Preparing to Deliver Meaningful Climate Change Education to Secondary Students

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BCAMSC
INNOVATION THROUGH INSPIRATION

SEAS SCHOOL FOR ENVIRONMENT AND SUSTAINABILITY
UNIVERSITY OF MICHIGAN

CCE FOR ME

Students demand high-quality climate change course offerings

TIMOTHY E. MUHICH AND RICHARD B. ROOD

Large numbers of Americans of all ages are interested in learning more about climate change education (CCE) (Perkins et al. 2017) and high schools have the opportunity to contribute to that learning. The *Next Generation Science Standards* (NGSS Lead States 2013) attempt to address climate change for high school students across disciplines. Despite the presence of climate change in *NGSS,* most high schools do not dedicate a class specifically to climate change or even to Earth Science. This leaves the burden of CCE to physics, chemistry, and biology classes, which often make space for it by mentioning the topic in ancillary form (Monroe et al. 2013).

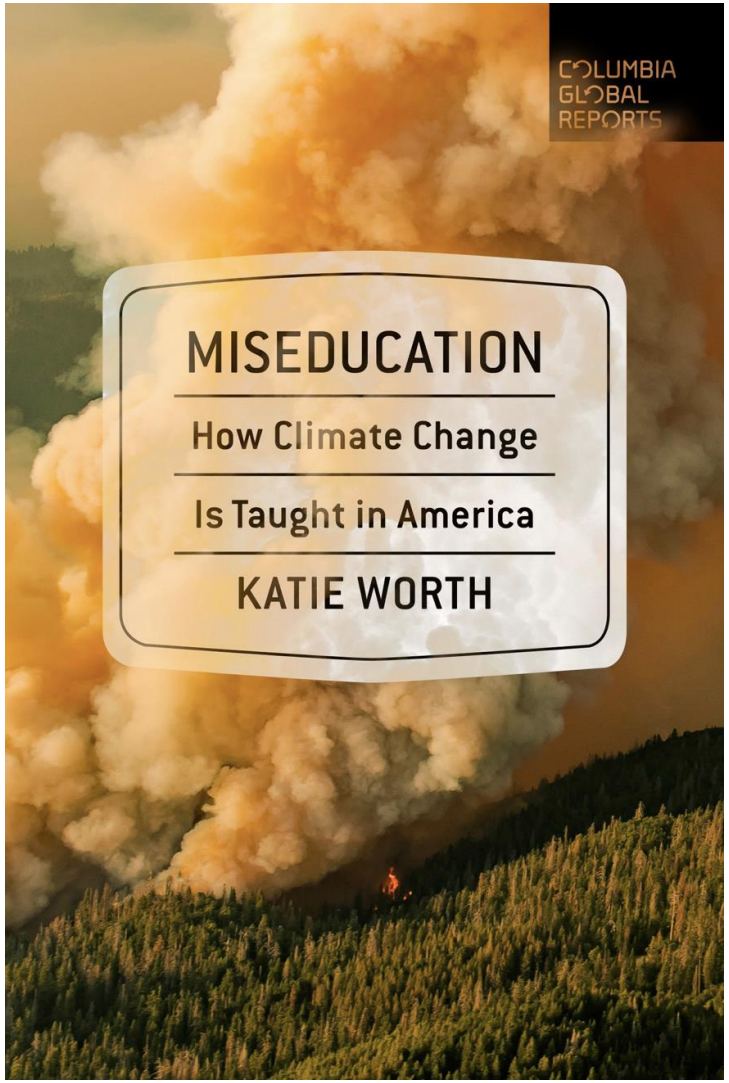
While it should be common practice to talk about climate change throughout the curriculum (NGSS Lead States 2013), only addressing climate when it comes up in other classes results in students graduating high school still unable to articulate the causes or effects of climate change as well as what needs to be done to address the problem (Monroe, Oxarart, and Plate 2013; Reid 2019; Schreiner, Henriksen, and Kirkeby Hansen 2005). Even if building climate change into other science classes was an effective strategy for teaching climate science, students would still not have gained climate literacy because CCE should also incorporate societal effects and climate justice (Stapleton 2019).

To leave students with applicable knowledge, CCE must be interdisciplinary. This allows students to address the most important questions—ones left out when CCE is just taught from an Earth Science perspective—such as "How might farmers adapt to changing climatic conditions? How might such adaptations affect the price of staple foods, such as corn or wheat?" (Monroe, Oxarart, and Plate 2013). Many articles reference what CCE should do (Chang and Pascua 2017; Monroe, Oxarart, and Plate 2013; Monroe et al. 2017; Reid 2019; Schreiner, Henriksen, and Kirkeby Hansen 2005; Stapleton 2019). None of these lists can be accomplished in passing (Supplementary Materials 1; see Online Connections). A stand-alone climate change course provides time for students to develop needed synthesis and skills and allows teachers in other classes to address climate change as it naturally comes up. In this case study, we provide evidence of that demand and propose a path for schools to deliver on it.

The study site

The Battle Creek Area Mathematics and Science Center (BCAMSC), a STEM school operated by Battle Creek Public Schools in Battle Creek, Michigan, began providing an interdisciplinary mini-course in climate change in 2004. Recognizing the impor-

How climate change is/should be taught in the US



- Americans are interested in learning more about climate change (Perkins et al., 2017)
- high schools have the opportunity to contribute to that learning.
- NGSS attempts to address climate change for students across disciplines (NGSS Lead States, 2013)
- Despite its presence in *NGSS,* most high schools do not dedicate a class specifically to climate change or even to Earth Science.
- This leaves the burden of CCE to physics, chemistry, and biology classes, which often make space for it by mentioning the topic in ancillary form (Monroe et al., 2013).
- Only addressing climate when it comes up in other classes results in students graduating high school still unable to articulate the causes or effects of climate change as well as what needs to be done to address the problem (Monroe et al., 2013; Reid 2019; Schreiner, et al., 2005).
- Even if building climate change into other science classes was an effective strategy for teaching climate science, students would still not have gained climate literacy because CCE should also incorporate societal effects and climate justice (Stapleton, 2019).

The features of high-quality CCE

- Leave students capable of engaging in climate change discourse (Chang and Pascua, 2017)
- Address mitigation and adaptation (Chang and Pascua, 2017)
- Increase adaptive and mitigation capacity of communities by helping students become able to make informed choices (Reid, 2019)
- It should be engaging and relevant (Monroe et al., 2017)
- Focus on impacts on human systems such as agriculture, health, extreme weather, infrastructure, and standard of living (Monroe et al., 2013; Stapleton, 2019)
- It must be interdisciplinary (Reid, 2019)
- It must address climate justice (Reid, 2019; Stapleton, 2019)
- It should empower students to act (Schreiner et al., 2005)
- Be project based and include active participation in the search for answers (Schreiner et al. 2005)
- It should not side-step emotion (Atkinson, 2022)

Climate Change & Michigan Forests

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Climate Change & Michigan Forests

Climate Change and the future of Michigan Cherries

The Concord Consortium
STEM Resource Finder

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High-Adventure Science: What is the future of Earth's climate?

