Stan Feighny
Eyes on Earth: Teaching Earth Science from Space
Fall 2020
10/13/2020

Cover Sheet Atmosphere Lesson 1 - The Keeling Curve for the Arctic

Missy Holzer, Ph.D

The lesson plan is being uploaded for submission with this cover sheet. The links in the lesson plan are to my shared Google Drive folder.

General Notes:
This lesson is rubric driven. There are four rubrics and Google form for grading. I have found that using rubrics for the formative assessment allows the teacher to award daily progress points and to keep the class focused on producing a product they can be proud of. The rubrics are revised as the lesson progresses and the students and I learn more. The revised rubrics are used in the final assessment.

Using the pdf should work fine for grading. If you have any difficulty or if you would like to get additional data or documents, please use the following links to bring up the products. These artifacts are shared with “anyone who has a link” and should open directly.

If it does not open, please send me an email and I will fix the permissions.

The Lesson plan, spreadsheet and a handout are in the Keeling Curve Lesson Deliverables folder.
https://drive.google.com/drive/folders/1HhacHISLtn3VcV3nC8ZY3L89SHYauY5t?usp=sharing

The rubrics are in the Rubrics for Keeling Curve folder.
https://drive.google.com/drive/folders/1eDqVugVHjHSMy_wXS7v5zVi6AdS-kw9w?usp=sharing

The References are on the last page of the lesson plan and on this document
https://docs.google.com/document/d/1PK6QgIbTinPCa5lV4CcNzLjx5mH-AqU1hPfdj9aiyEc/edit?usp=sharing

Thank you for this opportunity,

Stan Feighny

Lesson Title: The Keeling Curve for the Arctic

Author: Stan Feighny

Student Take-away (Post on one side of the board and review daily.)
(*HS-ESS2-2 Earth's Systems* | *Next Generation Science Standards*, 2013)

1. Earth's climate system is based on how electromagnetic energy from the sun is reflected, absorbed, stored and redistributed among the atmosphere, lithosphere, hydrosphere, cryosphere, and biosphere.
2. The flow of energy between these spheres creates dynamic and interactive systems.
3. Feedback effects can increase or decrease the changes in the original system, other systems, or the climate system in general.

Targeted Grade Level:
11,12 (Students who have completed Algebra II.) Co-enrollment with Physics or Pre-Calc is a benefit.

Schedule:
Six 45 minute blocks or three 90 minute extended blocks.
The links under the 5E Phases are to the lesson.
Each lesson has a return to this section.

Day	5E Phase	Topic and Associated Rubric
1.	Engagement	The Keeling Curve (*The Keeling Curve*, 2005) , what it means and how to use it
	Engagement	Build the project folder to organize work on the project.
2.	Exploration	Build a working vocabulary and basic understanding for the study.
3.	Exploration	Load data and create a plot for the Barrow Alaska Observatory CO_2.
4.	Explanation	Write an overview of the process.
5.	Elaboration	Use data to identify feedbacks in the Arctic Climate system including decrease in polar ice extent
6.	Elaboration	Use data to identify feedbacks in the Arctic Climate including reduction in the Arctic albedo effect.
7.	Evaluation	Check for understanding by using rubrics and peer review for Project Folder, Lab Report, Spreadsheet

NGSS Performance Expectation HS-PS2.1

(*HS-ESS2-2 Earth's Systems* | *Next Generation Science Standards*, 2013)

Students who demonstrate understanding can:

HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. [Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice.]

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing data in 9–12 builds on K–8 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. - - - - - - - - - - - - - - - - - - - ***Connections to Nature of Science*** Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena ● Theories and laws provide explanations in science. ● Laws are statements or descriptions of the relationships among observable phenomena.	**ESS2.A: Earth Materials and Systems** ● Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. **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.	**Stability and Change** ● Feedback (negative or positive) can stabilize or destabilize a system. ---------- ***Connections to Engineering,Technology, and Applications of Science*** **Influence of Engineering, Technology, and Science on Society and the Natural World** ● New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Standards:
Links under Standards are to Common Core (National Governors, 2010), ISTE (ISTE 2016), and NGSS (NGSS Lead States 2013) reference site documents.
Links under Learning Objective are to measurable student learning objectives in this lesson plan.

