Climate Across the Curriculum: Teaching Climate Change in the Classroom

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Increase awareness of Climate Change through pedagogical innovation

Bring climate studies into the mainstream education

Use pedagogy as a means to address a great concern of our time

National Resource Center on Climate Change at IISER Pune MHRD, GOI

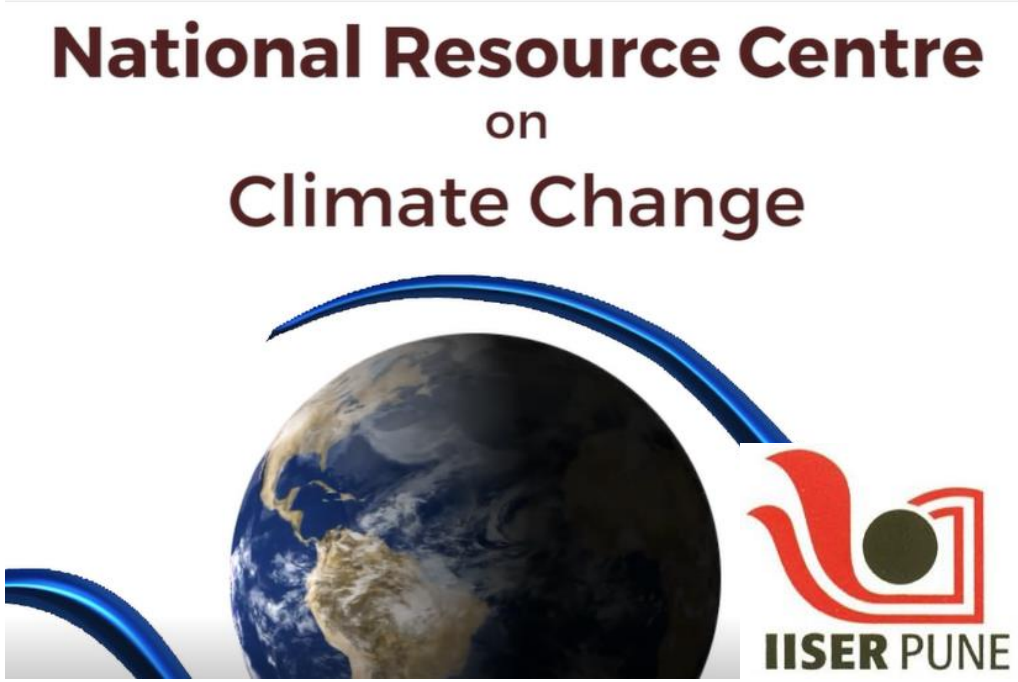
Overall objectives of the NRC

To empower faculty through training by providing latest developments in the subject domain including

Recent literature and reference material

New dimensions of knowledge

Pedagogical improvement



MOOC ON SWAYAM FOR HIGHER EDUCATION FACULTY TEACHING CLIMATE CHANGE

	TOPIC
1	Introduction to the Course
2	Introduction to Climate Science and Climate Change
3	Climate Archives, Data, & Climate Models
4	Climate Change: a) Past Records
	(i) Climate Change on Tectonic Timescales
	(ii) Climate Change on Orbital Timescales
	(iii) Climate Change on Glacial/Deglacial Timescales
	(iv) Climate Change on Millenial Timescales
	(v) Climate Change on Historical Timescales
5	Modern Climate Change: Climate Change Since the Industrial Revolution
6	Future Projections of Climate Change
7	Mitigation and Adaptation
8	Climate Change and Impacts in India
9	Climate Change and Impacts: (i) The Indian Monsoon (ii) Water Resources (iii) Biodiversity and Ecology (iv) Climate Change and the Himalayan Glaciers
10	Climate Change: Policy and Governance Global Negotiations and Domestic Policy Making
11	Climate Change and Society: Culture, Politics, And Social Dynamics
12	Teaching Resources and Pedagogical Practices

सत्यमेव जयते

MHRD | Government of India Ministry of Human Resource Development

All India Council for Technical Education

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On Camera Subject Matter Experts include Raghu Murtugudde (University of Maryland), D. Parthasarathy (Indian Institute of Technology Bombay), Pradeep Mujumdar (Indian Institute of Science Bangalore), Navroz Dubash (Centre for Policy Research Delhi), Malti Goel (Climate Change Research Institute Delhi), Deepak Barua (Indian Institute of Science Education and Research Pune), Argha Banerjee (Indian Institute of Science Education and Research Pune), Rahul Chopra (Indian Institute of Science Education and Research Pune).

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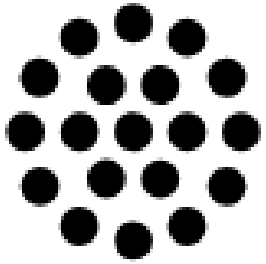


International Science Council

Integrating climate science with core curriculum of high school and undergraduate college syllabi

Idea is not to make climate change education a stand-alone topic rather bring it to the core of the science and mathematics curriculum

Allows educators to teach topics of their discipline (without deviating from prescribed syllabus)

Use of climate related examples will lead to increased climate awareness of students through school and college systems. Opportunity for significant impact

Tools and lesson plans stress on hands-on learning activities, are of different types, are location and language-specific (as far as possible) leading to effective learning

Partners

International Union of Biological Sciences IUBS

International Union for Quaternary Research INQUA

International Union of Soil Sciences IUSS

International Mathematical Union IMU

International Union of Geological Sciences IUGS

International Union of Geodesy and Geophysics IUGG

International Union of History and Philosophy of Science and Technology IUHPST

International Union of Forest Research Organizations IUFRO

African Union of Conservationists AUC

IMAGINARY

Committee on Data for Science and Technology CODATA

International Council for Science- Regional Office for Africa ICSU-ROA

National academies of Australia, India, Mongolia, South Africa, Ecuador & Egypt

UNESCO

World Climate Research Programme (WCRP)

World Meteorological Organization (WMO)

Lesson Plan: Teaching Glaciology, Glaciers and Glacial Retreat, and the Cryosphere-Climate Relationship

As a **high school** or **undergraduate Geography** or **Earth Sciences** teacher, you can use this set of computer-based tools to help you in teaching about **glaciers**, **the cryosphere**, and related topics such as **the impact of temperature and precipitation on glacial mass**, **glacial budgets**, and **glacial advance and retreat**.

This lesson plan helps students learn about glaciers, and the factors that affect the movement and size of glaciers. The activity will also enable students to understand the possible impacts of climate change on glaciers and the climate-cryosphere link.
Thus, the use of this lesson plan allows you to integrate the teaching of a climate science topic with a core topic in Earth Science or Geography.

Questions

Use this lesson plan to help your students find answers to:

- What climatic and environmental factors affect the size and motion of glaciers?
- How has an increase in global temperatures led to the shrinking of some glaciers?
- What is the relationship between climate and the cryosphere?
- How do glaciers provide evidence of climate change?

About Lesson Plan

Grade Level	High School, Undergraduate
Discipline	Geography, Earth Sciences
Topic(s) in Discipline	• Glaciers • Cryosphere
Climate Topic	Climate and the Cryosphere
Location	Global (region-specific activities also provided)
Languages	English (Visualization tool available in multiple languages)
Access	Online
Approximate Time Required	minimum 120 min (can vary)

Contents

Reading (20-30 min)	A reading that introduces the topic of glaciers and their formation https://nsidc.org/cryosphere/glaciers/questions/what.html https://nsidc.org/cryosphere/glaciers/questions/formed.html https://nsidc.org/cryosphere/glaciers/questions/components.htm
Visualization and associated activity (~30 min)	An interactive visualization and associated activity to visualize the shrinking and growing of a glacier as a result of changes in snowfa and temperature. Interactive Visualization: https://phet.colorado.edu/en/simulation/legacy/glaciers Associated Activity: https://phet.colorado.edu/en/contributions/view/4484?
Classroom/Laboratory Activity **(minimum 1 hr, can vary)**	A classroom/laboratory activity that uses Google Earth imagery an analysis of historical data to predict the complete melting of a glacier. https://serc.carleton.edu/quantskills/activities/glacial_retreat.ht

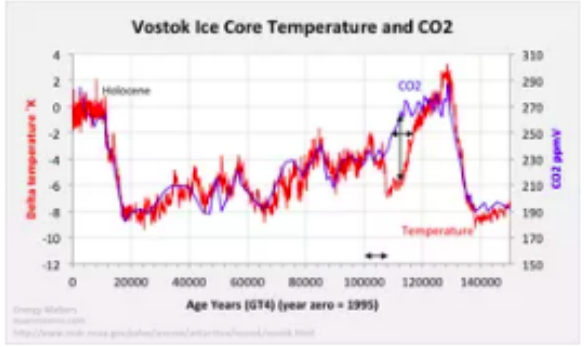
Here is a step-by-step guide to using this lesson plan in the classroom/laboratory. We have suggested these steps as a possible plan of action. You may customize the lesson plan according to your preferences and requirements.

