THE CEDAR POST

OCTOBER 1996 NO. 29

Report on Joint GEM/CEDAR Space Weather Workshop

A joint GEM and CEDAR Workshop on Space Weather was held as part of the 1996 GEM and CEDAR summer meeting activities. The principal objectives of the workshop were for the magnetospheric and aeronomic communities to educate each other about Space Weather from their perspective, and to learn where stronger links between the two fields and research programs would be mutually beneficial. Or, put another way, to answer the question "What inputs do the aeronomers need from the magnetospheric physicists and visa versa?"

The main component of the joint workshop was a combined GEM/CEDAR session held at the University of Colorado on Saturday, June 22, during the weekend between the CEDAR and GEM meetings. This was attended by about 100 scientists. Additionally, tutorials were given during both the CEDAR and GEM main workshops by members of the other community.

The morning of the joint meeting was taken up by a series of presentations on three topics: Space Weather Drivers - How do They Rank in Importance (G. Siscoe and R. Schunk); New Frontiers in Magnetosphere/Ionosphere/Thermosphere Coupling (T. Killeen and C. Russell); and a report on the science results and issues that resulted from the first joint CEDAR/GEM case study (November 1993; D. Knipp - M. Buonsanto). These presentations provided background and stimulation for the afternoons discussion, on which we focus in this report. The afternoon began with a panel discussion on "What are the Critical Problems and What is Needed to Solve Them?" The workshop split into three working groups to discuss scientific and practical goals.

The first working group, led by Harlan Spence and Santimay Basu, focused on the most critical problems from the users' perspective. They identified five distinct areas where space weather effects are important. These are listed in the table below.

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TOPIC	PROBLEM	CEDAR/GEM CONNECTION
Transionosphere Radio Communication	Equatorial and High Latitude Scintillation	Predicting ionospheric electric fields and their effect upon onset of instabilities.
Space Station and Man-in-Space	Collisions with Orbital Debris	Predicting solar and magnetospheric energy input into the upper atmosphere to better predict atmospheric densities and hence satellite drag.
Geolocation	Atmospheric Refraction of (GPS) Radio Signals	Specifying global electron density distribution in ionosphere and plasmasphere
Electric Power Transmission	Ground Induced Current (GIC) Transients	Predicting regional ionosphere currents.
Spacecraft Operations	Single event upsets and spacecraft charging	Predicting energetic particles and hot plasma environments along spacecraft orbits.

This working group also identified a number of science topics that would benefit from closer magnetosphere/aeronomy (i.e. GEM/CEDAR) collaboration:

- Exosphere/Magnetosphere Coupling (i.e. charge exchange).
- Magnetospheric/atmospheric heat flux.
- Ionospheric ion inflow and outflow.
- Magnetospheric particle precipitation.
- Magnetospheric/Ionospheric electromagnetic coupling (ionospheric and magnetospheric currents, convection electric fields, ionospheric conductivity).
- Ion-neutral particle coupling.
- Wave particle interactions and plasma instabilities.

The second working group, led by Michael Kelley and Alan Rodger, focused on the critical Space Weather science problems and issues that hinder scientific advance. They identified the following critical science problems (loosely in order from Sun to Earth):

- The source and propagation of Coronal Mass Ejections (CME).
- The formation and loss of radiation belts.
- Populating the magnetosphere from the ionosphere.
- The variability in time and space of magnetospheric energy flow into the upper atmosphere, which includes understanding the relationships between the IMF and convection patterns, substorm energy inputs and varying electric fields.
- Knowledge of the solar EUV flux.
- Ionospheric irregularities, both at high and low latitudes.
- Short-term variability of the neutral atmosphere.
- The effects of micro physics on macro structures, e. g., Alfven waves, plasma turbulence.

This working group made a number of recommendations. Concerning models, they concluded that we should move away from empirical and towards dynamic physical models that we should work towards combining, nesting or linking models, in order to achieve the appropriate feedbacks both internally and between models, that models should be self consistent, and that much more attention should be given to model validation by comparing outputs with observations quantitatively. Finally, it recommended that the Nov. '93 case study include more explicitly the "problem topics" listed in the table above.

Our understanding is not yet sufficient to be able to specify the critical data needed to provide space weather predictions. However, mechanisms need to be put in place that allow research scientists greater access to real time data with some modicom of data verification control. This would allow the development of mechanisms whereby the data critical for space weather predictions could be made available in a timely manner in the future. Beyond this, the working group recommended closer collaborations between CEDAR and GEM, perhaps annual joint meetings, had concern with the need for rapid progress with significant capabilities in place for the next solar maximum (2001-2002), and suggested an approach whereby we initially focus on a smaller number of issues on which we believe we can make significant progress in a short time.

The third working group, led by Geoffrey Crowley and Pat Reiff, discussed how to proceed with global case studies. Case studies are particular time intervals, often chosen because a particular type of event occurred (e.g., a magnetic storm), that are selected for a comprehensive study by the community. Focusing our limited resources onto study of a particular event maximizes the chances of understanding the complex interrelationships and coupling in the solar-terrestrial system. It also makes possible a comprehensive suite of reduced and interpreted data that characterizes the environment during that period. That data suite can be synthesized by various empirical models and can also be used to test and verify all types of physical models, as this data suite will usually contain both the input parameters needed by the model, and measurements corresponding to model outputs.

The working group first asked what lessons had been learned from the Nov. '93 Magnetic Storm which had already been extensively studied and reported on in the morning. Then it considered requirements for future campaigns, the science issues to be addressed and the data requirements. Although the Nov. '93 study had been very successful and had provided a great test bed for collaboration and for methods of data collection and promulgation, there were a number of problems with the period. Foremost was the lack of full solar wind coverage for the event. This lack was particularly critical to global magnetospheric models that wanted to try to reproduce the event. The fact that the event occurred near full Moon (making ground based optical data collection difficult) and not on an incoherent scatter radar world day meant that ionosphere coverage was not ideal. Furthermore, although there were several geosynchronous satellite data sets, there was no geotail data or global auroral imaging. Any new event selection should try to eliminate as many of these shortcomings as possible. The launch of several ISTP and related spacecraft (WIND, POLAR, SOHO, FAST, INTERBALL) in the last 2 years now eliminates many former shortcomings, and full advantages should be made of these spacecraft while they are all operational. Alerting ground based observatories to upcoming interesting spacecraft conjunctions so that they can coordinate data collection is an important first step. However, planning ahead does not ensure that interesting geophysical events will occur. The working group also recommended an "alert" mechanism be put in place so that observatories that can respond quickly can be notified of interesting events, for example a solar active region at the trailing edge of a CME, such as is thought to be the cause of the Nov. '93 storm.

This working group also identified various science questions that would benefit from a global case study. These included the magnetosphere/ionosphere dynamical response to a period of northward IMF, the triggering of substorms, the interaction of high speed solar wind streams with the Earth, the "quiet" magnetosphere, and the origin of the so-called "killer electrons" - MeV electrons that can cause significant spacecraft damage.

In summary, the first CEDAR/GEM Workshop on Space Weather was very successful in achieving its two main objectives: a better understanding by the magnetospheric and aeronomic communities of how "space weather" is perceived by the other, and of how we can collaborate better to solve our joint problems. The number of magnetospheric scientists attending, while sufficient for the needs of the discussion, was nevertheless a little disappointing. Of course it was much easier for CEDAR meeting attendees to remain in Boulder for another day to attend this workshop than it was GEM meeting attendees to include Boulder in their trip to Snowmass. Earlier and broader announcement of the workshop next time would certainly improve attendance. It was that agreed similar joint workshops are needed in the future, and the GEM and CEDAR Steering Committees will discuss how best to organize them.

Jeffrey Hughes and Michael Mendillo, Co-Chairmen

Recent Space Weather Developments

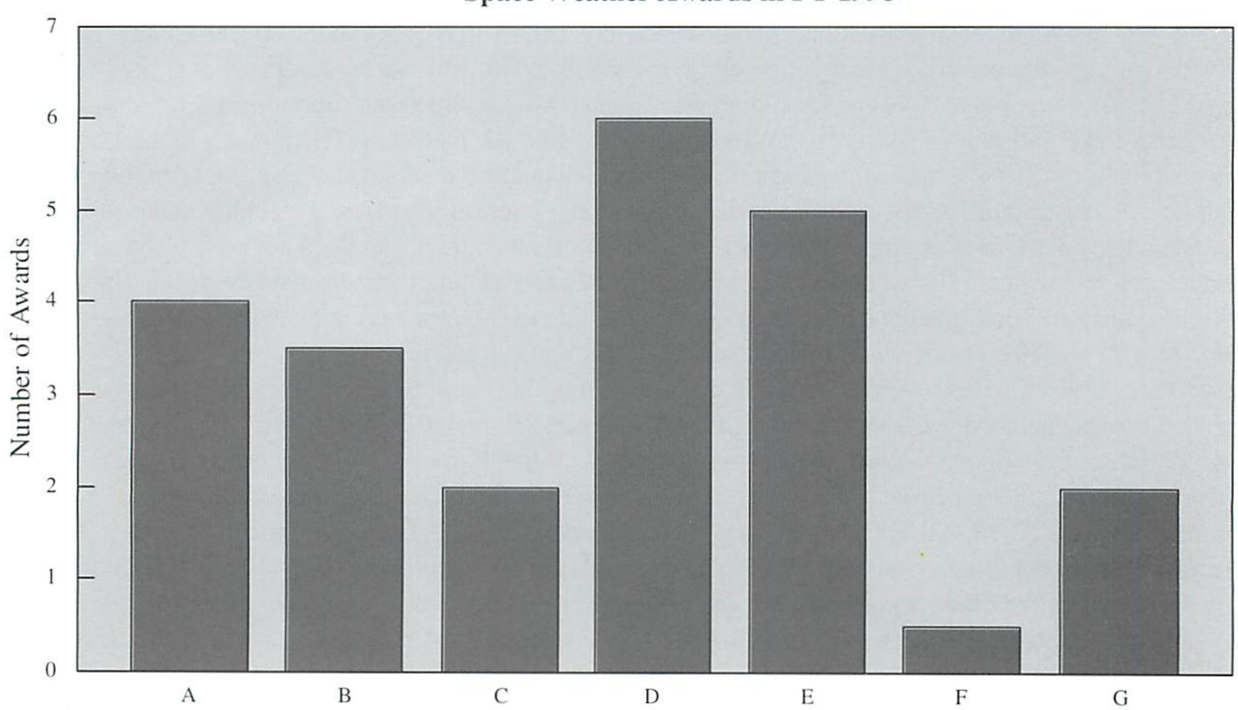
First Round of National Space Weather Program Awards Announced

The National Science Foundation has announced the 23 awardees selected for funding under the newly initiated National Space Weather Program (NSWP). Eighty-one proposals were submitted in response to the multi-agency program solicitation, with a total of $6,750,000 in requests for first year funding. The total funds available were $1.2 M and included contributions from NSF Atmospheric Sciences, NSF Office of Polar Programs, Office of Naval Research, and Air Force Office of Scientific Research. Most of the awards were three-year continuing efforts.

The Project Solicitation listed six areas of research identified as being of high priority in these early efforts to improve the Nation's ability to specify and forecast space weather conditions. These six areas included topics related to the Sun and solar wind, the magnetosphere, and the ionosphere/thermosphere system. The proposals submitted and selected were approximately equally divided in these three broad areas of research. A bar chart showing the distribution of the awards in these areas is shown below. Government agencies leading the NSWP are hopeful that a second Project Solicitation will be released early in 1997.

R. Behnke, Head
Upper Atmosphere Research Section

Space Weather Awards in FY 1996



A: Understanding and prediction of processes affecting solar variability
B: Coupling between the solar wind and the magnetosphere
C: Origin and energization of magnetospheric plasma
D: Triggering and temporal evolution of storms and substorms
E: Evolution of ionospheric irregularities and scintillations
F: Thermospheric dynamics and its coupling to the ionosphere
G: Other

Space Weather: Research to Operations
(Meeting Scheduled for January 16-17, 1997)

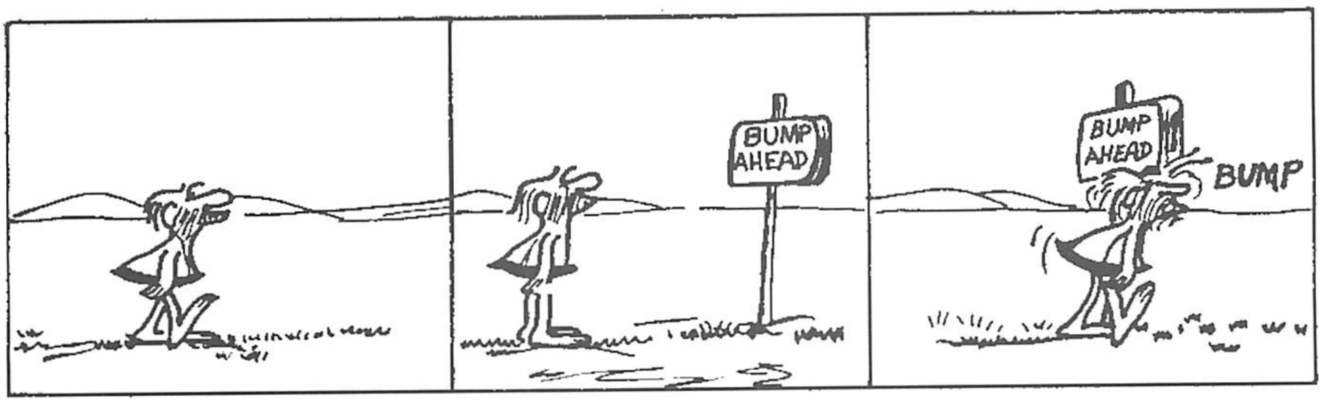
Recent funding from the NSF/DoD for space weather modeling has brought us to a new stage in the National Space Weather Program where more emphasis is needed on the transition of models to operations. A meeting to concentrate on the near-term and future transition of research models and data into operational use will be held in Boulder, CO, on January 16 and 17, 1997. The meeting is being jointly organized by the NSF Division of Atmospheric Sciences, the AF Phillips Laboratory Geophysics Directorate and the NOAA Space Environtment Center. The purpose of this meeting is to provide a forum for space environment modelers and other researchers to interact with people from organization that provide forecasts and services to space weather customers and to address the science problems that are important for space weather activities. The meeting will broaden the outlook of previous meetings, which concentrated on the GEM Global Geospace Circulation Model (GGCM), and will welcome participation from the solar, interplanetary, magnetospheric, and ionospheric communities. The meeting will provide an opportunity for modelers to show tools that are currently available for transition to space weather services, and especially for recent recipients of National Space Weather Program funding from NSF/DoD to show their plans and how they might interface with Rapid Prototyping Centers and Space Weather Operations.

Conveners: Howard Singer (SEC), Terry Onsager (SEC), Greg Ginet (AF) and Rich Behnke (NSF).
Program Committee Members: Bob Carovillano (NASA), Joe Huba (NRL), Jeff Hughes(GEM), Michael Mendillo (CEDAR) and Vic Pizzo (SHINE).

Additional details regarding the meeting agenda and logistics will be distributed shortly.