Standards	Learning Objective	Description	Rubric Used
Technology ISTE Standard 3	Creating Structure	Curate a variety of resources using digital tools to construct knowledge, produce creative artifacts and make meaningful learning experiences for themselves and others. (*ISTE Standards for Students | ISTE*, 2016)	Project Folder
Science NGSS HS-ESS2-2	Organizing Data	Organize and describe data that represents measurements of changes in atmosphere, lithosphere, hydrosphere, cryosphere, and biosphere, in response to a change in Earth's surface. (*HS-ESS2-2 Earth's Systems | Next Generation Science Standards*, 2013)	Lab Report Keeling Spreadsheet
Science NGSS HS-ESS2-2	Identifying Relationships	Use tools, technologies, and/or models to analyze the data and identify and describe relationships in the datasets, including: ● i. The relationships between the changes in one system and changes in another (or within the same) Earth system; and ● ii. Possible feedbacks, including one example of feedback to the climate. Students analyze data to identify effects of human activity and specific technologies on Earth's systems if present.	Lab Report Keeling Spreadsheet
Science NGSS HS-ESS2-2 .	Interpreting data	Use the analyzed data to describe a mechanism for the feedbacks between two of Earth's systems and whether the feedback is positive or negative, increasing (destabilizing) or decreasing (stabilizing) the original changes.	Lab Report

HSN-Q.A.1	Solving Problems	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. (*High School: Number and Quantity » Quantities* » Reason Quantitatively and Use Units to Solve Problems. » 1 | Common Core State Standards Initiative*, 2010)	Lab Report Keeling Spreadsheet
HSN.Q.A.3	Understanding Measurement	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (*High School: Number and Quantity » Quantities* » Reason Quantitatively and Use Units to Solve Problems. » 3 | Common Core State Standards Initiative*, 2010)	Lab Report Keeling Spreadsheet
CCSS.ELA-LITERACY.RST.11-12.4	Research	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics. (*English Language Arts Standards » Science & Technical Subjects » Grade 11-12 | Common Core State Standards Initiative*, 2010)	Lab Report - Visual Vocabulary
CCSS.ELA-LITERACY.RST.11-12.2	Write	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. (*English Language Arts Standards » Science & Technical Subjects » Grade 11-12 | Common Core State Standards Initiative*, 2010)	Lab Report - Overview Section

Measurable Student Learning Objectives:

Standards (Return)	Observable features of the student performance
Technology ISTE Standard 3	Students work as responsible digital citizens by **organizing Arctic project folders for use by others**.
Science NGSS HS-ESS2-2.1	Students use the NOAA Earth Science Research Laboratory website and the NOAA Earth System Data Explorer to **locate, organize, and describe data representing changes in atmosphere.**
Science NGSS HS-ESS2-2.1	Use spreadsheets and graphs to **analyze data and identify relationships** between CO_2, seasons in the Arctic, ice extent, and albedo effect.
Science NGSS HS-ESS2-2.2	Use a spreadsheet to analyze data and **identify feedbacks between CO_2 concentration, Arctic ice extent, and albedo effect.**
Science NGSS HS-ESS2-2.3	Analyze data and support a claim that the feedback is **positive or negative, and stabilizing or destabilizing to the original changes.**
HSN-Q.A.1	**Choose the correct units for analysis and graphing** of CO_2 concentration, ice extent change and albedo effect.
HSN.Q.A.3	Use measurement rules to determine the **number of significant figures** in the ice extent and albedo spreadsheet.
CCSS.ELA-LITERACY. RST.11-12.2	Students **research sources and build a vocabulary list** for the final lab report on the analysis of Keeling Curve for
CCSS.ELA-LITERACY. RST.11-12.4	Student **writes an overview** for the final lab report summarizing the results of analysis of the Keeling Curve in the Arctic.

