Atm Sci 250: Introduction to Climate Science
Lecture: MW 10-11:15a, Physics Bldg 146
Lab: M 2:30-4:20p, EMS W434
Spring 2023

Instructor:	Prof. Sergey Kravtsov
Contact:	kravtsov@uwm.edu, (414) 477-3306, GLRF 3003E/EMS W441
Office Hours:	MW 1:00-2:30p or by appointment. Feel free to stop by at any time to ask a question or set up an appointment.
Prerequisites:	Physics 209 & 214 (prerequisite), Comp Sci 202 (prerequisite), and Math 232 (corequisite), or instructor's consent
Course Website:	On Canvas (https://uwm.edu/canvas/)
Required Text:	Eli Tziperman, 2022: *Global Warming Science: A quantitative introduction to climate change and its consequences.* Princeton University Press, ISBN: 9780691228808, 336pp. https://press.princeton.edu/books/ebook/9780691228815/global-warming-science
Supplementary Reading:	Andreas Schmittner, 2018: *Introduction to Climate Science*. Open access at https://open.oregonstate.education/climatechange/

Course Description and Learning Outcomes

Fundamentals of climate system's inner workings and analysis methods. Climate subsystems and feedbacks, energy balance of the Earth, climates of the past, global warming, internal variability and predictability of climate, dynamical climate models, statistical approaches.

Upon the completion of this course, you will be able to:

- Explain the basic concepts behind our understanding of climate, climate variability and change, as well as climate predictability.
- Outline modern methods of climate analysis and discuss their advantages, limitations, and complementarity.
- Apply the programming skills developed during the course of study to analyze and model climatic maps and time series.

Grading

The final course grade will be based on your performance in the following (two grading schemes are offered, the scheme with the maximum grade will be used to compute the student's final grade):

54% or 36%	**Lab (workshop) assignments** (nine assignments, each worth 6% or 4%)
32% or 48%	**Writing assignments** (eight assignments, each worth 4% or 6%)
14% or 16%	**Final essay** (a focused compilation based on your writing assignments)

Grades will be assigned based on the following scale:

A	92.5-100%	**A-**	90-92.49%	**B+**	87.5-89.99%	**B**	82.5-87.49%
B-	80-82.49%	**C+**	77.5-79.99%	**C**	72.5-77.49%	**C-**	70-72.49%
D+	67.5-69.99%	**D**	62.5-67.49%	**D-**	60-62.49%	**F**	0-59.99%

Course structure and assignments

The course is largely based on and parallels an analogous Global Warming Science 101 course at the Harvard University. The course materials, including the module slides and lab (workshop) assignments, will be distributed through Canvas at UWM; they are similar, but not identical to their versions at https://courses.seas.harvard.edu/climate/eli/Courses/EPS101/. The course has eight (approximately biweekly) modules (see the schedule below) consisting of the lectures that closely follow select chapters of the course's textbook, which are the required reading for each module, as well as the lab (workshop) component.

Lab (workshop) assignments are built around process modeling and elementary visual and statistical analysis of climatic maps and time series. The labs are to be coded in Python; you will be provided with the template code and instructions in easy-to-use Jupyter Notebooks that you can access from anywhere on our JupyterHub. You are required to attend all of the scheduled lab sessions (see the course outline below): attendance will amount to 10% of the total lab grade; see the Lab Syllabus for further details. *The labs are due at 11:59p on the day before the next lab.* **You must pass the lab portion of the class with a grade of 60% or higher in order to pass the course! NO exceptions.**

A total of eight (naturally, biweekly) two-page (12-pt, double spaced, 1" margin) **writing assignments** ask you to summarize and reflect on each module's content, based on the material covered in class, the assigned reading, lab (workshop) results, **guiding questions** (provided at the end of each module) and your own research. Your target audience: the President's science adviser, a scientist but not a climate scientist. You are to introduce the issue and motivation, discuss the phenomenology based on observational/modeling results thus far, the climate-change ("worst-case") scenarios, strength/weaknesses/uncertainty of observational analyses and/or modeling approaches, the mechanisms/feedbacks that take place or are expected to take place, so that the adviser can understand the reason for the observed/expected climate behavior. All technical terms used need to be defined first, excluding basic statistical terminology. The essay is to conclude with a brief reasoned statement of the position the student recommends the advisor takes in public presentation of this issue. You are encouraged to think broadly, not necessarily restricting yourselves to the guiding questions. The summaries should be in a short essay format with appropriate sentence and paragraph structure; they should be professional, rather than social, in nature. I will provide feedback to you with each graded essay on both writing structure and content. *The essays are due by 11:59p on Monday of the week following the completion of each course module.*

The **final essay** (3–5 double spaced, 12pt-font, 1”-margin pages) can be largely a compilation of your writing assignments completed throughout the semester (augmented by the complementary in-class material) that is focused on one of a few suggested overarching topics listed below. You are encouraged to pick a topic early in the semester so that the focus of your writing assignments during the semester could be geared towards their final essay. *The final essay is due on May 15, 11:59p.*

Final essay suggested topics

- Why is climate changing?
- Why are climate predictions uncertain?
- Why do we need a hierarchy of models and statistical approaches to study climate?
- Is recent global warming human induced? How do we know?
- Are we to expect a climate catastrophe in the future?
- Pick a topic yourself (consultation with and approval by the instructor required).

