

Lesson Title: All About Winter Weather

Lesson Overview:

Students will investigate the properties and characteristics of winter hazards such as blowing snow and blizzards that impact the region.

Lesson Objectives:

Students will observe the effects of humidity on snowfall

Students will develop a plan for measuring snowfall and discuss how human activity influences drifting

Students will identify features on the Earth's surface that cause changes to Earth's systems

Students will research and create a poster identifying the types of storm systems that produce North Dakota blizzards

Students will use research skills to identify blizzards based on the weather patterns they observe.

Students will investigate the basic characteristics of visible light and how it behaves when refracted through prisms.

NSF Subject Classification: Regional Climate Studies

National Next Gen Standards:

HS-ESS3-1 Earth and Human Activity: 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.

HS-ESS2-2: Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.

North Dakota Standards:

Science 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.

Science HS-ESS2-2 Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.

RST.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific or technical context relevant to grade 9-10 or 11-12 texts and topics.

ELA W.8 Gather relevant information from multiple authoritative print and digital sources

c. Integrate information into the text selectively to maintain the flow of ideas.

d. Avoid plagiarism

SL.1 Initiate and participate in a range of collaborative discussions with diverse partner on grapes 9-10 or 11-12 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.

- a. Come to the discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate thoughtful, well-reasoned exchange of ideas.

Grade or Grade Band: 9-12

Time Needed: 6- 50 minute periods (two additional periods for the extension activities)

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Scientist Bio: Dr. Aaron Kennedy, Associate Professor, Atmospheric Sciences University of North Dakota

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As a child, I tracked tropical storms in South Carolina, to severe thunderstorms in northern Illinois. In response to this interest, I sought a meteorology degree at the U. of Oklahoma. My experiences there led me to pursue a career in research. Storm chasing cemented in my mind the importance of field work and direct observations of our atmosphere. After finishing my B.S. (2004), and M.S. (2006), I left Oklahoma to seek my Ph.D. at the U. of North Dakota. Instead of focusing on severe storms and tornadoes, I conducted climate research; ironically using data collected at the Atmospheric Radiation Measurement Southern Great Plains Site in Lamont, Oklahoma. After finishing my Ph.D. in 2011, I stayed at UND to pursue my NSF Postdoc fellowship, and I am now an associate professor.

My interests today include convection, clouds, winter weather, and climate. I focus on synergistic studies that use combinations of models/observations/reanalyses to advance our knowledge of these topics. I am also interested in local meteorology (such as blizzards and blowing snow) and the societal impacts it has on the region.

When I am not working, I love to hang out with my family including my amazing wife and three daughters. I love adventures, and will ride a bike just about anywhere. I commute year-round (even with the kiddos), and do a number of endurance cycling events. I love to experience the atmosphere first-hand, and I chase storms as time allows. Finally, I am an avid photographer and love to document my various adventures.



Summary of Research and/or Problem Being Studied

<https://ndus.edu/2020/01/20/und-atmospheric-scientist-aaron-kennedy-seeks-answers-to-the-chilling-mysteries-of-winter-storms/>

Preparation/Materials

Essential Terminology:

Jetstream- A fast flowing, narrow, meandering current of air in the atmosphere. Occurs in proximity to changes in temperature. Cold north of the Jet, Warm south of the jet.

Meridional: highly amplified troughs and ridges (highly curved)

Zonal: When the upper level winds are parallel to the lines of latitude. Low pressure system tend to move faster (west to east) when associated with a zonal flow.

