Topics in Environmental Geography
GEOG-G 440/540

Terrestrial Ecosystem Modeling

Department of Geography
Indiana University
Spring 2020 Syllabus

Lecture: Monday and Wednesday 9:30-10:45am
Lecture Location: Monday SB 138; Wednesday SB 221.
Instructor: Dr. Natasha MacBean
Office: Student Building 204
Email: nmacbean@indiana.edu
Office hours: Monday and Wednesday 10:45-11:45am

Short course description

This course introduces students to the major components of terrestrial ecosystem models – the land component of earth system models that are used in climate change projections. These components include biogeochemical, hydrology and energy cycles, as well as processes that impact ecosystems, such as disturbance, land use change and land management.

Course Objectives

This course introduces students to Terrestrial Ecosystem Modeling. Terrestrial Ecosystem Models (TEMs) – otherwise known as terrestrial biosphere models, land surface models, or dynamic vegetation models – typically form the land component of global scale earth system models that are used in IPCC climate change projections to model earth system responses to global environmental change. These models include biogeochemical, hydrology and energy cycles, as well as processes that impact ecosystems, such as disturbance, land use change and land management.

In this course, students will learn about each of these major components of TEMs. Students will also focus in depth on one specific component of TEMs that is pertinent to their research, interests or career goals via independent research and readings on the topic and an in-class project and presentation. We will also learn about the history of terrestrial ecosystem model development, particularly within the context of climate change modeling, the challenges of developing models, the remaining gaps or structural inadequacies of these models, and about quantifying and reducing model uncertainty via data assimilation.

In practical classes throughout the first ten weeks of the course, students will have a chance to develop a simple carbon cycle model, starting from the initial concept, through the equations, then the computational algorithm needed to implement the model, and finally to the writing the code (in Python). We will develop this model together in class and via practical

assignments. Students will then use this model to run experiments to better understand how models work, and to learn how we use models to better understand physical and biogeochemical processes. Some experience in computer programming would be helpful for the practical component, but is not necessary.

In the final part of the course, students will take turns to present and discuss scientific journal articles detailing the most recent global-scale TEM predictions as well as papers discussing disagreements between model predictions and controversial issues surrounding the field of modeling.

This course should be useful for anyone interested in, or carrying out research, in any aspect of how ecosystems are responding to global environmental change, regardless of the specific biome or timescale being studied. Having an understanding of how terrestrial ecosystem models work should add great value to their study area given the importance of these models in making future climate change projections that contribute to IPCC Assessment Reports. There are no pre-requisites for this course, but students must have completed a course in ecosystem science, hydrology, biogeochemistry, ecological climatology or another related field. Permission with consent of instructor.

Course Goals and Learning Outcomes

Course goals:
Students will complete this course with a foundational knowledge of what terrestrial ecosystem models are, how they are developed, and how they are used to make predictions about the response of the terrestrial biosphere to global change drivers. Students will be given a grounding in the basic principles of terrestrial ecosystem modeling from the overall concept to developing the equations, to writing the computational programming code needed to execute these models.

Learning outcomes:
At the end of this course, students should:

- Understand the basic components of terrestrial ecosystem models: biogeochemical cycles, hydrology, energy budget, disturbance, dynamic vegetation, and anthropogenic land use and management.
- Have in-depth knowledge of one of these components depending on student's own interests and research (see Class Project).
- Have an appreciation of the advantages, limitations and uncertainties of the models and of modeling in general.
- Learn how to develop a simple ecosystem model from identifying the initial concept and purpose of the model, through understanding the equations, through implementing these equations in scientific code that can be used to execute the model.
- Use the model we have built together in class to understand how computational models of ecosystem processes work and how they can be used to make predictions.
- Understand where TEMs fit in with Earth System Modeling and other types of modeling frameworks (e.g. regional climate models, catchment hydrology models, weather prediction etc)

- Understand how these models are used in climate and global change projections (such as in IPCC reports).
- Be able to read and understand high impact scientific literature that describes predictions made with these models within the context of understanding the impact of global change drivers (e.g. climate change, CO_2 emissions and land use change) on terrestrial ecosystems and the feedbacks to climate.

