What will we do to slow and or adapt to climate change?

What are the challenges?

Class 19: Climate Change Strategies, Mitigation and Adaptation

- What will we do to slow and or adapt to climate change?
- What are the challenges?

Learning Objectives

- Explain the difference between climate adaption and mitigation strategies
- List 2 climate adaption strategies that have so-far been proposed
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Amelia Poch

The Vermont Youth Climate Congress
What is it?

A gathering of around 150 students across Vermont to press our leaders of Vermont for BOLDER action on climate!

We will be drafting a declaration of freedom from fossil fuels and solutions to present to our legislators to put into policy before it’s too late!
Why?

Our generation will be the one to face the effects of climate change, although we are the least responsible.

The people currently in power haven’t done enough, so we must step up to the plate and do what we know is right to protect our planet!
The Goal

To send a strong message to our legislators that we are serious about demanding action to address the climate crisis.

Have strong media coverage of the event to show Vermonters we will continue to fight for what is just until we get it.

Have the youth more involved in politics that will impact their future.
More Info

• It will take place at the State House in Montpelier this Sunday, November 17th from 12:30 - 4:30 pm

• If you are interested in volunteering as a scribe for the committee sessions or to check in people at the event please email Kate@vpirg.org

• Please visit our website at:
  • https://vermontyouthcongress.com
Registration week – Geology classes next semester

- **GEOL 007** SU: Earth Hazards - Same teaching team - 11:40 12:55 T R
- **GEOL 096** Extraterrestrial Life – 4 faculty - 12:00 12:50 M W F
- **GEOL 055** Environmental Geology - 10:50 11:40 M W F

- **GEOL 195** Human Health and Geology - 10:05 11:20 T R
- **GEOL 235** Geochemistry of Natural Waters
- **GEOL 234** Global Biogeochemical Cycles

- **GEOG 143** Climatology - 02:50 04:05 T R
EXAM #2

Mean = 84.5
Median = 86.0

Grade Distribution:
- 90 - 100: 40
- 80 - 89: 70
- 70 - 79: 30
- 60 - 69: 10
Climate in the News

How Scientists Got Climate Change So Wrong

Few thought it would arrive so quickly. Now we’re facing consequences once viewed as fringe scenarios.

By Eugene Linden
Mr. Linden has written widely about climate change.

Report
Volume loss from Antarctic ice shelves is accelerating

The cumulative cost of the 16 separate billion-dollar weather events in the U.S. in 2017 was $306.2 billion, breaking the previous cost record of $214.8 billion (2005).
“For decades, most scientists saw climate change as a distant prospect. We now know that thinking was wrong. This summer, for instance, a heat wave in Europe penetrated the Arctic, pushing temperatures into the 80s across much of the Far North and, according to the Belgian climate scientist Xavier Fettweis, melting some 40 billion tons of Greenland’s ice sheet.

Had a scientist in the early 1990s suggested that within 25 years a single heat wave would measurably raise sea levels, at an estimated two one-hundredths of an inch, bake the Arctic and produce Sahara-like temperatures in Paris and Berlin, the prediction would have been dismissed as alarmist. But many worst-case scenarios from that time are now realities.”
How much will temperature increase by 2300?
• Depends on emissions!

With drastic emission cuts (RCP2.6), 1°C or less

‘Business as usual’ (RCP8.5), 4 - 12°C
REVIEW - The Longer View – 3000 CE

Figure from Aschwanden et al. (2019)
Under the highest emission scenario, Greenland gone, Antarctica smaller

Sea level 50 meters higher
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Climate Mitigation vs. Adaptation

Climate Adaptation Strategies

Climate Mitigation Strategies

Adaptation and Mitigation Challenges
Work with a partner: write down, and get ready to share, 3 mitigations and 3 adaptations to climate change (and rising CO₂ levels)
Dealing or not dealing with climate change will cost society – lives and money are on the line.

Doing nothing about the effects of CO$_2$ and climate change is not a “free ride”.

<table>
<thead>
<tr>
<th>Ambitious GHG mitigation</th>
<th>Smaller increase in global temperatures</th>
<th>Less sea-level rise</th>
</tr>
</thead>
<tbody>
<tr>
<td>= Less investment in adaptation and damage to coastal infrastructure</td>
<td></td>
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</table>
Mitigation and Adaptation

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Adaptation Strategies (not geoengineering, next class)

Sea level
Water supply
Winter sports
Sea level is rising at an easily measurable rate; result is increasing nuisance flooding
Impacts first felt at high tides and with storms
Impacts first felt at high tides and with storms
The impacts are more dramatic elsewhere – environmental justice issues
Dealing with rising sea levels there are choices

(Figure 5. Generic adaptation approaches for sea level rise. After IPCC CZMS 1990)

(Nicholls, 2011)
Raise your home and let floods happen - a short-term strategy

New Orleans, Louisiana

St Augustine, Florida
Amsterdam, Netherlands = floating homes (house boats)
Hard and soft infrastructure adaptation – is it enough?
Managed retreat – abandoning properties and perhaps entire cities and even nations to rising waters.

