

## MASTER COURSE SYLLABUS *Climate Science*

**Course Code:** SC 130

**Title:** *Climate Science for 21<sup>st</sup> Century Citizens*

**Short title:** *Climate Science*

**Catalog Description:** Earth's climate has changed in the past and will change in the future. Climate science and hypotheses about climate change and man's effects on climate figure prominently in the news and popular culture. However, forces and feedbacks impacting climate are poorly understood by the general public. This lack of understanding originates partially because climate science is complicated and interdisciplinary, and partially because addressing climate change requires significant changes in the global energy economy, turning it into a political issue with skewed and un-scientific public discourse. This course aims to cover parts of climate science that are well established, differentiate them clearly from parts of climate science where genuine uncertainty exists and use these contrasts to illustrate the scientific method, culture of science and science practices of the 21<sup>st</sup> Century.

**Class capacity:** 24 (Class size depends on discussions, intensive review of student writing and computer lab availability)

**Rationale :** Although climate science and hypotheses about climate change and man's effects on climate figure prominently in the news and popular culture, forces and feedbacks impacting climate are poorly understood by the general public. This lack of understanding originates partially because climate science is complicated and interdisciplinary, and partially because addressing climate change requires significant changes in the global energy economy, turning it into a political issue with skewed and un-scientific public discourse. This course aims to cover parts of climate science that are well established, differentiate them clearly from parts of climate science where genuine uncertainty exists and use these contrasts to illustrate the scientific method, culture of science and science practices of the 21<sup>st</sup> Century.

There is currently no course on climate science for non-majors in the Monmouth University curriculum. The course would also be included as an acceptable course in the Minor in Global Sustainability under the *Environment and Health* cluster.

### **Course Goals**

Climate Science for 21<sup>st</sup> Century Citizens (SC130) is designed to engage students in critical thinking about contemporary issues in climate science. This course introduces students to science that describes the major forces, feedbacks, cycles and oscillations that create climate at local and global levels. Changes in climate over geological as well as historic time will be studied, and impacts on biodiversity and man will be discussed. Students will use Climate Science as a tool to familiarize themselves with how modern science is practiced and how evidence is assessed by the scientific community.

The Monmouth University mission also explicitly states that students should demonstrate an understanding of global issues and challenges and be able to formulate solutions to global and regional problems: this course addresses this objective, with respect to climate science.

Specific course objectives include:

- To convey to students an appreciation for the complexity and functioning of the earth's climate systems;
- To acquaint students with contemporary climate issues;
- To examine the effects of human activities on climate;
- To enable students to understand why developing solutions to climate problems requires knowledge of scientific facts while at the same time accounting for cultural, social and economic considerations; and
- To empower students to think critically about climate science and how decisions about carbon emissions and other human activities might impact future climate

### **Assessable learning outcomes**

1. Demonstrate the ability to acquire and apply scientific information to reach well-justified conclusions including:
  - Differentiate among facts, laws, theories and hypotheses;
  - Identify reliable sources of information;
  - Interpret graphs and statistics;
  - Distinguish between correlations and causations;
  - Demonstrate the use of quantitative data in forming scientific explanations; and
  - Generate logical conclusions from acquired data.
2. Gain a base of knowledge in a scientific field (Climate science) including:
  - Define the major concepts in at least one area of science (Climate science);
  - Argue against common misconceptions and respond in a civil yet factual manner to a climate skeptic; and
  - Recognize the interconnectedness of scientific disciplines, specifically physics, chemistry and biology as relevant to climate science.
3. Gain an understanding of the nature of scientific inquiry as a means to increasing our knowledge of the natural world and as an approach to problem solving including:
  - Explain how, given evidence presented, one possible explanation does not explain that evidence as well as another possible explanation;

- Describe examples of specific pieces of evidence for mechanism (i.e., how something works) that are critical in providing support for a particular scientific explanation and its acceptance in the scientific sense;
  - Provide a narrative on how changing scientific knowledge leads to updating and increasing the accuracy of a scientific model;
  - List factors involved in making a decision in the face of uncertain knowledge; identify the role of probability of outcome, severity of outcome, and ethical considerations; and
4. Demonstrate an understanding of the role and impact of natural science on society including:
- Identify the scientific issues associated with global problems;
  - Explain the importance of societal support for scientific research; and
  - Explain how science has influenced history.

