SWS 6813C - Modeling Land Biogeochemistry

Catalogue Description Modeling the flow of water, carbon and nutrients from an Earth system perspective

Term	Spring Semester
Meeting Time	Tuesday Period 4-5 (10:40am – 12:35pm); MCCB 3086 (Computer Lab)
	Thursday Period 4 (10:40am – 11:30 pm); MCCB 3086 (Computer Lab)
Credits	3
Instructor	Stefan Gerber
	3179 McCarty Hall
	Phone: 352-294-3174
	sgerber@ufl.edu
Office hours	Thursday 12:30pm to 2:30 pm or by appointment

Course Prerequisite: A course that addresses ecosystem ecology, quantitative ecology/biogeochemistry and/or theory of carbon water and nutrient flow in a terrestrial system is required at 3000 level or higher (e.g. SWS 4180/5281, SWS 5224, PCB 5358, BSC 3307C, ABE 5643C, etc.) A minimal proficiency of calculus (e.g. MAC 2233: Survey of Calculus 1; PHY 2048 Physics with Calculus 1, or similar), as well as some programming experience in a basic computer language such as C or FORTRAN (e.g. COP3272: Programming using C) is advantageous but not a requirement.

Additional Course Information

Dynamic land models or land surface models are widely used as part of larger Earth system models and serve to represent exchange of energy (heat radiation momentum), water, carbon, and nutrients between land and the atmosphere/ocean system. We will investigate how these land models interact with the atmosphere and help with climate predictions. We further explore how biological processes are formulated mathematically to capture the broad range of plant functioning on a regional to global scale. We will particularly address how such processes are represented and resolved in a model code. We will take a look under the hood of such a model by boldly modifying the source code, thereby get a feel for the development/application cycle. We will then make use of a land surface model to explore effects global environmental change on vegetation and land surface dynamics.

Objectives

By the end of this course, students will be able to

- Describe processes represented in a dynamic global land model
- Apply and evaluate global land models for global change and biogeochemistry research
- Quantify linkages between land carbon cycles, water cycles, and climate
- Assess restrictions and limitations of mechanistic land surface models

Course Format

3 credit course where contact hours are divided into a two hour and one hour period per week. The weights of lecture, computer lab and discussion shift during the semester with focus on lectures initially, and moving towards labs and discussions with the progression of the semester.

Course text
No textbook. Reading assignments will be available on the course website https://elearning.ufl.edu/ in form of scientific papers (see also references below the course schedule). Optional, further reading include the following titles

- Bonan G, Ecological Climatology, 2002, Cambridge University Press
- Climate Change 2013 - The Physical Science Basis Contribution of Working Group I to the Fifth Assessment Report of the IPCC (available online www.ipcc.ch)
- Jacobson M.C. et al., 2000, Earth System Science from Biogeochemical Cycles to Global Change

Course Parts and Schedule
Note that the schedule is approximate, and pace may vary.

Week	Topic	Assignments	Reading
1-2	Introduction / scope of land surface model	- Program "Hello World" - Concept Map "global change on the land surface"	Beedlow et al., 2004 Friedlingstein, 2014
3-4	Flow of carbon in the land surface	- Track carbon in a complex land surface model - Evaluate your carbon cycle model	Sitch et al., 2003 Lenton et al., 2000
5-6	Photosynthesis theory and models	- Derive mathematical formulation of C4 photosynthesis - Modify photosynthesis code using alternate mathematical formulation	Farquhar et al., 1980 Haxeltine and Prentice, 1996
7-8	Canopy carbon, water, and energy balance	- Group Work: modify parameter in Earth System Model to find maximum rate of plant photosynthesis	Leuning, 1995
9-10	Water balance	- Flipped Class: teach the concepts of water flow in a land surface model - Group Work: minimize modeled runoff globally	Gerten et al., 2004
11-12	Soil organic matter	- Discuss residence times of carbon in terrestrial systems - Group Work: minimize data-model mismatch in soil organic carbon	Parton et al., 2007 Lloyd and Taylor, 1994
13-14	Plant Traits and Functional Types / Fire	- Group Work: engineer a hyper successful plant	Fisher et al, 2018 Thonicke et al, 2001
15-16	Final Project	- Final oral presentation - Final paper	

