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LESSON 2:

CLIMATE AND ENERGY BUDGET

Driving Question:

What part of the Earth system affects climate?

Sub-questions:

- What effect does the earth's energy budget have on climate?
- What is the greenhouse effect?
- How can climate feedback systems be understood?
- What is the difference between climate and weather?

Goal:

For students to be able to recognize how different energy transfers (fluxes) affect both global and regional climate, and gain a basic understanding of the greenhouse effect.

Grade Level:

9th Grade

Lesson time: 1.75-2 hours

Climate literacy principle addressed:

- Principle 4 - Climate varies over space and time through both natural and man-made processes.
- Principle 7 - Climate change will have consequences for the Earth system and human lives.

Learning Objectives:

- Students will demonstrate knowledge on what geographical factors influence climate such as earth's tilt, geographical location, closeness to water bodies, elevation, oceans, latitude and longitude through the Factors that Affect Earth's Climate Worksheet.
- Students will learn the difference between weather and climate through discussion and lecture.
- Students will gather information about the earth's energy budget from lecture.
- Students will gather information about the greenhouse effect and human influence on atmospheric CO₂.

Colorado State Standards & 9R Dashboards for Earth Systems

Science - High School:

- Earth Sciences Standard #4: Climate is the result of energy transfer among interactions of the atmosphere, hydrosphere, geosphere, and biosphere
- HSS 4a: Develop, communicate and justify an evidence-based scientific explanation that shows climate is a result of energy transfer.
- HSS 4c: Explain how a combination of factors such as Earth’s tilt, seasons, geophysical location, proximity to oceans and landmasses, elevation, and latitude and longitude determine climate.

Prior Knowledge Required:

- Knowledge of basic physics and chemistry, and understanding of weather processes such as precipitation, wind, high and low temperatures, solar radiation, etc.

Common student misconceptions and prior understandings:

- Students may confuse “natural variability” i.e. multi-year to decadal cycles (La Niña, El Niño, etc.) with climate change.
- The misconception that climate change is solely “global warming.”

Lesson 2 Materials and Handouts:

- Homework:
http://www.esrl.noaa.gov/gmd/education/lesson_plans/Atmospheric%20Trace%20Gases%20Involved%20in%20Global%20Change.pdf
-“Atmospheric Trace Gases Involved in Global Climate Change” chart for students to fill out.
- Materials:
 - Factors that Affect Climate Worksheet
 - Greenhouse Gases Terms and Definitions

Background Information:

- I. NOAA: Difference between climate and weather:
http://oceanservice.noaa.gov/facts/weather_climate.html
 - i. Climate modeling 101: short video explaining difference in weather and climate: *Trend and Variability*
http://nas-sites.org/climate modeling/page_1_1.php
- II. Earth's energy budget animated diagram:
<http://earthguide.ucsd.edu/earthguide/diagrams/energybalance/>
- III. NASA: Earth's energy budget:
<http://earthobservatory.nasa.gov/Features/EnergyBalance/>
- IV. Factors affecting global climate: including good graphics. Ocean currents and global climate sections. <http://www.nature.com/scitable/knowledge/library/factors-affecting-global-climate-17079163>
- V. Albedo: <http://nsidc.org/cryosphere/seaice/processes/albedo.html>
- VI. Greenhouse Effect: http://www.ucar.edu/learn/1_3_1.htm
- VII. Greenhouse Effect video:
<http://www.epa.gov/climatechange/kids/basics/today/greenhouse-effect.html>
- VIII. For information on CO₂ concentrations <http://co2now.org/>
- IX. Other effects of carbon dioxide in earth's atmosphere:
http://en.wikipedia.org/wiki/Carbon_dioxide_in_Earth%27s_atmosphere

Lesson 2 (1.75-2 hours)

1. Lecture and give students examples of the difference between weather and climate. Climate is the average atmospheric conditions of a region over a long period of time (decades to centuries), and weather is the short-term (days to weeks) conditions of the atmosphere. (10 minutes)
Use examples on the NOAA website (Background I)

2. Earth's energy budget: The earth and its many processes are powered by sunlight. Earth is not heated evenly, which can be explained by warm tropical regions at the equator and cold polar regions. (20 minutes)
 - If desired, show students animation in background information.
 - The sun's radiation provides the energy that generates ocean and atmospheric movements and processes.
 - Radiation (both solar and planetary) is absorbed and reflected by the earth system.
 - Albedo: Commonly referred to as the "reflectivity" or "whiteness" of a surface. White surfaces such as snow have a high albedo, and dark surfaces such as asphalt have a low albedo.

3. Lecture and activity on the factors that influence climate. Hand out "Factors that Affect Climate Worksheet", go over factors as a class, and have students' complete the regional climate activity. Adapted from NOAA Earth Systems Research Laboratory, Teacher Lesson Plans. Module 9: Factors that Affect Climate. http://www.esrl.noaa.gov/gmd/infodata/lesson_plans/
(35 minutes)
 - Factors that influence precipitation and temperature:
 - Latitude:
 - Proximity to large bodies of water
 - Proximity to mountain ranges
 - Prevailing winds
 - Elevation
 - Ocean currents
 - Human modification of land surface

4. Discuss the greenhouse effect. Background information above as well as show video if desired on basics of greenhouse effect. (1.56)
<http://www.epa.gov/climatechange/kids/basics/today/greenhouse-effect.html>

5. Lecture on greenhouse gases: where they come from and their effects on the planet. Go over Carbon dioxide, Nitrous Oxide, Methane, water vapor, tropospheric ozone, and CFCs. (15 minutes) Talk about atmospheric lifetime of these gases- which separates water vapor from other gases. Most gases have atmospheric lifetimes of 10-100 years (CO₂ is more than 100 years) whereas water vapor is a few weeks.

6. Go over CO₂ emissions change and the Keeling Curve: (15 minutes)

- The atmospheric CO₂ concentration is currently about 400 ppm
 - Charles David Keeling was known for his precise measurements of atmospheric carbon dioxide charted in the Keeling Curve from 1958 to his death in 2005.
 - Show curve here: <http://earthobservatory.nasa.gov/IOTD/view.php?id=5620>
7. Explain how CO₂ is emitted from human sources and how it is contributing to warming. Also go over how atmospheric CO₂ can be reduced effectively. (20 minutes)
- Human activities increase CO₂: burning fossil fuels, deforestation.
 - Use the climate change clicker quiz from CIRES if desired
 - Ways to decrease CO₂: Seafloor accumulation of marine sediments and accumulation of plant biomass, and increasing the number of trees and vegetation to absorb the CO₂. It should be conveyed that these methods are not sufficient to substantially decrease atmospheric CO₂ and that anthropogenic emissions have to be reduced in order to avoid dangerous levels of CO₂ in the atmosphere.
8. Wrap up and discuss homework (15 min): Homework: Students will use their notes and other sources if needed to fill out the greenhouse gas chart. Homework found here:
- http://www.esrl.noaa.gov/gmd/education/lesson_plans/Atmospheric%20Trace%20Gases%20Involved%20in%20Global%20Change.pdf