Ultralight aircraft
  - Autonomous versions of current aircraft (e.g., ER-2).
- Existing conventional aircraft need to be replaced or upgraded with more modern, higher performance craft (e.g., Gulfstream IV mid-sized jet), or in some cases duplicate existing facilities (i.e., a second DC-8).
- Advanced airborne instrument developments and applications continue in a number of geoscience areas, including the atmospheric, oceanographic, and terrestrial domains.

Selected Field Projects

Dr. Weinstein provided the following insights as a summation of his panel:

- Field programs are too expensive to be unplanned, hence extensive planning has gone into every one of the described projects.
- While understanding is the objective of all of these projects, model development is the long-term driver for this improved knowledge.
- The projects described are multinational, multi-agency, multidiscipline, and multi-platform in scope.
- These field campaigns have excellent prospects for success because of outstanding planning, the high calibre of participants, and the advanced technologies and equipment involved.

- Current funding levels are adequate, though more money would certainly be accepted.

Facility Managers'-Users' Forum

Dr. Vane provided the following items as a summary of this panel:

- An impressive array of facilities (aircraft and sensors) are currently available, with significant and growing elements in Canada and Europe.
- The level of funding to support the airborne facilities in those programs pre-dating the GCRP is reasonably adequate, although there is concern on the part of most facility managers about the lack of funds to replace existing capabilities as they approach the end of their useful lifetimes.
- A much greater concern surrounds the inadequate funding commitment by the GCRP to the airborne geoscience program. Overall demands on airborne facilities are increasing (e.g., to support EOS precursor efforts), without concurrent financial backing.
- Major areas of concern in the platform area include:
  - Mid-sized jet (e.g., Gulfstream) for atmospheric studies
  - Long-duration, high-altitude aircraft for studies of stratospheric processes and for access to remote regions for diurnal observations
  - More flight hours could be added with relatively little additional funding, with some platforms so unique and versatile (i.e., the NASA DC-8) and in demand that purchase of a duplicate craft is warranted.
- Major areas of concern in the sensor area include:
  - Support for "facility sensors" inadequate to meet growing demand
  - Funding to support greater use of "PI sensors" woefully inadequate
  - Funding to enhance existing sensors, let alone build new ones, is almost totally lacking.

4.2.2 Concluding Remarks

Dr. Lawless made a few prefatory remarks about the excellent Workshop attendance, even at its close, and the high information content of all the sessions; then he yielded the floor to Acad. Kondratyev for his impression of the proceedings. Acad. Kondratyev apologized for his failure to resist the temptation to speak, but that he found the interpersonal communication far more stimulating than merely reading of airborne campaigns in scientific literature. He praised the Steering Group's efforts to embrace the international community; however, a truly international forum necessitates third world participation. Obviously not an oversight, some mechanism must be developed to ensure their involvement in future Workshops and in ongoing global field campaigns.

Acad. Kondratyev had four suggestions that he wanted the audience to consider:

1) A NASA-sponsored International Compendium on Airborne Geoscience
2) An International Airborne Geoscience Society
3) Mandate of this Society to determine how tremendous existing potential can be employed in a more efficient manner (i.e., scientific priorities applied to regional environmental problems)
4) Strive for better cooperation in the utilization of research aircraft.

He stated that the Workshop fostered an excellent environment for the exchange of ideas and mutually beneficial research. If the infighting for flight time can be reduced and aircraft can be placed into the context of the most prevalent vital problems, then the Fourth Airborne Geoscience Workshop can be considered an unqualified success.

Jim Lawless took the podium, thanked Acad. Kondratyev for his active participation, and concluded the final session by listing the merits of the Fourth AGW. The Workshops have matured over time, with the Steering Committee taking the best from each preceding meeting and improving upon it. The mix of science and management emphases proves unique and beneficial to all concerned, fostering interaction between those who *coordinate* and those who actually *do* the science. The meeting frequency is just about right as the excellent attendance attests. Dr. Lawless was very impressed with the enthusiasm of the participants throughout the entire week, not just the initial sessions. The community must harness this energy to ensure a robust future for the airborne geosciences. The growing national focus on global change research now provides an opportunity for proaction through the agencies, the NAS, and the CEES. Of course, the emphasis on global science and global modeling underscores the need for fruitful international collaboration, cooperation that is already well underway.

After Dr. Lawless' remarks, Dr. Huning thanked the participants for their active involvement, praised the support staff for their tireless efforts, and adjourned the meeting.

APPENDIX A

Final Agenda and List of Registrants

(including Poster Presenters and Steering Group Luncheon Participants)

APPENDIX A

Final Agenda

Interagency Airborne
Geoscience Steering Group

FOURTH AIRBORNE GEOSCIENCE WORKSHOP
AGENDA

The Global Change Research Program has been developed to provide the focus for activities of each of the governmental agencies involved in the Earth Sciences. The primary goal of this workshop is to describe and discuss the many agency activities using airborne platforms and sensors.

Tuesday, January 29, 1991

7:00 - 8:30 am	**Registration**	
9:00 - 12:00 noon	**Morning Session**	
	Welcome, Workshop Chairman	Huning
	(Speaker allocations 20 minutes each; break will be taken)	
	Keynote Theme - Global Change Perspectives Keynote Speakers	
	NASA	Theon
	NSF	Shedlovsky
	NOAA	Shea
	ONR	Weinstein
	VIP Keynote	Kondratyev
12:00 noon	**Lunch**	
1:30 - 3:30 pm	**Afternoon Session**	
	(Speaker allocations 3 minutes each)	
	Poster Previews	
	Session Leader	Melfi
5:30 - 7:30 pm	**Poster Session and Mixer,** Faculty Club, UCSD	

Chairman Dr. James R. Huning
Code SE
NASA HQ, Washington, DC 20546 (202) 453-1728

Exec. Sec. Bernard Nolan
Earth Science Support Office
Suite 440, 600 Maryland Avenue, S.W.
Washington, D.C. 20024 (202) 479-0360/(703)780-1938

Participants
National Aeronautics and Space Administration (NASA)
National Oceanic and Atmospheric Administration (NOAA)
National Science Foundaton (NSF)
National Center for Atmospheric Research (NCAR)
U.S. Geological Survey (USGS)
U.S.A.F./Air Force Geophysics Laboratory
U.S.N./Office of Naval Research
U.S. Department of Energy (DoE)
With agencies of Canada, France and Germany

