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The Sun & Chicago: Its Weather, Climate, and Climate Change

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Introduction & Rationale

As a teacher, I am often part of discussions about whether to talk to students about climate change. Opponents of teaching climate change often argue that the topic is too depressing and overwhelming, and our students are too young to understand. I have been thinking about this over the past few months, and I agree that third-grade students are young, but I do not think they are too young to want to make sense of the world that they live in. I did a little math and it put the inaccuracy of this idea into perspective.

Think about this: In ten years my third graders will be young adults who will be graduating high school, ready to take on the world. They will be making their own decisions about housing, transportation, where to spend their money, and they will be both affecting and affected by climate change. They will decide what industry they want to work in, what they want to advocate for, what they value, and what type of person they want to be. Their contributions to our world will be crucial in the fight against climate change, but if we wait to start talking to them about it until it is less depressing and they are older, we might lose the opportunity for them to learn, and they may be influenced by misinformation found in popular sources. Climate change is urgent, and I argue that not discussing it with students will do more harm than good if lessons are done correctly. This generation of children will need accurate knowledge and an understanding of science to be able to make informed choices and be a force for change in our future.

My students are living with the reality of climate change and will face a future where many parts of their lives will be affected by climate change. They are the ones who will be our future engineers, scientists, biologists, and chemists who need to combat it and educate others about it. However, many of my third graders have misconceptions about what climate change is, how it is caused, and what we can do about it. I believe this partly comes from a lack of scientific knowledge about climate itself, and partly because they are sometimes given false or misleading information by adults.

Since I do teach third graders, I do not want to overwhelm them with too many catastrophic effects of climate change because it may make them feel apprehensive and detract from the science behind the lessons. I believe that talking about climate change on a global scale will also be too difficult for my students to grasp because they have not seen and do not interact with, say, polar bears at the North Pole and may feel helpless instead of motivated to affect change. To empower them as leaders who can help change something, I have decided that we will study climate change in the Great Lakes region with a focus on Chicago where we live (but this unit could be adapted for use in any community). We will learn about the effects that climate change is having and will have on Chicago in the future so, in ten years, these eight-year-olds will be knowledgeable adults who are empowered to make smart decisions about our planet.

For the past three years, I have noticed that my students' knowledge of our place in the solar system, our geographic location, and climate change is inaccurate and insufficient. I am often surprised by my students identifying Minnesota as a country or Chicago as a state. I hope for this six-week unit to serve as a basic grounding for students to recognize and understand our place in space as well as our place on Earth. For students to fully understand climate change, its causes, and its effects, we will learn what climate is and review data to discover how it is changing. Only after we have learned this background knowledge about climate can we dive deeply into the realities of and solutions to climate change.

Demographics

I teach third grade in Chicago Public Schools. My school is located on the North Side of Chicago and is a PK–8 school with just under 1,100 students. I have a moderately diverse class of 30 third graders who attend a neighborhood school in an area that has been becoming more affluent and less diverse in the past few years. Currently, our school is 43% white, 35% Hispanic, 7% Black, 6% Asian, and 7% Other. About 17% of our students have limited English capabilities and we have an excellent inclusion model for special education students who also represent about 17% of our population.

We recently lost our Title 1 funding because our poverty index dropped below the threshold; our low-income percentage is now 41.2%. However, this seeming affluence sometimes overshadows the reality of our student population. Each year, I have some students who experience homelessness and/or live in poverty and as a result, there is a range of background knowledge in our classroom. We do not have a specific social studies curriculum as we are an IB (International Baccalaureate) school. IB schools focus on student-led inquiry and transdisciplinary units that include deep learning about a topic across all the subjects. At my school, we have teacher-created IB units and we use the CCSS (Common Core State Standards) and NGSS (Next Generation Science Standards) for literacy, math, and science. We use the Illinois social science standards to build our units as well.

Content Objectives

Throughout this unit, students will engage deeply with the third grade NGSS standards and Illinois social studies standards to learn about our planet and their geographic location on Earth. They will complete experiments to learn why different parts of the Earth have different climates and learn the details of their local climate. They will learn how to identify their geographic location on a map and how to label it correctly. In our lessons, students will be able to explain why a particular place has a certain climate based on its geography. Students will learn about how climate differs from weather and use meteorological data and mathematical reasoning to see how the climate in their region has changed over time. Students will compare historic and present temperature and precipitation trends to see, tangibly, what the term climate change means. From there, students will research the causes and effects of climate change in the Great Lakes region to deeply understand the connection between the graphs they have created and what is happening in their local community. Students will have the opportunity to choose a climate change intervention tool and evaluate its usefulness. They will also make recommendations about how the item/intervention could be improved to help protect the Great Lakes region from the damaging effects of climate change.

Unit Content

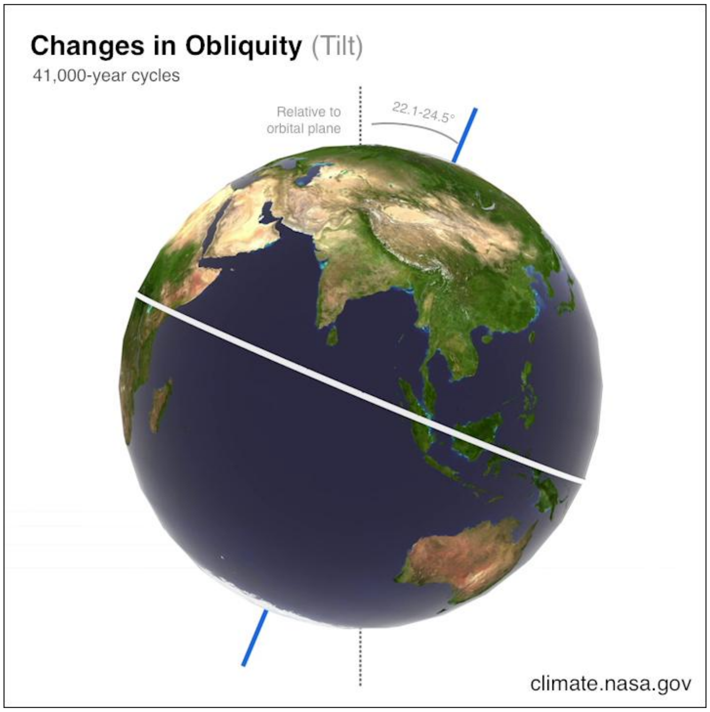
Earth and the Sun

Earth is the third planet from our Sun. The Sun is about five billion years old and is approximately halfway through its lifespan. Our Sun is a star that is quite ordinary in almost every way. The most exceptional thing about our Sun is that it is close to the Earth.[1] Earth is in what scientists call the Goldilocks zone: we are at the just right distance from the Sun for water to be liquid and for our lives as humans to be possible.[1] If we were much farther away from the Sun, Earth would be cold and frozen like Mars, but if we were much closer Earth would be unbearably hot like Venus.[1] Our life as we know it is only possible because of Earth's ideal distance from the Sun.