Earth & Space | 6-8 | 9-12 | Unit | 8 days

Please Note: HASBOT scoring is now working, but it is not reliably scoring accurately at the moment. You can use it with your students, but be aware that the scores it gives may not be in the same range as scores from previous years. We are working to resolve this issue. Questions? Please email **has@concord.org**.

Earth's temperature has increased over the past 120 years due to increased levels of greenhouse gases in the atmosphere. Through a series of guided

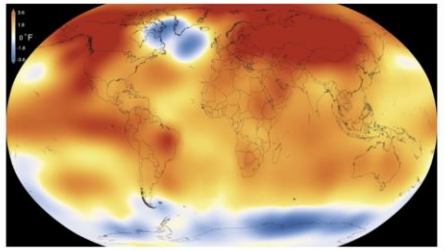

Image credit: NASA Goddard Institute for Space Studies

Unit Includes

- ✓ Teacher Edition
- ✓ Class Dashboard
- ✓ Pre- and Post-Tests
- ✓ Spanish-language Student Module
- ✓ Spanish-language Pre- and Post-Tests
- ✓ Automated Scoring and Feedback (HASBOT)

Stanford University Intranet

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Climate Change Education

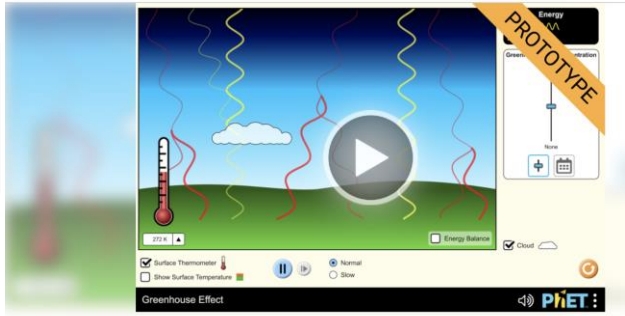
CLIMATE CHANGE EDUCATION

OVERVIEW
CURRICULUM
MIDDLE SCHOOL CURRICULUM
HIGH SCHOOL CURRICULUM

High School Curriculum

Students will be able to identify the relevance of studying climate

PhET



Greenhouse Effect

HTML5 Prototype: Prototypes are in their design phase and not fully tested. Learn more

An official website of the United States government Here's how you know

USDA Climate Hubs
U.S. DEPARTMENT OF AGRICULTURE

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REGIONAL HUBS ALL TOPICS ALL CLIMATE IMPACTS ALL ACTIONS & RESOURCES

Southwest Climate Hub About Topics Climate Impacts Actions & Resources Drought Partners

New Wildfire and Climate Change Module for High School Teachers

Home › Welcome to the USDA Southwest Climate Hub

By Kelly Steinberg

This spring (2022), Asombro is publishing a brand new education module for high school teachers in the Southwest. *Climate Change an* investigates the link between rising temperatures, increased drought, and wildfire in the forests, grasslands, and shrublands of the Sou Through three activities over five days, teachers and students build and burn model ecosystems, interpret and communicate data and mitigation strategies.

CLEAN
Committed to Climate and Energy Education

Climate and Energy Educational Resource Collection

NGSS & CLEAN at a Glance »

The CLEAN Collection is a high-quality and rigorously reviewed collection of climate and energy educational resources aligned with the Climate Literacy and Energy Literacy frameworks, and the Next Generation Science Standards.

Through peer-review, scientists and educators ensure scientific accuracy, pedagogic effectiveness, and classroom readiness for each resource.

The problem

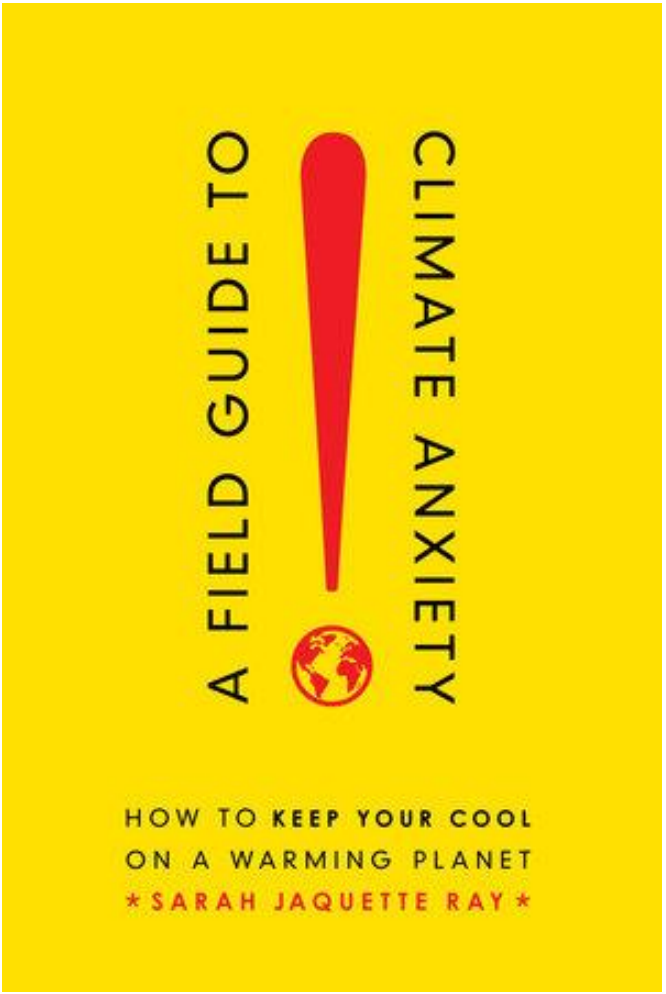
- how to get school administration to encourage the teaching of climate change, which depending on the location of the school may be seen by administration as divisive (Howe et al., 2015), even though for the most part, teaching it is now supported in theory (NAAEE, 2023)
- by teachers who know little (Monroe at al., 2013) have had (and want) little training in the subject (Ennes et al., 2021),
- in a way that accurately and completely addresses climate science and justice (Stapleton, 2019),
- when many science teachers still try to shy away from discussing or taking any sides when it comes to climate change (Nation and Feldman, 2022).

