THE ACS REFORM OF INTRODUCTORY SCIENCE COURSES

FOR

NON-SCIENCE MAJORS PROGRAM

This program is supported by the W.M. Keck Foundation of Los Angeles

Interim Report (06/15/06)

The Impact of Highway Traffic on Atmospheric Chemistry and Biological Processes:

A New "Lab" Science Course for Non-Science Majors at Washington & Lee University.

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Date of grant approval: February, 2006

Report Summary

In February of 2006, the ACS awarded the authors of this report a grant to establish a new science course at W&L that would be directed at non-science majors. Upon receipt of this grant, the authors submitted a proposal to the University Faculty Committee on Courses and Degree describing the new course and requesting that the course fulfill a lab science general education requirement. The committee acted quickly to approve the course with its general education status and made it available for the spring term registration. Simultaneously, the grant authors began purchasing the equipment that would be necessary for the course. The nature of these purchases are included in the main body of this report. Ultimately, all of the equipment necessary for the proposed field course was received before the beginning of the Spring term and was successfully used by the students in the course.

As proposed, the focus of this course was studying the impact of local highways on atmospheric composition as a function of distance and elevation relative to the major highway outside of Lexington, Interstate 81 ("I-81"). The course offered was limited to 10 students for reasons stated in our response to your request for further information about our initial proposal (see Appendix 1, response to "1: Question about course…"). The course enrollment included both science majors and non-science majors. The course had a lecture component, a field components, and a data analysis component. Student evaluations of the course and a survey of student understanding of various terms and concepts introduced during the course were collected at the end of the term.

Finally, a group of students will continue the data acquisition and analysis work that the members of the class began this spring. this summer. Modifications to the course

will be decided upon during the summer of 2006 and will be based upon the course evaluations by students, objective observations by Drs Tuchler and Hamilton, and results from the work accomplished by students this summer.

Grant Objectives

The application of the grant fund is intended both to improve science literacy among non-science majors in an area of great societal importance and to expose science majors to how society uses the information that they provide. The grant is also expected to introduce non-science majors to data acquisition and analysis using on their measurements. These objectives were achieved by introducing a new course at W&L that both satisfied a general education requirement for laboratory science and that was geared to students with little or no science background. The course was designed to allow science and non-science majors to exchange information and educate each-other as they collected and analyzed data in a collaborative way. The grant utilized the expertise of an experimental atmospheric chemist (Tuchler) and an experimental environmental biologist (Hamilton).

Goals and preliminary evaluation

The three fundamental goals of this grant are:

1) to provide non-science majors a science vocabulary and understanding of science methodology through both "active" (field research) and classroom learning as they address an important societal topic that is familiar to them and has significant implications for public policy;

2) to create a setting in which active, informed discussion can occur between scientists and non-scientists about a common, important issues affecting the community;
3) and to expose students to the inter-relationships among different disciplines of science and the importance of this relationship for addressing problems of societal importance.

Current Activities

During the summer, the PIs will review the student evaluations and surveys, will evaluate both the field and classroom components of the course, will oversee a group of students who will use the field equipment to identify additional monitoring sites. One of us (Tuchler) will travel to Virginia Polytechnic Institute to discuss research in Linsey Marr's group regarding aerosol formation and transport..

Delays Encountered

The significant delay in our progress to date was due to the late date of the grant awarding. The consequences of the late granting of money was anticipated and accounted for in the revision to the original proposal. This revision was noted in our response to reviewers comments (see Appendix I, the section beginning with "1: Question about course…", and Appendix II). Briefly, we had expected to work with the course equipment and perform preliminary monitoring during the winter term of the 2005-2006 academic year. Because the grant was not authorized until February, we did not have this opportunity. We necessarily reduced our enrolment limit to 10 students and

did much of our survey work to identify good monitoring sites with these students. The Syllabus for the course was not effected by the delay and thus will not require major modification, only tweaking lecture (see Appendix III).