FOURTH AIRBORNE GEOSCIENCE WORKSHOP
AGENDA

<u>Wednesday, January 30, 1991</u>

8:30 - 12:00 noon	**Morning Session**	
	(Speaker allocations 20 minutes each; break will be taken)	
	Agency Activities in Airborne Geoscience Panel Session and Discussion	
	Session Leader	McNeal
	NASA	McNeal
	NOAA	Mahler
	NCAR	Serafin
	DoD	Weinstein
	DOE	Mason
	Canada	MacPherson Bronstein
	Europe	Jochum
	Panel Discussion	
12:00 noon - 2:00 pm	**Luncheon with Paul MacCready** "Unusual Vehicles for Fun, Profit and Science"	
2:00 - 5:45 pm	**Afternoon Session**	
	(Speaker allocations 12 minutes each; break will be taken)	
	Platforms and Instrument Developments Panel Session and Discussion	
	Session Leader	Johnson
	Mid-Sized Jet	Johnson/R. Smith
	Airborne Hyperspectral Imaging	Goetz
	Very High Altitude, Unmanned	Tuck
	Airships	Blanc
	Ultralights	McCreight

FOURTH AIRBORNE GEOSCIENCE WORKSHOP
AGENDA

Wednesday, January 30, 1991 (Continued)

2:00 - 5:45 pm	**Afternoon Session (Continued)**	
	(Speaker allocations 12 minutes each; break will be taken)	
	Airborne Oceanography	Bane
	Airborne Turbulent Flux Measurements	Lenschow
	Airborne LIDAR Research	Melfi
	SAR Measurements	van Zyl
	Airborne Doppler Radar - Deriving Wind Fields	Jorgensen
	Laser Measurements - Atmospheric Chemistry	Webster
	Cloud Physics	Cooper
	Airborne Passive Microwave Measurements	Swift
	Airborne Data Collection	Goldstein
	Discussion	
Evening	Free	

Thursday, January 31, 1991

8:30 - 12:00 noon	**Morning Session**	
	(Speaker allocations 20 minutes each; break will be taken)	
	Selected Field Projects Panel Session and Discussion	
	Session Leader	Weinstein
	TOGA-COARE	Kuettner
	Airborne Arctic Ozone Expedition	Margitan
	ASTEX	Albrecht
	High Resolution Remote Sensing	Luther
	Terrestrial Ecosystems/MACs	Wickland
	GEWEX	D. Vane
	GTE	McNeal
	STORMS	Dirks
	Panel Discussion	

FOURTH AIRBORNE GEOSCIENCE WORKSHOP
AGENDA

Thursday, January 31, 1991 (Continued)

12:00 noon	**Lunch**	
2:00 - 3:30 pm	**Afternoon Session**	
	(Speaker allocations 3 minutes each)	
	Poster Previews	
	Session Leader	McFadden
5:30 - 7:30 pm	**Poster Session and Mixer,** Faculty Club, UCSD	

Friday, February 1, 1991

8:30 - 11:00 am	**Morning Session**	
	(Speaker allocations 10 minutes each; break will be taken)	
	Facility Managers' - Users' Forum Overview of Facilities and Discussion	
	Session Leader	G. Vane
	Panelists' Overviews of facilities used in support of interagency/international geoscience programs	
	NCAR	Radke
	NASA	W. Hall Navarro
	JPL	G. Vane
	NOAA	McFadden
	Canada	Bronstein McPherson
	DLR	Jochum
	France	Chalon
	Universities	P. Smith
	USAF	Pikell
	Discussion	
11:00 am	**Summary Impressions of Workshop**	Lawless
12:00 noon	**Adjourn**	Huning

APPENDIX A

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APPENDIX A

Final List of Poster Presenters

Scientific Poster Presentations
and Informal Reception
January 29 and January 31, 1991
University of California, San Diego Campus
Faculty Club

PROGRAM*

Tuesday, January 29 — **5:30 - 7:30 pm**

Koozer, Mark A., NASA/Ames Research Center
Ames Research Center C-130

Arnone, Robert A. and Paul E. LaViolette, NASA/Stennis Space Center
Aircraft Laser Derived Chlorophyll Distribution Across the Iceland-Faeroe Front

Bellmore, Michael A., Dan J. Rusk, R. Lynn Rose, and D. Ray Booker, Aeromet, Inc.
An Aircraft-Deployed Rawinsonde for Use in Remote or Hazardous Areas

Bowen, Stuart W., San Jose State University; K. Roland Chan, and T. Paul Bui, NASA/Ames Research Center
Calibration of the ER-2 Meteorological Measurement System

Brock, Charles A., Lawrence F. Radke, Peter V. Hobbs, University of Washington; and Bruce M. Morley, SRI International
Airborne Lidar Studies of Arctic Hazes

Browell, Edward V., NASA/Langley Research Center; Marta A. Fenn, and Susan A. Kooi, ST Systems Corporation
Airborne Lidar Measurements of Ozone During the 1989 Airborne Arctic Stratospheric Expedition

Chan, K. Roland, Leonhard Pfister, T. Paul Bui, NASA/Ames Research Center; Stuart W. Bowen, and Jonathan Dean-Day, San Jose State University
Applications of the ER-2 Meteorological Measurement System

Deck, Bruce, Martin Wahlen, Wadsworth Center for Laboratories and Research; Harley Weyer, NASA/Johnson Space Center; Peter Kubik, Pankaj Sharma, and Harry Gove, Nuclear Structure Research Laboratory
^{36}Cl in the Stratosphere

Tuesday, January 29 **5:30 - 7:30 pm**

Peterson, David L., NASA/Ames Research Center
Oregon Transect Ecosystem Research Project, A Multi-sensor Campaign (OTTER-MAC)

Friehe, Carl A. and Djamal Khelif, University of California, Irvine
Fast-Response Aircraft Temperature Sensors

Gasiewski, Albin J., D.M. Jackson, Georgia Institute of Technology; R.F. Adler, L.R. Dod, and J.C. Shiue, NASA/Goddard Space Flight Center
The Millimeter-Wave Imaging Radiometer (MIR)

Griffis, Andrew J., Calvin T. Swift, University of Massachusetts; and David LeVine, Goddard Space Flight Center
An Electrically Scanned Thinned Array Radiometer for Earth Remote Sensing

Hammer, Philip D., Francisco P.J. Valero, David L. Peterson, NASA/Ames Research Center; and William Hayden Smight, Washington University
Remote Sensing of Earth's Atmosphere and Surface using a Digital Array Scanned Interferometer-A New Type of Imaging Spectrometer

