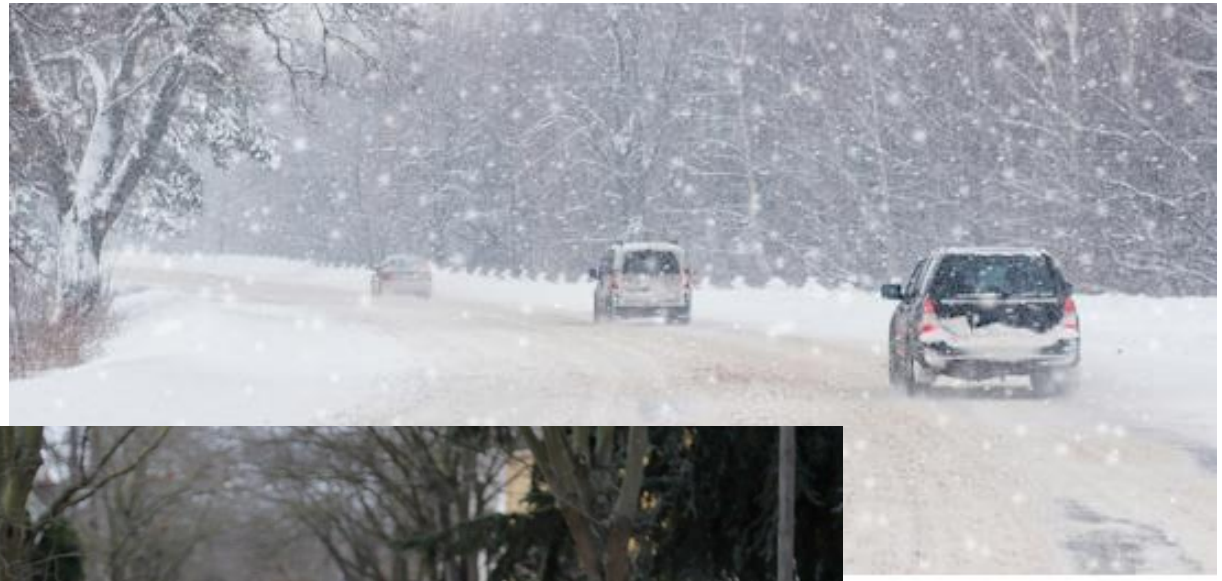
- NSTA STEM SF 2019

Making the Invisible Visible: Improve Your Teaching about Weather & Climate

Dr. Mike Passow
Lamont-Doherty Earth Observatory of Columbia University
and
Houghton Mifflin Harcourt Consulting Author

Houghton Mifflin Harcourt®
The Learning Company™

What are your earliest weather memories?



We are affected by weather every day, wherever we live.

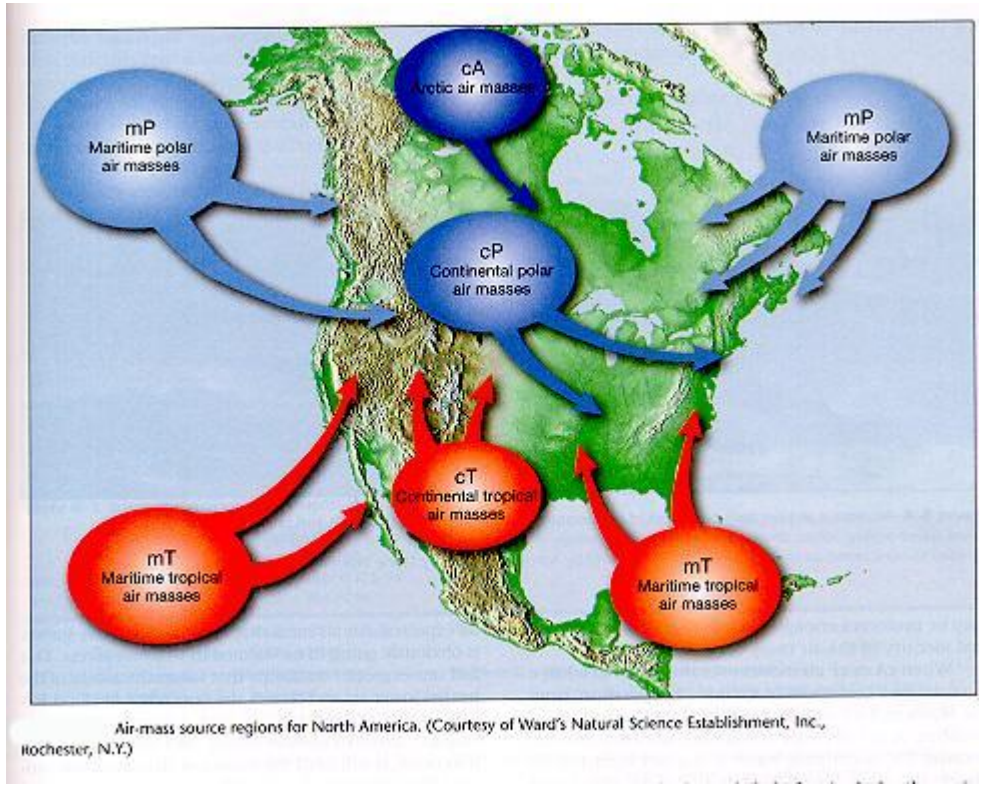
"Weather determines how we dress—Climate determines what we buy."

Weather elements include:

- Temperature
- Barometric pressure
- Wind speed and direction
- Humidity and dew point
- Clouds
- Special conditions such as lightning and fog

What causes our weather? (1)

- AIR MASSES
  large bodies of air with similar temperatures & moistures at any height

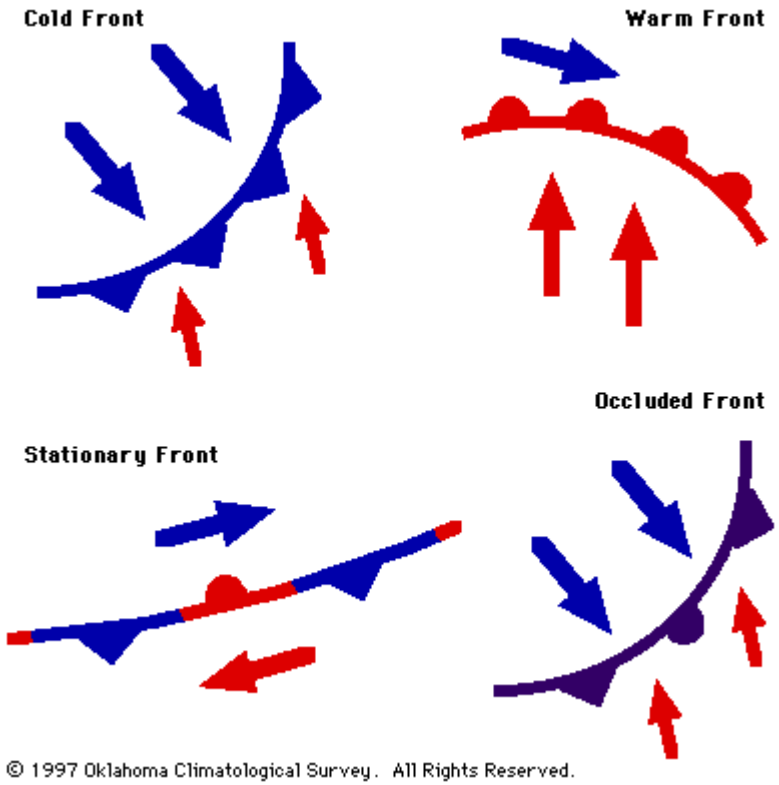


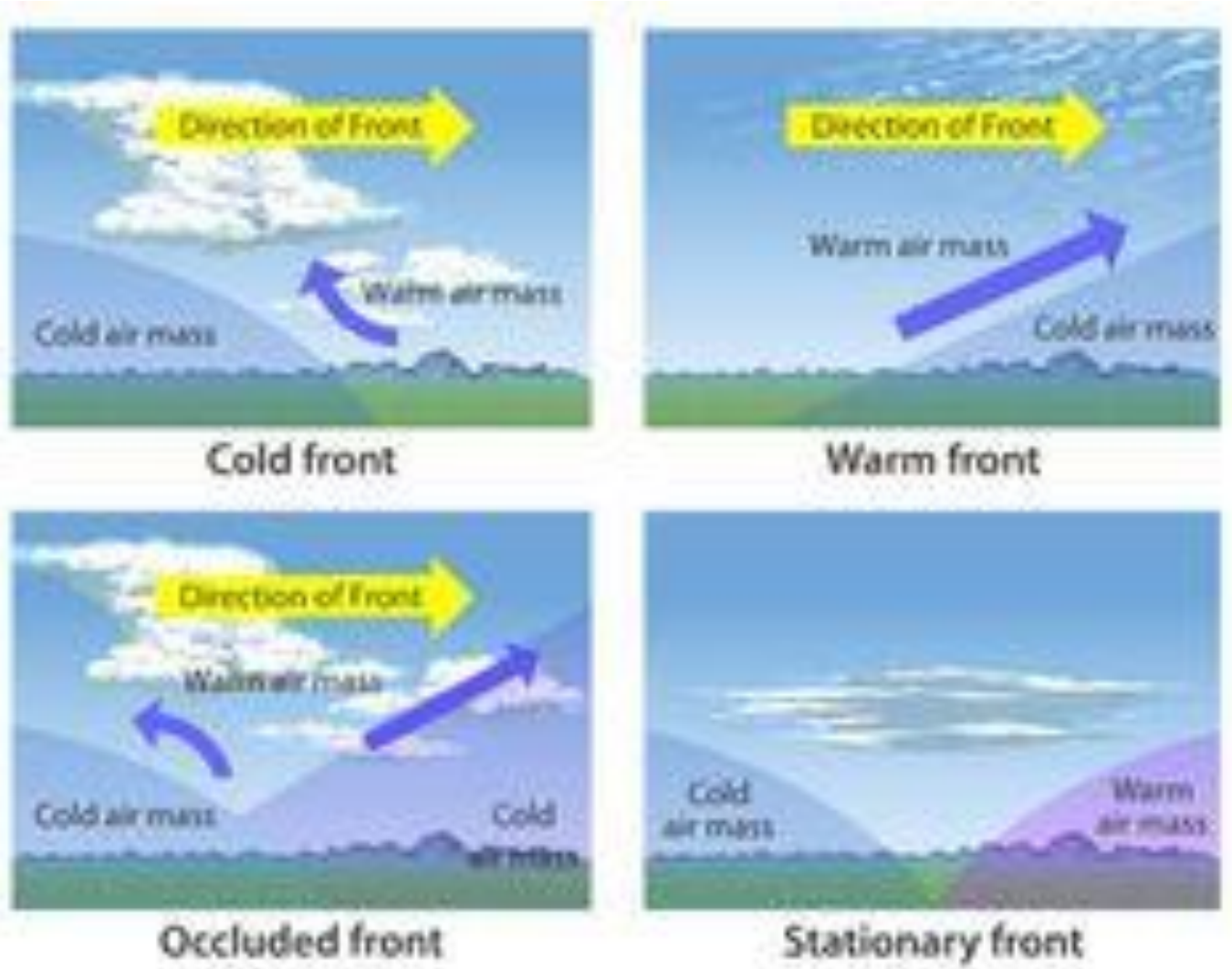
Air-mass source regions for North America. (Courtesy of Ward's Natural Science Establishment, Inc., Rochester, N.Y.)

https://earth.usc.edu/~stott/Catalina/WeatherPatterns.html

What causes our weather? (2)

