

Meteorology And Severe Weather

Summer 2019

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**BELLMORE-MERRICK
CENTRAL HIGH SCHOOL DISTRICT**

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Meteorology and Severe Weather

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Instructional Resources

- Unit PowerPoint Presentations
- Various Activities

Meteorology and Severe Weather

Course Overview:

- The purpose of this course is to give students a more in-depth experience with severe weather that they were introduced to in Earth Science. They will also have the opportunity to research ways to prevent their homes from damage associated with severe weather. Many students are now taking Earth Science in Middle School, therefore this course will give the students the opportunity to revisit one of the Physical Sciences in an upper-level course, with a more rigorous curriculum. This Severe Weather course will give students an opportunity to learn about every-day weather as well as different severe weather events that many of them will encounter in their life, if they have not encountered them yet.
- In this course, real-time data and current events should be stressed. During hurricane season, tropical storm tracking can be a daily occurrence. The NWS may re-locate pages. If a URL is broken, search on the parameter and NOAA to find a new link to current data.

Scope and Sequence

- **Unit 1: Weather Recap (Approximately 7 days)**

1. Daily Topics:

- Day 1: Terminology – Powerpoint slides 1-10
 - Reviewing terminology used in Earth Science in the Weather unit.
 - Activity – Make an anemometer
- Days 2-3: Clouds & Cloud Types & METAR Code Slides 11-38
 - Defining and describing cloud types
 - Location of clouds in atmosphere levels
 - Determining which cloud type it is from pictures
 - Zulu time
 - METAR Code
 - Activity – METAR Code Breaking Activity
- Days 4-5: Station Models (Slides 39 – 44)
 - Describing how METAR data is placed on station models
 - Analyzing station models
 - Activity – Station Model Activity
- Day 6-7: Isoplething (Slides 44-53)
 - Define isoplething
 - Define different types of isopleths
 - Describe how to isopleth
 - Examples of isobars and isotherms
 - Practice drawing isobars
 - Practice drawing isotherms
 - Activity – Isoplething Activity

2. Unit Assessment: Test/Quiz on associated topics.

- **Unit 2: Weather Maps & Synoptic Scale Storms (Approximately 12 days)**

- 1. Daily Topics:

- Day 1: High & Low Pressure Systems– Powerpoint slides 1-10
 - Revisiting isoplething
 - Creation of High & Low pressure areas
 - Describing areas of High pressure
 - Describing areas of Low pressure
 - Movement & Rotation of winds around areas of high/low pressure
 - Real world example to determine if high/low pressure area
 - Activity – Pressure Systems Activity
- Days 2-5: Air Masses & Fronts (Slides 11-38)
 - Name types of air masses
 - Describe Continental Polar air mass
 - Describe Continental Tropical air mass
 - Describe Maritime Polar air mass
 - Describe Maritime Tropical air mass
 - Show origin of air masses
 - What happens when air masses collide
 - Location of front between air masses
 - Describe cold fronts
 - Pictorial representation of vertical atmosphere at a cold front and associated cloud development
 - Description of what happens to air at cold front
 - Weather observations around cold fronts
 - Describe warm fronts
 - Pictorial representation of vertical atmosphere at a warm front and associated cloud development
 - Description of what happens to air at warm front
 - Weather observations around warm fronts
 - You be the meteorologist – determine the front
 - Anafronts vs katafronts
 - Locating fronts on a map
 - Isotherms
 - Isobar trough
 - Wind Shift
 - You be the meteorologist - Find the cold front on a map
 - You be the meteorologist – Find the areas of high and low pressure & locate fronts
 - Activity – Pressure Systems and Frontal Analysis
- Days 6-8: Occluded and Stationary Fronts and Dry Lines (Slides 39 – 51)
 - Describe Occluded Fronts
 - Picture of occluded low
 - Pictorial representation of vertical atmosphere around 2 types of occlusions
 - Surface analysis representation of 2 types of occlusions
 - Describe Stationary Fronts
 - Real world surface analysis of observations and conditions around a stationary front

- Stationary Fronts & Low Pressure development
- Description of a Dry Line
- Real world surface analysis of observations and conditions around a dry line
- Pictorial representation of vertical atmosphere around dry line
- Dry line and severe weather
- Satellite imagery of severe weather associated with a dry line
- Activity – More Frontal Analysis
- Days 9-11: Satellite & Radar Imagery & Precipitation types (Slides 52-106)
 - Satellite imagery & loops
 - Types of satellite imagery
 - Describing Visible Satellite
 - Albedo of different objects
 - Albedo of cloud types
 - Examples of visible satellite
 - Other things visible satellite detects
 - Example of fog on visible satellite
 - Example of snow on visible satellite
 - Example of smoke on visible satellite
 - Example of volcanic ash on visible satellite
 - Problem with visible satellite
 - Solution – Infrared Satellite
 - Description of Infrared Satellite
 - Example of infrared satellite
 - Describing enhanced infrared satellite
 - Example of enhanced infrared satellite
 - Using infrared and visible satellite in tandem
 - Describing Water Vapor imagery
 - Example of water vapor
 - Satellites that give us these images
 - Polar Orbiting satellites
 - Geostationary satellites
 - Example of geostationary satellite image
 - Description of GOES satellite
 - Current visible and infrared satellite images from GOES
 - Description of Radar
 - Picture of Radar Tower
 - Radar echo image
 - Movement of storms on radar
 - Description of Doppler velocity
 - Explanation of Doppler effect
 - Doppler velocity image
 - Image of Doppler radar & Doppler velocity
 - Doppler radar image of stratiform precipitation
 - Doppler radar image of convective precipitation
 - Activity – Satellite & Radar Analysis

- Day 12 – Precipitation Types
 - Hail formation
 - Precipitation types
 - Description of snow formation
 - Image of snow
 - Description of freezing rain formation
 - Image of freezing rain
 - Description of sleet formation
 - Image of sleet
 - Vertical atmosphere for each winter weather phenomenon
 - Hail vs Sleet
 - Thundersnow
2. Unit Assessment: Test/Quiz on associated topics.

- **Unit 3: Thunderstorms (Approximately 15 days)**

- 1. Daily Topics:

- Day 1: Introduction to Thunderstorms – Powerpoint slides 1-6
 - Discussion of thunderstorms and what they are. What we perceive them to be.
 - Weather map discussion including lightning strike data, satellite and radar
 - Definitions of lightning, thunder, severe thunderstorm, watches and warnings.
 - Dangers – General overview including climatology (where and when), fatalities temperature of lightning
- Days 2 and 3: Ingredients for a Storm Slides 7-16
 - NWS Video: Stages of a storm https://www.youtube.com/watch?v=ueodnoj_ezE
 - Review cloud formation
 - Demonstration: Cloud in a Bottle
 - Activity 1: Condensation in Our Atmosphere (lesson plan example)
 - Review convection currents – demonstrations of does it float and lava lamp; drawing currents in the atmosphere
 - The Florida Case – why does Florida have so many thunderstorms?
- Days 4 and 5: Our Vertical Atmosphere (Slides 17 – 19)
 - NWS radiosonde and balloon launch video in Powerpoint
 - Skew T / Log P diagrams – First two videos from PSU <https://www.e-education.psu.edu/meteo300/node/638>
 - Information from a Skew T Diagram
 - Limitations and new technology that may eliminate the limitations
 - Activity 2: Read https://www.weather.gov/jetstream/skewt_severe_max, then analyze a skew T/Log P from <https://www.spc.noaa.gov/exper/soundings> (recent or current if applicable), identify thunderstorm possibilities and reasons based on the diagram. Sample given in “July 22 2019 severe storms.”
- Day 6: Forcing the Air Up (Slides 20-28)
 - Cold and Occluded Fronts – reasons for lift, types of clouds, contrast with warm fronts
 - Orographic effect
- Day 7: Types of Thunderstorms (Slides 29-33)
 - Single Cell Thunderstorms – description, hazards
 - Multi-cell Storms – description, hazards
 - Supercells – description, hazards
 - Storm chasing videos
 - Activity 3: Draw a supercell including updrafts and down drafts
 - Weather map discussion using NWS forecast maps, radar and satellite (Slide 2 links)
- Day 8: Mesoscale Convective Systems (MCS) (Slides 34-37)
 - Descriptions and dangers
 - Weather map discussion if applicable
 - Squall Lines
 - Radar signatures: Bow echo and hook echo
 - Additional map discussion if applicable
- Day 9: Thunderstorm Hazards: Winds (Slides 38-42)
 - Wind damage – brainstorm, find recent storm data, class discussion
 - Downbursts, microbursts, gust fronts and derechos and images

- Activity 4: Article on Downdrafts/microburst and plane crashes and discussion questions.
 - Day 10: Thunderstorm Hazards: Flooding and Lightning (Slides 43-49)
 - Urban/Street flooding – class discussion, recent storm data
 - What causes lightning - Review of electricity
 - How does Lightning move?
 - Lightning safety
 - Activity 5: How far away is the storm? From NOAA Project Jet Stream
 - Day 11: Thunderstorm Hazards: Hail (Slides 50-53)
 - Definition of Hail vs. sleet
 - What causes hail
 - How to detect hail – radar, green sky
 - Hail dangers
 - What other hazards can occur with a thunderstorm? – Tornadoes
 - Days 12-15: Weather map reviews (sample in Powerpoint slide 54), Student Projects and Presentations
2. Activities/Projects:
- Activity 1: Condensation, How does dew form? How does this relate to thunderstorms?
 - Activity 2: Activity 2: Read https://www.weather.gov/jetstream/skewt_severe_max, then analyze a skew T/Log P from <https://www.spc.noaa.gov/exper/soundngs/> (recent or current if applicable), identify thunderstorm possibilities and reasons based on the diagram. Sample given in “July 22 2019 severe storms.”
 - Activity 3: Draw a supercell including updrafts and down drafts
 - Activity 4: Article on Downdrafts/microbursts and plane crashes and discussion questions
 - Activity 5: How far away is the storm? NWS Project Jet Stream
-
- Project: Case Study Thunderstorm
 - Find an area with thunderstorms forecasted on www.weather.gov
 - Provide the forecast, watches and warnings, and weather map
 - Discuss the type of thunderstorm, forecasted hazards, origin of moisture, and mechanism for lift/formation
 - Provide any storm reports (from local NWS homepage) after the storm and pictures, including a radar picture (from NWS web page)
 - Present Thunderstorm Case Study to the class
3. Unit Assessment: Create a Safety Brochure on Thunderstorms. Include signs, dangers, and ways to be prepared and safe in a storm.

- **Unit 4: Tornadoes (Approximately 8 days)**

- 1. Daily Topics:

- Day 1: Introduction to Tornadoes – Powerpoint slides 1-6
 - Overview with videos, Weather Channel dramatization at National Geographic video
Dramatized overview Weather Channel:
<https://www.youtube.com/watch?v=0cODBQqaGTw> National Geographic:
<https://www.youtube.com/watch?v=7KDz6dGQ5RE>
 - Weather map discussion including lightning strike data, satellite and radar and any discussion of possible tornadoes
 - Definitions – What is a tornado? How many occur annually, Introduce Project VORTEX 2
 - Small But Mighty: How big, how far, how powerful. Show Smithsonian video on Oklahoma City tornado
www.smithsonianmag.com/videos/category/science/explainer_vt_pl/
 - EF Scale
 - Dangers – General overview with fatalities slide
- Days 2: Where do thunderstorms happen? (Slides 7- 13)
 - Tornado climatology for New York
 - Tornadoes by state and square miles and strong tornadoes by state
 - What is tornado alley? - why severe storms form in tornado alley (brief review thunderstorm formation)
 - What months and times do tornadoes occur?
 - Activity 1: Severe Weather Expert (lesson plan)
- Day 3: How do tornadoes form? (Slides 14 - 19)
 - Overview of tornado formation
 - Close cousins and how they are different
 - Activity 2: Read <https://www.weather.gov/jetstream/tornado> and answer questions
 - Wild and Wacky tornado facts – multiple vortex tornadoes and video (https://www.youtube.com/watch?v=zsyWlak3_6M), clockwise tornadoes and fire whirls
- Days 4 and 5: Back to Supercells and Squall Lines (slides 20-26)
 - Formation and growing to include a tornado
 - Radar signatures that may indicate rotation
 - Activity 3: Tornado Outbreak May 2019 (or more current) – Each group is assigned a specific tornado and writes an article including key facts: location, time, duration, strength and what that means, damage, injuries/deaths, warning lead time. Students fill out a chart with key information to give an overview of the tornadoes in that outbreak. Extension: What can keep people safer in this type of outbreak?
- Day 6: Forecasting and Warning (Slides 27-28)
 - MRMS forecasting, radar signatures, GOES imagery, SKYWARN Spotter Network, Social Media (recent examples if possible)
 - Difference between tornado watch and tornado warning and what each means
 - Tornado warning NYC video <https://www.youtube.com/watch?v=oiBS0hYEubl> or something more recent
 - Activity 4: Explore Vortex 2 project and write about an interesting aspect of the project – present to class www.nssl.noaa.gov/projects/vortex2/
- Day 7: Weather Detective (Slides 29-34)

- What tornado damage can look like
 - How the NWS determines if it was a tornado
 - Suffolk County case study June 30, 2019
 - Microbursts vs. Tornadoes
 - Activity 5: Read article on Suffolk County Storm and answer questions
 - Day 8: Tornado Safety (slide 35)
 - How to stay safe in a tornado
 - Activity 6: Tornado facts vs. myths
2. Activities/Projects:
- Activity 1: Severe Weather Expert
 - Activity 2: Read <https://www.weather.gov/jetstream/tornado> and answer questions
 - Activity 3: Tornado Outbreak May 2019 (or more current) – Each group is assigned a specific tornado and writes an article including key facts: location, time, duration, strength and what that means, damage, injuries/deaths, warning lead time. Students fill out a chart with key information to give an overview of the tornadoes in that outbreak. Extension: What can keep people safer in this type of outbreak?
 - Activity 4: Explore Vortex 2 project and write about an interesting aspect of the project – present to class [www.nssl.noaa.gov/projects/vortex 2/](http://www.nssl.noaa.gov/projects/vortex2/)
 - Activity 5: Read article on Suffolk County Storm and answer questions
 - Activity 6: Tornado facts vs. myths
3. Unit 4 Assessment: Create a Building Code guide for tornado alley.

- **Unit 5: Tropical Cyclones (Approximately 10 days)**

- 1. Daily Topics:

- Day 1: Creation of a Hurricane – Powerpoint slides 1-16
 - Naming storms around the world
 - Hadley cell
 - ITCZ
 - ITCZ shift
 - ITCZ shift & winds steer hurricanes
 - Storms from Africa move westward
 - Image of sea surface temperature in August
 - Image of sea surface temperature through year
 - Image of sea surface temperature in wake of Hurricane Edouard
 - ITCZ shift & counterclockwise spin of hurricane
 - Why does one cluster turn into a hurricane and another one does not?
 - 4 ingredients to form a hurricane
 - Eye & Eye wall development
 - Hurricane Intensification
 - Days 2: Tropical Cyclone Intensification & What steers hurricanes? (Slides 17- 30)
 - Tropical Disturbance to Tropical Storm
 - Description of Tropical Storms
 - Why name storms?
 - History of naming of tropical storms
 - Current naming system
 - Current tropical storm names
 - Retired tropical storm names
 - Tropical storm to Hurricane
 - Saffir-Simpson Scale
 - Subtropical High
 - Image of surface winds/trade winds
 - Bermuda high
 - Synoptic Scale Systems steering hurricanes
 - Image of synoptic system steering
 - Day 3: When hurricanes make landfall (Slides 31-52)
 - What happens when hurricanes make landfall?
 - Rainfall
 - Winds
 - Storm Surge
 - Images associated with storm surge
 - Storm surge locations on Long Island
 - Real world examples of storm surge from Hurricane Sandy
 - Flooding example from Sandy
 - Storm surge damage from Sandy
 - Tornadoes
 - Watches & Warnings Associated with Tropical Cyclones
 - Examples of Watches & Warnings from Sandy
 - When do hurricanes generally form?

- Death of a hurricane
 - Wind shear
 - Example of wind shear from Hurricane Felicia
 - Lack of warm ocean water
 - Example of cut off from warm water for Hurricane Katrina
 - Problems with Saffir-Simpson scale
 - Days 4-5 : Activity – Hurricane Analysis
 - Day 5-10: Project – Hurricane Preparedness Project – Research preventative methods to protect your home.
2. Unit 4 Assessment: Quiz/Test on associated information.

- **Unit 6: Upper Air (Approximately 5 days)**

- 1. Daily Topics:

- Day 1: Introduction to Upper Air – Powerpoint slides 1-7
 - Why we need to know – airplanes, upper level winds steer storms, temperatures affect precipitation
 - Chart of the vertical atmosphere, temperature and pressure with elevation review
 - Review convection currents
 - Activity 1: Students share experiences with turbulence. Discussion of air acting as a fluid. Read article on turbulence and answer questions.
https://www.travelandleisure.com/travel-news/why-more-turbulence-on-flights?utm_source=emailshare&utm_medium=email&utm_campaign=email-share-article&utm_content=20190718&utm_term=672733
 - Days 2: Which way the Wind Blows (Slides 8-14)
 - The Wind does Blow from High to Low
 - The Coriolis Effect. Video: <https://www.youtube.com/watch?v=i2mec3vgeal>
 - Demonstration: When you spin a globe, which has to move faster to get around, a spot at the equator or a spot near the pole? If this was a track and you were running, who travels a greater distance in the same time?
 - Draw out global winds aloft, then introduce reasons it isn't so simple (smaller convection cells (Hadley, Ferrel and Polar), topography, storms
 - Handout on Jet Streams
 - Day 3: Which way will the storm move? (Slides 15-17)
 - True case February 23, 2019, which way will the storm move?
 - 500 mb charts are historically often used for storm development and movement
 - Isolines on the chart are isoheights, the height at which the pressure drops to that pressure.
 - 200 mb is also used for steering and storm development and represents top of troposphere
 - Identify troughs and ridges
 - Activity 2: Catch a Wave: Read <https://www.weather.gov/jetstream/common> Basic Wave Patterns. With a partner, search through upper air charts (500 mb, 300 mb and/or 200 mb) at <https://www.spc.noaa.gov/obswx/maps/> and find examples of each type of wave. Complete "Catch a Wave" handout. Answers can be submitted in paper or electronically and/or presented to the class.
 - Days 4: Predicting Precipitation Types (slides 21-24)
 - How precipitation type changes as it falls through the atmosphere
 - What are the different precipitation types
 - How snow type changes due to the temperature in which it forms
 - 850 mb temperature used as a predictor
 - 540 line (1000-500 mb thickness) used as a predictor
 - Day 5: How can I use this information? (Slide 25)
 - What I can now determine from looking at a weather model 4-panel chart
 - Introduce 700 mb level and the correlation with cloud cover
 - Activity 3 (lesson plan sample): Look at a current 4 panel chart/model data and a current weather map. Make a forecast for Merrick/Bellmore.

2. Activities/Projects:

- Activity 1: Students share experiences with turbulence. Discussion of air acting as a fluid. Read article on turbulence and answer questions. https://www.travelandleisure.com/travel-news/why-more-turbulence-on-flights?utm_source=emailshare&utm_medium=email&utm_campaign=email-share-article&utm_content=20190718&utm_term=672733 (or another article on turbulence)
 - Activity 2: Catch a Wave: Read <https://www.weather.gov/jetstream/common> Basic Wave Patterns. With a partner, search through upper air charts (500 mb, 300 mb and/or 200 mb) at <https://www.spc.noaa.gov/obswx/maps/> and find examples of each type of wave. Complete “Catch a Wave” handout. Answers can be submitted in paper or electronically and/or presented to the class.
 - Activity 3 (lesson plan sample): Look at a current 4 panel chart/model data and a current weather map. Make a forecast for Merrick/Bellmore
3. Unit 6 Assessment: Present the forecast to the class showing how you got the information from upper level charts.

- **Unit 7: Nor'easters and Blizzards (Approximately 6 days)**

1. Daily Topics:

- Day 1: Introduction to Nor'easters – Powerpoint slides 1-4
 - Nor'easter means the wind comes onshore from the northeast
 - Review of low pressure and wind directions
 - Typical Nor'easter set up and reasons for hazards
 - Typical development of a Nor'easter
 - Activity 1: The Force of the Wind worksheet
- Day 2: Bomb Cyclones (Slides 5-7)
 - What a "Bomb Cyclone" is and an example
 - Activity 2: Case study of March 2-3, 2018 nor'easter (lesson plan sample)
- Day 3: Nor'easter hazards (Slides 8-9)
 - Hazards – High winds, flooding, Possible blizzards
 - Precipitation type forecast difficulties due to rain/snow line
 - Activity 3: Water equivalent precipitation
- Day 4: Blizzards (slides 10-13)
 - What qualifies as a blizzard
 - Notable Blizzards and when they are also nor'easters
 - Ground Blizzard can occur when there is little to no falling snow
 - Precipitation types
 - Short Video: How to measure snow depth
- Days 5 and 6: Blizzard and Nor'easter Safety (Slide 14)
 - Hazards from blizzards
 - Class discussions of ways to protect life and property during a nor'easter
 - Activity 4: Together list the factors that may go into deciding whether to salt the roads
 - Activity 5: There is an upcoming nor'easter, create a flyer that the county may use alerting the public to the possible dangers, forecasting difficulties, and ways to protect life and property.

2. Activities/Projects:

- Activity 1: The Force of the Wind worksheet
- Activity 2: Water Equivalent Precipitation
- Activity 3 (lesson plan sample):
- Activity 4: Together list the factors that may go into deciding whether to salt the roads
- Activity 5: There is an upcoming nor'easter, create a flyer alerting the public to the possible dangers, forecasting difficulties, and ways to protect life and property.