Higdon, Noah S. and Edward V. Browell, NASA/Langley Research Center
Airborne Water Vapor DIAL System and Measurements of Water Vapor and Aerosol Profiles

Kover, Allan N., James W. Schoonmaker, Jr., and Clark H. Cramer, U.S. Geological Survey
The USGS Side-Looking Airborne Radar (SLAR) Program: An Update-SLAR Data on CD-ROM

Holmes, LaMont and Jim Hochstetler, Pacific Missile Test Center
Airborne Stabilized Optical Systems

Ismail, Syed and Edward V. Browell, NASA/Langley Research Center
Lidar Measurements of Polar Stratospheric Clouds during the 1989 Airborne Arctic Stratospheric Expedition

Johnson, Lee F., TGS Technology, Inc.; and David L. Peterson, NASA/Ames Research Center
Hyperspectral Data Analysis for Estimation of Foliar Biochemical Content Along the Oregon Transect

Tuesday, January 29 **5:30 - 7:30 pm**

Hoff, Axel M., Aerodata FlugmeBtechnik GmbH; W. Muller, Niedersachsisches Landesamt f. Immissionsschutz; and J. Werhahn, Fraunhofer-Inst. f. Atmospharische Umweltforschung
An Airborne Measurement System for Mass Fluxes of Air Pollutants

Langford, John S., Aurora Flight Sciences Corporation; and James G. Anderson, Harvard University
The PERSEUS Unmanned Scientific Research Aircraft

Mason, Allen S., David L. Finnegan, Gregory K. Bayhurst, Robert Raymond, Jr., Roland C. Hagan, Gary Luedemann, and Kenneth H. Wohletz, Los Alamos National Laboratory
MISERS GOLD Dust Collection and Cloud Characterization

MacPherson, J. Ian, National Research Council (Canada)
Recent Developments in Airborne Flux Measurement

Pelletier-Travis, Ramona, NASA/Stennis Space Center
Airborne Ground Penetrating Radar (GPR) for Peat Analyses in the Canadian Northern Wetlands Study

Wu, Shih-Tseng, NASA/Stennis Space Center
Polarimetric Radar for Assessing Subsurface Characteristics

Rusk, Dan J., Ray Harris-Hobbs, and Mark Bradford, Aeromet, Inc.
Observations of High Altitude Tropical (HAT) Cirrus and Their Implications

Scofield, Christine P. and Chien Nguyen, NASA/Ames Research Center
C-130 Data Distribution System (CADDS)

Shemdin, Omar H. and Dayalan Kasilingham, Ocean Research and Engineering
Quantitative Analysis of SAR Ocean Imaging

Smith, Paul L. and Andrew G. Detwiler, South Dakota School of Mines and Technology
Measurements of Electric Field using the Armored T-28 Aircraft

Spanner, Michael A., NASA/Ames Research Center; and Richard Waring, Oregon State University
Remote Sensing of the Seasonal Variation of Coniferous Forest Structure and Function

Strapp, J.W., W.R. Leaitch, H.A. Wiebe, K.G. Anlauf, J.W. Bottenheim, K. Puckett, G.A. Isaac, Atmospheric Environment Service (Canada), C.W. Spicer, T. Kelly, J. Hubbe, N. Laulainen, Battelle Memorial Institute, F. Slemr, J. Werhahn, and H. Giehl, Fraunhofer-Institut
A Four Aircraft Intercomparison of Air Chemistry Measurements

Taylor, John A., Lighter Than Air Technologies
Airship Support Services for Airborne Geoscience Applications

Wahlen, Martin, Scripps Institute of Oceanography; Nori Tanaka, Yale University; Robert Henry, New York State Department of Environmental Conservation; and Harley Weyer, NASA/Johnson Space Center
Profiles of (gamma)^{13}C and (gamma)D in Methane from the Lower Stratosphere

Vance, Mike, Gulfstream Aerospace
Gulfstream IV: The Productive Research Aircraft

Rogers, David P., Scripps Institution of Oceanography; Douglas W. Johnson, Royal Aerospace Establishment (England); and Carl A. Friehe, University of California, Irvine
The Structure of a Stable Internal Boundary Layer over the Coastal Ocean

Way, JoBea, Ron Kwok, John Holt, Jet Propulsion Laboratory; M. Craig Dobson, Kyle McDonald, and F. T. Ulaby, University of Michigan
Monitoring Forest Freeze-Thaw Cycles with Airborne SAR

Wegener, Steven, K. Roland Chan, Leonhard Pfister, and John Arvesen, NASA/Ames Research Center
High Altitude Aircraft Direction using Real-Time Scientific Analysis of Telemetered Data

Angelici, Gary L., Lidia Popovici, Sterling Software; and Jay Skiles, Technicolor Government Services
The Pilot Land Data System (PLDS) at the Ames Research Center Manages Aircraft Data in Collaboration with an Ecosystem Research Project

Baumgardner, Darrel, National Center for Atmospheric Research
An Error Analysis Model for Aircraft Measurements

Boyd, Janice D., NASA/Stennis Space Center
Air Deployed Expendable Probes in Oceanographic Research

Tuesday, January 29 **5:30 - 7:30 pm**

Weckler, Paul and Charles Pruszynski, Aeromet, Inc.
High Altitude Observatory (HALO) Aircraft Capabilities

McCandless, Walt, User Systems, Inc.
Beconless Search & Rescue Using Synthetic Aperture Radar

Van Zyl, Jacob, Jet Propulsion Laboratory
Update on the NASA/JPL AIRSAR System

Green, Robert, Jet Propulsion Laboratory
NASA/JPL Airborne Visible/Infrared Imaging Spectrometer (AVIRIS)

Menzies, Robert T., David M. Tratt, Alan M. Brothers, Stephen H. Dermenjian, and Carlos Esproles, Jet Propulsion Laboratory
Aerosol and Cloud Backscatter Measurements in the Thermal Infrared using an Airborne Backscatter Lidar

Thursday, January 31 **5:30-7:30 pm**

Degreef, Leo H., NASA/Ames Research Center
NASA DC-8 Airborne Research Laboratory

Browell, Edward V., NASA/Langley Research Center; Carolyn F. Butler, and Susan A. Kooi, ST Systems Corporation
Tropospheric Ozone and Aerosols Measured by Airborne Lidar During the 1988 Arctic Boundary Layer Experiment

