Using Energy Efficiency to Lower the Emissions Trajectory & Adapt to High Heat Days

(2-3 hours of in-class instruction and activities
4-14 hours of out of class assignments)

Contents

Unit Description

For most Californians, the climate issue remains geographically distant and easily dismissed. Teachers reinforce this distance in our classrooms when we describe potential climate impacts that are hundreds if not thousands of miles away. In this Unit, students will be introduced to Cal-Adapt, a web-based climate-adaptation planning tool that allows anyone to model climate in California down to the level of zip code. Students will use Cal-Adapt and other state planning tools to analyze climate data, discuss the local impacts of climate change, and learn about the ways in which society can mitigate and adapt to this problem. Finally, students will explore a specific mitigation or adaptation action proposed for their own community.

Learning Objectives

Students will be able to:

- Describe the scientific causes and impacts of climate change
- Forecast the potential climate change scenarios for their community
- Communicate the physical and social impacts of climate change on their community
- Identify and communicate potential climate change mitigation actions for their community
- Identify and communicate the potential adaptations to climate impacts for their community
- Design, document, and present a specific mitigation or adaptation action proposed for their community

Essential Questions

- What will climate change look like in the coming years for myself and my community?
- What are the various impacts climate change will have on myself and my community?
- What can I and my community do to reduce the emission of greenhouse gases to mitigate climate change?
- What can I and my community do to adapt to the coming impacts of climate change?

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Introduction to Climate Forecasting with Cal-Adapt

Setting the Stage: What is Cal-Adapt?

Using this 6 minute instructional video from Dr. Mark Stemen, introduce students to Cal-Adapt (https://cal-adapt.org/) and show how it allows the user to identify potential climate change risks in specific geographic areas throughout the state. Explain that Cal-Adapt synthesizes volumes of existing downscaled climate change scenarios and climate impact research and presents it in an easily available, graphical layout. Inform them that these are not forecasts - they are potential scenarios based on downscaled IPCC models to describe how climate may evolve in California.

Cal-Adapt is an excellent tool for starting the discussion to take action in response to climate change. The immediate and convenient accessibility to climate impacts supported by the latest research (downscaled to CA's geography) allows students to obtain knowledge of potential climate impacts in their area, and subsequently determine the vulnerabilities to those impacts. Once those vulnerabilities are identified, strategies can be developed to prepare for and respond to the impacts. The discussion truly begins once climate impacts and vulnerabilities are known, and this tool provides a convenient and effective way to explore this.

Some useful definitions

The future climate data used within Cal-Adapt represent a **projection** of potential future climate scenarios; they are not predictions. These data are meant to illustrate how the climate may change based on a variety of different potential social and economic factors.

A **scenario** is a coherent, internally consistent and plausible description of a possible future state of the world. It is not a forecast; rather, each scenario is one alternative image of how the future can unfold.

Impacts are consequences of climate change on natural and human systems.

Vulnerability with respect to climate change is the degree to which a system is exposed to, susceptible to, and (un)able to cope with and adapt to the adverse effects of climate change.

Adaptations with respect to climate change refer to adjustments in natural or human systems aimed at minimizing harm or taking advantage of beneficial opportunities.

Activity: Using Cal-Adapt

This handout consists of an instructional activity for students to navigate the Cal-Adapt software. Cal-Adapt is a web-based platform which allows you to forecast the future climate of your campus or community. As an integral piece of this course, becoming familiar with this software will assist students in understanding and analyzing how climate action will affect the future of our communities. This activity compiles a detailed list which instructs students on how to find data and

information through the webpage. It is encouraged that this activity is completed in order to familiarize students for future assignments and discussions.
Through the Cal-Adapt software, we are able to forecast two different scenarios; RCP 4.5 & RCP 8.5. RCPs, or 'Representative Concentration Pathways' scenarios that describe alternative trajectories for carbon dioxide emissions and the resulting atmospheric concentration from 2000 to 2100. They encompass the range of possible climate policy outcomes for the 21st century. More information regarding the two scenarios are outlined in the latter half of Handout 1.