SPACE WEATHER QUIZ:

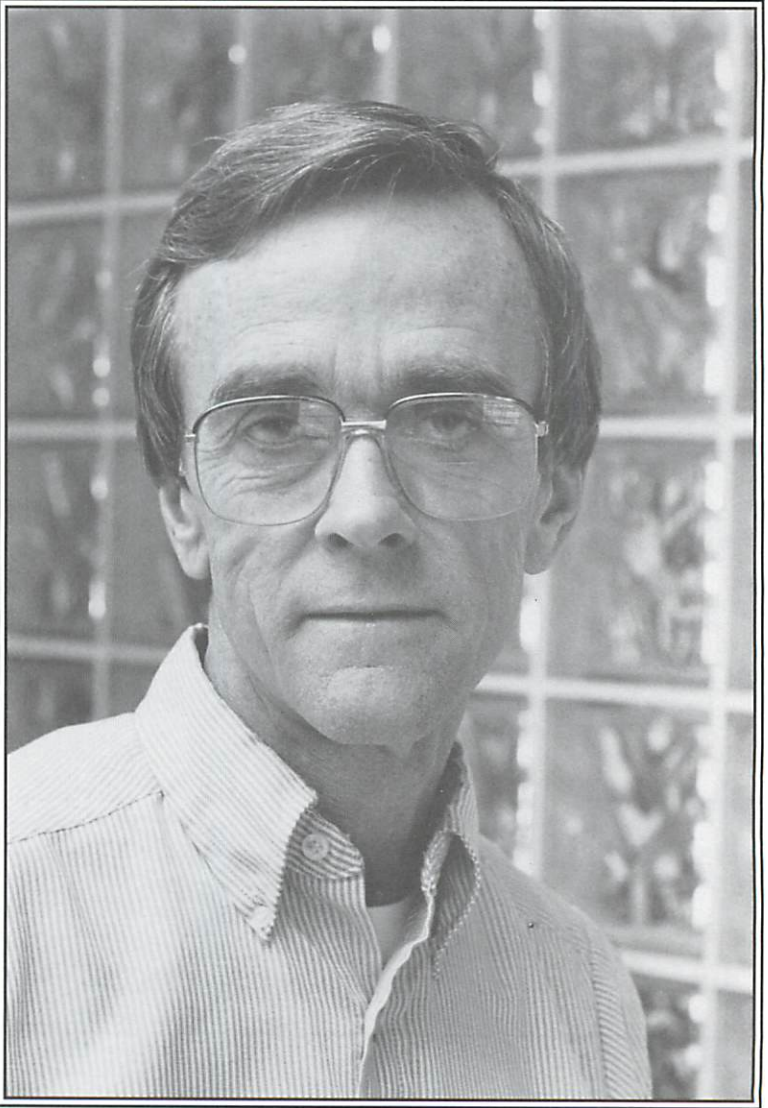
Is this "forecasting" or "nowcasting'?



Don Farley Wins the Appleton Prize

CEDAR Well Represented at URSI

Donald Farley, Professor of Electrical Engineering at Cornell University since 1967, was awarded the 1996 Appleton Prize at the International Scientific Radio Union (URSI) General Assembly held recently in Lille, France. The citation for the prize, awarded by the Council of the Royal Society of London once every three years, was for "contributions to the development of the incoherent scatter radar technique and to radar studies of ionospheric plasma instabilities." The prize commemorates the memory of Sir Edward Appleton, Nobel Laureate in physics in 1947 and President of URSI, 1934-52. The last American scientist to win this prestigious award was Peter Banks in 1978.



The CEDAR community is well aware that the incoherent scatter radar (ISR) technique is one of the most powerful tools for probing the ionosphere from the ground, even though the scatter from the tiny thermal fluctuations in electron density is very weak. The idea of ISR was first proposed by W. E. Gordon in 1958 at Cornell University (where Farley was then a graduate student). The scattering is more complex than Gordon realized in 1958, but the complications make the measurements a far richer source of information. From the spectrum of the scattered signal, one can determine most of the important parameters of the ionospheric plasma. Farley was one of the several pioneers who, in the early 1960s, independently developed the plasma kinetic theory (a new topic for most radio scientists in those days, and so each developed his own version), in collaboration with John Dougherty at the Cavendish Laboratory in Cambridge. In a series of five papers (three with Dougherty) the details for most cases of practical interest in the ionosphere were worked out.

Farley's work with the ISR technique extends far beyond theoretical considerations alone. Because of the ever-present need to improve spatial and temporal resolution of the ISR, sophisticated data-taking and processing methods are needed. Farley (sometimes jointly with his graduate students) was the first to develop and describe many of the techniques that are now routine (e. g., the use of multiple pulses and that of pulse compression via Barker codes). He has also remained closely associated with one of the major ISR observatories, the Jicamarca Radio Observatory in Peru, from its first observations in 1961 to the present (Director during 1964-67, now Principal Investigator of the NSF Cooperative Agreement that provides nearly all the funding for the Observatory).

The second theme of Farley's work has been radar studies of ionospheric plasma instabilities. Farley was the first to point out (in a 1963 paper that became a Current Contents 'Citation Classic' and won a Department of Commerce award) that a type of radar echo seen at the magnetic equator was due to a ion-acoustic plasma instability, driven by dynamo currents flowing in the ionospheric E-region. Farley's theory was the first of a true plasma instability (growing plasma waves) in the ionosphere. This area of research has continued to the present, with numerous experimental and theoretical publications (many in collaboration with his Cornell graduate students and postdocs) on equatorial and auroral electrojet and equatorial F-region instabilities, the latter commonly known as spread-F. The triggering of spread-F continues to be a 'hot topic' of study under the National Space Weather Program.

It must have been very gratifying for Farley that Gordon was on the podium (as Honorary President of URSI) when Farley received the Appleton Prize. It must have been equally pleasing to have many of his former Cornell graduate students be recognized at the same ceremony with URSI Young Scientist Awards. Farley's thesis advisor at Cornell, Henry Booker, was a student of J. Ratcliffe, who worked under Appleton at the Cavendish Laboratory in Cambridge; quite fittingly, this year's Booker Fellow (the best known of the Young Scientist Awards) was Farley's former student, John Sahr of the University of Washington (member of the CEDAR Steering Committee, 1993-96). The two other former Cornell students recognized with Young Scientist Awards were David Hysell of Clemson University, current CEDAR Steering Committee member, and John Cho of Arecibo Observatory, the CEDAR Prize Lecturer for 1993. Elaine Chapin, now at the Jet Propulsion Laboratory, California Institute of Technology also attended the URSI meeting with a Young Scientist Award. Elaine is a former student of Erhan Kudeki of the University of Illinois, who was himself a student of Farley. As Farley pointed out in his very enjoyable acceptance speech, "this makes Elaine something like the great, great, great, grand-student of Appleton!" This is how science flourishes from generation to generation, motivated by dedicated teachers.

Sunanda Basu
Chair of Commission G (Ionospheric Radio and Propagation)
U.S. National Committee of URSI

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Further details in this issue!!!!!

The 1996 CEDAR Meeting Workshop Reports

1996 CEDAR Meeting
University of Colorado June 16-22, 1996

The 1996 CEDAR Workshop was held between Sunday, June 16, and Saturday, June 22, at the University of Colorado in Boulder. The Sunday session was a workshop for students, and the subsequent Saturday was a joint CEDAR/GEM day, dedicated to the topic Space Weather (see companion article). A total of 270 persons registered for the Monday-Friday Workshops, coming from 39 universities and 25 research laboratories, with 6 universities and 3 laboratories outside the United States. NSF supported the on-site expenses for 109 students, including 4 students from the National Central University in Chung-Li, Taiwan, and 1 student each from England and Spain. These numbers are about the same as 1990-1991, or about a 14% decrease in attendance, posters, and institutions compared to the 1995 Meeting.

The joint CEDAR/GEM day on Saturday, June 22, drew just over 100 people, about half CEDAR and half GEM.

The CEDAR Prize lecture was given by Chester Gardner of the University of Illinois on the ALOHA/ANLC-93 Campaigns using lidar and other middle atmosphere instruments to study noctilucent clouds at high latitudes during the summer, and gravity waves and tidal perturbations around Hawaii. Iain Reid of the University of Adelaide gave the first tutorial on intercomparison of middle atmosphere winds from different instruments which was followed by a panel of 4 experts to discuss the issues in a new "debate" format. Bela Fejer of Utah State University gave a tutorial on low latitude storm time ionospheric electrodynamics using a large amount of data from the Jicamarca IS radar. The final tutorial was given by Richard Wolf of Rice University on magnetospheric models used in space weather and as inputs to ionosphere/thermosphere models. Hard copies of the transparencies are available, as are video tapes of these talks. Please contact Barbara Emery (emery@ncar.ucar.edu; HAO/NCAR, PO Box 3000, Boulder, CO 80307) if interested in obtaining copies.

There were 22 workshops this year, including the third annual student workshop where job prospects were discussed with a diverse panel. These workshops are reviewed elsewhere in this issue. This was the first year of CEDAR "Science Highlights," which were 15 minute talks given by Rashid Akmaev of the University of Colorado, Michael Reeves of the University of Michigan, Michael Sulzer of the Arecibo Observatory and Michael Taylor of the Utah State University.

There were 58 posters shown at the most popular poster session in CEDAR meeting history! The university did an outstanding job of catering the reception held at the same time. Students were first authors on 41 posters, and there were prizes for the best 4. The first prize of the Feynman lectures went to Robert States of the University of Illinois for his poster on a lidar system using a Fabry-Perot Interferometer. The second prize of an autographed copy of The Earth's Ionosphere by Michael Kelley went to Sergei Maurits of the University of Alaska for his magnetic storm model simulation. Two third prizes of University of Colorado sweatshirts were given to Christian Alcala of Cornell University and Rachel Cox of the University of East Anglia in the UK for their posters on the summer polar mesosphere and laboratory studies of upper atmospheric sodium ions, respectively.

New members of the CEDAR Steering committee were chosen, including the new student representative, Paul Castleberg of Cornell University, who spends most of his time at the Arecibo Observatory. Both Paul and David Hysell will be responsible for the student workshop at the 1997 CEDAR Meeting. David will also be the poster person, while Michael Taylor and Cassandra Fesen will organize the workshops. Gary Swenson and John Holt will find tutorial and CEDAR science highlight speakers. Michael Mendillo will be responsible for finding the CEDAR Prize Lecturer and Barbara Emery will be the local organizer. Anyone with any ideas for these events should contact the appropriate person. The 1997 CEDAR Meeting will be held at the University of Colorado between Sunday June 8 and Saturday June 14, 1997. This is a week earlier than the 1996 Workshop, but will still precede the GEM Workshop to be held at Snowmass June 16-20. The weekend in between (June 14-15) will be explored as a time to have a joint CEDAR/GEM/SHINE space weather meeting of some sort.

Barbara Emery, HAO/NCAR

POLITE Workshop

Convener: Philip Erickson
Date: Thursday, June 20
Attendance: 20+

A successful initial workshop on goals and future plans for the POLITE series of topside light ion World Day campaigns was held as part of the 1996 CEDAR workshop series. POLITE stands for Plasmaspheric Observations of Light Ions in the Topside and Exosphere, and aims to advance our understanding of the morphology and dynamics present in the topside ionosphere and the neutral exosphere. The encouraging response from the entire topside community to the POLITE effort indicates that significant advances in topside science should indeed be possible through this experimental effort.

The workshop began with a short series of presentations of radar results from the initial POLITE run on February 13-14, 1996, by Sixto Gonza'lez (Arecibo), Phil Erickson (Jicamarca, Millstone Hill), and Yadu Zambre and John Kelly (Sondrestrom). Phil also presented some plots of DMSP satellite data as it passed over each of the radar sites during the POLITE-1 period. Discussion during this period centered on the unusually quiet nature of the February period, as well as the somewhat low transition altitude seen at Millstone Hill. Robert Schunk also suggested simulating Millstone Hill IS spectra in an effort to make sure that large electric fields are not producing non-Maxwellian spectra which are incorrectly interpreted by fitting processes.

Most of the time, however, was spent on preparing for the POLITE-2 World Day which will occur on November 11-14, 1996. Several satellite and optical experimentalists expressed interest in participating in this upcoming campaign. The UARS photoelectron instrument was mentioned by Richard Link, and he and James Bishop may be able to provide global maps of the 10830 Å emission line of neutral helium. Fred Roesler raised the possibility of observations of neutral hydrogen with the Wisconsin H-alpha instrument. Bob Kerr's infrared Fabry-Perot will be on site at Millstone Hill to observe neutral helium as the incoherent scatter radar measures light ions. Combined with the Arecibo, Jicamarca, Millstone Hill, and Sondrestrom incoherent scatter radar facilities, the November period should thus be well covered.

Phil Erickson will be serving as the POLITE coordinator for the November campaign and future campaigns in 1997 (tentatively June and December). Those researchers wishing to participate in the topside observations or to find out more about the overall activities are encouraged to contact Phil at (617) 981-5769 or by e-mail at pje@hyperion.haystack.edu. We plan to organize future POLITE workshops at either AGU meetings or as CEDAR workshops to present results of recent campaigns and fine-tune subsequent observational efforts.

Arecibo Workshop

Convener: Craig Tepley
Date: Wednesday, June 19
Attendance: 60+

Following a suggestion made by Cassandra Fesen before the meeting, Paul Castleberg, a graduate student at Cornell University and current Arecibo resident, "volunteered" to lead the meeting discussions. Paul did an excellent job and returned the fire by calling on Craig Tepley and Mike Kelley to discuss the current status of the upgrade projects at Arecibo and future (post-upgrade) observational plans, respectively. Paul also discussed the lidar facilities and current observations, while Brett Isham reviewed upcoming HF facility campaigns and the details of our new atmospheric sciences highlights web page, AO-VIEW, that is under development.

The second half of the workshop consisted of an open forum to discuss and gauge the interest, and the need, for Arecibo to host a special science planning workshop, separate from the CEDAR Meeting. This workshop will likely take place sometime in the early part of 1997. This is a time when many of the upgraded systems will be completed, and is a good time to plan for new and unique investigations that can utilize the full potential of the clustered instruments at Arecibo. After a long period of limited facility use at Arecibo, we look toward reinvigorating our user community and at the same time, wish to solicit new investigators who can exploit the full potential of the "New Arecibo." A science planning workshop is one way to stimulate this activity.

Judging from the discussions at the meeting, community interest in such a separate workshop was moderately high. About 62% of those who answered the questionnaire were positive and expressed a desire to participate, so we decided to take the next step. Look for our first announcement, which will be sent out soon via e-mail. Until then, if you have any questions or wish to pass on any suggestions or comments, please do so by contacting either Mike Kelley or Craig Tepley.

<u>*Note added at press-time*</u>: Professor Kelley reports that the Arecibo Science Planning Workshop is now scheduled for 9-11 January 1997 at Arecibo.