Back to Standards

Rubrics are used for both formative and summative assessments.
Rubrics are revised during the project as new requirements are discovered. This is a fact of the working world - things change. I work on accepting change with my students everyday, as this is an important life skill. Using rubrics for the formative assessment allows the teacher to award daily progress points and to keep the class focused on producing a product they can be proud of.

Keeling Curve for the Arctic Project Folder Rubric
Lab Report Rubric
BRW (Annual) Keeling Curve Data Rubric
Arctic Ice Extent Data Rubric
Arctic Band Albedo Data Rubric
Google Form for Anonymous Student Sharing of Overview

Materials
This is a computer based activity that requires either Google sheets or Excel and Internet access.
Digital assets are linked throughout the lesson plan at the point used.

5E Model - Engage

Introduce the lesson with an anchoring phenomenon.
Facilitate student questions, discussion, etc. as appropriate.
Learn about what students already know and want to know.

Day 1 Part 1 - High Concentrations of CO_2 in the Arctic? What? There aren't even cars in the Arctic.
Return to Schedule

What the teacher does
Introduces the scenario for the lesson posting the following on the LMS:

After doing a good job on the VEGA project JPL Internship Office transfers you to a new assignment. This is common with summer interns as the employer wants to see how you work with different groups. The new assignment is with the NASA Earth Observatory. The headquarters for the Earth Observatory is in the Goddard Space Flight Center in Washington DC. Unfortunately you don't get to go there, but they have a project office at JPL. It is just across the campus of Caltech. You are to report next week.

On Monday you have a meeting with one of the scientists working with the Barrow Atmospheric Observatory (BRW) so you prepare for the meeting over the weekend. Researching current articles brings some pretty sobering news. The most dramatic article is on

the fires in the Arctic Circle (*A Heat Wave Thawed Siberia's Tundra. Now, It's on Fire.*, 2020) Linked to this you find that Arctic sea-ice (*Arctic Sea Ice Reaches 2019 Minimum Extent*, 2019) has hit its lowest level in 40 years. Further study shows that the Arctic is heating three times faster than the rest of the planet (*GMS: NASA Sees High Temperatures, Wildfires, and Annual Sea Ice Minimum Extent in Warming Arctic*, n.d.)and this could be due to the (Pistone et al., 2014).

To prepare for your first day you write a summary that integrates the issue on these three articles using the scientific writing style. From your freshman year you remember the keys to scientific style are: descriptive, active voice, no personal pronouns, no sequencing (first, second…).

Monday, you go to work at your new location across campus. Instead of a meeting, you get an email from your new boss.

Super Student,

> Welcome to the NASA Earth Observatory. Unfortunately, I will not be able to meet with you, but I have assigned another engineer (teacher's name goes here) to help you get started.
>
> Assignment: Use the Global Monitoring Laboratory (US Department of Commerce, n.d.-b)site to analyze the change in CO_2 concentration and its relationship to seasonal temperature change in the Arctic. Pay close attention to it's similarity to the Keeling Curve from the Mauna Loa Observatory.
>
> Study the ice extent data from NASA (*Arctic Sea Ice News and Analysis | Sea Ice Data Updated Daily with One-Day Lag*, n.d.).There is a concern that these changes are part of a feedback that accelerates temperature change in the Arctic. Once you have this data, identify and elaborate the feedbacks in the Arctic.
>
> Diane Stanitski
> Physical Scientist

First you look up Diane Stanitski and see her background on LinkedIN (wow - you are very lucky to work with such a well known scientist!). Then track down your mentor and ask for your starting assignment.

Day 1 Part 2 - Build the project folder to organize work on the project.
Return to Schedule

The mentor is waiting for you in her office. The mentor goes over the Keeling Curve (US Department of Commerce, n.d.-a)to help you understand the first assignment: Analyze NASA data and find out if there is a Keeling Curve for the Arctic.

The mentor hands out the Project Folder Rubric and goes over setting up the project folder. She explains that this is not your data, but the organization's data and it is your job to make sure it is organized and accessible.

Standards Addressed
Technology ISTE, Standard 3b,3C
Students work as responsible digital citizens by organizing data for use by others.