Textbook and Reading requirements

Textbook: Bonan, G. (2019) Climate Change and Terrestrial Ecosystem Modeling, 1st Edition, Cambridge University Press, UK.
Note: Supplemental readings will be provided on Canvas.

Chapters of the textbook may be set before each class. For their class projects, students will be required to read one or two chapters of the textbook in depth, together with ~5 associated journal articles (*note that graduate students may be expected to read more and/or to do their own literature search for the final project*). During the final part of the semester students will read in depth two journal articles per week (one per class) for our in-class paper presentation and discussion. The students will take turns to lead the discussion for each of those articles.

Course Format and Grading

In-class exercises: Four in-class exercises will be set for the practical part of the course. Students will need to complete the assigned exercises and submit them by the deadline.

Class Project: Each student will complete a class project which will be to learn in depth one particular part of the model (e.g. carbon cycle, or water cycle) and present that to the rest of the class. Each student will be given a reading list relevant to their chosen topic, but they will be encouraged to seek out other journal articles to complement their knowledge. The grade will be based on the detail and quality of the presentation., a 2-3 page literature review on the student's chosen topic, and a 10 question quiz the student prepares on the topic for the rest of the class.
Additional requirement for G589 students: the class project will be more extensive and based on your research interests. It will make up a greater percentage of your overall grade. Students will be expected to seek out further material in the form of journal articles than the reading list they are given.

Quizzes: as part of the Class Project, each student will prepare a 10 question quiz to test if the rest of the class has understood the material. The rest of the class will take all the set by the other students in their class and the overall grade will be the average across those quizzes.

Paper presentation and discussion: During the final part of the semester we will be discussing contemporary literature as a group. Students will take turns to lead the discussion for each of

those papers/articles. The grade will be based both on completing 1 page of questions per article to show their understanding of the material presented in the article, as well as each students' effectiveness in leading an engaging discussion on the article they lead the discussion for. Students will be taught methods of reading and discussing journal articles before this part of the course.

Grading (440): In-class exercises – 25%
Paper presentation and discussion – 30%
Class project – 40%
Quizzes – 5%

Grading (540): In-class exercises – 15%
Paper presentation and discussion – 20%
Class project – 60%
Quizzes – 5%

Grading Scale

97% - 100%	A+	77% - < 80%	C+
93% - < 97%	A	73% - < 77%	C
90% - < 93%	A-	70% - < 73%	C-
87% - < 90%	B+	67% - < 70%	D+
83% - < 87%	B	63% - < 67%	D
80% - < 83%	B-	60% - < 63%	D-
		< 60%	F

Grade Dissemination:
All grades will be posted on Canvas. Please make sure to track your own grades, as mistakes can occasionally occur. If you have received a grade by mistake, please see me for a correction in Canvas.

Course Policies & Services

Canvas: Class announcements, materials and updated information will be distributed via the course website on Canvas. Powerpoints of class notes will provided on Canvas after each class. All in-class assignments will be provided via Canvas and each group will upload their work via Canvas before the due date. All quizzes will also be provided on Canvas. You may need to adjust your settings to ensure you receive timely communications from this class. Check that your notifications are set appropriately by going to Canvas. In the top left of the window select "Account" then "Notifications" to review and change your preferences.

Assignments and Late Work: You may work with others on the exercises, but you may not copy directly from anyone. Your work must be your own. *Late exercises will have 10% deducted per day, but exercises will not be accepted once graded copies are returned to the class.* The only allowable exceptions pertain to the IU policy on religious observances, military duty and family emergencies, illness with a doctor's note, or prior permission from me. If you have an excused absence for any of these reasons, make arrangements in advance or ASAP to makeup missed activities. *Plagiarism and cheating in any form will not be tolerated.*

Attendance and participation: I except you to attend all classes. Your active participation in this class (aside from excused absences) will be reflected in your Class Project and Paper Presentation and Discussion grades.

Civility: I expect students to support one another in learning this material.