3. Unit 7 Assessment: Activity 5 flyer

- **Unit 8: Mesoscale Meteorology (Approximately 3 days)**

1. Daily Topics:

- Days 1-2: Lake Effect Snow & Land/Sea Breeze– Powerpoint slides 1-20
 - Describe Lake Effect Snow Conditions
 - How Lake Effect Snow forms
 - Lake Effect snow graphic
 - Satellite image of Lake Effect Snow
 - Radar image of Lake Effect Snow
 - Why Lake Effect Snow forms in bands
 - Localization of Lake Effect Snow
 - Lake Effect Snow Storm Totals
 - Areas where Lake Effect Snow forms
 - Have you ever experienced land/sea breeze?
 - When Land/Sea breeze phenomenon occurs
 - Describing formation of land breeze
 - Land breeze graphic
 - Describing formation of sea breeze
 - Sea breeze graphic
 - Sea breeze front
 - Radar image of sea breeze front
 - Satellite image of lake breeze
 - Activity – Mesoscale Activity
- Day 3: Haboobs, Santa Ana Winds (Slides 21-28)
 - Describing haboobs
 - Where haboobs occur
 - Thunderstorm & Haboob picture
 - Haboob in Arizona image & video
 - Santa Ana wind explanation & video
 - Setup necessary for Santa Ana wind formation
 - Winds squeezing through mountains graphic
 - Santa Ana Winds & Wildfires

2. Unit 8 Assessment: Test/quiz on associated information

- **Unit 9: Forecasting (Approximately 4 days)**

1. Daily Topics:

- Days 1-3: Introducing the Models – Powerpoint slides 1-18
 - Are forecasters always wrong?
 - Where are people getting their information?
 - Model improvement
 - Equations & Computer models
 - Computer model computer
 - Types of computer models
 - Models we will use
 - Strengths & Weaknesses of models
 - Overcoming model weakness
 - Ensemble models
 - Ensemble model confidence
 - Example of ensemble model for Hurricane Florence
 - Model uncertainty
 - Websites for models
 - Activity – Analyzing MOS Forecast Data
- Day 4: Meteorology vs Media-ology; Preventing the “Wrong” (Slides 19-32)
 - Issues with long-range forecasts
 - Scattered storms & precipitation probability percentage
 - Explain precipitation probability percentage
 - Snowfall ranges
 - Cone of uncertainty for hurricane tracks
 - Example of cone for Hurricane Florence
 - Example of social media misinformation – September snowfall
 - Example of social media misinformation – Hurricane Irma track
 - Hurricane Irma actual forecast track
 - Where to get accurate forecast information
 - Takeaways regarding forecasting
 - Activity – Read article “Miami Marlins Rain Delay Due to Weather App Usage”
- Ongoing Project – You be the Forecaster – Pairs of students prepare a forecast over the weekend for the upcoming week and present the forecast on Monday in class.

2. Unit 7 Assessment: Test/Quiz on associated content.

- **Unit 10: Wild and Unusual Weather (Approximately 7 days)**

1. Daily Topics:

- Day 1: The Year Without a Summer – Powerpoint slides 1-2
 - Overview – occurred because of a massive volcanic explosion
 - Video – historical video (<https://www.youtube.com/watch?v=r676Enlp8yg&t=345s> 7 minutes but there are many of varying lengths from which to choose)
 - Destruction – crop loss, famine, lingering effects; Also led to Frankenstein and other horror stories
 - Discussion: Can this happen today? What can we learn from this? [How to prepare for the unpredictable. Escape routes. How to deal with food shortages.] Where can you go to find information on this event.
- Days 2-3: The Joplin Tornado (slides 3-4)
 - Overview – occurred on a convectively active day, supercell
 - Destruction – Many lives lost, injuries, damage
 - There was warning, but many did not heed the warning. Discuss why.
 - Activity 1: Read the Joplin tornado service assessment (or parts). What did we learn from this? [some don't take warnings seriously enough] What has changed and hasn't changed?
- Days 4-6: Hurricane Sandy (slides 5-6)
 - Overview – no longer defined as a hurricane or tropical storm when it made landfall. Difficult decision by NWS.
 - Activity 2: Skype or Facetime with NWS personnel involved in the decision
 - Destruction: Flooding, lives lost, extensive property damage.
 - Activity 3: "Tracking Sandy" analysis (lesson plan). What did we learn from Sandy?
- Day 7: The Great Blizzard of 1888 (slides 7-8)
 - Overview – crippled NYC and the cities on the eastern seaboard, nor'easter, 50 foot snow drifts, approximately 400 deaths
 - Video: <https://www.youtube.com/watch?v=hC9Ux8fQWA4>
 - Discussion: Can this happen today. What did we learn from this? [subways, underground power lines] Where can you go to find information on the event?

2. Activities/Projects:

- Activity 1: Joplin Tornado Service Assessment
- Activity 2: Skype or Facetime with NWS personnel involved in the decision of how to categorize Sandy
- Activity 3: Tracking Sandy (sample lesson plan)

3. Unit 10 Assessment: Lessons Learned – Students chose a storm, write a paper and present their storm with a focus on the following:

- What were the weather conditions leading up to the storm?
- Provide an overview of the storm meteorology including forecast maps, weather maps, observations, precipitation totals, etc. Site all data sources (see prior assignments for ideas)
- Provide the impact to society including storm damage and death and injury reports.
- What lessons did we learn from the storm? How did society change or how should society change based on the lessons learned?

Sample Lesson/Unit 1 Weather Recap

METAR Code

- **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.**
- **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.**
- **HS-ESS2-8. Evaluate data and communicate information to explain how the movement and interactions of air masses result in changes in weather conditions.**
- **Science and Engineering Practices**
 1. Asking questions (science)/defining problems (engineering)
 2. Developing and using models
 3. Planning and carrying out investigations
 4. Analyzing and interpreting data*
 5. Using mathematics and computational thinking*
 6. Constructing explanations (science) and designing solutions (engineering)
 7. Engaging in argument from evidence*
 8. Obtaining, evaluating and communicating information*
- **Cross-cutting concepts from ELA and Math**
 1. Systems and Systems Modeling
 2. Energy and Motion
 3. Influences of Science, Engineering Math, and Technology on Society
- **Disciplinary Core Ideas**
 1. ESS2.A: Earth Materials and Systems
 2. ESS2.D: Weather and Climate

Method

Objectives:

The student will be able to:

- Convert Zulu time (GMT) to Eastern Daylight/Standard time
- Decipher a METAR code
- Take current observed data and place into a METAR code

Materials:

- METAR reference sheet
- METAR activity sheet
- METAR powerpoint

Activities:

1. Discuss zulu time and METAR code through powerpoint presentation.
2. Practice decoding METAR as a class.
3. Relate to code breaking from World War II.
4. Students work on METAR code breaking activity (see below).
5. Closure: There has to be an easier way to organize all this data. How should we organize this information??
Leads into the next day's discussion of station models.

Name: _____

Date: _____

METAR Code Breaking

Directions: Using your METAR reference sheet, determine what the following METAR codes are reporting.

1. **KBOS 241454Z 07005KT 10SM FEW040 FEW090 BKN160 24/12 A2994 RMK AO2 SLP139 T02440117**

2. **KMIA 241453Z 21012KT 10SM SCT033 SCT250 31/24 A3001 RMK AO2 SLP161 CB DSNT S MOV E T03110244**

3. KTPA 241458Z 26012KT 8SM -TSRA FEW018 BKN029CB OVC085 25/22 A2997 RMK AO2 WSHFT 1440 LTG DSNT
OCNL LTGICCG E-W TS E-W MOV E CB MOV E P0000 T02500222

4. KDTW 172000Z 30015G25KT 3/4SM R36/4000FT -SN BLSN BKN008 OVC040 M05/M08 A2992 REFZRA RMK SLP134

BONUS: KSLN 210553Z AUTO 02014KT 5SM BR OVC009 01/M01 A2982 RMK AO2
UPB11E12B44E47FZRAB29E44SNE11B12E14 CIG 007V014 SLP107 P0000 60005 T00061011 10011 20006 400330006
TSNO

Write the METAR Code for the following observations:

5. A nonroutine aviation weather report from MacArthur Airport in Islip, NY on the 31st day of the month at 2035UTC. It's an automated weather report with no human intervention. The wind is at 40° at 15 knots and is gusting to 30 knots. The visibility is ½ statute mile. Runway 20 has a visual range of 2000 ft. There is a thunderstorm at the location with heavy rain and hail that is ½ inch in diameter. There is a tornado in the vicinity. The clouds cover 7/8ths of the sky at 1500 ft and the sky is completely covered at 2000 ft by cumulonimbus clouds. The temperature at the station is 29°C and the dew point is 22°C. The altimeter is reading 29.15 inches of mercury. There was a tornado in the distance to the southwest that began 20 minutes past the hour. The peak wind was at 50° at 30 knots at 32 minutes past the hour. There is approximately 5 flashes of lightning per minute within the thunderstorm cloud and is 1 statute mile to the southwest. The thunderstorm began at 10 minutes past the hour. The hail stones are ½ inch in diameter.

Sample Lesson/Unit 2 Weather Maps & Synoptic Scale

Satellite & Radar

- **HS-ESS2-8. Evaluate data and communicate information to explain how the movement and interactions of air masses result in changes in weather conditions.**
- **Science and Engineering Practices**
 1. Asking questions (science)/defining problems (engineering)
 2. Developing and using models
 3. Planning and carrying out investigations
 4. Analyzing and interpreting data*
 5. Using mathematics and computational thinking*
 6. Constructing explanations (science) and designing solutions (engineering)
 7. Engaging in argument from evidence*
 8. Obtaining, evaluating and communicating information*
- **Cross-cutting concepts from ELA and Math**
 1. Systems and Systems Modeling
 2. Energy and Motion
 3. Cause and Effect
 4. Influences of Science, Engineering Math, and Technology on Society
- **Disciplinary Core Ideas**
 1. ESS2.D: Weather and Climate

Method

Objectives:

The student will be able to:

- Discuss how satellite imagery & loops work
- List the types of satellite imagery
- Describe Visible Satellite
- State the albedo of different objects and different cloud types
- List other things visible satellite detects
- State the problem with visible satellite
- Describe Infrared Satellite
- Describe enhanced infrared satellite
- Use infrared and visible satellite in tandem
- Describe Water Vapor imagery
- Compare & Contrast Visible, Infrared & Water Vapor Satellite images
- Discuss the satellites that give us these images
- Describe Polar Orbiting satellites
- Describe Geostationary satellites
- Describe GOES satellite
- Describe Radar
- Identify a Radar Tower
- Identify and analyze a Radar echo image
- Describe Doppler velocity
- Explain Doppler effect and use with Doppler velocity images
- Identify and analyze a Doppler velocity image
- Use images of Doppler radar & Doppler velocity in tandem
- Identify the Doppler radar image of stratiform precipitation
- Identify the Doppler radar image of convective precipitation

Materials:

- Satellite & Radar powerpoint
- Satellite & Radar activity

Activities:

1. Discuss satellite & radar through powerpoint presentation.
2. Analyze different satellite and radar images as a class.
3. Students work on Satellite & Radar Images activity (see below).
4. Closure: Look at current satellite and radar images and discuss.

Name: _____

Date: _____

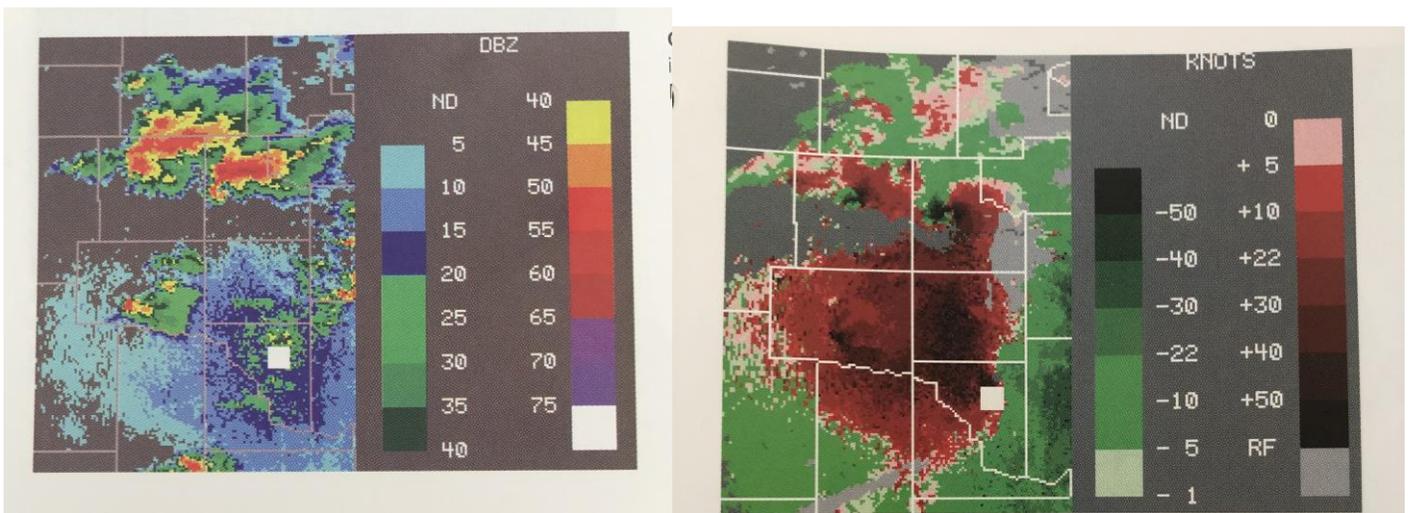
Satellite & Radar Analysis

Directions: Answer the questions that follow.

1. Devastating tornadoes struck Oklahoma and Kansas on May 3-4, 1999. More than 70 tornadoes were confirmed, with one tornado reaching F5, the highest ranking on the Fujita Scale of tornado intensity. The images below are the reflectivity and velocity images from the Oklahoma City Doppler radar at approximately 245Z on May 4, along with legends on the right to interpret the colors. The radar's location is marked with a white square in the lower right of these images. The area shown is about 130km (80mi) by 190km (120mi).

On the reflectivity image, oranges and reds correspond to heavy thunderstorms. On the velocity image green corresponds to winds blowing toward the radar site, while red corresponds to winds blowing away from the radar site (speed in knots).

- a) On the reflectivity image, two hook echoes, indicating thunderstorms that may be producing tornadoes, are very prominent. Locate them by circling them.
- b) These potentially tornadic thunderstorms show up well on the velocity images. Find their signature, and explain how the velocity imagery confirms the rotation occurring in these thunderstorms.



2. Figures "a", "b", and "c" below are satellite images taken at 16Z on August 20, 1997. Figure "a" is a visible image, "b" is infrared, and "c" is water vapor. Use these images to answer the following questions:
- Is the air at high altitudes over northwestern Ohio and northeastern Indiana dry or moist? Explain while referencing which satellite image helped you determine your answer.
 - Are there clouds in these areas? Explain while referencing which satellite image helped you determine your answer.
 - If there are clouds are they most likely low clouds or high clouds? Explain while referencing which satellite image helped you determine your answer.





Sample Lesson/Unit 3 Thunderstorms

- **Condensation in our Atmosphere**
- **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.**
- **Science and Engineering Practices**
 9. Asking questions (science)/defining problems (engineering)
 10. Developing and using models
 11. Planning and carrying out investigations
 12. Analyzing and interpreting data*
 13. Using mathematics and computational thinking*
 14. Constructing explanations (science) and designing solutions (engineering)
 15. Engaging in argument from evidence*
 16. Obtaining, evaluating and communicating information*
- **Cross-cutting concepts from ELA and Math**
 5. Systems and Systems Modeling
 6. Energy and Motion
 7. Cause and Effect
 8. Influences of Science, Engineering Math, and Technology on Society
- **Disciplinary Core Ideas**
 1. **Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.**

How does dew form? How do clouds form?
- **Method**

Condensation in Our Atmosphere

Severe Weather Grades 10-12

Objectives:

The student will be able to:

- Describe conditions needed for dew formation and cloud formation (condensation in our atmosphere)
- Read the dew point and relative humidity charts in the Earth Science Reference Tables
- Define dew point, frost point, condensation, dry-bulb temperature and ambient temperature
- Relate dew formation to cloud formation
- Read a thermometer

Materials:

- Ice
- Three Cans
- White Board Marker
- Three stop watches (or watches w/ second hands)
- Homework Worksheets (1 for each student)
- Water/sink
- Earth Science Reference Tables
- Thermometers (3)
- Condensation Worksheets (1 for each student)

Activities:

1. Define the problem [scientific method: identify the problem]: Tell the students that I really want to know how dew forms because when it forms on my car, I have to leave earlier to clean it off. I want to see if we can make dew form on the cans in the classroom.
2. Have a student measure and all students record the ambient air temperature or dry bulb temperature. Write it on the board.
3. Have students measure and all students record the temperature of the water in each can at “room temperature.” Write the temperatures on the board.
4. Ask how they think I can get dew to form on the outside of the cans [scientific method: form a hypothesis]. Explain that we will add hot water to one, nothing to the second and ice to the third to see if we get any dew.
5. Conduct the experiment:

Have students make a chart in their notebooks as I make it on the board as follows:

Time (seconds)	Can 1 (hot water added)		Can 2 (control)		Can 3 (ice added)	
	Temperature (°C)	Observations	Temperature (°C)	Observations	Temperature (°C)	Observations
0						
30						
.						
.						
300						

Break students into three groups. Explain that when they add the ice or hot water (group 2 can start at any time), one person should start the stopwatch and read the temperature every 30 seconds. The group should record the temperature and any changes to the outside of the can. If they get dew, they should tell the person reading the thermometer and write down the time and temperature of when they first saw the dew. Do not stop until they reach 300 seconds (5 minutes). [scientific method: collecting materials and observe, collect and record information]

6. After each group gets to 5 minutes, ask each group for their temperatures and observations. Write them on the board so that everyone can copy them. Hopefully, dew formed on the can with the ice. [scientific method: draw conclusions]
7. Ask the following questions, which assess interpretation of the information and analysis (through these questions we analyze the data and draw conclusions):
 - Where did the liquid come from? It condensed from water vapor in the air.
 - What did we do to get the water vapor condense to liquid? We cooled the can.

- What effect did cooling the can have on the air? The air touching the can cooled.
 - Where did the thermal energy in the air go? Into the water in the can by conduction.
 - What do we call the temperature below which dew forms? Dew point.
 - What do we need to form dew? Temperature cools below the dew point and a surface on which to condense.
 - What would we call the temperature if frost had formed? Frost point or dew point.
 - Based on our experiment, what is our estimate of the dew point?
 - Based on this information, how do clouds form? Temperature = Dew Point, something to condense on
 - Where does dew form and where do clouds form? Dew on surface, clouds aloft (up in the air)
 - Discussion: How can we determine temperature and dew point as we go up in our atmosphere? Why is this information important? Write down ideas and discuss
8. Relate the results to relative humidity. Ask these questions which assess recall, interpretation and analysis of the information:
- What is humidity? The amount of moisture in the air.
 - What is relative humidity? Amount of water vapor in the air compared the amount required for saturation at that temperature.
 - What does that have to do with dew point? At the dew point, the air is saturated. $RH = 100\%$
 - Hand out page 12 of the Earth Science Reference Tables. Can we determine the relative humidity in the room using this page and our experiment? Show them how to read the tables. Talk about our results.
9. Relate it back to the car. Ask why they think I had dew on my car? [scientific method: apply the information]
10. Hand out Condensation Worksheets. Give the students five minutes to work alone and then ten minutes to work in groups. These questions assess recall, interpretation and analysis.
11. Closure: What causes dew to form? What does this have to do with thunderstorms? We will be learning how to get this information at various levels of the atmosphere and how this can be forecasted.

Name: _____

Date: _____

Group: _____

Apply your Knowledge
Condensation Worksheet

1. What is the difference between dry-bulb temperature and ambient air temperature?

2. What is another name for dew point when it is below 0°C ?



3. What is the relative humidity when the dry-bulb temperature is the same as the dew point?

4. What are the ingredients required for condensation to be apparent?

5. If the dew point is 10°C and the air temperature is 20°C , is the relative humidity higher than, lower than or the same as when the dew point temperature is 10°C and the air temperature is 15°C ? How do you know? Check your response using the Earth Science Reference Tables.

6. Your cola is 5°C and the air temperature is 20°C . You keep getting in trouble because your drinks leave moisture rings in the new wood coffee table. Your wall hygrometer indicates that the relative humidity is 60%. If you do not want to get in trouble, should you use a coaster? Why or why not?



7. If your cola is 20°C and the air temperature is 20°C , will you need a coaster? Why or why not?

8. Based on today's class, what ingredients do you think are needed in order for clouds to form?



9. On a cold, clear, calm winter night, the temperature is expected to drop from 0°C to -8°C during the night. The dew point is currently -6°C . What, if anything, do you expect to find on your car in the morning?

10. At 10,000 meters, the temperature and dew point are both 2°F . What do you expect to occur?

11. Why is the temperature usually cooler as we go up in the atmosphere?

12. What causes a parcel of air to go up in altitude?

13. What do you think happens when a parcel of air is warmer than the surrounding air?

ANSWER SHEET

Apply your Knowledge

Condensation Worksheet

1. What is the difference between dry-bulb temperature and ambient temperature?

Nothing

2. What is another name for dew point when it is below 0°C?



Frost point

3. What is the relative humidity when the dry-bulb temperature is the same as the dew point?

100%

4. What are the ingredients required for condensation to be apparent?

Temperature below the dew point

A surface on which to condense

5. If the dew point is 10°C and the air temperature is 20°C, is the relative humidity higher than, lower than or the same as when the dew point is 10°C and the air temperature is 15°C? How do you know? Check your response using the Earth Science Reference Tables.

The relative humidity is lower because the air must cool more for the temperature to reach the dew point. If we look on the charts, the relative humidity is 51% for the first scenario and 74% for the second scenario.