**Methods of Instruction:** Discussions, computer laboratories, take home examinations (as formative experiences as well as evaluations), in class and homework exercises and problem sets, lectures.

**Methods of Evaluation**

- 2 midterm exams 30%  
*(Including take home portions)*
- Research paper 15%
- Class presentation 10%
- Daily activities 30%  
*(In class and homework problems and worksheets)*
- Final exam 15%

Grades Correspond to Point Totals As Follows:

A	950 – 1000	A-	900 - 949		
B+	870 – 899	B	830 – 869	B-	800 – 829
C+	770 – 799	C	730 – 769	C-	700 - 729
D+	670 – 699	D	630 – 669	D-	600 – 629
F	<600				

**Required Readings:**

Archer, D, (2012). *Global Warming: Understanding the Forecast*. 2<sup>nd</sup> Ed. John Wiley & Sons, Inc. Danvers, MA.

Henson, R. (2011). *The Rough Guide to Climate Change*. 3<sup>rd</sup> Ed. Rough Guides Ltd. London.

Students will be required to read **one** of the following supplemental texts which focus more on impacts of climate change on society and comment on parts of it in relevant homeworks and as part of their final paper and presentation.

Dessler, A. L. , Parson and E. A., (2010) The Science and Politics of Global Climate Change (2<sup>nd</sup> Ed), Cambridge University Press, Cambridge.

Faris, S., (2009) Forecast: The Surprising –and immediate – Consequences of Climate Change. Henry Holt and Co. N.Y.

Fagen, B. (2004), The Long Summer: How Climate Changed Civilization. Basic Books. N. Y.

Goodall, C. (2010) Ten Technologies to Save the Planet. Greystone Books, Vancouver.

Hulme, M. (2009). Why We Disagree about Climate Change. Cambridge University Press. Cambridge.

MacKay, D. J. C. , (2009). Sustainable Energy -Without the Hot Air. UIT Cambridge LTD

Selected websites will be accessed on a regular basis including:

Scripps Oceanographic Institute, <https://scripps.ucsd.edu/>

The Environmental Protection Agency, <https://www.epa.gov/>

### **Course Contact Hours:**

3 credit hours; 3 contact hours

### **Attendance Policy:**

Attendance is expected and participation in classroom discussions, lab activities and timely completion of assignments is a requirement of the course. Specific policies on completion of homework, lab activities, and exams will reveal indirect penalties for missing class.

### **Academic Honesty:**

As per the Monmouth University Undergraduate Catalog and Student Handbook, Monmouth University does not tolerate violations of the code of academic honesty.

Dishonesty in such academic practices as assignments, examinations, or other academic work will not be condoned. A student who submits work that is not original violates the purpose of Monmouth University and may forfeit his/her right and opportunity to continue at the University.

Any student caught in any form of cheating during an exam or any other course assignment will be failed in the course and the Department Chair for the student's major and the Provost of the University will be notified.

Please refer to section entitled *Academic Dishonesty and Student Code of Conduct* in the Student Handbook.

### **Students Who Need Special Accommodations:**

Student athletes must keep the professor informed in advance regarding absences necessitated by athletic events. Please follow all additional procedures set forth by the Department of Athletics.

Students with disabilities who need special accommodations for this class are encouraged to meet with the professor or the appropriate disability service provider on campus as soon as possible. In order to receive accommodations, students must be registered with the appropriate disability service provider on campus as set forth in the *Student Handbook* and must follow the University procedure for self-disclosure, which is stated in the *University Guide to Services and Accommodations for Students with Disabilities*. Students will not be afforded any special accommodations for academic work completed prior to disclosure of the disability or the completion of the documentation process with the appropriate disability service office.

