Meeting #2: Overview of Climate Change
– or –
Climate Change According to Ross, Walt, Brian, Austin, & Tim

Ross Salawitch & Walt Tribett

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Class Web Site: http://www.atmos.umd.edu/~rjs/class/honr229L

ELMS Page: https://myelms.umd.edu/courses/1229919

30 August 2017
1) Where do you stand on the climate change debate? (4 pts)

In other words, are you a Believer, a Denier, or Unsure? In addition to stating where you stand on the debate, please expound upon your standing in two to three sentences.

I am a believer. It's seems undeniable the climate change is a problem based on the fact that every year that passes becomes the hottest year on record. This is the only home we have and we have to care for it for the next generations.

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I am a firm believer in climate change. Additionally, I believe it is entirely or at least drastically worsened by human's presence on the planet.

In high school I was a policy debater, so I spent a whole year investigating human's impact on the environment, specifically our oceans, forcing me to be familiar with both sides of the arguments. However, I still am firm in my belief that climate change is real.
1) Where do you stand on the climate change debate? (4 pts)

In other words, are you a Believer, a Denier, or Unsure? In addition to stating where you stand on the debate, please expound upon your standing in two to three sentences.

I am a believer when it comes to the climate change debate.

I do believe that we are experiencing global warming and that a direct issue of this warming is the melting of the polar ice caps in Antarctica and in other places. For example, over the summer I visited Glacier National Park in Montana and a majority of the glaciers have melted since the park opened. I read that in 20 to 50 years there will be no more glaciers. Learning this just makes me believe more in climate change and that humans are the cause because in my opinion the glaciers are melting much faster than they should be if there were no humans messing around.
1) Where do you stand on the climate change debate? (4 pts)

In other words, are you a Believer, a Denier, or Unsure? In addition to stating where you stand on the debate, please expound upon your standing in two to three sentences.

Believer.

I believe that when the meteorologist who is a denier of climate change said "we've been told that the ice caps will melt, coasts will flood as oceans rise, powerful hurricanes will hit our coasts, and heat waves will heat the planet" he was actually making a point as there have been an increase statistically over the past 25 years in extremely powerful and damaging hurricanes. He spoke about the natural global warming that the planet goes through every million years or so and then went on to compare the events of that time period to the increase in global temperature over the last 40 years. If that pattern of 0.5 degree temp. increase continues we surely will be up to a 3 degree change in 240 years. That is nothing compared to a million or so years.

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In contrast, there is next to no evidence for the lack of climate change occurring, so I do not believe in the denial of it.
1) Where do you stand on the climate change debate? (4 pts)

In other words, are you a Believer, a Denier, or Unsure? In addition to stating where you stand on the debate, please expound upon your standing in two to three sentences.

I am a believer. The only question for me is whether climate change could be a cyclical change over the span of Earth's history in addition to modern man-made effects. I think this is an important question to investigate. If it is indeed cyclical, could the warming climate eventually reverse itself.
2) On a scale of 1 to 10, 1 being least important and 10 being most important, what priority should the United States government give towards curbing our nation's emissions of fossil fuels over the course of your lifetime, such that by year 2060, half of all energy in the U.S. would be achieved by renewable sources? (4 pts)

Please note:
• such a large scale transition to renewable energy will undoubtedly cause some economic disruption; the amount is hotly debated
• by renewable source, we mean technologies such as solar, wind, hydro, biofuels, even carbon capture and sequestration
• In addition to stating the priority level, support your reply with two to three additional sentences.

I would recommend a priority level of 8 for the transition from fossil fuels to renewables.

If we commit the resources to researching and developing renewable energy sources now while we still have the economic and societal structures in place to do so, I think we can avoid more severe and drastic consequences down the line (i.e. price inflation by oil cartels such as OPEC, resource conflicts, etc.). Furthermore, such a transition requires a lot of time to incubate and innovate ideas for the most cost effective and efficient means of energy production. An entirely new workforce will need to be trained in the skills necessary to produce such a change as well. Making the switch to 50% dependence on renewables is an action that has far reaching ramifications for both domestic and foreign policy and therefore deserves to be near the top of the priority list for the U.S. government.
2) On a scale of 1 to 10, 1 being least important and 10 being most important, what priority should the United States government give towards curbing our nation's emissions of fossil fuels over the course of your lifetime, such that by year 2060, half of all energy in the U.S. would be achieved by renewable sources? (4 pts)

Please note:
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I believe that the priority should be at an 8.