CCSS.ELA-LITERACY.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.

Formative/Summative Assessments
Use the rubric to walk-through and check student progress on the project folder. Give students progress points. Find out why some are falling behind.

What the Student Does:
Participates in the discussion about the Keeling Curve in the Arctic.
Writes a background document (three paragraphs) of the current Arctic climate issues.
Creates the project folder according to the rubric.
Uses the LMS to create a personal copy of the lab report.

Explore

Plan for students to engage in hands-on activities that are designed to facilitate conceptual change.

Day 2 - Build a working vocabulary and basic understanding for study.
Return to Schedule

What the teacher does:
Reviews the importance of setting up the project folder and checks for progress on the project folder.

Opens up the starting lab report and walks the students through the different sections.

Hands out the rubric and sets expectations for progress.

Standards Addressed
CCSS.ELA-LITERACY.RST.11-12.4
Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.

Formative/Summative Assessments
Walk-through check of student progress lab report and vocabulary. Give students progress points. Find out why some are falling behind.

What the Student Does:
Students research sources and build the visual vocabulary section of the lab report.
Students make a citation and link for each source used.

Day 3 - Load data and create a plot of CO_2 concentration in the Arctic using Google Sheets.
Return to Schedule

What the teacher does.
Shares the link to the Global Monitoring Laboratory and walks students through how to select and download the data for the study.
Please do not show students the results from the loading data and creating the scatter plot.This should be an ah-ha moment for them. They will also make some classic mistakes.

Walks students through the spreadsheet rubric sections on formatting and organization.
Uses the CO2 Concentration spreadsheet as an example showing style and organization.
This spreadsheet shows the annual CO_2 data and will not have a Keeling Curve.
The Arctic is monthly and will have a Keeling Curve showing monthly fluctuations.

Standards Addressed
Science NGSS HS-ESS2-2
Organize and describe data that represents measurements of changes in atmosphere, lithosphere, hydrosphere, cryosphere, and biosphere, in response to a change in Earth's surface.

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 (foc on mole fraction); choose and interpret the scale and the origin in graphs and data displays.

HSN.Q.A.3
Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
(Should mole fractions have a decimal?)

Formative/Summative Assessments
At the end of class do a walk-through check of the spreadsheet. Award students progress points as daily grade. Find out why some are falling behind. Review Dependent and Independent variables on graphs.

What the student does.
Goes to the Global Monitoring Laboratory and finds and downloads appropriate data set.
Uses the rubric to format the spreadsheet and add graphs to show the Keeling curve in the Arctic.
Answers the questions in the graphing section of the lab report.

Explain

Provide opportunities for students to demonstrate their new conceptual understanding, process skills, or behaviors.

Day4 - Write an overview for acquiring and analysing data for the Keeling Curve for the Arctic.
Return to Schedule

What the teacher does.
Shows examples of the Overview and Methods section of the lab report and explains the difference in structure and grammar of each. The overview section is descriptive and explanatory. The method section is written in active voice with a prescriptive tone. These are the most common styles in STEM technical writing.

Example Background Section
Scientific studies since the early 1800's have identified the existence of gases that insulate the earth. Over time these gases have become known as greenhouse gases as they allow the earth to warm like the glass surrounding the plants in a greenhouse. CO_2 is a powerful component in these gases. The global average temperature of the earth has been steadily rising. By studying the statistical relationship between CO_2 and global average temperature a clear linear and strongly correlated relationship is observed.

Example Method Section
Download CO_2 and Temperature files from the links to the NASA website. Use the example spreadsheet to create a tabs for CO_2, Temperature, Annual Average CO_2,Correlation Coefficient and LINEST() exercize. Load Temperature Data, transform and use Split-Text-To-Column function under Data dropdown to load data into columns. Repeat process for CO_2 data. Average Monthly CO_2 to Annual data and create a chart and line of best fit for annual data. Use external reference to populate Annual CO_2 data and Annual Temperature data to Correlation Coefficient Tab. Perform regression analysis on CO_2 data and Annual Temperature data. Create a key for regression analysis results. Answer post lab questions using spreadsheet as data source. This will be modified after the Elaborate phase to include the steps completed there.]