Tentative Course Outline

WEEK #	WEEK OF (Mon)	TOPIC	ASSIGNED READING/ WRITING	LAB/WORKSHOP
		Introduction		
1	Jan 23	- Course overview - Weather and climate - Climate subsystems and their intrinsic time scales, climate models - Forced, internal and coupled variability - Predictability of the first and second kind, uncertainty	Ch. 1 (no writing assignment)	Lab 1: Introduction to Jupyter notebooks, Python programming, basic math review
		Module 1: Greenhouse		
2–3	Jan 30	- Earth's energy balance - The greenhouse effect in a two-layer climate model - The emission height and lapse rate	Ch. 2	Lab 2
	Feb 6	- Wavelength-dependent black-body radiation - Energy levels and absorption - Broadening - Radiative forcing, logarithmic dependence on CO_2 - Other greenhouse gases, global warming potential - The water vapor feedback	Essay 1	
		Module 2: Temperature		
4–5	Feb 13	- Climate sensitivity and the role of the ocean • Equilibrium climate sensitivity • Transient climate response - Polar amplification and the associated feedbacks	Ch. 3	Lab 3
	Feb 20	- "Hiatus" periods - Decadal and longer internal climate variability (AMO, PDO) - Stratospheric cooling	Essay 2	
		Module 3: Sea level		
6–7	Feb 27	- Global-mean sea-level changes • Thermal expansion • Ice sheets and mountain glaciers • Land water storage	Ch. 4	Lab 4
	Mar 6	- Regional sea-level changes • Atmosphere–ocean interaction • Land changes • Gravitational effects	Essay 3	

Module 4: Ocean Circulation

8–10	Mar 13	- Wind-driven and thermohaline circulation - Atlantic Meridional overturning circulation (AMOC) - AMOC observations and projections	Ch. 6	Lab 5
	Mar 20	NO CLASS (Spring Break)		
	Mar 27	- The Stommel box model of AMOC - Multiple equilibria, tipping points, hysteresis - Consequences of AMOC collapse - Decadal and multidecadal internal climate dynamics	Essay 4	

Module 5: Clouds

11–12	Apr 3	- Cloud fundamentals - Moist convection and cloud formation	Ch. 7	Lab 6
	Apr 10	- Cloud microphysics - Cloud feedbacks and climate uncertainty	Essay 5	

Module 6: Hurricanes

13	Apr 17	- Tropical climate and El Niño/Southern Oscillation (ENSO) - Factors affecting hurricane magnitude - Potential intensity - Observed changes to hurricane activity	Ch. 8 Essay 6	Lab 7

Module 7: Droughts and precipitation

14–15	Apr 24	- Relevant processes and terms - Why droughts happen, climate teleconnections, the Indian Ocean Dipole - Detecting change: Observations, paleo proxy data	Ch. 12	Lab 8
	May 1	- Example projections: Southwest US and the Sahel - Understanding precipitation trends: Hadley cell expansion and weakening, “Wet getting wetter, dry getting drier” projections, precipitation extremes - A bucket model for soil moisture	Essay 7	

Module 8: Heat waves

16	May 8	- Physical processes - Heat stress - Future projections	Ch. 13 Essay 8	Lab 9

Course Credit Hour Statement

To comply with a Higher Learning Commission requirement, this course syllabus provides information on the investment of time by an average student to achieve the learning goals of the course. The amount of time that an average student should expect to spend on this class is given below:

- 37 hours in the classroom (face to face instruction, lectures)
- 28 hours in the classroom (face to face instruction, labs/workshops)
- 27 hours for completing the labs
- 46 hours for weekly readings
- 46 hours for writing assignments
- 8 hours for writing the final essay

The total number of hours: 192.

Departmental Regulations

Any room changes and/or course cancellations will be posted on departmental letterhead only.

University Regulations

University-Wide Rights and Regulations

The University of Wisconsin-Milwaukee has established a series of policies relating to student rights and regulations in this and all UWM-offered courses. You are encouraged to read through these policies at https://uwm.edu/secu/syllabus-links/ at your earliest convenience. Please notify me if you need special accommodations to meet any course requirements.

Statement of Academic Misconduct

The university has a responsibility to promote academic honesty and integrity and to develop procedures to deal effectively with instances of academic dishonestly. Students are responsible for the honest completion and representation of their work, for the appropriate citation of sources, and for respect of others' academic endeavors. Further information can be found at:

https://uwm.edu/academicaffairs/facultystaff/policies/academic-misconduct/

Statement of Discriminatory Conduct and Sexual Violence

Discriminatory conduct and sexual violence are reprehensible and will not be tolerated by the University. They subvert the University's mission and threaten the careers, educational experience, and well-being of students, faculty and staff. The University will not tolerate behavior between or among members of the University community that creates an unacceptable working environment. The policies on discriminatory conduct and sexual violence, including sexual harassment, can be found at:

https://uwm.edu/equity-diversity-services/policies/discriminatory-conduct-policy/