Multi-Campus UC Course for Bending the Curve

Upper-Division Undergraduate Level Course for Majors in Engineering, Humanities, Math/Science, & Social Science

Bending the Curve:
Climate Change Solutions

Students' Learning Guide

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Lecture 1: Climate Change Science

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List of Modules				
Module 1 Anthropocene & Planetary Stewardship	Module 2 Greenhouse Effect & Global Warming	Module 3 Why & How is Climate Changing	Module 4 Impacts	Module 5 Projected Warming & Summary

Overview: Climate change has become such a political issue, that it is fundamental to convey to the students the scientific basis of climate change. Students should be aware that climate change science has undergone the traditional scrutiny and rigor of scientific methods. It took thousands of peer reviewed studies over the last 100+ years and large quantities of data collected from ships, surface stations, air craft and satellites to arrive at the findings and conclusions described in this first lecture on climate change science. Specifically, the findings reported in this lecture are based on the following:

Analyses of trillions of bytes of data sets by thousands of scientists from around the world as reported in thousands of peer reviewed publications;
Reviews of these studies by science academies from around the world since the 1970s;
Reviews by national governments including the US government;
The above efforts culminated in the formation of the Intergovernmental Panel on Climate Change (IPCC) by the United Nations in 1989 with hundreds to thousands of scientists contributing to its periodic reports assessing, evaluating and updating the science and the data.

Lecture Review Questions:

1. Why is the current era called the Anthropocene?
   a) Because humans are inhabiting the planet
   b) Humans are changing only the climate
   c) Humans have become a geologic force impacting every aspect of the planet's environment as well as its natural resources

2. How do some pollutant gases warm the planet?

   a) By trapping the sun's heat
   b) By trapping the infrared heat from the surface and atmosphere
   c) By trapping the heat from the ozone layer

3. What are the major pollutant gases generated from human activities that are warming the planet?

   a) Nitrogen and Oxygen
   b) Carbon Dioxide, Water Vapor and Methane
   c) Carbon Dioxide, Methane, Nitrous Oxide and CFCs

4. Once emitted, how long does CO_2 stay in the atmosphere?

   a) Decade to centuries to thousands of Years
   b) One Year
   c) 10 Years

5. What are the major natural factors that cause climate change?

   A. Fires & volcanoes
   B. Variations in ocean circulation
   C. Variations in solar output & volcanoes
   D. All of the above

6. How much have natural factors contributed to the observed warming?

   A. About 20%
   B. 100%
   C. 0%

Discussion Questions:

1. How might the Great Acceleration have benefitted the natural world?

2. What are some super-pollutants that you might still see?

3. What are the 6 major human activities contributing to global warming?

4. How would you describe the difference between weather and climate and the role of both in climate change and global warming?

Class Activities:

1. Climate change scientists have asserted for few decades without success, that climate change problem has to be solved before it is too late. Have they succeeded or failed? If your opinion is that they have failed to persuade the society, discuss why and what would you do differently?

2. The planet's climate has changed significantly in the past; why are the current and future changes cause of great concern and that we should try to solve this problem?

3. List the 6 major problems facing the world, ranking them by order of their importance. If climate change is NOT among the six, discuss what would it take to rank climate change among the top six.

4. Imagine you ran into your congressional representative, who is skeptical of climate change science; How will you use the knowledge gained in this lecture (along with the supporting

materials) to persuade her otherwise? If you don't have good arguments to persuade her, what else would you want to know to develop a convincing case?

5. Check out the following for more discussion topics:

IPCC: Climate Change 2013. The Physical Science Basis: Frequently Asked Questions.
https://www.ipcc.ch/report/ar5/wg1/docs/WG1AR5_FAQbrochure_FINAL.pdf

Prof Ramanathan's view of two discussion topics:

Do you believe in climate change? & How do scientists know the observed changes are due to human activities?

These questions are asked to prepare students as they will inevitably be asked these questions in the future. I hope to train them to showcase that climate change is not one of faith ("believe"), but rather of objective science based on evidence and data. When I am asked these two questions, I respond as follows:

I don't have to believe in climate change. I rely on the data I have collected since the 1980's. In addition, I rely on the data collected by US agencies like NASA and NOAA, and numerous other national agencies from around the world. These data convincingly show the following:

A. *The earth's is warming*.
The change is not observed in one variable such as air temperature above the ground. The planetary warming is observed in the temperature of the ocean to a depth of at least 1000 meters; the temperature of the atmosphere up to about twelve kilometers. Equally importantly, the stratosphere (region above 15 km in the tropics and above 12 km in the polar regions) is cooling.

Why is this warming attributed to increase in CO_2 and other pollutants gases?
All of these changes, including the stratospheric cooling were predicted by scientists decades ago. In climate models, the observed pattern and magnitude of the warming can be simulated only when models include the increase in pollutant gases since the pre-industrial era.

B. *Earth's Climate is Changing*:
The warming is accompanied by: Increase in humidity of the atmosphere; increase in sea level; decrease in the sea ice extent in the arctic; melting of the alpine glaciers; melting of Greenland and west Antarctic glaciers; increase in the intensity of storms including the hurricanes and the intensity of rainfall; increase in extreme heat waves; and increase in the drought extent over the globe.

Why is this warming attributed to increase in CO_2 and other pollutants gases?
Most of the response of other climate variables (sea level, arctic sea ice extent, melting of glaciers & humidity increase) to the warming, were also predicted by scientists decades ago. In climate models, the observed pattern and magnitude of the warming can be simulated only when models include the increase in pollutant gases since the pre-industrial era. Increase in storm and rainfall intensity were not predicted, but basic physical and thermos-dynamical theories are able to account for the intensification.

Resources:
IPCC has published numerous scientific reports, but the two recent summaries aimed at a general audience are useful teacher guides:

I. Aimed at Educators who are not in Physical Sciences:

Climate Everyone's Business
Climate Change: Action, Trends and Implications For Business
The IPCC's Fifth Assessment Report, Working Group 1
https://www.cisl.cam.ac.uk/business-action/low-carbon-transformation/ipcc-climate-science-business-briefings/pdfs/briefings/Science_Report__Briefing__WEB_EN.pdf

II. For Educators with background in physical sciences

IPCC: Climate Change 2013. The Physical Science Basis: Frequently Asked Questions.
https://www.ipcc.ch/report/ar5/wg1/docs/WG1AR5_FAQbrochure_FINAL.pdf

III. In addition, the UN has assembled an e-course and the first Module of this course is on climate change science, which is about three times as long as this Lecture 1. This module has number of quizzes that might be of use in setting quizzes or exams.

UN CC: Learn. Introductory e course of climate change, Module 1.
https://unccelearn.org/
This site requires you to register for the online course before you can access the materials.

Lecture 2: Six Clusters & Ten Solutions For Bending the Curve

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List of Modules			
Module 1 Setting the Stage for Mitigation	Module 2 Six Clusters as the Organizational Principle	Module 3 The Ten Solutions	Module 4 Living Laboratories

Overview:

This lecture gives the overview for the entire series of lectures. It adopts the Ten Scalable Solutions as determined by the UC Climate Solutions Group. The UC Climate Solutions Group, composed of 50 top experts from all 10 UC campuses released their findings in Oct 2015 in a report titled: "Bending the Curve: Ten scalable solutions for carbon neutrality and climate stability,". http://uc-carbonneutralitysummit2015.ucsd.edu/_files/Bending-the-Curve.pdf. This course uses this report as a starting point for the design of this course.

Recognizing that climate change is not merely a technical challenge, the 10 solutions in the report also address the societal, regulatory and moral angles to the war on climate change as well as the difficulty of communicating the urgency to the public. Societal Transformation emerged as the second and third solutions. The summary report emphasizes that action on climate change is urgently needed, and that we already have the tools to slow global warming in the short-term. Taking immediate action will afford us the time needed to put in place the emerging technologies and make the cultural shifts that will allow the world to transition to a carbon-neutral future. The report emphasizes the need to scale up the use of existing carbon-neutral technologies as quickly as possible. Solar and wind power, electric light-duty vehicles, and efficient devices, particularly for lighting, air conditioning and industrial processes, are ready for widespread use now and the barriers to their adoption need to be lowered.

Lecture Review Questions:

1. Name the three classes of climate pollutants important for mitigation actions:

2. How much time do we have before climate change can become dangerous?

   A. Not much; about 15 years
   B. 50 Years
   C. 100 years

3. If society ignores the warnings by scientists, what is the projected warming by 2100?
   A. 1-3 C
   B. 4-6 C
   C. cooling of 1-3 C

4. Select all of the sectors of direct relevance to society that will be impacted by climate change.
   A. Housing
   B. Education
   C. Commerce
   D. Technology

E. Religion

5. True or false: The following is an inter-generational: Climate change can last for thousands of years and thus impact generations unborn who have very little or no role in climate pollution.

Discussion Questions:

1. Give two reasons why Societal transformation solutions should be ranked as high as #2 and #3. If you don't agree with this ranking, give two reasons why not.

2. The Six Clusters & Ten Solutions lists can be a bit unwieldy. Can you think of a simpler way to organize the solutions? Are there major missing pieces?

3. How would you start implementing the 10 solutions? Perhaps you'd begin with solution #1 and go down the list or put into place a governance mechanism to implement the solutions?

4. Which living laboratory would you take advantage and why?

Class Activities:

1. Mitigation vs Adaptation: Given the choice, would you rather mitigate and adapt at the same time; or adapt to climate change first and then mitigate later if necessary. Discuss the pros and cons of the two approaches.

2. Is climate change a solvable problem? Or is it like the nuclear threat or the population problem, both of which do not seem to have technical solutions.

3. Individual behavioral changes (e.g. riding a bus) to collective actions such as influencing your senator. Can the section come up with a list of actions and ranking of said actions?

Resources:

1. The Bending the Curve executive summary cited above.

2. IPCC Working Group III –AR5 Report: Climate Change 2014: Mitigation of Climate Change.
   Summary for Policy Makers

https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_summary-for-policymakers.pdf

3. UN CC: Learn. Introductory e course of climate change, Module 4: Climate Change Mitigation. https://unccelearn.org/

Lecture 3: Humans & Nature: How Did We Get Here?: Climate Justice & Equitable Approaches

Lecturer: Fonna Forman, UCSD
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List of Modules		
Module 1 Man + Nature	**Module 2** Climate Justice	**Module 3** Disproportionate Impacts

Overview:

This lecture explores historical and contemporary thought about man's relationship with the natural world. We will explore both religious and secular traditions for understanding this relationship as one of either dominion or harmony. And we begin to explore the negative impacts that dominion has historically inflicted on the world's most vulnerable people. In this context, students will be introduced to the impacts of climate change on vulnerable demographics today, and to the urgent imperative of climate justice.

Lecture Review Questions

1. What is Terra Nullius?
   a. A 17th century European explorer
   b. Land that is empty or underutilized
   c. Land that is too compromised, polluted or inaccessible to be useful to humans

2. "Adaptation" is:
   a. the capacity to teach others how to reduce carbon emissions
   b. the capacity to maintain one's livelihood and health in face of changing environmental patterns.
   c. the capacity to reduce carbon emissions

3. Which of the following statements are true?
   a. Those who contribute least to greenhouse gas emissions are also least vulnerable to the negative impacts of climate change.
   b. Those who contribute most to greenhouse gas emission bear primary responsibility for remediating the harms of climate change.
   c. Both and a and b are true

4. Climate Justice is concerned with remediating:
   a. the intergenerational impacts of climate change
   b. the intragenerational impacts of climate change
   c. both

Discussion Questions:

1. Describe both the religious and secular root of man's domain over nature.

2. What are some examples of disproportionate impacts of climate change on society?

3. What is climate justice? What responsibilities does it entail?

4. Why do the vulnerable lose more when disaster strikes?

Class Activities:

Break classroom into small groups, and ask students to reflect on the following questions, pausing between each one to ask several groups to report their response, and to solicit larger group conversation.

1. How did Terra Nullis historically justify man's dominion over nature and how does it work in the world today?

2. Why is the suburbanization of cities problematic, from the perspective of climate change?

3. How is the responsibility to the natural world connected with the responsibility to other humans?

4. How can your generation be mobilized as agents of climate justice?

Notes to instructor: The material in this lecture does not lend itself easily to structured multiple choice responses, since the goal here to provoke students to reflect on the world they inhabit, to consider our ethical responsibility to vulnerable people, and the various obstacles to mobilizing responsibility on a global scale. It is difficult to constrain thinking about these issues to multiple-choice responses. However, there are some definitional items that could be reviewed, to ensure that students are preparing for class. I have included some of these below. But in general, I think this lecture is less suited to examination / review than other lectures on the course.

Resources:

Mary Robinson Foundation: https://www.mrfcj.org/
Pope Francis, Laudato Si
http://w2.vatican.va/content/francesco/en/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si.html
UNHCR: http://www.unhcr.org/en-us/

Lecture 3: Humans & Nature: How Did We Get Here?: The Quest for Climate Justice

Lecturer: David N. Pellow, UCSB
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List of Modules			
Module 1 Defining Climate Injustice & Climate Justice	Module 2 Cases of Climate Injustice	Module 3 Global Climate Policy Frameworks	Module 3 What Might Climate Justice Look Like?

Overview

This lecture is intended as an introduction to the concepts of climate justice and climate injustice as key topics for understanding some of the major impacts of climate change on vulnerable communities, and what some of the most important elements are for promoting climate solutions. It draws primarily on research from the social sciences and discusses what climate (in)justice is (Module 1), examines cases of climate injustice (Module 2), introduces key Global Climate Policy Frameworks (Module 3), and explores the question, What Might Climate Justice Look Like? (Module 4).

The lecture is intended to facilitate a common understanding of what climate (in)justice is by allowing us to concretize these concepts through the examination of real cases where people and ecosystems are affected by climate change. These objectives and modules also help us to think about solutions to these problems from a global policy perspective as well as how we might implement solutions on the ground. Importantly, the discussion includes a consideration of solutions from mainstream institutions as well as social movements, offering the students the opportunity to think about and debate the merit of multiple possible pathways to climate solutions.

Lecture Review Questions:

1. Major Climate Policy Frameworks:
   a. have been so successful that climate change is much less of a threat today
   b. are well intended, but limited
   c. are superior to other alternatives, especially those involving social movements

2. The Climate Justice Movement:
   a. is of marginal significance for achieving climate solutions
   b. is a term that refers to the melting of glaciers
   c. is important for addressing climate change

3. Social Inequality:
   a. is important but will have to be addressed after we solve the climate crisis
   b. is a driving force behind the climate crisis
   c. will be intensified if we increase regulatory oversight of the oil and coal industries

4. African Americans, Indigenous Peoples, and Women:
   a. are disproportionately impacted by climate change and many are leading the climate justice movement
   b. are largely to blame for the climate crisis
   c. tend to care much less about environmental and climate issues than other groups

4. Climate Justice:
   a. focuses on the root causes of the climate crisis

b. reveals that climate solutions require systemic transformation rather than modest reforms
c. underscores that pursuing solutions through the mechanisms that caused climate change makes little sense
d. includes students working on fossil fuel divestment campaigns, urban gardening, and bikeable cities
e. all of the above

Discussion Questions:

1. Give an example of climate change as a social justice issue from your experiences.

2. Drawing on the lessons of climate (in)justice, how can we deepen and improve our responses to the challenges of climate change?