Options implementing meaningful CCE

Integration of Climate Change Across the Curriculum	**Implementation of Standalone Climate Change Course**	**Climate change as Part of an Extracurricular Activity**
1. Shows CC important and impacting all aspects of life 2. Ensures exposure to concepts by all students	1. Easy to implement 2. Students gain coherent storyline 3. Able to frame for student agency 4. Only requires CK and PCK by one teacher in a school	1. Much more freedom to do things that cannot be done in normal classes 2. Allows an ability to focus
1. CK and PCK needed by all teachers, this will require substantial PD 2. Diffusion of responsibility 3. Separation of impacts and solutions	1. Potentially limits exposure to those already interested 2. Limits scope of time to which student works in CC to one semester or one year	1. Limits exposure to those privileged enough to participate in extracurriculars 2. Relies upon
1. Siegner and Stapert, 2020	1. Muhich and Rood, 2022	1. Gutierrez et al., 2022

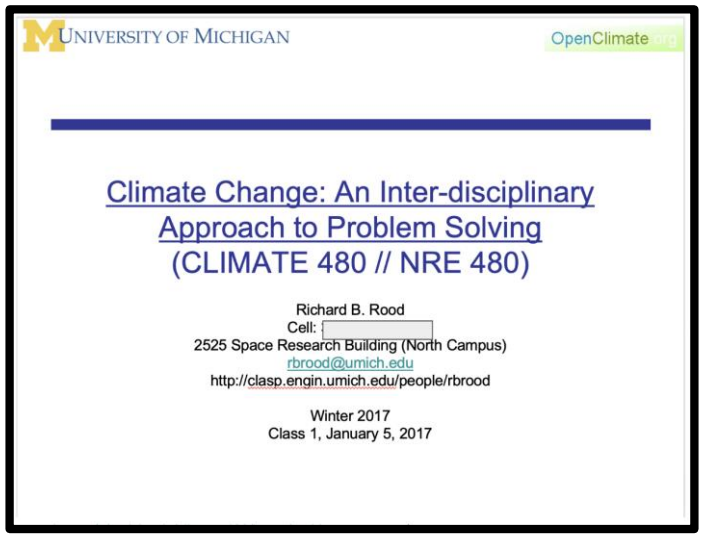
Mental Health

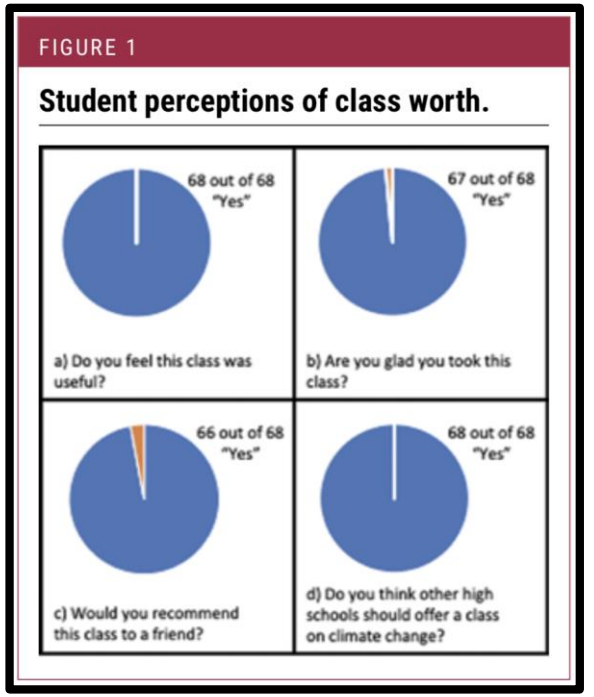
- Do you think we are doomed: On its face it is not a feel-good story, happier not to think about
- How to make it uplifting: Solution focused CCE may be effective at reducing mental health concerns (Vergunst and Berry, 2021)
- It can be hard, when students care, they put in the work
- This is very easy to screw up, and a lot of environmental education has been harmful to students (Ray, 2020)
- Emotions must not be sidestepped or dismissed (Atkinson, 2022)



Creating Honors GCC

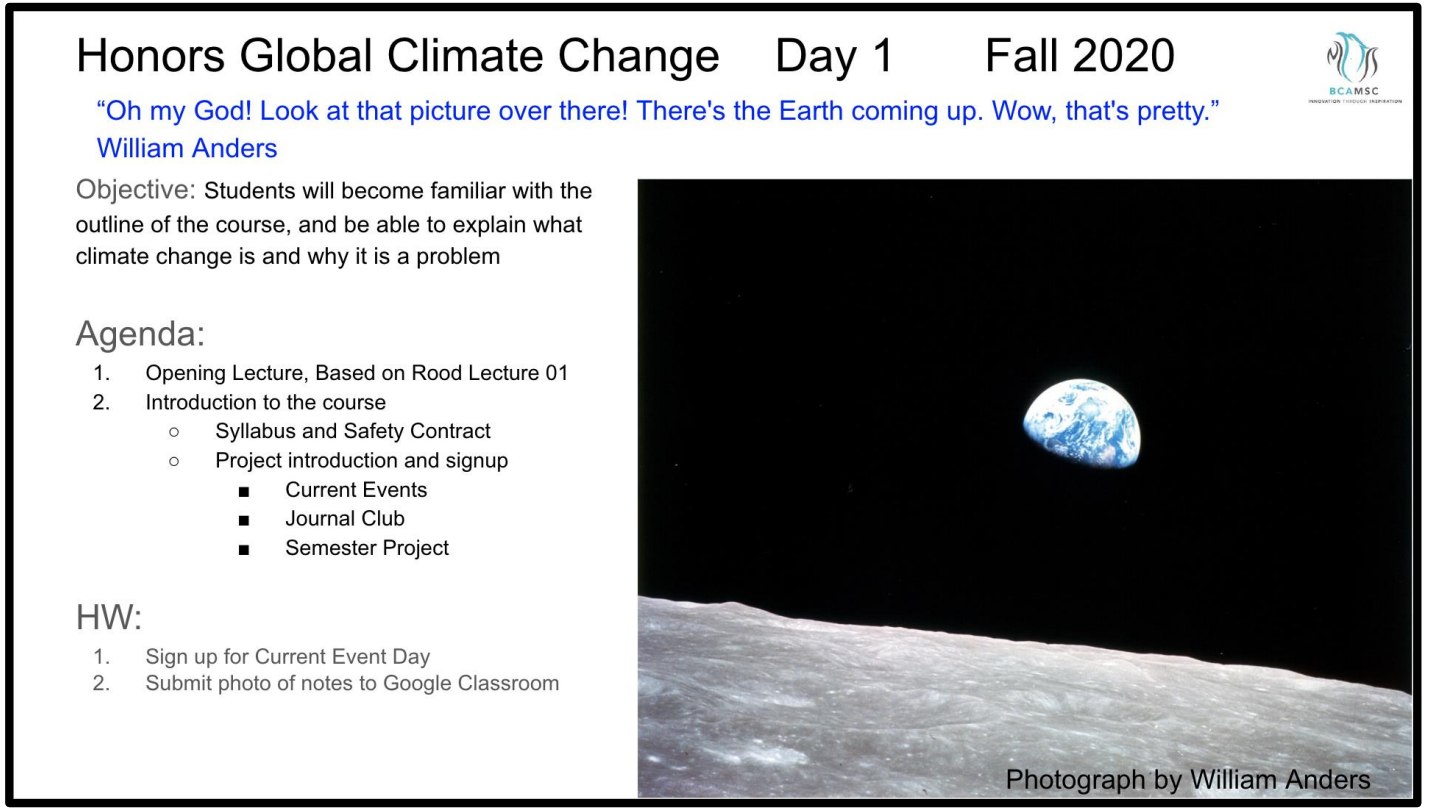
- “This class made me more aware of different things relating to climate change that I didn't even know existed and I have learned a lot of things that I can share with other people so they can become involved in the change as well”
- “Last year I knew I wanted to make a difference in the world, to leave it better than I found it. This class helped me learn how, it honestly was so inspiring to be in a class where everyone cares so much about these problems. This class was the best one I have taken throughout all of my years in school, it was very relevant gave me the tools I needed to find what I truly want to do. I am so grateful that I was able to take this class.”
- “I thoroughly enjoyed the class and think a lot of people need this to be educated individuals in our communities and solve this growing problem.”
- “I think this class was hands down the most useful and important class I have taken in high school. Thank you for being so passionate about educating us on the climate crisis. I wish this class was longer :(“





