Syllabus: CLIM102

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Course: CLIM102 *Introduction to Climate Change Science*

4 credit hours (3 hours lecture plus computer-based lab)

Prerequisites:

This course requires basic math skills (algebra, pre-calculus math or specified score on math placement test) and high school physics.
Other than use of spreadsheets, no computer programming is required.

Required Texts

Mann, Michael E. and Lee R. Krump 2016: *Dire Predictions: Understanding Climate Change*, 2nd Ed. Dorling Kindersley ISBN 978-1-4654-3364-0

Archer, David 2012: *Global Warming: Understanding the Forecast,* 2nd Ed., Wiley ISBN 978-0-470-94341-0

Course Description:

Why study climate science?

Climate science is the study of the Earth's atmosphere, oceans, ice and the physical processes that make Earth a habitable planet that sustains life. From this basis, scientists have combined observation with theory to understand the important effects of greenhouse gasses in regulating the climate. Scientists now know that the greenhouse gasses that have already been added to the atmosphere will cause significant changes in our climate for centuries to come, but that the effects of these changes can be just barely seen in observations made to date. Through the use of computer models, scientists attempt to forecast what the future climate might look like, and what kinds of changes are in store. This class looks at the basic science behind these models - We examine the basis for the models and their limitations, and how scientists cope with the uncertainties associated with the forecasts they make. Along the way in the lab, we will develop a sense of how computer simulation fits within the classic scientific method involving observation, theory and experimentation.

Class Format:

The class will involve class lectures, graded Blackboard discussion boards, pre-class reading assignments with quizzes, and in-class discussions. The material in the lecture sections will be coordinated with the lab. Laptops or tablet computers will be necessary in class.

Class Value:

Climate change is one of the major issues for this generation. Personal and social decisions and actions will influence the evolution of our planet as well be influenced by the changes likely to occur. This course should prepare you to better understand the science behind projections of climate change and the types of uncertainty associated with these statements.

Where the course fits:

This course is intended for students pursuing a course of study where climate variability and change may have a major impact and where knowledge of the scientific basis of climate change prediction would be valuable. For career paths in policy, social and/or political science, economics, environmental science, conservation, ecology, business, engineering, and many others, a knowledge of the strengths, methods and limits of climate models will serve you well. This course has become the first course for undergraduates taking the BS in Atmospheric Sciences degree.

Organization:

The course starts from the basic laws that govern the temperature of a bare planet orbiting a star then builds on that, adding elements that alter this basic balance - an atmosphere that acts like a greenhouse, different gasses in the atmosphere that change the heat balance, an atmosphere that moves and has weather and clouds. How do oceans, ice sheets and volcanoes alter this situation?

Next, we examine how we might evaluate our models - are they any good? Computer models are now used to design cars, jets and many other industrial goods, but these models can be thoroughly tested: verifying that the results in a wind tunnel agree with those of the computer model. On Earth, we don't have the ability to run tests! First, we turn to simulations of the past - can we simulate the ice ages, the climate before the industrial age, the 20th century? Next, we look at our skill predicting the weather - if we can predict the weather, why not just keep going and predict the next year, the next decade, the next century? We then consider chaos, and how 10 identical models started with tiny differences produce different results, and what that tells us about the system and about the models.

From the question of evaluating our models, we come across several sources of uncertainty: the chaos of weather, model errors and model omissions. We will look at these, particularly the trend toward including more and more processes into what are now becoming known as "Earth System Models" - models that include biology and ecosystems, chemistry, land use changes, and see whether becoming more complete means becoming more accurate.

Course Goals and Objectives:

The main learning objectives for this course are

1. To learn why climate scientists are so completely convinced that adding more greenhouse gasses to the atmosphere will cause the Earth's surface to be warmer than it would otherwise be.
2. To understand that climate is best thought of as "the statistics of weather" and that climate change means changes in the normal patterns of weather - warming here, cooling there; more extreme events such as droughts, severe storms, floods. This will enable you to think about how global warming might affect you or people around the world.