3. Why do you think market-based solutions dominate the climate change debate when they consistently fail to achieve results?

4. Why do you think government regulations have not achieved the desired goal of addressing climate change?

Class Activities:

1. 1) What would happen if we developed climate solutions without attention to social inequality? 2) Draft a sample/mock piece of legislation that would be an example of a climate solution that ignores social inequality. 3) Write down and discuss what you think the concerns of climate justice movement organizations might be regarding this legislation. 4) How would you respond to those concerns?

2. The Anthropocene is the name that scholars use to describe the current geological epoch, in which humans are the dominant influence on planet earth's climate and environment. Scholars have proposed other names as well, including the Capitalocene and the Wasteocene to reflect the view that this epoch is marked by the dominance of capitalism and the massive production of industrial and consumer waste, respectively. Have students break into groups and do the following: 1) answer the question—what do you think living in the Anthropocene, Capitalocene, or Wasteocene might mean for the future of humankind and ecosystem health? 2) Come up with your own term for a future geological epoch that you would like to live in, which would be characterized by climate justice, thriving democracies, and greater social equality. How might we work toward making that epoch become a reality?

Resources:

- David Ciplet, J. Timmons Roberts, and Mizan Khan. 2015. Power in a Warming World: The New Global Politics of Climate Change and the Remaking of Environmental Inequality. MIT Press.

- Riley Dunlap and Robert J. Brulle (Eds.). 2015. Climate Change and Society: Sociological Perspectives. Oxford University Press.
- Ergas, Christina and Richard York. 2012. “Women’s status and carbon dioxide emissions: A quantitative cross-national analysis.” Social Science Research 41(4): 965-976. July.
- Victoria Tauli-Corpuz and Aqqaluk Lynge. 2008. Impact of Climate Change Mitigation Measures on Indigenous Peoples and on their Territories and Lands. UN Permanent Forum on Indigenous Issues.
- United Nations WomenWatch. 2009. “Women, Gender Equality and Climate Change.”
- Richard Wilkinson and Kate Pickett. 2011. The Spirit Level: Why Greater Equality Makes Societies Stronger. Bloomsbury Press

Lecture 4: Impacts and Barriers to Solutions: Climate Change Impacts on Human Health

Lecturer: Gina M. Solomon, M.D., M.P.H., Clinical Professor of Medicine, UCSF
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List of Modules		
Module 1 Air: Hot & Dirty	Module 2 Water: Dry or Drown	Module 3 Disease: The Coming Plagues?

Overview

Common misperceptions of climate change include that it will not directly affect "us" (people in the United States, our local community, or our family), and that it will occur gradually and almost imperceptibly over the next century. This session demonstrates the direct and indirect links between climate change and human health, with examples intentionally focused on California to bring it home to the students. It also emphasizes the sometimes dramatic manifestations of climate change as weather patterns shift, causing more extreme droughts, fires, storms and floods. The first module focuses on air pollution and heat, both of which directly impact human health. The section on air pollution also touches on the air quality impacts of fossil fuel combustion. The second module emphasizes extreme weather events, including hurricanes, floods, droughts, and fires, with an emphasis on both the direct and the indirect health effects. The final module covers shifting patterns of infectious and non-infectious diseases, including vector-borne disease and harmful algal blooms. The key message at the end is that there are solutions that are a double-benefit because they help protect public health and also mitigate climate change. The hope is to motivate students around these win-win solutions.

Lecture Review Questions:

1. All of the following can trigger asthma attacks and are projected to worsen with fossil fuel combustion and climate change, <u>except</u>:
   a. Ozone ("smog")
   b. Ragweed pollen
   c. Carbon dioxide
   d. Particulate matter pollution

2. Which of the following health effects can occur after flooding?
   a. Injuries from falling or moving debris
   b. Skin or gastrointestinal illnesses
   c. Mental health problems
   d. All of the above

3. Heat waves have been linked to:
   a. More emergency department visits in cooler coastal areas than in hot inland areas
   b. Big increases in hospitalizations from asthma
   c. Decreases in violent crime rates
   d. Lower levels of ozone in the air

4. Which of the following patterns of illness are predicted with climate change?
   a. Lyme disease will move south into the tropics
   b. Dengue fever may move north into the southern half of the U.S.
   c. Illnesses from toxic algae will be less frequent
   d. California will be relatively unaffected by climate-related illnesses

5. Which of the following strategies can help reduce vulnerability to climate change's health effects?

a. Plant trees to keep communities cooler
b. Ensure access to medical care for everyone who needs it
c. Foster strong communities where people know and help their neighbors
d. All of the above

Discussion Questions:

1. What are two illnesses predicted with climate changes and what are the driving causes? How can we mitigate them?

2. Climate change worsens existing public health challenges. What is the general solution in one sentence in how public health can play a role?

3. How is massive population displacement one of the most serious impacts of climate change?

Class Activities:

1. Which of the health issues discussed in the modules concerns you most directly? Are there other health threats that might be linked to climate change?
    a. Not all climate-health threats are covered in these modules, and some are mentioned only briefly. Students could read more and identify other issues of concern. Students might also be motivated to learn more about specific health links. For example, a student who has asthma might be interested in learning more about the air pollution links, whereas a student whose family lives in Florida or Texas may want to focus on the health effects of hurricanes.
    b. Possible additional areas to explore include: crop loss/hunger, loss of critical species such as pollinators, fisheries collapse, waterborne disease outbreaks, other vector-borne diseases, massive population displacement, conflict/war. Students could be asked to form pairs or groups and research any of these links, or those covered in the modules, and do a short presentation for the rest of the class.

2. What are the most significant climate vulnerabilities on your campus and in your community?
    a. Students could research local vulnerability to sea level rise, riverine flooding, wildfire, air pollution, and other threats covered in the modules. There are California resources available that contain local information, including http://cal-adapt.org/, the Adaptation Planning Guide: http://resources.ca.gov/climate/safeguarding/local-action/ , the CalBRACE project: https://www.cdph.ca.gov/Programs/OHE/Pages/CC-Health-Vulnerability-Indicators.aspx. The California Department of Public Health (CDPH) has also produced climate vulnerability reports for many counties on California: https://www.cdph.ca.gov/Programs/OHE/Pages/ClimateHealthProfileReports.aspx.

b. Challenge the students to identify the top 3 vulnerabilities that they would worry about on campus or in the local community. They could then discuss what strategies might work to reduce these vulnerabilities and enhance resilience.

3. What are the vulnerabilities in your community?
   a. Students could choose different neighborhoods (with different socioeconomic or other characteristics) and do walk-throughs of those neighborhoods in pairs or small groups. They should develop and use checklists to identify factors that could increase vulnerability or resilience.
   b. Students could document the number of trees per block, green spaces, and the estimated square meters of paved surface as an estimate of the urban heat island effect https://www.epa.gov/heat-islands/learn-about-heat-islands. They could look at the buildings to see if there are air conditioners, cool roofs, and other factors that could protect occupants against excessive heat. They could also evaluate vulnerability to fire and flood on the ground and on maps. Bike lanes and sidewalks could also be documented, as could demographics (i.e. elderly, young children, disabled, who might be more vulnerable). The groups could document their findings and present them in class.

4. What can you do to reduce climate vulnerability?
   a. Students could brainstorm and make commitments of things that they will do to increase climate and health resilience in their family or community.
   b. Examples could include anything from checking on elderly relatives or neighbors during heat waves, to assembling an emergency kit for their home or their car, to educating their family or friends about links between climate change and health, to raising money for storm or wildfire victims or refugees. Other students may want to take various actions to reduce their own GHG footprint that are also health-protective (e.g. eating less meat, bicycling or walking more, etc.) The goal would be for each student to make a commitment to taking some action after this class.

5. How would you communicate to others the important links between climate change and our health?
   a. Students could develop their own ways to transmit this information to various audiences. They would first pick an audience (e.g. the general public, policymakers, university officials, other students, etc.). Then they would develop materials to communicate the information to these audiences.
   b. Products could include short videos, mock news stories, an op-ed, tweets, Facebook posts, cartoons, collages, paintings, a rap, their own PowerPoint presentations, a factsheet, or whatever they want to create.

Notes to instructor: The goals of these exercises are generally to get the students to look around them and think about the place where they are living and how they can ultimately help make it better and more resilient for the benefit of everyone living there. The hope is to turn the students into informed observers who can identify vulnerabilities and think creatively about local solutions,

whether in their home or their dormitory, or their community, and ultimately in other communities around the world.

Resources:

Overviews on Climate and Health:
The Lancet's series on climate and health: http://www.thelancet.com/climate-and-health
U.S. Global Change Assessment: https://health2016.globalchange.gov/

California websites with useful information on local climate vulnerabilities:

- Great general resource: http://cal-adapt.org/
- The Adaptation Planning Guide: http://resources.ca.gov/climate/safeguarding/local-action/
- The California Building Resilience Against Climate Effects (CalBRACE) project: https://www.cdph.ca.gov/Programs/OHE/Pages/CC-Health-Vulnerability-Indicators.aspx.
- The California Department of Public Health (CDPH) climate vulnerability reports: https://www.cdph.ca.gov/Programs/OHE/Pages/ClimateHealthProfileReports.aspx.

Lecture 4: Impacts and Barriers to Solutions: Sea Level Rise From Melting Ice

Lecturer: Eric Rignot, UCI Department of Earth System Science
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List of Modules		
Module 1 How Melting Happens	Module 2 History of Melting	Module 3 What We Can Do

Overview: This lecture provides fundamentals about how polar ice sheets melt in a warming climate, the physical processes of melt, how they relate to climate warming induced by emissions of greenhouse gases (Module 1), how much sea level rise is held in polar ice sheets, how ice sheet mass balance is being observed, how much ice sheets contribute to sea level at present, and what are the sectors at risk of contributing to rapid sea level rise in the future and why (Module 2). The last part of the lecture discusses what could be done about it, especially in the context of irreversible ice sheet retreat, and with regards to paleo records of rapid sea level rise in the past (Module 3).
In Module 1, the students are introduced to the physical processes that drive the decay of ice sheets, which is not just the melt from the ice surface but also the enhanced flow of glaciers to the oceans; emphasizing that the latter is the main vector of rapid change with the most uncertainty. We also introduce the connection between what is happening in the polar regions and greenhouse gas emissions. The Arctic and Antarctic are quite different, and it is important to understand these differences. The second module teaches the students about the sectors at risk so that they appreciate what is at stake and the consequences of unabated climate warming on sea level rise. The students will then learn that changes are widespread and already significant. In the final module, the students will learn that while some sectors are already retreating in an irreversible manner, a return to a colder climate, aka climate conditions of the 1980s, would slow down the process of decay, which means that prompt action on climate change can save the planet from the most disastrous sea level rise scenarios, but time is running out quickly.

Lecture Review Questions:

1. True/False: Ice melt in Greenland is almost entirely due to melting of the ice/snow surface from warmer air temperature.

2. True/False: We have not reached the point of no return in any part of Greenland or Antarctica.

3. True/False: The melting of ice sheets is not clearly related to climate warming.

4. True/False: The impact of climate warming is nearly the same in the Arctic and the Antarctic.

5. True/False: A warming at 1.5 degrees C above pre-industrial level is going to protect us from sea level rise from the ice sheets.

6. True/False: There are no solution readily implementable to transition to a carbon-free energy production. There is no solution to sequester carbon and return to pre-industrial GHG concentrations.

Discussion Questions:
1. Greenland and Antarctica are some of the most important regions for sea level rise. What are two other places you think are critical contributors?

Research and post two links to articles that you think best describe the process and/or impacts of melting ice.

Class Activities:

1. Go interview your community: classmates, people in the hallway, family members about melting of ice in the polar regions. Ask them: 1) do you believe in climate warming? 2) if scientists tell you it is real, are you willing to trust their reporting? 3) What evidence would convince you that ice is melting at the poles? 4) do you think ice melting at the poles is something that will happen in the near future, is already happening, or is fake news; 5) do you know how much sea level is locked in the ice sheets? Greenland? Antarctica? 6) do you think scientists have a good idea of how fast ice is melting into the ocean? 7) Do you know what the projection for sea level rise is for the end of the century; 8) do you know whether sea level rise will keep happening for centuries? 9) do you know if there is anything we can do about this, and if someone knows what to do, would you be willing to listen and take action?

2. Consider the impact of sea level rise along coastal areas. Try to imagine the impact of a 1 m sea level rise versus a 10 m sea level rise. Go on the web and find resources that conducted simulations of coastal flooding. Discuss among yourselves what went into the model and what could be the shortcomings of these models.

Resources:

For Educators with background in physical sciences
IPCC: Climate Change 2013. The Physical Science Basis: Frequently Asked Questions.
https://www.ipcc.ch/report/ar5/wg1/docs/WG1AR5_FAQbrochure_FINAL.pdf

Lecture 5: Lessons from California

Lecturer: Daniel Press, UC Santa Cruz, Environmental Studies Department
dpress@ucsc.edu

List of Modules					
Module 1 50 Years of California Policies: Air Quality	Module 2 50 Years of California Policies: Energy	Module 3 California: Big State & Small Energy Demand	Module 4 California's Climate Change Policies: AB 32 2006	Module 5 AB 32 Policies & Implementa-tion	Module 6 Beyond AB 32

Overview: This lecture introduces students to the steps that one climate change leader, California, has taken to reduce its greenhouse gas (GHG) emissions across a wide range of economic activities. Given the magnitude of the climate change challenge, it's easy to conclude that brand new or as-yet undiscovered mitigation and adaptation policies will be needed. But California's experience shows that decades-old policies and programs designed to improve air quality and energy efficiency, as well as spur large-scale use of renewable power sources, can all be used to combat climate change. So, climate change policies are neither unknown nor untried; indeed, much of the policy implementation required simply builds upon existing efforts that are widespread and well-understood. This lecture draws primarily from environmental policy and history literatures, with some attention to the engineering or technology dimensions of air and energy programs in California.

Module 1 begins with some history, discussing how very poor air quality, especially in the Los Angeles basin, spurred activists, scientists and policymakers to act. As is the case with many policy issues, early attempts often focus on defining the problem at hand. With regards to air quality, scientists first had to show how urban photochemical smog was formed, and then link smog formation to human activity, in general, and mobile sources (autos and trucks), in particular. All of California's air quality programs and regulations achieved great reductions in air pollution, but more needs to be done before all of the state's residents have access to healthful air.

