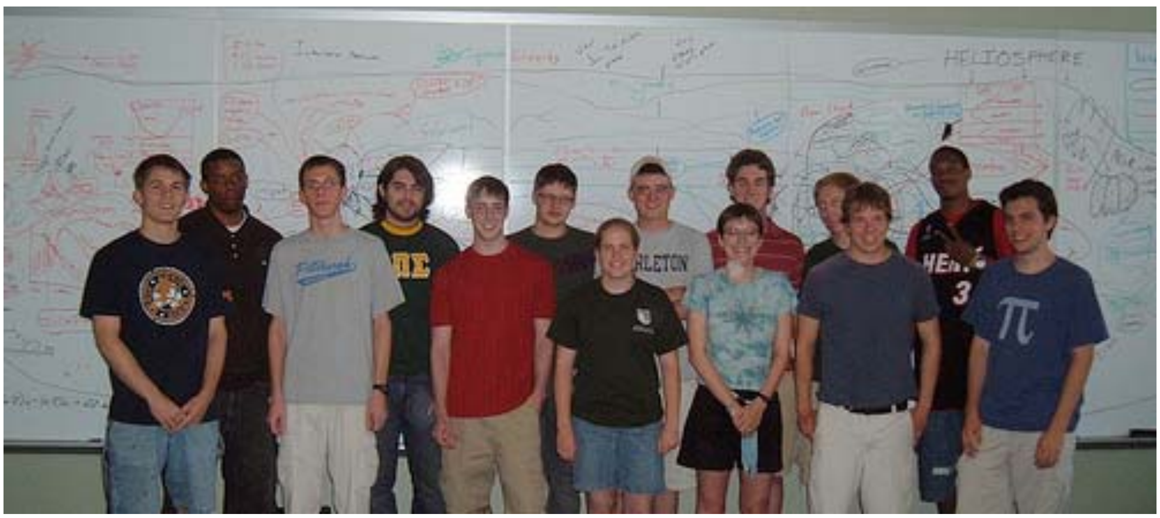
RESEARCH EXPERIENCE FOR UNDERGRADUATES
SITE PROGRAM IN SOLAR AND SPACE PHYSICS

THE LABORATORY FOR ATMOSPHERIC AND SPACE PHYSICS
THE UNIVERSITY OF COLORADO
THE NCAR HIGH ALTITUDE OBSERVATORY
THE NOAA SPACE WEATHER PREDICTION CENTER
THE NWRA COLORADO RESEARCH ASSOCIATES



2007 REU students.
Front left to right: Thomas Zimmermann, Michael Paniccia, David Marchese, Ellen Pettigrew, Rachel MacDonald, Jim Fuller, Peter Ashton
Back left to right: Julius Allison, Jonathan Ruel, Colin Triplett, Eric Greenfield, Will Flanagan, Ryan Schilt, Chris Moore

2007 Annual Project Report

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Project Summary – 2007 Boulder REU Site Program

The University of Colorado's Laboratory for Atmospheric and Space Physics (CU/LASP), leading a consortium of Boulder-based solar and space physics programs, initiated a Research Experience for Undergraduates (REU) Program in Solar and Space Physics in 2007. Funded primarily by the National Science Foundation (NSF) with consortium members supporting additional students, the goal of the program is to encourage U.S. undergraduate students to pursue graduate school studies and professional careers in solar physics and its related research and engineering disciplines. LASP's REU program began with a weeklong summer school spanning topics in solar and space physics with lectures given by scientists from across Boulder. After the summer school, students work closely with research scientists to complete an 8-week research project at one of the following organizations: CU/LASP, the National Center for Atmospheric Research (NCAR) High Altitude Observatory (HAO), the NOAA Space Weather Prediction Center (SWPC), and the Northwest Research Associates (NWRA) Colorado Research Associates (CoRA). At the close of the program, students present their research both as a presentation and poster and the best research is submitted to a national scientific conference.

The 2007 REU program had fourteen participants, six of which were paired with mentors at LASP, two at NOAA/SWPC, two at NWRA/CoRA, and four at NCAR/HAO. Projects ranged from theoretical to observational to applied, from helioseismology to space weather impacts on satellites.