Earth orbits, or revolves, around the Sun in a near-circular orbit and completes a journey around the Sun once every year.[2] While it is in orbit, Earth is rotating on its axis in space. Earth rotates from West to East and a complete rotation is a near-24-hour day here on Earth (a full day is technically 23 hours and 56 minutes).[3] Since the orbit is elliptical instead of a perfect circle, the Earth is slightly closer to the Sun at some points of the year and farther away at other points. While it may seem counterintuitive, the Earth is closest to the Sun around January 3 each year and farthest away from the Sun around July 4.[4] This information tells us that simply being closer to or farther from the Sun during Earth's revolution is not the reason that Earth has seasons.

Earth's Tilt

Earth does not sit straight up and down while it rotates. Instead, Earth is tilted at an angle of 23.4 degrees from vertical.[4] Scientists calculate the vertical line placement by measuring ninety degrees from Earth's orbital plane. The tilt oscillates between 22.1 and 24.5 degrees every forty-one thousand years and we are currently right in the middle of the range.[4] The angle that Earth's axis is tilted is called its obliquity.[2] This obliquity is the reason that Earth has seasons and the greater the angle of obliquity, the more extreme our seasons are.[2] Earth's obliquity is currently on the decrease but it will take thousands of years for anything to be affected by this change.[2]



(1) Figure 1. This image shows Earth's 23.4-degree tilt from vertical. (Image credit: NASA)

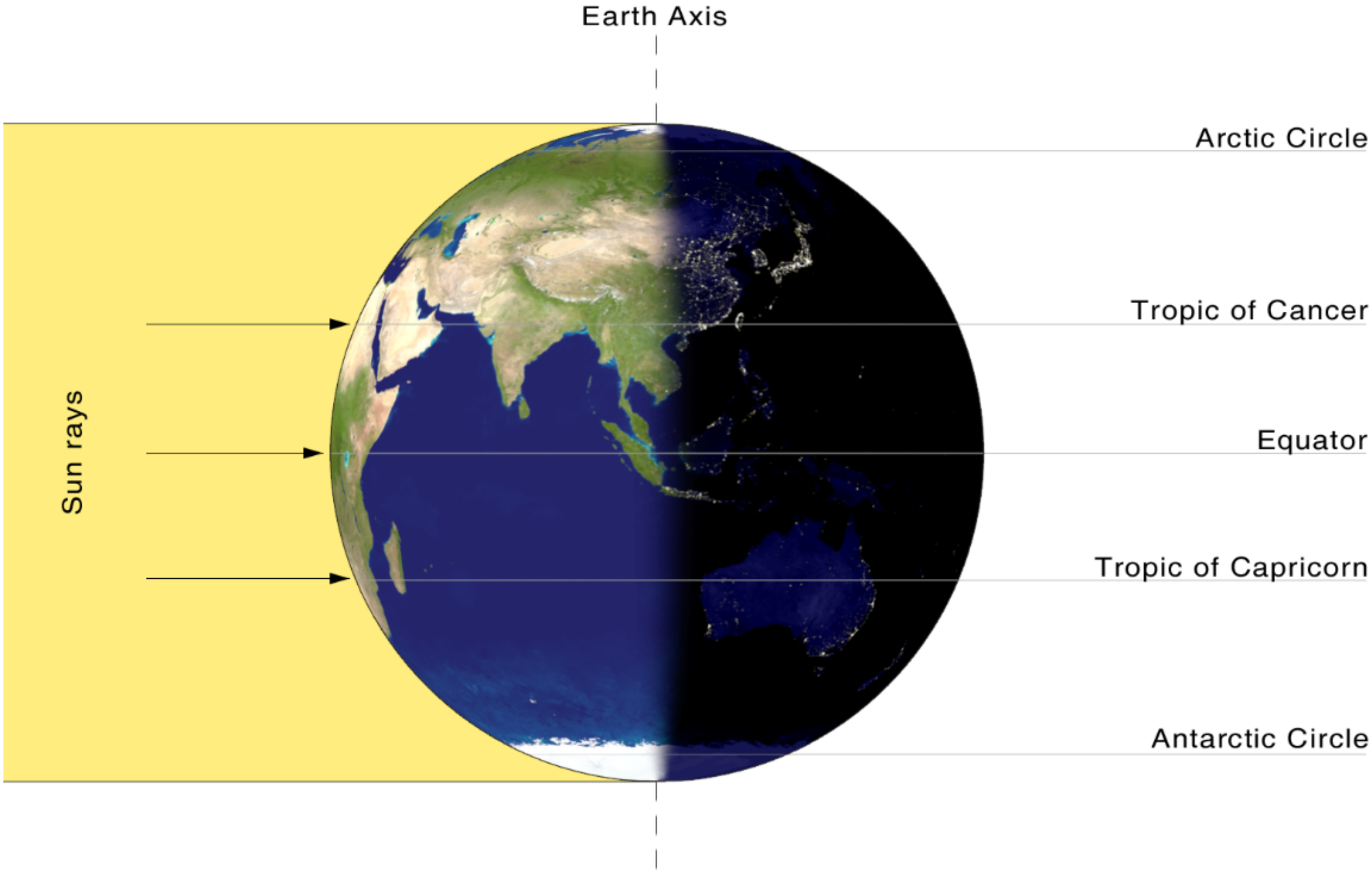
As we discussed, proximity to the Sun does not create the seasons. The reason for this is that the directness with which the rays of sunlight strike the Earth has a much greater effect on the temperature and climate of that area than does the closeness to the Sun.

