Radar and Lidar Equations: One and the Same?

The performance of radar and lidar systems is characterized by two expressions referred to as the radar and lidar equations. These equations tell the story of how energy is transmitted, scattered and received. In each case a large amount of energy is sent into the atmosphere, a small amount of the incident energy is scattered, and a smaller fraction of that scattered radiation finds its way back to the receiver. Both systems employ electromagnetic radiation but have evolved out of two quite separate research communities, each with its own vernacular. The purpose of this article is to emphasize the common ground for the two technologies in the hope that communication between the associated scientists and students will improve.

In each case we start with a form which is familiar to workers in each sub-field and end with nearly identical forms which can be recognized by all. By this point, perhaps, we will have learned something about how radars and lidars work and that they are not so dissimilar.

The Radar Equation[1]

$$P_r = \left(\frac{P_t G_t}{4\pi R^2}\right)(\Sigma)\left(\frac{A_r}{R^2}\right) \tag{1}$$

Written in this form the incoherent scatter radar equation tracks the progress of the radiation from transmission through to reception. Starting with the first term, if a pulse of power P_t was to originate from the mythical isotropic radiator, then at a distance R the power per unit area incident on a spherical shell is $P_t/4\pi R^2$. But radars are much more directional than an isotropic radiator by the factor G_t, the gain, and we arrive at the formula inside the first bracket. In the equation, $P_t G_t/4\pi R^2$ is thus the power delivered in each pulse per square meter into the region of

interest. In the next two terms, Σ is the backscattering cross section per unit solid angle [m^2] and A_r/R^2 is the solid angle of the receiving system.

The gain, G_t, of the main beam is inversely proportional to the 4π solid angle illuminated by the antenna ($G_t = 4\pi/\Omega$). The beam solid angle, Ω, can be expressed for large antennas as $\Omega \approx \lambda^2/A_t$. If the transmitting antenna is equal to or larger than the receiving antenna and we lump all the efficiency factors into a single effective reception area, A_{eff}, the radar equation can then be simplified to

$$P_r = P_t \frac{A_t A_{eff}}{\lambda^2 R^4}\Sigma \tag{2}$$

The backscattering cross section can be written as $\Sigma = \beta V_s$ where β is the backscattering cross section per unit volume [m^2/m^3] and V_s is the scattering volume. The volume term is of great interest when considering "soft" targets. If the scattering is from a missile, plane, satellite, etc., it is termed a hard target. But in atmospheric scattering, the signal depends on the number of scatterers contained in the entire beam volume, which increases with increasing range. Written in terms of the solid angle, the scattering volume is $V_s \approx \Omega R^2 \Delta R$, where $\Delta R = c\tau_r/2$ (τ_r is the receiver bin time) defines the range resolution of the measurement. Remembering that $\Omega \approx \lambda^2/A_t$, the radar equation then takes the following form:

$$P_r = P_t \beta \Delta R \frac{A_{eff}}{R^2} \tag{3}$$

Notice that for a soft target the signal falls off as R^{-2}, rather than R^{-4} as might be guessed, due to the ever increasing size of the scattering volume with distance squared.

[1]Taken from the CEDAR Radar School notes, 1992 - Donald T. Farley.

The Lidar Equation[2]

$$E_r(\lambda,R) = E_t \xi(R) T(\lambda,R) \beta(\lambda) \xi(\lambda) \frac{A_o}{R^2} \Delta R \quad (4)$$

This version of the lidar equation corresponds to the case of Rayleigh backscatter. E_t is the energy per pulse transmitted from the laser. The two-way attenuation coefficient is defined as $T(\lambda,R) = \exp[-\int \kappa(\lambda,R)dR]$, where $\kappa(\lambda,R) = \kappa(\lambda_t,R) + \kappa(\lambda_S,R)$ are inverse attenuation lengths for the transmitted and scattered radiation. The squiggles, ξ, represent system efficiency. The first squiggle is an overlap factor between the transmitter and receiver fields of view since these are often different in lidar systems. The second describes spectral losses in the receiver system, for example, due to narrow band optical filters and the quantum efficiency of photo tube detectors. $\beta(\lambda) = \Sigma(\lambda)/V_s$, as defined in the previous section, is the volumetric backscatter cross-section per unit solid angle $[m^2/m^3]$. With the lidar equation defined in terms of $\beta(\lambda)$, we have already circumvented the hard versus soft target discussion by assuming an extended scattering volume. The receiver acceptance solid angle is A_o/R^2 where A_o is the physical area of the receiving telescope. It should be mentioned that lasers typically emit light which is much more directional than that of radar radiation patterns so the approximation $\Omega \approx \lambda^2/A_{beam}$ is even better than for a radar system. The range resolution, ΔR, is again defined as $c\tau_r/2$, where τ_r is the sampling time. In lidar work the pulses (τ_t) are very short and each one is used to illuminate a ΔR much larger than the pulse length, i.e. $\tau_t \ll \tau_r$.

In the laser community it is typical to speak in terms of energy per pulse. However, an alternate form of the lidar equation is obtained by dividing by $\tau_t(\tau_r/\tau_t)$ [R. M. Measures, *Laser Remote Sensing: Fundamentals and Applications*, Krieger, Florida, 1992; Eq. (7.21)]

$$P_r(\lambda,R) = \left(\frac{\tau_t}{\tau_r}\right) P_t \xi(R) T(\lambda,R) \beta(\lambda) \xi(\lambda) \frac{A_o}{R^2} \Delta R \quad (5)$$

where the ratio (τ_r/τ_t) defines the equivalent number of laser pulses of length τ_t, which contributes to τ_r, such that $(\tau_t/\tau_r)P_t$ is the average transmitted power in the sampling interval.

We can rewrite the physical area as an effective area to include the efficiency terms as $A_{eff} = \xi(\lambda)\xi(R)A_o$. For simplicity, we will assume that the transmissiveness is on the order of unity when working in the visible wavelength regime. With these changes the following form

$$P_r = \left(\frac{\tau_t}{\tau_r}\right) P_t \beta \Delta R \frac{A_{eff}}{R^2} \quad (6)$$

which is nearly identical to the radar counterpart in Eq. (3).

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[2]Taken from the Lidar School, CEDAR 1991, Eq. (7.14), in the book by *Measures*.