Resources/Websites:

https://www.eoas.ubc.ca/courses/atasc113/sailing/met_concepts/11-met-marine-weather/11c-forecasting/

https://mrcc.illinois.edu/resources/guides/howto_airpres_grnhouseeff.pdf

<https://www.theweatherprediction.com/weatherpapers/071/index.html>

https://skybrary.aero/index.php/Colorado_Low

<https://www.weatherbug.com/news/What-Are-Alberta-Clippers>

<http://www.eumetrain.org/satmanu/CMs/AF/print.htm>

Materials needed:

Lesson 1:

- PowerPoint slides 5-8
- Activity 1: Blowing Snow Tank worksheet
- Aquarium
- Bucket
- fake snow (wet snow and dry snow)
- ruler
- small hand-held fan
- obstacles for tank (toy cars, plastic trees)

Lesson 2:

- PowerPoint slides 10-20
- 2 alcohol thermometers
- 2 glass beakers with water
- A handful of ice
- 3-4 foot long ribbon flag
- Activity II: Blizzards and Weather Patterns worksheet

Lesson 3:

- PowerPoint slides 21-26
- Storm System Research checklist
- Activity II -Part 2 Blizzard Identification Worksheet

Lesson 4:

- PowerPoint slides 38-45
- Activity III: Snowflakes and Optics worksheets
- Prisms
- 3D-printed snowflakes
- flashlight

Lesson 5:

- 2 Prisms per group
- 2 flashlights per group

PowerPoint – found as separate attachment

Procedure/Activities

Lesson 1: Blowing Snow 50 minutes

Preparation:

Create your wet snow mixture and place in a large container

Place dry snow mixture in a large container

1. Introduce the lesson with a brief overview of the first meteorologists in the region and historical data from infamous blizzards. (PPT Slides 2-3)
2. Ask students “What weather stories or legends have you heard about growing up?” and explain the theory behind any legend or stories students bring up. (PPT slide 4)
3. Ask students “What measurable qualities must be present in order for a winter event to be considered a blizzard”. Allow time for students to turn and talk to a neighbor then allow student to share out ideas. Display ppt. slide 5 with the National Weather Service definition of a blizzard.
4. Hand out the Activity 1: Blowing Snow Tank worksheet.
5. Draw students’ attention to the aquarium with 2 types of fake snow. Allow students to feel the two types of snow. Allow students time to think about and discuss the 3 questions under Step 1 on the worksheet
6. As the students watch, use the fan and attempt to blow the 2 types of snow into the buckets. Students should then answer all questions under Step 2 on the worksheet.
7. Level the snow in the tank and place objects around the tank. Make sure the lid is in place, use the fan to blow the snow around but keeping the fan in one spot. Once the snow has drifted, stop the fan.



8. Have students write down what they observe inside the tank.
9. Use a ruler and take measurements of snowfall at different spots in the tank and answer what range of snowfall is observed. State “Wind makes snowfall measurements incredibly difficult and care must be taken to make accurate observations. Ask students to devise a plan on how to get the most accurate snowfall totals after a blizzard
10. Watch the “Learn how to measure snowfall video”: <https://youtu.be/rsPTc3Xxe3g> Then watch the “How Is Snowfall Officially Measured?” video: <https://www.youtube.com/watch?v=oU1Wxm9UU3Y>
11. As a class discuss “Why do we need to measure snowfall?” and “How should we properly measure snowfall?”

Possible Extensions:

1. Discuss
 - a. How blowing/drifted snow impacts our region?
 - b. What challenges does drifting snow pose and how can we minimize these impacts?
2. Watch the following short videos for further ideas:
 - a. https://www.youtube.com/watch?v=GqM_m5pToqc
 - b. <https://www.youtube.com/watch?v=mjKcuKARK1M>
 - c. <https://www.youtube.com/watch?v=NiQXNujxmUw>