The United States government needs to think in long-term rather than short term. It will not matter if the economy is strong now if we cannot sustain ourselves in the future. As Jared Diamond discussed in his video, climate change problems are often a major cause of a society's collapse. If the United States cannot adapt to these problems, then this society will start to collapse as well, along with its economy. If we can have strong renewable energy sources by 2060, then we can improve the economy.
2) On a scale of 1 to 10, 1 being least important and 10 being most important, what priority should the United States government give towards curbing our nation’s emissions of fossil fuels over the course of your lifetime, such that by year 2060, half of all energy in the U.S. would be achieved by renewable sources? (4 pts)

Please note:
- such a large scale transition to renewable energy will undoubtedly cause some economic disruption; the amount is hotly debated
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- In addition to stating the priority level, support your reply with two to three additional sentences.

8. Although there would be high economic costs, renewable sources would be a long-term, permanent solution. The faster that the US transitions to these more eco-friendly sources, the less damage will be done for the environment. The best way this could be implemented would be in phases, because a rapid shift to renewable sources would undoubtedly cause economic, political, and national disruption. Perhaps the easiest way the US could undergo this transition is to advocate for and subsidize solar panels, which would greatly cut the use of carbon based fuels in homes. Many individuals who own solar panels even make a profit off of them, which would also greatly incentivize their use.
2) On a scale of 1 to 10, 1 being least important and 10 being most important, what priority should the United States government give towards curbing our nation's emissions of fossil fuels over the course of your lifetime, such that by year 2060, half of all energy in the U.S. would be achieved by renewable sources? (4 pts)

Please note:
- such a large scale transition to renewable energy will undoubtedly cause some economic disruption; the amount is hotly debated
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- In addition to stating the priority level, support your reply with two to three additional sentences.

I think it should be an 8 or 9 in priority for the US government, if not a 10.

As members of the global community, we use up a disproportionate amount of the world's nonrenewable energy resources, so we have a responsibility not just towards our own citizens, but to the world, to explore less harmful and short-sighted energy alternatives. I'm obviously not an expert, but I think exploring more renewable energy sources could help with the economic disruption that a shift away from coal and natural gas would cause .... if we could encourage a shift to renewable energy jobs for those who lack the skills for an increasingly professional economy, we could bring in a more stable source of income, while at the same time, bringing in renewable energy to the US.
3) Do you consider yourself to be politically liberal or politically conservative? If liberal, how liberal? If conservative, how conservative?

A simple phrase will suffice.

Please note the identify of the students providing this reply, as well as all replies to all ATs for his semester, will be held in strict confidence by the instructors. We will share replies to the class, but in a manner that preserves student anonymity.

I would describe myself as a moderate, tending to side with politically liberal ideas and thoughts.

*I believe it is important to consider both sides to an issue, and then proceeding to make a decision based on these inputs.*

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I consider myself to be more liberal but *I like to listen to the reasoning from both sides on controversial topics.*
2) On a scale of 1 to 10, 1 being least important and 10 being most important, what priority should the United States government give towards curbing our nation's emissions of fossil fuels over the course of your lifetime, such that by year 2060, half of all energy in the U.S. would be achieved by renewable sources? (4 pts)
3) Do you consider yourself to be politically liberal or politically conservative? If liberal, how liberal? If conservative, how conservative? A simple phrase will suffice. (2 pts)

Please note the identity of the students providing this reply, as well as all replies to all ATs for this semester, will be held in strict confidence by the instructors. We will share replies to the class, but in a manner that preserves student anonymity.

[Bar graph for 2016 Class]
3) Do you consider yourself to be politically liberal or politically conservative? If liberal, how liberal? If conservative, how conservative? A simple phrase will suffice. (2 pts)

Please note the identify of the students providing this reply, as well as all replies to all ATs for his semester, will be held in strict confidence by the instructors. We will share replies to the class, but in a manner that preserves student anonymity.