Going a step further, it is interesting to note the similarity in the incoherent and Rayleigh backscattering cross sections. We write the scattering cross section in the following suggestive form to highlight the similarity between the two methods:

$$\beta = N(Sr_e)^2 \quad ; \quad S = 1 \quad \text{Plasma} \quad (7)$$

$$\beta(\lambda) = N(Sr_e)^2 \left[\frac{500}{\lambda(nm)}\right]^4 \quad ; \quad S = 0.1 \quad \text{Rayleigh} \quad (8)$$

In these equations, N is the number density of scatterers and r_e is the classical electron radius.

The factor S has been included to take into account differences due to free versus bound electron scattering. As defined here, S=1 for the case of a free electron plasma and S=0.1 for atmospheric Rayleigh scattering at 500 nm wavelength. The results indicate that the cross section for unbound electrons (plasma) is roughly two orders of magnitude greater than that for bound electron states (typical of atmospheric constituents). Substituting these expressions for the cross section into our common form of the radar/lidar equation, we arrive at a final version of the two equations:

$$P_r = P_t N(Sr_e)^2 \Delta R \frac{A_{eff}}{R^2} \quad \text{Radar} \quad (9)$$

$$P_r = \left(\frac{\tau_t}{\tau_r}\right) P_t N(Sr_e)^2 \Delta R \frac{A_{eff}}{R^2} \left[\frac{500}{\lambda(nm)}\right]^4 \quad \text{Lidar} \quad (10)$$

As a hypothetical application, neglecting efficiency terms, we compare the power returned from 100 km with 1.5 km range resolution for both the Arecibo radar (noontime) and lidar (night or day) as indicated in Table 1 below:

Table 1

	Radar	Lidar
P_t	10^6 Watts	10^8 Watts
N	10^5 cm^{-3}	10^{13} cm^{-3}
S^2	1	$(0.1)^2$
A_r	7×10^4 m^2	0.4 m^2
τ_t/τ_r	1	1/1000
=====	============	============
P_r	8.3×10^{-15} Watts	4.8×10^{-15} Watts

The power received is of the same order of magnitude. However, experimental reality dictates that such measurements, while routine for the radar, are not possible for Rayleigh lidar. To see the difference, consider the results in terms of the number of photons received per pulse, obtained by dividing the power received by the energy per photon per range bin time (τ_r):

	Radar	**Lidar**
Photons/pulse	290,000	0.13

Though it is not typical to speak in terms of photon energy with the longer radar wavelengths, it is interesting to think in these terms. For the radar, the corresponding noise level is about 5000 photons per pulse so S/N is high during the day. At night, the plasma density drops below 10^3 cm^{-3} at 100 km and the radar signal-to-noise becomes of order unity. It is clear that even at night the lidar signal will be lost in a background noise at this altitude. However, as the sampling altitude decreases below 100 km, lidar systems consistently improve, while the radar S/N remains small. The next step involves studying the complex factors which determine the system noise, a step which is beyond the scope of this article.

Paul A. Castleberg, Cornell University
Michael C. Kelley, Cornell University

EISCAT and the International Scientific Community

The EISCAT Scientific Association performs investigations of the ionosphere and its coupling with the magnetosphere, the aurora, and the upper and middle atmosphere by using the incoherent scatter radar technique. EISCAT, located in northern Scandinavia close to 70° N and at 66° invariant latitude, is also used as a coherent scatter radar for studying instabilities in the ionosphere, for investigating the structure and dynamics of the middle and lower atmosphere, and as a diagnostic instrument in ionospheric modification experiments with the Heating facility.

The investments and operational costs are shared between the EISCAT Associate countries: Finland (SA), France (CNRS), Germany (MPG), Norway (Norges forskningsråd), Sweden (NFR) and the United Kingdom (SERC).

The EISCAT UHF radar operates in the 931 MHz band with a peak transmitter power of 1.5 MW and 32 m fully steerable dish antennas. The transmitter and one receiver are in Tromsø, Norway. Receiving sites are also located near Kiruna, Sweden, and in Sodankylä, Finland, allowing continuous tristatic measurements to be made. The monostatic EISCAT VHF Radar in Tromsø operates in the 224 MHz band with a peak transmitter power of 2 x 1.5 MW and a 120 m x 40 m parabolic cylinder antenna which can be steered mechanically in the meridional plane from vertical to 60° north of zenith; limited east-west steering is also possible using phasing cables. The EISCAT Heating facility is located close to the radar facility in Tromsø. It consists of 12 transmitters of 100 kW CW power, which can be modulated, and three antenna arrays covering the frequency ranges 3.85 MHz to 8 MHz.

A new third-generation radar is now being constructed on Svalbard, almost 1000 km north of Tromsø. This EISCAT Svalbard Radar (ESR) will operate in the 500 MHz band, initially with 500 kW peak power, 25% duty cycle and a 32 m fully steerable dish antenna. The ESR should be operational during first tests for internal use in the beginning of 1996.

The operations of EISCAT are distributed about equally between Common Programmes (CP) and Special Programmes (SP) and accumulate to more than 1500 hours per year. At present, seven well-defined Common Programmes are run regularly, particularly covering the Incoherent Scatter Coordinated Observation Days (World Days) in the International Geophysical Calendar. The corresponding analyzed Common Programme data (electron density, electron temperature, ion temperature and ion velocity) are available through the NCAR CEDAR Database in Boulder, CO, USA.

A large number of Special Programmes are defined individually by scientists from the EISCAT Associate countries. These experiments are frequently performed in collaboration with scientists from these countries as well as with scientists from all over the world.

Announcement of Opportunity for Use of EISCAT

In order to allow wider access to the EISCAT systems in Tromsø, Kiruna, and Sodankylä, a limited amount of experiment time can now be made available to a greater international scientific community for individual Special Programme experiments.

The proposals for such experiments should be preceded by a letter of intent to be submitted to the Director of EISCAT (address given below). It should be demonstrated in the letter of intent that the envisaged experiment will yield results which are competitive or novel to the state of the art. Solid reasons should be given as to why the EISCAT system is needed for such an experiment. The letter of intent will undergo a certain reviewing procedure to allow an initial assessment of the unique merit of the experiment. An evaluation as to whether such experiments could be technically performed with the EISCAT systems will also be done. It will further be considered whether the proposed experiment could be included in a collaboration with groups or individuals within the EISCAT Associate countries in cases where similar kinds of experiments are already being done or planned. Detailed information on the EISCAT systems and the guidelines for experiments should be acquired from EISCAT in writing before submitting a formal letter of intent for EISCAT experiments.

