The CEDAR Post

COUPLING, ENERGETICS AND DYNAMICS OF ATMOSPHERIC REGIONS

Issue #54 November 20, 2008

From the CSSC Chair

Welcome to the 2008 Fall issue of the CEDAR Post. This issue includes an update from the NSF, a summary of CSSC activities, a new element called CEDAR Roots, a status report on the Resolute Bay Incoherent Scatter Radar, a community corner providing meeting summaries from CEDAR-related conferences, current and future satellite collaborations, and summaries and highlights of the CEDAR 2008 workshop.

We continue to develop and improve the e-CEDAR elements of the program and regular visits to the CEDAR main wiki page, http://cedarweb.hao.ucar.edu/wiki, will give you access to CEDAR information, forums, email newsletters, opportunities, and much, much more.

We have also recently signed a contract with the University of Colorado to bring the CEDAR meeting back to Boulder 21-25 June 2010. It will be exciting to return to the birthplace of the CEDAR meeting 24 years later, but before we do, we will return this coming summer to The Eldorado Hotel in Santa Fe, New Mexico for the 23rd CEDAR workshop from 28 June – 2 July, 2009.

- Jeff Thayer, University of Colorado

Inside this issue:

An Update from NSF

Budgets

The FY09 budget for Aeronomy is unknown at this point; currently, it's anticipated to be similar to the FY08 budget. The outlook for new awards is slightly better than last year: more awards from the past are ending so that more funds are available for new awards.

CEDAR competition

CEDAR FY09 competition received a total of 40 proposals. There were eight collaborations, leaving 31 separate projects. The funding available for the competition was about $1M; the total first-year request was about $3M. NSF recommended awards for 11 projects, involving 16 PIs. The success rate (of about 35%) appears larger than last year's but this is somewhat misleading: in general, this year's budget requests were very modest, enabling more proposals to be funded.

CEDAR Postdoctoral Competition

The most recent CEDAR Postdoctoral Program competition received five proposals; four of them requested support for a female postdoctoral scientist. Two awards were made, one of them as a joint CEDAR/GEM postdoctoral position, as follows:

CEDAR/GEM Postdoc: Yue Deng
Mentor: Tim Fuller-Rowell, U. Colorado
Title: Assess the Impact of Non-Hydrostatic Processes on the Response of the Thermosphere/Ionosphere System to Magnetospheric Forcing

CEDAR Postdoc: Guiping Liu
Mentor: Thomas Immel, U. California-Berkeley
Title: The Effect of Atmospheric Tides on the Equatorial and Near-Polar Ionosphere

MRI Competition

For the FY08 MRI competition, 17 proposals were submitted to NSF/ATM (the Division of ATMospheric Sciences); only two of these were for the Upper Atmosphere Research Section, consisting of Aeronomy, Magnetospheric Physics, Solar Physics, and Upper Atmospheric Facilities. The sole Aeronomy submission was selected for funding. Congratulations to Mark Conde, University of Alaska –Fairbanks, for his project entitled "MRI: Development of a Thermospheric Wind Imager".

Space Weather

There is a target date for a Space Weather competition in January 2009 but proposers should be aware that at this time there is no money set aside in the FY09 budget for this competition. Please contact an NSF Program Officer before submitting a proposal.

Additional NSF/UARS Program Director

NSF is currently engaged in recruiting an additional program director for the Upper Atmosphere Research Section. The action was prompted by the increasing workload demands on current program officers, much of which is due to a substantial increase in the number of proposals submitted in the last few years.

Deadline for Aeronomy proposals?

The Aeronomy Program is considering implementing a deadline for proposals submitted to the "core" Aeronomy program, which currently has a rolling deadline; that is, proposals may be submitted at any time. This change is being considered in order to enable better strategic planning of the research funded by Aeronomy. Under the current system, it is difficult to allocate resources equitably across all the different research areas seeking support. If a deadline is implemented, the date selected will not be close to

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the deadlines for CEDAR and Space Weather. Please send your comments on this to cfesen@nsf.gov.

Arecibo

NSF is in the process of releasing a Dear Colleague Letter that will announce its intention to recomplete the management of the Arecibo Observatory. The timeline for release of the proposal solicitation is uncertain, but is expected to be early in 2009.

UAF facilities workshop

Back-to-back workshops were held in September at Haystack Observatory in Massachusetts. The first workshop was to discuss the facility needs of the Upper Atmosphere Research Section, including instruments and observatories for studying the space environment from Earth's upper atmosphere to the Sun's surface. Researchers with potential facility-class instruments and observatories were invited to participate in discussions about the obligations and responsibilities facilities have toward the larger community. They were also asked to make presentations with information about the expected user base and operational costs for these instruments. The second workshop was attended by staff from existing facilities, including the incoherent scatter radars, SuperDARN, and the Consortium for Rayleigh and Resonance Lidars. Discussions focused on management models that might better integrate the facilities and lead to more effective facility operations. Talks presented at the two facility workshops can be found at http://www.isr.sri.com/uars-uaf-2008/overview.html.

- Casandra Fesen and Robert Robinson, NSF Aeronomy and UAF Program Managers

Update on the NSF CubeSat program

NSF received a total of 29 proposals in response to its first solicitation for "Cubesat-based Science Missions for Space Weather and Atmospheric Research", all of which were of extraordinarily high quality. A selection was then made for the first NSF-sponsored CubeSat mission, to be launched in December 2009.

The mission selected is the "CubeSat-based Ground-to-Space Bistatic Radar Experiment – Radio Aurora Explorer". It is a collaboration between Hasan Bahcivan of SRI International of Menlo Park, Calif. and James Cutler of the University of Michigan, Ann Arbor. The satellite will be operated in coordination with the AMISR incoherent scatter radar to investigate radio aurora from field-aligned irregularities in the high-latitude ionosphere. The primary scientific objective of the Radio Aurora Explorer (RAE) mission is to understand the microphysics of plasma instabilities that lead to field-aligned irregularities (FAI) of electron density in the polar lower (80-300 km) ionosphere. The RAE mission is specifically designed to remotely measure, with extremely high angular resolution (~0.5 degree), the wave spectrum of ~1 m scale FAI as a function of altitude, in particular measuring the magnetic field alignment of the irregularities. Due to the magnetic field geometry at high latitudes this bi-static (ground radar to satellite) configuration, in which a narrow radar beam is scattered off the FAI and then observed by the CubeSat receiver, is the only way to perform these measurements.

A second award was also made. A launch has not yet been found for this mission but the target launch date is mid-to-late 2010.

The mission, named Firefly, is an atmospheric science mission aimed at investigating Terrestrial Gamma Ray Flashes (TGFs). TGFs are the result of Bremsstrahlung radiation produced by 10-20 MeV electrons that are thought to be accelerated upwards over thunderstorms. The science goals of Firefly are to probe the lightning-TGF relationship, determine which kinds of lightning produce TGFs, and search for evidence of common but weak TGFs, which could have a large integrated effect on the upper atmosphere and near-Earth space. To accomplish this, Firefly will carry a multi-instrument payload consisting of a gamma-ray detector, VLF radio receivers, and red and white light photometers.

The Firefly mission is a broad collaboration led by Doug Rowland of NASA Goddard Space Flight Center, Greenbelt, MD, and Allan Weatherwax of Siena College, Loudonville, NY, with participation also from Universities Space Research Association, Columbia, MD; Hawk institute for Space Science, Pocomoke City, MD; and University of Maryland Eastern Shore, Princess Anne, MD. "Integrating innovative and creative educational efforts with front-line research is what NSF is all about," said NSF Deputy Director Kathie L. Olsen. "The new CubeSat program uses the transformational technology of CubeSats to do just that. The Firefly mission is a terrific example of a program that will pursue scientific discovery, while providing unique and inspiring educational opportunities." Regrettably, these are all the missions that NSF will be able to start at this time. We still expect to have a second competition for the NSF CubeSat program; current plans are for a program solicitation with a deadline of February 10, 2009. Since NSF is operating under a Continuing Resolution again this year, the deadline will most likely be postponed by at least a few months.

- Theresa Moretto, NSF Program Manager

CEDAR Science Steering Committee Findings

The 2008 CEDAR Science Steering Committee (CSSC) met for a day and a half at the NSF on October 28 and 29, 2008. The meeting served to plan and organize the CEDAR 2009 meeting in Santa Fe, NM and to continue moving forward on the future direction of CEDAR. Details regarding the CEDAR 2008 meeting in Zermatt, Utah can be found later in this issue.

CSSC members responsible for specific CEDAR 2009 meeting elements are:

- Distinguished Lecture Lead: Jeff Thayer
- Prize Lecture Lead: Larisa Goncharenko, assisted by Diego Janches
- Poster Session Lead: Diego Janches
  - Assisted by: Bill Bristow, Mike Rouhonemi, Susan Skone
- Workshop Lead: Lara Waldrop
  - Assisted by: Hanli Liu, Meers Oppenheim
- Tutorial Leads: John Plane, John Noto
- Science Highlights Leads: Meers Oppenheim, Joe Huba
- Student Workshop Leads: Marco Milla and Jonathon Fentzke

A New CEDAR Lecture Series: The Distinguished Lecture

A new element to the CEDAR program is the CEDAR Distinguished Lecture. This new lecture series is to recognize individuals within the CEDAR community that have made sustained professional contributions to CEDAR. This distinguished award refers to a long-term sustained body of work, beyond the past 10 years, that has helped shape the CEDAR program through research and service. This lecture is distinctively different than the prize lecture series and will help put into perspective the advances CEDAR has made over the years. The first lecture will be given in an evening setting at the 2009 CEDAR meeting in Santa Fe.

CEDAR Future Direction

The CSSC continued discussions regarding the future direction of CEDAR under the working title of Integrative Aeronomy. This discussion drew upon the CEDAR presentation given by the CSSC chair at the 2008 CEDAR meeting and the feedback received during the open community lunch session. The plan for this development is to produce a strategy document that will be circulated to the community and vetted at the next CEDAR workshop. This process will lead to transformational research and a new direction for the CEDAR community.

A briefing on the CEDAR strategy document was presented by the CSSC chair to Dr. Tim Killeen, the assistant director of Geosciences at NSF, and Dr. Anne-Marie Schmoltner, head of NSF's lower atmosphere research section, during the CSSC October meeting. The CEDAR plan resonated well with the new strategic plan being formulated by the geosciences directorate. Updates and opportunities for community feedback on this process will be possible through the main pages of the CEDAR wiki in the near future.

Lower Atmosphere Connections

Presentations at the CSSC meeting were given on lower atmosphere / upper atmosphere. Connections. New findings show hot spots of gravity wave energy that need to be explored, polar stratosphere warmings affecting the whole upper atmosphere, and latent heat releases from tropospheric convective activity driving nonmigrating tides in the thermosphere. These processes and activities require more extensive coordinated activities between the two regions and programs. CEDAR workshops, AGU special sessions and other organized events are planned to further bolster this connection. Your input would be appreciated to help further advance this activity.

Satellite collaborations

Presentations and discussions at the CSSC meeting on satellite / groundbased collaborations were fruitful and need to continue to properly leverage the attributes of these two approaches to ITM observing. New findings were presented on solar wind high speed streams and their periodic nature having clear signatures in thermosphere density data from the CHAMP satellite and in IR emissions and O/N_2 ratios from the TIMED satellite. Extended ISR observations during the IPY are also revealing such direct connections to recurrent high speed streams. The launching of the C/NOFS Air Force satellite is an exciting opportunity for collaborations with the groundbased community and details of this mission are provided in the next section. Also CEDAR supports the NASA Mission of Opportunity called Global Observations of the Limb and Disk experiment (GOLD - a far-ultraviolet imaging spectrometer planned to ride on a geostationary comsat) and the NASA Small Explorer Program aeronomy selection called the Neutral-Ion Coupling Explorer (NICE). A description of the NICE mission is provided later in this Post while a description of the GOLD mission will be provided in the next Post issue.

- Jeff Thayer, University of Colorado

CEDAR Roots

This section of the Post is to clarify terms or common concepts that are rooted in CEDAR science. The goal is that this material will help educate the community and the masses by also posting this material to Wikipedia. Through a culmination of material we hope the CEDAR science and program can be more visible to the general public through Wikipedia pages provided by experts in the field.

AERONOMY - The term "aeronomy" has been used widely for many decades, but its origin has mostly been lost over the years. It was introduced by Sydney Chapman in a Letter to the Editor, entitled "Some Thoughts on Nomenclature", in Nature in 1946. In that letter he suggested that aeronomy should replace meteorology, writing that the word "meteor is now irrelevant and misleading". This proposal was apparently not received with much support so in short note in Weather in 1953 Chapman, (1953) wrote: "If, despite its obvious convenience of brevity in itself and its derivatives, it does not commend itself to aeronomers, I think there is a case for modifying my proposal so that instead of the word being used to signify the study of the atmosphere in general, it should be adopted with the restricted sense of the science of the upper atmosphere, for which there is no convenient short word."
In a chapter, he wrote in a 1960 book (Chapman, 1960), he gave his final and definitive definition, by stating that "Aeronomy is the science of the upper region of the atmosphere, where dissociation and ionization are important". Today the term refers to studies of the physics and chemistry of the ionosphere, thermosphere and mesosphere region of the atmosphere and is a "convenient short word" that reminds us of the contributing body of work by Sydney Chapman to this field.

