Teaching about Weather, Climate and Climate Change in Bergen County

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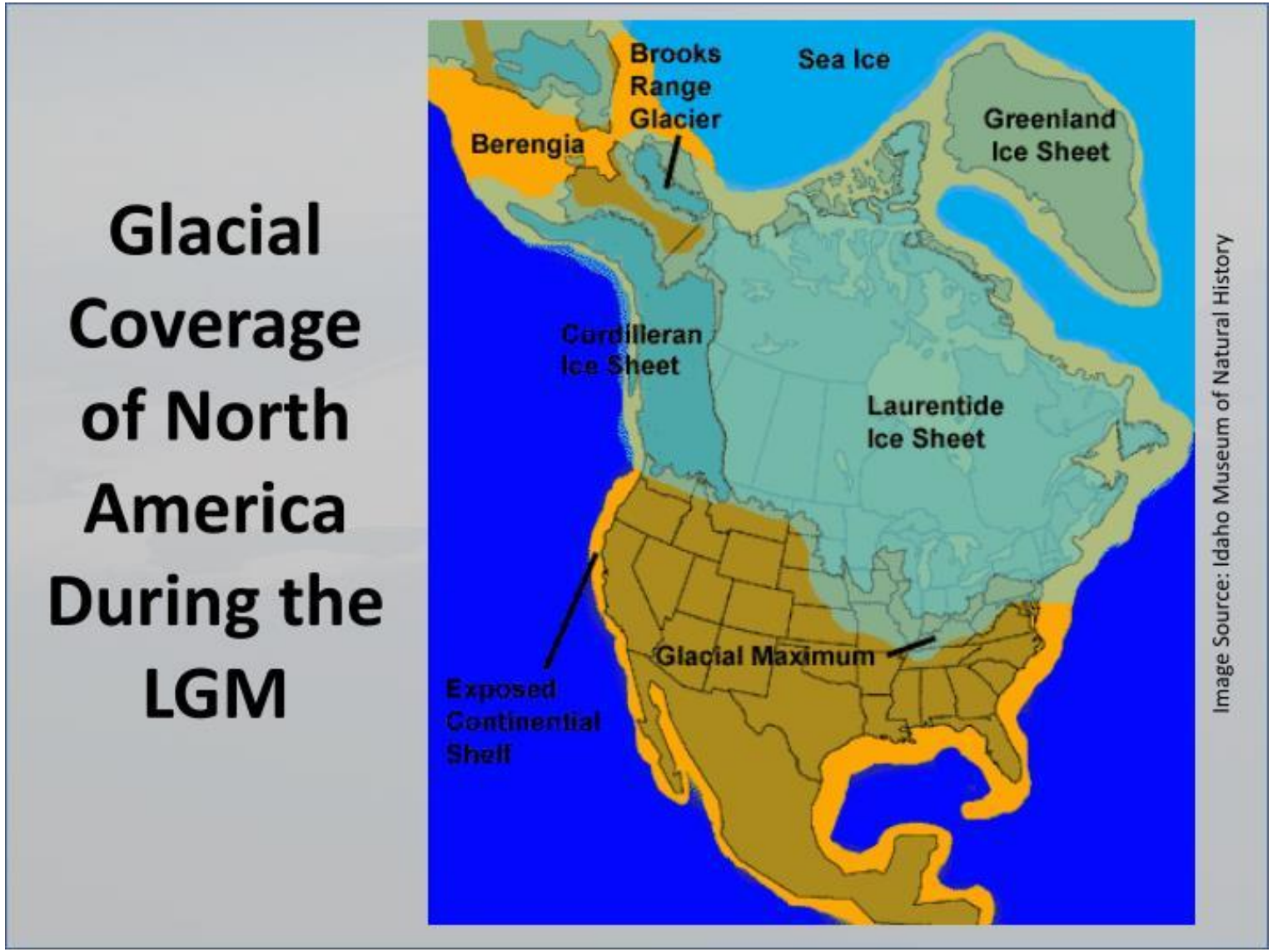
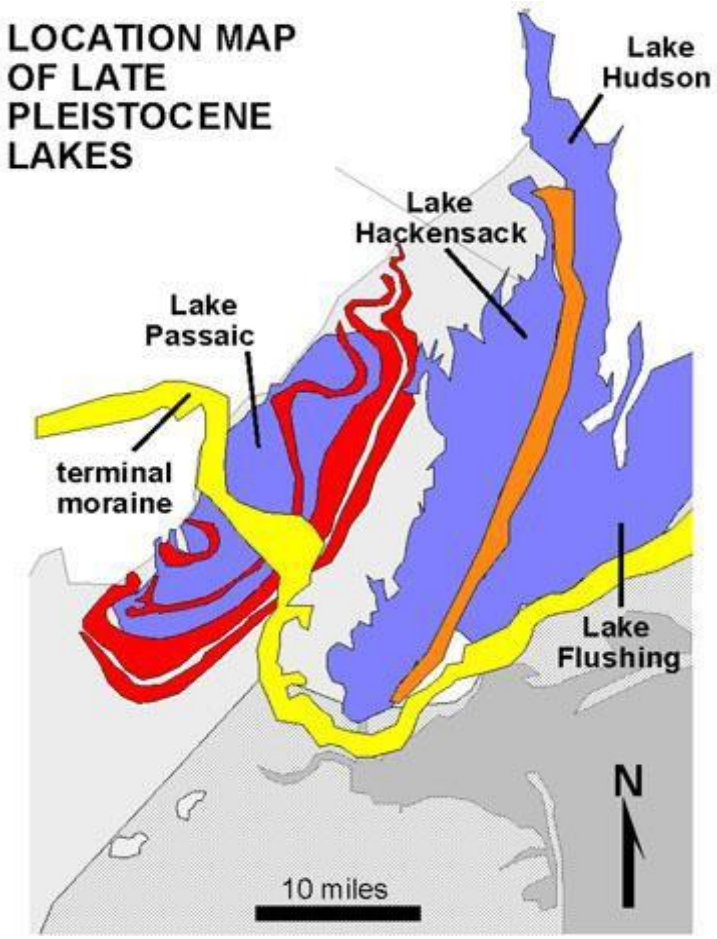
Science Educator (1970 – present)

What is your earliest weather memory?

My own earliest memory goes back 70 years, but geological evidence allows us to go back much further in time. 10,000 years ago, our region was under a few thousand feet of snow and ice

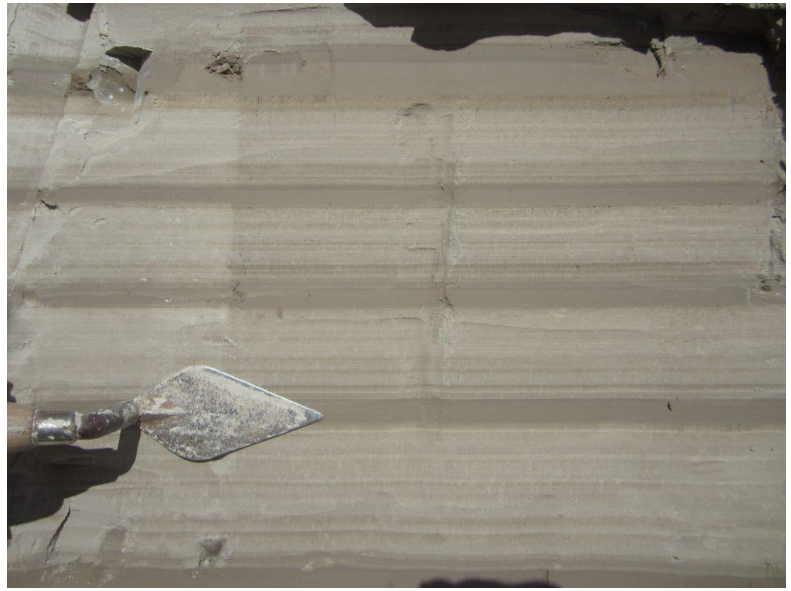


As the ice sheets melted, glacial lakes covered the landscape



https://3dparks.wr.usgs.gov/nyc/images/fig144.jpg

Where we now are was once the floor of a 200-ft deep lake that froze over and thawed annually, leaving thick deposits of clay. These were mined in the 19th and 20th century in places like Little Ferry to make bricks.



https://www.antarcticglaciers.org/glacial-geology/varves/

As the climate warmed, taiga-like coniferous forests covered our region, with large mammals (mastodons)

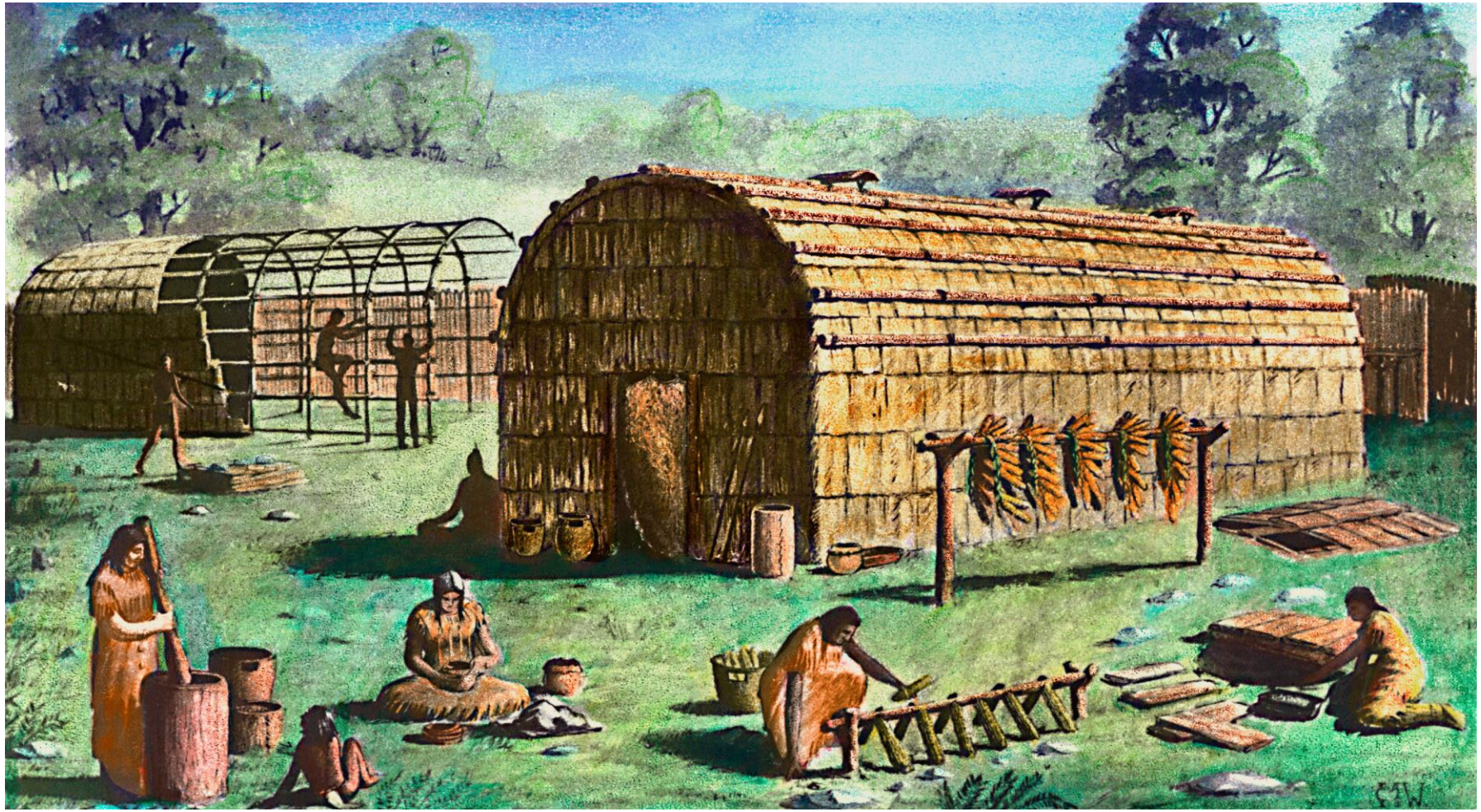
Hackensack Mastodon (1960)

Excavating the Dwarskill Mastodon (1974)

Continued warming over the centuries led to the expansion of the Eastern Woodlands forest

https://cdn.thinglink.me/api/image/568811426022424576/1240/10/scaletowidth

The areas was occupied by the Lenni Lenape, an indigenous group that lived in harmony with their environment and climate. They lived in communal longhouses in villages connected through family ties.



Some animals important to the Eastern Woodlands Indians are still with us

One leader of the Hackensack Indians was Chief Oratam, who lived in the 17th century and was critical to bring peace between indigenous people and the Dutch settlers

Land Acknowledgement Statement

- We respectfully acknowledge that Bergen County occupies land in **Lenapehoking**, the traditional and expropriated territory of the **Lenape**. As an institution, we recognize and support the sovereignty of New Jersey's three state-recognized tribes: the **Ramapough Lenape**, **Nanticoke Lenni-Lenape**, and **Powhatan Lenape** nations.
- We recognize the sovereign nations of the **Lenape** diaspora elsewhere in North America, as well as other Indigenous individuals and communities now residing in New Jersey.
- By offering this land acknowledgement, we commit to addressing the historical legacies of Indigenous dispossession and dismantling practices of erasure that persist today.
- We recognize the resilience and persistence of contemporary Indigenous communities and their role in educating all of us about justice, equity, and the stewardship of the land throughout the generations.

Part 1 Weather & Climate Science Basics

1A) Weather affects us everyday, everywhere

Weather is what you get, Climate is what you expect; or, Weather determines what you wear, Climate determines what you buy

Weather includes

- Temperature
- Air pressure
- Wind speed and direction
- Humidity & dew point
- Clouds
- Precipitation

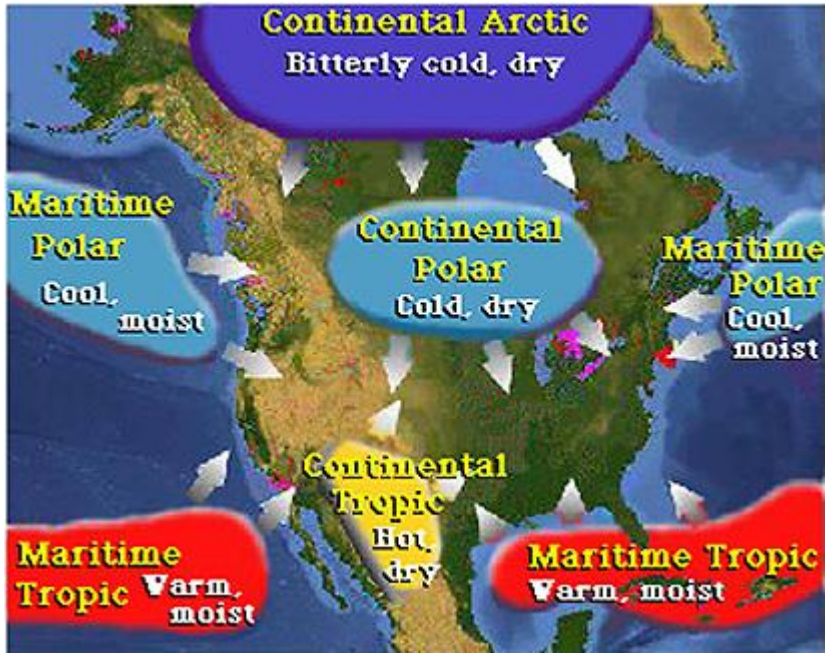
Climate describes

- All of the above
- Average (normal), high (maximum), and low (minimum)(30-year)
- Anomalies (variations from normal
- Record values
- Long-term conditions (droughts, floods)

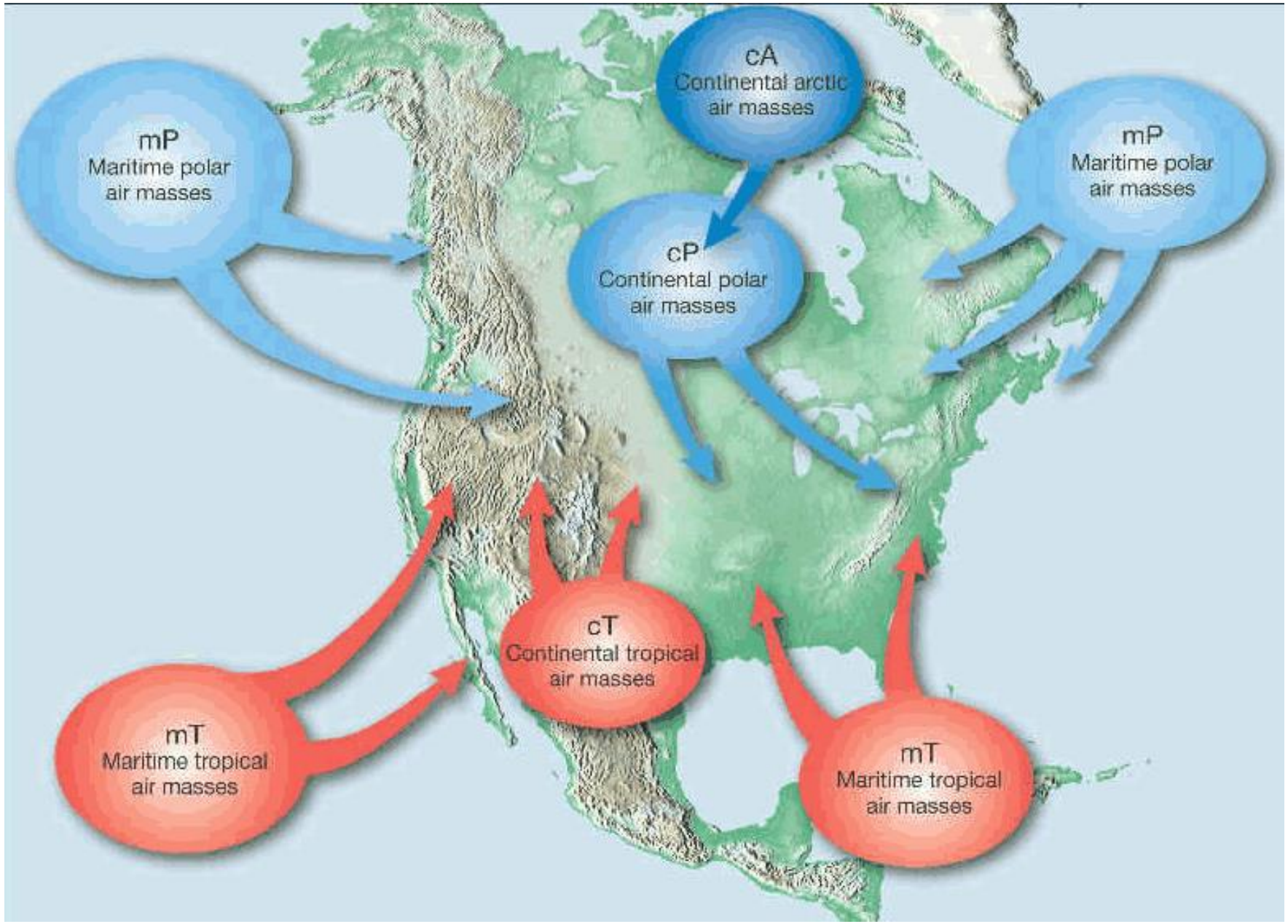
What, basically, causes weather?