When we look at how rays of sunlight strike Earth, we find that they hit the middle of the Earth, or the equator, much more directly than any other part of the globe. The rays here tend to strike at a near-perpendicular angle and more perpendicular sunlight rays are more direct. When thinking about temperature, the more direct the sunlight, the greater its heating capabilities.[4] There is a greater heating capability with more perpendicular, or direct, sunlight because the same amount of energy is spread over a smaller area; when rays are not perpendicular, the energy is spread over a larger area and less concentrated so individual places receive less heat energy. This direct sunlight is why places located in the equatorial areas are warm or hot most of the year and have little seasonal variation: they receive more consistent, perpendicular rays of sunlight throughout the year than places farther from the equator.[4] Moving away from the equator and going toward the poles, there is gradually less and less direct sunlight reaching parts of our planet and it hits parts of our planet that are north or south of the equator with gradually lesser angles. A lower angle means less direct sunlight and less heating ability. When we get to the poles, they are cold most of the year because they receive drastically less direct sunlight.

All areas of the Earth have seasons when the weather and temperature are different during different times of the year. Some places have more drastic seasonal differences than others, but the seasons are also due to Earth's obliquity combined with Earth's orbit around the Sun. Since Earth is tilted on its axis, the Northern Hemisphere is at times tilted towards the Sun while the Southern Hemisphere is tilted away from the Sun. When this happens, it is summer in the Northern Hemisphere because the Northern Hemisphere (including the North Pole) is receiving more direct sunlight and is exposed to the Sun's rays for a longer portion of time, which is why daylight lasts longer in the summer.[4] Conversely, it is winter in the Southern Hemisphere because the Southern Hemisphere is receiving much less direct sunlight and has a shorter exposure to that sunlight making for shorter, colder days.

As Earth progresses in its orbit around the Sun, its tilt remains the same, but the parts of the Earth that are tilted toward the Sun slowly shift. When the tilt causes the Southern Hemisphere to receive more direct sunlight for a longer time, it becomes summer on that part of our planet and winter in the Northern Hemisphere. Between summer and winter, we have spring and fall where the Sun's rays are more directly aimed at the equator than at either of the hemispheres.[4] Transitioning from summer to fall in the Northern Hemisphere, Earth's tilt and progression in its orbit cause the rays from the Sun to gradually shift more directly to the equator so the Northern hemisphere receives less direct sunlight and becomes cooler. By September, we have the fall equinox (around September 21) where night and day each last twelve hours in both hemispheres.[4] This signals the transition away from summer in the Northern Hemisphere. As the Earth continues its orbit, the Southern Hemisphere, which is experiencing spring during this time, will gradually start to get more and more direct sunlight for a longer period and transition to its summer months. At the same time, the Northern Hemisphere will be getting less and less of the Sun's rays and transition to winter.

In the polar regions of our planet, seasons occur but both the North and South Poles remain cool year-round because the sunlight's energy is less concentrated in these areas.[1] When one of the poles is tilted toward the Sun, the area near that pole has daylight for 24 hours because the entire area is in the sunlight's path even as the Earth rotates. At the opposite pole, where it is tilted away from the Sun, there are 24 hours of darkness, or night, because the Sun's rays are not directed at that part of our planet.[4] When we look at how the Sun's rays are directed at the Earth, they strike the equator at a nearly perpendicular angle and the poles at a lower angle, so the Sun's energy is more spread out as we get to the poles.[4] This means that there is less potential for heating from the Sun in these regions and they are cooler throughout the year.



(2) Figure 2. In this image, we can see how the Sun's light energy hits different parts of the Earth at different angles because of the tilt of the Earth. The equatorial part of the Earth receives the most concentrated energy from the Sun because its rays strike the surface with a near-perpendicular angle. We can also see how the poles receive less concentrated sunlight because the angle with which the sunlight strikes them is lower. (Image credit: Wikimedia, Creative Commons License CC-BY-SA-2.0)

Earth's Atmosphere & The Greenhouse Effect

Earth has an atmosphere that prevents it from becoming extremely hot or extremely cold. Without an atmosphere, the average temperature on the Earth would be below the freezing point of water, while the part in the Sun would be hotter than boiling water.[1] Neither of these scenarios is suitable for human habitation, which is why our atmosphere is so important to supporting life on Earth.

Our atmosphere traps some of the energy coming from the Sun and this helps to warm the surface of Earth. The majority of the light energy that comes from the Sun comes in the form of visible light. Earth itself (its oceans and land) absorbs much of the energy and heat. The visible light energy penetrates through our atmosphere and is also absorbed by Earth.[1] The Earth's surface radiates infrared wavelengths (infrared is what we feel as heat) of energy back into our atmosphere but our atmosphere does not allow this infrared radiation to escape back into space.[1] The energy is, in effect, trapped inside our atmosphere and warms Earth's surface, as heat.[1] This warming effect is sometimes referred to as blanketing, like a blanket that warms our planet.[1]

Shorter wavelengths of light have higher energy. As Earth's surface heats up, it starts to produce radiation at shorter wavelengths because it is getting warmer. Wavelength and temperature have an inverse relationship whereas one increases, the other decreases.[5] Our atmosphere absorbs mainly longer wavelengths and they are thus trapped inside of Earth's atmosphere, while the shorter, higher energy wavelengths are reradiated back out until we reach equilibrium again at an increased temperature.[1] The trapping of energy inside our atmosphere to warm Earth's surface is known as the Greenhouse Effect because it is the same science behind how greenhouses that grow plants stay warm.