A workshop on "Comparative Aeronomy" was held at ISSI during the week of June 25-29, 2007. Participation of this workshop was by invitation only due to space limitations at the available meeting facility. The structure of the meeting was such that each of the 32 selected topics were allocated a 30 minute presentation, which was then followed by 20 minutes of open discussion. A book has been created that is based on those presentations, but is not a collection of the talks, but is a synthesis, presented as 11 chapters. This was the second week-long conference dealing with this topic; the first with
the same title was held as a Chapman Conference at the Yosemite National Park during February 8-11, 2000. A full-day symposium on comparative aeronomy was subsequently sponsored by the Royal Astronomical Society in London in January 2003. These meetings, and some preceding CEDAR Workshops, have clearly established that there is a great deal of similarity in the physical and chemical processes controlling the various upper atmospheres and ionospheres in the solar system. Yet, there are significant differences as well due to such factors as distance from the Sun, different neutral atmospheres, roles of intrinsic and induced magnetic fields, and the presence of a surface or regolith of the object under study. Therefore it has become quite clear that there is a great deal to be learned by discussions among scientists working on different aeronomical problems in diverse settings in our Solar System and, increasingly, on extra- solar-system planets.

- Andrew Nagy, University of Michigan

References: Chapman, S., Some thoughts on nomenclature, Nature, 157, 105, 1946.
Chapman, S., Nomenclature in Meteorology, Weather, 7-8, 62, 1953.
Chapman, S., The Thermosphere – The Earth's Outermost Atmosphere, Physics of the Upper Atmosphere, J.A. Ratcliffe (Ed), Academic Press, 1960.

Announcements? Accolades? Accomplishments?

Please continue to submit information to the Post editor at Jeffrey.thayer@colorado.edu

Resolute Bay Incoherent Scatter Radar

Resolute Incoherent Scatter Radar (RISR) nearing completion.

The new National Science Foundation-funded AMISR at Resolute Bay, Nunavut, Canada, is scheduled to be on-line by the end of 2008. The annual ship, which arrived in September, brought a crane, power distribution containers, power plant, and the 128 panels to be installed on the support structure. The bulk of the support structure was assembled shortly before the ship's arrival, and the top portion of the structure and the panels were installed in less than two weeks. The diesel-generator set that will provide power to the ISR has been installed, the cabling on the panels is being finished, and the scientists and engineers from SRI International's Center for Geospace Studies are scheduled to go to the site in November to test and calibrate the new radar.

This first AMISR face (RISR-N) is northward looking. The second face will be southward looking and is a proposed joint project led by the University of Calgary seeking funding from the Canadian Foundation for Innovation in order to fully populate the structure. This second face includes partnerships with other Canadian universities and the NSF.

The two systems will provide height-resolved measurements of the ionosphere over approximately 20° of invariant latitude. The basic parameters measured by ISR are the electron density, electron and ion temperatures, and ion motion. From these, a number of other parameters can be derived, including the *F*-region convection and the neutral- and electro-dynamics through the *E* region. The RISR will provide measurements that will add key elements to coordinated studies by the world's high-latitude ISRS.

The RISR and the Poker Flat incoherent scatter radar (PFISR) are the first ISRs built with funding from the National Science Foundation. They were designed by SRI International and use phased-array technology and distributed solid-state power amplifiers to enable nearly instantaneous 3-D imaging of the ionosphere and upper mesosphere. Both PFISR and RISR are operated and managed by SRI International for the National Science Foundation. More information, including how to request time on the system, can be found at www.amisr.com.

- John Kelly, SRI International

First AMISR northward looking face in Resolute Bay.

Community Corner

Report on the 12th International Symposium on Equatorial Aeronomy (ISEA-12)

The International Symposium on Equatorial Aeronomy (ISEA) is a historic meeting, initiated by ionospheric scientists in the early sixties soon after the Jicamarca radar started its operation near Lima, Peru in the early 1960s. ISEA has been established over the years as an important event for the world's research community interested in the physics of the low- and mid-latitude upper atmosphere and ionosphere. Since the first symposium in Huaychulo, Peru nearly five decades ago, ISEA is held regularly every 3 to 5 years in different locations around the globe. It represents an opportunity for researchers in the aeronomic community to review and evaluate their scientific achievements over the period since the previous ISEA, share their most recent results and ideas, and discuss possibilities for new directions in research, joint experiments and observational campaigns.

The **12th International Symposium on Equatorial Aeronomy (ISEA-12)**, was hosted by the Ionospheric Physics Lab, at the Department of Physics, University of Crete. It was held from 18 to 24, May 2008 at the Royal Knossos Conference Hotel to the east of Heraklion on the island of Crete, Greece. 170 participants, both senior and young scientists, from 25 countries, attended the symposium. A total of 250 papers (about 150 oral and 100 posters) were presented by invited and contributing authors during 11 scientific sessions distributed over a period of a week. The topics covered a wide range of research areas, reflecting the need to study the Earth's ionosphere - atmosphere system in a coupled sense. ISEA-12 comprised sessions on the dynamics of the middle atmosphere, mesosphere and thermosphere, *E*- and *F*-region plasma physics and ionospheric electrodynamics, including large scale ionospheric modeling and simulation, atmosphere-ionosphere coupling processes and phenomena, magnetic storm and space weather effects, and a session on new experimental techniques and instruments. In addition, and for the first time in its long history, ISEA-12 started with a full day of tutorials on key topics given by leading members of the aeronomic community, and ended with a session of invited expert talks on future research trends and unresolved problems. The works of the symposium, its program and abstracts, are included in the ISEA-12 ***Book of Abstracts*** which is available for inspection and download at the symposium's web page: http://isea12.physics.uoc.gr.

The ISEA-12 Organizing Committee is also proud to have produced the ISEA-12 ***Book of Tutorials,*** a high quality publication volume of 150 pages that was offered to all the symposium participants. Its scope was to allow the reader to gain a wider perspective on fundamental scientific aspects of low- and middle-latitude aeronomy, as they have evolved over the past five decades of research since the first ISEA meeting. It includes six tutorials which constitute comprehensive reviews of the present state of knowledge on key research areas of ionospheric and upper atmospheric science. The topics covered in this book are: upper atmosphere waves and dynamics (Prof. Bob Vincent, University of Adelaide), equatorial E- and F-region plasma irregularities and instabilities (Prof. Don Farley, Cornell University; Dr. Ron Woodman, Radio Observatorio Jicamarca), mid-latitude electrodynamics and plasma physics (Prof. Michael Kelley, Cornell University), internal and external influences on ionospheric electrodynamics at low and middle latitudes (Prof. Rod Heelis, University of Texas at Dallas), as well as lower and middle atmosphere electrical phenomena and electrodynamics (Prof. Umran Inan, Stanford University). The emphasis is on the observational characteristics of the various aeronomic phenomena at low and middle latitudes and the governing physical principles, theories and mechanisms, which define a working set of interpretations. The material of this book aims to allow the members of the community, whether they are specialists or not, to comprehend the recent developments in research and thus obtain a clearer picture of the current state of understanding concerning low- and middle-latitude aeronomy. The organizing committee and the participants of ISEA-12 dedicated this book to the memory of ***Tor Hagfors***, an outstanding scientist, a dear colleague and friend, who suddenly passed away on January 17, 2007. Based on the kind approval of the tutorial authors, the Organizing Committee makes the ISEA-12 ***Book of Tutorials*** available to everyone interested, by posting its entire pdf version in the symposium's web page at http://isea12.physics.uoc.gr.

The works (including also most of the oral and poster presentations in ppt or pdf forms) and other happenings of ISEA-12 will be compiled in a user-friendly DVD volume, presently under creation, to be distributed to every participant. Also a large number of authors have expressed interest in publishing their presentations in a Special Issue of *Annales Geophysicae* entitled "12th International Symposium on Equatorial Aeronomyu (ISEA-12)". The team of Guest Editors

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includes: Christos Haldoupis (University of Crete, Greece), Jonathan Makela and Erhan Kudeki (University of Illinois at Urbana-Champaign, USA), Jorhe Chau (Radio Observatorio de Jicamarca, Peru), Dora Pancheva (Academy of Sciences Geophysical Institute, Bulgaria), and Dave Hysell (Cornell University, USA). The paper submission deadline is September 30, 2008.

The ISEA-12 organizing committees, who have been responsible for the scientific program and the overall organization, wish to cordially thank everyone for their attendance and valuable support of the symposium in every respect and particularly for their scientific contributions. Many thanks are also extended to the national (Greek) and international sponsors (http://isea12.physics.uoc.gr), including the National Science Foundation Division of Atmospheric Sciences, for providing funds that assisted the participation of many colleagues from various countries, mostly young scientists and PhD students.

At the end of ISEA-12 it was unanimously felt that the symposium had been a great success, both scientifically and socially, and that the low- and mid-latitude aeronomic community has gained new momentum to carry on its research tasks and challenges into the future. To maintain the momentum and progress, the ISEA-12 Science Advisory Committee accepted the invitation of our Peruvian colleagues to host the 13th International Symposium on Equatorial Aeronomy in Peru in 2012. This will commemorate the 50th anniversary of ISEA. The journey continues!

- Christos Haldoupis, University of Crete

The Sunanda and Santimay Basu Early Career Award

This year marks a new award being given out by the Space Physics and Aeronomy (SPA) section of the American Geophysical Union (AGU), thanks to a generous gift from Sunanda and Santimay Basu. The Sunanda and Santimay Basu Early Career Award seeks to recognize an individual scientist for making an outstanding contribution to furthering Sun-Earth Systems Science (SESS) research done in developing nations. This contribution should further the understanding of both plasma physical processes and their applications for the benefit of society. The recipient will be invited by the Space Physics and Aeronomy Section to present a paper at AGU's Fall Meeting. A certificate of appreciation, three years' membership in AGU, and travel funds will be provided.

To provide a little bit of background on the establishment of the award:
In 2007 when Sunanda and Santimay Basu decided to endow this AGU award, they had 82 years of AGU membership between them! Sunanda became a member at age 22 when she was a Master's student at Boston University during a two-year stay in the US. The more difficult phase of being space physicists was encountered when they returned to India and Santimay wanted to build a Space Physics Group at the Institute of Radio Physics at Calcutta University while Sunanda earned her Ph.D. there. In the absence of any off-the-shelf equipment, Santimay successfully built satellite-signal receiving equipment from electronic components. This group is continuing space weather research, and his former students are leading the effort. On the other hand, Sunanda, even though she managed to become the first woman to get her Ph.D in Radio Physics from Calcutta University, had great difficulty in obtaining a suitable position there. This obstacle proved a

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turning point for the family, with Sunanda successfully applying for an NRC post-doctoral position at the Air Force Geophysics Laboratory near Boston and with Santimay (and their son) joining her in the US. They have since pursued rewarding research careers and have been an integral part of the CEDAR community. Given their experience, they decided to endow an Early Career Award which opens up the potential for the recipient to benefit from the recognition and interactions with peers at the pre-eminent meeting in their field.

The SPA Basu Award Committee, chaired by Jonathan Makela, is pleased to announce that Prof. Yao Chen of Shandong University in China has been selected to receive the inaugural Sunanda and Santimay Basu Early Career Award in Sun-Earth Systems Science. This award recognizes the significant contributions to Space Physics that Prof. Chen has made with his 2D MHD solar wind model as well as his role in successfully developing a new space physics program at Shandong University. He was chosen from a field of 6 excellent nominees.
The Sunanda and Santimay Basu Early Career Award will be an annual award given out each year at the AGU's Fall Meeting. If you know of someone deserving of this recognitions, we strongly encourage you to nominate them for the 2009 award. Nominations should be prepared by an AGU member or other geoscientist who is knowledgeable of the candidate's qualifications and include the following information:

- nominator's name and title, address and contact numbers;
- nominee's name and title, institutional affiliation, and address;
-
- a statement (not to exceed 2 pages) of the action(s) or achievement(s) for which the candidate is nominated;
- two letters of support from AGU members or from other recognized geoscientists belonging to institutions other than that of the nominee;
- a curriculum vitae of the nominee (not to exceed 3 pages).

- Jonathan Makela,
University of Illinois at Urbana Champaign

International Laser Radar Conference in Boulder, Colorado

Beginning in 1968 with its first meeting in Boulder, Colorado, the International Laser Radar Conference (ILRC) returned to Boulder this summer during 23–27 June 2008, holding its 24th ILRC meeting marking its 40th anniversary. Throughout its 40 years of history the ILRC has been the focal point for presentation of new scientific results and advances in methodologies by scientists from all over the world working in the field of laser remote sensing of geophysical properties. The 24th ILRC emphasized not only the most recent advances in lidar technologies and new methodologies, but also the latest applications in variety of scientific topics, ranging from atmospheric wind, aerosol, cloud, air quality and climate to middle and upper atmospheric research with combined groundbased, airborne, and spaceborne lidars. Increased research activities were seen in areas like space-based lidar, development of lidar networks, and spread of lidar activities throughout the world. The ILRC encourages young scientists to attend and present work, ensuring the vitality of the lidar field. At the same time, ILRC remains an enjoyable and stimulating meeting at which the international lidar community can get together to renew acquaintances, present new results, and discuss and even argue over controversial topics and future directions. The ILRC is held biennially under the oversight of the International Coordination-group for Laser Atmospheric Studies (ICLAS). The 2008 conference was co-hosted by NOAA and NCAR.

