Physical Aspects of Climate Change
(Atmosphere, Oceans, Cryosphere)

Program Duration: 4, 90 minute blocks OR 8, 45 minutes classes
Grade Level(s): HS Earth Space Science

Program Overview

This program covers the physical aspects of climate change. There are three main activities that cover the direct content: Atmosphere, Oceans, and Cryosphere. This program is intended for classroom teachers to use as direct instruction and a hands-on activity for the students to complete. Direct instruction is given as a PowerPoint the teacher can project and a student note sheet has been created for interactive notebooks, or for students to fill out digitally. In addition, a lab has been curated that pairs with the material so students can have a kinesthetic learning experience to reinforce the material learned. Activities for vocabulary development and review have been included as well as an end of the unit assessment where students show their knowledge of how the interactions between the Atmosphere, Cryosphere and Ocean create climate zones.

Indiana State Standards Covered:

- ES 3.1: Create flowcharts that show the exchange of carbon and oxygen between the lithosphere, hydrosphere, biosphere, and atmosphere, including carbon dioxide and methane. Explain how human activities such as farming and industry, temperature change in oceans, and natural processes such as volcanic eruptions can speed or slow the cycling from reservoirs within the solid earth and oceans into the atmosphere.
- ES 3.3: Analyze and explain how events on one side of the world can alter temperature and precipitation around the globe. Analyze and explain the possible effects of natural and human-driven processes on our atmosphere and climate.
- ES. 4.1: Create a model that shows the composition, distribution, and circulation of gases in Earth's atmosphere. Show how carbon and oxygen cycles affect the composition through gas exchange with organisms, oceans, the solid earth, and industry.
- ES. 4.2: Create models to demonstrate the circulation, retention, and reflection of heat in regards to the atmosphere, solid land, and bodies of water including lakes and oceans. Demonstrate the effects of cities, various terrain, cloud cover, sea ice, and open water on albedo. Examine local and global heat exchanges, including land & sea breezes, lake effects, urban heat islands, and thermohaline circulation.
- ES 4.4: Create a model to demonstrate how the Coriolis effect influences the global circulation of the atmosphere. Explain how changes in the circulation of the atmosphere and oceans can create events such as El Niño and La Niña.

Science and Engineering Practices

2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Cross-Cutting Concepts

2. Cause and effect
4. Systems and system models
7. Stability and change

Materials

Unit Intro	Lesson 1 (Atmosphere)	Lesson 2 (Oceans)	Lesson 3 (Cryosphere)
● Computer and projector to play the video ● White boards for students to brainstorm questions ● Large blank poster paper to write and display students questions around the classroom ● Printed copies of the Climate Intro notes, or a pdf uploaded for students to fill out digitally ● Vocab foldables for interactive notebook ● Access to Quizlet so students could play Quizlet live if there is time	● Computer/Projector to present direct instruction material (PowerPoint) ● Printed copies of the note sheet for notebooks (or a pdf of note sheet for students to fill out digitally) ● Printed copies of the Vocabulary building note sheet or a pdf for students to fill out digitally ● 2 Tupperware containers with lids ● 2 thermometer probes (digital) ● 2 grow lights (must be infrared) ● 2 ring stands ● Small beaker ● Dry ice ● Black construction paper ● Scissors ● Ruler ● Timer or stopwatch	● Computer/Projector to present direct instruction material (PowerPoint) ● Printed copies of the note sheet for notebooks (or a pdf of note sheet for students to fill out digitally) ● two transparent containers (plastic baggies work really well) ● straws ● bromothymol blue ● pH meter ● tap water ● Dry ice	● Computer/Projector to present direct instruction material (PowerPoint) ● Printed copies of the note sheet for notebooks (or a pdf of note sheet for students to fill out digitally) ● Two large bins ● Water ● Ice ● Rulers ● Heat lamps ● Rocks, blocks or something to signify land

Materials needed for Summative Assessment:

- Projector to show the students the example poster and if you are doing the digital version of the assignment
- Posterboard
- Markers, colored pencils and crafts supplies for poster decoration
- iPads, Chromebooks or some other device to research components of their climate zone.