After successful assessment, an official response to the letter of intent will be issued by EISCAT, stating the priority given to the experiment. A detailed proposal should then be submitted, following as closely as possible the instructions provided in the EISCAT response. After

final reviewing, experiment operation time will be allocated according to the EISCAT rules. The conventional rule for Special Programme experiments, that EISCAT will provide the allocated experiment time free of charge, will apply, but EISCAT does not contribute to travel and all other related expenses.

More general information on EISCAT's systems, operations, rules, scientific results, and publications can be obtained from:

The Director, EISCAT Scientific Association
P.O. Box 812, S-981 28 Kiruna, Sweden.

Jürgen Röttger, EISCAT

CEDAR Proposal Submission Information

Proposals submitted in November, 1993 as part of the CEDAR New Technology Initiative are currently under review. Thirty-three proposals were received in response to this announcement with over $6 M in first year funding requested. The results of this competition will be announced in March.

The next deadline for general CEDAR science proposals is May 1, 1994. Note that this differs from the estimated date given in the New Technology Initiative announcement. Funding will still begin in early FY 95.

Because the November solicitation was restricted to instrumentation and facilities development, proposals submitted for the **May 1 deadline** should be strongly oriented toward scientific studies. However, modest instrumentation upgrades or operational support included as part of these scientific investigations will also be considered. Note that there will no longer be a solicitation for CEDAR proposals to be submitted in November. Until further notice, it can be assumed that CEDAR proposals will be solicited for submission on or around **May 1** of each year with funding to be provided as early as possible in the next fiscal year.

Special Note. **The National Science Foundation will soon announce significant changes in proposal format that will become effective on April 4, 1994. Information about the new guidelines is contained in the** *Grant Proposal Guide* **(NSF Publication 94-2). This publication replaces the** *Grants for Research and Education in Science and Engineering* **(NSF 92-89). CEDAR proposals submitted for the May 1 deadline must follow the new guidelines.**

Sunanda Basu, NSF

Odile de la Beaujardiere Named New Program Director for NSF Magnetospheric Physics

As of mid-January, Odile de la Beaujardiere is the new Program Director for Magnetospheric Physics. I have great confidence in Odile and am sure that this appointment will be beneficial to the GEM program. Please give your best support to Odile as she works to advance space plasma physics at NSF. I will be returning to the University of Maryland as a research faculty member in the Institute for Physical Science & Technology (IPST); phone: (301) 405-4829; e-mail: eastman@astro.umd.edu.

The new address for the National Science Foundation since its move to Arlington, VA is:

National Science Foundation
GEO/ATM, Suite 775
4201 Wilson Boulevard
Arlington, VA 22230
Phone: (703) 306-1519
Fax: (703) 306-0377
e-mail: teastman@nsf.gov (unchanged)

Tim Eastman, NSF

AIDA Data Archived in the CEDAR Database

The troposphere/stratosphere portion of the Arecibo 430-MHz data taken during the AIDA campaign have now been processed and archived in the CEDAR Database. The periods of coverage are 1989/3/7 to 3/15, 3/28 to 4/11, and 5/1 to 5/9, corresponding to the three "scenes" of "Act '89." Approximately 5 to 20 km in altitude are covered with 300-m resolution and integration times on the order of 30 sec to 1 min. Available in the database are the line-of-sight velocities, SNRs, and Doppler spectral widths. For information on how to access these data, contact Roy Barnes at bozo@ncar.ucar.edu. Before embarking on scientific interpretations or further processing of the data, we urge users to read the explanatory text in the headers which come with the data files (this is a general comment which applies to all database files). Any questions regarding this data set should be addressed to the lower/middle atmosphere radar scientist at Arecibo, John Cho at jcho@naic.edu.

John Cho, Arecibo Observatory

Planning Meeting:
Turbopause Transition Rocket Campaign

The Turbopause Transition Study Workshop held at the Annual CEDAR Meeting last summer defined a number of scientific issues of interest with respect to the dynamics, electrodynamics, and chemistry of the mesosphere/lower thermosphere or D and E region height range. The topics discussed included:

1. The need for more accurate measurements of the eddy and molecular diffusion coefficients, especially across the turbopause/homopause transition;

2. The effect of the upward gravity wave momentum flux on the height range above the turbopause;

3. Possible modulation of eddy diffusivity by the background tidal fluctuations;

4. Evidence for the eddy diffusive effects above the apparent turbopause height;

5. The relationship between the eddy diffusivity and airglow;

6. Exothermic heating in the mesosphere;

7. The relationship between sporadic E layers and sudden sodium layers.

The discussion at the workshop clearly showed that there are a number of important, outstanding questions that can best be addressed with a combination of in situ sounding rocket and ground-based measurements. Many of the questions have arisen as a result of either the CEDAR-sponsored AIDA campaign or the CRRES sounding rocket campaign, both of which were carried out in Puerto Rico. A number of investigators have already indicated interest in participating in a new rocket campaign to focus on the mesosphere/lower thermosphere region. The proposed campaign will require close cooperation between CEDAR for the ground-based component and NASA for the sounding rocket component.

We are planning to submit a sounding rocket campaign proposal to NASA in response to the next NRA. We anticipate that proposals will be due in August or early September. The target date for the campaign is the summer of 1996. Two possible launch sites have been discussed: Puerto Rico and Barking Sands, Hawaii. Puerto Rico has the advantage that the launch site has been used in the past by NASA/Wallops. The incoherent scatter radar, lidar, and other instrumentation at the Arecibo Observatory would be critical to many or all of the experiments. Barking Sands has not been used previously by Wallops, but launch facilities are available at the site. Furthermore, the new steerable telescope facilities at Haleakala and the excellent conditions for optical observations make the site attractive. The lack of significant radar instrumentation is a drawback.

In order to better define the scientific questions, to determine the measurements required to address the science issues, and to determine the most effective way to group the measurements, we will hold a one-day proposal planning meeting in early April, 1994 at the NASA/Wallops Flight Facility located at Wallops Island, VA. Wallops is centrally located, easily accessible, and was chosen to take advantage of the input regarding logistics, choice of site, and scheduling that NASA personnel can provide. April 6 is the nominal date for the meeting, but the schedule can be adjusted if necessary to accommodate as many interested investigators as possible. Those interested in participating in the proposed campaign, either with sounding rocket or ground-based measurements, should contact

Miguel F. Larsen
Dept. of Physics
Clemson University
Clemson, SC 29634

by e-mail (larsen@metradr.phys.clemson.edu), by fax (803/656-0805) or by phone (803/656-5309) to get additional information about the Wallops meeting and/or the proposed campaign.