6. Your cola is 5°C and the air temperature is 20°C. You keep getting in trouble because your drinks leave moisture rings in the new wood coffee table. Your wall hygrometer indicates that the relative humidity is 60%. If you do not want to get in trouble, should you use a coaster? Why or why not?

Yes because the difference in temperature between the air and the soda is more than the difference between the dry-bulb and wet-bulb temperatures when the temperature is 20°C and the relative humidity is 60%. Although the soda will gain heat from the air, the initial temperature is below the dew point.

7. If your cola is 20°C and the air temperature is 20°C, will you need a coaster? Why or why not?

There is no transfer of energy. However, dew can form if the missing ingredient was a surface on which to condense. I would probably see condensation elsewhere.

8. Based on today's class, what ingredients do you think are needed in order for clouds to form?

Temperature below the dew point

A surface on which to condense

14. On a cold, clear, calm winter night, the temperature is expected to drop from 0°C to -8°C during the night. The dew point is currently -6°C . What, if anything, do you expect to find on your car in the morning?

Frost because the dew point is lower than 0°C and the temperature is forecast to go below the dew point. Note that dew point will fall as water freezes or condenses out, but not as the dry bulb temperature. Therefore, there is a good chance the dew point and air temperature will both be -6°C to -8°C .

15. At 10,000 meters, the temperature and dew point are both 2°F . What do you expect to occur?

Condensation. Cloud formation.

16. Why is the temperature of a parcel of air cool as we go up in the atmosphere?

Air pressure is lower

17. What causes a parcel of air to go up in altitude?

Heating (convection) and forcing (fronts, orographic)

18. What do you think happens when a parcel of air is warmer than the surrounding air?

It continues to rise. Unstable.

Sample Lesson/ Unit 4 Tornadoes

Severe Weather Expert

Severe Weather Grades 10-12

- **How do Weather Experts find and interpret information?**
- **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.**
- **Science and Engineering Practices**
 1. Asking questions (science)/defining problems (engineering)
 2. Planning and carrying out investigations
 3. Analyzing and interpreting data*
 4. Using mathematics and computational thinking*
 5. Constructing explanations (science) and designing solutions (engineering)
 6. Obtaining, evaluating and communicating information*
- **Cross-cutting concepts from ELA and Math**
 1. Cause and Effect
 2. Influences of Science, Engineering Math, and Technology on Society
- **Disciplinary Core Ideas**

Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.

- **Method**

Objectives:

- Students will be able to find and verify severe storm forecasts using storm report data
- Students will be able to define of severe weather terminology used by the National Weather Service for watches and warnings.
- Students will interpret and appreciate the hazards that cause fatalities and injuries in the U.S. and pose and answer questions based on their analysis of the data presented.

Materials:

Chrome books or electronic device with internet access (1 per student)

“Severe Weather Expert” packet (1 per student)

Procedure:

- 1- Do Now: The class lists the locations and approximate dates of the severe weather they experienced.
- 2- The teacher asks the students about their own experiences. The class discusses where they have encountered severe weather and whether tornadoes are common at on Long Island.
- 3- The teacher shows charts and graphs with the climatology of New York tornadoes and of tornadoes in the US.

- 4- Based on prior knowledge of thunderstorms, the class discusses the likelihood of tornadoes in different months/seasons.
- 5- The teacher explains to the class that much of the information we find on severe storms in online at the NOAA web sites. The class is assigned to work in groups of two on the Severe Weather Expert packet. The teacher helps the students find the correct data.
- 6- After the students complete and submit the packet, the class reviews the answers and shares ideas on severe weather climatology and safety.
- 7- Closure: The teacher asks when and where would you expect to find tornadoes? Are tornadoes ever found in other months/times/places? Has anyone changed their thoughts on severe weather since the beginning of the lesson? What should you do in a tornado watch and tornado warning?

Severe Weather Expert (packet)

Part I: Background

On November 16, 2015 at 10:30 a.m. CST, the National Weather Service (NWS) Storm Prediction Center (SPC) located in Norman, OK issued a Convective Outlook that was valid from November 16 at 1630Z to November 17 at 1200Z which started: “Summary...Severe storms are expected to develop initially over the central and southern high plains late this afternoon into this evening. An extensive squall line should form tonight and push eastward across parts of Oklahoma and Texas. Tornadoes...damaging winds...and large hail are anticipated.”

1. Did the forecast on November 16th issued above for tornadoes, large hail and damaging winds verify at http://www.spc.noaa.gov/climo/reports/151116_rpts.html ____ Yes/No

How many Tornadoes Reports? ____ Hail Reports? ____

2. According to the annual summary for 2015 at https://www.spc.noaa.gov/climo/online/monthly/2015_annual_summary.html, which two months had the greatest number of severe weather storm reports? _____. Were there any severe weather reports in December? _____. Where did November rank in the number of tornado reports? _____. What does this tell us about when severe weather can occur?

Two years prior on November 17th, a large section of the U.S. experienced particularly dangerous, destructive, long-track tornadoes. http://www.spc.noaa.gov/climo/reports/131117_rpts.html The Washington, Illinois tornado was preliminarily rated as an EF-4 on an EF-0 to EF-5 scale with a path length (tornado on the ground) of over 40 miles.

Tornadoes, severe thunderstorms, hail and strong damaging winds have plagued the Gulf States, Mid-West and Southeast throughout 2011 and into the spring of 2012 with a burst of tornadoes in the summer of 2012 in the northeast, especially Massachusetts and once again in the Midwest in Fall of 2013 and not as numerous in 2014. These strong winds and storms have necessitated the National Weather Service to issue statements to the public

that pertain to winds that are associated with local convective storms (i.e., thunderstorms). One segment of the public targeted is those who drive "high profile vehicles," such as tractor-trailers, RVs, or campers that can be tipped over by strong winds.

- A "**high wind warning**" is issued to warn the public that sustained winds of 40 mph or greater are expected to last for one hour or longer. This warning is also used if winds of 58 mph or greater are anticipated for any time duration.
- A "**wind advisory**" is issued to advise the public of anticipated sustained wind speeds of 30 mph or greater lasting one hour or longer, or gusts to 45 mph for any duration.

-

SEVERE LOCAL STORM TERMINOLOGY

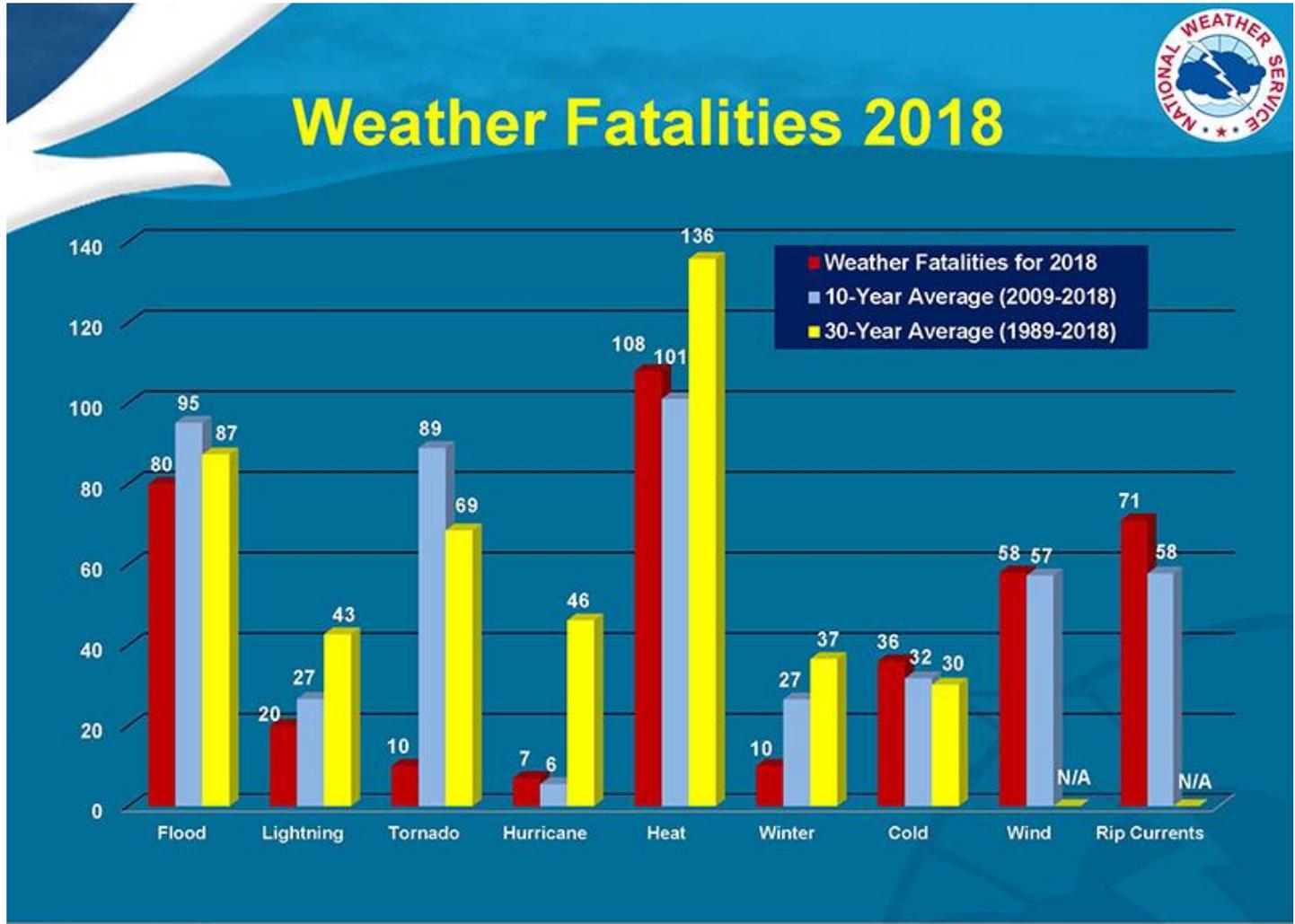
The following terminology is utilized by the National Weather Service (NWS) for those public statements that pertain specifically to severe local storms. These storms are usually convective and contain **severe weather** with large hail 1 inch (quarter-size) in diameter or larger (criteria as of 1/5/10) and/or strong winds (58 miles per hour or greater) (50 kts) as well as tornadoes and flash flooding due to excessive precipitation in thunderstorms. A description of those statements used to alert the public for flash floods and other pertinent terms are listed below:

- **Severe thunderstorm watch** -- Issued by the Storm Prediction Center <http://www.spc.noaa.gov/> in Norman, OK as opposed to the local NWS Forecast Office (NYC in Upton or Albany, NY or Mt. Holly, NJ, for example) to alert the public that conditions are favorable for development of thunderstorms meeting any of the criteria of large hail (1-inch diameter or larger) and/or strong winds (58 miles per hour or greater) (50 kts) in or close to the watch area. Watches typically are in effect for several hours.
- **Severe thunderstorm warning** -- Issued by the local NWS Forecast Office to warn the public that a thunderstorm producing 1-inch (2.54-centimeter) or larger diameter hail and/or winds equal to 58 miles per hour or greater is imminent or occurring. The warning indicates where the severe thunderstorm(s) has/have been located, what communities are to be affected and the primary threats to public safety that are associated with the storm(s). Persons in the affected area should take immediate action. Initial here for five points and keep it to yourself.
- **Tornado watch** -- Issued by the Storm Prediction Center (SPC) to alert the public that **conditions are favorable for the development of tornadoes in and close to the watch area, which is delineated in the tornado watch statement**. These watches are issued with information concerning the watch area and the length of time they are in effect. Tornado watches are usually in effect for several hours.
- **Tornado warning** -- Issued by the local NWS Forecast Office **to warn the public that a tornado has been sighted by storm spotters or has been indicated by Doppler radar**. These warnings are issued with information concerning where the tornado is presently located and what communities are in the anticipated path of the tornado. The public is expected to heed these warnings and take appropriate action.

3. On November 17, 2013, how many states had tornado reports? Which ones?

4. How are the reports organized (circle one)? **By severity/by time/by location**
5. What important information is shown in red? _____

Part 2: Severe Weather Hazards



The United States has the highest number of tornadoes of any country in the world. More than 1,000 tornadoes are reported each year on average across the country. The public has the notion that tornadoes cause more fatalities than most other weather events. This lab will examine whether this is always true. The U.S. government archives the number of fatalities and injuries with the various types of weather as well as the number of incidences of severe weather by the Storm Prediction Center (SPC). The statistics on fatalities associated with severe weather are summarized in the graphic above and can be found at the Natural Hazard Statistics: <http://www.nws.noaa.gov/om/hazstats.shtml>.

6. a. What weather hazard in 2018 was responsible for the highest number of fatalities? _____
- b. What age group(s) do you think made up the majority of these fatalities in the highest weather hazard category? _____
- c. How do you think the number can the number be reduced?
-

7. The 30-year average number of hurricane fatalities (1989-2018) is much higher than the 10-year average (2009-2018). Why do you think this is the case?
-

8. Visit <http://www.nws.noaa.gov/om/hazstats.shtml> and change the year under “U.S. Summaries” to 2005. What was the number of hurricane fatalities? What happened in 2005 that caused this number to be so much higher than the average?
-
-

9. Visit <http://www.nws.noaa.gov/om/hazstats.shtml> and change the year under “U.S. Summaries” to 2014.
- a. What 2014 weather-related event had the highest combined number of fatalities and injuries? What had the second most? Why was the number from Hurricanes zero?
-

- b. The number of fatalities and injuries from extreme cold temperature events in 2014 represents what percentage (rounded to the nearest tenth of a percent) of the total combined number of fatalities and injuries from weather events? _____
- c. Which killed more people in 2014 (circle one)? (**lightning, flash floods, or tornadoes**)
- d. Which inflicted more economic property damage in 2014 (circle one)? (**river floods, flash floods, hail or tornadoes**)

10. Visit <http://www.nws.noaa.gov/om/hazstats.shtml> and change the year under “U.S. Summaries” to 2018.

- a. Which two weather events caused the most money in damage? _____

b. How *might* the numbers change if the statistics included **only** the U.S. States (and not the territories)? _____

c. Did more males or females perish from 2018 natural hazards in the U.S? _____

Why might this be the case? _____

d. Switch to "State Summaries": Which state had the most weather related fatalities in 2018? _____ Why might this be the case? _____.

11. Visit <http://www.nws.noaa.gov/om/hazstats.shtml> and change the year under "U.S. Summaries" to 2017.

a. Which two consecutive months had the greatest number of natural hazard fatalities in 2017? _____ and _____.

b. Weather-wise, why do these two consecutive months on average have a high number of fatalities from year to year? _____

Utilize Any of the Information on <http://www.nws.noaa.gov/om/hazstats.shtml> to answer the following:

12. In 2016, **in which location/place** did the fatalities in New York State from lightning occur? _____.

13. In 2018, **in which location/place**, not state, did most lightning fatalities occur? _____. How might this number be reduced? _____

14. What does the designation "BF" under lightning mean? _____. Why is this particularly concerning? _____

15. In 2017, **in which location/place**, not state, did the majority of tornado deaths occur? _____

16. In 2014, out of the 47 total tornado fatalities, _____ occurred in schools, while _____ occurred in mobile/trailer and permanent homes combined. How many of the 47 total tornadoes fatalities occurred while the victims were in vehicles/towed trailer? _____. What are some reasons the number of tornado deaths in schools is small? _____

17. In 2018, how many weather-related deaths were reported in New York State? _____. What weather event(s) caused these deaths – circle the one that caused the most fatalities? _____

18. In 2018, how many total states reported fatalities from tornadoes? _____

19. In 2019, how many total states reported fatalities from tornadoes? _____. Which state(s) had the most fatalities from tornadoes? _____

20. Which state in 2019 experienced the most weather-related injuries & fatalities combined?

21. Why is the dollar amount of crop damage important? _____
22. What is Fire Weather and why is it listed in the annual summaries as a weather event?

23. Based on the annual # of fatalities from 1940 to 2018, which natural hazard has shown & generally maintained a downward trend? _____
24. How has the dollar amount of all hazard damages varied over the time period from 1988 to 2018?
_____2
25. Compose and answer an original interesting, educational question **based on multiple parameters of data, not dependent on a single entry in any given table**, not answered by the text or asked by your teacher. Pose the question here and answer it **on the next page showing how you determined your answer** based on the data presented in any or all of the tables and figures.

Answer your posed question below **and include the reference to the data table(s) utilized.**

Then show another group your question.

What was their answer? _____

Did she/he answer it correctly? _____

If not, what did she/he do wrong or clarify the question below:

Severe Weather Expert (packet) ANSWER KEY

Part I: Background

On November 16, 2015 at 10:30 a.m. CST, the National Weather Service (NWS) Storm Prediction Center (SPC) located in Norman, OK issued a Convective Outlook that was valid from November 16 at 1630Z to November 17 at 1200Z which started: "Summary...Severe storms are expected to develop initially over the central and southern high plains late this afternoon into this evening. An extensive squall line should form tonight and push eastward across parts of Oklahoma and Texas. Tornadoes...damaging winds...and large hail are anticipated."

1. Did the forecast on November 16th issued above for tornadoes, large hail and damaging winds verify at http://www.spc.noaa.gov/climo/reports/151116_rpts.html ___ **Yes/No yes**

How many Tornadoes Reports? ___ **50** ___ Hail Reports? ___ **42** ___

2. According to the annual summary for 2015 at https://www.spc.noaa.gov/climo/online/monthly/2015_annual_summary.html, which two months had the greatest number of severe weather storm reports? ___ **June & July** ___. Were there any severe weather reports in December? ___ **Yes** ___. Where did November rank in the number of tornado reports? ___ **4th** ___. What does this tell us about when severe weather can occur? **Can occur in any month but more common in the summer**

Two years prior on November 17th, a large section of the U.S. experienced particularly dangerous, destructive, long-track tornadoes. http://www.spc.noaa.gov/climo/reports/131117_rpts.html The Washington, Illinois tornado was preliminarily rated as an EF-4 on an EF-0 to EF-5 scale with a path length (tornado on the ground) of over 40 miles.

Tornadoes, severe thunderstorms, hail and strong damaging winds have plagued the Gulf States, Mid-West and Southeast throughout 2011 and into the spring of 2012 with a burst of tornadoes in the summer of 2012 in the northeast, especially Massachusetts and once again in the Midwest in Fall of 2013 and not as numerous in 2014. These strong winds and storms have necessitated the National Weather Service to issue statements to the public that pertain to winds that are associated with local convective storms (i.e., thunderstorms). One segment of the public targeted is those who drive "high profile vehicles," such as tractor-trailers, RVs, or campers that can be tipped over by strong winds.

- A "**high wind warning**" is issued to warn the public that sustained winds of 40 mph or greater are expected to last for one hour or longer. This warning is also used if winds of 58 mph or greater are anticipated for any time duration.
- A "**wind advisory**" is issued to advise the public of anticipated sustained wind speeds of 30 mph or greater lasting one hour or longer, or gusts to 45 mph for any duration.

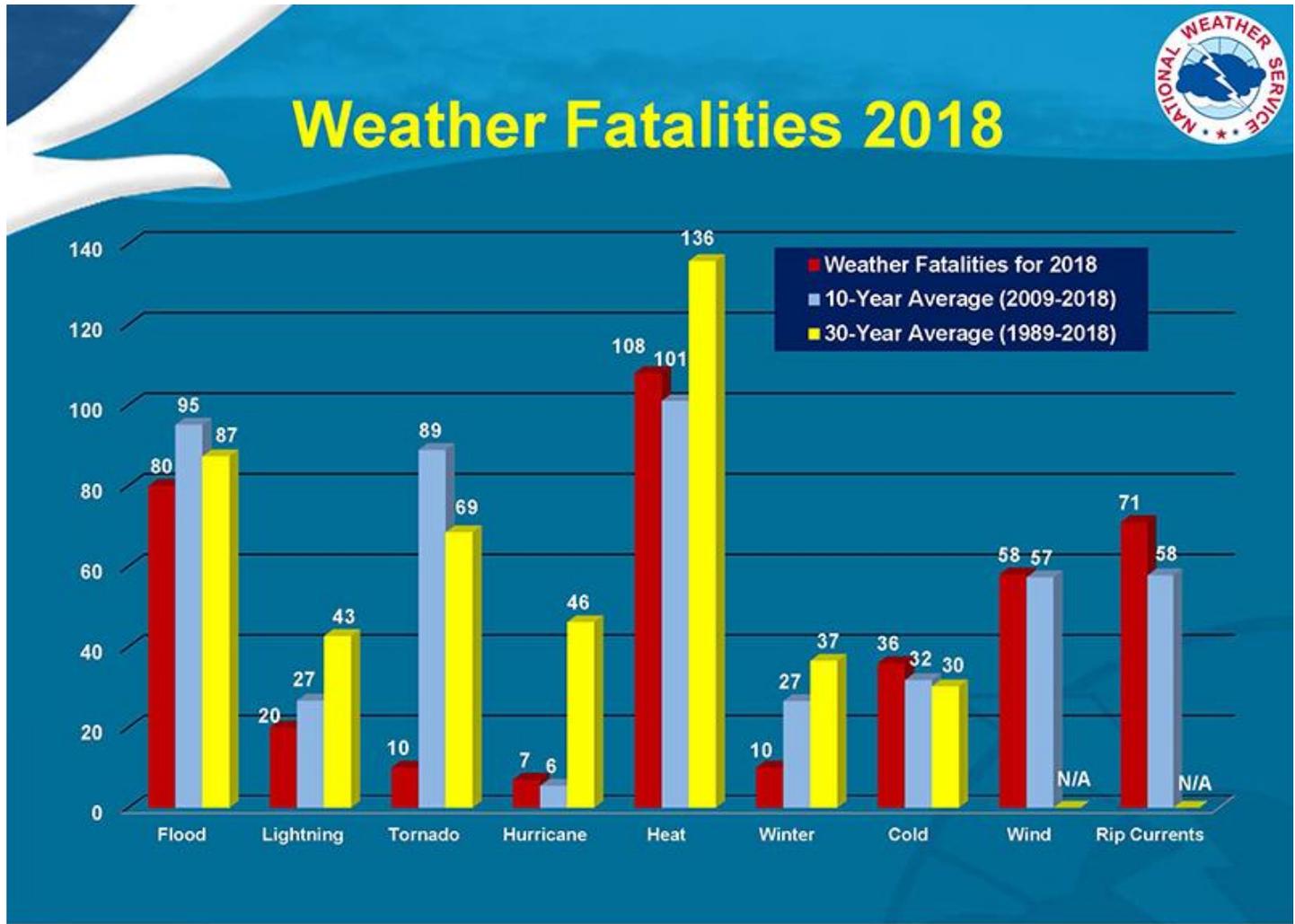
SEVERE LOCAL STORM TERMINOLOGY

The following terminology is utilized by the National Weather Service (NWS) for those public statements that pertain specifically to severe local storms. These storms are usually convective and contain **severe weather** with large hail 1 inch (quarter-size) in diameter or larger (criteria as of 1/5/10) and/or strong winds (58 miles per hour or greater) (50 kts) as well as tornadoes and flash flooding due to excessive precipitation in thunderstorms. A description of those statements used to alert the public for flash floods and other pertinent terms are listed below:

- **Severe thunderstorm watch** -- Issued by the Storm Prediction Center <http://www.spc.noaa.gov/> in Norman, OK as opposed to the local NWS Forecast Office (NYC in Upton or Albany, NY or Mt. Holly, NJ, for example) to alert the public that conditions are favorable for development of thunderstorms meeting any of the criteria of large hail (1-inch diameter or larger) and/or strong winds (58 miles per hour or greater) (50 kts) in or close to the watch area. Watches typically are in effect for several hours.
- **Severe thunderstorm warning** -- Issued by the local NWS Forecast Office to warn the public that a thunderstorm producing 1-inch (2.54-centimeter) or larger diameter hail and/or winds equal to 58 miles per hour or greater is imminent or occurring. The warning indicates where the severe thunderstorm(s) has/have been located, what communities are to be affected and the primary threats to public safety that are associated with the storm(s). Persons in the affected area should take immediate action. Initial here for five points and keep it to yourself.
- **Tornado watch** -- Issued by the Storm Prediction Center (SPC) to alert the public that **conditions are favorable for the development of tornadoes in and close to the watch area, which is delineated in the tornado watch statement.** These watches are issued with information concerning the watch area and the length of time they are in effect. Tornado watches are usually in effect for several hours.
- **Tornado warning** -- Issued by the local NWS Forecast Office **to warn the public that a tornado has been sighted by storm spotters or has been indicated by Doppler radar.** These warnings are issued with information concerning where the tornado is presently located and what communities are in the anticipated path of the tornado. The public is expected to heed these warnings and take appropriate action.