1. Introduce the topic through an online reading	• Introduce the topic of glaciers and their formation. • Use the following resources as the primary or supplementary reading material to teach your students about glaciers, their formation, and the components of a glacier: • https://nsidc.org/cryosphere/glaciers/questions/what.html • https://nsidc.org/cryosphere/glaciers/questions/formed.html • https://nsidc.org/cryosphere/glaciers/questions/components.html • This content is provided by the National Snow and Ice Data Center (NSIDC).
2. Explore the topic further through an interactive visualization and associated activity	Now, conduct an activity using an interactive visualization tool to help your students learn about the effects of changes in snowfall and temperature on glaciers. • Download PhET's interactive visualization tool, "Glaciers", from https://phet.colorado.edu/en/simulation/legacy/glaciers. • Download the associated activity, "Investigating Glaciers" developed by John Judkins (Rio Rancho High School), from https://phet.colorado.edu/en/contributions/view/4484?. • Conduct the activity and discuss how glaciers are affected by changes in temperature and snowfall. • Discuss how temperature changes caused by climate change may impact glaciers globally. • Discuss how the study of glaciers can help in drawing inferences about the Earth's changing climate.
3. Conduct a classroom/laboratory activity	Next, help your students investigate the melting of glaciers through a classroom/laboratory activity, "When will there no longer be glaciers in Glacier National Park" from SERC Carleton, developed by Carol Ormand, Wittenberg University. In this activity, students will analyze and interpret historical data for the Grinnell Glacier to predict when the glacier might completely melt. • Download the teaching material and activity files from https://serc.carleton.edu/quantskills/activities/glacial_retreat.html • Conduct the exercises described in Part I – Part V of the teaching material (student handout).

Lesson Plan: Atomic Number, Mass Number, Isotopes and Isotopic Ratios, and Isotopic Compositions as Climate Proxies

As a high school or undergraduate teacher of **Chemistry or Earth Sciences**, you can use this set of computer-based tools to help you in teaching atomic number, mass number, isotopes and isotopic ratios, the use of isotopic ratios to calculate temperature, and the use of isotopic composition to recreate past temperatures and climate. This lesson plan allows students to understand **isotopes, isotopic ratios, the relationship between isotopic compositions and temperature, and how isotopic compositions** are used to recreate past temperature and climate.
Thus, the use of this toolkit allows you to integrate the teaching of a climate science topic with a core topic in Chemistry or Earth Sciences.

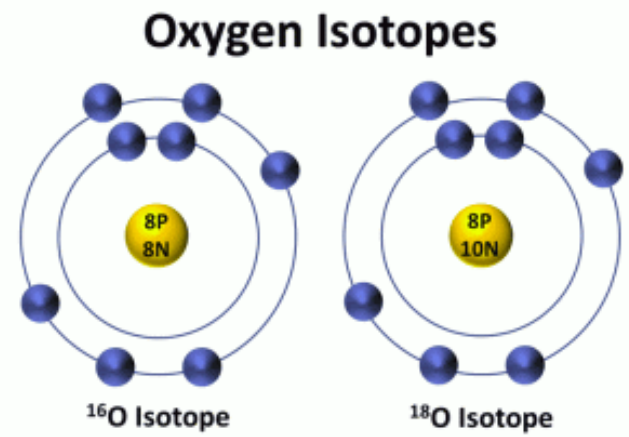
VOSTOK ICE CORE TEMPERATURE AND CO2



Questions

Use this lesson plan to help your students find answers to:

1. *What is an isotope?*
2. *What is the relationship between isotopic compositions and temperature?*
3. *How can you use oxygen isotope data in an ice core to determine temperature?*
4. *How can you use isotopic compositions to reconstruct past climate?*



About Lesson Plan

Grade Level	High School, Undergraduate
Discipline	Chemistry, Earth Sciences
Topic(s) in Discipline	• Atomic Number, Mass Number • Isotopes and Isotopic Ratios • How isotopic ratios are used to calculate temperature • How isotopic composition is used to recreate past temperatures and climate
Climate Topic	Climate and the Cryosphere, Climate Variability Record
Location	Global
Languages	English (Simulation tool available in multiple languages)
Access	Online, Offline
Approximate Time Required	130-150 min

Contents

Micro-lecture (video) (~10 min)	A micro-lecture that introduces the concepts of atomic number, ma number, and isotopes. https://www.khanacademy.org/science/chemistry/atomic-structu and-properties/introduction-to-the-atom/v/atomic-number-ma number-and-isotopes
Reading (20-30 min)	A reading about isotopic ratios, the relationship between isotopic compositions and temperature, and how isotopic compositions are to recreate past temperature and climate. https://www.seas.harvard.edu/climate/eli/research/equable/isotop
Classroom/ Laboratory activity (~ 90 min)	A classroom/laboratory activity to recreate the climate of the last 5(years approximately using oxygen and hydrogen isotopic composit ice cores from Antarctica. University of Washington Program on Climate Change: Laboratory Activity, From Isotopes to Temperature (Spruce Schoenemann, UW and Space Sciences) https://pcc.uw.edu/education/classroom-resources/climate-teach modules/uwhs-atms-211-from-isotopes-to-temperature-influen of-orbital-forcing-on-ice-core-records/

Here is a step-by-step guide to using this lesson plan in the classroom/laboratory. We have suggested these steps as a possible plan of action. You may customize the lesson plan according to your preferences and requirements.

1.Introduce the topic through a micro-lecture (video)	• Discuss the components of an atom. • Play the micro-lecture (video), "Atomic number, mass number, and isotopes", to introduce the concepts of atomic number, mass number, and isotopes. The video will help students understand the definitions of the terms through examples of hydrogen, carbon, and uranium isotopes. • The video, "Atomic number, mass number, and isotopes" from Khan Academy is available at https://www.khanacademy.org/science/chemistry/atomic-structure-and-properties/introduction-to-the-atom/v/atomic-number-mass-number-and-isotopes • Note: For a more detailed exploration of isotopes, atomic mass, and methods to calculate the average atomic mass, you may use the PhET simulation tool and associated activity listed in the Additional Resources section of this lesson plan. This activity will enable your students to calculate the average atomic mass of sample mixtures of isotopes by using various methods.
2. Discuss using an online reading	Next, read and discuss "Isotope Analysis" from Harvard University to introduce the occurrence and distribution of oxygen isotopes. Further, the reading will help your students understand isotopic ratios, the relationship between isotopic compositions and temperature, and how scientists can use isotopic compositions to recreate past temperature and climate. The reading, "Isotope Analysis" from Harvard University is available at https://www.seas.harvard.edu/climate/eli/research/equable/isotope.html
3. Conduct an activity using an interactive visualization	Now, explore the relationship between isotopic compositions and climate through a hands-on classroom/laboratory activity, "From Isotopes to Temperature", created by Spruce Schoenemann, UW Earth and Space Sciences: In this activity, your students will analyze isotopic compositions of ice core data from Antarctica to infer past temperatures and climate. Students will plot graphs in MS Excel to perform data analysis and interpretation. • Download the documents for the From Isotopes to Temperature Lab from https://pcc.uw.edu/education/classroom-resources/climate-teaching-modules/uwhs-atms-211-from-isotopes-to-temperature-influences-of-orbital-forcing-on-ice-core-records/. • Read the content in the PowerPoint Presentation (background information). • Download the files and conduct the activity described in Lab 1 of the module.

SAMPLE PEDAGOGICAL TOOLS FOR TEACHING TOPICS IN DISCIPLINES USING CLIMATE RELATED EXAMPLES

DISCIPLINES:

GEOGRAPHY
BIOLOGICAL SCIENCES
CHEMISTRY
PHYSICS
EARTH SCIENCES
ENVIRONMENTAL SCIENCES
MATHEMATICS
STATISTICS
SOCIAL SCIENCES
ECONOMICS
HUMANITIES

BIOLOGICAL SCIENCES

What do Squirrels know about Climate Change?

This activity enables students to determine how biodiversity may be influenced by climate change. They will learn about changes in the distribution and habitat of squirrels over time, and will discuss climate change as a potential cause of changes in biodiversity.

READ MORE

Beyond the byte: Mosquitoes and Malaria

This activity enables students to examine the relationship between temperature and the geographical distribution of malaria, and to determine how climate change may affect the spread and distribution of the disease. Students will use maps and temperature data sheets to determine the locations where malaria is known to occur and the temperature ranges in these locations. Further, they will discuss and explore the potential impact of climate change and the resulting change in temperature on the geographical distribution of malaria.

READ MORE

Signs of the Seasons: A New England Phenology Program

The resources in this lesson plan introduce the link between phenology and climate change. Students can work on a range of activities–learn about phenology, investigate phenological events, and analyze phenological data (of monarchs, milkweed, and dandelions) by plotting graphs.