Dr. Xinzhao Chu from the University of Colorado, along with Dr. Philippe Keckhut of France and Dr. Chikao Nagasawa of Japan, chaired the program committee for the session of "middle and upper atmosphere physics and chemistry". Upon the request of the ILRC organizing committee, Dr. Chu presented an invited talk on advances in middle atmosphere research with lidar, in which she emphasized how middle atmosphere research could serve as a gateway to whole atmosphere climate studies and modeling, and how middle and upper atmosphere lidar technologies have advanced to address CEDAR-related science topics. Contributed talks to this session were given by P. E. Acott et al. of Colorado State University, B. Thurairajah et al. of the University of Alaska, M. Gerding et al. of the Leibniz-Institute of Atmospheric Physics, Germany, and C. G. Carlson et al. of the University of Illinois at Urbana-Champaign. Upper atmosphere lidar posters

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included contributions from Argentina, China, France, Germany, Greece, India, Italy, Japan, Russia, and the United States. US institutions included Arecibo Observatory, Colorado Research Associates, Colorado State University, Johns Hopkins University, University of Alaska, and University of Colorado. Student posters were presented from Dr. Chu's and Dr. Thayer's CU research groups and Dr. She's CSU research group. The NSF Major Research Instrumentation project, "A mobile Fe-resonance/Rayleigh/Mie Doppler Lidar," awarded to Dr. Chu and Dr. Thayer in Fall 2007 was highlighted in poster presentations at the ILRC.

An exhibit at the conference was developed to promote the new Consortium of Resonance and Rayleigh Lidar (CRRL) supported by the NSF Upper Atmosphere Research Facility program. The CRRL is a university-based lidar consortium with applications to middle and upper atmosphere.

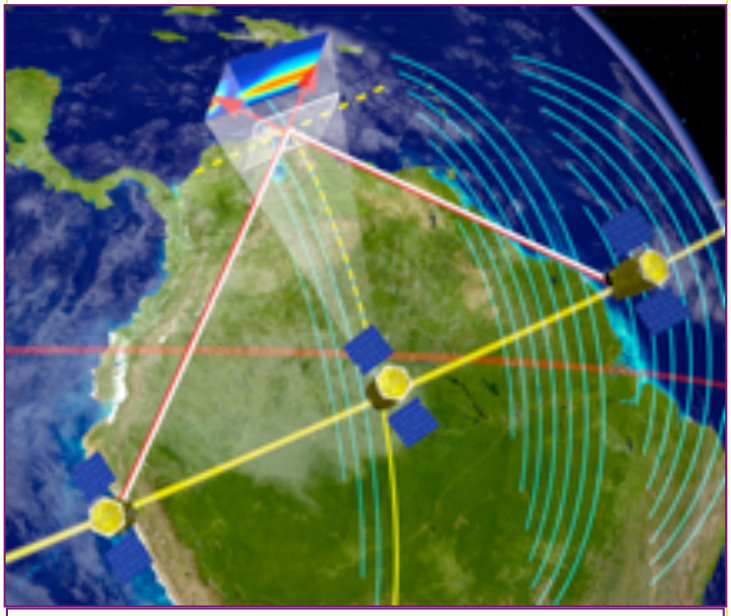
- Xinzhao Chu, University of Colorado

The 24th ILRC crowd on the Boulder campus of the University of Colorado in 2008.

CEDAR Satellite Collaboration

NICE opportunity for CEDAR science

The Neutral-Ion Coupling Explorer (NICE), is an aeronomy mission proposed in response to NASA's 2007 Small Explorer announcement (SMEX). It is one of six missions selected for further study, of which only two will be selected for flight in the year 2012-2014 timeframe. It is the one mission of the six with a science focus on geophysics. The Global Observations of the Limb and Disk experiment (GOLD), a far-ultraviolet imaging spectrometer planned to ride on a geostationary comsat, is also under consideration (as a SMEX mission of opportunity) for a possible 2014 launch. The selection of these two NASA missions currently under study, along with the recent launch of AIM (a previously selected SMEX), indicate the possibility of a new focus on aeronomy by the US space agency, and a great new era in collaborative space- and ground-based research efforts for CEDAR.



NICE shown in operation from 3 successive positions in one orbit 550 km over South America. The Fabry-Perot observations from the perpendicular views of its fore and aft channels are combined to calculate vector winds in the column of air viewed remotely at the center of the pass. The magnetic field line relevant to the in situ ion drift measurement maps down to the remotely viewed region.

The CEDAR program has made significant gains toward its goals by incorporating space-based observations of Earth's middle and upper atmosphere into its array of scientific tools. In the past decade, the cooperative efforts of the TIMED-CEDAR program demonstrated the great potential of integrating space-based measurements into ground-based investigations in order to advance understanding of the coupling of energy and momentum across atmospheric regions. In that time, additional space-based resources including COSMIC and CHAMP, launched by international partners, have added new capability to the study of aeronomy. Entering into its 7th year of operation, TIMED continues to contribute to CEDAR, but NASA has planned no new Solar Terrestrial Probes (the Heliophysics mission line that flew TIMED) to build upon the remarkable discoveries stemming from TIMED-CEDAR.

NICE will study the coupling of the thermosphere and ionosphere, measuring neutral winds and temperatures, neutral density and composition, and ion densities with a suite of both remote sensing and in-situ instruments. To be launched from the Kennedy Space Center, NICE will remain at low latitudes to focus on the dense plasma of the equatorial ionospheric anomaly and how it is modified in response to energy inputs originating both from below and above. To make these measurements, it will carry ultraviolet limb imagers operating in the extreme (55-90 nm) and far ultraviolet ranges (135-160 nm). These two instruments combine to retrieve both daytime and nighttime ionospheric density profiles, as well as neutral density and composition profiles. NICE will also carry a 2-channel Fabry-Perot interferometer that will retrieve vector winds and temperatures in the 90-300 km altitude range. In addition to these remote sensing instruments, NICE carries an ion drift instrument that will measure vector ion velocity at the spacecraft. This compliment of four instruments will provide a complete picture of the dynamic interaction between the ionospheric plasma and the dominant background gas of the thermosphere at all levels of magnetic activity. In its low inclination (24°) 550-km circular orbit, NICE will often measure F-region ion drifts on magnetic field lines that map directly down to the location of the remote neutral wind and density measurements. With thousands of such conjunctions, NICE will perform a very detailed study of the F-region effects of the dynamo electric fields produced by neutral winds in the lower ionosphere.

Ground-based measurements will compliment the NICE mission, which will make repeated, daily passes over the well-instrumented Caribbean and South American regions familiar to CEDAR scientists. NICE hopes to boost this collaboration with the additional selection of a SMEX-"Science Enhancement Option" to select a site in Northern Brazil for new instrumentation to specifically study

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gravity waves that modify the neutral winds in the E-region. The addition of a NASA-supported ground station has recent precedent with the successful deployment of 20 semi-autonomous all-sky camera and magnetometer observatories for the THEMIS mission. This effort clearly benefits already from the existing network of facilities supported by NSF and international partners, and would allow NICE to expand its science investigation into more areas of current interest to CEDAR.

The prospects for NICE and GOLD depend mainly upon the successful completion of their respective concept studies, but enjoy the benefit of continued expression of interest from the CEDAR and broader geophysics communities. Furthermore, the numerous interesting and surprising scientific discoveries made in the course of the past decade of aeronomical research, combining space- and ground-based assets to gain system-level understanding, make a positive case for the continuation of this successful approach to geophysical research. UC Berkeley, UT Dallas, U of Illinois, Michigan Aerospace and Orbital Sciences Corp. are working together with other partner institutions to make NICE a success. Please visit the website at http://sprg.ssl.berkeley.edu/NICE for more detailed information and descriptions of NICE.

- Thomas Immel,
University of California, Berkeley

Initial Results from the C/NOFS satellite

The Communication / Navigation Outage Forecasting System (C/NOFS) satellite was launched on April 16, 2008 into a 13° inclination, elliptical orbit between 400 and 850 km altitude.

C/NOFS is an Air Force mission with participation from NASA to advance our understanding of equatorial spread-F disturbances and their associated radio wave scintillation, with the goal of improving ionospheric scintillation forecasts. A network of ground-based instruments that monitor the ionosphere and the presence of scintillation is also part of the C/NOFS Mission.

Instruments on the satellite measure electric fields, plasma characteristics, neutral winds, and the strength of scintillation-producing irregularities. Models and algorithms assimilate the satellite observations and combine them with ground-based and other satellite data to forecast the global ion density as well as the regions where strong ionospheric irregularities are likely to produce scintillation. In this paper we briefly list the instruments and show samples of preliminary ion density and electric field data.

Satellite Instruments

Each of the six sensors on the satellite is working as expected. They are as follows:

1. *The Planar Langmuir Probe (PLP)* measures the ambient ionospheric density and electron temperature. Donald Hunton from the Air Force Research Laboratory is the Principal investigator (PI).

2. *The Ion Velocity Meter (IVM)* measures the ion drift vector, the ion temperature, and ion composition. Roderick Heelis from the University of Texas at Dallas is the PI.

3. *The Neutral Wind Meter (NWM)* measures the *in situ* neutral wind vector. Gregory Earle from the University of Texas at Dallas is the PI. Together, IVM and NWM form the Coupled Neutral Dynamics Investigation (CINDI), sponsored by NASA.

4. *The Vector Electric Field Instrument (VEFI)* measures the AC and DC electric and magnetic fields. An ion density probe and an optical lightning detector are also included. Robert Pfaff from the NASA Goddard Space Flight Center is the PI.

5. *The Coherent Electromagnetic Radio Tomography (CERTO)* instrument is a coherent radio beacon that transmits at three frequencies (150 MHz, 400 MHz and 1067 MHz). Paul Bernhardt from the Naval Research Laboratory is the PI.

6. *The C/NOFS Occultation Receiver for Ionospheric Sensing and Specification (CORISS)* is a dual-frequency GPS receiver that measures TEC between C/NOFS and GPS satellites. Paul Straus from The Aerospace Corporation is the PI.

Ionospheric Densities, Irregularities and Plasma Drifts – First Results

Ion density for one orbit is shown in Figure 1. The one-minute integrated ionospheric density derived from the PLP appears as a black line in the top panel. The one-second integrated density is highlighted in green. The blue line indicates the satellite altitude with the thicker portion marking when the satellite is in darkness. The sampling rate is usually set at 32 Hz during the day and 512 Hz at night. The FFT from the 512 Hz ion density is presented as color

Continued...

spectrograms in the middle panel. The lower panel shows the satellite trajectory and magnetic equator in red and green, respectively. Please note that the calibration of the ion density is still preliminary. The data provide an example of plasma irregularities formed at a very late local time, around midnight, rather than just after sunset as is frequently the case. This feature is probably due to the fact that the solar activity is at a minimum.

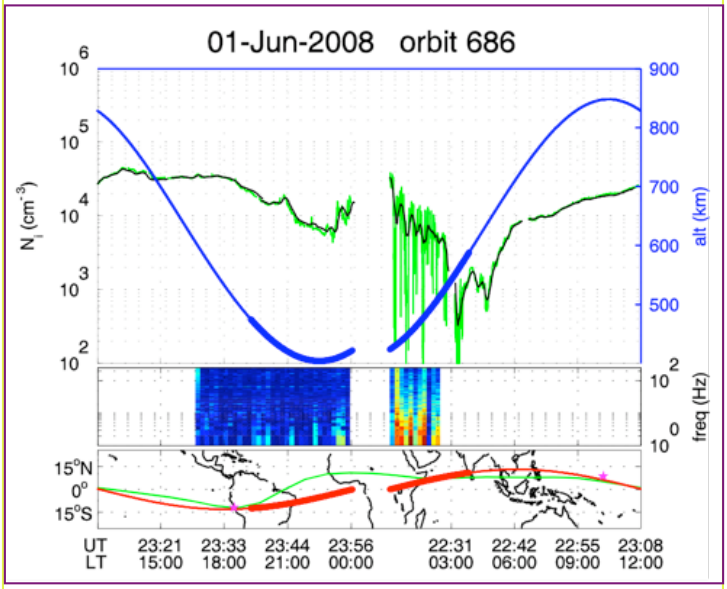

FIGURE 1

The zonal and meridional components of the DC electric field from VEFI are shown in the top three panels of Figure 2, along with the ion density measured from the VEFI trigger probe. Note how large the drifts are, reaching 50 to 100m/s. Similar large plasma drifts have been seen repeatedly in the data. Again, this is probably due to the low solar activity.

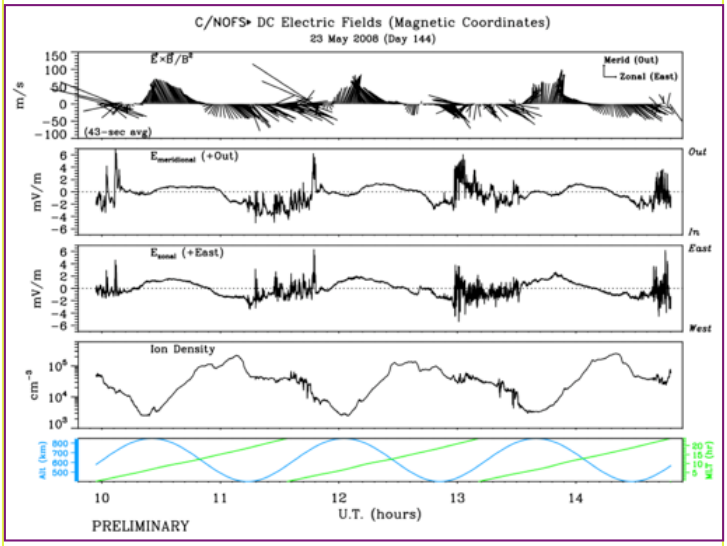

FIGURE 2

Concluding Remarks

The C/NOFS satellite is in orbit, and all instruments are working. The F10.7 index is at its lowest value since the beginning of the space age, and C/NOFS is providing a wealth of unusual observations of the ionospheric behavior during very low solar minimum conditions. We anticipate that C/NOFS will also supply important observations during times of higher solar activity, since it is expected to stay on orbit for about four more years.

