Syllabus
Numerical methods and modeling - ATOC 4500/7500-002, Spring 2018
Current as of : 03/05/18

General Information

- Instructor: Prof. Alexandra Jahn
- Office location: SEEC N151A
- Phone: 303-735-3352
- E-mail: Alexandra.jahn@colorado.edu.
- Class Meeting Times and Location: Tuesday and Thursday, 2:00 pm-3:15 pm in HUMN 1B35
- Office hours: Tuesdays and Thursdays, 3:15pm to 4pm in the classroom, and by appointment.
- Class website: On Canvas

Course learning goal: You will learn how to convert physical descriptions of the earth system into numerical weather and climate models. This will involve learning how to make assumptions to simplify complex systems, how to discretize and code mathematical equations so they can be solved on a computer, and how to assess if the result and approximations are reasonable.

Course Outcomes and topics
By the end of the course, students will be able to:
1. **Translate scientific concepts into a numerical model**
    a. Identify a question
    b. Define a system, its components and how they are connected, and its boundaries
    c. Use appropriate assumptions to simplify a complex problem
    d. Pose the simplified problem in mathematical terms so it can be solved on a computer
2. **Create a numerical climate model for a scientific problem**
    a. Code up mathematical description of problem in python
    b. Define boundary conditions
    c. Perform parameter estimation
    d. Run model (debug as needed before)
    e. Comparison of results with observations/back of envelope estimates
    f. Refine model (back to 1c or later) → Recognize the iterative nature of model development
3. **Use a simple model (existing or constructed) to address a research question**
    a. Quantify Results
    b. Assess model sensitivity
    c. Assess if assumptions are reasonable

Some of the topics we'll cover (subject to change based on progress)
- Basics of Climate Science
- Overview of Weather and Climate Models
- Jupyter Notbooks
- Python3
- Scientific Python
- Basic Numerical Methods (Taylor Series, centered difference, Newtons Method)
- Time discretization (Euler Fwd, Euler Back, Leapfrog, Runge-Kutta, Consistency, Stability, Order of Accuracy)
- Numerical Solution of ODEs and PDEs
    - Initial Value Problems (Chaos)
    - Energy Balance Models
    - Radiative Transfer Models
    - Multi-layer Energy Balance models
    - Tracer transport (Diffusion and Advection)
- Simple models of the climate system (single column and latitudinal varying)
- Missing processes in simple versus full scale climate models

Teaching Approach: This will be an interactive class, using active learning techniques, aspects of a flipped class, and lots of hands-on programming. Regular attendance and participation is required.

Grading: Your grade in this class will be calculated based on the formula below:

<u>Total Grade:</u> 100%= Homework (30%), in class Quizzes, Clicker answers, class participation, and in-class assignments (20%), Midterm exam (25%), Final Project (25%).

The standard CU grading scheme will be used to convert % into letter grades for the final grade. No rounding or last minute extra credit projects, so please plan ahead for the grade you want in this class. I'm always happy to help if you ask and can tell you how you are doing.

There will be additional assignments and exam questions for graduate students taking ATOC7500-002 and/or the grading of assignments and exams /projects will be according to a different grading scale than for students taking this class as ATOC4500-002.

Homework: Homework and in-class assignments will require you to solve problem sets related to the class content, often by programming something and reflecting on the results. Some collaboration on the Homework and in-class assignments is encouraged and/or required. However, unless explicitly stated otherwise, **you are expected to ultimately submit your own work and your own thoughts**, and to give proper credit to others for previous work and ideas. This means, **you need to be able to explain each answer and each line of code if asked about it and cite your sources.** If it is found that you submitted Homework copied from someone/somewhere else or written by someone else, this represents an Honor code violation and will be reported as such. Giving credit to who wrote the code/answers will avoid the Honor code violation but will result in a 0 for that

assignment, as you are asked to submit your own work. So please just don't do that and submit your own work, and get help from me or classmates if you get stuck. That requires to start early on the assignments, as last-minute help is hard to get. No late homework will be accepted. Homework and in-class assignments need to be submitted to the google-drive uploader for this class, with your name in the file name: https://driveuploader.com/upload/2ij8n4zgrU/

Textbook: Reading for this class is posted on Canvas. No textbook is required.