Burpee, Robert W., Joseph S. Griffin, James L. Franklin, and Frank D. Marks, Jr., NOAA/Hurricane Research Division
Analysis of Observations from a P-3 Aircraft in Support of Operational Hurricane Forecasting

Cherniss, Susan C., Sterling Software; and Christine P. Scofield, NASA/Ames Research Center
NASA/Ames Research Center DC-8 Data System

Flamant, Pierre H., CNRS
The French Airborne Backscatter LIDAR LEANDRE-1

Garvin, James B., Jack L. Bufton, John F. Cavanaugh, NASA/Goddard Space Flight Center; William B. Krabill, Thomas D. Clem, Earl B. Frederick, and John L. Ward, NASA/Wallops Flight Facility
High-Resolution Measurements of Surface Topography with Airborne Laser Altimetry and the Global Positioning System

Gregory, Gerald L., James M. Hoell, Jr., NASA/Langley Research Center; and Douglas D. Davis, Georgia Institute of Technology
Airborne Sulfur Trace Species Intercomparison Campaign: Sulfur Dioxide, Dimethylsulfide, Hydrogen Sulfide, Carbon Disulfide, and Carbonyl Sulfide

Hain, James H.W., Associated Scientists at Woods Hole
Whales and Ocean Habitats: Exploratory Research Using Airships

Harris-Hobbs, Ray, Arleen Lunsford, R. Lynn Rose, Aeromet, Inc.; Kathy L. Giori, Joel Kositsky, and Robert A. Maffione, SRI International
Airborne Field Mill Research Platform

Hochstetler, Ron, Airship Operation & Service
A New Look at the Airship as a Geoscience Research Platform

Hoge, Frank E., NASA/Wallops Flight Facility; and Robert N. Swift, EG&G
Airborne Oceanographic Lidar Participation in the U.S. Joint Global Ocean Flux Study (JGOFS)

Hood, Robbie E., Roy W. Spencer, and Mark W. James, NASA/Marshall Space Flight Center
The Advanced Microwave Precipitation Radiometer: A New Aircraft Radiometer for Passive Precipitation Remote Sensing

Jedlovec, Gary J., Mark W. James, NASA/Marshall Space Flight Center; Matthew R. Smith, Universities Space Research Association; and Robert J. Atkinson, General Electric Company
A PC-Based Multispectral Scanner Data Evaluation Workstation: Application to Daedalus Scanners

Kelly, Patrick, Douglas Rickman, and Eric Smith, NASA/Stennis Space Center
End-to-End Remote Sensing at the Science and Technology Laboratory of John C. Stennis Space Center

Thursday, January 31 **5:30 - 7:30 p.m.**

Krabill, William B., NASA/Wallops Flight Facility; Chreston F. Martin, and Robert N. Swift, EG&G
Applying Kinematic GPS to Airborne Laser Remote Sensing

Lawless, James G., NASA/Ames Research Center; and Lisa J. Mann, TGS Technology, Inc.
Status Report on the Land Processes Aircraft Science Management Operations Working Group

Mascart, Patrick, Meteo France, CNRM, Toulouse, France; M. Ravaut, INSU-DT, Paris, France; P. Flamant, LMD, Palaiseau, France; and A. Druilhet, LA, Toulouse, France
The New French ARAT Aircraft Program

McIntosh, Robert E. and Steve Carson, University of Massachusetts, Amherst
Geophysical Modeling of Backscatter from the Ocean Surface at C-Band

Mollo-Christensen, Erik, NASA/Goddard Space Flight Center; and J. David Oberholtzer, NASA/Wallops Flight Facility
The Surface Wave Dynamics Experiment (SWADE)

Rothermel, Jeffry, William D. Jones, NASA/Marshall Space Flight Center; Diana Hampton, Sverdrup Technology, Inc.; Vandana Srivastava, University Space Research Association; Maurice Jarzembski, NASA/Marshall Space Flight Center
Airborne Coherent Continuous Wave CO_2 Doppler Lidars for Aerosol Backscatter Measurement

Bowdle, David A., University of Alabama in Huntsville; Jeffry Rothermel, James E. Arnold, NASA/Marshall Space Flight Center; and Steven F. Williams, University of Alabama in Huntsville
GLObal Backscatter Experiment (GLOBE) Pacific Survey Mission

Russell, Philip B., NASA/Ames Research Center; David P. Lux, Dryden Flight Research Facility; R. Dale Reed, PRC Systems Services; Max Loewenstein, and Steven Wegener, NASA/Ames Research Center
Science Requirements and Feasibility/Design Studies of a Very-High-Altitude Aircraft for Atmospheric Research

Shelton, Gary A. and Bruce Coffland, NASA/Ames Research Center
The High Altitude Aircraft Program of NASA/Ames Research Center

Smith, Dean S., University Research Foundation; and Jack L. Bufton, NASA/Goddard Space Flight Center
The Remotely Piloted Vehicle as an Earth Science Research Aircraft

Smith, William L., Steven A. Ackerman, Hugh B. Howell, Allen H.-L. Huang, Robert O. Knuteson, Henry E. Revercomb, and Harold M. Woolf, University of Wisconsin, Madison
Cloud and Trace Gas Remote Sensing with the High-Resolution Interferometer Sounder (HIS)

Spinhirne, James D., John F. Cavanaugh, NASA/Goddard Space Flight Center; S. Chudamani, Science Applications International Corporation; Jack L. Bufton, and Robert J. Sullivan, NASA/Goddard Space Flight Center
Visible and Near Infrared Observation on the Global Aerosol Backscatter Experiment (GLOBE)

Portigal, Frederick P., James V. Taranik, and Christopher D. Elvidge, University of Nevada System
Extraction of Reflectance from 1989 AVIRIS Radiance Data using LOWTRAN 7 Atmospheric Models

Tjernstrom, Michael, Uppsala University
Airborne Observations of the Inhomogeneous Marine Boundary Layer in a Coastal Region

Wachs, Peter, P. Vorsmann, Aerodata FlugmeBtechnik GmbH
METEOPOD-An Airborne Module for Atmospheric Turbulence Measurements

Walthall, Charles L., University of Maryland; James Irons, Phillip Dabney, Goddard Space Flight Center; David Peterson, NASA/Ames Research Center; Darrel Williams, NASA/Goddard Space Flight Center; Lee Johnson, TGS Technology, Inc.; and Jon Ranson, NASA/Goddard Space Flight Center
Advanced Solid-State Array Spectrometer (ASAS) Data Sets from the 1990 Field Season: A Unique Look at Two Forested Ecosystems

