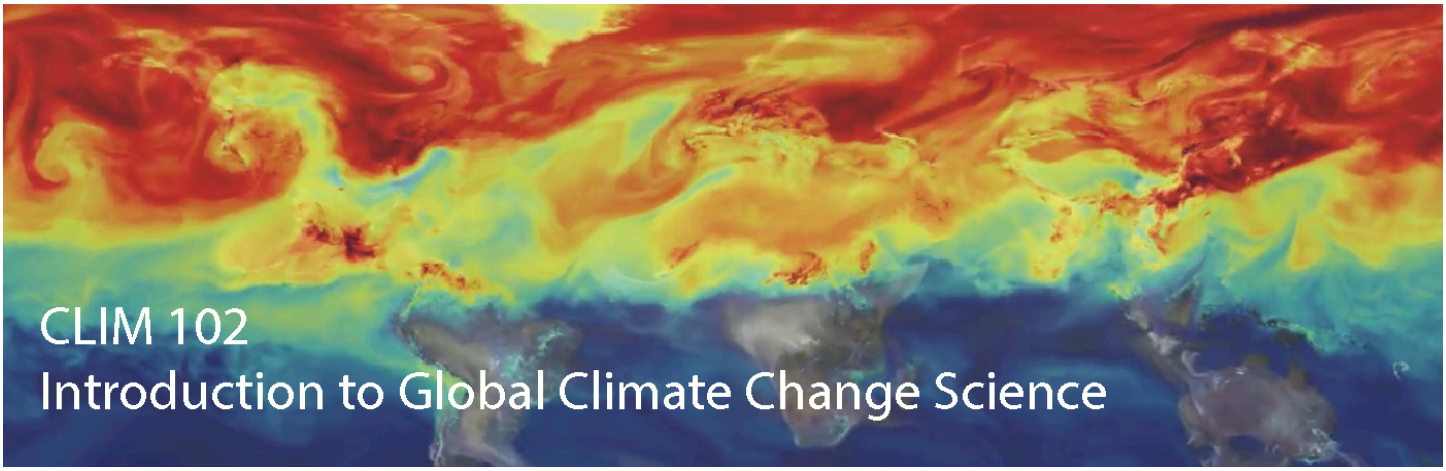

Instructors:

Dr. Natalie Burls - Lecture
Dept. of Atmospheric, Oceanic, & Earth Sciences
http://cos.gmu.edu/aoes/profile-natalie-burls/
Office Hours: Tuesdays 12-1pm or by appointment
Research Hall, Room 273, Fairfax Campus
Office: (+1) 703-993-5756
Email: nburls@gmu.edu

Dr. Kathy Pegion – Online Lab
Dept. of Atmospheric, Oceanic, & Earth Sciences
http://mason.gmu.edu/~kpegion
Office Hours: By appointment (in-person and online)
Research Hall, Room 270
Office: (+1) 703-993-5727
Email: kpegion@gmu.edu

In-Person Lab Instructor: Dr. Ralph Getzandanner - rgetzand@masonlive.gmu.edu
Office Hours: By appointment

Learning Assistants: Sean Jones - sjones66@masonlive.gmu.edu & Aaron Molloy - amolloy@masonlive.gmu.edu
Office Hours: TBD see Blackboard for weekly updates on LA office hours and review sessions.

4 credit hours (3 hours lecture plus computer-based lab)
Lectures (CLIM 102 - 001): Tuesday & Thursday 10:30 - 11:45, Venue: David King Jr. Hall 1006
Lab Sections:
CLIM 102 – 201 Tuedays 13:30 - 16:10, Venue: Innovation Hall 326
CLIM 102 – 203 Thurdays 13:30 - 16:10, Venue: Innovation Hall 203
CLIM 102 – 204 Wednesdays 13:30 - 16:10, Venue: Innovation Hall 129
CLIM 102 – 2D1 Online

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

Archer, David 2012: *Global Warming: Understanding the Forecast,* 2nd Ed., Wiley, ISBN 978-0-470-94341-0
This text is absolutely essential for the course and is not expensive. The bookstore has hard copies. Electronic copies can also be purchased.