Creating Honors Global Climate Change

- Unit 1:
  - Understanding Climate and how it is changing
- Unit 2
  - Impacts of climate Change
- Unit 3
  - What to do about it



Current Events

GLOBAL CLIMATE CHANGE
Vital Signs of the Planet

SCIENTIFIC AMERICAN

OpenClimate.org

Climate

the ENVIRONMENT REPORT

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Scientific Source

Popular Source

IPCC Sixth Assessment Report
Impacts, Adaptation and Vulnerability

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Climate Change 2022: Impacts, Adaptation and Vulnerability

The Working Group II contribution to the IPCC Sixth Assessment Report assesses the impacts of climate change, looking at ecosystems, biodiversity, and human communities at global and regional levels. It also reviews vulnerabilities and the capacities and limits of the natural world and human societies to adapt to climate change.

Grand Rapids, MI

Historical and Future Climate Information

GLISA
A NOAA RISA TEAM

WEST MICHIGAN SUSTAINABLE BUSINESS FORUM

Main Points

- Temperatures are rising, but extremes will be moderated (lessened) by Lake Michigan.
- Winter temperatures are becoming less severe.
- Winter precipitation is transitioning to more rain and freezing rain as opposed to snow.
- Intense precipitation events have increased, but the timing of events in the future is not especially predictable.
- Increased drought is possible as more precipitation is projected to fall in shorter, intense events with longer dry periods in between.

Extreme Heat

Hot Days (92˚F) - Days with high temperatures at or above 92˚F are fairly common, and there has not been an increase in the number of days over 92˚F over the last 100 years. Multiple consecutive days experiencing max temperatures above 92˚F occur about once every other year, and the duration of extended hot days has been declining over the record. In 1897 there was a max of 9 consecutive days at or above 92˚F, but since the 1950's these types of events are limited to 3-4 consecutive days on average. By mid-century (2050), models suggest anywhere from one week up to one month more of days over 90˚F per year.

Hot Days (103˚F) - Days with temperatures at or above 103˚F (not taking into account the heat index when temperatures can feel hotter) are rare (only 6 on record, and only one of those was since the 1930's). The record maximum temperature was 108˚F. Geographically, the hottest temperatures are typically in the most urban parts of Grand Rapids (a result of the urban heat island effect) and locations farther away likely do not experience the same intensity of extreme heat. There are also very few (3) instances where multiple consecutive days were greater than or above 97˚F, making this level of prolonged heat rare. By mid-century (2050) models suggest up to two weeks more per year of days over 100˚F, but such hot days will not necessarily occur consecutively.

Heat Waves - Heat waves can result from a combination of different drivers including high humidity, daily high temperatures, high nighttime temperatures, stagnant air movement, etc. In the future, models project an increase in the number of days experiencing high temperatures that could lead to additional heat waves, especially since air stagnation events are projected to increase. There is greater certainty that summer nighttime low temperatures will continue to increase, thereby making it more difficult for people to cool off at night during extended heat events. In addition, periods of future drought will also contribute to extreme heat.

Extreme Cold

Cold Days (-20˚F) - Days with temperatures at or below -20˚F have only been observed 11 times in the 125-year record for Grand Rapids, MI, making it a rare event, and all but three were prior to 1900. In addition, consecutive days at or below -20˚F have not occurred since 1900. In the future there are projected to be even fewer very cold days, so this type of event will be even more rare.

Cold Days (-10˚F) - Days with temperatures at or below -10˚F have been observed very few times in the last 30 years, but were more common during the 1960s-80s. Since 1900, there have only been three instances where a max of three consecutive days were at or below -10˚F, and the majority of cold events of this intensity were only one- or two-day events. In the future there are projected to be even fewer very cold days, so this type of event will be even more rare.

Cold Days (10˚F) - Days with temperatures at or below 10˚F are fairly common and occur on average about 23 times per year. Cold events of three or more consecutive days at or below 10˚F are also more common and occur on average about 2-3 times per year. In the future there are projected to be fewer cold days, so this type of event will likely occur less frequently.

Wind Chill (-15˚F) - Since the mid 1970's, eight years never experienced wind chill values less than -15˚F and 10 years experienced less than 10 hours per year (1994 experienced the most number of hours totalling about 5 days worth). In general, more recent years have been characterized by fewer hours annually below this threshold, but there is great year-to-year variability. The data indicate wind chill values in Grand Rapids are driven more by cold temperatures than high wind speeds. This suggests even fewer wind chill hours in the future below -15˚F as very cold temperatures will become more rare.

Flood Indicators

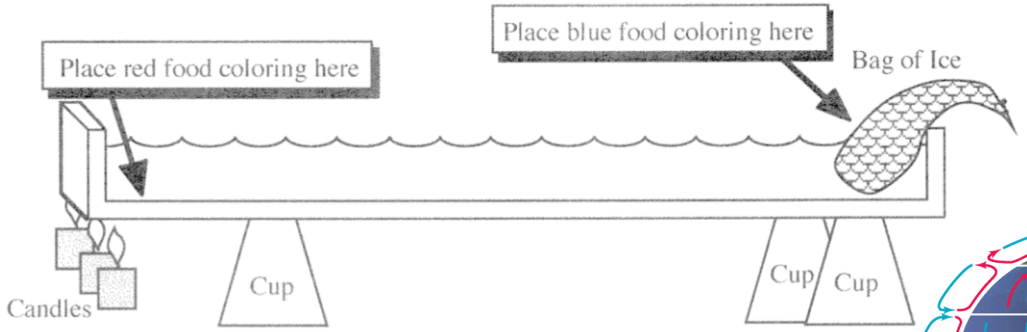
Floods can occur under a variety of conditions not necessarily caused by heavy or extended periods of rainfall. For example, relatively little rainfall could initiate flooding conditions if the ground is already saturated, or if winter snow pack melts quickly. In the future, flooding associated with winter snow melt and winter rain is more likely. In urban environments, the amount of impervious surfaces and management of runoff also plays a major role in the potential for flooding.