Williams, Darrel L., NASA/Goddard Space Flight Center; Charles L. Walthall, University of Maryland; and Douglas Young, NASA/Wallops Flight Facility
A Pointable, Helicopter-Based Remote Sensing Data Acquisition System for Collecting Bidirectional Reflectance Data

Williams, Darrel L. and K. Jon Ranson, NASA/Goddard Space Flight Center
The 1990 Forest Ecosystem Dynamics Multisensor Aircraft Campaign

Thursday, January 31 **5:30 - 7:30 p.m.**

Michael Miller and Chris Higgins, Wright-Patterson Air Force Base
Availability of Air Force Aircraft and Support for Geoscience Research

Brenguier, J.L., CNRM

Goodale, Brent, Ames Research Center
DC8 Medium Altitude Missions

Evans, Diane L., Jet Propulsion Laboratory and Raymond E. Arvidson, Washington University
The Geologic Remote Sensing Field Experiment (GRSFE): The First Geology Multisensor Airborne Campaign

Lancaster, Justin, California Space Institute

APPENDIX A

Steering Group Luncheon Participants

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APPENDIX B

Draft Resolution

DRAFT RESOLUTION

of the

FOURTH AIRBORNE GEOSCIENCE WORKSHOP

At its January 1991 meeting, the international airborne geoscience community assessed the prospects for having adequate airborne observational facilities to study current critically important problems in environmental science, including global change and Earth system science. The over 170 participants involved in atmospheric, oceanic, and terrestrial research in seven countries were dismayed to learn that few if any of the sponsoring agencies in the various nations have comprehensive plans to provide for replacement or major upgrades to research aircraft platforms or instrument systems. At the same time, planned research tasks demand that large, complex, multinational experimental campaigns be undertaken worldwide with a variety of advanced airborne platforms and instrument systems.

The participants have concluded that an acute international infrastructural problem exists. While society is faced with incredibly complex environmental problems, the airborne observational facilities necessary to study and help solve these problems are currently inadequate, and appear likely to remain that way for the foreseeable future.

National and international budget planners seem to have left this crucial ingredient out of their scientific plans. The airborne geoscience community, as represented by the participants of this Workshop, urge the responsible agencies to take immediate steps to address this deficiency. The agencies should work individually and collectively to provide the resources needed to permit the systematic replacement and upgrading of the most important airborne observational facilities, based upon scientific priorities.

This resolution has been discussed by the participants at the Fourth Airborne Geoscience Workshop, and has been unanimously endorsed by the Steering Group on Airborne Geoscience.

Steering Group on Airborne Geoscience

La Jolla, California, USA
January 31, 1991

DRAFT

APPENDIX C

Selected Handouts

C1. Kondratyev's References
C2. Anne Jochum's Presentation

APPENDIX C1

Publications by

Academician

Kirill Ya. KONDRATYEV

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of the USSR Academy of Sciences

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FAX (812) 218-41-72

IN ENGLISH

Weather and Climate on Planets. Pergamon, 1982

Radiation Characteristics of Atmosphere & Surface. India, 1987

Bering Sea Experiment. NASA, 1987

Volcanoes & Climate. WMO Publication, 1988

Climate Shocks: Natural & Anthropogenic. Wiley, 1988

ISLSCP. UNEP Publ., 1989

Remote Sensing of Soils and Vegetation. Taylor & Francis, 1990

Aerosols and Climate. (Gidrumeteoizdat, in Press, 1991)

Global Climate Processes. (Cambridge Univ. Press, in Press, 1991)

IN RUSSIAN

Satellite Climatology. Gidrumeteoizdat, Leningrad, 1983

WCRP: The Present State and Perspectives. VINITI, Moscow, 1985

Green House Effect of the Atmosphere and Climate. VINITI, Moscow, 1986

Global Climate. VINITI, Moscow, 1988

Earth's Radiation Budget. Gidrumeteoizdat, Leningrad, 1988

Planet Venus. Gidrumeteoizdat, Leningrad, 1989

Global Ozone Dynamics. VINITI, Moscow, 1989

Publications by

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FAX (812) 218-41-72

IN RUSSIAN (Continued)

Remote Sensing of the Biosphere. Nauka, Moscow, 1989

Optical Properties of Natural Waters and Remote Sensing of Phytoplankton. Nauka, Leningrad, 1989

Planet Mars, Gidrumeteoizdat, Leningrad, 1990

Energy-Active Zones: Conceptual Aspects (Vols. 1 & 2). VINITI, Moscow, 1989

Key Issues of Global Ecology. VINITI, Moscow, 1990

V.G. Gorshkov. Energetics of the Biosphere and Stability of the Environment. VINITI, Moscow, 1990

Summary Surveys:

1. Key Issues of Global Ecology and the Requirements for Satellite Observational Data
2. Global Security and the Ecological Component
3. The IGBP: The States and Perspectives
4. The Earth and the Biosphere

APPENDIX C2

AIRBORNE GEOSCIENCE IN EUROPE

A.M. Jochum, DLR
P. Mascart, CNRM

- Background
- Organizations Involved in Airborne Geoscience
  - Research Interests
  - Aircraft and Instrumentation
- Major New Developments
- Programs with Aircraft Component
  - European
  - National
- Major Field Projects
- Summary

ORGANIZATIONS INVOLVED

CH

Lapeth (Lab. Atmos. Physics, Swiss Tech. University)
Boundary Layer, Mesoscale, Air Pollution
* Motorglider — Met, Chem