3. On November 17, 2013, how many states had tornado reports? Which ones? _____ **7, Indiana, Ohio, Michigan, Tennessee, Missouri, Kentucky, Illinois** _____
4. How are the reports organized (circle one)? **By severity/by time/by location**
5. What important information is shown in red? _____ **Injuries** _____

Part 2: Severe Weather Hazards



The United States has the highest number of tornadoes of any country in the world. More than 1,000 tornadoes are reported each year on average across the country. The public has the notion that tornadoes cause more fatalities than most other weather events. This lab will examine whether this is always true. The U.S. government archives the number of fatalities and injuries with the various types of weather as well as the number of incidences of severe weather by the Storm Prediction Center (SPC). The statistics on fatalities associated with severe weather are summarized in the graphic above and can be found at the Natural Hazard Statistics: <http://www.nws.noaa.gov/om/hazstats.shtml>.

6. a. What weather hazard in 2018 was responsible for the highest number of fatalities?
 heat
- b. What age group(s) do you think made up the majority of these fatalities in the highest weather hazard category? elderly
- c. How do you think the number can the number be reduced?

Cooling centers, central air in buildings _____

7. The 30-year average number of hurricane fatalities (1989-2018) is much higher than the 10-year average (2009-2018). Why do you think this is the case?

_____ There weren't as many US landfalling tropical storms in the past 10 years _____

8. Visit <http://www.nws.noaa.gov/om/hazstats.shtml> and change the year under "U.S. Summaries" to 2005. What was the number of hurricane fatalities? What happened in 2005 that caused this number to be so much higher than the average?

1,016 Hurricane Katrina _____

9. Visit <http://www.nws.noaa.gov/om/hazstats.shtml> and change the year under "U.S. Summaries" to 2014.
- a. What 2014 weather-related event had the highest combined number of fatalities and injuries? What had the second most? Why was the number from Hurricanes zero?

Winter Storms; Tornadoes; Few landfalling tropical storms and hurricanes _____

- b. The number of fatalities and injuries from extreme cold temperature events in 2014 represents what percentage (rounded to the nearest tenth of a percent) of the total combined number of fatalities and injuries from weather events? 11% _____
- c. Which killed more people in 2014 (circle one)? (*lightning, flash floods, or tornadoes*)
- d. Which inflicted more economic property damage in 2014 (circle one)? (*river floods, flash floods, hail or tornadoes*)
10. Visit <http://www.nws.noaa.gov/om/hazstats.shtml> and change the year under "U.S. Summaries" to 2018.

a. Which two weather events caused the most money in damage? _____ Fire weather & Tropical storms/hurricanes _____

b. How *might* the numbers change if the statistics included **only** the U.S. States (and not the territories)? _____ Reduction in all numbers from tropical storms/hurricanes _____

c. Did more males or females perish from 2018 natural hazards in the U.S? **males** _____

Why might this be the case? _____ male firefighters _____

d. Switch to “State Summaries”: Which state had the most weather-related fatalities in 2018? _____ **CA** _____ Why might this be the case? _____ **Wild fires** _____.

11. Visit <http://www.nws.noaa.gov/om/hazstats.shtml> and change the year under “U.S. Summaries” to 2017.

a. Which two consecutive months had the greatest number of natural hazard fatalities in 2017? _____ **July** _____ and _____ **August** _____.

b. Weather-wise, why do these two consecutive months on average have a high number of fatalities from year to year? _____ **More of severe weather occurs in those months, including tropical storms and forest fires** _____

Utilize Any of the Information on <http://www.nws.noaa.gov/om/hazstats.shtml> to answer the following:

12. In 2016, in which location/place did the fatalities in New York State from lightning occur? _____ **Under trees** _____.

13. In 2018, in which location/place, not state, did most lightning fatalities occur? _____ **outside** _____. How might this number be reduced? _____ **When Thunder Roars go Indoors; more lead time in forecasts; etc.** _____

14. What does the designation “BF” under lightning mean? _____ **ball field** _____. Why is this particularly concerning? _____ **children at the mercy of umpires and coaches** _____

15. In 2017, in which location/place, not state, did the majority of tornado deaths occur? _____ **mobile homes/trailers** _____

16. In 2014, out of the 47 total tornado fatalities, _____ **0** _____ occurred in schools, while _____ **38** _____ occurred in mobile/trailer and permanent homes combined. How many of the 47 total tornadoes fatalities occurred while the victims were in vehicles/towed trailer? _____ **5** _____. What are some reasons the number of tornado deaths in schools is small? _____ **Time of day; time of year; shelters** _____

17. In 2018, how many weather-related deaths were reported in New York State? _____ **13** _____. What weather event(s) caused these deaths – circle the one that caused the most fatalities? _____ **cold** (1), heat (2), lightning (1), tornado (1), **wind** (3), winter weather (2), other (3) _____

18. In 2018, how many total states reported fatalities from tornadoes? _____ **9** _____.

19. In 2019, how many total states reported fatalities from tornadoes? _____ **TBD** _____. Which state(s) had the most fatalities from tornadoes? _____ **TBD** _____

20. Which state in 2019 experienced the most weather-related injuries & fatalities combined? _____ **TBD** _____

21. Why is the dollar amount of crop damage important? _____ **Economic loss, possible famine and supply/demand problems, farming economy** _____

22. What is Fire Weather and why is it listed in the annual summaries as a weather event? Wild Fires; It is listed because it can be caused by lightning and spreads due to heat and wind.
23. Based on the annual # of fatalities from 1940 to 2018, which natural hazard has shown & generally maintained a downward trend? Lightning
24. How has the dollar amount of all hazard damages varied over the time period from 1988 to 2018?
Varies greatly based on weather events which are highly variable from year to year. Events that effect large areas like floods, tropical storms and wild fires are highly variable.
25. Compose and answer an original interesting, educational question **based on multiple parameters of data, not dependent on a single entry in any given table**, not answered by the text or asked by your teacher. Pose the question here and answer it **on the next page showing how you determined your answer** based on the data presented in any or all of the tables and figures.

Answer your posed question below **and include the reference to the data table(s) utilized.**

Then show another group your question.

What was their answer? _____

Did she/he answer it correctly? _____

If not, what did she/he do wrong or clarify the question below:

Sample Lesson/Unit 5 – Tropical Cyclones

Hurricane Analysis

- **HS-ESS2-8. Evaluate data and communicate information to explain how the movement and interactions of air masses result in changes in weather conditions.**
- **Science and Engineering Practices**
 1. Asking questions (science)/defining problems (engineering)
 2. Developing and using models
 3. Planning and carrying out investigations
 4. Analyzing and interpreting data*
 5. Using mathematics and computational thinking*
 6. Constructing explanations (science) and designing solutions (engineering)
 7. Engaging in argument from evidence*
 8. Obtaining, evaluating and communicating information*
- **Cross-cutting concepts from ELA and Math**
 1. Systems and Systems Modeling
 2. Energy and Motion
 3. Cause and Effect
 4. Influences of Science, Engineering Math, and Technology on Society
- **Disciplinary Core Ideas**
 1. ESS2.D: Weather and Climate

Method

Objectives:

The student will be able to:

- Refresh their isoplething skills
- Locate the eye of a hurricane on a personally isoplethed map and justify their positioning of the eye
- Analyze and evaluate the evacuation routes in a fictitious location during a hurricane landfall
- Plot the location of a hurricane during its life
- Determine the location of the steering Bermuda high for a hurricane and justify the position.

Materials:

- Tropical Cyclones powerpoint
- Hurricane analysis activity

Activities:

1. Discuss tropical cyclones through powerpoint presentation.
2. Analyze recent hurricanes, their track, growth, life, etc.
3. Students work on Hurricane Analysis activity (see below).
4. Closure: Discuss project that will be completed next. Students will have the opportunity to research ways to protect their home from hurricane damage.

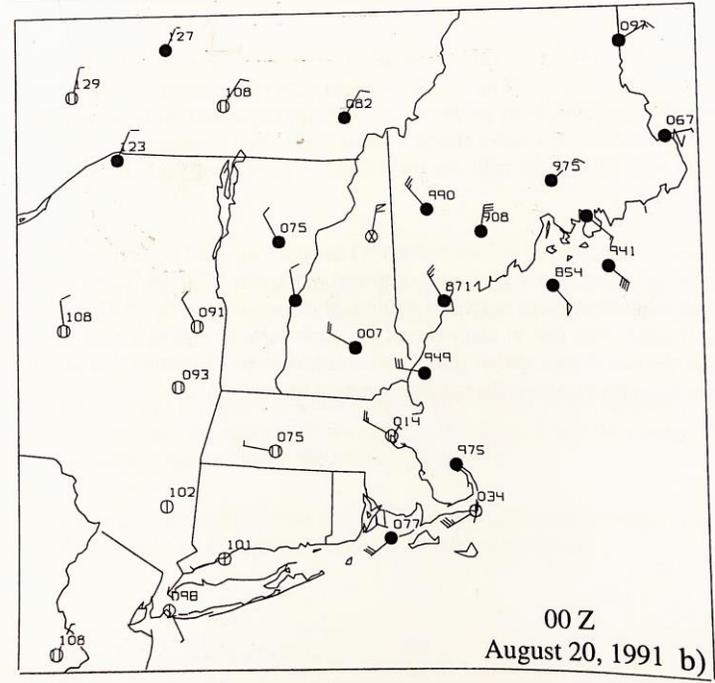
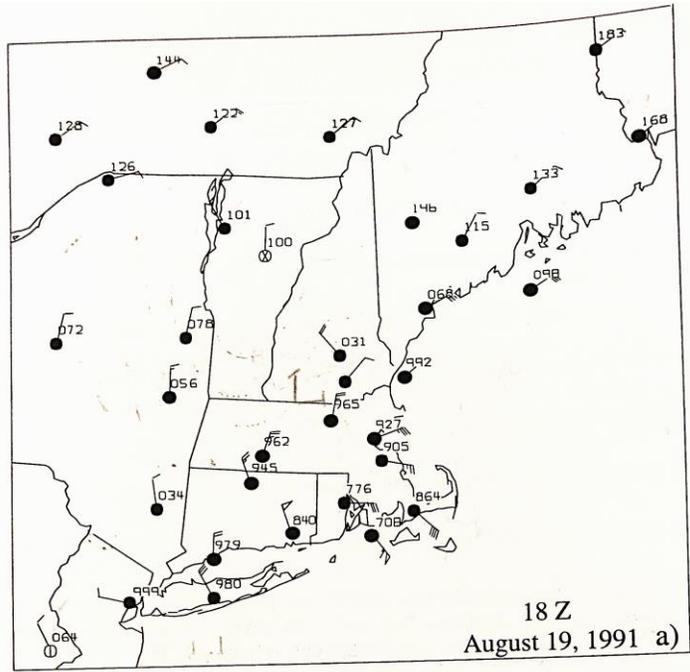
Name: _____

Date: _____

Hurricane Analysis

Directions: Answer the questions that follow.

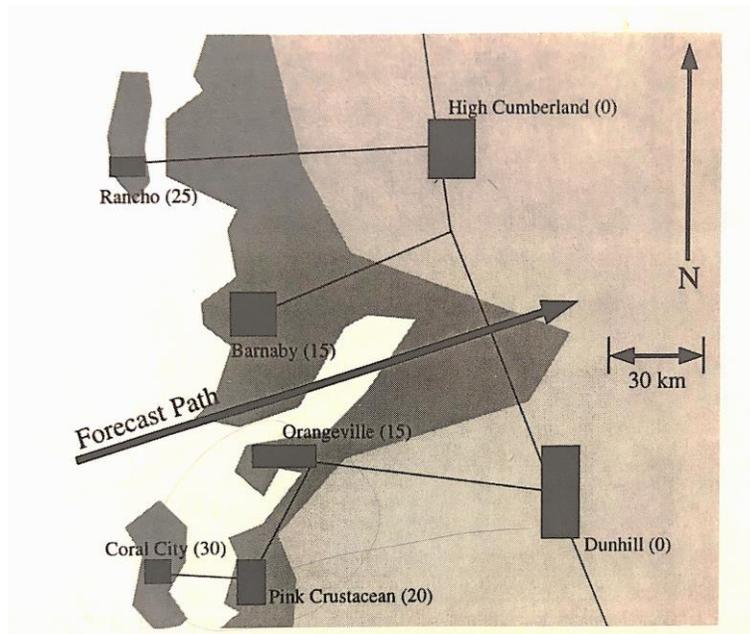
1. The surface weather maps in figures “a” and “b” from August 1991 correspond to the period when Hurricane Bob affected the coast of the northeastern United States.
 - a. On each map, draw the 992mb, 996mb, and 1000mb isobars.
 - b. Indicate with an “X” the approximate location of the eye of the hurricane on each map. Justify your positioning of the “X” in a few sentences below.



2. You are the Disaster Emergency Director of Valencia County, a fictitious county along the west coast of Florida. A map of the county is given in the figure below. The National Hurricane Center has just issued a hurricane warning for your area, and forecasters say that the eye of Hurricane Robert, a category-5 storm, will likely pass just north of Orangeville in 22 hours. The forecasted path of the storm is shown in the figure below. Assume that the outer edge of the eye wall of Robert has a radius of 30km (19mi). A computer model used to estimate what land areas will be affected by a hurricane’s storm surge predicts that the dark-shaded areas along the coast will be inundated with water. Times for evacuation of the individual communities (in hours) are given next to their names. Primary highways are shown. Based on the forecasted track, answer the following questions from the media:

- a. Can all the communities be evacuated in time? If not, which one(s) can't?

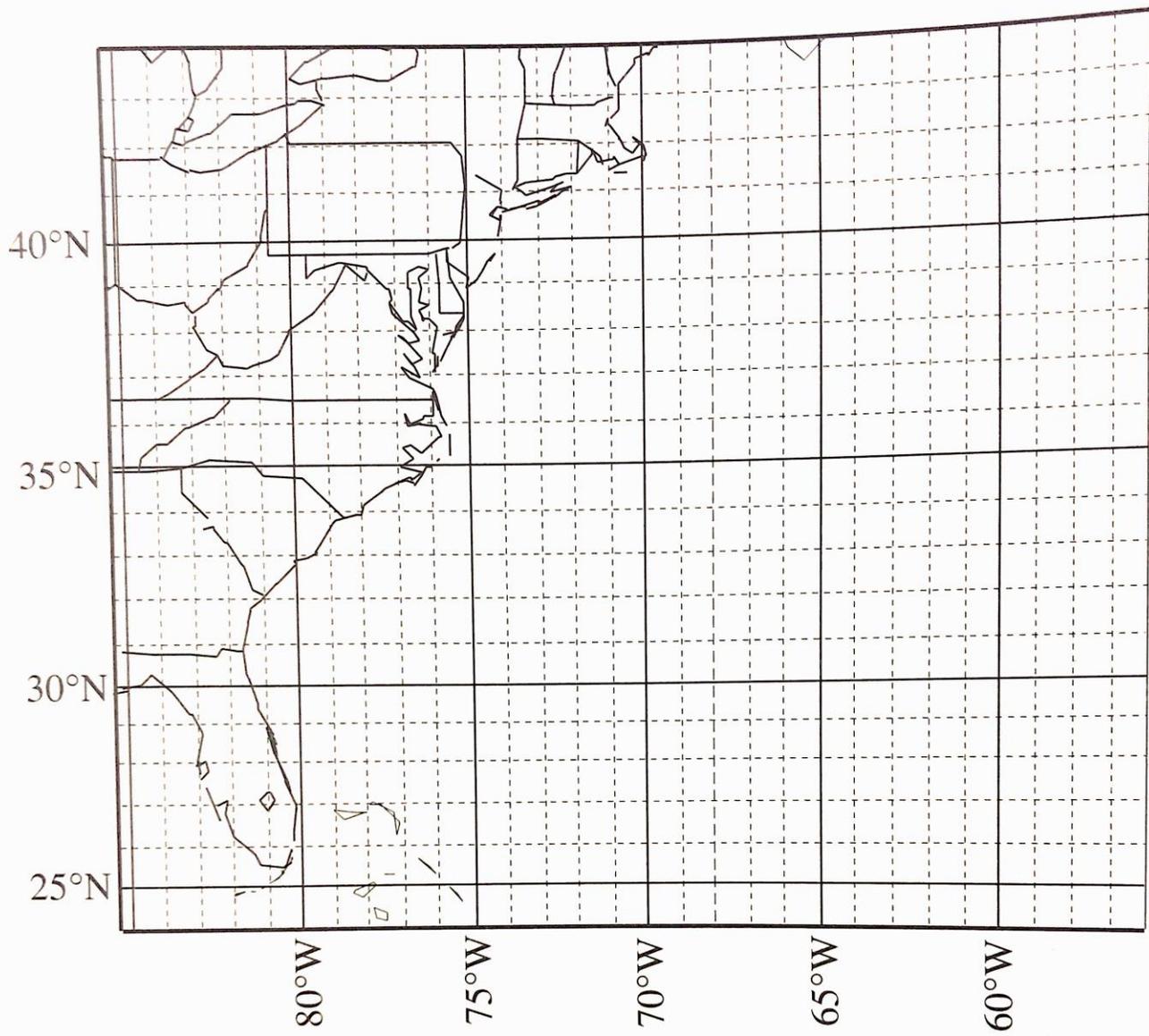
- b. Which community (or communities) is going to face the worst storm surge? Justify your answer.
- c. Which of the communities that cannot be evacuated are you most concerned about? Why?
- d. If you could have one more primary highway between two cities, what cities would be connected?
- e. How would this help?



3. Late on August 31, 1993, Hurricane Emily skirted the Outer Banks of North Carolina, but its eye never came inland. Below you are given the latitude (in °N), longitude (in °W), and maximum sustained wind speed (in knots) for Emily at 00Z and 12Z on each day from August 26 to September 3, 1993.

<i>Lat (°N)</i>	<i>Lon (°W)</i>	<i>Date</i>	<i>Time (GMT)</i>	<i>Wind Speed (knots)</i>
28.30	60.70	Aug. 26	00Z	45
27.40	61.20	Aug. 26	12Z	60
26.60	62.40	Aug. 27	00Z	60
26.30	63.50	Aug. 27	12Z	60
26.60	65.20	Aug. 28	00Z	75
27.40	66.90	Aug. 28	12Z	75
28.60	68.20	Aug. 29	00Z	70
30.00	69.20	Aug. 29	12Z	70
31.20	70.20	Aug. 30	00Z	70
31.80	71.40	Aug. 30	12Z	75
32.40	73.00	Aug. 31	00Z	80
33.60	74.70	Aug. 31	12Z	95
35.60	74.90	Sep. 1	00Z	100
37.50	72.70	Sep. 1	12Z	95
39.00	68.50	Sep. 2	00Z	90
39.20	63.60	Sep. 2	12Z	90
38.60	59.60	Sep. 3	00Z	80
37.50	57.70	Sep. 3	12Z	70

- On the figure below, plot the location of Emily at each time given above (use the official tropical storm and hurricane symbols). When the storm was a hurricane, indicate next to the hurricane symbol the Saffir-Simpson category.
- On the figure below, indicate with an "H" where you think the average position of the Bermuda high was during the time period from August 26 through September 3. Justify your answer in a few sentences below.