PEDAGOGICAL TOOL EXAMPLES: DISCIPLINE BIOLOGICAL SCIENCES

What do Squirrels know about Climate Change?

Contributed by: Beth Norman, Allan Ashworth, and Russell W. Graham

Topic: Squirrels – Nuts about climate change

Map the changes in biodiversity (squirrels and their habitats) to climate change.

This tool can be used as an aid to teach topics such as Biodiversity, Animal Diversity (Chordates, Mammals), Evolution and Behavior (Species and Speciation), Ecology (Populations; Zoogeography)

Goals

Students should be able to do the following:

- Learn what animals are related to one another in the squirrel family
- Understand how climate change alters the distributions of species and modifies biodiversity through time.
- Use databases to analyze change.

Assessment

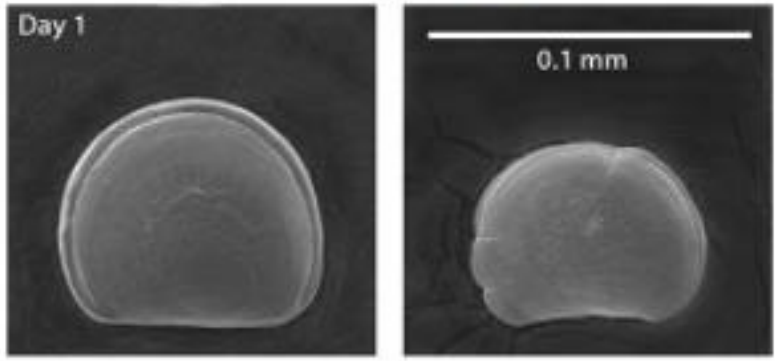
- Completed categorization of species by family and by habitat, determination of selected state habitats, determination of habitats for selected fossil localities.
- Completed interpretation of habitat and climate change based on the presence or absence of members of the Sciuridae (squirrel species).
- Discussion of interpreted climate change.

About the Tool

Tool Name	What do Squirrels know about Climate Change?
Discipline	Biological Sciences
Topic(s) in Discipline	Biodiversity, Animal Diversity, Evolution and Behavior, Species and Speciation, Ecology, Populations, Zoogeography
Climate Topic	Climate and the Biosphere
Type of Tool	Laboratory Activity
Grade Level	High School, Undergraduate
Location	North America
	USA
Language	English
Translation	
Developed by	Beth Norman, Allan Ashworth, and Russell W. Graham
Hosted at	Teach the Earth, Science Education Research Center (SERC) at Carleton College
Link	https://serc.carleton.edu/NAGTWorkshops/climatechange/paleoclim_activity_ideas/squirrels.html
Access	Online
Computer Skills	Basic

CHEMISTRY

Ocean Acidification and Oysters Lab



This classroom/laboratory activity allows students to understand how marine organisms may be affected by increased ocean acidification caused by climate change. Students explore and analyze the relationship between the growth of oyster larvae and the chemistry of ocean water by using data from the Whiskey Creek Hatchery in Oregon, USA.

READ MORE

Variations climatiques et composition isotopique de l'oxyène (O18_16 (Oxygène))

The tool allows a student to learn about the isotopes of oxygen (O18 and O16); to understand the relative distribution of these isotopes in the atmosphere, ocean and cryosphere; and to explore how these isotopes can be used as indicators of paleoclimate.

READ MORE

PEDAGOGICAL TOOL EXAMPLES: DISCIPLINE CHEMISTRY

An interactive visualization tool: To conduct a classroom activity allowing the students to observe, understand, explore and analyze the molecular structure of carbon compounds (CO_2 , CH_4), the effect of electromagnetic radiation on the molecules, and the role of greenhouse gases in climate change.

PEDAGOGICAL TOOL EXAMPLES: DISCIPLINE MATHEMATICS

Using trigonometric functions to model climate

In this exercise students are provided with local temperature data of Wellington, New Zealand and they model fluctuations in temperature dats using sine and cosine functions. This activity can be replicated for any location where local temperature data is available.

READ MORE

Global Warming: A Zonal Energy Balance Model

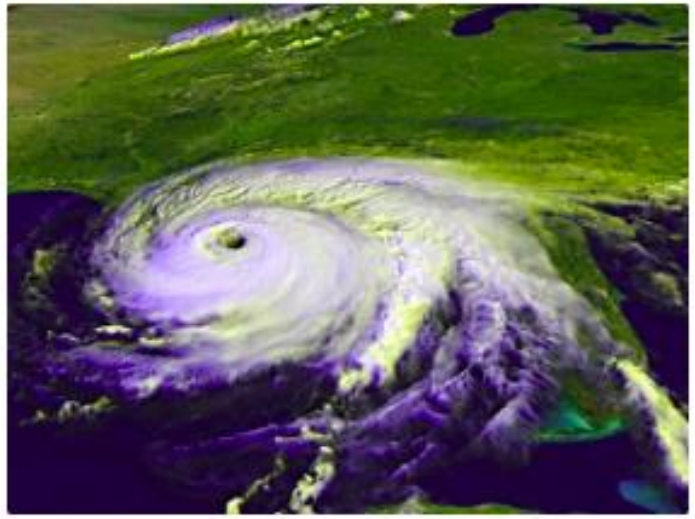
This laboratory activity involves creating an Energy Balance Model for planet Earth by writing code in MATLAB or Mathematica. Students create their model that focuses on the distribution of Earth's surface temperature in response to carbon emissions in the atmosphere.

Mauna Loa Yearly Average CO2

In this activity, students are provided with mean atmospheric CO2 concentration from the Mauna Loa observatory from 1950 to the present. This dataset and associated exercise can be used to teach introductory calculus and topics in differentiation such as polynomial differentiation, tangent line problem, and curve fitting amongst others.

PEDAGOGICAL TOOL EXAMPLES: DISCIPLINE STATISTICS

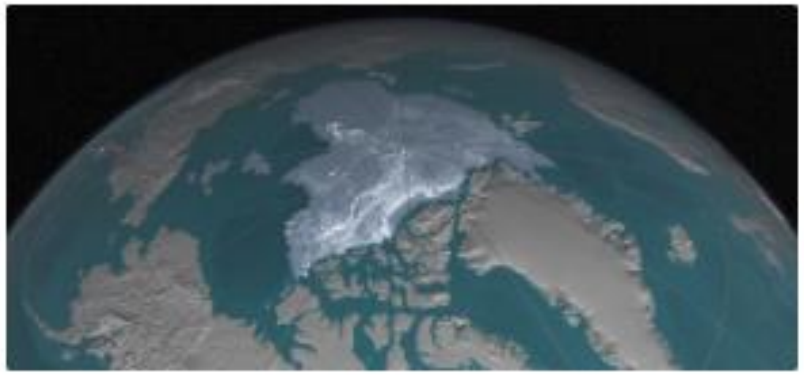
Is There a Trend in Hurricane Intensity?



This laboratory activity allows a student to explore trends in hurricane intensity, the possible impact of climate change on hurricanes, and understanding uncertainty in trends. This tool can be used as an aid to teach topics such as Data Analysis, Linear Slope,Confidence Interval, Student's t-distribution, and Standard Deviation in Statistics.

READ MORE

Arctic Ice Data



In this exercise, students learn to use statistical methods on climate data from the Arctic. They run the linear regression on the average monthly extent of Arctic sea ice from 1979 to the present.

READ MORE

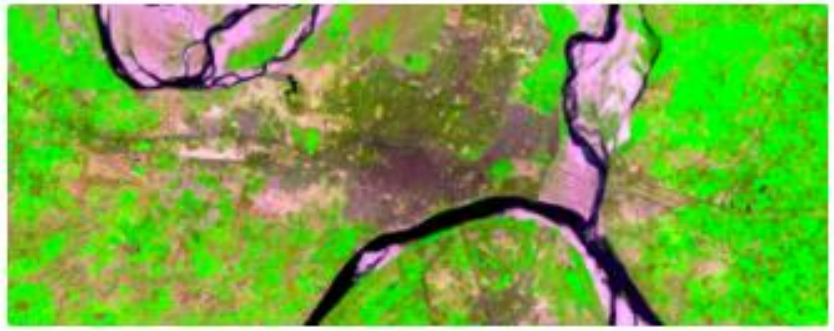
PEDAGOGICAL TOOL EXAMPLES: DISCIPLINE ECONOMICS

Introducing the economic concept of 'tragedy of the commons' using global warming

In this laboratory activity, students learn that the atmosphere of planet Earth can be considered as a "commons" and that it is affected by human activities such as global warming. The activity also asks students to consider possible economic drivers as potential solutions for the global warming "tragedy".

READ MORE

The Economics of Global Climate Change



This lesson plan contains several sections that introduce the Economics of Climate Change such as Cost Benefit Studies, Climate Change and Inequality, Policy Responses to Climate Change including Mitigation, Carbon Taxes, Cap and Trade, amongst others. It also contains discussion questions and exercises.