THE JOURNAL OF ATMOSPHERIC AND TERRESTRIAL PHYSICS ANNOUNCES

The availability of a special October 1996 issue of JATP titled:

INVITED REVIEW ARTICLES FROM THE 1995 CEDAR WORKSHOP

You may purchase a copy by sending a check or money order for $25.00 ($20.00 plus $5.00 shipping) to:
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USA

Data Analysis Workshop

Convener: Scott Palo
Date: Thursday, June 20
Attendance: 40

The first CEDAR workshop on data analysis was a success with quality discussion on a wide range of topics. The format of this two hour workshop had five invited speakers to motivate discussion on current data analysis issues: Todd Valentic, Ron Clark, Jamie Bergen, Jeff Thayer and Scott Palo. Although a little tight on time, these speakers covered several data processing issues: (1) the results obtained by two different meteor radar processing systems using the same observations, (2) significance levels for power spectra and the Lomb-Scargle periodogram, (3) possible errors in Rayleigh lidar temperature inversions, (4) and errors resulting from the extraction of tidal parameters from data with periodic gaps. While there was discussion on all of the material presented, two major themes appeared to emerge. The first was the need for cross-validation of analysis procedures. Two possible ideas for cross-validation were the development of a test data set and the addition of validated processing algorithms to the CEDAR database. The second major issue was how to incorporate data analysis issues into the CEDAR meeting. Suggested possibilities included the continuation of the data analysis workshop to address current processing issues, and another data school or a CEDAR tutorial to provide an overview of currently accepted or newly developed data processing methods which are of interest to the CEDAR community. If you have any additional ideas or suggestions regarding this workshop please contact Scott Palo (palo@ucar.edu).

MISETA Workshop

Convener: John Meriwether
Date: Friday, June 21
Attendance: 40+

The initial discussions at this year's workshop reviewed milestone objectives for MISETA to assess its progress in investigating equatorial aeronomy. In the last year MISETA has been quite productive: its achievements include a special session at the AGU last December, a total of 11 journal papers in progress, submitted, or published, two completed campaigns with excellent data, and a third campaign scheduled for Fall 1996. At the CEDAR workshop, the participants discussed whether to broaden the MISETA horizon to include the equatorial aeronomy of the Pacific. This discussion was followed by a show and tell review of the results from the MISETA II campaign that took place in April, 1996. The talks centered on two major themes: large scale thermal structure and the issue of scintillation and spread-F activity. The workshop concluded with a discussion of the planning for the MISETA III campaign scheduled to begin on 1 October 1996. It appears likely that the Peru optical and radar observations will be supplemented by similar observations from northern Chile and from Tucuman (Argentina). For further details or additional information on the MISETA working group please contact one of the coordinators: John Meriwether, e-mail: john.meriwether@ces.clemson.edu, or Cassandra Fesen, e-mail: fesen@utdallas.edu

The Great CEDAR Phase III Logo Contest!!!

Send ideas and sketches to:
Professor Tim Killeen
Space Physics Research Laboratory
University of Michigan
Ann Arbor, MI 48109-2143

CEDAR-TIMED Collaboration Workshop

Convenors: Joseph E. Salah, John W. Meriwether
Date: Wednesday, June 19
Attendance: 100

The purpose of the workshop was to provide a discussion forum on the opportunities for collaboration between the TIMED satellite program and the CEDAR ground-based program, and to solicit input from the community for the proper planning for this collaboration. The workshop followed presentations made during the CEDAR plenary session by Mary Mellott (NASA/HQ) and Sam Yee (APL) on the TIMED program and the satellite instruments and capabilities, and by Jeff Forbes (U. Colorado) on the scientific motivation for ground-based support of the TIMED mission.

Brief presentations were made at the workshop on the technical issues associated with proper validation of the TIMED instruments (John Meriwether, Clemson), and on three scientific topics that have been identified by the TIMED science team as key projects for ground-based collaboration: small scale waves (presented by Dave Fritts, U. Colorado), large scale waves (Jeff Forbes, U. Colorado), and Joule heating (Geoff Crowley, APL).

Based on the overflow attendance at the workshop, the dynamic discussions, and the comments provided by the attendees, it is clear that there is strong interest and motivation for a well-organized collaboration between CEDAR and TIMED, as the two programs share many of the same scientific objectives. Many useful comments were provided by the attendees. Recommendations were made to get together with the UARS groups in order to review their experience in the validation of instruments, and to stay away from complex situations such as auroral conditions when such validation is attempted. It was also suggested that continuous measurements at specific sites would be most useful for small scale wave studies. The availability of properly distributed arrays of instruments to study waves and tides should be researched and, in particular, contact should be made with the PSMOS effort being organized by Gordon Shepherd. The need for adequate time and funds to properly deploy instruments was emphasized, as well as the need for southern hemisphere coverage. The importance of involving the international community in this collaboration was also discussed, and a suggestion was made to look into the organization put in place for the CLUSTER mission to enable space and ground-based collaboration. Ideas for expanding the science opportunities through TIMED-CEDAR collaboration, such as the study of electrodynamics, were also suggested.

Finally, various models for collaboration between the TIMED science team and the CEDAR working groups were presented by Joe Salah (MIT) as a catalyst for group discussion. In some of these models, coordination of the ground-based activities would be carried out by instrument or model coordinators while, in others, various team arrangements would be organized around TIMED or CEDAR science projects. Most attendees appeared to favor the team arrangements, and the definition of these teams could precede or follow the development of proposals submitted in response to program announcements.

It was clear that much work is still needed to fully define the collaboration and the mechanisms for its implementation. The initial brief workshop indicated much interest in a more complete discussion of the topics presented at CEDAR. The idea of a dedicated two-day workshop bringing together the space and ground-based upper atmospheric communities, including international partners, to define the parameters and mechanisms for the collaboration was recommended and deemed essential for a successful program. It was advised that it is essential that such a dedicated workshop be held soon, if the TIMED satellite were to be launched in early 2000 as presently projected. Salah agreed to define goals and approaches for such a workshop for review by NASA and NSF, and Mary Mellott indicated her plans to further pursue the idea with NSF and examine ways to facilitate holding a workshop on a timely schedule.

[_Note added at press time_: The TIMED Science Working Group met at APL on September 11, 1996, and endorsed the idea of a joint workshop. NASA approved the plan for such a workshop. APL will work out the support requirements. It is expected that the workshop will be held at APL in the March 1997 time frame. Further information will be distributed to the community as workshop plans are defined.]

Jicamarca Radio Observatory Workshop

Convener: Donald Farley
Date: Thursday, June 20
Attendance: 50+

The year's goal was to describe recent research and developments at the Observatory and to discuss future plans. After a brief overview by Farley, W. Swartz discussed incoherent scatter temperature measurements. Moving the radar beam farther from perpendicular to B seems to have cleared up a long standing problem. E. Kudeki discussed a new processing scheme (full spectral analysis) for drift measurements that has substantially improved the data quality. Even the zonal drifts now have very little statistical scatter. D. Hysell showed the first results of imaging irregularities using a new antenna module that doubles the longest possible E-W baseline. B. Fejer discussed ongoing modeling work and comparisons with Jicamarca drifts. B. Reinisch described digisonde drift measurements at Jicamarca. R. Woodman described Peruvian/Jicamarca collaborations, including MST studies with the University of Piura and some interesting PMSE (polar mesospheric summer echoes) data obtained in Antarctica with a mini-Jicamarca radar. PMSE can be observed in Antarctica, but they are much weaker than in the northern hemisphere. Other Jicamarca work was presented in the MISETA and POLITE workshops.

The JULIA system (an unattended, lower power radar) is now operational at Jicamarca, although it still uses some "borrowed" equipment. It has already been used for some observations. There was considerable discussion of, and enthusiasm for, the idea of upgrading the Jicamarca antenna so that the beam position can be rapidly (electronically) switched. This would allow interleaving of complementary measurements and would benefit virtually every research program. It will require 128 high power phase switches, however, and will be expensive, so we are proceeding cautiously. The goal is to design and build one or more prototype switches and thoroughly test them in operation in the antenna before proposing the full upgrade.

Anyone interested in further information on Jicamarca should contact Farley; donf@ee.cornell .edu and/or Woodman; ron@roj.org.pe or ron@ geo. igp. gob.pe.

MSIS/HWM Update Workshop

Convener:: Mike Picone
Date: Friday, June 21
Attendance: 30

The purpose of this workshop was to inform the community of plans by NRL for updating the MSIS neutral atmosphere and HWM wind models and to solicit information regarding data sets on which to base future revisions of the model. Al Hedin, producer of the models, has recently retired, and NRL has committed resources to further their development. The work will take place at the Space Science Division of NRL, in the Upper Atmospheric Physics Branch headed by Bob Meier. Mike Picone, head of the Upper Atmospheric Modeling Section, will direct the effort. Daniel Melendez-Alvira and Owen Kelley will be significant contributors. Bill Oliver and Michael Buonsanto have been major participants in the initial steps of the revision process.

Al Hedin has suggested that the first order of business for the MSIS update is an improved neutral temperature data base. As a significant portion of the MSIS direct temperature data came from the Incoherent Scatter Radar (ISR), key topics of this workshop were the technique of neutral temperature retrieval from ISR data and the availability of appropriate ISR data sets. Bill Oliver summarized the status of this activity, including recent results on the "Burnside Factor," as described in an earlier workshop chaired by Joe Salah. He also discussed extraction of the neutral oxygen density ([O]) from ISR data. The discussion was quite optimistic regarding the use of energy balance to retrieve the exospheric temperature, T_{ex}, from the ISR measurements, especially since the results have only a weak sensitivity to the value chosen for the Burnside Factor. On the other hand, far greater care is necessary in deriving [O]. While the group set no firm rules for obtaining accurate values of T_{ex}, restriction to ISR data near the region of the F2 peak was deemed to be safe, except perhaps for low-latitude winter nights, when an important amount of H^+ might exist, even near the F2 peak.

Mike Picone discussed a number of experimental (ARGOS, RAIDS) and DMSP (SSULI) systems built by NRL for future multi-year satellite missions over the next twenty years. These and other systems (e.g., TIMED and SSUSI) will measure neutral temperature and major neutral thermospheric species on the dayside and ionospheric F-layer O^+ on the day and night sides. The resulting tidal wave of data will significantly enhance the MSIS model and standard ionospheric models.

The workshop covered the status of ISR data sets developed at Millstone Hill and Arecibo and of neutral temperature measurements by Fabry-Perot Interferometry. In particular, Michael Buonsanto has developed a significant set of data on T_{ex} using Millstone Hill measurements covering the past eight years. Mike Sulzer has completed a significant enhancement of the Arecibo ISR data set covering the last eleven years. In addition, Mike Sulzer provided an illuminating discussion on ISR data analysis in general.

Additional topics of considerable interest concerned improvements of MSIS performance in predicting the atomic hydrogen concentration and the temperature in the mesosphere and lower thermosphere. The workshop also covered limitations regarding the latitudinal and epochal coverage of the underlying data sets and discrepancies between the MSIS [O] and recent rocket-borne ultraviolet measurements at various levels of solar activity.

For further information, please contact either Mike Picone (T: 202-404-7880, F:202-404-8090, or picone@uap.nrl.navy.mil) or Bill Oliver (T: 617-353-4694, F: 617-353-6440, or wlo@bu.edu). We plan a similar meeting at the 1997 CEDAR Workshop.

Atomic Oxygen Ion-Neutral Collision Frequency

Convenor: Joseph E. Salah
Date: Monday, June 17
Attendance: 70

The purpose of the workshop was to assess whether it is time to revise the CEDAR interim standard for the atomic oxygen collision frequency which was adopted at the 1992 CEDAR Meeting and recommended for community usage [Salah, *GRL, 20*, 1543, 1993]. The interim standard has achieved the objective of facilitating the comparison of experimental data and theoretical model results using a common collision frequency model adopted from Roger Burnside's work at Arecibo [Burnside et al., *Ann. Geophys. 5A*, 343, 1987], and confirmed by other observations elsewhere that were available at that time. This collision model was expressed as a factor of 1.7 ("Burnside factor") times the value given by Dalgarno [*JATP, 26*, 989, 1964]. The 1992 workshop also motivated special attention to this important parameter in ion-neutral coupling and, as a result, substantial effort has since been devoted by various groups to the investigation of the apparent discrepancies between various approaches to its determination. A session was devoted at the Spring 1996 AGU session to this topic. The CEDAR 1996 workshop reviewed these various results and developed an updated consensus on the ion-neutral collision frequency for atomic oxygen.

The status of three approaches to the determination of the atomic oxygen collision frequency were discussed at this workshop - theoretical models, laboratory measurements, and empirical analysis. Theoretical models were reviewed by Dean Pesnell (Nomad Research, Inc. & NASA/GSFC) who reconfirmed that his model still stands given the available potential energy curves. He indicated that he does not expect any changes in his recommended "factor of 1.3" relative to the Dalgarno formulation [Pesnell et al., *GRL, 20*, 1343,1993]. Pete Hickman (Lehigh U) described his study of the sensitivity of the collision cross-section to the fine structure of atomic oxygen, but showed that when a proper averaging over various states is conducted, his results agree with the Pesnell value.

Laboratory measurements in progress by Ken Smith (Rice U), who was unable to attend, were discussed based on his presentation at the Spring 1996 AGU meeting. He expects to complete his measurements of the atomic oxygen collision cross-section at high energy (50 eV) in the next few months, but measurements at the ionospheric thermal energies (sub-eV) are more difficult and will take a longer time. Various attendees commented on the importance of obtaining the high energy measurements to confirm those made by R. Stebbings in 1964, even though we have to rely on theory to extend these numbers to the relevant energy levels.

Empirical analysis included studies at Millstone Hill and EISCAT. Bill Oliver (NCAR and Boston U) explained his use of the ion thermal energy balance to compute the atomic oxygen cross- section using Millstone Hill data. He obtained a "factor of 0.75" which he explained may indicate the presence of a "hot oxygen" heat source that needs to be included in the thermal energy balance. He noted that he is comfortable with a "factor of 1.3" if hot-O accounts for 1-2% of atomic oxygen at 400 km during solar minimum, and less at solar maximum. Michael Buonsanto (MIT) described his careful recomputation of the collision frequency factor from a large data set of ion drifts and neutral winds at Millstone Hill, using Monte Carlo statistics, and set a revised value of a "factor of 1.2 ± 0.2." A summary of EISCAT results provided by Alan Aylward (UCL) were then reviewed, with emphasis on the importance of eliminating data with systematic errors when computing the collision frequency from radar-optics wind measurements [Davis et al., *Ann. Geophys. 13*, 541, 1995]. Although only a small set of data is available so far from EISCAT, a factor less than 1.7 is certain, and the best approximate value is around 1.2-1.3 based on what is available so far, but this is not considered to be enough to draw definite conclusions. Future plans at EISCAT for carefully coordinated measurements between radar and optics along the magnetic field lines and tristatically were then described.

The general discussion on whether we should move towards a revised standard at this time was quite spirited. There was general agreement that the interim standard of 1.7 is likely to be too high, and various attendees strongly urged that it should be changed in light of the new results. The question was raised whether we should wait for further confirmation from the laboratory measurements, from the new EISCAT experiments, and from the recomputation of the value from more recent and larger Arecibo data set. It was reported that Kazem Omidvar (NASA/GSFC) was interested in carrying out the Arecibo analysis using a technique proposed by Colin Hines at the AGU meeting, which attempts to eliminate systematic errors.

The chief concern about waiting for the new results was that they may take over a year or so, and during that time, we would continue to use an "incorrect" value, given what we now know about the derivation of this parameter. There was general pressure to move to the best value we have today, even though there is a risk that further changes may occur later. The consensus was to reduce the factor to 1.3, and call it the "revised interim standard". The equation adopted is that given (Eq. 5) in the Pesnell et al. paper [*GRL, 20*, 1345, 1993]. The assembled students were asked their opinion and they voiced no objection to the consensus!