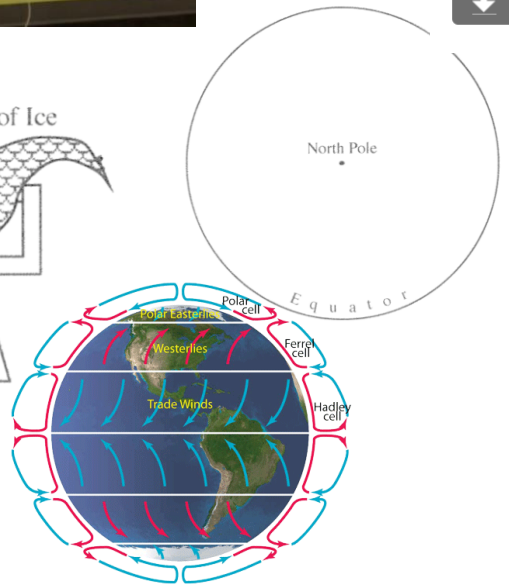
Heavy Rain (1-hour events) - The number of hours per year experiencing heavy rain over 0.3 inches per hour has gradually increased from 16 annual hours to 20 hours on average since 1975 with strong year-to-year variability. The projections do not explicitly provide 1-hour event information, because precipitation is reported at the daily time scale. However, extreme daily precipitation is projected to increase, so it is feasible increases may be in part due to more intense hourly events.

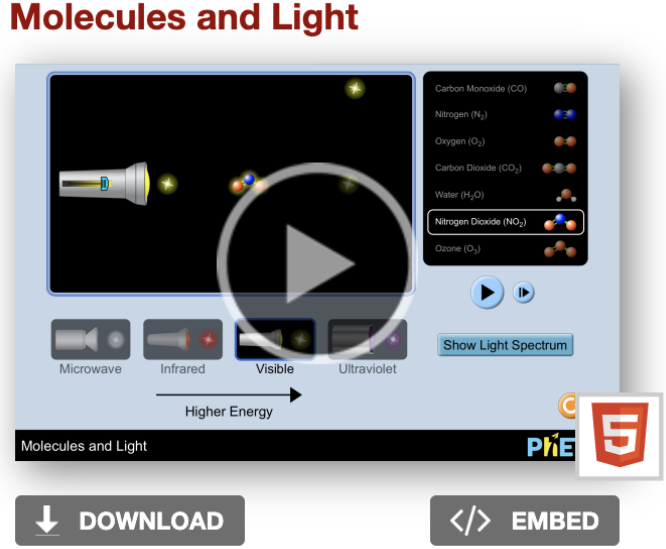
Heavy Rain (35-hour events) - The number of times per year experiencing over 1 inch of rain in 35 hours has increased since 1975 with strong year-to-year variability. Trends are positive but not as strong for 35-hour events receiving over 1.25 and 1.5 inches, and there is very little change in the number of 35-hour events per year receiving over 2 inches of rain. However, by mid-century (2050) up to a week more of days receiving over 2 inches of rain is projected.

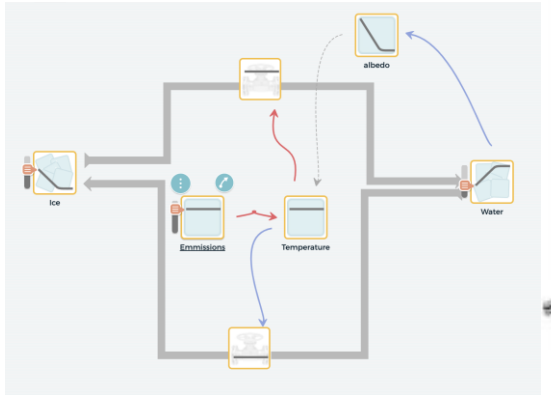
Heavy Rain (2-week events) - Periods of 2 weeks receiving 3

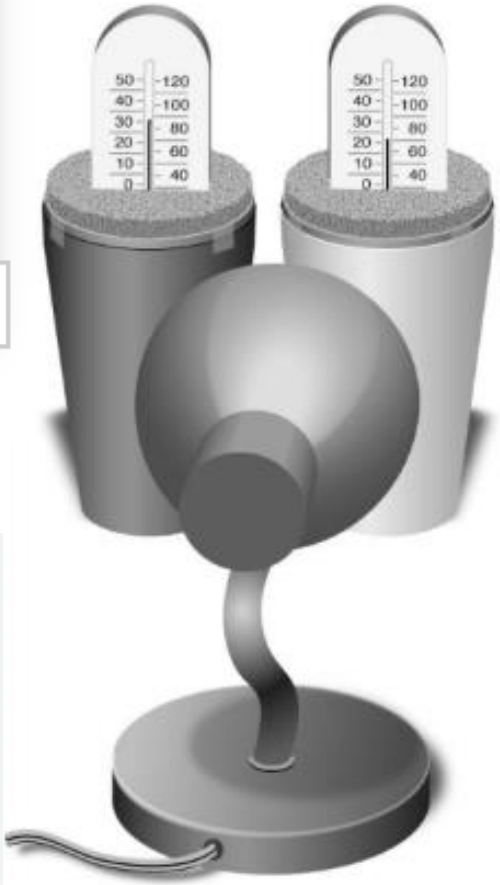
HGGC: Unit 1, Understanding climate and how it's changing



