Chariho Regional School District - Science Curriculum
September, 2016

METEOROLOGY CURRICULUM

Unit 1: Introduction to Meteorology

OVERVIEW

Summary

In this unit students will be introduced to the field of meteorology. They will explore the technologies that have helped make weather forecasting more accurate over time. Students will review the basic organization of the earth's spheres and the more detailed structure of the atmosphere. Students will also be introduced to the chemical and physical components of the earth that work together to create the weather systems we see daily and how this contributes to the global climates.

Content to Be Learned

- Define meteorology.
- Explore historical and recent technologies that support the field of meteorology.
- Describe composition, structure, and properties that make up the earth's systems (lithosphere, atmosphere, hydrosphere, and biosphere).
- Identify the importance of gases (Nitrogen, Argon, Oxygen, Carbon dioxide, Ozone, CFC's, Methane, water vapor).
- Describe the composition, structure, and properties that make up the earth's atmosphere (troposphere, stratosphere, mesosphere, thermosphere, ionosphere, ozonosphere, homosphere, heterosphere).
- Discuss the role of ozone, and its chemical composition.
- Review pressure, jet stream, density, Boyles and Charles' gas laws.
- Identify factors that affect weather patterns over the earth's surface.
- Identify factors that affect climates.
- Describe the climates of the earth.
- Describe the formation of the earth's early atmosphere and key gases.

Practices

- Constructing explanations and designing solutions.
- Analyzing and interpreting data.

Crosscutting Concepts

- Systems and system models.

Essential Questions

- Historically, how has the field of meteorology changed due to advances in technology?
- How do the components of the earth's system work together to create the dynamics that we see as weather?
- What does the atmosphere do for me?

Next Generation Science Standards

Students who demonstrate understanding can:

HS-ESS3-6. **Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.** [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [*Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Using Mathematics and Computational Thinking
Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

- Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations.

Disciplinary Core Ideas

ESS2.D: Weather and Climate

- Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. *(secondary)*

ESS3.D: Global Climate Change

- Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.

Crosscutting Concepts

Systems and System Models

- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

Connections to other DCIs in this grade-band:
HS.LS2.B ; HS.LS2.C ; HS.LS4.D ; HS.ESS2.A

Articulation of DCIs across grade-bands:
MS.LS2.C ; MS.ESS2.A ; MS.ESS2.C ; MS.ESS3.C ; MS.ESS3.D

Common Core State Standards Connections:
Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-ESS3-6)
MP.4	Model with mathematics. (HS-ESS3-6)
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-ESS3-6)
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. *(HS-ESS3-6)*
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS3-6)

Unit 2: The Atmosphere

OVERVIEW

Summary

Students will begin this unit learning about how the rotation and motion of the earth contributes to heating and seasonal variation. Students will learn sources of energy, heat and temperature on earth and how heat is transferred. Temperature variations and how temperature is controlled will be explored as well as movement of water through the atmosphere. This unit will close by learning about various cloud formations, how wind is created and the relationship between pressure and wind. Students will focus on the elements of weather:

precipitation, clouds, fog, wind, and temperature.

Content to Be Learned

- Explain and describe the earth-sun relationship.
- Identify and explain three methods of transferring energy through the atmosphere.
- Describe the electromagnetic spectrum and electromagnetic radiation.
- Describe blackbody radiation and its impact on earth's weather systems.
- Identify factors, measurement, and scales of temperature.
- Discuss humidity and movement of water through the atmosphere (mixing ratio, saturation, relative humidity, dew point, wet bulb temperature, vapor pressure).
- Describe cloud formation and different types of cloud groups (include types of fog).
- Explain the Bergeron process.
- Identify and explain forms of precipitation.
- Discuss the relationships between air pressure and wind.
- Identify and trace global winds and ocean currents.
- Explain how global wind and air currents contribute to predicting weather.
- Identify and describe air masses.

Practices

- Using mathematics and computational thinking.
- Planning and carrying out investigations.
- Developing and using models.