1. Air Masses

Large parcels of air with similar temperature and humidity at any elevation



http://www.fas.org/irp/imint/docs/rst/Sect14/Sect14_1b.html



https://d279m997dpfwgl.cloudfront.net/wp/2019/01/air-masses.png

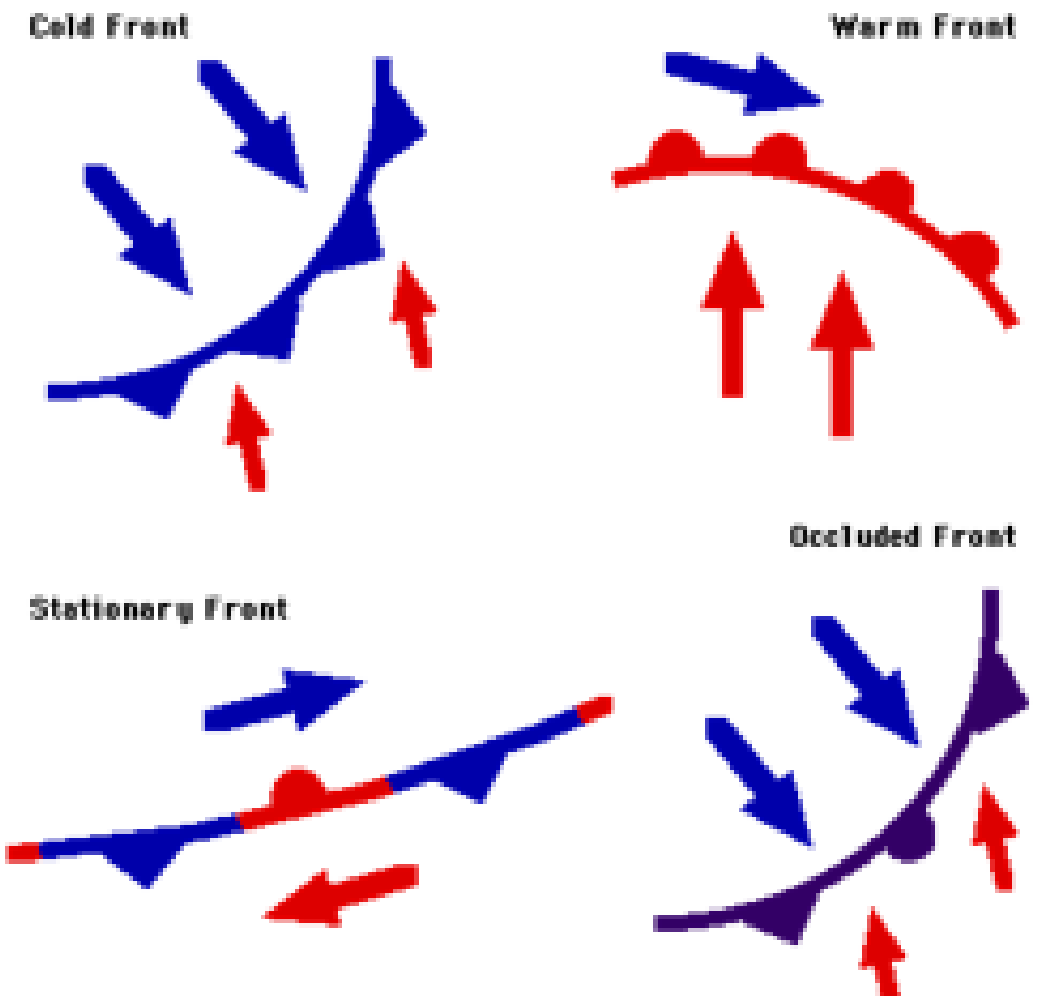
4 Basic Types of Air Masses

- Continental Polar (cP) – dry and cool or cold
- Maritime Polar (mP) – humid and cool
- Continental Tropical (cT) – dry and hot
- Maritime Tropical (mT) – humid and warm

What, basically, causes weather?

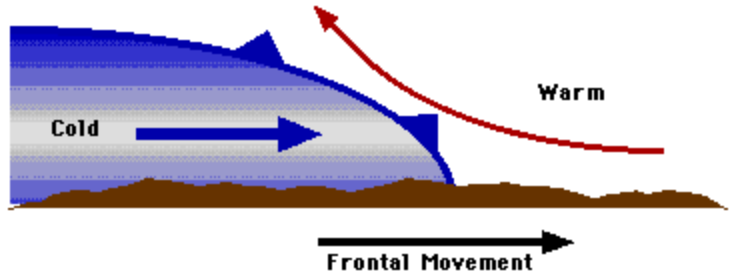
2. Weather Fronts

Boundary zones where air masses "battle" to move over regions



Cold Fronts

Cold Front – cooler air pushes under warmer air



- Relatively steep slope
- Move relatively fast (25 mph/40 km per hr)
- Often bring violent weather – strong thunderstorms, squall lines, tornadoes
- Cooler weather, clearing skies, change in wind direction

http://okfirst.mesonet.org/train/meteorology/Fronts.html

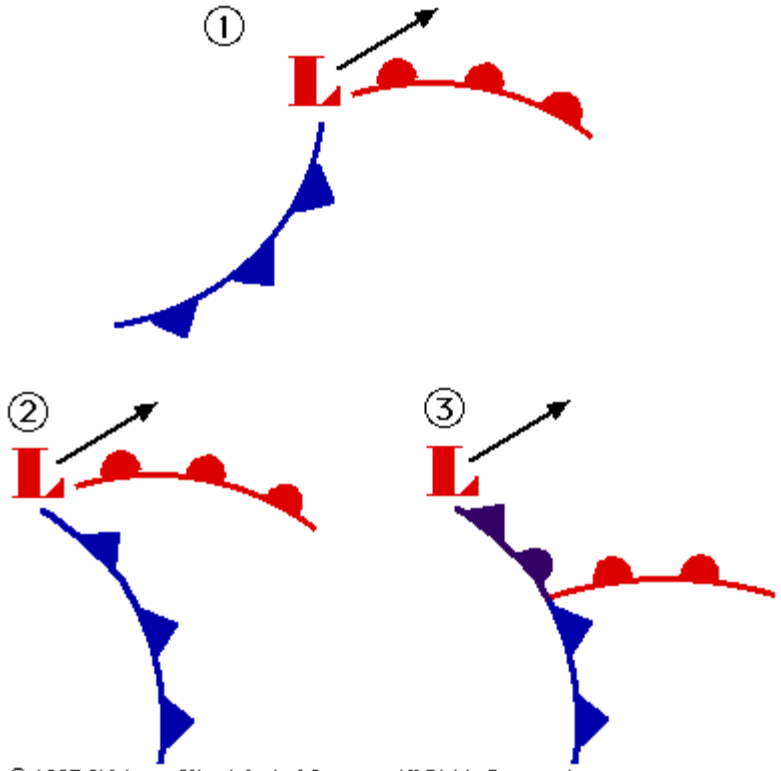
ent, move more slowly

ouds, then altostratus/altocumulus, the

r stratocumulus

Occluded Front

- Forms when a second cold front overtakes a warm front and lifts it
- Weather ahead of the occlusion is similar to that of warm front, and weather behind similar to that of a cold front

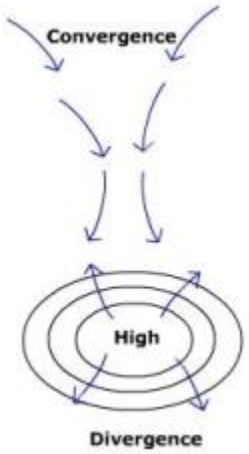


Stationary Front

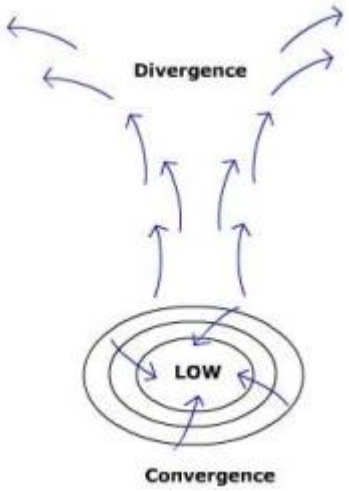
- Forms when neither air mass can push the other
- Other form when polar air masses are significantly modified (“stalled cold fronts”)
- Behave like mild warm fronts—gentle precipitation, overcast
- Winds on both sides may be parallel to the front

Comparing Highs and Lows
(‘the clock is high, the counter is low’)

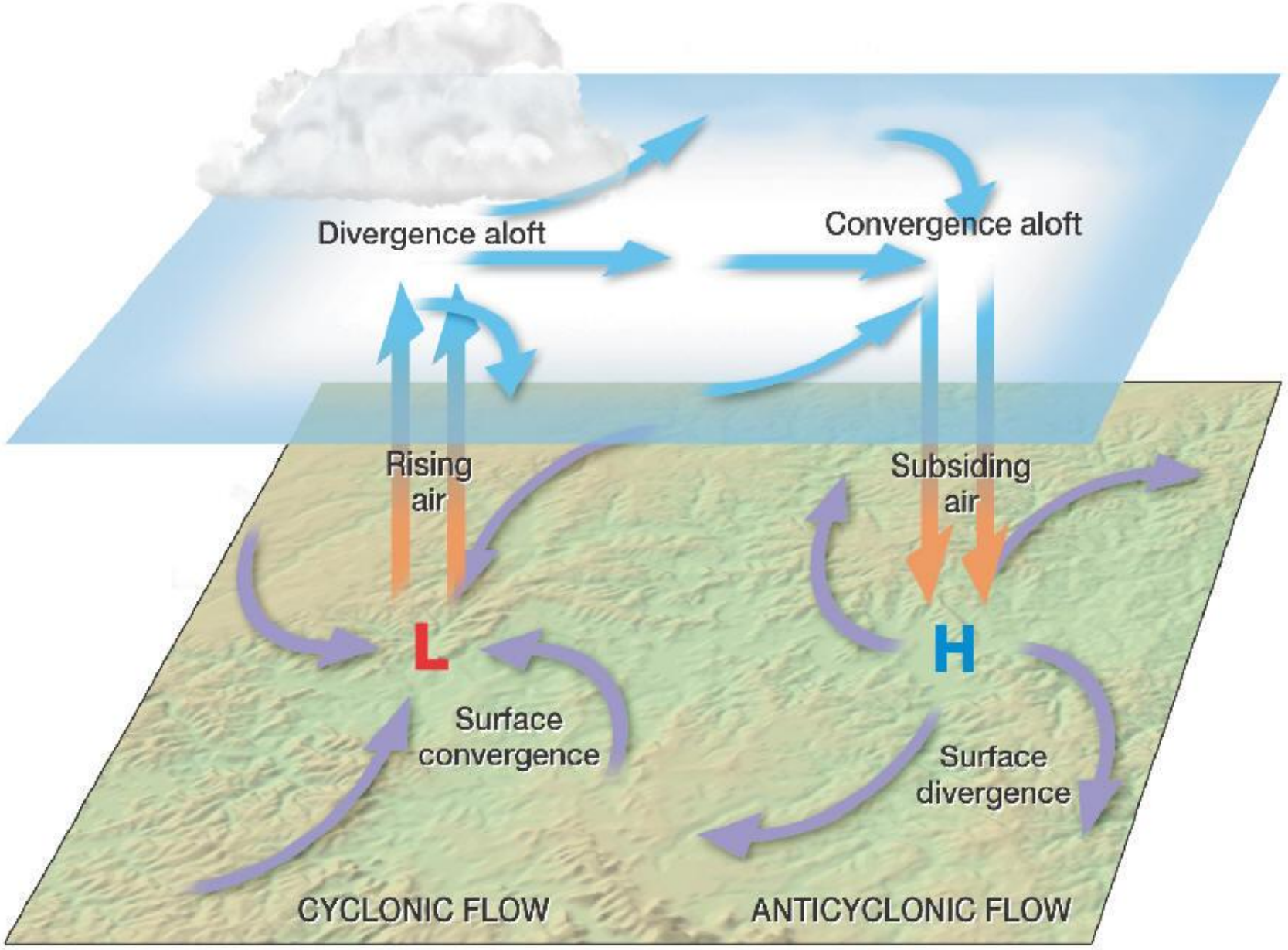
- Air in anticyclones moves downward, outward, clockwise



- Air in cyclones moves inward, counter-clockwise, upward

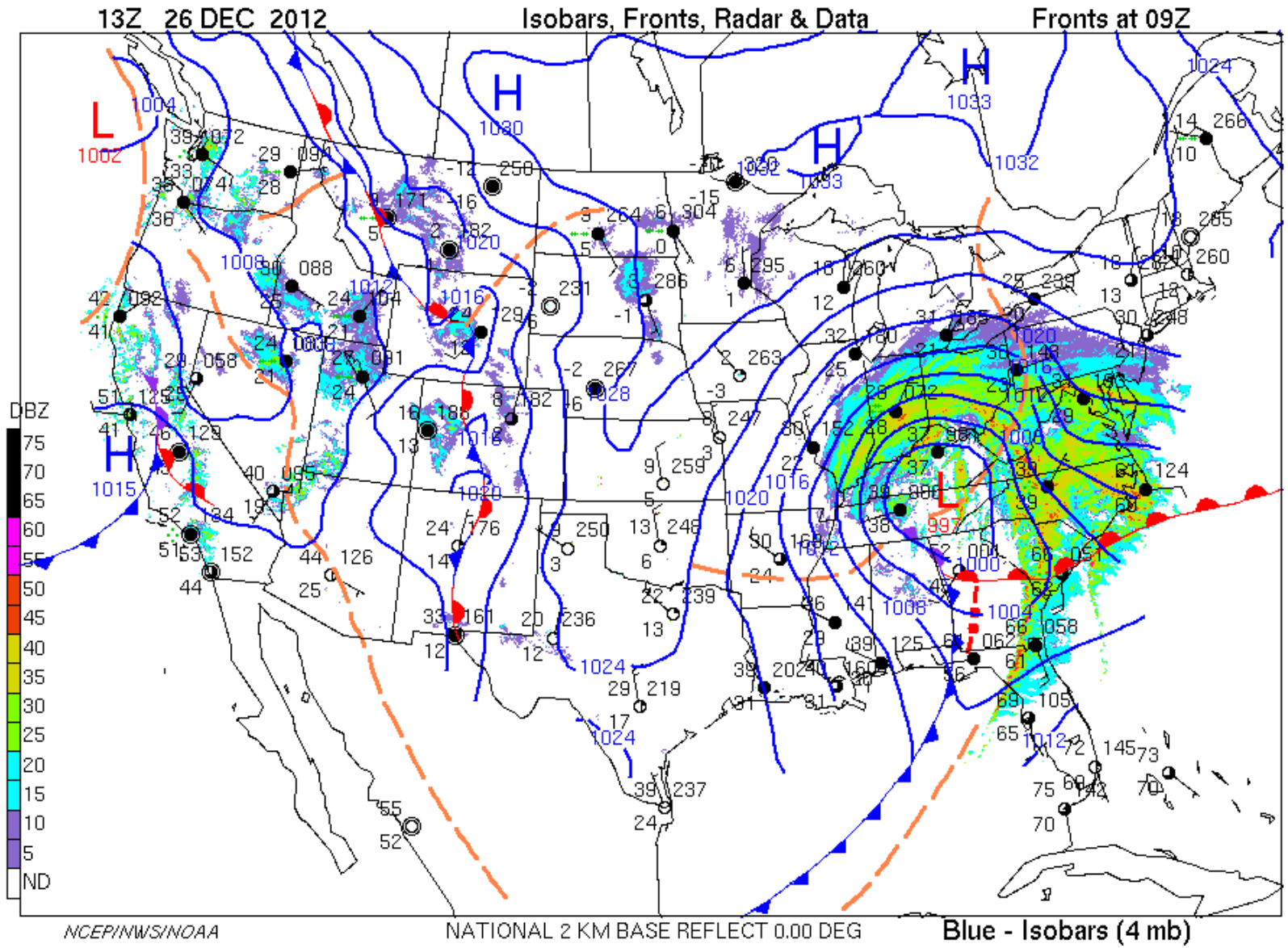


http://www4.uwsp.edu/geo/faculty/ritter/geog101/textbook/circulation/cyclones_and_anticyclones.html



http://www.geography.hunter.cuny.edu/~tbw/wc.notes/6.air.pressure.winds/airflow_associated_with_cyclones.anticyclones.htm

Weather Maps



Observing weather

- Thermometers (temperature)
- Barometers (pressure)
- Anemometers (wind speed)
- Wind vane (direction)
- Hygrometer (humidity, dew point)

Monitoring Weather on the Surface
ASOS – Automated Surface Observing System

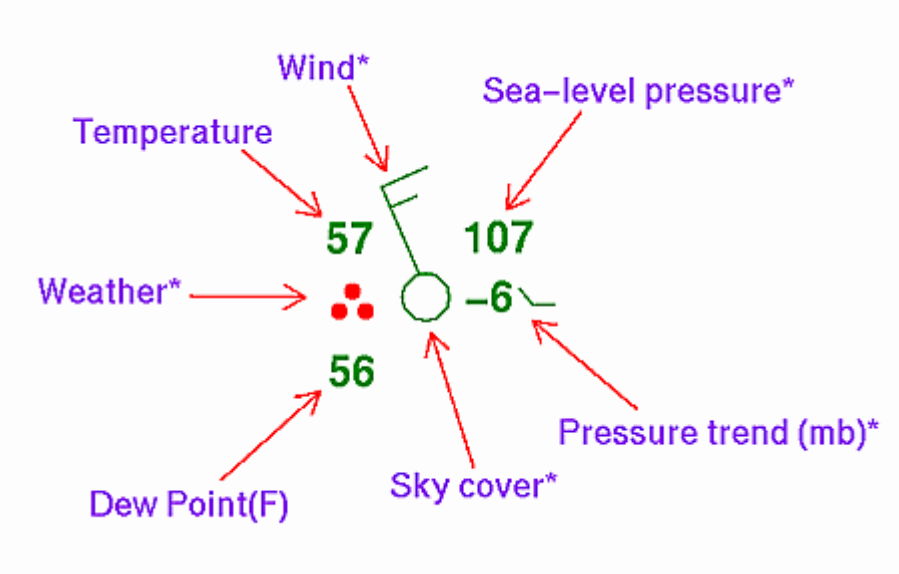
Automatically collects data every minute, 24/7

- Sky conditions
- Temperature
- Pressure
- Humidity
- Wind
- Visibility/fog/haze
- Precipitation

http://www.nws.noaa.gov/ost/asostech.html

Summarizing Weather Data – ‘Station Models’

Coded diagram to represent conditions at location



http://www.hpc.ncep.noaa.gov/html/stationplot.shtml

NATIONAL WEATHER SERVICE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Local forecast by "City, St" or ZIP code

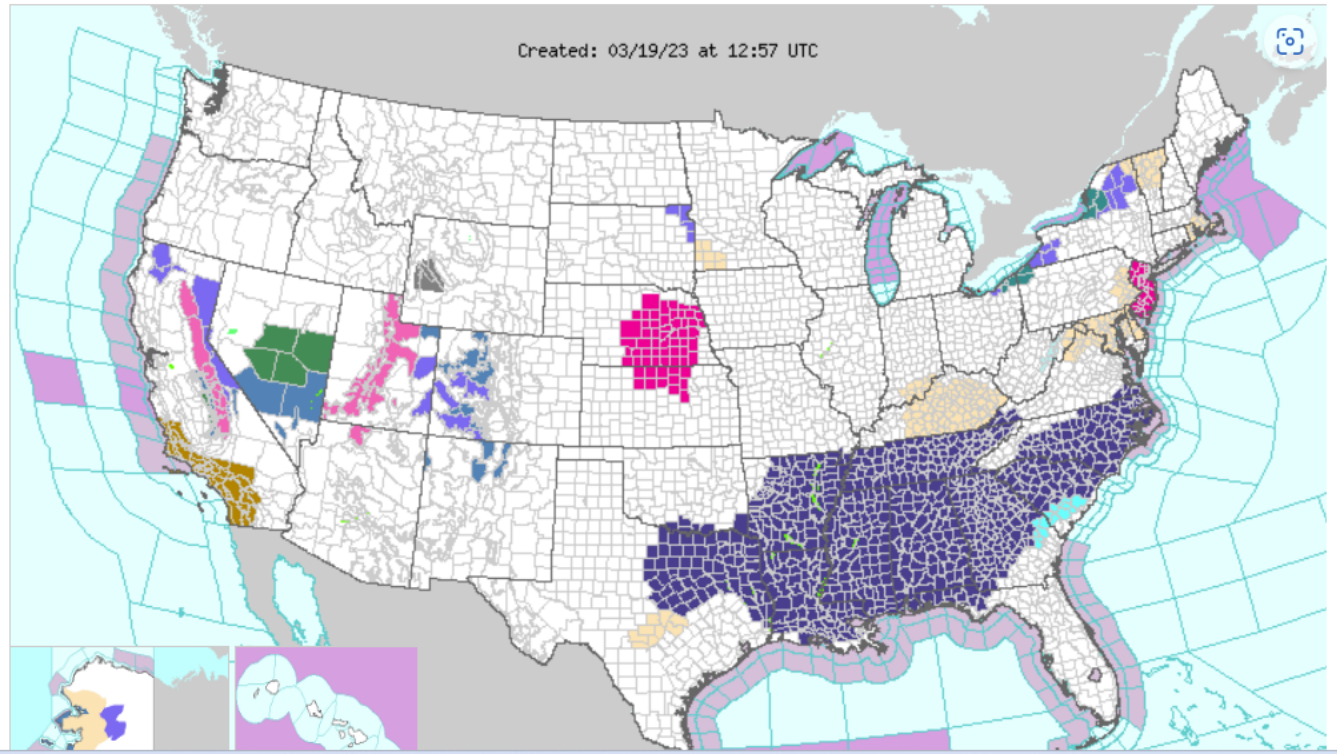
Enter location ... Go

Location Help

Lake Effect Snow Continues Over the Eastern Great Lakes; Parade of Storms to Impact the Western U.S.