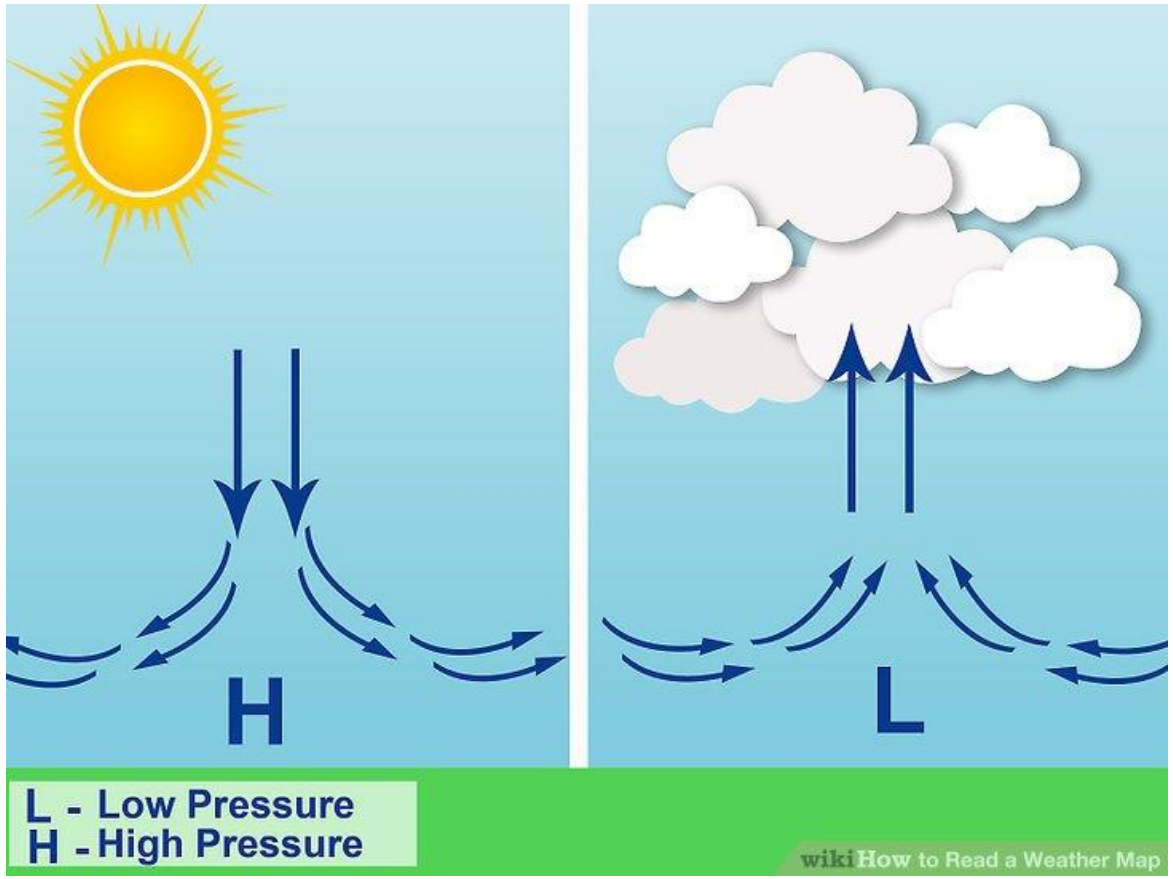
- WEATHER FRONTS

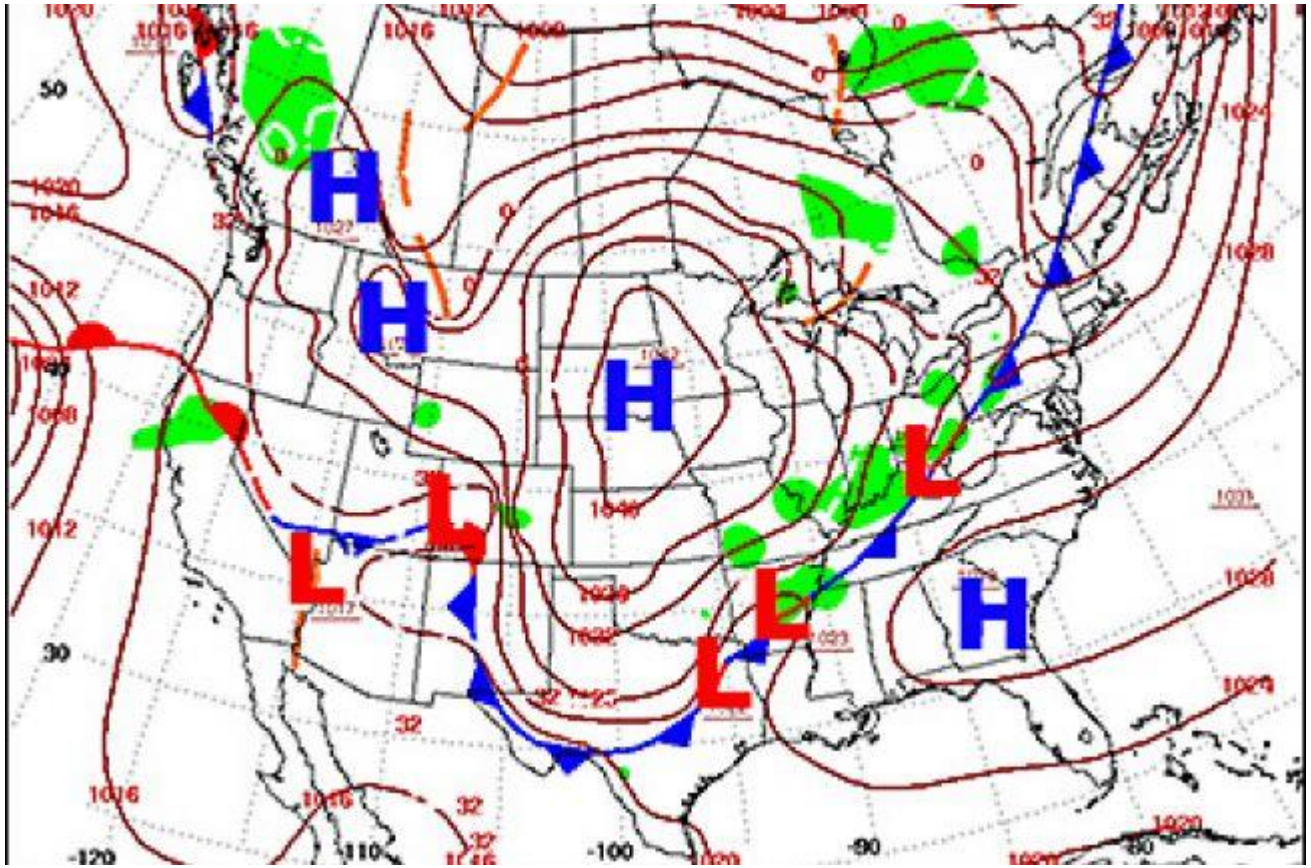




What causes our weather? (3)

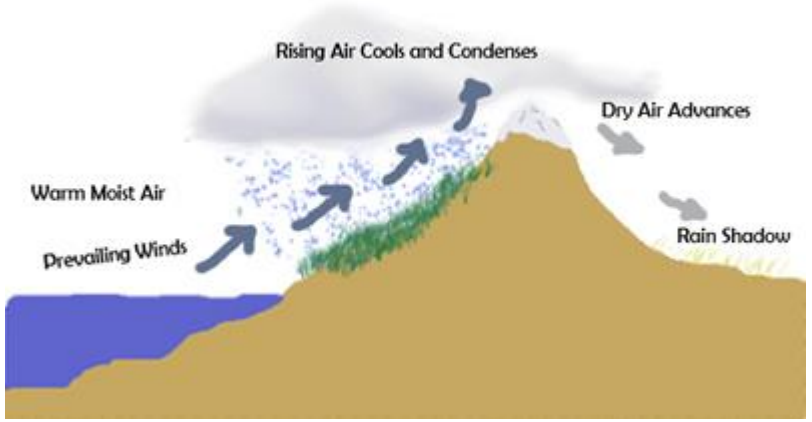
- Low pressure (cyclones) and High pressure (anticyclones) systems





What other factors affect weather & climate?

Mountain (orographic) effects



Lake effect snows

Storms

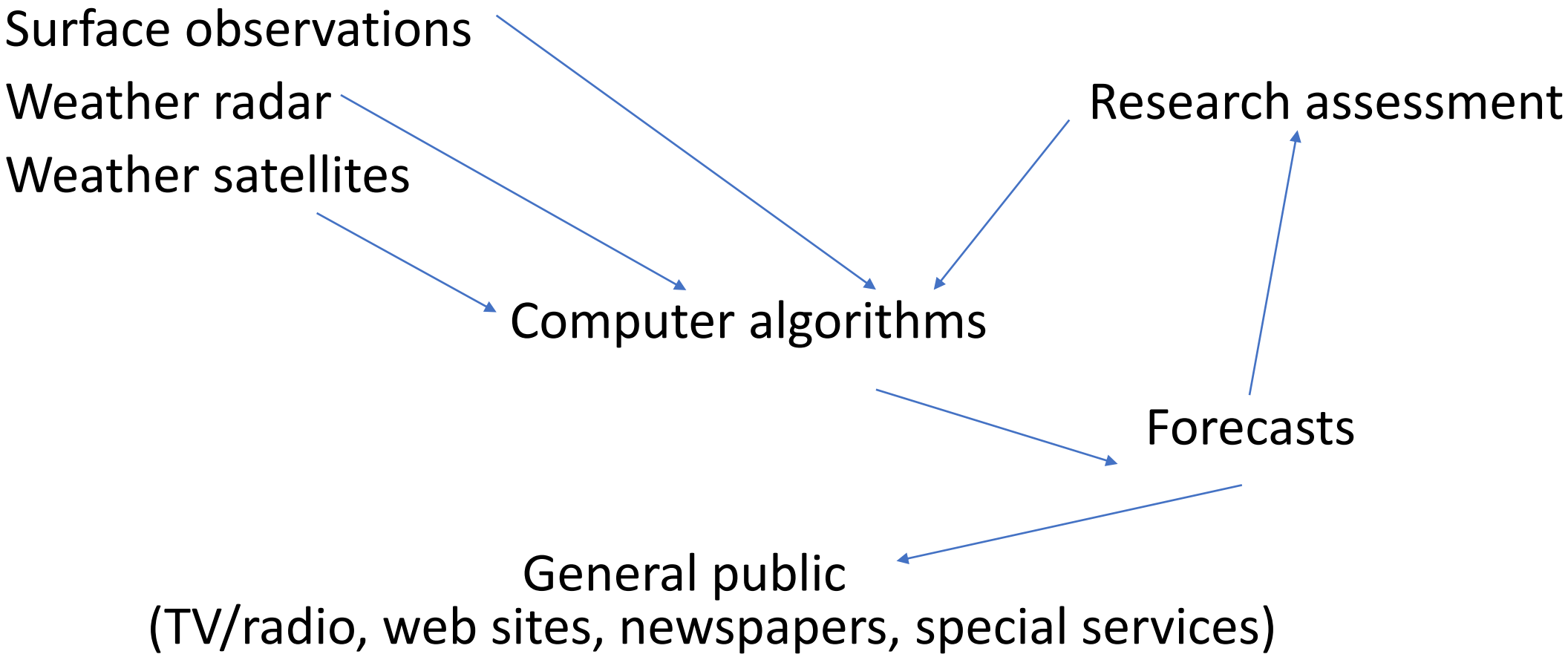
Monitoring weather local to global

Surface Observation systems

Radar

Satellites

How are weather forecasts made?

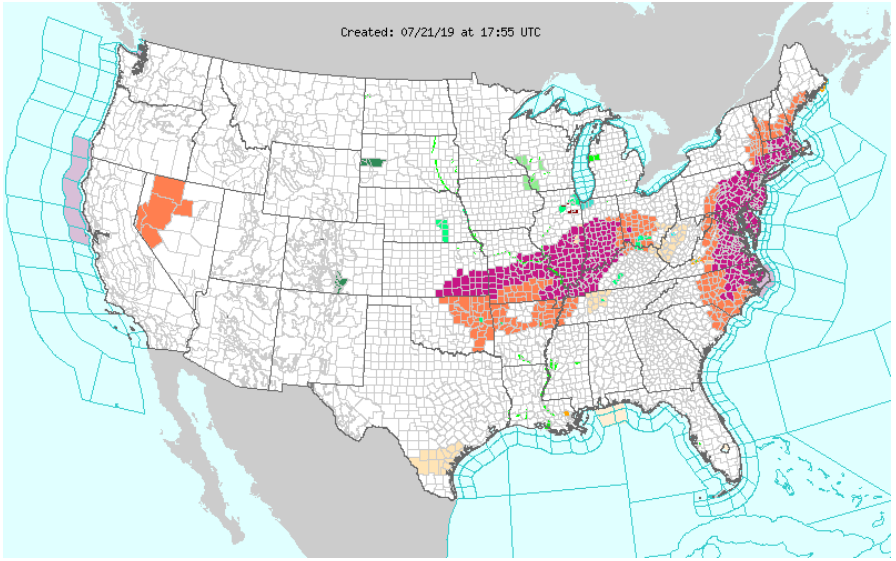


How can you observe weather in your classroom?

- Web-based weather monitoring
  National Weather Service https://www.weather.gov/

NATIONAL WEATHER SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Weather-Ready Nation
National Oceanic and Atmospheric Administration



NWS/other cell phone
emergency warning networks

National Weather Service

https://www.weather.gov

NATIONAL WEATHER SERVICE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

HOME | FORECAST | PAST WEATHER | SAFETY | INFORMATION | EDUCATION | NEWS | SEARCH | ABOUT

Local forecast by "City, St" or ZIP code

Enter location ... Go

Location Help

Sunday Brings Heat Relief For Some; Flash Flood Threat Along Cold Front

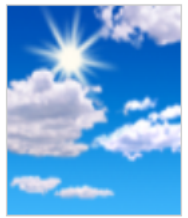
A cold front shifting across the Central Plains, Midwest, Great Lakes and Northeast on Sunday will bring some relief from the heat with cooler and drier air. Excessive heat holds Sunday roughly south of I-70. Heavy rain from thunderstorms along the front may bring flash flooding. Read More >

