Advanced topics in AOS: Climate Change

MATH-GA 3010
Spring 2024

Instructors:
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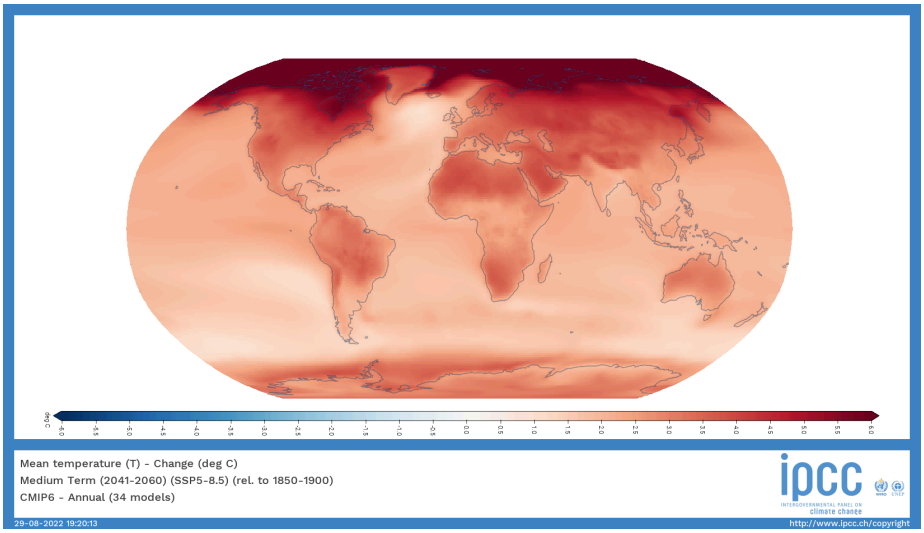

Meeting times and location

Lectures:
Monday 11:00-12:50
Warren Weaver Hall 201

Textbook:

The course will be alternate between a primary textbook and recent research articles.

Required textbook:

1. Hartmann, D: 2015: *Global Physical Climatology,* (2nd edition). Elsevier Science and Technology.

Additional text:

1. Pierrehumbert, R., 2010: *Principles of planetary climate*, Cambridge University Press, 652pp.
2. IPCC, 2021: *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*[Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, In press, doi:10.1017/9781009157896.

Description:

The Earth's atmosphere and oceans have been warming for the last 50 years, and are expected to do so until at least the end of this Century. Human activities, primarily the emission of carbon dioxide due to the burning of fossil fuels, are the main driving forces behind these changes. In this course, we will assess the physical basis for anthropogenic climate change, study the evidence for climate change over the last few decades, and analyze some of its potential future impacts. We will concentrate on four major areas:

1. Physical climatology: how different components of the climate system - land, atmosphere, oceans, and cryosphere - interact with each other, resulting in the climate we experience?
2. The greenhouse effect and climate feedbacks: what factors determine the temperature of the Earth, how a change in atmospheric composition affects it, and what other mechanisms can modulate the amount of warming?
3. Historical changes in the climate systems: how has the climate of the Earth evolved from its geological past to the modern time, and what does it tell us about what may happen over the course of the 21st Century?
4. Changes in the hydrological cycle and extreme weather: how does climate change translate into regional weather patterns? why do we see increase in both floods and droughts? What is happening with extreme weather like tropical cyclones?

As an advanced topics course, the class will also invite students to be active participants. About one-third of the course will be dedicated to discussing materials from the textbook, one-third will be focused on recent papers on climate change, and the last third will be for discussion and presentation of student research.

Expectation:

This course is aimed at graduate students interested in active climate research. Students are expected to read the material ahead of each class, to be active participants in the lecture. In addition, through the semester, each student will lead the discussion of several papers and will organize develop and present a course project:

Course project:

As part of the course, the students will propose, develop, investigate and present an individual course project.