Heavy lake effect snow will continue downwind of Lakes Erie and Ontario into Sunday. A parade of storms will bring additional heavy rain and mountain snow to the Western U.S. this coming week. Energy from each of these storms will likely then move across the central and eastern U.S. with areas of snow and blowing snow to the north and heavy to severe thunderstorms to the south. Read More >

WRN



New York, NY

Hazardous Weather Conditions

- Hazardous Weather Outlook
- Red Flag Warning in effect from March 19, 10:00 AM EDT until March 19, 08:00 PM EDT

En Español | Share

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

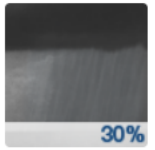
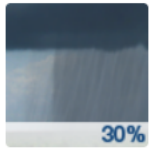
Fair
30°F
-1°C

Humidity	34%
Wind Speed	W 15 G 28 mph
Barometer	30.01 in (1016.0 mb)
Dewpoint	5°F (-15°C)
Visibility	10.00 mi
Wind Chill	19°F (-7°C)
Last update	19 Mar 8:51 am EDT

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

Extended Forecast for
Hackensack NJ

Click here for hazard details and duration

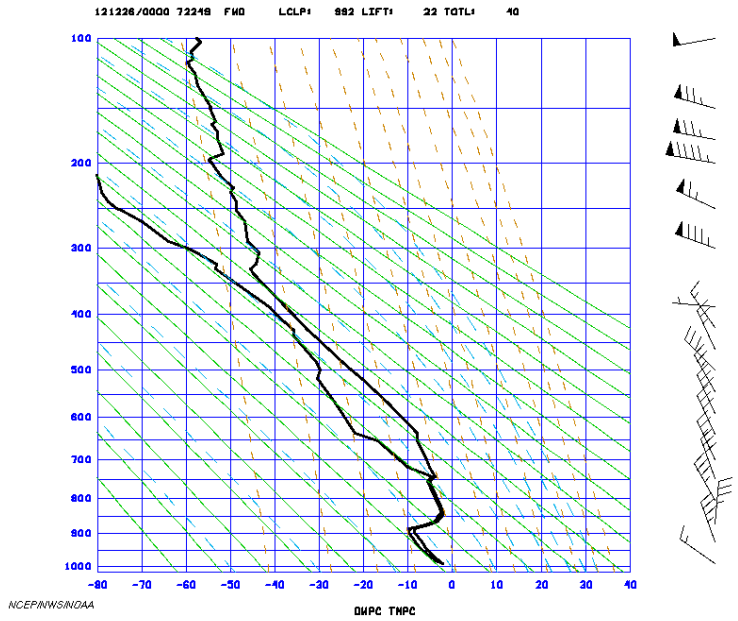
Today	Tonight	Monday	Monday Night	Tuesday	Tuesday Night	Wednesday	Wednesday Night	Thursday
Red Flag Warning								
							 30%	 30%
Increasing Clouds	Mostly Clear	Sunny	Mostly Clear	Sunny	Partly Cloudy	Partly Sunny	Chance Showers	Chance Showers

Weather occurs in 3-D

- **Radiosondes** carried by weather balloons give data about conditions aloft
- Temperature, pressure, winds, relative humidity
- Carried by weather balloon up to more than 100,000 ft

http://www.ua.nws.noaa.gov/factsheet.htm

Launched 2x a day at 0000 GMT and 1200 GMT



Stuve diagram shows radiosonde information

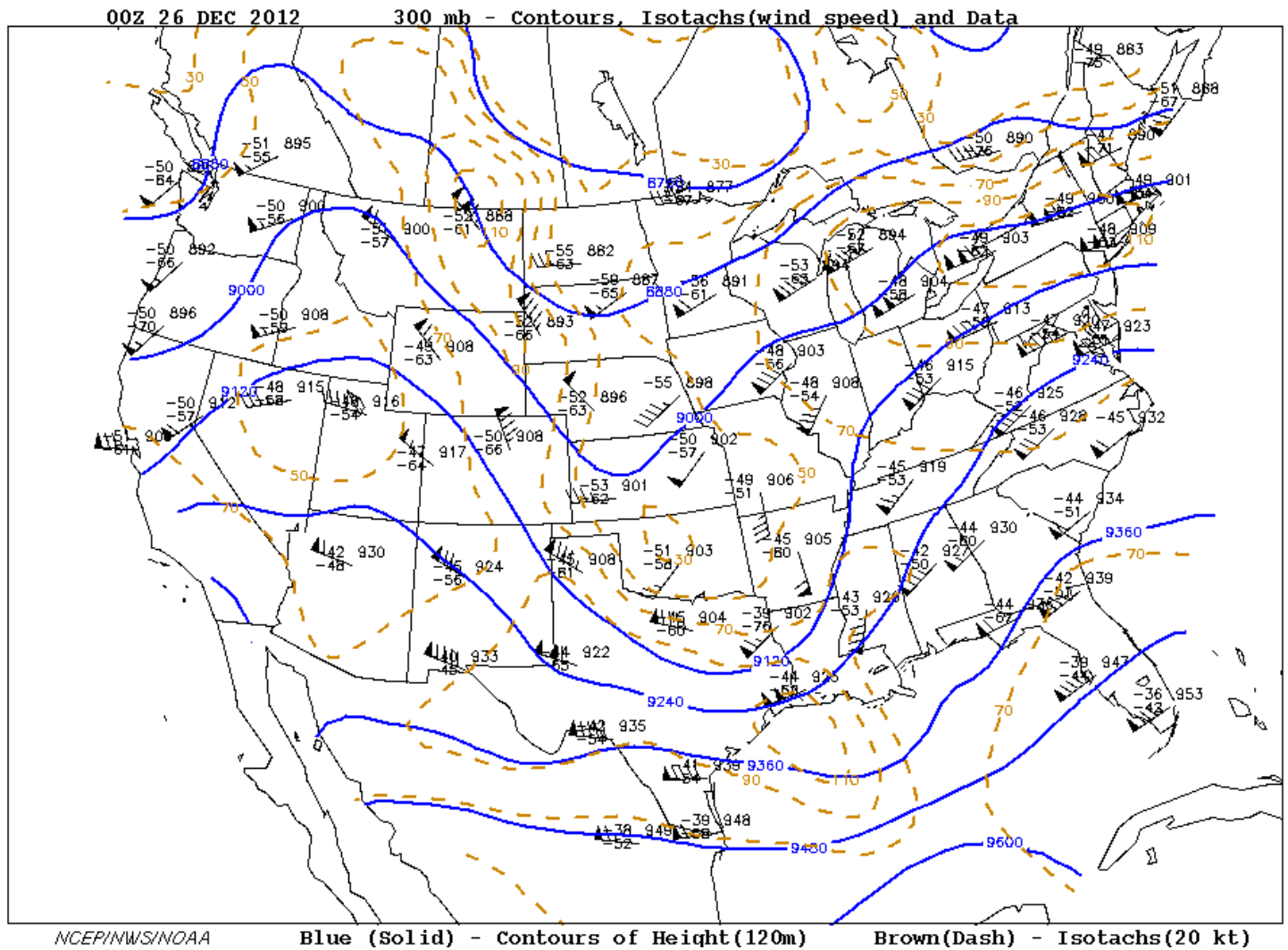
Upper Atmosphere Observations

Weather Balloon – launched twice daily from locations across the US and world

(note: Not a Chinese spy balloon)

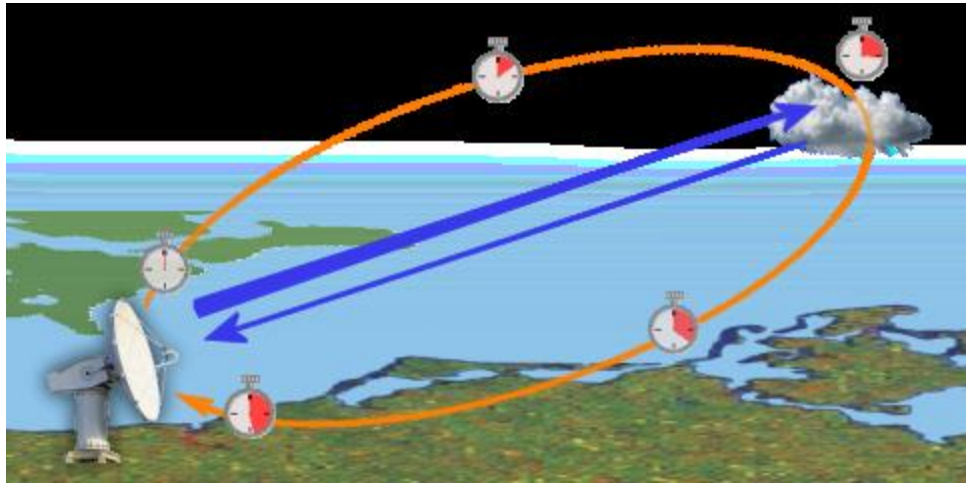
Weather satellite

Upper-Air Weather Maps (especially useful to forecaster and aviators)

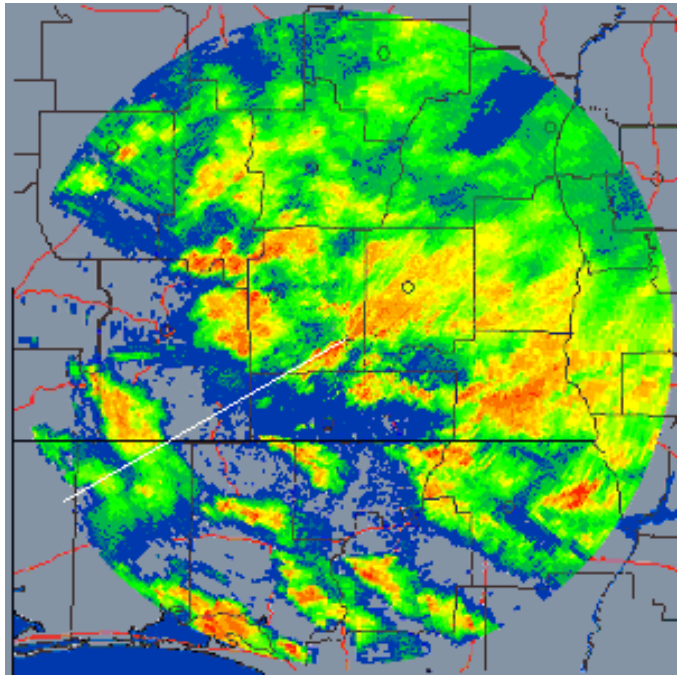


Weather Radar

Emits radio-wavelength signals and records echoes that detect clouds, precipitation, and winds in a 200-mi (320-km) radius



http://www.radartutorial.eu/15.weather/wx04.en.html



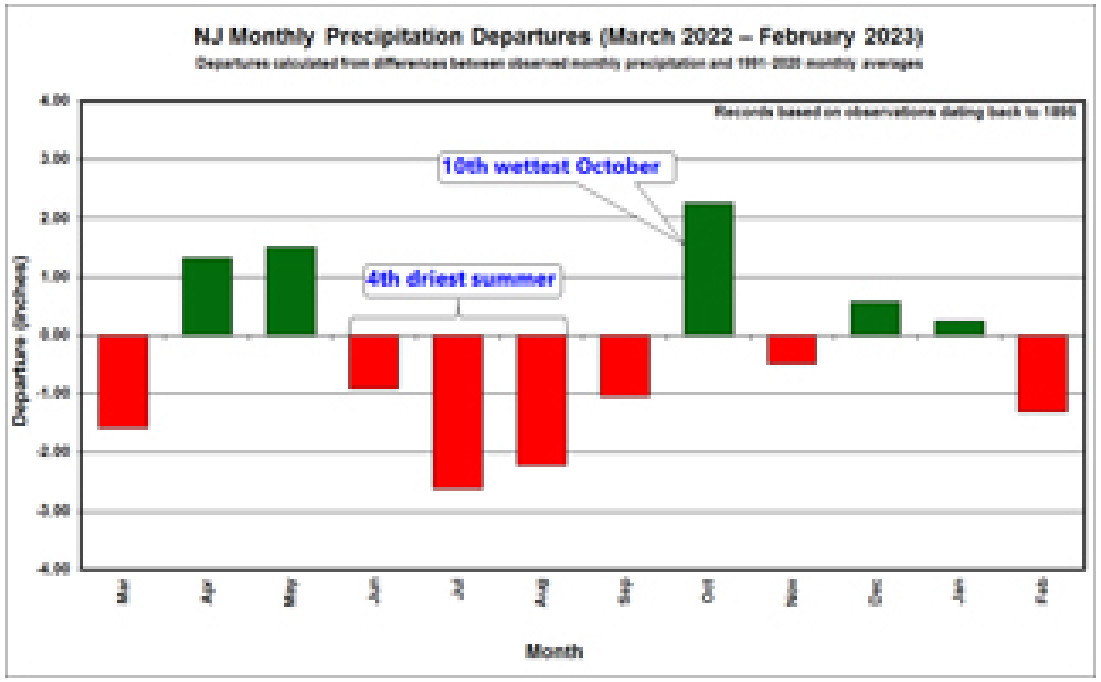
Activity 1) How do you/your students get their weather information? (7 - 10 minutes)

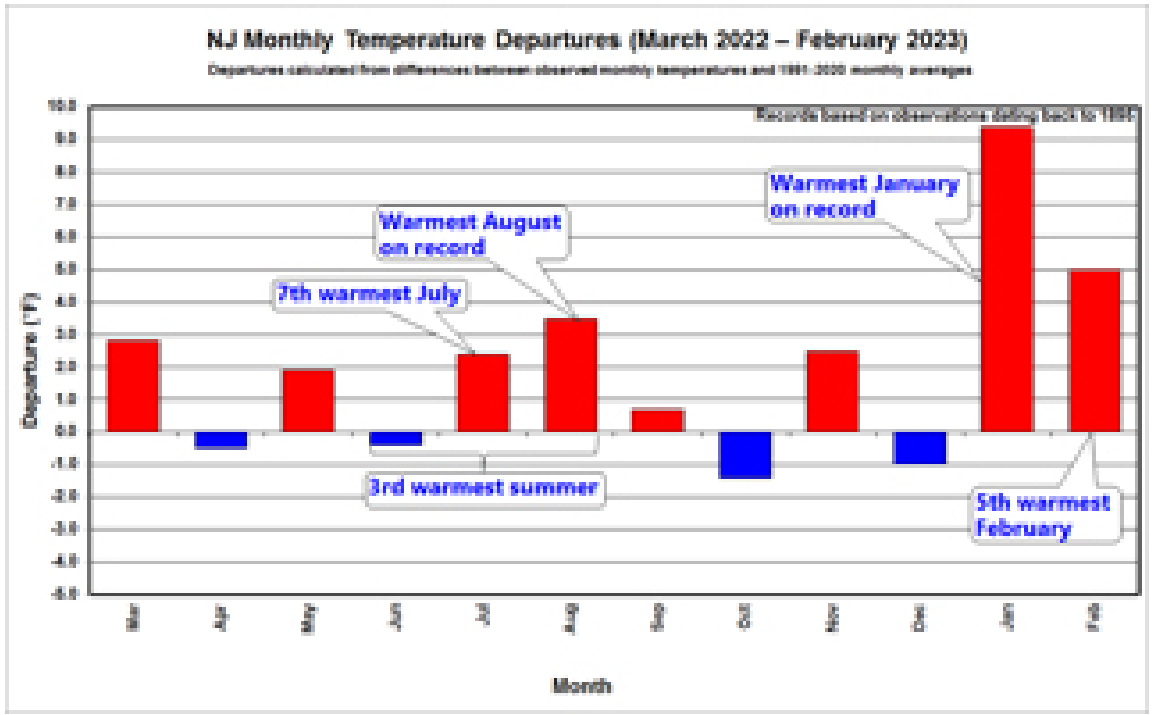
Ben Franklin said, “some people are weather wise, most are otherwise.”

- What can you do in your classroom to help them become more weatherwise?
- How could you suggest careers as a meteorologist or meteorological technician to your students?