WRN WEATHER-READY NATION

ACTIVE ALERTS | FORECAST MAPS | RADAR | RIVERS, LAKES, RAINFALL | AIR QUALITY | SATELLITE | PAST WEATHER

MY FORECAST

Englewood NJ

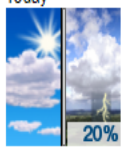


Fair

90°F

32°C Get Detailed info

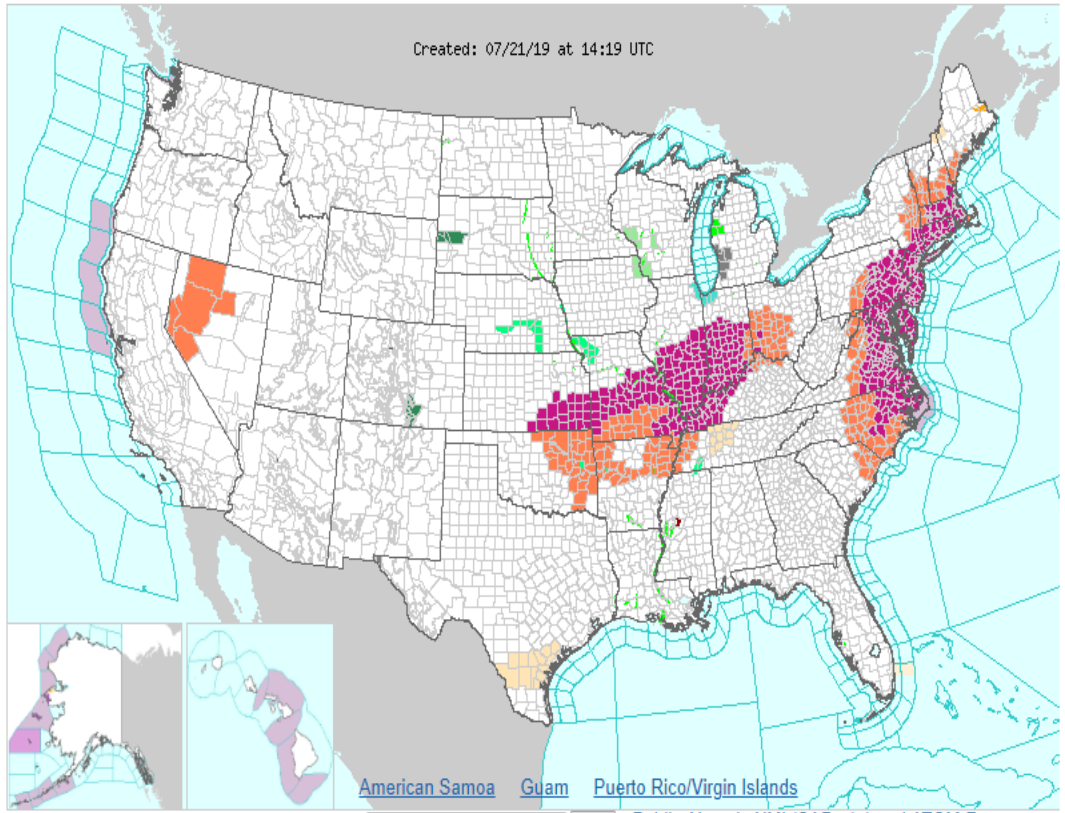
Today



Mostly Sunny then Heavy Rain

High: 100°F

Tonight



NATIONAL WEATHER SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Go
View Location Examples

Your local forecast office is
New York, NY

News Headlines
- Latest Briefing Heat Through Early This Evening As Well As Flash Flood Potential Mon - Tue
- Dangerous Heat Through Sunday
- Stay Safe in the Heat

Additional Headlines

Hazardous Weather Conditions
- Hazardous Weather Outlook
- Excessive Heat Warning until July 21, 09:00 PM EDT
- Flash Flood Watch in effect from July 22, 12:00 PM EDT until July 23, 08:00 AM EDT
- Air Quality Alert

En Español | Share

Current conditions at
Teterboro, Teterboro Airport (KTEB)
Lat: 40.86°N Lon: 74.06°W Elev: 7ft.

Fair
90°F
32°C

Humidity	59%
Wind Speed	NW 9 mph
Barometer	29.80 in (1009.1 mb)
Dewpoint	74°F (23°C)
Visibility	10.00 mi
Heat Index	99°F (37°C)
Last update	21 Jul 9:51 am EDT

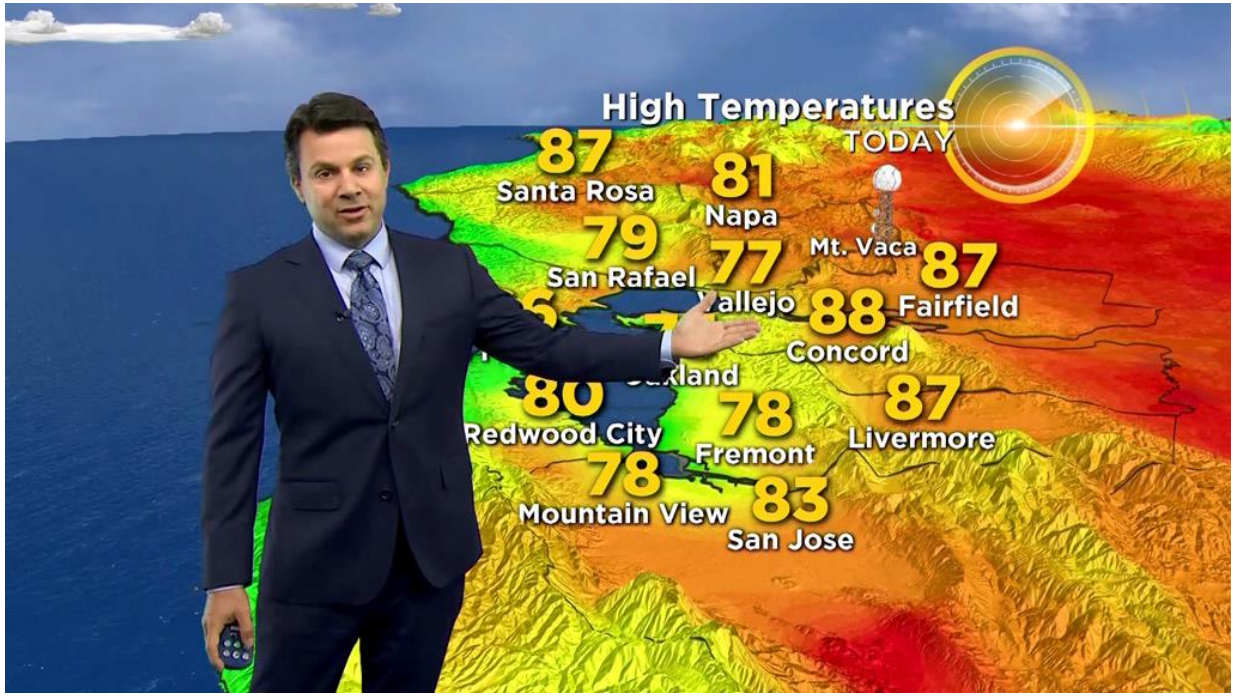
More Information:
Local Forecast Office
More Local Wx
3 Day History
Mobile Weather
Hourly Weather Forecast

Extended Forecast for
Englewood NJ

Click here for hazard details and duration

NOW until 9:00pm Sun	Today	Tonight	Monday	Monday Night	Tuesday	Tuesday Night	Wednesday	Wednesday Night
Excessive Heat Warning	Excessive Heat Warning		Flash Flood Watch	Flash Flood Watch				
20%	20%	30%	80%	90%	60%			
Excessive Heat Warning	Mostly Sunny then Heavy Rain	Heavy Rain	Heavy Rain	Heavy Rain	Showers Likely	Mostly Cloudy	Mostly Sunny	Partly Cloudy
	High: 100 °F	Low: 76 °F	High: 84 °F	Low: 71 °F	High: 81 °F	Low: 66 °F	High: 84 °F	Low: 66 °F

- Local and national TV & radio



- Other networks—ex: CoCoRahs, GLOBE , Oklahoma Mesonet

CoCoRaHS - Community Collabo

https://www.cocorahs.org

COMMUNITY COLLABORATIVE RAIN, HAIL & SNOW NETWORK

"Because every drop counts"

Select Language

Home | Countries | States | View Data | Maps | My Data Entry | Login

Welcome to CoCoRaHS! "Volunteers working together to measure precipitation across the nations."

Main Menu

- Home
- About Us
- Join CoCoRaHS
- Contact Us
- Donate

Resources

- FAQ / Help
- Education
- Training Slide-Shows
- Videos
- Condition Monitoring
- Evapotranspiration
- Soil Moisture

- Volunteer Coordinators
- Hail Pad Distribution/Drop-off
- Help Needed
- Printable Forms

- *The Catch*
- Message of the Day
- Publications
- CoCoRaHS Blog
- Web Groups
- State Newsletters
- Master Gardener Guide
- State Climate Series
- March Madness
- WxTalk Webinars

- Sponsors
- Links
- CoCoRaHS Store

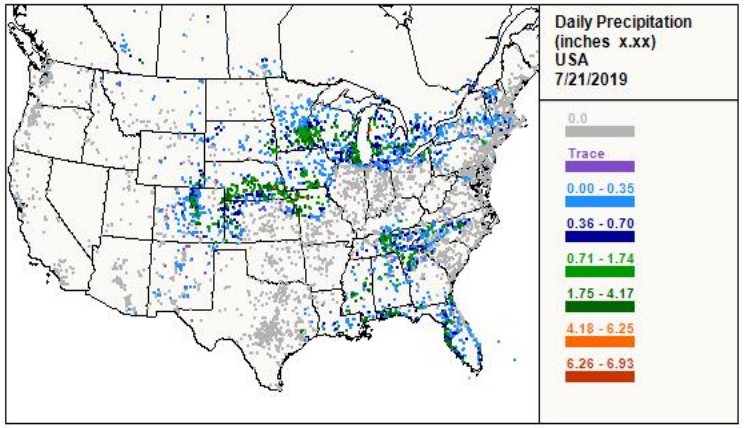
AMBASSADOR WRN WEATHER-READY NATION

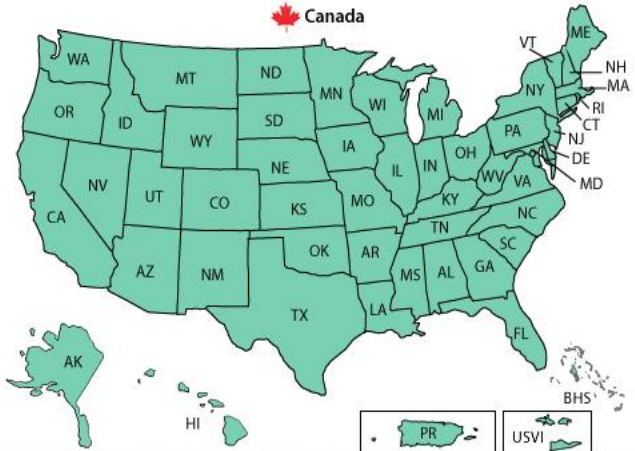
NOAA

Who uses CoCoRaHS Observations?

Reports received today 7/21/2019 as of 10:49 AM EDT

Daily	Multi-day	SigWx	Hail	Condition	ET
6,861	74	1	0	71	93





JOIN CoCoRaHS

TRAINING SLIDE-SHOWS

Training Animations

Things to know about...
Rain
Hail
Snow

Download on the App Store

ANDROID APP ON Google Play

CoCoRaHS WxTalk Webinar Series

Purchase an official

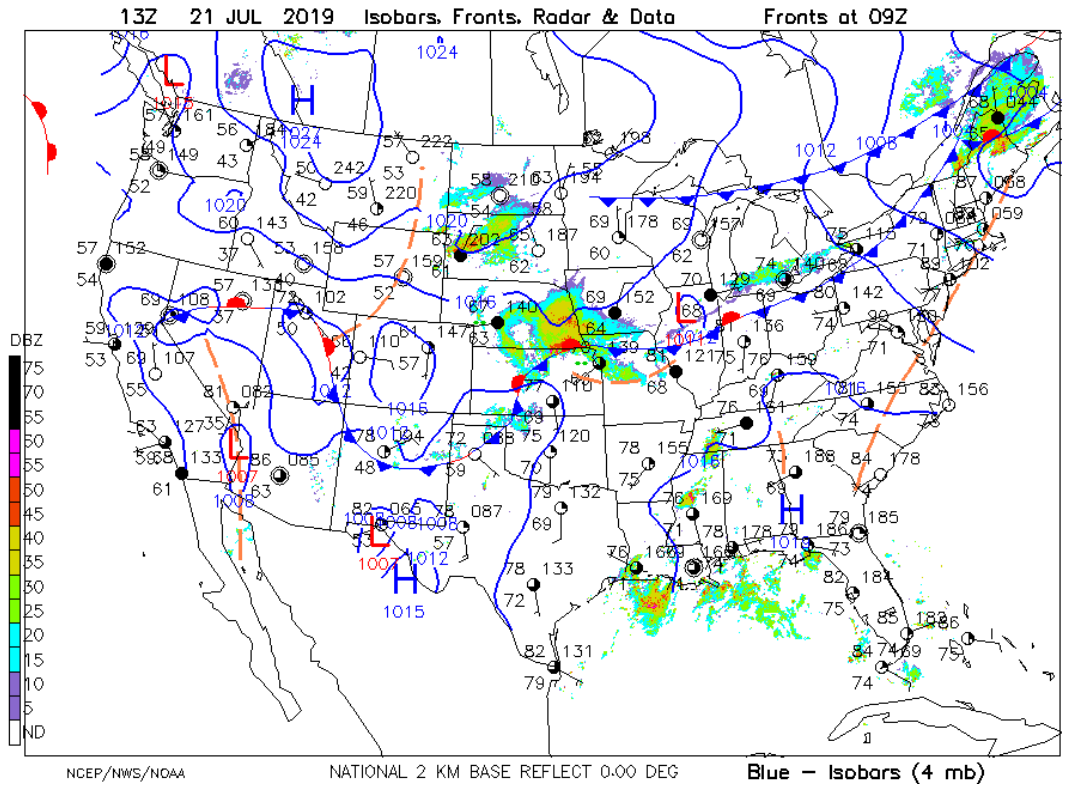
Discussion stop 1

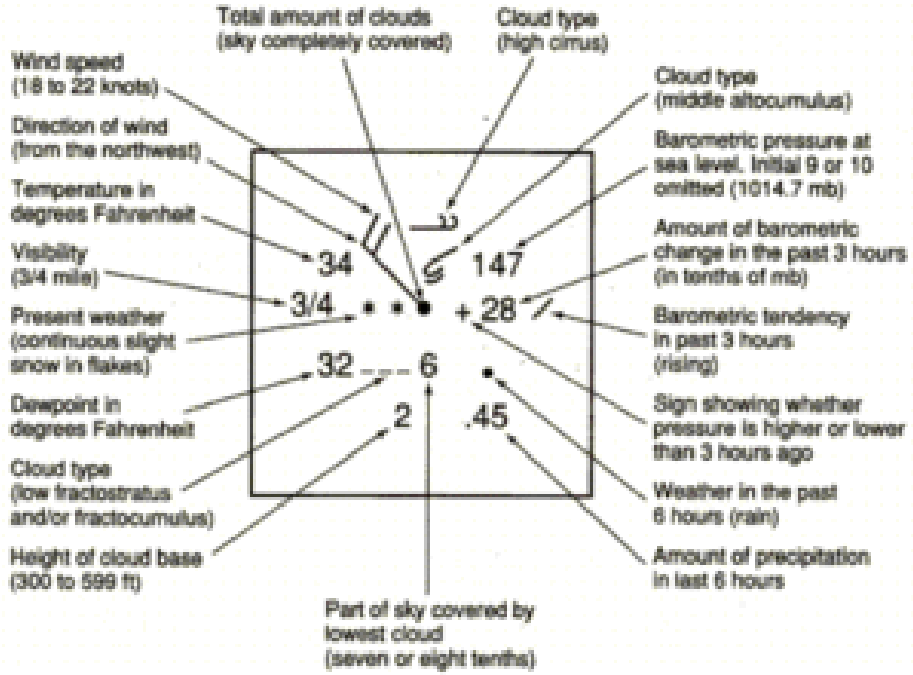
8 minutes

- How can your school get more reliable weather and climate information on which to make operating decisions?