Accordingly, the adopted revised interim CEDAR standard for the atomic oxygen ion-neutral collision frequency is:

$$\upsilon_{O^+-O} = 3.0 \times 10^{-11}\, T_r^{0.5}\, (1 - 0.135 \log T_3)^2\, n(O)$$

where $T_r = (T_i + T_n)/2$, $T_3 = T_r/1000$, $n(O)$ is in cm^{-3}, and υ is in sec^{-1}

LIDAR Workshop

Conveners: Jeff Thayer and John Meriwether
Date: Monday, June 17
Attendance: 50+

Purpose: The LIDAR workshop was designed to provide an open forum for animated discussion of important issues in the LIDAR field relevant to the CEDAR program.

Format: The workshop was conducted in a roundtable format with a convener directing the flow of the discussion and elucidating focused concepts. The audience was composed of a good mix of graduate students and researchers either involved directly with LIDAR programs or interested in the subject. Topics were introduced and then open for discussion to the general audience.

1. *Resonance LIDAR Measurements*

- Temperature/Wind Techniques: This discussion focused on the current efforts to develop Potassium systems capable of wind and temperature measurements in the mesopause region and the potential and feasibility of determining temperature by the iron Boltzmann technique. The iron Boltzmann technique is based on monitoring the resonance returns from two different energy states of iron and using the Boltzmann relation to determine the temperature. It was emphasized that this approach would use broadband lasers and simple receivers that would lead to a more robust field instrument.
- Other Resonance Lines (i.e., calcium, calcium ion, iron, potassium): This was a short discussion concerning the approaches used to monitor resonance lines other than sodium and the potential physics to be obtained from such a measurement. It was clearly stated that if adequate measurements of the potassium density were made in a few disparate geographical locations over the past years, the signal limitations of potassium temperature and wind LIDAR systems would have been clearly recognized.
- Sporadic Layers: An important area of discussion was the measurement of sudden or sporadic layers of both ion and neutral alkali metals and the importance of these measurements at sites coincident with active radiowave systems such as digisondes and incoherent scatter radars. Important questions concerning the latitudinal differences of these sporadic layers were discussed hinting that different mechanisms may be at play for low and high latitude sporadic layers.

2. *Rayleigh LIDAR Measurements*

- Temperature Inversion Layers: This discussion began with an overview of how Rayleigh LIDARs derive the temperature in the middle atmosphere. Emphasis was placed on using other measurements, such as OH rotational temperature measurements, to provide a starting temperature for the downward integration used in the Rayleigh temperature analysis. It was followed by a detailed discussion of mesospheric temperature inversion layers observed in Utah as well as comparisons with model simulations.
- Doppler Techniques: An interesting contribution was made by Jonathan Friedman in which he showed that the iodine absorption cell may well be used to determine Doppler shifts. The principle is complicated to explain, but in essence the detector is monitoring an iodine cell transmission of the backscattered signal from the sky. A Doppler shift would either increase or decrease the signal detected because the transmission profile of the cell is sufficiently narrow to see signal from the half-power point of the source profile. The sensitivity would be no different than that for a Fabry-Perot detector but there is an advantage in that no spectral scanning of the backscattered signal is required.
- Noctilucent Cloud Measurements: Rayleigh LIDAR measurements of noctilucent clouds over Greenland were presented along with derived temperature measurements of the cold summer mesosphere. A discussion concerning other instruments to augment these observations followed. UV spectrograph measurements in Greenland along with the LIDAR observations of

the NLCs in the summer of 1995 was a good example of combining instrumentation to advance NLC research.

Action Items: Large aperture systems were discussed and interest in using these systems for future research was emphasized as an important action item. Another action item discussed was to coordinate the various LIDARs for common observation periods either to support World Day efforts or satellite programs such as TIMED. A possible example of such a coordinated effort is being proposed for this coming winter to support the MLTCS campaign in January 6-10, 1997. Please contact Richard Collins (rlc@hoffa.gi.alaska.edu) if you are interested in participating in such an event.

Comments: Overall positive feedback was received from the workshop attendees concerning format, content, and time management. Suggestions were made to provide more of a LIDAR tutorial prior to the detailed discussions which followed. However, this may not be feasible in a workshop setting given the time constraints.

Future Plans: Next year's workshop might include an analysis of daytime capabilities for LIDAR systems and/or a more science-oriented workshop. Jonathan Friedman and Richard Collins expressed interest in organizing the workshop next year.

Contacts: As Jeff Thayer and John Meriwether have organized the workshop for the past two years, it would probably be best to contact either or both of them to discuss workshop plans for next year. Their e-mail addresses are jeff_thayer@qm.sri.com and john.meriwether@ces.clemson.edu.

Storm Study Workshop

Convener: Michael Buonsanto
Date: Friday, June 21
Attendance: 50

This was the 13th in a series of Workshops/ Sessions held since 1990. After introductions of those present, Michael Buonsanto presented an introduction to the CEDAR Storm Study. This was followed by status reports on studies of the March 1990 and June 1991 events, and then on two major ongoing projects:

1. *November, 1993, National Space Weather Interval*

- Gary Bust reported results of a detailed study of the night of November 4, using the MACE radio tomography chain. The derived reconstructions span the 25-70° geomagnetic latitude range and the 50-850 km altitude range. Following the storm onset early on November 4 a deep ionization trough developed, localized near 56°. The trough widened and became more structured over the course of the night. Strong mid-latitude Spread F was also seen.
- Barbara Emery presented AMIE equipotential and conductance patterns. A high speed solar wind stream was well anti-correlated with the Dst index during this event. A 10° drop in the auroral boundary latitude was seen. The availability of AMIE patterns will enable accurate modeling of the ionosphere and thermosphere during this event using the TIEGCM and other first-principles models.
- Rick Link presented initial results from the UARS Particle Environment Monitor (PEM). PEM provides data on the spectral characteristics and spatial distribution of energetic electrons and protons injected into the outer atmosphere, giving a quantitative picture of global energy deposition. A comparison with AMIE results will follow.
- The plasmaspheric response as observed by the Los Alamos VLBI interferometer was described by Michael Buonsanto on behalf of Gary Hoogeveen and Abe Jacobson. Large amplitude TEC disturbances were seen on the nights of November 5, 6, and 7, which can be explained by an inward motion of the plasmapause. The TEC fluctuations may be due to a Rayleigh-Taylor or interchange instability.
- Mike Ruohoniemi showed SuperDarn convection patterns, including a well-defined convection vortex found near 2200 UT on November 3. This lasted about 20-30 min, and coincided with the growth phase of a substorm seen in magnetometer data. Mike plans to carry out a comparison with AMIE results as a testbed for selection of different data sources.
- Roger Smith reported the response of winds and temperatures in the lower thermosphere above Mt. John, New Zealand (40° S), from 557.7 nm FPI observations. Neutral temperature increased by ~100K and the meridional wind increased by

65-70 m/s on the night of November 4 compared to a quiet night.

- Phil Richards described a study of F2 peak parameters observed by Australian ionosondes. NmF2 measurements at Hobart (43° S) showed a large positive phase which was well-reproduced by the FLIP model. However, the negative phase on November 5 was not seen in the FLIP model, indicating that increases in N2 and O_2 densities occurred which were larger than those predicted by the MSIS-86 model.
- Ron Clark showed meteor wind data recorded at Durham, NH. These indicate a shift in the zonal mean wind in the upper mesosphere and lower thermosphere which may be a response to the geomagnetic storm. Since it is still not known whether significant effects of geomagnetic activity often occur in the mesosphere, Ron plans to assemble mesosphere/lower thermosphere wind data from other locations to look for storm effects.
- Fred Biondi reported some initial results from Arequipa, Peru, where data were collected during the November 2-11, 1993 interval. Large perturbations in the winds and significant temperature variations were seen in response to the geomagnetic storm.

2. ***May, 1995 Storm Interval***

- Michael Buonsanto summarized the solar-geophysical conditions prevailing during the May 1-5, 1995 period, as well as the Millstone Hill incoherent scatter radar data. Good IMF data are available which show an abrupt southward turning of the IMF early on May 2 followed by arrival of a high speed solar wind stream which was present for the remainder of the interval. Kp reached 6+ on May 2 and geomagnetic activity continued through May 5. Large enhancements in NmF2 were seen at Millstone Hill on the evenings of May 2, 3, and 4, accompanied by rises of hmF2. Large fluctuations in the meridional neutral wind were seen each night, indicating the likely passage of traveling atmospheric disturbances.
- Monica Coakley reported on neutral temperatures at Millstone Hill determined from two sets of Fabry-Perot measurements of OI 6300 and from a heat balance calculation applied to IS radar data for the night of May 1-2, 1995. The data show heating that is consistent with the commencement of the storm. The data indicate the need for further work to fully identify the nature of the heating as well as the difference between the neutral temperatures determinations after the commencement.
- Josh Semeter presented results from the Boston University CEDAR Optical Tomographic Imaging Facility (COTIF) for the night of May 2. Measurements from four locations spanning the latitude range 41-47° N were used in conjunction with a nonlinear regularized tomography algorithm to reconstruct the volume emission rates in the latitude/altitude plane. Josh presented a comparison of the volume emission rates reconstructed using COTIF observations with photochemical equilibrium estimates made using coincident ISR measurements and the MSIS neutral atmosphere model.
- Michael Mendillo then presented airglow observations from Puerto Rico which showed a large depletion imbedded in a bright airglow background on May 3. This coincided with equatorial spread F observed at both Arecibo and Arequipa, and an extremely large fof2 value seen at Arecibo coincident with a 150 km drop in hmF2.
- Mike Sulzer described the Arecibo incoherent scatter data in more detail. The foF2 value of 13 MHz was the largest value seen at midnight at Arecibo in several years. The coincident hmF2 drop was accompanied by a rapid collapse of the O^+/H^+ transition level.
- Xiaoqing Pi presented global maps of total electron content obtained from GPS data obtained at over 90 sites worldwide. He compared the results with Topex-Poseidon data. The maps showed a substantial dusk effect in TEC, in agreement with the Millstone and Arecibo radar data, superimposed on a TEC decrease compared to previous quiet-time levels.
- Jeff Thayer reported on Sondrestrom incoherent scatter radar data. Strong electric fields and Joule heating were observed on May 2. High altitude resolution E region data will allow the height distribution of Joule heating to be accurately characterized.
- Mike Ruohoniemi described the SuperDarn data. Data from four radars were available. Large flows were seen at 0000-0400 UT on May 2, with >1 km/s ion velocities seen just before 0400; then coherent echoes disappeared due to absorption.

- The participants agreed to accept the May 1-5, 1995 storm period as a CEDAR Storm Study interval based on the interesting phenomena which occurred, as presented at this workshop. This interval is also designated as a "CADITS/MLTCS" period on the World Day calendar, so the data collected were designed to enable investigation of both E region/lower thermosphere and F region/upper thermosphere phenomena. The interval is designated as the "LTCS 11" campaign, and the LTCS community has shown particular interest, since geomagnetic activity effects on the lower thermosphere are not well characterized.

Future plans for the CEDAR Storm Study were discussed. Participants agreed to hold a 3-day workshop at Millstone Hill at the end of March, 1997. This workshop will replace the informal session normally held at the Fall AGU meeting in San Francisco or January URSI meeting in Boulder. Potential participants are urged to contact Michael J. Buonsanto, mjb@oceanus. haystack.edu

MSX 1996 CEDAR WORKSHOP REVIEW

Convenors: Gerry Romick, Bob O'Neil, and Mike Taylor
Date: Thursday, June 20
Attendance: 40+

The MSX workshop began with a quick review of the Spacecraft instrument complement and its current operation by Bob O'Neil and Jerry Romick. Data from the visible imagers on airglow observations in the southern hemisphere were shown in video format supplemented with viewgraphs on the type of spectral data that was obtained. Other data on stellar occultations were presented as the spacecraft followed a star setting below the horizon. Refraction and absorption effects were most apparent. Sam Yee presented a brief review of how refraction can be used to obtain the tropospheric temperature profile as well as water vapor content of the region.

Mike Kendra presented a discussion on the spacecraft orbit and how the various data collection observational configurations fit in with overpasses of individual as well as chains of ground stations. Mike Taylor then considered plans for ground site coordination, particularly for airglow and auroral sites over the next several months. There was some discussion about how to arrange coordination between ground observers and MSX overpasses. The decision was that Mike Taylor and Mike Kendra would be the primary contacts for initiating such cooperative campaigns. Further information on spacecraft activities and ground site coordination can now be obtained from our new web address:
http://www.plh.af.mil/gpo/earthlimb/home/html

The MSX Spacecraft has operated very well since the workshop. Both infrared and UV/Visible data has been obtained of the earth's limb and ground in darkness and sunlight. Data also includes stars occulted and refracted as they set below the horizon, aurora and lightning displays. Ground based coordinations have occurred over the Antarctic, the DOE Atmospheric Radiation Measurement Cloud and Radiation testbed (ARM CART) program site in Oklahoma, Hanscom Air Force base (radar cloud measurements), the University of Wisconsin LIDAR sites and during an Aerosol Campaign over Wallops Island. Future CEDAR coordinations are planned at Millstone Hill, NH, Poker Flat Research Range, AK, Bear Lake Observatory, and UT. We plan to schedule the bulk of our northern auroral experiments Nov.'96 - January'97 in coordination with the POLAR Satellite over either Poker Flat, Svalbard, or Kiruna/Tromso, Norway. If you are interested in participating please contact Mike Taylor (Taylor@psi.sci.sdl.usu.edu) or Mike Kendra (Kendra@pldac.plh.af.mil) with suggestions for additional sites, opportunities or specific spacecraft sensor and pointing configurations.

Analysis of the data is proceeding on several levels. Some of the infrared and UV/Visible imaging data is being processed for scene characteristics such as histogram moments, power spectral densities and auto-correlation functions. Wave and structure parameters, temperature profiles, auroral activity, cloud heights, temperature and other scene characteristics are being investigated. It is also planned to use data from other satellites and ground sites in conjunction with MSX measurements to determine:

(a) The density of minor atmospheric constituents such as NO, ozone, CO_2, etc., at different altitudes and locations on the Earth.
(b) Auroral particle energy characteristics and infrared radiators.

(c) Temperature variations in the troposphere, stratosphere and mesosphere.
(d) Optical signatures of Sprites and their spectral distribution with altitude
(e) Gravity wave activity in the mesosphere, ocean color, and terrain signatures and associated atmosphere corrections.

Opportunities for collaborative measurements are sought to fully utilize the measurement capabilities of the MSX sensors.

Millstone Hill Workshop

Convener: John Foster
Date: Monday, June 17
Attendance: 60

The second CEDAR Millstone Hill Observatory Workshop started with a brief overview of Observatory activities. This was followed by a description of the Firepond Lidar Initiative (J. Salah, J. Meriwether) which will establish a powerful Rayleigh lidar facility adjacent to the radar using the MIT Lincoln Laboratory 48-inch Coude-focus telescope and a 25-Watt Clemson University laser. A series of presentations by MHO young investigators highlighted combined ISR-airglow studies (R. Lancaster), ISR-MWR tidal studies (L. Goncharenko), and daytime FPI-ISR comparisons (M. Coakley). Telescience remains a strong activity at MHO and developments for real-time Internet access to MHO were presented by J. Holt. T. Killeen discussed the inclusion of real-time modeling output with such observations. Plans for a coordinated multi-instrument mid-latitude campaign to study substorms were described by J. Foster. The Millstone Hill Experimenters Working Group meets in the Boston area on a semi-annual basis and facilitates Observatory multi-instrument coordination. Contact Phil Erickson for MHOEWG details (pje@hyperion.haystack.edu). It is planned that the Millstone Hill Observatory Workshop will be an annual CEDAR event. Contact John Foster for further details or for additional information concerning activities or scheduling at Millstone Hill (jcf@hyperion.haystack.edu). A wealth of information is available over WWW at http://hyperion.haystack.edu/homepage.html.