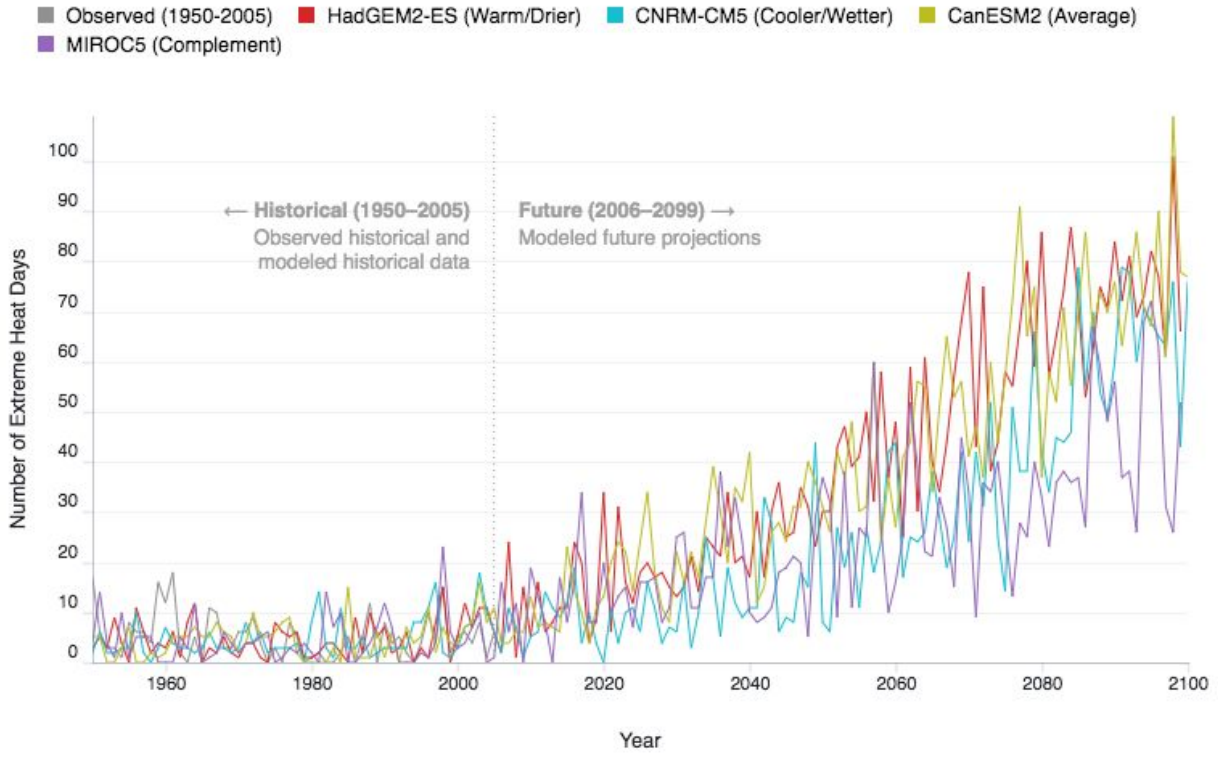
Assignment:
Assignment #1 leads students through using the Annual Average Temperature and Precipitation Tool in Cal-Adapt. By forecasting the future temperature, students are prompted to complete research on the historic average maximum temperature for their area, the average maximum temperature for a 4.5 RCP scenario, and the average maximum temperature for an 8.5 scenario. After completing this research, students will be asked to apply these data projections to further analyze how a future with climate action will differ from one without adaptation and mitigation efforts. The same questions will be posed after students research and analyze what changes in average precipitation may mean for their communities.

Setting the Stage: Extreme Heat (EH)

For most areas around the state, the climate models project a significant rise in the number of days exceeding what is now considered extremely hot for the given area. For purposes of Cal-Adapt, an extreme heat day is defined as a day in a year when the daily maximum temperature exceeds the 98th historical percentile of daily maximum temperatures based on observed historical data from 1961–1990 between April and October.

Number of Extreme Heat Days by Year

This chart shows number of days in a year when daily maximum temperature is above the extreme heat threshold of 103.9 °F. Data is shown for Chico under the RCP 8.5 scenario in which emissions continue to rise strongly through 2050 and plateau around 2100.