READ MORE

PEDAGOGICAL TOOL EXAMPLES: DISCIPLINE SOCIAL SCIENCES

A Global Challenge: 'Climate Refugees'

In this lesson plan, students are introduced to the concept of 'Climate Refugees', learn about how climate change is forcing large populations to migrate from their homes and what should the societal response be to such a human migration caused by climate change.

READ MORE

Our Changing Climate (Food System and Climate Change)

In this lesson plan, students are introduced to the linkages between the food system and climate change. The lesson plan focuses on the contribution of the food system to climate change and means of reducing it as well as the effect of climate change on agriculture.

Climate Change | A Human Health Perspective: A Student Exploration of the Impacts of Climate Change on Human Health in the United States

In this lesson plan, students learn about the impacts of climate change on human health. The lesson plan contains several modules and case studies on issues such as Temperature-related Death and Illness; Air Quality Impacts; Vector-Borne Diseases; Water-Related Illness; Food Safety; Mental Health and Well-Being.

PEDAGOGICAL TOOL EXAMPLES: DISCIPLINE HUMANITIES

Cli-Fi: Climate Science in Literary Texts

"This module addresses both aspects of climate literacy: understanding of climate science through data analysis and interpretation, and understanding of literary tools and techniques through which climate science is portrayed. The module is designed to be completed in introductory natural science classes where literature is not typically included as well as in humanities classes where climate change science is not normally addressed." (quoted from https://serc.carleton.edu/integrate/teaching_materials/climate_fact/index.html)

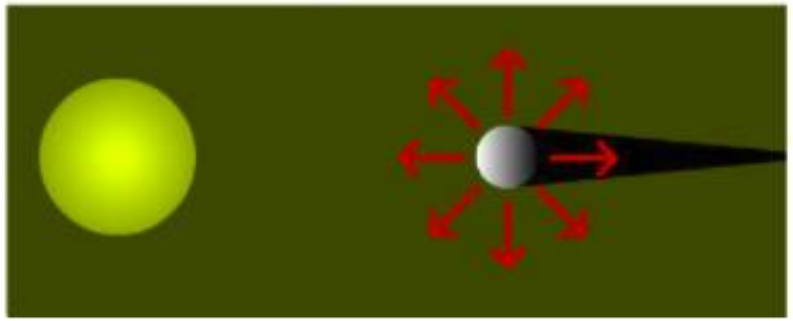
READ MORE

Climate Justice in BC: Lessons for Transformation

This educational resource consists of eight modules that situates climate justice within the context of British Columbia's ecology, history, economy and community. The modules are Introduction to Climate Justice, Reimagining our Food System, Transportation Transformation, Rethinking Waste, Fracking Town Hall, Green Industrial Revolution, Imagining the Future We Want, Challenges to Change.

PEDAGOGICAL TOOL EXAMPLES: DISCIPLINE PHYSICS

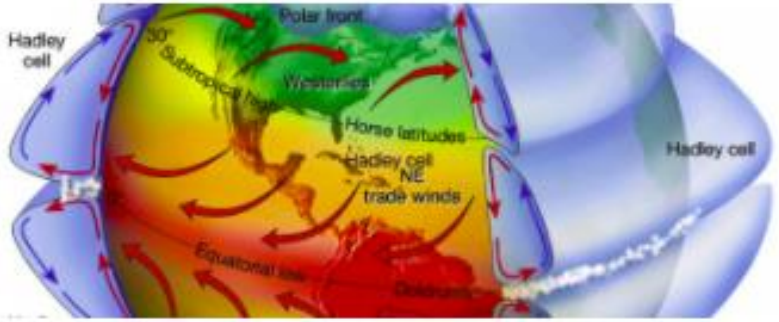
Planetary Energy Balance



The interactive simulations in this tool help students understand blackbody radiation and the effect of albedo on the temperature of a planet.

READ MORE

Hadley Circulation using NASA Merra Reanalysis Model



This laboratory activity helps students to understand radiation, heat transport, convection, and energy/mass conservation by interpreting and mapping the Hadley circulation with the help of data from a reanalysis model. Students will learn about the Hadley cell and Hadley circulation, and their influence on climate.

READ MORE

Geography

Classroom/Laboratory Activity: Climate Change and Food Security in Africa

A classroom/laboratory activity to learn about suitable climatic conditions for a crop and to determine how climate

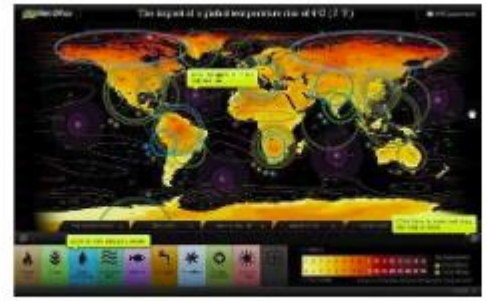
Teaching Module: Climate Refugees

A teaching module to learn about climate refugees, specific examples of climate change-related migration, challenges in resettling climate refugees, and

Read more.

Visualization, Classroom/Laboratory Activity: A Story Map on Climate Change and Human Migration

A visualization and classroom/laboratory activity to learn about regions and communities that are affected by the problem of climate refugees



Visualization: If Global Temperature Rises by 4 °C

An interactive visualization to observe the effects of a global temperature increase of 4 °C on human health, agriculture, forests,

Read more.

Visualization: The Effects of Sea-level Rise on the Coast of California

An interactive visualization to observe and understand the possible effects of sea-level rise and different storm scenarios on the coast

Read more.

Visualization: Glaciers and Climate Change

An interactive visualization to visualize the shrinking and growing of a glacier as a result of changes in snowfall and

E-learning Course: Climate Change Adaptation and Mitigation in African Cities

E-learning Course: Impact of Climate Change on Cities

An e-learning course to understand how cities are impacted by and influence

Classroom/Laboratory Activity: Determining Coastal Vulnerability to Sea-Level Rise

A classroom/laboratory activity to learn about the rate of sea-level rise and the response of shorelines to sea-level change.

Mobile App: Glaciers of the World

A mobile app to learn about glaciers across the world.

Read more.

PEDAGOGICAL TOOL EXAMPLES: DISCIPLINE EARTH SCIENCES

Lab: Vostok Ice Core

The tool allows a student to explore how isotopes can be used as indicators of paleoclimate and reconstruct the paleoclimate using data from the Vostok ice core.

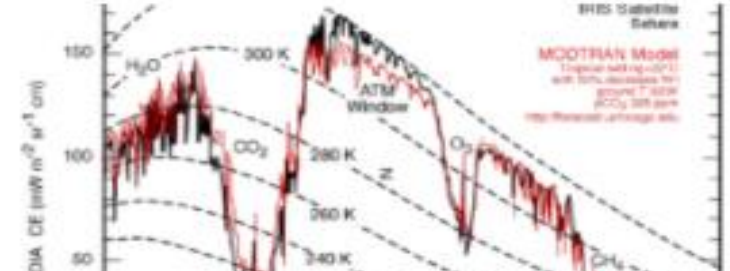
READ MORE

Build Your Own Earth

This interactive visualization allows learners to build their own Earth, and to configure various parameters and factors affecting the climate. The factors include the tilt of the Earth's axis, the eccentricity of the Earth's orbit, the solar constant, the distribution of the continents and oceans, and the carbon dioxide concentration of the atmosphere.

READ MORE

MODTRAN Infrared Light in the Atmosphere



This model demonstrates the effect of greenhouse gases on outgoing energy flux and compares various greenhouse gases such as carbon dioxide, methane, and water vapor with respect to the absorption of infrared radiation.

READ MORE

PEDAGOGICAL TOOLS ALSO CATEGORIZED ACCORDING TO CLIMATE TOPIC FOR EDUCATORS TEACHING CLIMATE CHANGE COURSES

CLIMATE TOPICS (Focus on factors that determine the climate of the Earth:
Role of Earth's Orbital Parameters, Atmosphere, Biosphere, Lithosphere, Cryosphere, Anthroposphere and their interactions

Climate variability record (long-term and short-term)

- Anthropogenic CO_2 versus natural CO_2 variability and temperature record

Role of Earth's Orbital Parameters; Milankovitch Cycles

Role of Earth's Atmosphere:

- The Layer Models and how to determine surface temperatures of the planet
- Greenhouse Gases and their role in climate change
- Winds, Clouds, Coriolis Effect, Hadley Circulation, Walker Circulation

The Oceans and their role in climate change: Thermohaline Circulation, El Niño Southern Oscillation, Carbon in the Ocean

CLIMATE TOPICS CONTINUED

The Biosphere and its role in climate change

The Lithosphere and the weathering (Urey) reaction

The Cryosphere and climate

Long term Cycles and Feedback Mechanisms including the Carbon Cycle

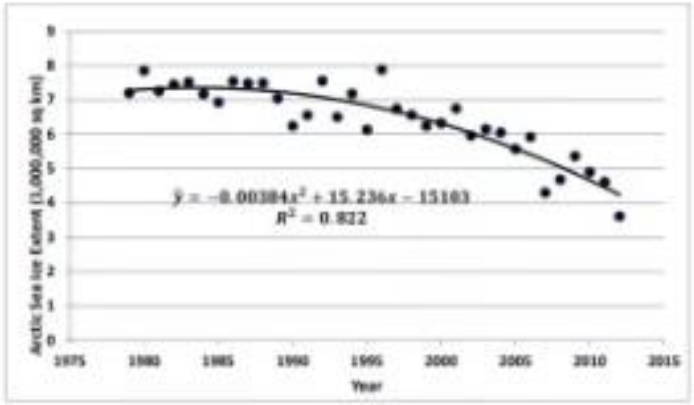
Catastrophic Climate Scenarios. Snowball Earth, Runaway Greenhouse Effect

Energy, Economics and Climate Change

Policies, Politics and Environmental Governance

Disasters and Hazards: Hurricanes, Cyclones, Tropical Storms; Floods; Droughts; Health and Disease

Climate and the Cryosphere



Teaching Module: Analyzing Climate Science Data through Simple Statistical Techniques

A teaching module that demonstrates the use of linear and quadratic regression to analyze Arctic sea ice extent data and

Read more.