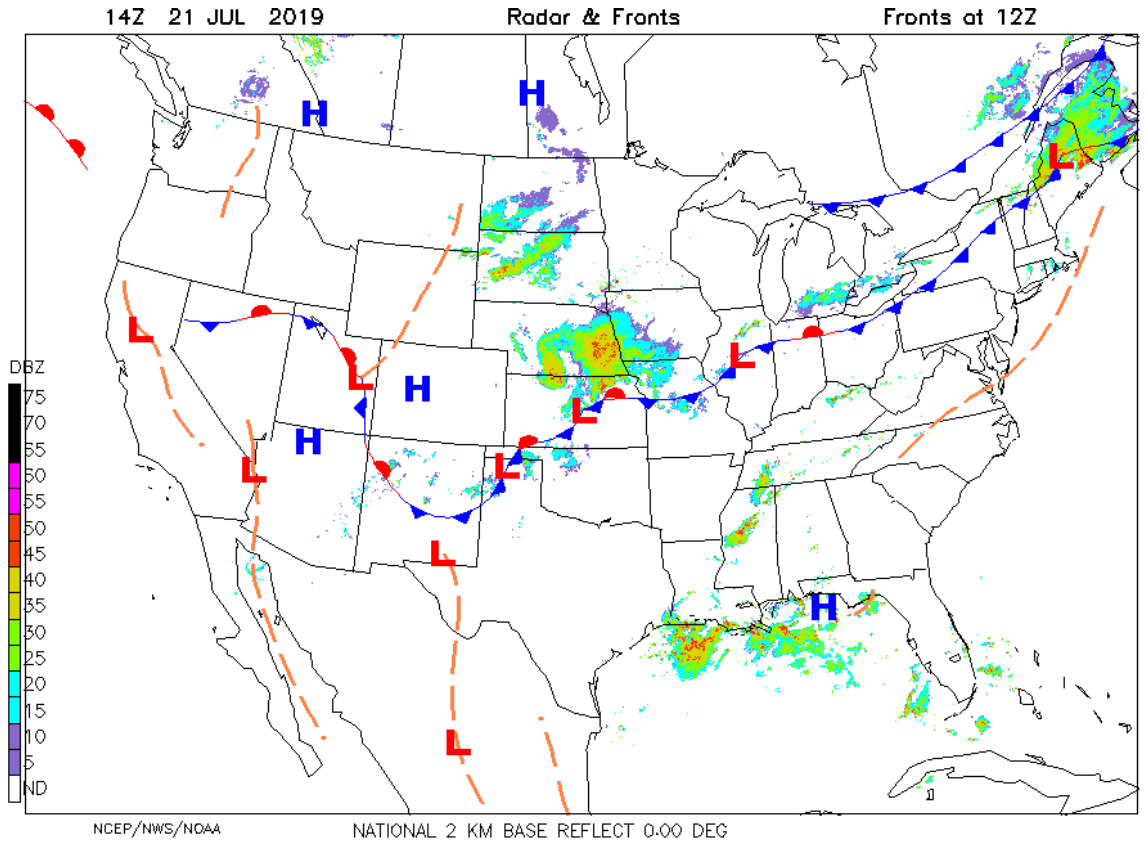
What weather ‘skills’ should your students learn?

- Station models—interpreting and creating
- Weather maps

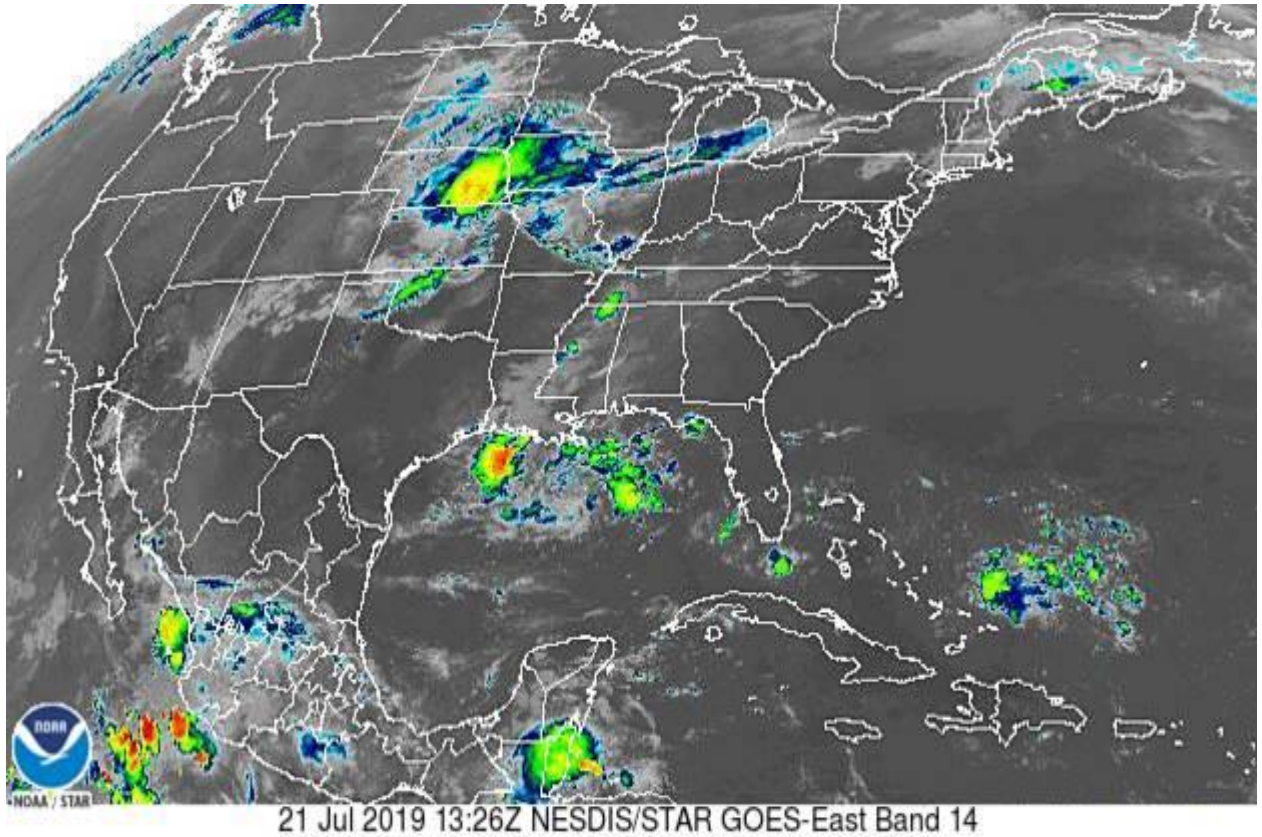




- Radar images



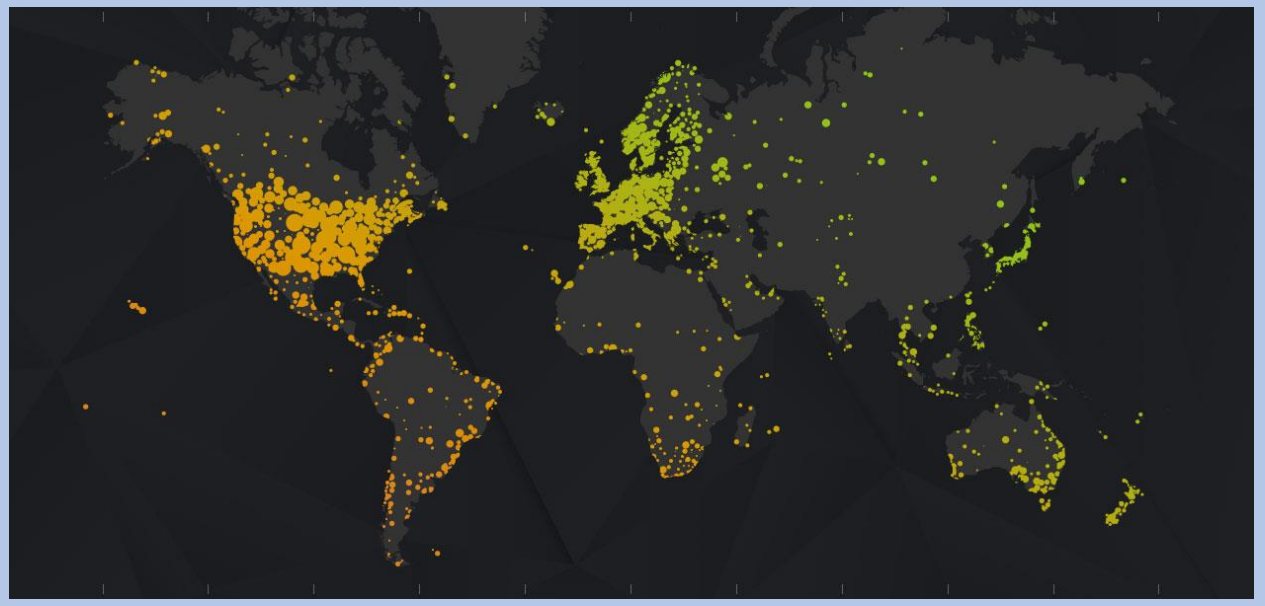
- Satellite images

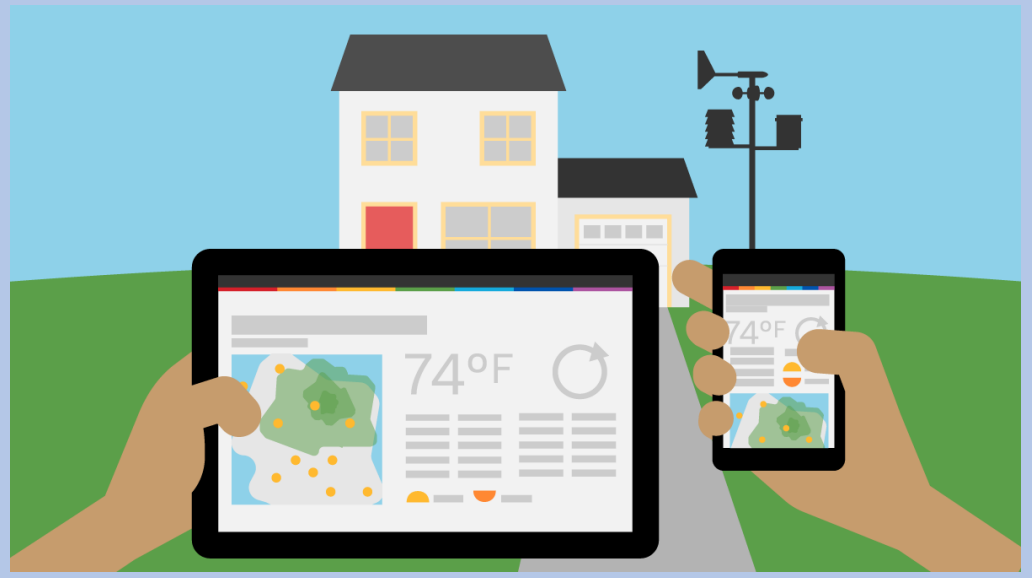


How can you observe weather in your classroom?

- School-based weather instruments
  - What instruments should you have?
  - How should they be mounted?
  - In what ways should you share the data?

Should you join a weather reporting network?