While the overall goal of this course is to give an overview of how climate forecasting is done and its basis in the natural sciences, along the way we will

- Provide an appreciation for the history of scientific thought, especially as influenced by modern computational advances;
- Explore the nature of the scientific method of observation, theory and experiment as applied to problems of prediction;
- Introduce the student to the methods of modern climate modeling - how models are constructed, tested, verified and used;
- Give an appreciation for the sources of confidence and uncertainty associated with climate model predictions;
- Provide a basis for continued learning and understanding climate science or the application of climate modeling results in a field such as policy, economics, social science or other natural sciences..

Mason Core Learning Objectives:

This course covers all 5 of the Mason Core Natural Science learning goals:

1. Understand how scientific inquiry is based on investigation of evidence from the natural world and how scientific knowledge and understanding evolves based on new evidence and differs from personal and cultural beliefs.

We cover the role of observation and theory in guiding the formation of models and how the models are tested against those observations. We study the role of additional paleo and historical data and how models are re-evaluated and tested against new evidence.

2. Recognize the scope and limits of science.

We distinguish between the science of climate and the applied science of actually making forecasts, the difference between empirically verified forecasts and experimentally verified theory.

3. Recognize and articulate the relationship between the natural sciences and the application of science to societal challenge.

Global warming is one of the leading drivers of societal change, we explore the role of science in attempting to forecast the climate, and how those forecasts interact with social change. We look at what the models imply for adaptation and mitigation strategies, and we look at how social sciences and economics might draw information from climate models.

4. Evaluate scientific information (e.g. distinguish between primary and secondary sources, assess credibility and validity of information)

We spend a significant amount of time on assessing the credibility of climate and Earth system models.

5. Participate in scientific inquiry and communicate the elements of the process

The lab sessions are designed to guide students through model simulations that require careful and systematic experiments. Some sessions are designed to allow students to formulate their own experiments, for which they will need to develop and test hypotheses, analyze the evidence and interpret what they achieve.

Tentative Schedule of classes:

The first part of the course will develop the scientific basis for global warming theory, and will focus primarily on Archer's text. The second part will rely on the Mann and Krump text to explore consequences, impacts, adaptation and mitigation.

Semester Schedule – Fall 2015

Week	Unit	Monday	Wednesday	Lab
1	Introduction	Welcome and Introduction. Course outline and procedures. Introduction to the IPCC and UNFCCC	Energy. How do we move it about? What is heat and temperature? What is the Earth's energy balance.	Introduction to Lab, spreadsheets and graphing
2	Energy and Radiation	Longwave and shortwave radiation. It's the stuff it encounters that is different.	The spectrum - looking down from space.	Writing Lab reports
3	Greenhouses?	How does a greenhouse work?	Pianos, kitchen sinks, etc. Why is a greenhouse gas a greenhouse gas?	How a greenhouse works
4	Greenhouse Gasses and how they work	How do GHGs work? the lapse rate	The skin temperature argument.	Modeling Greenhouse Gas Response
5	Feedbacks	Water vapor, snow and ice, vegetation,	Clouds - a big uncertainty	Radiation III - gasses and clouds
6	Weather and Climate	Climate causes weather?	Mid-term exam	Lapse Rate, Skin Temperature and Convection
7	Is this new?	Records from the near and distant past	Human vs natural causes	The Spherical Earth
8	Carbon Cycle	CO2 in and out of the atmosphere	Modeling climate	Feedbacks
9	Climate Change Projections	Climate sensitivity	Fossil fuel emissions scenarios	The Carbon Cycle
10	What do we really think will happen?	Patterns of heat, precipitation, and more	Tipping points and feedbacks	Predicting Energy Use
11	Climate Change Impacts	Costs of a warming world. Sea level rise.	Ecosystems, biodiversity, extinctions	The Perturbed Carbon Cycle
12	Climate Change Impacts	Droughts and floods, air pollution and wildfire.	Migration, conflict, famine and disease	
13	Vulnerability and Adaptation	No class	No class	Modeling Climate Change
14	Mitigation strategies	Stopping global warming - how?	Sources of GHGs	Terrestrial Vegetation
15	Mitigation strategies	Update from Paris	Update from Paris	
16			Final Report Due	

Course Structure and Grading Criteria:

The course grade will be based on homework (20%), discussion boards and classroom participation (20%), mid-term exam (20%), laboratory work (20%) and final (20%). Participation in discussions and classroom is required, and graded based on a demonstration that you understand the concepts and are contributing to the discussion.