Module 2 reprises the themes in module 1, but focuses on California's innovative energy policies instead of air quality. Module 3 shows that California's energy policies also succeeded (with occasional stumbles), thereby greatly improving the state's energy efficiency and greening it power generation mix (towards renewables and away from fossil fuels). These energy gains have resulted in a state whose carbon footprint, in tons of CO2 equivalents per capita, is much lower than the rest of the US, but still higher than the world average. Module 4 introduces students to the concept of policy tools, especially contrasting traditional command-and-control regulation with market incentives such as taxes and tradeable permits. Module 4 then goes on to introduce AB 32, California's landmark climate bill, the Global Warming Solutions Act of 2006. Module 5 covers the mix of strategies California employs to implement AB 32 and related legislation. The final module (6), takes students beyond AB 32, showing what challenges remain in reaching California's climate policy goals and what some future approaches might look like.

Lecture Review Questions:

1. True or False: One of the shortfalls of renewable energy is the seasonality of the resources.

2. One of the challenges of climate change is the _____ threat that makes it harder for humans to react to.

3. Stabilizing the climate will require _____ fossil fuel CO2 emissions?
   a. 25% reduction
   b. 50% reduction

c. 75% reduction
d. 100% reduction

4. Which is not a political & behavioral challenge discussed in the lecture?
   a. Psychological biases
   b. Public goods problem
   c. Collective teamwork
   d. Problem invites “risk seeking” behavior

Discussion Questions:

1. Research and share two specific obstacles, one from each category of obstacles to the climate change problem as discussed in the lecture, that you see in an industry of your choice.
2. How is collective action a problem in climate change?

Class Activities:

1. Of the 6 challenges presented, which one do you think is greatest? Have you seen examples of these challenges in your community?
2. How can we work towards solving economic challenges of decarbonizing energy?

Lecture 6: Carbon Neutrality Initiative of UC

Lecturer: Matthew St. Clair, UC Office of the President
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List of Modules		
Module 1 What Role Can Universities Play?	**Module 2** UC's Carbon Footprint and Climate Solutions	**Module 3** UC's Education Footprint

Overview

This lecture aims to share the roles that universities can play in addressing global climate disruption. By showing how UC is an example of such a role, this lecture demonstrates how UC can act as a framework transferrable to other large organizations. Additionally, this lecture communicates how addressing climate change as an organization is still a work in progress: there continues to be large barriers in achieving net carbon neutral emissions at UC.

Lecture Review Questions:

1. What is the biggest source of greenhouse gas emissions for UC?
   a. Electricity
   b. Natural gas
   c. Water

2. Which is not a UC Policy Goal for 2020?
   a. Reduce greenhouse gas emission to 1990 levels
   b. Achieve zero Waste
   c. Reduce potable water usage by 50%
   d. Procure 20% sustainable food

3. Check all projects that are part of UC's educational footprint programming:
   a. Water-Energy-Climate Nexus Living Laboratory
   b. Battery Energy Storage Living Laboratory
   c. Faculty Climate Action Champions
   d. Carbon Neutrality Student Fellowship Program
   e. Cost Avoidance through Energy Efficiency

4. Check all that is a UC Policy Goal for 2025
   a. Achieve carbon neutrality
   b. Strive to have at least 4.5% of commuter vehicles be zero emissions vehicles
   c. Reduce potable water by 36%
   d. Zero emissions or hybrid vehicles account for 50% all campus vehicle
   e. Reduce percentage of commutes by single occupancy vehicles by 10%

5. True or False: How to communicate complexity and how to change organizational culture and decision-making is a barrier and challenge to climate change.

6. True or False: Biogas is a silver bullet for achieving carbon neutrality

7. True or False: Effective leadership can overcome most challenges.

Discussion Questions:

1. What are the typical carbon neutrality strategies?

2. What examples of these strategies have you observed on your campus?

3. What role did students play in getting the UC to commit to sustainability and climate action goals, and how can this be used to inspire future students?

4. What is the biggest source of greenhouse gas emissions for UC and why might that be the case?

Class Activities:

1. What can individual students, faculty, and staff do to further the goal of carbon neutrality?

2. How does UC's approach compare to that of large cities and companies, or even the state of California?

Lecture 6: Bending the Curve: Lessons from UC: Energy Efficiency Management at UCI

Lecturer: Jack Brouwer, UC Irvine
jb@apep.uci.edu

List of Modules			
Module 1 Energy Efficiency: Overview	Module 2 Energy Efficiency: Campus Operations	Module 3 Energy Efficiency: Generation of Power	Module 4 Energy Efficiency: Utilization of Power

Overview

This lecture provides an overview on the impacts of energy efficiency and how it can be embodied by the UC system. The lecture shows how solar and fuel cell power generation are complementary sources of power, and walks through the power generation dynamics and end-use dynamics of these systems.

Lecture Review Questions:

1. True/False: The Los Angeles basin has met air quality standards for ozone, a component of smog, for many years.

2. About how much of California's electricity is produced by renewable sources like hydro, solar and wind?
   a. 75%
   b. 90%
   c. 40%
   d. 20%

3. Policy tools, like taxes or tradeable permits, generally have the following features:
   a. Government specifies environmental quality goals, but not how the goals should be achieved.
   b. Government specifies environmental quality goals and how the goals should be achieved.
   c. Government dictates the technology that must be used for pollution control.
   d. Government provides information so that consumers can make "greener" choices.

4. California's climate strategy includes which of the following elements?
   a. Large-scale geoengineering projects to scrub CO_2 from the atmosphere.
   b. Increases in nuclear power for electricity generation.
   c. Billions of dollars in urban mass transit projects.
   d. A doubling of energy efficiency in existing buildings throughout the state.

5. True/False: California is on track to meet its AB 32 goal for 2020.

6. True/False: Total greenhouse gases related to transportation emissions in California started to go down in 2008 and have never reversed course.

Discussion Questions:

1. How did the geography of the Los Angeles basin exacerbate the photochemical smog problem? How do you think geographic features of your hometown help or hinder air pollution control?

2. What do you think of the California Climate Strategy? Which do you think has the greatest impact on bending the curve?

3. Module 5 discusses the accomplishments and shortcomings of AB32. Discuss with your peers what you think of the Act – did it succeed or fail? Why or why not?

Class Activities:

1. Module 2 discusses many of the energy efficiency and renewable power efforts implemented in California over the last 40-50 years. Are any of these familiar to you? For example, do you know if your appliances or car are relatively efficient or inefficient? How can you tell?

2. Check out the California Energy Commission and/or your local utility's websites on energy efficiency and renewable energy. Are energy audits available? Do they offer rebates for renewable energy equipment (like solar panels) or energy efficient appliances?

3. Module 4 introduces different kinds of policy tools. We encounter many of these every day. Think of one policy using a command and control approach. How might the same thing be accomplished with a market incentive such as a tax or tradeable permit?

4. Ultimately, California's climate policy innovations will be most effective if they are widely adopted around the world. Give some thought to which approaches you think might be most promising in different parts of the US and in other countries.

Lecture 7: Science & Technology Pathways for Bending the Curve: Energy Technology Pathways

Lecturer: Scott Samuelsen, UCI
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List of Modules		
Module 1 Energy Demand and GHG Intensity through 2015	Module 2 Role of Combustion	Module 3 Paradigm Shifts in Electricity & Transportation

Overview

This lecture describes the evolving energy technologies and associated paradigm shifts in response to environmental pressures (climate change, urban air quality), geopolitical pressures, finite natural resources, and national security (fuel independence). The focus is on the major energy sectors, the generation, distribution, and use of electricity, and transportation.

Lecture Review Questions:

1. What two products do we derive from combustion?
   a. Major products of combustion, and pollutants
   b. Challenges to climate, and challenges to urban air quality
   c. Useful energy, and exhaust

2. What are the exhaust products of combustion, and how do they affect the environment?
   a. Major products of combustion (including CO2, climate change) and pollutants (urban air quality)
   b. electric power, and vehicle power
   c. CO, HC, and NOx

3. In addition to contaminating the atmosphere with carbon and pollutants, what other major impact does combustion have on the atmosphere?
   a. Consumption of air
   b. Consumption of oxygen
   c. Emission of particulate

4. What are the major attributes that differentiate fuel cells from combustion?
   a. Combustion generates carbon emissions and fuel cells do not
   b. Efficiency, emission of pollutants (none from fuel cells), and noise
   c. Combustion uses natural gas and fuel cells do not

Discussion Questions:

1. What is your main mode of transportation and what is the principal technology used historically and today to power it?

2. Name a reason for the paradigm shifts in the generation of electric power and vehicle power and a potential enabling factor for that shift not mentioned in the lecture.

3. What is the role of combustion in your life?

4. What is a paradigm shift and what is the last paradigm shift that you encountered?

Class Activities:

1. What is an example of a “paradigm shift” that you have seen in your community? Would this be a perceived as a shift for others in your community? Why or why not?

2. Based on what you have learned so far, which renewable energy source would you like to implement for transportation and why? Compare and contrast with another student’s answer.

Lecture 7: Science & Technology Pathways for Bending the Curve: Transportation Pathways for BtC

Lecturer: Daniel Sperling, UC Davis
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List of Modules		
Module 1 Energy Demand and GHG Intensity through 2015	Module 2 Role of Combustion	Module 3 Paradigm Shifts in Electricity & Transportation

Overview

This lecture focuses on the impact that transportation has on climate change and its role in bending the climate change curve. It highlights the challenges that society faces in shifting to sustainable transportation and how the solutions to these challenges require transdisciplinary approaches—political, technological, and economic.

Lecture Review Questions:

1. True or False: Transportation is largest emitter of GHGs in California and the US.

2. Which is not a leg of the "3-legged stool" framework?
   a. Vehicle Use
   b. Vehicle Code
   c. Vehicles

3. True or False: Buses are less energy intense (per passenger mile) than cars in the US.

4. Which is not true?
   a. Petroleum is an ideal fuel for vehicles in many ways
   b. Almost exclusive dependence on oil means a slow transition to transportation energy alternatives
   c. Very low carbon vehicle technologies are ready for the mass market
   d. Fossil energy revolution is resulting in more oil at lower cost

Discussion Questions:

1. What role does transportation play in producing carbon emissions? Research metrics in your county.

2. What does the three-legged stool represent and how does each leg contribute to a strategy for reducing emissions from the transportation sector? Which strategy do you support the most?

Class Activities

1. How do transportation problems and solutions vary from location to location? Choose two cities with different transportation infrastructure and compare them. Highlight why a "one solution fits all" approach may not be appropriate.

2. Provide examples of activities that addresses each leg of the stool that can be completed on an individual, state, and national level.

Lecture 8: Your Leadership

Lecturer: Hahrie Han, UCSB Department of Political Science
hahrie@ucsb.edu

List of Modules				
Module 1	**Module 2**	**Module 3**	**Module 4**	**Module 5**
Why Collective Action?	What is a Social Movement?	What is the Role of Leadership?	What Can I Do? (Part 1)	What Can I Do? (Part 2)

Overview:

This lecture is intended as an introduction to role of social movements in helping to create climate solutions. It draws primarily on research from political science and sociology and discusses why we might need a social movement (Module 1), what a social movement is (Module 2), introduces the role of leadership in social movements (Module 3), and identifies a set of leadership practices students can engage (Modules 4 and 5).

In introducing why social movements and collective action are needed in Module 1, the lecture seeks to help students conceptualize climate change as a problem of political power. Not only do we need technical solutions to solve climate change, we also need to shift the power dynamics in society that make it so challenging for individuals, organizations, and markets to live carbon-neutral lives. This helps ground students in an understanding of why movements are needed.

The remaining modules seek to help students see that no matter what their background is, they can have a role to play. Module 2 defines social movements in a way that helps students see that multiple different kinds of people play a role. Module 3 introduces a concept of leadership that focuses not on positional authority, but instead on the willingness of a person, any person, to commit to trying to engage others in action. Module 4 and 5 then teaches students who have committed to that kind of leadership what they can do to engage others.

Lecture Review Questions:

1. True/False: The right piece of technology will solve our climate problems.

2. What does it mean to think of climate change as a problem of power?
    A. In problems of power, politicians are the ones who have to create the solution.
    B. In problems of power, people who want the change the most don't have the resources they need to make the change they want.
    C. In problems of power, the solutions require a fight, or conflict, to solve it.

3. True/False: Social movements only recruit people who support their cause to join them.

4. Fill in the blank: Social movements seek to make change by recruiting [blank] to take action.

5. True/False: To inspire people to take action, facts are more persuasive than stories.

6. True/False: In social movements, we should not have any hierarchy and allow everyone to work independently.

7. True/False: Research shows that movements that have more money or more people on their side tend to win.

Discussion Questions:

1. How is social movement leadership defined? Do you agree with this? Why or why not?

2. In social movements, what is perceived as success? How might this differ from technology's definition of success?

3. Module 1 argues that climate change is, in part, a problem of power. What are some organizational structures that you think might be part of the problem?

Class Activities:

1. Some people may disagree with or feel uncomfortable with the characterization that climate change is, in part, a problem of power. How about you? Do you agree or disagree? Why do you think it might make some people feel uncomfortable?

2. Module 2 argues that social movements are complex constellations of players and arenas. Look at the list of players who are identified. Can you imagine what role each plays in social movements? Can you think of examples of each type of player in the climate movement?

3. Module 3 argues that leadership begins with accepting responsibility for engaging others. Do you accept the responsibility to engage others around climate solutions? Why or why not?

4. Modules 4 and 5 describe a set of leadership practices that movement leaders use to develop a movement. How comfortable are you engaging those practices? Which seem like they will be hard? Why?

5. Module 4 describes a set of leadership practices movement leaders use to build power. Many of these are dependent on developing relationships with others. Why do movement leaders have to develop relationships with others? How comfortable are you doing so?

6. Make a list of particular players in the climate movement. Compare your list to the list of potential movement players in Module 2. What does that tell us about who is involved—or missing—from today's climate movement?

7. Consider mobilizing a local climate change solutions movement on campus (or within a department on campus) using your favorite (or most popular) social media. Based on the learning in Module 2, develop a plan to identify and engage the players who could affect a social movement at this local level.

8. Your team has been asked to take responsibility for engaging other groups on campus for a climate change solutions awareness day. Your team will develop a plan to identify the key tasks and distribute them among members of your team. Each member will identify leadership practices they will use to ensure the climate change solutions awareness day is a success.

