Introduction

Global Warming Science, EPS101

Eli Tziperman

https://courses.seas.harvard.edu/climate/eli/Courses/EPS101/
Global Warming Science

A hands-on intro to the science of global warming and its consequences

Venice flooding, 2019

San Angelo, Texas, 2011

Time lapse of clouds: 2 hours in 2 min
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**Time & location:** Wednesday 3-5:45, HUCE seminar room 440, 4th floor, 26 Oxford St

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**Grading:** Writing tasks/workshops/presentations: 70%; coaching: 15%; Participation: 15%
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Class overview
1. **Greenhouse** effect: why is CO$_2$ causing warming? How and how much?
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The basics

1. **Greenhouse** effect: why is CO$_2$ causing warming? How and how much?

2. **Temperature**: how much is/ will it warm? Was there a hiatus? Why more in the Arctic? Climate sensitivity/ role of the ocean?
1. **Sea level** rise: is it rising? Accelerating? Will it accelerate? Global vs. local effects.

![Graph showing sea level rise](image)
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2. **Ocean acidification**: the other CO₂ problem! The chemistry, effects on ocean life
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The oceans

1. **Sea level** rise: is it rising? Accelerating? Will it accelerate? Global vs. local effects.
2. **Ocean acidification**: the other CO$_2$ problem! The chemistry, effects on ocean life
3. **Ocean circulation**: is it collapsing? will it? The day after tomorrow! why?

![Graph showing sea level rise](image1)

**Figure 1.1**: Greenhouse, warming, and sea level rise. Beginning with greenhouse gases, the blue line in Figure 1.1a shows the iconic Mauna Loa CO$_2$ record collected since 1958, preceded by an ice-core based reconstruction. CO$_2$ concentration has been at 280 ppm for over 10,000 years, since the last ice age, and has therefore increased by about 50% so far, at an unprecedented speed. There is, of course, no doubt that CO$_2$ is increasing and that the increase is attributable to anthropogenic burning of fossil fuel. Once in the atmosphere, we will see that it will take thousands of years for the CO$_2$ to naturally decline after anthropogenic emissions are eliminated. Chapter 2 addresses the question...
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The atmosphere

1. **Hurricanes**: are they already getting stronger, how do they work, why we expect them to strengthen, analyzing past data, predicting future strength
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1. **Hurricanes**: are they already getting stronger, how do they work, why we expect them to strengthen, analyzing past data, predicting future strength

2. **Clouds**: why are they the biggest source of uncertainty in predictions?
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The cryosphere

1. **Greenland & Antarctica**: how will they respond? Instabilities, ice stream acceleration

![Image of cryosphere]
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The cryosphere

1. **Greenland & Antarctica**: how will they respond? Instabilities, ice stream acceleration
2. **Arctic sea ice**: the canary in the coal mine. Why has it melted so much? What next?
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The cryosphere

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3. Mountain glaciers: why have they been retreating so dramatically?
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Consequences of warming

1. **Droughts**: what's causing them, will they get more frequent? Stronger? less? Why?
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That Siberian Heat Wave? Yes, Climate Change Was a Big Factor
An analysis of recent record temperatures found that climate change made this year’s long hot spell 600 times more likely.

*NYTimes, 2020*
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Consequences of warming

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3. **Forest fires**: which ones are increasing? related to anthropogenic warming?

That Siberian Heat Wave? Yes, **Climate Change Was a Big Factor**
An analysis of recent record temperatures found that climate change made this year's long hot spell 600 times more likely.
NYTimes, 2020
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5. Introduce the issue and the motivation, discuss any changes observed so far, the worst case scenario for 2100, uncertainty, and the mechanisms/feedbacks that take place or are expected to take place so that the adviser can understand the reason for the observed/expected changes.
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9. Conclude with a brief reasoned statement of the position you personally recommend the adviser take in public presentations on this issue.
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10. Submit two PDF files with writing and Jupyter workshop solution notebook (all cells evaluated in order, downloaded as pdf) via GradeScope by Wednesday at 2 pm.
“The great global warming swindle”

Learning to deal with criticism…
Claims made in the great global warming swindle: 1/3

1. We are told that global warming is proved beyond any doubt – lies!
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3. There were periods with 10 times as much CO₂, we should see the consequences in the geologic record.
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4. None of the major climate changes of the last 1000 years can be explained by CO₂
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8. CO₂ forms only a very small part of the earth’s atmosphere (ppm).
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8. CO₂ forms only a very small part of the earth’s atmosphere (ppm)
9. CO₂ never drove climate in the past
Claims made in the great global warming swindle: 2/3

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11. CO$_2$ is a very minor greenhouse gas, much smaller than water vapor
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17. In the 70s, experts warned of a global ice age coming soon
18. Climate models are based on hundreds of assumptions, all it takes is for one assumption to be wrong, and the forecast is useless
19. Models assume CO2 is the main cause for climate change, rather than sun or clouds.
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20. Warming $\Rightarrow$ smaller EPTD $\Rightarrow$ less storminess, not more hurricanes
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21. You can get anything with a model by tweaking a parameter
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Claims made in the great global warming swindle: 3/3

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22. Models give wild speculation the appearance of respectable science
23. Sea level rises only because of warming, not melting, will take a very long time.
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20. Warming => smaller EPTD => less storminess, not more hurricanes

21. You can get anything with a model by tweaking a parameter

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23. Sea level rises only because of warming, not melting, will take a very long time.

24. Tropical diseases (Malaria) won't spread northward: mosquitoes are not tropical. There were serious malaria breakouts in Russia.
19. Models assume CO2 is the main cause for climate change, rather than sun or clouds.

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24. Tropical diseases (Malaria) won’t spread northward: mosquitoes are not tropical. There were serious malaria breakouts in Russia.

25. Greenland was much warmer 1000 years ago, and did not melt.
Claims made in the great global warming swindle: 3/3

19. Models assume CO2 is the main cause for climate change, rather than sun or clouds.
20. Warming => smaller EPTD => less storminess, not more hurricanes
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27. Ice in Antarctica always breaks off and melts, news only because of satellite data. Ice is always moving. Happens every spring.
1. There is no consensus among climate scientists
2. The IPCC and its final conclusions are political
3. Climate scientists needs [the] problem in order to get funding
4. Thatcher fought oil&coal workers, promoted nuclear power, & funded global warming
5. Environmentalists won all their battles, adopted global warming to remain revolutionary
6. Social activists needed new tool against capitalism, post communism
7. Money poured into research area attracted people whose only interest is global warming
8. Principles of journalism abandoned because with no global warming environmental journalists will loose their jobs
9. IPCC reports distorted & inconsistent with peer review, without coauthor approval.
10. Global warming is a new religion opponents are viewed as heretics
11. Policies against global warming have a disastrous effect on the poor
13. If the rich developed world cannot afford expensive sustainable energy, neither can the developing world
workshop: introduction to python

TODO now:

• Go to EPS101 course Canvas site -> FAS on demand -> start Jupyter server.

  • [ Alternatively, hopefully not needed: install the latest anaconda from https://www.anaconda.com/products/individual#download-section ]

• Download the 1st-class python code and data set from canvas: introducing_python.ipynb, introducing_python_variables.pickle

• Upload both files to Jupyter server and star going over the workshop.
Starting the Jupyter notebook via FAS on demand on Canvas