ENVIRONMENT

Rising seas give island nation a stark choice: relocate or elevate

“This strategy is a political quagmire. It involves tremendous legal and equity issues, because not all property owners are willing sellers.”
A $6.5 billion sea wall to stop Venice from flooding. The Mose project remains unfinished and so in 2018, most of the city was again underwater. London is doing the same on the River Thames.

Build big – barriers to hold back rising seas
Will need to waste far less water as climate warms
Skiing in a challenge when there’s no snow – enter man-made and stored snow

Craftsbury Vermont, fun course

Dresden, Germany, world cup race course
Remember icehouses where winter ice was stored under sawdust for use in the summer? Faculty and students from UVM are working with the Craftsbury Outdoor Center to test and refine methods of oversummer snow storage to see if we can do the same with thousands of cubic meters of snow! The goal is reliable nordic skiing in late fall and early winter while at the same time reducing energy costs and carbon emissions from snow making. And, as you can see in this video, it's just plain fun to ski in July.
More than 60% of the stored snow survived over the summer!
Mitigation and Adaptation

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Climate Mitigation vs. Adaptation

Climate Mitigation Strategies

Climate Adaptation Strategies

Climate Mitigation Strategies

Adaptation and Mitigation Challenges
Climate Change Mitigation – some proposed ideas

Goal = Get CO$_2$ out of the atmosphere

1. Carbon capture and storage
2. Enhanced chemical weathering—almost geoengineering
3. Ecosystem protection and enhancement
4. Decarbonizing our energy system
Kyoto Protocol – First signed in 1997 by 193 countries. President Bush withdrew the US in 2001. Aim was to reduce greenhouse gas emissions, but the biggest emitters (US, China, India) did not reduce and emissions continued to rise.
Paris Climate Agreement – Signed in 2016. Goal is to keep global temperature increase below 2°C, ideally below 1.5°C.

No mechanism to force any country to reduce emissions by a certain time. Voluntary emissions targets, not legally bound
Greenhouse-gas emissions could take many paths in the coming years, resulting in differing levels of warming relative to pre-industrial levels. Thanks to policies that have already been implemented by governments around the world, temperatures are not expected to rise as high by 2100 as they otherwise would. But to achieve the 1.5 °C and 2 °C targets set by the 2015 Paris climate accord, more-aggressive emissions reductions will be needed.
1. Carbon capture and storage – with fossil fuels – reduce CO$_2$ rise

The distance between the power station and the CCS storage facility can extend to distances of over 500 kilometres.

CO$_2$ is injected and stored underground.

Impermeable cap-rock keeps CO$_2$ underground.

The CO$_2$ is pumped to a depth of about 1.5 km or more.

Depleted oil or gas reservoir.

Natural saline aquifer.

Inset right: CO$_2$ becomes stabilised within the porous rock as it forms natural compounds with the surrounding brine and minerals.

Source: European Commission, DG TREN.
1. Carbon capture and storage – with biomass – net CO\textsubscript{2} reduction
“It hadn’t broken down, it hadn’t rotted or degraded or anything,” said Hamill, a physicist with a deep interest in green technologies. “And that made people say, ‘Hmmm, you know, if biochar can be put in soils and not break down for hundreds of years, this could be a real solution to global warming.’”

Hamill has degrees in physics and biophysics. She began as an Air Force officer and became a program manager with the Defense Advanced Research Projects Agency. Since 2003, she has been with NASA Langley in several technology management roles. She has promoted biochar to various interest groups in the Hampton Roads region for 10 years.
Biochar is an old idea.

Terra preta (Black earth in Portuguese) is black because of charcoal content. It’s human made and improves infertile Amazonian soils.

Charcoal is stable in soil for thousands of years, binding and retaining minerals and nutrients.
Adding Biochar to soils has multiple benefits – both for climate and plants.
How Crushed Volcanic Rock in Farm Soil Could Help Slow Global Warming — and Boost Crops

A new study explores how planet-warming carbon dioxide could be absorbed using 'enhanced rock weathering,' a natural process sped up to fight climate change.