Climate ‘Normals’

- 30-year period, updated every 10 years (currently 1990 – 2020)
- Many specialized data sets are available through organizations such as CIESEN and the IRI (International Research Institute Climate and Society at Columbia)



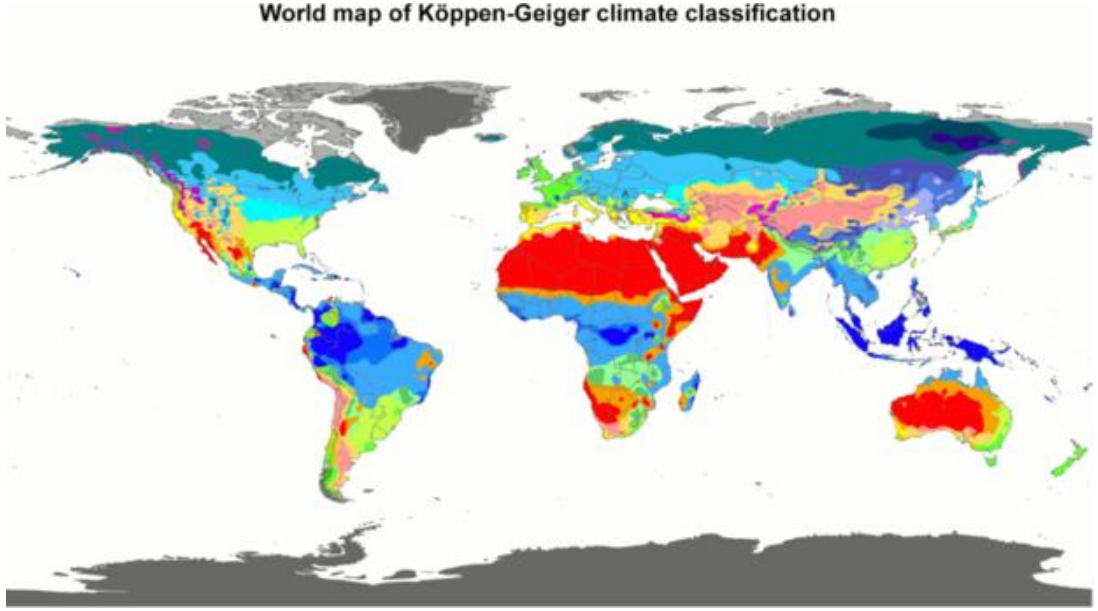


Additional factors that influence climates

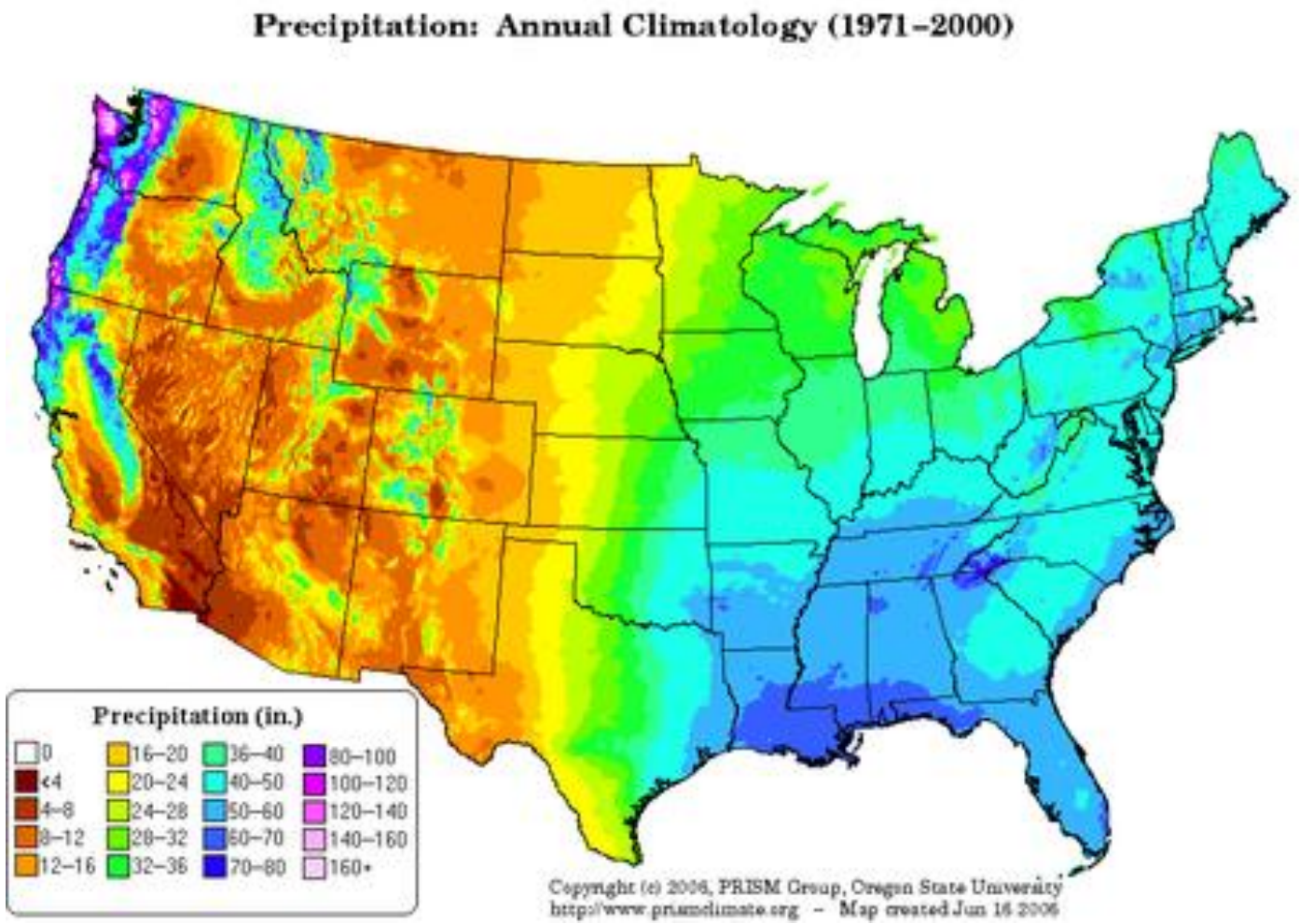
What causes/influences climate?
1) Local influences

Geographers recognize a number of factors that affect a region's climate:

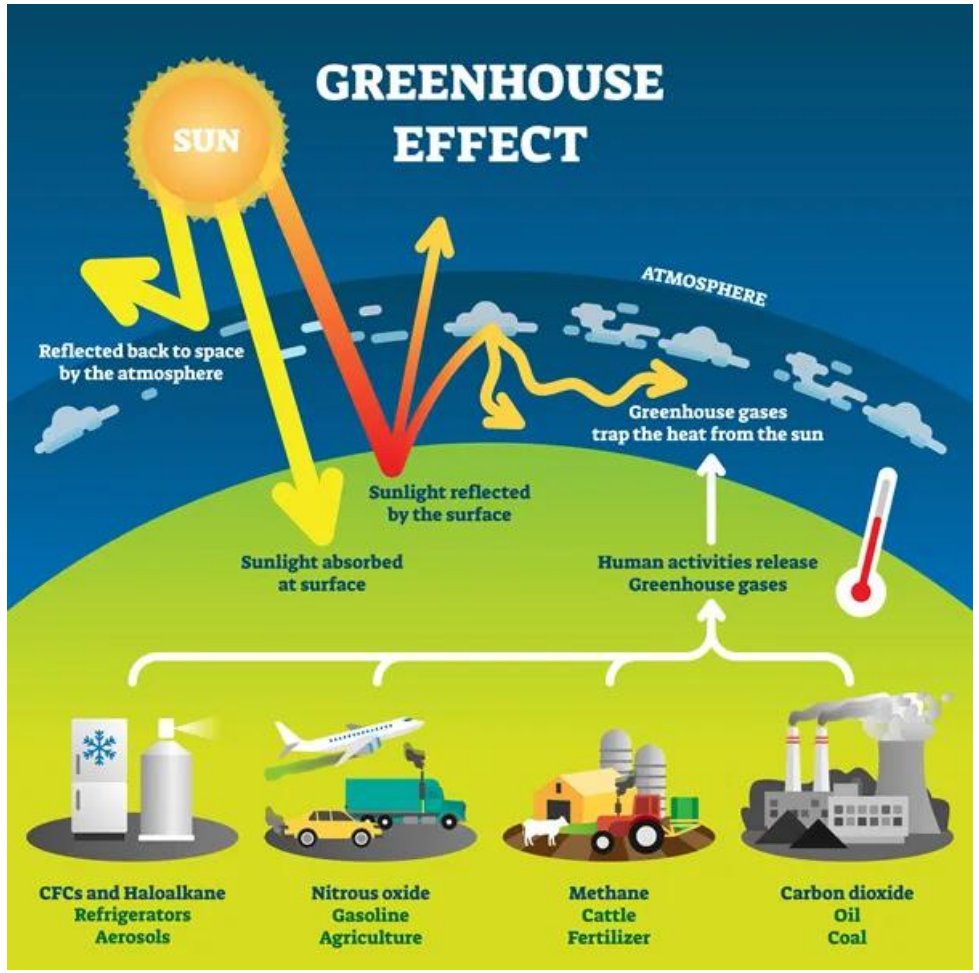
- latitude
- elevation
- proximity to large water bodies, mountains, or other surface features
- Orientation (direction faced)
- Temperature patterns
- Moisture patterns

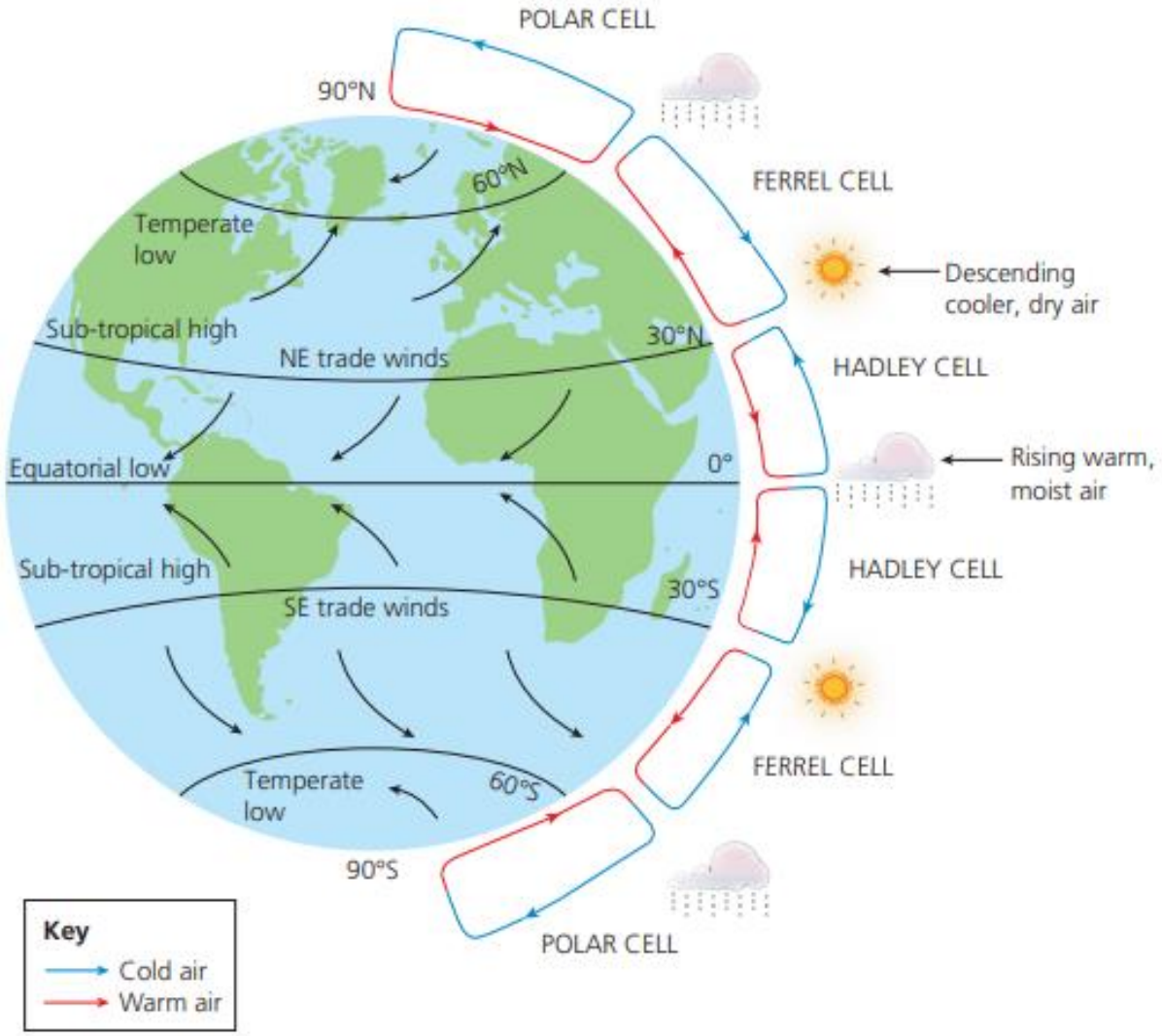


What causes/influences climate
2) Regional Patterns



3) Global factors that influence climates





Greenhouse Gases

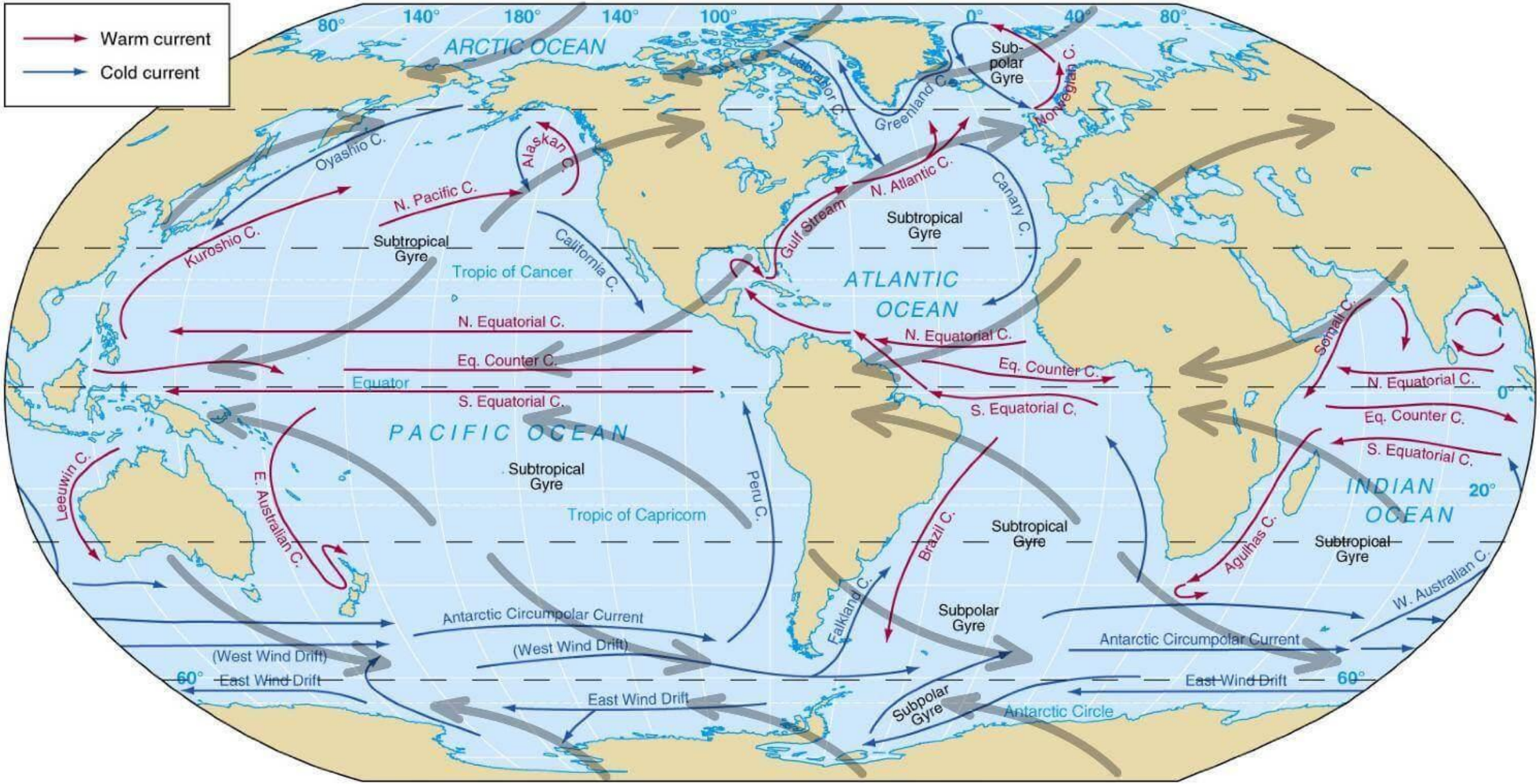
<u>Natural greenhouse gases</u>

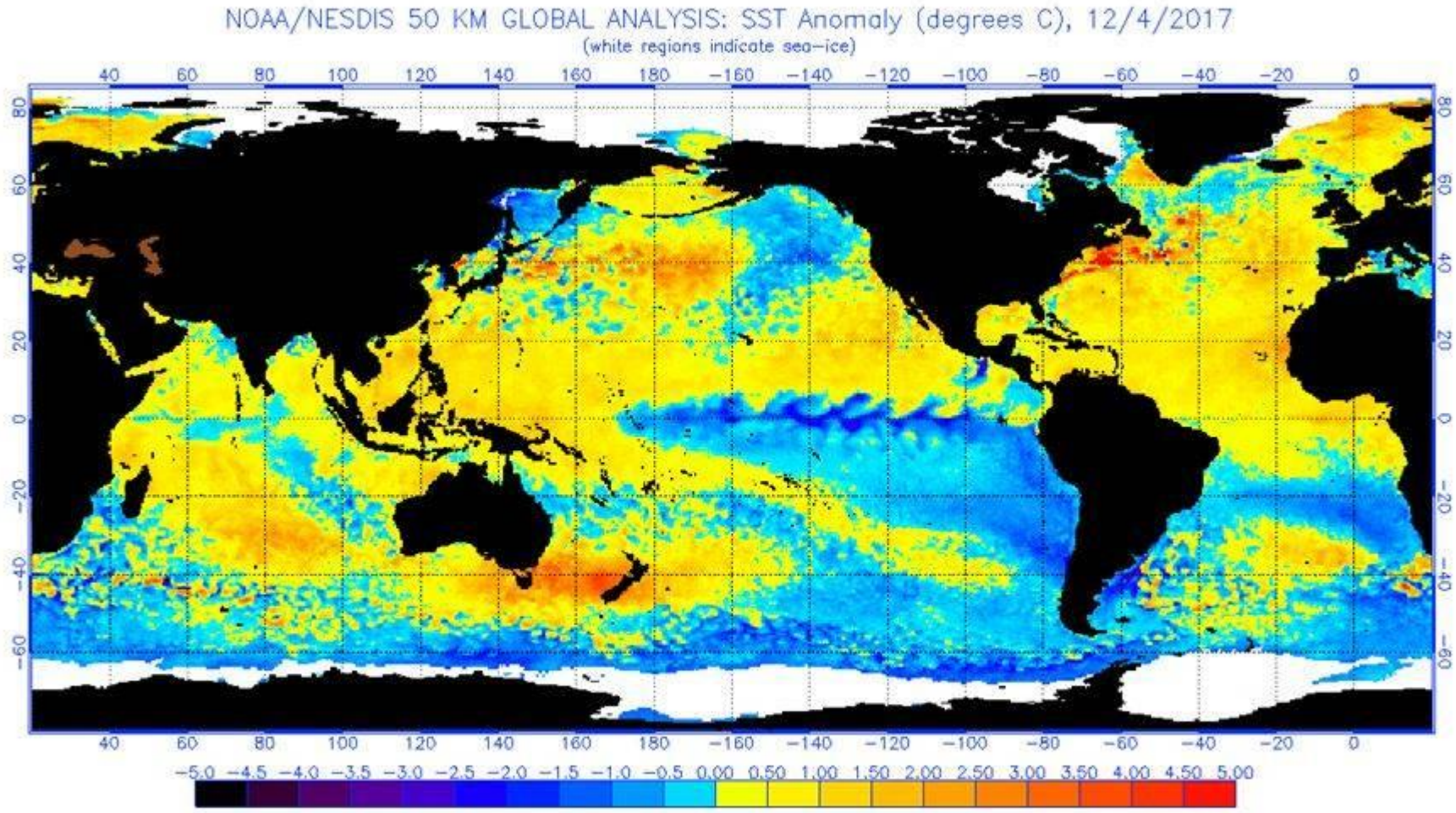
- Water (H_2O)
- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxide (N_2O)
- Ozone (O_3)

<u>Anthropogenic (man-made) greenhouse gases</u>

- Hydrofluorocarbons
- Sulfur hexafluoride
- Nitrogen trifluoride
- Perfluorocarbons

They can retain heat energy and act as blankets to warm the atmosphere.