Lecture 9: Behavioral Changes: Changing Social Norms & Behavior

Lecturer: Fonna Forman, UCSD
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List of Modules		
Module 1 Integral Solutions	Module 2 Go Local: Living Laboratories	Module 3 UCSD Community Stations

Overview:

Too often people see climate change as primarily a technological or policy problem – that if we get the policy right, and get the technology right, we can tackle the problem. In this lecture, we address the importance of integrating social solutions as well. How do we change social attitudes and behaviors regarding climate change? We stress the importance of working at the local scale, and focus on cities and universities as institutions uniquely capable of instigating broad social change.

Lecture Review Questions:

1. What does this lecture focus on?
   a. Culture of collaboration
   b. Culture of communication
   c. Culture of challenge

2. Which is not a strategy mentioned is the lecture?
   a. Bottom-up mobilization
   b. Ethical destinies
   c. Technology transfer

3. Which is part of the UCSD Community Stations Agenda? Choose all that apply.
   a. Supporting community-based climate education for students
   b. Increasing knowledge about climate change and environmental health in our partner communities
   c. Stewarding high-impact climate interventions at neighborhood scale

4. Which is not part of the UCSD Community Stations?
   a. UCSD Garden
   b. UCSD EarthLab
   c. UCSD CASA
   d. UCSD DIVINA

5. True or False: Bogota and Curitiba are cities that exemplifies municipalities committed to equitable green urbanization.

Discussion Questions:

1. How have Latin American cities been so successful at tackling problems of climate change while reducing social disparity?

2. What are some of the social barriers of technology transfer?

3. What does it mean to take an “integral” approach to tackling climate change? What are the benefits and difficulties of such an approach?

Class Activities:

1. Why have mayors been such successful agents of progressive climate action? Why have so many cities become important living laboratories?

2. Why are universities particularly well-suited to lead local climate action initiatives? What is your university doing? How can the UC San Diego Community Stations model be scaled?

3. Why is changing social attitudes and behavior essential to tackling climate change?

Notes to instructor: The material in this lecture is less suited to a structured multiple choice or true / false quiz than other lectures in the course, since the goal here is to provoke students to reflect on the social determinants of climate change, and the opportunities for changing values and behaviors. There are few "hard facts" in this lecture, other than the case studies offered to demonstrate public opinion research findings on how attitudes and behaviors change.

To review student engagement, I would recommend requesting a one-paragraph response to the following question: Why is changing social attitudes and behavior essential to tackling climate change?

Resources:

UC San Diego Community Stations: http://blum.ucsd.edu/comsta.html
UCSD EarthLab: http://groundworksandiego.org/earthlab/the-earthlab/
Project Surya: http://www.projectsurya.org/

Lecture 9: Behavioral Changes: The Role of Religion in Bending the Curve

Lecturer: Jack Miles, UC Irvine
milesj@uci.edu

List of Modules		
Module 1 Blind and Lame	**Module 2** When Washington Won't	**Module 3** Neither Blind Nor Lame

Overview

The key premise of this lecture is that our course as a whole aims to **bend** the curve, not just to observe it, and to **motivate climate stabilization**, not just to enumerate the consequences of destabilization. Motivation can come from political ideology, commercial interest, aesthetic inspiration, philosophical conviction, inter-generational solidarity, academic ambition, or religious faith in any of its many forms. This lecture illustrates religious motivation with two examples in Module 3, but the lecture's most important point is that **facts alone do not confer motivation to act on the facts**. Thus, merely educating the public about the facts of global warming does not in itself bend the curve of public opinion toward mobilization. Something else, whatever it is, must be brought to bear.

Module 1 acknowledges the historical tension between science and religion in the West but then, quoting Einstein, claims that science and religion can nonetheless play complementary roles. Module 2, noting that time is now short for major climate stabilization, details the ways that the Trump Administration has halted or reversed all federal measures addressing the climate crisis. The point? In the immediate future, efforts that bypass national politics and go directly to the public are more important than ever, and religious engagement is one potentially theater for that public appeal. Module 3 offers the mentioned two examples, both Christian, after a prelude on how great social movements often begin in private dreams. These two religious options are **not** the only two, however: a point stressed in the conclusion.

Pedagogically, given that many students (not to mention many professors) are irreligious, the utility of a lecture focusing on religion is the way that it highlights the necessity—for atheists and agnostics no less than for religious practitioners—to invoke something more than sheer fact when attempting to "convert" a climate-change skeptic or agnostic or the typical "no-opinion" man-on-the-street to join a new public constituency motivated to bend the curve nationally and internationally.

What motivates **you?** What do you go by? How do you move from any given value system to commitment or even activism to save the planet when nobody is paying you for your time? That's the core question.

Discussion Questions/Class Activities:

1. What history underlies suspicion of religion as a potential partner in a coalition for climate stabilization? Give an example.

2. Do you yourself trust the motives of religious leaders? Do you trust the motives of scientists? Do you trust the media? Facebook? Among people you know outside the university, what category of leadership is most trusted?

3. Why are Evangelical Christians of special importance in this connection? What portion do they constitute of the American population?

4. In what sense is science without religion lame? Do correct data compel "correct" social action in an area like climate change? If your goal were to motivate "climate change warriors," what values, if any, could you assume that you and your target audience have in common?

5. How would you reply to someone who intends to take no action to stabilize the climate because, he asks, “What has posterity ever done for me?”

6. Stage a classic debate, pro and con the advisability of involving organized religion in an effort to stabilize the world’s climate. Thus,
   RESOLVED: Organized religion can and must be drawn into any global effort to slow global warming and stabilize the climate.
   Divide the class in two (Affirmative vs Negative), and then in two again (Statement and Rebuttal).
   Group Affirmative One offers an opening statement defending the resolution.
   Group Negative One offers a rebuttal.
   Group Negative Two offers an opening statement attacking the resolution.
   Group Affirmative Two offers a rebuttal.

7. Why is it important to pursue rapid climate mitigation?

8. If no significant action can be expected from the federal government on behalf of climate stabilization, are there other American actors who aspire to take up the slack? If so, who are they?

9. Which is easier: persuading officeholders whose minds are made up about climate change, or changing the public mind and thus transforming the electorate as happened, e.g., in the Civil Rights Movement?

10. Each student has seven elected representatives responsible for taking a position, one way or another, on the pressing matter of climate change: the President, two U.S. Senators, one U.S. Representative; the Governor, one State Senator, and one State Assemblyperson. Each student is assigned to determine the position of at least one representative (other than the president) and as many as six, and then to report his/her findings to the class. Presentations can be staged over several classes. A key background issue: is California taking up the slack left by Washington’s withdrawal from international engagement with climate change? Another: for which representatives is this a priority, and for which isn’t it?
    This classroom activity can obviously be modified for other U.S. states or other democratic countries.

11. Rev. Martin Luther King Jr. electrified America with his “I have a dream” speech preached on the Washington Mall in the nation’s capital. That was a civic dream that originated, however, in a private, religious dream. Can you imagine something similar happening in other domains than civil rights?

12. Pope Francis argues that your dignity, your own self-respect, dictate that you should be committed to saving Planet Earth from global warming. Do you agree? Do you feel that working to mitigate global warming is a moral obligation? If so, on what basis? The pope offers one. Can you think of another? Or do you believe that there is and can be no moral obligation?

13. Of the Christian motives for climate change that the "Call to Action" enumerates, which, if any, speak to you? Which can you imagine using to "convert" a friend to climate change activism?

14. Many who are "spiritual but not religious" have no particular hostility toward religion but no interest in being part of organized religion. Does this description fit you? If so, can you devise a new way to combine more "humanistic" motives with effective organization of the sort that served the Civil Rights Movement so well in the 1960s, but this time in defense of the planet? Does, say, https://350.org constitute such a winning combination? If not, what would?

15. Conduct this thought experiment. You have the opportunity for an all-expenses-paid, round-trip visit to Paris. (Any comparably distant destination may be substituted.) This trip is purely a vacation, and you have no reason to go than the pure pleasure of being a tourist in an exciting and interesting new place. BUT you know that your round-trip flight will quadruple your carbon footprint, dumping tons and tons of carbon dioxide into the atmosphere. In the short run, there is nothing, absolutely nothing, within your reach that will do more harm to the planet than your taking this trip. What consideration—religious, philosophical, political, or other—would persuade you to put the long-term interest of the planet ahead of your short-term recreational interest?

    This is an exercise that can be modified to work in the third person. Thus, "A friend of yours has been given the opportunity for an all-expenses-paid," etc. And then, "What argument would you use to persuade your friend to put the long-term interest of the planet ahead of her short-term recreational interest?"

Note to instructor: Though, of course, no one's religious affiliation or otherwise may be made to play a role in his/her hiring or other participation in university life, there is no bar against inviting students, on a purely voluntary basis, to discuss their religious identity, affiliation, attitude pro or con, and so forth. From this starting point, doors may open into various exercises leading a student informed by "Bending the Curve" out into one or another community whose known values may be linked, motivationally, to the agenda of climate stabilization. In this regard, each class's enrollment will be different—some rich in such opportunities, others poor. The instructor has the option of inquiring and then exploring possibilities.

Review Questions:

1. True or False: Given the mingled history of science and religion, conventional wisdom assumes that the two will be natural partners in confronting a major environmental crisis.

2. True or False: The history of race relations in the West proves that once people know the scientific truth about race, racial justice quickly follows.

3. When Einstein wrote, "Science without religion is lame, religion without science is blind," he meant:
   a. Scientists are often narrow, clergymen are often ignorant.
   b. Scientists must become more devout, clergymen must become more scientific.
   c. Science needs religion for motivation, while religion needs science for information: the two are complementary.

4. True or False: In the absence of top-down, federal support for climate stabilization, the only remaining agency capable of slowing global warming is organized religion.

5. What are the four claims of "Climate Change: An Evangelical Call to Action"?

Notes to instructor:
"Bending the Curve" is a course open to humanities students as well as those in STEM and social science, but I am reliably informed that mine is the only component lecture taught by a humanities professor. As such, it constitutes an opportunity for the instructor to play to the strength of humanities enrollees who, otherwise through much of the course, may feel left out and be scrambling just to keep up. JM milesj@uci.edu

Resources:

Online resources:

The most important and most convenient online resource for the study of religion and ecology, including religion and climate stabilization, is the Yale Forum on Religion and Ecology. http://fore.yale.edu. A newsletter published by the Yale Forum now goes out to some 10,000 subscribers.
Jones, Robert et al. Believers, Sympathizers, & Skeptics, Why Americans Are Conflicted About Climate Change, Environmental Policy and Science, findings from the PRRI/AAR Religion, Values, and Climate Change Survey (Washington DC and Atlanta, GA: Public Religion Research Institute and American Academy of Religion, 2014). 45 pp.

This is the survey some of whose results are cited in Module One.

Book, journal, or film resources:

Bergoglio, Jorge Mario, Pope Francis. Encyclical Letter Laudato Si' of the Holy Father Francis on Care for Our Common Home. 98 pp.

http://w2.vatican.va/content/francesco/en/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si.html

Carroll, John E. et al, editors. The Greening of Faith: God, the Environment, and the Good Life (Hanover and London: University Press of New England, 1997), foreword by Bill McKibben. 228 pp.

An anthology notable for collecting statements and theoretical reflections from a variety of different religious traditions and philosophical perspectives.

Cobb, John, Jr., and Herman E. Daly. For the Common Good: Redirecting the Economy toward Community, the Environment, and a Sustainable Future, second edition, updated and expanded (Boston: Beacon Press, 1994). 534 pp.

A major theoretical synthesis by a noted theologian, Cobb, and a senior economist, Daly.

Daedalus, Fall 2001 (MIT Press), Religion and Ecology: Can the Climate Change?

Available gratis as a PDF download. This bellwether learned journal devoted an entire issue to the subject of religion and ecology—a major early state-of-the-question survey.
https://www.amacad.org/content/publications/publication.aspx?d=845

Gardner, Gary T. Inspiring Progress: Religions' Contributions to Sustainable Development (New York: W.W.Norton, 2006). 209 pp.

A short book but packed with concrete examples of environmental activism under religious auspices, with acknowledged debts to Gardner's earlier work with the Worldwatch Institute.

Gardner, Gary. Invoking the Spirit: Religion and Spirituality in the Quest for a Sustainable World (Washington DC: Worldwatch Institute, Worldwatch Paper 164, State of the World Library, 2002). 62 pp.

From the opening summary: "Religions possess one or more of five sources of power. They shape people's worldviews, wield moral authority, have the ear of multitudes of adherents, often possess strong financial and institutional assets, and are strong generators of social capital, an asset in community building. All of these assets can be used to help build a socially just and environmentally sustainable world."

Gore, Al. Earth in the Balance: Ecology and the Human Spirit (New York: Plume, 1992). 407 pp.

Gore's Academy Award-winning film (and companion book) An Inconvenient Truth is now better known than this earlier book, written when he was still a senator and then vice-presidential candidate, but this book deals explicitly with the role of values, spirituality, and religion—an area that An Inconvenient Truth chose to omit.

Gottlieb, Roger S. A Greener Faith: Religious Environmentalism and Our Planet's Future (New York and Oxford: Oxford University Press, 2006). 312 pp.

This is a work that has been successfully used in a course on religious environmentalism at UC Irvine. Gottlieb, a professor of philosophy at Worcester Polytechnic, visits, describes, and reflects upon a set of American instances of effective environmental activism under widely varying religious auspices.

Gottlieb, Roger S., editor. The Oxford Handbook of Religion and Ecology (New York and Oxford: Oxford University Press, 2006). 662 pp.

This reference book has three divisions. In the first, different contributors engage different religious traditions under the heading of environmentalism. In the second, a set of theoretical or political issues relevant across various traditions are presented, including genetic engineering, ecofeminism, and several others. In the third, activism is surveyed with a global perspective, specifically including Latin America and Africa.

The Green Bible (New York: HarperOne, 2008).

This is an edition of the learned 1989 New Revised Standard Edition of the Bible with ecologically relevant verses printed in green type. Classic "red-letter" editions of the Bible printed the words of Jesus in red. This edition borrows and adapts that idea. The work has a foreword by Nobel Laureate South African Bishop Desmond Tutu. A useful tool, especially in Evangelical Christian contexts, but not easily employed by the general reader since the relevance of green verses is never explained and is only sometimes immediately evident.

Grim, John and Mary Evelyn Tucker. Ecology and Religion (Washington, D.C.: Island Press, 2014, in the Foundations of Environmental Studies Series).

Described by its publisher as a "primer," this work traces four key themes across four religious traditions: Native American Religion, Orthodox Christianity, Confucianism, and Hinduism. It notes how religious teachings have variously promoted or retarded ecological well-being.

Grim, John, Willis Jenkins, and Mary Evelyn Tucker. Routledge Handbook on Religion and Ecology (London and New York: Routledge, 2017).