Video,Visualization: Climate Change and Glaciers in the European Alps

A video and visualization to learn about glacier modeling and the prediction of the future of glaciers by using mathematical

Read more.

Classroom/Laboratory Activity: Climate Change, the Cryosphere, and Rising Sea Levels

A classroom/laboratory activity that introduces the relationship between climate and the cryosphere, explains how sea-level rise can be predicted (based

Classroom/Laboratory Activity: Glacial Retreat in Glacier National Park

A classroom/laboratory activity to learn about glacial retreat and to predict the complete melting of a glacier (specifically, for an

Visualization: Melting Ice Sheets and Sea Level Rise

An interactive visualization to explore the effects of melting ice sheets and the resulting sea level rise on coastal areas.

Read more.

Visualization: Glaciers and Climate Change

An interactive visualization to visualize the shrinking and growing of a glacier as a result of changes in snowfall and

Reading: Glaciers as Indicators of Climate Change

A reading that introduces the topic of glaciers and their formation.

Classroom/Laboratory Activity: Reconstruction of Paleoclimate by Using Isotopic Composition Data

A classroom/laboratory activity to learn about the isotopes of hydrogen and oxygen, analyze the isotopic

How Yukon glaciers are responding to climate change

Climate and the Biosphere

Videos: Climate Change and the Biosphere

A series of micro-lectures (videos) for an overview of the relationships between the Earth's climate, the biosphere, and the lithosphere.

Classroom/Laboratory Activity: Squirrel Species Distribution and Climate Change

A classroom/laboratory activity to examine and analyze squirrel species distribution and habitat data (from the USA) over time, and to

Read more.

Classroom/Laboratory Activity: Climate Change and Phenology in Plants (Flowering)

A classroom/laboratory activity to learn about phenology and phenological events, and to understand the potential impacts of climate change on

Teaching Module: Climate Change & Phenological Events in Plants and Animals

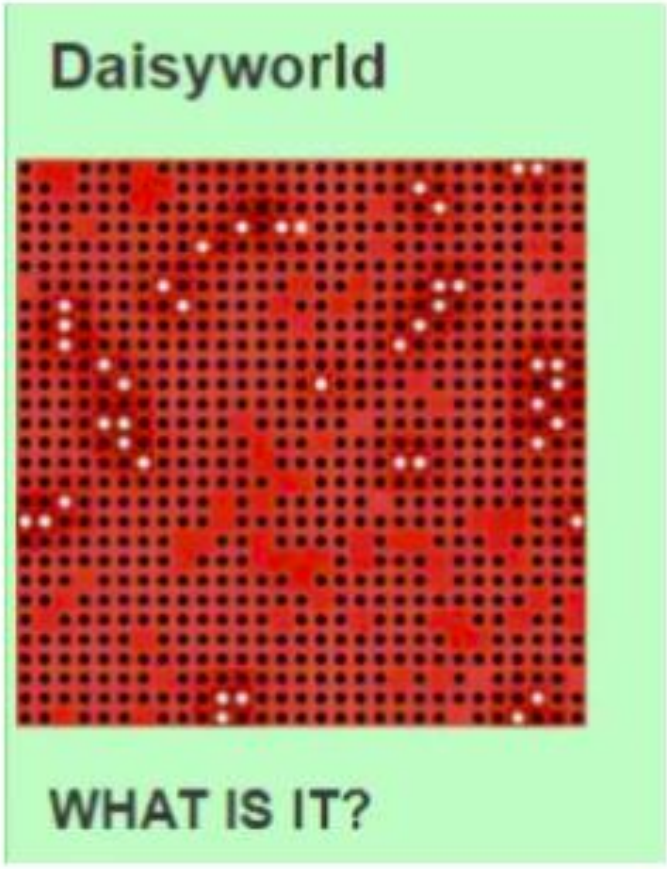
A set of resources to understand the link between periodic life-cycle events in plants and animals (such as flowering, leaf-out,

Read more.

Climate Change May Put Half of North American Birds at Risk of Extinction

An article from National Geographic about how climate change may pose a risk of extinction to more than half of

Read more.



Model/Simulator: Daisyworld—A Model to Explore the Gaia Hypothesis

A model/simulator to explore the Gaia hypothesis and the concepts of albedo and hysteresis through the example of daisies (living

Climate Change and Migratory Behavior

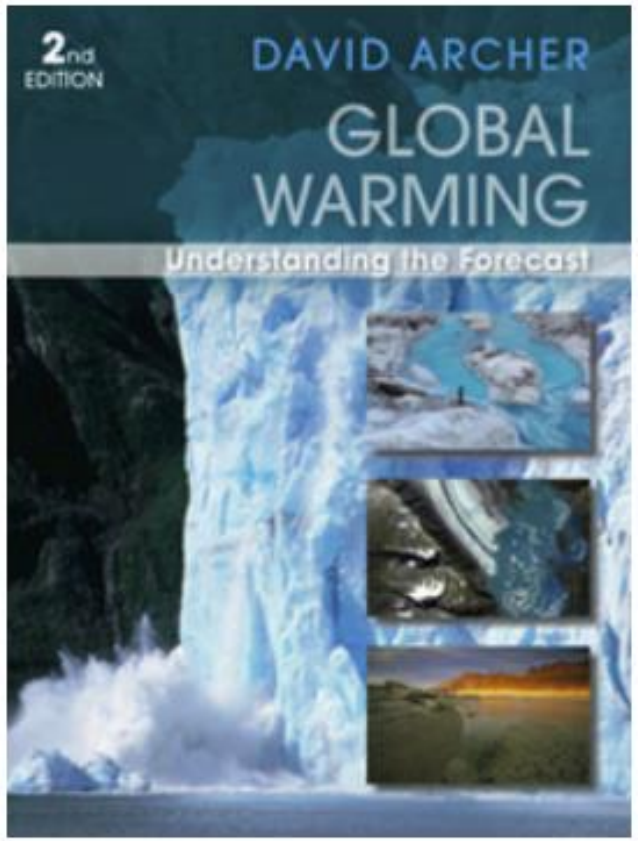
This guided lecture and discussion helps students to understand the possible impact of climate change on animal migration (an important

Read more.

PEDAGOGICAL TOOL TYPES

- MODELS / SIMULATORS
- INTERACTIVE VIZUALIZATION
- CLASSROOM OR LABORATORY ACTIVITY
- VIDEO LECTURES
- GAMES
- MOBILE APPS
- AUDIO / AUDIO PODCASTS