THE GLOBE PROGRAM

- https://www.wunderground.com/weatherstation/overview.asp

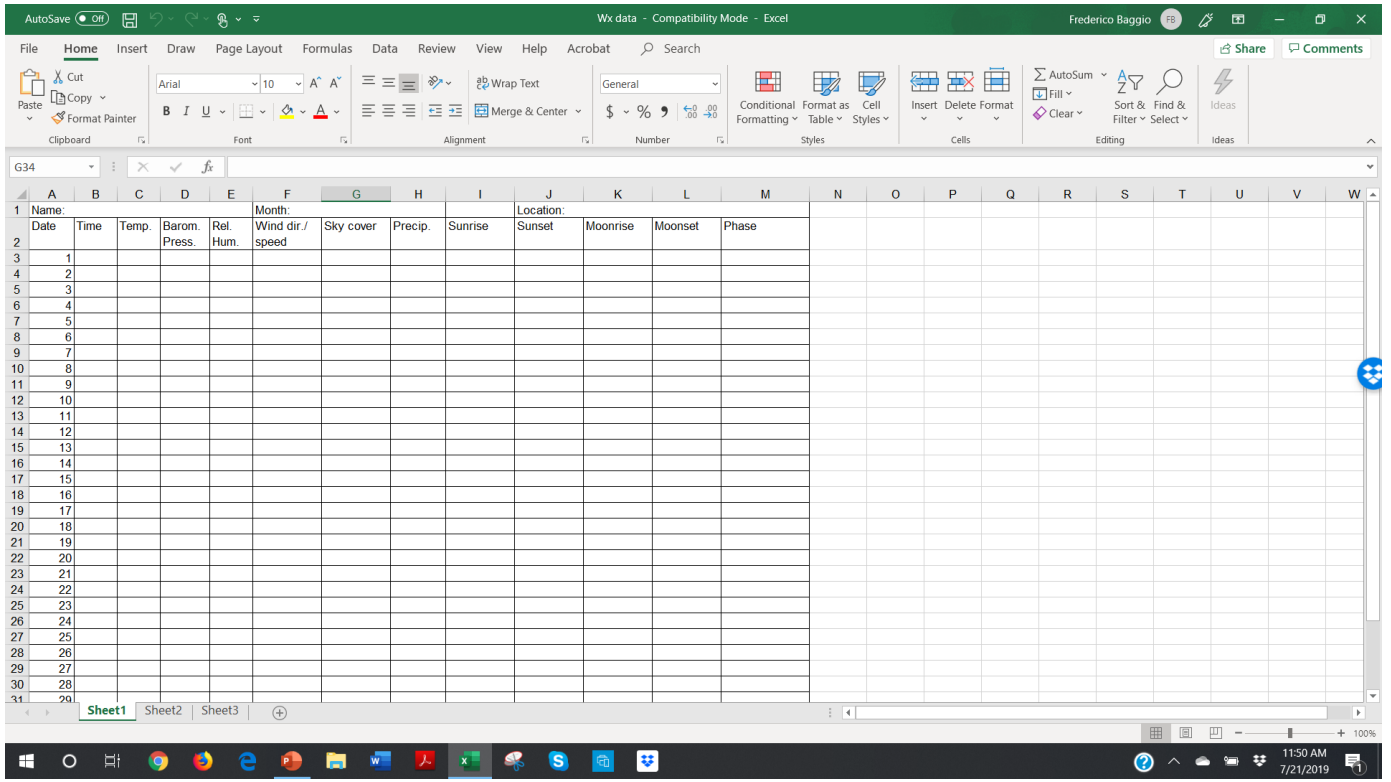
Discussion stop 2

8 minutes

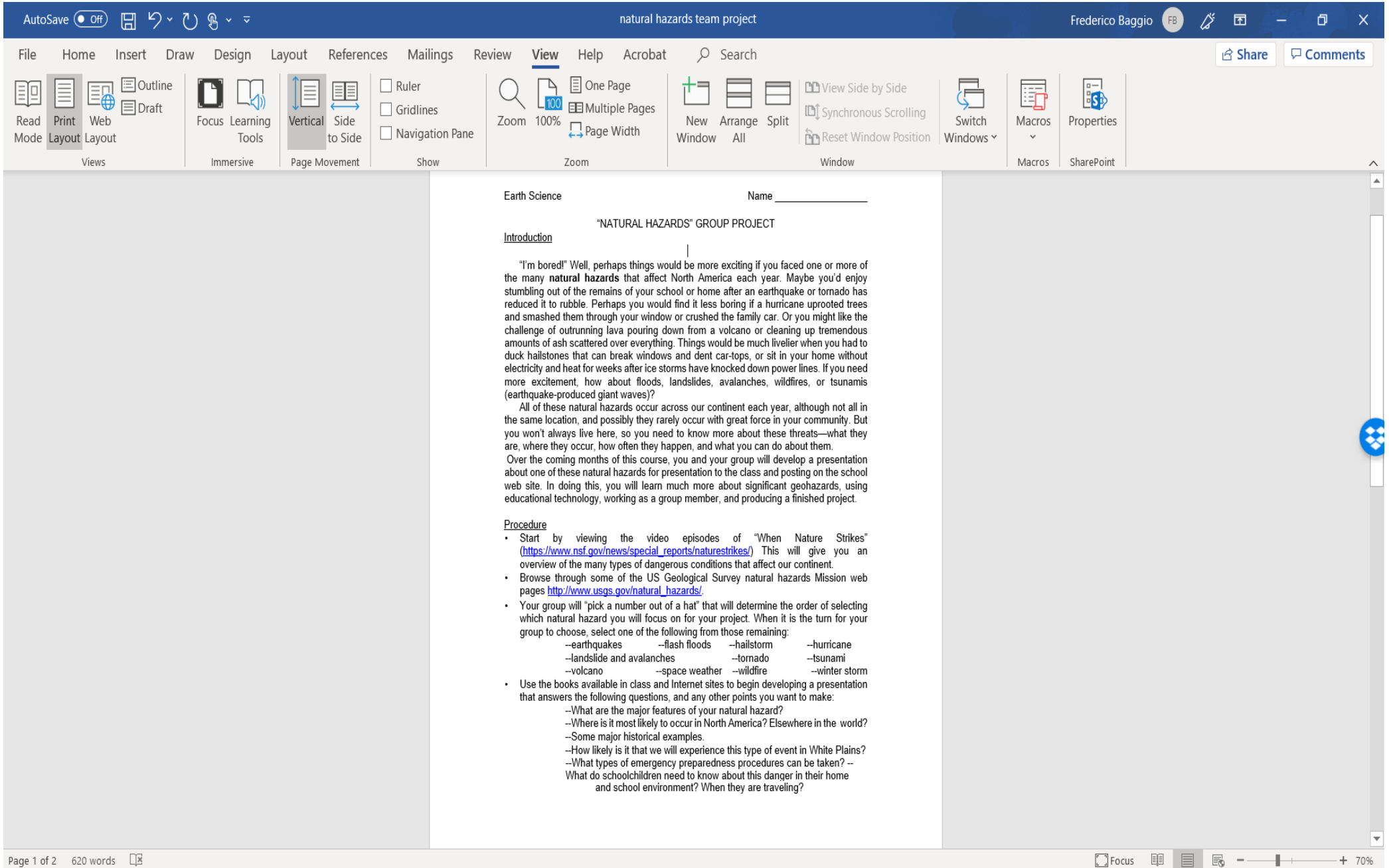
- How can you incorporate hands-on and web-based weather info into your curriculum?

Suggestions for Class Activities and Projects

"do-now" – Collecting daily weather and almanac (sunrise/sunset/ moonrise/moonset/phase) data



- Natural Hazards Group Project



Earth Science Name _____

"NATURAL HAZARDS" GROUP PROJECT

Introduction

"I'm bored!" Well, perhaps things would be more exciting if you faced one or more of the many **natural hazards** that affect North America each year. Maybe you'd enjoy stumbling out of the remains of your school or home after an earthquake or tornado has reduced it to rubble. Perhaps you would find it less boring if a hurricane uprooted trees and smashed them through your window or crushed the family car. Or you might like the challenge of outrunning lava pouring down from a volcano or cleaning up tremendous amounts of ash scattered over everything. Things would be much livelier when you had to duck hailstones that can break windows and dent car-tops, or sit in your home without electricity and heat for weeks after ice storms have knocked down power lines. If you need more excitement, how about floods, landslides, avalanches, wildfires, or tsunamis (earthquake-produced giant waves)?

All of these natural hazards occur across our continent each year, although not all in the same location, and possibly they rarely occur with great force in your community. But you won't always live here, so you need to know more about these threats—what they are, where they occur, how often they happen, and what you can do about them.

Over the coming months of this course, you and your group will develop a presentation about one of these natural hazards for presentation to the class and posting on the school web site. In doing this, you will learn much more about significant geohazards, using educational technology, working as a group member, and producing a finished project.

Procedure

- Start by viewing the video episodes of "When Nature Strikes" (https://www.nsf.gov/news/special_reports/naturestrikes/) This will give you an overview of the many types of dangerous conditions that affect our continent.
- Browse through some of the US Geological Survey natural hazards Mission web pages http://www.usgs.gov/natural_hazards/.
- Your group will "pick a number out of a hat" that will determine the order of selecting which natural hazard you will focus on for your project. When it is the turn for your group to choose, select one of the following from those remaining:

  --earthquakes --flash floods --hailstorm --hurricane
  --landslide and avalanches --tornado --tsunami
  --volcano --space weather --wildfire --winter storm
- Use the books available in class and Internet sites to begin developing a presentation that answers the following questions, and any other points you want to make:

  --What are the major features of your natural hazard?
  --Where is it most likely to occur in North America? Elsewhere in the world?
  --Some major historical examples.
  --How likely is it that we will experience this type of event in White Plains?
  --What types of emergency preparedness procedures can be taken? --
  What do schoolchildren need to know about this danger in their home and school environment? When they are traveling?

School and local “weather clubs”

- Every school has “weather weenies”
  Give them an organized outlet for their interest with a school club
  Let them make announcements at the end of the day

- Bring in Professional and/or amateur experts
  NWS WCO (Warning and Coordination Officer) and other outreach
  AMS local chapters and weather clubs




Project Atmosphere
The Maury Project
DataStreme Program
› DataStreme Atmosphere
DataStreme Ocean
DataStreme Earth's Climate System
Course Schedule
Local Implementation Teams
DataStreme Application Form
Educational Materials

Education Program
American Meteorological Society
1200 New York Ave NW
Suite 500
Washington, DC 20005
Tel: 202-737-1043
Fax: 202-737-0445
e-mail: amsedu@ametsoc.org

DataStreme Atmosphere

DataStreme Atmosphere is a 13-week course offered twice a year to selected participants nationwide. Directed toward middle-school teachers, but open to all K–12 teachers, you will…

- Learn about the relationships between atmospheric variables and weather patterns
- Utilize real-time data from NOAA, NASA, and other reputable sources
- Investigate atmospheric instability, precipitation processes, and windshear
- Dig into the development of thunderstorms, tornadoes, and hurricanes
- Analyze weather conditions with an online GIS platform and satellite imagery

Check out the public, real-time data portal for DataStreme Atmosphere

Weather Studies Maps & Links

All the maps and links references in the Weather Studies eInvestigations Manual, as well as a plethora of other helpful sites, are available below. If you find them helpful during your class, come back in afterward for a refresher or to investigate any weather events as they happen to you.

Video Models

- Hand-Twist Model
- Pressure Blocks
- Coriolis Effect

Overview

- NWS "Weather Page"
- NOAA's nowCOAST mapping portal
- Local NWS Forecast Offices

Surface Maps

- Pressures
- Isobars & Pressures
- Isobars, Fronts, Radar & Data
- Temperatures
- Isotherms & Temperatures
- Isotherms, Fronts & Data
- 00Z - Analysis
- 12Z - Analysis
- U.S. - Data
- Northwest - Data
- Midwest - Data
- Northeast - Data
- Southwest - Data
- Mid-Atlantic - Data
- Southern Plains - Data
- Southeast - Data
- 24-Hour Minimum Temperature
- 24-Hour Maximum Temperature
- 24-Hour Precipitation
- Meteograms for Selected Cities
- State Surface Data - Text
- NWS Surface Analyses
- Available Surface Stations
- CoCoRaHS - Community Collaboration Rain, Hail & Snow Network
- Weather Prediction Center - Surface weather systems including regional maps
- Unisys Weather Map System - Map source and archive for surface, upper air, and satellite

Project Atmosphere
The Maury Project
DataStreme Program
- DataStreme Atmosphere
- DataStreme Ocean
- DataStreme Earth's Climate System
- Course Schedule
- Local Implementation Teams
- DataStreme Application Form

Educational Materials

Education Program
American Meteorological Society
1200 New York Ave NW
Suite 500
Washington, DC 20005
Tel: 202-737-1043
Fax: 202-737-0445
e-mail: amsedu@ametsoc.org

DataStreme Earth's Climate System

DataStreme Earth's Climate System is a 13-week course offered twice a year to selected participants nationwide. Directed toward middle-school teachers, but open to all K–12 teachers, you will...

- Investigate the relationships between global climate, the Earth's atmosphere, and the world's ocean
- Discover causes of both natural and anthropogenic climate change
- Utilize real-time data from NOAA, NASA, and other reputable sources
- Investigate data and results from the most recent National Climate Assessment
- Learn about climate models, climate variability, and predicting and adapting to the future

Check out the public, real-time data portal for DataStreme Earth's Climate System.