A new overview by two of the "founding fathers" (and an important founding mother) of this emergent field, foregrounding diverse understandings of the key terms religion and ecology.

Hescox, Mitch and Paul Douglas. Caring for Creation, The Evangelical's Guide to Climate Change and a Healthy Environment (Minneapolis: Bethany House, 2016). 184 pp.

This is a breakthrough statement by Hescox, an Evangelical pastor, and Douglas, an Evangelical Christian and a trained meteorologist, who was converted to climate change activism through his observations of extreme weather events.

McKibben, Bill, editor. American Earth: Environmental Writing Since Thoreau (New York: Library of America, 2008), foreword by Al Gore. 1047 pp.

A major literary anthology with a political edge that grows sharper in the later entries, published by the premier publisher of American literary classics, the Library of America.

McKibben, Bill. The Comforting Whirlwind: God, Job, and the Scale of Creation (Cambridge, MA: Cowley Publications, 2005). 73 pp.

A personal meditation by McKibben, a practicing Methodist Christian, published by Cowley Publications, a ministry of the brothers of the Society of John the Evangelist, a monastic order in the Episcopal Church.

Religions of the World and Ecology. This is the overall name of an extensive series of volumes in the format "_____ and Ecology"—for example, Islam and Ecology. Here is a link to the relevant page at Harvard University Press:
http://www.hup.harvard.edu/collection.php?cpk=1057

Ostrow, Marty and Terry Kay Rockefeller, producers. Renewal. www.renewalproject.net. 2015

This is a ninety-minute documentary film about eight episodes of activism in defense of the environment, each under the auspices of a different religious tradition. The noted Bill McKibben said of it, "The religious-environmental movement is potentially key to dealing with the greatest problem humans have ever faced, and it has never been captured with more breadth and force than in Renewal. I hope this movie moves many more people off the fence and into action."

Tucker, Mary Evelyn. World Wonder: Religions Enter Their Ecological Phase (Chicago, Open Court, 2003). 166 pp.

Tucker's original academic training was in Chinese religion. This monograph grew from the Second Memorial Hsüan Hua Lecture, honoring a twentieth century Chinese Buddhist thinker and emissary of Buddhism in the West.

Tucker, Mary Evelyn and John A. Grim, editors. Worldviews and Ecology: Religion, Philosophy, and the Environment (New York: Orbis Books, 1994).

A very early anthology of writers inspired by the Catholic environmental theologian Thomas Berry, edited by Mary Evelyn Tucker, the current director of the Yale Forum on Religion and Ecology, mentioned near the conclusion of Module Three.

Lecture 10: Local and Bioregional Solutions to Climate Change

Lecturer: Keith Pezzoli, Ph.D., UC San Diego
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List of Modules					
Module 1 Localization and the Bioregional Transition	Module 2 Green Infrastructure, Ecosystems & Climate Action Plans	Module 3 Trees	Module 4 Food Forests	Module 5 Food Waste, Energy, and Soil	Module 6 Make Change Happen: Priorities for Action

Overview

This lecture has four learning objectives that will be addressed in the following ways:

1. The first objective deals with the concept of localization. Global demands and stresses on earth's natural systems have generated a need for more localized solutions to climate change. Localization is part of the larger territorial shift in social, cultural, economic and ecological relationships that we call the bioregional transition.
2. The second objective deals with green infrastructure and its importance in climate change mitigation. Green Infrastructure incorporates natural systems and functions into cities and settlements while improving a city's resiliency to climate change. Green Infrastructure utilizes ecosystem structure/function/composition and ecological landscape design as methods for climate change mitigation.
3. The third objective speaks to actions taking place at local levels. This set of three modules includes videos narrated by students that revolve around the theme of local solutions. The narratives identify trees, food forests, and soil not only as solutions for 'bending the curve' (mitigating climate change) but also as mechanisms for addressing social empowerment, food disparities, and environmental justice.
4. The final objective discusses ways in which you, as citizens of bioregions, can become actively involved with local solutions for mitigating climate change. This module provides ways to connect the dots across otherwise disconnected approaches to climate change.

Lecture Review Questions:

1. What is necessary to maintain the health of plants, trees, and the ecosystems they support?
   a. Clean water
   b. Pure air
   c. Fertilizers containing the correct balance of nutrients
   d. A healthy living soil

2. How much food produced for human consumption is wasted due to the inefficiencies of the supply chain and the compilation of food waste?
   a. exactly 50%
   b. more than 66%
   c. more than 33%
   d. less than 10%

3. In what way(s) do/does composting improve the health of the environment?
   a. Composting can improve planetary biomass production.
   b. Composting acts as a carbon sink by sequestering carbon in soils and plants.
   c. Composting rejuvenates the soil by providing it with organic matter that supports insects, annelids, and microorganisms vital to the continuation of biogeochemical cycles.
   d. All of the above

4. _____ of carbon could be sequestered per year in agricultural soils.

a. 500 million tons
b. 1.2 billion tons
c. 10 million tons
d. 9.8 billion tons

5. The products of anaerobic digestion can contribute to which environmental or industrial processes?
   a. Produces sludge that brings nutrients back to the soil as processed organic fertilizer
   b. Produces biogas that can be used to generate electricity, provide natural gas for cooking, or processed for use in fuel cells
   c. A and B
   d. none of the above

6. What benefits do fruit trees bring?
   a. carbon sequestration
   b. shade/cooling
   c. food source
   d. improves soil, water, and air quality
   e. all of the above

7. What benefits de planting fruit trees for yourself and your local community bring?
   a. food security
   b. more nutritious
   c. more variety
   d. control over fertilizer and pesticides
   e. all of the above

8. What's the best way students can get involved with fruit trees?
   a. buy and plant one
   b. visit a local community garden/orchard
   c. read about them online
   d. cold-call experts over the phone
   e. all of the above

9. What is the most important thing to maintain for a healthy fruit tree/food forest?
   a. pure water
   b. healthy soil
   c. clean air
   d. love
   e. all of the above

Discussion Questions:

1. Global political, economic and ecological megatrends are giving rise to urban and rural development strategies referred to as *localization* (in part, as reactions against *globalization*)? Identify one or more of these global megatrends.

2. Around the world there is a rising level of interest in local and bioregional approaches to climate change mitigation and adaptation. Give an example that involves biota (e.g., trees, vegetation) and/or soil.

3. According to an estimate shared during this lecture, how many billion tons of CO2 do experts say we will need to pull out of the atmosphere by 2100 in order to avert major climate disruptions on a planetary scale?

4. Of the estimated 500 to 1000 billion tons of CO2 (or about 150 to 300 billion tons of carbon) that we need to sequester by 2100, how much of this can be accomplished through ecosystem management and restoration?

Class Activities:

1. Evaluate the strengths and limitations of local place-based efforts to address climate change (e.g., solutions focused on neighborhoods, cities and towns), as compared to solutions that are more national and global in scope (e.g., National Climate Plans, Paris Climate Accord)
2. What is green infrastructure? Identify examples of green infrastructure and indicate the degree to which you think these examples might improve climate change mitigation and/or adaptation.
3. Distinguish how a bioregional approach, including the design of local, place-based Natural and Managed Ecosystem Solutions, differs from, and can complement other types of solutions (e.g., Technology-Based Solutions).
4. When it comes to addressing climate change mitigation and adaptation, how important is local community knowledge? Can local community knowledge (e.g., from neighborhood residents, community-based organizations) help improve science-society relations and democratic public reasoning? How so?
5. Anaerobic digesters and compost bins can be used as methods of carbon sequestration and putting food waste back to the soil. In detail, compare and contrast these composting methods, describing how they each relate to food waste reduction, the continuation of healthy ecosystems, and production of goods that humans can use.
6. Describe how composting can lead to carbon sequestration. How does this improve soils and benefit environmental and human health?
7. Describe how different academic disciplines can still work on improving the health of the environment and soils. How does collaboration with different groups help accomplish common goals?
8. In the anaerobic digester module (module 5) the narrator discusses how she followed her passion of becoming an environmental engineer by joining organizations that were working

on projects she was interested in. Now it's your turn! Make a list of projects that you are interested in pursuing and why. Then, find organizations on your campus and elsewhere that work on these projects that you're interested in. How could you get involved?

9. Trees have a dynamic set of uses for the environment, people, and industry. What are some of the ways, in addition to climate, that trees help with?
10. Community gardens offer broad cross-collaborative opportunities in the planning, maintenance, and utilization of fruit trees and food forests. Brainstorm different ways academia can engage students to work interdisciplinary to address the importance of healthy fruit trees.
11. How can strategies and policy regarding food waste mitigation and climate action intersect with food forests?

Notes to instructor:

Resources for some deeper exploration on these topics:

Percentage Increases in Global Demand for Food, Energy, and Water
http://www.theguardian.com/science/2009/mar/18/perfect-storm-john-beddington-energy-food-climate
Green Infrastructure
https://www.epa.gov/green-infrastructure/what-green-infrastructure
https://www.asla.org/ContentDetail.aspx?id=43535 *This page includes a number of organizations, resources and research focused on green infrastructure

Lecture 11: Public Opinion & Communication: Climate Change Science Communication

Lecturer: Richard C. J. Somerville, UC San Diego
Email: rsomerville@ucsd.edu

List of Modules				
Module 1 Preparation	Module 2 Stories	Module 3 Metaphors	Module 4 Language	Module 5 Solutions

Overview

Climate change is a subject on which experts and the public don't agree. The public thinks it is scientifically controversial. The scientists who do the research know that the great majority of them - about 97% - agree on the fundamental facts. The controversy is political, not scientific.

The purpose of this lecture is to provide some solid scientific information, and some hints and resources that will be helpful in learning to communicate with others about climate change science in a mutually respectful non-partisan way.

The website climatecommunication.org is an outstanding collection of resources. Use it. Here is the mantra: Use simple clear messages, repeated often, by a variety of trusted messengers. This lecture reflects many ideas for combining accurate science with effective techniques for communicating.

Our community - climate experts - has awakened to the complex challenges of communicating about climate change, when much more than the science is at issue. Our awareness now includes cultural and psychological issues. Still, most people still say they need more information about the science, so we are challenged to deliver that information in more accessible and effective ways.

Trusted messengers can have an enormous impact and can motivate people to bring about change. Think of Mahatma Gandhi, or Nelson Mandela, or Martin Luther King, Jr. Climate change is much more than a scientific topic. I am convinced that confronting climate change is fundamentally a moral and ethical issue.

All of us can improve our communication skills by considering our audience, the people we are speaking with. We should know who *they* are, and what *they* care about.

Being well informed about the science of climate change is a key to preparing to communicate it. For example, learn the most common myths and falsehoods about the science, and be prepared to refute them convincingly.

If wise climate policy is to be informed by the best and most up-to-date climate science, then the scientists themselves have a critical role to play in communicating their science to the wider world.

Lecture Review Questions:

1. What is not a rule of effective communication?
    a. Simple messages
    b. Repeated often
    c. Trusted listeners

2. Which must you know for effective communication? Check all that apply.
   a. Your doubters
   b. Your audience
   c. Yourself
   d. Your topic

3. Which are techniques for effective communication? Check all that apply.
   a. Use stories and metaphors
   b. Have a simple message
   c. Use jargon
   d. Emphasize solutions and optimism

4. True or False: Communicating with the public requires leading with lots of background information.

Discussion Questions:

1. List at least four terms that have different meanings for scientists and the public, and provide a better choice for each of them.

A partial list is in the box below, an expansion of a slide in this lecture. The box is taken from the paper "Communicating the Science of Climate Change, by Richard C. J. Somerville and Susan J. Hassol, available at https://www.climatecommunication.org/resources/#articles

Terms that have different meanings for scientists and the public		
Scientific term	**Public meaning**	**Better choice**
enhance	improve	intensify, increase
aerosol	spray can	tiny atmospheric particle
positive trend	good trend	upward trend
positive feedback	good response, praise	vicious cycle, self-reinforcing cycle
theory	hunch, speculation	scientific understanding
uncertainty	ignorance	range
error	mistake, wrong, incorrect	difference from exact true number
bias	distortion, political motive	offset from an observation
sign	indication, astrological sign	plus or minus sign
values	ethics, monetary value	numbers, quantity
manipulation	illicit tampering	scientific data processing
scheme	devious plot	systematic plan
anomaly	abnormal occurrence	change from long-term average

2. List at least four important scientific findings that illustrate our understanding of recently observed and predicted climate change.

Here is a partial list:

We have measured the carbon dioxide content of the atmosphere and shown it is increasing.
We have proven that carbon dioxide and other gases, and particles, can trap heat and cause warming.
We have discovered that the warming observed in recent decades is due to human activities.
We have found that cumulative emissions of heat-trapping gases determine how much the world will warm.
We understand that reducing emissions of heat-trapping gases will limit the warming.
We find that natural climate change such as ice ages starting and ending did not cause the recent warming.

3. Explain for non-scientists at least four kinds of observational evidence that show that the global climate has recently experienced warming.

Here is a partial list:

The atmosphere is warming.
The ocean is warming.
Sea level is rising.
Ice sheets and glaciers are shrinking.
Arctic sea ice extent is decreasing.
More high temperature records are being set than low temperature records.
The water vapor content of the atmosphere is increasing.

Class Activities:

1. Play a game in which some students take on the role of Uncle Pete, who does not accept the findings of climate change science, and other students take on the role of climate scientists who attempt to persuade Uncle Pete that climate change science is correct.

https://thebulletin.org/thanksgiving-advice-how-deal-climate-change-denying-uncle-pete10196 is an article that may be helpful.

Urge each student to engage with their own Uncle Pete. Have a civil conversation. In his heart, Uncle Pete would surely agree that everybody is entitled to his own opinions, but not to his own facts. And it is science that supplies the facts about climate change.