- Source: Cal-Adapt. Data: LOCA Downscaled Climate Projections (Scripps Institution of Oceanography), Gridded Historical Observed Meteorological and Hydrological Data (University of Colorado, Boulder).
- Four models have been selected by California's Climate Action Team Research Working Group as priority models for research contributing to California's Fourth Climate Change Assessment. Projected future climate from these four models can be described as producing:
  - A *warm/dry* simulation (HadGEM2-ES)
  - A *cooler/wetter* simulation (CNRM-CM5)
  - An *average* simulation (CanESM2)
  - The model simulation that is most unlike the first three for the best coverage of different possibilities (MIROC5)

The health impacts from extreme heat are well-known. Heat exhaustion is a milder form of heat-related illness that can develop after several days of exposure to high temperatures and inadequate or unbalanced replacement of fluids. It is the body's response to an excessive loss of the water and salt contained in sweat. Those most prone to heat exhaustion are elderly people, people with high blood pressure, and people working or exercising in a hot environment.

Heat stroke occurs when the body is unable to regulate its temperature. The body's temperature rises rapidly, the sweating mechanism fails, and the body is unable to cool down. Body

temperature may rise to 106°F or higher within 10 to 15 minutes. Heat stroke can cause death or permanent disability if emergency treatment is not provided.

Activity: Forecast Extreme Heat Days and Heat Waves

This assignment will work within the Cal-Adapt software to help students forecast extreme heat days and heat waves. Additionally, if needed, refer back to Handout 1 to refamiliarize with how to find this data accurately. Once students have calculated the extreme heat temperature thresholds for their communities, they will forecast the number of extreme heat (EH) days for 2050 under both the RCP 4.5 and 8.5 scenarios. After collecting this research, students will apply this data in an effort to analyze the importance of acting on climate change. Students will be prompted to scaffold their understanding of how extreme days will affect their communities and propose ways to adapt to these impacts to facilitate discussion. After this, students will be asked to look into the timing of extreme heat events to forecast when the first heat waves will happen during the school year for their community.

Setting the Stage: Climate Justice

The protests following the murder of George Floyd amplified the need and the call from our students to address systemic racism and oppression in all of our teaching. In this context, students are seeking to understand why environmental harms, like polluted water or toxic air, are not equally distributed. This environmental injustice has produced environmentally disadvantaged communities that suffer disproportionate impacts of climate change. Compounding the unfairness of environmental injustice, these communities often contributed less to generating the global greenhouse gas emissions that are causing climate change, and they are less likely to have the financial capital to rebound from a climate disaster like fire, flooding, or displacement from sea level rise.

Activity: Identifying Disadvantaged Communities

In-class instructional time will be used to compare and contrast communities. Instructors should plan to introduce CalEnviroScreen (CalEnviroScreen 3.0 | OEHHA) to their students during this time and analyze the indicator sets used. Note that communities within the top 25 percentile (numerical value 75 or above when looking at the software) are considered 'disadvantaged' by SB 535. The SB 535 disadvantaged communities are listed visually via an interactive map here. Additionally, instructors will draw the connection between environmental justice issues and the negative impacts of climate change. Students and instructors can reference Handout 2 for detailed instructions on how to use CalEnviroScreen.

Assignment:
Students will explore disproportionate environmental health effects using the CalEnviroScreen tool. In Assignment #3, students will use CalEnviroScreen to locate the Disadvantaged Communities (DAC) in their own regions. Students should refer back to Handout 2 as a directional document for

the software. CalEnviroScreen showcases indicators such as ozone, PM2.5, diesel, pesticides, toxic releases, traffic, drinking water, cleanups, groundwater threats, hazardous waste, impaired water, solid waste, asthma, low birth rate, cardiovascular rate, education, linguistic isolation, poverty, unemployment, and housing burden. Students will answer a series of questions in an effort to understand the importance of climate justice and what communities may be most vulnerable to an unpredictable climate.

Taking Action: Mitigation and Adaptation Strategies

Activity: Adaptation Projects

Greenhouse gases take approximately fifteen years from release to begin impacting the temperature. So, the GHGs that will impact us in 2030 have already been released. We can only adapt to them. By teaching students about the practicalities of what a life adapted to climate change looks like, and the costs involved in adaptation, we hope that this instruction will also build interest and motivation to explore mitigation measures in the next exercise. By discussing the necessary adaptations, students will take in-class instruction/discussion into an at-home research assignment outlined in more detail below.