Approved Budget and Expenses to Date

	Proposed Budget Item	Quantity	Proposed Expense	To Date Expense	Difference
1	Dusttrak Aerosol Monitor	2	$9,000	10138	$1,138
2	Filter Cassettes for Particulate Analysis	6	$450	300	($150)
3	Ashing Furnace	1	$2,500	1500	($1,000)
4	Crucibles for Ashing	24	$560	137	($423)
5	Portable Weather Stations	2	$2,260	1467	($793)
6	Diffusion Tubes (NOx, SOx, and CO)	130	$1,100	351	($749)
7	PI Summer Salary	2	$4,000	0	$0
			$19,870	$13,893	($5,977)
	Additional Budget Item:				
	5 Weeks of Summer Research for 1 Student (balance to be paid from other grants)		2000	0	

Conclusion:

The PIs are pleasantly surprised by just how well this course has met and exceeded their stated goals and objectives. The eager participation by the non-science majors was better than expected and the results of our exit survey indicate that all students dramatically improved their vocabulary in the field of atmospheric science. The PIs look forward to continuing to develop the field and classroom components of this course during the summer. The PIs are currently searching for additional funding to purchase two more DustTraks and two more weather stations as a first step to expanding the class for the next offering to much larger enrollments than the currently expected 20 students.

Appendix 1: Response to Reviewer's Inquiry

01/13/06

Timothy J. Ward
Professor and Chair
Chemistry Department
Millsaps College
1701 N. State Street
Jackson, MS 39210

re ACS Mini-Grant Application

Dear Dr Ward,

Dr. Hamilton and I have chosen to directly address the questions that arose from your committee's review of our proposal as opposed to incorporating our reply into the proposal. Thus please find in this letter the a list of the four "Points to Address" that were provided in your email of 12/08/05, followed by our responses. Along with this cover letter, we have included a separate copy of our proposal, which has not been modified and is provided for your convenience.

"1: Questions about course – expected student enrollment; faculty time demands to devise a completely new course during their winter term while teaching; what happens during repeat offering of course?"

> The proposed course will be offered during our spring term. Dr. Hamilton and my intention is to limit the enrollment for the course to 30 students during the 6 week spring term. We arrived at this number based on 1) the number of aerosol monitors that would be available for the field work component of the course (requested 3 x TSI DUSTTRAK Aerosol Monitor Model 8520), and 2) the number of student that would be in each group to perform the field measurements on each day of the week (2 students per group).
>
> With regard to enrollment, the limit noted above assumed that we would be able to test the equipment with students (both scientist and non-scientists) during the current winter term. We felt this necessary as neither of us are experts at working with this equipment. We can not anticipate the difficulties that the students might encounter in the field with this equipment and believed that our approach would have been an effective method to prepare for the full scale launch of the course in the spring. Because we do not have the equipment and were thus not able to accomplish this fundamental work before this spring term, our current plan is to launch the course this spring, but to limit the enrollment to 10 students. By doing

this, we will be in a more realistic position to teach the course and to test student use of the equipment in the field.

With regard to the feasibility of constructing a new course during the winter term, Dr. Hamilton and I have been working steadily on the material and plans for the course since the middle of the fall term, 2005. We have a general outline for the course and many of our lectures near completion. In addition to the new material that we have developed, we will use material from associated courses that we have taught. Finally, Dr. Hamilton has a reduced teaching load during the winter term due to his exceptionally heavy load in the fall. Thus his teaching schedule will not interfere with the development of this new course, including preliminary testing of the equipment.

With regard to the future of the course, we expect that this course will be offered every spring for the next several years and that it will become an important part of the environmental studies program at W&L.

2. "More explanation of assessment of knowledge and learning outcomes, i.e., what are they and how will they be accomplished?"

Learning outcomes will include knowledge of basic concepts in atmospheric science,. understanding of the scientific method, understanding of the relationship of science to society, and both effective and accurate scientific communication of this relationship with others in the class. All of these will be accomplished through classroom presentation and through "doing science" in the lab and in the field. This approach will ultimately expose students to a combination of chemistry and biology in order to address issues of relevance to the surrounding community.