Full reference of reading (papers)

Beedlow, P. A., D. T. Tingey, D. L. Phillips, W. E. Hogsett, and D. M. Olszyk. 2004. Rising atmospheric CO2 and carbon sequestration in forests. Frontiers in Ecology and the Environment 2:315–322.
Farquhar, G. D., S. Caemmerer, and J. A. Berry. 1980. A biochemical model of photosynthetic CO2 assimilation in leaves of C3 species. Planta 149:78–90.
Fisher, R. A., C. D. Koven, W. R. L. Anderegg, B. O. Christoffersen, M. C. Dietze, C. E. Farrior, J. A. Holm, et al. 2018. Vegetation demographics in Earth System Models: A review of progress and priorities. Global Change Biology 24:35–54.
Friedlingstein, P., M. Meinshausen, V. K. Arora, C. D. Jones, A. Anav, S. K. Liddicoat, and R. Knutti. 2013. Uncertainties in CMIP5 Climate Projections due to Carbon Cycle Feedbacks. Journal of Climate 27:511–526.
Gerten, D., S. Schaphoff, U. Haberlandt, W. Lucht, and S. Sitch. 2004. Terrestrial vegetation and water balance—hydrological evaluation of a dynamic global vegetation model. Journal of Hydrology 286:249–270.
Haxeltine, A., and I. C. Prentice. 1996. A general model for the light-use efficiency of primary production. Functional Ecology 10:551–561.
Lenton, T. M. 2000. Land and ocean carbon cycle feedback effects on global warming in a simple Earth system model. Tellus B 52:1159–1188.
Leuning, R. 1995. A critical appraisal of a combined stomatal-photosynthesis model for C3 plants. Plant, Cell and Environment 18:339–355.
Lloyd, J., and J. A. Taylor. 1994. On the temperature dependence of soil respiration. Functional Ecology 8:315–323.
Parton, W., W. L. Silver, I. C. Burke, L. Grassens, M. E. Harmon, W. S. Currie, J. Y. King, et al. 2007. Global-scale similarities in nitrogen release patterns during long-term decomposition. Science 315:361–364.
Sitch, S., B. Smith, I. C. Prentice, A. Arneth, A. Bondeau, W. Cramer, J. O. Kaplan, et al. 2003. Evaluation of ecosystem dynamics, plant geography and terrestrial carbon cycling in the LPJ dynamic global vegetation model. Global Change Biology 9:161–185.
Thonicke, K., S. Venevsky, S. Sitch, and W. Cramer. 2001. The role of fire disturbance for global vegetation dynamics: coupling fire into a Dynamic Global Vegetation Model. Global Ecology & Biogeography 10:661–677.

Course Assessment and Grading

Student learning is assessed based on individual assignments, group work and an individual final project.

Individual assignments: Throughout the semester, students will work on individual homework assignments that range from preparation for discussion to synthesizing the materials taught, with typically one assignment due each week, counting 35 % towards the final grade. See also course schedule "Assignment".

Group Projects: In these projects students will explore model features in more detail. Throughout the course (see course schedule), groups will receive a total of four challenges, in which they are asked to modify model parts to behave in a specific way. This includes 1) maximizing rates of primary productivity at a selected site, 2) minimizing runoff at a global scale, 3) bring soil organic carbon as close as possible in agreement with data, and 4) groups will compete against each other with their design of a plant functional type. Grading will focus less on specific results, rather the student's work will be evaluated based on critical examination of the task and the understanding and use of the full breadth of modeling options. Active participation and willingness to experiment is a must. The four challenges together count 35 % towards the final grade.

The final project broadly entails work with a land surface model and students choose a topic of their own. This may include model tests (for example sensitivity analysis, comparison against a specific data set), scenarios (for example climate change), model improvements and/or further model development (refining a process, or addition of new processes). The final project can (not necessarily required) be tailored to the student's graduate degree topic. The result of the final project will be communicated through a detailed written report, and a broader oral presentation which are both graded, each counting 15 % towards the final grade.