Sample Lesson/Unit 6 Upper Air

- **Using Upper Air to Forecast the Weather**
- **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.**
- **Science and Engineering Practices**
 1. Asking questions (science)/defining problems (engineering)
 2. Developing and using models
 3. Planning and carrying out investigations
 4. Analyzing and interpreting data*
 5. Engaging in argument from evidence*
 6. Obtaining, evaluating and communicating information*
- **Cross-cutting concepts from ELA and Math**
 - Patterns
 - Systems and Systems Modeling
 - Energy and Motion
 - Cause and Effect
 - Scale, Proportion, and Quantity
 - Influences of Science, Engineering Math, and Technology on Society
- **Disciplinary Core Ideas**
 - a. **Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.**
Forecasting the weather using upper air models
 - **Method**

Forecasting the Weather Using Upper Air Models

Severe Weather Grades 10-12

Objectives:

The student will be able to:

- Use models of the upper atmosphere to predict weather at the surface of the Earth
- Communicate prediction to the class using supporting data
- Argue in support of their forecast

Materials:

- Chrome books or electronic device with internet access (1 per student)
- Smartboard
- Upper Air data handout “My First Forecast” (1 per student)
- “My First Forecast” Presentation Chart (1 per student)

Activities:

1. Define the problem [scientific method: identify the problem]: Tell the students that we need a weather forecast for tomorrow at 7 PM because of a sporting event. Should we sell the tickets?

2. Students will work in groups to access the weather models at <https://mag.ncep.noaa.gov/> and choose “Panels” “NAMER” and “GFS_200_wnd_ht, 500_vort_ht, 1000_500_thick, 850_temp_ht” Starting with Forecast Hour 000, answer the questions on the Upper Air Data handout.
3. Each group will come to the Smartboard and present their analysis of the weather leading up to 7 PM tomorrow and their forecast. While they listen, the other students will complete the “My First Forecast” Presentation Chart.
4. Group discussion: The teacher will correct any misconceptions about the weather by making his or her own presentation. The students can then discuss their ideas and come up with a class forecast.
5. Closure = The teacher asks the students which chart they found most useful in this particular forecast and why. The teacher will remind the students that forecasters use various charts to make critical forecasts every day. The teacher will collect the Handout and the Presentation Charts from each student.
6. Homework (to be completed the following evening and submitted): Was your forecast correct? Why or why not? If you made another forecast, what if anything would you do differently?

Rubric for Assessment (out of 16 points):

Category	4	3	2	1
Handout	Well thought out and scientific	Well thought out but missing accurate science	Not well thought out but complete	Incomplete
Presentation	Engaging and accurate	Accurate or engaging but not both	Weak	Difficult to understand
Homework	Well thought out and reflective	Well thought out or reflective but not both	Inaccurate	Incomplete
Forecast	Very accurate (more than class forecast)	Somewhat accurate (similar to class forecast)	Not accurate (or less accurate than class forecast)	Not anywhere close (assuming class forecast was close)

Add 1 point for every “most interesting” vote and 1 point for every “most scientific” vote.

Sample Lesson/Unit 7 Nor'easters and Blizzards

- **Case Study March 2-3, 2018 Nor'easter**
- **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.**
- **Science and Engineering Practices**
 1. Planning and carrying out investigations
 2. Analyzing and interpreting data*
 3. Constructing explanations (science) and designing solutions (engineering)
 4. Engaging in argument from evidence*
 5. Obtaining, evaluating and communicating information*
- **Cross-cutting concepts from ELA and Math**
 1. Patterns
 2. Energy and Motion
 3. Cause and Effect
 4. Scale, Proportion, and Quantity
 5. Influences of Science, Engineering Math, and Technology on Society
- **Disciplinary Core Ideas**
 1. **Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.**
Using data to analyze a storm and learn from the past.
- **Method**

How does dew form? How do clouds form?

Case Study March 2-3, 2018 Nor'easter

Severe Weather Grades 10-12

Objectives:

The student will be able to:

- Analyze surface and upper air weather maps to describe storm movement and development
- Find and analyze storm data from National Weather Service products
- Seek and find reliable media information regarding storms on the internet
- Create an argument-based speech on a timely and important NWS decision

Materials:

- Chrome books or computers (1/student)
- Case Study March 2-3, 2018 Nor'easter packet (1/student)
- Storm event spreadsheets (1/student)

Activities:

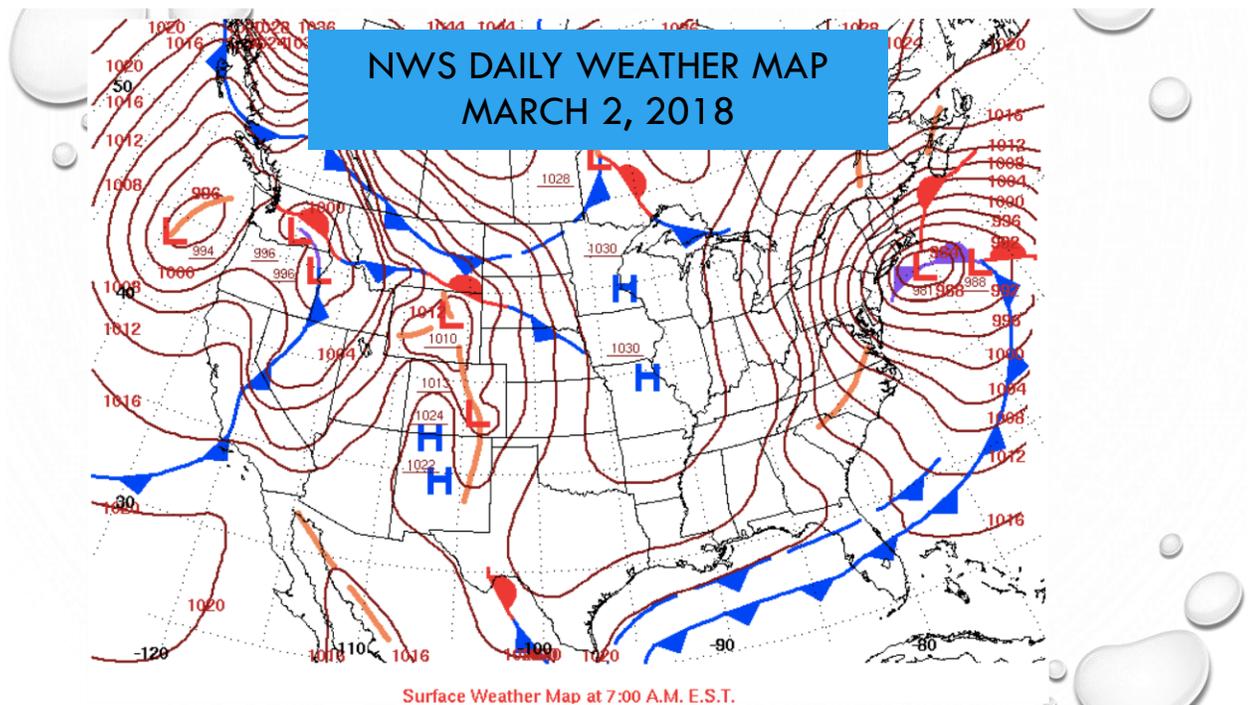
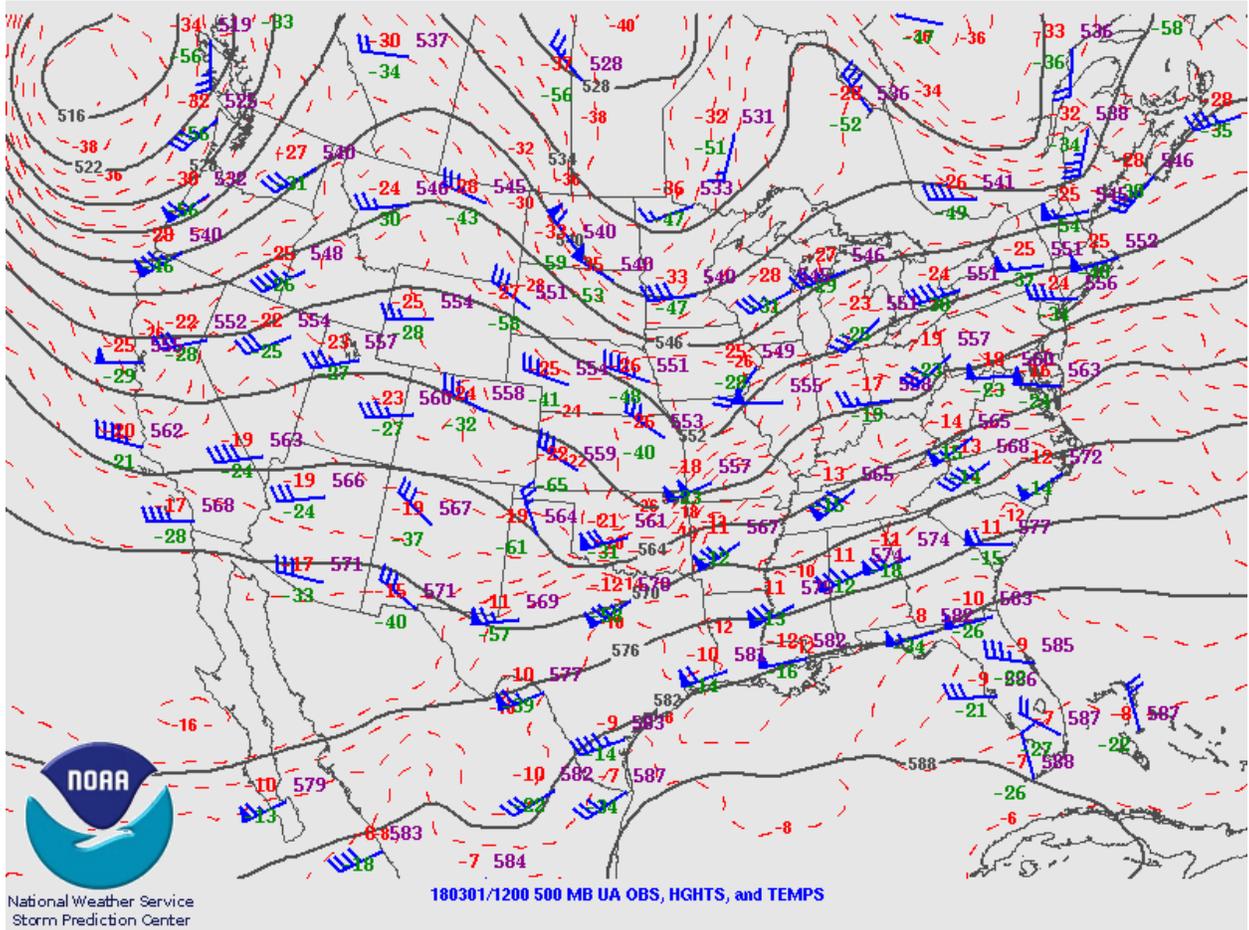
1. Motivation: The teacher will ask the students to recall times when they had a "snow day" and whether they felt the call was the right decision. The teacher will also ask the students if they have had times when there was no "snow day" but felt that there should have been one.

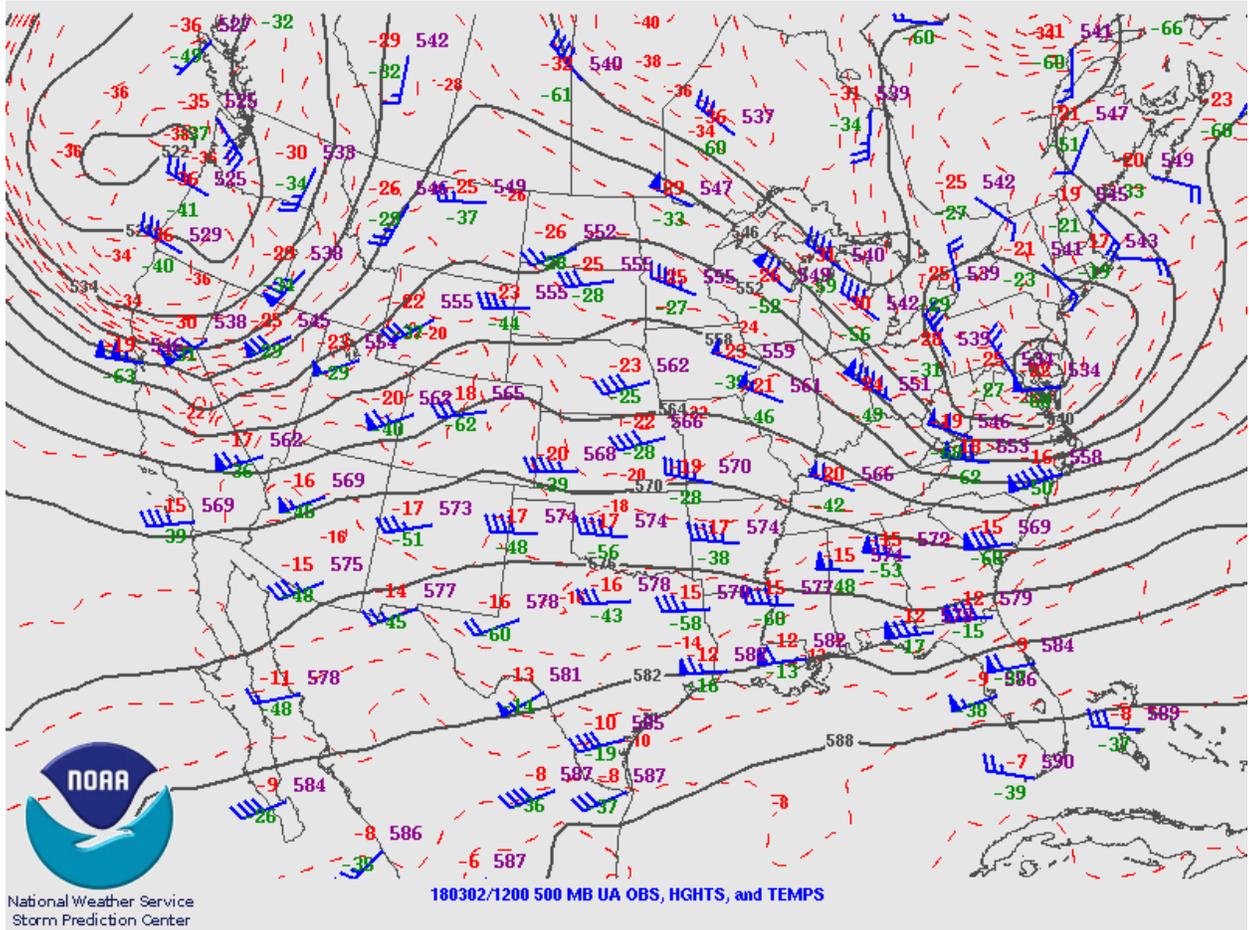
2. The teacher will go over the popular term “bomb cyclone” using the power point on Nor’easters and the example. The class will discuss whether it is easy or difficult to predict what will happen in such a case.
3. The teacher will hand out the “Case Study March 2-3, 2018 Nor’easter” and ask the students to answer the questions while the teacher helps the students find the information.
4. The class will discuss the results of the case study.
5. Relate it back to snow days: What makes it so difficult to forecast for a snow day from a nor’easter? The time of year (sun angle and melting), rain/snow line. What other factors from the storm may influence the decision? High winds, heavy rain and flooding.
6. Students will take turns giving their speech to the class.
7. Closure: What makes a nor’easter so powerful? Why are we concerned about nor’easters on Long Island? Where can we find reliable information after a storm? What do you think can happen when all the snow around the Hudson tributary begins to melt? We will be studying water equivalent precipitation tomorrow.

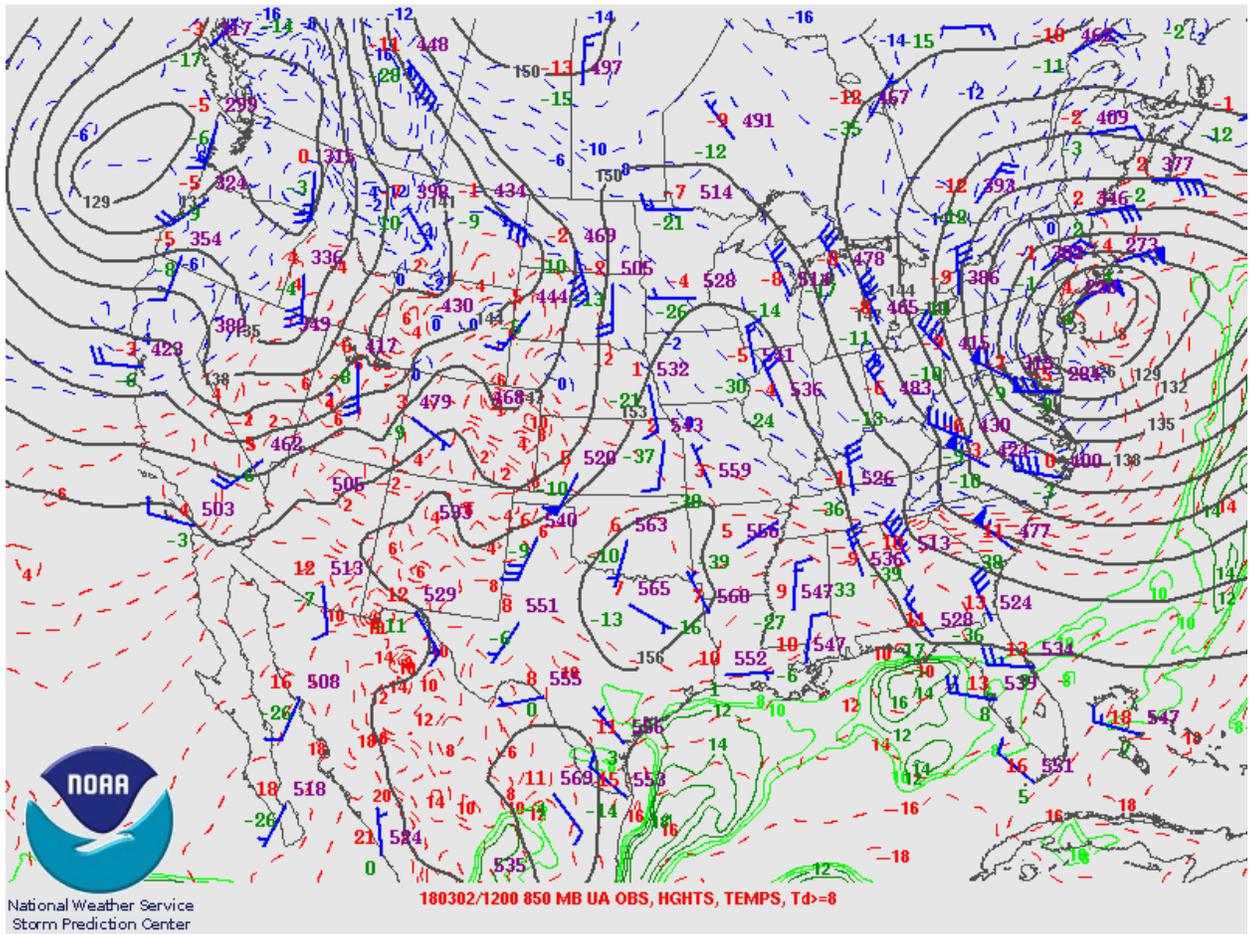
Speech grading rubric:

Dimension	Excellent	Very Good	Fair	Needs Work
Followed directions	4	3	2	1
Position well thought out and supported	6	4	3	1
Use of suggestions for persuading an audience	4	3	2	1
Eloquence of written speech	4	3	2	1
Correct spelling and grammar	2	1.5	1	0.5

18.5-20 = A; 16.5-18 = A-; 14.5-16 = B+; 12.5-14 = B; 10.5-12 = B-; 8.5-10 = C+; 6.5-8 = C, 5.5-6 = C-; 4.5-5 = D, <5 = F







STORM SUMMARY NUMBER 7 FOR GREAT LAKES TO NEW ENGLAND WINTER STORM
 WITH COASTAL WIND AND RAIN
 NWS WEATHER PREDICTION CENTER COLLEGE PARK MD
 1000 AM EST SAT MAR 03 2018

...AN INTENSE LOW PRESSURE SYSTEM CONTINUES ITS SLOW EASTWARD
 MOTION AWAY FROM THE COAST. THERE ARE VERY SCATTERED AND LOW
 INTENSITY RAIN SHOWERS ACROSS SOUTHEAST MASSACHUSETTS AND WITHIN
 OFFSHORE WATERS OF LONG ISLAND AND NEW ENGLAND.

WIND ADVISORIES REMAIN IN EFFECT ALONG COASTAL COUNTIES OF NEW
 ENGLAND AND LONG ISLAND.

FOR A DETAILED GRAPHICAL DEPICTION OF THE LATEST

WATCHES...WARNINGS AND ADVISORIES...PLEASE SEE WWW.WEATHER.GOV

AT 900 AM EST...A SURFACE LOW PRESSURE SYSTEM WITH AN ESTIMATED CENTRAL PRESSURE OF 974 MB...28.76 INCHES...WAS ABOUT 400 MILES SOUTHEAST OF NANTUCKET...MASSACHUSETTS. SURFACE OBSERVATIONS AND DOPPLER RADAR INDICATED MOST OF THE LINGERING SHOWERS LIMITED TO COASTAL PORTIONS OF SOUTHERN NEW ENGLAND AND LONG ISLAND BUT ARE MAINLY OFFSHORE. WINDS ARE REDUCING BUT GUSTS CONTINUE OVER 40 MPH AT NANTUCKET AND MARTHAS VINEYARD MASSACHUSETTS AS WELL AS UP TO 30 MPH ACROSS LONG ISLAND.