Warm current
Cold current
ARCTIC OCEAN
ATLANTIC OCEAN
PACIFIC OCEAN
INDIAN OCEAN
80°
140°
180°
140°
100°
0°
40°
80°
20°
60°
Oyashio C.
Alaskan C.
N. Pacific C.
Kuroshio C.
Subtropical Gyre
California C.
Tropic of Cancer
N. Equatorial C.
Eq. Counter C.
Equator
S. Equatorial C.
Leeuwin C.
E. Australian C.
Peru C.
Tropic of Capricorn
Antarctic Circumpolar Current
(West Wind Drift)
East Wind Drift
Labrador C.
Greenland C.
Sub-polar Gyre
Norwegian C.
Gulf Stream
N. Atlantic C.
Canary C.
Subtropical Gyre
N. Equatorial C.
Eq. Counter C.
S. Equatorial C.
Brazil C.
Falkland C.
Subpolar Gyre
Somali C.
N. Equatorial C.
Eq. Counter C.
S. Equatorial C.
Agulhas C.
Subtropical Gyre
W. Australian C.
Antarctic Circumpolar Current
East Wind Drift
Subpolar Gyre
Antarctic Circle



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Activity 2) Sources of Climate Information (10 minutes)

Groups 1 and 3

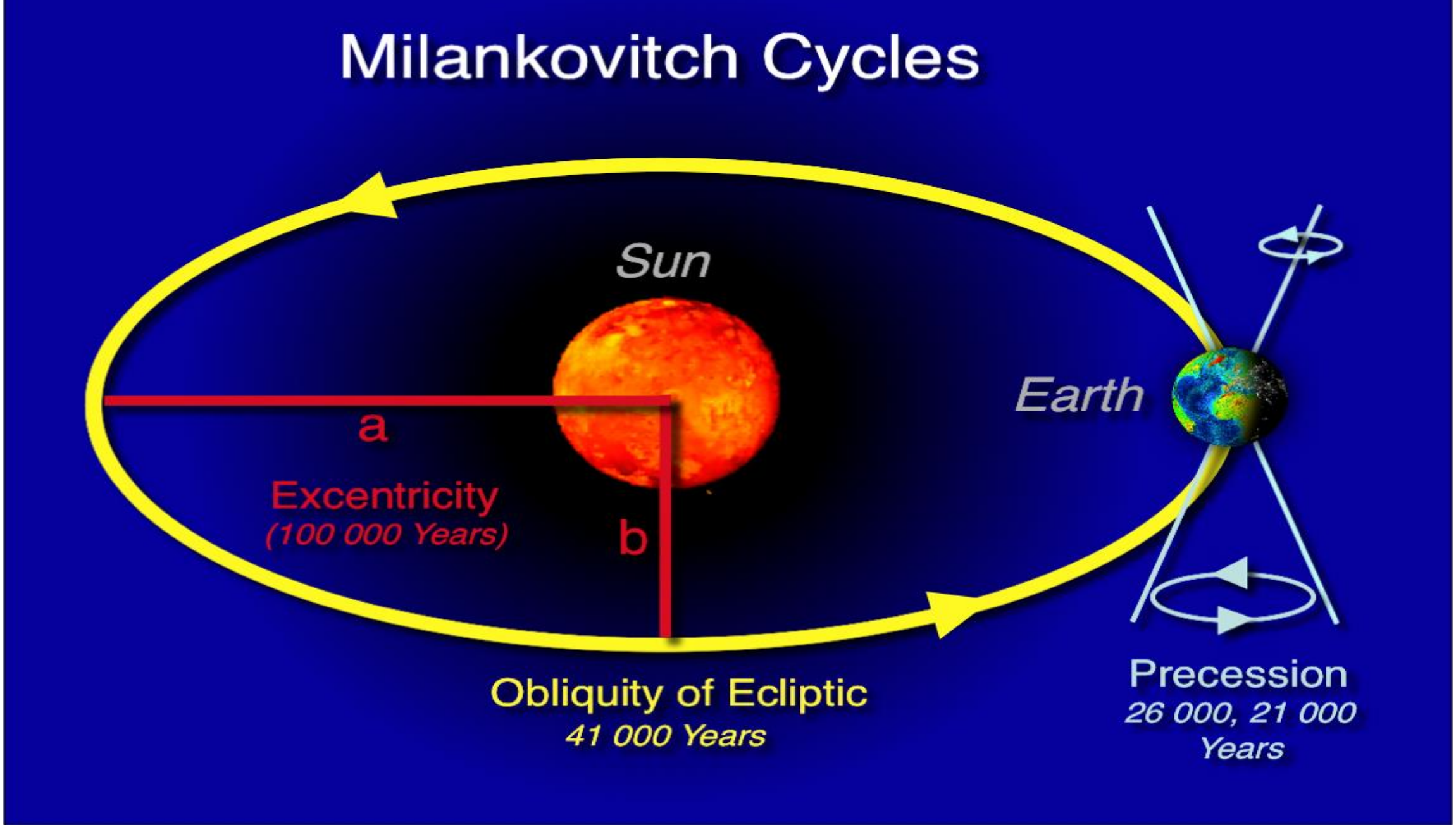
Go to https://www.climate.gov/

What types of information are available on this website, and how could you use it in your classroom

- Groups 2 and 4

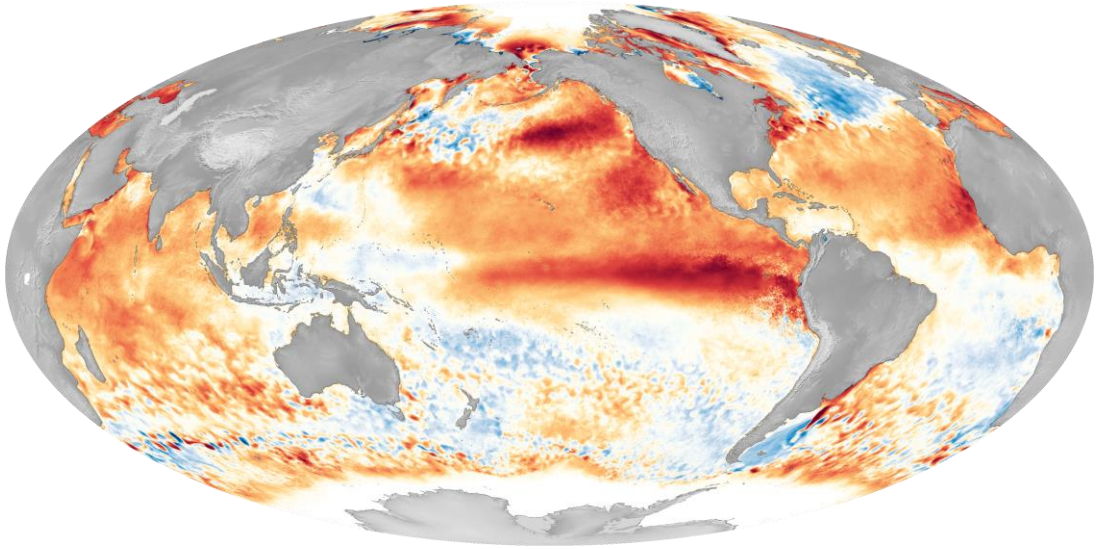
Go to:
https://climate.rutgers.edu/stateclim/

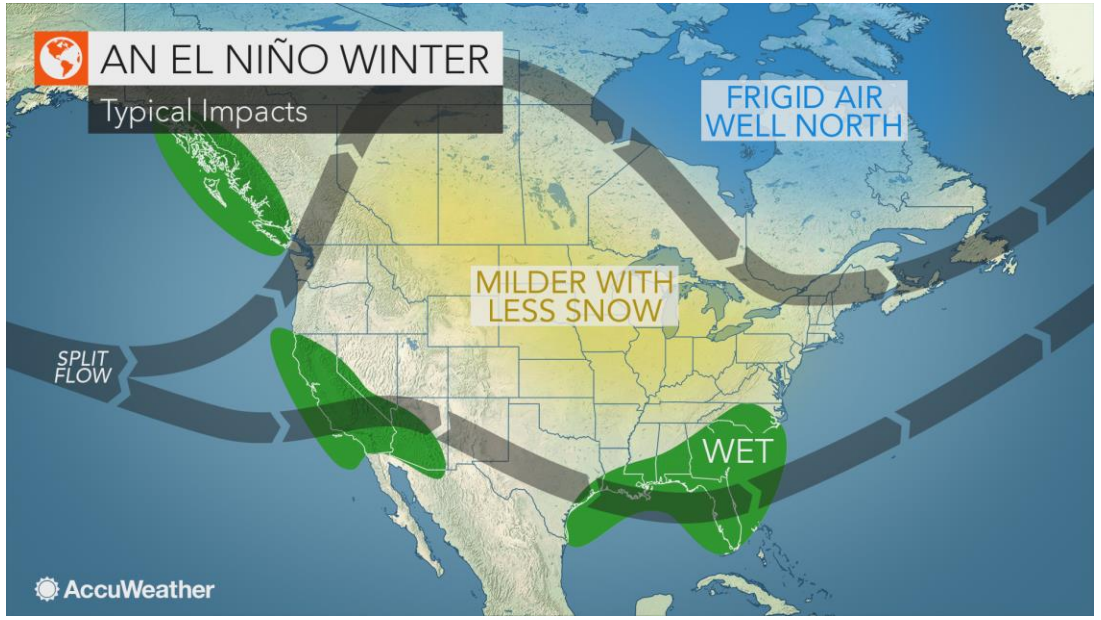
What types of information are available on this website and how can you use it in your classroom?



[Milankovitch Cycles (ossfoundation.us)]

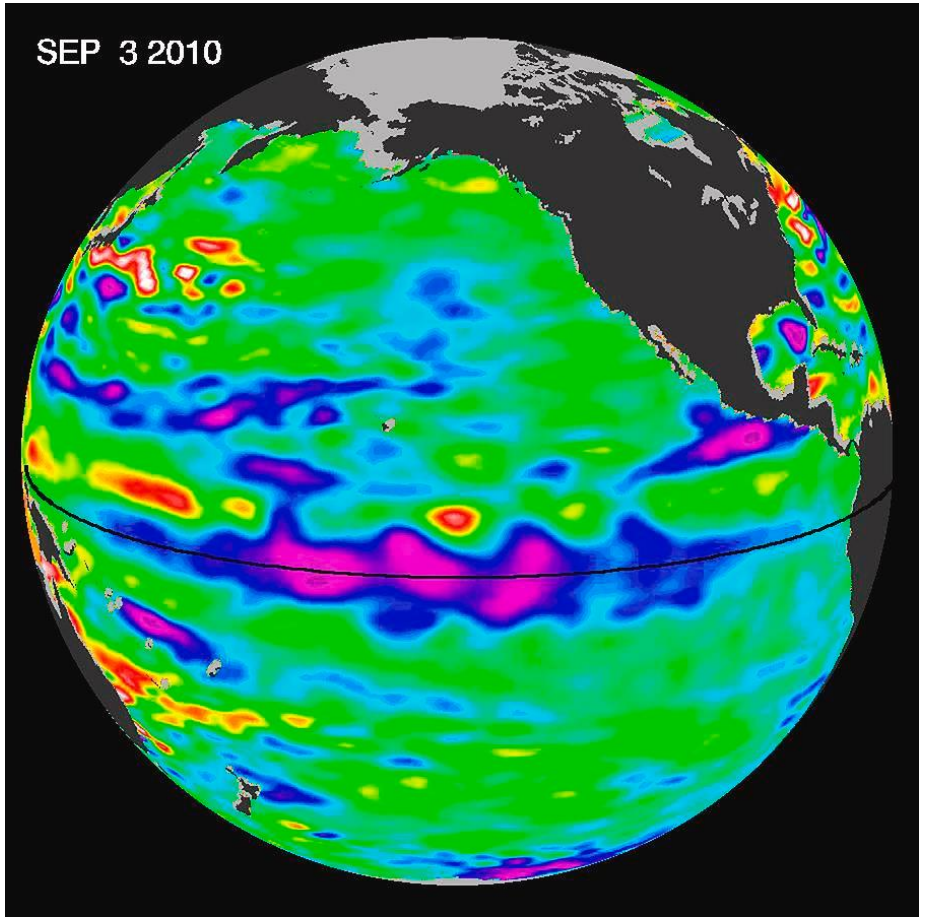
El Nino-La Nina
Periodic changes in Pacific Ocean

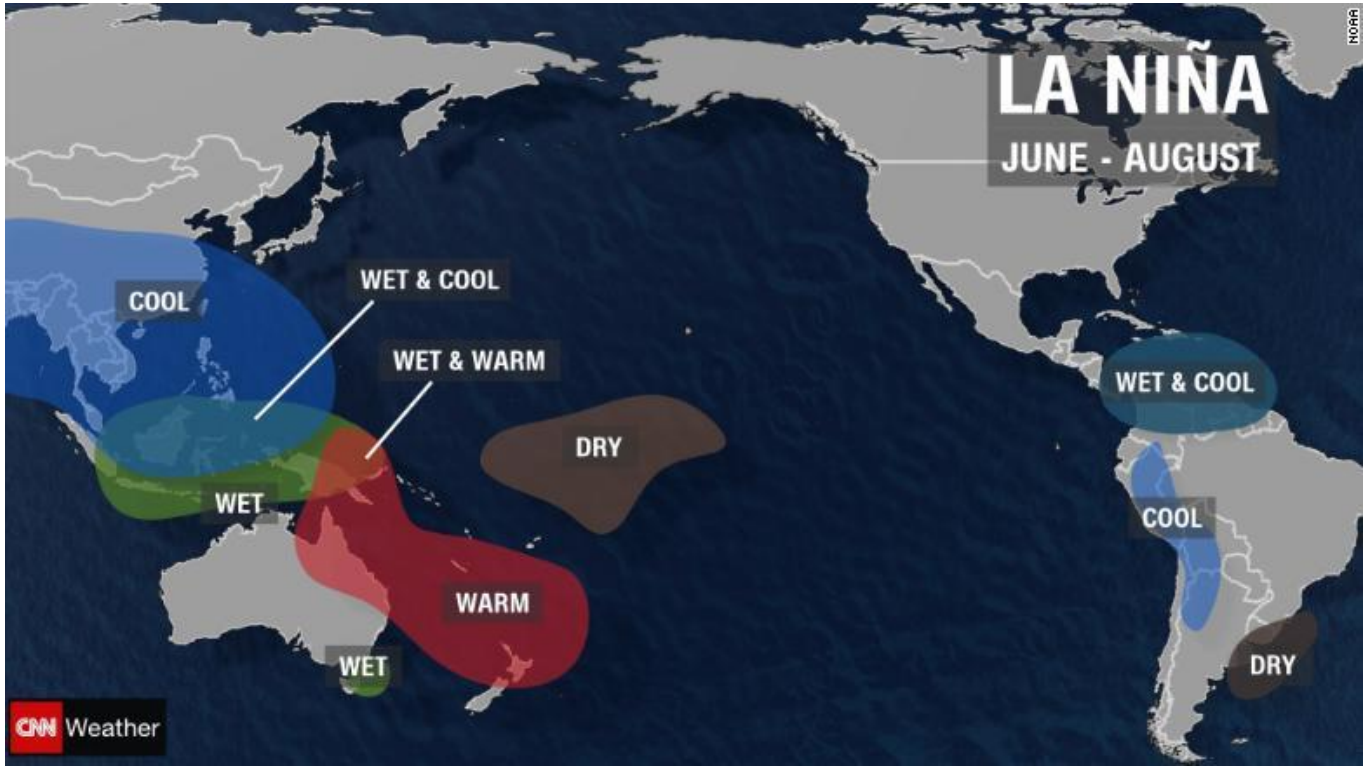




https://www.nnvl.noaa.gov/images/GlobalMaps/ElNino.png

La Nina





https://images.search.yahoo.com/search/images?p=la+nina+image&fr=mcafee&type=E211US105G0&imgurl=http%3A%2F%2Fnews-images.weatherzone.com.au%2Ftwc%2FLa-Nina.png#id=2&iurl=https%3A%2F%2Fimages.fineartamerica.com%2Fimages-medium-large-5%2F3-la-nina-nasascience-photo-library.jpg&action=click

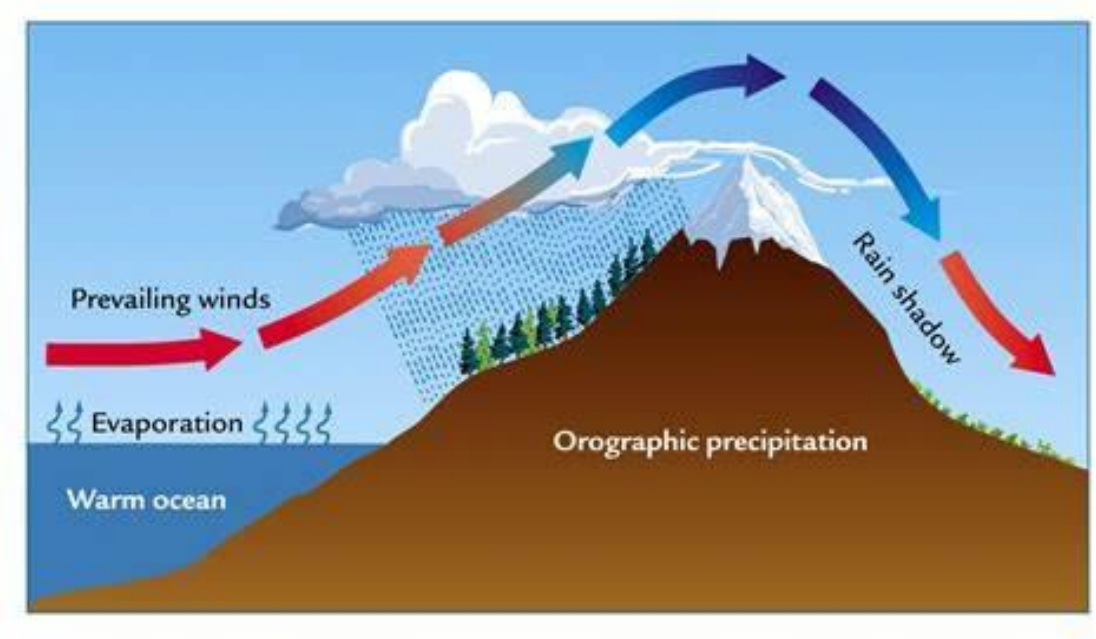
Activity (10 minutes)

- Go to: https://toolkit.climate.gov/reports/climategovs-el-nino-page

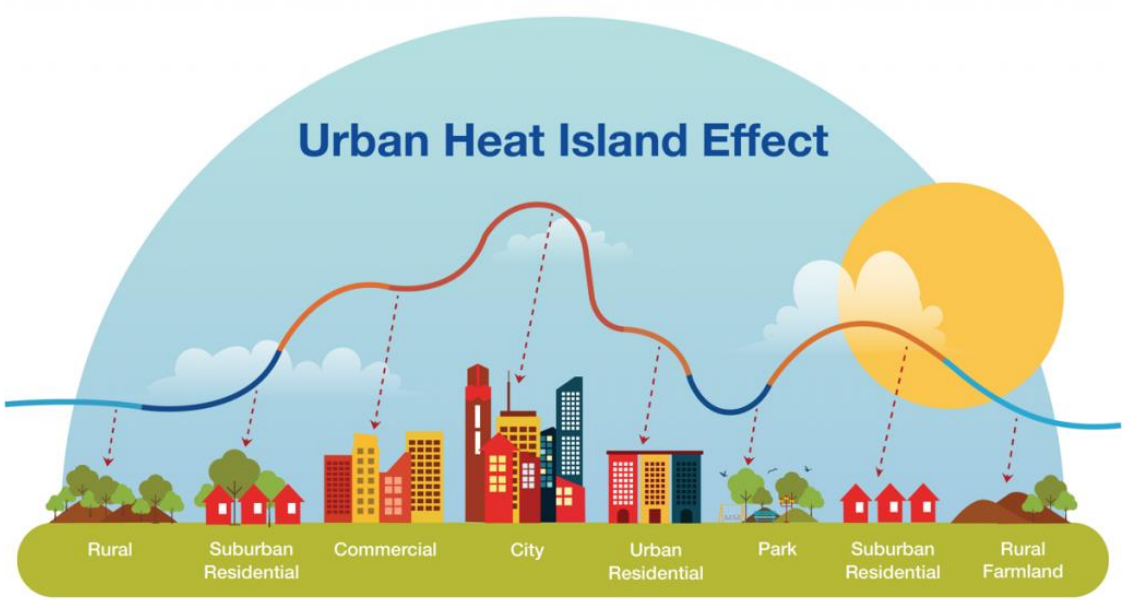
- Group 1) What are the usual impacts of El Nino conditions on the continental U.S.?
- Group 2) What are the usual impacts of La Nina conditions on the continental U.S.?
- Group 3) What are the impacts of El Nino and La Nina on Australia?
- Group 4) What conditions dominate now? What is the current forecast?