Academic Integrity: As a student at IU, you are expected to adhere to the standards detailed in the *Code of Student Rights, Responsibilities, and Conduct* (*Code*). Academic misconduct is defined as any activity that tends to undermine the academic integrity of the institution. Violations include: cheating, fabrication, plagiarism, interference, violation of course rules, and facilitating academic dishonesty. When you submit an assignment with your name on it, you are signifying that the work contained therein is yours, unless otherwise cited or referenced. Any ideas or materials taken from another source for either written or oral use must be fully acknowledged. All suspected violations of the *Code* will be reported to the Dean of Students and handled according to University policies. Sanctions for academic misconduct may include a failing grade on the assignment, reduction in your final course grade, and a failing grade in the course, among other possibilities. If you are unsure about the expectations for completing an assignment or taking a test or exam, be sure to seek clarification from your instructor in advance. Please also see this website for the IU College of Arts and Science's policies on Academic Integrity.

Plagiarism and Academic Dishonesty: Plagiarism is the act of taking someone else's work and presenting it as your own. Plagiarism can occur in several forms, but whether the action is intentional or not, it is in violation of the IU Student Code of Conduct. Copying and pasting text off of the Internet or any other source is NOT acceptable, as this is stealing someone else's work. If you use an author's materials verbatim, you must place these words in quotation marks, and must correctly reference them. Proper references must be placed in the text as well as in the bibliography. Be aware that when citing sources, you must do so not only when a passage is a direct quotation, but also when paraphrasing. Failure to do so will result in a "0" for the project. If you have questions or concerns regarding how to properly cite your resources, please ask me or contact Campus Writing Services. Additionally, if you are new to this university, are unclear about what plagiarism is, or would like a brief review of IU's standards, please look here and here.

Note Selling: Several commercial services have approached students regarding selling class notes/study guides to their classmates. Selling the instructor's notes/study guides in this course is not permitted. Violations of this policy will be reported to the Dean of Students as academic misconduct (violation of course rules). Sanctions for academic misconduct may include a failing grade on the assignment for which the notes/study guides are being sold, a reduction in your final course grade, or a failing grade in the course, among other possibilities. Additionally, you should know that selling a faculty member's notes/study

guides individually or on behalf of one of these services using IU email, or via Canvas may also constitute a violation of IU information technology and IU intellectual property policies; additional consequences may result.

Students with Disabilities: The Americans with Disabilities Act (ADA), the Indiana Civil Rights Act, and Indiana University policy prohibit discrimination in educational programs against students with disabilities. Disabilities may include medical, auditory, visual, learning, psychological, mobility, or neurological problems. It is the policy of Indiana University to provide reasonable accommodations in a timely manner and on an individualized basis while maintaining institutional standards of performance. These accommodations are designed to counter the effects of disabilities where they may pose a barrier to the education process; they will not give the student an easy grade or an advantage over other students. Every attempt will be made to accommodate qualified 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 into place and are not retroactive; captions and alternate media for print materials may take three or more weeks to get produced. Please contact Disability Services for Students at http://disabilityservices.indiana.edu or 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 AM to 5 PM, Monday through Friday. You can also locate a variety of campus resources for students and visitors that need assistance at: http://www.iu.edu/~ada/index.shtml. See the Office of Disability Services for Students for accommodation and documentation.

Bias reporting: As your instructor, one of my responsibilities is to create a positive learning environment for all students. Bias incidents (events or comments that target an individual or group based on age, color, religion, disability, race, ethnicity, national origin, sex, gender, gender identity, sexual orientation, marital status or veteran status) are not appropriate in our classroom or on campus. What should you do if you witness or experience a bias incident? Report it by submitting a report online (http://biasincident.indiana.edu) or calling the Dean of Students Office (812-855-8187).

Religious Observances: See here from more information on religious accommodation.

Sexual Harassment: As your instructor, one of my responsibilities is to help create a safe learning environment on our campus. Title IX and our own Sexual Misconduct policy prohibit sexual misconduct. If you have experienced sexual misconduct, or know someone who has, the University can help.

If you are seeking help and would like to speak to someone confidentially, you can make an appointment with:

The Sexual Assault Crisis Service (SACS) at 812-855-8900

Counseling and Psychological Services (CAPS) at 812-855-5711. For information about services offered to students by CAPS:
http://healthcenter.indiana.edu/counseling/index.shtml.