Supplementary Texts

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

Dessler, Andrew 2016: Introduction to Modern Climate Change, 2nd Ed. Cambridge University Press, ISBN 978-1-107-48067-4

Course Goals and Objectives:

The main learning objectives for this course are

1. To learn why climate scientists are 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.
3. To learn how to use scientific notation and extract information from quantitative plots but focusing on units and unit analysis.

While the overall goal of this course is to give an overview of how climate change 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 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.

Tentative Class Schedule

This course will develop the scientific basis for global warming theory, and will focus primarily on Archer's textbook.

Week	Unit	Tuesday Class	Thursday Class	Lab	Readings
1 20 Jan	Introduction	Welcome and Introduction. Course outline and procedures.	Energy. How do we move it about? What is heat and temperature?	Introduction to Lab, spreadsheets and graphing: graphing temperature data	Archer Ch. 1
2 27 Jan	Energy and Radiation	Longwave and shortwave radiation. It's the stuff it encounters that is different.	The spectrum – Everything radiates	Blackbody Radiation	Archer Ch. 2
3 3 Feb	Weather and Climate	Weather versus climate Climate causes weather?	Earth's energy balance	Blackbody Radiation Continued	Archer Ch. 6
4 10 Feb	The Greenhouse Effect	How does a greenhouse work? Bare-rock planet	Pianos, kitchen sinks, etc.	What causes seasons?	Archer Ch. 3
5 17 Feb	Greenhouse Gasses and how they work	What makes a Greenhouse Gas a Greenhouse Gas?	Bending, Stretching, Atmospheric Windows	How a Greenhouse Works	Archer Ch. 4
6 24 Feb	Temperature Structure of the Atmosphere	Lapse Rate, Pressure and Altitude, Expansion and Compression and Heat	Water vapor, Heat and Convection	***Mid-term Review***	Archer Ch. 5
7 2 Mar	Feedbacks	What is a Feedback The Ice-Albedo Feedback	***Mid-term Thurs, Mar 5 10:30-11:45***	Modeling Greenhouse Gas Response	Archer Ch. 7
	Spring Break				
8 16 Mar	More Feedbacks	Water-Vapor Feedback	Cloud Feedbacks	Lapse Rate and Skin Temperature	Archer Ch. 7
9 23 Mar	Carbon Cycle	The chemistry of Carbon	CO_2 in and out of the atmosphere	Feedbacks ***Introduction to Climate Change Mythbusters Lab***	Archer Ch. 8 & 9
10 30 Mar	Making the Forecast / Climate Change Projections	Modeling Earth's Climate & Climate Sensitivity	How are humans perturbing the carbon cycle? Fossil fuel emissions scenarios	The Carbon Cycle	Archer Ch. 9 & 10

11 6 Apr	Climate Changes So Far	Records from the near and distant past – Why is climate changing?	Human vs natural causes	Human vs. Natural Causes	Archer Ch. 11
12 **Earth Week!** 13 Apr	What do we really think will happen?	Patterns of heat, precipitation, and more	Tipping points and feedbacks	Modeling Climate Change	Archer Chapter 12
13 20 Apr	Climate Change Impacts and Vulnerabilities	Costs of a warming world: Sea level rise, droughts and floods, air pollution and wildfire	Ecosystems, biodiversity, extinctions	***Climate Change Mythbuster Lab (no late credit, must be present in class)***	NCA & IPCC Reports
14 27 Apr	Adaptation and Mitigation Strategies, Conflict, Famine, Disease and Solutions	Stopping global warming - how?	Sources of GHGs An Ethical Problem *Last day to turn in labs*	*Final Exam Review*	Archer Ch. 13
12 May	**Final Exam**	10:30 am – 1:15 pm in David King Jr. Hall 1006			

Course Structure and Grading Criteria:

The course grade will be based on weekly in-class assignments and quizzes (15%), weekly reading and homework assignment (20%), a mid-term exam (20%), laboratory work (25%) and a final (20%). When determining final grades, the lowest quiz grade, lowest homework grade and lowest lab grade will be dropped.