Weather and Climate

Earth's climates are generally defined as the average weather, temperature, and precipitation that an area has over long periods. Climate can change somewhat over months or years, but an area's climate is generally predictable based on what has happened in the past. Climate prediction also includes predictions of extreme weather events, like hurricanes or tornadoes. When we are predicting the climate of a region, it's important to take into account more than just the atmosphere. The oceans, landforms, proximity to ice, and the biosphere also all play a role in an area's climate.[6]

The biosphere is made up of all the living things on our planet.[6] All living things are a part of the biosphere and, in turn, affect the area's climate through what materials and gases they input and output and the way they interact with the land or water around them.[7] The lithosphere, hydrosphere, and cryosphere also affect an area's climate, especially in the long term.[1]

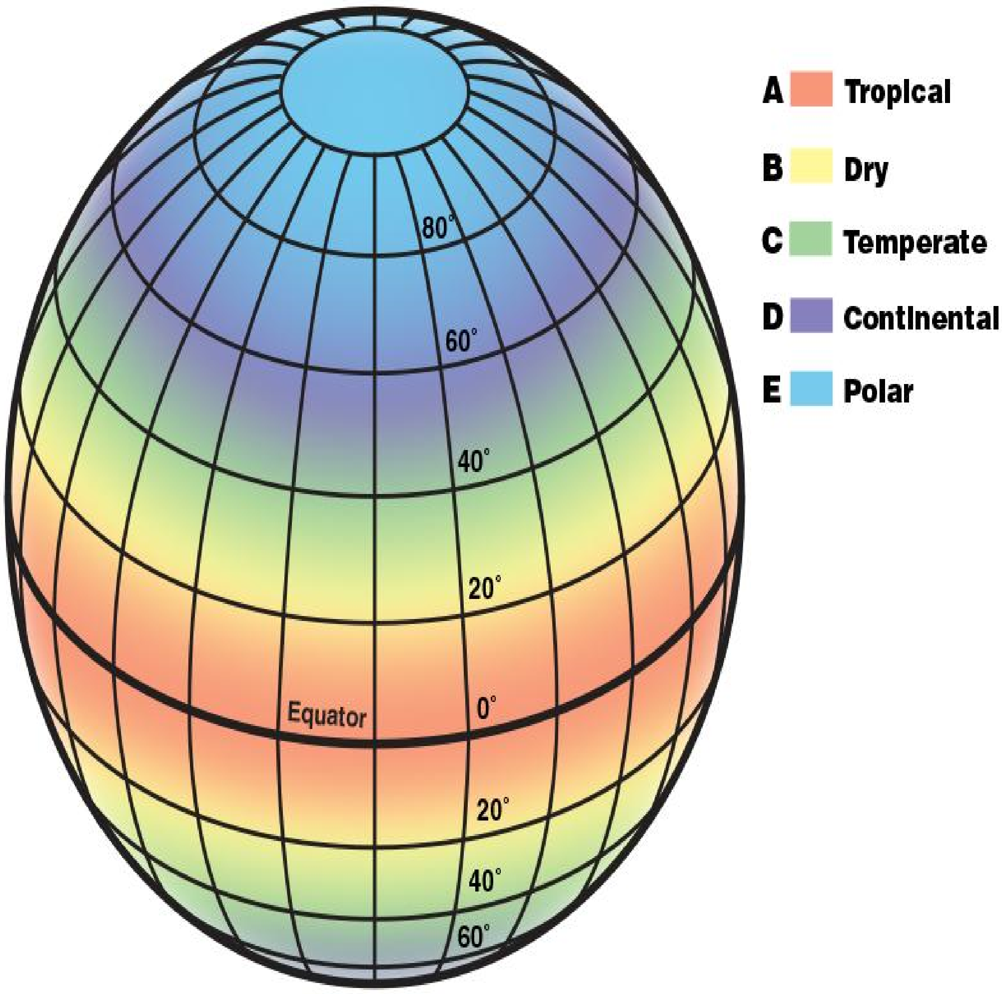
The lithosphere is the solid part of the Earth's crust that contains continental plates, soil, and all of Earth's physical features such as mountains, valleys, canyons, etc.[8] The lithosphere affects climate because the landforms interact with our atmosphere to determine elements like temperature and air pressure in a region.[8] For example, mountains have much lower air pressure and lower temperature because of their high altitudes so the climate here is cold, snowy, and icy.[8] When we look at the liquid water near a region such as oceans, lakes, and rivers we are looking at the hydrosphere, while the cryosphere is the frozen water such as ice and snow contained on Earth such as glaciers, sea ice, and mountain tops.[6] The kinds of water that are near a region impact that area's climate, particularly the precipitation and humidity. Since oceans absorb much of the infrared energy that comes from the Sun, the areas of the ocean that get more concentrated sunlight have more evaporation and more water vapor going into the air; these areas tend to have more precipitation in the form of rain because the heat and evaporation are highest here.[9]

Weather, on the other hand, is the atmosphere's current state and is much harder to predict than climate.[6] Weather consists of factors such as precipitation, temperature, humidity, sun, clouds, visibility, air pressure, and windiness to describe the way that the atmosphere is behaving on that given day.[6] Weather changes much faster than climate. Climate changes happen over months to years, while weather changes can happen in minutes, hours, and days. Predicting weather accurately is difficult to do beyond a few days ahead because of the unpredictability of atmospheric changes, while predicting climate accurately is easier.[6]

When thinking about weather vs. climate, it may help to remember that the climate of a region is the average weather conditions (temperature, precipitation, etc.) observed over a long period of time and thus more easily anticipated, while weather is the day-to-day occurrences in the atmosphere. Another way to think about it is, "Climate is what you expect. Weather is what you get".[6]

Climate Zones of Earth

Earth's major climate zones are related to the seasons and the reason that they exist is the same reason that seasons exist. Looking at how concentrated the sunlight is in a particular area of the Earth helps us determine what the climate will be like. Sunlight's concentration decreases as we go north or south of the equator and the five major climate types that have been identified on Earth differ based on how close to or far from the equator the areas are. Climates change by latitude and appear on climate models of the Earth, like the one below, as bands, depending on how much average sunlight energy they receive from the Sun.[10] By looking at the latitude of a location, we can begin to determine its climate type. To describe the climate of a specific area, we would also need to consider information in the previous section such as the living things there, landforms, and proximity to water.



(3) Figure 3. This graphic shows the banded design of the climate types on planet Earth. These climate types are an approximation as the climate of a specific area is determined by its latitude along with other geographical factors. (Image credit: scijinks.gov)

For third graders, we will focus on the five major climate types as identified by The National Oceanic and Atmospheric Administration (NOAA): Tropical, Dry, Temperate, Continental, and Polar. There are more detailed, specific climate types once we consider all factors in regions around the globe, but for this unit it makes the most sense to focus on these five so students can see the relationship between the heating of the

Earth and the climate zone in a region.

The red climate zone that is approximately between 20 degrees North Latitude and 20 degrees South Latitude is the Tropical climate zone. This climate has warm-hot temperatures all year round and receives a high amount of precipitation.[10] The average yearly temperature in the Tropical climate is 64 degrees Fahrenheit or 18 degrees Celsius.[10] This climate is so warm and humid because it sits on the equator where it receives the most direct sunlight all year round. The oceans that surround many of the places in this climate zone also absorb much of the infrared or heat energy from the Sun, causing evaporation of water which comes back to Earth in the form of rain.