Assignment:
In Assignment #4, students will be prompted to research an adaptation project that your campus or community could develop to prepare for the impacts of climate change. You may decide to focus students on adapting to a particular climate impact, such as extreme heat, or you might decide to invite them to broadly investigate climate adaptations to the most pressing climate impacts in their community.

To assist students with their brainstorming, here is a list of potential adaptations to extreme heat that are common to California communities:

- Tree planting to provide shade at schools and parks
- City-established "cooling centers" with culturally appropriate activities
- Seasonal readiness activities and an extreme heat warning system
- Extreme heat "siesta time" and "cool night" community gatherings to help people lower their body temperatures
- Providing care for "mobility-challenged" and other vulnerable populations, including transportation to cooling centers
- Solar panels shading parking lots with energy storage and the ability to "island" into a microgrid during a power outage for reliable power during climate emergencies

Supplemental Assignment: Extreme Heat Survey
In Assignment #5, students will survey different communities on their knowledge of extreme heat and how community members personally respond to extreme heat days. Students will then compare and contrast the replies. Extreme heat affects disadvantaged communities (DAC) differently and the difference can be seen in the various personal adaptation measures

undertaken by members of these different communities. Another way for students to be exposed to the disproportionate impacts of climate change is by surveying members of different communities on their responses to extreme heat. Past users of this survey have found that wealth and income influence the responses to extreme heat. When asked how they would respond to extreme heat, for example, turning on the air conditioning was the primary response for people outside of a DAC, while travel to air conditioning was the primary response to people living in a DAC.

The same unequal impacts can be seen when questioned about which of their activities were limited by extreme heat. People in the DAC avoided cooking in the heat to avoid heating their house. Few outside the DAC mentioned not cooking, under the assumption they have air conditioning to cool the house back down. Both groups avoided exercise. DAC residents could not do physical work; non-DAC residents could not walk the dog. People in the DAC tended to stay local if they left the home looking for a cooler location (mall, shopping, movie) while those outside the DAC often mentioned leaving town or going on vacation.

Activity: Mitigation Measures

We need to reduce greenhouse gas emissions in order to move from the 8.5 RCP scenario to the 4.5 RCP scenario as outlined in Cal-Adapt. One way to reduce GHG emissions is by using less energy. Burning fossil fuels accounts for roughly 63 percent of our electricity here in the United States according to the EPA.[1] Burning fossil fuels such as coal takes carbon reservoirs that are safely buried within the Earth and releases them into the atmosphere. Guide discussion on ways to reduce household energy usage as well as ways campuses could reduce their energy use. *Prompt students to collectively compile a list of ways that energy is wasted both residentially and on campus. We recommend a working google document to provide a platform for collaboration.*

Additionally, if instruction is in-class rather than online, teachers can explore the topic of phantom loads as a mitigation measure. This activity will use a watt-meter in order to collect data on energy used passively. If interested, refer to this handout for a more detailed approach to a student-facing activity that can illuminate the link between phantom energy and GHG emissions as they may relate to mitigation efforts. If students do not have access to a watt meter, the same activity may be completed with online research (here is a no watt-meter version of the handout above).

In the assignment explanation below, students will use what they have learned through instruction to complete an assignment directly related to mitigation measures as they relate to appliance swaps. We will explore how our current energy habits result in GHG production and how *Energy Star appliances* can mitigate some of our impact.

[1] https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

Assignment:
In this assignment, students will investigate whether there is an opportunity to swap an appliance to Energy Star approved options. They will calculate costs of their current energy usage, kilowatt-hours, as well as the reduction in GHG these appliances would provide. Reference Assignment #6 for synthesizing questions and calculation specifics.

More ideas for this assignment may include:

- Reducing phantom loads as explained above
- Advocacy opportunities to lead an energy-saving campaign
- Building envelop audit to reduce air infiltration and the resulting loss of heated or cooled air

Supplemental Activity: Storytelling Using Cal-Adapt
Developing an adaptation plan to prepare for extreme heat can become too daunting for students and such an assignment could quickly become discouraging. Another approach is to have students write fictional stories set in the future that describe a successful adaptation that has been completed and is making life better in a climate changed future. The idea is to tell the story of a past action (undertaken now but seen from 2050) that encourages students and others to begin taking adaptation actions today.