What causes/influences climate?
3) Local influences

- Orographic (mountain) effects

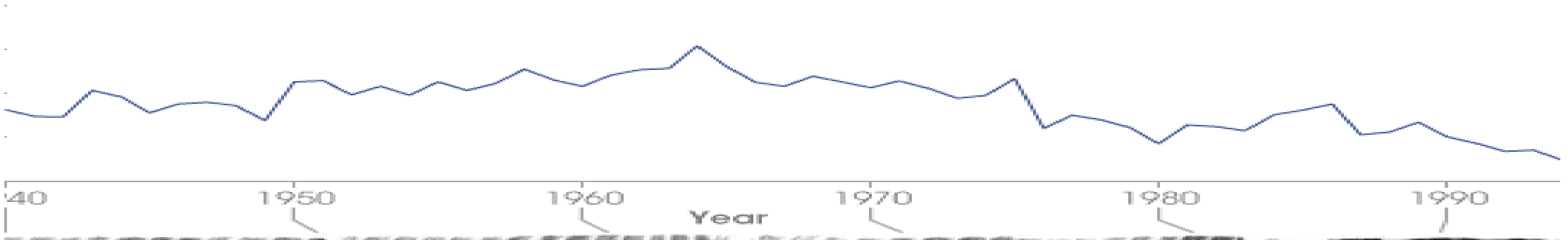


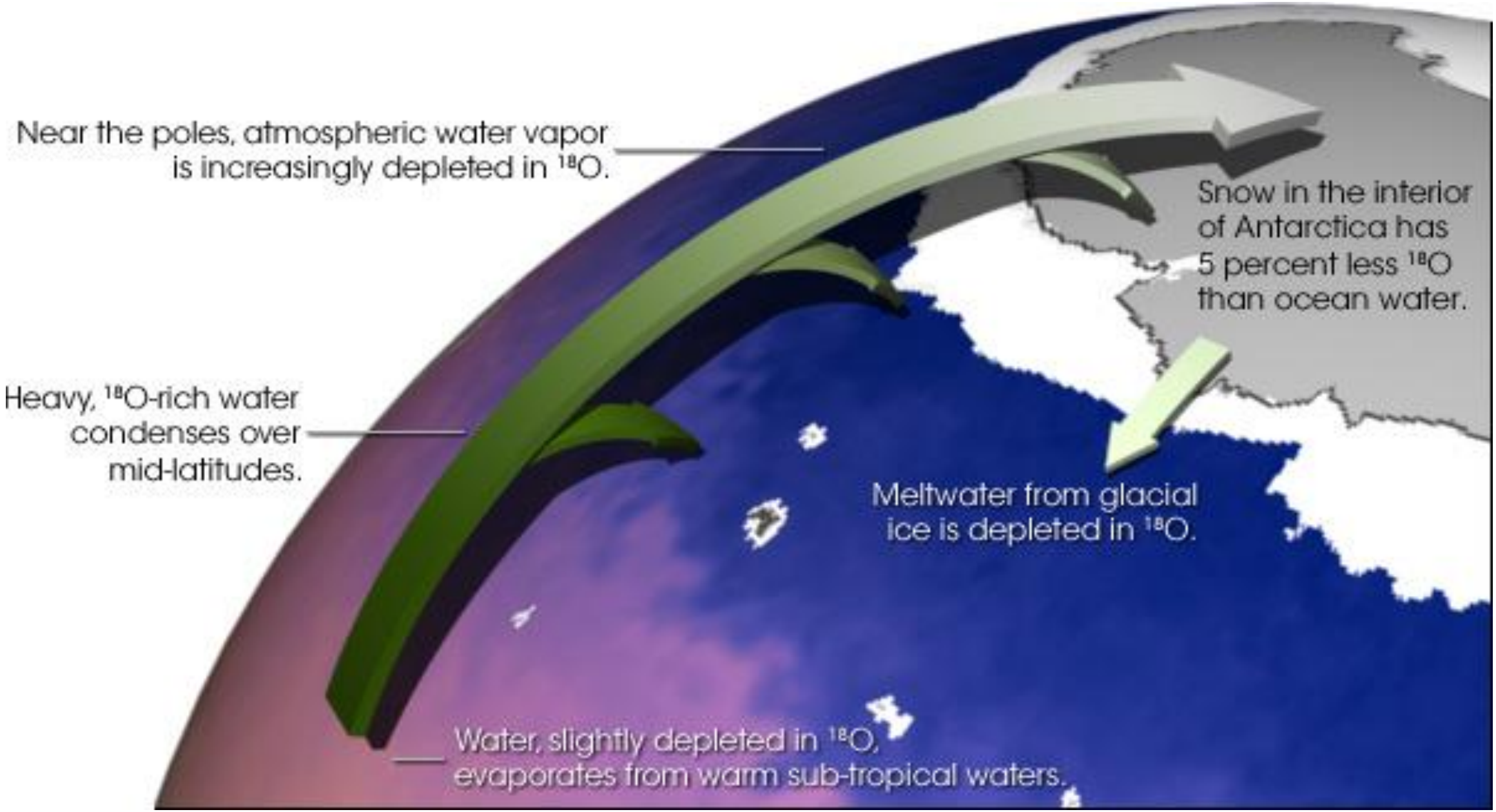
Urban “Heat Island”



Paleoclimate proxies – Part 1

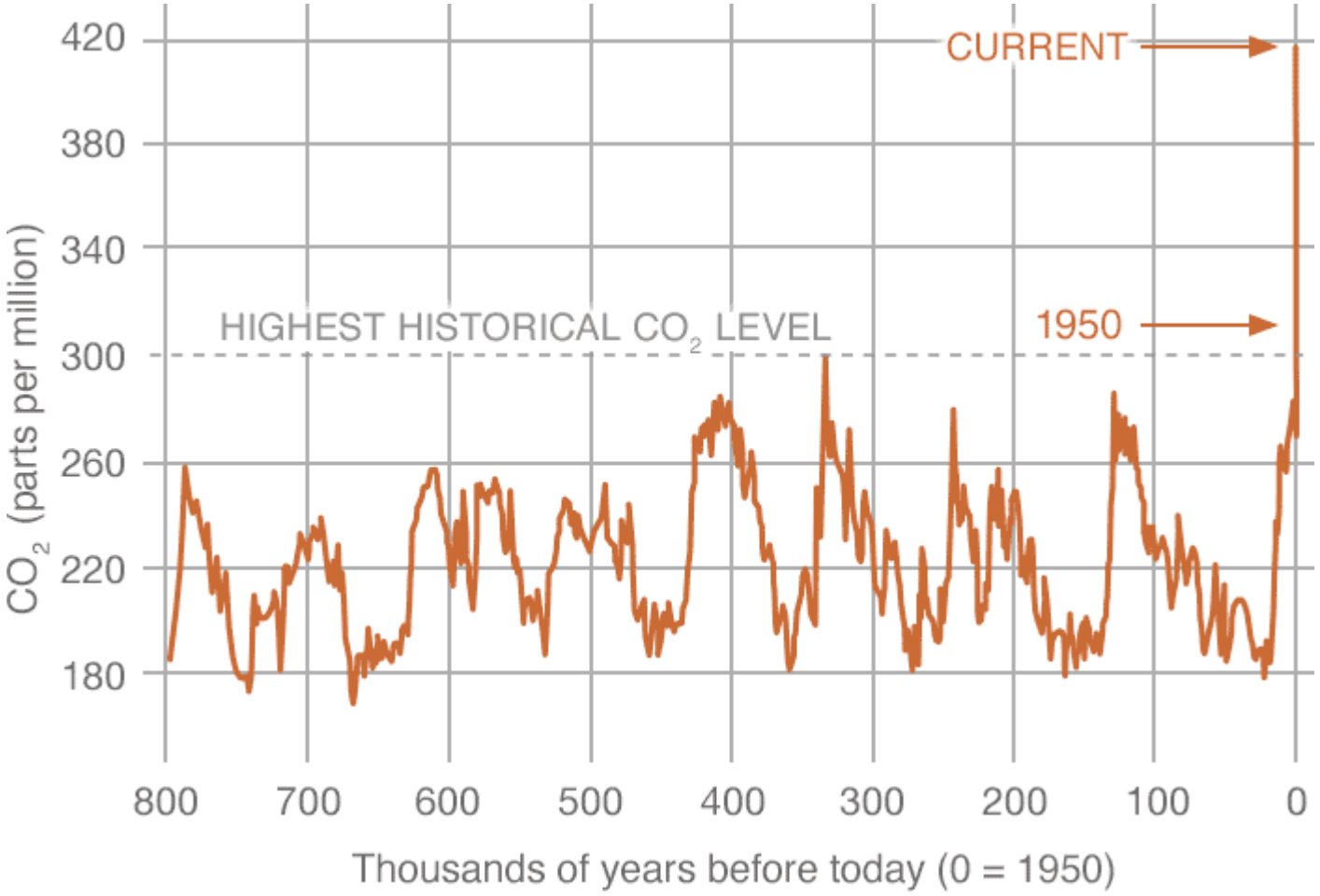
- Oxygen isotopes in ice cores, shells, and microfossils
- Carbonate ($CaCO_3$) fossil shells of forams, corals, and other organisms, and siliceous (SiO_2) fossils of diatoms contain isotopes of Oxygen.
- O-18 is heavier and precipitates faster, O-16 is lighter and evaporates faster, so the O-18/O-16 ratio can be used to determine whether the temperatures were relatively warmer or cooler at the time the organisms lived



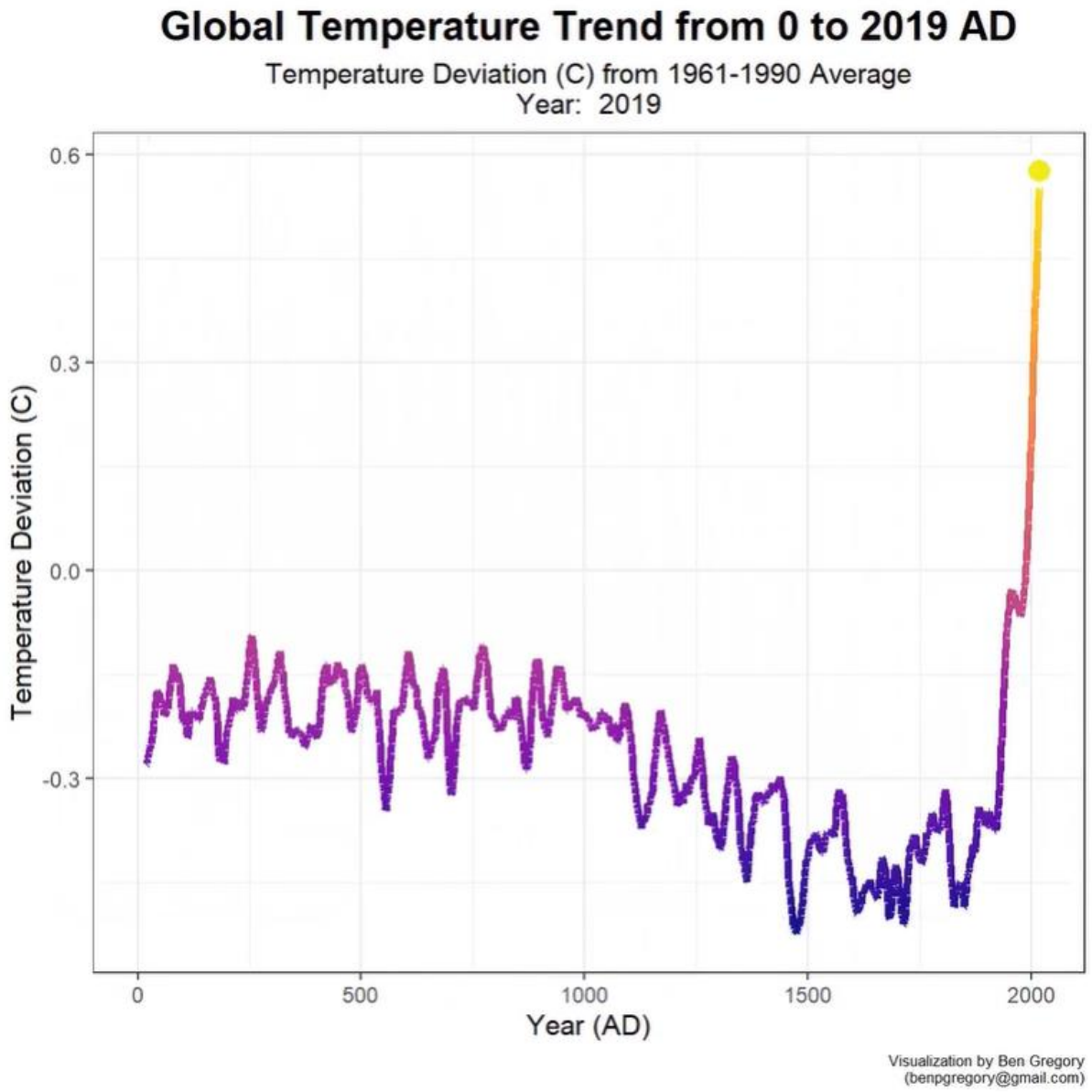


Source: https://earthobservatory.nasa.gov/features/Paleoclimatology_OxygenBalance

Global temperature trends



https://climate.nasa.gov/vital-signs/carbon-dioxide/



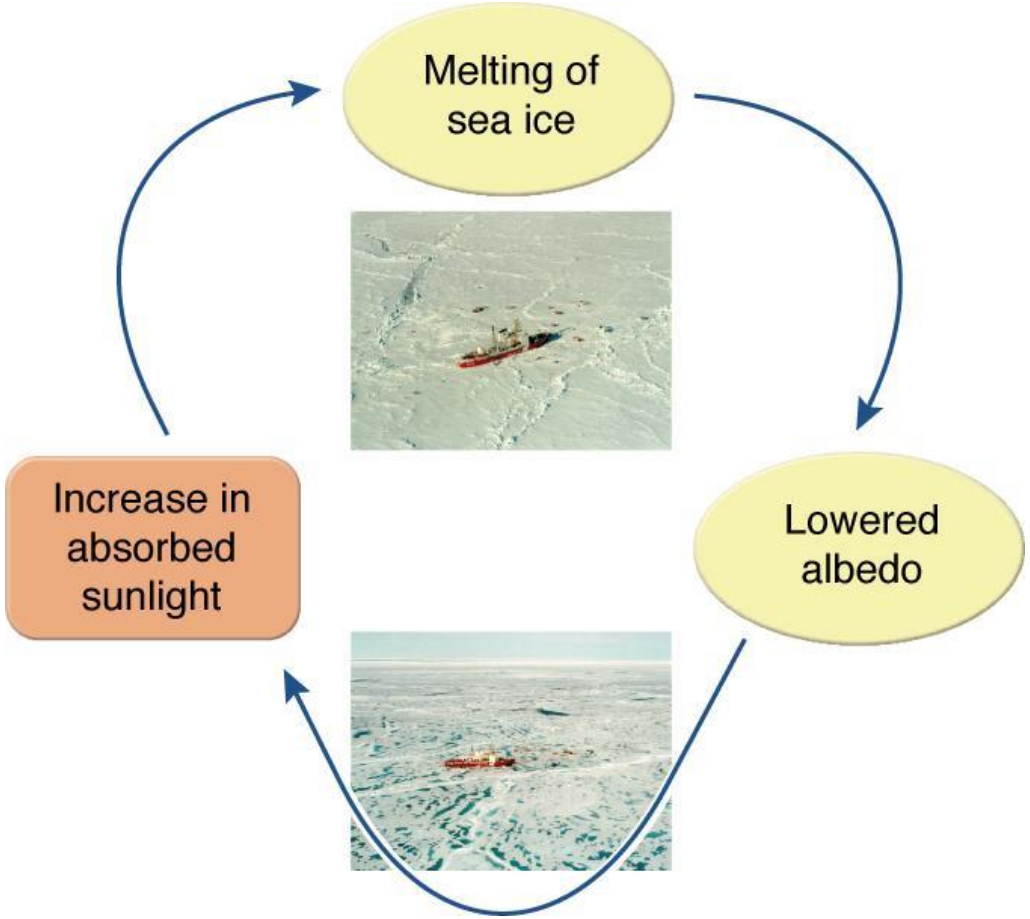
https://images.search.yahoo.com/search/images?p=global+temperature+patterns+over+time+graph&fr=mcafee&type=E211US105G0&imgurl=https%3A%2F%2Fassets.weforum.org%2Feditor%2FIXOp1xthuSDlPNBqPb-hJzkVY2yeQTptx6Bt5tFGTJ4.PNG#id=4&iurl=https%3A%2F%2Fassets.weforum.org%2Feditor%2FIXOp1xthuSDlPNBqPb-hJzkVY2yeQTptx6Bt5tFGTJ4.PNG&action=click

Climate Change and Human Impacts

- Melting glaciers
- World glaciers melting at accelerating rate

Albedo—portion of incoming light reflected back to space
Ice and snow have high albedos (warm more slowly)
Dark surfaces have low albedos (warm faster)

- As glaciers melt and expose darker land or water, surfaces warm and continue to impact the albedo
- This is an example of a **positive feedback loop**
- What are some other examples of feedback loops in science?