We are very interested in determining whether we have achieve our goals for the course as established in our proposal. There are a variety of assessment methods that we intend to apply in an effort to accurately evaluate our success. These assessment tools include traditional assessment through assigned papers that reflect upon both in-class and field work, through required presentation of the research and results to the rest of the class, and through anonymous end of the term surveys to be administered via Flashlight online surveys (CTL Silhouette, Washington State University). Finally, a additional survey covering interest and knowledge in atmospheric science and the environment will be required during the first week of class. This same survey will be again administered at the end of the course.

3. "Provide information on how information will be disseminated among members of the ACS and to appropriate discipline groups. For example what role will the Faculty play in assisting students' dissemination?"

Students will be producing a final report, PowerPoint presentation or posters relating to their work. This work will have oversight of the faculty and will undergo peer review as well. Select final products that capture the results of the course will be placed on a local website to which other ACS institutions will have access. Also, other ACS members with have access through the Palladian and the Electronic Palladian list server. Finally, if invited, the structure of the course, recommendations for adaptation, and the results of our work with student will be presented at the ACS workshop on Non-science major reform.

4. "How do you see this model being transferred to or adapted by other ACS institutions?"

We believe that the general project that we propose to you is of interest to any rural or urban ACS institution that is interested in engaging students in addressing local environmental problems such as air quality, water quality or soil pollution. If successful, our non-science majors will feel comfortable and inspired to address such issues as they will learn science. Certainly, other ACS schools are interested in developing lab classes for non-science majors and the general ideas behind our course, if successful, are transferable and are not project specific.

We thank you in advance for consideration of our proposal and encourage you to contact us with any additional questions that you may have or to request additional information regarding the "Points of Interest" that we have addressed above.

Sincerely,

Matthew Tuchler
Department of Chemistry
Washington & Lee University
(tuchlerm@wlu.edu)

and

Bill Hamilton
Department of Biology
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(hamiltone@wlu.edu)

Appendix II: Original Proposal

THE ACS REFORM OF INTRODUCTORY SCIENCE COURSES
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Date of proposed period of grant: December 2005- December 2006

Summary

Funds sought by this proposal will be used to develop a field course to study the impact of local highways on both atmospheric composition and plant health as a function of distance and elevation relative to a major highway (Interstate 81 or "I-81"). This course has been designed to involve both science majors and non-science majors and will have lecture, laboratory, and field components. This course will be offered for the first time in the Spring term of 2006, will initially involve 20-30 students, and will be a major addition to the science component of the environmental studies curriculum at W&L. Introduction of this course at Washington & Lee University is timely in that there is a proposed major expansion of I-81 and no known air quality or environmental impact study. In addition, and of particular relevance to this project, the authors know of no air quality monitoring in the Shenandoah Valley within 60 miles of W&L. For the field studies, the proposed class will be divided into groups of four students, each of which being responsible for collecting and analyzing data from chosen locations at different elevations and proximity to I-81. Ultimately, all groups will combine the data and arrive at a class summary of their observations. In addition to posting it on a Web page, the class will submit their final summary report and any additional comments to the appropriate state agencies that are considering the highway expansion. Students will also be encouraged to inform both state and local government officials regarding their results.

Hamilton and Tuchler have successfully team taught in the past, have discussed the proposed course in detail, and have research expertise that compliment the atmospheric and biosphere impacts to be studied by the students in the proposed course.

Project Description

Introduction

Atmospheric science and its interface with the biosphere has increasingly been the subject of research in fields as varied as chemistry, biology, geology, and medicine. Beyond interest in the anthropogenic impacts on global climate, scientists are interested in local impacts of atmospheric composition on plant health and diversity and human health (IPCC Third Assessment Report: Climate Change , "Climate Change 2001: Impacts, Adaptation, and Vulnerability"; "Climate Change 2001: Synthesis Report"). In particular, micro-atmospheres are increasingly studied and modeled in both mega-cities and in smaller, rural communities. Much of this research is focused on the formation of, composition of, and diurnal variations of coarse aerosols (10-2.5 μm) and fine aerosols (2.5 μm or smaller), both of which are implicated in respiratory and cardiovascular effects in humans. In general, particulate matter (PM) is composed of liquid and solid particles that are suspended in the air and are subject to variation in transport as a function of wind, temperature, elevation and time of day. PM is both naturally occurring and a result of human activities. The major sources of PM are cars, trucks, wood burning, and coal-fired power plants. In Rockbridge County, however, the major source of PM is the car and truck activity on I-81, which cuts a path through the Shenandoah valley and lies 3 miles east of the campus of W&L. The geography of the surrounding Lexington is such that the aerosols that are created on I-81 get stuck in the valley and end up in our gardens, our streams, and our forested lands. This is relevant to the W&L students, many of whom regularly enjoy outdoor activities such as hiking, biking, climbing, canoeing, fishing, etc. Also, many of the students live off-campus, either near