This class will take on somewhat of a flipped classroom style in that you will be expected to read the relevant chapter of the textbook, any other supplementary text or videos, and the class slides, ahead of class. The lecture time during each class will be short with a large part of class time spent on group activities and quizzes intended to cement understanding.

Blackboard homework assignments will be assigned weekly on Monday evenings and will be due the Sunday evening of the same week. For example, your first homework assignment will be made available on Mon, Jan 20 and will be due Sun, Jan 26th. For the first ten weeks each homework (HW) assignment will review the chapter from *Global Warming: Understanding the Forecast* covered in class that week. These first ten homework assignments are to be completed on your own with no help from other students, they serve as a week-by-week evaluation of your understanding of the content and allow you to assess what you do and don't know. The Learning Assistant assigned to the class will hold weekly sessions to assist in reviewing past and current HW concepts. For the last four weeks you will receive one "mini-project" homework assignment, to be completed in groups. For this final homework assignment, you will look at climate change evidence and impacts over Virginia or another US state of your choice.

This semester, there are 4 lab sections. Three of the lab sections will meet in-person for 3 hours. One of the lab sections will be online only. You must attend the lab section for which you are registered. 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.

Late Homework Policy

As mentioned above, the weekly HW is due by the end of Sunday (11:59pm) each week. After this time, HW turned in one week late (up until 11:59pm) will receive a 25% penalty, HW turned in after this will receive a 50% penalty. All HW must be turned in by Fri, May 1 @ 11:59pm to receive credit.

Grade Disputes

Any dispute regarding a grade on any assignment must be made in writing via email within 1-week of receipt of the grade on that assignment.

Makeup Exams

Students must be present to take the mid-term and final exam in person. A make-up exam will be given only in the case of an emergency. Documentation of an emergency must be provided. The student must notify the Instructor within 24hrs of the exam to schedule a make-up. No make-up of the mid-term exam will be given once the answers have been discussed in class. **The final exam will only be given during the official day and time. The final exam cannot be given at any other day/time for reasons other than official Mason Business or a documented medical emergency.** If another GMU final has been scheduled at the same time as

your CLIM 102 final please email Prof. Burls at least 1-month prior to final exams.

Incomplete

If you wish to take an incomplete for this class, you must make a request in writing to the Instructors of both Lecture and Lab and meet with both to discuss the situation and plan for completion of the coursework by the required deadline.

Extra Credit

Extra credit may be given at times at the discretion of the Instructors. Students should not expect extra credit. Extra credit opportunities will not be given by student request. If you complete the assignments, you should not need extra credit.

Lab Specific Policies

Lab Due Dates

Lab due dates are based on your assigned lab section as follows:

Lab Section	Meeting Day	Due Date
201	Tues	Mon @11:59pm
203	Wed	Tues @ 11:59pm
204	Thurs	Wed @ 11:59pm
2D1	Online	Wed @ 11:59pm

A 30 min grace period will be allowed to accommodate technical issues. After this time labs are considered late and grade deductions will follow the late lab policy - labs turned in one day late (up until 11:59pm) will receive a 25% penalty, labs turned in after 1-day late will receive a 50% penalty. All labs must be turned in by Fri, May 1 @ 11:59pm to receive credit. The final lab (Lab #12), involves group presentations during lab class and is not eligible for late credit. All students must be in attendance and participate with their group to receive credit for the final Lab (Lab #12).