Exams and Quizzes: There will one midterm, on **March 8th**. Short in-class quizzes may occur unannounced throughout the semester to check on understanding. There will be no final exam. There will be no make-up exam for the midterm, only the option to take an oral exam with me if you have a documented emergency. No make-up quizzes or make-ups in-class assignments. The lowest two in class assignment scores will automatically be dropped to account for two missed classes (or a bad day).

Final project: There will be a final class project at the end of the semester, carried out in small groups, which will require a class presentation and coding. Details to be announced in class.

Clickers: Clickers are required for this class, and you need to register your clicker. I require them to encourage participation from everyone, to allow you to gauge your understanding so you don't have to wait until the midterm to notice you don't understand something, and for me to get feedback. There are no make-ups for missed clicker participation due to forgotten/malfunctioning clickers or missed classes. The two lowest class clicker grades will automatically be dropped to account for these incidences. Clickers start to count from class 2 onward.

Google drive: You will need a google drive account for this class to store your code/assignments. You have access to a google drive account through CU, using your identikey. See https://www.colorado.edu/composition/set-google-account.

Webpage: The class website is on Canvas. I will also post material on google drive, including lecture slides (after class), in a folder I will share with everyone next week. The class web site contains a copy of the course syllabus, announcements, homework assignments, additional reading assignments, and grades for the class. Instead of emailing me questions about class content, policies, or homework, please post them in the discussion forum, so everyone can benefit from the answer. If you know the answer to another students question, please answer it, it will count towards your class participation grade!

Conduct: Respect your fellow students at all times. The University of Colorado Boulder (CU Boulder) is committed to maintaining a positive learning environment. CU values diversity in all its forms. Anything that creates an environment that is hostile is considered unwanted behavior in this class and at CU in general. Intent is not required for a comment

or action to be inappropriate, insulting, or amount to harassment or discrimination. So, comments, jokes, stereotypes and generalizations involving a protected class should be avoided completely at CU to ensure a positive learning environment for everyone. Please turn your cell phones to silent during class. If you have to take an important call or respond to an important text message immediately, please leave the class to take care of that. Computer use using the class is limited to the class activities. Please no e-mail, Facebook, or surfing unrelated to the course. After one warning, you will be asked to leave class for the day for such behavior.

University wide policies:
Honor Code
All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the academic integrity policy. Violations of the policy may include: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, resubmission, and aiding academic dishonesty. All incidents of academic misconduct will be reported to the Honor Code Council (honor@colorado.edu; 303-735-2273). Students who are found responsible for violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code Council as well as academic sanctions from the faculty member. Additional information regarding the academic integrity policy can be found at the Honor Code Office website.

Classroom Behavior Policy
Students and faculty each have responsibility for maintaining an appropriate learning environment. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. Class rosters are provided to the instructor with the student's legal name. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records. For more information, see the policies on classroom behavior and the Student Code of Conduct.

Students with Disabilities
If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the Disability Services website (www.colorado.edu/disabilityservices/students). Contact Disability Services at 303-492-8671 or dsinfo@colorado.edu for further assistance. If you have a temporary medical condition or injury, see Temporary Medical Conditions under the Students tab on the Disability Services website and discuss your needs with your professor.

University of Colorado Policy on Discrimination and Sexual Harassment

The University of Colorado Boulder (CU Boulder) is committed to maintaining a positive learning, working, and living environment. CU Boulder will not tolerate acts of sexual misconduct, discrimination, harassment or related retaliation against or by any employee or student. CU's Sexual Misconduct Policy prohibits sexual assault, sexual exploitation, sexual harassment, intimate partner abuse (dating or domestic violence), stalking or related retaliation. CU Boulder's Discrimination and Harassment Policy prohibits discrimination, harassment or related retaliation based on race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. Individuals who believe they have been subject to misconduct under either policy should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127. Information about the OIEC, the above referenced policies, and the campus resources available to assist individuals regarding sexual misconduct, discrimination, harassment or related retaliation can be found at the OIEC website.

Religious Observances
Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, please contact me **in the first two weeks of the semester** if you have a conflict with any scheduled exams or assignments due to religious observances. See the campus policy regarding religious observances for full details.