PEDAGOGICAL TOOL TYPE: MODELS



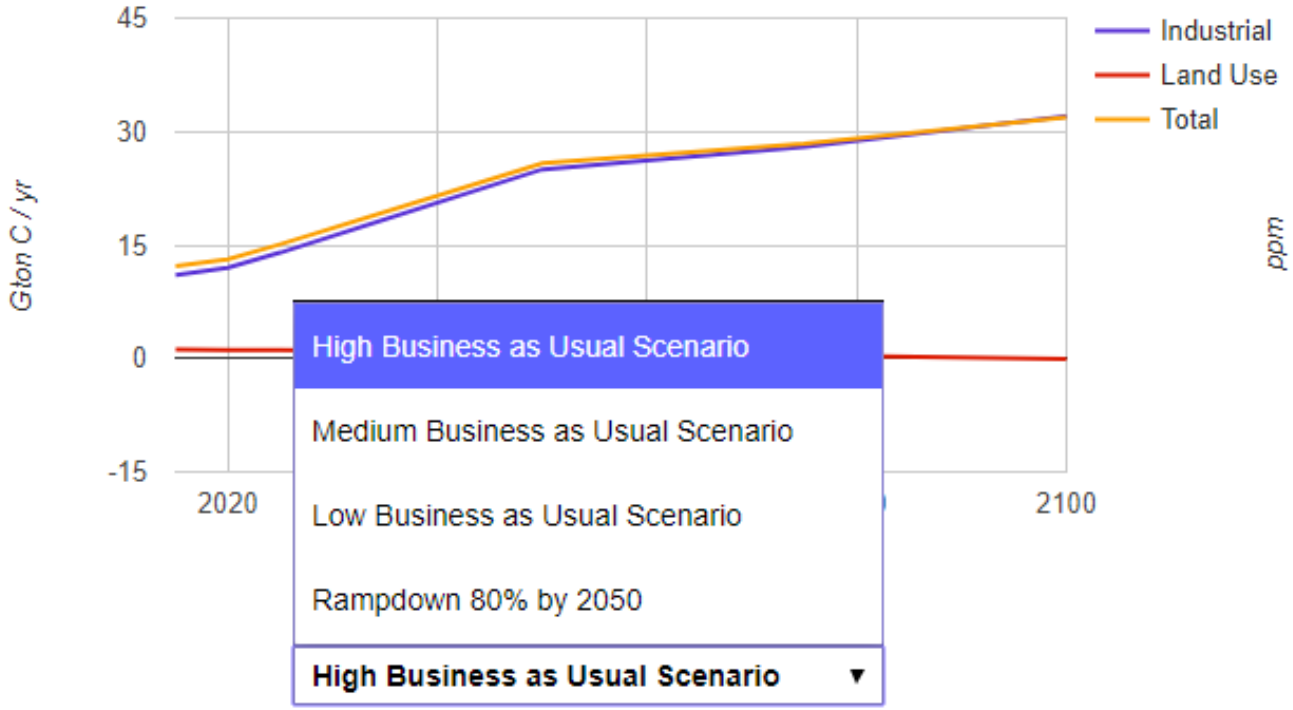
Models

Modtran *Infrared Radiation in the Atmosphere*	*Run me*
NCAR *Radiation Code Visible + Infrared Radiation*	*Run me*
Methane vs. CO_2 *Climate response to a slug of gas*	*Run me*
Methane *in the Atmosphere*	*Run me*
GEOCARB *Geological Carbon Cycle*	*Run me*
Orbital Forcing *of Earth's climate*	*Snapshot* *Time Series*
ISAM *Climate Impacts Model*	*Run me*
Hubbert's Peak *Oil Supply Calculator*	*Run me*
Kaya Identity *Growth of the Human Footprint*	*Run me*
GHCNM *Browse the Global Meterological Data and Compare with AR5 Climate Models*	*Run me*
AR5 Maps *Maps of AR5 Climate Model Output*	*Run me*
ISM *Interactive Ice Sheet Model*	*Run me*

ISAM Integrated Impacts of Climate Change

About this model

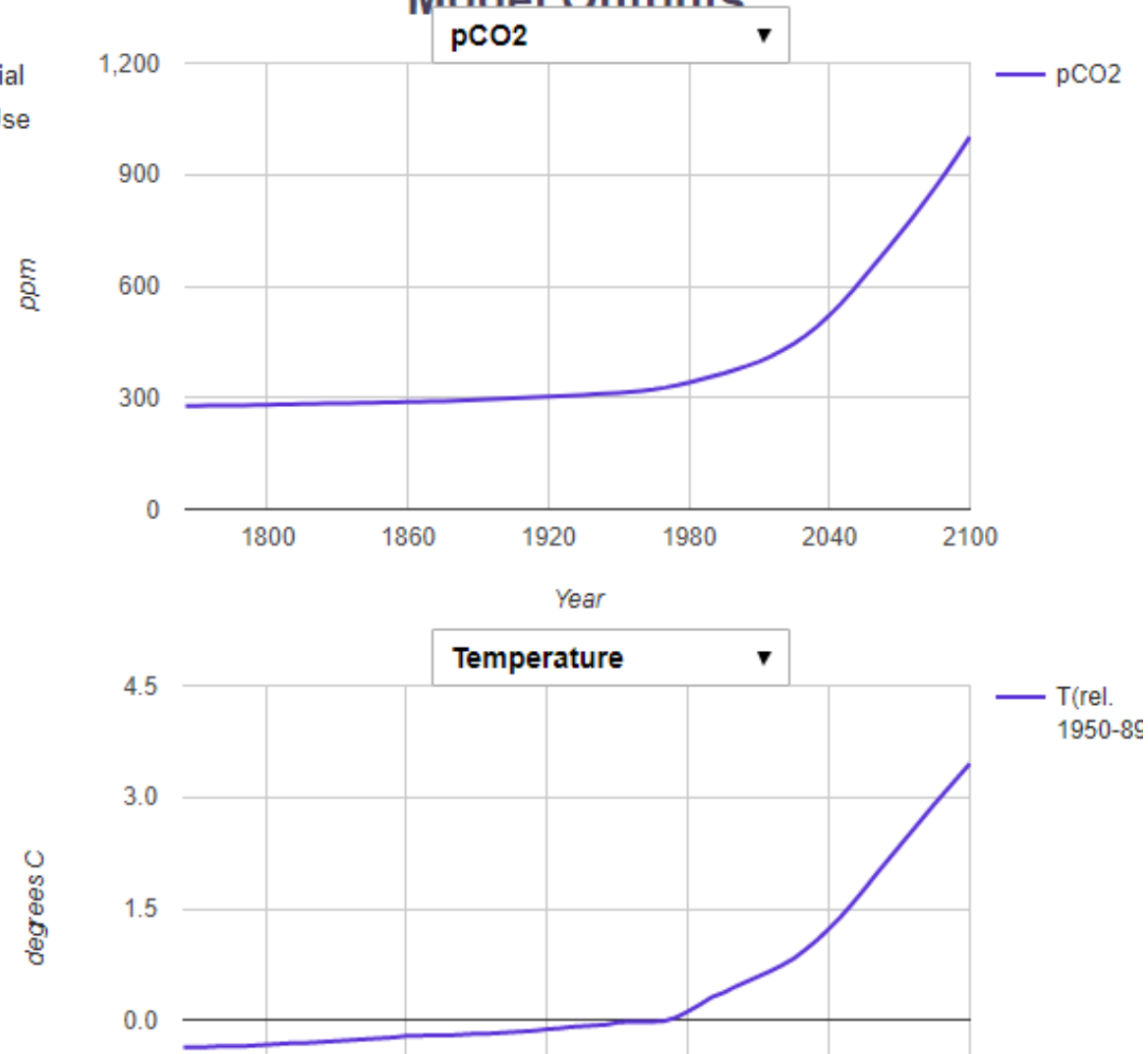
Model Inputs



Emissions in Gton C / yr

	2015	2020	2025	2050	2075	2100
Fossil fuels	11	12	14	25	28	32
Land use	1.2	1.1	1.1	0.8	0.4	-0.1

Model Outputs



TEACHING TOOLS CLIMATE SCIENCE AND CLIMATE CHANGE

Visualizations

Visualization: Radiation Balance and the Climate of a Planet

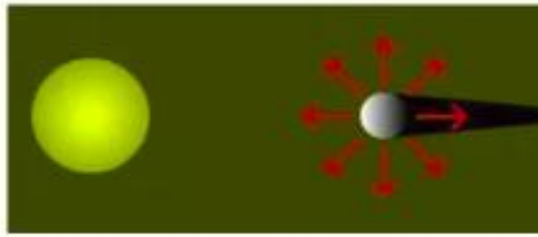
A visualization to learn about the factors that influence the climate of a planet.

Read more.

Visualization, Classroom/Laboratory Activity: A Story Map on Climate Change and Human Migration

Visualization: The Greenhouse Effect

A visualization to observe, understand, explore, and analyze the molecular structure of carbon compounds (CO_2, CH_4), the effect of electromagnetic



Visualization: Blackbody Radiation and Planetary Temperatures

A visualization to understand blackbody radiation, the effects of albedo and sola brightness on the temperature of a planet, and

Read more.