The success of the 2007 REU program in Solar and Space Physics can be attributed largely to the dedicated mentors at the participating organizations as well as the communication between students, mentors, and organizations. Graduate students at LASP assisted with instruction both during the summer school program and provided continual support for the duration of the program. A collegial atmosphere was maintained, and the students supported each other both with research and moral support.

Participants

Recruitment

The 14 undergraduate students (12 male and 2 female; 12 Caucasian and 2 African American) were selected from a total of 29 applicants. Students were recruited for the 2007 program through the SPA newsletter, SolarNews, through distributions of flyers to a broad spectrum of colleges and universities, through all consortium institutions and their listservs, and through the LASP REU Website (http://lasp.colorado.edu/reu). Particular efforts were made to recruit students from underrepresented areas, using NASA's Minority University Space Initiative (MU-SPIN) network and contacting astronomy, physics, engineering, mathematics, and natural sciences departments at Historically Black Colleges and Universities, as well as Hispanic Serving Institutions.

Selection and Project Pairing

Scientists interested in mentoring an REU student were asked, in the Spring of 2007, to submit a project proposal which outlined the project and the mentors, along with the skills the student would need to successfully complete the project. More than one mentor was generally required for the project, and all mentors were required to participate in the summer school and weekly brown bags, as well as the student symposium. Projects were reviewed for scientific merit and quality of student involvement.

A review panel made up of scientists from each REU institution met to discuss candidates and the project proposals. Students were chosen for the REU program based on background, grades, letters of recommendation, and articulation of areas of interest. Students were paired with research projects based on their background and ability, as well as their stated interest.

Students were notified of their acceptance, along with their project assignment. They were given a chance to change their project. Mentors and students were then put into contact with each other in the month or two before the beginning of the program, in order to get the student ready for the summer.

Table 1. List of Participants/College/Advisors/REU Site

Student	College/ University	Advisor(s)	REU site
Idatonye "Julius" Allison	Alabama A&M University	Marty Snow, Greg Holsclaw	CU/LASP
Peter Ashton	Boston University	K.D. Leka, Graham Barnes	NWRA/CoRA
Will Flanagan	University of Colorado	Keith MacGregor	NCAR/HAO
Jim Fuller	Whitman College	Sarah Gibson, Giulianna de Toma	NCAR/HAO
Eric Greenfield	Montana State University	Yuhong Fan, B. C. Low	NCAR/HAO
Rachel MacDonald	University of Washington	K.D. Leka, Graham Barnes	NWRA/CoRA
David Marchese	Bucknell University	Douglas Biesecker, Christopher Balch	NOAA/SWPC
Christopher Moore	University of Iowa	Phillip Chamberlin, Thomas Woods, Frank Eparvier, Rachel Hock	CU/LASP
Michael Paniccia	Florida Institute of Technology	Dan Baker, Scott Elkington, Shri Kanekal, Xinlin Li	CU/LASP
Ellen Pettigrew	Dartmouth College	Steven Hill, Vic Pizzo, Doug Biesecker	NOAA/SWPC
Jonathan Ruel	Embry-Riddle Aeronautical University	Erik Richard, Martin Snow	CU/LASP
Ryan Schilt	University of Colorado	Mark Rast, Juan Fontenla	CU/LASP
Colin Triplett	University of Michigan	Astrid Maute, Yue Deng, Art Richmond	NCAR/HAO
Thomas Zimmermann	University of Iowa	Tom Woods, Jerry Harder	CU/LASP

2007 Program Activities

Solar and Space Physics Summer School

The first week of the REU program was devoted to a summer school that gave students a complete overview of solar physics, space weather, the Sun-Earth connection, and instrument design. In addition, a half-day course in IDL was provided for those students that needed this background for their project.

The goals were to provide necessary background for the research the students would undertake and give a broad overview of the science and engineering involved so that students could better understand the research of their peers even if it did not directly apply to their own research. The talks and sessions were given by scientists and engineers from the all of the participating organizations.