The C/NOFS satellite data are available to interested scientists who should contact the instrument PIs. In addition, C/NOFS data will be provided through a NASA web site as soon as the physical parameters deduced from the instruments are thoroughly validated—probably in February 2009.

- Odile de La Beaujardière, Donald Hunton, Patrick Roddy, Air Force Research Laboratory, Space Vehicles Directorate, Hanscom AFB; Robert Pfaff, NASA Goddard Space Flight Center, MD
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Acknowledgements. The C/NOFS mission is supported by the Air Force Research Laboratory, the Department of Defense Space Test Program, the National Aeronautics and Space Administration (NASA), the Naval Research Laboratory, and The Aerospace Corporation. The C/NOFS satellite was built by General Dynamics C4 Systems, Spectrum Astro Space Systems.

CEDAR Workshop 2008

Summary of the 2008 Workshop

The CEDAR (Coupling, Energetics and Dynamics of Atmospheric Regions) Workshop for 2008 was held at the Zermatt Resort in Midway, Utah from Monday June 16 through Saturday June 21, with Sunday June 22 as the day for the NSF Community Models Workshop joint with CEDAR, GEM and SHINE. A total of 320 participants, 64 coming to CEDAR for the first time, came from 66 institutions, 9 outside the United States and Puerto Rico. There were 37 universities, 21 laboratories, and 8 small businesses. Of the 114 CEDAR students and post-docs, 25 were undergraduate students, and 8 came from universities or labs in Brazil (2), Taiwan (1), Japan (1), Peru (1), the UK (1), and Canada (2). About 20 more came this year compared to last year, although there were 10 fewer universities represented this year and about the same number of students came.

This year, we continued the CEDAR Wikipedia wiki for the workshop at http://cedarweb.hao.ucar.edu, available to all participants to upload their presentations and link them via editing, or to make comments on the Forum. The tutorials and other plenary talks are linked via the agenda, workshop descriptions and presentations are linked on the workshop list, and posters on the poster list. Major materials will also be moved to the archive of old meetings.

The theme of the Student Workshop on Sunday was "Space Weather Influences on the Ionosphere", arranged by Jonathan Fentzke of the University of Colorado. The keynote talk was given by Tom Bogdan of the NOAA Space Weather Prediction Center, Joe Huba of the Naval Research Lab gave a student tutorial, and Janet Kozyra of the University of Michigan and others gave mini-tutorials. These and other talks are available in .pdf form via the agenda on the wiki. After 4 PM, the students had

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free time for soccer at the Midway Elementary School. Other student sponsored social activities were Power Frisbee and salsa dancing taught by Ilgin Seker of Pennsylvania State University. The student social events were mostly arranged by Romina Nikoukar of the University of Illinois, who was the second year student on the CSSC (CEDAR Science Steering Committee). The new student representative joining Jonathan is Marco Milla of the University of Illinois.

The CEDAR Prize Lecture was given in the Tuesday plenary session by Sharon Vadas of Colorado Research Associates (part of Northwest Research Associates) on "The coupling of the lower atmosphere to the thermosphere via gravity wave excitation, propagation and dissipation". Three tutorials were presented on the following days by Han-Li Liu of the National Center for Atmospheric Research on "Atmospheric gravity waves: Applying classroom physics to research", Thomas Immel of the University of California at Berkeley on "Imaging geospace: Providing critical understanding of Earth's atmosphere-ionosphere system", and by David Hysell of Cornell University on "Inverse Methods in Aeronomy". The three morning talks at the Student Workshop, the CEDAR Prize Lecture, and the regular tutorials were video-taped and are available on DVDs. Please contact Barbara Emery (emery@ucar.edu, HAO/NCAR, PO Box 3000, Boulder CO 80307) if interested in obtaining hard copies and/or DVDs.

The CEDAR Science Steering Committee chair, Jeff Thayer of the University of Colorado introduced the concept of "Integrative Aeronomy". Science highlights were given by Dave Fritts of the Colorado Research Associates, by Janet Kozyra of the University of Michigan, and by Andy Christensen who retired from Aerospace Corporation, but is heading a NASA committee on strategic planning in geospace. Cassandra Fesen of the National Science Foundation updated the community about NSF issues. Susan Avery of Woods Hole Oceanographic Institute discussed CAWSES II, and John Kelly of SRI International gave the status of the Resolute Bay Incoherent Scatter Radar (RISR). Wayne Hocking of the University of Western Ontario in Canada talked about atmospheric networks, Daniel Morrison of the Applied Physics Lab of John Hopkins University talked about a virtual observatory, Eric Kihn of NOAA talked about the electronic Geophysical Year, and Alan Weatherwax discussed the International Heliophysics Year.

We heard five CEDAR Post-Doc reports. Final reports were given by Ningyu Liu of the Pennsylvania State University (now at Florida Institute of Technology) and by Mariangel Fedrizzi of the NOAA Space Weather Prediction Center. Interim reports were given by Joseph Comberiate of the Applied Physics Lab, Carlos Martinis of Boston University, and Jonathan Snively from the Utah State University. Including the Student Worskhop and special Advanced Modular ISR (AMISR) Science Planning Meeting with six sessions, there were 25 workshops total, two less than last year.

There were 134 posters at the Tuesday and Thursday poster sessions, 15 more than last year. There were 82 student posters, 61 in the student poster competition. Prizes were a certificate and various cash prizes. Winners, and then others, could also choose from a selection of classic books, most donated by Alan Peterson of Whitworth College and by Barbara Emery of the National Center for Atmospheric Research (NCAR). The judges picked first place winners ($125 each) from each session - Sarah Broadley (MLTS-03) of the University of Leeds in the UK, and Nicholas Pedatella (EQIT-13) of the University of Colorado; and honorable mentions ($75 each) - Kathrin Haeusler (COUP-06) of the GeoForschungsZentrum in Germany, visited NCAR this summer, and Tzu-Wei Fang (EQIT-08) of NCAR and the National Central University in Taiwan. Three undergraduate prizes ($50 each) were given to Allen Kummer (MLTS-01) of the Pennsylvania State University, Jonathan Sparks (METR-03) of the University of Colorado, and Katherine Roach of the University of Maryland and the Naval Research Lab. The judges also liked posters by Amal Chandran (U CO), Loren Chang (U CO), Jonathan Fentzke (U CO), and Sean Harrell (CSU) from the first session, and posters by Patrick Alken (U CO), Akshay Malhotra (PSU), Brady O'Hanlon (Cornell), and Marcin Pilinski (U CO) in the second session. Thanks to all the judges who spent so much of their time judging the posters, and thanks to all the students who participated in the student poster competition.

We took a 48-passenger bus from Boulder, Colorado to Midway and back with between 9 and 11 passengers. This bus was then used to take the students to their soccer field, for field trips, for lunch trips to Heber City and dinner trips to Park City. The field trips were to Heber City on Thursday to ride the Heber Valley Railroad and to Utah Olympic Park outside of Park City on Friday. Many participants were able to enjoy the free jazz in the streets of Park City Friday evening.

Sunday June 22 was the day in between the CEDAR and the joint GEM/SHINE Workshop which was also at the Zermatt Resort. This Sunday was the Student Workshop for GEM/SHINE and the joint CEDAR/GEM/SHINE NSF Community Models

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Workshop. Approximately 80 attended, about half from the CEDAR Workshop. One of the major goals of the workshop was to devise a plan for the next level of space weather models after the Center for Integrated Space Weather Modeling (CISM) project ends in 4 years. Another question was if a center is needed, should this organizing center be virtual or real, and what role should the Community Coordinated Modeling Center (CCMC) at NASA play. We heard 'Lessons Learned from Current Modeling Activities" in the morning, and heard from "Modelers" and the "User Community" in the afternoon. The discussion was fruitful, and although opinions on a new "brick-and-mortar" or "virtual" center were mixed, most agreed that the CCMC is doing a good job and should be utilized more within the Space Weather Community.

The 2009 CEDAR Workshop will return to the Eldorado Hotel in Santa Fe, New Mexico from Sunday June 28 (Student Workshop) to Thursday, July 2. CEDAR 2010 is at the University of Colorado. We meet with GEM in 2011.

- Barbara Emery, NCAR

The 2007 CEDAR Prize Lecture

The 2008 CEDAR prize lecture was awarded to Dr. Sharon Vadas of Colorado Research Associates, an affiliate of Northwest research associates. This award recognizes her significant contribution to CEDAR-related research in the past four years. Her recent theoretical work on the generation and propagation of gravity waves in the mesosphere and thermosphere has shed new light on wave energy and momentum transfer. In particular, in Vadas and Fritts [2005], Sharon derived a new anelastic gravity wave dispersion relation that includes explicitly the dissipative effects of molecular viscosity and thermal diffusivity, important effects in the thermosphere. This paper represents a significant development over the classical Hines [1960] gravity wave work, allowing the damping of gravity waves to be included in the linear dispersion relation. Ray tracing results performed by Vadas and Fritts [2006] and Vadas [2007] illustrate where waves should dissipate and deposit their momentum and energy into the thermosphere, which allows gravity wave effects on the ionosphere to be quantified. Recently, Vadas and Nicolls [2008] have extended the applicability of Sharon's work by showing that measurements of a wave's vertical wavelength as a function of altitude can give a measurement of the background thermospheric wind, for which ground-based (daytime) measurements are particularly difficult.

We would like to thank Dr. Vadas for an insightful presentation relating her work to important issues within the CEDAR community.

Sharon L. Vadas and Michael J. Nicolls, 2008: "Using PFISR Measurements and Gravity Wave Dissipative Theory to Determine the Neutral, Background Thermospheric Winds" GRL, in press.

Sharon L. Vadas, 2007: "Horizontal and vertical propagation, and dissipation of gravity waves in the thermosphere from lower atmospheric and thermospheric sources", J. Geoph. Res., 112, A06305, doi:10.1029/2006JA011845.

Sharon L. Vadas and David C. Fritts, 2006: "The influence of solar variability on gravity wave structure and dissipation in the thermosphere from tropospheric convection", J. Geoph. Res., 111, A10S12,doi:10.1029/2005JA011510.

Sharon L. Vadas and David C. Fritts, 2005: "Thermospheric responses to gravity waves: Influences of increasing viscosity and thermal diffusivity", J. Geoph. Res.,110, D15103,doi:10.1029/2004JD005574.

- Jeff Thayer, University of Colorado

Summary of the 2008 Tutorials

This year the CSSC selected CEDAR topics covering different altitudes and latitudes as well as different insruments, modeling and techniques that represent the broad research activities of the CEDAR community.

The first 2008 tutorial was presented by Han-Li Liu on Atmospheric Gravity Waves: Applying Classroom Physics to Research. In this tutorial, Dr. Liu covered atmospheric oscillation under buoyancy, gravity wave dispersion, polarization, energy and momentum fluxes. He reviewed the Eliassen-Palm theorems and gravity wave-mean flow interaction. Finally, he discussed gravity wave sources, propagation and impacts.

There are many useful insights that can be gained from studying the dispersion/polarization relations and the energy and momentum flux. For instance, it can be determined that a gravity wave is a transverse wave, and as it is a vertically propagating wave, its phase line can't be vertical or horizontal. Gravity waves are an important agent for atmospheric coupling. They transport momentum and energy from the lower to the upper atmosphere. They can be excited by any process that can cause vertical displacement of atmospheric parcels: convection, orography (i.e. mountain ranges), auroral heating, tsunamis, etc. Gravity waves propagate in a complex wind system and their impacts on the atmosphere involve interactions from global scale to microscale. Areas in need of research include the need for a detailed understanding of the gravity wave breaking process and its interaction to turbulence. There is also a need to better understand how gravity waves regulate and modulate precipitation, and to fully understand the role gravity waves play in the ionosphere and thermosphere. Dr. Liu concluded his talk by emphasizing the role that the CEDAR community can play in addressing these science needs, including the support of observational networks and ground based observations with high spatial and temporal resolution.

Our second CEDAR tutorial was presented by Dr. Thomas Immel of the Space Sciences Laboratory, University of California, Berkeley, on "Imaging Geospace: Providing Critical Understanding of Earth's Atmosphere-Ionosphere System."
Dr. Immel first reviewed the history of 2-D imaging of Earth's upper-atmospheric airglow emissions. As he noted, imaging of the airglow emissions from space was first achieved with a lunar-based imager during Apollo 16. Dr. Immel organized his talk by first discussing what terrestrial emissions originate in the upper atmosphere, and then described different instruments that could measure these emissions. He concluded his talk by showing how other experiments/datasets/models could contribute to make these airglow measurements more useful/revealing.
The Earth is a net radiator at several wavelengths due to the relatively large solar EUV fluxes. Major daytime emissions of O are at 1304 and 1356 A. The major emission of N2 is the Lyman Birge Hopfield band system between 1350 and 2200. During the night, photoelectron fluxes drop drastically and recombination of ionospheric O+ is the primary source of FUV (far ultraviolet) light. Finally, the coupling of magnetospheric currents, electric fields, and energetic plasma distinctly modifies the atmosphere, and has a clear signature in the aurora. It was apparent early on that comparisons of the ratio of particular auroral emissions in the FUV could be used to back out attributes such as the mean energy deposition.