PEDAGOGICAL TOOL TYPE: LABORATORY ACTIVITY

Beetles, Mammals, and Plants: Is Climate Driving Range Shifts Since the Last Glacial Maximum

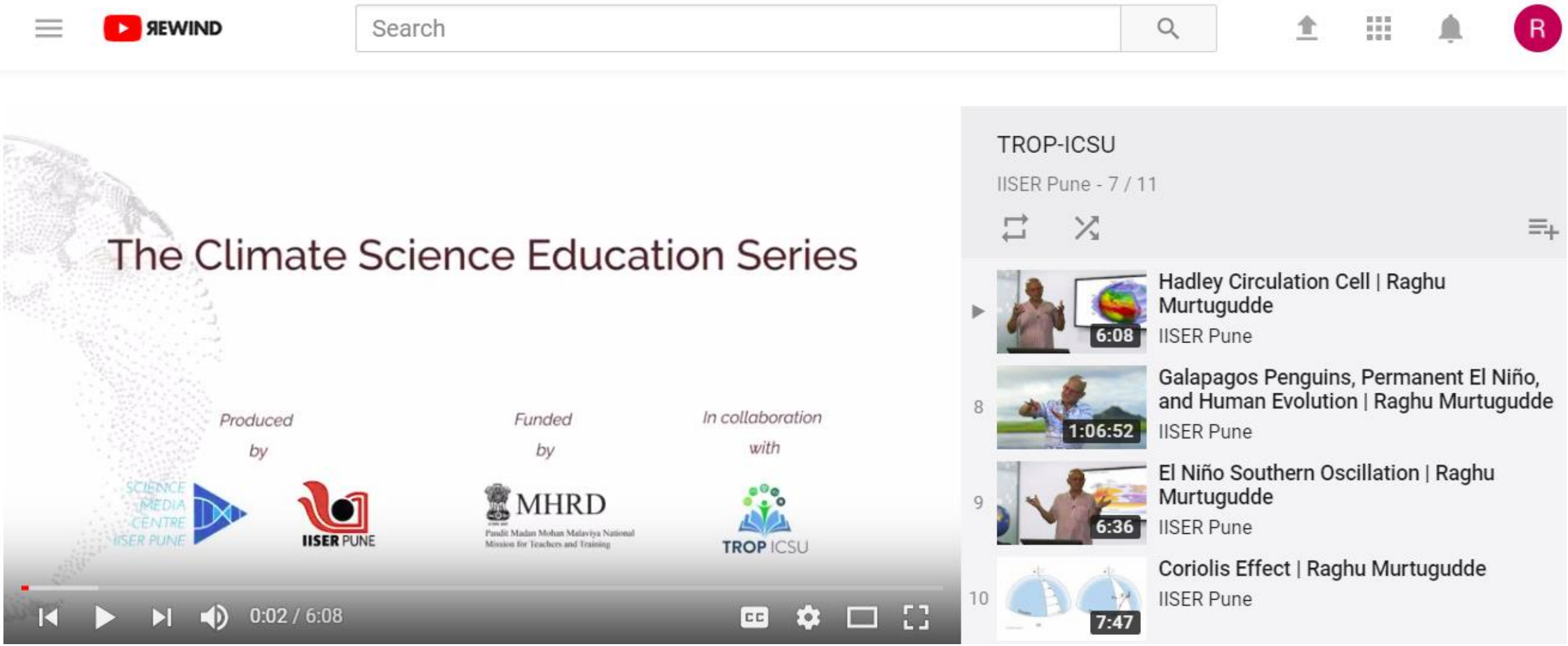
In this exercise, students will learn how organisms responded to the change in climate since the last glacial maximum (LGM) in North America. Using the Neotoma database and ArcGIS Online, students will create taxon modern distribution maps for the species of beetles, mammals, and plants found at the Conklin Quarry fossil site in eastern Iowa. By comparing the modern species ranges of these taxa, students will interpret what the environment may have been like in eastern Iowa during the LGM.

Students will be able to:

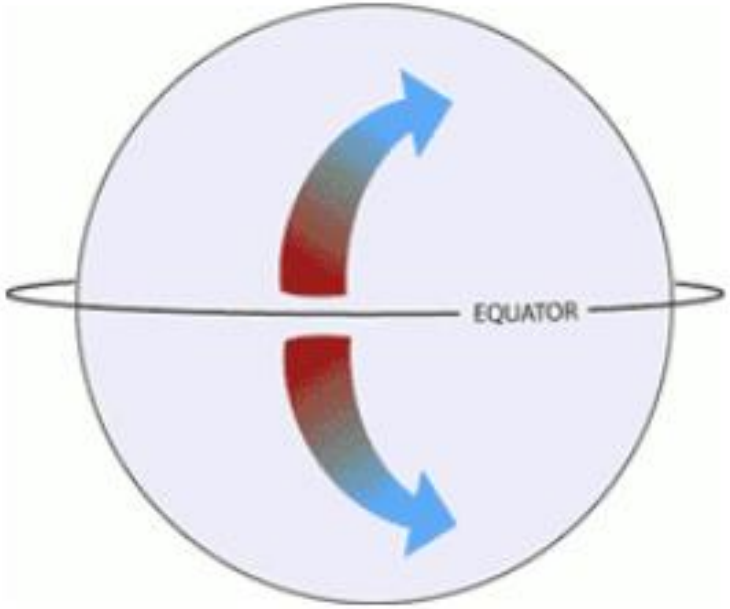
- Search and download data from the Neotoma database
- Create a map using ArcGIS Online
- Interpret taxon range shifts using GIS
- Infer the complexity of using various taxa to reconstruct Pleistocene environments

This lesson is designed as a 2 hour lab in an introductory physical geology, historical geology, earth science, environmental science, or biology class.

PEDAGOGICAL TOOL TYPE: VIDEO LECTURES / MICRO-LECTURES



TEACHING TOOLS CLIMATE SCIENCE AND CLIMATE CHANGE
VIDEO LECTURE / VIDEO MICRO-LECTURE



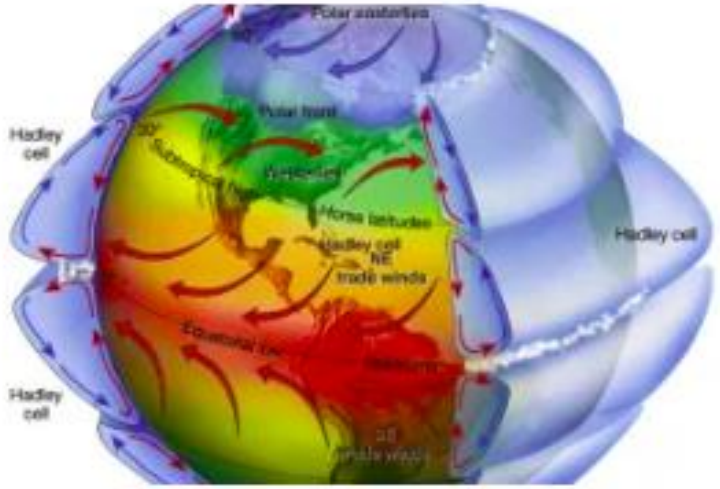
Video: Coriolis Effect

Climate Science Education Series Developed by Science Media Center, Indian Institute of Science Education and Research, Pune, India Coriolis Effect

Read more.

Video: Galapagos Penguins, Permanent El Niño, and Human Evolution

Climate Science Education Series Developed by Science Media Center,



Video: Hadley Circulation Cell

Climate Science Education Series Developed by Science Media Center, Indian Institute of Science Education and Research, Pune, India Hadley Circulation

Read more.

TEACHING TOOLS CLIMATE SCIENCE AND CLIMATE CHANGE

Games

Game: Understanding Climate Vulnerabilities and Building Climate Resilience

A game that provides an immersive learning experience to visualize the possible effects of climate change on our cities and

Beat the Uncertainty: Planning Climate-Resilient Cities

In this game, students will make decisions and policies to improve the resilience of a city in the face of

Read more.

AdaptNation

In this print-and-play version of a tabletop game, students lead fictional cities and assume decision-making roles to help their cities

Read more.

Visualization, Model/Simulator, Game: Build Planet Earth

A visualization/model/game to build your own version of planet Earth and learn about the Earth's climate system and the factors

Game: Climate Change and Human Health—Analysis and Policies

A computer-based game to understand the impact of climate change on health and to determine actions/policies for preventing the spread

Read more.

MANCHESTER 1824
The University of Manchester

Build Your Own Earth

Home | Tutorials | About | Credits

Earth 1 | + Add Earth 2

Earth

view climate model

Recent | Ancient | Alien

Current Day 2015

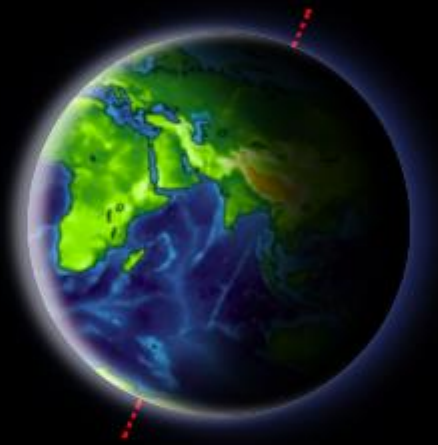
Climate property

Atmosphere | Ice | Land | Ocean

Mean Temperature

Set analysis level:

Surface



Obliquity: 23.4463°
Eccentricity: 0.016724
Solar Constant: 1367 W/m²

Perihelion Day: 2
mvelp: 77.961°

Gases:	1000	326	1750	236	527	Recent Earth: Max
		326	1750	236	527	

TEACHING TOOLS CLIMATE SCIENCE AND CLIMATE CHANGE AUDIO

Imagining Climate Change

Discussion on climate and culture and imagination with writers Amitav Ghosh, Lidia Yuknavitch and visual artist Kambui Olujimi. Audio conversation

Read more.