Solar and Space Physics Summer School 2007 June 11-15	
Speaker	**Topic**
Eparvier, F (LASP)	Sun-Earth System Overview
Harder, J (LASP)	REU Training: Solar Irradiance/Radiometry
Woods, T (LASP)	Current and Future Solar Observing Missions
Richard, E (LASP)	Spectroscopy and Instrument Design
Rempel, M (HAO)	Dynamics of the solar convection zone
Fan, Y (HAO)	The Magnetic Nature of Coronal Mass Ejections
Chamberlin, P (LASP)	Solar Flares
Gosling, J (LASP)	The Solar Wind
Eriksson, S (LASP)	The Earth's Magnetosphere and its Coupling with the Solar Wind
Elkington, S (LASP)	An overview of Earth's space radiation environment: the radiation belts
Kanekal, S (LASP)	Energetic particles in the Heliosphere and the Magnetosphere
Lu, G (HAO)	Earth's Atmosphere, with focus on the upper atmosphere - above 100km
Viereck, R (SWPC)	Space Weather: What is it? How Will it Affect You?
Murtagh, B, Spencer, M (SWPC)	Space Weather Cycles and their Impacts
Hill, S (SWPC)	Solar Drivers of Space Weather
Zwickl, R (SWPC)	Space Weather Radiation Hazards (Space Radiation Fact Sheet)
Onsager, T (SWPC)	The Radiation Belts and Killer Electrons
Fuller-Rowell, T (SWPC)	The Ionosphere and its Impact on Communications and Navigation
Singer, H (SWPC)	Space-Based Assets for Space Weather Forecasting: Past, Present, and Future

IDL Summer School 2007: Dr. Marty Snow and Rachel Hock
Topic What is IDL? Basic Syntax (data types, vectors, arrays, etc.) Functions, Procedures, & User Library Basic I/O (including exercize) Plotting & Printing (including another exercise) Image Processing Tips & Tricks

Research Projects

The summer 2007 LASP REU students spent an average of 8 weeks working as full-time research assistants, with some continuing their research into the fall semester or employed by the organization with which they worked. At the end of the program, each student presented his or her research work to mentors and REU peers, and the session was open to scientists from the community as well. This gave students the unique opportunity to present research in a professional setting, getting feedback, encouragement, and research assistance from participants. The students also presented research work during a poster session. A brief description of each student's project follows.

Idatonye "Julius" Allison (Alabama A&M University) [Advisors: Dr. Marty Snow and Dr. Greg Holsclaw, LASP] examined how the geocorona, and lyman alpha is vital to the study of Earth's atmosphere. Julius used data from Solstice II instrument on SORCE to map the lyman alpha airglow density in the geocorona at different zenith angles relative to the spacecraft.

Peter Ashton (Boston University) and **Rachel MacDonald** (University of Washington) [Advisors: Dr. K.D. Leka and Dr. Graham Barnes, NWRA/CoRA] studied whether the magnetic kink instability can trigger solar energetic events. To answer this question, they determined whether active regions can contain magnetic twist sufficient to undergo the kink instability. Solar active regions were evaluated based on available data, solar flare activity, and the presence of emerging flux. For isolated bipoles within candidate active regions, the amount of magnetic twist present in the regions' magnetic fields was calculated for comparison with a theoretical critical value. Preliminary results included at least one active region for which the magnetic twist present was sub-critical, and thus inconsistent with the kink instability as a trigger, and yet the region produced a small solar flare.

Will Flanagan (University of Colorado) [Advisor: Dr/ Keith MacGregor, NCAR/HAO] established absorption line profiles for rapid, differentially rotating stellar models. The project involved the morphology of line profiles in differentially rotation 2 solar mass stellar models. The models were taken from the Self-Consistent-Field Method of Jackson, MacGregor, Skumanich, 2004. He worked with code that constructs the Mg II λ4481 absorption line in the models. He optimized the line profile code using inherent symmetries and a Voigt function algorithm. The program was also modified to account for line and continuum opacity dependence on latitude, due to gravitational darkening. Using this modified code for generating profiles, Principal Component Analysis (PCA) was used to analyze the input parameters of the code. The parameters analyzed are most notably those of inclination and rotation, as well as others such as microturbulence. This analysis hopes to quantify the effect of differential rotation on absorption line profile shapes.

