EAS A474/G574: Current and Future Trends in Extreme weather
Detection, attribution, and projection of changes in extreme weather

Course Syllabus
Indiana University, Bloomington, Fall Semester 2020

Instructor
Prof. Travis A. O'Brien
Earth and Atmospheric Sciences
Assistant Professor
GS-3004

Location/Time
BH 342
MW 12:20-1:35 p.m.

Contact Number: 812-269-2051 (e-mail preferred)
obrienta@iu.edu

Office Hours
Office Hours TBD

Official office hours and location are noted above. I am on campus all day for most days of the week, and I welcome meeting with any of you at a mutually convenient time. My door is open to all of you, figuratively speaking; and if my door is literally open, it means I’m available to talk. Do feel free to drop by.

Prerequisites
None

This is a quantitatively oriented class that will make extensive use of two main quantitative skills:

- algebra (including the use of Greek symbols), and
- reading and interpreting graphs.

In order to benefit from this class, students should be adept at algebraic manipulation of equations/expressions, able to interpret two-dimensional graphs and contour maps, and have some foundational knowledge what climate change is and why it is happening. For example, EAS E-122 “Earth’s Dynamic Atmosphere” provides an adequate introduction to climate change science.

This course will involve statistics and (for graduate students) some programming. This course will introduce essential statistics and programming concepts, so neither are required as a prerequisite.
Students should reach out to the instructor if they are unsure whether they have an appropriate background to succeed in this course.

**Required Materials**

A laptop.

Reading materials will be provided digitally.

**Course Description**

An overview of methods, peer-reviewed studies, national reports, and international reports that inform our understanding of the detection, attribution, and projection of changes in extreme weather. Covers questions that are common in popular media like “Was Hurricane Florence caused by climate change?” as well as more scientifically well-posed questions like “Has the risk of Florence-like storms changed in the observational record?”, “What factors have caused the risk of Florence-like storms to change?”, and “How might the risk of Florence-like storms change in the future?” Students will gain hands-on experience analyzing changes in the risk of extreme weather in real-world data.

**Course Objectives**

By the end of the course, students will be able to summarize the current scientific understanding of the impact of anthropogenic climate change on extreme weather: both in terms of what we know and how we know it.

Students taking the course for graduate credit will additionally be able to critique existing studies that detect and attribute climate change, and they will be able to analyze changes in extremes in real-world data.

**Course Outline**

Week 1. Overview of detection, attribution, and projection
Week 2. Generalized Extreme Value theory, part 1
Week 3. GEV theory, part 2
Week 4. Counterfactual simulation D&A methodologies, part 1
Week 5. Counterfactual simulation D&A methodologies, part 2
Week 6. Pseudo-global warming simulation D&A methodologies
Week 7. Observation-based D&A methodologies
Week 8. Extremes in the National Climate Assessment
Week 9. Extremes in the Intergovernmental Panel on Climate Change report
Week 10. The BAMS State of the Climate Report
Week 11. Media coverage of extreme weather and climate change
Week 12. Non-stationary GEV theory
Week 13. Methods for estimating GEV parameters
Week 14. Current literature critiques and final project practicum
Week 15. Final project presentations
Course Format

This is a 3 unit course for advanced undergraduates with and for graduate students.

Students taking the course for graduate credit have a more extensive set of learning objectives. The overall course content will be the same for students taking the course for undergraduate credit or undergraduate credit. The graduate portion will have additional responsibilities, such as additional homework problems, leading group projects, and leading in-class discussions.

The course content is covered in two 75 minute classes each week. Classes will be a mix of lecture, discussion, and in-class projects. While all of the material will be introduced in 2.5 hours of class each week, a substantial component of the learning will occur outside of lecture: homework assignments, weekly reading assignments, reports, and a final project.

Lecture

During each lecture, we will start the class by revisiting topics from the previous class(es). This will be followed by the introduction of a new topic, and we will work through examples of the new concept. These examples will take the form of brief laboratory experiments or demonstrations where practical.

Lecture attendance is mandatory, and it is imperative that everybody show up to lecture on time. The review at the beginning of each class helps reinforce concepts and helps prime our brains for learning new concepts.

Homework and Reading Assignments

In a typical week, there will be one homework assigned at the end of each lecture and one collected at the beginning of each lecture. The homework assignments will be small (1-3 questions, usually) and should not take more than an hour to complete. (I encourage feedback on the homeworks if this is not the case!) The purpose of these frequent assignments is to bring concepts from previous classes into your working (short-term) memory; the more frequently a concept is brought into working memory, the better its chance of being stored in your long-term memory.

Each lecture will also usually have some amount of reading assigned for the next lecture. It is my hope that the students will do the reading and homework at different times when possible (again because of the working memory idea), but I won’t require this. In addition to the homework assignments, I will ask for a paragraph-length summary of reading assignments. I will provide instructions on each homework assignment as to what should be read and summarized; if instructions for the summary are omitted from the homework, then the summary is not required.

Graduate Practical Section

Students enrolled in the course for graduate credit will be required to attend a weekly practical section for the course. This section is designed to teach graduate students the programming skills necessary to carry out GEV analysis on real-world data. Later in the semester, these sections will be designated for students to work on the final project.
The date, time, and location of this section will be determined in consultation with the graduate students during the first week of class.

**Grading Policy**

The following is the official grading policy for the course. It is written in great detail so that there is no question about how/when grades are assigned, augmented, or reduced. At my discretion, there may be exceptions to the following policies to accommodate extreme circumstances, but exceptions will only be granted if they are requested before a given assignment is due or an exam is given.

