HS. Weather and Climate

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.

NOAA
Carbon Cycle
Basic introduction to the Carbon Cycle
http://www.noaa.gov/resource-collections/carbon-cycle

NOAA
NOAA Paleoclimatology
How would you characterize the climate in your backyard? How do current weather conditions compare with climate over the past 30 years, 100 years or 1000 years? Have changes in climate conditions over time influenced stream or river flows? The Data Access page provides you with online resources to help you answer these questions and more. Check out the learning activity "Distribution of Climates on the Earth" developed by Dr. Heather Stoll at Williams College.
https://www.ncdc.noaa.gov/paleo/ctl/data.html#

NOAA's Earth System Research Laboratory
Global Monitoring Division
This toolkit was designed to support educators in teaching the fundamental scientific concepts of climate change. A significant challenge to teaching climate change lies in the abstract nature of the most basic concepts underlying climate science. For instance, the intangible nature of greenhouse gases makes it difficult for students to conceive of their existence and increasing abundances. Recent trends in greenhouse gas concentrations are well understood due to ongoing, accurate and precise measurements around the globe, yet the certainty and relevancy behind this science is still misconceived by the general public.
https://www.esrl.noaa.gov/gmd/education/carbon_toolkit/

NOAA's Earth System Research Laboratory
Global Monitoring Division
Teacher Background: Understanding Feedback loops
This is a great document that discusses feedback loops and their direct effects on Earth's climate.
https://www.esrl.noaa.gov/gmd/education/info_activities/pdfs/TBI_understanding_feedback_loops.pdf

NOAA's Earth System Research Laboratory
Physical Sciences Division
Clouds and Climate
Clouds play a vital role in our climate by regulating the amount of solar energy that reaches the surface and the amount of the Earth's energy that is radiated back into space. The more energy that is trapped by the planet, the warmer our climate will grow. If less energy is collected, the climate will become cooler. Understanding this energy balance is fundamental to answering any of the questions posed by climate change.
https://www.esrl.noaa.gov/psd/outreach/education/science/clouds_and_climate.html

NOAA's Earth System Research Laboratory
Global Monitoring Division
Teacher Background: Earth's Atmosphere
This is a great document providing a thorough description of the atmosphere.
https://www.esrl.noaa.gov/gmd/education/info_activities/pdfs/TBI_earths_atmosphere.pdf

NOAA's Earth System Research Laboratory
Global Monitoring Division
Teacher Background: Biogeochemical Cycles
Biogeochemical cycles are intricate processes that transfer, change and store chemicals in the geosphere, atmosphere, hydrosphere, and biosphere. The term biogeochemical cycles expresses the interactions among the organic (bio-) and

inorganic (geo-) worlds, and focuses on the chemistry (chemical-), and movement (cycles) of chemical elements and compounds. In its simplest form, cycling describes the movement of elements through various forms and their return to their original state. This is a great document on introduction to biogeochemical cycles.
https://www.esrl.noaa.gov/gmd/education/info_activities/pdfs/TBI_biogeochemical_cycles.pdf

NOAA's Earth System Research Laboratory
Global Monitoring Division
Frequently asked questions about climate change
https://www.esrl.noaa.gov/gmd/education/faq_cat-1.html

NOAA's Earth System Research Laboratory
Global Monitoring Division
Teacher Background: Natural Climate Change
The natural variability and the climate fluctuations of the climate system have always been part of the Earth's history. To understand climate change fully, the causes of climate change must be first identified. The earth's climate is influenced and changed through natural causes like volcanic eruptions, ocean currents, the Earth's orbital changes, solar variations and internal variability.
https://www.esrl.noaa.gov/gmd/education/info_activities/pdfs/TBI_natural_climate_change.pdf

UCAR – Community Program
Sea Level Change: Basics – ***Requires generating a free account***
This lesson describes the physical processes, both natural and human-induced, that lead to changes in sea level. The processes described include climate induced changes in ocean heat content and volume, natural oceanic cycles, and both natural and human-induced changes in coastal land elevation. The learning is enhanced with rich graphics and periodic questions.
https://www.meted.ucar.edu/

UCAR – Community Program
Climate Chang: Fitting the Pieces Together– ***Requires generating a free account***
This module discusses climate change, particularly as it is currently being affected by increasing concentrations of greenhouse gases emitted by human activities. It also covers signs of climate change, how scientists study climate, the current thinking on future changes, and what can be done to minimize the effects.
https://www.meted.ucar.edu/

HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.