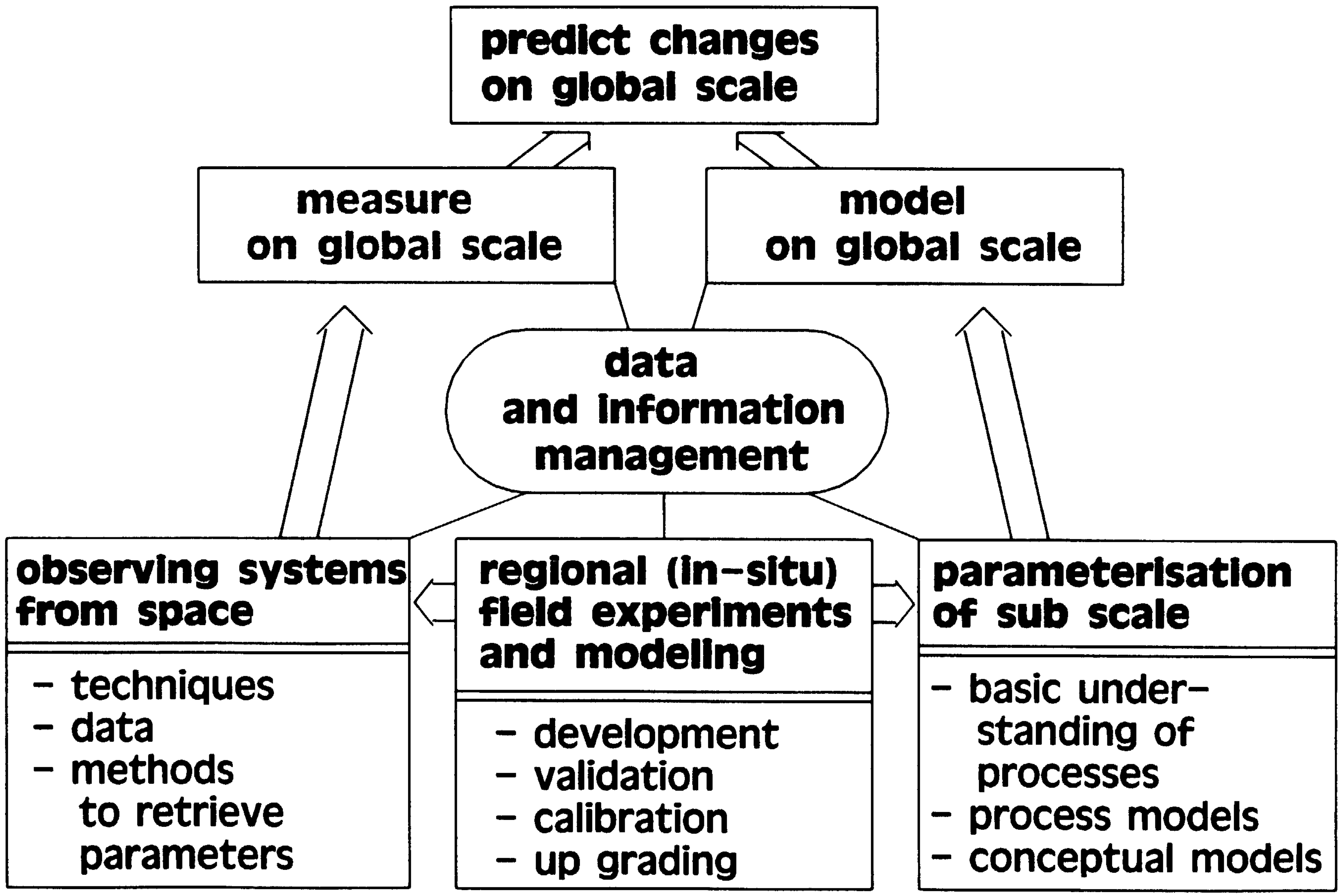
D

Aerodata/IfU (Fraunhofer Institute for Environmental Res.)
Air Pollution
King Air — Met, Chem
Hawker Siddley 125 — Chem

AWI (Alfred Wegener Inst. for Polar Research)
Polar and Marine Res.
Dornier Do 128 — Met, Rad, Camera
Dornier Do 228 — Met, Rad, Camera, Turb, Drop

DLR (German Aerospace Research Establishment)
Multipurpose
Falcon 20 — Met, Rad, Turb, μϑ, Rem, (Chem)
Dornier Do 228 — Met, Rem, (Chem)
* ~ Do 228 — Met, Chem, Rem, Turb, Rad, Mϑ
Queen Air — Met, Chem
Dornier Do 28 — Met, μφ, Icing, Rem
3 Motorgliders — Met, Turb, O_3, T_s

K/K (Nuclear Res. Center)/Air Force/Aerodata/DLR
Tropospheric Ozone
* Transall — Rem, Chem


predict changes
on global scale
measure
on global scale
model
on global scale
data
and information
management
observing systems
from space
- techniques
- data
- methods
to retrieve
parameters
regional (in-situ)
field experiments
and modeling
- development
- validation
- calibration
- up grading
parameterisation
of sub scale
- basic under-
standing of
processes
- process models
- conceptual models

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ORGANIZATIONS -2

	TU Braunschweig (Tech. University)/IfU/Aerodata	
	Flight Mechanics	L. General
	Dornier Do 128	Met, Turb (Chem)
	U./MPI Hamburg/GRSS	
	Cloud Physics	
	ZUF (Environmental Research Center)	
	Air Chemistry	
	Piper PA 31	Chem
F	IGN (Nat'l Geographic Inst.)/Météo Nationale (Weather Service)/CNES (Nat'l Center for Space Studies)/INSU (Nat'l Inst. of the Universe): ARAT	
	Multipurpose	
	Fokker F27	Met, Rad, Turb, Rem, μφ, (Chem)
	Météo Nationale	
	Multipurpose	
	Fairchild Merlin IV	Met, Rad, Turb, μφ, Chem
	Piper PA 23 Aztec	Met
GB	NPTECH (Nat'l Poner Tech—Former CERL)	
	Air Chemistry	
	Jetstream	Chem

ORGANIZATIONS-3

	RAE (Royal Aerospace Establishment)	
	Multipurpose	
	Hercules C-130	Met, Rad, Turb, μφ, Chem, Rem, Drop
	UMIST (U. of Manchester)	
	Cloud Physics	
	* Cessna	Met, μφ, Turb
MC	Private Owner/Lapeth	
	Boundary Layer, Mesoscale	
	Motorglider	Met
NL	Geosens	
	Air Pollution	
	Piper PA 31	Met, Chem
	* King Air	Met, Chem, Turb
P	U. of Warsaw	
	Cloud Physics	
	Motorglider	Met, LWC
	*Antonow	Met, Chem, Turb