M. F. Larsen, Clemson University
M. C. Kelley, Cornell University

1994 Annual CEDAR Meeting Plans

This year, the morning plenary sessions will be in the Math 100 lecture hall at the University of Colorado instead of at NIST. Parking permits for the week are available for $7.50/vehicle if you mark this on your registration form. Otherwise, only a few of these will be available at the meeting, and any extra will cost at least $15/vehicle. The parking is in lot 436 on the northeast corner of Colorado Avenue and Regent Drive. This is just across the street from the Engineering Center where URSI meetings are held. Math 100 is just west of the Engineering Center. The two poster sessions are tentatively scheduled from the morning break to lunch in the Hallet dormitory lounge on Monday and Wednesday. The afternoon workshops will be held concurrently at the two NCAR labs, Mesa in south-west Boulder and Foothills in the north-east. In 1993, the fire marshal objected to over 50 persons in rooms with only 1 door. We will send out an e-mail questionnaire to pre-registrants in May after the workshops have been determined to find out which workshops should be grouped in which building. There are regular shuttle runs between the two labs every 30 minutes, taking about 20 minutes in transit, so people can go between workshops at the different locations. The TIMED workshop is scheduled at the NCAR Mesa Lab on Saturday, June 25. There is a possibility that workshops that are proposed late will be held on Saturday as well.

There will be a reception Monday evening at the Coors Brewery in Golden, Colorado, about 25 minutes south of Boulder. We will be in two separate reception areas, and 45 minute tours of the facility will be offered continuously between about 6 and 8 PM. This reception will offer a light buffet as well as free Coors beer. There will be another buffet on Wednesday, June 22 on the Tree Plaza of the NCAR Mesa Lab.

Barbara Emery, NCAR

1994 Annual CEDAR Meeting:
Workshops, Workshops, Workshops!

As in previous years, the afternoon sessions at the Annual CEDAR Meeting, June 20-24, 1994, will be devoted to workshops. At the 1993 meeting we had approximately 25 individual workshops distributed over five afternoons with attendance ranging from ten or so to over a hundred people depending on the subject.

The comments received by the Steering Committee about the workshop topics, organization, and scheduling during the last meeting have generally been positive. The afternoon sessions continue to be a strong attraction for the meeting attendees, and there appears to be a general feeling that the format is useful for both the experienced researchers and the less experienced graduate students just entering the field. However, while the feedback has been generally positive, there has also been input from the attendees over the last two years that many of the afternoon workshops are losing the workshop atmosphere and that many of the sessions are becoming more similar to AGU sessions with a tightly scheduled series of talks and little time for discussion. These issues were raised by Craig Tepley last year when he arranged the schedule for the 1993 workshops.

In spite of much discussion at the Steering Committee meetings and discussion with individuals, no clear solution to the problem has surfaced. To a large extent, the problem is a result of the great success of the meeting. A loosely organized workshop conducive to participation by the majority of the audience is simply not possible when the attendance at the workshop is one hundred people or more. Any suggestions from the CEDAR community will be gratefully accepted.

We will make every attempt to reintroduce the workshop atmosphere as much as possible at the 1994 summer meeting by encouraging the workshop organizers to specifically include time for discussion in the schedule. The seating and table arrangement can also affect the workshop atmosphere. We encourage the organizers to consider the best layout for their workshop rather than just accept the arrangement found in the room assigned to them. For example, one of the workshop organizers last summer requested seating for a panel at the front of the room. We will make every effort to accommodate the wishes of the organizers along these lines.

At the 1994 meeting, the afternoon workshops will be split between the Mesa and Foothills Lab. Having the workshops at two such widely separated locations is clearly undesirable, but there is no single location available that can accommodate all the sessions. Last year, all the workshops were held at the Foothills Lab, but objections from the Fire Marshal about overcrowding in the meeting rooms has precluded that option. The good news is that more space will be available. The rooms will be less crowded, and there will be more room for creative seating arrangements with, e.g., panels seated at the front of the room. The bad news is that much more careful planning will be required to avoid conflicts between workshops, especially those held on the same afternoon at the Mesa and Foothills Lab.

Those wishing to organize a workshop at the 1994 Annual CEDAR Meeting should make a request as soon as possible but no later than **March 31, 1994**. Please submit a workshop title and a brief summary of the workshop topic to: M. F. Larsen, Dept. of Physics, Clemson University, Clemson, SC 29634. An estimate of the expected attendance, based on experience from last year, will be helpful in the preliminary planning phase. Information

provided by the workshop organizers about potential conflicts with other workshops will also be appreciated. The material can be submitted via e-mail to larsen@metradr.phys.clemson.edu or by fax to (803) 656-0805. I can be reached by phone at (803) 656-5309 if there are questions that require an immediate reply.

Miguel F. Larsen, Clemson University

Second HLPS/GAPS Workshop to be Held Near Boulder, Colorado

The HLPS (High Latitude Plasma Structures) Group of CEDAR with its Solar-Terrestrial Energy Program (STEP) Working Group 3 counterpart GAPS (Global Aspects of Plasma Structures) will hold a joint three-day workshop on June 27-29, 1994 at the Peaceful Valley Lodge and Conference Center, Lyons, Colorado, located about 30 miles from Boulder (60 miles northwest of Denver) in a pleasant mountain environment. This will be the second such workshop, the first having been held at the same location two years ago. Sixty-one participants, including 15 from 12 countries other than the U.S., attended this highly successful first workshop. A noteworthy feature of the workshop was the presence of 12 graduate students and 4 postdocs who took an active part in the deliberations. A selection of 18 papers presented at that workshop will appear in the special section of the January/February 1994 issue of *Radio Science*.

The primary objectives of the second workshop will be the discussion of the results obtained during HLPS/GAPS experimental campaigns and conjugate mid-latitude campaigns conducted during the current low sunspot phase; the modeling of plasma structures in the ionosphere; and open discussions on how to go from mesoscale ionospheric weather modeling to irregularity growth rate modeling and, hence, to scintillation modeling. The specific topics for discussion will be similar to those presented at the first workshop with greater emphasis on modeling high and middle latitude macro- and mesoscale plasma structures. The second Peaceful Valley Workshop will follow the annual CEDAR Workshop to be held in Boulder, June 20-24, 1994 and will be organized by Jan J. Sojka of Utah State University [phone: (801) 750-2964; fax: (801) 750-2992; e-mail: fasojka@sojka.cass.usu.edu (INTERNET)] who, with Ed Weber, is Co-Chair of the HLPS group. All future inquiries regarding the detailed program, attendance, etc., should be directed to Jan Sojka. An e-mailing with abstract deadline and registration information will be distributed this month.

