Investigating Extreme Weather

In this unit, students will gain experience analyzing data to evaluate extreme weather events. They will build an understanding that interpreting extreme weather depends upon understanding what is typical or expected for weather in a particular location at a particular time of year. Climate data are essential for being able to evaluate current weather conditions and events in a broader context. Students will also explore extreme weather events in their local area and learn the importance of data collection for community preparedness and emergency response and mitigation.

Unit Question: What is Extreme Weather?

- What kinds of weather does Mount Washington experience? What factors contribute to the harsh conditions there?
- How are data used to evaluate weather to determine if it's extreme?
- How can communities prepare for and respond to mitigate the impacts of extreme weather events?

Lesson-by-Lesson Overview

Lesson 1. Exploring extreme weather
What is extreme weather?
This lesson launches the unit by inviting students to begin exploring the concept of extreme weather, applying their learning from the Local Unit. Students reflect on and discuss their own experiences with extreme weather and think about the information or data they may need to assess whether a weather event is "extreme."

Students are then introduced to Mount Washington as a place that some people have described as the "Home of the World's Worst Weather." Through text, videos, and discussion, students learn about some of the characteristics of the mountain and the kinds of weather experienced there. The lesson also connects to careers in science by highlighting the role of the observers who work on Mount Washington. This lesson includes an optional career activity that could be added to this lesson or used elsewhere in the unit.

Learning Objectives
Students will be able to:

- Identify examples of extreme weather and what makes them extreme
- Explain some factors influencing the weather on Mount Washington
- Describe what data are collected on Mount Washington and their purpose

Lesson 2. Temperature on Mount Washington
What is the temperature like on Mount Washington in February?
This lesson explores the temperatures on Mount Washington for two 48-hour periods: February 15-16, 2015 and February 15-16, 2016. Students will investigate the concept of "extreme weather" by interpreting and creating data visualizations of temperatures on the mountain. They

will also look at data across a 30-year period as an opportunity to evaluate how their data compares to 30-year climate data. Finally, they will make a claim, supported by data, about whether the temperatures during a specific weather event were extreme.

Learning Objectives

Students will be able to:

- Describe how scientists measure temperature-related variables.
- Create and interpret data visualizations of temperatures on Mount Washington.
- Describe temperature data for a specific weather event using statistical measures.
- Make a claim, supported by data, about whether the temperatures during a specific weather event were extreme.

Lesson 3. Air Masses and Temperature

What caused the low temperatures on February 15-16, 2015?

This lesson lays the foundation for understanding the role of air masses in helping to explain some of the temperature data discoveries students made in Lesson 2. Students will share their initial ideas about the causes of temperature variations and fluctuations on Earth. They will make predictions about how air masses move and then view a demonstration that uses colored water of varying temperatures to show how cool and warm air masses move. Students will also explore relationships between visual representations of temperature in graphs and maps.

Learning Objectives

Students will be able to:

- Explain how changes in temperatures around the Earth cause the formation of air masses.
- Identify different types of air masses.
- Analyze maps and graphs to explain temperature change.

Lesson 4. Wind on Mount Washington

Was the wind on Mount Washington on February 15-16, 2015 extreme?

This lesson explores the winds on Mount Washington on February 15–16, 2015. Students will work to create data visualizations of wind speeds on the mountain to investigate the concept of "extreme weather." They will also look at data across a 30-year period as an opportunity to evaluate how their data compare to 30-year climate data. They will conjecture about relationships between temperature and other weather variables and learn how scientists measure wind speed on Mount Washington.

Learning Objectives

Students will be able to:

- Describe how scientists measure wind-related variables.
- Create and interpret data visualizations of wind speed on Mount Washington.
- Describe wind data for a specific weather event using statistical measures.
- Examine average data across 30 years to evaluate typical and extreme wind conditions.

Lesson 5. Air Pressure and Wind

What causes extreme wind?

In this lesson, students explore the concepts of air pressure and learn about high and low pressure systems to answer the question: *What caused the high winds during the 2015 Presidents' Day storm?* They watch videos and engage with short readings to learn about air pressure, air pressure systems, and their relationship to wind patterns. Students use CODAP to create and analyze time series graphs of two variables, wind and pressure. At the end of

the lesson, they examine weather maps of the 2015 Presidents' Day storm to try to explain what caused its high winds.

Learning Objectives

Students will be able to:

- Describe what air pressure is.
- Explain how wind is related to air pressure.
- Create and analyze visual displays of air pressure to identify wind conditions

Lesson 6. Other Weather Events on Mount Washington

What is the weather like at other times of the year on Mount Washington?

In this lesson, students will apply their data skills to enact an investigation of a weather event on Mount Washington. Using CODAP they will create time series graphs of temperature and wind speed to try to tell a story of the data. They will create dot plots to examine the distribution of data, determine averages and compare them to climate data. Students will present their data analysis and make a data-supported claim about whether the event was extreme weather.

Learning Objectives

Students will be able to:

- Create and analyze a time series graph of a weather event on Mount Washington
- Create dot plots to describe a distribution of data and find averages
- Make a claim supported by data about whether an event is extreme weather.

Lesson 7. Pressure during Weather Events

What was the pressure like during the weather events of Lesson 6?

In this lesson, students will use CODAP to create graphs of pressure for the weather events they investigated in Lesson 6. They will explore the relationships between weather components by creating graphs of two variables and examining patterns in the data displays. They will examine surface analysis maps to further investigate patterns and relationships they identified in their CODAP analysis. Students will use their analysis of the data to paint a picture of the overall weather conditions during the time period.