The yellow climate zone that is located approximately between 20-30 degrees North Latitude and 20-30 degrees South Latitude is called the Dry climate zone. These areas are generally hot in the summer and warm in the winter. Dry climates still receive concentrated sunlight but do not have the same oceanic evaporation and precipitation that we see in the Tropical climate zone because most places in this climate band are not located by a large body of water. Since there is no large water source to evaporate and come back as rain, Dry climates receive low precipitation and water evaporates quickly, leaving the landscape generally dry.[10] The Dry climate zone is where many deserts are located due to the high degree of evaporation and low precipitation.

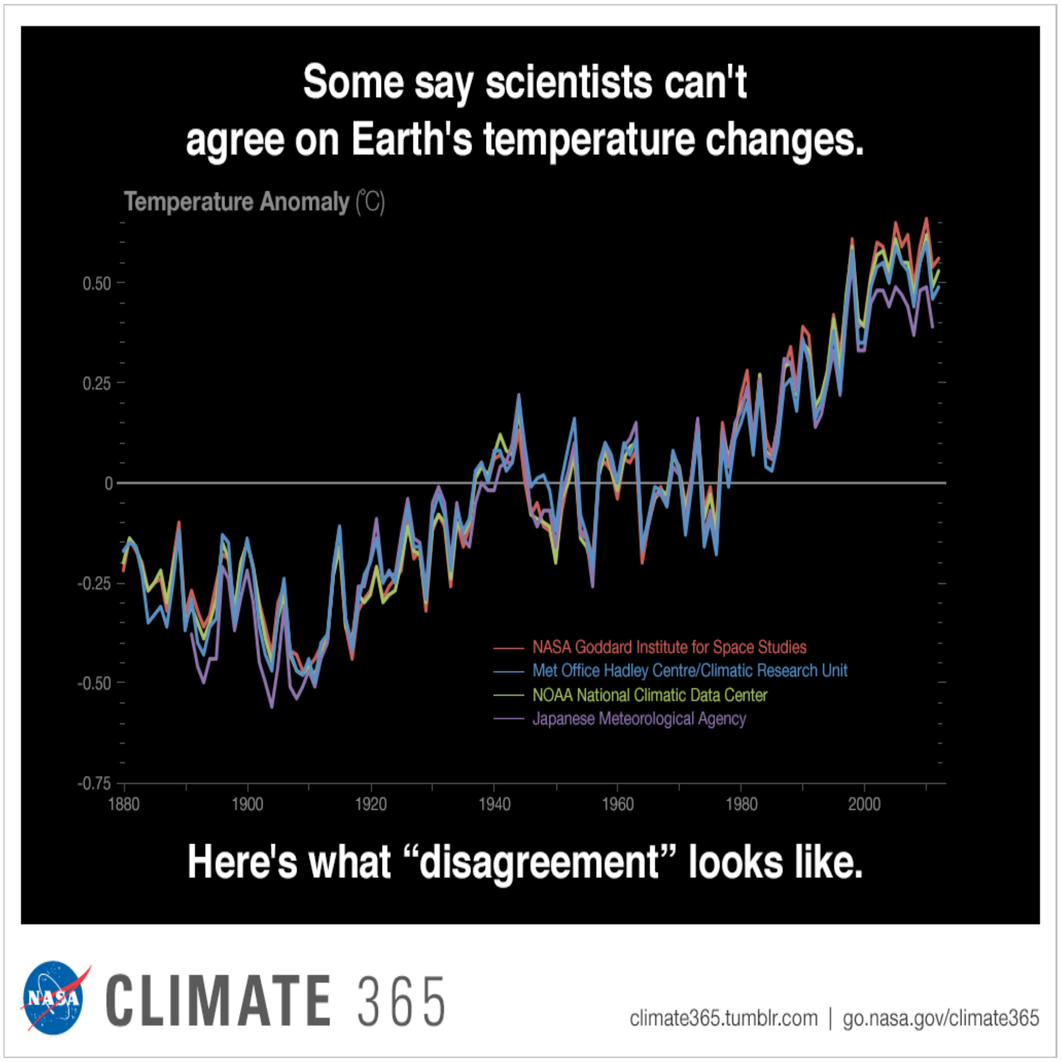
The green climate zone between approximately 30-40 degrees North Latitude and 30-40 degrees South Latitude is called the Temperate climate zone. This climate zone is farther away from the equator and gets less concentrated sunlight, so we start to see seasons with mild, cool temperatures in winter and hot, humid summers.[10] There is a large amount of variability in this climate, depending on how close to water an area is and how far north it is.

The purple climate zone between approximately 40-60 degrees Latitude, both north and south of the equator, is called the Continental climate zone. As this climate is farther away from the equator, the temperature all year round is lower. These regions typically have warm summers and cool or cold winters. In the northern part of these regions, temperatures can get below –22 degrees Fahrenheit in the winter months.[10] Places near water, such as the Great Lakes, can see humid summers because of water evaporation.

The blue climate zone at the top and bottom of the globe, near the North and South Poles, is fittingly called the Polar climate zone. As we discussed, temperatures near the poles are cold year-round because the sunlight is less direct in these areas, so there is less heat energy coming from the Sun.[10] Much of the frozen water contained in the cryosphere in the form of glaciers and ice sheets is located in the Polar climate zone and, even in summer, the region typically does not see temperatures above 50 degrees Fahrenheit, although that may be changing with rapid climate change.[10]

Rapid and Recent Climate Change

Climate change has become a controversial, politicized topic and one on which many people have their own opinion. However, the science behind the recent, rapidly occurring climate change is clear and irrefutable. Since climate is the expected weather pattern in a region over a long period, climate change, then, is a change to these expected patterns. Climate change is a shift in the mean, or average, temperatures in a region.[6] Taking a look at the graph below, we can see the steep increase in Earth’s temperature over the past century.



