5E Integrated STEM Lesson Plan – Template

Lesson Title: Introduction to Earth's Atmosphere
Author: Sarah Roi
Topic: Earth's Atmosphere
Targeted Grade Level: High School 9-12
Time Needed: 6-50 minute class periods.
Subject Integration:

- Science
- Engineering
- Math

Justification:

The objective of this lesson is for students to identify the different characteristics of the Earth's atmosphere, explain the function of the atmosphere and explore its importance to the planet by describing how it makes Earth so unique as compared to other planets in our solar system. Students will learn about how the sun's thermal energy enters and moves through the atmosphere and how the ozone layer protects us from harmful ultraviolet radiation from the sun. Students will then explore the ozone hole and its causes, ending our unit with an analysis of 40 years of NASA ozone hole data. Students will create an informative digital poster about the zone as it changes seasonally and over time. Students will highlight factors that contribute to the increase in size of the hole as well as factors that contribute to the decrease in size. Finally students will Analyze the current status of the ozone.

Standards:

- **HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedback that causes changes to other Earth's systems.**
- **HS-ESS2-3. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.**
- **HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.**
- **HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.**

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts:
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among	HS-ESS2A: Earth Materials and Systems ● Earth's systems, being dynamic and interacting, cause feedback effects	Energy and Matter ● The total amount of energy and matter in closed systems is conserved. (HS-ESS2-6)

variables between systems and their components in the natural and designed world(s).

- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS2-3),(HS-ESS2-6)

Analyzing and Interpreting Data
Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-ESS2-2)

Planning and Carrying Out Investigations
Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-ESS2-5)

that can increase or decrease the original changes. (HS-ESS2-2)

- Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. (HS-ESS2-3)

ESS2.D: Weather and Climate

- The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-2)
- Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6),(HS-ESS2-7)
- Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-6)

- Energy drives the cycling of matter within and between systems. (HS-ESS2-3)

Structure and Function

- The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. (HS-ESS2-5)

Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS2-7)
- Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS2-2)

Common Core State Standards

ELA/Literacy -

- RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-ESS2-2),(HS-ESS2-3)
- RST.11-12.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. (HS-ESS2-2)
- WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-ESS2-5)
- SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-ESS2-3)

Mathematics -

- MP.2 Reason abstractly and quantitatively. (HS-ESS2-2),(HS-ESS2-3),(HS-ESS2-6)
- MP.4 Model with mathematics. (HS-ESS2-3),(HS-ESS2-6)
- HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS2-2),(HS-ESS2-3),(HS-ESS2-6)
- HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-3),(HS-ESS2-6)
- HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-2),(HS-ESS2-3),(HS-ESS2-5),(HS-ESS2-6)

ITEEA Standards

(*N/A)*

Measurable Student Learning Objectives:

- Students will be able to describe structure of the atmosphere

- Students will be able to describe how the sun's thermal energy is transferred throughout the atmosphere via conduction, convection and radiation.
- Students will be able to explain how air pressure and density are affected by increase in altitude.
- Students will be able to explain why seasons occur and how sun thermal energy affects the earth at different times of the year.
- Students will be able to describe the greenhouse effect and how it provides a comfortable environment on earth for life
- Students will be able to analyse the ozone layer describing the factors that contribute to the hole above Antarctica.

Nature of STEM:

Scientific Knowledge is Open to Revision in Light of New Evidence

- Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. (HS-ESS2-3)

Science is a Human Endeavor

- Technological advances have influenced the progress of science and science has influenced advances in technology . (HS-ESS3-3) Science and engineering are influenced by society and society is influenced by science and engineering. (HS-ESS3-3)

Engaging Context/Phenomena:

Students will be engaged with a photo of a woman with an ultraviolet radiation filter which exposes hidden skin damage. there would be more damage if it were not for the atmosphere, most specifically, the ozone layer. It is important that the students understand that the thin layer of the atmosphere is responsible for protecting not only our skin but all life on earth. Without the atmosphere, Earth would look more like Mars, barren void of life.