Jim Fuller (Whitman College) [Advisors: Dr. Sarah Gibson and Dr. Giulianna de Toma, NCAR/HAO] modeled coronal cavities in order to establish their densities. Cavities in coronal helmet streamers can easily be seen in whitelight coronograph images. However, they are difficult to observe without contamination from the obstructing presence of features along the line of sight such as the helmet streamer surrounding the cavity. His goal was to find cases where such spurious non-cavity contributions are minimal, and can be incorporated in a density analysis as conservatively estimated uncertainties in the data. He helped create a model of coronal cavities in which a cavity exists as an axisymmetric torus that encircles the Sun at constant latitude. Using Mauna Loa Solar Observatory (MLSO) polarized brightness data showing that the cavity that exists from January 25- 31 of 2006 fits the parameters of the model. By examining the geometry of the model and the physics of the polarized brightness of scattered white light in the corona, he showed that it is possible to observe the cavity without significant contribution from surrounding material. Using a Van de Hulst of inversion of polarized brightness measurements, a radial density profile for cavity material and for the surrounding helmet streamer was calculated. The results show the cavity density to be roughly 30% lower than a helmet streamer and roughly twice as great as a coronal hole. He also researched how the geometry of cavities imaged using emission line data can provide guidelines for determining whether a given cavity is unobstructed enough so that it can be analyzed for density and temperature profiles of cavity material.

Eric Greenfield (Montana State University) [Advisors: Dr. Yuhong Fan and Dr. B. C. Low, NCAR/HAO] worked to create a model of coronal helmets with prominences. The process by which coronal mass ejections are accelerated from the surface of the sun is not well understood. A possible explanation is that a solar prominence may serve to anchor the magnetic field associated with a coronal helmet allowing magnetic energy to grow beyond the open field limit. Once this limit is surpassed the helmet may relax to a less energetic open field state and be expelled as the CME. He analyzed this situation using a partially open magnetic field representing an idealized 2D coronal helmet is constructed based on the conditions required of a potential magnetic field. A prominence was then introduced as a vertical sheet along the equator extending from the surface to some height r_{sh}. Some amount of magnetic flux was then set to thread through the prominence sheet. The magnetic energy resulting from this partially open magnetic field configuration was calculated using the Virial Theorem. The amount of flux set to thread through the prominence is directly related to the energy of the overall field as well as the mass contained along the prominence. The calculated energy was then compared to the energy of the completely open field.

David Marchese (Bucknell University) [Advisors: Dr. Douglas Biesecker and Dr. Christopher Balch, NOAA/SWPC] compared the Costello Geomagnetic Activity Index model and several JHU/APL models for Kp prediction. The planetary K index, or Kp, is a measure of the level of magnetic activity in the Earth's magnetosphere. Large Kp values have been shown to correlate with high levels of geomagnetic activity often responsible for a range of adverse effects including satellite damage, electric power grid collapse, and the disruption of radio communication and GPS navigation. Models that predict Kp allow preventative measures to be taken against potentially catastrophic system failures making it extremely useful for space weather forecasters to know the probability that a model's predictions will be accurate. He evaluated four models; the Costello Geomagnetic Activity Index model and three models developed by the Applied Physics Lab at Johns Hopkins University. Validation studies of these models were performed to find distributions of official Kp values for a given prediction. Various levels of solar activity were tested to look for solar cycle dependency. The overall performance of the Costello model was compared to that of the JHU/APL models. These evaluations demonstrated that the Costello model tends to over predict Kp consistently for all values. He concluded that additional validation studies need to be carried out to determine if the JHU/APL models perform significantly better than the Costello model.

Chris Moore (University of Iowa) [Advisors: Dr. Phillip Chamberlin, Dr. Thomas Woods, Dr. Frank Eparvier, and graduate student Rachel Hock, CU/LASP] studied energy contributions to the TSI from the from the VUV (0.1-190 nm) for the impulsive and gradual phases of the solar flare on October 28, 2003. He used the Flare Irradiance Spectral Model (FISM), which is based on data from the SEE instrument onboard the Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) satellite to analyze the variations at individual wavelengths. The different wavelengths give insight to the solar activity in different regions of the solar atmosphere. These data were decomposed into the two phases of a solar flare (Impulsive and Gradual). The VUV estimations from FISM were compared to the TSI measurements in order to obtain the fractional spectral contributions of the total energy released during the solar flare on October 28, 2003 in both the impulsive and gradual phases.