one of the two James River tributaries (Maury River and Buffalo Creek) that pass through Rockbridge County or in the wooded land upon which these PM created on I-81 fall. Thus the impact of this PM is not isolated to the science majors of our community. Therefore exploring the impacts of these aerosols on the environment is ideal for a new course for non-scientists and scientists alike.

This proposal utilizes the expertise of an experimental atmospheric chemist (Tuchler) and an experimental environmental biologist (Hamilton) in a new course at W&L designed to improve the science literacy among non-science majors in an area of great societal importance. The course is also designed to allow science and non-science majors to exchange information and educate each-other in a way that is becoming more important as environmental policy decisions need to be addressed.

Goals

The three fundamental goals of this proposal are:

4) to provide non-science majors a science vocabulary and understanding of science methodology through both "active" (field research) and classroom learning as they address an important topic that is familiar to them and has significant implications for public policy;
5) to create a setting in which active, informed discussion can occur between scientists and non-scientists about a common, important issues affecting the community;

6) and to expose students to the inter-relationships among different disciplines of science and the importance of this relationship for addressing problems of societal importance.

Achieving these goals for the student will depend upon close student-student and student-faculty contact, both types of which will be regularly encouraged. Also, the visible collaboration between two traditional science fields, as represented by Hamilton and Tuchler and the materials to be used by the students, will inspire the students to think outside the box of the traditional disciplines. All of the stated goals are consistent with the Environmental Studies program at W&L, the Chemistry department and the Biology department. The proposed course will add a much needed science component to the environmental studies program and will provide a needed lab-based course for non-scientists.

Background and Significance

Over the past 50 years, interstate highways have replaced train tracks to provide the major artery of commerce and travel. In addition, these arteries deliver significant and concentrated pollutants such as lead, zinc, iron, chromium, cadmium, nickel, copper, hydrocarbons, carbon monoxide, nitrogen oxides, and sulfur oxides. When released to the atmosphere, these pollutants may remain as gases to be washed out, or they can "condense" to form small, suspended aerosols that are themselves transported into the surrounding environment. Of particular interest to the proposed course is the particulate matter (PM), i.e., aerosols, which are of significance to both human health and plant

ecology in the region surrounding the highway via runoff or atmospheric transport followed by direct deposition.

As there is no current effort associated with W&L nor with any known organization in the south-central valley to measure, evaluate, or monitor the impact of PM on the region, the proposed course will have an immediate impact on the University and the surrounding community. The proposed course is ideally suited to educate the non-scientist about how a scientist might approach the socially and societally important questions regarding human impact on the environment. Similarly, this course provides the opportunity for the science student to engage non-scientists on a common issue so that they can learn about how a non-scientist would approach the problem. Both the science and non-science majors will learn about the difference in emphasis and importance that arises from a different background – we claim that this is a significant and unique result of the proposed course.

Description of Student Course Experience:

This course will be offered as a full course load in the spring term at W&L, i.e., students in the class will take no other class that term. The course will fulfill a general education requirement and is designed with the non-science major in mind. Both Hamilton and Tuchler have taught non-major courses.

The proposed course will consist of classroom lectures by Hamilton and Tuchler, an occasional visiting speaker from the Economics Department at W&L or from the Law School at W&L, and both a laboratory component and a field component (described in

the next section). The classroom lecture will occupy at least 4 hours per week and the laboratory and field parts will occupy at least 8 hours per week.