...SELECTED PEAK WIND GUSTS IN MILES PER HOUR EARLIER IN THE EVENT...

...CONNECTICUT...

NEW LONDON	69
BRIDGEPORT	62
BDL BRADLEY ARPT	52
WILLIMANTIC ARPT	52
BRISTOL	51
NEW HAVEN	49
HARTFORD-BRAINAR	46

...WASHINGTON DC...

AMERICAN UNIVERSITY	66
CATHOLIC UNIVERSITY	66
US CAPITOL 1 S	66
WASHINGTON	66
SILVER SPRING 1 SSE	64
ADAMS MORGAN 1 E	61
GEORGETOWN 1 NNE	58
THE MALL 1 S	58

...DELAWARE...

LEWES NOS	66
DOVER	62
DEWEY BEACH	61
MIDDLETOWN	58
WILMINGTON NEW CASTLE	58
GREENWOOD	54
BLACKBIRD	52
REDDEN	49
SUSSEX COUNTY ARPT	49
GEORGETOWN	47
MILTON	46
SEAFORD	46
TOWNSEND	46
...GEORGIA...	
MOUNTAIN CITY 3 ESE	49
...KENTUCKY...	
LEXINGTON/BUEGRASS ARPT	48
FRANKFORT/CAPITAL CITY ARPT	44
...MASSACHUSETTS...	
BARNSTABLE	93
EAST FALMOUTH	92
WELLFLEET	91
NANTUCKET	90
OAK BLUFFS	88
WOODS HOLE	88
MARSHFIELD	87
PLYMOUTH	85
MARSTONS MILLS	80
SCITUATE	80
ORLEANS	75
VINEYARD HAVEN	75

EDGARTOWN	74
HAYANNIS AIRPORT	74
BOSTON	70
CHARLESTOWN	70
LOGAN AIRPORT	70
MASHPEE	69
CAMBRIDGE	67
MARTHAS VINEYARD	67

...MARYLAND...

BALLENGER CREEK 2 NW	71
COBB ISLAND 2 SE	69
GAITHERSBURG	69
PATUXENT RIVER	69
SABILLASVILLE 4 SSW	68
ANDREWS AFB 1 N	67
ANNAPOLIS - US NAVAL ACADEMY	64
GRASONVILLE	64
FAIR HILL	63
OCEAN CITY MUNICIPAL ARPT	62
BALTIMORE-WASHINGTON INTL ARPT	61
HAGERSTOWN REGIONAL	61
FROSTBURG	60
GARRETT AIRPORT	46

...NORTH CAROLINA...

OREGON INLET CG	66
CEDAR ISLAND FERRY	64
CHERRY POINT	62
STUMPY POINT	62
ASHEVILLE REGIONAL ARPT	58
ASHFORD 3 S	55
CHINA GROVE 2 NW	55
JEFFERSON/ASHE COUNTY ARPT	55

BEECH MOUNTAIN	52
BOOMER 3 ESE	51
WATAUGA COUNTY HOSPITAL HELIPORT	50
SALUDA 2 SSW	48
COLUMBUS 3 ESE	45
FLETCHER 2 E	44

...NEW JERSEY...

BRANDYWINE SHOAL NOS	74
CAPE MAY	71
DENNISVILLE	71
LEBANON	71
SOUTH PLAINFIELD	65
WASHINGTON TWP	65
HARVEY CEDARS	62
LAWRENCEVILLE	62
ATLANTIC CITY INTL ARPT	61
FORTESQUE	60
MCGUIRE AFB	51

...NEW YORK...

BAYVILLE	78
MIDDLE ISLAND	78
EATONS NECK	69
JFK AIRPORT	67
LARCHMONT HARBOR	66
JONES BEACH	64
WHITE PLAIN	63
GREAT GULL ISLAND	60
NAPEAGUE	52
ROCHESTER GREATER INTL ARPT	43

...OHIO...

ELYRIA/LORAIN COUNTY ARPT	51
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CLEVELAND/BURKE ARPT	48
COLUMBUS/OHIO STATE UNIV ARPT	48
YOUNGSTOWN-WARREN RGNL ARPT	48
MARION	45
AKRON-CANTON ARPT	44
CINCINNATI/NORTHERN KY INTL ARPT	43
...PENNSYLVANIA...	
NORTHEAST PHILADELPHIA	62
BUSHKILL CENTER	60
LEHIGH VALLEY INTL ARPT	60
POCONO MOUNTAINS	60
WEST GROVE	60
FLEETWOOD	59
PHILADELPHIA INTL	59
CHERRY HILL	58
POCONO MOUNTAINS MUNICIPAL	58
JOHNSTOWN/CAMBRIA COUNTY ARPT	56
PITTSBURGH INTERNATIONAL ARPT	56
ERIE INTL ARPT	54
...RHODE ISLAND...	
LITTLE COMPTON	83
BLOCK ISLAND	71
CHARLESTOWN	70
NEWPORT ARPT	67
GREEN ARPT	64
PROVIDENCE	64
WESTERLY ARPT	56
PRUDENCE ISLAND	53
NORTH PROVIDENCE	51
...SOUTH CAROLINA...	
TRYON 3 SW	55

TUXEDO 4 S 49

...VIRGINIA...

CHESAPEAKE LIGHT TOWER 79

ETLAN 78

DAHLGREN 3 NE 75

WASHINGTON/DULLES INTL ARPT 71

CHINCOTEAGUE 1 WSW 70

SLATE MILLS 70

SWIFT RUN 2 ESE 70

STANARDSVILLE 69

AMICUS 64

WALLOPS ISLAND 64

QUANTICO MARINE CORP 63

ROANOKE 62

RONALD REAGAN WASHINGTON ARPT 62

LEESBURG EXECUTIVE ARPT 61

WILLIAMSBURG 55

BLACKSBURG 49

NORFOLK 49

...WEST VIRGINIA...

WINCHESTER 15 W 76

BRUSHY RUN 65

PETERSBURG 1 S 59

MARTINSBURG 58

CHARLESTON 55

CANAAN HEIGHTS 52

GRANT COUNTY ARPT 50

MARTINSBURG/WEST VA RGNL ARPT 50

ELKINS/RANDOLPH CO ARPT 49

CLARKSBURG/BENEDUM ARPT 47

BUCKHANNON 46

BECKLEY/RALEIGH COUNTY ARPT 44

...SELECTED STORM TOTAL SNOWFALL IN INCHES WHERE THE EVENT HAS ENDED...

...CONNECTICUT...

SHARON	6.0
CANAAN 1 N	4.0
LITCHFIELD	1.5

...MASSACHUSETTS...

PLAINFIELD	12.0
SAVOY	10.0
ROWE	9.6
STOCKBRIDGE	8.5
EAST HAWLEY	6.7
HEATH	6.1
LEYDEN	6.0
GREAT BARRINGTON	5.0
BECKET	4.0
SANDISFIELD 3 S	4.0
NORTH ADAMS	3.5
FRANKLIN	2.1
WORCESTER	1.2

...MICHIGAN...

WIXOM	7.4
ANN ARBOR	6.1
CLARKSON	6.0
MUNITH	6.0

...NEW JERSEY...

BRANCHVILLE	16.5
HIGHLAND LAKES	14.0
HIGH POINT	13.5

RANDOLPH TWP..MORRIS CO.	11.3
VERNON	11.0
MONTAGUE	10.2
SCHOOLEYS MOUNTAIN	9.0
GREEN POND	8.7
WEST MILFORD	8.3
WANTAGE	7.5
JEFFERSON	7.0

...NEW YORK...

COBLESKILL	39.3
RICHMONDVILLE	37.5
HALCOTT CENTER	35.0
JEFFERSON	34.5
GILBOA	30.0
SCHOHARIE	30.0
AMSTERDAM	29.8
DUANESBURG	26.0
GLEN	26.0
WEST KILL	26.0
WINDHAM	26.0
PARIS	25.2
KNOX	25.0
DELANSON	24.0
HOBART	24.0
WYOMING	24.0
DAVENPORT	23.0
FORESTVILLE	22.0
NEW HARTFORD	22.0
JAMESVILLE	21.1
GREENE 2SE	21.0
ONEIDA	20.0
ONEONTA	20.0
PHOENICIA 6 NW	20.0

KIRKWOOD	19.0
EAST SYRACUSE	18.8
MERIDALE	18.0
THURSTON 1 N	17.5
ANCRAMDAL	17.0
AVERILL PARK	16.1
CORINTH	15.9
FISHHOUSE	15.5
BINGHAMTON NWS	12.4
KIAMESHA	12.1
BUFFALO	12.0

...PENNSYLVANIA...

COOLBAUGH	23.6
TOBYHANNA	20.0
LAKEVIEW	12.7
BLOOMING GROVE	12.0
FALLS	10.2
NORTH HONESDALE	10.0
THOMPSON	9.5
WAYNE	9.0
BRYN MAWR	8.5
DURYEA	8.2
BERWYN	7.0
MOOSIC	7.0
PHILADELPHIA	2.5

...RHODE ISLAND...

FOSTER 1 W	1.1
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...VERMONT...

WOODFORD	14.0
LANDGROVE	13.2
PAWLET	7.0

CHESTER 6.0

...SELECTED PRELIMINARY STORM TOTAL RAINFALL IN INCHES WHERE THE
EVENT HAS ENDED...

...CONNECTICUT...

FENWICK	3.32
JEWETT CITY	3.28
MIDDLETOWN	3.28
FAIRFIELD	3.27
THOMPSON	2.80
HAMPTON	2.39
MANSFIELD	2.34
STAFFORD SPRINGS	2.23
DANIELSON	2.20
HEBRON	2.00

...MASSACHUSETTS...

EAST BRIDGEWATER	5.74
BROCKTON	4.61
WEST HARWICH	3.96
RANDOLPH	3.88
BOURNE	3.75
FAIRHAVEN	3.69
SIASCONSET	3.67
HANOVER	3.61
NORTON	3.61
WEST ISLAND	3.37
TAUNTON 4 SE	3.34
PLYMOUTH	3.28
WAREHAM	3.27
EAST MILTON	2.92
MARION	2.90
BEVERLY	2.78

BOSTON	2.02
...	
...MAINE...	
PITTSTON FARM	1.39
...	
...NEW HAMPSHIRE...	
GORHAM AIRPORT	2.03
HOLLIS	1.88
NEW IPSWICH 1 S	1.54
RINDGE 3 ESE	1.40
...	
...NEW JERSEY...	
HOBOKEN	2.84
RIDGEWOOD	2.50
NEWARK AIRPORT	2.40
WEEHAWKEN	2.32
TETERBORO AIRPORT	2.21
PASSAIC	1.99
...	
...NEW YORK...	
WEST HILLS	3.92
LAKE GROVE	3.44
OAKDALE	3.43
SMITHTOWN	3.40
ISLIP	3.34
EAST MASSAPEQUA	3.32
UPTON	3.14
HEWLETT	3.00
HICKSVILLE	2.83
TOPT HILL	2.82
NYC/JFK INTL	2.70
CENTRAL PARK	2.24
NYC/LA GUARDIA	2.17

...PENNSYLVANIA...

TITUSVILLE 6.3 SW	2.35
LEEPER 0.9 WSW	2.23
SANDY LAKE 1.8 ENE	2.12
TIONESTA 7.3 SSE	2.08

...RHODE ISLAND...

WESTERLY	4.85
FOSTER 1 W	3.32
EAST PROVIDENCE	3.10
NEWPORT	2.61
WARWICK	2.54
PORTSMOUTH	2.28
BURRILLVILLE	2.10
NEWPORT 3 NE	1.86
WESTERLY 2 SE	1.56
PROVIDENCE 8 S	1.48
HOPE VALLEY	1.13
WETHERSFIELD	1.13

THE INTENSE LOW PRESSURE SYSTEM WILL CONTINUE TO MOVE FARTHER INTO THE ATLANTIC TODAY...STRONG WIND GUSTS UP TO 55 MPH ARE EXPECTED TO CONTINUE FOR SOUTHEASTERN NEW ENGLAND AND EASTERN LONG ISLAND PARTICULARLY ALONG THE COAST AND ISLANDS. FOR MOST OF THE MID-ATLANTIC INTO THE NORTHEAST...OCCASIONAL WIND GUSTS BETWEEN 30 TO 45 MPH WILL CONTINUE INTO TODAY.

THIS WILL BE THE LAST STORM SUMMARY ISSUED BY THE WEATHER PREDICTION CENTER FOR THIS EVENT. PLEASE REFER TO YOUR LOCAL NATIONAL WEATHER SERVICE OFFICE FOR ADDITIONAL INFORMATION.

GALLINA

Public Information Statement
 Spotter Reports
 National Weather Service Albany NY
 1225 PM EST Sat Mar 03 2018

The following are unofficial observations taken during the past 30 hours for the storm that has been affecting our region. Appreciation is extended to highway departments, cooperative observers, Skywarn spotters and media for these reports. This summary also is available on our home page at weather.gov/albany

*****STORM TOTAL SNOWFALL*****

LOCATION	STORM TOTAL SNOWFALL /INCHES/	TIME/DATE OF MEASUREMENT	COMMENTS
CONNECTICUT			
...Litchfield County...			
Kent	8.0	730 PM 3/02	Fire Dept/Rescue
Norfolk	6.5	800 AM 3/03	Co-Op Observer
Sharon	6.0	200 PM 3/02	Broadcast Media
1 N Canaan	4.0	700 PM 3/02	Dept of Highways
5 NNW Winsted	2.8	500 AM 3/03	CoCoRaHS
Litchfield	1.5	700 PM 3/02	Dept of Highways

MASSACHUSETTS

...Berkshire County...			
Florida	12.0	907 AM 3/03	Meteorologist
Savoy	12.0	906 AM 3/03	Meteorologist
Hinsdale	10.0	924 AM 3/03	Meteorologist
4 SSW Savoy	10.0	1100 AM 3/02	Broadcast Media
Lenox	8.0	946 AM 3/03	Meteorologist
Great Barrington	5.0	950 AM 3/03	Meteorologist
Pittsfield	4.0	952 AM 3/03	Meteorologist
Becket	4.0	351 PM 3/02	WeatherNet6
3 S Sandisfield	4.0	520 PM 3/02	Social Media
North Adams	3.5	430 PM 3/02	Social Media

NEW YORK

...Albany County...			
5 W Westerlo	34.0	835 AM 3/03	Meteorologist
1 S Berne	29.0	838 AM 3/03	Meteorologist
Knox	26.0	847 AM 3/03	Meteorologist
1 W Altamont	26.0	842 AM 3/03	Meteorologist
Westerlo	24.0	848 AM 3/03	Meteorologist
1 W Berne	23.0	850 AM 3/03	Meteorologist
3 N Selkirk	18.5	700 AM 3/03	CoCoRaHS
Ravena	14.5	425 PM 3/02	WeatherNet6
2 S Colonie	14.5	630 AM 3/03	CoCoRaHS
1 WNW Watervliet	13.0	135 PM 3/02	Public
2 SSW Altamont	13.0	815 AM 3/03	CoCoRaHS
Cohoes	13.0	339 PM 3/02	WeatherNet6
Boght Corners	12.6	200 PM 3/02	NWS Employee
4 WNW Ravena	12.5	700 AM 3/03	CoCoRaHS
Delmar	12.4	757 PM 3/02	Social Media

1 W Albany	12.0	700 AM	3/03	CoCoRaHS
2 W Albany	12.0	641 PM	3/02	Retired NWS Emp.
Albany Intl Ap	11.9	651 AM	3/03	ASOS
Colonie	11.5	417 PM	3/02	WeatherNet6
3 NW Guilderland	10.0	433 PM	3/02	NWS Employee
Westmere	10.0	943 AM	3/03	Meteorologist
2 WNW Guilderland	10.0	700 AM	3/03	CoCoRaHS
1 E North Bethlehem	9.8	655 PM	3/02	NWS Employee
1 SW Guilderland	8.5	1235 PM	3/02	Public
Albany	8.5	700 PM	3/02	Official NWS Obs
...Columbia County...				
Ancramdale	17.0	447 PM	3/02	WeatherNet6
Taghkanic	16.7	707 AM	3/03	WeatherNet6
Kinderhook	15.0	900 PM	3/02	Storm Total as of 9PM
Chatham	15.0	855 AM	3/03	Meteorologist
Philmont	15.0	418 PM	3/02	Social Media
4 SE Elizaville	14.0	610 PM	3/02	Social Media
Valatie	13.0	900 AM	3/03	Meteorologist
Niverville	13.0	410 PM	3/02	Social Media
Livingston	12.0	903 AM	3/03	Meteorologist
Austerlitz	11.5	342 PM	3/02	WeatherNet6
Copake	11.0	911 AM	3/03	Meteorologist
5 ENE Philmont	10.0	103 PM	3/02	Public
...Dutchess County...				
1 NE Red Hook	15.1	700 AM	3/03	CoCoRaHS
3 SE Pine Plains	14.0	600 PM	3/02	Elevation 700 feet.
4 SE Elizaville	14.0	610 PM	3/02	Social Media
6 ESE Pleasant Valle	11.5	700 AM	3/03	CoCoRaHS
3 NE Lagrange	11.5	630 PM	3/02	Trained Spotter
Poughquag	11.0	648 PM	3/02	Trained Spotter
5 ESE Red Hook	10.5	1200 PM	3/02	Social Media
Millbrook	10.0	807 PM	3/02	Trained Spotter
5 ENE Lagrange	10.0	245 PM	3/02	Public
Wassaic	9.2	121 PM	3/02	Public
2 SSE Hopewell Junct	8.8	700 AM	3/03	CoCoRaHS
Lagrange	8.5	706 PM	3/02	Trained Spotter
2 W Poughquag	8.1	1216 PM	3/02	Public
1 NE Fishkill	8.0	700 AM	3/03	CoCoRaHS
3 W Dover Plains	8.0	142 PM	3/02	Public
2 ENE Hopewell Junct	6.0	800 AM	3/03	CoCoRaHS
Rhinebeck	5.8	450 PM	3/02	Trained Spotter
Poughkeepsie	5.7	645 AM	3/03	Co-Op Observer
Hyde Park	3.0	430 PM	3/02	Trained Spotter
Red Oaks Mill	2.5	825 PM	3/02	Trained Spotter
...Fulton County...				
7 NW GLOVERSVILLE	20.0	800 AM	3/03	Co-Op Observer
Mayfield	18.0	1159 AM	3/02	Emergency Manager
Oppenheim	16.0	854 AM	3/03	Meteorologist
Fishhouse	15.5	325 PM	3/02	WeatherNet6
Northville	15.5	337 PM	3/02	WeatherNet6
Gloversville	15.0	857 AM	3/03	Meteorologist
1 E Perth	14.0	859 AM	3/03	Meteorologist
Perth	13.5	336 PM	3/02	WeatherNet6
...Greene County...				
Halcott Center	35.0	734 PM	3/02	WeatherNet6
Hunter	28.0	842 AM	3/03	Meteorologist
West Kill	26.0	352 PM	3/02	WeatherNet6

Windham	26.0	245	PM	3/02	Social Media
Acra	25.0	847	AM	3/03	Meteorologist
Norton Hill	21.0	633	AM	3/03	WeatherNet6
Greenville Center	21.0	323	AM	3/03	WeatherNet6
Freehold	17.0	853	AM	3/03	Meteorologist
4 NNE Cairo	17.0	530	AM	3/03	CoCoRaHS
Earlton	15.0	825	PM	3/02	WeatherNet6
1 W Freehold	12.0	1238	PM	3/02	Public
Cairo	10.0	233	PM	3/02	WeatherNet6
Coxsackie	10.0	943	AM	3/03	Meteorologist
Platte Clove	7.1	700	AM	3/03	Co-Op Observer
Catskill	6.5	954	AM	3/03	WeatherNet6
...Hamilton County...					
Piseco	8.0	352	PM	3/02	WeatherNet6
Inlet	8.0	645	PM	3/02	Trained Spotter
Indian Lake	6.5	520	AM	3/03	WeatherNet6
Wells	6.5	431	PM	3/02	WeatherNet6
3 ENE Piseco	6.0	700	AM	3/03	CoCoRaHS
2 SW Indian Lake	5.3	815	AM	3/03	Co-Op Observer
Long Lake	3.0	953	AM	3/03	Meteorologist
...Herkimer County...					
Danube	8.0	700	PM	3/02	Social Media
Ohio	7.0	130	PM	3/02	Public
...Montgomery County...					
Amsterdam	29.8	423	PM	3/02	WeatherNet6
Glen	28.0	835	PM	3/02	WeatherNet6
Canajoharie	28.0	840	AM	3/03	Meteorologist
Palatine Bridge	19.0	412	PM	3/02	WeatherNet6
Fonda	16.0	531	AM	3/03	WeatherNet6
Fort Plain	8.7	700	AM	3/03	CoCoRaHS
...Rensselaer County...					
Grafton	20.0	854	AM	3/03	Meteorologist
Averill Park	16.1	800	AM	3/03	CoCoRaHS
Troy	15.9	700	AM	3/03	Co-Op Observer
Center Brunswick	15.3	338	PM	3/02	WeatherNet6
Wyantskill	15.0	856	AM	3/03	Meteorologist
Schodack	14.0	926	PM	3/02	Trained Spotter
East Greenbush	13.5	910	AM	3/03	Meteorologist
2 NE Troy	12.8	700	AM	3/03	CoCoRaHS
1 N Sycaway	12.8	500	PM	3/02	NWS Employee
Speigletown	12.0	329	PM	3/02	WeatherNet6
Castleton-On-hudson	12.0	904	AM	3/03	Meteorologist
West Sand Lake	12.0	900	AM	3/03	Meteorologist
Valley Falls	11.0	908	AM	3/03	Meteorologist
2 NE Mechanicville	10.7	1238	PM	3/02	Public
East Schodack	10.1	1215	PM	3/02	Social Media
1 ESE Averill Park	10.0	200	PM	3/02	Public
5 E Waterford	9.5	700	AM	3/03	CoCoRaHS
Petersburg	7.5	452	AM	3/03	WeatherNet6
4 ESE Nassau	5.6	748	AM	3/03	CoCoRaHS
...Saratoga County...					
Corinth	16.0	855	AM	3/03	Meteorologist
Lake Desolation	15.4	959	PM	3/02	WeatherNet6
Wilton	15.0	856	AM	3/03	Meteorologist
2 S Clifton Park Cen	13.6	515	PM	3/02	Retired NWS Emp.
Edinburg	13.2	850	PM	3/02	WeatherNet6