The computer lab will meet for 3 hours. Each lab will cover a chapter from *Global Warming: Understanding the Forecast,* with online problems taken from the end of each chapter. You are expected to come to lab having read the week's chapter and being ready with questions about the concepts.
The lab has its own Blackboard course, which will contain supplemental materials, lecture notes, and problem sets.

Accommodations for Disabilities

If you have a documented learning disability or other condition that may affect academic performance you should: 1) contact the Office for Disability Services (SUB I, Rm. 4205; 993-2474; http://ods.gmu.edu) to determine the accommodations you need; and 2) talk with me to discuss your accommodation needs.

In addition to providing your professor with the appropriate form, please take the initiative to discuss accommodation with me at the beginning of the semester and as needed during the term. Because of the range of learning differences, faculty members need to learn from you the most effective ways to assist you. If you have contacted the Center for Disability Services and are waiting to hear from a counselor, please tell me.

Academic Integrity

GMU is an Honor Code university; please see the Office for Academic Integrity for a full description of the code and the honor committee process. The principle of academic integrity is taken very seriously and violations are treated gravely. What does academic integrity mean in this course? Essentially this: when you are responsible for a task, you will perform that task. When you rely on someone else' s work in an aspect of the performance of that task, you will give full credit in the proper, accepted form. Another aspect of academic integrity is the free play of ideas. Vigorous discussion and debate are encouraged in this course, with the firm expectation that all aspects of the class will be conducted with civility and respect for differing ideas, perspectives, and traditions. When in doubt (of any kind) please ask for guidance and clarification.

More information: http://www.gmu.edu/departments/unilife/pages/honorcode.html

Privacy

Students must use their MasonLIVE email account to receive important University information, including messages related to this class. See http://masonlive.gmu.edu for more information.

Cell Phones & Laptop Computers

Laptops or tablet computers are required for participation in class projects.
Cellphones must be turned off or on vibrate. Please do not take calls or text in the lectures.

Useful Campus Resources:

University Catalog: http://catalog.gmu.edu/
University Policies: http://universitypolicy.gmu.edu/

University Writing Center	Offers both in-person and online writing assistance for students, including online writing guides, reference guides, and style manuals. Additionally, the Writing Center provides assistance to faculty who are interested in holding in-class writing workshops, developing effective writing assignments, or evaluating students' writing.
Counseling and Psychological Services	Offers faculty and staff consultation about how to help students that experience difficulties that impact their learning, including how to respond to students in crisis. In particular, the Mason Cares, faculty referral guide, and students of concern are primary resources for faculty and staff. Students can take advantage of psychological services, a variety of learning services, multicultural services, and educational programs that support students' educational goals.
Academic Advising and Transfer Center	Advises students who are thinking about changing majors or who need assistance with their transition to Mason from another institution.
English Language Institute	Holds workshops for students whose first language is not English.

Learning Services	Learning Services provides a variety of experience based learning opportunities through which students explore a wide range of academic concerns, including those listed below. Presentations on a variety of academic skill topics are available to the university community. The programs are open to all George Mason University students free of charge. Services are confidential and use of these services does not become part of the student's academic record. • The Academic Counseling Program provides individual support to students with learning differences such as attention deficit disorder or learning disabilities. • Academic Skills Workshops and individual study skills counseling provide learning experiences to improve academic skills. • The Certificate in Academic Skills Program provides a structured, yet individualized program of study to develop academic skills. • The Tutor Referral Program maintains a roster of undergraduate and graduate students available to provide fee-for-service tutoring assistance. Learning Services staff are available to consult with faculty and staff regarding student learning needs.
Office of Diversity, Inclusion and Multicultural Education (ODIME)	Serves students, cultural organizations, and the Mason community by promoting an environment that fosters and values human understanding and diversity. ODIME seeks to provide services and programs that will instill university-wide appreciation for diverse perspectives and ensure equal levels of inclusion, participation, and retention of underrepresented student groups in their quest for a quality.