Confidential Victim Advocates (CVA) at 812-856-2469 IU Health Center at 812-855-4011.

More information about available resources can be found here:
http://stopsexualviolence.iu.edu/help/index.html.

It is also important that you know that Title IX and University policy require me to share any information brought to my attention about potential sexual misconduct, with the campus Deputy Title IX Coordinator or IU's Title IX
Coordinator. In that event, those individuals will work to ensure that appropriate measures are taken and resources are made available. Protecting student privacy is of utmost concern, and information will only be shared with those that need to know to ensure the University can respond and assist.
I encourage you to visit **stopsexualviolence.iu.edu** to learn more.

Support services for Students

Writing Tutorial Services:
For free help at any phase of the writing process—from brainstorming to polishing the final draft—call Writing Tutorial Services (WTS, pronounced "wits") at 855-6738 for an appointment. When you visit WTS, you'll find a tutor who is a sympathetic and helpful reader of your prose. To be assured of an appointment with the tutor who will know most about your class, please call in advance.

Tutorials are available at the following times and locations. Call 5-6738 for an appointment:

WTS in the Information Commons on the first floor of the Wells Library
Monday-Thursday 10:00 a.m. to 8:00 p.m.
Friday 10:00 a.m. to 5:00 p.m.

Walk-in tutorials are available when WTS has an opening, but the appointment book often fills in advance.

Walk-in tutorials only:

WTS in the Briscoe, Teter, and Willkie Academic Support Centers
Sunday-Thursday 7:00 p.m. to 11:00 p.m.

Knowledge base and UITS support center:
For any technical support, see the Knowledge Base or go to the UITS Support Center website.

Get no-cost access to hundreds of software programs and applications through IUware and IUanyWare. All you need is your IU email address.

Use IUware to install software directly onto your hard drive. Use IUanyWare to stream 400+ apps on your desktop or through the mobile app with your IU login.

Visit iuware.iu.edu and iuanyware.iu.edu, or contact the UITS Support Center to learn more.

Schedule

Please see the following page.

Please note that this tentative syllabus/schedule may change without notice in order to reflect the needs of our classroom. See the course webpage on Canvas for updates.

Week	Date	Topic
1	13-Jan	Introduction to the course and terrestrial ecosystem modeling
1	15-Jan	History of terrestrial ecosystem modeling
2	20-Jan	**Martin Luther King Jr Day – No Class**
2	22-Jan	Main components of TEMs: energy balance
3	27-Jan	Main components of TEMs: hydrology
3	29-Jan	Main components of TEMs: vegetation
4	3-Feb	Main components of TEMs: carbon cycle, nutrients and disturbance
4	5-Feb	Main components of TEMs: agriculture and land management
5	10-Feb	Introduction/planning for Class Project
5	12-Feb	Plan for class project
6	17-Feb	Class project
6	19-Feb	Practical: Building a carbon simple model
7	24-Feb	Class project
7	26-Feb	Practical: Building a carbon simple model
8	2-Mar	Class Project
8	4-Mar	Practical: Simple model – model evaluation
9	9-Mar	Class project
9	11-Mar	Practical: Simple model – sensitivity/uncertainty analysis and DA
10	16-Mar	**Spring Break**
10	18-Mar	**Spring Break**
11	23-Mar	Class project presentations
11	25-Mar	Class project presentations
12	30-Mar	Class project presentations
12	1-Apr	Class project presentations
13	6-Apr	Class project presentations
13	8-Apr	Class project presentations
14	13-Apr	Paper presentation and discussion (remainder of semester)* Topics will include: - Exploring the latest IPCC/CMIP6 model results - Feedbacks to the atmosphere - Model inter-comparison studies - Remaining biases/missing processes - Controversial modeling predictions of which global change drivers are impacting ecosystems, the environment and climate Implementing human activity in TEMs
14	15-Apr	
15	20-Apr	
15	22-Apr	
16	27-Apr	
16	29-Apr	

* *Note: depending on the size of the class and therefore the number of class project presentations, this section of the course may start one or two weeks earlier or later.*