1 W Saratoga Springs	13.0	540 PM	3/02	Social Media
Gansevoort	13.0	325 PM	3/02	Social Media
Stillwater	13.0	1230 PM	3/02	Social Media
3 S Saratoga Lake	12.5	700 AM	3/03	CoCoRaHS
Saratoga Springs	12.1	600 AM	3/03	CoCoRaHS
Saratoga Lake	12.0	900 AM	3/03	Meteorologist
2 ESE Ballston Spa	12.0	810 AM	3/03	CoCoRaHS
1 W Gansevoort	11.7	630 AM	3/03	CoCoRaHS
3 NNE Mechanicville	11.7	937 PM	3/02	Emergency Manager
Ballston Spa	10.5	453 PM	3/02	WeatherNet6
Mechanicville	10.0	924 AM	3/03	Meteorologist
Malta	10.0	1038 AM	3/02	WeatherNet6
Charlton	10.0	352 PM	3/02	WeatherNet6
2 SE Clifton Park	8.0	600 AM	3/03	CoCoRaHS
Halfmoon	8.0	945 AM	3/03	Meteorologist
...Schenectady County...				
Delanson	30.0	838 AM	3/03	Meteorologist
Duanesburg	27.0	554 AM	3/03	WeatherNet6
Schenectady	13.0	800 PM	3/02	WeatherNet6
Rotterdam	12.0	845 AM	3/03	CoCoRaHS
South Schenectady	11.0	120 PM	3/02	NWS Employee
Glenville	9.0	440 PM	3/02	WeatherNet6
...Schoharie County...				
5 S Sharon Springs	40.0	831 AM	3/03	Meteorologist
Richmondville	40.0	502 AM	3/03	WeatherNet6
Cobleskill	39.3	953 PM	3/02	Trained Spotter
Schoharie	35.3	939 PM	3/02	WeatherNet6
Middleburgh	34.7	443 AM	3/03	WeatherNet6
Jefferson	34.5	402 PM	3/02	WeatherNet6
Summit	32.0	836 AM	3/03	Meteorologist
Charlotteville	31.0	510 AM	3/03	WeatherNet6
Esperance	30.0	837 AM	3/03	Meteorologist
Gilboa	30.0	418 PM	3/02	WeatherNet6
North Blenheim	28.0	954 AM	3/03	Meteorologist
...Ulster County...				
6 NW Phoenicia	20.0	600 PM	3/02	Trained Spotter
West Shokan	2.5	515 AM	3/03	WeatherNet6
2 NE Kerhonkson	0.1	700 AM	3/03	Public
2 WNW Saugerties	0.1	700 AM	3/03	Public
...Warren County...				
Lake Luzerne	13.0	600 AM	3/03	Co-Op Observer
2 WNW Warrensburg	11.3	800 AM	3/03	CoCoRaHS
Warrensburg	11.0	407 PM	3/02	WeatherNet6
Queensbury	11.0	909 AM	3/03	Meteorologist
...Washington County...				
Hartford	9.0	1117 AM	3/02	WeatherNet6
Hebron	7.0	947 AM	3/03	Meteorologist
Whitehall	6.0	948 AM	3/03	Meteorologist
Fort Edward	6.0	430 PM	3/02	Trained Spotter
Hudson Falls	5.8	616 AM	3/03	WeatherNet6
Salem	5.0	951 AM	3/03	Meteorologist
Cambridge	4.5	952 AM	3/03	Meteorologist

VERMONT

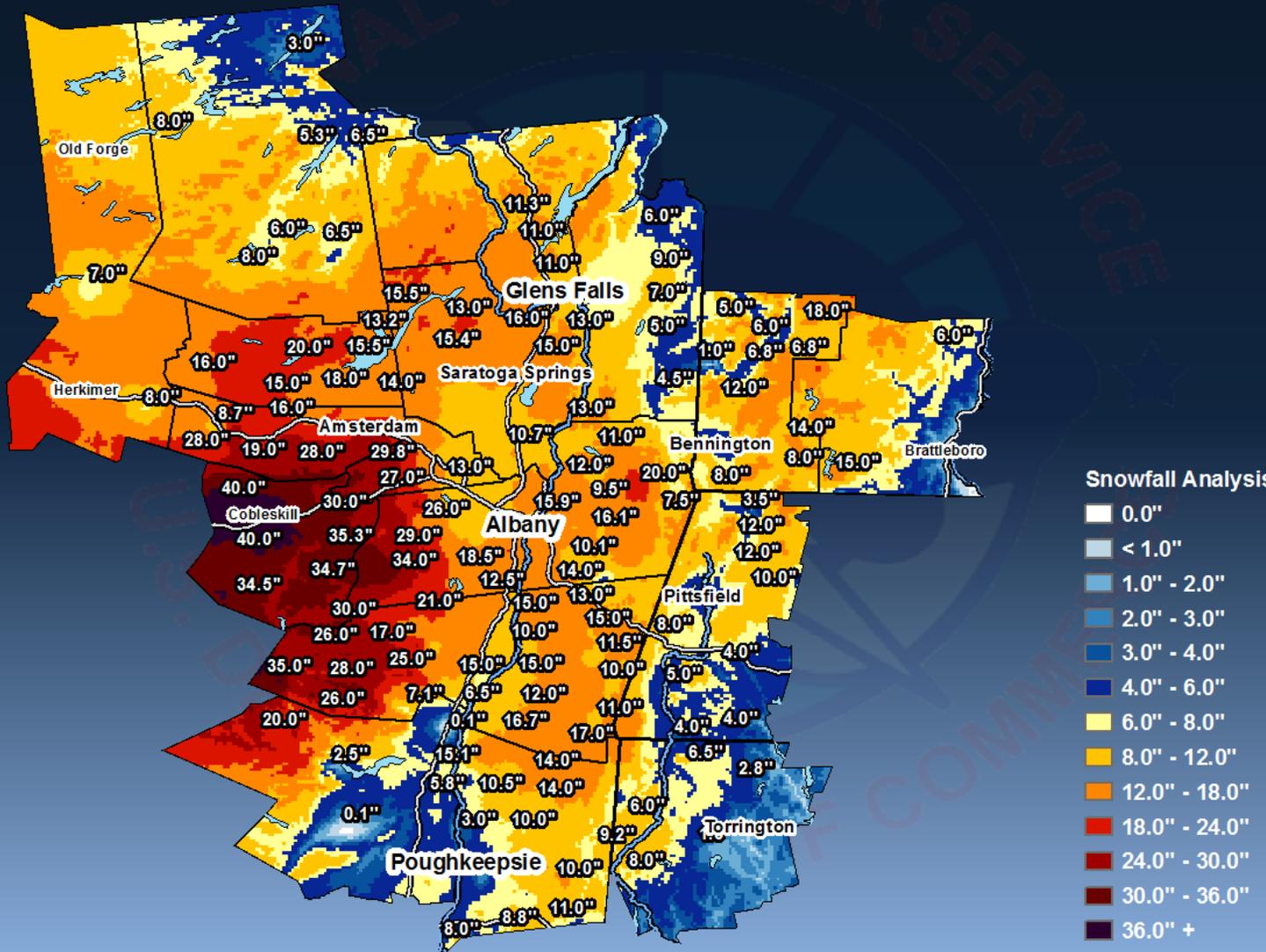
...Bennington County...					
1 WNW Weston	18.0	700 AM	3/03	CoCoRaHS	
Woodford	14.0	548 AM	3/03	WeatherNet6	
Landgrove	13.5	951 PM	3/02	WeatherNet6	
Shaftsbury	12.0	906 AM	3/03	Meteorologist	
8 E Bennington	8.0	944 AM	3/03	Meteorologist	
Pownal	8.0	944 AM	3/03	Meteorologist	
Manchester Center	6.8	539 AM	3/03	WeatherNet6	
1 E Manchester Cente	6.8	700 AM	3/03	CoCoRaHS	
Manchester	6.0	341 PM	3/02	WeatherNet6	
Dorset	5.0	140 PM	3/02	Trained Spotter	
Bennington	3.5	953 AM	3/03	Meteorologist	
West Arlington	1.0	513 AM	3/03	WeatherNet6	
...Windham County...					
3 W Jacksonville	15.0	857 AM	3/03	Meteorologist	
3 WSW Charlestown	6.0	700 AM	3/03	CoCoRaHS	

&&

National Weather Service Albany, NY

Snowfall Analysis 03/02/2018 01:00AM to 03/03/2018 01:00AM

Data Source: Regional Observations(PNS)



This is an experimental product. Care should be taken in using the data. Unofficial observations are plotted. Values at interpolated locations may not represent actual precipitation totals.

Nor'easter Questions

1. Based on the daily weather map and the 500 mb map for March 1, what direction would you expect the storm to move?

2. Is this storm considered a “Bomb Cyclone”? Why or why not?
3. What happened in the 500 mb map between March 1 and 2 that helped change the path and intensity of the storm?
4. How many states were affected by this storm?
5. What types of hazards occurred with this storm? Which of those occurred on Long Island?
6. What was the peak wind gust on Long Island and where did it occur? Is the force of the wind stronger, weaker or the same as a Category 1 Hurricane?
7. Was this storm considered a blizzard anywhere in NY? If so, where?
8. What was the maximum snowfall from this storm through noon on March 3? About where did it occur?
9. Why do some counties have a steep gradient when it comes to snowfall from this storm?
10. Did any snow fall on Long Island?
11. Looking at the 850 mb map, what evidence can you find that supports the snowfall totals with this storm?
12. Do you think calling for a snow day in Ulster County (the county just west of Poughkeepsie) would have been a popular choice? What would go into their decision?

13. Find two reliable articles on the storm and write a bibliography entry for each.

14. What, if anything, did you learn from the articles that you could not find in the data attached to this assignment?

15. Can you find any additional evidence of death or injury with the storm? What caused death or injury?

16. Can you find evidence of a name for this storm? What was the name? What advantages and disadvantages come from naming storms?

Riley

Should Nor'easters be named like Hurricanes? The weather Channel names winter storms, but the NWS does not want to name nor'easters and winter storms. Weigh the pros and cons.

Pros	Cons

17. Write a brief (less than 5 minutes) argument speech to the National Weather Service, convincing them to name or not name nor'easters using the following guidelines.
- a) Establish your credibility: Show that you are an expert and have given this a lot of thought.
 - b) Address both sides of the issue and show that you considered each side before formulating an opinion.
 - c) Construct an intelligent and thoughtful argument, using facts, as well as the opinions of other professionals (you can find these online).
 - d) Indicate why it is important for the audience to agree with you.
 - e) Ask the NWS to do something (name or not name storms).

Nor'easter Questions **Key**

1. Based on the daily weather map and the 500 mb map for March 1, what direction would you expect the storm to move?

To the East

2. Is this storm considered a "Bomb Cyclone"? Why or why not?

Yes, because the central pressure dropped more than 24 mb in 24 hours

3. What happened in the 500 mb map between March 1 and 2 that helped change the path and intensity of the storm?

The isoheights moved more south to north bringing the storm up towards the top of a ridge

4. How many states were affected by this storm?

19+DC

5. What types of hazards occurred with this storm? Which of those occurred on Long Island?

High wind, blizzard, heavy snow, winter storm, winter weather, coastal flood

Long Island: Coastal Flood, high wind

6. What was the peak wind gust on Long Island and where did it occur? Is the force of the wind stronger, weaker or the same as a Category 1 Hurricane?

78 mph Bayville and Middle Island

The same as a Cat 1 Hurricane

7. Was this storm considered a blizzard anywhere in NY? If so, where?

Yes, in Sullivan County, Delaware County and Otsego County NY

8. What was the maximum snowfall from this storm through noon on March 3? About where did it occur?

40 inches in Schoharie County, 5 miles south of Sharon Springs and Richmondville, upstate NY (Central NY)

9. Why do some counties have a steep gradient when it comes to snowfall from this storm?

The rain snow line, and differences in topography (elevations and uplifting and proximity to water)

10. Did any snow fall on Long Island?

No

11. Looking at the 850 mb map, what evidence can you find that supports the snowfall totals with this storm?

The 850 mb temperature is above 0 in the eastern part of the storm and over Long Island and is below zero in the western part of the storm and over upstate NY

12. Do you think calling for a snow day in Ulster County (the county just west of Poughkeepsie) would have been a popular choice? What would go into their decision?

Probably not since not much snow. Decision takes into account winds, flooding, and cost of loss of a day.

13. Find two reliable articles on the storm and write a bibliography entry for each.

14. What, if anything, did you learn from the articles that you did not find in the data attached to this assignment?

15. Can you find any additional evidence of death or injury with the storm? What caused death or injury?

Yes, boy crushed by tree falling on his home in Putnam County. Most deaths with this storm attributed to falling trees

16. Can you find evidence of a name for this storm? What was the name? What advantages and disadvantages come from naming storms?

Yes, Riley

Should Nor'easters be named like Hurricanes? The weather Channel names winter storms, but the NWS does not want to name nor'easters and winter storms. Weigh the pros and cons.

Pros	Cons

17. Write a brief (less than 5 minutes) argument speech to the National Weather Service, convincing them to name or not name nor'easters using the following guidelines.

- a. Establish your credibility: Show that you are an expert and have given this a lot of thought.
- b. Address both sides of the issue and show that you considered each side before formulating an opinion.
- c. Construct an intelligent and thoughtful argument, using facts, as well as the opinions of other professionals (you can find these online).
- d. Indicate why it is important for the audience to agree with you.
- e. Ask the NWS to do something (name or not name storms).

Sample Lesson/Unit 8 – Mesoscale Meteorology

Lake Effect Snow & Land/Sea Breezes

- **HS-ESS2-8. Evaluate data and communicate information to explain how the movement and interactions of air masses result in changes in weather conditions.**
- **Science and Engineering Practices**
 1. Asking questions (science)/defining problems (engineering)
 2. Developing and using models
 3. Planning and carrying out investigations
 4. Analyzing and interpreting data*
 5. Using mathematics and computational thinking*
 6. Constructing explanations (science) and designing solutions (engineering)
 7. Engaging in argument from evidence*
 8. Obtaining, evaluating and communicating information*
- **Cross-cutting concepts from ELA and Math**
 1. Systems and Systems Modeling
 2. Energy and Motion
 3. Cause and Effect
 4. Influences of Science, Engineering Math, and Technology on Society
- **Disciplinary Core Ideas**
 1. ESS2.D: Weather and Climate

Method

Objectives:

The student will be able to:

- Describe Lake Effect Snow Conditions
- Explain how Lake Effect Snow forms
- Analyze satellite images of Lake Effect Snow
- Analyze radar images of Lake Effect Snow
- Explain why Lake Effect Snow forms in bands
- List areas where Lake Effect Snow forms
- Discuss when Land/Sea breeze phenomenon occurs
- Describe the formation of land breeze
- Describe the formation of sea breeze
- Explain a sea breeze front
- Analyze radar images of sea breeze front
- Analyze satellite images of lake breezes

Materials:

- Mesoscale Meteorology powerpoint
- Mesoscale Meteorology activity

Activities:

1. Discuss lake effect snow and land/sea breezes through powerpoint presentation.
2. Students work on Mesoscale Meteorology activity (see below).

3. Closure: More mesoscale meteorology tomorrow – some phenomena with interesting names!

Name: _____

Date: _____

Mesoscale Meteorology Activity

Directions: Answer the following questions as described below.

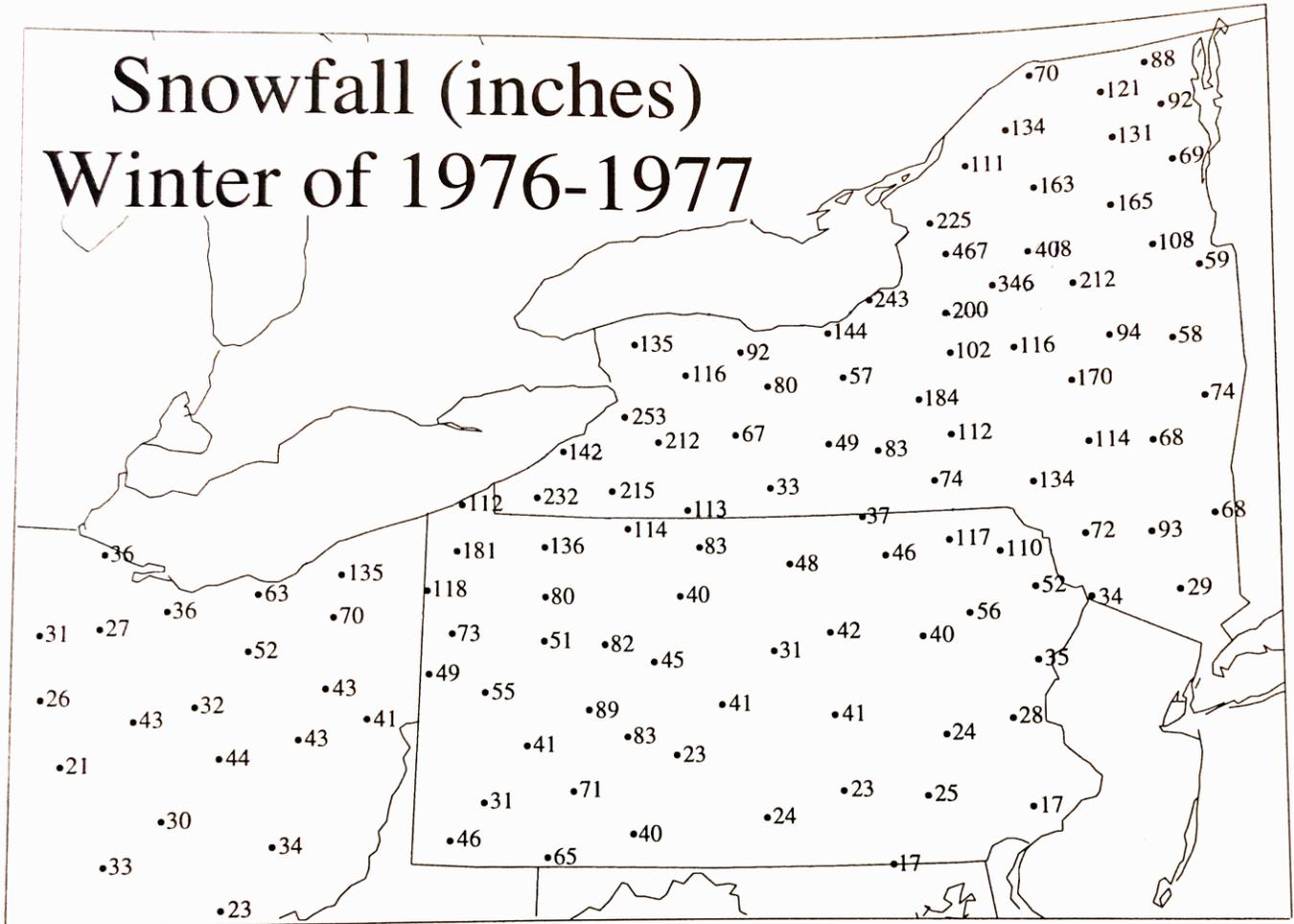
1. In the figure below, you are given a map of snowfall totals (in inches) for the winter of 1976-1977. The winter in this part of the country was extremely cold, but snowfall amounts were generally light, with a notable exception.
 - a. Draw the 100-inch, 200-inch, and 300-inch isopleths. Shade in areas that received more than 30 inches of snow.
 - b. What mesoscale winter weather phenomenon was primarily responsible for all this snow?

 - c. Based on the shape of the snowfall patterns, what wind direction appears to have predominated during this winter?

 - d. Explain.

Snowfall (inches)

Winter of 1976-1977



2. The figure below is a satellite image of the eastern Great Lakes.
 - a. With a heavy line, mark the lake-breeze front (that is, the leading edge of the lake-breeze) to the south of Lakes Erie and Ontario, and also adjacent to those parts of Lake Huron that are visible.
 - b. Estimate the wind direction at Erie, PA (Erie is adjacent to the lake). Which way do you think it's blowing? Explain your reasoning.
 - c. Estimate the wind direction at Cleveland, OH (also on the lake). Which way do you think it's blowing? Explain your reasoning.
 - d. Identify an area where the lake-breeze front from one lake is nearing the lake-breeze front from another lake, enhancing the cloud development. Circle this area on the map.
 - e. Given the choice of August 3rd or February 3rd, what day do you think this image was taken?

f. Justify your answer.



Sample Lesson/Unit 9 – Forecasting

Analyzing MOS Data

- **HS-ESS2-8. Evaluate data and communicate information to explain how the movement and interactions of air masses result in changes in weather conditions.**
- **Science and Engineering Practices**
 1. Asking questions (science)/defining problems (engineering)
 2. Developing and using models
 3. Planning and carrying out investigations
 4. Analyzing and interpreting data*
 5. Using mathematics and computational thinking*
 6. Constructing explanations (science) and designing solutions (engineering)
 7. Engaging in argument from evidence*
 8. Obtaining, evaluating and communicating information*
- **Cross-cutting concepts from ELA and Math**
 1. Systems and Systems Modeling
 2. Energy and Motion
 3. Cause and Effect
 4. Influences of Science, Engineering Math, and Technology on Society
- **Disciplinary Core Ideas**
 1. ESS2.D: Weather and Climate

Method

Objectives:

The student will be able to:

- Discuss why people think forecasters are always wrong
- Discuss where most people are getting their information
- Discuss how models have improved over the years
- List the types of computer models
- Name the models we use
- Discuss the strengths & weaknesses of each model
- Discuss how to overcome the model weaknesses
- Describe ensemble models
- Analyze examples of ensemble models
- Discuss model uncertainty
- Know what websites to visit for models
- Analyze all the models we will use to create forecasts

Materials:

- Forecasting powerpoint
- Miami Marlins article
- Analyzing MOS Forecast Data activity

Activities:

1. Discuss forecasting the weather through powerpoint presentation.

2. Read article regarding the Miami Marlins opening day and rain delay
3. Students work on Analyzing MOS Forecast Data activity (see below).
4. Closure: Discuss project that will be completed next. Students will have the opportunity to create forecasts for their classmates.