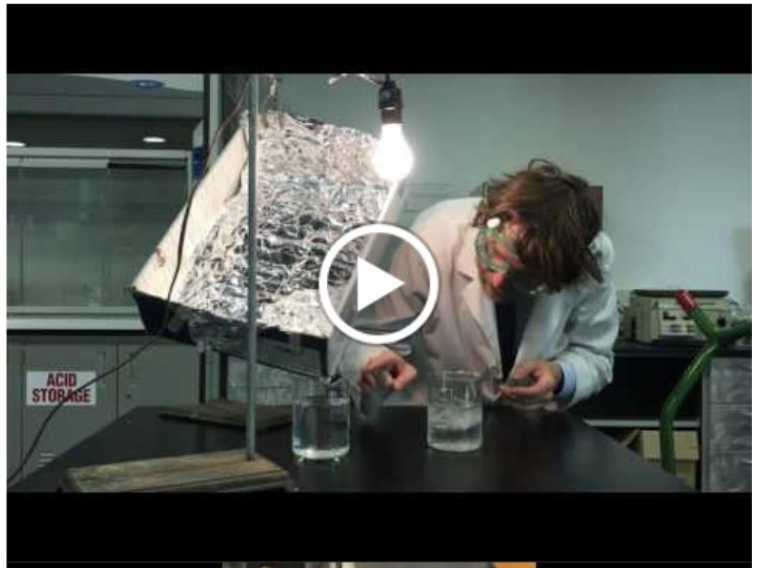


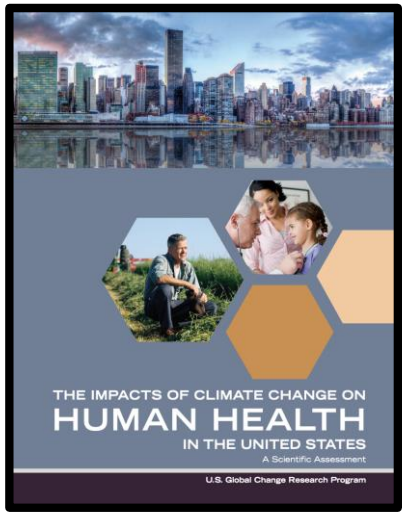


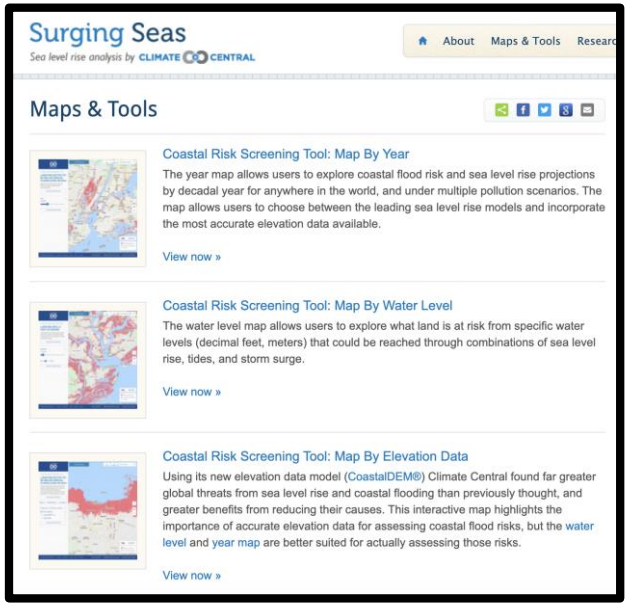


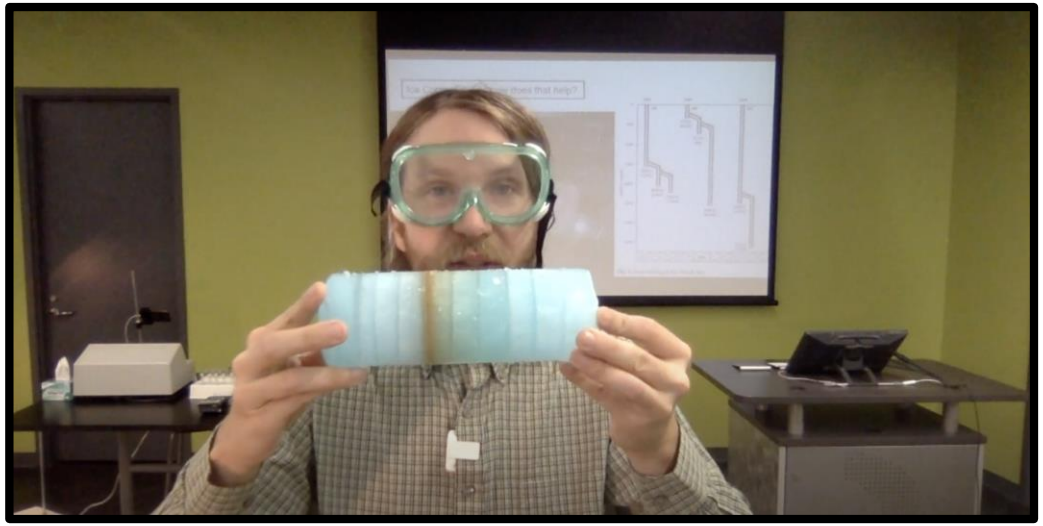


HGGC: Unit 2, The impacts of climate change

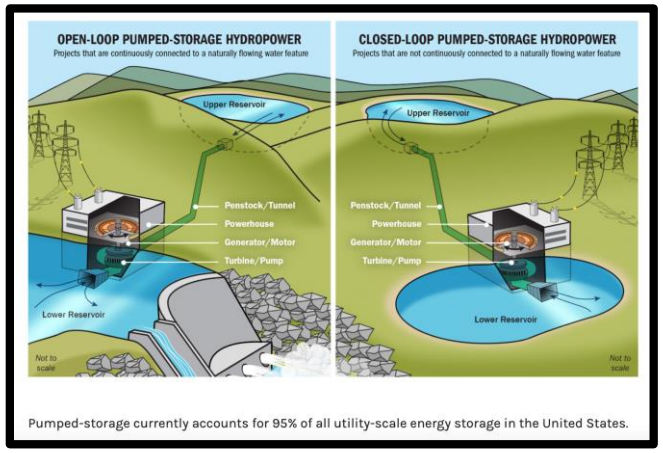




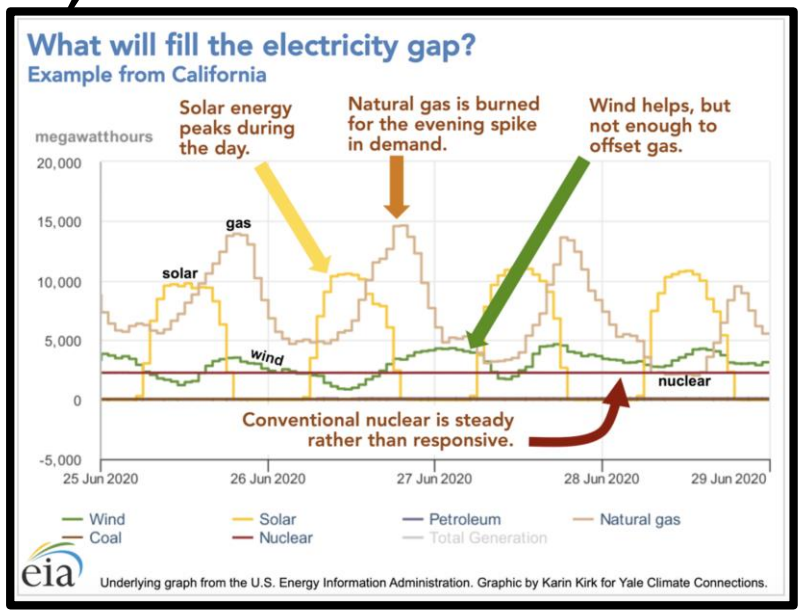




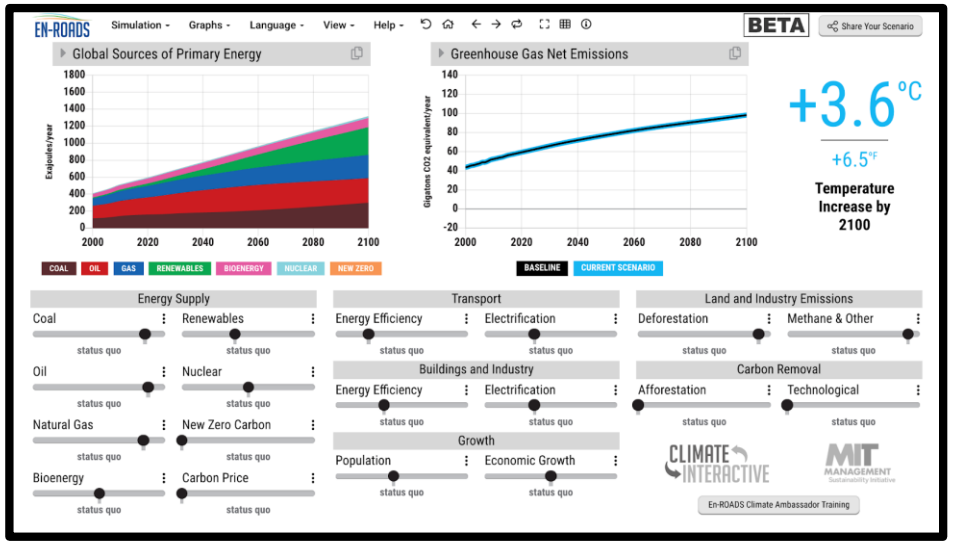
HGGC: Unit 3, What to do about it