Link to Google Drive Folder for the ENTIRE climate unit!

Climate Unit Introduction:

This program is intended to be used as an introduction to a larger climate unit that might include impacts of climate change and what students can do to mitigate climate change.

When Introducing the unit consider the following activity

Climate Unit Introduction Activity: 20 minutes

1. Have the students watch the following video: https://www.youtube.com/watch?v=dcBXmj1nMTQ
2. Have students work in groups to come up with a list of questions they have after the video
    a. It is alright to guide student questions. Examples might include:
        i. What causes climate change?
        ii. Why does climate change cause floods and also droughts?
        iii. Does everywhere experience climate change the same?
        iv. How does the greenhouse effect work?
3. Post the list of questions somewhere in the classroom for you and the students to reference as you go through the unit. This is great practice to ensure the material being taught is relevant to what the students actually want to learn.
    a. Possibly organize the questions into the following categories
        i. Atmosphere
        ii. Ocean
        iii. Cryosphere
        iv. Impacts of Climate Change
        v. How can we solve the problems of climate change

Introduction of New Material/Review of Old Material (30 minutes)

For the remainder of class take this opportunity to review concepts that students need to understand before beginning the climate unit such as:

- Atmospheric composition
- Atmospheric circulation
- Albedo
- Ocean heat capacity
- Ocean circulation
- Cryosphere components

Attached: Climate Intro Slide Show and Notes

Vocabulary Development: (40 minutes or assigned as homework)

There will be many new vocabulary words that students may need to know in order move forward in this unit. Take some time to develop those vocabulary words.
Follow the link to find Physical Aspects of Climate Change Quizlet:
https://quizlet.com/590519939/climate-change-unit-from-cees-flash-cards/?new

Attached is a **Vocabulary Foldable** for an interactive notebook

Lesson 1: Atmosphere

Introduction/Anticipatory Set/Bellringer

Guide students to think about atmospheric components of climate. Display the following "bellringer" question or ask it out loud for students to consider;
What do you remember about how the atmosphere affects climate?
Have students Think, Pair, Share their answers

Transition by telling students that today you will be going into more detail about the physical aspects of climate change. We are going to begin by covering Atmosphere.
Refer to the questions the students generated about atmosphere from the previous day.

Activity 1 – (45 minutes)

Materials

- Computer and Project to project the PowerPoint to students
- Printed copies of the note sheet or a pdf uploaded so that students can fill it in digitally

Instructions and/or Summary of Activity

The PowerPoint has been designed for teachers to give direct instruction to their students. Students will fill out a note sheet as they listen to the teacher. This note sheet can be printed for an interactive notebook or filled in digitally on their iPads or Chromebooks.
Teachers should pause to ask students the discussion questions within the lecture. In addition, there are graphs that the teacher may want the students to attempt to analyze on their own.

Attached: Atmosphere PowerPoint and Atmosphere student note sheet

When the direct instruction section is finished, do the following closure activity to help students internalize the information:
Exit Ticket: Before we begin our lab please take out a half sheet of paper and complete the following tasks. When you are finished bring me the paper and go to your lab station.

3 - the three most important things you learned from the notes?
2 – two things I found interesting
1 –one question I still have?

Activity 2 – 45 minutes

Materials

- 2 tupperware containers with lids
- 2 thermometer probes (digital)
- 2 grow lights (must be infrared)
- 2 ring stands
- Small beaker
- Dry ice
- Black construction paper
- Scissors
- Ruler
- Timer or stopwatch

Instructions and/or Summary of Activity

This lab reinforces the concept of greenhouse effect on the atmosphere. Students are asked to conduct an experiment with two different atmospheric compositions in sealed containers. They will be using heat lamps and temperature probes to determine how CO2 effects the temperature of the atmosphere.

