Artificial Intelligence and Climate Change

Course number

INAF U6544

Instructors

David Sandalow
Alp Kucukelbir

Meeting dates / times / location

Tuesday, January 28

Tuesday, February 4

Tuesday, February 11

Tuesday, February 18

Tuesday, February 25

--No classes during March

Tuesday, April 1

Tuesday, April 8

- All classes 4:10-6pm

Location TBD

Credits

1.5

Prerequistes

(i) Energy System Fundamentals or equivalent, and (ii) a basic understanding of climate change science. (Some familiarity with AI concepts and terminology is helpful, but neither programming experience nor previous AI coursework is required.)

Course overview

Artificial intelligence (AI) is a hot topic. More than 200 million people now use ChatGPT each month, tens of billions of dollars have poured into AI projects in the past year and policymakers around the world are considering how best to respond to the growth in AI.

Meanwhile countries around the world are struggling to respond to climate change. Based on global average temperatures, July 22, 2024 was the warmest day ever recorded; 2023 was the warmest year ever recorded; and the 10 warmest years on record are the past 10 years. Yet despite encouraging developments, including the dramatic drop in the price of renewable energy in the past decade, global emissions of greenhouse gases continue to climb.

Can AI help reduce emissions of greenhouse gases? Will increased power demand for AI lead to greenhouse gas emission increases, outweighing any benefits? Can AI help with adaptation to climate change? Should policymakers encourage the use of AI to help fight climate change and discourage AI applications that may increase greenhouse gas emissions? If so, how?

This course will cover these questions. The course is an advanced seminar. After an initial class session covering core AI concepts, we will explore different ways AI could help reduce greenhouse gas emissions and adapt to climate change, as well as ways in which AI could lead to greenhouse gas emissions increases. We will explore barriers to the use of AI to respond to climate change, risks of using AI for that purpose, policy options for addressing these risks and barriers, and ways in which different stakeholders can work together in using AI tools to fight climate change.

Course admission

Please submit a short statement (four paragraphs or less) explaining your background on the topics covered in the course and reasons for taking the course. Preference will be given to students with a background in climate and energy policy, AI or both.

Course grade

Grading will be based on weekly responses to the readings, participation in class, a paper proposing a program that uses AI tools to fight climate change or policy with respect to AI and climate change and a presentation to the class on your proposal. Your course grade will be calculated as follows.

Component	Percentage
Weekly responses to the readings	15 %

Component	Percentage
Attendance & participation	15 %
Final project paper	50 %
Final project presentation	20 %

One- to two-page responses to the weekly readings are due at 11:59pm the day before each class session. We will score your weekly responses as 0 for “below expectations,” 1 for “meets expectations,” and 2 for “exceeds expectations.”

Attendance at each class session is central to the course. Active and thoughtful participation in class discussions will be weighted favorably in grading.

The core assignment for the course is a paper proposing a program that uses AI tools to fight climate change or policy with respect to AI and climate change. Each student will present their proposal to the class as a whole, using a PPT deck. Additional details on these assignments will be distributed at the first class session.

The course may not be taken Pass/Fail.

Background readings

The course will closely follow these sources:

- (Sandalow et al. 2024)
- (Gentine et al. 2024)
- (Olawade et al. 2024)
- (Chan et al. 2024)

We recommend reading these materials and familiarizing yourself with their content, in addition to doing the weekly readings assigned below.

Use of large language models

ChatGPT and other LLMs will be important tools in your work in the years ahead. We encourage you to use them in assignments for this course if you like. If you do so, please be mindful of the limitations of these tools, including the risk that responses they provide may contain inaccurate information and fail to reflect the level of expertise expected in graduate school work product.

In part because LLMs are new, we would like to see how you use them in assignments for this course. If you use ChatGPT or another LLM in an assignment for this course, please include the prompts you used and the LLM's responses as attachments to your final product.

We will grade the assignments you submit by their quality, not by the extent you may have edited responses provided by an LLM. If you are satisfied with the response provided by an LLM, please feel free to copy-and-paste that response into your final product. However please be aware (as noted above) that LLMs may provide responses that contain inaccurate information and fail to reflect the level of expertise expected in graduate school work product.