Mike Paniccia (Florida Institute of Technology) [Advisors: Dr. Dan Baker, Dr. Scott Elkington, Dr. Shri Kanekal, and Dr. Xinlin Li, CU/LASP] analyzed data flow interruption anomalies onboard the Cluster Spacecraft from August 2000 through March 2005, and determined how many were the result of space weather. There are three main types of anomalies caused by space weather: surface charge, deep dielectric discharge, and single event upset. The goal of his project was to analyze the 131 anomalies that occurred on the Cluster Spacecraft during this time period. He established that there were 86 anomalies that were the result of space weather, with 37 surface charging, 31 single event upsets, and 18 deep dielectric discharging. He correlated the anomalies with higher space weather indices.

Ellen Pettigrew (Dartmouth College) [Advisors: Dr. Steven Hill, Dr. Vic Pizzo, and Dr. Doug Biesecker, NOAA/SWPC] corrected sun-center coordinates for a large subset of data from The Solar X-ray Imager (SXI) on the GOES-12 satellite. While it was operational (April 2003 April 2007), it accumulated over two million images, which are stored and made available to the public by the National Geophysical Data Center (NGDC). In a large subset of this database the sun-center coordinates that are recorded in image headers have errors of up to 30 arcseconds, significantly reducing the database's utility to researchers by preventing the use of standardized image-analysis procedures. These errors are strongly correlated to thermal distortions in instrument components and therefore they can be reduced in post-processing by the implementation of an empirical correction factor based on temperature values. In this project, she performed statistical analyses to determine an appropriate correction factor and this correction was implemented in existing image-processing code. The correction factor was shown to successfully reduce the pointing errors to fewer than 5 arcseconds for a significant majority of all images tested.

Jon Ruel (Embry-Riddle Aeronautical University) [Advisors: Dr. Erik Richard and Dr. Martin Snow, CU/LASP] evaluated the effect of wavelength binning on solar irradiance extinction altitude by atmospheric ozone absorption. Current atmospheric models such as the CCM2 and CAM3 employ the δ-Eddington approximation, which includes a binning of the solar spectrum to 8 bins. Using the first 6 bins, 200-305 nm, he compared the solar irradiance penetration at 1nm wavelength resolution to the 6-bin averaged irradiance spectrum. The analysis began by constructing a 1-dimensional model atmosphere consisting of only ozone molecules. Next, he used ozone absorption cross-section data in conjunction with the model atmosphere to calculate optical depth for all wavelengths at all altitudes. Finally, solar spectral irradiance data was taken from the SORCE mission and, using Beer's Law, the transmitted irradiance was calculated for all altitudes and integrated over wavelength. This resulted in an extinction altitude of around 29 km. He performed a similar analysis using irradiance data averaged over each of the 6 wavelength bins, which gave an extinction altitude of around 38 km. This results in a difference in irradiance of almost 0.6 W/m2 at 47 km and almost 100% difference in the 6-bin model at 40 km. He concluded that when employing the wavelength binning, solar irradiance energy is deposited higher in the atmosphere than should be expected.

Ryan Schilt (University of Colorado) [Advisors: Dr. Mark Rast and Dr. Juan Fontenla, CU/LASP] studied image correction techniques and image restoration. He used image correction techniques were used on solar disk images form the Precision Solar Photometric Telescope (PSPT) to improve contrast and establish a better magnetic structure identification. In order to better understand how the restoration process affects identification, a "quality" is defined for a given image. That measure is then used to divide images into quality categories. An image from each category was run through the identification process, restoration process and then the identification again. When comparing these results between the quality categories it was then observed that the image that had a higher quality rating in the beginning tended to have a smaller difference in the areas that were identified.

Colin Triplett (University of Michigan) [Advisors: Dr. Astrid Maute, Dr. Yue Deng, and Dr. Art Richmond, NCAR/HAO] compared the 2005 Weimer and HAO empirical high latitude models of energy transfer in terms of Poynting Flux. The 2005 Weimer Model has been seen as a very good approximation for the energy input of the Ionosphere. The HAO Empirical Model also models interaction of geomagnetic conditions and the upper atmosphere energy input. To make sure that the HAO Empirical Model is working correctly, he compared the model against an the 2005 Weimer model to establish if it is just as good or better for predicting conditions in the Ionosphere. After comparing these two models in both electric and magnetic fields, electric and magnetic potentials, Poynting flux, and total flux he concluded that the HAO Empirical Model, through it has difference from the 2005 Weimer Model, is a good model for the conditions of the upper atmosphere energy input.