Resources:

Climate Communication website: www.climatecommunication.org

Educational resources:
(See: www.climatecommunication.org/resources/#educational-resources)

National Academies Resources for Teachers: http://nas-sites.org/teachers/

EPA Global Climate Change Website: http://epa.gov/climatechange/kids/index.html

Climate Insights 101: http://pics.uvic.ca/education/climate-insights-101

Earth the Operator's Manual: http://earththeoperatorsmanual.com/

NASA's Climate Kids Page: http://climatekids.nasa.gov/

Climate Literacy & Energy Awareness Network: http://cleanet.org

Message Development:

Make to Stick: *Why some ideas survive and others die*, by Chip and Dan Heath

Switch: How to change things when change is hard, by Chip and Dan Heath
More resources available at www.heathbrothers.com

Books for scientists on talking to the media and public:

Am I making myself clear? A scientist's guide to talking to the public, by Cornelia Dean

A Scientist's Guide to Talking with the Media: Practical advice from the Union of Concerned Scientists, by Richard Hayes and Daniel Grossman

Websites for Debunking Common Climate Myths:

www.skepticalscience.com
www.realclimate.org

Videos:
(See: http://www.climatecommunication.org/resources/#videos)

Earth: The Operator's Manual, a documentary with Richard Alley
www.earththeoperatorsmanual.com

Hans Rosling: 200 Countries, 200 Years, 4 Minutes - The Joy of Stats
http://www.youtube.com/watch?v=jbkSRLYSojo

Brian Greene interview on The Colbert Report, May 2008:
http://www.colbertnation.com/the-colbert-report-videos/167386/may-27-2008/brian-greene

Useful reports:
(See: http://www.climatecommunication.org/resources/#reports)

Global Climate Change Impacts in the United States
Interactive website at: http://nca2009.globalchange.gov/

State of the Climate Video and Highlights
http://www.climatewatch.noaa.gov/video/2010/soc2009

http://www.ncdc.noaa.gov/bams-state-of-the-climate/2009.php (click to download "Report at a glance: Highlights" - 10 pages, great graphics)

Solutions:

“A Plan to Power 100 Percent of the Planet with Renewables” by Mark Jacobson and Mark Delucchi
http://www.scientificamerican.com/article.cfm?id=a-path-to-sustainable-energy-by-2030

Lecture 11: Public Opinion & Communication: Climate Communication

Lecturer: Jon Christensen, UCLA
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List of Modules		
Module 1 Why Climate Communication Often Fails	Module 2 How Climate Communication Works	Module 3 Moving Beyond Doom and Gloom

Overview:

This lecture is a brief introduction and overview of research on climate communication and the lessons that we can take away from that research to communicate more effectively. The lecture touches on why we have failed to communicate effectively, how climate communication actually works, and some models for more effective communication. Since this is very much area an of ongoing research and learning, I would encourage students to continue to follow the research, debates, and discussions in this field, and to continue to experiment and learn. Successful communication is about listening carefully, trying to reach audiences where they are and bring them along, and then listening carefully to learn how effective your efforts have been and how they might be improved. It is a never-ending, lifelong challenge and opportunity for learning and improving. This lecture is just a start. I have listed more extensive resources and further readings below for those interested in learning more.

Lecture Review Questions:

1. Which is not a segment of thought concerning climate change?
   a. Cautious
   b. Alarmed
   c. Dismissive
   d. Engaged

2. True or False: It is important to know your audience when you communicate.

3. Which is not considered a working strategy in effective communication?
   a. Connect individual to collective actions
   b. Showing agency—people doing things
   c. Modeling individual roles

4. Why does climate change communications fail?
   a. Problem is far away in space and time
   b. It's an abstract problem we can't see and don't feel
   c. Feels too big to stop
   d. All of the above
   e. Just A and B

Discussion Questions:

1. What are the Six Segments of America on attitudes toward climate change? Map your community along these segments.

2. Following Module 1, Why Climate Communication Often Fails: Find an article about climate change online. Which climate communication weaknesses does it display?

Class Activities:

1. Following Module 2, How Climate Communication Works:

    - Have students think about a person they know who is different from themselves in many ways.
    - Ask them to think about that person's frames, narratives, and values. Ask them to make a note about each of those elements: frames (the ways that people see and interpret the world), narratives (the stories they tell about themselves and the world), and values (what is important to them).
    - Then ask them to think how those frames, narratives, and values would affect how that person would interpret the article about climate that they analyzed after the first module of this lecture.
    - Ask them to write a paragraph describing this person and his or her likely response to the article.
    - Ask them to write a paragraph describing how the article could have been changed to more effectively communicate with this person.
    - Ask students to volunteer to share their paragraph with the class.
    - Discuss.

2. Following Module 3, Moving Beyond Gloom and Doom:

    - Have students watch one of the "Climate Lab" videos produced by the University of California and Vox.
    - Ask them to analyze how the video used the lessons they learned in this lecture.
    - Ask them to consider whether the video displayed any of the climate communication weaknesses discussed in this lecture.
    - Ask them to think about how would they would improve the video.
    - Ask them to write a one-page analysis of the video, including recommendations for improvements.
    - Ask them to write a one-page "treatment" or description of a short video that they would suggest for the "Climate Lab" series.

Resources:

Climate Lab video series from the University of California and Vox: https://www.universityofcalifornia.edu/climate-lab

"UCLA's Jon Christensen on the theory and practice of climate change communication," interview by John Mecklin, Bulletin of Atomic Scientists, 27 July 2017. https://thebulletin.org/ucla%E2%80%99s-jon-christensen-theory-and-practice-climate-change-communication10976

"Climate gloom and doom? Bring it on. But we need stories about taking action, too," Jon Christensen, The Conversation, 8 August 2017.

Yale Program on Climate Communication: http://climatecommunication.yale.edu/

George Mason University Center for Climate Change Communication: https://www.climatechangecommunication.org/

Why We Disagree About Climate Change: Understanding Controversy, Inaction and Opportunity, Mike Hulme. Cambridge: Cambridge University Press, 2009.

What We Think About When We Try Not to Think about Climate Change: Toward a New Psychology of Climate Action, Per Espen Stoknes. White River Junction, VT: Chelsea Green Publishing, 2015.

Don't Even Think About It: Why Our Brains Are Wired to Ignore Climate Change, George Marshall. London: Bloomsbury, 2014.

Escape from the Ivory Tower: A Guide to Making Your Science Matter, Nancy Baron. Washington, DC: Island Press, 2010.

Houston, We Have a Narrative: Why Science Needs Story, Randy Olson. Chicago: University of Chicago Press, 2015.

If I Understood You, Would I Have This Look on My Face? My Adventures in the Art and Science of Relating and Communicating, Alan Alda. New York, Random House, 2017.

Lecture 12: Paris Agreement and Its implementation

Lecturer: David G Victor, UC San Diego
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List of Modules			
Module 1 Needed International Cooperative Institutions	Module 2 Brief History of Climate Diplomacy	Module 3 The Paris Agreement	Module 4 Six Implementation Challenges

Overview

For nearly thirty years, there have been international diplomatic talks on climate change. So far, those talks have had very little real impact on the emissions that cause climate warming. This lecture will examine why international cooperation is needed along with different strategies for improving cooperation. It will explain why the Paris Agreement is widely expected to be more effective than earlier agreements. It will also explain what to look for as Paris unfolds. A central challenge in diplomacy is not making agreements; it is implementation.

Lecture Review Questions:

1. Which are six implementation challenges? Choose all that apply.
    a. Making "Pledge and Review" work
    b. Building a Verification System
    c. Building a Following
    d. Proper Leadership

1. True or False: One striking thing about the Paris Agreement is that almost every country participated.

2. True or False: The US signed the Paris Agreement.

3. What was not a characteristic of the Paris Agreement?
    a. Allows for flexible geometry
    b. Less reliance on binding commitments
    c. Clear cut and immediately deep
    d. Universal participation

4. What is not a policy review mechanism?
    a. TWO Trade Policy Review Mechanism
    b. G5 Mutual Peer Review on Renewable Energy
    c. IMF Article IV reviews
    d. OECD policy review

Discussion Questions:

1. Why is international cooperation needed?

2. Why was there a declining impact of the Kyoto Protocol?

3. Why is the Paris agreement expected to be more effective than Kyoto?

Class Activities:

1. Which of the six implementation challenges do you think is the greatest challenge? Why?

2. Despite the much more flexible framework of the Paris Agreement why are many countries not honoring their pledges?

Resources:
IPCC Working Group 3, chapter 13.
UNFCCC.int (where you can find the Paris agreement)
Victor, Global Warming Gridlock (a book, 2011)
Victor, Why Paris Worked, Yale 360

Lecture 13: Economics: Impacts and Policy

Lecturer: Max Auffhammer, University of California Berkeley
auffhammer@berkeley.edu

List of Modules		
Module 1 The Mitigation Challenge	**Module 2** Economic Impacts of Climate Change	**Module 3** Economic Regulation: Overcoming Market Failures

Lecture Review Questions:

1. Emissions in 2016 are ___% higher than in 1991.
   a. 25
   b. 35
   c. 45
   d. 55
2. Emissions will come from _____ countries.
   a. Developed
   b. Developing
   c. Least Developed

3. True or False: 40% of housing stock in California are located in very high-risk fire areas.

4. True or false: most sectors are well studied and subsequently well prepared for climate change.

5. How do we mainly regulate emissions through economics? Check all that apply.
   a. Command and control
   b. Incentive based regulation
   c. Cash flow

Discussion Questions:

1. What is one way that markets fail?

2. Why do economist like incentive-based policies? What is needed in order to have a successful policy of any kind?

Class Activities:

1. Choose a command and control regulation and an incentive-based regulation. How do the benefits and costs differ between the two methods?

2. What is lacking in how we evaluate policies? How would you improve them?

Lecture 14: Market-Based Climate Policy

Lecturer: Mark Jacobsen, University of California San Diego
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List of Modules		
Module 1 The Value of Market-Based Incentives	Module 2 Current Climate Policy & Carbon Prices	Module 3 In Depth: Incentives in the Automobile Sector

Overview

*This segment is divided into three sections: the goal of the first segment ("*The value of market-based incentives") is to provide a review of the basic lessons from economics regarding the improved efficiency offered by policy that places incentives in the market (for example a carbon tax) as opposed to direct regulation (for example technology mandates). The second section ("Current climate policy and carbon prices") transfers these ideas to climate change policy, broadly defined. It discusses how market-based incentives can be used to provide the broadest possible base for climate policy. Finally, the third section ("In depth: Incentives in the automobile sector") moves to a "micro" example of the same subject: when regulating cars, the sets of incentives placed matter very much for efficiency. Gasoline taxes tend to emerge as the most economically efficient instrument and have been shown to be far more cost-effective than direct regulations like fuel economy standards.

Lecture Review Questions:

1. Which of the following carbon-saving activities are incentivized by California's cap-and-trade system?
   a. Switching away from fossil fuels in electricity generation
   b. Driving less
   c. Installing insulation in attics
   d. None of the above
   e. All of the above

2. Fuel economy standards have been estimated to be _____ times costlier per gallon saved than a gasoline tax.
   a. 3 to 5
   b. 10 to 20
   c. Same cost
   d. 30 to 50

3. The Supreme Court case Massachusetts vs. EPA (2007) is one of the most important legal decisions regarding greenhouse gas regulation. What did the court rule?
   a. That the EPA has the right to set limits on carbon dioxide and other greenhouse gases.
   b. That Massachusetts has the right to regulate carbon dioxide and other greenhouse gases as long as the emissions occur within the state.
   c. That Massachusetts can set nationwide limits on carbon dioxide and other greenhouse gases.
   d. That the EPA must set limits on carbon dioxide and other greenhouse gases.

4. Which of the following is an example of a "double dividend" from consumer protection?
   a. A policy that requires consumers to buy smaller vehicles, and the consumers save money since smaller vehicles are typically cheaper than larger ones.

b. A policy that requires households to add insulation, and it turns out that the energy savings are greater than the cost of the insulation.
c. Subsidies to solar power large enough to cause solar to be cheaper than buying electricity from the grid.
d. Subsidies to research and development that cause energy-saving light bulbs to be cheaper than standard incandescent light bulbs.

Discussion Questions:

1. Leakage through policy overlap (where multiple levels of government act simultaneously) is a particular worry with city level policies. Provide some examples of inefficient policy overlaps and how you might solve them.

2. Both California's carbon cap-and-trade system and Australia's (former) carbon tax exclude agriculture. Why do you think this is? Why does this imply a reduction in efficiency?

Class Activities:

1. Consider the climate goal of reducing (or eliminating) the use of electricity produced by coal. Make a table of (at least) six ways we can work toward this goal. For each item, discuss what regulations or incentives are in place to promote that activity (for some items, it may be that no laws or incentives exist at all). Then, consider how a carbon tax would work to place an incentive along each dimension.

2. Which of the items in (1) should be promoted the most from an economic efficiency perspective; which items on the list are the very cheapest ways to reduce coal-fired electricity generation?

3. Think about the two basic ways to reduce emissions from cars: (i) more efficient cars, and (ii) fewer cars. Is one policy easier or more effective to implement than another? What politics are likely to enter the decision? Do gasoline taxes lead to one or both of these effects?

Lecture 15: Energy Implications of Transportation

Lecturer: Professor Matt Barth, University of California-Riverside, Department of Electrical and Computer Engineering; Director of the Center for Environmental Research and Technology
barth@cert.ucr.edu

List of Modules				
Module 1 Major Concerns of Transportation	Module 2 Transportation Emissions and Energy Impacts	Module 3 Sustainable Transportation Solutions	Module 4 Impacts of Intelligent Transportation Systems on Energy & Emissions	Module 5 Role of Vehicle Automation on Energy & Emissions

Overview

This lecture gives an overview on the energy and greenhouse emissions impacts of transportation. Transportation as a whole contributes approximately 1/3 of the GHG emissions, so we need to understand the complex relationship between transportation and climate change. More importantly, it is important to figure out solutions.

The lecture first outlines the relationship between transportation and energy and GHG emissions. (note that earlier lectures should describe that fossil fuel based energy use and GHG emissions are proportionally related). The lecture then describes solutions in terms of vehicle designs, fuels, and Intelligent Transportation System techniques. The lecture finishes by discussing the future of transportation and the potential impacts from vehicle automation.

Lecture Review Questions:

1. What is the best average speed to travel at to minimize your GHG emissions?

    a. 10 mph
    b. 15 mph
    c. 50 mph
    d. 90 mph

2. Which is not a main area of Intelligent Transportation System?
    a. Vehicle-based ITS technology
    b. Traffic system technology
    c. Interstate network technology
    d. Driver behavior technology

3. Which selection below represents one of the four different “levels” where automation can be applied to transportation?
    a. Automated Powertrain in Management
    b. Vehicle Dynamics
    c. Traffic Dynamic Automation
    d. Infrastructure Related Automation

4. What is a major transportation concern? Select all that apply.
    a. Safety
    b. Efficiency
    c. Economics
    d. Human population number

Discussion Questions:

1. What is “induced travel demand” and how does it relate negatively towards GHG emissions?

2. What are criteria pollutant emissions and how are they different from GHG emissions? Which do you think is most impactful to human health?

3. What are the three main areas of Intelligent Transportation Systems and what are some examples from each?

Class Activities:

1. Safety is an important issue of transportation; we want to reduce traffic accident fatalities and fatalities due to pollutant emissions as much as possible. Discuss in groups what you think an acceptable number of traffic deaths per year would be. Will we ever get to zero traffic deaths through vehicle automation? Will pollutant emissions be reduced to zero so as not to cause health related deaths?

2. Go online and examine the Urban Mobility Scorecard website: https://mobility.tamu.edu/ums/. How has traffic congestion grown in your city? Is congestion getting better or worse? Why don't we simply build many more roads to mitigate traffic congestion?