![2017 Class Bar Chart]
Earth’s Climate History: A Longgggg View

Climate History, 500 Million ybp to Present

- **Era 4**: Lucy, H. sapiens first appear
- **Era 3**: Agriculture Begins
- **Era 2**: Anthropocene
- **Era 1**: Pre-industrial

**CO₂ (ppm)**
- Rise of Forests
- Pangea Breaks Apart

**ΔT (°C) from preindustrial**
- Rise of Mammals
- Dinosaurs

- **Era 6**: Ice Ages
- **Era 5**: Greenland Glaciation

Million ybp
- 500 400 300 200 100 60 50 40 30 20 10 5

Thousand ybp
- 700 500 300 100 15 10 5

ybp
- 800 600 400 200

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Greenhouse Gases: Common Era

Greenhouse Gases: Common Era

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Carbon Dioxide (CO₂): Modern Era: The Keeling Curve

http://www.esrl.noaa.gov/gmd/ccgg/trends/full.html
### ΔRF Terms

**Well-mixed GHGs**
- CO₂
- CH₄
- N₂O
- ODS
- Other F-gases

**Ozone**
- Stratospheric
- Tropospheric
- H₂O Vapor from CH₄
- Contrails + Induced Cirrus

**Stratospheric Water**

**Contrails**

**Surface Albedo**
- Land Use
- Black Carbon on Snow

**Total Aerosol**
- Aerosol Direct Effect
- Aerosol-Cloud Interaction

**Total Anthropogenic**

**Natural Processes**
- Solar Irradiance

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ΔRadiative Forcing of Climate: 1750 to 2011

ΔRF Terms

Well-mixed GHGs

Ozone

Stratospheric Water

Contrails

Surface Albedo

Total Aerosol

Total Anthropogenic

Natural Processes

CO₂ is dominant anthropogenic GHG

δ

ΔRF Terms

Well-mixed GHGs

CO₂

CH₄

N₂O

ODS

Other F-gases

human activities

Ozone

Stratospheric Water

Contrails

Surface Albedo

Total Aerosol

Total Anthropogenic

Natural Processes

ΔRF (W m⁻²)

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Δ Radiative Forcing of Climate: 1750 to 2011

Aerosols tend to cool, counteracting RF of CO₂
Interestingly, net effect of all human activities about equals RF of CO₂.
Radiative Forcing of Climate

The Greenhouse Effect
Some of the infrared radiation passes through the atmosphere but most is absorbed and re-emitted in all directions by greenhouse gas molecules and clouds. The effect of this is to warm the Earth’s surface and the lower atmosphere.

Solar radiation powers the climate system.

Some solar radiation is reflected by the Earth and the atmosphere.

About half the solar radiation is absorbed by the Earth’s surface and warms it.

Infrared radiation is emitted from the Earth’s surface.

FAQ 1.3, Figure 1. An idealised model of the natural greenhouse effect. See text for explanation.

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Radiative Forcing of Climate: The Anthropocene


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Climate Projections Driven by Prescribed GHG Levels

- Future abundance of CO₂, CH₄, N₂O & minor GHGs provided to climate models
- Representative Concentration Pathway (RCP) scenarios; number represents increase in RF of climate, units of W m⁻², that will occur at end of this century

FAQ 12.1, Figure 1 | Global mean temperature change averaged across all Coupled Model Intercomparison Project Phase 5 (CMIP5) models (relative to 1986–2005) for the four Representative Concentration Pathway (RCP) scenarios: RCP2.6 (dark blue), RCP4.5 (light blue), RCP6.0 (orange) and RCP8.5 (red); 32, 42, 25 and 39 models were used respectively for these 4 scenarios. Likely ranges for global temperature change by the end of the 21st century are indicated by vertical bars. Note that these ranges apply to the difference between two 20-year means, 2081–2100 relative to 1986–2005, which accounts for the bars being centred at a smaller value than the end point of the annual trajectories. For the highest (RCP8.5) and lowest (RCP2.6) scenario, illustrative maps of surface temperature change at the end of the 21st century (2081–2100 relative to 1986–2005) are shown for two CMIP5 models. These models are chosen to show a rather broad range of response, but this particular set is not representative of any measure of model response uncertainty.
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IPCC (2013) projects 2°C rise in global mean temperature if CO₂ reaches 560 ppm, twice the pre-industrial level (CO₂ reaches 560 ppm in 2053 within RCP 8.5)

CMIP5 estimates of GMST diverge from data, past decade

ΔT: Global mean surface temperature (GMST) anomaly: i.e., rise in GMST since 1850 to 1900
CMIP5: Climate Model Intercomparison Project #5: i.e., climate models used by IPCC (2013)
IPCC: Intergovernmental Panel on Climate Change