Thomas Zimmermann (University of Iowa) [Advisors: Dr. Tom Woods and Dr. Jerry Harder, CU/LASP] used solar spectral irradiance (SSI) data from the SORCE mission to compare quiet sun days with active ones. Facular Brightening in sunspots and active regions increase the solar irradiance and contributes to solar variability. Using the fractional difference between quiet and active days, he estimated how much solar variability can be caused by Facular Brightening.

Brown Bags and Science Presentations

Brown bag sessions were provided weekly to give students an opportunity to experience the environment and research activities at the various organizations. Each week, the session was held at one of the facilities, science researchers gave short presentations, and the facilities were toured. Toward the end of the summer, students began presenting their research in 10-15 minute presentations, receiving feedback from their peers and scientists to aide with research progress and to get ready for their final presentations.

On August 2 and 3, students presented their work at a Student Symposium held at CU/LASP. Students prepared scientific posters, as well as a 30-minute presentation. The Symposium was attended by all of the REU mentors, along with interested scientists from all of the REU institutions. Presentations and posters can be found at:

http://lasp.colorado.edu/~reu/summer-2007/final-schedule.html

Evaluation of the 2007 REU Program

A series of formative and summative evaluation tools were used to determine the progress and effectiveness of the REU program on participants. Our evaluation employed a mid-summer and post-summer anonymous survey to gauge the impact of the program, both in terms of participant growth and to determine areas where the program might be improved. In addition, participants were polled for ideas for program improvements, new lines of inquiry, and suggestions for activities are a vital component of the program development.

Throughout the summer, students will meet with REU program staff to see how things are going, identify any trouble spots, and make sure that the program is meeting the participants' needs. This provided critical feedback for the staff and allowed the program to be optimized for each student. Likewise, throughout the program, science teams were asked to assess the progress of the undergraduate, in hopes of identifying problems that might be addressed "mid-flow".

Students will continue to be followed up annually by program staff to identify career choices and destinations (and have signed permissions to allow us to follow them). Follow-up will include career surveys developed by LASP to track its graduate students after they've completed their degree. We will modify this survey for the REU program. It is our hope to be able to track students for at least 5 years. Depending on their career track, this will allow us to gauge their pursuit of advanced degrees and/entry into a profession. This year's evaluation results can be found in Appendix A.

Lessons Learned for the 2008 REU Program

Although the student feedback was largely positive, we are taking many of their comments to heart and looking at the following changes to the program:

- Better coordination and integration of the summer school, including more hands-on and lab-based exercises.
- The opportunity to extend the experience to 10 weeks. This will impact the number of students the program can support and will be explored in January, 2008.
- Reorganizing the weekly brown bag schedule to better fit the research flow.

Current Status for 2008

We currently anticipate 35-40 applications for the 2008 REU Program in Solar and Space Physics. We have the same resource commitments from the participating institutions and believe we will be able to fund between 12 and 14 students. In addition, two students from 2007 will be returning to Boulder to continue working with their mentors.

APPENDIX I – Boulder REU Program Evaluation

Part A. Post-REU Questionnaire

2007 REU Evaluation	1= Agree	5= Disagree AVG.
A. Application Process		
1 Applying to the REU program was straightforward.		1.2
2 The REU staff was responsive in providing information.		1.2
3 I felt that the project I was assigned to met my interests		1.9
4 The initial program package contained the information I needed to get ready for the program.		1.7
B. Bear Creek Apartments		
1 The apartment met my needs for the program.		1.1
2 The household items provided by the program were sufficient for the summer.		2.4
3 The Bear Creek staff was responsive.		1.9
4 The Bear Creek Apts. are well situated, allowing easy access to REU sites.		1.4
C. Travel arrangements		
1 Travel arrangements were straightforward.		1.2
2 REU staff was supportive and helpful in arranging travel.		1.1
D. The REU Summer School		
1 The week-long summer school was a good preparation in solar and space physics.		1.5
2 The lectures were informative and useful.		2.1
3 I knew most of what was presented in the summer school.		3.6
4 The summer school provided information I needed for my project.		2.6
5 The summer school was a good use of my time.		2.1
6 The IDL short course was useful.		2.5
7 The IDL short course helped me with my project.		2.0
8 The IDL provided me with enough information to help me.		2.5
E. The REU Project		
1 My REU project was well matched to my stated interests.		1.8
2 My advisors spent time with me getting started.		1.3
3 My project was well defined with a clear path of tasks and analysis.		1.8