Climate change impact: Intensifying Storms

Hurricanes

Warmer surface waters are causing stronger tropical storms

Storms need ocean heat, atmospheric humidity, and winds, and changing climates can affect all three of these.

There may not be more storms each year, but they will be more intense, with increase in potential damages and deaths

Nor'Easters

Nor'easters are low-pressure systems that forms off the northeast coast in winter

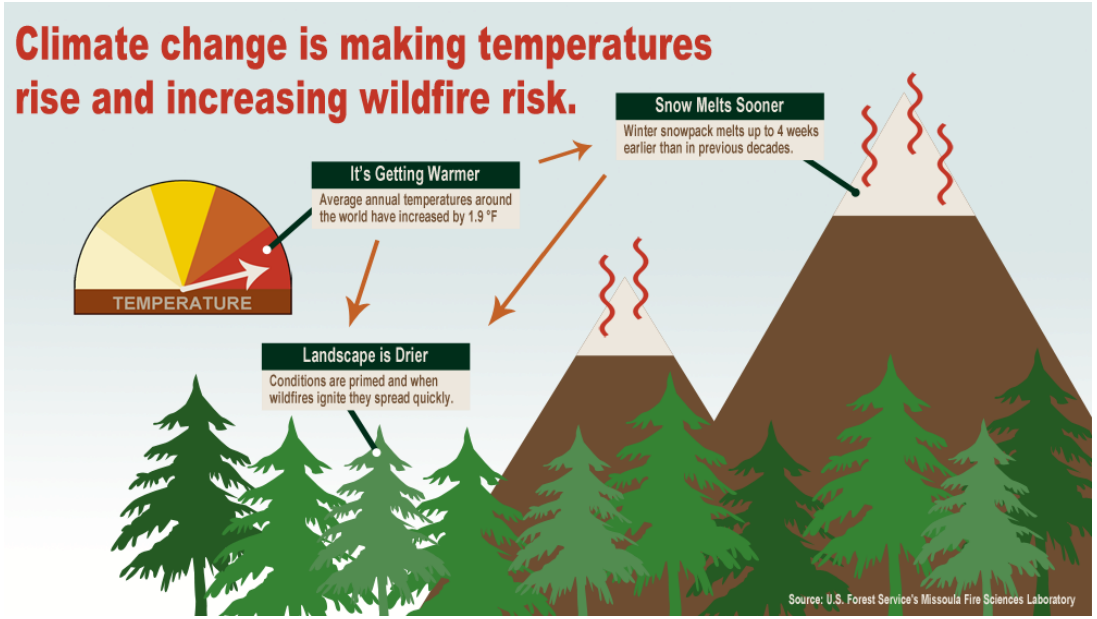
Many derive strength from difference between cold air over Canada and warm air over the Atlantic

Blizzard of 1978 caused 99 deaths and $250 million in damages

Again, not necessarily more, but more intense

Droughts and Wildfires

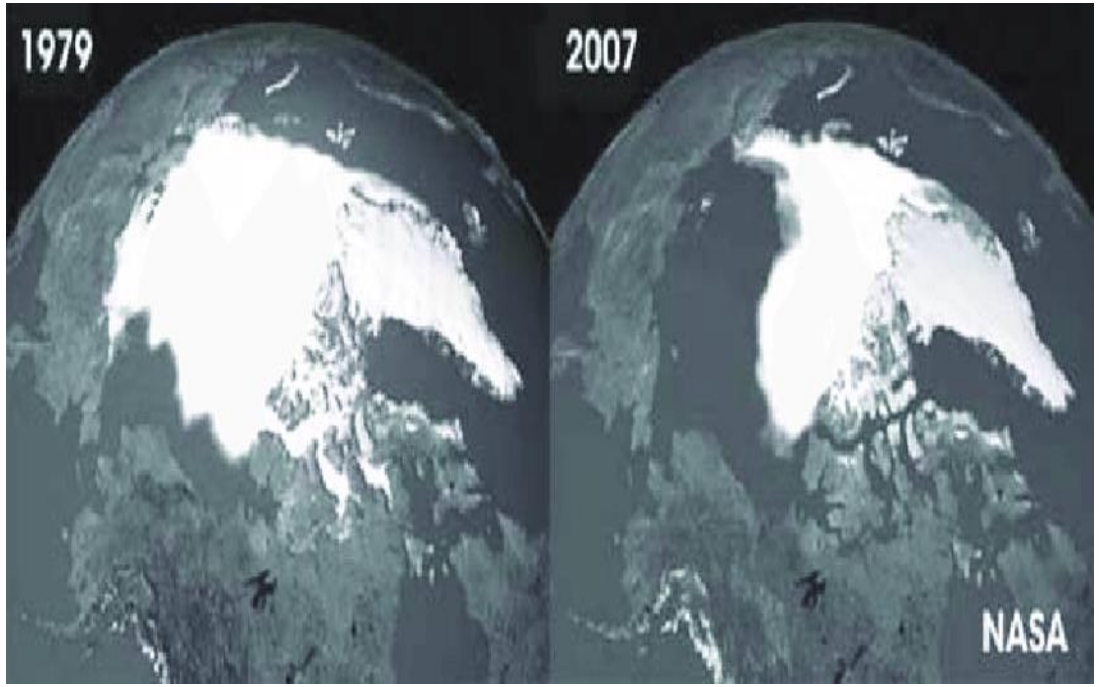
- As air mass patterns shift away from moisture sources, air becomes drier and more droughts may occur. Vegetation becomes more vulnerable to becoming kindling for fires.
- Droughts also affect aquifers and underground water sources, as well as snow pack.
- Major impacts on water resources and agriculture.



https://www.doi.gov/sites/doi.gov/files/uploads/climatechange4_1.png

Climate Changes and Cold Spells

- As Arctic ice cover diminishes, the jet stream becomes weaker and artic air can dip further south, bringing cold spells to the northern US and southern Canada
- Changing temperatures mean changes in the polar vortex (strong winds circulating around the north pole)



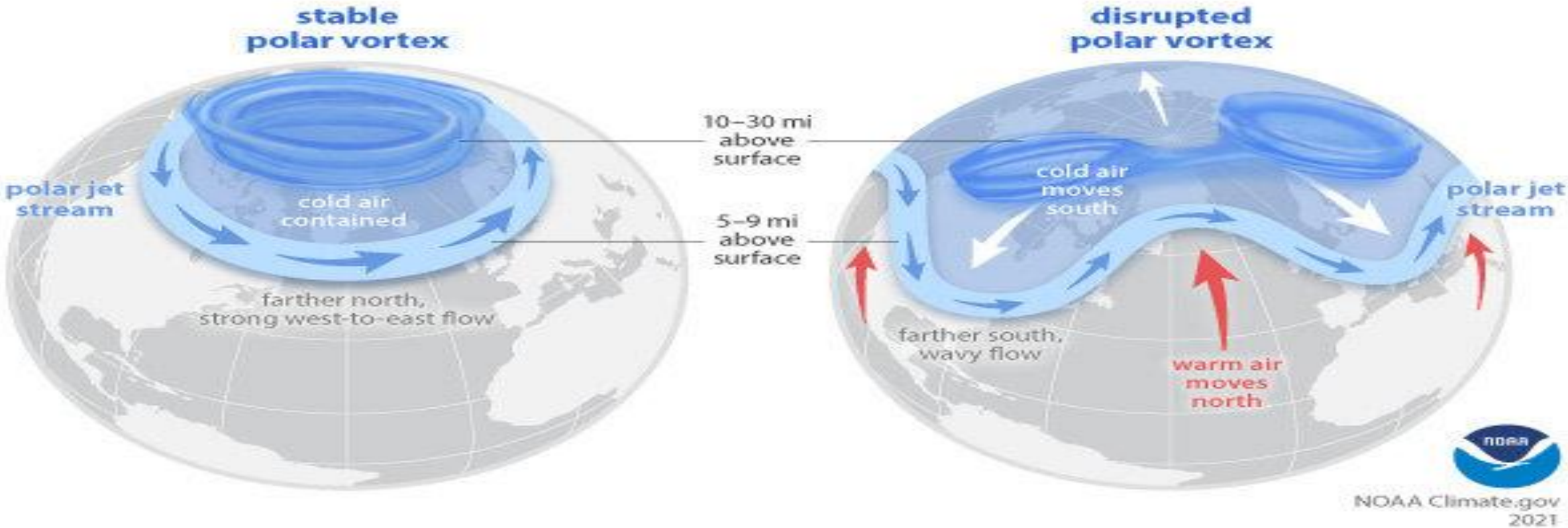
https://images.search.yahoo.com/search/images?p=arctic+snow+cover+over+the+years&fr=mcafee&type=E211US105G0&imgurl=https%3A%2F%2Fwww.researchgate.net%2Fprofile%2FC-R-Bijoy%2Fpublication%2F263089099%2Ffigure%2Ffig1%2FAS%3A572733467889664%401513561707733%2FNASA-Satellite-Image-showing-Loss-of-Arctic-Summer-Ice-Cover-over-the-Last-30-Years.png#id=2&iurl=https%3A%2F%2Fwww.researchgate.net%2Fprofile%2FC-R-Bijoy%2Fpublication%2F263089099%2Ffigure%2Ffig1%2FAS%3A572733467889664%401513561707733%2FNASA-Satellite-Image-showing-Loss-of-Arctic-Summer-Ice-Cover-over-the-Last-30-Years.png&action=click

Understanding the polar vortex

The Arctic polar vortex is a strong band of winds in the stratosphere, surrounding the North Pole 10–30 miles above the surface.

The polar vortex is far above and typically does not interact with the polar jet stream, the flow of winds in the troposphere 5–9 miles above the surface. But when the polar vortex is especially strong and stable, the jet stream stays farther north and has fewer "kinks." This keeps cold air contained over the Arctic and the mid-latitudes warmer than usual.

Every other year or so, the Arctic polar vortex dramatically weakens. The vortex can be pushed off the pole or split into two. Sometimes the polar jet stream mirrors this stratospheric upheaval, becoming weaker or wavy. At the surface, cold air is pushed southward to the mid-latitudes, and warm air is drawn up into the Arctic.



https://www.climate.gov/news-features/understanding-climate/understanding-arctic-polar-vortex

Paleoclimate proxies (Part 2a)

- Dendrochronology (tree rings)
  width (wide or narrow) indicate weather/climate conditions during growth season
  pattern can be used to find the age of the tree

  overlapping patterns can extend length of time involved in the study

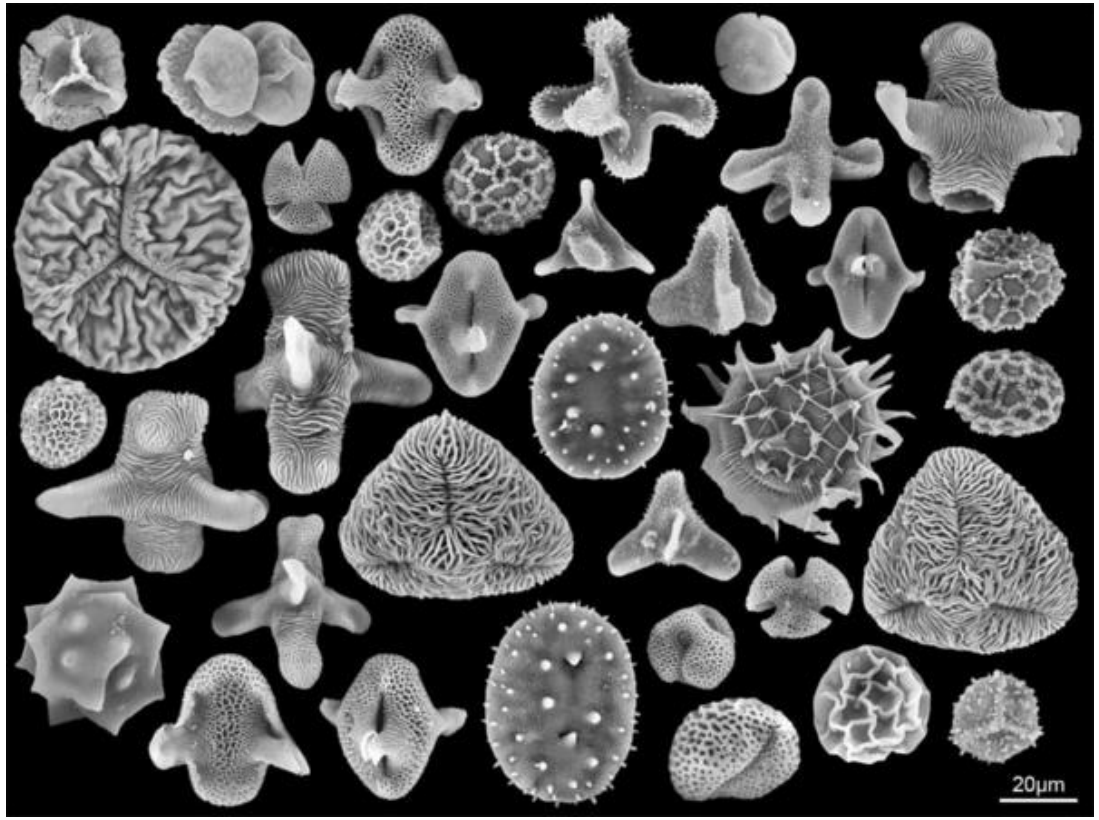
Paleoclimate proxies (2b)

- Palynology (pollen)

  Pollen is extremely resistant to decay

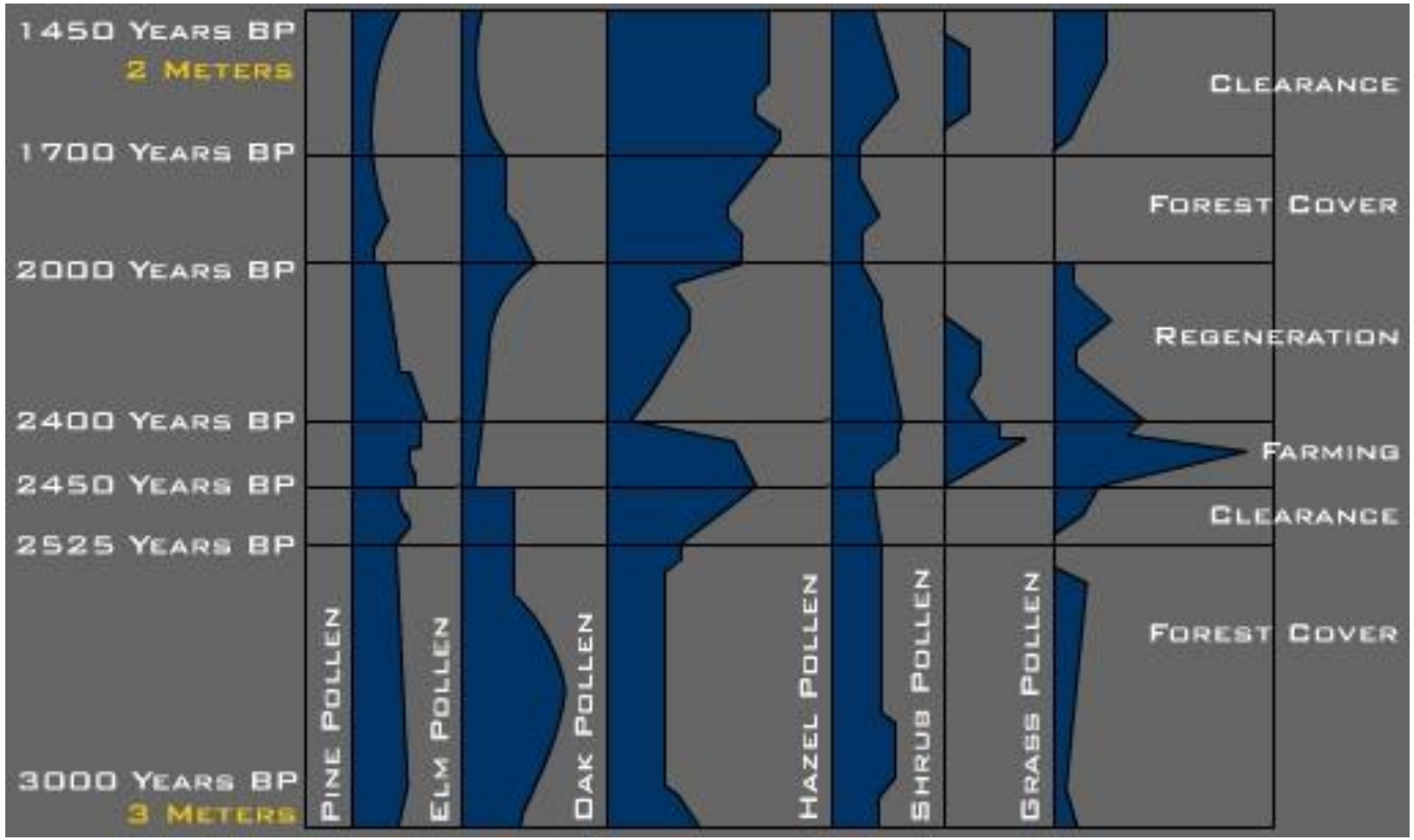
  Collected in cores from swamps and other wetlands

  Can reveal changes in plant ecosystems over time



https://nmnh.typepad.com/.a/6a01156e4c2c3d970c01b7c79ece86970b-600wi

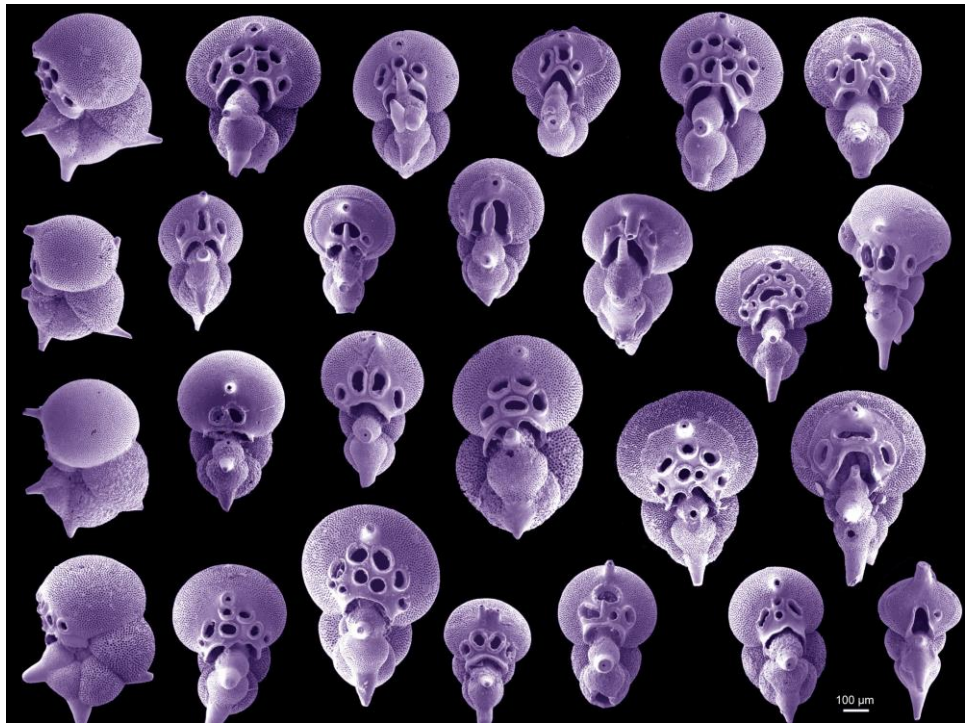
Pollen can reveal changes in plants over time



