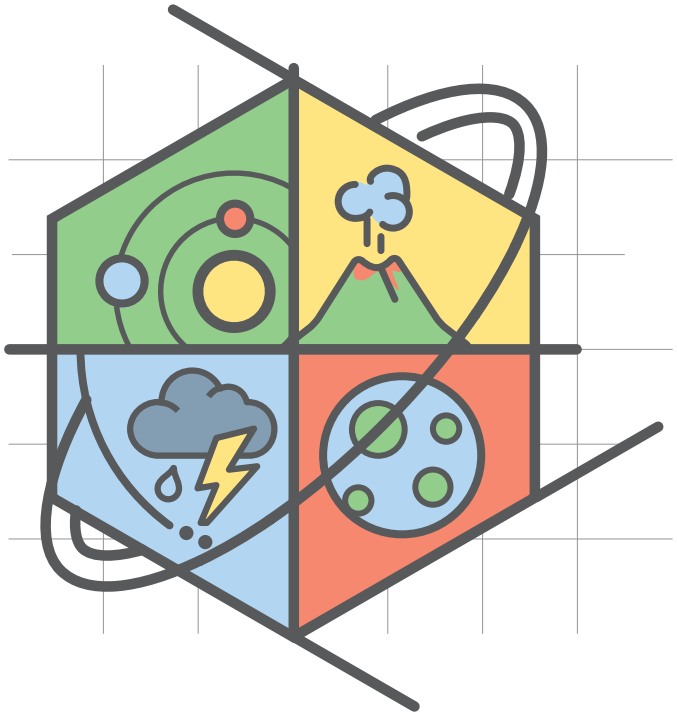

Tornado Alley!

A Study of Weather & Climate

Middle School NGSS Unit

STEM

A digital copy of this document is available on the STEM Materials Center website at:
https://www.stemmaterials.org/tornado-alley/

STEM
Science
Technology
Engineering
Math

A program of Educational Service District 112 supporting Next Generation Science Standards

Background on the Core Scientific Ideas in this Unit

From Barbara McNaught Watson. Comment on, "Tornadoes." Scholastic., www.scholastic.com/teachers/article/tornadoes

More tornadoes form in the central United States than anywhere else in the world. Over the Plain States, especially in the spring and sometimes fall, you will often find the right conditions for the formation of tornadoes. First, I'll explain what tornadoes are. Tornadoes are spawned from thunderstorms. To have thunderstorms, you must have moisture to form a cloud and fall as rain. The moisture over the plains comes from the Gulf of Mexico. Next, you need the air to be unstable, which means that once it begins to rise, it will continue to rise. As the day's sun beats down, the warm air, with its Gulf moisture, begins to rise. Hot, moist air rises just as you see steam rising out of a tea kettle. It cools as it rises even higher and condenses into clouds. A third ingredient to get a thunderstorm going is something that will focus where the air is rising, such as a cold front. Typically, over the plains (especially in the spring) you will get a clash of the warm, moist Gulf air from the south and the cooler, drier Canadian air from the north. The boundary between these two air masses is called a cold front. Often along the front is a line of strong thunderstorms. However, only one percent of all thunderstorms produce tornadoes. What makes the plains unique in spawning so many tornadoes is that it lies east of the Rockies. Air that descends off of these mountains is warm and dry, and helps to start a thunderstorm rotating. You need the winds to change direction with height in a clockwise manner to get a thunderstorm rotating. It is out of the rotating thunderstorm that the tornado descends down to the ground. In the plains, the winds near the ground blow warm, moist air from the south. Farther, off the surface, the wind turns southwest and then west as you encounter the dry, warm air from the Rockies. This combination with the cold front helping to trigger the thunderstorms makes tornadoes more common in the plain states.

BACKGROUND (cont.)

WHAT WILL STUDENTS KNOW AT THE END OF THIS UNIT?

- Different climate conditions and patterns result from the various ways that the Sun's energy is transmitted throughout the geosphere.
- Unequal heating of and the rotation of the earth causes patterns of atmospheric and oceanic circulation that determine regional climates.
- There are predictable patterns that describe the formation and interaction of varying bodies of air and water.
- Catastrophic events such as hurricanes and tornadoes result from a combination of interacting systems and conditions.
- Catastrophic events can have negative impacts on people and scientists use specific rating scales to categorize and alert the public of these events

