

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, predict, mitigate, and prepare for the 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.**
2. **Grow into true colleagues for their mentors and other UMBS researchers.**

Program Structure

The program structure follows directly from our two primary goals.

In general, 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 duration of the program. Actual time commitments will be worked out between the student, mentor, and co-Directors.

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. 12-14 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. 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. **Unlike many undergraduate research experiences, we want our REU students to feel like accomplished researchers rather than simply someone else's research assistant.**

To have the kind of complete research experience our program strives for, the student should (with all necessary guidance from the committee):

- 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, orally in a public symposium at the end of the summer, and as a poster at the end of August, all with sufficient attention to the interdisciplinary implications of their results.

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 to by the mentor, can take primary responsibility for particular phases of the project (*e.g.* statistical analysis).

We would like to note that, in our program, 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 the remote Weeks 1 and 2 and, if possible, prior to the start of the program, students interact frequently with mentors to discuss their individual research projects. During this time, mentors engage students in discussions about the big picture and experimental design during three meetings scheduled by the student. Students learn how to prepare a workplan during the “Constructing a Workplan” workshop and, shortly after submitting a completed workplan to all committee members, schedule a 45-minute meeting with the full committee consisting of Dave, Steve and the mentor serving as Chair. During this meeting, the student discuss her/his big picture, research questions, and experimental design with the full committee. 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. At the start of Week 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. However, REU students have priority for all questions and comments; mentors, Dave, and Steve can only ask questions or make suggestions if all REU students are finished doing so. 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. During Week 3, 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 proposal

presentation and during subsequent meetings with the mentor and/or Dave and Steve. Mentors return a set of comments within one week.

4. By the end of Week 7 or start of Week 8, REU students are encouraged to:
 - a. submit a preliminary version of their final paper (the mentor will provide written comments), and
 - b. present a practice version of their final talk to their mentor, who will provide verbal and/or written feedback).
5. During the last week, 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 13 (the day before departure), each REU student submits a final paper, written in a form appropriate for submission to the most relevant journal.
7. On Saturday, August 27 (two weeks after departure), each REU student presents a final poster, constructed in a form appropriate for presentation at a scientific conference, during a virtual poster symposium via Zoom.

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.