Standards Addressed
CCSS.ELA-LITERACY.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.

Formative/Summative Assessments
Teacher shares Google form to collect the written sections from students. These are made anonymous by the teacher. This will allow the teacher to go over with class to show good examples and what to avoid.

Elaborate

Create more challenging experiences to help the students develop a deeper and broader understanding, sharpen process skills, or solidify behaviors.

Day 5 - Use data to identify feedbacks in the Arctic Climate system including decrease in polar ice extent.
Return to Schedule

What the teacher does.
Shows the NASA Goddard video on Arctic Sea Ice (Ramsayer, 2020)and discusses the technical meaning of ice area and ice extents.

The data for the decrease in ice extent is from the National Snow and Ice Data Center and is linked under the Sea ice analysis data spreadsheets (*Sea Ice Data and Analysis Tools | Arctic Sea Ice News and Analysis*, n.d.). Simply download the data and load it back into Google sheets. There are twelve tabs in this workbook. Discuss with the students which they would select as most representative. They should read the documentation in the workbook to choose this. After discussion, allow students to choose their own tab and then compare the results.

Here is an example of the expected student work for Decrease in Ice Extent.
https://docs.google.com/spreadsheets/d/1L2bCHtGRCtpZ59TFrOnh1hQ7CkljVtj7xd1bToG3abE/edit#gid=217708303

What the student does.
Reads pages 8-9 of the documentation for the Arctic Ice Extent.
Selects the data that best represents the change in the ice extent.
Takes notes as the teacher goes over the example of expected work for Decrease in Ice Extent.
Follows the Ice Extent Rubric to create the spreadsheet.
Answers question in the lab report document for this section.

Standards Addressed
Science NGSS HS-ESS2-2
Use the analyzed data to describe a mechanism for the feedbacks between two of Earth's systems and whether the feedback is positive or negative, increasing (destabilizing) or decreasing (stabilizing) the original changes.

Formative/Summative Assessments
The spreadsheet rubric will have been revised by this point in the lesson. Students use the new rubric to build the product.

Day 6 - Use data to identify feedbacks in the Arctic Climate including reduction in the Arctic albedo effect.
Return to Schedule

What the teacher does.
Shares the link to the Earth System Data Explorer and walks students through how to select and download the data for the study. If there is time, have the students go through the tutorial ({\i{}My NASA Data Tutorial}, n.d.) and find the data on their own. If running short on time, the teacher can prepare and walk students through the data selection process. If the lesson is out of time, load the data from the Arctic Band Albedo Data to the LMS and have the students make the monthly graph.
Goes over spreadsheet rubric.

Go over the The Study of Earth as an Integrated System (*The Study of Earth as an Integrated System*, n.d.) paying close attention to the definition of Climate Feedbacks.

What the student does.
Takes notes as the teacher goes over the example of expected work for the Arctic albedo effect.
Follows the Arctic Band Albedo Data rubric to create the spreadsheet.
Locates and loads the Earth System Data Explorer data for the Arctic Band Albedo Data into the student Google sheet.
Creates a graph with a series for each month (March - August) for the period 2000 through 2019.

Answers questions in the lab report document for this section.

Standards Addressed

Science NGSS HS-ESS2-2

Use the analyzed data to describe a mechanism for the feedbacks between two of Earth's systems and whether the feedback is positive or negative, increasing (destabilizing) or decreasing (stabilizing) the original changes.

Formative/Summative Assessments

The spreadsheet rubric will have been revised by this point in the lesson.
Students use the new rubric to build the product.

Evaluate

Encourage students to assess their understanding and abilities.
Evaluate student progress toward achieving the educational objectives.

Day 7 - Check for understanding by using rubrics and peer review
(May take two days depending on how the students have kept up.)
Return to Schedule
Return to Rubrics
What the teacher does.
Reviews and improves the rubrics for the folder, spreadsheets, and lab report.

What the student does.
Completes the lab report question section.
Checks spreadsheets with rubrics
Rewrites the Overview and Method section of the lab report to include new activities and understanding.
Checks lab report with rubric.