Intergovernmental Panel on Climate Change (IPCC)
IPCC Working Group I Contribution Summary for Policy Makers
The Working Group I contribution to the IPCC's Fifth Assessment Report (AR5) considers new evidence of climate change based on many independent scientific analyses from observations of the climate system, paleoclimate archives, theoretical studies of climate processes and simulations using climate models. It builds upon the Working Group I contribution to the IPCC's Fourth Assessment Report (AR4), and incorporates subsequent new findings of research.
Click on Summary for Policymakers
http://climatechange2013.org/ report

IPCC Part 2: Impacts, Adaptation, and Vulnerability
http://www.ipcc.ch/report/ar5/wg2/

IPCC Part 3: Mitigation of Climate Change
http://www.ipcc.ch/report/ar5/wg3/

IPCC Report Grapics:
http://www.climatechange2013.org/report/reports-graphic/

Lawrence Livermore National Laboratory (LLNL)
Interactive Energy & Climate Simulation – Game
Written Instructions Below – Video on website
Earth is facing a large problem that we need energy more and more each year. We have mainly been relying on oil and coal, but these are major contributors to Green House gasses. What can we do to keep up with our energy requirements and not turn our planet into a giant dessert? It is up to you to decide! In this simulation, LLNL used the most powerful super computers to combine to the most up-to-date climate models and energy data, and you will use this info to produce enough energy to meet the world's needs for the next few decades. You begin with a fixed amount of money and you need to decide how to spend it using a mix of different energy sources, some are more expensive than others, for example each unit of oil and coal is cheaper than wind and nuclear, but you need to keep an eye on your carbon eye print. Relying completely on coal isn't a good idea, because of how much carbon is emitted into the atmosphere. On the right side, you see how much energy you need to produce for each decade both for transportation needs and for electricity. Keep in mind that some energy sources only work for electricity not transportation and vice versa. The red column on the left shows you how much carbon you are producing into the atmosphere. You can reduce the amount by using some of your money on carbon capture on the bottom left. After each decades worth of play something unexpected will happen in your world a spinning wheel will randomly produce good or bad luck to the energy picture which will affect your game play. Remember the object of the game is to produce the required level of energy with the available money at hand, while keeping the amount of carbon emissions low enough to avoid climate change.
Scroll down to the bottom of the place and click "Play: Climate Energy Fusion Simulation"
https://camelclimatechange.org/camel/activities/game_climateene.html

United States Environmental Protection Agency (EPA)
Carbon Footprint Calculator
Find a quick rough estimate of your carbon footprint by using U.S. average values.
https://www3.epa.gov/carbon-footprint-calculator/

NOAA's Pacific Services Center (PSC)
Global Science Investigator
The interactive globe system allows you to see impact of climate change.
http://csc.noaa.gov/psc/dataviewer/#view=slr

NOAA's NWS Climate Prediction Center (CPC)
CPC delivers real-time products and information that predict and describe climate variations on timescales from weeks to years thereby promoting effective management of climate risk and a climate-resilient society. The CPC products are operational predictions of climate variability, real-time monitoring of climate and the required data bases, and assessments of the origins of major climate anomalies. The products cover time scales from a week to seasons, extending into the future as far as technically feasible, and cover the land, the ocean, and the atmosphere, extending into the stratosphere.
http://www.cpc.noaa.gov/

Developed by multiple agencies and across the world – For info please see Conditions of Use
The Global Calculator
The Global Calculator is a model of the world's energy, land and food systems to 2050. It allows you to explore the world's options for tackling climate change and see how they all add up. With the Calculator, you can find out whether everyone can have a good lifestyle while also tackling climate change.
http://tool.globalcalculator.org/globcalc.html

NOAA's Earth System Research Laboratory
Global Monitoring Division
Teacher Background: Climate Change and Population

This is a great paper that discusses what is going to happen as our climate changes and our population continues to grow.
https://www.esrl.noaa.gov/gmd/education/info_activities/pdfs/TBI_population_and_climate_change.pdf

NOAA's Earth System Research Laboratory
Global Monitoring Division
Teacher Background: Ecosystem Response to Climate Change
This is a brief paper discussing the effects of climate change on the ecosystem.
https://www.esrl.noaa.gov/gmd/education/info_activities/pdfs/TBI_climate_change_and_ecosystem_response.pdf

NOAA's Earth System Research Laboratory
Global Monitoring Division
Teacher Background: Climate Change and Coral Reefs
This is a great paper discussing the effects of climate change on coral reefs.
https://www.esrl.noaa.gov/gmd/education/info_activities/pdfs/TBI_coral_reefs_and_climate_change.pdf

NOAA's Earth System Research Laboratory
Global Monitoring Division
Teacher Background: Climate Change and Disease
This is a brief paper discussing climate change and how it will impact diseases around the world.
https://www.esrl.noaa.gov/gmd/education/info_activities/pdfs/TBI_climate_change_and_disease.pdf

UCAR – Community Program
Climate and Water Resources Management, Part 1: Climate Variability and Change – ***Requires generating a free account***
Climate Variability and Change describes the terminology, global evidence, regional manifestations, and basic science of global climate variability and anthropogenic change, with a focus on water resources management. The lesson presents this information using rich graphics, animations, and interactions. Key messages are highlighted from the 2014 National Climate Assessment, produced by the United States Global Change Research Program.
https://www.meted.ucar.edu/

UCAR – Community Program
Introduction to Climate Models – ***Requires generating a free account***
This module explains how climate models work. Because the modeling of both weather and climate share many similarities, the content throughout this module draws frequent comparisons and highlights the differences. We explain not only how, but why climate models differ from weather models. To do so, we explore the difference between weather and climate, then show how models are built to simulate climate and generate the statistics that describe it. We conclude with a discussion of models are tuned and tested.
https://www.meted.ucar.edu/

UCAR – Community Program
Climate Change and Regional Impacts – ***Requires generating a free account***
This short module is an overview of the different effects climate change produces in different regions of the United States. In addition to discussing impacts already being experienced, the module presents information on how climate scientists use specialized models and statistical techniques to estimate how regional climates are likely to change in the future.
https://www.meted.ucar.edu/

HS-ESS2-8. Evaluate data and communicate information to explain how the movement and interactions of air masses result in changes in weather conditions.