30% - Homework

15% - In class discussion and exercises

30% - Written reports

25% - Final exam (undergrad) or Final project (grad)

**Homework – 30%**

Assignments will be turned in digitally via Canvas. The grade for each homework assignment will be dropped by 25% if not turned in before the start of the lecture on the day that the given assignment is due. The assignment will not be counted at all if not turned in by 11:59PM of the day in which it is due.

**In-class discussion and exercises – 15%**

There will be substantial in-class discussion: particularly related to assigned reading material. Students who systematically do not actively participate in discussions may receive a reduced ‘participation’ grade; I will reach out directly to any student whose level of engagement might result in a reduction.

There will also be a number of in-class exercises designed to support learning of core concepts. These will be graded on a binary scale: 0% if not completed and turned in, and 100% if completed and turned in.

**Final exam (undergrad) or Final project (grad) – 25%**

(undergrad) Students enrolled in the course for undergraduate credit will take a final exam during the final exam time scheduled by the registrar for this class. The exam will be designed to synthesize concepts from the entire course.

(grad) Students enrolled in the course for graduate credit will be expected to turn in a final project that uses pre-existing GEV software to analyze extremes in real-world data. The graduate section of the course will be designed around developing the skills necessary to do this final project. Undergraduate students may, with the approval of the instructor, enroll in the course for graduate credit.

**Written Reports – 30%**
There will be at most three written reports throughout the semester. The goal of the reports will be to summarize and synthesize topics covered in the class.

Final Grade

The final grade for the course will be the sum of percentages from each of the above categories, with any extra credit applied. No individual assignment or exam will be curved. At the end of the course, and at my discretion, the grading scale may be adjusted (only downward) such that the threshold for receiving a given grade is lowered. The grading scale will not be shifted to the detriment of any student. Percentages will be rounded prior to assigning grades. The following table provides the highest thresholds that will be applied to achieve a given letter grade for the course:

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<thead>
<tr>
<th>Percentage</th>
<th>Grade</th>
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<tr>
<td>98-100%</td>
<td>A+</td>
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<tr>
<td>93-97%</td>
<td>A</td>
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<td>90-92%</td>
<td>A-</td>
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<td>87-89%</td>
<td>B+</td>
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<td>83-86%</td>
<td>B</td>
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<td>80-82%</td>
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<td>77-79%</td>
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<td>73-76%</td>
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<td>70-72%</td>
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<td>63-66%</td>
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<td>60-62%</td>
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Academic Honesty Policy

Students are expected to adhere to the IU Code of Student Rights, Responsibilities, and Conduct. Any work in this course that is deemed to be a product of academic dishonesty will receive an automatic 0, and I will refer any involved students to the Office of Student Conduct. The following outlines some of the course-specific policies regarding academic honesty.

Homework

Students are strongly encouraged to work in groups on homework assignments, however all work that is turned in must be entirely the student’s own. Specifically, I draw the ethical/unethical line for homework assignments at direct copying of assignments. If I find that answers from two or more homework assignments are implausibly identical, all assignments involved will receive an automatic 0 and the student(s) will be referred to the Office of Student Conduct.
Written assignments and projects

The same policies for homework assignments apply to any course projects. In addition, plagiarism should be strictly avoided. Students should be sure to cite any sources used and to quote any text (paraphrased or direct quoted) that is not the student’s own. Students should consult with me if uncertain about what constitutes plagiarism. If a written assignment is found to be plagiarized in any way, that assignment will receive an automatic 0 and the student(s) will be referred to the Office of Student Conduct.

Exams

During any exam, I expect that each student does their own work for the entirety of the exam. Students are also expected to comply with any exam-specific rules (e.g., rules regarding external materials allowed in the exam, talking during the exam, etc.). Communication among/between students about the content of the exam is strictly prohibited during exams. An exam begins when I start to distribute the exams and an exam ends when I collect the last exam. I will regard communication of exam contents during an exam as cheating, and all students involved will receive an automatic 0 and will be referred to the Office of Student Conduct.

Learning Outcomes

By the end of the course, undergraduate students will be able to:

- Recall the various methods of detection and attribution (D&A) used for extreme weather
- Summarize the assumptions and limitations of various D&A methodologies
- Explain why Generalized Extreme Value (GEV) theory is central to D&A methodologies
- Compare GEV theory to the central limit theorem
- Classify existing studies into methodological categories
- Summarize the current scientific understanding of the impact of anthropogenic climate change on extreme weather
- Compare the various D&A methodologies

By the end of the course, graduate students will be able to:

- Recall the various methods of detection and attribution (D&A) used for extreme weather
- Summarize the assumptions and limitations of various D&A methodologies
- Explain why Generalized Extreme Value (GEV) theory is central to D&A methodologies
- Compare GEV theory to the central limit theorem
- Classify existing studies into methodological categories
- Summarize the current scientific understanding of the impact of anthropogenic climate change on extreme weather
- Compare the various D&A methodologies
- Summarize the statistical conditions under which GEV theory is valid
- Check the validity of implicit and explicit assumptions in existing D&A studies
• Critique existing D&A studies and press coverage of them
• Execute existing GEV parameter estimation code on real-world data

Accommodations

Every attempt will be made to accommodate students with disabilities (e.g. mental health, learning, chronic health, physical, hearing, vision, neurological, etc.). You must have established your eligibility for support services through the appropriate office that services students with disabilities. Note that services are confidential, may take time to put in place, and are forward moving. Captions and alternate media for print materials may take three or more weeks to get produced. Please contact the Disability Services for Students (DSS) at 812-855-7578 as soon as possible if accommodations are needed. The office is located on the third floor, west tower, of the Wells Library, Room W302. Walk-ins are welcome, 8 a.m. to 5 p.m. Monday through Friday. You can also locate a variety of campus resources for students and visitors who need assistance at [iu.edu/~ada](http://iu.edu/~ada).