(4) Figure 4. This graphic from NASA demonstrates the anomaly, or deviation from the norm, in the average temperature of the Earth. Looking at the graph, we can see that four separate institutions have plotted the temperature of Earth and it has been steadily rising for the past eighty years or so. NASA explains that each institution analyzes their data a bit differently, but that the highs and lows on the graphic align with each other.[11] We can also see that the warming over the past few decades has been quite rapid and the decade we are currently in is the warmest one yet.[11] (Image credit: NASA)

Earth's average temperature has increased by about one degree Celsius since the year 1900 and most of this warming has occurred in the past fifty years.[6] Even this one-degree increase that we see in the graph causes drastic changes for Earth and its climate. Coupled with the observations of plants, animals, ocean heating, and more elements of the natural world, the evidence shows incontrovertible proof of climate change.[6]

Milankovitch Cycles & Climate

Although the rapid climate change and global warming effects that we are seeing on our planet are caused by human activities, Earth's climate does vary over tens of thousands of years due to the Sun's influence on our planet.[1] It is important to recognize the difference between these long-term variations in our planet's climate and the human-induced climate change we are seeing now.

Milankovitch cycles are changes in Earth's position relative to the Sun that occur over long periods of time.[2] Changes from Milankovitch cycles occur over tens of thousands of years and we would not see much measurable change during our lifetime as we do with the current climate change.[2] Milankovitch cycles determine when our Earth enters and exits Ice Ages.[2] The three main factors that determine Milankovitch cycles are: 1) Earth's orbit shape 2) Earth's tilt or obliquity 3) The way that Earth's rotational axis faces, called precession.[2, 6]

Earth's orbit shape resembles a circle, but it is not a perfect circle.[2] Over one-hundred-thousand-year periods, Earth's orbit changes to slightly more elliptical (oval-shaped) due to the gravitational pull of Saturn and Jupiter, as these gas giants have a larger gravitational pull than Earth.[2] When Earth's orbit is at its most elliptic, the difference in incoming solar radiation between Earth's closest point to the Sun and its farthest point from the Sun is much larger than when Earth's orbit is more circular.[2] This difference is because Earth is farther away from the Sun at its farthest point in an elliptical orbit than it is at its farthest point in a circular orbit. More circular orbits mean our seasons will be more equal, while a more elliptical orbit means that some seasons will be slightly longer than others.[2]

Earth's obliquity, as we discussed before, is our planet's angle of tilt and the reason we have seasons.[2] Earth's obliquity oscillates between 22.1 and 24.5 degrees.[2] When the degree of obliquity is higher, seasons are more extreme because each hemisphere will get more solar radiation when it is tilted toward the Sun in its summertime and less solar radiation when it is tilted away from the Sun during winter.[2] Higher obliquity is seen during times of deglaciation - when ice sheets and glaciers are melting.[2] A lower tilt angle means milder seasons and more build-up of glaciers and ice sheets near the poles; if Earth had no tilt we would not have seasons at all.[2] Earth's tilt cycles between its high and low every forty-one-thousand years.[2]

During Earth's rotation, its axis doesn't stay perfectly still, but instead sways or wobbles.[2] This wobbling is known as precession. Precession is caused by gravitational interactions between the Sun and the moon that cause the Earth to swell more at the equator, changing its rotation slightly.[2] Precession causes seasons to be more extreme in one hemisphere and more moderate in the other hemisphere.[2] It also causes the timing of the seasons to change slightly and they will gradually begin earlier in our calendar year.[2] Axial precession cycles take place over twenty-six thousand-year periods.[2]

Milutin Milankovitch, the Serbian astronomer and mathematician who came up with the cycles now known by his name, took into account that some seasonal changes and solar radiation are more likely to affect change than others.[2] He was able to calculate that Ice Ages occur every forty-one thousand years and his calculations were supported by historic evidence that Ice Ages did occur at this interval between one and three million years ago.[2] However, starting about eight-hundred thousand years ago, evidence demonstrated that the Ice Age cycle increased to every one-hundred thousand years, although scientists are not sure why.[2]

Because Milankovitch cycles occur over such long timescales, they cannot be a causal factor in the rapid global warming and climate change phenomena that we are seeing today. There has not been a significant change in the amount of solar radiation that Earth is receiving from the Sun that would cause such extreme warming.[2] Earth is in an Interglacial period between Ice Ages and the Milankovitch cycle predictions indicate that our planet, without the increased greenhouse gases, would be cooling, not warming.[2] This evidence illustrates that, while Milankovitch cycles can cause shifts in climate, they are not the driver of the climate change we are seeing at present.

Causes of Rapid, Recent Climate Change

The drastic changes that we are seeing in the temperature of our planet and the climates all over the world are caused by human activities; mainly the emission of greenhouse gases into the atmosphere.[2, 12] It is predominantly caused by the burning of fossil fuels which release greenhouse gases such as carbon dioxide, methane, water vapor, nitrous oxide, and fluorinated gases into our atmosphere.[13] Some of these gases, especially methane, are also released during livestock production and certain agricultural practices.[13]

Carbon dioxide emissions are the largest contributors to the climate change and global warming patterns that we are seeing, primarily due to the extensive burning of fossil fuels such as coal, natural gas, and petroleum. The amount of carbon dioxide present in our atmosphere has increased since the time of the Industrial Revolution, when factories and businesses started burning fossil fuels on a larger scale, by about 40%.[14]

When carbon dioxide and other greenhouse gases are released into our atmosphere, they accelerate the greenhouse effect that our planet already has and continue to push the equilibrium temperature higher. As we discussed earlier, the infrared energy that we get from the Sun is trapped inside Earth's atmosphere and helps to warm Earth's surface. Earth then radiates infrared, or heat, radiation back out. When we add greenhouse gases to the atmosphere, they trap even more of the infrared radiation inside the atmosphere, radiation that would have normally been radiated back out, and increase the temperature of our planet. As our planet heats up, it begins to radiate higher energy, i.e., shorter-wavelength, infrared radiation that is now trapped in the atmosphere causing temperatures to increase. The equilibrium temperature that our planet had before the excess of greenhouse gases is thrown off because these gases are trapping radiation that would normally be radiated back out. The temperature of the Earth's atmosphere will continue to increase as we add more greenhouse gases to the atmosphere because more, higher energy radiation is trapped inside. Higher energy radiation leads to higher temperatures and the cycle of warming will continue. The planet Venus is an example of a runaway Greenhouse Effect, where temperatures on its surface are about 900 degrees Fahrenheit due to the high levels of carbon dioxide trapped within its thick atmosphere.