Heat exhaustion and heat stroke are the two big impacts of extreme heat that will require us to adapt:

- Heat exhaustion is a milder form of heat-related illness that can develop after several days of exposure to high temperatures and inadequate or unbalanced replacement of fluids. It is the body's response to an excessive loss of the water and salt contained in sweat. Those most prone to heat exhaustion are elderly people, people with high blood pressure, and people working or exercising in a hot environment.
- Heat stroke occurs when the body is unable to regulate its temperature. The body's temperature rises rapidly, the sweating mechanism fails, and the body is unable to cool down. Body temperature may rise to 106°F or higher within 10 to 15 minutes. Heat stroke can cause death or permanent disability if emergency treatment is not provided.

Assignment:
In this assignment, the story will describe an adaptation that is keeping people from getting heat exhaustion or heat stroke. Student stories should be set in 2050 to match their Cal-Adapt forecasts. The adaptation they will describe does not eliminate the increase in temperature, but the story will show how the adaptation is making the hotter days more bearable, and in some cases, even enjoyable, if it involves play.

Extensions - Use the other tools on Cal-Adapt:

- Use the Sea Level Rise tool to check for coastal and inland flooding.

- Use the Wildfire and Snowpack tools to forecast secondary climate impacts on our watersheds and wildlands.
- Use the Degree Days tool to explore projected changes in Heating Degree Days and Cooling Degree Days, which are a common proxy for energy needed to heat and cool buildings, respectively.
- What additional impacts do students see from those changes?

Resources: A Note from Dr. Mark

I have used Cal-Adapt in four different class projects. This module covers those four projects, including syllabi, course assignments, and an extensive reading list organized by topic.

- In 2016, students used Cal-Adapt to forecast the future climate for Chico, and in consultation with City staff, propose possible adaptations.
- In 2017, students, working with a Civic Spark Fellow, used Cal-Adapt and the California Adaptive Planning Guides to produce a climate vulnerability assessment for the City of Chico.
- In 2018, students used Cal-Adapt to produce a story-based vulnerability assessment of Chico State.
- In 2019, high school students used Cal-Adapt to forecast their local climate impacts

UC-CSU NXTerra is a resource for college teachers from across all disciplines and anyone seeking to enhance their teaching and learning about the climate crisis, critical sustainability, and climate justice studies, both inside and outside the classroom.

This article in the Guardian describes the scientific consensus on climate change: "The scientific consensus that humans are causing global warming is likely to have passed 99%, according to the lead author of the most authoritative study on the subject and could rise further after separate research that clears up some of the remaining doubts.

Three studies published in Nature and Nature Geoscience use extensive historical data to show there has never been a period in the last 2,000 years when temperature changes have been as fast and extensive as in recent decades.

It had previously been thought that similarly dramatic peaks and troughs might have occurred in the past, including in periods dubbed the Little Ice Age and the Medieval Climate Anomaly. But the three studies use reconstructions based on 700 proxy records of temperature change, such as trees, ice and sediment, from all continents that indicate none of these shifts took place in more than half the globe at any one time."

https://climate.nasa.gov/scientific-consensus/

From the NASA Global Climate Change Site: "Multiple studies published in peer-reviewed scientific journals[1] show that 97 percent or more of actively publishing climate scientists agree*: Climate-warming trends over the past century are extremely likely due to human activities. In addition, most of the leading scientific organizations worldwide have issued public statements

endorsing this position." The site provides a partial list of these organizations, along with links to their published statements and a selection of related resources.

Extreme Heat links:

https://www.ready.gov/heat
https://www.ready.gov/extreme-heat-safety-social-media-toolkit

Launched in February 2003, Ready is a National public service campaign designed to educate and empower the American people to prepare for, respond to and mitigate emergencies, including natural and man-made disasters. The goal of the campaign is to promote preparedness through public involvement.

Extreme heat is a period of high heat and humidity with temperatures above 90 degrees for at least two to three days. In extreme heat your body works extra hard to maintain a normal temperature, which can lead to death. In fact, extreme heat is responsible for the highest number of annual deaths among all weather-related hazards.

The Extreme Heat Safety Social Media Toolkit has safety and preparedness messages you can share on your social media channels. You can either copy these messages directly or customize them to reach your audience.