Funded by the American Meteorological Society, the DataStreme Earth's Climate System course has a strong leadership component where participants become a climate science leader and a part of a national community facilitated by the American Meteorological Society

Discussion stop 3

4 minutes

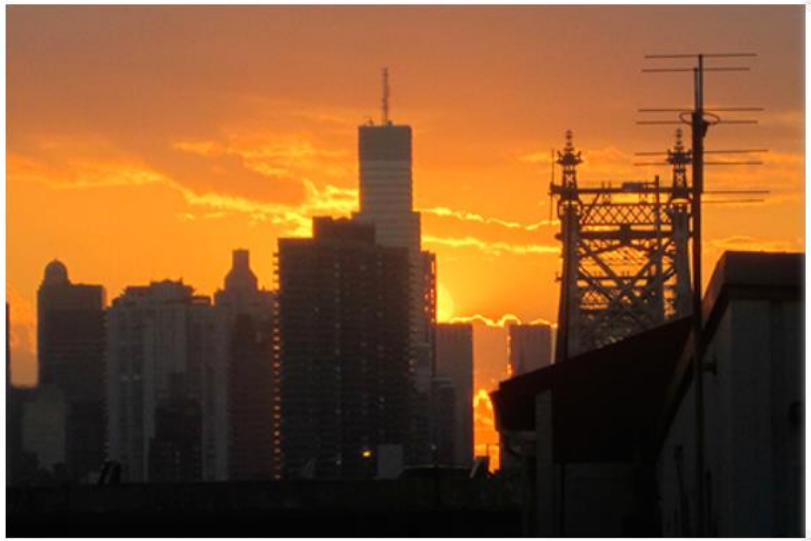
- What will you do to tap into NWS, AMS, and other resources to support your students' (and your) interests in weather?

Teaching about Climate

- “Climate determines what you buy, weather decides what you wear”
- “Climatology” focuses on long-term (30-year or more) averages and extremes
- Current climate statistics based on 1981-2010 – will adjust in 2020

Climate.gov
science & information for a climate-smart nation

Featured on Climate.gov



Extreme heat Tweet chat: Learn more about extreme heat, the urban heat island effect, and how communities are reducing heat risks

July 17, 2019

Filed in: News & Features

On Friday, July 19, from noon to 1:00 p.m. Eastern, join four heat health experts in a tweet chat about extreme heat, how it's changing, and how communities are building climate resilience.

Recent Topics

Opportunities to Build Your Weather, Ocean, and Climate Science Literacy by Leveraging the AMS-Cal U Partnership

June 11, 2019

Filed in: Teaching Climate

Toolbox for Teaching Climate & Energy

February 26, 2018

Filed in: Teaching Climate

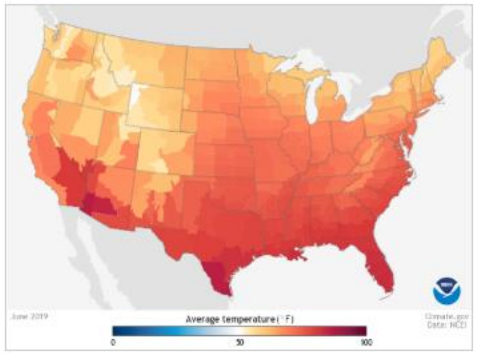
Summer Institute for Climate Change Education

February 18, 2019

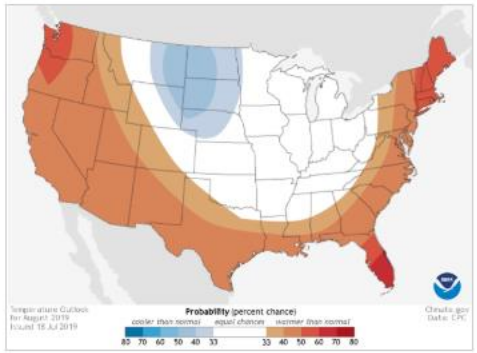
Filed in: Teaching Climate

Climate.gov
science & information for a climate-smart nation

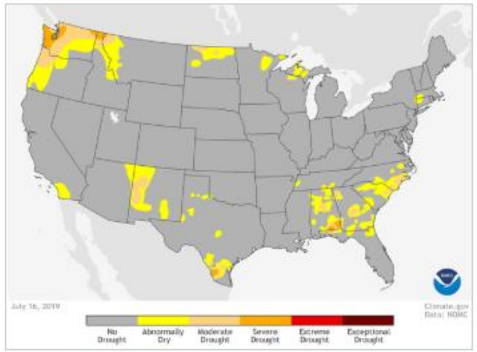
Data Snapshots: Reusable Climate Maps

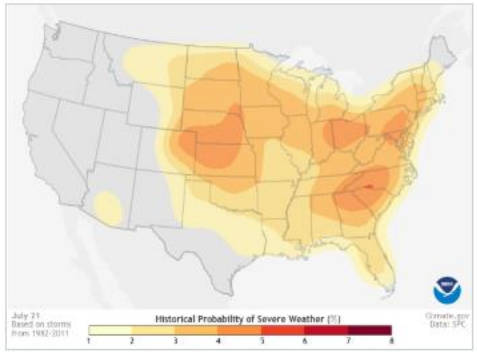


Average Monthly Temperature



Monthly Temperature Outlook





Browse the Dataset Gallery

This visual catalog with convenient filtering options can help you find the climate data you need. How-to instructions can help you navigate data access tools.

Enter the Dataset Gallery

GIS Data Locator (Advanced Users)

Launch Map Application

Climate Data Primer

Ready to learn some of the basics about climate data? Find out about measuring, modeling, and predicting climate and ways to find and use climate data.

The Primer includes information on instruments used to measure weather and climate; how weather observations relate to climate products; how climate scientists check the quality of observations, and tools you can use for exploring climate data

Open the Primer's table of contents

Climate.gov
science & information for a climate-smart nation

Featured Resources 1 2 3 4

Summer Institute for Climate Change Education

August 5, 2019 to August 7, 2019

The 14th Annual Summer Institute for Climate Change Education will be in Washington D.C, co-hosted by the Lowell School.

view event

Teaching Climate Literacy

Climate and energy are complex topics. There are many ways to approach climate

Professional Development view all

Sep 18

NSTA Science Update: Pulse of the Planet: The State of the Climate in 2019

Search

Grade Level

- Any -

Climate Change Research

EPA research improves knowledge of the health and environment effects of climate change and provides sustainable solutions for communities to effectively manage and reduce the impacts of a changing climate.

Research Areas for Climate Change

- Air Quality and Climate Change
- Ecosystems and Climate Change
- Energy and Climate Change
- Human Health and Climate Change

Popular Research Topics

- Impacts of Nitrogen and Sulfur Deposition on Ecosystems
- Modeling the Interactive Effects from Nitrogen Deposition and Climage Change
- Black Carbon Research

Key Links

- EPA Research
- U.S. Global Change Research Program
- Climate Change Adaptation Research Center

Recent Updates

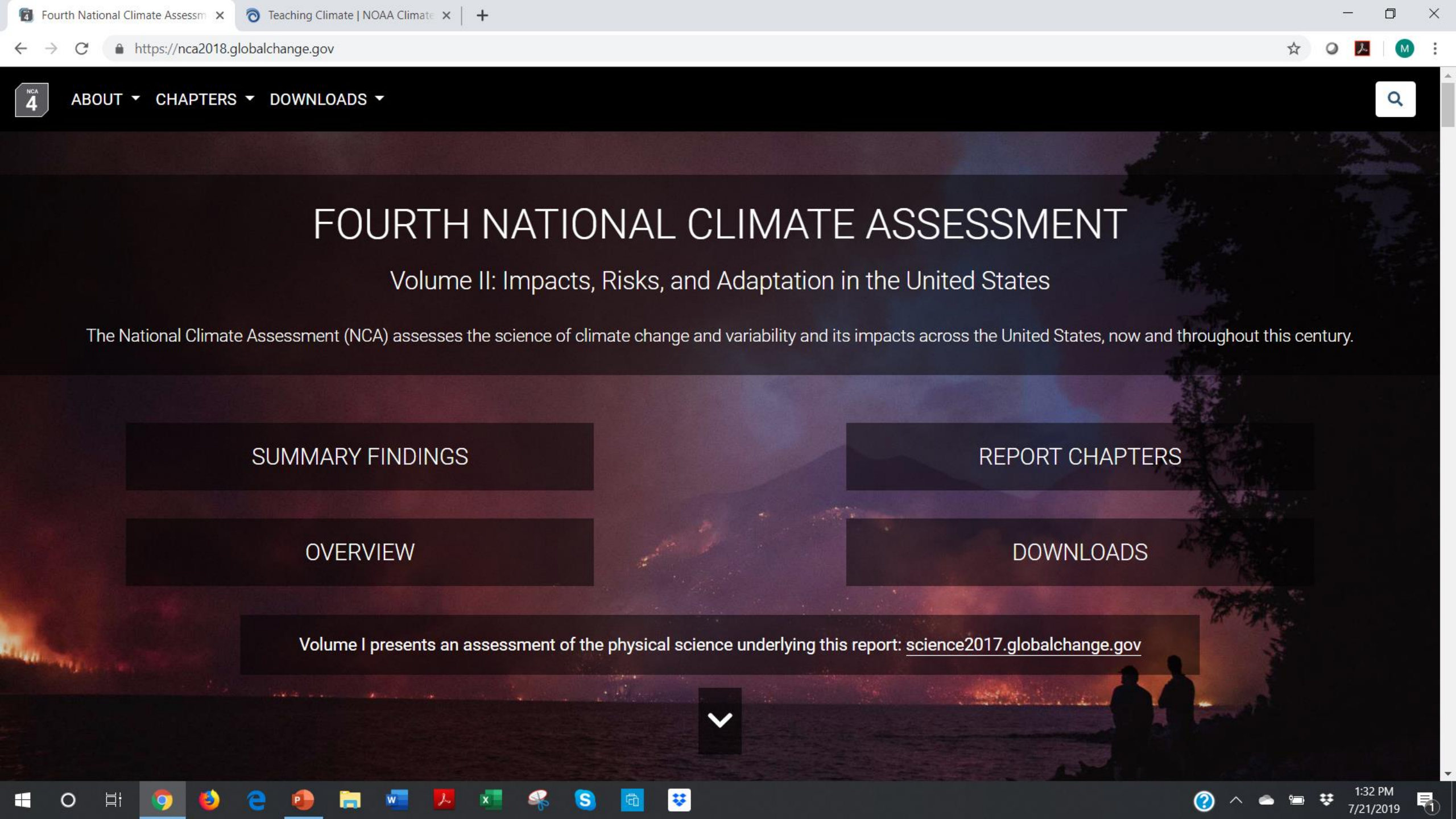
Get Climate Change Research News by email

EPA Web Archive

Search EPA Web Archive

Search

Content in EPA's Web Archive is no longer being updated and links may not function; however, the materials in this archive may be useful as background documents to supplement current information or to provide a historical perspective on a topic. For current information, visit www.epa.gov.


Fourth National Climate Assessm
Teaching Climate | NOAA Climate
https://nca2018.globalchange.gov
ABOUT
CHAPTERS
DOWNLOADS
FOURTH NATIONAL CLIMATE ASSESSMENT
Volume II: Impacts, Risks, and Adaptation in the United States
The National Climate Assessment (NCA) assesses the science of climate change and variability and its impacts across the United States, now and throughout this century.
SUMMARY FINDINGS
REPORT CHAPTERS
OVERVIEW
DOWNLOADS
Volume I presents an assessment of the physical science underlying this report: science2017.globalchange.gov
1:32 PM
7/21/2019

FOURTH NATIONAL CLIMATE ASSESSMENT

Summary Findings

These Summary Findings represent a high-level synthesis of the material in the underlying report. The findings consolidate Key Messages and supporting evidence from 16 national-level topic chapters, 10 regional chapters, and 2 chapters that focus on societal response strategies (mitigation and adaptation). Unless otherwise noted, qualitative statements regarding future conditions in these Summary Findings are broadly applicable across the range of different levels of future climate change and associated impacts considered in this report.

1. Communities

> *Climate change creates new risks and exacerbates existing vulnerabilities in communities across the United States, presenting growing challenges to human health and safety, quality of life, and the rate of economic growth.*

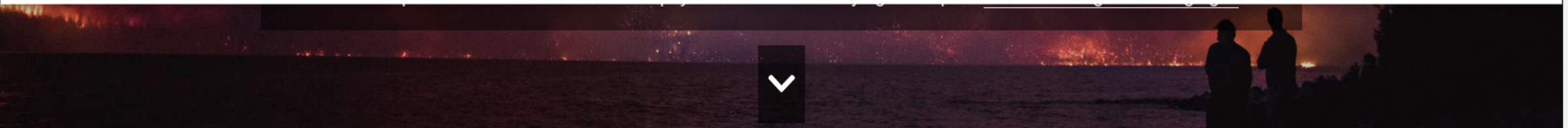


Figure 25.1: Temperature Has Increased Across the Southwest

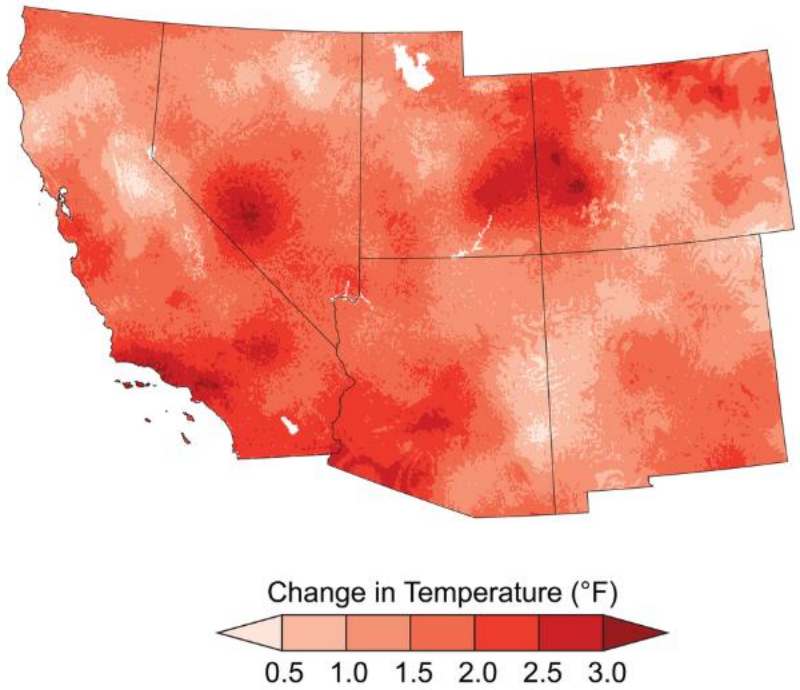


Figure 25.1: Temperatures increased across almost all of the Southwest region from 1901 to 2016, with the greatest increases in southern California and western Colorado.[23] This map shows the difference between 1986–2016 average temperature and 1901–1960 average temperature.[23] Source: adapted from Vose et al. 2017.[23]

California State Climatologist | California State Meteorologist

The California State Climatologist collects and interprets climate data for California, and disseminates climate data and information through various means including this website. The California State Climatologist is a function of the Division of Flood Management and is a member of the American Association of State Climatologists.