Tuchler's classroom lectures will cover an introduction to global atmospheric composition, atmospheric modeling, atmospheric transport, and particulate formation and composition. Hamilton's classroom lectures will include an introduction to photosynthesis, nutrient uptake, soil microbial processes, stress responses of organisms, and ecosystem function.

An extension of the classroom component associated with the class will be a student run "Journal Club". This club will meet once a week for one hour. At each meeting several members of the class will be responsible for presenting an article or perspective in a leading research journal (e.g., Science, Nature) that they have identified and which is relevant to the course. Peer evaluation and teacher feedback will be provided to the student by the instructors. This club is seen as an opportunity for the non-science student to extend the knowledge that they have accumulated in the course, thus giving them a confidence and independence for addressing issues involving science in the future.

Description of Proposed Field and Laboratory Activities

The students will be divided into several groups to perform the field work and laboratory work. Following an introduction to the equipment and to various data analysis techniques, the groups of student will run all field measurements independently. They will be responsible for calibrating all of their measurements so that comparisons between the results of different groups may be made. Within each group responsibilities will be

rotated so that all students gain experience with each technique. Field work will be conducted in two phases, which are briefly summarized below.

The first phase involves PM monitoring at sites whose location will be determined by instructors. This initial monitoring will involve pair-wise sampling and will serve as a survey. Monitoring sites will be located at the overpasses of the two local James River tributaries along I-81, in rural locations on both sides of the highway, and at various elevations on the Blue Ridge Mountains. The amount of aerosols of different sizes in the atmosphere will be quantified in real time using the requested DUSTTRAK Aerosol Monitors (TSI, Shoreview, MN; Budget Item 3). These monitors will be calibrated to standards so that they may be compared with results from the SHENAIR project. Identification of the aerosol chemical composition will be determined by air-pump sampling/collecting all aerosols onto filters (SKC Inc., Eighty Four, PA; Budget Item 6). The filters will be combusted in an ashing furnace (Budget Items 1 and 2), extracted using standard techniques, and analyzed for metals by ICP spectrophotometry which is available at W&L in the geology department. During sampling at each site, wind speed and direction, temperature, solar radiation, and relative humidity will be monitored (Onset Computers, Bourne, MA; Budget Item 4). These variables are important for developing patterns of particulate deposition and creating a model of transport patterns.

The sites for the second phase of sampling will be determined by the students and will be based on the results of the first phase of monitoring. Extensive sampling will be performed at these second phase sites, with the addition of quantifying daily cycles of aerosols. Furthermore, the gaseous components at these sites will be quantified using diffusion tubes that quantify nitrogen oxides, sulfur oxides, and carbon monoxide (SKC

Inc., Eighty Four, PA; Budget Item 6). Leaf and soil samples will be collected and analyzed for metal content using the same methods as the air sampling filters.

Any additional equipment or supplies that may be required for the proposed course are standard in the stockrooms of the biology or chemistry departments and are thus readily available.

Requested Budget

	Item	Price	Quantity	Total
1	Ashing Furnace	$2,500.00	1	$2,500.00
2	Crucibles for Ashing	$15.00	24	$360.00
3	TSI DUSTTRAK Aerosol Monitor Model 8520	$4,500.00	2	$9,000.00
4	Portable Weather Stations	$1,200.00	2	$2,400.00
5	Diffusion Tubes (NOx, SOx)	$9.00	130	$1,170.00
6	Filter Cassettes for Particulate Analysis	$60.00	9	$540.00
7	Summer Salary	$2,000.00	2	$4,000.00
				$19,970.00

With the exception of the summer salary, the requested budget will provide the funds necessary to provide equipment materials that are required for the course. The specifics pertaining their application are contained in the "Description of Proposed Field and Laboratory Activities" section above. The requested summer salary is for Hamilton and Tuchler as they work together and with students to review and modify the course.