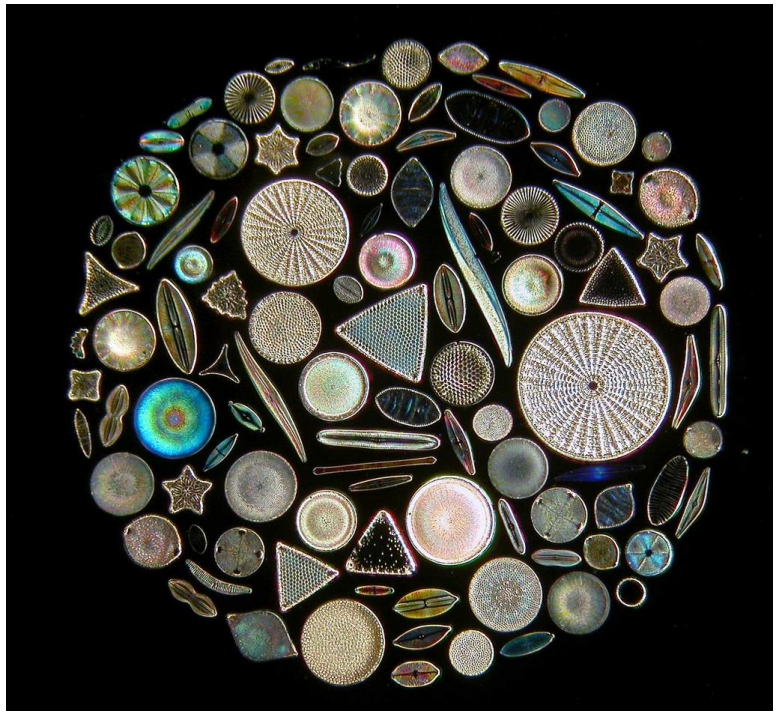
https://la.utexas.edu/users/denbow/labs/palynology.htm

Paleoclimate Proxies Part 2c

- Foraminifera



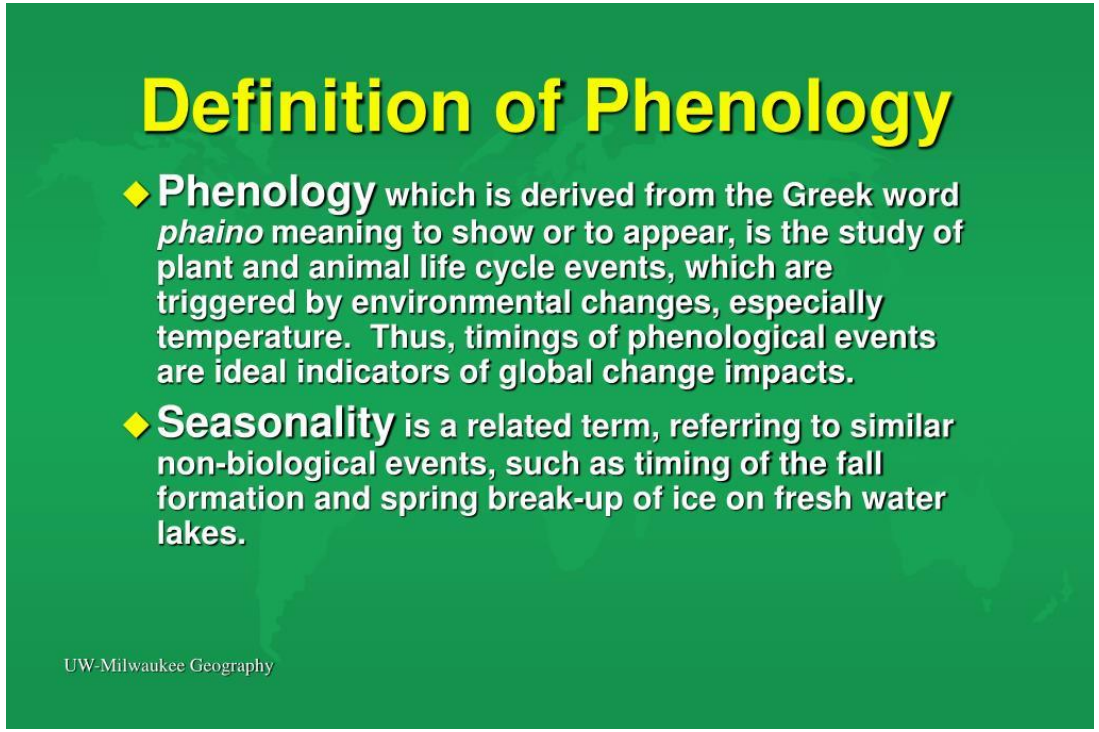
- Diatoms



Many other types of microfossils are climate - sensitive

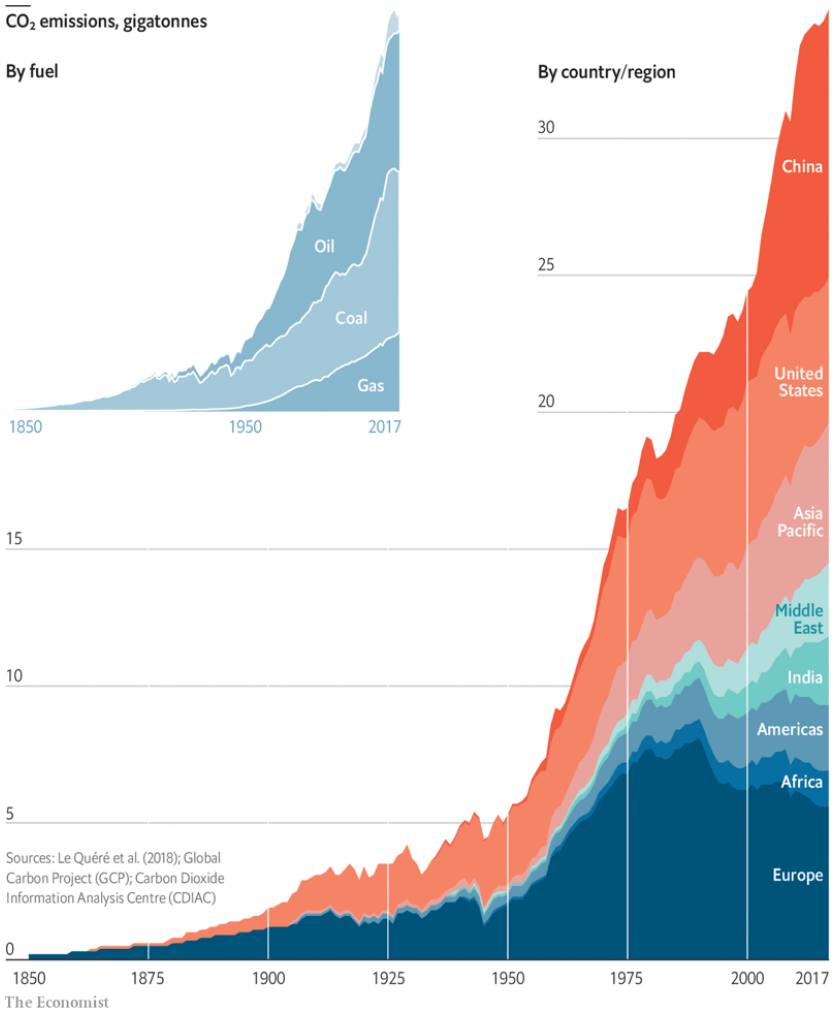
Phenology

- Study of cyclic and seasonal natural phenomena, especially in relation to climate and plant and animal life
- Examples include when first shoots or leaves appear, when ice cover on lakes melts, when migrating animals appear or leave



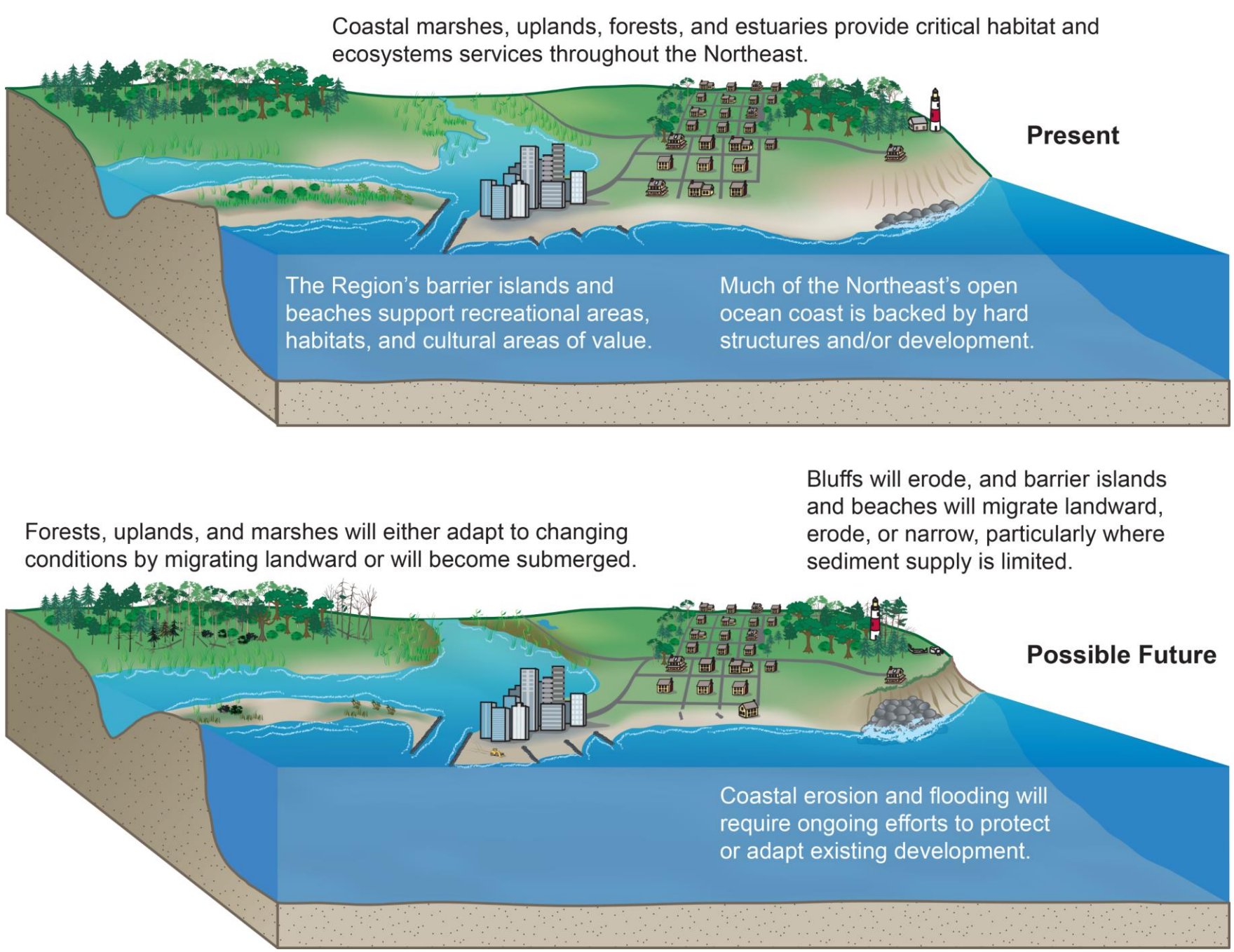
Excellent way to document changing climates

Evidence and cause of Climate Change



Part 3
Some Projected Impacts of Climate Change for Our Region
Northeast - Fourth National Climate Assessment (globalchange.gov)

- Increased rainfall intensity (possibly more flood damage)
- Strain on infrastructures will require rebuilding and mitigation
- Enhanced urban heat island effect (impact on health)
- Sea level rise (loss of property and communities)
- Rising temperatures (heat stress on vulnerable populations, services)
- Changes in lengths of cold and warm seasons



Northeast - Fourth National Climate Assessment (globalchange.gov)

Impacts of Climate Change

- ***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.***

- **Extreme temperatures leave many families living in poverty with less food, less clean water, lower incomes and worsening health.**
- **Droughts and flooding can destroy crops and cut access to clean water.**

https://www.savethechildren.org/us/what-we-do/emergency-response/climate-change?cid=Paid_Search:Bing_Paid:TT_Climate:Nonbrand:090622&s_kwcid=AL!9048!3!!p!!o!!climate%20change&&msclkid=0f551a8de773127798dd7e9bf6cb74c1&gclid=0f551a8de773127798dd7e9bf6cb74c1&gclsrc=3p.ds

Predictions for Sea Level Rise

		2030	2050	2070			2100			2150		
				Emissions								
	Chance SLR Exceeds			Low	Mod.	High	Low	Mod.	High	Low	Mod.	High
Low End	> 95% chance	0.3	0.7	0.9	1	1.1	1.0	1.3	1.5	1.3	2.1	2.9
Likely Range	> 83% chance	0.5	0.9	1.3	1.4	1.5	1.7	2.0	2.3	2.4	3.1	3.8
	~50 % chance	0.8	1.4	1.9	2.2	2.4	2.8	3.3	3.9	4.2	5.2	6.2
	<17% chance	1.1	2.1	2.7	3.1	3.5	3.9	5.1	6.3	6.3	8.3	10.3
High End	< 5% chance	1.3	2.6	3.2	3.8	4.4	5.0	6.9	8.8	8.0	13.8	19.6

**2010 (2001-2019 average) Observed = 0.2 ft*

https://njclimateresourcecenter.rutgers.edu/climate_change_101/sea-level-rise-in-new-jersey-projections-and-impacts/

Part 4

Samples of classroom activities and addressing the Standards

- ESS2.D: Weather and Climate
  Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. (MSESS2-6)
  Because these patterns are so complex, weather can only be predicted probabilistically. (MSESS2-5)
  The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents. (MS-ESS2-6)

Climate Change Education in the Classroom

- With the adoption of the 2020 New Jersey Student Learning Standards (NJSLS), New Jersey became the first state in the nation to include climate change across content areas. These standards are designed to prepare students to understand how and why climate change happens, the impact it has on our local and global communities and to act in informed and sustainable ways.

Possible opportunities for you and your students

- Chemistry of climate change
- Physics and engineering of climate change
- Math of climate change (probability)
- Climate and changing ecosystems
- Climate change and water supply
- Climate injustice
- Climate financing and law (national and international)
- Instrument technician

- “ADAPTATION and MITIGATION”

Exploring Resources for Classroom Activities

- 4th National Climate Assessment
  https://nca2018.globalchange.gov/
- Intergovernmental Panel on Climate Change (IPCC)
  https://www.ipcc.ch/
- Office of NJ State Climatologist
  https://climate.rutgers.edu/stateclim/
- Northeast Regional Climate Center
  https://climate.rutgers.edu/stateclim/
- US Facts/Climate
  https://usafacts.org/issues/climate

Other Useful Resources

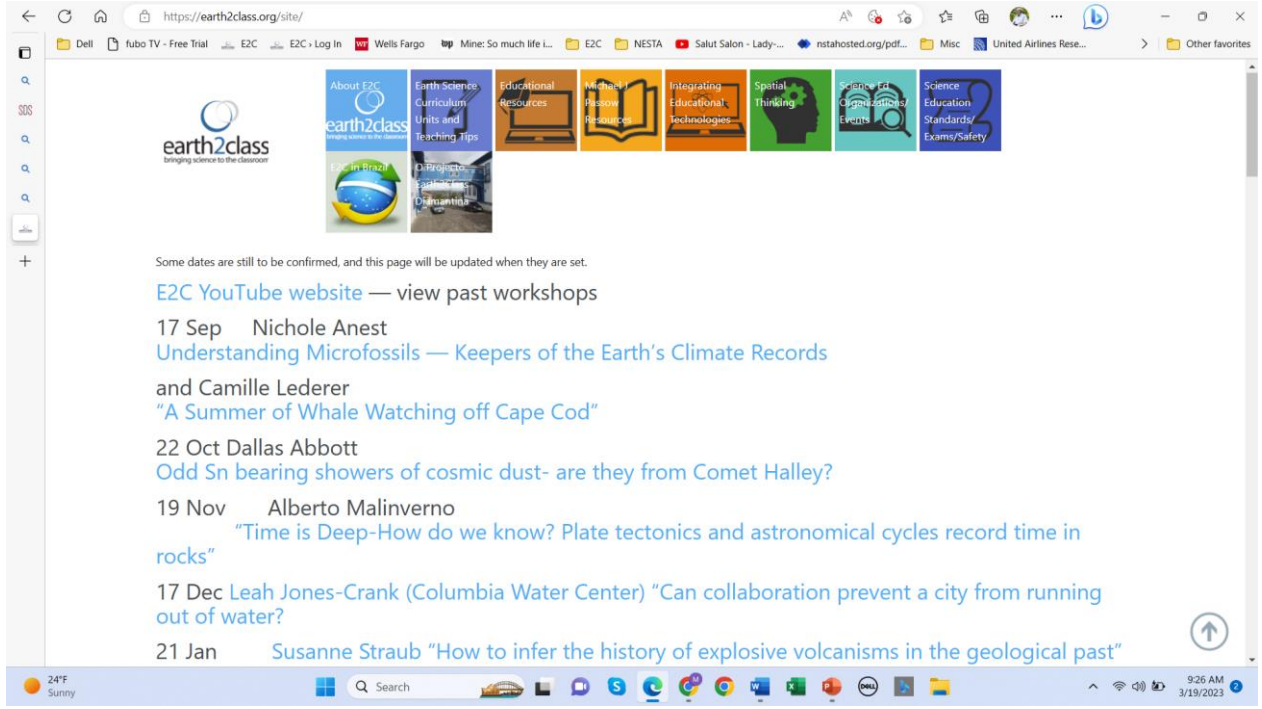
- Montclair State University Land Acknowledgement Statement
  - https://www.montclair.edu/land-acknowledgement-statement/

- Meadowlands Environmental Center
  - https://www.njsea.com/meadowlands-environment-center/
  - https://www.montclair.edu/land-acknowledgement-statement/

  - Three classroom activities I used with my students available at https://earth2class.org/site/?page_id=6134
- What Factors Can Affect Climate chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://earth2class.org/site/wp-content/uploads/2017/04/What-factors-affect-climate.pdf
- How Can We Observe, Represent, Analyze, and Compare Climate Data? chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://earth2class.org/site/wp-content/uploads/2016/12/climate_analysis_generic.pdf
- Phenology and Climate Patterns chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://earth2class.org/site/wp-content/uploads/2016/12/Phenology.pdf

- Weather Tech jobs
- https://www.indeed.com/q-Weather-Instrument-Tech-jobs.html?vjk=9d0017dc00de9c56

Earth2Class programs at Lamont-Doherty Earth Observatory



- You are cordially invited to attend these free programs (offered for now via zoom) and learn directly from Columbia research scientists about their cutting edge investigations. Email me (see next slide) to get on the mailing list).
- Students also invited

Thank you!

michael @earth2class.org

This slide show will be available at
https://earth2class.org/site/?page_id=4969

(Earth2Class.org, Michael J Passow resources)