3. Discuss in groups the four main ways of reducing GHG emissions transportation: 1) build more efficient vehicles; 2) use less carbon intensive fuels; 3) reduce VMT; and 4) improve transportation efficiency through ITS and automation. Which one do you think will have the largest impact? What approach will have the smallest impact? What are the timeframes for making significant change in any one of the approaches?

4. If you had an automated vehicle in the future, would you use that vehicle more than you do now? Estimate how much your driving would change, and figure out how your GHG emissions would also change.

Resources:

Sustainable Transportation:

Visit National Center for Sustainable Transportation for a variety of resources: https://ncst.ucdavis.edu/

Intelligent Transportation Systems:

Visit US Department of Transportation Joint Program Office on ITS for a variety of resources: https://www.its.dot.gov/

Autonomous Vehicles:

https://www.rand.org/topics/autonomous-vehicles.html

https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety

https://www.americanprogress.org/issues/green/reports/2016/11/18/292588/the-impact-of-vehicle-automation-on-carbon-emissions-where-uncertainty-lies/

Lecture 16: New Technologies & Innovations For Carbon Neutrality: Renewable Energy

Lecturer: Scott Samuelsen, UCI
gss@uci.edu

List of Modules			
Module 1 Alternatives to Combustion	Module 2 Fuel Cell Technology	Module 3 Evolution of the Electric Grid	Module 3 Smart Grid Technology

Overview

This lecture describes the evolving energy technologies and associated paradigm shifts to transform the electric grid and transportation fuels to 100% renewable.

Lecture Review Questions:

1. What, in addition to energy storage, is required to manage and complement the limited capacity factor and dynamics (diurnal variation and intermittency) associated with renewable solar and wind power generation?
   a. Non-combustion, clean, firm (24/7, load-following) power generation
   b. Combustion peakers
   c. Alternative fuels

2. Upon which fuel cell component does the type (PEMFC, PAFC, MCFC, SOFC) of fuel cells embody?
   a. Temperature
   b. Electrode
   c. Electrolyte

3. In support of a 100% renewable future, what is the progression of fuels for fuel cells (electric power and vehicle power) from the fuels available today, to the renewable fuel projected to be abundant in the future?
   a. Natural gas → biogas-→ hydrogen
   b. Natural gas → biogas → renewable hydrogen
   c. Natural gas → syngas → hydrogen

4. Identify two attributes of smart-grid technology
   a. Facilitate a 100% renewable grid, achieve environmental goals (GHG, urban air quality)
   b. Facilitate a 100% renewable grid, improve fuel economy
   c. Facilitate a 100% renewable grid, facilitate messaging

5. What are the three principal roles that renewable hydrogen portends?
   a. Capture of otherwise curtailed renewable power, subsequent utilization through fuel cells (electric power, vehicle power), and blimp buoyancy
   b. Capture of otherwise curtailed renewable power, storage, and manufacturing
   c. Capture of otherwise curtailed renewable power, storage, and subsequent utilization through fuel cells (electric power, vehicle power)

Discussion Questions:

1. What is the major technology do we have now that do you think was considered science fiction back in the 1950's?

2. If fuel cells are to be as ubiquitous as computers are today, what are positive and negative impacts?

3. What are examples of transportation merging with the electric grid? Map three in your community.

Class Activities:

1. While the increasing deployment of solar and wind electric generation resources produce renewable power, what challenges accompanying the deployment? How can we mitigate them?

2. What are examples of technologies required to support a 100% renewable grid?

Lecture 17: Technologies for SLCPs Mitigation

Lecturers:

Modules 1-3: V. Ramanathan, UCSD, Scripps Institution of Oceanography
vramanathan@ucsd.edu

Modules 4-5: Durwood Zaelke, UCSB
zaelke@igsd.org

List of Modules				
Module 1 SLPCs: Reduces Near-Term Warming	Module 2 Black Carbon: Major Climate Pollutant	Module 3 Methane Mitigation	Module 4 Montreal Protocol	Module 5 Kigali Amendment

Modules 1-3

Overview: This lecture describes, Climate Change Solutions #9:
Immediately make maximum use of available technologies & regulations to reduce methane emissions by 50%, black carbon emissions by 90% & phase out hydrofluorocarbons.

We have put enough greenhouse gases already in the atmosphere to warm the planet by more than 1.5C by 2030 and with continued emissions beyond 2030, the planet is likely to warm by 2C before 2050. As introduced in lecture 1, we can think of greenhouse gases as a blanket covering the planet and trapping the infrared heat emitted by the surface and the air. The blanket is already too thick. We need to thin out this blanket within the next two decades. Because of the long life-time of CO_2 in the air, and the inertia of the energy sector, we cannot thin the blanket by just cutting emissions of CO_2. But we can thin the blanket of short lived climate pollutants, since their life-times range from a week for black carbon to about a decade for methane and HFCs. Furthermore, there are off-the-shelf technologies for reducing the emissions drastically within about 10 to 15 years. By doing so, we can reduce the warming by about 0.6C or by almost 50% of the projected warming from now until 2050. The lecture describes the available technology measures for achieving this immediate slowing of the warming.

Lecture Review Questions:

1. Why are SLCPs called super pollutants?
   a. They are more common that other pollutants
   b. Per ton of emission, these are ten to thousand times more potent than a ton of CO2 emission

2. If the entire world stops emitting black carbon today, how long will it take for the black carbon concentration in the atmosphere to reduce drastically (i.e., by more than 70%).
   A. 25 years
   B. 6 months
   C. Several weeks

3. How does black carbon damage the health of people? Choose all that apply.
   a. Leads to over 3 million mortalities every year
   b. Second to their largest global warming agent
   c. Melts sea ice and glaciers
   d. Causes global dimming and decreases monsoon rainfall

4. True or False: The bottom three billion people contributes 50% of carbon dioxide emissions.

Discussion Questions:

1. Find and share an article on a city mitigating SLCPs.

2. Name the three most important measures to reduce black carbon emission. Which might be the easiest to implement?

3. Name the five ways by which methane leads to warming. Which do you think is more critical, and why?

Class Activities:

1. There is concern that targeting SLCPs could take attention away from CO2 emissions.
   - If you have the same concern, explain why policy makers have the inability to address more than one solution? What can be done to address this concern?
   - If you think this is a non-issue, discuss how you will persuade the policy maker. Explain the local benefits to the jurisdiction that mitigates SLCPs.

2. Methane is emitted by multiple sources (Refer to module 3; slide 9). If your city does not have the funds to target all of them, what would be your top choice for mitigation? And why?

3. Consider the situation, where nations focus just on CO_2 emissions, and the warming exceeds 2 C by 2050 and leads to dangerous tipping points with frequent extreme events such as heatwaves etc. What are the responses available to society?
   Discuss this with the perspective of the wealthiest one billion who are responsible for most of the pollution; and the poorest 3 billion who had little to do with the pollution but can face existential threats. Prioritize them and list 3 most important actions you will recommend to each group.

4. Consider topic 3 above, and describe how faith leaders can help the disastrous situation. How will you use what you learned in this class to attempt societal transformation?

5. Consider the emissions of your local area, and describe the specific SLCPs mitigation measures your local area can take to contribute to the global mitigation actions.

Notes: The class should be divided into groups with about 4 or 5 maximum in each group. Pose the activity or discussion first; give the groups about 10 minutes to discuss among themselves before engaging in a discussion.

Resources:

1. The Bending the Curve executive summary cited above. Executive Summary of the Report, Bending the Curve:10 scalable solutions for carbon neutrality and climate stability.
2. http://uc-carbonneutralitysummit2015.ucsd.edu/_files/Bending-the-Curve.pdf2. Shindell, D., et al (2012) Simultaneously Mitigating Near-Term Climate Change and Improving

Human Health and Food Security, *Science,* 335, pp.183-9

3. V. Ramanathan & D.G. Victor, "To Fight Climate Change, Clear the Air", *The New York Times OpEd*, November 27, 2010.

Modules 4-5:

Overview

This lecture covers short-lived climate pollutants (SLCPs)—also known as super pollutants—and their impacts on the climate. The solutions covered in this section focus on the feasibility of reducing emissions of SLCPs with existing and proven technologies that will limit near-term warming through the end of the century. As a whole, this lecture isolates specific climate pollutants, focusing on their impact on the climate and the ways in which they can be reduced to avoid warming in the crucial near-term, which helps to breakdown the broader and often overwhelming field of climate mitigation and itemizes solutions that contribute to the larger scheme to reduce warming.

Module 4 discusses the development and success of the Montreal Protocol so as to set the stage for the potential success for the reductions of HFCs under the Kigali Amendment to the Protocol, which is handled in Module 5. Module 4 tells the story of the Montreal Protocol, from the initial scientific discoveries to the development of the Vienna Convention for the Protection of the Ozone Layer, to the Montreal Protocol. The rich history of the Montreal Protocol highlights the challenges of pulling together the international community to achieve a monumental goal. The students will gain from this an understanding of the efforts required to establish and then continuously strengthen an international agreement while also gaining understanding of the potential for success.

Module 5 elaborates on the Kigali Amendment to the Montreal Protocol, under which countries will phase down the use of HFCs that have high Global Warming Potential in the next several years. As with previous amendments, the Kigali Amendment requires developed countries to begin their transition away from HFCs first, with developing countries following several years later, following the principle “common but differentiated responsibility and respective capabilities.” In an innovation, for the first time the Kigali Amendment created two groups within the developing countries—the first starting their phasedown in 2024 and the second group, made up of India, Pakistan, and Gulf States, in 2028. (Developed countries must start their phase down by 10% when the Kigali Amendment enters into force, which will be on 1 January 2019, provided 20 parties have ratified.) The students should refer back to the progression and success of Module 4 to further their appreciation for the potential success expected from the Kigali Amendment in the reducing warming through phasing down HFCs. The success of the Montreal Protocol has reduced climate warming already in the phasedowns of CFCs and HCFCs and other fluorinated gases, and will continue to reduce warming with the upcoming reduction of HFCs. The success also highlights the ability of the international community to work together to solve a global problem, which can be inspiring for other avenues of climate protection.

Lecture Review Questions:

1. Where is the ozone layer?
    A. Trophosphere
    B. Stratopshere
    C. Mesophere

2. What does the ozone layer absorb?
   A. Green wavelength
   B. Radiation
   C. Ultraviolet

3. How soon after Molina and Rowland made their discovery about CFCs depleting the ozone did Ramanathan discover that CFCs were also greenhouse gases?
   A. One year
   B. Five years
   C. Ten years

4. What health issues would not result from a depleted ozone layer?
   A. Skin cancer
   B. Asthma
   C. Eye damage
   D. Cataracts
   E. Immune suppression

5. When was the Montreal Protocol first adopted?
   A. 1977
   B. 1987
   C. 1997

6. How many parties signed the Montreal Protocol?
   a. 79
   b. 97
   c. 167
   d. 197

7. What is the most abundant HFC?

   a. HFC-23
   b. HFC-134a
   c. R410a

8. How much would the carbon budget be reduced if the growth of HFCs was not restricted by the Kigali Amendment?
   A. 10-30%
   B. 30-60%
   C. 60-90%

9. How much warming will be avoided by the Kigali Amendment?
   A. 0.5ºC by 2100
   B. 1.0ºC by 2150

C. 0.5ºC by 2150

Discussion Questions:

1. What health issues result from a depleted ozone layer?

2. How many amendments to the Montreal Protocol have there been so far? How many further adjustments? Why are amendments important?

3. What are some of the key reasons that make the Montreal Protocol so successful?

4. How many chemicals phased out so far? Emissions avoided between 1990 and 2010?

Class Activities:

1. The Montreal Protocol is considered one of the first international treaties to reflect the precautionary approach to environmental issues, which urges policymakers to take action in the face of scientific uncertainty. Given the state of scientific knowledge at the time of the Protocol, how reasonable was it to take this approach? How does this compare to the progress with climate change under the UNFCCC?

2. One year following Mario Molina and Sherry Rowland's discovery that CFCs appeared to be destroying the protective stratospheric ozone shield, UCSD Professor V. Ramanathan found that CFCs were also powerful greenhouse gases. How did these discoveries influence the form of the Montreal Protocol?

3. Some of the companies that made CFCs attacked the credibility of the scientists, including Molina and Rowland, who found that their invitations to scientific conferences and talks drying up. Given the critical role the science played in the development of the Montreal Protocol, what are your thoughts on scientists as advocates for political change? Should there be any limitation to their involvement? Should scientists let their work speak for them? Should they have a place at the negotiation table and/or in front of legislative bodies?

4. How did consumer boycotts impact CFC phasedown and the subsequent national and international regulations? Could these sorts of actions be used for other climate issues? What sorts of boycotts could be useful for tackling climate issues? What other similar actions could be taken?

5. Health benefits from protecting the stratospheric ozone layer were helpful in encouraging policy and generating public acceptance. In what ways can health issues be incorporated to developing other climate policies? Are there other collateral benefits that could be emphasized for promoting climate protection?

6. The Montreal Protocol is a "start-and-strengthen" treaty. What are the benefits to structuring a treaty this way? Should other climate issues be handled in a similar fashion? How could other treaties be structured to mimic this successful aspect of the Montreal Protocol?

7. The Kigali Amendment the Montreal Protocol to include HFCs under the Protocol took nearly a decade. What pieces of the puzzle were crucial to turning the tide for accepting phasing down these chemicals that did not destroy ozone under a treaty built specifically for protecting the stratospheric ozone layer?

8. What are the practical reasons for considering energy efficiency adjustments while changing HFC refrigerants?

9. The Montreal Protocol targeted a specific set of chemicals (known as fluorinated gases used primarily as refrigerants, to make insulating foams, and as solvents) whereas the climate problem incorporates a wider range of pollutants from a large number of different sectors, which makes the climate problem inherently more challenging than the ozone problem. In what ways can the lessons learned from the success of the Montreal Protocol be extended to other climate issues? Do you think climate policy would be more effective if it took a sectorial approach and developed other tailor-made treaties to address, for example, the steel industry, aluminum industry, cement industry?

10. Media is instrumental for communicating and explaining climate issues. Many issues with the Montreal Protocol were handled in various op-eds and news articles that reached the general public as well as policymakers. Consider what media sources would be best for disseminating climate information? Are there media and communication avenues that are better for climate communication? Worse? What concerns or issues arise in covering these topics in the media and how can they be avoided?

11. As the range of climate friendly alternatives to HFCs expanded, countries and their industries were more willing to agree to the Kigali Amendment. What alternatives exists for other climate pollutants? How can these be readily incorporated to enhance and speed up a global transition to a safer climate?