UNIT OVERVIEW

Lesson No.	Duration	Materials Needed	Focus	Assessment Options
1	6+ days	Computers with internet access Blank map of the U.S.	**Engage** • Engage students by having students connect to their background knowledge about tornadoes, watch footage of a tornado and create a KLEWS chart. • Students study the different types of data that they are exposed to online. • Students identify the 10 states that experience the most tornadoes and create a map. • Students create a CER argument to identify the state most affected by tornadoes.	KLEWS Chart (initial assessment) Labeled maps of U.S. CER Arguments
2	10+ days	*Check Catastrophic Events Lesson 3-5 for full materials list.* *Plus*: Chart paper Markers Computers Vernier Stainless Steel Temperature Probes (one per lab group Vernier Lab Quest (one per lab group)	**Explore** • Students plan and carry out an investigation to distinguish between the effects of heat on soil and water. • Students investigate how the temperature changes above a cool or hot source. Students create a model showing how the energy of the Sun is cycled in the geosphere. • Students investigate the results of different air masses interacting. • Students create an initial model to describe how the interaction between sun, air, water, and land can create a tornado.	Models of Sun, water, air and land interactions Explanatory models of Tornado Alley

UNIT OVERVIEW (cont.)

3	8+ days	Computer with internet access *Check "I Can't Take the Pressure" for full materials list.* *Check Catastrophic Events Lesson 6 for full materials list.*	**Explain & Expand** • Students create an initial predictive model of what happens to air at the beach. • Students test their models using the Land and Sea Breezes interactive simulation. • Students explore the effects of atmospheric pressure on weather conditions through a series of investigations. • Students use an interactive simulation to test their ideas and strive to create certain weather conditions.	Initial model of beach Model of tornado formation
4	7+ days	*Check Catastrophic Events Lesson 2 for full materials list.* Computer with internet access Blank map of U.S. Chart paper an markers	**Evaluate** • Students are re-directed to the phenomenon of tornadoes and read about how scientists rate the intensity of a tornado. • Students investigate the properties of a vortex through an investigation which they use to explain the phenomenon of a tornado. • Students research and elaborate on the disastrous effects of a tornado. • Final Assessment: students create a labeled explanatory model to explain why tornadoes form more often in Tornado Alley than in any other place on Earth.	Explanations of vortex model Assessment and Rubric: detailed explanatory model of Tornado Alley

LESSON 1: Introduce the Phenomenon

Day 1

Materials Needed
Computer and Internet Access

Introduce students to the puzzling phenomenon of the Tornado Alley by presenting students with the driving question of the Unit: Why do you think tornadoes form more often in Tornado Alley than in any other place on the Earth?

Show students footage of some tornadoes: https://www.youtube.com/watch?v=bjb7QtMEBUg

Show students a large map of the United States with Tornado Alley labelled. https://extension.illinois.edu/treehouse/images/3317_1_large.jpg

Have students work in small groups to brainstorm the following ideas: What causes tornadoes to form? What are tornadoes? Why are they so common in Tornado Alley? The teacher can then facilitate a gallery walk or discussion where students are able to share their ideas. Work with students to create a KLEWS Chart that will be revisited throughout the Unit. http://static.nsta.org/files/sc1506_66.pdf The teacher can take this opportunity to assess student understanding of concepts.

Show students additional footage of the destruction caused by tornadoes and discuss the damage caused by tornadoes. https://www.youtube.com/watch?v=43VoMesUd2Q Are there ways to keep safe during a tornado?

Day 2

Materials Needed
Computer and Internet Access

Students are presented with the driving question: What data do we typically process to make decisions? Students examine and discuss the types of data that they are exposed through commonly viewed websites.

Students engage in a data analysis activity, "A Tornado in my State," where they study, organize, and present their findings of data of the number of tornadoes in the United States. Students are striving to understand and organize this data so that they will be able to figure out where exactly Tornado

LESSON 1 (cont.)

Alley is and will later be able to study the climatology of the region to make sense of this natural phenomenon. https://www.teachengineering.org/activities/view/cub_natdis_lesson08_activity3

Days 3-4

Materials Needed
Computer and Internet Access
Blank map of the United States

After students have studied and graphed their data, provide them with a map of the United States and ask them to represent the data they found on this map. Data Sets by State

According to the data they looked at, exactly where is Tornado Alley? Are there any states not within that geographical region that still experience a large number of tornadoes?

Have students use information on the NOAA website (http://www.nssl.noaa.gov/research/tornadoes/) to discuss the different types of tornadoes and the damage that they cause. Ask each group: how can you define what the most affected state is? What factors can you consider (cost of damages, deaths, etc.)? Ask students to discuss this data and come up with a consensus in their groups about what defines "most affected."