Crosscutting Concepts

- Energy and matter.
- Structure and function.
- Cause and effect.

Essential Questions

- What role does water play in the atmosphere?
- How does electromagnetic radiation from the sun create the foundation for the earth's global climate?
- Why would changing the axis tilt change weather in the northern and southern hemispheres?
- How do various types of precipitation form?

Next Generation Science Standards

Students who demonstrate understanding can:

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.** [Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.] [*Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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

- Use a model to provide mechanistic accounts of phenomena.

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

- Science arguments are strengthened by multiple lines of evidence supporting a single explanation.

Disciplinary Core Ideas

ESS1.B: Earth and the Solar System

- Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. *(secondary)*

ESS2.A: Earth Materials and Systems

- The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.

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.

Crosscutting Concepts

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Connections to other DCIs in this grade-band:
HS.PS3.A ; HS.PS3.B ; HS.LS2.C ; HS.ESS1.C ; HS.ESS3.C ; HS.ESS3.D

Articulation of DCIs across grade-bands:
MS.PS3.A ; MS.PS3.B ; MS.PS3.D ; MS.PS4.B ; MS.LS1.C ; MS.LS2.B ; MS.LS2.C ; MS.ESS2.A ; MS.ESS2.B ; MS.ESS2.C ; MS.ESS2.D ; MS.ESS3.C ; MS.ESS3.D

Common Core State Standards Connections:

ELA/Literacy -

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-ESS2-4)*

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-ESS2-4)
MP.4 Model with mathematics. (HS-ESS2-4)
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-ESS2-4)
HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-4)
HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-4)

Students who demonstrate understanding can:

HS-ESS2-6. **Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.** [Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

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 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.	**ESS2.D: Weather and Climate** • Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. • Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.	**Energy and Matter** • The total amount of energy and matter in closed systems is conserved.

Connections to other DCIs in this grade-band:
HS.PS1.A ; HS.PS1.B ; HS.PS3.D ; HS.LS1.C ; HS.LS2.B ; HS.ESS3.C ; HS.ESS3.D

Articulation of DCIs across grade-bands:
MS.PS1.A ; MS.PS3.D ; MS.PS4.B ; MS.LS2.B ; MS.ESS2.A ; MS.ESS2.B ; MS.ESS2.C ; MS.ESS3.C ; MS.ESS3.D

Common Core State Standards Connections:
Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-ESS2-6)
MP.4	Model with mathematics. (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-ESS2-6)
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-6)
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-6)

Students who demonstrate understanding can:

HS-PS4-1. **Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.** [Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.] [*Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9-12 level builds on K-8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations.	**PS4.A: Wave Properties** • The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Connections to other DCIs in this grade-band:
HS.ESS2.A

Articulation of DCIs across grade-bands:
MS.PS4.A ; MS.PS4.B

Common Core State Standards Connections:
ELA/Literacy -

RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. *(HS-PS4-1)*

Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-PS4-1)
MP.4	Model with mathematics. (HS-PS4-1)
HSA-SSE.A.1	Interpret expressions that represent a quantity in terms of its context. (HS-PS4-1)
HSA-SSE.B.3	Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. *(HS-PS4-1)*
HSA.CED.A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. *(HS-PS4-1)*

Unit 3: Atmospheric Dynamics and Predicting Weather

OVERVIEW

Summary

In this unit students will put into motion the concepts learned in the previous unit. This section will begin with a review of gravity and Newton's laws. From here, students will learn how the global winds, ocean currents, and stability of the atmosphere help meteorologists to predict weather and patterns. Students will begin to learn the symbols that meteorologists use to denote various weather data and how to read these maps to make predictions of daily weather. Students will analyze data to make predictions and explain those predictions based on learned phenomenon. Students will also learn about how weather patterns change in response to el nino and la nina.