Jan J. Sojka and Ed Weber
Co-Chairmen, NSF CEDAR HLPS Working Group

1993 CEDAR Workshop Video Tapes Still Available

Copies of the notes from the 1993 CEDAR tutorials, Prize Lecture, and the Data Analysis School have been available since late summer. The videos were edited and copied to 5 separate tapes at a cost of $80 per set for NTSC, and $125 per set for PAL or SECAM. Copies were sent out in November, but more copies are still available. The five tapes are:

Tape 1: School #1 - R. Clark, *Introduction to the Fourier Equations*

Tape 2: Tutorial #5 - D. Torr, *Photochemistry of the Lower Thermosphere and Mesosphere*; School #2 - S. Avery and S. Palo, *The Periodogram and its Statistical Properties*

Tape 3: Tutorial #3 - R. Walterschied, *Atmospheric Gravity Wave Effects on the Climate, Dynamics and Compo-*sition of the Upper Mesosphere and Lower Thermosphere (MLT)*; School #3 - R. Vincent, *Exploring Data Using Fourier Techniques*

Tape 4: Tutorial #1 - J. Forbes, *Tidal and Planetary Waves;* School #4 - F. Vial, *Nonstationary Time Series*

Tape 5: Tutorial #2 - R. Meier, *Ultraviolet Spectroscopy and Remote Sensing*; Tutorial #4 - G. Rostoker, *Geomagnetic Substorms*; Prize Lecture - J. Cho, *Radar Scattering from the Coldest Place in our Atmosphere: Polar Mesosphere Summer Echoes*

If you wish to get a copy of the tapes or a free copy of the notes, please contact Dr. Barbara Emery at the address listed on the registration form.

Barbara Emery, NCAR

Call for Poster Papers: CEDAR 1994

Last year there were about 70 posters, 55 of which were presented by students. This was an increase of 35% over 1992. Like last year, there will be prizes for the best student posters. Poster space is 4 feet tall by 3.5 feet wide. There are two poster sessions tentatively scheduled in the lounge of the Hallet Hall dormitory in the late morning sessions on Monday and Wednesday. There will be no preview poster sessions. Please indicate on the registration form if you plan to submit a poster, and send a title and list of authors to:

Dr. Jeffrey Thayer
SRI International
333 Ravenswood Avenue
Menlo Park, CA 94025
Phone: (415) 859-3557
Fax: (415) 322-2318
e-mail: jeff_thayer@qm.sri.com

Please note whether or not the first author is a student.

Barbara Emery, NCAR

Nominations Requested for the 1994 CEDAR Prize Lecture

The CEDAR Prize Lecture was established in 1989 to recognize outstanding scientific contributions to the CEDAR Program. Selection is based upon a research paper either presented, submitted, or published during the past year. The candidate will present a special 30-minute lecture at the 1994 CEDAR Meeting. Previous CEDAR prize lecturers are:

1989 - Art Richmond, *Assimilative Mapping of Ionospheric Electrodynamics*
1990 - Mike Mendillo, *The Discovery of a Sodium Magneto-Nebula Around Jupiter*
1991 - Craig Heinselman, *Sondrestrom MUSCOX - Capabilities and New Results*
1992 - Colin Hines, *The Doppler Spreading Theory of Gravity Wave Spectra*
1993 - John Cho, *Radar Scattering from the Coldest Place in our Atmosphere*

The 1994 CEDAR Prize Lecture recipient will have the choice of either a free registration or a free video tape of the 1994 tutorials and Prize Lecture. Nominations for this year should be submitted by **April 30** to:

Dr. Michael C. Kelley
318 Engineering & Theory Center
Cornell University
Ithaca, NY 14853.
Phone: (607) 255-7425
Fax: (607) 255-6236
e-mail: mikek@ee.cornell.edu

Barbara Emery, NCAR

Correction to Issue 20

To clarify the Roble report in the September 1993 issue of the CEDAR Post, please note that John Y. N. Cho, *not* John Sahr, presented the CEDAR Prize Lecture at the annual CEDAR meeting in Boulder, CO. Apologies and congratulations to Dr. Cho.

Arecibo Data and the CEDAR Database

We wish to alert users to some issues pertaining to certain Arecibo data submitted to the CEDAR Database. Two research groups working with specific incoherent scatter radar data sets have noted some inconsistencies which may be indicative of problems in data and/or reduction procedures. At the Arecibo Friends Workshop during last summer's CEDAR meeting we mentioned that we were addressing this issue and we plan to report a complete summary at this year's meeting. For now, we wish to offer a brief, intermediate progress report.

The areas of concern mainly involve nighttime electron-to-ion temperature ratios, offsets in the measured ion drifts, and inconsistently calibrated electron densities, the last of which can sometimes result in apparent temporal discontinuities. The period in question extends from October 1985 to the most recent data archives at NCAR, but involves only a few data sets from that period. That is, most of the data are unaffected, are of high quality, and would not benefit greatly from further analysis. However, we have recently improved the analysis algorithms to assure the most consistent behavior and quality of the Arecibo radar data supplied to NCAR, and this will ultimately result in a replacement of some of the existing NCAR holdings.

The steps that we have taken so far include a detailed comparison of several data analysis programs that were independently developed by the Arecibo scientific staff and aeronomy researchers at Cornell University. These programs were found to yield basically similar results for the same input conditions. To check for uniformity, we reobtained the Arecibo data sets from NCAR, since over the years, several individuals have had responsibility for database input and as such, a consistent data behavior over time may not be assured. A more refined analysis of many of these data yielded similar, if not identical, results as those archived at NCAR. However, there were a few cases where improvements in the quality of the results were observed. For any improvement made in data processing techniques over the years, one has to gauge whether or not it is significantly worth the extra effort to go back through the archives and reprocess all previously submitted data, or to simply implement what we now know to be a better way to handle future results. This issue is currently being discussed.

We wish to assure the user community that we are concerned that problems may have slipped through the cracks, so to speak. We also wish to remind the community that interaction with the CEDAR Database is a mutual responsibility. If there is a concern about some aspect of Arecibo data, it is important to communicate with us about it, so that the staff members involved can address the issues in a timely manner. This is the way that the operation of CEDAR Database was originally intended. This form of mutual cooperation is the only way we can all assure the quality of the archived data.