Lesson 2: Weather Patterns 50 minutes

1. Display ppt slide 9 on the board and allow students time to study the two blizzard graphics. Discuss “How many blizzards has the region seen in any given winter?” and “What Months have the most blizzards?”
2. As we discuss the next slide keep this guiding question in mind “Why do you think our region sees so many blizzards?”
3. Display ppt slide 10, review the topographic map of North Dakota and discuss the natural features that shape the land surface in North Dakota. It is important to point out that the land features make a wind funnel through the Red River Valley.
4. Continue the discussion with the map of ground cover on ppt slide 10. Notice on the map that Northern MN has vast forests while ND has large areas of grassland and cropland. What other features of the Red River Valley make it a target for blizzards?
5. Display ppt slide 11 and direct students to the following website to research and identify features on a weather map: https://www.eoas.ubc.ca/courses/atc113/sailing/met_concepts/11-met-marine-weather/11c-forecasting/
6. Display ppt slide 12 and present the information on pressure and how height can decrease the amount of pressure
7. Demonstrate pressure changes with 2 alcohol thermometers with ice water and room temperature water: https://mrcc.illinois.edu/resources/guides/howto_airpres_grnhouseeff.pdf
8. Explain to students that high pressure in the summer brings hotter weather while high pressure in the winter brings colder weather. The inverse is true for low pressure in summer means cooler weather while low pressure in winter means warmer weather. (ppt slide 13)
9. Refer back to the air pressure demonstration while presenting ppt slides 14-17 to help explain how changes in pressure cause winds. Point out the lines on the map on ppt slide 14 and look for tight spacing of isobars. The tight spacing is an indication of faster wind speeds.
10. Demonstrate with a 3-4-foot piece of ribbon or a ribbon flag how the Jetstream movement can change. Begin by waving the ribbon in a large circle around you. Point out the troughs and ridges as the “Jetstream” moves around the “Earth” (you are the Earth)

Assessment: Using the information from ppt slides 11-17, have students work in pairs to complete the Activity II: Blizzards and Weather Patterns worksheet.

Lesson 3: Blizzard Pattern Identification. (2-50 minute periods)

1. Begin the lesson with a brief overview of three storm systems that may produce blizzards: Alberta Clippers, Colorado Lows, and Artic Fronts ppt slides 21-26.
2. Split the class into groups of three. Each group will be creating a poster with information about the three different storm systems that may produce North Dakota blizzards.
3. Handout the Storm System Research Checklist to each student. Group members each choose one of the three systems and use class time to gather information about that storm system. If students are struggling, direct them to some of the following websites to assist them:

<https://www.theweatherprediction.com/weatherpapers/071/index.html>

https://skybrary.aero/index.php/Colorado_Low

<https://www.weatherbug.com/news/What-Are-Alberta-Clippers>

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4. Once each group has gathered the necessary information on each storm system, they will display their information on a group poster. Posters can then be displayed in the room or hallway. Grade

Assessment:

1. Hand out the “Winter Weather Pattern Matching Exercise” and the “Blizzard Identification Worksheet”
2. Students will use the information from the group poster exercise as well as the weather identification information they learned in lesson 2, to match the 3 case studies with the correct storm systems

Mediation/Support for students that need it:

Use mixed ability level grouping for students who may need more support. Roles may need to be assigned within groups to encourage individual accountability

Extensions: (Optional 50 minute period)

Winter Weather Safety: Frost Bite and Hypothermia slides 30-34

- Have students create action plans, survival kits, or brochures detailing the need for winter weather safety
- Have students create infographics or PSA explaining the differences between winter watches, warnings and advisories

Lesson 4 (50 minute period)

Preparation: Create an account with Polleverywhere.com. Create a class poll with the question “What determines the type of snowflake that forms

1. Display the 3-Dprinted snowflakes on several tables spread throughout the room, allow students to move throughout the room, handle and observe the different properties of each flake.
2. Introduce the lesson using PollEverywhere and display the following question on the screen “What determines the type of snowflake that forms?”. Allow students to send their answers to the board using the PollEverywhere code.
3. Display the PollEverywhere responses on the board and discuss as a class the responses
4. Present ppt slides 36-38 detailing the environments that determine the type of snowflake that is formed
5. Hand out the Snowflakes and Optics: Crystal Matching Sheet. Students will again move around the classroom examining the 3-D printed snowflakes and matching each model to the appropriate type indicated on the sheet that was handed out.

Assessment:

Using the temperature and supersaturation graph as well as information from the storm system posters made in the last lesson, students should answer the questions on the backside of the Snowflakes and Optics: Crystal Matching Sheet.