Has Humanity Pushed Earth into a New Geological Epoch: the "Anthropocene?"

In this audio podcast from the Climate History Podcast, "Professor Dagomar Degroot interviews Professor John McNeill (Georgetown University) about

How Yukon glaciers are responding to climate change

This audio podcast discusses how glaciers in the Yukon are responding to climate change. It focuses on changes in the

Read more.

PEDAGOGICAL TOOLS: LANGUAGES

Variations climatiques et composition isotopique de l'oxygène ($^{18}O/^{16}O$)

auteurs: Jean-Yves Guchereau et Pierre Perez , Lycée de Bagatelle (Saint-Gaudens)

Terminale S - Enseignement de spécialité
Thème 1- Du passé géologique à l'évolution future de la planète
1- Les climats passés de la planète
Notions et contenus : « les changements du climat des 700 000 dernières années »

Activité 1 : utilisation du logiciel O18_16

Pré-requis nécessaires :

- notions d'isotopes de certains éléments (oxygène, hydrogène, carbone…). Les isotopes les plus légers, stables, sont toujours les plus abondants. Les isotopes les plus légers ont tendance à diffuser et à réagir plus facilement que les isotopes les plus lourds.

La molécule d'eau renferme de l'oxygène, on distingue l'eau de mer et l'eau douce (vapeur, pluie et glace).

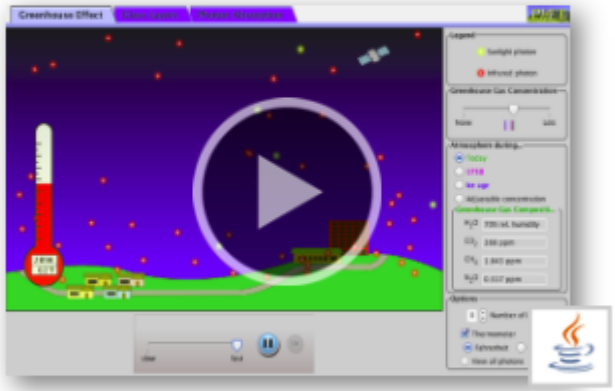
PhET INTERACTIVE SIMULATIONS

University of Colorado Boulder

Simulations

- New Sims
- HTML5
- **Physics**
  - Motion
  - Sound & Waves
  - Work, Energy & Power
  - **Heat & Thermo**
  - Quantum Phenomena
  - **Light & Radiation**
  - Electricity, Magnets & Circuits
- Biology
- **Chemistry**
  - **General Chemistry**
  - Quantum Chemistry

The Greenhouse Effect



- Greenhouse Effect
- Greenhouse Gases
- Heat

DOWNLOAD EMBED

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▶ FOR TEACHERS

▶ FOR TEACHERS

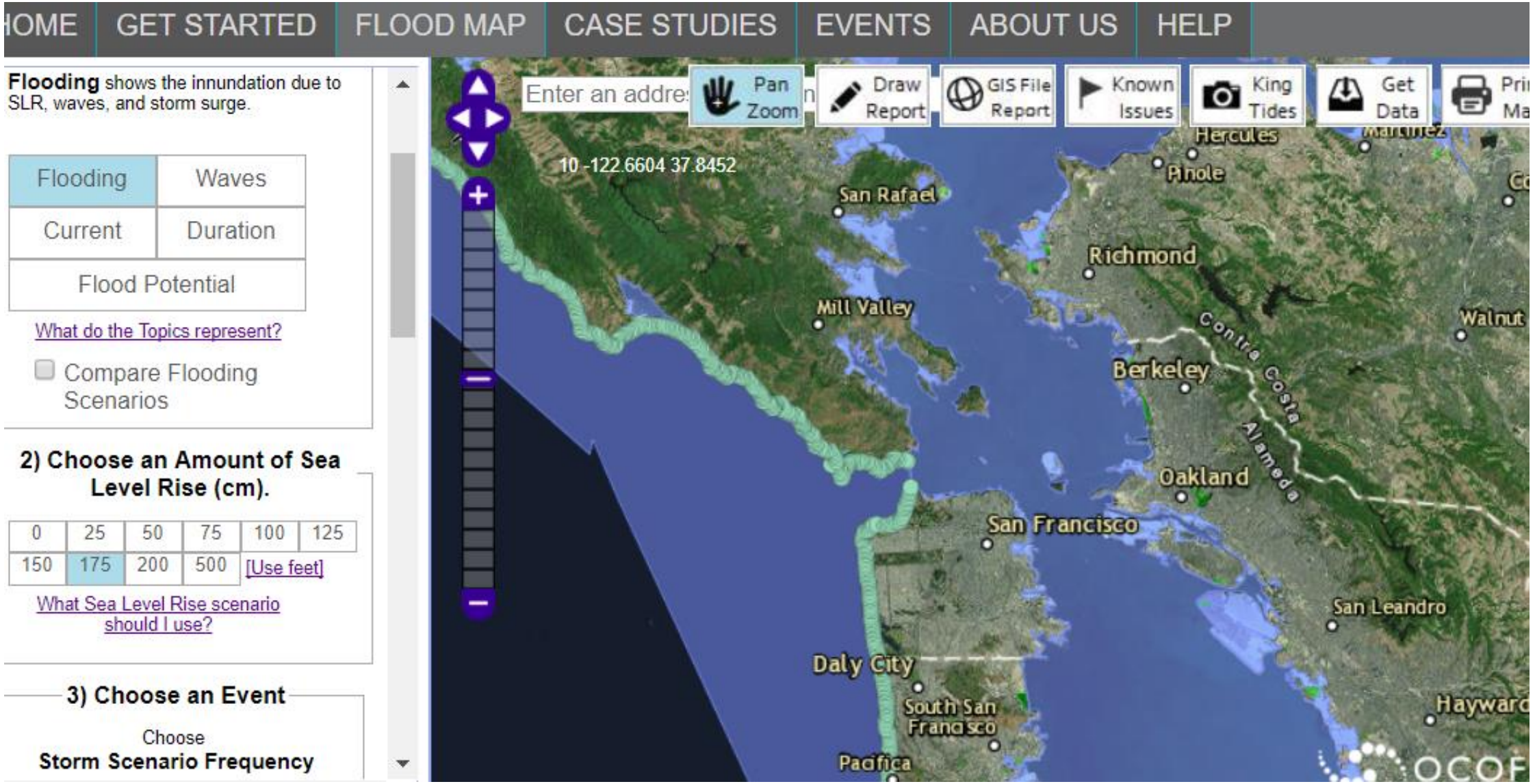
▼ TRANSLATIONS

LANGUAGE	
Albanian	All shqip
Arabic	All العربية
Basque	All Basque
Belarusian	All беларускі
Bosnian	All Bosanski
Chinese (Simplified)	All 中文 (中国)
Chinese (Traditional)	All 中文 (台灣)
Croatian	All hrvatski
Czech	All čeština
Danish	All Dansk
Dutch	All Nederlands
Estonian	All Eesti
Finnish	All suomi
French	All français
Galician	All Gallegan
German	All Deutsch
Greek	All Ελληνικά
Hebrew	All עברית
Hungarian	All magyar
Italian	All italiano
Japanese	All 日本語
Kannada	All Kannada
Khmer	All Khmer
Korean	All 한국어
Lao	All Lao
Macedonian	All македонски
Malay	All Bahasa Melayu
Norwegian Bokmal	All Norsk bokmål
Persian	All فارسی
Polish	All polski
Portuguese	All português
Portuguese (Brazil)	All português (Brasil)
Serbian	All Српски
Slovak	All Slovenčina
Spanish	All español
Spanish (Mexico)	All español (México)
Spanish (Peru)	All español (Perú)
Spanish	All español (España)

LOCATION SPECIFIC PEDAGOGICAL TOOLS
NEW ZEALAND

Visualize the relationship between climate change and the spread of some infectious diseases in New Zealand. This tool can be used as a visualization aid to teach topics such as **Health and Diseases, Epidemiology, Infectious Diseases and Vector-borne Diseases, Climate Change and the Spread of Diseases**.

OUR COAST OUR FUTURE FLOOD MAPS
CALIFORNIA COAST



Comic: The Possible Effects of Climate Change in the Bahamas

NATIONAL ADVISORY BOARD
on Climate Change & Disaster Risk Reduction
GOVERNMENT OF VANUATU

Climate Change and Environmental Education

CHILD FRIENDLY SCHOOLS

A companion to the
Child Friendly Schools Manual

unite for children

unicef

Climate Change and You!

JOIN THE TROP-ICSU FAMILY

We welcome contributions to our collated suite of pedagogical tools that can be used to teach concepts in climate change along with the core curriculum in science and mathematics.

To recommend a relevant tool that you have developed, modified or used, please CONTACT us.

tropicsu.org

rahul.chopra@tropicsu.org