Timeline

The proposed course will be offered in the spring term of the 2005-2006 academic year. Purchasing a testing of all proposed equipment will begin immediately upon receipt

of the grant. This testing will involve students in a way that will allow the course instructors to identify challenges in uses. The testing will begin in the winter term, 2006, allowing the instructors plenty of time to evaluate the field guides and usage instructions that will be provided the various groups in the spring term. Following the Spring term, evaluation by the students of the various aspects of the course will be collected and modifications, if necessary, will be made. These modification will be made by the instructors during the summer of 2006. Any modifications to equipment operation will be tested with students during either the summer or the fall term of the 2006-2007 academic year.

Impact on Washington & Lee University

The proposed course is ideal for W&L as its seeks to broaden the local reach and impact of environmental studies program by including field science courses in the Shenandoah valley. The proposed course would also serve to fill a general education requirement in laboratory science. In order to optimize the impact on W&L, additional development of the labs will be pursued over the summer of 2006, as will a review of all course material.

Evidence of Institutional support

The support of both the Biology and Chemistry departments for developing this interdisciplinary course and their willingness to commit significant faculty and material resources to this course indicates the seriousness of the institution to developing science courses for non-scientists and increasing science literacy on our campus.

Evaluation and Dissemination

The course will have a website associated with and available to the public. On the website will be a complete description of the course, a lecture syllabus, and a description of the field study. Finally, the data collected and the students conclusions based on that data will be published on a separate page, hyperlinked to the main page. This data will be presented as a summary of all the groups data. Together, the students will arrive at a summary of their observations and a statement of any conclusions or recommendations.

The class will submit their final report and any additional comments to the appropriate state agencies that are considering the highway expansion. Students will also be encouraged to inform both state and local government officials regarding their results.

Appendix III: Syllabus

Atmospheric Science – From the Ground Up

"So little to do and so much time to do it!....
Wait…
Reverse that."
Willy Wonka (Gene Wilder version)

Biology 120/Chemistry 120- - Spring, 2006
Texts (Resources):

Office Hours: posted outside of our offices and by appointment

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Catalogue Description:

One of the most complex and important physical systems that scientists must understand is the climate. Predictions regarding climate change and the impact of human activity on that change are made based on our understanding of the complex interactions that drive atmospheric composition and the interaction of the atmosphere with the biosphere and the geosphere. Currently, our society is asking critical questions regarding the impact of climate change and the drivers behind that change. These questions are both global and local in reach. The answers to these questions may have significant impact on the world economy and the choices we make in our country, our states, and our towns.

Washington & Lee is located three miles from I-81, a major trucking route for interstate commerce. The pollutants generated by the traffic on I-81 impact the atmosphere (the air we breath), watersheds (including Chesapeake bay), plants, and soils on local and regional scales. In this course, field and laboratory exercises will include the analysis of atmospheric inputs from I-81 and its' impacts on soil and plant concentrations of contaminants. Lectures will provide background so that informed hypothesis may be made relating to the influences of highways on local and regional atmospheres and environmental contamination will be tested.

Introduction:

Science based courses typically include developing a vocabulary, introducing a collection of equations, and creating a conceptual foundation. These are then used in

tandem to solve problems dealing with various chemical, biological, geological, or physical situations. Ultimately, we hope that these tools will get us to the "right" answer. What if there is no "right" answer…only a "better" answer? What do we do? Interestingly, much national environmental policy is based on a "better" answer or, worse, no answer at all.

Perhaps the most uncertain, but most important, subject in society today is our treatment of the environment. There are no right answers for some of the issues that we as a society are addressing, only better answers. Surprisingly, even the better answers may be disputed as being worse and vice versa, which makes for some interesting conversation among scientists and policy among politicians. This course is designed to expand your understanding of how we, as scientists, can provide data that can be used to answer questions regarding our atmosphere.

What are we doing in Bio/Chem 120 (2006):

Atmospheric Science is a very hot, global topic that influences policy, business and personal decisions made around the world. You will not learn everything about atmospheric science in this course, but you will learn a vocabulary consistent with the field of Atmospheric Science, learn a few equations that are useful to understanding basic processes in the atmospheres, and learn the basic modeling technique of atmospheric and biological systems. By learning these, you will become more intelligent about the discussions that are ongoing in the newspapers, scientific literature and the government, especially as these discussions pertain to the atmosphere, its composition, and the impact of this atmosphere on the earth based systems upon which we depend.