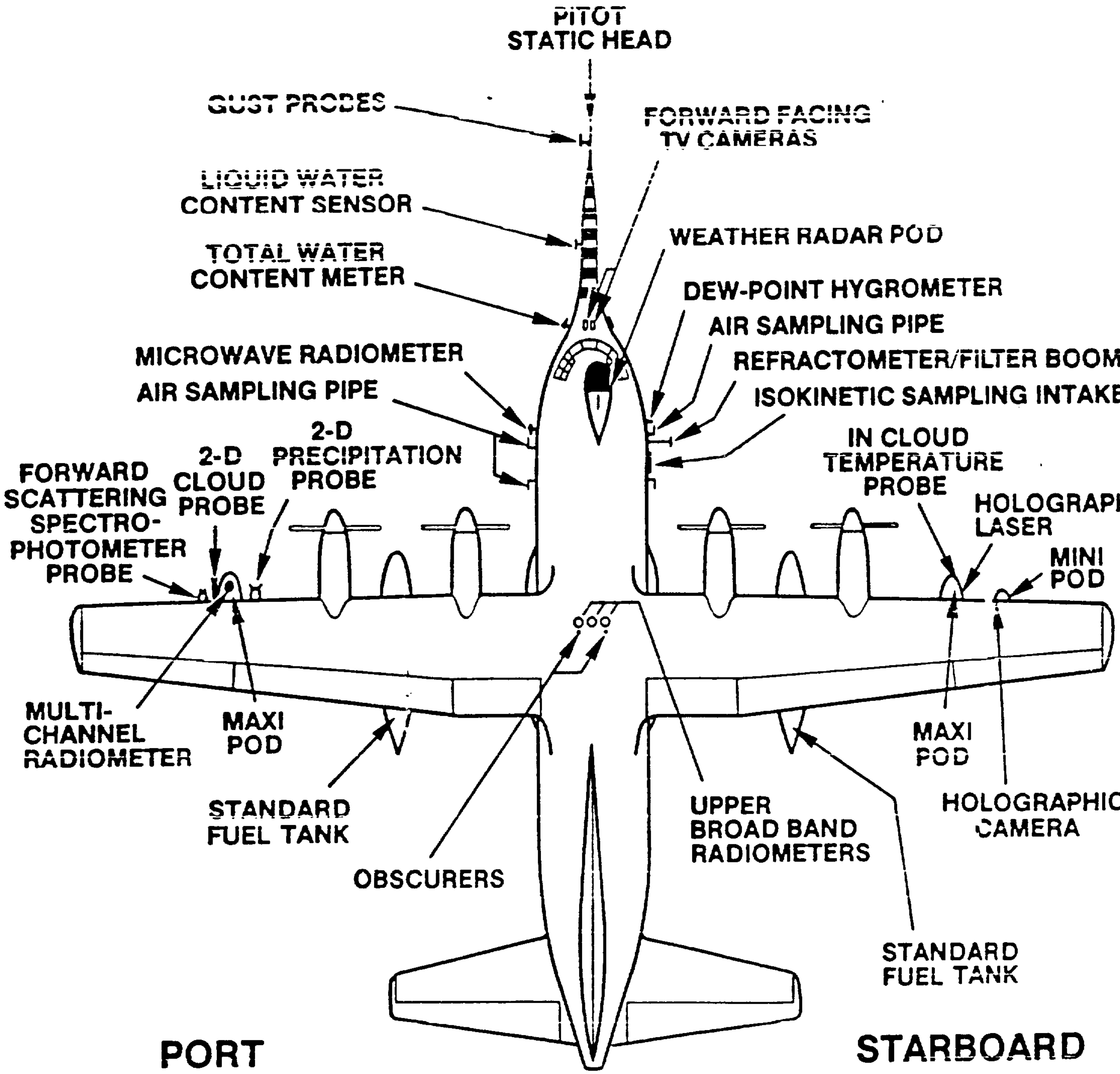
ORGANIZATIONS-3 (CONT.)

S	MIUU (Met. Inst, Uppsala University)	
	Boundary Layer, Mesoscale	
	Sabreliner 40A	Met, Rad, Turb, LWC
	Stockholm University	
	Air Chemistry, Aerosol and Cloud Physics	
		Chem, μφ

ORGANIZATIONS-4

T	U. of Istanbul	
	Boundary Layer	
	Motorglider	Met
SU	Akademia Nauk (Academy of Sciences)	
	Multipurpose	Atmos./Land/Ocean
	Inst. of Atmos. Optics	Cloud and aerosol
	[Aeroflot]	Lidar
	Inst. of Lake Studies	Ocean and water surface
	Helicopter MI6	Rem
	Inst. of Radioelectr	Soil and water
	Ilyushin IL-18	Rem (Active and passive microwave)
	Hydrometeorological Commitee	
	Atmos. Land, Ocean	
	Main Geophysical Observ	Multipurpose
	IL-18	Met, Rad, μφ, (Chem), Rem
	Central Aerological Observ	Cloud, weather mod.
	Inst. of Arctic	Ice reconnaissance
	Antonov	Rem (SLAR)
	Center of Agricultural Res	AgroMet
	Tupolev	Rem (VIS, IR, MW, SLAR)

MRF HERCULES XV208
LOCATION OF INSTRUMENTS



VIEW FROM ABOVE

MAJOR NEW DEVELOPMENTS

- ARAT
  (Avion De Recherche Atmosphérique et de Télédétection)
  Atmosphere, Land, Ocean
  4 French agencies: IGN, INSU, CNES, DMN
  Met, Rad, Turb, μφ, (Chem)
  Rem Backscatter Lidar (—>DIAL—>doppler) LEANDRE

  IR Imaging Spectrometer
  Multispectral pushbroom (<—>SPOT)
  X-band SAR HH/VV
  High-frequency radiometer VARAN
  POLDER

- Dornier Do-228 Environmental Lab
  Atmosphere, Land, Ocean
  DLR/Aerodata Fall 1991
  Met, Rad, Chem, Turb, (μφ), Rem

- Long Range Jet
  Atmosphere, Land, Ocean
  DLR + ?

AIRBORNE REMOTE SENSING AT DLR

- Aerosol Backscatter Lidar
- Water Vapor DIAL
- Ozone DIAL
- SAR C-/X-Band Vert. Polarization (full polarization, 3 freq 1992)
- SLAR
- Microwave Radiometers
- TM Simulator
- Metric Cameras
- Multispectral Scanner
- ROSIS (Reflective Optics System Imaging Spectrometer)
  430-850 nm, ≤5nm Resolution
- Wind Lidar

—> Calibration and Ground Truth Experiments

EUROPEAN PROGRAMS WITH MAJOR AIRBORNE COMPONENT

CEC

- STEP (environment)
- EPOCH (climate)

JRC/ESA

- EARSEC (remote sensing)

Some ESA/EOP related—Some EOS related

- Space sensor technology (development and calibration)

National Funding

- EUROTRAC (environment)
  TRACT, FATE, TOR, BIATEX
- GEWEX —EU
- IGBP—EU
- Alpine Countries (Air Pollution)
- Other Bi-/Tri-Lateral Programs

—> EGS (European Geophysical Society)
Role of A/C in Land/Atmosphere Programs

MRF PLANNED MAJOR CAMPAIGNS

1. **TOASTE.** Summer 1991 - U.K.