4	**My project was completed during the summer.**	**1.9**
5	**My project was a reasonable challenge for me.**	**1.6**
6	**My project was too easy.**	**3.1**
7	**My project was too hard.**	**3.4**
8	**When my advisor wasn't available, others in their groups were.**	**2.1**
9	**I felt that my mentor created a supportive working environment that allowed me to work effectively.**	**1.4**
10	**If I had a chance, I would consider working with my advising team again.**	**1.8**
11	**The brown bag lunches were a good way to keep in touch with the group.**	**1.4**
12	**I expect to continue to work on my project with my mentor after the summer is over.**	**3.1**

F. Extracurriculars

1	**The REU staff provided good opportunities to explore Boulder and Colorado.**	**1.4**
2	**The REU staff was responsive to needs as they arose.**	**1.2**
3	**I wish there had been more activities planned.**	**2.9**
4	**I didn't really need any activities planned.**	**3.7**

F. Overall

1	**I would recommend the REU program to others.**	**1.1**

Part B. REU Student Comments about their Mentors

Student #1
- Your enthusiasm and passion for the research was an inspiration.
- You were always available when I needed your help…

Student #2
- I felt that the project was very interesting and was a good level of difficulty.
- My mentor was available for help…and was very attentive

Student #3
- I enjoyed working on this project, despite all the setbacks.
- I think the only thing I could have asked for is more time.

Student #4
- [My mentors} were very good at explaining the complicated concepts involved in our project.
- The project was a little vague at first, but that's the nature of that kind of work.

Student #5
- I enjoyed the opportunity to explore to space physics and programming.
- Your help with IDL at the beginning of the summer and guidance throughout my internship were indispensable.
- I hope that my work will be able to help with any future students involving the models.

Student #6
- I have learned vast quantities about a wide range of topics and appreciate the time you have spent teaching me.
- There is no project or mentor that I would have rather worked with.

Student #7
- I found my project interesting, however, more advisor input would have been nice.
- My advisors were very helpful when they were actually around.
- I would recommend them to work next year, assuming they would be around more.

Student #8
- I felt my mentors were a great match for me.
- There were not only very knowledgeable about all aspects of my project, but also very interested in my project.
- They were more than available when I needed help.
- They would also stop by just to make sure everything was going well throughout the week.

Student #9
- I feel that my mentor did a good job at guiding me through my research project this summer.
- He was helpful, available and easy to communicate with.
- He defined the scope of my project very well and he had a good idea of how to structure it so that it could be completed within the time available.
- I appreciated he allowed me the independence that I wanted to complete the project.

Student #10

- You were an amazing mentor this summer.
- You did a great job introducing me to my project and filling me in on all the background info.
- The project allowed me to creatively investigate the physics of coronal cavities and learn a great deal about all aspects of solar physics.
- You did not simply use me to perform a boring or simple part of your own research, but rather worked interactively with me on your project.
- You were almost always available for questions and receptive to my opinions. Conversely, you did not impose too much on my work and allowed me the freedom to learn and make progress on my own.

Student #11

- [My mentor] did an excellent job introducing me to the material I needed to know for my research.
- He left most of the focus of my research up to me, however I feel that my mathematics background (my primary major) was not used at all.

Student #12

- You helped my with a lot of IDL and helping understand the science.

Student #13

- The experience was both fun and educational.
- I appreciate how you would always found out an answer what I asked you a question that you didn't know.

Student #14

- My mentors…were both great. They were always helpful and generous with their time.
- Both of them plan to collaborate with me after the summer with plans to publish a paper in the near future.