The HLPS (High Latitude Plasma Strucutres) Workshop

Convenor: Jan Sojka
Date: Monday, June 17
Attendance: 60

The goals of the '96 HLPS (High Latitude Plasma Structures) workshop were to maintain and promote community interaction between researchers in the area; discuss results from the campaigns in the past year and plan the future CEDAR HLPS/STEP GAPS campaigns; coordinate data analysis and HLPS-related publications; and provide graduate students with educational information on the key research areas of the HLPS group.

Convenor Jan J. Sojka (Utah State University), co-chair of the HLPS working group, initiated the workshop by outlining the objectives of the workshop and summarizing the major HLPS-related activities in the past year. Of particular note was the recent HLPS/GAPS special section of Radio Science (May-June, 1996) that contained nine papers from the 1994 Peaceful Valley Workshop. This was followed by two tutorials on polar cap arcs, which is one of the major research areas of the HLPS group. The observational aspect of polar cap arcs was covered by C. Valladares' (Boston College) tutorial talk, while L. Zhu's (Utah State University) presentation focused on the theories and modelings of polar cap arcs. These two tutorials not only provided graduate students with an overall picture of the polar cap arc research area, but also offered an in-depth discussion of the most recent progress, problems, and suggestions for future research in this specific area. The first session of the workshop was then concluded by a round table discussion on the past and future HLPS campaigns chaired by R. Doe (SRI). Specifically, an update on the February 1996 patch campaign was given and future campaigns during the 1996-97 winter were discussed.

At the start of the second session, J. Doolittle (Lockheed Research Lab) gave an invited presentation in which he provided an overview of the Antarctic AGO (Automatic Geophysical Observatories) project and discussed the observatory capabilities in the context of HLPS, i.e., polar cap ionospheric and thermospheric physics, with the focus on possible conjugate studies. At the present time there are 5 US AGOs in operation (see table below.)

AGO	Geographic Latitude	Geographic Longitude	CGM Latitude	CGM Longitude
P1	-83.86	129.61	80.14	16.75
P2	-85.67	313.62	69.81	19.21
P3	-82.76	28.58	71.78	40.09
P4	-82.01	96.76	80.00	41.51
P5	-77.23	123.52	86.74	29.41
Other sites operating with similar equipment are:				
South Pole	-90.00	000.00	74.02	18.35
McMurdo	-77.85	166.67	79.94	326.82
and at least one more US AGO is planned:				
P6	-69.51	130.01	84.92	215.16

Each of the AGO sites is instrumented with a range of Antarctic Science instruments. The subset of relevance to the HLPS/GAPS community is referred to as the Polar Experiment Network for Upper-Atmospheric Investigation (PENGUIN). This suite of instruments are:

Experiment	Investigation	Co-Investigators	Institution
Imaging Riometer	Ionospheric absorption	T. J. Rosenberg	U. Maryland
Fluxgate & Search Coil Magnetometer	Geomagnetic fluctuations and pulsations	L. J. Lanzerotti	Bell Labs
		C. G. MacLennan	Bell Labs
		A. Wolfe	NYC Tech. College
		R. L. Arnoldy	U. New Hampshire
		M. Engebretson	Augsburg College
		H. Fukunishi	Tokyo University
ELF/VLF Receiver	Whistlers, radio noise	U. S. Inan	Stanford University
		D. L. Carpenter	Stanford University
LF/HF Receiver	Auroral radio noise	J. LaBelle	Dartmouth College
All-sky Camera	Aurora and Airglow	S. B. Mende	U. C. Berkeley
		J. H. Doolittle	Lockheed-Martin

For scientists interested in following up on studies using the AGO data, it is probably most efficient to interact with Dr. Doolittle directly.

This was followed by a presentation given by P. Guzdar (University of Maryland, College Park). He presented some initial results from 3-D nonlinear simulations of the gradient drift instability in the high-latitude ionosphere and showed how the third-dimension (vertical) affects the structuring of the plasma patch/blob. Then the workshop went into the traditional HLPS-mode, i.e., the short presentations and informal discussion. The individuals giving short presentations included: D. Decker (Boston College); R. Smith (University of Alaska); C. Valladares (Boston College); and J. Scali (University of Massachusetts, Lowell). In addition to purely scientific topics, several other important issues were raised and discussed. These included: how the HLPS working group can make significant contributions to the planned NSF Polar Cap Observatory since the research areas of the working group are so closely related to the scientific objectives of the observatory; how the community can be involved in SHEBA, an NSF Polar Program Initiative; and how to better communicate with each other in the planning and implementation of campaigns.

The HLPS working group regularly holds workshops to promote community interactions, these include three-day regular workshops (about every other year) and half-day mini-workshops (every other year during the CEDAR meeting). So far, two regular HLPS workshops have been held jointly with the STEP GAPS working group and papers from the workshops were published in two special sections of *Radio Science*. A third, three-day HLPS workshop (1997) is in the planning stage. Currently, the CEDAR HLPS working group is co-chaired by Jan Sojka (Utah State University) and Ed Weber (Phillips Lab), while the STEP GAPS working group is chaired by Sunanda Basu (Director, NSF Aeronomy Program). The HLPS group has a significant international participation and scientists from about fifteen countries have been and are involved in the HLPS activities. The group has a Web site to keep contact among researchers within the group (http://logan.cass.usu.edu/HLPS/), while messages concerning campaigns or other HLPS topics should be e-mailed to Jan Sojka at fasojka@sojka.cass.usu.edu for inclusion in the Web pages.

Topside Workshop

Convenor: Sixto A. Gonza'lez
Date: Wednesday, June 19
Attendance: 50

The purpose of this workshop was to have representatives from the ISR, optical, satellite and modeling communities show their respective results so that we could identify prospective areas of collaboration. In addition, we had a presentation from Mike Sulzer (NAIC) describing new developments in ISR data reduction for low s/n and, in particular, how these improve our topside measurements. We expect to continue these discussions as part of a Workshop that will be held at Arecibo in January 1997. For more information contact any of the following: Graham Bailey (G.Bailey@sheffield.ac.uk); Bob Kerr (kerr@moe.bu.edu) Sixto Gonza'lez (sixto@naic.edu)

Student Experience Workshop

Convenors: Todd Valentic, John Sahr
Date: Sunday, June 16
Attendance: 80+

For the third consecutive year, a Student Experience Workshop addressed issues of special interest to graduate and undergraduate students in the CEDAR community.

The workshop is quite informal, frequently taking the form of a panel discussion (as it did this year). The panel included individuals whose scientific training prepared them for employment in both traditional (academic research) and non-traditional (science writing, elementary education) areas.

In each case the panelists shared their experiences and observations about their careers, which parts they found enjoyable, difficult, which kinds of qualifications helped obtain a position, which mattered little, and which might hurt. For example, the two faculty panelists reluctantly acknowledged that superb teaching skill was not tremendously helpful in acquiring tenure and promotion. Science writing proved to be challenging and interesting in the variety of topics presented to another panelist.

As a second component, we discussed the results of a survey of recent aeronomy graduates from US institutions. Although the employment situation has been difficult for the past five years, the new scientists rising in the CEDAR community seem to be relatively content with their lot --- at least the thirty who responded to the survey. Among other things, these students were mostly satisfied with their educational experience, had been fairly well employed, and had found employment that suited them. Because of the nature of the survey's presentation (through the World Wide Web) it has limited validity, but it is fair to interpret the survey's results with optimism.

It is quite likely that this Workshop will continue in some form in subsequent CEDAR meetings; John Sahr will welcome inquiries at jdsahr@ee. Washington.edu.

New CEDAR Science Steering Committee (CSSC)

At the conclusion of this year's meeting, Jeffrey Forbes (Chairman), John Sahr, and Jeffrey Thayer completed their terms on the committee. We are indebted to them for their leadership, service and commitment during the past three years.

We welcome Rod Heelis, Michael Taylor and David Hysell as new members of the committee. Paul Castleberg (Cornell) replaces Todd Valentic (Colorado) as student representative. As our first international member, we welcome Gordon Shepherd.

Listed below are the names and addresses of the current CSSC members for the 1996-97. You are invited to contact any of these individuals as a means of bringing matters to the attention of the CSSC committee.

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Status Reports on CEDAR Major Research Instrumentation Grants

For the FY 94 CEDAR grant cycle, a special one-time, all-instrument competition was conducted in an attempt to achieve a major upgrade in new equipment available to the Aeronomy community. The panel below gives the results of that competition. To brief the CEDAR community on the status of these instruments, the CEDAR Post initiated a series of progress reports with issue # 27 (1996), when the CEDAR Optical Tomographic Imaging Facility (COTIF) was described by Semeter and Mendillo. In this issue, eight additional reports are provided.

FY 94 CEDAR Competition

Number of proposals submitted:	33
Total requested for FY 94:	$6M
Total Funds Available:	$1.1M
Number of proposals recommended:	9

Ben Balsley, University of Colorado
Modification of Jicamarca for Continuous, Low-Power Operations: The JULIA System

Timothy Killeen, University of Michigan
A Complement of Optical Instruments for the Polar Cap Observatory

Michael Mendillo, Boston University
CEDAR Optical Tomographic Imaging Facility (COTIF)

Hans Mossmuller, University of Nevada
Approaching "Ultimate" Lidar Temperature and Wind Measurements in the Mesopause Region

Chiao-Yao She, Colorado State University
Approaching "Ultimate" Lidar for Temperature and Wind Measurements in the Mesopause Region

Fulamabas Sivjee, Enbry-Riddle University
Class I Imaging Spectroscopic Facility for Optical Remote Sensing of Airglow and Auroral Processes in the Polar Middle Atmosphere and Thermosphere

Michael Taylor, Utah State University
A Two-Dimensional Temperature Mapper for Short Period Mesospheric Gravity Wave Measurements

Craig Tepley, Cornel University
Resonance Lidar Studies at Arecibo Observatory

Vincent Wickwar, Utah State University
Resonance Lidar to Study the Upper Mesophere and Lower Thermosphere

Resonance Lidar Development At The Arecibo Observatory

by Craig Tepley, Arecibo Observatory

Our proposal to the FY94 Instrumentation Competition under the CEDAR Program was to develop a tunable resonance fluorescence lidar capability for the Arecibo Observatory located in Puerto Rico. Co-Investigators on the proposal are Dr. Jonathan Friedman of NAIC/Arecibo and Profs. Michael Kelley and Clifford Pollock of Cornell University. Mr. Paul Castleberg, a Cornell graduate student, is playing a major role in this effort as well. Adding a resonance lidar to the Arecibo instrumental complement was necessary in order to provide a thorough and unique capability for upper atmospheric studies and to satisfy the experimental needs of many visiting investigators at this National Center.

Nearly 90% of the support of this proposal was used to purchase equipment. Approximately two-thirds of those funds acquired a tunable alexandrite ring laser for the lidar transmitter. The remaining hardware costs were used for receivers and spectral diagnostic instrumentation. The alexandrite laser (manufactured by Light Age, Inc.) was delivered to Arecibo in October 1995 and later that month was installed in one of two reconverted surplus equipment shelters. In the second shelter, we installed a vertically pointed, 80 cm diameter cassegrain telescope and detection equipment for the receiver. We plan to use this bistatic configuration, and the temporary facilities to house the lidar, until the system can be moved to its permanent location in a new building that is currently under construction. We will also move the Arecibo Doppler Rayleigh lidar and there will be additional space for visiting equipment as well. After the move, we plan to have a fully pointable resonance lidar using a coaxial configuration that is similar to the existing Rayleigh system.

One goal of our observational program at Arecibo is to understand the structure and dynamics of the mesopause region and lower ionosphere between approximately 75 and 125 km. The lower half is a region where meteors generally ablate to individual metallic atoms and ions, which then get caught up in the complex ion-neutral chemistry and are slow to fall out of this region of space. By probing the resonance lines, or *fingerprints*, of certain metal atoms and ions, we can use them as tracers of atmospheric conditions such as the chemistry itself, meteoric input, and eventually the winds and temperatures as we improve our measurement techniques to observe the Doppler components of the backscattered spectra. One important requirement is already satisfied, that is, the narrow linewidth of the alexandrite's ring-laser configuration will make such Doppler observations possible.

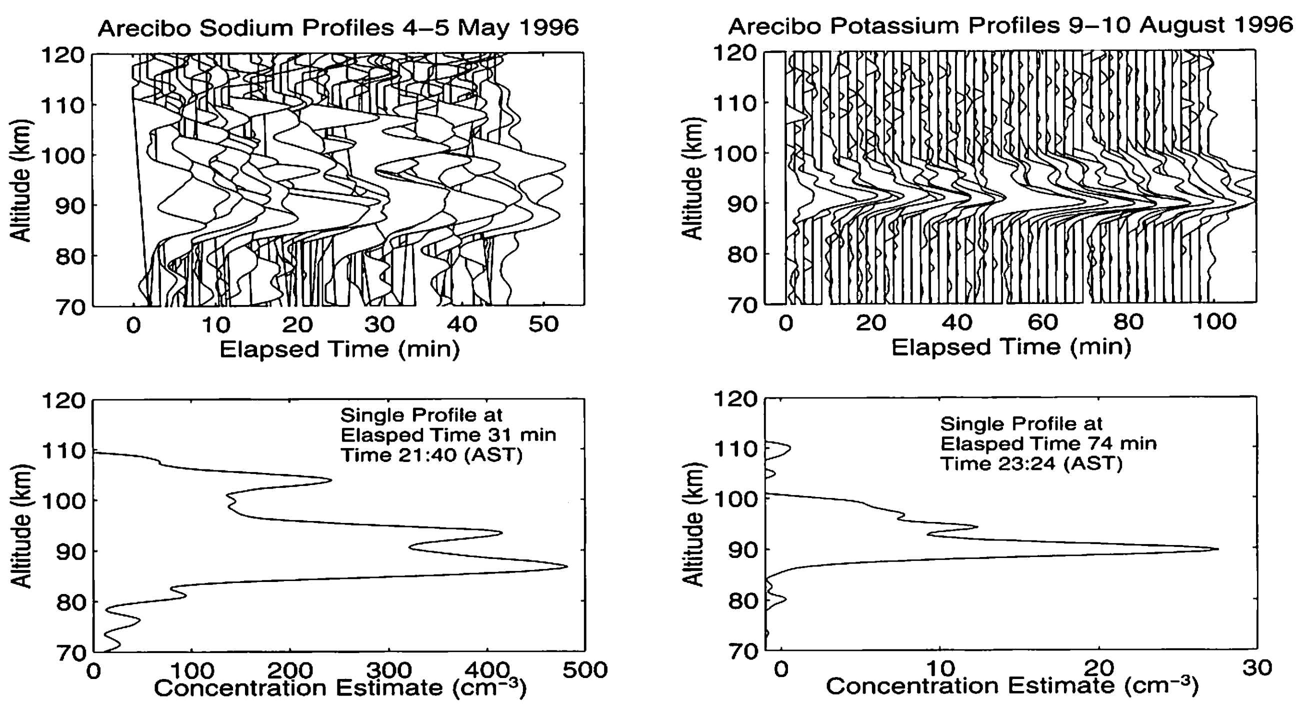
The alexandrite laser is tunable between 730 and 800 nm, a spectral region where potassium can be directly observed, and several other species, such as Fe, Al, and Ca^+, are observable by frequency doubling the laser's fundamental tuning range to the blue portion of the spectrum. A two-step process of Raman shifting to the infrared (using a hydrogen-filled Raman-cell) and frequency doubling to the yellow is needed to reach the sodium resonance wavelength at 589 nm. Much of the laser energy is lost in these conversions, but laser linewidths remain narrow, and sodium is abundant and has a large scattering cross-section, which enables good observations of the concentration of the sodium layer over Arecibo in about a few minutes of integration time. Accurate potassium concentrations, on the other hand, can be measured in less than a minute.