Resources:

IGSD Primer on Hydrofluorocarbons (HFCs)

Montreal Protocol (text of the treaty)

Annexes to the Montreal Protocol

UNEP Handbook for the Montreal Protocol (very long, but has *everything* about the Montreal Protocol)

OzonAction Summary of the Montreal Protocol (short summary)

Kigali Amendment decision (within MOP28 Decisions)

UNEP Kigali Amendment FAQ

Chapter 10: Stratospheric Ozone Protection, *in* International Environmental Law and Policy (5th Edition) (David Hunter, James E. Salzman, and Durwood Zaelke).

Lecture 18: Enhancing Carbon Sinks

Lecturer: Whendee Silver, UC Berkeley
wsilver@berkeley.edu

List of Modules			
Module 1 Introduction to Land Based Solutions	**Module 2** Soils	**Module 3** Agriculture and Forestry	**Module 3** Carbon Sequestration Case Study

Overview

The lecture is a combination of basic concepts of land-based mitigation approaches and a case study from Northern California that demonstrated soil carbon sequestration. One of the important points to stress is you have to think holistically to catch upstream or downstream emissions and leakages in greenhouse gas emissions.

Lecture Review Questions:

1. Which of the following statements about soil carbon sequestration is true? Select all that apply.
   a. It can eliminate the need for emissions reduction in other sectors
   b. It can solve climate change by removing all the excess CO_2 from the atmosphere
   c. It temporarily removes carbon from the atmosphere
   d. It is an approach for climate change mitigation with many co-benefits.

2. How does carbon get into soils? Select all that apply.
   a. From ozone in the atmosphere
   b. From the deposition of waste products and the mortality of plants and animals
   c. From organic amendments
   d. From rainfall and snowmelt

3. Which of the following are true? Select all that apply.
   a. Photosynthesis > Microbial Respiration = Soil Carbon Sequestration
   b. Photosynthesis < Microbial Respiration = Soil Carbon Sequestration
   c. Global Soil Carbon Stock > Global Atmospheric Carbon Stock
   d. Global Soil Carbon Stock < Global Atmospheric Carbon Stock

4. True or False: California is the largest dairy producer in the US.

5. Livestock manure is a large source of _____, a potent greenhouse gas.
   a. Carbon dioxide
   b. Methane
   c. Nitrous oxide

Discussion Questions:

1. How can land management contribute to climate change mitigation?

2. Is emissions reduction alone sufficient to stop climate change? Why or why not?

3. What are some potential problems with forest carbon sequestration?

4. Find and share other examples of natural carbon sequestration.

Class Activities:

1. We need to get carbon out of the atmosphere to slow climate change. Emissions reduction is essential, but not enough to Bend the Curve. How can you spread the word? How can you help people understand what is needed to slow climate change? Students can discuss this in small groups and report back to larger class. Encourage students to think creatively both about the message and the form of delivery. For example, students may decide that outreach to local business leaders is needed. How do you engage these people to help them both understand the concepts and act on it?

2. Soil is a great place to store excess carbon. How can you promote soil carbon sequestration? Ask students to use Google maps or Google Earth to determine the potential land areas within 50 miles of their campus that might be available for C sequestration projects. Do this in groups and get the groups together to compare values.

3. Agriculture and forestry can be part of the solution. How can you change your eating and purchasing habits to contribute to this solution? How can you help spread the word on the potential for climate friendly agriculture and forestry? Small group or whole class discussions.

4. Scientists working with stakeholders can advance new strategies for carbon sequestration while supporting sustainable food production. What would be your dream team for carbon removal? Small group or whole class discussions.

5. How can you help move your ideas forward towards reality? This is a like a strategic planning session, with the goal of empowering students to translate their ideas into action. Open ended discussion with the whole class.

Lecture 20: What Role will Negative Emissions Play in Managing Our Climate?

Lecturer: Roger Aines, Chief Scientist of the Energy Program, Lawrence Livermore National Laboratory
aines1@llnl.gov

List of Modules				
Module 1	Module 2	Module 3	Module 4	Module 5
Intro	Removing and Storing CO_2	Recycling CO_2	California Story	Summary

Overview: This lecture introduces the fundamentals of negative emissions and carbon dioxide removal from the atmosphere, as well as explains the significance of this strategy in mitigating climate change. The strategy of removing carbon dioxide from the atmosphere is outlined, and the lecture describes the mechanics of these engineered systems as well as their limitations. Students are then presented the idea of recycling carbon dioxide to make carbon-based products rather than utilizing oil. The lecture finishes with a case study on California and how their emissions per sector provides opportunities and challenges for further emission reduction via carbon dioxide removal.

Lecture Review Questions

1. Multiple Choice: 1/5 annual production of oil is _____?
    a. One gigaton
    b. One megaton
    c. One gigagram

2. True/False: We can put carbon dioxide back underground as a liquid.

3. True/False: Carbon removal potential of a forest increases with time.

4. True/False: The cost of electricity is no longer a barrier to industrial growth.

5. Multiple choice: Transportation, refining, and oil production makes up ___% of California's greenhouse gas emissions in 2016?
    a. 32%
    b. 42%
    c. 52%

6. Multiple choice: Which sector is the problem in California regarding carbon emissions?
    a. Agriculture
    b. Waste
    c. Transportation
    d. Housing

7. Multiple answer: In order to achieve California 2045 and Paris Agreement Goals, what needs to occur?
    a. Renewable electricity will be cheap.
    b. Carbon economy will die.
    c. Up to 20 billion tons per year of carbon dioxide must be removed from the atmosphere after 2050.
    d. We will rely only on technology.

Discussion Questions/Class Activities:

1. Consider the different active carbon removal strategies in this lecture. Rank them in the order of efficacy in your opinion. Now rank them again in the order which you think is most likely to be implemented. Do these rankings match? Why or why not?

2. For each carbon removal strategy, consider stakeholders that would be for and against the strategy. What reasons do these entities have for promoting or discouraging these strategies? What compromises might need to take place?

3. Consider California's Low Carbon Fuel Standard. What are some benefits and challenges to this framework? Do you think that this framework is scalable, meaning that other states and countries can adopt it?

4. How can policy support technological development for negative carbon emissions?

Lecture 21: Religion, Ethics, and Climate Change

Lecturer: Mary Evelyn Tucker, Yale Forum on Religion and Ecology, Yale University
maryevelyn.tucker@yale.edu

List of Modules		
Module 1	**Module 2**	**Module 3**
Climate Emergency	Papal Encyclical	Journey of the Universe

Overview: This lecture presents climate change as a moral issue and provides background on how a variety of religions are addressing climate change as an ethical dilemma. The lecture introduces an overview or the roles that religious organizations and communities can take in developing climate change solutions. Students will learn how the academic field of religion and ecology can bring together science, religion, and environmental ethics in orderto understand climate change as a moral issue that requires moral responses.

Lecture Review Questions

1. True/False: Instrumental valuation of nature is the value of nature to humans and is a commodity to be used for profit.

2. Multiple Choice: Which is not considered a religious value or ethic?
    a. Value of “creation”
    b. Ethics of “stewardship” & “creation care”
    c. Only on anthropocentrism
    d. Value for future generations

3. True/False: 75% of the world’s people are religious.

4. Multiple Choice: Which is not a shared value among the religions discussed?

a. Reverence for the future of life
b. Respect for myriad species
c. Restraint in use of natural resources
d. Redistribution of technology and aid

5. Fill in the blank: _____, released in 2015, is considered one of the most influential documents of all world religions on the climate change issue.

Discussion Questions/Class Activities:

1. Of the religious leaders shared in the lecture, which would you like to have dinner with and why? What are two questions that would you like to ask them?

2. Consider your community. Which religion is most prevalent? How would you provide a climate message for this audience? Write a one paragraph pitch. If the opportunity is available, try presenting this pitch to one of your community members and engaging them in this conversation.

3. Discuss why Laudato Si was so influential and how next steps could be made after this document. What are 3 actions that the authors might want to continue? How about 3 actions by the readers?

4. Chose a climate crisis that is occurring today. How might these different religions respond to this? What are some differences and similarities?

Resources:

CFR Religion and Foreign Policy: The Fourth National Climate Assessment.
https://www.globalchange.gov/nca4

Laudato Si "On Care for Our Common Home" May 24, 2015.
http://w2.vatican.va/content/francesco/en/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si.html

Lecture 22: ate Change, Christianity, and the Real Challenges

Lecturer: Katharine Hayhoe, Texas Tech University
Katharine.Hayhoe@ttu.edu

List of Modules				
Module 1 Religious Objections	Module 2 What Science Says	Module 3 What the Bible Says	Module 4 The Real Problem	Module 5 The Way Forwrd

Overview: This lecture provides an introduction into "religious sounding" arguments against climate change, and how these arguments do not reflect science or the Christian doctrine. By understanding the real source of these objections, which are political and not theological, this lecture demonstrates how connecting values across ideologies is key to constructive conversations.

Lecture Review Questions

1. True/False: One religious-sounding objection to climate change is that humans cannot control what God controls (climate).

2. Multiple Choice: Approximately ____% of research scientists identify with a religious label.
    a. 15%
    b. 25%
    c. 40%
    d. 50%

3. Multiple Choice: Which is *not* a religious-sounding argument?
    a. Those scientists are all godless atheists.
    b. God is in control, not humans.
    c. If I buy climate change, then I have to buy a new earth too!
    d. God said he would never flood the earth again.

4. True/False: As the world warms, we're seeing stronger, bigger, faster hurricanes.

5. True/False: One of the most dangerous myths is that "Caring about a changing climate means you are a liberal."

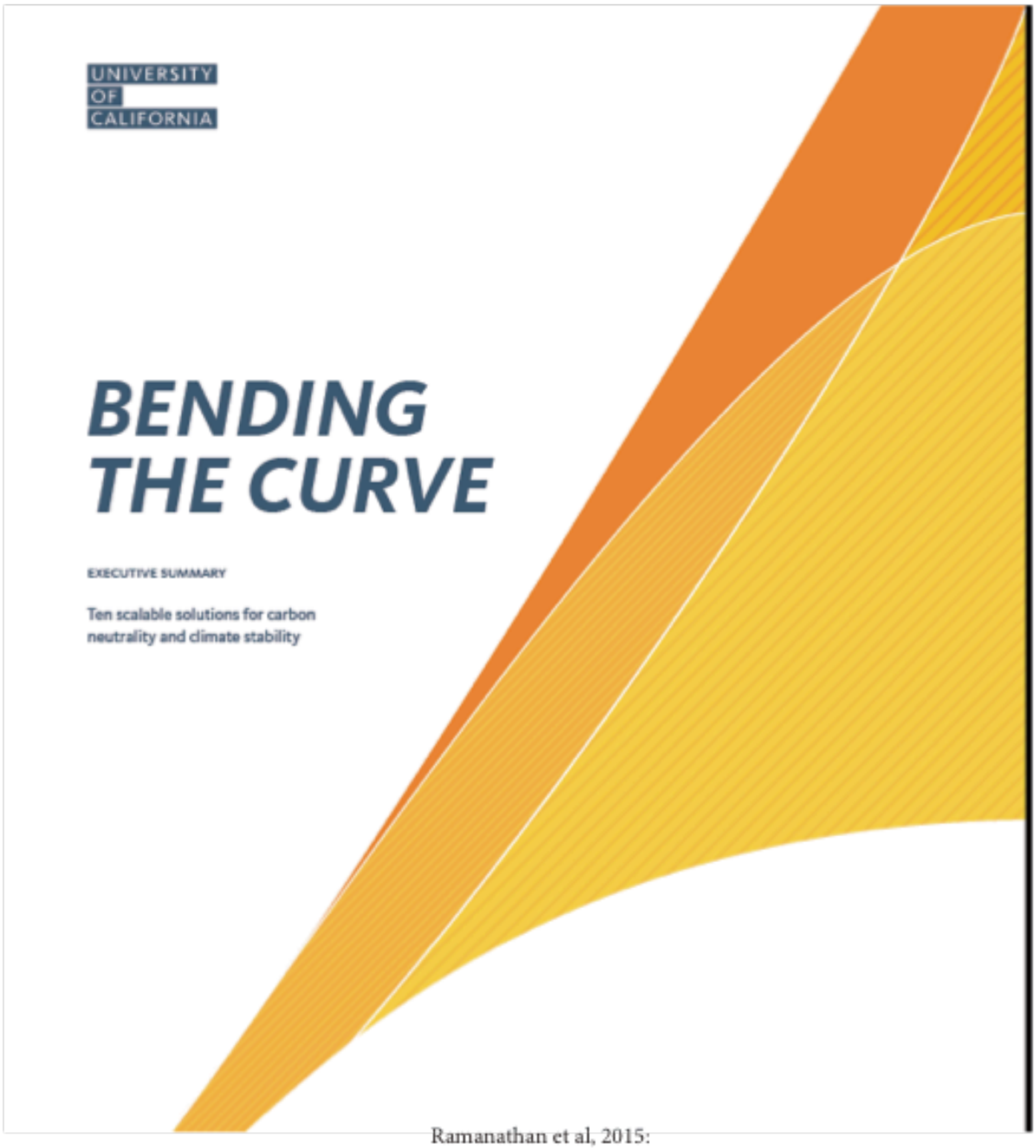
Discussion Questions/Class Activities:

1. You are having a conversation with someone who is dismissive of climate change. Their argument is that "God is in control, not humans. Even if the climate is changing, there's nothing we can do about it, because God is in control." How do you respond?

2. Research has shown that from 1994 to present day, the median Democrat and median Republican have drifted further away from each other and closer to the extremes of the political ideologies. How does this impact the openness to climate change science? How can you mediate this?

3. One myth of climate mitigation is that "The only viable solutions are punitive, harmful, and/or immoral, and I can't agree with any of them." What are three solutions that you have that can bust this myth?

4. Think of someone in your life who is dismissive of climate science. Using the bond and connect, explain, and inspire framework, how would you navigate a conversation with them on climate change?



Ramanathan et al, 2015:
Executive Summary of the Report, *Bending the Curve: 10 scalable solutions for carbon neutrality and climate stability*.
Published by the University of California, October 27, 2015
https:// uccarbonneutralitysummit2015.ucsd.edu/_files/Bending-the-Curve.pdf

Bending the Curve: Climate Change Solutions

UNIVERSITY OF CALIFORNIA Carbon Neutrality Initiative

Berkeley UNIVERSITY OF CALIFORNIA

UCDAVIS UNIVERSITY OF CALIFORNIA

UCIrvine University of California, Irvine

UCLA

University of California UCMERCED

University of California Office of the President

UCSF University of California San Francisco

UC San Diego

UNIVERSITY OF CALIFORNIA SANTA CRUZ

UCSB UNIVERSITY OF CALIFORNIA SANTA BARBARA

UNIVERSITY OF CALIFORNIA UCRIVERSIDE