Dr. Immel then discussed several different types of imagers Carruther's original instrument, suppressive imaging and spectroscopic imaging instruments and concluded his talk by showing how the combination of imaging, theory, and in-situ observations has led to significant new insights. For examples, he described the first global observations of the equatorial ionospheric anomaly (EIA) by IMAGE which showed reductions in density and height/latitudinal extent in different sectors

The third tutorial was presented by David Hysell, Professor at Cornell University and Principal Investigator of the Jicamarca Radio Observatory. The title of the tutorial was "Inverse methods in Aeronomy". The talk explored solution methods for inverse problems with examples taken from radio science and related fields. Inverse methods permeate almost every aspect of research in the geosciences as

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well as other natural and physical sciences and engineering generally. The data from which scientists and engineers make statistical inferences are generally incomplete, inaccurate, and inconsistent, and the optimal determination of the physical parameters responsible for a given dataset can be challenging to say the least. Inverse methods are used to address the problem systematically and constitute a rapidly growing, multidisciplinary field. Three examples of current research in Aeronomy were provided: (1) full-profile analysis of Incoherent Scatter Radar measurements at Jicamarca, (2) aperture synthesis radar imaging of coherent scatter targets from low and high latitude regions, and (3) ionospheric density profiles from radio occultation observations. In all three cases, David pointed out the need of using inverse methods, the advantages of the new methods compared to traditional fitting methods, and some of scientific implications of the obtained parameters.
The viewgraphs of these three tutorials are available on the CEDAR website.

- Anthea Coster, Massachusetts Institute of Technology

Summary of the 2008 Student Poster Session

Diego Janches, Rick Doe, and Simon Shepherd of the CSSC, with the help of Susan Baltuch and Barbara Emery, organized this year's poster competition. There were 62 student posters entered in the competition this year with 8 undergraduates presenting (out of 134 total posters). Posters were divided into two groups, Mesosphere – Lower Thermosphere (MLT) and Ionosphere – Themosphere – Magnetosphere (ITM), based on predetermined topical categories.

As always the success of the poster competition relies on the dedication of *volunteer* judges who give up valuable networking and socializing opportunities to perform the difficult task of identifying winners from the pool of outstanding posters in the competition. We thank the 12 judges who performed this important task admirably.

38 MLT student posters were judged on Tuesday evening and 24 ITM student posters were judged on Thursday evening. Judging was performed in two stages. For each night of the competition, every poster was first judged on its stand-alone merit without the student present. Students were then

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interviewed by *anonymous* judges and a group of finalists were determined. To determine a first-prize and honorable mention, each of the six judges visited the remaining posters in the pool of finalists. Prizes were also awarded to outstanding undergraduate posters.

It was acknowledged that the quality of posters has risen to a very high level in the CEDAR student poster competition. The quality of the posters makes the judging a difficult task. This year was no exception with many outstanding posters. We offer a few suggestions to keep in mind when preparing posters for next year's competition:

Written Poster:

- Should be clearly visible from several feet away
- Label figures and figure axes
- Tell a story of your research
- Organize like a journal article
  - Title (headline)
  - Abstract
  - Sections and figures
  - Details

Oral Presentation:

- Do not just read your poster
  - Tell your story
  - Use your figures as talking points
- Practice your presentation
- Do not be afraid to admit you don't know something

Most of all, keep up the good work! Thanks to the students for putting together so many outstanding posters this year. Thanks again to Susan and Barbara, and to the dedicated judges. A special thanks to the Zermatt Resort manager who provided the wardrobe for the event.

- Simon Shepherd, Dartmouth College
- Diego Janches, Colorado Research Associates
- Rick Doe, SRI International

2008 Student Poster Session Winners

First Place:
MLT – Sarah Broadley, "Calcium Ion Chemisty in the Upper Atmosphere", University of Leeds.

ITM – Nicholas Pedatella, "Longitudinal Structure of the Low-Latitude F-Region Ionosphere", University of Colorado.

Honorable Mention:
MLT – Kathrin Haeusler, "Nonmigrating Tidal Signals in the Thermospheric Zonal Wind as Observed by CHAMP", GeoForschungsZentrum Potsdam.

ITM – Tzu-Wei Fang, "Wind Dynamo Effects on Ground Magnetic Perturbation and Vertical Drifts", NCAR.

Outstanding Undergraduates:
Jonathan Sparks, "Seasonal and Diurnal Variability of the Meteor Flux at High Latitudes Observed using PFISR", University of Colorado.

Kate Roach, "Altitude Dependence of Thermospheric Winds in HWM07", University of Maryland.

Allen Kummer, "Day to Night Variability of Non-specular Radar Meteor Trails", The Pennsylvania State University.

Summary of the 2008 CEDAR Student Workshop

The theme of the 2008 Student Workshop on Monday was 'Space Weather Influences on the Ionosphere', organized by Jonathan Fentzke of the University of Colorado – Boulder. To open the workshop students were treated to the traditional NSF welcome by Dr. Richard Behnke, followed by a retrospective given by the CSSC chair Dr. Jeffery Thayer. The keynote presentation given by Dr. Thomas Bogdan, Director of NOAA's space weather prediction center helped introduce students to the topic of space weather and motivated the pursuing presentations on Ionospheric effects, science and coupling due to space weather with his talk: 'Space Weather and the Ionosphere'. Dr. Bogdan's keynote was followed up by a solid theoretical tutorial given by Dr. Joseph Huba of NRL titled: 'Magnetosphere-Ionosphere-Thermosphere Coupling Processes' aimed at educating students on the physics and modeling of space weather. The remainder of the talks engaged students via active question and answer sessions, brain storming small satellites, and an interactive CCMC demo to close the session. A big thanks goes out to all of the speakers, participants, conference organizers, and of course the NSF for helping to make this year's student workshop a big success! The presentation materials from all of the speakers can be found on the CEDAR wiki under the workshop agenda page for your viewing pleasure. After the official adjournment at 4pm, students had the opportunity to enjoy the beautiful weather and activities organized by second year student rep Romina Nikoukar from the University of Illinois. Students and 'Students' at heart headed to the playing fields at nearby Midway Elementary School for ultimate frisbee and the annual CEDAR soccer game. Students also were able to enjoy the amenities at Zermatt, such as the sand volleyball court, swimming pool, and spa/recreation facility. In addition, to the activities available to students after the workshop on Monday there was a student reception, breakfast with NSF, and a salsa dancing night to help students unwind during the conference. In addition, Jonathan succeeds Romina as the second year rep and the CSSC welcomes the incoming first year student rep Marco Milla from the University of Illinois.

- Jonathan Fentzke, University of Colorado

Summary of the 2008 CEDAR Topical Workshops

Tuesday, June 17

Space Science Instrumentation workshop with conveners Frank Lind and Julio Urbina

The Space Science Instrumentation workshop was attended by on the order of 45 to 50 people over the course of two hours. The workshop consisted of an introduction by Frank and Julio followed by invited speakers, discussion, and time for unscheduled presentations. Speakers were encouraged to identify common "patterns" in their work and Frank highlighted common patterns for the students during the changes between presentations.

The first speaker was Mark Conde of UAF who discussed mesospheric and thermospheric wind measurements by tracking the drifts of chemical trails released by sounding rockets. Mark discussed a new method for releasing a geographically dispersed "constellation" of chemical puffs by ejecting multiple sub-payloads from a single rocket. Each sub-payload will carry a small amount of chemical in an ampule; the chemical will be dispersed in a puff by shattering the ampule explosively. The goal is to disperse a few tens of these puffs over a region of around 100 km horizontal radius and a few tens of km in altitude. With all ampules launched from a single rocket, the entire constellation of puffs should be deployed within 1-2 minutes, which will greatly improve on any previous experiment.

The second speaker was Chuck Swenson of Utah State who focused on several examples from sounding rocket and ISS measurements. These measurements were used to provide examples of a number of important patterns. These included the importance of comparison between techniques, the necessity of understanding the instrument response function (and where you don't understand it), and the necessity of precise calibration. Often when the data from such procedures doesn't make sense it can reveal an important insight into the performance of an instrument.

The third speaker was Eliana Nossa of Cornell University. Eliana described a 30 MHz imaging radar system which has been deployed to Alaska and which overlooks the HAARP facility. The radar system is self contained and automated. Example data from the system was shown with the HAARP facility producing a modulation of coherent scatter in the radar field of view.

The fourth speaker was Simon Shepard of Dartmouth College. Simon discussed the deployment of a number of mid-latitude SuperDARN radar systems. Two such systems are now in place at Wallops Island and Blackstone and several more systems are planned for deployment in the near future. These radar systems overlook the plasmasphere boundary layer and have have already made interesting observations of temperature gradient driven instabilities. They are well positioned for monitoring storm time conditions. Key to the development of these new systems has been an improved and less expensive antenna design.

The fifth speaker was Cesar Valladares of Boston College. Cesar discussed the design of the LISN network including the deployment sites, the challenges of operating many remote sites, and the computing infrastructure used to collect and organize the data. Cesar discussed methods for estimating bias in TEC measurements from the LISN system.

A number of speakers gave brief presentations during the unscheduled discussion period. These included :

Christopher Watts of UNM who discussed the Long Wavelength Array which is a low frequency radio telescope currently being built in the southwest USA. This instrument is designed primarily for astronomical observations but will produce high precision ionospheric estimates as part of its online calibration. An overview of the instrument was presented along with a status update on the development. Example data from a VLA experiment was presented.

Marcin Pilinski of UC Boulder discussed the DANDE (Drag and Atmospheric Neutral Density Explorer) project. This satellite instrument is designed to be a low cost method of measuring drag effects on spacecraft between 100 and 350km altitude. The discussion focused primarily on the neutral mass spectrometer design and testing.

Frank Lind of MIT Haystack observatory discussed the ISIS (Intercepted Signals for Ionospheric Science) project. This instrument array has been deployed to mid-latitudes to provide observations of the plasmasphere boundary layer using active and passive radio techniques. The status of the instrument array was discussed along with early observations.

Overall there was a reasonable level of questioning and discussion given the size of the audience and the limited time available.

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Wednesday, June 18

Ground-space models for Studying Atmospheric Coupling workshop with conveners Han-Li Lu, Dave Suskind and Bob Schunk

In recent years there has been rapid development of general circulation models extending from the ground to the thermosphere. It is timely for the CEDAR community to learn the status of such model development, and to discuss issues in developing and validating these models, application of the models in studying atmospheric coupling, and whole atmosphere and/or upper atmosphere data assimilation.

Steve Eckermann presented the recent development of the NOGAPS-ALPHA, which now extends from the ground to ~100 km and includes non-LTE heating and cooling, prognostic ozone, H2O, CH4, and N2O, and parameterization of non-orographic gravity waves. The NOGAPS data assimilation system (NAVDAS) uses 3DVar methods and has been extended to assimilate upper atmosphere data (Aura MLS and TIMED/SABER). It also has the capability to ingest single-point measurements, which is valuable for CEDAR. The first results from an assimilation to support the AIM Small Explorer Mission were presented. Han-Li Liu reported that the NCAR WACCM has recently been extended to include the thermosphere and ionosphere (without electrodynamics). The model resolves compositional, temperature, and wind structures from the ground to the upper thermosphere in a self-consistent way. These fields and their seasonal variability compare well with climatology, and strong short-term variability is seen in the thermosphere.

Bob Schunk reported on a study of short-term variability in the ionosphere by incorporating fields from NOGAPS and WACCM as boundary conditions at 90 km in GAIM. Short-term variability with planetary-wave periods (2-20 days) is also identified in TEC and magnetometer data, and the need to study their sources using a whole atmosphere model was identified by Art Richmond and Wenbin Wang. Wenbin Wang also demonstrated that solar wind bear variability with periods between 5-15 days, which induces ionosphere/thermosphere variability with similar periods. A whole atmosphere model will be valuable in delineating the relative roles of lower atmospheric driving and solar wind driving. Variability on smaller and shorter time scales due to gravity waves needs to be simulated by regional models, and Larry Gardner described the development of one such model. This model extends from the ground to 600 km altitude and 600 km in the horizontal direction.

Most global models assume hydrostatic equilibrium, which is a valid assumption on global scales. As the model resolution increases, we are now approaching scales where such assumption is becoming questionable. Deng/Ridley used GITM, which is a non-hydrostatic global model, to demonstrate that the vertical wind due to intensive auroral heating could reach 60m/s around 250 km, comparable to FPI measurements of the thermospheric wind. As a comparison, TIEGCM simulation with the same amount of auroral heating yields vertical wind less than 5m/s.

The development of whole atmosphere models pose unique challenges, for example, the dominant physical processes and the respective temporal scales can be quite different at different atmosphere regions. Art Richmond pointed out the need to solve electrodynamics equations along magnetic field lines due to the significant anisotropy in electric conductivity, thus the need for conversion between the geomagnetic and geographic coordinate systems.

Results from whole atmosphere models could be very sensitive to the gravity wave parameterization used in the model. Dave Siskind showed that the mesospheric and thermospheric responses during a stratospheric sudden warming (SSW) are very sensitive to the both the orographic and non-orographic schemes used in the model, and observational constraints are needed to reduce the uncertainty in gravity waves. Constraints on gravity wave by observations during SSW were also discussed in another workshop, Coupling of Atmospheric Regions during Stratospheric Sudden Warmings.