Late Lab Policies

One day late (up until 11:59pm+30min grace period the following day): 25% penalty
After 1-day late: 50% penalty
All labs must be turned in by Fri, May 1 @ 11:59pm to receive credit.
For in-person lab sections, the final lab (Lab #12), involves group presentations during lab class and is not eligible for late credit.
Students must be in attendance and participate with their group to receive credit for the final Lab (Lab #12).
Instructions for Lab #12 for the online lab section will be provided separately via Blackboard

Group Work

- For in-person lab sections, the labs will be completed in groups. For the online lab section, group work options will be provided separately via Blackboard.
- The maximum group size will be determined by the Instructor based on the number of students
- Groups may change throughout the semester at the discretion of the Instructor.
- For in-person lab sections, all group members must be present in lab class to participate in group lab reports.
- If a student is assigned to an in-person lab section and they do not attend lab class, they must complete the lab and submit their report independently.
- All group members will receive the same lab grade.
- Any dispute over a group member's participation in the lab must be made in writing within 24 hours of lab submission. Each group member must provide a written description of the contribution to the lab of all group members. To resolve the dispute, each group member may be required to meet with the Instructor individually.

How to be successful in this class

1. Attend class and lab regularly – note that in-class quizzes make up 15% of your grade and you may miss important information regarding the lab if you are not present in lecture.
2. Read the Archer textbook chapters – the homework and labs are based on the text

3. Complete all assignments and labs – we assign homework to give you practice with the course material, the lowest homework grade will be dropped. This means that if you do poorly on one assignment, it does not impact your grade. If do poorly on 2 assignments, you can still recover because there are 10 other assignments across which you can improve your grade.
4. Complete and turn in all lab reports – a zero for an assignment has a big negative impact on your grade. Some points are better than no points.
5. Complete all work on time – late labs have point deductions, late homework cannot be accepted.
6. If you do poorly on a homework or lab, this is the first indication that you need help. If you get help right away, your grade can recover before it is too late. ***Please make use of the Learning Assistant assigned to this class***, who will hold regular office hours. Ask questions in lecture and/or lab. If you still do not understand something, go to office hours and ask more questions.

Emergencies and Extenuating Circumstances

The class grading policies are designed to accommodate emergencies and extenuating circumstances. Specifically, the lowest lab, homework, and quiz grade will be dropped and labs can be turned in late (with penalty). Therefore, no special accommodations will be provided for lab, homework, or quizzes due to a short-term emergency or extenuating circumstances. If a student has a significant issue that extends beyond one week of class (e.g. 1 homework, 1 quiz, 1 lab), students are encouraged to come to office hours to discuss any specific issues and/or seek assistance from the appropriate student services (e.g. Office of Disability Services, Counseling and Psychological Services, Academic Advisor).

Grading Schema

Grades Scored Between				Will Equal
95	% and	125	%	A+
85	% and	Less Than	95%	A
82	% and	Less Than	85%	A-
78	% and	Less Than	82%	B+
75	% and	Less Than	78%	B
72	% and	Less Than	75%	B-
68	% and	Less Than	72%	C+
65	% and	Less Than	68%	C
60	% and	Less Than	65%	C-
55	% and	Less Than	60%	D
0	% and	Less Than	55%	F

Important Dates

Please see the university calendar [https://registrar.gmu.edu/calendars/spring-2020/ - dates] for drop dates with and without a tuition penalty.

Late Registration and/or Add

Students who register or add the course after the first assignments are due are responsible for making up all materials and assignments that have been missed. The student must:

a) Meet with the course Instructors and discuss the plans for revised assignment due dates.
b) Agree *in writing* with the Instructor regarding the due dates for missed assignments.
c) Failure to do so may result in grading penalties or a zero on missed assignments.