The goal of this course is to apply basic principles of more traditional fields such as physics, geology, chemistry, and biology to describe the processes that control the chemical composition and evolution of the Earth's atmosphere and environment. In this course you will utilize methods employed by scientists to 1) measure particle emissions from automobiles along I-81, 2) quantify soil and plant contaminants, and 3) model atmospheric and biological interactions.

Atmospheric Science is a threshold field in Environmental science, in that it is highly relevant to many environmental pollution problems such as acid rain, stratospheric ozone depletion, photochemical smog production, and global climate change. This course may be the beginning of your thinking about these problems, but we hope that it will not be the end.

Evaluation in Chem/Bio 120 (2006):

Class Participation: 10%

This course will have lecture, discussion and field/laboratory components. Thus, when a reading assignment is made, you are expected to come to the next class prepared to discuss the material. You are not expected to necessarily understand the material in great detail (questions of Dr. T or Dr. Hamilton are encouraged), but a working, conversational knowledge of the content is expected.

Clearly, *participation requires attendance*. If you are not going to be present in class, we need to be alerted before class meets. There are at least 24 class hours this

term, of which you may miss two without penalty taken from your participation grade. If you attend all the classes, you will receive an end of the term bonus.

Quizzes: 30%

You will be given four, 30-40 minute quizzes over the course of the term.

Thursday 04/27/06.
Thursday 05/04/06.
Tuesday 05/16/06.
Thursday 05/24/06.

If you miss a quiz without consulting us in advance (before the class hour) you will receive a grade of zero. If you do miss a quiz and have alerted us in advance of your absence, you will be required to take the quiz within 24 hrs, unless the instructors agree to a further extension. The policy on quizzes is strict: you must have an extremely good excuse not to take tests on time.

Field Work./Team Work 25%

You will be spending more than half of the course as part of a group in the field collecting data on air composition, temperature, and wind velocity. Thus being prepared for "lab" every time you go into the field is essential to successful completion of the task at hand. Preparation is also critical to for careful data acquisition and the quality of your data. Finally, your ability to collaborate with other group members is necessary. You will be graded on your level of preparation and on your ability to work with other. The evaluation will be based in part on pier evaluation and in part on qualitative analysis by the instructors.

Problems/Data Analysis 15%

We will assign homework over the course of the term and expect that you will have it finished at the time that it is due. There will be no extensions and late work will be refused without the most extraordinary explanation. You may work together on these problems and we hope that you will.

Presentation: 10%

You will be required to work with one other person and to make a 30-35 minute, PowerPoint presentation to the class on a topic relevant to Atmospheric Science. Examples of topics that you may cover are included below. You are not required to assume one of these topics and may choose your own, subject to the approval of either of the instructors. The topics will be distributed on a 1st come, 1st-served basis. You will make your presentation during our presentation luncheon on a date to be determined by the class during the last week of the term. Your presentation should incorporate vocabulary and content that we have covered during the course of the term. For example, if you are interested in discussing the ozone hole over Antarctica, you may incorporate notions of aerosols and their impact on the destruction of ozone

Final Paper: 10%

Your final paper will be based on the material in your presentation. In the final draft, you will include any responses to questions that arose during your presentation. You are welcome to turn in a rough draft of your paper for either of the instructors to edit. However, we believe that your piers are the best editors and thus recommend that you try them first.

Possible Paper Topic Ideas:

- The Hydrogen Economy
- The Discovery of Global Warming
- Measuring the Atmosphere by Satellite Observation.
- Measuring the Atmosphere by Ground Based Observation.
- Measuring the Atmosphere by Airplane.
- The Source of Carbon Reservoir Estimates.
- Acid Rain – Sources and Impact
- Aerosols and Plants.
- Climate Change Policy: Impacts and Responses.
- Evolution of the Atmosphere
- Impact of Climate Change on Human Society
- Impact of Climate Change on Plants and Animals (e.g., will trees grow better with more CO2 around?)