

UMBS REU Program in Climate Change in the Great Lakes Region: Atmosphere-Hydrosphere-Biosphere Interactions

Program Rationale

Virtually all ecological systems are already affected by one or more components of climate change, including increasing temperature, altered precipitation patterns and other changes to the hydrological cycle, altered timing of important life cycle events, and increasing atmospheric CO₂ and ozone, all of which are very likely to intensify in the future. In many cases, different components of climate change will act synergistically. For instance, increasing atmospheric greenhouse gasses will result in higher temperatures and more severe rainstorms, which together are likely to have a stronger impact on ecosystems than either alone; stream macroinvertebrates may be able to acclimate to changes in streamflow or water temperature, but not to both simultaneously. We currently know little about such atmosphere-hydrosphere-biosphere interactions, despite the fact that they are crucial to understand and anticipate impacts of global change.

Although traditionally approached as separate disciplines, ecology, atmospheric science, and hydrological science are intimately linked via global climate change. Therefore, interdisciplinary thinking is required to understand the multiple causes and consequences of climate change. The essential research that will provide this understanding will be best accomplished by young interdisciplinary researchers who, to be effective, must first become interdisciplinary thinkers.

Program Goals

Our program is designed to train promising young scientists to understand, discuss, investigate, and ultimately solve the complex interdisciplinary global environmental issues of the 21st century. We do this by providing a total immersion experience in interdisciplinary thinking and research, together with the professional skills essential for a productive and impactful career in science. All parts of the program are necessary to accomplish these goals; neither the structured activities (primarily workshops) nor the student's research project (which addresses some aspect of Biosphere-Atmosphere-Hydrosphere Interactions) alone provides a full interdisciplinary training experience.

To facilitate the development of young scientists who are considering careers involving interdisciplinary ecological, atmospheric, and hydrological causes and consequences of global change, we try to help students:

1. Develop as interdisciplinary thinkers, and
2. Grow into true colleagues for their mentors and other UMBS researchers.

Program Structure

The program structure follows directly from our two primary goals.

REU students are expected to be involved with some aspect of the REU program approximately eight hours per day, six days per week for the approximately nine weeks in residence at UMBS.

Approximately 30% of program time is dedicated to “**Perspective Broadening Activities**” designed to help students develop as interdisciplinary thinkers. To accomplish this, we provide

- a. 11 full- or half-day workshops throughout the summer, half of which provide knowledge fundamental to interdisciplinary biosphere-atmosphere-hydrosphere thinking (climate change, atmospheric processes, biogeochemical cycles, forest-atmosphere-hydrosphere interactions, aquatic ecosystem-atmosphere interactions), and half of which provide opportunities for skills development (workplan construction, experimental design and statistics, oral and written communication, ethics, and graduate school),
- b. a weekly reading group focused initially on climate change, and

- c. the weekly UMBS evening research seminars

The remaining approximately 70% of program time is dedicated to the student's **Individual Research Project** (which also helps students develop as interdisciplinary thinkers). Each student will have a research committee, headed by the mentor and including Dave and Steve.

To have the kind of complete research experience our program strives for, the student should:

- a. become acquainted with the relevant literature;
- b. play a role in identifying the research question(s), and understand the interdisciplinary nature of those questions;
- c. play a role in designing experiments and/or observations to test the research questions;
- d. gather a substantial amount of data;
- e. perform appropriate statistical analyses of the data;
- f. interpret the results; and
- g. present the results in a scientific report suitable for publication and orally in a public symposium at the end of the summer, with sufficient attention to the interdisciplinary implications of their results.

As indicated below, the mentor has primary responsibility for ensuring that his/her student(s) experience all seven components of what we believe to be a complete research experience. However, Dave and Steve have secondary responsibility and, if requested, can take primary responsibility for particular phases of the project (*e.g.* statistical analysis).

We would like to note that one strength of our program is that students are expected to play an active role in identifying the research questions and designing the experiments to answer those questions (steps b and c above). We believe this allows more opportunity for scientific growth than an experience in which the student is simply given a question and experimental protocol.

All students in our program receive extensive mentoring (commensurate with need, of course) from the mentor(s), Dave, and Steve; together, we can provide an interdisciplinary perspective.

More Detail about the Individual Research Project

The skills a particular student gains will differ from project to project, but will always include hypothesis testing, experimental design, statistical analysis, and oral and written communication of results.

1. During Weeks 1 and 2, students interact daily with mentors to discuss progress on individual projects. During this time, mentors engage students in discussions about the big picture and experimental design. The student's mentor, Dave, and Steve form a research committee (simulating a graduate thesis committee), with the mentor serving as Chair. Students learn how to prepare a workplan during the "Constructing a Workplan" workshop on Sunday, June 25, and submit a completed workplan to all committee members on Wednesday, June 28. Each student schedules a 45-60 minute committee meeting on June 30 or July 1 (attended by the student, mentor, Dave, and Steve) to discuss his/her big picture, research questions, and experimental design. Committee meetings continue as needed through the summer, and provide a forum for discussing revisions of experimental design and issues of data analysis, interpretation and presentation. Students are responsible for arranging committee meetings; however, the mentor, Dave, or Steve can initiate a committee meeting if necessary.
2. On Monday, July 3, students give individual semi-formal oral presentations (10 minutes followed by 15 minutes of discussion) of their proposed projects to an audience consisting of REU students, Dave, and Steve. Mentors are also welcome to attend. These oral presentations serve three key

purposes: (1) familiarizing REU students with one another's projects, thus facilitating discussions about research projects among participants, (2) providing an early opportunity for questions and comments about research design, and (3) giving each participant public speaking experience.