The Arecibo resonance fluorescence lidar became operational in the spring of 1996 and has begun to produce interesting data on the conditions of the 75 to 110 km altitude region. After a period of initial testing and software development, we have preliminary observations in hand, and have embarked on a regular observing program. The accompanying figure is an example of some of the measurements, which were made by Paul Castleberg and Jonathan Friedman. It demonstrates that the lidar is able to probe both sodium and potassium at their respective resonance wavelengths of 589 and 770 nm.

These preliminary observations demonstrate the effective use of this new resonance fluorescence lidar at Arecibo, and we plan to use this new instrument, together with our other radar and optical systems to study the details of the upper atmosphere at low latitudes. For example, during the coming year we plan to explore the scattering properties of other prominent meteoric metals, in particular iron and calcium. Most of the metals, which have their resonance lines in the visible part of the optical spectrum, exist in their neutral form. Their ionized counterparts usually have ultraviolet resonances, but these cannot be observed from the ground because of strong absorption of the ultraviolet by ozone in the stratosphere. Calcium, on the other hand, is special because it has visible resonance lines for both its ionized and neutral form making it ideal to observe with ground-based tunable lidar. Its ionized form can extend through the E-region ionosphere as well, which makes it a prime candidate to map the conditions at those altitudes.

As an ion, Ca^{+} can encounter wind-shear that often occurs in the lower ionosphere and will form, or get caught up in the layers of ionization that we normally observe as Tidal Ion Layers, often referred to as Sporadic-E. In the past, visiting lidars deployed at Arecibo have on occasion observed large enhancements in the lidar backscattered emissions from neutral species like Na. We refer to such enhancements as Sudden Sodium Layers, or Sudden Atom Layers for the case of another metal. The point is that this is an enhancement observed in the neutral species through some unknown mechanism, and is not an enhancement of the ions where one might expect a more rapid development like a Sporadic-E layer. Thus, we anticipate that observations of Ca and Ca^{+} made with the lidar, together with simultaneous incoherent scatter radar observations of the electron concentration and the development of such tidal ion layers at Arecibo, may shed light (so to speak) on the puzzling phenomena of sudden atom layers. This exploration will be part of our resonance lidar program during the coming year.

Aside from our own program of initial exploratory observations, the Arecibo resonance and Rayleigh lidar systems will soon be ready for visitor use. The Arecibo Observatory has always been a visitor oriented facility and this applies not only to the primary radar systems, but also to the use of its variety of ancillary instruments. As our upgrades to the instrumentation at Arecibo near completion, in particular for the radar systems, we will soon announce a call for observing proposals that will reinitiate an era of full operation. Look for this announcement, which will appear in our NAIC Newsletter, on our Web page (http://www.naic.edu), and in the CEDAR Post. We look forward to renewed community interest and involvement in all aspects of the atmospheric sciences program at Arecibo.



Preliminary observations of sodium (left) and potassium (right) measured with the Arecibo resonance fluorescence lidar. We show both a time series (top) and a single profile (bottom). These measurements were made with the necessary injection seeding for narrow spectral width operation but without a precise wavelength locking method, which resulted in an underestimate of the species concentrations. Laser pulse energies were 1-2 mJ at 589 nm for sodium and 75 mJ at 770 nm for potassium. The fundamental tuning range for alexandrite is 730-800 nm, so that while potassium lies in this range, sodium requires a Raman shift and frequency doubling. Next, we will improve the laser locking precision and will obtain simultaneous incoherent scatter radar and resonance lidar observations of the mesopause region.

Class I Imaging Spectroscopic Facility For Optical Radar

by Gulambas Sivjee, Embry-Riddle University

A high throughput, very sensitive CCD spectrograph, to record very low light level airglow and auroral optical emissions, has been developed as part of the CEDAR instrumentation program. The spectrograph has a modified Czerny-Turner configuration of optical elements; it is fitted with a 0.5 m focal length spherical-mirror collimator, and a 110 mm square, 1200 grooves/mm plane diffraction grating, blazed around 7500 Å. A 50 mm arc-length Fastie-type curved entrance slit enhances the throughput of the spectrograph; its micrometer controlled slit-width can be adjusted between 0 mm and 3 mm, with a precision of about 5 microns. An f/1.2, 80 mm diameter clear aperture compound lens replaces the focusing mirror in the Czerny-Turner spectrometer and focuses the spectrum on a thinned, back-illuminated CCD chip. The spectrograph employs a multi-stage-thermoelectrically (TE) cooled, low dark current, low read-out noise, scientific grade CCD detector. The latter consists of 1024 x 1024 pixels; each pixel is 24 microns square. In first order operation, the spectrograph covers a free spectral range (FSR) of about 2600 ° in the NIR region. Using a 0.5 mm entrance slit-width results in an emission line profile whose full width, at half the maximum (FWHM) intensity, is about 9 Å for a 7000 Å line, and about 7 Å for a 96000 Å line; the average FWHM, over the FSR (~ 7200 Å - 9600 Å) is 8 Å. An order sorting filter is placed in front of the entrance slit to block out unwanted light in different orders from entering the spectrometer. Spectral sensitivity measurements and field-flattening of the CCD pixels are accomplished with the aid of a black-body (T = 1273 K) source, and a NIST traceable calibrated quartz iodide lamp, illuminating a Lambertian screen. High signal-to-noise ratio (S/N) spectra of moderately bright auroras have been recorded with this system using less than one second CCD exposure time (see Figure). However, data storage constraints limit automated continuous field-site operation of the CCD spectrograph to long exposure mode (~ 2 minutes) of the CCD in order to compact the massive amount of data recorded with the system.

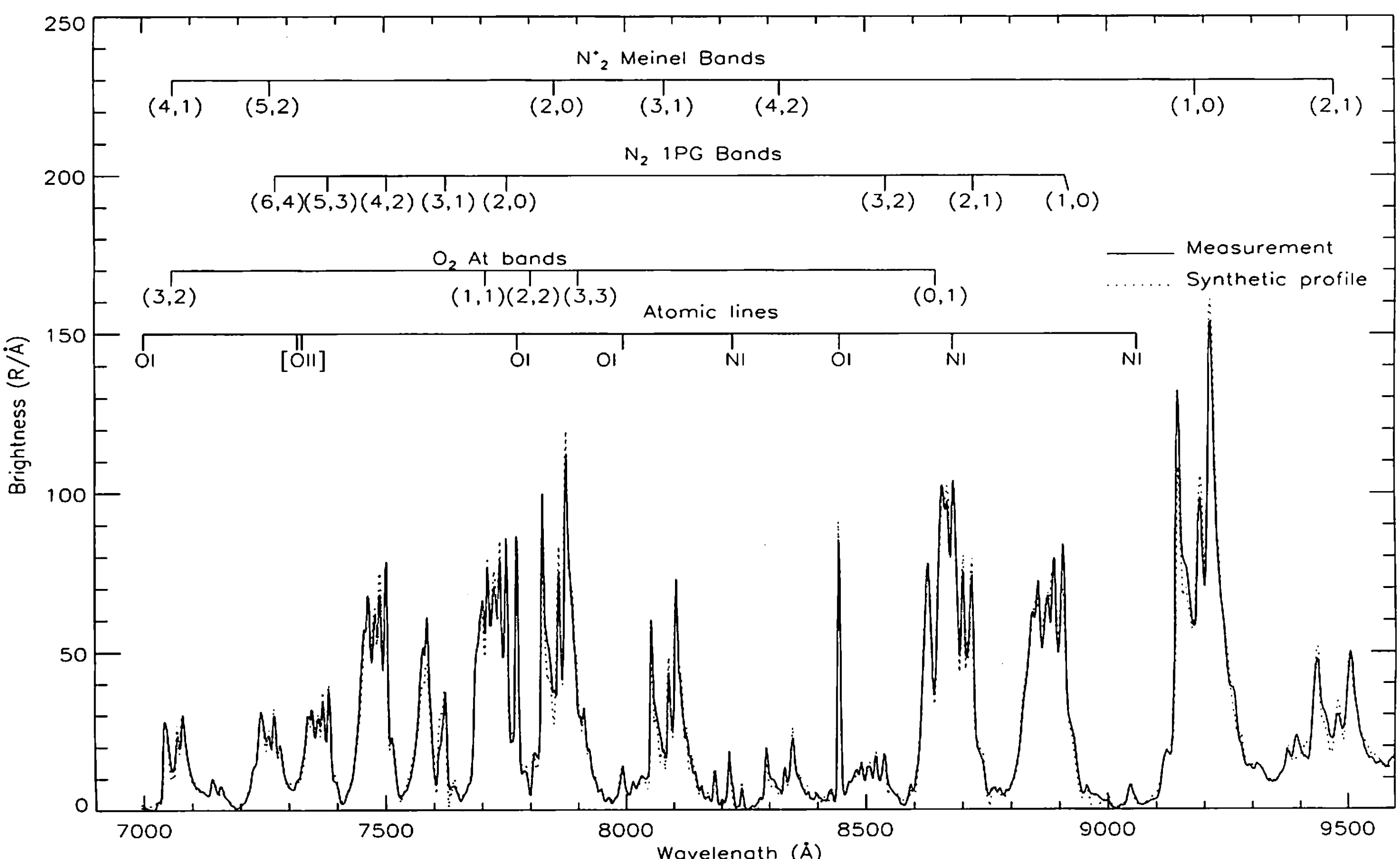


Figure 1. Auroral Spectrum recorded with one second exposure of the new CCD spectrograph. Continous and dotted curves represent measurements and model calculations respectively.

Approaching "Ultimate" Lidar For Temperature And Wind Measurements In The Mesopause Region

by C. Y. She, M. A. White and D. A. Krueger, Colorado State University

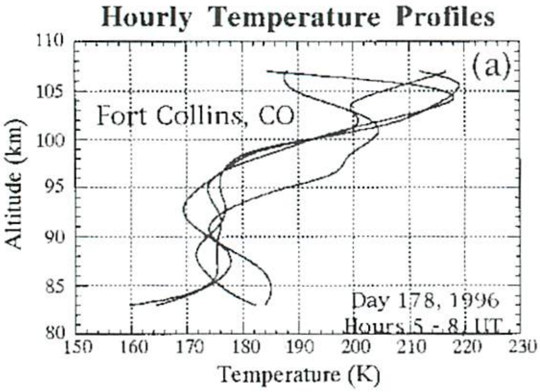
When this CEDAR Class I Instrument proposal was made, the narrowband Na lidar at Colorado State had proven to be capable of routine temperature measurements in the mesopause region. A few nights of line-of-sight wind measurements were made as well. The transmitter using several lasers is complex, and the measurement which requires data acquisition at different laser frequencies may be contaminated by atmospheric Na density variations. To further improve the lidar, two transmitter modifications were proposed. First, a CW tunable source at 589 nm based on sum-frequency generation of two commercial cw monolithic solid-state YAG lasers was to be developed at the Desert Research Institute to replace the cw argon-ion pumped dye laser system. Its implementation will considerably reduce the size of the transmitter and operation cost, and make the system transportable. Second, a tandem acousto-optic modulator (AOM) system which can shift the cw beam to two pre-selected frequencies was to be developed at Colorado State to replace the single-frequency modulator for simultaneous temperature/wind measurements. This will allow the cyclic transmission of three different frequencies on a pulse-to-pulse basis (20 Hz), eliminating the effect of Na density variations during a measurement, and increasing both the stability of lidar operation and the accuracy of measurement. In addition, we also proposed a minimal receiver enhancement at Colorado State to conduct dual-channel lidar operation for momentum flux measurements. With these modifications, we hope to have a prototype system which approaches the "ultimate" (or "ideal") lidar for temperature and wind measurements in the mesopause region.

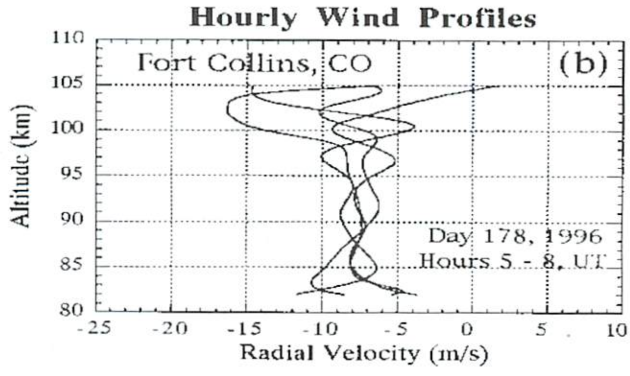
The major component of this prototype "ultimate" lidar is, of course, the development of a compact CW solid-state laser source at 589 nm by means of sum-frequency generation. The demonstrated feasibility and progress of this project is given in a companion write-up by Moosmuller and Vance of the Desert Research Institute. The progress in receiver enhancement and in tandem AOM implementation at Colorado State is described below.

The enhanced receiving system will consist of two Zenith pointing telescopes (Celestron 14), each of which will receive the 15° off-zenith lidar return collected by a pair of steerable mirrors pointing to the appropriate directions. The plane of transmitting and receiving lines-of-sights will be aligned alternately along East-West and North-South to measure momentum-flux as done in radar technique. The construction portion of this project has been carried out mainly by Colorado State undergraduates, Tom Connor and Larry Belcher. At this point, one set of the steerable mirrors has been constructed and tested. We are in the process of testing this system and constructing the second set of steerable mirrors.

For simultaneous temperature/radial wind measurements, we lock the CW laser at one frequency, ν_α, and use the tandem AOM to provide the additional two frequencies at $\nu_t \pm = \nu_a \pm 630$ MHz necessary for the wind/temperature measurement. By incorporating this tandem-AOM unit into the existing apparatus the ring-dye laser's CW beam may be up or down shifted to match the 20Hz firing rate of the pulsed Nd:YAG laser, which is triggered by the synchronizing electronics of the shifting unit. The tandem-AOM system itself utilizes, in order, a polarizing beam splitter, periodic series of lenses and accousto-optic (AO) crystals, quarter-wave plate, and a back mirror to achieve double-pass frequency shifting by either AO crystal into the same exit beampath. A mechanical chopper-wheel before the back mirror selects which beam order (shifted or unshifted) is allowed to traverse the unit, and provides the primary synchronization, switching microwave power to the crystals and triggering the pulsed transmitter and receiver systems. Lidar returns from each frequency are collected, electronically sorted, and simultaneously integrated, thereby eliminating the effect of atmospheric Na density fluctuations. These returns may be manipulated into ratios sensitive to both temperature and radial wind. All mechanisms are now working and we have opted to perform the more sensitive test of this arrangement by measuring vertical wind and temperature profiles.