It is critical to validate the climatology from whole atmosphere models against observations and empirical models. Preliminary validations have been conducted on WACCM and NOGAPS-ALPHA results. The community is now actively involved in validating the model results with observations. Tao Yuan presented a comparison of climatological winds and temperature from WACCM, HAMMONIA, and TIME-GCM with those obtained from multiple years of lidar measurement at CSU. Loren Chang compared migrating diurnal tide observed by multiple ground-based sites during the CAWSES tidal campaigns with that from CMAM, WACCM, and TIME-GCM/ECMWF. Larisa Goncharenko reported on the progress in the inter-comparison of observed tides during the CAWSES tidal campaigns.

The NRL-HWM has often been used to provide thermospheric wind climatology, and Doug Drob reported that it has been recently updated to include HRDI/WINDII winds. TIME-GCM results have been used where no data is available (e.g. polar region and night time in the lower thermosphere).

Chaotic error growth determines the predictability of a model system, and Han-Li Liu showed that in

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WACCM the error growth is the largest in the MLT and winter stratosphere--regions where planetary waves are strong. The error growth in WACCM is generally controlled by the error growth in the troposphere, which is likely associated with baroclinic/barotropic instability. Tomoko Matsuo's research in applying ensemble Kalman filter (EnKF) to MLT data assimilation signifies the importance of error growth in a forecast model.

EnKF data assimilation technique is being applied to physics based ionosphere models. Ludger Scherliess reported the development of a full-physics based GAIM model using EnKF, which can be used to determine the ionospheric drivers at low to mid-latitudes and global electron density distribution. Dave Pawlowski showed results from GITM EnKF data assimilation experiments and demonstrated improvement of TEC calculation by applying the EnKF technique.

From the presentations and discussions of this four-hour workshop, it is found:

- There is a clear need to validate whole atmosphere models with observations and empirical models so that the right baseline climatology can be obtained from these models. This will also help reduce uncertainties in model parameterizations. CEDAR is already playing an active role in the process.
- Better quantification of thermosphere/ionosphere variability demands whole atmosphere modeling.
- Regional scale models are needed to understand large variabilities on "weather" scales in the upper atmosphere.
- The predictability of the upper atmosphere is strongly influenced by the predictability of the troposphere. Its implication for data assimilation of the whole atmosphere should be further explored.

For data sparse systems, such as the ionosphere, ensemble Kalman filter technique applied to physics-based models proves to be a valuable tool in quantifying the variability of the systems.

Meteors and the Upper Atmosphere workshop with conveners Lars Dyrud and Diego Janches

Every year approximately 100,000 tons of meteoric material impacts Earth's atmosphere near 100 km altitude. However, many questions remain on this meteor mass and energy flux and the impact of this flux on upper atmospheric chemistry and ionization. For example, global yearly mass flux estimates are not constrained to within an order of magnitude. Of particular importance to the CEDAR community is that meteors account for all of the dust, metal neutral and ionized particles in the upper atmosphere (since there is no convection or diffusion of atoms or particles of this size from the ground all the way to 100 km). Further, meteoric dust is also thought to provide the condensation nuclei for polar mesospheric clouds PMC (high altitude clouds near 80 km), which is the focuses of a current NASA mission (AIM). Yet it remains unclear whether variability in meteor flux generates variability in PMC occurrence. Additionally, CEDAR researchers have used radar reflections from meteor trails to remotely sense winds and temperatures near the mesopause (a very difficult place to take meausurements, too high for lidar to low for fabry-perot measurements). With some success for winds but little success for temperatures. To address these issues, we invite presentations on the physics of meteors and their interaction with the atmosphere and ionosphere. Specific discussion is encouraged on the observation of meteors with NSF and CEDAR supported facilities, or the theoretical interpretation of such observations. We encourage contributions of research attempting to better understand meteors or general aeronomy via meteor observations, including upper atmospheric chemistry and metal layers. We also invite presentations of radar, Lidar and optical observations. Theoretical studies or simulations of the meteors and meteor trail interactions with the atmosphere/ionosphere are also invited.

It is expected that much discussion and presentations during this workshop will center on large radar observations of meteors including observations from Arecibo, Jicamarca, and AMISR, as CEDAR researchers have made serious contributions to the field of meteor science and meteor aeronomy using these radars over the past decade.

World Day Planning workshop with convener Wes Swartz

A planning meeting of the URSI Incoherent Scatter Working Group (ISWG) for the 2009 "World Day" (WD) schedule was held as one of the Wednesday afternoon CEDAR workshops. The ISWG is tasked to coordinate about 500 hours of experiments at all the incoherent scatter radars each year. As part of the IPY effort, most of ISRs had joint operations for considerably more hours than this.

Eight proposals were submitted in response to this

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year's solicitation. These are summarized below along with comments from the meeting and the reviewers.

1. Dynamics and temperature of the lower and upper thermosphere during Sudden Stratospheric Warming
• Investigators: Larisa Goncharenko, Peter Hoffmann, Irfan Azeem, and William Ward
• Requested length – 10 days
• Objectives:
– Measure winds and temperatures in thermosphere
• Before and during sudden stratospheric warmings
– Compare with average conditions
– Examine coupling effects
• Special needs:
– Month long alert period
– January or February
• Comments:
– This effort was met with considerable enthusiasm because of its unexpected relationship to the winter variability of the Jicamarca drift measurements.
– January or February

2. Temporal development of wind reversals and temperature of the lower and upper thermosphere during spring transistion
• Investigators: Larisa Goncharenko and Peter Hoffmann
• Requested length – 10 days
• Objectives:
– Measure wind, electron and ion temperatures
• Before and after spring transition
– Examine energy deposition derived from mesospheric radars
– Examine factors responsible for circulation changes
• Special needs:
– Month long alert period
– September
• Comments:
– After some discussion about the large fraction of the WD effort requested for just two proposals, it was decided that this experiment would only run in the Fall if the Stratospheric Warming 10-day request was not run in January or February.

3. ISR/GPS Coordinated Observation of Electron Density Variations
• Investigators: Shun-Rong Zhang and Anthea Coster
• Requested length – 5 days
• Objectives:
– To study latitudinal variations of the ionosphere
• American logitude sector, plasma layer behavior
– To examine time and latitudinal variations in the electron contend of the plasmasphere
– To test the GPS TEC mapping function
• Special needs:
– November or December
• Comments:
– Support recommended.
– See comments under #5.

4. Coordinated study of Quasi-Periodic Medium-Scale Traveling Ionospheric Disturbances with Extended Latitude Coverage
• Investigators: John Mathews, Frank Djuth, D. Livneh, I. Seker, Mike Sulzer, Craig Tepley, S. Smith, William Bristow, John Foster, and Mike Nicolls
• Requested length – Three 2-day periods
• Objectives:
– Are MSTID's related to QP thermospheric waves observed at AO, MSI, Poker Flat and others?
– Under what geophysical conditions do these QP disturbances exist
• Special needs:
– High time resolutions (5 minutes or better)
• Comments:
– This was a highly rated request.

5. Terrestrial effects of solar wind processes
• Investigators: Alexis Rouillard, Chris Davis, Ivan Finch, and Ian McCrea
• Requested length – Two 24-hour periods
• Objectives:
– Measure effects of
• equatorial solar coronal holes
• fast solar streams
• CME's
• solar flares
• Special needs:
– Select observing dates one month in advance
• Comments:
– There was considerable discussion about the feasibility of giving the advance notice needed to fulfill this request. Only the coronal holes can be predicted one month in advance (and this not with certainty) with the other events transitioning from the sun to the earth in a few days or a few hours.
– This one can be combined with the ISR/GPS (#3 TEC mapping) run, especially because the TEC mapping planners would love to catch a storm in their 5-day run.

6. Global Measurements of the Meteor Input Function
• Investigators: John Plane and Diego Janches
• Requested length – Two 24-hour periods
• Objectives:
– Measure micrometeor input function
• Geographical, seasonal, diurnal behavior
• Special needs:
– One period near a solstice
– One period near an equinox

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• Comments:
– It was pointed out that the radar modes required do not provide the "standard ISR" parameters (Ne, Te, Ti, Vi).
– Deemed a reasonable request, but possibly limited to just one 24-hour period instead of the two requested.

7. International PMSE Intervals
• Requested length – TBD
• Objectives:
– Global polar, not just regional as other campaigns
• Special needs:
– June – August
• Comments:
– Since this is a polar phenomena, the question arose whether the other radars should participate. (Note Sondrestrom's high frequency is not conducive to detecting PMSE.) The other radars could be scheduled at the same time to pursue other strictly low latitude objectives, C/NOFS for example, that could perhaps provide the advantage of more common days. Otherwise the effort could be coordinated apart from the full WD program.

8. International Auroral Intervals
• Requested length – TBD
• Objectives:
– Simultaneous measurements in European and American auroral sectors
– Measure inflow into the polar cap in one sector
– And outflow in the other sector
• Special needs:
– European and American auroral sectors in darkness
• Comments:
– This is another strictly polar phenomena, and coordinated directly with EISCAT, ESR, Sondrestrom, RISR, and PFISR separately from full WD program.

9. C/NOFS Support
• Investigators: Odile de La Beaujardiere, David Hysell, Wes Swartz
• Requested length – TBD
• Objectives:
– Forecasting ionospheric irregularities that adversely impact communication and navigation systems.
• Special needs:
– None
• Comments:
– Satellite is now in orbit and instrumentation looks good.
– Low inclination orbit, so prime data will come from low latitude radars.
– As many overhead passes need to be supported as possible.
– Coordination will be primarily with individual radars, but WD periods should also be exploited as events at other latitudes may become part of the forecasting scenarios.

10. Synoptic
• Investigators: Wes Swartz and Jan Sojka
• Requested length – TBD
• Objectives:
– Fill in data base with missing conditions, seasons, etc.
• Special needs:
– None
• Comments:
– These days are not formally proposed.
– See WD schedule.

Other Discussion:
Sixto Gonzalez said that Arecibo will add one day to the beginning of each world day run to help ensure full coverage of the scheduled days. Tony van Eyken proposed that we prepare for another "World Year" during the coming solar max. The value of these long runs (a la the IPY run) was strongly supported by Jan Sojka. The community should be aware that the Resolute AMISR (RISR) is scheduled to be online by the end of 2008 and we need to capitalize on the momentum that this should generate. Wes Swartz's extended term as the Chair of the URSI Commission G Incoherent Scatter Working Group ends at the URSI General Assembly in August. The current Vice Chair, Ingemar Häggström, with then take over as Chair.
The initial template for the 2009 schedule only included provision for the first 4 proposals, and the other 4 were submitted too late to be incorporated. The schedule and its updates will be posted at:

http://people.ece.cornell.edu/wes/URSI_ISWG/2009WDschedule.htm.
Bear in mind that as of this report, the posted schedule has not yet been updated!

As a reminder, a description of the World Day proposal procedure can be found at:

http://people.ece.cornell.edu/wes/URSI_ISWG/RequestingWD.doc.

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Analysis problems of Fabry-Perot interfrerometer imaging systems with conveners John Meriwether and Jonathan Makela

On Wednesday during the CEDAR 2008 meeting a data analysis workshop was held with the aim of discussing analysis procedures for data gathered from imaging Fabry-Perto interferometers (FPIs). Currently, several research groups work with such data, and the analysis procedures that have been developed are varied from one group to another. Thus, it is important to establish how well the results from the different analysis procedures compare with one another. As a way of bringing a focus to the workshop discussions, a set of images was distributed to interested parties for analysis before the CEDAR meeting. The images consisted of simulated data of the 630.0-nm emission with known parameters (which served as a baseline case for validation of the analysis routines) and actual data collected from an imaging FPI operated in Fort Yukon, Alaska by Prof. John Meriwether of Clemson University. Results of each group's analysis were presented and intercompared.

The analysis approaches used were several including Fourier series representation for the instrument function (Meriwether and Makela), a 2-dimensional model convolved with the instrument function (Conde and Chau), and the Univ. of Wisconsin approach which evaluates the direct convolution of the instrument function with the 630.0-nm Gaussian profile. During the workshop, discussion was had as to common difficulties experienced in the data analysis and general improvements that could be made to each group's procedures.

The conclusion reached at the close of the workshop was that the final data products (temperatures and neutral wind estimates) obtained by the various groups were fairly similar (generally within the error bars given by the analysis routines) despite the different approaches taken.

Space Weather Effects and Aeronomy Studies at the Plasmaspheric Boundary Layer workshop with conveners Anthea Coster and Mike Ruohoniemi

The plasmasphere encompasses the doughnut-shaped region of closed, dipolar field lines in the innermost portion of Earth's magnetosphere. Previously viewed as a relatively inactive component of the couple solar wind – magnetosphere system, new measurement techniques have revealed a host of dramatic effects that indicate the importance of understanding the dynamics of the inner magnetosphere and magnetically conjugate subauroral ionosphere. This workshop was convened to introduce the CEDAR community to the new results and to identify areas of potential collaboration between experimentalists, modelers, and the GEM community. Several review talks were followed by presentations on focused science results and a lively discussion of outstanding scientific questions.