Effects of Climate Change in the Great Lakes Region

Climate change will affect the Great Lakes area in a multitude of ways. The ones we'll be discussing are effects on fish and wildlife, flooding, extreme weather, water quality, and recreation.

The Great Lakes are home to over one hundred and seventy species of fish and more than thirty-five hundred species of plants and animals.[12] These animals rely on the Great Lakes for water, breeding, and food supply, as this is their primary habitat. There are species of plants and animals here that are native to this area and are not found anywhere else in the world.[12] Climate change will cause air temperatures to increase and patterns of precipitation to change.[12] These changes will affect plants' and animals' habitats and their ability to survive and thrive in their native habitat. Some species will be forced northward or westward toward cooler weather.[12] The increased precipitation and changes in ice cover will also affect Great Lakes species because the amount of ice cover during winter months is decreasing while the surface temperature of the water is increasing.[12] Warmer water temperatures may not allow some fish species to breed and survive. Warmer temperatures in the air will push mammals and insects farther north and allow them to colonize new areas, bringing with them new diseases and pathogens, and disrupting the local ecosystem.[12] When smaller mammals, birds, and insects move northward, predators of these animals will be affected as well if they cannot find an alternative habitat and food source.[12]

When non-native animals migrate into new habitat areas, they are trespassing on native species' habitat and may jeopardize food supply, shelter, and space for native animals.[12] Large mammals, like moose, are especially vulnerable to climate change as white-tailed deer and wolves move into territory that was once occupied by moose.[12] Wolves prey on moose calves and white-tailed deer may out-compete moose for habitat and food.[12] As climate change continues to get worse, species of animals and plants face the threat of extinction and endangerment.

Birds and fish can be adversely affected by the warming water temperatures because warmer water breeds bacteria that can cause disease. When fish are exposed to water that is contaminated, the fish become infected as well. When birds ingest contaminated fish, they become sick and often die of these diseases, such as botulism.[12] Botulism outbreaks have been increasing in the past decades due to warmer water where the bacteria flourish.[12]

As precipitation increases due to climate change, flooding is also expected to increase in the Great Lakes region.[12] Between 1901 and 2015, the entire United States had a 4% increase in precipitation, while the Great Lakes region increased by 10% with large precipitation events contributing heavily to the increase.[12] The increased water and higher likelihood of large precipitation events will cause flooding. Urban areas with surfaces that cannot absorb water (concrete, roofs, roadways etc.) are especially vulnerable to extreme flooding which can cause damage to homes, roadways, humans, animals, and other infrastructure.[12] Extreme flooding can also cause soil erosion; this could do a lot of damage to the Midwest's agricultural production.[12]

Climate change also causes an increase in extreme weather events such as severe thunderstorms, heatwaves, and droughts.[12] Heatwaves in the Midwest can cause severe illness and death, especially to people who already have respiratory problems such as asthma.[12] Increased air temperature increases pollution and decreases air quality, making it more difficult for individuals with respiratory problems to breathe.[12] Extreme heat can also cause heatstroke. Extremely hot days in the summer are expected to increase by about 23 days per year by the end of the century while extremely cold days will decrease.[12] However, lake effect snows with high amounts of snowfall will increase, causing economic damage and costing the city money.[12]

Severe storms and tornadoes are expected to increase with rising temperatures. These events can bring about human and animal deaths, infrastructure destruction, and millions of dollars of economic damage.[12] People who live in under-resourced areas are more likely to experience damaging effects from these storms such as home displacement, damage to their home, and barriers to transportation because of the location and quality of most low-income housing.[12]

Water quality is affected by Great Lakes' climate change due to the growth of toxic bacteria, algae blooms, and sewer overflows.[12] There are over thirty-four million people that live in the Great lakes area and depend on the lakes for drinking water.[12] Poor water quality and higher water levels can overload water treatment facilities and may lead to people getting sick from water-borne pathogens.[12] E. Coli is especially abundant in the Great Lakes region and quite costly to eradicate from water; the cost of clean drinking water is likely to increase with climate change as water treatment becomes more expensive.[12]

Recreation and tourism bring the Great Lakes region approximately sixteen billion dollars per year.[12] Toxic algae blooms, increased bacteria, higher water levels, and dangerous storms will increase the likelihood of beach closures and swim advisories.[12] This may deter tourists or cause injuries or deaths to people who do not follow advisories when the lake is not safe. The industry stands to lose money when more days out of the year are considered unsafe for boaters, swimmers, and fishermen.[12]

Strategies to combat climate change in the Great Lakes Region

There is no one, perfect strategy to combat climate change. Some strategies aim to decrease the amount of carbon dioxide in the air, while others hope to mitigate the effects of a warming planet. One solution is planting an abundance of trees and creating more forests, as forests are a natural absorber of carbon dioxide during their photosynthesis process.[12] However, planting more forests may replace land once used for farming and hurt the agriculture industry.[12]

The soil erosion, droughts, and flooding that hurts agricultural production can be mitigated with improved irrigation, growing different crops, or changing how farms are managed.[12] In urban areas, building ‘green’ roofs or ‘cool’ roofs as a part of city infrastructure can help lessen the extreme heat from heatwaves. Green roofs are roofs covered with plants and cool roofs are roofs made of reflective material.[15] These roofs helped lower temperatures in cities in Europe, but often affected air circulation in ways that counteracted some of the cooling benefits.[15] The overall effect was still a cooling effect, but the downsides of these strategies should be weighed carefully before their adoption.[15]

Another strategy that reduces carbon dioxide emissions is regulating companies’ emissions and making companies pay for the carbon dioxide that they produce. Some companies have already vowed to lower their emissions and/or offset their carbon emissions by planting trees, donating to and investing in renewable energy sources, or sending money to companies working to offset carbon emissions.[16]   The biggest problem with this strategy is that wealthy people typically release the most carbon dioxide with their activities and this gives them a way to continue an emissions-heavy lifestyle while less wealthy people in the developing world are directly affected by climate change consequences.[16]

Using alternative sources of energy, such as wind, sunlight, and nuclear power will help dramatically reduce emissions from fossil fuels. With these options, often the barrier is the cost and convenience. Solar panels can require a large investment upfront to put in panels and the batteries need to be replaced every ten years or so, but they can produce a good amount of energy to power a home. Another barrier is fossil fuel companies that lobby on behalf of their corporations and impede change.