### **Selected Bibliography** (works available in the Monmouth University Library designated with\*):

Archer, D.A. and Rahmstorf, S. (2010). *The Climate Crisis: An Introductory Guide to Climate Change*. Cambridge University Press. Cambridge UK.

Bradley, R. S. (2011). *Global warming and Political intimidation: How Politicians Cracked Down on Scientists as the Earth Heated Up*. University of Mass. Press\*

Folger, T. (2013). *Rising Seas*. National Geographic. 224 (2), 30-60.

Giddens, A. (2009). *The Politics of Climate Change*. Polity Press, Cambridge UK \*

Henson, R. (2011). *The Rough Guide to Climate Change*. 3<sup>rd</sup> Ed. Rough Guides Ltd. London.

Lemke, P., J. Ren, R.B. Alley, I. Allison, J. Carrasco, G. Flato, Y. Fujii, G. Kaser, P. Mote, R.H. Thomas and T. Zhang, 2007: *Observations: Changes in Snow, Ice and Frozen Ground*. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Mathez, E. A. (2009). *Climate Change: The science of Global Warming and our Energy Future*. Columbia University Press. New York.

Newman, J.A., Anand, M., Henry, H. A. L., Hunt, S., Gedalof, Z.(2011). *Climate Change Biology*. CAB International, Oxford.\*

Oreskes, N., Conway. E. M. (2010). *Merchants of Doubt*. Bloomsbury Press, NY. NY.

Schneider, S. H., and Londer, R. (1984). *The Coevolution of Climate and Life*. Sierra Club Books. San Francisco.\*

Sliver, J. (2008). Global Warming and Climate Change DeMystified: A self teaching guide. McGraw Hill

Stocker, T. et al. (2013). Working group I contribution to the IPCC fifth assessment report, climate change 2013: the physical science basis (accessed Nov 28 2013)

Tans, P. NOAA/ESRL (2012).

### Web-based resources

Union of concerned scientists

<https://www.ucsusa.org/>

Scripps Oceanographic Institute

<https://scripps.ucsd.edu/>

The Environmental Protection Agency

<https://www.epa.gov/>

**Effective Date of Implementation or Latest Revision:** Fall 2014

## Sample Schedule

### Climate Science for 21<sup>st</sup> Century Citizens

**Readings:** There are 13 chapters the *Archer* textbook, so each week, beginning with the first week you are responsible for reading the corresponding chapter. In week 14 you are responsible for reading the summaries of the supplemental texts posted on e-campus by your fellow students.

**Models:** We will study several “models” in this class, to explore ideas about how climate works. In climate science a model can be anything from a very simple hypothesis of how the system might work (eg. Archer’s Bare Rock Layer Model, which he calls ...”a toy, demonstrating an idea” ) to mathematically complicated equations that are potentially predictive of as yet unobserved physical events. We will study the assumptions of models, their strengths and weaknesses and which scientific mechanisms support each model. When multiple explanations for phenomena are being discussed (e.g. increased Carbon Dioxide in the atmosphere is caused by volcanism vs. human causes) models will be used to explore alternatives.

**Mathematics:** Mathematics is a powerful tool in science and in life. We will use basic mathematics extensively in this class, but we will go slowly and not assume that you know how to read any equation without orientation.

#### **Weeks 1-5. Humans in context: Living on a Greenhouse Earth. Understanding the world around us.**

*Science topics: Greenhouse effect. Water cycle. Matter: atoms & chemical bonds; gases vs. liquids. Electromagnetic waves, photons, and interaction with matter. Energy.*

*The process of science: Introduce conceptual framework for class: Models, alternative explanations, and the importance of evidence for mechanisms. Apply framework to Example Model 1: CFCs led to ozone destruction.*