Part C. REU Student Comments on the Program Office

Student #1

- Completely taken by surprise by the week of solar/space physics classes.
- Impressed by the staff and the organization of the program.
- The level of correspondence before and after arriving in Boulder was spectacular.
- I enjoyed the activities provided by the REU staff but I wish there were more.

Student #2

- I feel that the weeklong talks were a little too much during each day.
- I feel that the lectures were too long and it is a task to stay focused for all of the talks.
- The Bear Creek apartments were at a good location and they were very nice.

Student #3

- I had a great time this summer, and I feel that I learned a lot about solar physics and scientific research in general.
- [The summer school] were some long days. It seemed like a lot of the material was either below our level or way above.
- [The last brown bag] seemed unnecessary. It was a little redundant with the final presentations. It was good in general, except for having to schlep out to anywhere from CoRA.
- I'm not so sure I like the idea of turning the research into a contest.

Student #4

- All the staff were extremely helpful and responsive.
- The apartments are nice.
- Having the rent covered was great!
- The program felt too short. With the lectures during the first week and all the presentation and poster prep during the last two weeks, it seemed like we only had 5 weeks to work on science. I would recommend either making it a 10-week program or at least giving the option of working longer.
- I would have been good if you'd warned us the whole first week was going to be a summer school -- was not mentally prepared for that.
- It would be good to have the option to direct-deposit paychecks.

Student #5

- I learned a lot about solar/space physics and programming, both of which I enjoyed the exposure to.
- The group activities were quite enjoyable and it was nice to get to know some of the other students in the program.
- The apartments were very nice, though the mail system could have been much better.

Student #6

- The REU program was a wonderful experience.
- The REU program has helped me for years to come.

Student #7

- I think your program was pretty sweet.
- The research was interesting and not 'busy work'.
- I think more IDL training would be very helpful.
- …the satellite crash course wasn't very useful.

- As someone who attended every one of Erin's adventures, I found them quite enjoyable and should continue in the future.
- You really need to get a getter poster printer.

Student #8

- This was an excellent program that really increased my interest in solar physics, space weather and related fields.
- My research project was well designed with great direction.
- There were also good opportunities outside of research to enjoy Boulder.

Student #9

- REU staff, Emily and Erin especially, were always helpful concerned about making sure we have the best experience possible.
- Brown bag lunches were a nice opportunity to interact with other students and mentors from other labs.
- Organized activities were a fun way to get together and see Boulder/Colorado.
- It would have been nice to be offered the opportunity to work on a small side project. At time, my project was delayed, so I would have liked something else to work on to keep me from being bored.
- I would have liked having more girls in the program.

Student #10

- You did a great job of coordinating everything to make for a productive and fun summer.
- The housing was ideal and you were very helpful in communicating with us after we were accepted to the program.
- The first week of lectures…was very helpful and informative. However, many of the lecturers gave similar talks that were quite redundant. It would have been nice if you could have the lecturers coordinate with each other beforehand.
- You did a good job of providing opportunities for us to socialize with each other.
- I also think you did a great job working with other institutions and matching us with appropriate projects/mentors.
- You might consider making this a ten-week program so that we are able to accomplish more.

Student #11

- I did this program to better understand solar astronomy research and REU allowed me to accomplish this goal.
- As informative as they were, I feel [the summer school lectures] were too long and many of the speaker's talks overlap greatly. Perhaps for the future, the speakers could coordinate more and shorten the amount of time we were listening.

Student #12

- The weeklong summer school was too long.

Student #13

- I found that the program was well organized besides the fact that it is only a year old. I was happy with the fact that all involved (students, mentors and people in charge) were enthusiastic and willing to help.
- The experience was beyond my expectations.
- There was a good balance of research, group activities, and personal time for the length of the REU.

- I know [the summer school] was necessary but they were hard days, so maybe find a way to break up the day more.

Student #14

- The REU experience was by far one of the most beneficial experiences of my college career.
- My research exposed me to problems and methods not covered in my curriculum.
- Some days during the summer school were too long. There was a lot of information presented in a short amount of time. Maybe fewer lectures on the first day to ease us into the week.
- I would have been okay with a 10-week program. I was able to accomplish a lot in only 8 weeks but another 2 weeks would have been nice.