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 me 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: It is expected that students adhere to the George Mason University Honor Code as it relates to integrity regarding coursework and grades. The Honor Code reads as follows: "To promote a stronger sense of mutual responsibility, respect, trust, and fairness among all members of the George Mason University community and with the desire for greater academic and personal achievement, we, the student members of the University Community have set forth this: Student members of the George Mason University community pledge not to cheat, plagiarize, steal and/or lie in matters related to academic work." More information about the Honor Code, including definitions of cheating, lying, and plagiarism, can be found at the Office of Academic Integrity website at http://oai.gmu.edu

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.

Privacy

Students must use their Mason 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 during class.

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.

Useful Campus Resources:

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

Student Support Resources on Campus (https://ctfe.gmu.edu/teaching/student-support-resources-on-campus)

Name of Resource	Description of Resource
Assistive Technology Initiative	Manages the production of accessible text for Mason students with disabilities. They also ensure access to information technology and communications to the entire university community through the use of adaptive equipment and provision of technical assistance.
Center for Academic Advising, Retention, and Transitions	Advises students who are thinking about changing majors or who need assistance with their transition to Mason from another institution.
Copyright Resources Office	Provides assistance to faculty and students regarding copyright policies.
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.
Disability Services	Implements and coordinates reasonable accommodations and disability-related services that afford equal access to university programs and activities.
International Programs and Services	Provides guidance to students and scholars studying and working at George Mason University on immigration, employment and taxation, and adjustment issues, while fostering cross-cultural understanding through programs highlighting global themes.
Learning Services	Provides a variety of experience based learning opportunities through which students explore a wide range of academic concerns. Services include support to students with learning differences, individual study skills counseling, individualized programs of study, and provision of tutoring resources. 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.
Lesbian, Gay, Bisexual, Transgender, Queer, and Questioning Resources	Promotes the academic success, health and well-being of lesbian, gay, bisexual, transgender, and queer (LGBTQ) students and their allies. Also works to sustain and strengthen a campus climate of safety, equity, inclusion, and respect in which LGBTQ and ally students can succeed and thrive at Mason.
Mathematics Tutoring Center	Offers tutoring on a walk-in basis for all George Mason University students who are enrolled in math courses up to MATH 290.
Military Alliance Program (M.A.P.)	Provides faculty and staff participants with an understanding of military students at Mason and how they can be supported. Upon completion of M.A.P. training, participants are certified by the Office of Military Services as a "Military Friendly Staff Member".
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.

Name of Resource	Description of Resource
Office of the Ombudsman	Acts as a unique resource for students to discuss concerns and complaints and serves as a safe space to facilitate the resolution of conflicts. As an impartial party, the office does not take sides in any conflict and operates independently of any formal channels at the university.
Safe Zone	Creates a safer, more welcoming and inclusive campus environment to strengthen community and encourage networking among faculty, staff, and students toward the goal of supporting the well-being of LGBTQ people.
Social Action and Integrative Learning (SAIL)	Fosters experiential learning opportunities on campus, regionally, and globally for the Mason community with a particular emphasis on effecting positive social change. SAIL is Mason's home for service-learning initiatives.
Student Conduct	Provides information about university policies, the student conduct process, and resources for faculty related to addressing student behaviors of concerns and other disruptive behaviors.
Student Health Services	Provides high quality health care, counseling, education, and prevention services in support of student learning and retention.
Student Support and Advocacy Center	Provides comprehensive services for students in an effort to foster the safety and well-being of the Mason community. SSAC services include assisting students who are encountering barriers to their academic success or personal growth, interpersonal violence prevention, alcohol and drug education, health promotion/healthy relationships, student crisis intervention, and connecting students with appropriate campus and off-campus resources.
UNIV Courses and Programs	Serves as a resource and development center for undergraduates, providing courses, programs, and services to facilitate students' personal and academic success.
University Career Services	Provides information on career choices, internships and employment, and graduate and professional school.
University Life	Enhances students’ in- and out-of-class experiences, in addition to facilitating interactions among faculty, staff, and other students. These resources help students achieve academically, stay healthy, get involved with campus life, find jobs, and identify resources to enrich their learning.
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.