Based on the data of our warming planet, strategies that reduce carbon dioxide emissions and carbon dioxide in the air are critical. Perhaps a combination of the aforementioned strategies or a new solution is necessary to ensure that our planet is livable for future generations.

Teaching Strategies

Guided Inquiry

In guided inquiry, the teacher provides appropriate resources about the topic students are investigating and gives students a way to capture information. Oftentimes I provide a note-catcher or graphic organizer for students to collect the important information. In my experience, this strategy is especially effective for younger students who may have a hard time finding good sources or feel overwhelmed with the amount of information. Guided inquiry sessions allow students to be autonomous in their learning but ensure that they are staying on task and have access to appropriate source material.

I plan to do guided inquiry sessions for the project at the end of the unit where students learn about different climate change mitigation strategies. I also plan to incorporate it into the beginning of our unit when students learn about what factors affect our climate in Chicago.

Science Journals

Students will use a graphing notebook as their science journal. The graph paper will allow students to complete graphing activities related to temperature and precipitation. We will use these journals as a space for students to take notes, glue in figures or graphs, draw observations, and write out hypotheses. This way, all their information is in one place, and they can easily refer back to something we learned earlier in the unit.

Classroom Activities

Mapping Climates onto Paper Globes

Each student will get their own foldable paper globe that resembles the shape of our Earth. Then, using a flashlight and light sensor, we will measure the strength of the light (simulating the sunlight) at different latitudes on the paper globe. We will color the paper globe in different colors to demonstrate how concentrated the light energy is at different latitudes on the paper globe. I will be using a template that already has latitude lines on it. When students are finished with this project, it should resemble Figure 3. Students will write and draw about what kind of climate they expect in each of the different zones and then compare their hypotheses with facts from scientific readings. By having students physically map out the climates and see the relationship to the Sun's energy, it will make it more tangible and concrete for young students who may have trouble understanding this concept just by reading or watching a video.

Evaluating a Climate Change Intervention

Students will be given a list of climate change interventions that we have read about together in class. They will get to choose one of the tools or strategies and research it, evaluate it using a rubric, and offer suggestions for improvement. Depending on the tool, students will have the option to re-design the item and submit their suggestions to a local leader who utilizes this intervention in his/her work. This activity will be used as the culminating project for the unit as a way for students to get involved with and take action in their local community. It offers students a large amount of choice and freedom to explore. It also gives students a real purpose and a real audience for their final project.

Graphing and Comparing Temperatures & Precipitation

Students will graph the daily maximum temperature and daily precipitation in the month of April for the year 2021 on two separate graphs. We will label the axes of the graphs, create appropriate scales, and learn how to make a line graph accurately. Once we have finished these graphs, students will look at historic data from 1900 and use a different color to graph the temperature and precipitation data from 1900 on top of their previous line graphs (5). They will then make observations and hypotheses about what is happening with weather and climate based on the information and patterns observed in their graphs.

Jigsaw Reading

For different readings in the unit, students will be split into groups and each group will be assigned a specific article, portion of an article, or item to read about. Once all the groups have completed their reading and have become familiar with their assigned topic, they will be put into heterogeneous groups with one person from each of the topics. Each student will take turns teaching the content that they learned to the rest of the group. This provides students with an opportunity to learn from each other instead of from the teacher and encourages them to learn about something so deeply that they can effectively explain it to others.

Resources

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Classroom materials

To successfully complete this unit, students will need paper globes, flashlights, coloring tools, light sensors, and graphing notebooks.

Appendix on Implementing District Standards

This unit dives deeply into some of the third-grade weather and climate NGSS standards. Students will map out climates of the world and see how climate changes with latitude. This activity ties in with NGSS standard 3-ESS2-2 where students need to describe different climates in the world. The NGSS standard 3-ESS2-1 requires that students be able to represent weather data in tables and describe the typical weather (or climate) in an area. Students will be graphing both temperature and precipitation to compare past and present temperatures in the Chicago area. NGSS requires that students be able to “make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard” (6). In this unit, students will focus on the impacts of climate change in their community and evaluate the usefulness of a tool to combat climate change.

Since I work at an IB school, it is important that the units I create target both science and social studies standards while tying in CCSS during individual lessons. There is a lot of room for research and inquiry in this unit, which aligns with the Illinois Social Science inquiry standards SS.IS.1.3-5 and SS.IS.2.3-5 that require students to ask essential questions and supporting questions to help with their inquiry. Students will inquire about why Earth has different climates, why we have seasons, whether the Sun is a cause of climate change, and mitigation strategies related to climate change. This unit also allows students to get involved in identifying problems caused by climate change in their communities and how people are trying to solve them; social science standard SS.IS.7.3-5 encourages students to participate in problem-solving in their local community. Students will learn some basic geography of their area and be able to label important areas on the map, which aligns with geography standard SS.G.1.3. Overall, this unit should give students a solid foundation in weather and climate, their geographic location, and get them involved in their local community through problem-solving.

Individual lessons in this unit will be designed to incorporate the literacy CCSS, with a focus on informational text reading. Standards that align closely with this work are CCSS.ELA-Literacy.RI.3.1, CCSS.ELA-Literacy.RI.3.2, and CCSS.ELA-Literacy.RI.3.3. These standards reference students' understanding of main idea of an informational text, asking good questions, and describing cause and effect within a scientific concept.

Notes

(1) Image credit: NASA from https://climate.nasa.gov/

(2) Image credit: Wikimedia CC-BY-SA-2.0 at https://en.wikipedia.org/wiki/Equinox#/media/File:Earth-lighting-equinox_EN.png

(3) Image credit: scijinks.gov, a NOAA product at https://scijinks.gov/climate-zones/

(4) Image credit: https://climate.nasa.gov/climate_resources/9/graphic-earths-temperature-record/

(5) NOAA and The National Weather Service provide free historic weather data for a multitude of areas. The search function allows teachers to find the weather information they want students to look at and NOAA will email it as a table. The table is student-friendly to look at and can be printed to assist with graphing weather trends. (https://www.ncdc.noaa.gov/cdo-web/)

(6) Weather and climate NGSS standards for third grade can be found at https://www.nextgenscience.org/topic-arrangement/3weather-and-climate

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