Content to Be Learned

- Review of Newton's laws of Inertia, acceleration, action-reaction, centrifugal force, and gravity.
- Identify causes of winds and types of winds.
- Discuss the relationships between air pressure and wind.
- Identify and trace global winds and ocean currents.
- Explain how global wind and air currents contribute to predicting weather.
- Identify and describe air masses.
- Relate the Coriolis Effect to weather patterns.
- Explain how warm, cold, stationary and occluded fronts affect weather patterns.
- Analyze weather data to predict weather patterns.
- Describe and interpret weather maps and reports.
- Explain how data is collected for weather maps and forecasts, and identify symbols used in a weather station model.
- Analyze data to forecast week long weather outlook.
- Describe and explain the factors that act as climate controls such as proximity to water, topography, and latitude.
- Explain the interrelationship between the circulation of the oceans and weather and climate.
- Describe how el nino and la nina affect climate.

Practices

- Developing and using models.
- Using mathematics and computational thinking.
- Constructing observations and designing solutions.
- Analyzing and interpreting data.

Crosscutting Concepts

- Cause and effect.
- Systems and system models.

Essential Questions

- How does the sun's energy output and the ocean's circulation interact to create weather patterns?
- What can cloud observations tell us about weather?
- What air masses cause weather in the U.S?
- How do they know where it will rain vs. snow?

Next Generation Science Standards

Students who demonstrate understanding can:

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.** [Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.] [*Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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 variables between systems and their components in the natural and designed world(s).
- Use a model to provide mechanistic accounts of phenomena.

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence
- Science arguments are strengthened by multiple lines of evidence supporting a single explanation.

Disciplinary Core Ideas

ESS1.B: Earth and the Solar System
- Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. *(secondary)*

ESS2.A: Earth Materials and Systems
- The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.

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.

Crosscutting Concepts

Cause and Effect
- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Connections to other DCIs in this grade-band:
HS.PS3.A ; HS.PS3.B ; HS.LS2.C ; HS.ESS1.C ; HS.ESS3.C ; HS.ESS3.D

Articulation of DCIs across grade-bands:
MS.PS3.A ; MS.PS3.B ; MS.PS3.D ; MS.PS4.B ; MS.LS1.C ; MS.LS2.B ; MS.LS2.C ; MS.ESS2.A ; MS.ESS2.B ; MS.ESS2.C ; MS.ESS2.D ; MS.ESS3.C ; MS.ESS3.D

Common Core State Standards Connections:

ELA/Literacy -

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-ESS2-4)*

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-ESS2-4)
MP.4 Model with mathematics. (HS-ESS2-4)
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-ESS2-4)
HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-4)
HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-4)

Students who demonstrate understanding can:

HS-PS2-1. **Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.** [Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.] [*Assessment Boundary: Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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.

Disciplinary Core Ideas

PS2.A: Forces and Motion
- Newton's second law accurately predicts changes in the motion of macroscopic objects.

Crosscutting Concepts

Cause and Effect
- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Connections to other DCIs in this grade-level:
HS.PS3.C ; HS.ESS1.A ; HS.ESS1.C ; H.ESS2.C

Articulation of DCIs across grade-bands:
MS.PS2.A ; MS.PS3.C

Common Core State Standards Connections:

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-PS2-1)*
RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1)
WHST.11-12.9	Draw evidence from informational texts to support analysis, reflection, and research. *(HS-PS2-1)*

Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-PS2-1)
MP.4	Model with mathematics. (HS-PS2-1)
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-PS2-1)
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. *(HS-PS2-1)*
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS2-1)
HSA.SSE.A.1	Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1)
HSA.SSE.B.3	Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1)
HSA.CED.A.1	Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1)
HSA.CED.A.2	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. *(HS-PS2-1)*
HSA.CED.A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. *(HS-PS2-1)*
HSF-IF.C.7	Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases. *(HS-PS2-1)*
HSS-IS.A.1	Represent data with plots on the real number line (dot plots, histograms, and box plots). *(HS-PS2-1)*

Unit 4: Severe Weather

OVERVIEW

Summary

This unit will focus on severe weather. Students will examine severe weather produced in association with cumulonimbus clouds as well as large tropical storms or hurricanes. Students will look at the conditions that create severe weather as well as the impacts on humans. Students will analyze data associated with storms, discuss measurements of these storms, and evaluate plans to help increase survival during such storms including forecasting intensity.