Climate vs. Weather (What to expect vs. What is happening)

Climate is the expected state of weather variables such as precipitation or temperature. Climate values are defined as averages of weather variables over time periods such as 30 years. For example, the monthly mean temperature for December is a climate variable. This value is computed using observed temperatures in December over a time period of 30 years. Weather is the state of the atmosphere at a given moment in time. An example would be the air temperature on January 1, 2006. Over time, the individual weather values are incorporated into the climate values as they are averaged into the long-term value. A climate forecast provides information on how close the coming monthly values are expected to compare to the long term values for large spatial areas. A weather forecast is much more specific in that it provides information on temperature, precipitation, wind, etc. for the next several days at given locations. For weather summaries and forecasts, please visit the California State Meteorologist section.

The California Hydroclimate Report

Recent observed extremes in temperature and precipitation have raised awareness of the potential influence of a

Contact Us

Additional contact information is available in the directory, or select the buttons below to email the Division of Flood Management or join our mailing list.

Email Us

Join Our Mailing List

Tags

Data | Hydrology | Science | Flood Management

ONJSC at Rutgers University

RUTGERS New Jersey Agricultural Experiment Station

Office of the New Jersey State Climatologist · Rutgers University · 54 Joyce Kilmer Avenue · Lucy Stone Hall B224 · Piscataway, NJ 08854

Home

Quick Links
NJWxNet
New Jersey Forecast
National Forecast
NOAA Climate.gov

NJ
Current Conditions
Current Forecasts
Climate Information

US
Current Conditions
Current Forecasts
Climate Information

Other
Coastal Observations
El Niño/La Niña
Hurricanes

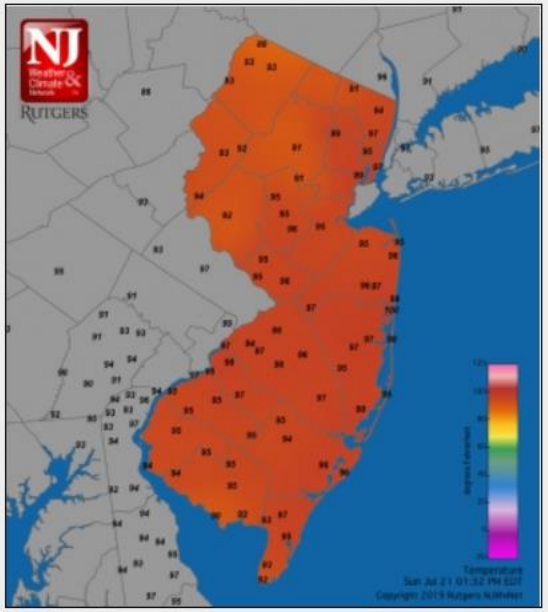
ONJSC
Outreach
About ONJSC
Research
Staff

Partners

Contact Us

Copyright and Data Disclaimer Information

Latest from the NJWxNet



Latest temperatures across NJ appear in the above map. Click on the map or here, the New Jersey Weather Network, for much more information.

Interested in becoming a volunteer weather observer? Click here to learn more about the CoCoRaHS Network!

Frequently Updated Climate Data

Winter 2018-2019 Snow Event Totals

Monthly Statewide/Divisional/County (1895-Present)

Monthly Station

Monthly Maps

Latest News

New NOAA NJ Climate Change Report

A man waits for rescuers while surrounded by flash flood waters in Westville (Gloucester County) on June 20th. Photo by Elizabeth Robertson/The Philadelphia Inquirer.

Plenty Green: June 2019 Recap

Dr. David A. Robinson
July 8, 2019

The moist and mild pattern of late spring and early summer has left the Garden State quite green. There is nothing new to this pattern, as

1:37 PM
7/21/2019

Monthly Climate Tables

Office of the NJ State Climatologist, Rutgers University

The National Centers for Environmental Information (NCEI) has launched a new divisional climate dataset called **nClimDiv**.
This dataset replaces the traditional **Drd964x** values that NCEI and the ONJSC have used for many years.
[show more]

Select State/Division/County

New Jersey (Statewide)

NJ Climate Divisions Map

Select Element

Maximum Temperature
Minimum Temperature
Average Temperature
Precipitation
Heating Degree Days
Cooling Degree Days

Legend

M — missing data
max value in a column
top 5 max values in a column
min value in a column
bottom 5 min values in a column

Data provided by...

NCEI — National Centers for Environmental Information

New Jersey (Statewide)

Monthly Total Precipitation (in.)

Rank	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1	1895	4.36	1.24	3.28	5.08	3.13	3.09	4.15	2.06	1.06	3.56	3.07	2.78	36.86
2	1896	1.61	6.88	5.65	1.35	3.54	5.49	5.38	1.68	4.25	2.41	3.12	1.21	42.57
3	1897	2.65	3.67	2.74	3.92	5.37	3.37	11.37	4.89	1.76	2.26	4.87	4.48	51.35
4	1898	4.10	3.45	3.15	3.58	6.77	2.07	4.63	5.45	2.05	5.51	6.60	3.63	50.99
5	1899	3.75	5.71	6.32	1.67	1.94	2.57	5.74	3.91	5.40	2.44	2.29	2.07	43.81
6	1900	3.57	5.23	3.44	2.32	4.40	3.20	4.55	2.79	2.81	3.59	3.35	2.55	41.80
7	1901	2.46	0.96	4.60	6.05	5.47	1.74	5.69	9.22	3.57	1.92	2.52	7.41	51.61
8	1902	3.24	6.31	4.21	3.58	1.93	6.90	4.51	3.75	5.54	6.06	2.30	7.31	55.64
9	1903	3.94	4.82	4.77	3.83	0.64	7.73	5.29	5.96	3.17	8.12	1.29	4.09	53.65
10	1904	2.04	2.54	3.47	3.22	2.40	2.03	4.70	6.28	4.77	2.72	2.20	2.11	42.47

Search the CPC
Go
About Us
Our Mission
Who We Are
Contact Us
CPC Information
CPC Web Team
USA.gov

Monitoring & Data Index

Monitoring and Data

Oceanic & Atmospheric Monitoring and Data

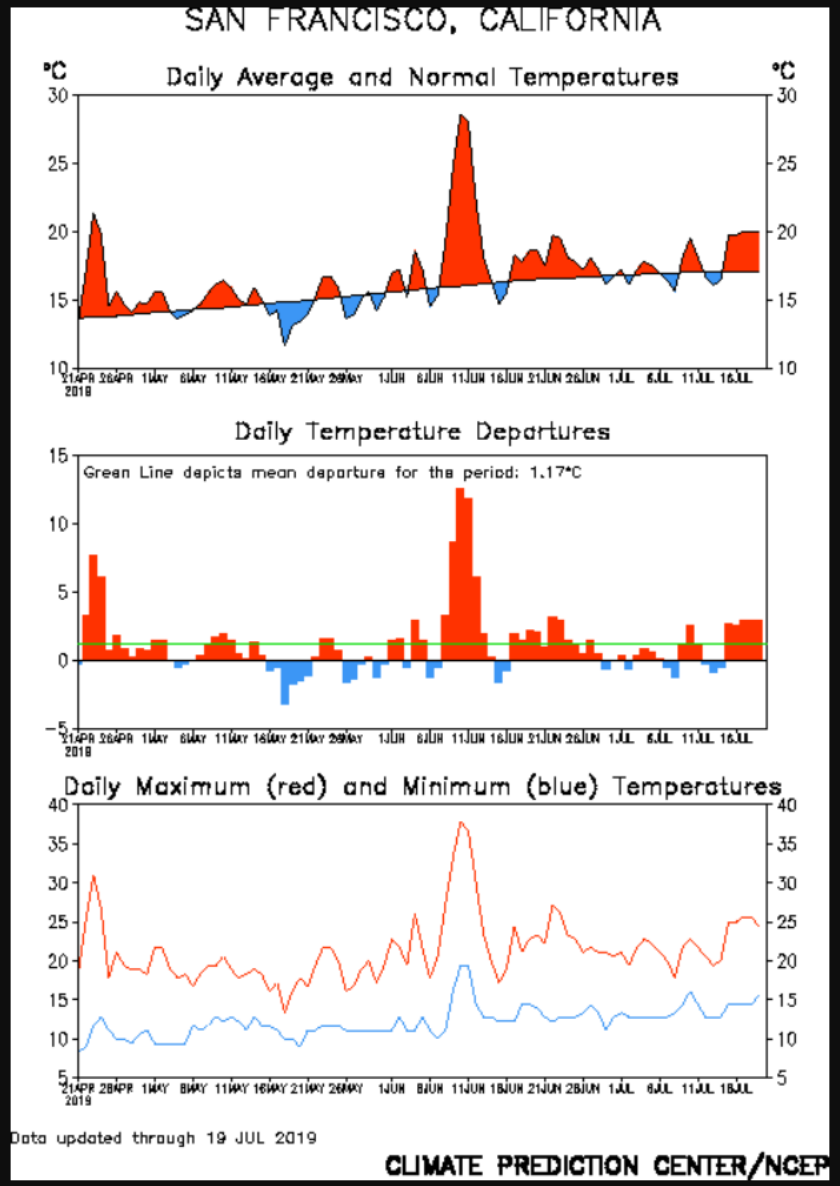
- Monitoring Weather & Climate in Realtime
- Climate Diagnostics Bulletin
- Preliminary Climate Diagnostics Bulletin Figures
- Monthly Atmospheric & Sea Surface Temperature Indices
- Weekly ENSO Update
- NCEP's Global Ocean Analysis
- Madden-Julian Oscillation
- Arctic Oscillation
- Global Precipitation Analysis
- Monitoring Atlantic Hurricane Potential
- Monitoring East Pacific Hurricane Potential
- Northern Hemisphere Teleconnection Patterns
- Stratosphere Home
- Stratospheric Ozone
- Global Data Display System
- Reanalysis: Atmospheric Data
- North American Monsoon Experiment

United States Climate Data & Graphics

ENSO Impacts on the United States

- ENSO Home Page
- Previous ENSO Events

Precipitation and Temperature



Discussion stop 4

4 minutes

- What will you do to tap into NWS, AMS, and other resources to support your students' (and your) interests in climate and climate change?

NGSS: Where and how should we teach weather & climate?

From the earliest grades, we need to help students learn about weather.

- **K-ESS2-1 Use and share observations of local weather conditions to describe patterns over time.**
- **K-ESS3-2 Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather.**
- **3-ESS3-2 Obtain and combine information to describe climates in different regions of the world.**
- **5-ESS2-1 Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.**

Middle School students can handle more complex ideas

- **MS-ESS-1 Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.**
- **MS-ESS2-4 Develop a model to describe the cycling of water through Earth's systems driven by energy from the Sun and the force of gravity.**
- **MS-ESS2-5 Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.**
- **MS-ESS2-6 Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.**
- **MS-ESS3-2 Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.**

High School should complete preparation for lifelong learning and becoming a scientifically-literate citizen

- **HS-ESS2-2 Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth Systems.**
- **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-ESS2-6 Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.**
- **HS-ESS3-1 Construct an explanation based on evidence for how the availability of nature; resources, occurrence of natural hazards, and changes in climate have influence human activity.**
- **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-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.**