Lesson 5 (50 minute period)

Essential Terminology:

Scattering- Interaction with light and objects like ice crystals. Light changes direction from a straight path due to changes in density along the path of the light.

- Different Types of Scattering
 - Reflection – Mirroring back of the light to where it started.
 - Refraction – Light is deflected when going through an object
 - Diffraction – bending of light around an obstacle or opening.

1. Present ppt slides 40-41 allowing students time to study the pictures of the Halo, Sundogs and explain how the light is refracted by hexagonal ice crystals suspended in the air.
2. Present ppt slide 42 and explain how the appearance of the pillars as light are from light reflecting off on the ice crystals suspended in the air
<https://www.atoptics.co.uk/halo/dogfm.htm>
<https://www.atoptics.co.uk/halo/platpill.htm>
3. Separate students in small groups depending on the number of prisms and lights available. Each group should have at least 2 prisms and 2 flashlights
4. Allow students time to explore the optics they can create using the prisms and flashlights.
5. Questions to explore:
 - a. How does the angle of light impact the optical phenomenon?
 - b. How is color separated?

Standards Alignment

ND Science Standard(s):

Science 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.

Science HS-ESS2-2 Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.

Disciplinary Core Idea: e.g.

ESS3.B: 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.

ESS2.A: Earth Materials and Systems Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.

North Dakota DPI Standards:

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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.

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 tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.

Cross Cutting Concepts

- Cause and Effect-Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
- Stability and Change- Feedback (negative or positive) can stabilize or destabilize a system

Unit Objectives

- Students will observe the effects of humidity on snowfall
- Students will develop a plan for measuring snowfall and discuss how human activity influences drifting
- Students will identify features on the Earth's surface that cause changes to Earth's systems
- Students will research and create a poster identifying the types of storm systems that produce North Dakota blizzards
- Students will use research skills to identify blizzards based on the weather patterns they observe.
- Students will investigate the basic characteristics of visible light and how it behaves when refracted through prisms.

Additional Lesson Resources / Materials

References:

“ATSC 113 Weather for Sailing, Flying & Snow Sports.” *Weather Map Interpretation*,
www.eoas.ubc.ca/courses/atsc113/sailing/met_concepts/11-met-marine-weather/11c-forecasting/.

“Midwestern Regional Climate Center.” *MRCC*, mrcc.illinois.edu/.
https://mrcc.illinois.edu/resources/guides/howto_airpres_grnhouseeff.pdf

Websites for purchasing materials

For the wet, heavy snow: https://www.amazon.com/SnoWonder-Instant-Artificial-Great-Making/dp/B00KVNXE04/ref=sxsts_sxwds-bia-wc-p13n2_0?cv_ct_cx=fake+snow&dchild=1&keywords=fake+snow&pd_rd_i=B00KVNXE04&pd_rd_r=cdf143ac-9bd8-422c-80e9-5f186780b274&pd_rd_w=RSkzm&pd_rd_wg=B9ehn&pf_rd_p=1da5beeb-8f71-435c-b5c5-3279a6171294&pf_rd_r=JM73XFGD0Q1B78JC6GQP&psc=1&qid=1592922770&sr=1-2-70f7c15d-07d8-466a-b325-4be35d7258cc

For the dry, lighter snow:

https://www.amazon.com/gp/product/B0769MM8R4/ref=ppx_yo_dt_b_asin_title_o04_s00?ie=UTF8&psc=1
Fan: <https://www.amazon.com/Handheld-VersionTECH-Rechargeable-Household-Traveling/dp/B01HGI0S6O>
Prisms: https://www.wish.com/product/5a0a7c5da0c3b41c995b1831?from_ad=goog_shopping&display_country_code=US&force_currency_code=USD&pid=googleleadwords_int&c=%7BcampaignId%7D&ad_cid=5a0a7c5da0c3b41c995b1831&ad_cc=US&ad_curr=USD&ad_price=2.92&hide_login_modal=true&share=web

Ribbon flag: <https://www.orientaltrading.com/web/browse/processProductsCatalog?sku=14/1798>