Learning Objectives

Students will be able to:

- Identify patterns in time series graphs of pressure
- Make connections between time series graphs of pressure and surface analysis maps of the same weather event
- Use displays of data to make a conjecture about what the weather was like during the time period displayed

Lesson 8. Hurricanes and Tropical Storms

Why do hurricanes and tropical storms cause so much wind and precipitation?

This lesson will confirm for students that the weather events they have been investigating were hurricanes or tropical storms that hit Mount Washington. They learn about how hurricanes form and why they bring such high winds and large amounts of precipitation. They will also learn how hurricane data are collected and what data benchmarks designate a storm a hurricane versus a tropical storm. The lesson then shifts to a focus on Tropical Storm Irene and students will learn how Mount Washington experienced the storm and what its impacts were there.

Learning Objectives

Students will be able to:

- Explain the conditions necessary for a hurricane to form and sustain its energy
- Describe how hurricane weather data are collected and used

- Describe the origins and path of Tropical Storm Irene and its impact on Mount Washington and the surrounding region.

Location Specific Lessons: New England

Lessons 9 and 10 explore Tropical Storm Irene further by examining datasets from local weather observation stations in New Hampshire and Maine where the storm hit. Because these lessons are tailored to these particular locations, they not be relevant to students in other parts of the country.

Lesson 9. Tropical Storm Irene (Location Specific)

Was the weather during Tropical Storm Irene extreme in our area? (Maine & NH)

In this lesson, students will work in small groups to conduct a data investigation of the wind and precipitation data in their local area during Tropical Storm Irene. They will identify what aspects of the storm were extreme and learn about the path of the storm and its impact on their region.

Learning Objectives

Students will be able to:

- Create CODAP graphs to evaluate the winds in my local area during Tropical Storm Irene
- Interpret precipitation graphs to determine how actual precipitation compared to normal precipitation and record highs and lows
- Make claims supported by data about whether aspects of the storms were extreme

Lesson 10. Lessons of Irene (Location Specific) (Maine and NH)

How did our community respond to Irene and what was the recovery like?

In this lesson, students will learn about the recovery efforts after Irene by completing a reading reflecting on the lessons of the storm. They will also learn about resources provided by their state government to help residents learn about extreme weather preparedness.

Learning Objectives

Students will be able to:

- Use data and facts to describe the impact of the Tropical Storm Irene
- Explain recovery efforts that occurred in the community after the storm
- Describe some key resources for emergency preparedness and safety

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I. Connections to Next Generation Science Standards (NGSS)

Science and Engineering Practices (for Grades 6-8)

Practice 1: Asking questions

- Ask questions
  - that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.
  - to identify and/or clarify evidence and/or the premise(s) of an argument.
  - to determine relationships between independent and dependent variables and in models. ○ to clarify and/or refine a model or an explanation.

Practice 4: Analyzing and interpreting data*

- Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships.

- Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships.
- Analyze and interpret data to provide evidence for phenomena.
- Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible.
- Analyze and interpret data to determine similarities and differences in findings.

Practice 5: Using mathematics and computational thinking

- Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends.

Practice 6: Constructing explanations and designing solutions

- Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena.
- Construct an explanation using models or representations.
- Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.

Practice 7: Engaging in argument from evidence*

- Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.

**Focal practices in the unit*

Disciplinary Core Ideas (for Grades 6-8)

ESS2.D: Weather and Climate

- Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. (MS-ESS2-6)

Cross Cutting Concepts (for Grades 6-8)

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS2-5)

Systems and System Models

- Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. (MS-ESS2-6)

Stability and Change

- Stability might be disturbed either by sudden events or gradual changes that accumulate over time. (MS-ESS3-5)

MS. Weather and Climate: Performance Expectations (PE's) that are Addressed

MS-ESS2-5. Collect [or analyze] data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions. *Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide.*

II. Connections to Common Core State Standards for Mathematics

Standards for Mathematical Practice

CCSS.MATH.PRACTICE.MP2 Reason abstractly and quantitatively.

CCSS.MATH.PRACTICE.MP3 Construct viable arguments and critique the reasoning of others.

Content Standards

Investigate patterns of association in bivariate data

CCSS.MATH.CONTENT.8.SP.A.1

Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering, outliers, positive or negative association, linear association, and nonlinear association.

Draw informal comparative inferences about two populations

CCSS.MATH.CONTENT.7.SP.B.3

Informally assess the degree of visual overlap of two numerical data distributions with similar variabilities, measuring the difference between the centers by expressing it as a multiple of a measure of variability. *For example, the mean height of players on the basketball team is 10 cm greater than the mean height of players on the soccer team, about twice the variability (mean absolute deviation) on either team; on a dot plot, the separation between the two distributions of heights is noticeable*.

Develop understanding of statistical variability.

CCSS.MATH.CONTENT.6.SP.A.2

Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape.

CCSS.MATH.CONTENT.6.SP.A.3

Recognize that a measure of center for a numerical data set summarizes all of its values with a single number, while a measure of variation describes how its values vary with a single number. **Summarize and describe distributions.**

CCSS.MATH.CONTENT.6.SP.B.4

Display numerical data in plots on a number line, including dot plots, histograms, and box plots. CCSS.MATH.CONTENT.6.SP.B.5

Summarize numerical data sets in relation to their context, such as by:

A. Reporting the number of observations.

B. Describing the nature of the attribute under investigation, including how it was measured and its units of measurement.

C. Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered.

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