Anthea Coster introduced the workshop by briefly describing the plasmasphere and plasmapause. She illustrated the appearance of the plasmasphere from deep space with the aid of pictures from the IMAGE satellite. These showed the erosion of the plasmasphere during storm conditions and the emergence of plumes. Jan Sojka then explained that the current models do not describe the plasmasphere very well. In particular, the models do not explain how electric fields reach inside the plasmasphere nor can they account for rapid time variations. As of now, only empirical relationships exist to describe the interactions of cool and hot particles and the interactions of particles with waves. T. Grebowsky commented from the floor that the interaction of the ring current with waves is an open problem and that the MHD models are inadequate to describe these processes.

John Foster emphasized the role of the boundary layer of the plasmasphere as the interface between the auroral magnetosphere and the IT-dominated inner region. The layer extends across ~1 L-shell and has active exchange of wave-particle energy and momentum. He reviewed the range of effects associated with perturbation of the plasmaspheric boundary layer, including SAPS, SED, SAID, and SAR arcs, and recalled early studies that explained whistler chorus in terms of wave-particle interaction at the PBL. He described how the disturbed ring current drives field-aligned current into the subauroral ionosphere and that flow and thermal gradients at the PBL lead to instability.

In the second part of the workshop the presentations shifted to application of specific techniques to observe effects related to the PBL. J. Michael Ruohoniemi showed examples from the new mid-latitude SuperDARN radars. In addition to the expansion of auroral electric fields to mid-latitudes during storms, these showed the spatial extent and temporal dynamics of SAPS and SAID events. During less disturbed periods the radars routinely detect backscatter from plasmapause irregularities; a joint Millstone Hill ISR – Wallops SuperDARN study has shown that these are due to the temperature gradient instability (TGI). The plasmapause backscatter renders views of the ionospheric electric

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field in the subauroral ionosphere and a movie was presented that showed the impact of substorm activity over several hours of MLT using simultaneous observations from the Wallops and Blackstone radars.
Michael Mendillo described ground-based observations of stable auroral red (SAR) arcs, which arise when the ring current encounters the edge of the plasmasphere during energization events. The arcs, despite their name, are structured and time variable. Of particular note, he described a case-study of a single SAR arc on the night of 29 Oct 1991 (Baumgardner et al., Annales Geophysicae, 25,2593-2608,2007). This SAR arc could possibly have been the brightest one since 1975. The Boston University CEDAR Optical Facility at the Millstone Hill/Haystack Observatory measured a peak value of above-atmosphere brightness of 13,500 R +- 20 %. This is compared to long-term averages of SAR arcs measured at the Millstone Hill location of 500 R +- 270R (and 20% uncertainty). It was concluded that the extremely high brightness levels observed were due to the heating of electron densities not in the trough but with the higher Ne values equatorward of the trough. This activity expresses important aspects of the dynamics of the inner magnetosphere, and of the relationship between the ring-current plasmasphere boundary and the mid-latitude trough. .
Phil Erickson spoke on ionospheric plasma waves generated in the vicinity of the PBL and observed on a sidelobe of the Millstone Hill ISR. The ISR measurements and new techniques utilizing passive radio observations show fingers of SAIDs moving poleward due to conductivity variations. The variability of the electric fields is being studied and the complex interaction of field-aligned currents and conductivity variations that underly this variability needs to be explored.
Susan Skone offered a view of space weather effects in subauroral ionosphere. She described the impact of scintillations on GPS applications and reviewed advances in GPS technology that offer mitigation. She discussed the error imparted to WAAS navigation from ionospheric perturbations and traced the source of the errors to the large gradients that develop near plumes.
The workshop concluded with an exchange of views on basic questions posed from the floor, such as the reasons for inconsistency between the magnetospheric and ionospheric manifestations of PBL processes and the limiting conditions for SAPS electric fields. The participants felt that the CEDAR community can provide necessary measurements and insight into the coupling and interdependence of magnetospheric processes with the subauroral ionosphere and neutral atmosphere and that future workshops - possibly to include GEM researchers - should be organized on this theme.

Thursday, June 19

Research Opportunities at Millstone Hill Observatory with conveners Phil Erickson, Frank Lind, Anthea Coster

The 2008 CEDAR Workshop "Research Opportunities at Millstone Hill Observatory" highlighted the range of exciting science possible at mid-latitudes, with a special focus on the capabilities of the mid-latitude Millstone Hill CEDAR Class 1 Facility and how they can be used to address outstanding and unresolved science questions.
Phil Erickson began the workshop by describing the Class I CEDAR instrumentation available at Millstone Hill, including the NSF Upper Atmospheric Facilities supported incoherent scatter radar with full local, regional, and wide coverage plasma profile capability and a spatial range from the northern Canadian maritimes to just north of Puerto Rico. The MIT maintained MADRIGAL distributed database is available as well to serve data from Millstone and other ISRs and to place measurements in regional and mesoscale context, using ancillary instrumentation such as GPS TEC maps, ISIS RF capture platforms, and a virtual empirical ionospheric model suite. The Millstone Hill ISR database spans more than 4 solar cycles and contains specific unique data sets (30 day runs, biweekly 30 hour IPY observations, stratospheric warming campaigns) ideal for multiple climatology, model/data comparison, and storm studies.
Phil continued with broad "one-slide science" coverage of topics with significant unexplained features in the mid-latitude ionosphere: the role of plasmasphere boundary layers at mid latitudes in disturbance electric field penetration, long term ionospheric trends and climatologies, mid-latitude tidal studies with multiple observations and models, lower-upper atmosphere coupling during stratwarm events, and mid-latitude traveling ionospheric disturbance (TID) studies using multiple techniques. All of these science topics are the subject of community focus and separate workshops, and have plenty of unsolved problems appropriate for new researchers and students.
Anthea Coster described significant mid-latitude space weather effects over the heavily populated continental US, focusing on geophysically driven storm-enhanced density (SED) structures and the sub-auroral polarization stream (SAPS), along with resultant effects on operational systems such as maritime differential GPS and other navigation systems. She emphasized that the statistical nature

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and individual event characteristics of these effects are of crucial importance and relevance to the wider community as well as CEDAR.

Phil Erickson returned to describe the wide range of mid-latitude physics within the plasmasphere boundary layer, at the interface between the auroral magnetosphere and the ionosphere/thermosphere dominated inner region. He covered in more detail outstanding questions regarding SED, SAPS, wave/particle interactions, and optically driven hallmarks of magnetosphere/ionosphere coupling such as stable auroral red arcs (SAR arcs). A wide list of unanswered puzzles about PBL dynamics followed which address the full range of magnetosphere-ionosphere-thermosphere coupling effects, all hot topics in the CEDAR and GEM communities from mesoscales to microscales.

Michael Mendillo next presented some thoughts on ionospheric variability at mid-latitudes, focusing on comparisons of models and long duration incoherent scatter radar runs. Comparisons of TIME-GCM and ionosonde records at mid-latitudes reveal that variability has interesting features which do not always correlate in a straightforward manner to the presence or absence of geomagnetic activity, as one would initially think. Long duration runs from the Millstone Hill ISR present a valuable resource to resolve this puzzle, especially as some of these present full vector velocity/electric field as well as altitude dependent ion and neutral temperature information.

Jean-Pierre St. Maurice then contributed a wide range of thoughts on mid-latitude plasma wave structures and resulting coherent backscatter techniques for probing these with ground based radars. He emphasized that a vast number of mid-latitude puzzles exist, such as radar echoes from small scale structures within thin layers, where localization with respect to gradients is not always as expected. So-called trough echoes in the middle of the plasmasphere boundary layer also require further study, as their generation mechanism has not been completely pinned down. Finally, both the E and F region ionosphere require much further study to elucidate the drivers of wave structures. In particular, SED events may have enough gradients and electric fields to trigger interchange instabilities.

The session concluded with two presentations on the future plans and vision for the Millstone Hill facility. John Noto (SSI) described the large number of upgrade paths and plans for the passive optics facility at Millstone, with several new red line and green line capabilities coming online soon providing both airglow intensity and all-sky imaging capability for winds. Frank Lind described the concept and plans for the Millstone Advanced Radar System (MARS), being developed with MIT Lincoln Laboratory and others as a next generation phased array architecture. MARS is a broadband array design with highly integrated all-digital receiver and exciters at the individual radar element level backed by supercomputing signal processing. The design retains wide field coverage and scanning capabilities, and the MARS concept is a multi-role instrument with ionosphere / upper atmosphere radar, radio astronomy, lower atmosphere, and heliosphere application. MARS is currently the subject of ongoing technical studies, and will represent a significant advance in Millstone Hill's capabilities.

Audience questions were addressed throughout the presentations, and the participants left with a greater understanding of the enormous range of unexplored science possible in the exciting and dynamic mid-latitude region.

Friday, June 20

The Second AMISR Science Planning Meeting: PFISR II workshop with conveners Josh Semeter

The Poker Flat Incoherent Scatter Radar (PFISR) has been operational since January of 2007. As described in many tutorial talks, PFISR presents a new sampling paradigm for ISR-driven science. Initial investigations with the facility have demonstrated the efficacy of pulse-to-pulse steering and sampling in a variety of creative ways (see http://isr.sri.com/iono/amisr/ for information and publication list). Initial results were highlighted at the Fall 2007AGU meeting ("Advances in high-latitude incoherent scatter science." http://www.agu.org/cgi-bin/sessions5?meeting=fm07&part=SA43A) and in a JASTP special issue (to be published Fall 2008).

This purpose of this session was to provide a more informal forum for discussion of recent PFISR activities, and plans for future campaigns. Mike Taylor presented coordinated optical and radar image measurements of noctilucent clouds and polar mesospheric summer echoes. Kristina Lynch led a discussion about requirements for PFISR support of rocket campaigns, with particular emphasis on

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experiences from the ROPA experiment. Don Hampton provided a detailed status report about the PFISR optical instrumentation program. Diego Janches discussed D-region measurements using PFISR. Robert Michell presented results from a careful comparison of radar and imaging observations related to Naturally Enhanced Ion-Acoustic Lines (NEIALs). Gabriel Michhue Common volume observations of Farley-Buneman waves with coherent/incoherent scatter radars at high latitudes. Shasha Zou discussed imaging ionospheric azimuthal flow bursts and the relationship to aurora. And, finally, Joshua Semeter presented initial results of an experiment aimed at volumetric imaging of the ionospheric response to substorm auroras The session concluded with a brainstorm on PFISR future plans.

CEDAR Science in Latin America workshop with conveners Carlos Martinis and Diego Janches

This workshop aimed to present current efforts to perform scientific projects, from both observational and modeling points of view, with relevance to CEDAR in the Latin American sector. We had nine presentations in the 2 hour session, many of which covered recent and current deployment of instrumentation, including lidars and optical cameras in Cerro Pachon, Chile; a meteor Radar in Tierra del Fuego; a new all-sky imager in Central Argentina, near the Arecibo Magnetic Conjugate point; and an optical array through out the Caribbean sector. Modeling of gravity wave seeding of equatorial Spread-F as well as campaign results from the Brazilian sector were also discussed. The speakers were Jorge Chau from Jicamarca Radio Observatory, John Noto from Scientific Solutions Inc.; Vince Eccles from Space Environment Corporation, Diego Janches from CoRA/NWRA; Carlos Martinis from Boston University; Jonathan Makela and Alan Liu from University of Illinois; Dominique Pautet from Utah State University; and Jonathan Friedman from the Arecibo Observatory. The speakers and the topics discussed reflected the large efforts invested by our community to build and deploy instrumentation, conduct observation campaigns and develop models. These efforts will help us better understand coupling between different atmospheric regions, inter-hemispheric differences and similarities, and will strengthen our commitment to foster international collaboration.
The conveners, Diego Janches and Carlos Martins would like to thank everyone that took part and attended this year's workshop.

Coupling of atmospheric regions during stratospheric sudden warmings workshop with conveners Larisa Goncharenko and Han-Li Liu

This workshop presented an opportunity for the CEDAR research community to review recent results related to variability in the mesosphere, lower and upper thermosphere and ionosphere during stratospheric sudden warmings (SSW).
Large variability in the MLT region is evident during SSW from both observations and numerical simulations. High latitude Rayleigh lidar data (Rich Collins, University of Alaska) indicate "elevated stratopause" (cooling at ~40-60km and warming at 65-75km) as well as decrease in the gravity wave activity during January 2004 SSW. South Pole Station rotational temperature data (Irfan Azeem, Embry-Riddle Aeron. Univ.) show mesopause cooling prior to 2002 SSW and concurrent abatement of gravity wave activity. As highlighted by Peter Hoffmann (Leibniz-Institute of Atmospheric Physics, Germany), mesospheric response to stratospheric warming events includes downward propagation of the wind reversal (i.e. stratwarming starts earlier in the mesosphere than in upper stratosphere) and reduced gravity wave activity and energy dissipation rate in the MLT region, which is consistent with the mesospheric cooling. Mid-latitude (54N, 12E) lidar data (Michael Gerding, Leibniz-Institute of Atmospheric Physics, Germany) shows average mesospheric cooling of the order of ~50% of stratospheric warming and a change in the altitude distribution of wind field from winter to summer-type pattern. As reported by Titus Yuan, mid-latitude lidar data (40oN, 105W) during January 2008 SSW indicates stronger westward and northward mean winds, increase in the 24-h diurnal tide for the meridional component and 12-h tide for the zonal component. Observations by Aura/MLS and TIMED/SABER (David Siskind, NRL) showed large temperature variation at high latitudes from the stratosphere to the lower thermosphere during the 2005-2006 major SSW, including an "elevated stratopause" around the peak warming. This feature is reproduced by a TIME-GCM/ECMWF simulation of this time period. Han-Li Liu (NCAR) presented analysis showing that the interaction between gravity wave and mean wind during the SSW is responsible for the observed temperature change in the MLT region, and that the "elevated stratopause" is caused by adiabatic warming, driven primarily by a westward gravity wave forcing, that initially started in the lower thermosphere in the early stage of SSW. The westward forcing, thus the adiabatic warming, descends after the peak warming as the

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eastward jet in the MLT weakens. Results from TIME-GCM and NOGAPS-ALPHA (David Siskind, NRL) simulations demonstrate the sensitivity of MLT variability to gravity wave parameters. SSW events could therefore be good cases for constraining gravity wave parameterization.