Name: _____

Date: _____

Analyzing MOS Forecast Data

Directions: Answer the question that follows using the information given.

1. MOS is a combination of output from a computer model and statistically derived information from previous runs of that computer model.

The following example shows MOS guidance derived from the NGM. A line-by-line explanation follows.

1. OKC	SC	NGM	MOS	GUIDANCE	7/22/00	0000	UTC												
2. DAY	/JULY 22				/JULY 23				/JULY 24										
3. HOUR	06	09	12	15	18	21	00	03	06	09	12	15	18	21	00	03	06	09	12
4. MX/MN							86				68				87				70
5. TEMP	74	72	71	77	81	83	81	76	73	70	69	75	82	85	84	78	75	72	71
6. DEWPT	68	68	68	69	68	68	69	69	68	67	67	68	67	66	65	67	67	66	66
7. CLDS	SC	BK	OV	BK	BK	BK	BK	BK	BK	OV	BK	SC	SC	SC	SC	CL	CL	CL	SC
8. WDIR	09	09	07	13	13	12	11	10	11	09	08	12	11	13	14	13	14	15	16
9. WSPD	08	09	10	08	08	06	08	07	06	05	06	06	06	06	07	04	05	03	03
10. POP06			21		44		28		14		13		13		9		3		5
11. POP12							52				22				18				7
12. QPF			3/		1/		0/2		0/		0/1		0/		0/0		0/		0/0
13. PTYPE	R	R	R	R	R	R	R	R	R	R	R		R		R		R		R
14. POZP	0	0	0	0	0	0	0	0	0	0	0		0		0		0		0
15. POSN	0	0	0	0	0	0	0	0	0	0	0		0		0		0		0
16. SNOW			0/		0/		0/0		0/		0/0		0/		0/0		0/		0/0
17. CIG	7	7	6	6	6	6	7	7	6	6	6		5		7				
18. VIS	5	5	5	5	5	5	5	5	5	5	5		5		5				
19. OBVIS	N	N	N	N	N	N	N	N	N	N	F		N		N				

Line 1: Three-character station code, date and time of model initialization (UTC is Z-time). In this case, "OKC" is Oklahoma City, OK, and the model was initialized at 00Z on July 22, 2000.

Line 2: DAY: Month and day when the forecast in the rows below is valid. This forecast covers the period from July 22 to July 24, 2000.

Line 3: HOUR: Hours (in Z-time on the corresponding day) when the forecast in the columns below is valid. In this case, the forecast information starts at 06Z on July 22 and goes through 12Z on July 24.

Line 4: MX/MN: Maximum and minimum temperatures for the specified days. For example, the "86" represents the forecast high for July 22, while the "68" represents the forecast low for the morning of July 23.

Line 5: TEMP: Temperature (in °F) at the specified time.

Line 6: DEWPT: Dew point (in °F) at the specified time.

Line 7: CLDS: Cloud cover at the specified time. "CL" means clear (no cloud cover); "SC" means scattered clouds, or partly cloudy skies (10 to 50% of sky cloud-covered); "BK" stands for broken, or mostly cloudy (60 to 90% of sky cloud-covered); "OV" means overcast, or cloudy (100% of sky cloud-covered).

Line 8: WDIR: Wind direction at the specified time as a compass direction, in tens of degrees. So "09" is an east wind, "18" is a south wind, "27" is a west wind, and "36" is a north wind. In this example, the "14" at 00Z on July 24 is a southeast wind.

Line 9: WSPD: Wind speed (in knots) at the specified time. For example, at 00Z on July 24 the wind speed is forecast to be 7 knots (1 knot = 1.15 mph).

Line 10: POP06: Probability of measurable precipitation (0.01 inches or more of liquid) for the 6-hour period ending at the specified time. For example, the "28" at 00Z on July 23 indicates a 28% chance between 18Z on July 22 and 00Z on July 23.

Line 11: POP12: Probability of measurable precipitation (0.01 inches or more of liquid) for the 12-hour period ending at the specified time. For example, the "52" at 00Z on July 23 indicates a 52% chance between 12Z on July 22 and 00Z on July 23.

Line 12: QPF (Quantitative Precipitation Forecast): Precipitation amounts for the 6-hour and 12-hour periods ending at the specified time, in the form A/B, according to the following code:

A – 6-hour period	B – 12-hour period
0 – No precipitation	0 – No precipitation
1 – 0.01 to 0.09 inches	1 – 0.01 to 0.09 inches
2 – 0.10 to 0.24 inches	2 – 0.10 to 0.24 inches
3 – 0.25 to 0.49 inches	3 – 0.25 to 0.49 inches
4 – 0.50 to 0.99 inches	4 – 0.50 to 0.99 inches
5 – 1 inch or more	5 – 1.00 to 1.99 inches
	6 – 2.00 inches or more

As an example, the "0/2" at 00Z on July 23 means that no precipitation is forecast during the previous 6-hour period (18Z on July 22 to 00Z on July 23) with 0.10 to 0.24 inches forecast during the previous 12-hour period (12Z on July 22 to 00Z on July 23).

Line 13: PTYPE: Most likely precipitation type at the specified time (assuming that precipitation is occurring): "R" is rain, "S" snow, and "Z" freezing rain or sleet.

Line 14: POZP: If precipitation is occurring at the specified time, the probability that it is freezing rain or sleet.

Line 15: POSN: If precipitation is occurring at the specified time, the probability that it is snow.

Line 16: SNOW: Snow amount for the 6-hour and 12-hour periods ending at the specified time, in the form A/B.

A – 6-hour period

B – 12-hour period

0 – No snow

0 – No snow

1 – Trace to less than 2 inches

1 – Trace to less than 2 inches

2 – 2 inches or more

2 – 2 to less than 4 inches

4 – 4 to less than 6 inches

6 – 6 inches or more

Line 17: CIG: The ceiling height at the specified time, based on the following code: “1” means less than 200 ft; “2” means 200 to 400 ft; “3” means 500 to 900 ft; “4” means 1000 to 3000 feet; “5” means 3100 to 6500 ft; “6” means 6600 to 12000 ft; and “7” means greater than 12000 ft. The ceiling is defined as the level of the base of the lowest cloud layer that is broken or overcast.

Line 18: VIS: The horizontal visibility at the specified time, based on the following code: “1” means less than 1/2 mile; “2” means 1/2 mile to 7/8 mile; “3” means 1 to 2 3/4 miles; “4” means 3 to 5 miles; and “5” means greater than 5 miles.

Line 19: OBVIS: The obstructions to visibility at the specified time: “H” means haze, “F” means fog, while “N” means neither fog nor haze.

Below is some NGM MOS guidance. Use it to answer the questions that follow.

1.	DCA	NGM MOS GUIDANCE																03/06/91	0000	UTC
2.	DAY	/MAR 6						/MAR 7						/MAR 8						
3.	HOUR	06	09	12	15	18	21	00	03	06	09	12	15	18	21	00	03	06	09	12
4.	MX/MN							59				39				54				24
5.	TEMP	37	34	33	38	45	53	52	49	46	43	40	42	47	51	42	39	35	30	24
6.	DEWPT	27	28	28	30	32	36	40	38	41	41	37	33	28	27	25	21	20	19	19
7.	CLDS	OV	OV	OV	OV	OV	OV	OV	OV	OV	OV	BK	BK	BK	SC	SC	SC	CL	CL	CL
8.	WDIR	26	18	08	12	14	14	15	18	24	27	28	29	29	29	29	33	01	02	00
9.	WSPD	01	04	06	10	11	12	16	18	13	15	12	20	24	22	14	12	14	08	00
10.	POP06			4		9		46		85		62		3		7		12		8
11.	POP12							49				91				8				19
12.	QPF			0/		0/		1/1		3/		2/4		0/		0/0		0/		0/0
13.	PTYPE	S	S	S	S	S	R	R	R	R	R	R	R	R	R	R	R	S		Z
14.	POZP	8	10	12	6	0	0	0	0	0	1	3		0		2		24		35
15.	POSN	65	67	70	48	41	14	11	13	15	16	20		9		16		50		42
16.	SNOW			0/		0/		0/1		0/		0/0		0/		0/0		0/		0/0
17.	CIG	4	5	4	4	5	6	7	6	3	2	1		5		6				
18.	VIS	3	4	3	5	5	5	5	4	2	2	1		3		4				
19.	OBVIS	H	H	H	N	N	N	N	F	F	F	F		H		H				

- a. What location is this MOS Guidance for (the first two letters of the three-letter identification code should give it away)?

- b. At what time and on what date was the model initialized?

- c. What's the high and low temperature forecast for March 7?

- d. What's the lowest temperature forecast during the period covered by this MOS guidance?

- e. When does that lowest temperature occur?

- f. During what 6-hour period is the greatest probability of precipitation?

- g. What about a 12-hour period?

- h. During that 12-hour period, what are the 6-hour and 12-hour amounts of precipitation predicted?

- i. At what time are the strongest winds predicted?

- j. What are the speed and direction of those winds?

- k. At what time are the lowest ceiling and the lowest visibility predicted?

- l. What are the predicted values of these two quantities?

- m. What is the obstruction to visibility at this time?

- n. Using all the information given for the forecast at 00Z on March 7, describe what the weather will be like at that time at DCA.

NAM MOS (MET)

KISP	NAM MOS GUIDANCE																8/25/2019 1200 UTC				
DT /AUG	25/AUG				26				/AUG				27				/AUG				28
HR	18	21	00	03	06	09	12	15	18	21	00	03	06	09	12	15	18	21	00	06	12
N/X							57					72							74	66	
TMP	72	72	66	63	60	59	62	67	70	70	65	62	61	60	65	71	72	70	67	67	70
DPT	55	54	54	56	55	53	55	53	52	53	54	56	56	57	59	59	61	62	63	65	69
CLD	BK	BK	SC	FW	CL	SC	BK	SC	BK	BK	SC	SC	FW	FW	BK	BK	BK	BK	OV	OV	OV
WDR	05	06	06	05	04	04	03	04	06	07	07	07	07	07	07	10	13	14	13	14	13
WSP	14	14	12	10	11	09	11	11	10	11	06	05	05	04	06	07	08	07	05	04	06
P06			0		0		1		0		0		2		8		6	10	24	20	
P12							1				0				8			10		25	
Q06			0		0		0		0		0		0		0		0	0	0	0	
Q12							0				0				0			0		0	
T06		0/	0	0/	0	0/	0	0/	2	0/	1	0/	0	0/	0	0/	4	0/	6	3/	0
T12				0/	0			0/	2			0/	1			0/	4		2/	6	
CIG	7	6	6	8	8	8	5	8	6	8	8	8	8	8	8	8	8	8	7	6	3
VIS	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
OBV	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

- a. What location is this MOS Guidance for?

- b. At what time and on what date was the model initialized?

- c. What's the high and low temperature forecast for August 26th?

- d. What's the lowest temperature forecast during the period covered by this MOS guidance?
- e. When does that lowest temperature occur?
- f. During what 6-hour period is the greatest probability of precipitation?
- g. What about a 12-hour period?
- h. During that 12-hour period, what are the 6-hour and 12-hour amounts of precipitation predicted?
- i. At what time are the strongest winds predicted?
- j. What are the speed and direction of those winds?
- k. At what time is the lowest ceiling predicted?
- l. What is the predicted value of this quantity?
- m. In what 12-hour period is the highest potential for thunderstorms?

Sample Lesson/Unit 10 Wild and Unusual Weather

- **Tracking Sandy**
- **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.**
- **Science and Engineering Practices**
 1. Asking questions (science)/defining problems (engineering)
 2. Analyzing and interpreting data*
 3. Using mathematics and computational thinking*
 4. Constructing explanations (science) and designing solutions (engineering)
 5. Obtaining, evaluating and communicating information*
- **Cross-cutting concepts from ELA and Math**
 1. Patterns
 2. Energy and Motion
 4. Cause and Effect
 5. Scale, Proportion, and Quantity
 6. Influences of Science, Engineering Math, and Technology on Society
- **Disciplinary Core Ideas**
 1. **Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.**
Using data to analyze a storm and learn from the past.
- **Method**

Tracking Sandy

Severe Weather Grades 10-12

Objectives:

The student will be able to:

- Track a storm using a hurricane tracking chart
- Use their prior knowledge to interpret storm data observations
- Draw conclusions about Sandy
- Evaluate preparedness procedures and make recommendations for the future

Materials:

- Hurricane Tracking Charts (1/student)
- Tracking Sandy activity sheets
(1/student)
- Sandy Observation Data (1/student)

Activities:

1. The teacher will ask the students to list what they already know about Superstorm Sandy. The teacher will then list the information on the board and hand out the Tracking Sandy Sheets.

2. The class will read the introduction together. Some students may still have recollection of Sandy or know what the impact was on their family and friends. Students will be asked to share stories. If possible, the teacher will share some stories as well.
3. The students will be given the hurricane tracking charts and the Tracking Sandy data. They will then complete the tracking chart for Sandy and answer the questions.
4. The class will review the answers together.
5. The teacher will instruct the students to complete the homework assignment in which they will investigate their own (if relevant) Sandy story or that of their friends and neighbors. The students will come up with ideas on how to be better prepared.

TRACKING SANDY

In this investigation, you will track the motion of “Superstorm” Sandy and chart its development and changes over the course of its existence. The effects of Sandy on the eastern seaboard were significant. The damage estimate for the northeast is over \$50 billion. Many states qualified for federal disaster relief. In the United States, 72 direct deaths were noted, 48 of which were in New York. In addition, at least 87 deaths were indirectly associated with Sandy, not including those due to limited access to healthcare during the immediate recovery [National Hurricane Center].

Storm Surge caused much of the damage from Sandy. According to the National Hurricane Center, the following inundations (water levels on usually dry ground), expressed above ground level, were prevalent along the coast due to the storm tide (combination of astronomical tides and storm surge).

Staten Island and Manhattan 4 – 9 ft

Brooklyn and Queens 3 – 6 ft

The Bronx and Westchester County 2 – 4 ft

Long Island (Nassau and Suffolk Counties) 3 – 6 ft

Hudson River Valley 3 – 5 ft

Materials –

- Atlantic Hurricane Tracking Chart
- Sandy Data

Procedure

- Plot the latitude and longitude of Sandy for each observation given. You should write the advisory number (ADV) next to the plotted location. Note that the time of each advisory is in Z time. Connect each point with a line segment to show the direction of movement.
- Use a different colored pencil for each category under “STAT” to show the development and changes of the storm. Use the symbol for hurricane  when the storm is a hurricane.

Media buildup prior to the storm was extensive. What was your experience with Sandy? What were the experiences of your friends and neighbors?

Answer the following questions in complete sentences:

1. Looking at the columns for windspeed and air pressure, describe the relationship between these two variables.
2. The columns for wind speed and pressure do not include units. Based on your knowledge of meteorology, what units are used for wind and pressure on this chart.
3. Calculate the rate of motion (speed) that Sandy tracked between 10/29 03Z and 10/30 03Z in km/hr.
4. What direction do hurricanes usually move when they are north of 30°N latitude? Why do you think that is? How does this affect Long Island?

5. How was Sandy's track atypical (unusual)? Why do you think Sandy took an atypical path north of Cape Hatteras?

6. Based on your chart, where did Sandy make landfall?

7. What kind of a storm was Sandy when it made landfall?

8. Visit <http://www.weather.gov/okx/Hurricane> Sandy.

a. What was the maximum wind speed detected on Long Island?

b. Why was Sandy not considered a hurricane?

c. Write 2 things you learned about Sandy that you didn't already know.

9. Based on the chart and your knowledge of storms, what are some factors that made Sandy so devastating?

10. Up to five years after the storm, some south shore residents were asked to raise their homes. Many had already renovated their homes after Sandy. In your opinion, is this a good idea? Explain.

Tracking Sandy Homework:

Speak to your family and friends about their experiences with Sandy. Answer the following:

1. What actions did people in your neighborhood take prior to the arrival of Sandy?

2. Where were you during the storm? What was your experience while the storm was hitting Long Island?

3. How were your family and friends affected by the damage from the storm? What difficulties did they face after it was over?

4. Is there anything you would do differently in the event a hurricane was predicted to hit Long Island.

5. What lessons did we learn from Sandy on Long Island?

Date:	22-29	OCT	2012			
Hurricane-2	SANDY					
ADV	LAT	LON	TIME	WIND	PR	STAT
1	13.5	-78	10/22/15Z	25	1003	TROPICAL DEPRESSION
1A	13.5	-78.5	10/22/18Z	25	1003	TROPICAL DEPRESSION
2	12.5	-78.5	10/22/21Z	35	999	TROPICAL STORM
2A	12.7	-78.7	10/23/00Z	40	998	TROPICAL STORM
3	12.7	-78.6	10/23/03Z	40	998	TROPICAL STORM
3A	12.9	-78.7	10/23/06Z	40	998	TROPICAL STORM
4	13.3	-78.6	10/23/09Z	40	998	TROPICAL STORM
4A	13.4	-77.9	10/23/12Z	40	997	TROPICAL STORM
5	13.8	-77.8	10/23/15Z	45	993	TROPICAL STORM
5A	14.1	-77.6	10/23/18Z	45	993	TROPICAL STORM
6	14.3	-77.6	10/23/21Z	45	993	TROPICAL STORM
6A	14.8	-77.5	10/24/00Z	45	993	TROPICAL STORM
7	15.2	-77.2	10/24/03Z	50	989	TROPICAL STORM
7A	15.7	-77.1	10/24/06Z	55	988	TROPICAL STORM
8	16.3	-77	10/24/09Z	60	986	TROPICAL STORM
8A	16.6	-76.9	10/24/12Z	60	983	TROPICAL STORM
9	17.1	-76.7	10/24/15Z	70	973	HURRICANE-1
9A	17.6	-76.8	10/24/18Z	70	973	HURRICANE-1
10	18.3	-76.6	10/24/21Z	70	970	HURRICANE-1
10A	18.7	-76.4	10/25/00Z	75	968	HURRICANE-1
11	19.4	-76.3	10/25/03Z	80	954	HURRICANE-1
11A	20.1	-75.9	10/25/06Z	95	957	HURRICANE-2
12	20.9	-75.8	10/25/09Z	90	960	HURRICANE-2
12A	21.6	-75.5	10/25/12Z	90	967	HURRICANE-2
13	22.4	-75.5	10/25/15Z	90	964	HURRICANE-2
13A	23.5	-75.4	10/25/18Z	90	963	HURRICANE-2
14	24.5	-75.6	10/25/21Z	90	963	HURRICANE-2
14A	24.8	-75.8	10/26/00Z	85	965	HURRICANE-2
15	25.3	-76.1	10/26/03Z	80	968	HURRICANE-1
15A	25.8	-76.5	10/26/06Z	75	968	HURRICANE-1
16	26.3	-76.9	10/26/09Z	70	968	HURRICANE-1
16A	26.4	-76.9	10/26/12Z	70	970	HURRICANE-1
17	26.7	-76.9	10/26/15Z	70	970	HURRICANE-1
17A	27.1	-77.1	10/26/18Z	65	971	HURRICANE-1
18	27.3	-77.1	10/26/21Z	65	971	HURRICANE-1
18A	27.5	-77.2	10/27/00Z	65	970	HURRICANE-1
19	27.7	-77.1	10/27/03Z	65	969	HURRICANE-1
19A	28.1	-76.9	10/27/06Z	65	969	HURRICANE-1
20	28.6	-76.7	10/27/09Z	60	969	TROPICAL STORM
20A	28.8	-76.8	10/27/12Z	65	960	HURRICANE-1
21	29	-76	10/27/15Z	65	958	HURRICANE-1
21A	29.7	-75.6	10/27/18Z	65	961	HURRICANE-1
22	30.2	-75.2	10/27/21Z	65	961	HURRICANE-1
22A	30.5	-74.7	10/28/00Z	65	961	HURRICANE-1
23	30.9	-74.3	10/28/03Z	65	960	HURRICANE-1
23A	31.5	-73.7	10/28/06Z	65	960	HURRICANE-1
24	31.9	-73.3	10/28/09Z	65	960	HURRICANE-1
24A	32.1	-73.1	10/28/12Z	65	951	HURRICANE-1
25	32.5	-72.6	10/28/15Z	65	951	HURRICANE-1
25A	32.8	-71.9	10/28/18Z	65	951	HURRICANE-1
26	33.4	-71.3	10/28/21Z	65	952	HURRICANE-1
26A	34	-70.9	10/29/00Z	65	950	HURRICANE-1
27	34.5	-70.5	10/29/03Z	65	950	HURRICANE-1
27A	35.2	-70.5	10/29/06Z	65	950	HURRICANE-1
28	35.9	-70.5	10/29/09Z	75	946	HURRICANE-1
28A	36.8	-71.1	10/29/12Z	75	946	HURRICANE-1
29	37.5	-71.5	10/29/15Z	80	943	HURRICANE-1
29A	38.3	-73.1	10/29/18Z	80	940	HURRICANE-1

30	38.8	-74.4	10/29/21Z	80	940	HURRICANE-1
31	39.8	-75.4	10/30/03Z	65	952	POST-TROPICAL CYCLONE