- What are the issues? Greenhouse effect, Global Warming, and Climate change. Who are the players - citizens, scientists, industry, regulators)?[Class 1] *Archer Chapter 1.*
- A success story: CFCs & saving the ozone. What made this a success story? How does this compare to the global warming story? How did we know that the CFC Model (MODEL1) provides the correct explanation? [Weeks 1/2]
- The Greenhouse Effect & greenhouse gases. [Weeks 2/3/4]
  - Blackbody Radiation, solar radiation. The layer model of earth’s temperature. [Weeks 2 and 3] *Archer 2 & 3.*
  - Gases, molecular vibration and light, - Introduction to gas laws, bond vibration and interaction of IR light with greenhouse gases. [Week 4] *Archer 4*
- Atmospheric structuring- more gas laws , how temperature and pressure support earth’s atmosphere, water and latent heat. [*Archer 5*] Exam 1 [Week 5]
- Post-Exam: How is the Greenhouse analogy accurate and how is it wrong? Lead into weather vs. climate (and next topic). [Week 5]

#### **Weeks 6-10. Is the Earth warming? Is the warming caused by humans?**

*Science topics: Weathering. Plate tectonics. Isotopes. Chemical reactions, including redox. Global cycle of carbon.*

*The process of science: Apply conceptual framework to Example Models 2 (Earth is warming much more quickly than ever) and 3 (The warming is caused by humans). The devil is in the details: quantitative thinking, why the skeptics' alternative hypotheses cannot account for what we see, and the importance of mechanisms.*

- MODEL 2: The Earth is warming much more quickly than ever. The Earth's thermostat. Global climate changes over the ages & recent trends. How do we understand variability in temperature? [Weeks 6-7]
  - How weather affects climate, climate variability, Coriolis forces, reflection and albedo [Archer 6]
  - Complexity in the earth system and feedbacks- positive and negative, ice albedo feedback to introduce positive feedback as an amplifier. Feedbacks in the Paleoclimate record.
  - [Archer 7]
- MODEL 3: The warming is caused by humans: What are alternative explanations about what can be causing the accelerated warming & how does the evidence help us choose the right ones? [Weeks 8-9]
  - Carbon Chemistry, the Carbon Cycle, Solar Cycling – Redox equations, [Archer 8]
  - Fossil Fuels and Energy –fossil fuels and their chemistry, historical patterns of fuel use in the last 150 years, How can we use past patterns to model future carbon emissions? [Archer 9]
- Global Energy Budget – revisiting the ozone model- Combined climate drivers- Is the carbon in the atmosphere the result of burning fossil fuels? What is the evidence? Alternative explanations, variability of climate revisited [Archer 10]
  - Exam 2 [Week 10]

### **Weeks 11-14. What can a degree of warming do? What can we do about it? Making decisions in a complex world.**

*Science Topics: Impacts of increased CO<sub>2</sub> and CH<sub>4</sub> on aquatic and terrestrial organisms over modern and historical timescales; biological extinctions. Biological adaptability and known evolutionary limitations. The meaning of "adaptation" in biological versus social contexts.*

*The process of science & decision-making: Apply conceptual framework to Example Model 4 (Consequences of Climate Change). What are the certainties and uncertainties regarding global warming? Assessing risk (probability of outcome) and severity of consequences when making decisions. Role of ethics in decision-making. Sustainability as a model.*

- MODEL 4: Multitude of effects of temperature change & their consequences on human societies, economics, health, etc. and on life on Earth. Organismal adaptability & evolution [Weeks 11 / 12]
  - Paleoclimate, review of modern climate data records, climate variations on orbital time scales. In class activity correlating paleoclimate data and biodiversity using marine genera as a diversity proxy. [Archer 11]
  - Potential climate impacts – emergent effects of increased energy on climate variability, ice and sea level, ocean circulations reprise. [Archer 12]



- What are the certainties and uncertainties regarding global warming? – and what should we do about the expected consequences? Societal Adaptation to climate change is a major goal in the US government’s responses to climate change; compare with sustainability. Are sustainable technologies really sustainable over historic timescales? [*Archer 13*, Week 13]
- Presentations and discussion of student reports. [Readings -*posted summaries of supplementary readings*] [Week 14]

**Week 15. Final Exam.** Take home and in class portions.