Attached: Global Warming and Greenhouse Effect lab

Note: If this lab cannot be done in class due to lack of dry ice or materials. The following link has a great digital version of this students can do on their iPads or Chromebooks.
https://phet.colorado.edu/en/simulation/greenhouse

Wrap-up

Wrap up the class by going over the analysis questions with the students. Help them to understand the connection between atmospheric carbon dioxide and global climate change.

Discuss how humans are affecting this by their actions. Discuss how even though a couple countries are the big hitters for GHG emissions it affects the whole planet because of global air circulation.

Suggested Reading

https://www.ipcc.ch/report/ar5/wg2/

Suggested Videos:
https://www.youtube.com/watch?v=U8pZzYfzFMM
https://www.youtube.com/watch?v=rdGtcZSFRLk
https://www.youtube.com/watch?v=7fd03fBRsuU

Attached:
Atmosphere PowerPoint
Atmosphere Notes
3,2,1 Exit Ticket
Global Warming and Greenhouse Gases Lab

Lesson 2: Oceans

Introduction/Anticipatory Set/Bellringer
Have students watch this video of the ocean temperatures over 22 years
https://www.youtube.com/watch?v=GxDEwVwW9to

Have them write down all of their observations in their notebook or on a whiteboard as a group. Have them share out what they saw.
Ask guided questions to get the students thinking about where the heat comes from, why does the heat distribution change from year to year, ocean currents and ice accumulation.

Activity 1 – (45 minutes)

Materials

- Computer and Project to project the PowerPoint to students
- Printed copies of the note sheet or a pdf uploaded so that students can fill it in digitally

Instructions and/or Summary of Activity
The PowerPoint has been designed for teachers to give direct instruction to their students. Students will fill out a note sheet as they listen to the teacher. This note sheet can be printed for an interactive notebook or filled in digitally on their iPads or Chromebooks.
Teachers should pause to ask students the discussion questions within the lecture. In addition, there are graphs that the teacher may want the students to attempt to analyze on their own.

Attached: Oceans PowerPoint and Oceans student note sheet

When the direct instruction section is finished, do the following closure activity to help students internalize the information:
Question Stems: Have students write questions about the lesson on cards, using question stems framed around Bloom's Taxonomy. Have students exchange cards and answer the question they have acquired.

Activity 2 – 45 minutes

Materials

- 2 transparent containers
- 2 drinking straws (preferably reusable or compostable) or hollow pasta or hay
- Bromothymol blue indicator solution
- pH meter
- Dry ice
- Tap water

Instructions and/or Summary of Activity

Students will be using and acid base indicator to look at how adding carbon dioxide to water decreases the pH. They will be looking at how small amounts of carbon dioxide (breathing into the container) compares with large amounts of carbon dioxide (dry ice) changes the pH. The lab comes with discussion questions so that the students can internalize what they have learned.

Attached: Oceans Lab

Note: An extension for this lab could include having one container with organic spinach in it sitting in the windowsill. The spinach will do photosynthesis and increase the pH of the water. This can be a review of the carbon cycle and a possible talking point for mitigation strategies of excess carbon dioxide in the atmosphere. Other extension ideas that would be great discussion points would be to Instead of dry ice, bubble smoke from a candle into the indicator solution. You can also Investigate and discuss activities that students can do to reduce their carbon footprint.

Wrap-up

Wrap up the class by going over the analysis questions with the students. Help them to understand the connection between atmospheric carbon dioxide and global climate change.

Talk about how oceans are a commons (something that everyone uses). Brainstorm how ocean acidification might affect food security. Get students to think about ocean primary productivity and food webs.