- week 3: Identify a main research topic as well as a couple of supporting paper
- week 6: Preliminary research presentation
- week 10: Research report draft
- Week 14: Research presentation
- Exam week: final report

Schedule:

Week	Date	Topic	Textbook chapters	Other
1	1/22	Class overview - Global energy balance and fundamentals of electromagnetic radiation	Hartmann Ch. 2 - Ch. 3.5	
2	1/29	Radiative transfer and Radiative-convective equilibrium	Hartmann Ch. 3.6-3.13	Jeevanjee (2021)
3	2/5	Surface energy balance	Hartmann Ch. 4	Byrne and O'Gorman (2018)
4	2/12	The hydrological cycle - Introduction to data and models for the final project	Hartmann Ch. 5	Held and Soden (2006) Research proposal
5	2/19	(no class - Presidents' Day)	(no class)	(no class)
6	2/26	Atmospheric circulation Preliminary research presentation	Hartmann Ch. 6	Pauluis et al. (2008)
7	3/4	Atmospheric circulation continued	Hartmann Ch. 6	
8	3/11	Climate variability Preliminary research presentation	Hartmann Ch. 8	Vallis (2010)
9	3/18	(no class - Spring break)	(no class)	(no class)
10	3/25	Natural Climate Change and history of the Earth's climate	Hartmann Ch. 9	Osman et al. (2021)
11	4/1	Climate Sensitivity	Hartman Ch. 10	
12	4/8	5-min project presentation Climate Sensitivity	Hartmann Ch. 10	Sherwood et al. (2020) 1-3
13	4/15	Climate Sensitivity	Hartman Ch. 10	Sherwood et al. (2020) continued
14	4/22	Extreme weather	IPCC	Zhang et al. (2021)
15	4/29	Discussion of research reports		
16	5/6	Research presentation		
17	5/13	Exam week - Final report is due		

Papers

Byrne, Michael P., and Paul A. O'Gorman. "Trends in continental temperature and humidity directly linked to ocean warming." *Proceedings of the National Academy of Sciences* 115.19 (2018): 4863-4868.

Held, Isaac M., and Brian J. Soden. "Robust responses of the hydrological cycle to global warming." *Journal of climate* 19.21 (2006): 5686-5699.

Jeevanjee, Nadir, Daniel DB Koll, and Nicholas Lutsko. ""Simpson's Law" and the spectral cancellation of climate feedbacks." *Geophysical Research Letters* 48.14 (2021): e2021GL093699.

Osman, Matthew B., et al. "Globally resolved surface temperatures since the Last Glacial Maximum." *Nature* 599.7884 (2021): 239-244.

Pauluis, Olivier, Arnaud Czaja, and Robert Korty. "The global atmospheric circulation on moist isentropes." *Science* 321.5892 (2008): 1075-1078.

Sherwood, Steven C., et al. "An assessment of Earth's climate sensitivity using multiple lines of evidence." *Reviews of Geophysics* 58.4 (2020): e2019RG000678.

Vallis, Geoffrey K. "Mechanisms of climate variability from years to decades." *Stochastic physics and climate modelling* 1234 (2010).

Zhang, Yi, Isaac Held, and Stephan Fueglistaler. "Projections of tropical heat stress constrained by atmospheric dynamics." *Nature Geoscience* 14.3 (2021): 133-137.

Final note - As instructors, we will strive to create a safe, respectful, and inclusive environment for all students regardless of their identity. We recognize and value diversity inside and outside of the classroom, and recognize that each student has a unique contribution to make and brings with them different strengths and weaknesses. We welcome your ideas for how to promote a better understanding and deeper learning in this class as a community. Please feel free to ask questions, to participate in discussions, and to suggest new approaches to the class content. Please also feel welcome to raise any issue you may have in class or outside of class, including reporting incidents of bias or discrimination, whether intentional or unintentional, either to me, to your advisor(s)/mentor(s), or by using the NYU Bias Response Line.