Email Addresses

- David Sandalow `<dsandalow@columbia.edu>`
- Alp Kucukelbir `<alp@cs.columbia.edu>`
- Please submit all assignments to `<AI-ClimateCourseAssignments@gmail.com>`

Office hours

TBD

Please sign up for Prof. Sandalow's office hours at `https://www.wejoinin.com/sheets/frkhk`

Class sessions

Week 1-- Tuesday January 28 | Core AI Concepts

Required readings

- Kucukelbir, A., Chapter 1: Introduction to Artificial Intelligence in (Sandalow et al. 2024)
- (Kaack et al. 2022)

Suggested readings

- The history of AI: (Russell 2019)
- Excellent overview on CCM: (Gates 2021)

Discussion questions

1. What is AI?
2. How is AI different than traditional software?
3. What can AI do and not do?
4. What issues are policymakers considering in regulating AI?

Week 2 – Tuesday February 4 | Power Sector

Required readings

- Donti, P., Chapter 2 in (Rolnick et al. 2022)
- Sandalow, D., Zhiyuan, F., Carter, M., Chapter 3: Power Sector in (Sandalow et al. 2024)
- (Ahmad et al. 2021)
- (Donti and Kolter 2021)

Suggested readings

- High-risk AI applications: (Truby et al. 2022)
- Overview of AI in nuclear energy: (Suman 2021)
- AI for nuclear fusion: (Seo et al. 2024)

Discussion questions

1. How can AI help reduce greenhouse gas emissions in the power sector?
2. How is this different than manual techniques or traditional software?
3. What are the principal barriers to AI helping reduce emissions in the power sector?
4. What are the principal risks of using AI to help reduce emissions in the power sector?
5. What steps can be taken to address these risks and barriers?

Week 3 – Tuesday February 11| Food Systems

Required readings

- Karl, K., et al., Chapter 4: Food Systems in (Sandalow et al. 2024)
- (Jung et al. 2021)
- (Paudel et al. 2021)

Suggested readings

- Reinforcement learning for crop management: (Gautron et al. 2022)
- Reinforcement learning for crop breeding: (Younis et al. 2024)

Discussion questions

1. How can AI help reduce greenhouse gas emissions in food systems?
2. How is this different than manual techniques or traditional software?
3. What are the principal barriers to AI helping reduce emissions in food systems?
4. What are the principal risks of using AI to help reduce emissions in food systems?
5. What steps can be taken to address these risks and barriers?

Week 4 Tuesday February 18 | Large Language Models

Required readings

- Loehr, D., Chapter 11: Large Language Models in (Sandalow et al. 2024)
- ("Climate Policy Radar" 2024) website at `https://www.climatepolicyradar.org`
- (Zhu and Tiwari 2023)
- (Silva et al. 2023)

Suggested readings

- LLMs for processing 100,000 climate studies: (Callaghan et al. 2021)

Discussion questions

1. How can large language models help respond to climate change?
2. What are the principal barriers to large language models helping respond to climate change?

3. What are the principal risks of using large language models to help respond to climate change?

4. What steps can be taken to address these risks and barriers?

Week 5 Tuesday February 25 | Greenhouse Gas Emissions from AI

Required readings

- Sandalow, D., Chapter 15: Greenhouse Gas Emissions from AI in (Sandalow et al. 2024)

- (Luers et al. 2024)

- IEA (2024), Electricity Mid-Year Update - July 2024, IEA, Paris `https://www.iea.org/reports/electricity-mid-year-update-july-2024`

- Sayumi Take (2024), Boom in data centers challenges clean power goals in Asia; Nikkei Asia, Tokyo, Japan, `https://asia.nikkei.com/Business/Energy/Boom-in-data-centers-challenges-clean-power-goals-in-Asia`

- Antonio Olivo (2024), Internet data centers are fueling drive to old power source: Coal; The Washington Post, Washington, D.C., `https://www.washingtonpost.com/business/interactive/2024/data-centers-internet-power-source-coal/`