BY GEORGINA GUSTIN  Follow @georgina_gustin

FEB 20, 2018

2. Enhance natural weathering systems

Enhanced crop vigour and yield due to greater uptake of Si, Ca, K and micronutrients

Enhanced root growth due to improved pH, nutrient supply and physical conditions

Weathering products in surface and groundwater runoff (less N, higher Si:N ratio)

Deposition and sequestration

$3H_2O + CO_{2(g)} + CaCO_3(s) \rightarrow H_4SiO_4(s) + Ca^{2+}_(aq) + 2HCO_3^-(aq)$

$CaSiO_3(s) + 2CO_{2(g)} + 3H_2O \rightarrow Ca^{2+}_(aq) + 2HCO_3^-(aq)$

CO$_2$ from respiration of roots and other soil organisms

Applied basalt or mill ash, which also contains K and other nutrients
3. Climate Change Mitigation – bring on the trees

Growing and re-growing forests (and their soils) can sequester lots of carbon.

Source: Economic Research Service, USDA.
3. Well managed coastal zones hold large amounts of Carbon

**What is Coastal Blue Carbon?**

Coastal blue carbon is a term that recognizes the role of coastal ecosystems in the global carbon cycle. Mangroves, tidal marshes and seagrass meadows, collectively called coastal blue carbon ecosystems, extract carbon dioxide from the atmosphere and coastal waters over thousands of years.

**Carbon Sequestration**

"Carbon sequestration" refers to the removal and storage of CO₂, extracted from the atmosphere. "Blue carbon" refers to sequestered CO₂ stored in the form of organic carbon in vegetation (biomass) and soils.

- Approximately 48% of carbon sequestration to long-term sediment storage across the entire ocean occurs within just 2% of the area hosting blue carbon ecosystems.
- Aside from their climate regulating benefits, coastal blue carbon ecosystems provide an array of other ecosystem services including support of healthy fish stocks for maintaining food security, filtration of sediment protecting coral reefs and defense against erosion and flooding in populated coastal lowlands.
- More than half of the world's population lives within 200 km of the coast, drawn to the environmental and economic services provided by these ecosystems.
4. Decarbonizing the global energy system – tough road
Electrification is likely; hydrogen is possible and linked to electricity (for water splitting)
Which of the following is NOT a climate change adaptation?

A. Raising houses so they flood less often
B. Armoring the coast to prevent flooding and erosion
C. Carbon capture and storage
D. Storing snow over summer so you can ski in the fall
E. Managed retreat from coastal zones
Which of the following is NOT a climate change mitigation?

A. Reforestation and afforestation
B. Biochar addition to soils
C. Drip irrigation
D. Enhanced chemical weathering of rock
E. Biomass burning and carbon capture
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The biggest challenge and why we are teaching this class

- 24% of Americans believe that half of climate scientists, or fewer, think human-caused global warming is happening.
- 36% believe that between 51 and 90 percent of scientists think global warming is happening.
- 17% correctly understand that almost all climate scientists think global warming is happening.
- 21% don’t know.

Source: Yale Program on Climate Change Communication survey conducted in April; figures do not add up to 100 percent because of rounding.
Carbon capture and storage does NOT come cheaply nor is the technology mature.

Direct-air-capture's scale problem

All the air in the Grand Canyon only contains

1,270 tons of CO₂

Grand Canyon's volume is 1.67 billion cubic meters

Energetically tough to get low levels of CO₂ from a BIG atmosphere

Figure 1: The high cost of carbon capture

<table>
<thead>
<tr>
<th>Source: IEEFA</th>
<th>Without CCS</th>
<th>Current cost of CCS</th>
<th>Long-term goal for cost of CCS</th>
<th>Solar + storage</th>
<th>Wind + storage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$30</td>
<td>$60/ton CO₂</td>
<td>$30/ton CO₂</td>
<td>Recent PPA (Indiana)</td>
<td>Recent PPA (Colorado)</td>
</tr>
<tr>
<td></td>
<td>$96</td>
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Getting off fossil fuels takes time but we may **not have much time** before the system flips...and we cross tipping points.
We explore the risk that self-reinforcing feedbacks could push the Earth System toward a planetary threshold that, if crossed, could prevent stabilization of the climate at intermediate temperature rises and cause continued warming on a “Hothouse Earth” pathway even as human emissions are reduced.
Summary

**Mitigation** – reducing carbon levels in the atmosphere to reduce impacts

**Adaptation** - the process of adjustment to actual or expected climate and its effects

**Decarbonization** is real solution

The **biggest challenge** is public awareness