Suggested Reading

https://www.ipcc.ch/report/ar5/wg2/

NOAA Education ocean acidification resources

Data in the Classroom: Ocean acidification (online lessons)

Understanding ocean acidification activities

offsite link

NOAA Ocean Acidification Program

Pacific Marine Environmental Laboratory: Ocean acidification

Suggested Videos:
https://www.youtube.com/watch?v=6SMWGV-DBnk
https://www.youtube.com/watch?v=fgBozLCGUHY

Attached:
Oceans PowerPoint
Oceans Note sheet
Ocean Acidification and Carbon Dioxide Lab

Lesson 3: Cryosphere

Introduction/Anticipatory Set/Bellringer:
Ask students what the cryosphere is. See if they can break the word apart. See if they think about "cryogenically frozen" things. Once you guide them and they end up with the answer "ice" have them see if they can list everything that would be in the cryosphere – other than snow. The next question would be, "How does the cryosphere effect the earth's climate" See if they can give you an answer. Have them struggle through it. Put the question on the board and come back to it at the end of the lecture to see if they can answer it better.

Activity 1 – (45 minutes)

Materials

- Computer and Project to project the PowerPoint to students
- Printed copies of the note sheet or a pdf uploaded so that students can fill it in digitally

Instructions and/or Summary of Activity

The PowerPoint has been designed for teachers to give direct instruction to their students. Students will fill out a note sheet as they listen to the teacher. This note sheet can be printed for an interactive notebook or filled in digitally on their iPads or Chromebooks.
Teachers should pause to ask students the discussion questions within the lecture. In addition, there are graphs that the teacher may want the students to attempt to analyze on their own.

Attached: Cryosphere PowerPoint and Cryosphere student note sheet

When the direct instruction section is finished, do the following closure activity to help students internalize the information:
Snowball fight! Have the students write one thing they learned from the lesson on a scrap piece of paper. Have them wad up the paper into a "snowball." Set a timer and have the students throw the paper in a snowball fight. Have them pick up the snowballs that are closest to them and keep throwing for about 15 seconds. When the snowballs are thoroughly mixed and you don't think a student will pick up their own, have the students pick up the snowball closest to them and read what is written. This is such a fun way to review the material and students can hear things they may not have picked up during the lecture.

Activity 2 – 45 minutes

Materials

- Large bins
- Water
- Ice
- Rocks, blocks or something to represent land
- Ruler
- Additional craft supplies
- Heat lamps

Instructions and/or Summary of Activity

Students are creating a model in bins of sea ice and land ice (ice sheets) and how climate change will affect melting and sea level rise. This bin will be set up at the beginning of the lab and while they wait for the ice to melt, they will be working on a sea level rise simulation. This simulation has them analyze maps and assess risks for sea level rise in certain areas. Students are analyzing data and making connections to the cryosphere and global warming.

Attached: Cryosphere Lab (Melting Ice and Sea Level Rise)

Note: **Teachers: What they should find:** They should find that sea ice does not contribute significantly to sea level rise because sea ice floating in ocean water displaces approximately the same amount of water as it contributes to the ocean when it melts.

Adapted Lab link: https://serc.carleton.edu/earthlabs/cryosphere/6.html

- Contains:
    - Overview & Teaching Materials
    - Printable Materials
    - Student Notebooks for Lab
    - Teaching Notes and Tips
    - Assessments Written Responses to Discussion Questions & Written Test ○ Additional Teacher Resources

Wrap-up

Wrap up the class by going over the discussion questions in the lab.
Even though we live in Indiana, have student brainstorm how rising sea levels might affect us here in the Midwest.

Suggested Reading

https://www.ipcc.ch/report/ar5/wg2/

Suggested Videos:
https://www.youtube.com/watch?v=L2H_vIqyWTU
Nasa has a whole series on the cryosphere! Super cool!

Attached:
Cryosphere PowerPoint
Cryosphere Notes
Cryosphere Lab

Physical Aspects of Climate Change Assessment
Climate Zone Posters

Introduction:
This can be used as a possible assessment for this section of the climate unit. Students can do this in groups or individually. You can make a Performance Task or a Practice Activity. Students will be looking at various climate zones and analyzing how the atmosphere, ocean, and cryosphere interact to create the precipitation and temperature conditions in that climate zone.

Expected Outcomes of the Assessment:
Students will make the connections that climate is the result of systems interacting with each other. Students will understand that even if they have been assigned an arid or hot climate that the cryosphere plays a role in the climate regulation of the entire planet. Students will make connections on how future climate change will affect their assigned climate zone. At the end students can do a gallery walk of their posters so that other students can see and understand the effects of the atmosphere, ocean, and cryosphere on the climate zones.