Assignments turned in late results in a loss of half of the maximum points, unless late turn-in is caused by excused absences.

Letter Grade	Sum of % Points (p)
A	≥95
A-	90 ≤ p < 95
B+	85 ≤ p <90
B	80 ≤ p < 85
B-	75 ≤ p < 80
C+	70 ≤ p < 75
C	65 ≤ p < 70
C-	60 ≤ p < 65
D+	55 ≤ p < 60
D	50 ≤ p < 55
D-	45 ≤ p < 50
E	< 45

Course	Maximum % Points
Individual Assignments	35
Group Work	35
Final Project/Report	15
Final Oral Presentation	15

For information on current UF policies for assigning grade points, see **https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx**

Attendance and Make-Up Work

Requirements for class attendance and make-up exams, assignments and other work are consistent with university policies that can be found at: **https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx**.

Online Course Evaluation Process

Student assessment of instruction is an important part of efforts to improve teaching and learning. At the end of the semester, students are expected to provide feedback on the quality of instruction in this course using a standard set of university and college criteria. These evaluations are conducted online at **https://evaluations.ufl.edu**. Evaluations are typically open for students to complete during the last two or three weeks of the semester; students will be notified of the specific times when they are open. Summary results of these assessments are available to students at **https://evaluations.ufl.edu/results**.

Academic Honesty

As a student at the University of Florida, you have committed yourself to uphold the Honor Code, which includes the following pledge: "*We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honesty and integrity."* You are expected to exhibit behavior consistent with this commitment to the UF academic community, and on all work submitted for credit at the University of Florida, the following pledge is either required or implied: *"On my honor, I have neither given nor received unauthorized aid in doing this assignment*."

It is assumed that you will complete all work independently in each course unless the instructor provides explicit permission for you to collaborate on course tasks (e.g. assignments, papers, quizzes, exams). Furthermore, as part of your obligation to uphold the Honor Code, you should report any condition that facilitates academic misconduct to appropriate personnel. It is your individual responsibility to know and comply with all university policies and procedures regarding academic integrity and the Student Honor Code. Violations of the Honor Code at the University of Florida will not be tolerated. Violations will be reported to the Dean of Students Office for consideration of disciplinary action. For more information regarding the Student Honor Code, please see: **http://www.dso.ufl.edu/sccr/process/student-conduct-honor-code**.

Software Use

All faculty, staff and students of the university are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against university policies and rules, disciplinary action will be taken as appropriate.

Services for Students with Disabilities

The Disability Resource Center coordinates the needed accommodations of students with disabilities. This includes registering disabilities, recommending academic accommodations within the classroom, accessing special adaptive computer equipment, providing interpretation services and mediating faculty-student disability related issues. Students requesting classroom accommodation must first register with the Dean of Students Office. The Dean of Students Office will provide documentation to the student who must then provide this documentation to the Instructor when requesting accommodation

0001 Reid Hall, 352-392-8565, **www.dso.ufl.edu/drc/**

Campus Helping Resources

Students experiencing crises or personal problems that interfere with their general well-being are encouraged to utilize the university's counseling resources. The Counseling & Wellness Center provides confidential counseling services at no cost for currently enrolled students. Resources are available on campus for students having personal problems or lacking clear career or academic goals, which interfere with their academic performance.

- *University Counseling & Wellness Center, 3190 Radio Road, 352-392-1575,* **www.counseling.ufl.edu**

    Counseling Services

    Groups and Workshops

    Outreach and Consultation

    Self-Help Library

    Wellness Coaching

- U Matter We Care, **www.umatter.ufl.edu/**

- *Career Connections Center,* First Floor JWRU, 392-1601, **https://career.ufl.edu/**.

Student Complaints:

- Residential Course: **https://sccr.dso.ufl.edu/**
- Online Course: **http://www.distance.ufl.edu/student-complaint-process**