Performs a peer review on another student's spreadsheet and lab report.
Organizes all project work for in a folder and checks with Project Folder Rubric
Checks all files have names that explain use.

Fixes lab report and google sheet to incorporate peer review recommendations.

Turns in clean rubric with name and class with peer reviewed rubric attached.
Submits link to **folder** on LMS for teacher grading.

Standards Addressed

CCSS.ELA-LITERACY. 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.

Formative/Summative Assessments

Summative assessment based on final rubrics for Project Folder, Spreadsheets, Lab Report.

These need to be updated to reflect learning during the lesson that the students added.

References

A heat wave thawed Siberia's tundra. Now, it's on fire. (2020, July 6). Science. https://www.nationalgeographic.com/science/2020/07/heat-wave-thawed-siberia-now-on-fire/

Arctic Sea Ice News and Analysis | Sea ice data updated daily with one-day lag. (n.d.). Retrieved October 13, 2020, from https://nsidc.org/arcticseaicenews/

Arctic Sea Ice Reaches 2019 Minimum Extent. (2019, September 23). https://www.youtube.com/watch?v=2XKYdSqf2ss

English Language Arts Standards » Science & Technical Subjects » Grade 11-12 | Common Core State Standards Initiative. (2010). http://www.corestandards.org/ELA-Literacy/RST/11-12/

GMS: NASA Sees High Temperatures, Wildfires, and Annual Sea Ice Minimum Extent in Warming Arctic. (n.d.). Retrieved October 13, 2020, from https://svs.gsfc.nasa.gov/13722

High School: Number and Quantity » Quantities » Reason quantitatively and use units to solve problems. » 1 | Common Core State Standards Initiative*. (2010). http://www.corestandards.org/Math/Content/HSN/Q/A/1/

High School: Number and Quantity » Quantities » Reason quantitatively and use units to solve problems. » 3 | Common Core State Standards Initiative*. (2010). http://www.corestandards.org/Math/Content/HSN/Q/A/3/

HS-ESS2-2 Earth's Systems | Next Generation Science Standards. (2013). https://www.nextgenscience.org/pe/hs-ess2-2-earths-systems

ISTE Standards for Students | ISTE. (2016). https://www.iste.org/standards/for-students

My NASA Data. (n.d.). Retrieved October 13, 2020, from https://mynasadata.larc.nasa.gov/basic-page/tutorials-using-earth-system-data-explorer

Pistone, K., Eisenman, I., & Ramanathan, V. (2014). Observational determination of albedo decrease caused by vanishing Arctic sea ice. *Proceedings of the National Academy of Sciences*, *111*(9), 3322. https://doi.org/10.1073/pnas.1318201111

Ramsayer, K. (2020, September 21). *2020 Arctic Sea Ice Minimum at Second Lowest on Record* [Text]. NASA. http://www.nasa.gov/feature/goddard/2020/2020-arctic-sea-ice-minimum-at-second-lowest-on-record

Sea Ice Data and Analysis Tools | Arctic Sea Ice News and Analysis. (n.d.). Retrieved October 11, 2020, from https://nsidc.org/arcticseaicenews/sea-ice-tools/

The Keeling Curve. (2005, June 25). [Text.Article]. NASA Earth Observatory. https://earthobservatory.nasa.gov/images/5620/the-keeling-curve

The Study of Earth as an Integrated System. (n.d.). Climate Change: Vital Signs of the Planet. Retrieved October 13, 2020, from https://climate.nasa.gov/nasa_science/science

US Department of Commerce, N. (n.d.-a). *ESRL Global Monitoring Laboratory—FTP Navigator*. Retrieved October 13, 2020, from https://www.esrl.noaa.gov/gmd/dv/data/index.php?category=Greenhouse%2BGases&site=BRW&parameter_name=Carbon%2BDioxide

US Department of Commerce, N. (n.d.-b). *ESRL Global Monitoring Laboratory—FTP Navigator*. Retrieved October 13, 2020, from https://www.esrl.noaa.gov/gmd/dv/data/