Craig Tepley, Arecibo Observatory

Graduate Student Fellowships to Work with the CEDAR Database

Again this year, there is an opportunity available for two graduate students to work intensively with the CEDAR Database around the time of the 1994 CEDAR Workshop. We anticipate that they would arrive before the meeting on Wednesday, June 22, would work on workstations with database personnel before the meeting, attend the meeting, and then work between June 27 and June 30 (Thursday) after the meeting. Recipients will have their dormitory rooms paid for the entire time and will receive an extra $26/day for the extra time they are in Boulder. The NCAR shuttle service can get them from campus to Foothills or the Mesa Lab. Friday, July 1 is a NCAR holiday. Only students with some significant database project will be considered, and both students will be from different institutions in order to spread their knowledge around. A sample application form follows. Please include this information in your application. The selection committee will consist of some members of the CEDAR Steering Committee and some members of the CEDAR Database. Applications are due in by **April 30**, and the selection will be made by **May 9**. Applications can be mailed, faxed, or e-mailed to Dr. Barbara Emery at the address listed in the registration form. If e-mailed, the advisor approval and statement of support can be sent in separately via e-mail or otherwise.

Sample Application to Use the CEDAR Database
June 23-30, 1994

Name:
Institution Address:
E-mail Address:
Graduate Advisor:
Expected degree and date of graduation:
Expected CEDAR Database project:
(i.e., Need data from instruments or models....
      Need to select parameters....
      Project about ....
      Expected benefits ....)
Advisor approval and statement of support.

Barbara Emery, NCAR

University of Western Ontario
Atmospheric Dynamics Group Position(s) Available

One and possibly two research associate positions are available in the Atmospheric Dynamics group of the Physics Department at the University of Western Ontario, London, Canada. The position(s) can commence on or after January 1, 1994, and are for a duration of 1 year; further extensions may be possible.

The Atmospheric Dynamics group operates a wind-profiler radar operating at 40.68 MHz, and also analyzes data recorded with a 2 MHz spaced antenna radar located at the same site as the VHF radar. These systems are used to obtain information about winds, waves and turbulence in the troposphere, and lower and upper middle atmosphere. The group also has close links with other middle atmosphere facilities at the University, including a lidar and other optical equipment.

The successful applicant(s) should hold a Ph.D. in atmospheric sciences or a closely related field, and have experience working in middle atmospheric or tropospheric studies. Practical experimental experience with using atmospheric radars, or data produced by them, is important.

The appointee will be expected to undertake original scientific research. Responsibilities will include participation in group research programs, monitoring the current instrumentation, collecting and archiving data, and analysis of data. Independent research using the group's facilities will also be actively encouraged, and time will be made available for this. Presentations at conferences and publications in international journals will be encouraged.

Salary levels will be commensurate with experience, but will equal or exceed $30,000 per annum. Further information can be obtained from:

Prof. W. K. Hocking
Phone: +1 (519) 661-3652 or +1 (519) 661-2111, ext. 6438
email: whocking@canlon.physics.uwo.ca

Applications including the names of 3 referees should be sent as soon as possible to:

Ms. Roslyn Moorhead
Dept. of Employee Relations
Room 262, Stevenson-Lawson Building
The University of Western Ontario
London, Ontario, N6A 5B8

In accordance with Canadian Immigration requirements, this advertisement is directed to Canadian citizens and permanent residents of Canada. The University of Western Ontario is committed to employment equity, welcomes diversity in the workplace, and encourages applications from all qualified individuals including women, members of visible minorities, aboriginal persons, and persons with disabilities.

Stockholm University, Department of Meteorology
Post-Doctoral Positions Available

In the fairly near future the Atmosphysics Group of the Department of Meteorology, Stockholm University, in Sweden will be announcing two positions at the post-doctoral level. Normally these positions are for two years, renewable for a further two years.

The group is involved in rocket investigations of the upper atmosphere with in-situ techniques for the measurement of minor constituents. Other activities are the remote sensing of the upper atmosphere by spectroscopic methods and the interactions associated with mesospheric aerosol. It is expected that one of the applicants would work in this field. For further information please contact Professor Georg Witt via phone: +46-8-164-343, fax: +46-8-157-185, or e-mail: gwitt@misu.su.se.

The second position is associated with our current involvement in the Swedish small satellite project "Odin." To be launched in 1997, Odin is mainly a sub-mm wave receiver/spectrometer that will be used to record thermal emission from the stratosphere and mesosphere to determine the concentrations of such gases as ozone, chlorine monoxide, water vapor, etc. In addition, Odin will carry an optical spectrograph measuring backscattered sunlight in the limb-scanning mode. The successful applicant will be involved in all aspects of the planning of the observations including simulations, practical trials of the instrumentation, etc. A background in remote sensing techniques, particularly with mm-wave sensing, would be an advantage. For further information please contact Dr. Donal Murtagh via phone: +46-8-164-345, fax: +46-8-157-185, or e-mail: donal@misu.su.se.

Graduate Students and Travel Grants for CEDAR 1994

All students from U.S. or foreign institutions who attend the CEDAR meeting will have their registration fees waived. A list of students, their interests, and graduation dates will be distributed at the meeting. A bulletin board will be provided for job or general announcements. Students will introduce themselves to the community during the first session on Monday morning. An e-mail address is very helpful to have since many announcements will be sent first via e-mail.

NSF has provided money for travel and per diem for students from U.S. institutions or students from foreign universities who will be visiting a U.S. institution during the summer and so will have a U.S. sponsor. Preference will be given to graduate students, but involved undergraduates are also welcome. Applications for travel funds must be received by **April 30, 1994**. Students will receive their per diem payment after the meeting and must make their own lodging arrangements.

Professional Travel in Denver will make airline reservations for students travelling from cities where the government rate to Denver is cheaper than the early reservation, Saturday night stayover rate. At the moment, these cities are: Baltimore, Boston, Cincinnati, Dallas, Dayton, Detroit, Houston, Huntsville, Los Angeles, Orlando, Salt Lake City, San Francisco, Seattle, Spokane, and Tucson. If you are flying from one of these cities, contact the Groups Department of Professional Travel at (800) 333-6338 or (303) 488-0570 (fax: (303) 488-0505) to make airline reservations **after May 9**. Students travelling from other cities are responsible for getting their own tickets for a Saturday night stayover (either June 18 or 25) and will be reimbursed after the meeting. Note that only the TIMED workshop is scheduled for Saturday, June 25, so if you are not planning to attend that workshop, or are not sure, choose June 18 so you can leave Friday, June 24 (or Saturday, June 25 if you do decide to attend). If you must stay over a Saturday night, Professional Travel can get your tickets if you prefer, but we would like you to pay for them if you cancel. Government tickets can be cancelled without penalty. If you find a cheaper Saturday night fare than the one listed, NCAR will pocket the difference to spend on other things. Students are **not required** to stay the whole period, and Saturday night stayover tickets can be altered for about $30, which students would be expected to pay. However, the dormitory package is from Sunday night through Thursday night, with possible extensions of time on either end. Hence, if you only plan to come for part of the meeting, stay at a hotel instead.