Content to Be Learned

- Describe factors that lead to atmospheric instability.
- Describe the air mass thunderstorm and its stages (cumulus, mature, and sissipating).
- Discuss the conditions for tropical cyclones.
- Identify the four types of thunderstorms (single cell, multicell cluster, squall line and supercell).
- Explain the cause of lightning.
- Describe how tornados form and move.
- Differentiate between hurricane types: cyclones vs. typhoons.
- Describe conditions necessary for the development of tropical storms.
- Describe how storm surges arise and their impacts.
- Forecast the intensity of a storm given data.
- Investigate and explain the occurrence and effects of storms on human populations and the environment.

Practices

- Constructing explanations and designing solutions.
- Analyzing and interpreting data.

Crosscutting Concepts

- Cause and effect.
- Systems and system models.

Essential Questions

- What conditions are needed to set up: Thunderstorms, Tornadoes, Hurricanes, and Blizzards?
- Why do thunderstorms happen in the late afternoon?
- Why do so many tornadoes happen in the mid-west?
- What is the difference between a hurricane and a tropical storm?
- How do natural disasters impact human populations and civilizations?

Next Generation Science Standards

Students who demonstrate understanding can:

HS-ESS3-1. **Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.** [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific knowledge, principles, and theories.

- Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Disciplinary Core Ideas

ESS3.A: Natural Resources

- Resource availability has guided the development of human society.

ESS3.B: Natural Hazards

- Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations.

Crosscutting Concepts

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

- Modern civilization depends on major technological systems.

Connections to other DCIs in this grade-band: N/A

Articulation of DCIs across grade-bands:
MS.LS2.A ; **MS.LS4.D** ; **MS.ESS2.A** ; **MS.ESS3.A** ; **MS.ESS3.B**

Common Core State Standards Connections:

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-ESS3-1)*

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-ESS3-1)

Mathematics -

MP.2 Reason abstractly and quantitatively. *(HS-ESS3-1)*

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-ESS3-1)*

HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. *(HS-ESS3-1)*

HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *(HS-ESS3-1)*

Unit 5: Human Impacts and Climate Change

OVERVIEW

Summary

This unit will focus on human impact and the impacts of Global Climate Change. Students will learn about the greenhouse effect. They will also evaluate evidence of Global Climate Change and will discuss the natural and human causes of it. Consequences of global warming will be explored and students will suggest mitigation strategies for these consequences. Students will also be asked to evaluate laws and policies that may create limits on our ability to preserve our natural resources.

Content to Be Learned

- Discuss and explain the Greenhouse effect.
- Describe contributions to air pollution and its impacts.
- Describe different types of climate data.

- Distinguish among different types of climatic changes and why they occur.
- Identify how humans impact the global climate (burning fossil fuels, acid precipitation, greenhouse effect, ozone depletion).
- Compare and contrast natural and human impact on climate change.
- Analyze the effects of laws and policies, technology, and economics on management of natural resources.
- Research how human impacts on the earth are being modeled and managed to reduce future impacts.
- Explain how humans are managing natural resources to sustain human societies and the biodiversity that are supported by them.
- Suggest solutions to an issue surrounding global climate change. Consider constraints, costs, environmental and other impacts.

Practices

- Using mathematics and computational thinking.
- Constructing explanations and designing solutions.
- Analyzing and interpreting data.

Crosscutting Concepts

- Stability and change.
- Systems and system models.

Essential Questions

- How does the ocean drive our weather systems and climate change?
- What are the natural and human causes of past/present climate change?
- Is there anything humans can do to slow down climate change or is it too late?
- What scientific evidence is there to support Global Climate change?
- Why do people say global warming is a hoax?
- How can technology support lessening the impacts of climate change?