Data Integration:

The students will utilize NASA's Ozone Watch website, where over 40 years worth of ozone levels have been collected using false image maps focusing on the area above the Antarctic continent. This is the infamous area where a hole exists. Students will analyze this realtime NASA data to track the hole as it fluctuates through seasons as well as through the decades.

Differentiation of Instruction:

- This can easily be conducted as a teacher-led experimentation where teachers can walk the students through the exercise guiding them to the correct conclusion.
- This lesson can be shortened or lengthened as needed
- These documents can be translated using google translate or some other such translation tool

Real-life Connection

The atmosphere provides a way to collect and distribute thermal energy throughout the planet. This explains why we have tropical regions, polar regions, and mid latitudes. The atmosphere creates a phenomenon called he greenhouse effect as well as protection from sun harmful radiation. Without the atmosphere we would not be able to live here on Earth.

Possible Misconceptions:.

- Underestimate the importance of the atmosphere
- The greenhouse effect is bad
- The ozone hole is caused solely by human activity.

Lesson Procedure:

5E Model	5E Objectives

Engage: 10-15 minute	**Procedure:**
	Complete slide 2 in their Atmosphere Digital Scientific Notebook.
	● Have students complete individually then discuss as a class
	● Besure to highlight:
	  ● Ultraviolet light is a form of radiated energy from the sun that is damaging to all life on the planet.
	  ● Does anyone know what protects us from this harmful energy?
	Modifications
	● review what an observation versus an inference prior to this exercise
	● walk through these exercise together
	Standards Addressed
	NGSS Disciplinary Core Idea:
	● **HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.**
	NGSS Science and Engineering Practices:
	● Analyzing and Interpreting Data to provide evidence for phenomena
	● Obtaining, Evaluating, and Communicating Information by constructing an explanation that includes qualitative or quantitative relationships between variables that predict and/or describe phenomena
	
	Formative/Summative Assessments
	● Answers to the observations, see Atmosphere Digital Scientific Notebook Key for some suggested observations.
	Resources
	● Atmosphere Digital Scientific notebook.
	● Atmosphere Digital Scientific Notebook Key
	● McKenna, T. J., & Zieminski, C. (n.d.). *UV Sun Damage*. Phenomena for NGSS. NGSS. Retrieved October 11, 2021, from https://www.ngssphenomena.com/.
	● Titus J. Brinker. (2018). *Sunface (1.1)*[Mobile App]. App Store. https://apps.apple.com/us/app/sunface-uv-selfie/id1226606410

Explain: 2-50 Minute period	**Procedure Earth's Energy Flows and Climate (1 day):** ● complete the PBS learning: Earth's energy flows and climate investigation ● Using the information you have learned, create a flow chart on Slide 8 of your of Atmosphere Digital Scientific notebook on how the earth's thermal energy gets cycle through the atmosphere. ● Be sure to label where conduction, convection, and radiation are occuring. ● Feel free to use the shapes and arrows provided or your own clip arts which can be found from google. **Modifications** ● This could be done in small groups or as a class. ● This could be done in expert groups as well. ● Provide a scaffolded flow chart having the students just label the ways energy is transferred **Standards Addressed:** NGSS Standards: ● HS-ESS2-3. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. ● HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. ● HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. NGSS Disciplinary Core Idea: HS-ESS2A: Earth Materials and Systems ● Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. (HS-ESS2-3) Stability and Change ● Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS2-2) NGSS Crosscutting Concepts: Energy and Matter ● Energy drives the cycling of matter within and between systems. (HS-ESS2-3) Literacy:

- RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-ESS2-2),(HS-ESS2-3)
- SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-ESS2-3)

Mathematics:

- MP.2 Reason abstractly and quantitatively. (HS-ESS2-2),(HS-ESS2-3),(HS-ESS2-6)
- MP.4 Model with mathematics. (HS-ESS2-3),(HS-ESS2-6)
- HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS2-2),(HS-ESS2-3),(HS-ESS2-6)
- HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-3),(HS-ESS2-6)
- HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-2),(HS-ESS2-3),(HS-ESS2-5),(HS-ESS2-6)