Students who drive will receive $0.28/mile or the equivalent airfare, whichever is smaller. If the average airfare is significantly smaller than the listed value at the end of May, students who drive will get the higher value. The per diem (which includes meals, lodging and miscellaneous) is currently set at $20 per day, or $140 for 7 nights stayover. If there are extra funds, the per diem will be increased up to $25/day. Hopefully, the universities can help their students in this area.

Last year 175 students had their registration fees waived and 142 received travel assistance. The *Application for Student Financial Support* on the back of the registration form requires the signature of the research advisor. This form should be received by **April 30** to be considered for support, but all students should fill it out in order to be included on the list of students, their interests, and their advisors, which will be available at the meeting. Please send these forms to Dr. Barbara Emery at the address shown on the registration form. This form can be e-mailed if your advisor sends a separate e-mail confirmation as well.

Barbara Emery, NCAR

HAO/NCAR Graduate Research Assistantships Available

1995 Newkirk Graduate Research Assistantships in the High Altitude Observatory are available at the National Center for Atmospheric Research. Assistantships are offered to those enrolled in university studies leading to a Ph.D. degree. The student must declare his or her intention of working on a Ph.D. thesis in cooperation with an HAO staff member and should be enrolled full-time in a university graduate program having common interest with HAO research goals. Due by **April 15, 1994** are: 1) a brief statement from the student indicating research interests and goals; 2) three letters of recommendation from university faculty members or research supervisors who are familiar with the student's work (please note that this is the student's responsibility); 3) official transcripts of undergraduate and graduate courses; and 4) where appropriate, a statement from a faculty research advisor concerning the proposed joint effort with an HAO staff member. Send applications to:

HAO Visitors Committee
HAO/NCAR
P.O. Box 3000
Boulder, CO 80307

Further details may be obtained by writing to the above address or by sending e-mail to Peggy Searcy at searcy@hao.ucar.edu.

Boulder Lodging and Local Transportation Information

The facilities listed below have blocked rooms for workshop participants between the nights of June 18-June 25, 1994. Reservations must be accompanied by a credit card charge number or a deposit for the first night's lodging; Visa, MasterCard, American Express, and Discover credit cards are accepted at most of the hotels. Cancellations must be made before 4:00 PM on the arrival day to avoid being charged for the first night's lodging. The blocks of rooms at special workshop rates are only being held until the dates indicated below and they may fill up early. **MAKE ALL RESERVATIONS AS SOON AS POSSIBLE AND SPECIFICALLY MENTION THE CEDAR WORKSHOP HOSTED BY NCAR.** (If using a Travel Agent, have them identify you in the same manner.) Participating hotels and rates for June 18-June 25, 1994 are:

Hotel	Single*	Double*	Deadline	No. of Rooms
Days Inn 5397 S. Boulder Road Boulder, CO 80303 (303) 499-4422; Fax: (303) 494-0269	$64	$69 (Up to 4 People)	May 18	65
Holiday Inn of Boulder 800 - 28th Street Boulder, CO 80303 (303) 443-3322 or 1-800-542-0304	$69	$69	May 18	35
Courtyard by Marriott 4710 Pearl East Circle Boulder, CO 80301 (303) 440-4700 or 1-800-321-2211; Fax: (303) 440-8975	$75	$75	June 6	35
Homewood Suites Hotel 4950 Baseline Road Boulder, CO 80303 (303) 499-9922 or 1-800-225-5466; Fax: (303) 499-6702 6	$99 for a Suite w/Kitchen (will accommodate 3-4 people)		May 18	15

RESERVE ROOMS BEFORE DEADLINES TO ASSURE LOWER RATES

All hotels have comfortable accommodations and all of them, except the Courtyard, can provide shuttle service to local meetings if requested by individuals *in advance* (based on availability). The Days Inn and Homewood Suites provide free continental breakfasts with lodging. Homewood Suites also has a free social hour Monday through Thursday. Checkout times are 12:00 noon. All hotels have swimming pools. We were unable to book blocks of rooms at the Broker Inn or the Clarion again this year, but some individual rooms may be available.

444-3330   443-3850

*Hotel rates do not include 9.55% sales tax.

UNIVERSITY OF COLORADO DORMITORY ROOMS AND MEALS

	Single	Double	No. of Rooms
Main Campus Conference Housing Area 142 Cheyenne-Arapaho Hall Boulder, CO 80310 Fax: (303) 492-4646	$133.67	$109.02 (per person)	70(S), 70(D)

[NOTE: FOR EMERGENCIES ONLY: (303) 492-6885 (Suzy Campbell or her secretary)]
e-mail: campbell%eagle@vaxf.colorado.edu

NO PHONE-IN RESERVATIONS ACCEPTED. PLEASE SEND THE REGISTRATION FORM PROVIDED HEREIN TO THE MAIN CAMPUS CONFERENCE HOUSING AREA. Rates for the campus package include a dormitory room from 6/19 to 6/23 and breakfast every day from 6/20 to 6/24. Early arrivals (6/18) and late departures (6/25) will pay an extra $22.46/night (single) or $17.35/night (double, per person). Also, have only ONE individual in charge of each group from each university. CU accepts VISA and MasterCard. The above prices include the 9.55% sales tax. Please check in at Hallett Hall. Parking permits for a week may be requested on the registration form for $7.50 (price at the meeting will be at least $15/vehicle).

GROUND TRANSPORTATION (Airport). The Rocky Mt. Supercoach (303/499-1951, ~$15.00) and the Boulder Airporter Limousine Service (303/321-3222, ~$12.00) will take reservations for direct transportation between Denver International Airport, the hotels, and the University. Their schedules are staggered so you may find one more convenient for your arrival/departure.

DAY CARE. For child care while you attend the Workshop, Children's World at 5377 Manhattan Circle in Boulder will accept children on a drop-in basis (based on space availability). Children's World also offers summer field-trip programs. If you're interested, please call Maribeth Scott at (303) 494-3694. Many other day care facilities are listed in the Boulder telephone directory under "Child Care."