   - Investigating ozone exchange between the stratosphere and troposphere.

2. **ERS-1.** Autumn 1991 - Trondheim

   - Calibrating a satellite instrument for measuring surface wind using sea state.

3. **FATE.** Autumn 1991 - Ascension

   - Validation of sea surface temperature measurements from an along track scanning radiometer.

4. **GRAVITY WAVES.** Autumn 1991 - U.K.

   - Investigating the production and dissipation of orographically forced gravity waves.

MRF PLANNED MAJOR CAMPAIGNS (CONT.)

5. **FRONTS 92**. Spring 1992 - U.K.

   - Studying active cold fronts and comma cloud systems.

6. **ASTEX.** Summer 1992 - Azores

   - Investigating the transition from stratocumulus to trade wind cumulus.

7. **EUCREX.** Autumn 1993 - ?

   - Microphysics and radiation characteristics of cirrus.

MAJOR FIELD PROJECTS - D

- ARKTIS 91 — February 1991 — Spitzbergen
  Arctic boundary layer and stratus.

- EFEDA — June 1991/1994 — "HAPEX"
  Land-surface processes in very dry area.

- "DDR" — Several dates 91/92 — East Germany
  Transport and deposition of chemical species (SO_2, NO_x, et al.)

- X-SAR/SIR-C Test Site — Jun/Jul 1991 — South Germany
  System calibration and ground truth.

- DONAURIED — July 1991/1993 — South Germany — GEWEX-D
  ABL processes over complex terrain.

- REFLEX 2/3 — Sep 91/Jul 92 — Spitzbergen
  Surface energy balance over polar ocean.

- KATTEGAT — June 1992 — Sweden/Denmark
  No_x transport in marine and coastal boundary layer.

- CLEOPATRA — Jun - Aug 92 — South Germany — GEWEX-D
  Cloud processes.

- POLLUMET — Jul - Aug 92 — Central Switzerland
  Transport and deposition over rough terrain.

- TRACT — September 1992 — Southwest Germany
  Transport and mass balance in complex terrain.

Tableau II

CAMPAGNES SCIENTIFIQUES ARAT POUR 1991 (-1-)				
N° PROPOSANT	THEME	CONFIGURATION ARAT et Lieux	PROPOSTION C.S. Classement (Durée)	Dates
91-01 Vidal-Madjar (CRPE)	Structure Végétation	POLDER,ISM, VARAN (Orgeval)	A (6H)	Campagne PNTS/NASA (10/6-20/7)
91-02 Jacques (L. Arago)	Médimar	POLDER (Banyuls)	A (10H)	(26/3-9/4)
91-03 Podaire (LERTS)	CRAU 91	POLDER (La Crau)	A (10H)	Campagne PNTS/NASA (10/6-20/7)
91-04 Scanvic (BRGM)	Cartographie Géologique	ISM (Cholet)	A (-)	Reporté en 1992
91-05 Le Corre (CAESS)	Cartographie Multicapteurs	PUSH BROOM, ISM,VARAN (Bretagne)	B (-)	Reporté en 1992
91-06 Pelon et al. (SA,LMD,LA)	Préparation SOFIA/ASTEX	LEANDRE (Creil et Bretagne seulement)	A (40H. en 2 campagnes)	(29/4-8/6) et (18/11-5/12)

Tableau II (suite)

CAMPAGNES SCIENTIFIQUES ARAT POUR 1991 (-2-)				
N° PROPOSANT	THEME	CONFIGURATION ARAT et Lieux	PROPOSTION C.S.	
			Durée	Dates
91-07 Froidefond (CRESO)	Flux Sédimentaires	PUSH BROOM, VARAN,POLDER (G. Gascogne)	C (-)	-
91-08 Cruette (Paris VI)	Tests Therm. Sonique	Base Météo (Creil)	B (2H)	Vols locaux à intercaler
91-09 Sotin (Paris Sud)	Spectrométrie Beni Boussera	ISM (Maroc)	A (6H)	Campagne PNTS/NASA (10/6-20/7)
91-10 Pinet (OMP)	Minéralogie Roches Endogènes	ISM (Ariège, Espagne)	A (4H)	Campagne PNTS/NASA (10/6-20/7)
91-11 Rudant (Paris VI)	Reconnaissance Objets Géologiques	VARAN (Sud France)	A (4H30)	Campagne PNTS/NASA (10/6-20/7)
91-12 Trautmann (CEREG)	Hydrologie Moyenne Montagne	PUSH BROOM et VARAN (Voges)	A (4H)	(1/10-15/10)

Tableau II (fin)

CAMPAGNES SCIENTIFIQUES ARAT POUR 1991 (-3-)				
N° PROPOSANT	THEME	CONFIGURATION ARAT et Lieux	PROPOSTION C.S.	
			Durée	Dates
91-13 Martin, Bonsang (EERM,CFR)	Physicochimie Couche Limite Marine	Base Météo. Physicochimie (Bretagne)	C (-)	-
91-14 Godin (SA)	Campagne O_3 ELSA pour EASOE	LEANDRE (Suède)	A (40H)	(6/12-29/12) et suite en 92
91-15 Dedieu (LAMA)	Télédétection Multispectrale de la neige	PUSH BROOM, ISM,VARAN (Alpes)	A (5H, en 1992)	Reporté en 1992 (Décembre)
91-16 Alcaydé (CESR)	Validation ISM	ISM (Sud-Ouest France)	A (15H)	Campagne PNTS/NASA (10/6-20/7)
91-17 Rivière et al. (Thomson)	Vols de tests Bathymètre Lidar	Bathymètre Lidar (Bretagne)	D Irrecevable, transmis au C.D.	-
TOTAL 91 :			141H30	

SUMMARY

- 10 European countries involved in AG
  18 organizations + 2-7
  4 major facilities/aircraft
  31 aircraft +~10
- *In situ* technology well established
  continuous new development
- Remote basic sensors established
  Advanced become available/operational
  New developments in many areas
- Field programs
  Multisensor
  Multi A/C
  Multisystem
  Interdisciplinary
  International
- Global programs becoming established nationally: GEWEX, IGBP