Formative/Summative Assessments

- The students Flowchart (see Atmosphere Digital Scientific Notebook Key)

Resources

- Atmosphere Digital Scientific notebook.
- Atmosphere Digital Scientific Notebook Key
- PBS. (2021). *Earth's Energy Flows and Climate*. Earth's Energy Flows and Climate. https://d3tt741pwxqwm0.cloudfront.net/WGBH/pcep14/pcep15-int-energyflows/index.html#

Procedure Seasons Why do we have them (1 day):

- Read the article Seasons on Actively Learn answer the black box questions as you read
  a. For people living in the Northern Hemisphere, why is the longest day of the year experienced on summer solstice?
  b. How does Earth's tilt explain when and why the southern hemisphere experiences winter?
  c. Provide evidence to support the claim that people living on or near the equator do not experience seasons; their climate stays fairly consistent all year long.
- Complete the Explore Learning Gizmo Seasons Why Do We Have Them? (Explore Learning is a subscription service)
- Follow the Exploration guide instructions to navigate the gizmo. Answer the questions on the exploration guide as you investigate.
- When you are finished answer the questions on slide 9 of your Atmosphere Digital Scientific notebook.

Modifications

- This could be done in small groups or as a class.

Standards Addressed:

NGSS Standards:

- HS-ESS2-3. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.
- HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.
- HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

NGSS Disciplinary Core Idea:

HS-ESS2A: Earth Materials and Systems

- Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. (HS-ESS2-3)

Stability and Change

- Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS2-2)

NGSS Crosscutting Concepts:

Energy and Matter

- Energy drives the cycling of matter within and between systems. (HS-ESS2-3)

Literacy:

- RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-ESS2-2),(HS-ESS2-3)
- SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-ESS2-3)

Mathematics:

- MP.2 Reason abstractly and quantitatively. (HS-ESS2-2),(HS-ESS2-3),(HS-ESS2-6)
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- HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS2-2),(HS-ESS2-3),(HS-ESS2-6)
- HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-3),(HS-ESS2-6)
  - HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-2),(HS-ESS2-3),(HS-ESS2-5),(HS-ESS2-6)

Formative/Summative Assessments

- Actively learn Black box questions
  a. The Northern Hemisphere is tilted toward the sun at this point.

b. The southern hemisphere experiences winter when EArth;s axis is tilted toward the sun.
c. Even though the earth is tilting towards or away from the sun, areas around the equator never change therefore their climate is very consistent and they do not experience seasons like the mid latitudes.

- Answer to the slide 9 Gizmo check for understanding. See the Atmosphere Digital Scientific Notebook Key

Resources

- Actively Learn. Seasons. (n.d.). Retrieved October 10th, 2021, from https://reader.activelylearn.com/student/4002588/notes
- Atmosphere Digital Scientific notebook.
- Atmosphere Digital Scientific Notebook Key
- Explore Learning. (2021). *Greenhouse Effect Gizmo : ExploreLearning*. ExploreLearning : Seasons Why Do We Have Them? https://gizmos.explorelearning.com/index.cfm?method=cResource.dspView&ResourceID=372

Procedure It's the reason for the season Wrap up (15 min):

- Complete slide 10 in your Atmosphere Digital Scientific notebook.
- Feel free to use any of the notes and activities we have completed thus far to explain the gif.
- Answers should be in complete sentences.