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Registration Form
1994 Ninth Summer NSF CEDAR Workshop
June 20–25, 1994

National Institute of Standards and Technology – NIST
National Center for Atmospheric Research – NCAR

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1. **PLEASE PRINT**

   Name: _____

   Institution: _____

   Address: _____

   _____

   Telephone: (_____)_____ Fax: (_____)_____

   E-mail: _____ Citizenship: _____

   Are you a: Student ( )   Tutorial Speaker ( )   Neither ( )

   NOTE: Students registering after **May 31** will be charged a $5.00 late fee. Students wanting travel funds should register **before April 30**.

2. I plan to present a poster at the meeting _____. **NOTE**: Send title and author list to Dr. Jeffrey Thayer by **May 31** to be considered. (For address, please see *Call for Poster Papers*.) Also, please identify the first author as student or nonstudent, as students will be given preference if there are space limitations.

3. I plan to attend the reception / tour at Coors Brewery in Golden, CO on Monday, June 20 (additional $10.00) _____.

4. I plan to attend the buffet on the Tree Plaza at NCAR on Wednesday, June 22 (additional $15.00) _____.

5. **FEES:** The regular total fee for the CEDAR Workshop (registration plus Coors and buffet) is $85. Parking, if needed, is extra. **ALL FEES, INCLUDING PARKING, ARE WAIVED FOR STUDENTS AND TUTORIAL SPEAKERS. However, parking permits not requested on this form must be purchased by the attendee. Fees for guests or late assessments are not waived. NOTE**: Foreign registrants are not assessed the $15.00 late fee provided they register by **May 31** and may delay payment until the meeting.

   (a) Regular registration - $60.00 _____. (Registration by **May 31**.)

   (b) Retiree Registration - $20.00 _____. (Registration by **May 31**.)

   (c) Coors Brewery reception/tour - $10.00 _____.

   (d) Guest(s) for Coors reception/tour - $10.00/ea or $5.00/child _____.

   (e) NCAR buffet - $15.00 _____.

   (f) Guest(s) for NCAR buffet - $15.00/ea or $7.50/child _____.

   (g) University parking permit - $7.50 _____. (Request by **June 10**.)
   (If purchased at the meeting, ≥$15.00)

   (h) Late registration fee - $15.00 _____. (Registration **after May 31**.)

   (i) Late **student** registration fee - $5.00 _____. (Registration **after May 31**.)

   GRAND TOTAL, 1994 CEDAR WORKSHOP FEES (a-i) $ _____.

NOTE: If registration payment is not enclosed with this form, please be certain that checks sent separately identify you and the workshop. Checks for the workshop (including parking permits or guests for Coors or the buffet) should be made payable to NCAR. NCAR does not accept VISA or MasterCharge. Foreign registrants may pay on arrival provided their registration forms are mailed early. Please send correspondence to: Barbara Emery, HAO/NCAR, P.O. Box 3000, Boulder, CO 80307-3000; Phone: (303) 497-1596; Fax: (303) 497-1589; Internet: emery@ncar.ucar.edu; SPAN: 9580::"emery@ncar.ucar.edu".

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STUDENTS Please complete BOTH sides of this registration form.

</div>

Application for Student Financial Support
to Attend the Annual CEDAR Meeting

All students are eligible to receive a registration fee waiver, including those from non-U.S. institutions. Travel funds and per diem funds are also available for students from U.S. institutions. All students must fill out this application form, which is input for the list of students and their interests available at the meeting. Application deadline is **April 30, 1994**. See the article on student travel grants for further information.

PLEASE PRINT

Name: _____

University Address: _____

_____

_____

Phone: (___)_____ Fax: (___)_____ E-mail: (___)_____

Mailing Address (if different): _____

_____

_____

Expected Degree and Date of Graduation: _____

Advisor(s) and Phone Number: _____

Research Interests: _____

_____

_____

_____

Instruments, Models, or Data Used: _____

_____

_____

_____

Advisor's Signature of Student Status:

I confirm that the applicant is a ( ) graduate ( ) undergraduate student at my university or research laboratory and is working on a research project related to the CEDAR Program.

Research Advisor's Signature: _____

University of Colorado Summer Conference Housing Application
Main Campus

PLEASE COMPLETE THE INFORMATION REQUESTED BELOW AND SEND TO THE ADDRESS INDICATED AT THE BOTTOM OF THIS FORM.

Name of Conference: *NSF CEDAR Meeting, Summer 1994*

Participant's Name: _____ Sex: _____
                              (last)   (first)

First Night's Lodging: _____ Last Night's Lodging: _____
                              (date)   (date)

Address: _____ City: _____ State: _____ Zip: _____

Telephone: (Home) _____ (Business) _____

Please request one of the following:

   *Single Room _____ Double Room _____ (Roommate Preference if Any) _____

   Special Requests (Smoker/Nonsmoker, etc.) _____

   *There are a limited number of single rooms. If a single room is unavailable, you will share a double room with another conference participant.

Complete if Accompanied by Spouse and/or Family:

Spouse's Name _____ First Night's Lodging _____ Last Night's Lodging _____

Child's Name _____ Age _____ Sex_____ Dbl _____ Sngl _____ 1st Night _____ Last Night _____

" Name _____ Age _____ Sex_____ Dbl _____ Sngl _____ 1st Night _____ Last Night _____

" Name_____ Age _____ Sex_____ Dbl _____ Sngl _____ 1st Night _____ Last Night _____

Will a rollaway bed be needed? _____ Crib? _____ **Total Number in Party** _____

PAYMENT IS DUE AT CHECK-IN. Cash, traveler's checks, personal checks, VISA and MasterCard will be accepted. DO NOT SEND MONEY IN ADVANCE. PHONE-IN REGISTRATIONS ARE **NOT** BEING ACCEPTED, BUT IN CASE OF ANY QUESTIONS OR EMERGENCIES, THE AREA MANAGER'S TELEPHONE NUMBER IS (303) 492-6885.

MAIL TO: Main Campus Conference Housing Area
             142 Cheyenne-Arapaho Hall
             Boulder, CO 80310
                    or
             Fax: (303) 492-4646
             e-mail: campbell%eagle@vaxf.colorado.edu

The Cedar Post

Dr. Michael C. Kelley
School of Electrical Engineering
318 E & TC
Cornell University
Ithaca, NY 14853

Address correction requested.

Dr. Barbara Emery
HAO/NCAR
P.O. Box 3000
Boulder, CO   80307