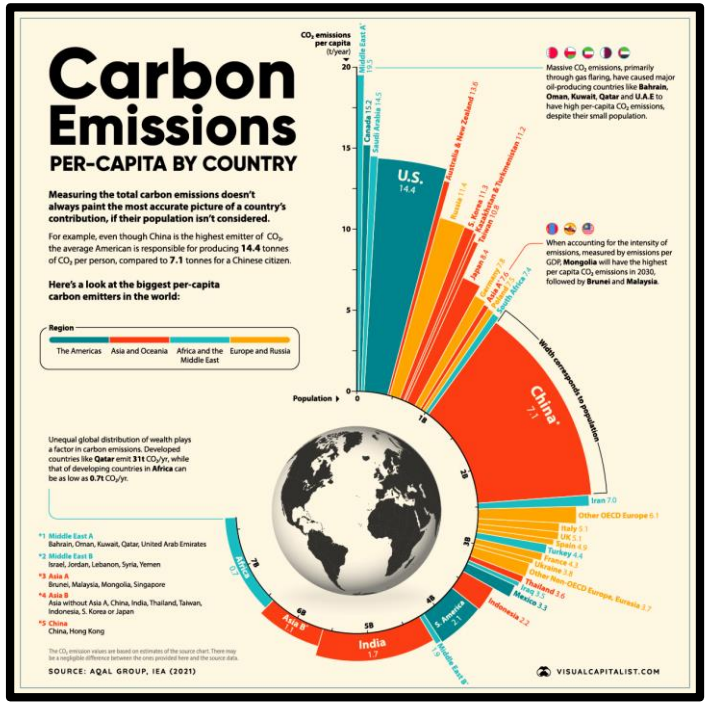


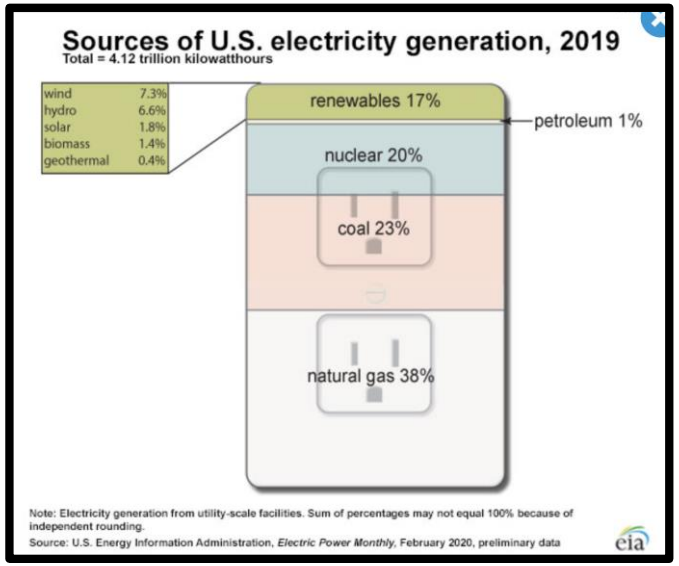
Pumped-storage currently accounts for 95% of all utility-scale energy storage in the United States.

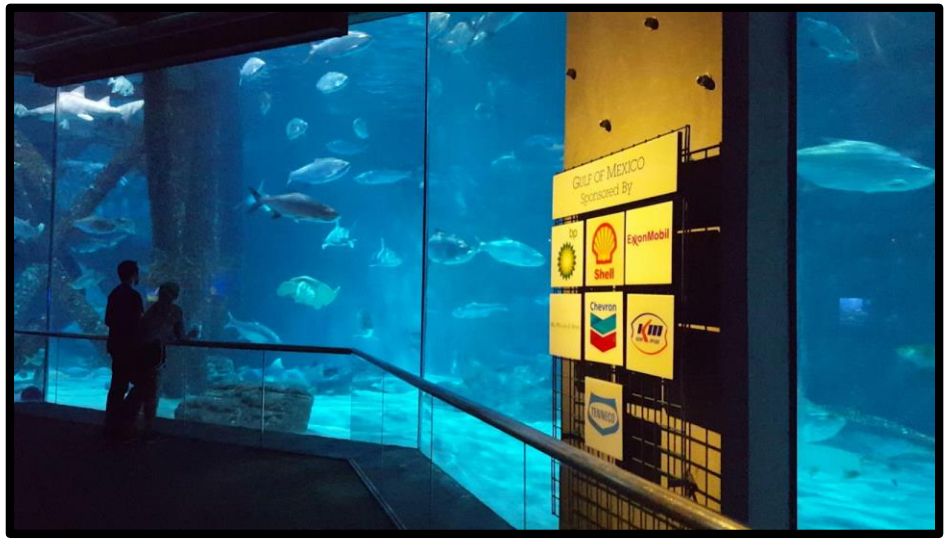


Underlying graph from the U.S. Energy Information Administration. Graphic by Karin Kirk for Yale Climate Connections.