Modifications

- provide a scaffolding or specific vocab words to help them formulate the explanation
- work in partners with thoughtful pairing
- Work through it as a group guiding them towards the correct answer

Standards Addressed:

NGSS Standards:

- HS-ESS2-3. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.
- HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.
- HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

NGSS Disciplinary Core Idea:

HS-ESS2A: Earth Materials and Systems

- Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection,

	which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. (HS-ESS2-3) Stability and Change ● Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS2-2) NGSS Crosscutting Concepts: Energy and Matter ● Energy drives the cycling of matter within and between systems. (HS-ESS2-3) Literacy: ● RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-ESS2-2),(HS-ESS2-3) ● SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-ESS2-3) Mathematics: ● MP.2 Reason abstractly and quantitatively. (HS-ESS2-2),(HS-ESS2-3),(HS-ESS2-6) ● MP.4 Model with mathematics. (HS-ESS2-3),(HS-ESS2-6) ● HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS2-2),(HS-ESS2-3),(HS-ESS2-6) ● HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-3),(HS-ESS2-6) ● HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-2),(HS-ESS2-3),(HS-ESS2-5),(HS-ESS2-6) **Formative/Summative Assessments** ● Their final explanation for the gif. (see Atmosphere Digital Scientific Notebook Key) **Resources** ● Atmosphere Digital Scientific notebook. ● Atmosphere Digital Scientific Notebook Key ● McKenna, T. J., & Zieminski, C. (n.d.). *Winter Vs Summer*. Phenomena for NGSS. NGSS. Retrieved October 12, 2021, from https://www.ngssphenomena.com/.
Elaborate: 1-50 Minute class period.	**Procedure The GreenHouse Effect (1 day):** ● Complete slide 11 in your Atmosphere Digital Scientific notebook., ● Watch the Paul Anderson video and answer the questions as you watch ● As a class review the answer so the questions **Modifications** ● Complete this activity as a whole group or small group discussion

- Stop and start the video as Anderson explains how different forms of light affect the different molecules.

Standards Addressed:

Disciplinary Core Ideas:
HS-ESS2A: Earth Materials and Systems

- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-2)
- Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. (HS-ESS2-3)

ESS2.D: Weather and Climate

- The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-2)
- Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-6)

NGSS Crosscutting Concepts:
Energy and Matter

- Energy drives the cycling of matter within and between systems. (HS-ESS2-3)

Structure and Function

- The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. (HS-ESS2-5)

Stability and Change

- Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS2-2)

Literacy:

- WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-ESS2-5)
- SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-ESS2-3)

Mathematics:

- HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-3),(HS-ESS2-6)

	• HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-2),(HS-ESS2-3),(HS-ESS2-5),(HS-ESS2-6) **Formative/Summative Assessments** • Students answers to the Greenhouse effect questions on slide 11 see Atmosphere Digital Scientific Notebook Key **Resources** • Atmosphere Digital Scientific notebook. • Atmosphere Digital Scientific Notebook Key • Bozmen Science. (2014, April 21). *The Greenhouse Effect* [Video]. YouTube. https://www.youtube.com/watch?v=3ojaDMadZXU
Evaluate- **2-50 min class periods**	**Procedure Sticky note brainstorming Ozone (1day):** • Complete slide 12 in your Atmosphere Digital Scientific notebook., • using the NASA Ozone Watch Website answer the post it note questions **Modifications** • Complete this activity as a whole group or small group discussion • provided fill in the blank answers to the questions for the students to complete • turn this into a matching type of situation where they have the question and the answer and after the read they should be able to match the appropriate answer to the question. **Standards Addressed** Disciplinary Core Ideas: HS-ESS2A: Earth Materials and Systems • Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-2) • Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. (HS-ESS2-3) ESS2.D: Weather and Climate • The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-2)

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Formative/Summative Assessments

- Students' responses to the sticky note questions (see Atmosphere Digital Scientific Notebook Key)

Resources

- Atmosphere Digital Scientific notebook.
- Atmosphere Digital Scientific Notebook Key
- NASA Ozone Watch. (2018, October 18th). *Ozone Facts*. NASA Ozone Watch. Retrieved October 12, 2021, from https://ozonewatch.gsfc.nasa.gov/facts/ozone_SH.html

Procedure Identifying Ozone Variations (2 days):

- Create groups of 4
- For the final evaluation student will investigate the ozone hole during the 2013 year
- use the Daily animation from 2013 from the NASA site Ozone Watch, to answer the question for part 1 and 2 on slide 13 of your Atmosphere Digital Scientific notebook.
- For part 3 you will be doing an analysis of the ozone hole from 1979 to present day watching it change seasonally as well as through the decades.
- Create an interactive Poster on slide 15 (or others if you need to duplicate the slide for more room) highlighting your analysis of the hole over the past 40 years.