Ask each group to use their data and discussion to come to a consensus and select one state that is "most affected" by tornadoes.

Days 5-6

Materials Needed
Computer and Internet Access

After each group has selected which state is most effected by tornadoes, have students use CER (claims, evidence, and reasoning) to explain their choice. Once students have created their Claims, have them share their claims via a gallery walk.

Video about CER (for teacher): https://www.youtube.com/watch?v=5KKsLuRPsvU

Reconnect students to the KLEWS Chart, what new information have they learned that they can add to the chart? Have any of their wonderings been addressed?

LESSON 2: Heating and Cooling the Earth

Days 1-2: The Sun's energy and the Earth

Introduce students to the crosscutting concepts of energy and stability and change. Ask students, what type of energy and energy transfer do you witness during a tornado? What evidence can you think of to back up your claim?

Is a tornado a phenomenon that is an example of a stable incident, or is there change/instability happening? What evidence can you use to back up your claim?

Explain to students that before we can understand the phenomenon of tornadoes, we will have to study how energy is transmitted between systems in the earth.

Tell students that in order to understand how energy is transmitted, we will be studying how different parts of the earth heat up in different ways.

Catastrophic Events Lesson 3: Heating Soil and Water

Ask students to take detailed observations about the investigation.

Reconnect to the storyline by asking students—how can you apply what you learned to the map of the United States to understand where temperatures are higher vs lower? Provide students with a map of the United states (and surrounding body of water) and allow them to write down areas that they feel would heat up more and areas that would be cooler. Ask students to make a prediction about the temperature of the ground and air where they live.

Transition students into a field experience in the "Schoolyard Study" ("Middle School Science with Vernier" Lesson 8) where they measure ground and air temperatures around their school. Did their results match their predictions? How would the soil temperature differ in other parts of the U.S.?

Materials Needed

Look at Lesson 3 in Catastrophic Events for full list of materials.

Vernier Stainless Steel Temperature Probes (one per lab group)

Vernier Lab Quest (one per lab group)

LESSON 2 (cont.)

Days 3-5: Heating and Cooling Air

Connect to the phenomenon: Now that students have studied how sunlight directly affects the temperatures of water and the land, it is time to take things a little further and study how the temperature of ***air*** may vary based on certain conditions.

Day 3: Catastrophic Events Lesson 4: Heat Transfer and the Movement of Air –Students will study how the temperature of air will vary based on the type of material placed at the bottom of a convection tube (hot water or crushed ice). After students have written and discussed their reflections, connect to the phenomenon: how might the temperature and behavior of air masses create conditions that cause tornadoes? Read "Air Masses" on page 49 after discussion and facilitate discussion. What parts of our explanations and conclusions were on point?

Day 4: Sun's Angle of Incidence Graphing Activity- Connect to phenomenon: do you think that the location of the place on earth has an effect on how it heats up and how the air might heat above it? Have students conduct the investigation and write their observations carefully in their notebooks. After the investigation, have students reflect on their location. How will the angle of incidence in Washington differ from the angle of incidence in South America and close to the equator? What about Tornado alley? What are the latitudes there? Is there great variation in the latitudes/temperatures of the states involved? How might the location of these states be affected by air masses above and below the region?

Day 5: Based on what students have learned about air masses and temperature, how can they try to better understand what is happening with Tornado Alley? What can students add to the KLEWS chart that will help them answer the guiding question? Have students create a model to show how energy from the sun affects air, land, and water.

Materials Needed

Look at Lesson 4 in Catastrophic Events for full list of materials.

For Sun's Angle of Incidence Activity (one set per group): white construction paper, large-block graph paper, 1 flashlight, tape, black marker

LESSON 2 (cont.)

Days 6-9: Interacting Air Masses

Now that students have studied how energy flows from the sun to the earth and causes variations in temperatures, they will study what happens when masses of different temperatures are interacting with each other. Look at the map of the U.S. and specifically at Tornado Alley. Based on previous observations/discussions, what different types of air masses might there be? Ask students to write some questions regarding these air masses. Examples of questions: What happens when a cold air mass hits a hot air mass? What happens when two hot air masses collide?

Then have students engage in Catastrophic Events Lessons 5: Convection Currents in the Air. Reconnect to the phenomenon: where might there me convection currents in the atmosphere in U.S. and how might they contribute to different types of weather patterns?