3. On Monday, July 10, each REU student submits to the committee a draft of his/her *Introduction and Materials and Methods*, which have been revised to reflect comments and suggestions provided during the oral presentation and during subsequent meetings with the mentor and/or Dave and Steve. Mentors return a set of detailed comments to the REU participant within one week.
4. At the start of Week 9, REU students are encouraged to:
 - a. submit a preliminary version of their final paper (detailed written comments will be provided by the mentor), and
 - b. present a practice version of their final talk to their mentor, who will provide verbal and/or written feedback).
5. On Thursday, August 17, each REU student gives a formal 15-minute oral presentation in a symposium open to the entire UMBS community. These presentations are intended to simulate an oral paper at a professional meeting and are typically attended by 20-30 non-REU faculty, investigators, graduate students and non-REU undergraduates. Presenters receive feedback during a 10-minute question period and from their committee afterwards.
6. On Saturday, August 19 (the day of departure), each REU student submits a final paper, written in a form appropriate for submission to the most relevant journal.
 - *students' receipt of the second half of their REU stipend will depend, in part, on submission of an acceptable paper (as judged by the mentor, Dave, and Steve).

This sequence of activities exposes each REU student to all phases of scientific research from hypothesis and project conception to written and oral presentation of results and conclusions.

REU Student Responsibilities

1. Active and engaged participation in all **Perspective Broadening Activities**
 - a. workshops are a primary vehicle for developing as an interdisciplinary scientist
2. Active and timely participation in all **Evaluation Activities**
 - a. very important to complete evaluations on time
 - *students' receipt of the second half of their REU stipend will depend, in part, on submission of all evaluations
 - b. very important to respond to NSF request for information within 1 week of receipt
3. Primary responsibility for **Individual Research Progress**
 - a. invest substantial time in research (laboratory and literature)
 - b. seek frequent guidance from research mentor(s)

Mentor Responsibilities

1. Primary responsibility for oversight of student research
 - a. communicate frequently with students (we suggest daily contact during first 2 weeks, and contact via phone, video chat, and/or e-mail if you are away from camp)
 - b. encourage students to consider interdisciplinary underpinnings and implications of the research project
 - c. assist students to define goals and prepare professional-quality drafts and final reports

- d. ensure full participation of graduate students acting as co-mentors
 - e. encourage students to interact regularly with members of the broader UMBS community
2. Support the philosophy and goals of the REU program
 - a. encourage students to participate actively in all REU workshops, reading groups, evaluations, etc.
 - b. respond promptly to REU mentor evaluation requests
 - c. include REU students as co-authors in the reporting of research results at conferences and/or in publications, as appropriate

Co-Directors (Dave & Steve) Responsibilities

1. Primary responsibility for program structure
 - a. organize summer schedule and make it available to students and mentors
 - b. design and deliver most Perspective Broadening Activities
 - c. structure activities to help students acquire essential skills in global change science, experimental methods, and professionalism
2. Secondary responsibility for oversight of student research
 - a. assist students in seeking guidance from mentors, the UMBS community, and the literature
 - b. assist students to produce goal and work statements and professional-quality reports
3. Oversight of program evaluation
 - a. generate evaluation instruments and schedule evaluation activities
 - b. report evaluation results to National Science Foundation
4. Logistical support
 - a. organize meeting times and locations
 - b. distribute REU-related documents to students and/or mentors

Program Staff Responsibilities

1. Travel, coordination of evaluation activities, and assorted other logistics: Peggy Meade

Other Logistics

1. REU student research funds (\$500 per student for research supplies)
 - a. Check with Sherry in the Stockroom, or Bob at his Lakeside office across from the Stockroom to see if the Station can provide the item in question. If UMBS does not have the item, ask where they would recommend that you purchase it.
 - b. Go to the Administrative Office for a requisition (with UM tax exempt number) or vendor credit card. You or your mentor should NOT make any purchases without doing this first.
 - c. It will NOT be possible to receive cash reimbursements for purchases made. However, UMBS has arrangements with over 40 vendors, so there should not be a problem finding the supplies you need.
2. REU student use of UMBS vehicles (for research purposes only)

IMPORTANT NOTE: the REU program has priority access to one minivan only. Since there are 10 REU students this summer, it's very important to try to use alternate transportation (including bicycles), or carpool whenever possible. Before driving any UMBS vehicle, you'll need to fill out

an online Driver Authorization form, using the link Peggy sent you.

If you need to use a UMBS minivan:

- a. A Vehicle Request Form (available in the mailroom) must be completed as far in advance as possible, signed by your mentor, Dave, or Steve, and turned in to the Administrative Office. All vans are located in the parking lot near the Maintenance Garage. Upon return, record the mileage, return the keys to the lockbox in the Maintenance Garage, and return the completed form to the “report slot” on the mailroom wall.
- b. To use a motorized UMBS boat, follow the same procedure but use a boat request form.

Please check with the Administrative Office if you have any questions regarding these procedures.