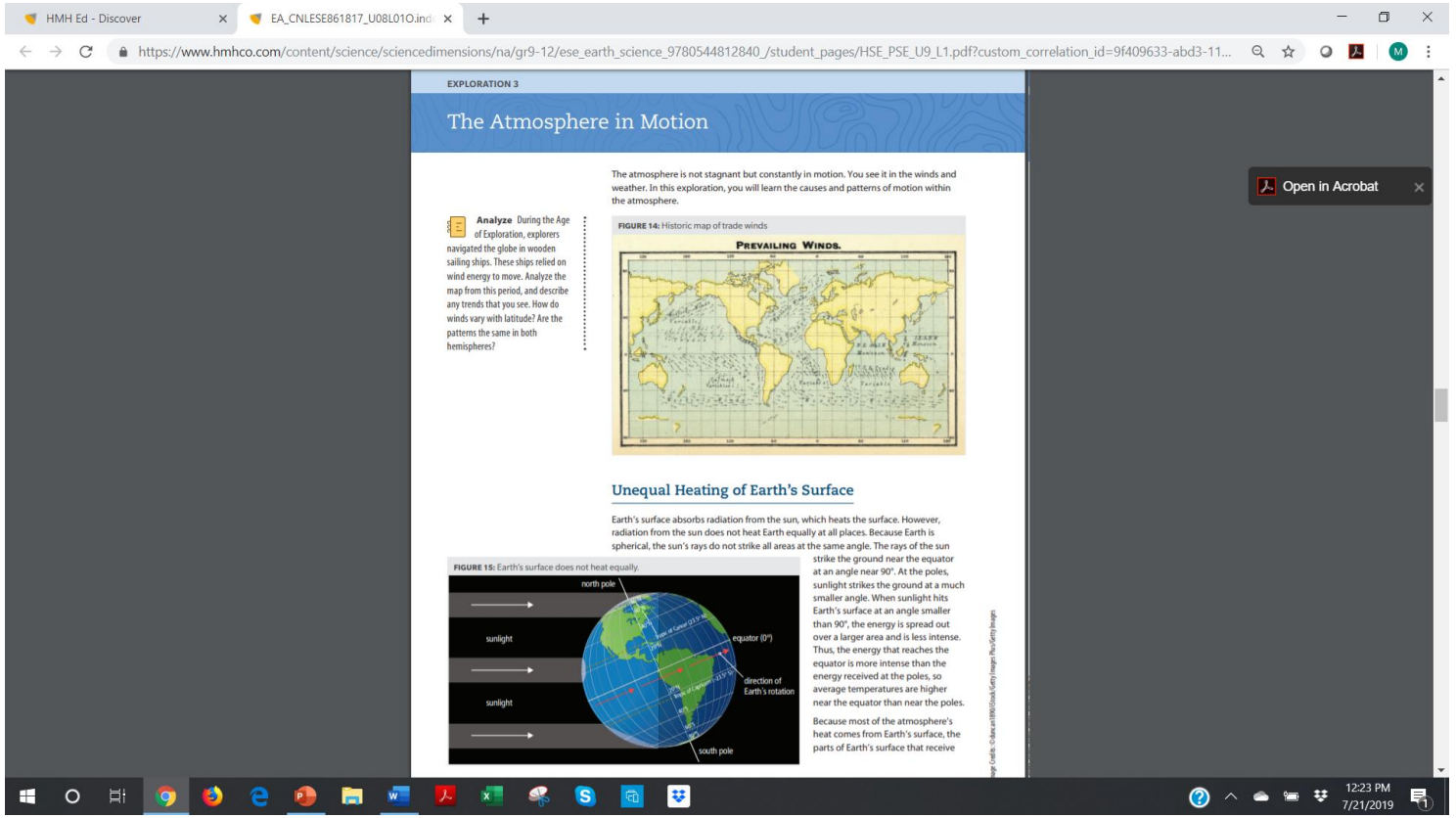
Discussion stop 5

4 minutes

- How are your school and District preparing to meet these NGSS expectations?

HMH Resources

For students



ENGAGE: Lesson Phenomenon

Lesson Objective

To describe the composition of Earth's atmosphere, explain the cycling of gases in Earth's atmosphere, compare the characteristics of each layer of Earth's atmosphere, explain how energy from the sun is distributed on Earth, and describe the Coriolis effect.

Can You Explain It?

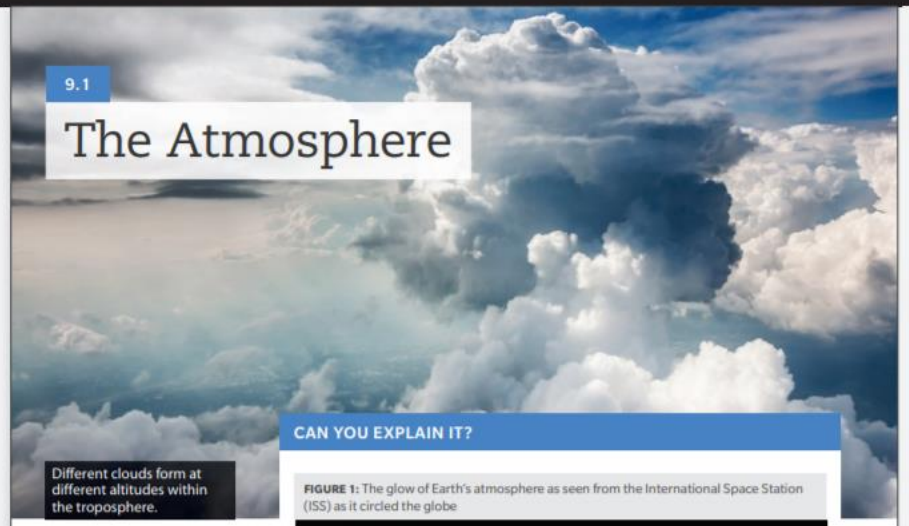
Students are asked to record their initial thoughts about the layers of the atmosphere. Students will collect evidence related to this phenomenon throughout the lesson and revisit this question at the end of the lesson, using what they have learned about the roles of the different atmospheric layers and the reasons for their existence to answer this question.

Collaboration

Accessing Prior Knowledge You may wish to have students read and discuss the question as a whole-class activity. In this way, you can get a good sense of the level of prior knowledge that students may have about the layers of the atmosphere. A few students may be familiar with some of the different layers, such as the stratosphere. Ask students to consider how the atmosphere changes with altitude and what role the ozone layer, surface heating, and gravity play in the temperature, density, and compositional changes with altitude.

EVIDENCE NOTEBOOK

1. Students should be able to see 3 or more layers in the photograph of the atmosphere. As the lesson continues, they should be able to record observations about each of the layers and what goes on in them.
2. Each layer has a different temperature and pressure. The



CAN YOU EXPLAIN IT?

FIGURE 1: The glow of Earth's atmosphere as seen from the International Space Station (ISS) as it circled the globe

1 **Gather Evidence** Record observations about Earth's atmosphere, the layers of the atmosphere, and what occurs in each. As you explore the lesson, gather evidence to help explain the structure of the atmosphere, what occurs in each layer and how the atmosphere interacts with other earth spheres.

The layer of gases that surrounds Earth is called the *atmosphere*. The atmosphere is made up of air, a mixture of chemical elements and compounds. The atmosphere protects Earth's surface from the sun's radiation, helps regulate the temperature of Earth's surface, and redistributes the energy absorbed from the sun.

The atmosphere is constantly changing. Weather systems form, move across Earth's surface, and dissipate. Weather systems do not move randomly but follow patterns. Although such patterns can make the weather predictable, there is still much that we do not know about this important sphere of Earth.

2 **Explain** From the ISS view, the atmosphere appears to be made of several layers. Why do you think the atmosphere has different layers? What roles might

CONTINUE YOUR EXPLORATION Guided Research

Collaboration

You may choose to assign this activity or direct students to the Online Interactive Student Edition, where they can choose from all of the available paths. These activities can be assigned individually, to pairs, or to small groups.

Studying the Atmosphere from Space

Students' proposals should include information on how the approach works, the technology needed to make the idea a reality, and any known blocking points that have yet to be resolved.

WHST.9-12.1 Write arguments focused on discipline-specific content.

Explore Online

The Coriolis Effect

Students will research the Coriolis effect in greater detail, focusing on its effects (e.g., its impact on the direction of cyclone and hurricane spin and the need to correct the courses of airplanes and rockets).

Building with Wind

Students will locate and conduct a hands-on activity in which they use an electric fan to filter sand from larger stones and to produce sand dunes, demonstrating how wind naturally sorts material and produces complex shapes.

Guided Research

Studying the Atmosphere from Space

For many atmospheric studies, Earth orbit provides the best vantage point for making observations of the atmosphere. One of the many difficulties in studying Earth from space is the tremendous cost associated with putting equipment and researchers in orbit. Currently, it costs about $10 000 to put a pound of instruments into outer space.

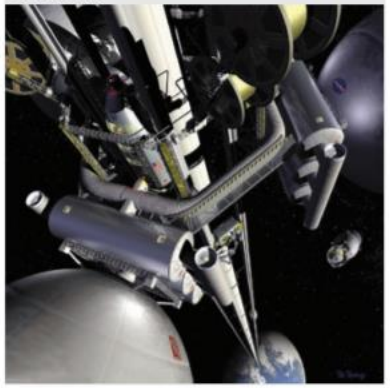
So, how do instruments and people get into outer space? In the 1950s, rocket planes like the X-15 tried to enter outer space; although they could reach the edge of space, they did not have enough velocity to enter orbit.

Rockets burn chemical fuels to generate enough thrust and velocity to reach outer space. Early rockets like the German V-2 and Mercury Redstone could reach outer space but not enter orbit. More powerful single-stage and multi-staged rockets such as the Atlas, Titan, and Saturn rockets could generate enough thrust and velocity to send payload into orbit, to the moon, and beyond. All of these rockets were single-use, expendable rockets.

In the 1970s and 1980s, the United States developed a reusable space shuttle that was capable of reaching low Earth orbit and returning to Earth. The shuttle used chemically propelled rocket engines as well. Chemically propelled rockets are explosive and expensive. NASA has been researching alternate ways to put scientific equipment and researchers into outer space. These ideas include some of the following:

- **Space elevator**—A strong cable is tethered between the ground and a satellite in geosynchronous orbit, an orbit of 22 500 miles (35 786 km). An elevator can be attached to the cable to take payloads into space. The idea was tested on a shuttle flight with a tethered satellite in 1992.
- **Sky hook**—A tethered system similar to the space elevator. One end is attached to a satellite in high orbit. The other end is in a lower position. A payload could be lifted to the lower end of the hook. The two ends would spin and switch positions, thereby lifting the payload to the higher orbit.

FIGURE 24: Future travel to Earth orbit may involve a space elevator.



- **Magnetic rail gun**—A large track containing a series of superconducting magnets generates force on the payload vehicle, which has no engine, and accelerates it to velocities capable of reaching orbit.
- **Space cannon**—Similar to the magnetic rail gun, but it uses explosives like an artillery cannon to launch a payload into space.

None of these ideas has yet been tested fully on the scale required for actual use.

Language Arts Connection Choose one of the ideas for getting people into outer space. Research the idea, and write a proposal on how that idea has the potential to be developed. In your proposal, defend your idea with costs and benefits.

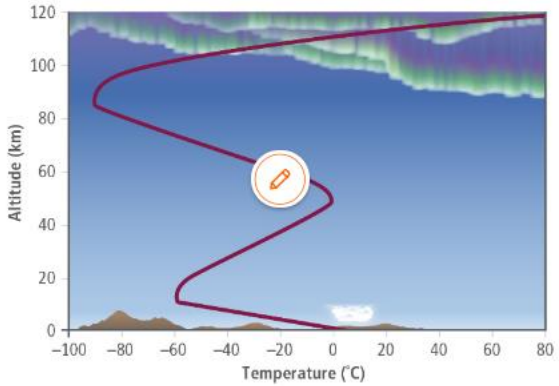
THE CORIOLIS EFFECT | BUILDING WITH WIND | Go online to choose one of these other paths.

Layers of the Atmosphere

Think about the atmosphere at different altitudes. When traveling up a mountain road to a high altitude, you may have noticed that your ears "pop" somewhere along the way. Perhaps you noticed that at higher altitudes, it is often colder than near sea level. These observations indicate that the atmosphere is not the same at all altitudes.

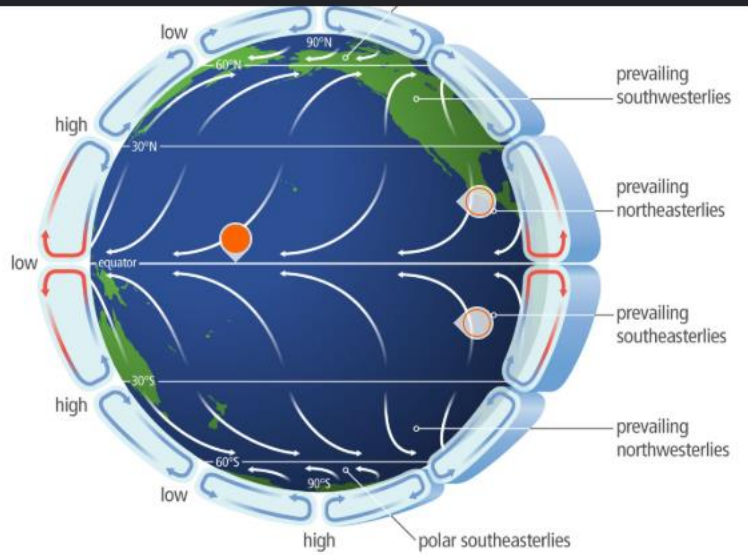
Levels in the Atmosphere

Examine the graph of altitude versus temperature. Does the temperature vary evenly with altitude—does it have an overall trend? If so, draw the trend. If not, draw horizontal lines at the altitudes at which trends in temperature reverse.



At which specific altitudes do the trends in termperature changes occur? Select all that apply.

- [ ] A. Temperature changes occur at 11 km.
- [ ] B. Temperature changes occur at 30 km.
- [ ] C. Temperature changes occur at 60 km.
- [ ] D. Temperature changes occur at 49 km.
- [ ] E. Temperature changes occur at 85 km.



Low pressure at the equator

The equator is a low-pressure area because of the relatively large amount of solar radiation it receives. As a result, air flows toward the equator at the surface—it converges.

How might the existence of low-pressure bands at the equator and 60° and the existence of high-pressure bands at 30° and the poles affect the types of biomes in those areas?

Start typing...

Possible Answer

The warm air at the equator rises and spreads north and south at high altitudes. As the air travels away from the equator, it begins to cool and sink at about 30° north and 30° south. The sinking air is dense and creates a

Questions?

- Dr. Mike Passow

Earth2Class Workshops
Lamont-Doherty Earth Observatory of Columbia University
and
Houghton Mifflin Harcourt
Consulting Author

michael@earth2class.org