- Gaurav Sharma, (2023), How Multibillion Dollar Investments In AI Are Driving Oil And Gas Sector Innovation; Forbes Media, Jersey City, New Jersey, `https://www.forbes.com/sites/gauravsharma/2023/08/14/how-multibillion-dollar-investments-in-ai-are-driving-oil-and-gas-sector-innovation/`

- Sudeep Srivastava, (2024), Unleashing the Potential of Artificial Intelligence in the Oil and Gas Industry — 10 Use Cases, Benefits, Examples; Appinventiv, Noida, Uttar Pradesh, India, `https://appinventiv.com/blog/artificial-intelligence-in-oil-and-gas-industry/`

- (Tomlinson et al. 2024)

- Renee Cho, (2023), AI's Growing Carbon Footprint; Columbia Climate School: State of the Planet, `https://news.climate.columbia.edu/2023/06/09/ais-growing-carbon-footprint/`

Discussion questions

1. What percentage of global greenhouse gas emissions are currently attributable to computing operations for AI?

2. What percentage of global greenhouse gas emissions are currently attributable to AI supply chains?
3. How much will these emissions grow in the years ahead?
4. What policies could help address emissions increases?
5. How much is use of AI by the oil and gas industry increasing greenhouse gas emissions?

Week 6 Tuesday April 1| Manufacturing & Proposal Presentations

Part 1

Required readings

- Kucukelbir, A., Chapter 5: Manufacturing Sector in (Sandalow et al. 2024)
- (Ozbay and Almquist 2023)
- (Shahbazi et al. 2016)
- (Hendrickson et al. 2024)

Discussion questions

1. How can AI help reduce greenhouse gas emissions in manufacturing?
2. How is this different than manual techniques or traditional software?
3. What are the principal barriers to AI helping reduce emissions in manufacturing?
4. What are the principal risks of using AI to help reduce emissions in manufacturing?
5. What steps can be taken to address these risks and barriers?

Part 2

Students present their proposals — 8 minutes each.

Week 7 Tuesday April 8 | Proposal Presentations (cont.)

Students present their proposals — 8 minutes each.

Academic integrity statement

The School of International & Public Affairs does not tolerate cheating and/or plagiarism in any form. Those students who violate the Code of Academic & Professional Conduct will be subject to the Dean's Disciplinary Procedures. Cut and paste the following link into your browser to view the Code of Academic & Professional Conduct online:

`http://sipa.columbia.edu/resources_services/student_affairs/academic_policies/deans_discipline_policy.html`

Please familiarize yourself with the proper methods of citation and attribution. The School provides some useful resources online; we strongly encourage you to familiarize yourself with these various styles before conducting your research:

`http://sipa.columbia.edu/resources_services/student_affairs/academic_policies/code_of_conduct.html`

Violations of the Code of Academic & Professional Conduct should be reported to the Associate Dean for Student Affairs.

Bibliography

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Callaghan, Max, Carl-Friedrich Schleussner, Shruti Nath, Quentin Lejeune, Thomas R Knutson, Markus Reichstein, Gerrit Hansen, et al. 2021. "Machine-Learning-Based Evidence and Attribution Mapping of 100,000 Climate Impact Studies." *Nature Climate Change* 11 (11): 966–72.

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Gentine, Pierre, Geneva List, Kyoko Thompson, Theresa Pardo, Xin Li, George Berg, and Lauren Bennett. 2024. "AI for Climate and Nature: Landscape Assessment." https://www.climate.columbia.edu/ai-climate-nature-landscape-assessment; Columbia University & Bezos Earth Fund.

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Jung, Jinha, Murilo Maeda, Anjin Chang, Mahendra Bhandari, Akash Ashapure, and Juan Landivar-Bowles. 2021. "The Potential of Remote Sensing and Artificial Intelligence as Tools to Improve the Resilience of Agriculture Production Systems." *Current Opinion in Biotechnology* 70: 15–22.

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