According to observations, gravity wave variance also changes during SSW. Chihoko Yamashita (NCAR student) analyzed the gravity wave variance change in the stratosphere and MLT using the TIME-GCM simulation of the 2002 Southern Hemisphere SSW. According to this analysis, the gravity wave variance peaks before the maximum warming in the stratosphere and after the peak warming in the MLT. The former is in general agreement with previous stratospheric observations. In the MLT region, however, observations have suggested decrease of variance. Analysis of model results also showed large spatial variability of the gravity wave variance in both stratosphere and mesosphere. This corroborates with Rich Collins results, indicating large spatial variability in the vortex structure during SSW. This has important implications for interpreting data from single site ground based observations.

Presentations by Koki Chau (Jicamarca), Mike Sulzer (Arecibo Observatory), Larisa Goncharenko (MIT, Haystack Observatory), Mike Nicolls (SRI International), Anja Stromme (SRI International) and Tony van Eiken (EISCAT Association) summarized observations by incoherent scatter radars during the January 2008 World Day campaign and all suggest that SSW may impact the ionosphere. At low latitude (Koki Chau, Jicamarca), a profound change in electric field occurred during the January 2008 SSW, January 2003 SSW and December 2000 SSW. This change includes significant increase in the F region vertical drift in the early morning and decrease in the afternoon. The F-region peak electron density is decreased due to a redistribution of electron density. At lower mid-latitude (Michael Sulzer, Arecibo), preliminary analysis of selected days indicates unusually strong daytime electric field and a daytime "collapse" of F-region electron density. Analysis of data at middle and high latitudes was focusing on SSW signatures in ion temperature. As presented by Larisa Goncharenko (Haystack Observatory, MIT), a cooling in the large altitude range (150-300km) and warming in a narrow altitude band (120-140km) was observed during stratospheric warming of January 2008 at middle latitude. The lower thermospheric warming is consistent with TIMEGCM predictions, albeit it is observed at lower latitude. At the high latitude, PFISR data (Michael Nicolls, SRI International) show cooling at 80-100km, which is consistent with previous mesospheric observations, as well as increased winds in the lower thermosphere. As indicated by Anja Stromme (SRI International) and Tony van Eiken (EISCAT), ionospheric parameters at high latitudes (EISCAT, Svalbard, Sondrestrom, PFISR radars) are strongly controlled by magnetospheric drivers, and search for SSW effects is more complicated than at lower latitudes.

The associated discussion indicated that although previous observational and numerical studies have suggested change of lower thermosphere temperature, O, and E region electron density, coupling with electrodynamics has not been explored. It was also recognized during discussion that both the Millstone Hill and Arecibo radar show large semi-diurnal signatures around the maximum warming in 2008.

From the presentations and the discussions, there are interests to further pursue the following issues:

1. The 2008 SSWs are well observed thanks to the IS radar observation campaign. This campaign also coincides with the 4-th Tidal Campaign (Dec 2007 – Jan 2008). This gives us an excellent opportunity to study the lower and upper atmosphere coupling. Numerical simulation using TIME-GCM is being planned for this time period.
2. What is responsible for the difference between observation and model simulation regarding gravity wave variance? What is a proper interpretation of the reduction of radar spectral width during SSW: decrease in temperature or decrease of turbulence intensity?
3. A challenge for the observational community is to determine the change in gravity wave characteristics and gravity wave momentum flux during SSW.
4. How different ionospheric and thermospheric parameters (winds, electric field, temperatures, electron density) respond to SSW? How the ionospheric response vary in time in relationship to SSW (lead or delay)? How does it vary with latitude/longitude?
5. The coupling with the ionosphere and electrodynamics will be explored using both observational and numerical results. What caused the ionosphere electron density "collapse" as observed by Arecibo ISR? Does semi-diurnal tide play a role? Is it related to SSW?

Saturday, June 21

Jicamarca and C/NOFS Amigos workshop with conveners Odile De La Beaujardiere, Koki Chau, Dave Hysell and Doug Rowland

The first half of the workshop was decicated to the C/NOFS mission, and the second half to new experiments, programs, and developments at Jicamarca. There was naturally considerable overlap. The following presentations were made to the worhshop attendees, which numbered about 60.

- Odile de la Beaujardiere - C/NOFS mission and status
- John Retterer - C/NOFS models and forecasting effort
- Don Hunton - PLP instrument status
- Rob Pfaff - VEFI instrument status
- Rod Heelis - CINDI / IVM instrument status
- Greg Earle - CINDI / NWM instrument status
- Paul Straus - CORISS instrument status
- Paul Bernhardt - CERTO instrument status

All the satellite instruments appear to be functioning normally, and calibration/ validation efforts are underway.

- Jorge Chau: Facility update, 150-km echoes
- John Meriwether: Recent results from Arequipa
- Marco Milla: ISR spectrum perpendicular to B: Magnetoionic effects
- Gerald Lehmacher: Radar cross-section, meteor radar, and HF radar at Jicamarca
- Meers Oppenheim: Large-scale simulations of FB turbulence
- Joe Huba: Three-dimensional modeling of ESF
- Dave Hysell: 2D simulations of collisional shear instability
- Fabiano Rodrigues: HF Doppler radar probing of ionospehric structure

Attention was drawn to the fact that the geomagnetic topology over Jicamarca is changing rapidly and that it should be possible for the immediate future to make highly accurate ISR drift measurements up to very high altitudes. New experimental features of the 150-km echoes suggesting the importance of velocity-space vs. configuration-space instabilities were also highlighted. Three efforts aimed at simulating gradient-driven plasma instabilities in the E and F regions in three dimensions were described. A number of new experimental efforts targeting mesospheric flows and irregularities including MST, MF, and meteor radar techniques were discussed. Finally, a very detailed investigation of magnetoionic effects on ISR spectral observations near perpendicular to B was presented.

The workshop concluded with an appeal from Jicamarca for proposals for observing time and experiments to support the C/NOFS satellite. This is the first satellite with plasma experiments and open data availability to fly over Jicamarca in a generation, and it can be exploited to advance any number of scientific objectives in equatorial aeronomy. Proposals can be formal or informal. Proposal pressure from the community will be helpful in securing more observing hours in upcoming years.

New Understanding of Thermospheric Density and Composition Structure and Variability workshop with conveners Jeff Thayer and Art Richmond

New thermosphere data sets, such as CHAMP and GRACE, and funded research activities have generated a resurgence in studying the thermosphere on daily, seasonal and long-term time scales. This workshop solicited participation through presentations of new observations, new modeling studies, and new findings related to thermosphere density and composition structure and variability. The workshop was well attended with over 40 participants and 16 presentations were given. Meeting minutes can be found on the CEDAR workshop wiki page.

The purpose of this workshop was to increase collaboration among researchers studying thermosphere neutral density and composition structure and variability. **Art Richmond** opened the workshop with a general discussion of thermosphere properties and provided the impetus for the workshop. **John Emmert** introduced long term trends in satellite drag data that indicated a decrease in thermosphere density of -2.68% / decade after removing solar cycle and annual cycle effects. **Liying Qian** presented seasonal variations in thermosphere density using NCAR – TIEGCM. To produce seasonal changes observed in O/N2 ratio by GUVI, the eddy diffusivity at the lower boundary of the TIEGCM needed to have a seasonal variation. A comment to this study was to see whether seasonal variations in geomagnetic forcing can produce the same effect.

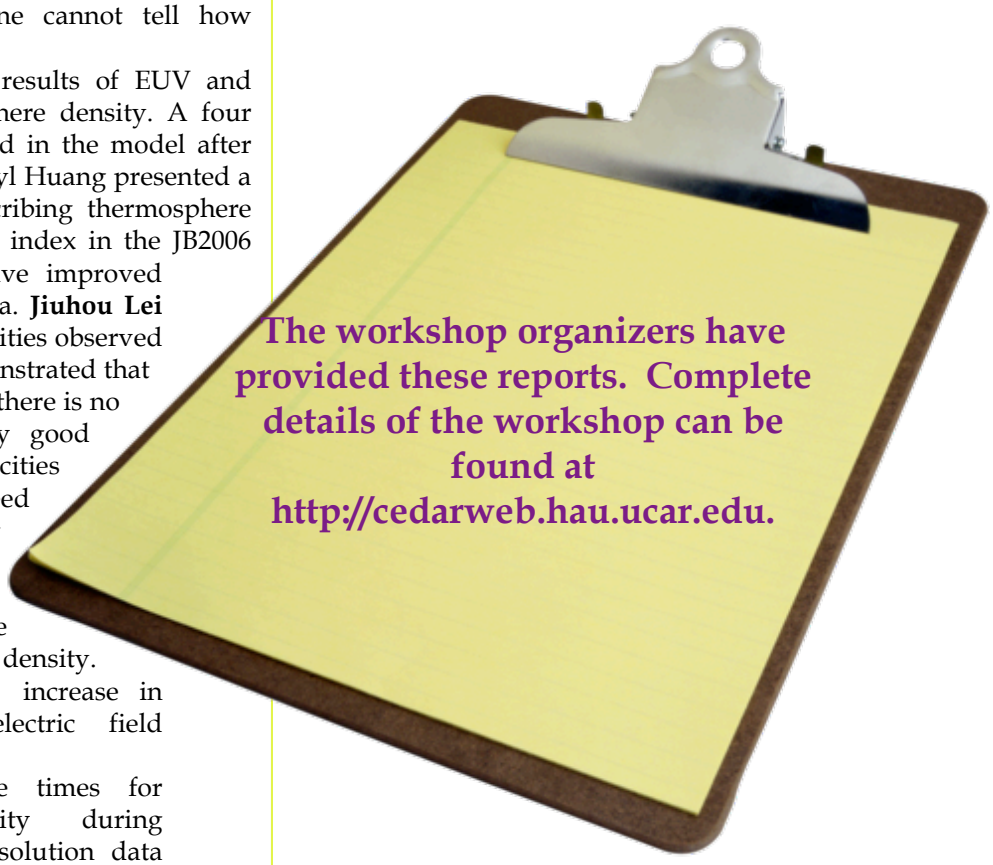
Marcin Pilinksi (a CU graduate student) presented work on addressing the estimate of the satellite drag coefficient and the inherent difficulties in modeling the accommodation coefficient. **Doug Drob** introduced an updated NRL horizontal wind model

Continued...

with new data sets added and an improved algorithm. **Kathrin Haeusler** (a graduate student at the Geoforschungszentrum Potsdam) presented results from her colleague **Stefanie Rentz** concerning the CHAMP residual thermosphere density around the dayside cusp region. The anomalous cusp increase in density was about 30% for the 2002-2005 data set and is less distinct in the southern hemisphere. **Tomoko Matsuo** analyzed spatial patterns of CHAMP density variability using EOFs, finding that 99.2% of the density variability can be represented by the mean and the first four EOFs. **Chin Lin** presented latitudinal variations in neutral density and enhancements in thermosphere density observed above 70 degrees latitude during quiet times. These quiet time enhancements seem to occur around the morning to noon MLT regions. One comment was that such a localized feature will not be reacquired by CHAMP due to satellite precession and so one cannot tell how transient is the feature.

Geoff Crowley presented model results of EUV and Joule heating effects on thermosphere density. A four hour time lag is generally observed in the model after being forced by Joule heating. Cheryl Huang presented a new approach to empirically describing thermosphere density response by using the Dst index in the JB2006 model. The model seemed to have improved when compared with CHAMP data. **Jiuhou Lei** presented CHAMP density periodicities observed at 5, 7, 9, 13.5 and 27 days. He demonstrated that for periodicities less than 13.5 days there is no response by F10.7 and that very good correlations exist with periodicities observed in the solar wind high speed streams and Kp index. **Art Richmond** presented work performed by **Yue Deng** on electric field variability and the response of the thermosphere density. Model results indicate a 30-40% increase in thermosphere density when electric field variability is included.

Eric Sutton presented response times for CHAMP thermosphere density during geomagnetic storms. The high resolution data indicated that lag time varied with latitude and that as short as 1 hour response was observed in the high latitude summer with 2-3 hours at lower latitudes. **Delores Knipp** introduced Poynting flux measurements from DMSP 15 with interesting enhancements at the dayside cusp region. **Aaron Ridley** summarized a study of magnetic pole position and its effect on thermosphere density. Stronger density response was modeled when the pole is displaced towards night than towards day. **Art Richmond** addressed composition effects due to high latitude heating and the estimate of net upward molecular flux. The model assumed a time constant to Joule heating events of 10-100 minutes. **Astrid Maute** described model results when varying the spatial scale of the energy deposition, finding that narrower heating distributions with the same amount of energy as wider heating distributions produced substantially stronger response in thermosphere composition.



The workshop organizers have provided these reports. Complete details of the workshop can be found at http://cedarweb.hau.ucar.edu.

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