Next Generation Science Standards

Students who demonstrate understanding can:

HS-ESS3-4. **Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*** [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific knowledge, principles, and theories. • Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**ESS3.C: Human Impacts on Earth Systems** • Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. **ETS1.B: Developing Possible Solutions** • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. *(secondary)*	**Stability and Change** • Feedback (negative or positive) can stabilize or destabilize a system. ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Science, Engineering, and Technology on Society and the Natural World** • Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.

Connections to other DCIs in this grade-band:
HS.LS2.C ; **HS.LS4.D**

Articulation of DCIs across grade-bands:
MS.LS2.C ; **MS.ESS2.A** ; **MS.ESS2.E** ; **MS.ESS3.B** ; **MS.ESS3.C** ; **MS.ESS3.D**

Common Core State Standards Connections:

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-ESS3-4)

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ESS3-4)

Mathematics -

MP.2 Reason abstractly and quantitatively. *(HS-ESS3-4)*

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-ESS3-4)

HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. *(HS-ESS3-4)*

HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *(HS-ESS3-4)*

Students who demonstrate understanding can:

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.** [Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] [*Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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 computational models in order to make valid and reliable scientific claims.

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Connections to Nature of Science

Scientific Investigations Use a Variety of Methods

- Science investigations use diverse methods and do not always use the same set of procedures to obtain data.
- New technologies advance scientific knowledge.

Scientific Knowledge is Based on Empirical Evidence

- Science knowledge is based on empirical evidence.
- Science arguments are strengthened by multiple lines of evidence supporting a single explanation.

Disciplinary Core Ideas

ESS3.D: Global Climate Change

- Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.

Crosscutting Concepts

Stability and Change

- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

Connections to other DCIs in this grade-band:
HS.PS3.B ; HS.PS3.D ; HS.LS1.C ; HS.ESS2.D

Articulation of DCIs across grade-bands:
MS.PS3.B ; MS.PS3.D ; MS.ESS2.A ; MS.ESS2.D ; MS.ESS3.B ; MS.ESS3.C ; MS.ESS3.D

Common Core State Standards Connections:

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-ESS3-5)

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-ESS3-5)*

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. *(HS-ESS3-5)*

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-ESS3-5)

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-ESS3-5)

HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. *(HS-ESS3-5)*

HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS3-5)

Students who demonstrate understanding can:

HS-ESS3-6. **Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.** [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [*Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Using Mathematics and Computational Thinking
Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

- Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations.

Disciplinary Core Ideas

ESS2.D: Weather and Climate

- Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. *(secondary)*

ESS3.D: Global Climate Change

- Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.

Crosscutting Concepts

Systems and System Models

- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

Connections to other DCIs in this grade-band:
HS.LS2.B ; **HS.LS2.C** ; **HS.LS4.D** ; **HS.ESS2.A**

Articulation of DCIs across grade-bands:
MS.LS2.C ; **MS.ESS2.A** ; **MS.ESS2.C** ; **MS.ESS3.C** ; **MS.ESS3.D**

Common Core State Standards Connections:
Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-ESS3-6)
MP.4	Model with mathematics. (HS-ESS3-6)
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-ESS3-6)
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. *(HS-ESS3-6)*
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS3-6)

Students who demonstrate understanding can:

HS-ETS1-3. **Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.**

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories.

- Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Disciplinary Core Ideas

ETS1.B: Developing Possible Solutions

- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.

Crosscutting Concepts

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology 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.

Connections to HS-ETS1.B: Developing Possible Solutions Problems include:

Earth and Space Science: HS-ESS3-2, HS-ESS3-4 **Life Science:** HS-LS2-7, HS-LS4-6

Articulation of DCIs across grade-levels:

MS.ETS1.A ; MS.ETS1.B

Common Core State Standards Connections:

ELA/Literacy -

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. *(HS-ETS1-3)*

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-3)

RST.11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. *(HS-ETS1-3)*

Mathematics -

MP.2 Reason abstractly and quantitatively. *(HS-ETS1-3)*

MP.4 Model with mathematics. (HS-ETS1-3)