Modifications

- Thoughtful pairing of groups
- Isolate the images you want the students to interpret instead of having them find the images. There should be at least 4 images for every year you choose (spring, summer ,winter, fall) as the ozone hole has a seasonal fluctuation. Also 1989 was the year the Montreal Protocol was enacted eliminating the use of Chlorofluorocarbons (CFC's). CFC's were major contributors to the breakdown of the ozone layer. Over the last 5 years there has been a rise in renewable and reusable resources. Excess greenhouse gases increase the size of the ozone hole as well. Finding specific years to investigate for the students would be helpful for struggling learners
- The archives are broken down into decades. It is recommended that the students analyze at least the first, middle and last year of the decade even though environmental protocols are enacted all the time, changes are not necessarily noticeable for several time.

Standards Addressed

Disciplinary Core Ideas:

HS-ESS2A: Earth Materials and Systems

- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-2)
- Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. (HS-ESS2-3)

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- WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-ESS2-5)

- SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-ESS2-3)

Mathematics:

- HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-3),(HS-ESS2-6)
- HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-2),(HS-ESS2-3),(HS-ESS2-5),(HS-ESS2-6)

Formative/Summative Assessments

- Summative assessment will be the students' resulting Interactive Poster. Students will be using NASA archived data as well as current data to analyze the hole in the ozone over the past 40 years. They must address the time of year the hole is largest, particular decades when the hole was largest, contributing factors to increase in hole size, factors that reduce the hole size.
- Identifying Ozone Variations Interactive Poster Rubric

Resources:

- Atmosphere Digital Scientific notebook.
- Atmosphere Digital Scientific Notebook Key
- NASA Ozone Watch. (2018, October 18th). *Ozone Maps*. NASA Ozone Watch. Retrieved October 12, 2021, from https://ozonewatch.gsfc.nasa.gov/monthly/monthly_1979-01_SH.html
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Procedure It could be worse! (15 min):

- wrapping up the unit students will reflect on the GIF using the ultraviolet camera
- on slide 16 of the Atmosphere Digital Scientific notebook, reflect on what you have learned about the atmosphere. Explain:
  - 3 ways the atmosphere keeps Earth safe for us to live
  - 2 ways humans are depleting the ozone layer
  - 1 way you can help keep the ozone layer stable.

Modifications

- Work as a class to summarize what has been discussed
- provide the students a list of if formation and have them drag and drop it into categories.

Standards Addressed

Disciplinary Core Ideas:

HS-ESS2A: Earth Materials and Systems

- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-2)
- Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. (HS-ESS2-3)

ESS2.D: Weather and Climate

- The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-2)
- Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-6)

NGSS Crosscutting Concepts:

Energy and Matter

- Energy drives the cycling of matter within and between systems. (HS-ESS2-3)

Structure and Function

- The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. (HS-ESS2-5)

Stability and Change

- Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS2-2)

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Teacher Background:

This lesson is best served as an introduction to the Atmosphere. Making sure the students understand that the atmosphere is not one large mass covering our planet, but rather layers with different characteristics that affect each of the other layers. Teachers should familiarize themselves with these layers and their characteristics. Teachers should familiarize themselves with the earth's energy budget, how and why energy is conducted, conducted and radiated throughout the atmosphere and how this contributes to things like climate bands and the seasons of each hemisphere. Lastly teachers should be familiar with the ozone layer and its importance as a protective layer for UV radiation coming from the sun. Teachers need to understand the mechanics of the greenhouse effect and how it is a necessary feature of the atmosphere to maintain a comfortable climate here on Earth. Teachers should understand there is hole in the ozone over Antactica and that it is a natural phenomena influenced by temperature fluctuations, and that the natural fluctuations are being influenced by human activities. This hole threatens the greenhouse effect making it less efficient which ultimately leads to an imbalance in the energy budget.