IPCC (2013) projects 2°C rise in global mean temperature if CO$_2$ reaches 560 ppm, twice the pre-industrial level (CO$_2$ reaches 560 ppm in 2053 within RCP 8.5)

**Rise in global mean T, RCP 8.5, relative to 1850 to 1900 baseline:**
Mean $= 2.82 \pm 0.41$ °C

IPCC back of the envelope projection of “indicative likely range” of global warming, given tendency of climate models to run “too hot”

CMIP5 estimates of GMST diverge from data, past decade

$\Delta T$: Global mean surface temperature (GMST) anomaly: i.e., rise in GMST since 1850 to 1900

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**IPCC**: Intergovernmental Panel on Climate Change
AAWR: Attributable Anthropogenic Warming Rate


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**AAWR**: Attributable Anthropogenic Warming Rate

**AerRF\textsuperscript{2011}**: Aerosol Radiative Forcing, Year 2011


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\textbf{AAWR:} Attributable Anthropogenic Warming Rate

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AAWR: Attributable Anthropogenic Warming Rate

OHC: Ocean Heat Content
CMIP5: Climate Model Intercomparison Project #5
GCM: Global Climate Model

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Actual AAWR is about a factor of 2 smaller than AAWR from climate models; about three-quarters of these models warm faster than our empirical upper limit.
Paris Climate Agreement, Dec 2015:

Article 2, Section 1, Part a):

Objective to hold “increase in GMST to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels”

INDC: Intended Nationally Determined Contributions to reduce GHG emissions
• Submitted prior to COP21-UNFCCC meeting in Paris
• Extend from present to year 2030

GMST: Global Mean Surface Temperature
COP: Conference of the Parties
UNFCCC: United Nations Framework Convention on Climate Change
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**GMST**: Global Mean Surface Temperature  
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**Nov 2014:**
Presidents Obama & Xi announce:
- U.S. will reduce GHG emissions to 27% below 2005 level by 2025
- China will peak CO$_2$ emissions by 2030 with best effort to peak early
Color Bar: Probability a particular future ΔT will occur, based on the assumption that whatever value of climate feedback needed to fit past climate will persist into future

**EM-GC**: Empirical Model of Global Climate (i.e., Univ of Md model)

**CMIP5**: Climate Model Intercomparison Project #5: i.e., climate models used by IPCC (2013)

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**RCP 2.6, 4.5, & 8.5**: GHG scenarios with 2.6., 4.5, and 8.5 W m\(^{-2}\) RF of climate in 2100

**Uncertainty** in “Our Projection” due to various population projections
**INDC**: Intended Nationally Determined Contribution (to release emission of GHGs)

**Unconditional**: We promise, no matter what, to have and to **hold** ...
**INDC**: Intended Nationally Determined Contribution (to release emission of GHGs)

**Unconditional**: We promise, no matter what, to have and to *improve* ...
**INDC**: Intended Nationally Determined Contribution (to release emission of GHGs)
**Unconditional**: We promise, no matter what, to have and to improve ... &
**Conditional**: GHG reductions contingent on financial and/or technology transfer
**World Energy Consumption and CO₂ Emissions, Modified to Meet RCP 2.6 in 2030**

- **a**  
  - History  
  - Nuclear  
  - Renewables  
  - Fossil Fuels CCS  
  - Coal *  
  - Natural Gas *  
  - Liquid Fuels *  
  - * No CCS

- **b**  
  - * No CCS  
  - Coal *  
  - Natural Gas *  
  - Liquid Fuels *  
  - RCP 8.5  
  - RCP 4.5  
  - RCP 2.6

**CCS:** Carbon Capture and Sequestration


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Paris Climate Agreement, Dec 2015:

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Summer 2017:
President Trump states U.S. intends to withdraw from Paris Climate Agreement

[Image: President Donald Trump announced in June that the U.S. will leave the agreement. | Tasos Katopodis/AFP/Getty Images]

Class Enrichment #1

Please RSVP ASAP if you can attend

http://c2es.us1.list-manage.com/track/click?u=51c9ddbc6717eccd5dc9aad7b&id=4dc16c6097&e=af11e19530
Discussion #1, one week from today

- Chapter 2 of Collapse by Diamond (41 pages)
- AT 01: 4 questions; due start of class
- Template to help the discussion leader posted at:
  http://www.atmos.umd.edu/~rjs/class/honr229L/lectures/HONR_229L_2017_discussion01_template.ppt