With four nights of data collection, hourly averaged profiles have been calculated. As an example, we show in figures below the results of (a) temperature and (b) vertical wind measurements taken at the night of June 25, 1996. The hourly temperature profiles are seen to display the expected range of values. However, the vertical winds show a systematic bias of roughly -8 m/s, a value considerably larger than expected, indicative of a possible unexpected instrumental problem. Recent experiments suggest that the centroid frequency of the pulsed output may not be the same as the frequency of the CW seeding laser which serves as the frequency marker via Doppler-free fluorescence spectroscopy. If the centroid frequency of the pulsed output is blue shifted from that of the CW laser by 13 MHz, a bias in vertical wind velocity of -8 m/s will result. The same frequency shift will only give a temperature bias of less than 1 K. Although for most atmospheric studies, only rms winds are of interest, we will nonetheless pursue the measurement with the intention to monitor this frequency shift in real time to allow corrections to be made for this effect.





A CW Solid-State Laser System For Mesopause Diagnostics

by Hans Moosmüller, Desert Research Institute, and Joe Vance, University of Nevada

In the short time since being developed at Colorado State University, the high spectral resolution sodium lidar has proven to be capable of making significant geophysical measurements of the temperature profiles in the mesopause region. The use of these lidar systems for the routine measurement of wind velocity profiles is also anticipated. Essentially identical units have been installed by research groups in Illinois and Ontario. An important element of the transmitter is a stable, tunable, narrowband continuous wave (CW) laser beam that seeds the high power pulsed dye amplifier at the sodium resonance wavelength of about 589 nm. The present unit, consisting of an argon-ion laser and a single-mode ring dye laser has the versatility required of an exploratory system but has excessive space, power, and maintenance requirements. These requirements would be very difficult to fulfill in a mobile unit or for operation at a remote (e.g., high latitude) site. A simpler system would also facilitate more frequent routine observations without excessive resource requirements.

Currently, a narrowband, solid-state cw source of sodium resonance radiation is being developed at the Desert Research Institute. This light source uses two commercially available cw Nd:YAG lasers, one operating at 1.06 μm and the other at 1.32 μm to sum-frequency-generate light at 589 nm. While the generated light is only tunable over 120 GHz, (i.e., 0.14 nm), this tuning range is fully sufficient as it is roughly centered on the 1.5-GHz wide sodium D_2 resonance line used for mesopause diagnostic. This solid-state system is much smaller in physical size, has low power requirements, and is much simpler than the currently used cw dye laser system.

The sum frequency generation takes place in a congruent lithium niobate ($LiNbO_3$) crystal which has high optical nonlinearity and sufficient birefringence to achieve phase matching. The two infrared laser beams are overlapped and focused into a 5-cm long crystal. To generate sum frequency radiation, momentum conservation has to be obeyed. This requirement is referred to as phase matching. For our arrangement this condition can be satisfied if the lithium niobate crystal is heated to 227 °C with spatial and temporal temperature stability of better than 0.05 °C. To fulfill these requirements a custom crystal oven had to be built. The resulting single pass setup has successfully generated narrowband sodium resonance radiation with a power of 3 mW. To demonstrate ease of operation and adequate spectral characteristics, this system has been used to measure sub-Doppler spectra of the sodium D_2 line. Figure 1 shows a conventional saturated fluorescence spectrum recorded with our new light source.

The three narrowband sub-Doppler features, which are used to set the absolute laser frequency for mesopause measurements, are clearly visible. In addition, frequency modulated saturated fluorescence spectroscopy was easy to implement due to the fast frequency modulation capabilities of the solid state lasers. Figure 2 shows a corresponding frequency modulated spectrum which is essentially a derivative of the conventional spectrum, strongly enhancing the narrow features of interest. The center of the sub-Doppler feature is characterized by the zero-crossing of the signal, which makes it ideally suited for frequency locking purposes.

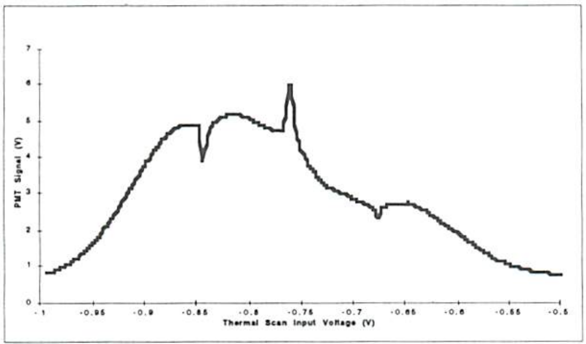


Fig. 1: Saturated Fluorescence Spectrum of the Sodium D_2 line: signal (v) vs. thermal scan input voltage (v)

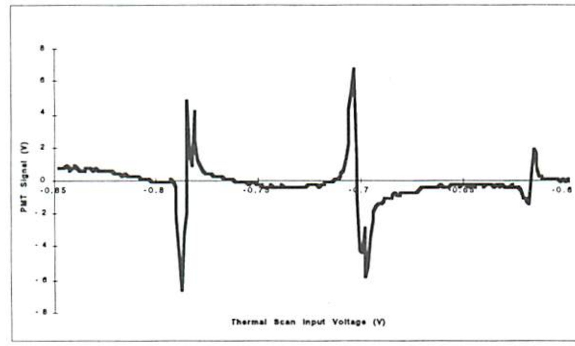


Fig. 2: Frequency Modulated Saturated Fluorescence Spectrum of the Sodium D_2 line: signal (v) vs. thermal scan input voltage (v)

The 3-mW output power of the single pass setup is insufficient as input for the pulsed dye amplifiers used in the currently operating high spectral resolution sodium lidar systems. Either the pulsed amplifiers have to be modified, for example by the addition of a fourth amplification stage, or the output power of the cw system has to be raised to well above 100 mW. We are pursuing the second approach with the goal of building a direct replacement for the cw dye laser system. To increase the output power, the single pass $LiNbO_3$ crystal is replaced by a monolithic $LiNbO_3$ ring resonator, effectively increasing the intensity of one or both infrared input beams in the nonlinear crystal by one to two orders of magnitude. A monolithic ring resonator enhancing solely the 1.32 μm input has recently yielded an output power of nearly 40 mW, an order of magnitude improvement over the single pass output. A newly designed monolithic $LiNbO_3$ resonator which enhances the intensity of both input beams has just been manufactured. It is expected to increase the output power by up to another order of magnitude, yielding well above 100 mW of cw sodium resonance radiation, sufficient for the current pulsed amplifiers. The completed system will be tested as part of the Colorado State University high spectral resolution sodium lidar.

Resonance Lidar To Study Temperatures, Winds, And Metal Densities In The Upper Mesosphere And Lower Thermosphere

by V. B. Wickwar, T. D. Wilkerson, D. Rees and S. C. Collins, Utah State University

Utah State University (USU) received a CEDAR infrastructure award to obtain an alexandrite ring laser from Light Age, Inc. (LAI) to make resonance-scatter lidar observations. Currently, we are obtaining temperatures between 30 and 90 km with Rayleigh-scatter observations. One of the goals with the alexandrite is to extend the temperature profiles upwards to 105 km and to do so with good time resolution. (This will also enable us to improve the accuracy of the Rayleigh temperatures between 70 and 90 km.) Because many effects originate low in the middle atmosphere and grow with altitude, the resulting continuous range of observations between 30 and 105 km is much more valuable for understanding the physics than small portions of the range. For instance, we will be better able to examine the interactions among gravity waves, tides, planetary waves, and winds that give rise to critical layers, wave saturation, and possibly to the recently discovered double mesopause. Other goals include making wind observations between 80 and 105 km and examining the distributions of several different species of metals that arise from meteoric deposition. A technological goal is to demonstrate that an alexandrite-based lidar provides a simple way to obtain resonance-scatter temperatures and winds.

This alexandrite laser is the culmination of a lengthy development by LAI for von Zahn's research group, first at Bonn, now at Kuhlungsborn. Our group and the one at Arecibo have gained considerably from this development effort. The characteristics of this laser and its ring configuration are ideal for resonance-scatter observations. Alexandrite lasers are vibronic, or phonon-terminated, i.e., a close coupling exists between vibrational and electronic states in the crystal lattice that allows the laser to be tunable over an extended range of wavelengths--720 to 810 nm. This provides access to important resonance lines: the K resonance lines can be reached directly; the Ca and Mg^+ lines can be reached by a combination of tuning, Raman-shifting in N_2, and frequency doubling; the Ca^+, Al, Mg, and Fe lines can be reached by tuning and frequency doubling; and Na can be reached in two ways that are described below. With this laser, unidirectional ring lasing is established in a two-rod cavity, producing single longitudinal and transverse mode (TEM_{00}) pulses having an energy output of 250 mJ with a pulse length of 100 ns and a repetition rate of approximately 25 Hz. These characteristics give rise to pulses with spectral widths of the order of 30 MHz. After Raman shifting and frequency doubling, we would still have pulses with spectral widths less than 100 MHz, which is important for obtaining good temperatures and velocities.

Controlling the gain of the alexandrite ring resonator is accomplished by seeding the cavity with narrow-band radiation from a semiconductor CW laser diode. These laser diodes have extremely narrow line widths and are relatively easy to control in frequency (wavelength). With the ring resonator locked to the laser diode, the output of the alexandrite laser has the same frequency as the laser diode and a spectral width that is only slightly greater. Thus, the laser is tuned by picking the appropriate laser diode and tuning it by varying its temperature and the current across its semiconductor junction. Similarly, the laser is stabilized by stabilizing the laser diode. This is done by careful thermal control of the laser diode and by means of a feedback loop involving changing the current to the laser diode to maximize the light from the diode that passes through a Fabry-Perot etalon. Thus the laser diode is locked to the etalon, which provides ultimate frequency control both for tuning and for stability. It is in this etalon that our version of the alexandrite ring laser differs from the others. The etalon, provided by Hovemere, Ltd., is hermetically sealed and temperature controlled. The plate separation is controlled by piezo-electric crystals that are capacitance stabilized. The separation can be held constant to stay at one frequency or stepped to scan in frequency. This type of capacitance-stabilized etalon (CSE) has been well tested in FPIs used for airglow wind and temperature observations and in very precise wavemeters. In addition to high precision, the CSE provides great flexibility when changing from one resonance line to another.

The CSE was integrated into the laser at LAI in November 1995. Simultaneously, a Hovemere, Ltd., high-resolution laser wavemeter (LWM), for assessing the spectral quality of the beams from the laser diode and the ring laser was deployed at LAI. They were subsequently transported to USU, and the alexandrite ring laser was installed at the Atmospheric Lidar Observatory (ALO) in February 1996. Since then, the development effort has been concentrated on two areas: characterizing and optimizing the frequency stability of the laser diode and laser and testing procedures for generating emission at the frequencies of the Na D2 lines (at 589 nm). This emission can be obtained by frequency doubling the first Stokes emission when laser output at 791 nm is Raman shifted in H_2. It can also be obtained from the first anti-Stokes emission when laser output at 780 nm is Raman shifted in H_2. These two procedures are currently being compared. The first method has been used previously. Initial tests of the second method indicate that it may be nearly as good, while being simpler to implement. (It is also easier to locate good 780-nm laser diodes than 791-nm laser diodes.) This laboratory work relies heavily on the LWM, which will later be used in real time to analyze each emitted laser pulse to ensure that it has the correct wavelength, spectral width, and energy. When the next round of operations funding, we look forward to turning the beam skyward and beginning Na temperature observations. When the new steerable telescope is finished shortly thereafter, we also look forward to starting wind observations.

Cedar Mesospheric Temperature Mapper For Investigating Short Period Gravity Waves

M.J. Taylor and W. R. Pendleton, Jr., Utah State University.

As part of the CEDAR initiative to develop new instrumentation for upper atmospheric research, Utah State University was awarded funds to design, construct and test a high performance, solid state (CCD) imaging system capable of mapping short-period (~10-60 min) mesospheric gravity wave signatures in the temperature and intensity fields of the near infrared (NIR) OH Meinel (M) nightglow emission (altitude ~87 km).

The instrument design was based on a proven photometric technique to determine mesospheric temperature (using intensity ratios of selected OH M(6,2) P1-branch rotational lines) and has taken full advantage of recent enhancements in performance of large area CCD arrays that feature exceptionally high quantum efficiencies and low noise characteristics. Construction of the system has proceeded well, and field tests were initiated at Bear Lake Observatory (BLO) during March, 1996. Measurements obtained to date indicate that the instrument has essentially achieved its design performance and is capable of regularly obtaining high signal-to-noise-ratio images (~80-100:1) of the OH M (6,2) P1(2) and P1(4) rotational emissions necessary for precise (1-2%) determinations of temperature perturbations induced by short-period gravity waves. Future plans include extensive field measurements in conjunction with all-sky NIR imaging and narrow field (~1°) Michelson interferometer measurements of the zenith OH emission to characterize the instrumental response under a range of geophysical conditions. These measurements will be coordinated with dedicated data collection events (DCEs) over BLO by the MSX satellite during the first year of operation.