Materials Needed

Look at Lesson 5 in Catastrophic Events for full list of materials

Day 10: Formative Assessment

Have students pause to reflect on their investigations so far. Based on everything they have been studying and learning, ask them to create a model that explains the occurrence of tornadoes in Tornado Alley. Ask students to work in teams to create a visual model (poster) of the interactions that may cause the abundance of tornadoes in that region. Students must use evidence from their investigation to back up their ideas and can use captions to make connections between their model and the evidence they found. Facilitate a gallery walk where students are able to give each other feedback on the models. The teacher can assess for developing student understanding.

Materials Needed

Chart paper and markers

Computer and Internet Access

LESSON 3: Weather and Climate

Days 1-2: A Day at the Beach

Connect to the phenomenon: tell students that you will be continuing your study of climate conditions by studying what happens when different air masses interact. Tell students that we are trying to further develop our understanding of this so we can see how different air masses interact to promote the abundance of tornadoes in Tornado Alley.

Have students create a predictive model of what happens to air at the beach. What do they know about hot vs cold air? Have students use the Land and Sea Breezes Interactive Simulation to collect data and to verify their predictions.

Ask students to revisit and revise their initial models based on the data they collected from the simulation.

Materials Needed

Computer with internet access

Days 3-5: The Pressure is On

Day 3: Ask students to brainstorm what "pressure" is. Do they see any evidence of pressure being present during a tornado? If so, how? Facilitate a discussion where students can share their ideas.

Immediately engage students in the lesson called: "I Can't Take the Pressure". Ask students to take detailed notes of their observations in their Science Notebooks.

Day 4: Have students engage in the Cloud in a Bottle activity: Catastrophic Events Lessons 6: Temperature, Pressure, and Cloud Formation. Does Hurricane formation have anything to do with tornado formation? What have students learned that they can add to the KLEWS chart? Have they answered any of their wonderings? Bring students' attention back to the models they created in previous lesson. Is there something they would like to adjust or change?

Materials Needed

For "I Can't Take the Pressure" Lesson look at materials list on website.

Look at Lesson 6 in Catastrophic Events for full list of materials.

LESSON 3 (cont.)

Day 6-7: Currents and Weather Patterns

Materials Needed
Computer with Internet Access

Day 6: Students will now be studying how convection currents may cause certain extreme weather conditions. Reconnect to the phenomenon by asking students to take a look at their model of the United States and of why Tornado Alley experiences so many tornadoes. Students will be studying what happens when different air fronts are colliding with each other. What is an air front? Where do they think different air fronts are colliding?

Engage students in reading pages 63-67 in Catastrophic Events Lessons 5: Convection Currents. What information have they acquired that explains the type of a fronts present near Tornado Alley and what type of weather might be typical of that region? Students can write out their predictions.

Day 7: Have students use the Weather Front Interactive Simulation to have students test their predictions. Then, have students work in teams to try to create certain weather conditions. What patterns can they find? What types of weather are typical for certain fronts?

Day 8: So, What is a Tornado?

Based on all the new information students have learned and all the new data they have collected from the investigations, what exactly might a tornado be? Ask students to come up with an initial model of exactly what a tornado is. Show several videos of tornadoes and ask students to look at the map of the United States (specifically of the weather fronts that are interacting over Tornado Alley) and to come up with a model that shows how a tornado forms. Tell students that they will be optimizing this model at the end of their next lesson and that their final model will be able to very accurately represent what a tornado is.

Possible extension activity: Have students engage in Data Puzzle 2 from NSTA's Publication. Earth Science Puzzles Making Meaning from Data.

LESSON 4: Twisters

Day 1-2: Vortexes

Day 1: Start by reading "That's a Fact" (pgs. 20-23) Catastrophic Events Lesson 2: Introducing Storms and facilitate a discussion where students are able to share their thoughts about the following questions: What do you know about how tornadoes form? What types of weather conditions facilitate the formation of a tornado? What are the different measurements that help scientists categorize the intensity of a tornado? What scale do they use?

Have students take a look at this information on the Fujita Versus Enhanced Fujita Scale. Ask students to think in teams: How are the two scales different? Why do you think Scientists came up with the "enhanced" scale?

Day 2: Engage students in the lesson Catastrophic Events Lesson 2: Introducing Storms where students model a vortex. Have students think about the vortex model. How is it similar to what they can observe in a tornado or a hurricane? In teams, have students use the vortex as a model to explain what happens when a tornado hits.

Materials Needed

Computer with internet access

Look at Lesson 2 in Catastrophic Events for full list of materials.

Day 3-5: Forces of Nature

Direct students to explore Tornadoes using National Geographic Interactive: Forces of Nature. Ask students to work in teams to digest the information on this page. What information can you collect that will help you to develop your model of why Tornado Alley is the most tornado-prone region in the world? It may be helpful to provide students with an information cataloging handout/template to help them organize the information they find.