Materials

- A device where students can do research – iPad, chromebook, computer lab
- Posterboard if students are doing a physical poster
- A projector and computer for you to show the sample project
- Markers, colored pencils, rulers and various craft supplies for students to decorate their posters.

Instructions and/or Summary of Activity

If you are doing this as a summative assessment (Performance Task):
Have students pick a climate zone, outlined in the Climate Introduction PowerPoint or the Physical Aspects of Climate Change Assessment PowerPoint. Go through the example humid continental example provided so that students understand what you are expecting. In addition, look at the attached grading rubric. Have students work alone or in pairs to create a poster, physical or digital, that displays the information about their climate zone. Most of the information they will be able to research with a quick Google search. However, the section that asks them to explain how the atmosphere, ocean and cryosphere interact to create the climate zone will need to be their own thoughts. From what they have learned in these 4 lessons, students should be able to make connections and describe how the systems interact with each other. Some climate zones will be more obvious than others. For example, the arid climate zone, students may have trouble connecting the cryosphere to this climate region, but guide them to understand how hot the planet would be without the cryosphere and how global air circulation enables cold air from the poles to circulate with warm air from the equator.

When students have finished their posters (this took my class about 45 minutes to do digitally, it will take longer if they are making a physical poster) have them share their posters with the class so that other students can learn about each climate zone.

Make sure to review student work before presenting to the class to ensure that students are not misinformed about the climate zones.

If you are doing this as a class group activity:
Use the Physical Aspects of Climate Change Assessment PowerPoint on Google Drive. Share the link with students so that they can edit the PowerPoint. It would be important to make a copy of this PowerPoint for each class. Have students work in the google slides. Check student progress and suggest corrections if necessary. When every student is finished project the slides and have the students present about their climate zone.

Sample Rubric

Criteria for Success	0 – did not attempt	1 – put pencil to paper in a meaningful way	2 – missing one key piece of understanding	3 – Meets expectations	4 – Exceeds expectations – makes real world connections
Precipitation, Temperature, and Plants	Did not attempt	Missed 2 of the components	Missed one of the 3 components	Did accurate research and found the correct precipitation and temperature conditions for their climate zone. Included some examples of plants	Completed everything in 3, but explained temperature and precipitation fluctuations due to seasons. Gave many examples of plants
Interactions between Atmosphere, Ocean and Cryosphere	Did not attempt	Missed 2 of the components OR gives very little explanation how each effect climate.	Missed one of the 3 components OR tries to explain how each component effect climate, but maybe misses key understanding.	Explained how each component contributes to the conditions of the climate zone. Uses key vocabulary such as air mass and ocean currents.	Explained how each component contributes to the conditions of the climate zone. Uses key vocabulary such as air mass and ocean currents. Makes the connections that if their zone is not directly affected by the cryosphere, the cryosphere still effects overall global temperatures.
Global Warming Impact on Climate Zone	Did not attempt	Tried, but really missed the mark. Has no concept of how Global warming might impact their climate zone.	Gave a very brief explanation of how climate change may affect the climate zone, for example, they may have said “it gets hotter and will rain more”	Explained how temperature and precipitation might change due to climate change. Explains how the seasons might be different.	Everything in 3 and in addition explains how the animals and plants of that climate zone might be affected by climate change

Credits:

- Group Leader: Skylee Shaffer
  - Team Atmosphere:
    - Olivia Little Miyauchi – PowerPoint
    - Paula Robert - Student Note sheet
    - Sam Blakeslee - Lab
  - Team Ocean:
    - Shampaygne Jeffries - PowerPoint
    - Kamala Nair – Student Note Sheet
    - Kylie Thomsen - Lab
  - Team Cryosphere:
    - Mary Moffett - PowerPoint
    - Janae Washington – Student Note Sheet
    - Kianna Rice - Lab