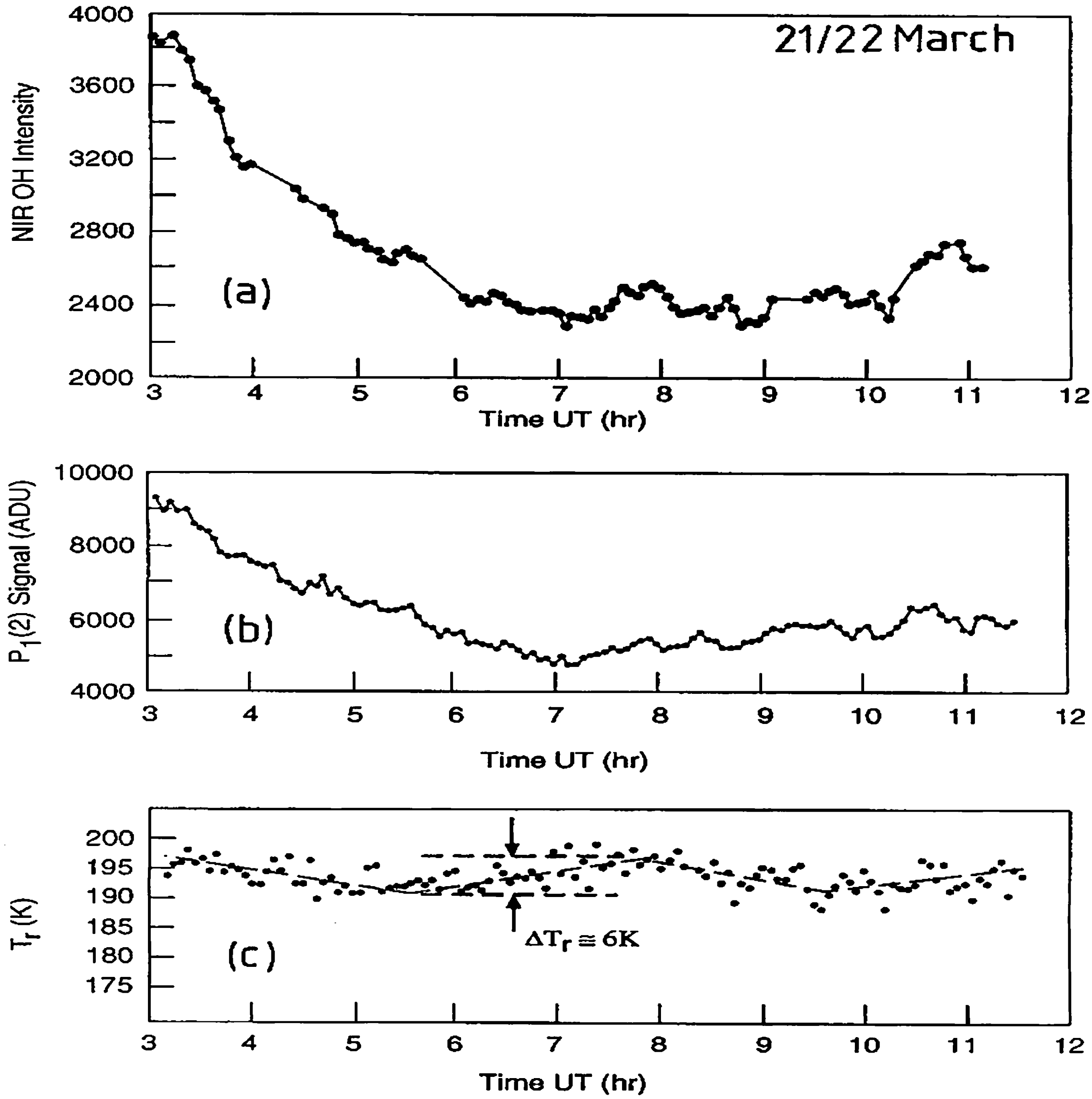
The primary scientific motivation for developing this instrument was driven by the need for detailed two-dimensional spatial and temporal information on the temperature and intensity wave field induced by gravity waves. These data are important for investigating: (a) gravity wave propagation and wave ducting, (b) seasonal characteristics and variability, and (c) the nightglow parameter eta (the ratio of fractional intensity to temperature change) critical for modeling studies. The optical arrangement for the "Temperature Mapper" consists of a large format Pentax 6x7 cm, primary lens (~75° circular field) followed by a temperature stabilized filter wheel containing up to five narrow band (~1.2 nm) interference filters. A Keo Consultants telecentric lens is used to pass the light through the filters at near normal incidence which is then re-imaged onto a large format (6.45 cm^2), back illuminated, CCD array comprising 1024 x 1024 pixels. The high quantum efficiency (~50%) at NIR wavelengths, low dark current (0.1 e^-/pix/s), low read noise (3.6 e^- RMS), and excellent linearity (0.03%) of this device provide an exceptional capability for quantitative measurements of the OH vibrational transitions. Typical exposure times of ~60 sec are used for each λ doublet resulting in a nominal 3 min cycle time for each temperature determination (i.e., including a background measurement).

To obtain large signal-to-noise (S/N) ratios necessary for the temperature determinations, the image data are binned (8 x 8) on chip down to 128 x 128 pixels. The effect of binning is to reduce the spatial resolution resulting in a field of view for each "superpixel" of 0.6° x 0.6° which corresponds to a footprint of 0.9 km x 0.9 km at OH heights and is sufficient to resolve even very short horizontal wavelength waves (~5 km). During field tests at BLO, the Temperature Mapper was operated alongside our all-sky imager. Wherever possible these measurements have been compared with OH observations obtained by a CEDAR Bomem Michelson interferometer (P. Espy) that was operated at the USU campus (~ 38 km from BLO). Images of the temperature mapper data were presented at the CEDAR Workshop (June, 1996) but are not easily reproduced here. Instead we present zenithal data from one night to illustrate the current "unoptimized" performance of the system.

The accompanying figure compares OH measurements obtained by the Temperature Mapper with broad-band data recorded by the all-sky imager for 21/22 March, 1996, when no short-period wave activity was detected. Panel (b) shows the relative intensity of the P1(2) line with the background removed. (To minimize the influence of stars, 3 x 3 averaging about the zenith pixel has been used.) The corresponding relative intensity of the broad-band OH measurements is plotted in panel (a) while panel (c) shows the OH (6,2) rotational temperatures derived from the intensity ratio P1(4)/P1(2). It is clear that the zenith intensity, as depicted in panels (a) and (b), decreased considerably during the night and that the trends in the two time series are very similar. The number of signal counts for the P1(2) measurement was typically around 6000 (compared with dark counts of ~600) indicating that the measurements were signal-noise limited and implying an estimated precision of the P1(2) intensity data of σ =

1.5%. In contrast, the temperature variations (panel c) were quite modest (range 190-200° K), indicating a mean of 194 ñ 2.1° K in good agreement the Bomem interferometer measurements of the OH M(4,2) temperatures which gave a mean value of 199° K and a standard deviation of 7° K over the period 03:00-06:00 UT when Bomen data were available.

In summary, the performance of the Temperature Mapper has yet to be optimized, but preliminary estimates of the key sensitivity parameters indicate a large system responsivity of 1.5 counts/sec/R/superpixel and a dark count rate of ~10 counts/sec/superpixel. Under these conditions S/N ratios ~90:1 were achieved for a nominal 100 R min exposure.



Plots showing (a) zenithal nightglow intensity variations recorded on 21/22 March 1996, determined from the all-sky broad-band) H image data and, (b) the $P_1(2)$ line of the OH M(6,2) band using the Temperature Mapper. Plot (c) shows the corresponding OH M(6,2) rotational temperatures derived from the intensity ration $P_1(4)/P_1(2)$.

The Julia System At Jicamarca

Ben Balsley, Don Farley and Ron Woodman

Our NSF CEDAR major instrumentation grant was to upgrade the Jicamarca Radio Observatory by incorporating an independent, low-power transmitter, a set of receivers, and an analysis system to be used with the existing large (300m x 300m) 50 Mhz antenna array. The underlying philosophy for this upgrade was to make use of the Jicamarca antenna during the (approximately) 90% of the time when the large radar system does not operate because of required maintenance, repair procedures, parts replacement, excessive operating costs, or other causes. The idea was to provide a completely independent, inexpensive, lower-power radar system call JULIA (for Jicamarca Unmanned Long-term Investigations of the Atmosphere), to provide relatively continuous and extended coverage of those atmospheric and ionospheric phenomena that can be studied using much lower transmitter power than that typically employed at Jicamarca. Examples include Spread F, equatorial Sporadic E, the 150 km echoes, and the lower atmospheric region below about 20 km.

JULIA was proposed as a "stand alone" radar. This means that except for possible antenna repairs the normal operation of the station will be unaffected by running JULIA. Moreover, JULIA can be operated in the absence of technical personnel. Unmanned low-power operation coupled with the much lower operating costs (total power consumption of a few kw) therefore extends operations over weekends and holidays.

The JULIA project began in May 1994, with a scheduled completion date in May 1996. Owing to unexpected delays in Boulder (personnel changes), in Lima (customs), and at Jicamarca (which was closed for several weeks during the second year of this project), a no-cost six month extension was requested and granted, moving the final completion date until November 1996.

The current status of the JULIA Project follows:

- All items have been specified, purchased, shipped and have cleared customs
- The transmitters, and analysis systems are currently in place and operating. One exception is the interface board for the PC data collection system, which is being modified and should be ready within the month.
- The receiving systems have been completed and need to be tested and calibrated.
- The 10 kw diesel generator needs only to be inter-connected to the existing power grid.

Major portions of the JULIA system already have been tested successfully using substitute receivers and analysis systems borrowed from the primary Jicamarca system. Low-power data have been gathered on all of the processes listed above.

In summary, JULIA is nearing completion, has been successfully tested, and can soon be used by anyone in the scientific community who needs extended data sets on atmospheric and ionospheric processes at Jicamarca.

A Fabry-Perot Interferometer For The Early Polar Cap Observatory

by Tim Killeen, Michael Reeves, Qian Wu, Paul Hays, and Rick Niciejewski, University of Michigan

The Space Physics Research Laboratory (SPRL) of the University of Michigan was supported under a 2-year CEDAR grant to develop, deploy, and operate two instruments at Resolute Bay, Canada, the site of the Early Polar Cap Observatory, EPCO. After extensive modifications at SPRL, the two instruments were shipped and installed at Resolute late during the 1994/95 observing season and were put into full routine operational status at the start of the 1995/96 operating season. They are: 1) A Fabry-Perot interferometer (FPI) with a detection scheme based on the Circle-to-Line (CLIO) technique (see Figure 1); and 2) A digital all-sky monochromatic camera (ASC) system with a thermoelectrically-cooled bare CCD detector and a programmable filter wheel.

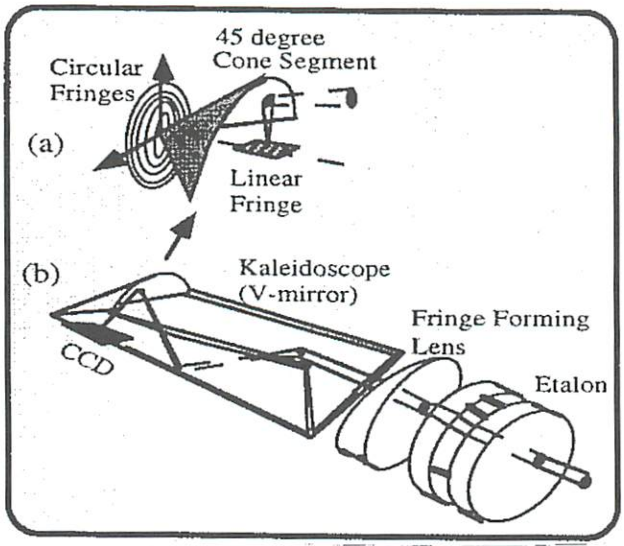


Figure 1. Schematic of Circle-to-line Optical system in the EPCO FPI system.

The FPI is optimized for the measurement of Doppler winds and temperatures from OH emissions near 86 km altitude. The first results from the FPI and ASC have been presented at the Fall (1995) and Spring (1996) AGU meetings, as well as at the CEDAR summer workshop in 1996. Both instruments are fully functional and the FPI, in particular, is providing extremely high quality mesospheric wind data.

Figure 2 shows an example of zonal and meridional winds measured by the FPI on January 5, 1996. The instrument was configured to perform a five-point scan (four cardinal directions and the zenith). The packing of the data points and their associated error bars indicate an unprecedented sensitivity for a ground-based FPI measurement of mesopause winds. Our instrument has the ability to simultaneously image nine orders on the CCD detector, while maintaining extremely low read noise. This performance is enabling us to measure winds at rates approaching those associated with the Brunt-Vaisala frequency - thus directly observing gravity waves via their Doppler wind signatures.

The operation of the FPI and ASC instruments and other state-of-the-art instruments at EPCO will greatly enhance our ability to address many outstanding scientific issues ranging from polar cap energetics, small scale gravity waves, to mesospheric and lower thermospheric dynamics. Coordinated data taking strategies have been worked out between SPRL and Canadian optical observers which will enable systematic coverage of the key atmospheric emission lines.

Data from the EPCO instruments managed by SPRL are available for use by any member of the CEDAR community through the CEDAR data base. In addition, instrument modes can be reconfigured for specific campaign operations on request.

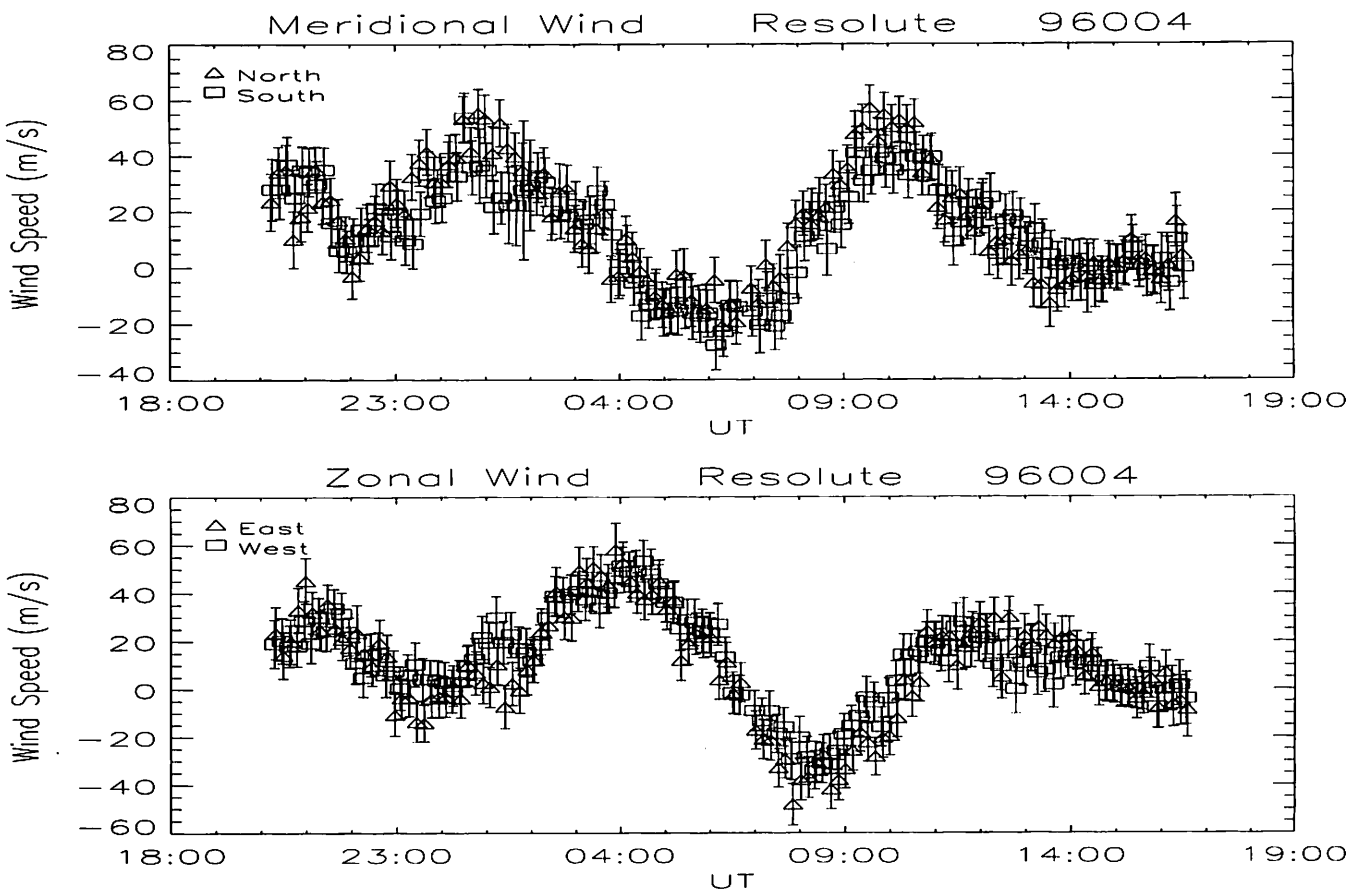


Figure. 2. Zonal (a) and meridional (b) winds at ~ 86 km altitude measured using FPI OH observations on January 5, 1996.

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