Materials Needed

Computer with Internet Access

LESSON 4 (cont.)

Day 6-7: Formative Assessment

Materials Needed
Computer with internet access
Blank United States Map
Chart paper and markers

Students will be creating a model to explain "Why tornadoes form more often in Tornado Alley than in any other place on Earth?" Provide students with a blank map of the United States with tornado alley labeled. Students are responsible for creating a labeled model to show how different geographical patterns cause this area to be so tornado prone. Ask students to use evidence that they have collected throughout the Unit to support their model. You can also ask students to write

The process can be broken down into the following parts:

1. What is the question you are trying to answer?
2. Brainstorm and collect evidence: Go back and look at the other data you collected and the other initial models you were creating after each investigation. How can you use this information to answer the question?
3. What other information/evidence did you find during your research sessions that you can use to help create your explanatory model?
4. How can you illustrate your ideas in a way that will help explain the phenomenon of Tornado Alley?

The teacher can assess the students' explanatory model and written support.

*Example Assessment and Rubric: Develop a model explaining why tornadoes commonly form in tornado alley

(Example of assessment of student's ability to model a phenomenon: Garbage Patch Phenomenon (MS-ESS2-6) and Rubric for assessing students ability to create explanatory and predictive models.)

How This Unit Supports Next Generation Science Standards

MS-ESS2 Earth's Systems

The materials/lessons/activities outlined in this activity are just one step toward reaching the Performance Expectations listed below. Additional supporting materials/lessons/activities will be required. NGSS connections are derived from the Evidence Statements for the Performance Expectations listed below.

Peformance Expectation	**Connections to Classroom Activity** *Students:*
MS-ESS2-5: Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions. MS-ESS2-6: Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.	• Begin to study the geography of the United States and create their initial model describing how geographical characteristics of an area may make a region more prone to experiencing tornadoes. • Collect data as evidence that the Earth is heated unevenly due to the way that different materials absorb sunlight. • Create models to show how different interacting fronts in the U.S. can cause different weather conditions and determine regional climates. • Create models to show how air circulates at the beach. • Study the effects of pressure and different properties of a region that lead to patterns of certain types of weather. • Begin to study the geography of the United States and create their initial model describing how geographical characteristics of an area may make a region more prone to experiencing tornadoes.

How This Unit Supports Next Generation Science Standards (cont.)

SCIENCE & ENGINEERING PRACTICES	
Engaging in Argument from Evidence Planning and Conducting Investigations Analyzing and interpreting data	• Students create mathematical representations of data (graphs, charts, etc.). • Students create an initial model of what they think a tornado is and how it forms. • Students construct an explanation which includes an argument based on evidence about which state is most affected by tornadoes. • Students collect and study data to see how varying temperatures of water, air, and land can cause specific weather conditions. • Students develop and refine several models to show how differences in temperature and pressure can cause various weather conditions. • Students study how the circling of water in the atmosphere creates fronts that interact in different ways to produce certain weather patterns. • Students study how different geographical regions have temperatures that affect the formation of air masses and influence the climate of a region. • Students create a model of what happens to air at the beach, they then test their model and make adjustments. • Students analyze and collect data about what happens when two fronts interact and create a model of what air fronts are acting to create the conditions of Tornado Alley. • Students create a model to explain how a tornado forms. They use evidence to develop and solidify their explanation.

How This Unit Supports Next Generation Science Standards (cont.)

DISCIPLINARY CORE IDEAS	
ESS2.C The Roles of Water in Earth's Surface Processes ESS2.D Weather and Climate ESS3.D Natural hazards	• Analyze data that shows where tornadoes are more common. • Describe why certain areas experience more tornadoes than others. • Students study how the circling of water in the atmosphere creates fronts that interact in different ways to produce certain weather patterns. • Students study how different geographical regions have temperatures that affect the formation of air masses and influence the climate of a region.
CROSSCUTTING CONCEPTS	
Stability and Change Influence of Science Cause and Effect Matter and Energy Patterns Scale Proportion and Quantity	• Try to construct an explanation for why certain areas are more prone to tornadoes. • Identify patterns in data and how they can be illustrated geographically. • Discuss how energy flow can cause certain weather conditions. • Discuss the causes of tornadoes. Discuss the damaging impact of tornadoes. • Identify patterns in temperature and climate patterns • Identify fronts that bring stability in weather conditions and fronts that bring change. • Discuss how energy flows in the geosphere.