NOAA's National Ocean Service
Synoptic Meteorology
Synoptic means "view together" or "view at a common point". Synoptic meteorology is primarily concerned with large-scale weather systems, such as extratropical cyclones and their associated fronts.
http://oceanservice.noaa.gov/education/yos/resource/JetStream/synoptic/synoptic_intro.htm

NOAA's National Weather Service
NOAA's National Weather Service Introduction to Synoptic Meteorology
The word *synoptic* means "view together" or "view at a common point". Therefore, synoptic meteorology is primarily concerned with viewing the weather at a common point -- time. This website discusses different forms of air masses, high and low pressure systems and their associated weather patterns.
http://www.srh.noaa.gov/jetstream/synoptic/synoptic_intro.html

NOAA's National Weather Service
NOAA's National Weather Service Introduction to Upper Air Charts
This website will guide you to understanding weather maps.
http://www.srh.noaa.gov/jetstream/constant/constant_intro.html

NOAA's National Weather Service
NOAA's National Weather Service Introduction to Remote Sensing
This website is a crash course to understanding how meteorologists use satellites to forecast the weather.
http://www.srh.noaa.gov/jetstream/remote/remote_intro.html

NOAA's National Weather Service
NOAA's National Weather Service Introduction to Thunderstorms
This website goes into detail how thunderstorms for by describing in detail the three necessity ingredients for thunderstorms to develop. This link will take you through the stages of a thunderstorm, the different types of thunderstorms and the hazards it creates.
http://www.srh.noaa.gov/jetstream/tstorms/tstorms_intro.html

NSSL - National Severe Storms Laboratory
Severe Weather 101 – Thunderstorms
Thunderstorms are a great way for the atmosphere to release energy. When warm moist air meets colder drier air, the warm air rises, the water vapor condenses in the air, and forms a cloud. As the water vapor condenses it releases heat, which is a form of energy. A large amount of the thunderstorm's energy comes from the condensation process that forms the thunderstorm clouds. As the thunderstorm progresses, eventually the rain cools the entire process down and the energy is gone. This is a great website that describes the different types of thunderstorms, also how thunderstorms form by the interactions of air masses, plus much more.
http://www.nssl.noaa.gov/education/svrwx101/thunderstorms/

NOAA's National Weather Service
What side of a front does precipitation fall?
http://www.wrh.noaa.gov/ggw/newsletter/winter_05/Fronts_w_Figs.pdf

EU Metrain's Synoptic Textbook
This 190-page text, which is based on a series of university lectures, provides comprehensive information on synoptic meteorology. There's a general introduction to synoptic followed by chapters on tropospheric circulation, air masses, boundary layer and weather, wind fields, jet streams, vertical motions, high and low pressure, convective systems, numerical parameters in vertical cross sections, mid-latitude cyclones, the tropopause, and fronts. A number of the examples in the textbook are from Northern Europe.
http://eumetrain.org/synoptic_textbook.html

NOAA's National Weather Service
Learn how to draw your own weather map
http://www.srh.noaa.gov/jetstream/synoptic/ll_analyze.html

Enhanced Data Display
This displays current observations such as: Temperature, Wind (knots), radar, satellite and can show forecasts for parameters (CONUS – can zoom in anywhere in the USA). You can use this tool to see how warm or cold their location is compared to other locations. This system can show cold fronts, radar imagery to track storm systems and more. This program needs minor training but it is a great tool to talk about the weather around a specific area or around the US.
http://preview.weather.gov/edd/

UCAR – Community Program
NWP Essentials: NWP and Forecasting – ***Requires generating a free account***
This lesson introduces forecasters to the complex and multifaceted process for creating a forecast. It also discusses how NWP fits into that process. In addition, the lesson provides a broad overview of the basic components of NWP and how they combine to produce a model forecast.
https://www.meted.ucar.edu/

Forecasting links that use current data:

Storm Prediction Center
http://www.spc.noaa.gov/

National Weather Service
http://www.weather.gov/

The National Center for Atmospheric Research
http://weather.rap.ucar.edu/model/

Storm Prediction Center
http://www.spc.noaa.gov/exper/mesoanalysis/

Storm Prediction Center
http://www.spc.noaa.gov/exper/

Penn State University
http://mp1.met.psu.edu/~fxg1/ewall.html

Weather Prediction Center
http://wpc.ncep.noaa.gov