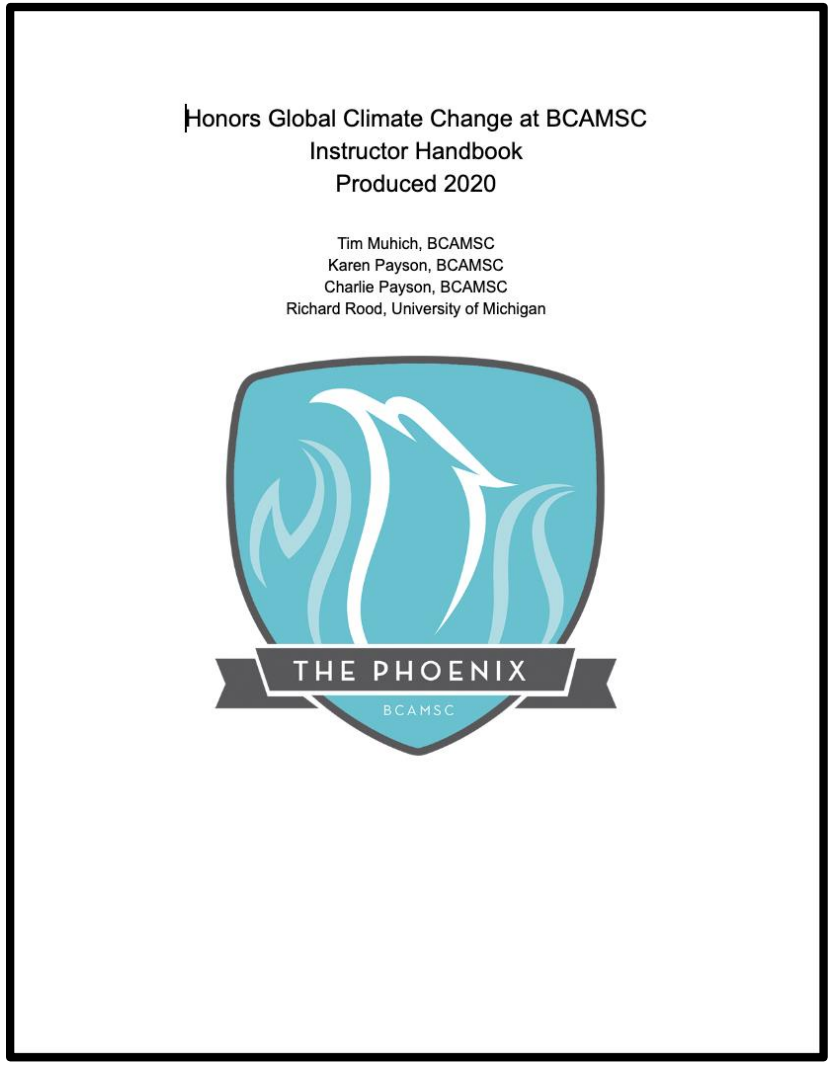




HGGC: Accessing Curriculum

- Available through The Science Teacher (Muhich and Rood, 2022)
- Available through Gooru
- Available through tmuhich@umich.edu

- Needs refinement
- Needs tailoring


Honors Global Climate Change at BCAMSC
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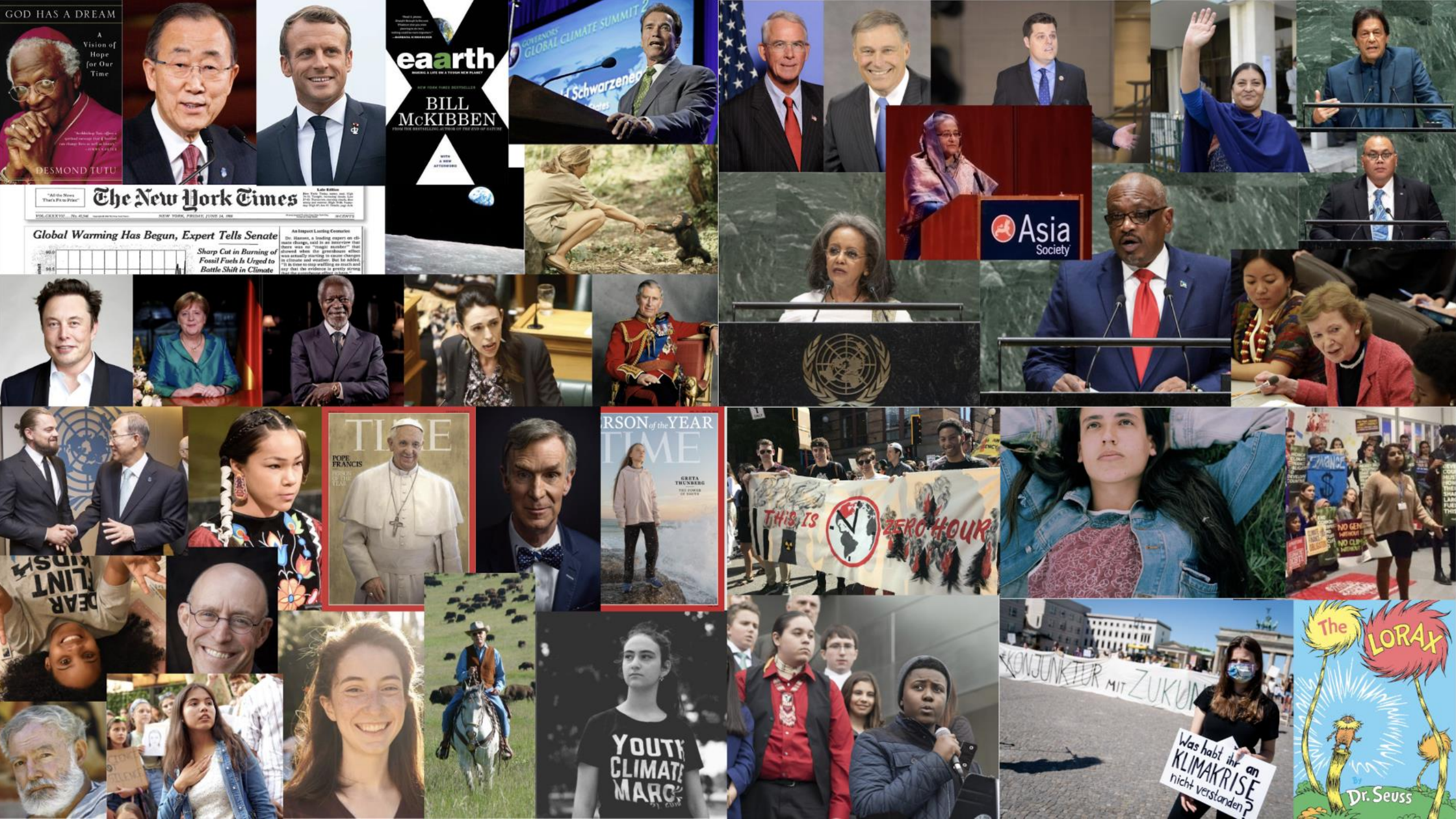
GOD HAS A DREAM
A Vision of Hope for Our Time
DESMOND TUTU
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The New York Times
Global Warming Has Begun, Expert Tells Senate
Sharp Cut in Burning of Fossil Fuels Is Urged to Battle Shift in Climate
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TIME
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THIS IS ZERO HOUR
YOUTH CLIMATE MARCH
KONJUNKTUR MIT ZUKUNFT
Was habt ihr an KLIMAKRISE nicht verstanden?
The LORAX
Dr. Seuss

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